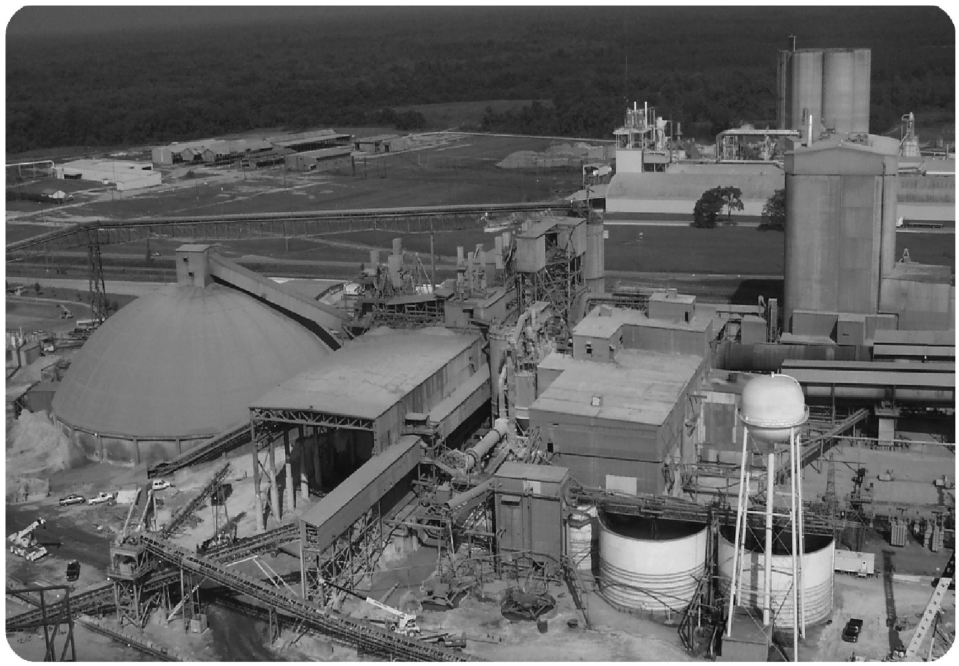
User Manual

Original Instructions

Allen-Bradley

PowerFlex 7000 Medium Voltage AC Drive Air-Cooled ('B' Frame)—ForGe Control

Catalog Number 7000



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Rockwell Automation

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

	WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.

	SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
	ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

Preface

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Notes:

Purpose

This document provides procedural information for managing daily or recurring tasks involving the PowerFlex® 7000 medium voltage 'B' frame drives (heatsink and heatpipe models).

Summary of Changes

This manual contains new and updated information as indicated in the following table.

Topic	Page
Added warning for motor filter capacitors and indicative fault codes	51
Changed input frequency to ±5%	177

Who Should Use This Manual

This manual is intended for use by personnel familiar with medium voltage and solid-state variable speed drive equipment. The manual contains material that enables regular operation and maintenance of the drive system.

What Is Not in This Manual

This manual provides information specific to maintaining the PowerFlex 7000 'B' frame drive. This document does not include topics such as:

- Physically transporting or siting the drive cabinetry
- Installing or commissioning procedures
- Dimensional and electrical drawings generated for your order
- Spare parts lists compiled for your order.

Rockwell Automation provides the site- and installation-specific electrical and design information for each drive during the order process cycle. If they are not available on site with the drive, contact Rockwell Automation.

If you have multiple drive types or power ranges, ensure you have the correct documentation for each specific PowerFlex 7000 product:

- 'A' frame for lower-power air-cooled, configurations (up to approximately 1250 hp/933 kW)
- 'B' frame for higher-power, air-cooled configurations (standard or heatpipe models)
- 'C' frame for all liquid-cooled configurations

General Precautions

ATTENTION: This drive contains ESD (electrostatic discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference Allen-Bradley publication 8000-4.5.2, "Guarding Against Electrostatic Damage" or any other applicable ESD protection handbook.

ATTENTION: An incorrectly applied or installed drive can result in component damage or a reduction in product life. Wiring or application errors, such as, undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures may result in malfunction of the system.

ATTENTION: Only personnel familiar with the PowerFlex 7000 Variable Frequency Drive (VFD) or Adjustable Speed Drive (ASD) and associated machinery should plan or implement the installation, startup, and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

ATTENTION: To keep arc resistant structural integrity, if applicable, the following rules must be followed:

- The pressure relief vent may not be tampered with, and it is not to be used as a step.
- No unapproved alterations can be made to the enclosure.
- All covers, plates, and hardware removed for installation or maintenance purposes must be re-installed and properly secured. Failure to do so voids the arc resistant structural integrity.
- Power cable entry points are to be treated as the boundary to a hazardous location and must be sealed accordingly. Failure to do so voids the arc resistant structural integrity.
- A plenum or chimney must be used to direct the arc flash energy to a suitable location. Failure to do so voids the arc resistant structural integrity. See publication 7000-IN007.
- All wiring between the low voltage panel and the power cell must be routed through a suitable cable gland to ensure flames and gases are not transmitted into this area (as fitted from factory).
- The medium voltage doors must be properly secured using the handle mechanism (if provided), the key interlock (if provided), and the door bolts. Failure to do so voids the arc resistant structural integrity.

Commissioning Support

After installation, Rockwell Automation medium voltage support is responsible for commissioning support and activities in the PowerFlex 7000 product line.

Phone: 519-740-4790

Option 1 for technical and option 4 for commissioning questions

MVSupport_technical@ra.rockwell.com or
MVSupport_services@ra.rockwell.com

Rockwell Automation support includes, but is not limited to:

- quoting and managing product on-site start-ups
- quoting and managing field modification projects
- quoting and managing customer in-house and on-site product training

Abbreviations

This table contains abbreviations used throughout this document.

Table 1 - Abbreviations

Abbreviation	Description
ACB	Analog Control Board
AFE	Active Front End
ASD	Adjustable Speed Drive
CMC	Common Mode Choke
CSI	Current Source Inverter
CT	Current Transformer
DMM	Digital Multimeter
DPM	Drive Processor Module
HECS	Hall Effect Current Sensor
HMI	Human Machine Interface
HPTC	High Performance Torque Control
IFM	Interface Module
IGDPS	Isolated Gate Driver Power Supply
LV	Low Voltage
MOV	Metal-oxide Varistor
MV	Medium Voltage
GN	Grounding Network
OIB	Optical Interface Board
OIBB	Optical Interface Base Board
PIV	Peak Inverse Rating
PLC	Programmable Logic Controller
PWM	Pulse Width Modulated
SCB	Signal Conditioning Board
SCR	Silicon-controlled Rectifier
SGCT	Symmetrical Gate Commutated Thyristor
SHE	Selective Harmonic Elimination
SIL	Safety Integrity Level
SPGDB	Self-powered Gate Driver Board
SPS	Self-powered SGCT Power Supply
STO	Safe Torque Off
TSN	Transient Suppression Network
UPS	Uninterruptible Power Supply
VFD	Variable Frequency Drive
VSB	Voltage Sensing Board
VSI	Voltage Source Inverter
XIO	External Input/Output

Product Certification

Product Certifications and Declarations of Conformity are available online at: www.rockwellautomation.com/products/certification.

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
PowerFlex 7000 Medium Voltage AC Drive (C Frame) - ForGe Control (Marine), publication 7000-TD002	Provides troubleshooting, parameters, and specification information for MV variable frequency drives
PowerFlex 7000 Medium Voltage AC Drive (A Frame) - ForGe Control, publication 7000A-UM200	Provides detailed information on hardware replacement, overview, control and power component definition, maintenance and specifications for air-cooled medium voltage variable frequency drives
PowerFlex 7000 Medium Voltage AC Drive (B Frame) Installation - ForGe Control, publication 7000-IN007	Provides detailed installation and pre-commissioning procedures and information
PowerFlex 7000 Medium Voltage AC Drive (B Frame) Transportation and Handling - ForGe Control, publication 7000-IN008	Provides receiving and handling instructions for Medium Voltage variable frequency drive and related equipment
PowerFlex 7000 Medium Voltage AC Drive (C Frame) - ForGe Control, publication 7000L-UM303	Provides detailed information on hardware replacement, overview, control and power component definition, maintenance and specifications for liquid-cooled medium voltage variable frequency drives
PowerFlex 7000 HMI Offering with Enhanced Functionality, publication 7000-UM201	Provides detailed information to configure, set up, operate, update and troubleshoot the PowerFlex 7000 HMI Interface Board
HMI Interface Board Software Updater and Firmware Download Procedure, publication 7000-QS002	Provides quick start information on updating HMI Interface Board software
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website: rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at http://www.rockwellautomation.com/global/literature-library/overview.page.

Notes:

PowerFlex 7000 Drive Overview

The PowerFlex™ 7000 drive is a general-purpose, standalone, medium voltage drive that controls speed, torque, direction, starting, and stopping of standard asynchronous or synchronous AC motors. This drive works on numerous standard and specialty applications such as fans, pumps, compressors, mixers, conveyors, kilns, fan-pumps, and test stands in industries such as petrochemical, cement, mining and metals, forest products, power generation, and water/waste water.

The PowerFlex 7000 drive meets most common standards from these organizations:

- National Electrical Code (NEC)
- International Electrotechnical Commission (IEC)
- National Electrical Manufacturers Association (NEMA)
- Underwriters Laboratories (UL)
- Canadian Standards Association (CSA).

The drive is available with the world's most common supply voltages at medium voltage, from 2400…6600V. The design focuses on high reliability, ease of use, and lower total cost of ownership.

Topology

The PowerFlex 7000 drive uses a pulse width modulated (PWM) – current source inverter (CSI) topology. This topology applies to a wide voltage and power range. The power semiconductor switches used are easy-to-series for any medium voltage level. Semiconductor fuses are not required for the power structure due to the current limiting DC link inductor.

With 6500V PIV rated power semiconductor devices, the number of inverter components is minimal. For example, only six inverter switching devices are required at 2400V, 12 at 3300…4160V, and 18 at 6600V.

The PowerFlex 7000 drive also provides inherent regenerative braking for applications where the load is overhauling the motor, or where high inertia loads are quickly slowed down. The drive uses the following:

- Symmetrical gate commutated thyristors (SGCTs) for machine converter switches
- SGCTs for active front-end (AFE) rectifier configurations for the line converter switches
- Silicon-controlled rectifiers (SCRs) for 18-pulse rectifier configurations

The PowerFlex 7000 drive provides a selectable option for enhanced torque control capabilities and increased dynamic control performance. This high-performance torque control (HPTC) feature delivers 100% torque at zero speed and provides torque control through zero speed with smooth direction transition.

Rectifier Designs

Configurations

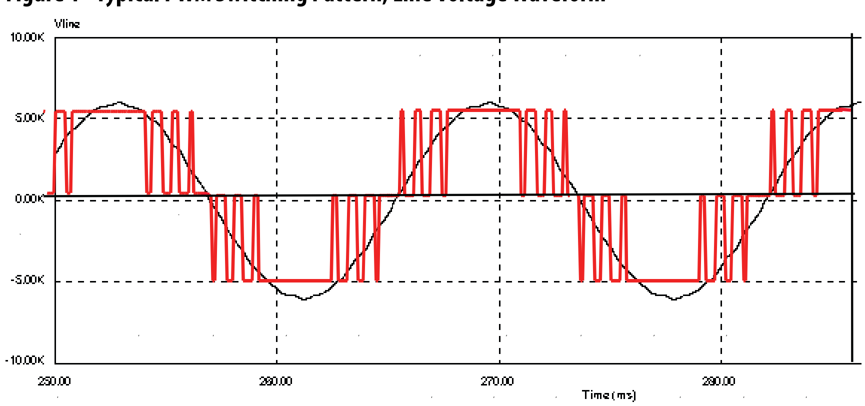
The PowerFlex 7000 drive offers three rectifier configurations for 'B' frame drives:

- Direct-to-Drive™ (AFE rectifier with integral line reactor and CMC)
- AFE rectifier with separate isolation transformer
- 18-pulse rectifier with separate isolation transformer

Direct-to-Drive

Direct-to-Drive technology does not require an isolation transformer or multiple rectifier bridges as in voltage source inverter (VSI) topologies offered by others. The approach is completely different. Instead of multiple uncontrolled rectifiers, a single AFE rectifier bridge is supplied. The rectifier semiconductors that are used are SGCTs. Unlike the diodes that are used in VSI rectifier bridges, SGCTs are turned on and off by a gating signal. A PWM gating algorithm controls the firing of the rectifier devices, similar to the control philosophy of the inverter. The gating algorithm uses a specific 42-pulse switching pattern called selective harmonic elimination (SHE) to mitigate the 5th, 7th, and 11th harmonic orders.

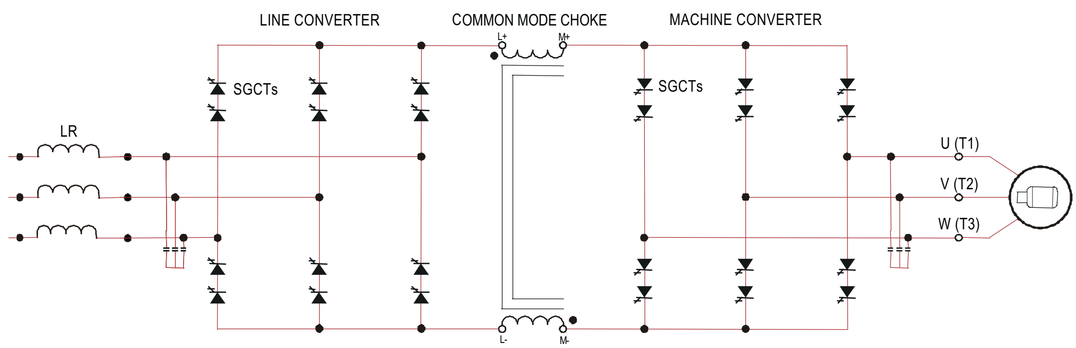
Figure 1 - Typical PWM Switching Pattern, Line Voltage Waveform



A small integral line reactor and capacitor addresses the high harmonic orders (13th and above) and provides virtually sinusoidal input voltage and current waveforms back to the distribution system. This configuration delivers excellent line-side harmonic and power factor performance to meet IEEE 519-1992 requirements and other global harmonic standards in virtually all cases. This setup also provides a simple, robust power structure that maximizes uptime by minimizing the number of discrete components and the number of interconnections required.

A CMC mitigates the common mode voltage seen at the motor terminals, so standard (non-inverter duty rated) motors and motor cables can be used. This technology is ideal for retrofitting existing motor applications.

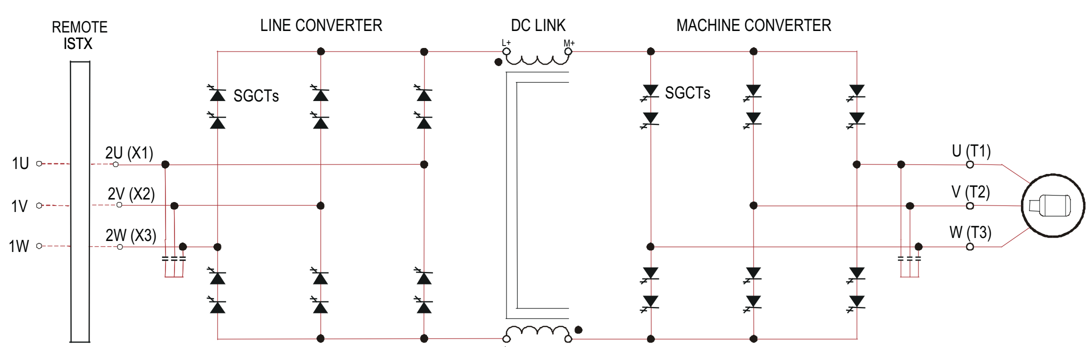
Figure 2 - 3300/4160V Direct-to-Drive (Transformerless AFE Rectifier)



AFE Rectifier with Separate Isolation Transformer

For applications when the line voltage is higher than the motor voltage, a transformer is required for voltage matching. In this case, providing an AFE rectifier with a separate isolation transformer is ideal (indoor and outdoor transformer versions are offered). The isolation transformer replaces the requirement for an integral line reactor and replaces the requirement for a CMC that is supplied in the Direct-to-Drive rectifier configuration. However, the AFE rectifier, its operation, and advantages are the same as the Direct-to-Drive configuration.

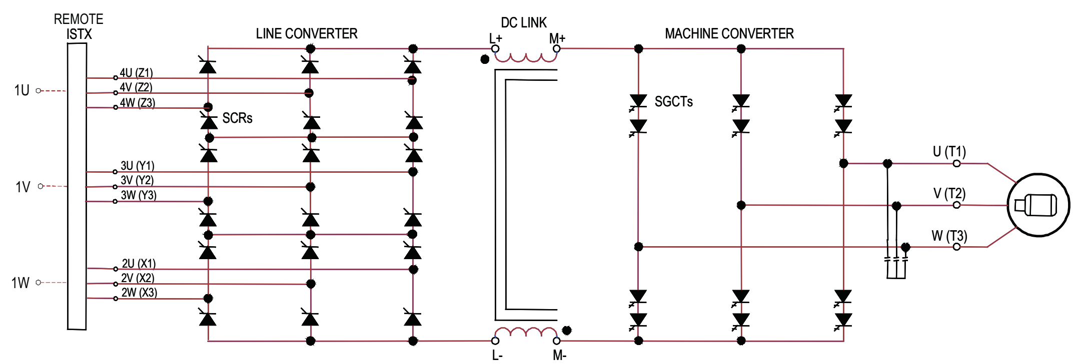
Figure 3 - 3300/4160 AFE Rectifier with Separate Isolation Transformer



18-pulse Rectifier with Separate Isolation Transformer

For high power constant torque applications and/or when the line voltage is higher than the motor voltage, a transformer is required for voltage matching (indoor and outdoor transformer options are available). The 18-pulse rectifier uses SCRs instead of the SGCTs used for an AFE rectifier. When used for high power constant torque applications, the 18-pulse rectifier has lower losses than the AFE rectifier, making 18-pulse ideal for the highest power requirements. The 18-pulse isolation transformer provides the required input impedance and addresses common mode voltage just like the separate isolation transformer used with the AFE rectifier. However, instead of a PWM rectifier switching pattern and a single rectifier bridge, the 18-pulse configuration mitigates line side harmonics through harmonic current cancellation in the isolation transformer phase shifted secondary windings. The inverter is the same configuration for all available rectifier options.

Figure 4 - 3300/4160V 18-pulse Rectifier with Separate Isolation Transformer



Cooling Technology

These VFDs are supplied with heatsinks for most configurations and heatpipes for the highest-power AFE configurations. While both configurations draw heat away from the semiconductors, heatpipes are bigger, more efficient, and require larger fans and airflow.

Information and graphics in this manual show both configurations.

Motor Compatibility

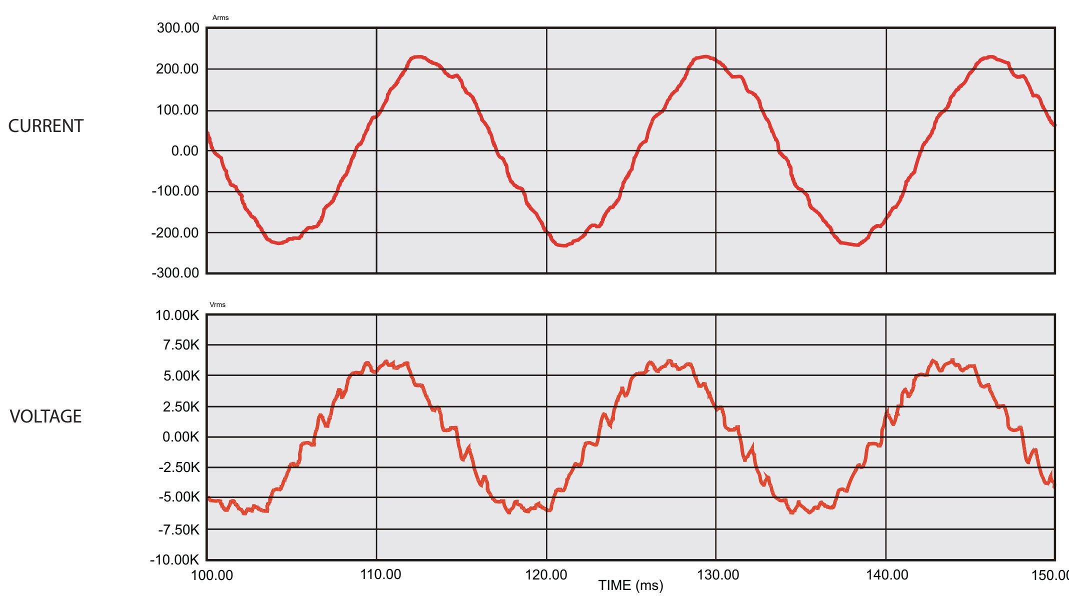
The PowerFlex 7000 drive achieves near-sinusoidal current and voltage waveforms to the motor, resulting in no significant additional heating or insulation stress. Temperature rise in the motor connected to the VFD is typically 3 °C (5.5 °F) higher compared to across-the-line operation. Voltage waveform has dv/dt of less than 50 V/µs. The peak voltage across the motor insulation is the rated motor RMS voltage divided by 0.707.

Reflected wave and dv/dt issues often associated with VSI drives are a non-issue with the drive. Figure 5 shows typical motor waveforms. The drive uses a SHE pattern in the inverter to eliminate major order harmonics, plus a small output capacitor (integral to the drive) to eliminate harmonics at higher speeds.

Standard motors are compatible without de-rating, even on retrofit applications.

Motor cable distance is virtually unlimited. Rockwell Automation has tested this technology for controlling motors up to 15 km (9.3 mi) away from the drive.

Figure 5 - Motor Waveforms at Full Load, Full Speed



Simplified Electrical Diagrams

2400V

Figure 6 - 2400V – Direct-to-Drive (Transformerless AFE Rectifier)

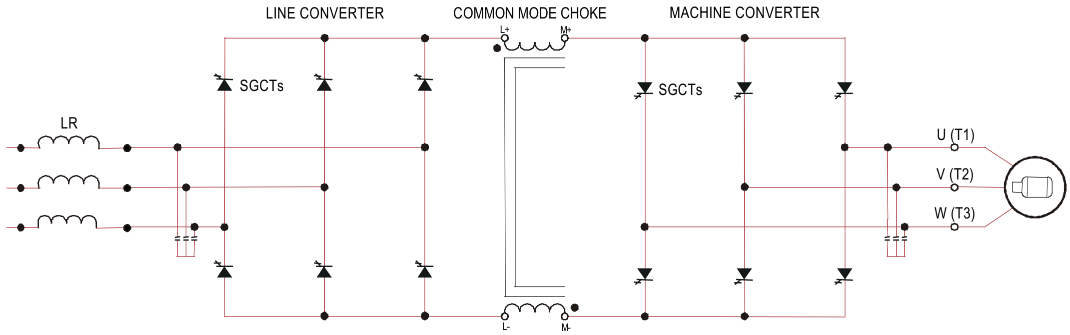


Figure 7 - 2400V – AFE Rectifier with Separate Isolation Transformer

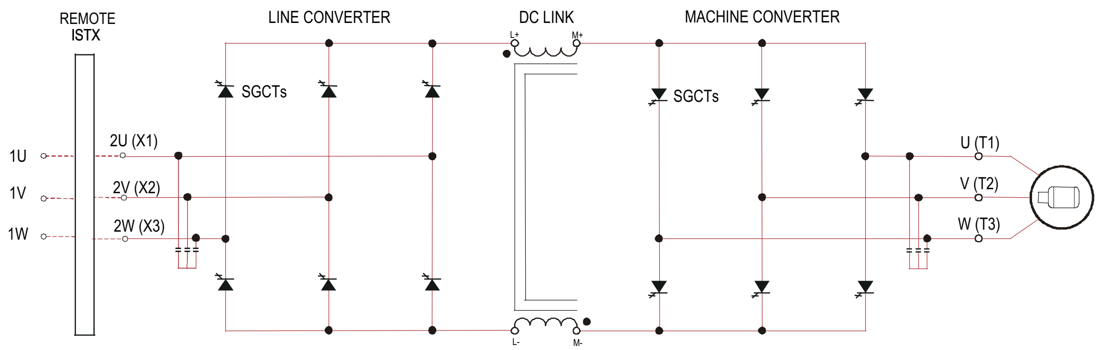
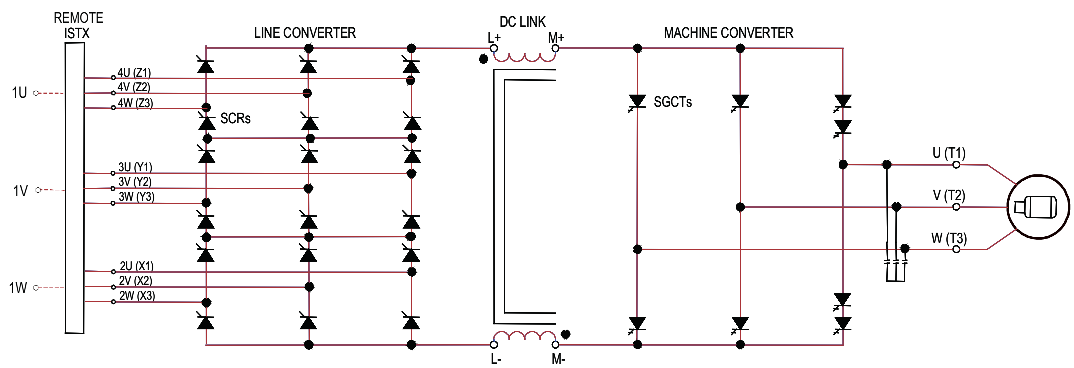


Figure 8 - 2400V – 18-pulse Rectifier with Separate Isolation Transformer



3300/4160V

Figure 9 - 3300/4160V – Direct-to-Drive (Transformerless AFE Rectifier)

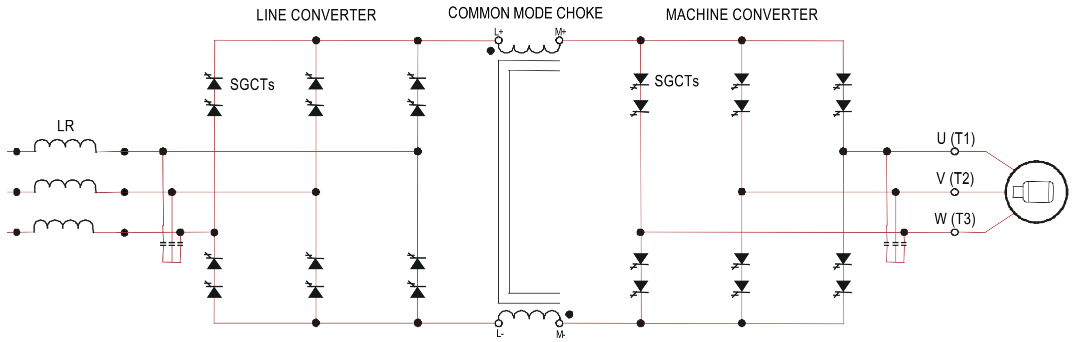


Figure 10 - 3300/4160V – AFE Rectifier with Separate Isolation Transformer

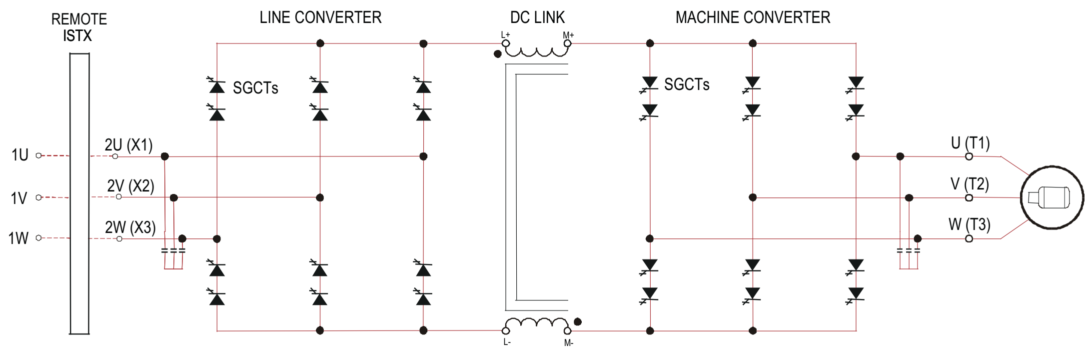
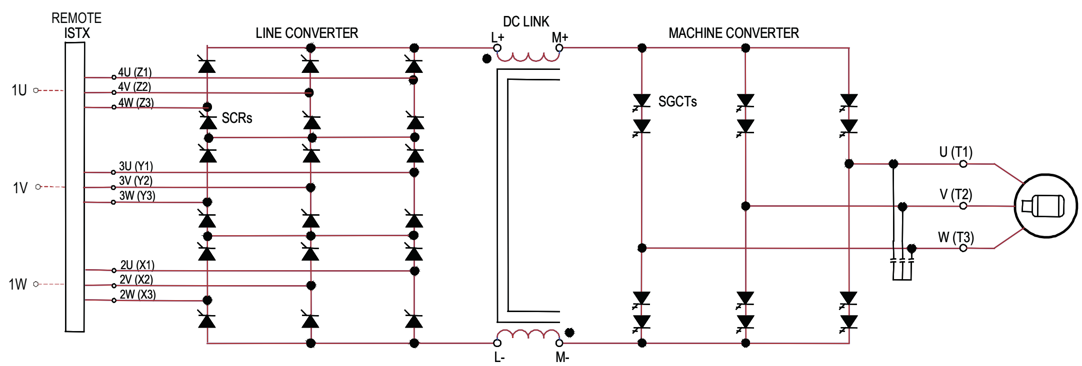


Figure 11 - 3300/4160V – 18-pulse Rectifier with Separate Isolation Transformer



6600V

Figure 12 - 6600V – Direct-to-Drive (Transformerless AFE Rectifier)

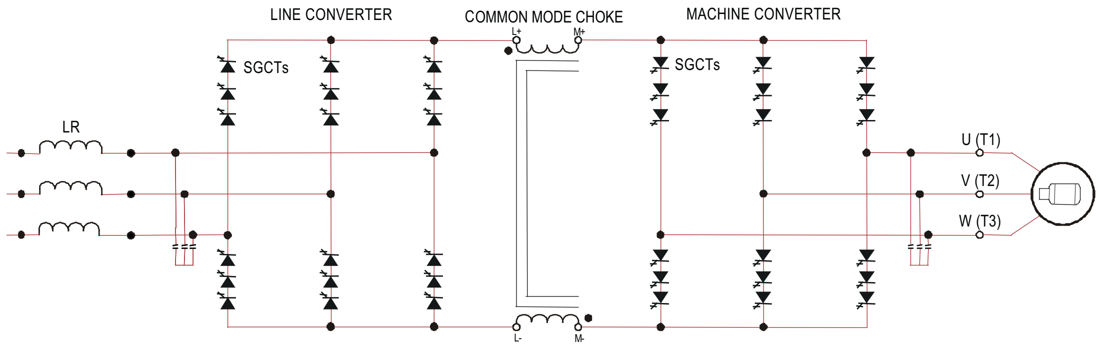


Figure 13 - 6600V – AFE Rectifier with Separate Isolation Transformer

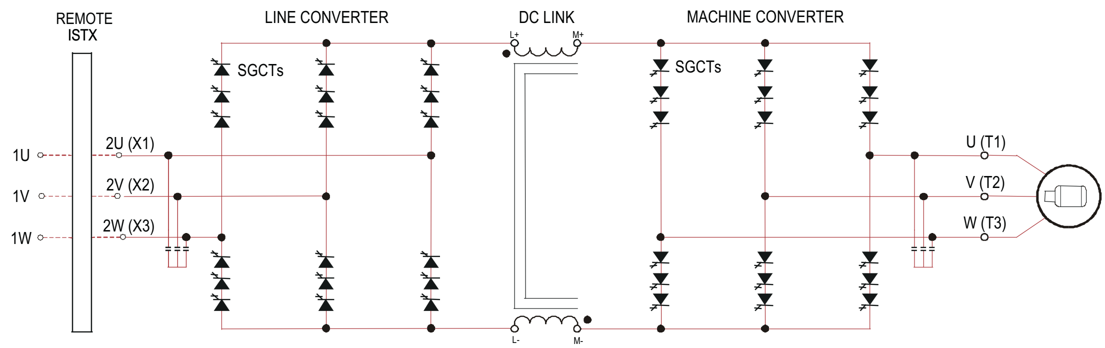
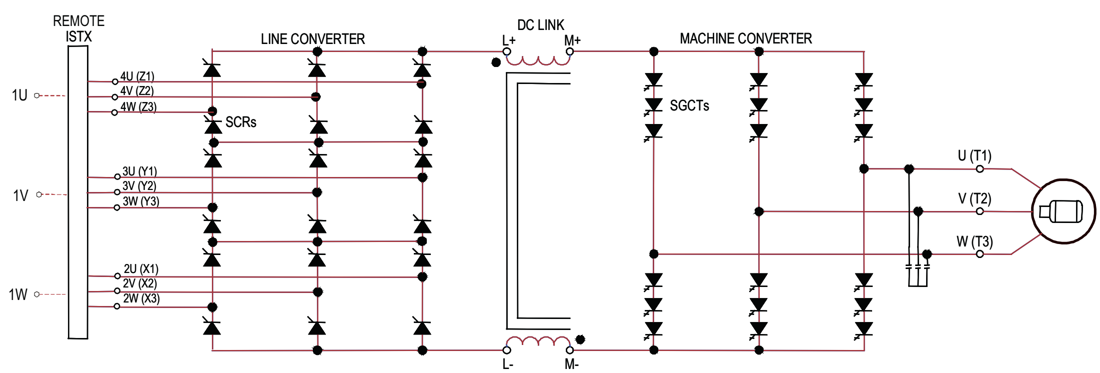


Figure 14 - 6600V - 18-pulse Rectifier with Separate Isolation Transformer

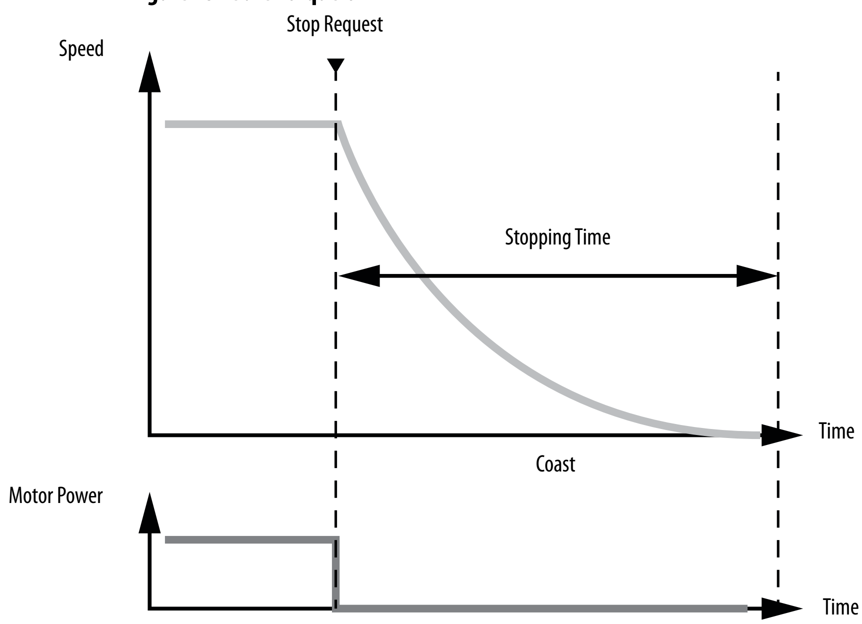


Functional Safety

Safe Torque Off

Safe Torque Off is a functional safety feature that is integrated into the PowerFlex 7000 drive, available for AFE and Direct-to-Drive configurations. The drive can receive a safety input signal (for example, from an optical sensor or a safety gate) and remove rotational power from the motor, allowing the motor to coast to a stop. After the Safe Torque Off command is initiated, the drive will declare that it is in the safe state. The drive itself remains powered and the safe state is reliably monitored to help ensure no rotational torque can be delivered to the motor. The drive can return rotational power to the motor after the Safe Torque Off condition has been reset.

Figure 15 - Safe Torque Off



An internal safety relay provides for the safety input and reset circuits.

Safe Torque Off can be used in AFE and Direct-to-Drive rectifier drive configurations for A, B, and C frames. Safe Torque Off cannot be used for parallel drives, N+1, N-1, synchronous transfer and 18-pulse drive configurations.

This feature is certified by TÜV for use in safety applications up to and including Safety Integrity Level 3 (SIL3) and Category 3, Performance Level e (Cat 3, PL e). More information on functional safety and SIL and PL ratings can be found in the following standards:

- EN 61508
- EN 62061
- EN 61800-5-2
- EN 13849-1

See publication 7000-UM203 for more information that is related to the functional safety option.

ArcShield Technology

The PowerFlex 7000 drive with ArcShield™ technology significantly reduces arc flash hazards and minimizes the risks that are associated with the operation and maintenance of electrical equipment. ArcShield technology is available for AFE Direct-to-Drive configurations and is designed to help protect employees and minimize unplanned outages and downtime. The PowerFlex 7000 drive system with ArcShield option is a fully integrated Allen-Bradley® CENTERLINE® controller and PowerFlex 7000 drive combination. This safety feature redirects the energy from an arc flash event through the top of the enclosure. Personnel protection is maintained while in front, at the side, or behind the enclosure and when the low voltage control door is open.

The PowerFlex 7000 drive with ArcShield technology meets the following safety standards:

- IEEE C37.20.7
- CSA C22.2 No. 22-11
- EEMAC G14-1
- IEC 62271-200 Annex AA
- IEC 62477-2 (DRAFT)

Arc resistant enclosures contain the pressure from an arc flash event using reinforced support members, plates, and uses 12-gauge steel for all doors, sides, roof, and back sheets.

Bolted MV doors with robust door hinges add to the security of the main doors. An aluminum pressure relief vent on the roof opens to redirect the pressure upwards. A plenum exhaust system, above the pressure relief vent, channels the superheated gas, vaporized copper, and steel to a controlled location.

Figure 16 - PowerFlex 7000 Drive with ArcShield Technology

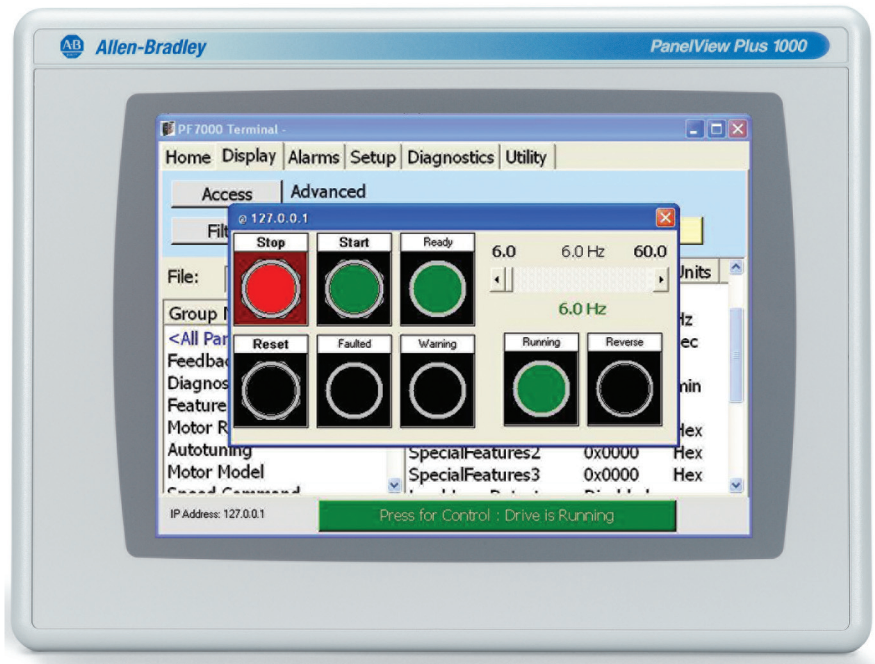
Operator Interface

The human-machine interface (HMI) board is an HMI-enabling device for the PowerFlex 7000 drive. The board lets you acquire all the necessary executable tools, documentation, and reports required to commission, troubleshoot, and maintain the drive.

Via the HMI board, the user can choose the style and size of the desired Windows-based operator terminal to interact with the drive (for example, PanelView™ CE terminal, laptop, or desktop computer). The HMI board removes past issues with compatibility between the drive and configuration tools, as all the necessary tools are acquired from the drive.

The HMI board is well suited for applications that require remote placement of the operator terminal and remote maintenance.

Figure 17 - Operator Interface



Basic Configurations

There are three basic configurations for the HMI.

Remote-mounted HMI

The HMI is not mounted in the traditional location on the low voltage door of the VFD. A remote mounting plate, complete with E-Stop push button, and HMI is supplied loose for you to mount wherever desired. The HMI connects to the VFD via a hardwired ethernet cable. There is no significant functional distance limitation.

This is ideal for non-PLC users wanting to control and monitor remotely (for example, at the driven machine or control room). This is also ideal if you, for example, have policies in place to control access to medium voltage equipment and the associated requirements of PPE when using the operator interface at the VFD.

Locally-mounted HMI

Similar to the previously offered PanelView 550, the HMI is mounted on the LV door of the VFD. There is also a service access port (RJ-45 connector) on the LV door.

No HMI supplied

A service access port (RJ-45 connector) is located on the LV door of the VFD. You can use your own laptop as the HMI. All programs required to use the laptop as the HMI are stored in the VFD. Their laptop is connected to the VFD via a hardwired Ethernet cable, when required. This is ideal for unmanned sites, where a dedicated HMI is not required.

See publication 7000-UM201 for detailed instruction for the HMI.

See publication 7000-UM151 for detailed instruction for 'B' frame drives using the PanelView 550 HMI.

Power Component Definition and Maintenance

This section provides an overview of the control components and cabling of your PowerFlex® 7000 'B' frame drive. This section also details a number of regular or recurring maintenance tasks that will keep your drive in peak operating condition.

Figure 20 through Figure 26 identify the control components and cabling of your drives. Where appropriate, separate diagrams and instructions are available for both the heatsink and the heatpipe 'B' frame models.

For information regarding power wiring and cabling connections (as might be necessary for routine maintenance), see the PowerFlex 7000 'B' frame installation manual, publication 7000-IN007.

Control Power Off Tests

Perform the following checks before applying control power to the drive. Rockwell Automation recommends that you complete these checks in the sequence they are presented here.

IMPORTANT	See publication 7000-IN012 for additional information on drive insulation resistance testing.

Interlocking

When the input contactor option is purchased, a key interlock is provided to prevent access to the medium voltage compartments of the drive unless the input isolation switch is locked in the open position.

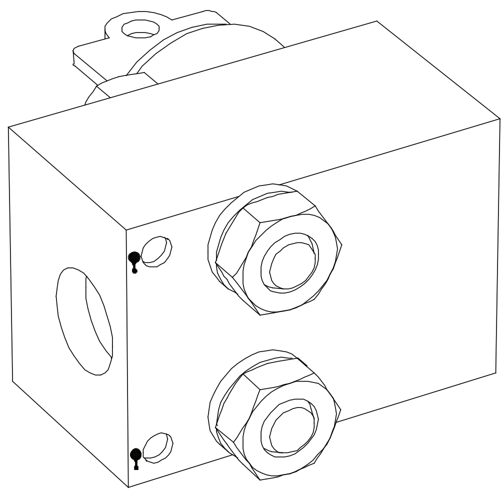
Where the input switching device is provided by others, Rockwell Automation will provide a key interlock on the medium voltage compartment of the drive, and a matching interlock for installation by others on the upstream device. The interlock shall be installed in a manner that ensures the power to the drive is off and the drive is electrically isolated whenever the key is freed.

Although key interlocks shipped with all medium voltage equipment are aligned in the factory, they often move out of position during shipping or are often misaligned when the cabinet is set down on an uneven floor.

ATTENTION: Servicing energized industrial control equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of control equipment. Hazardous voltages can exist in the cabinet even with the circuit breaker in the off position. We recommend that you disconnect or lock out control equipment from power sources, and confirm discharge of stored energy in capacitors. If you must work in the vicinity of energized equipment, the safety-related work practices of NFPA 70E, Standard for Electrical Safety in the Workplace, must be followed.

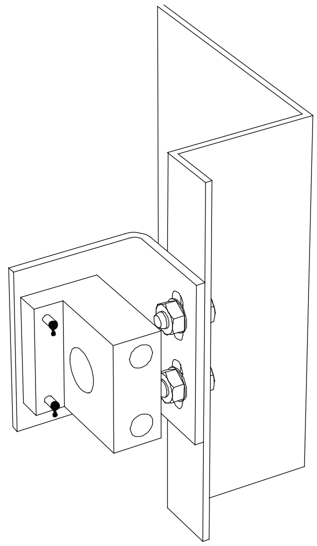
To align the deadbolt key interlock with its counterpart, follow these steps.

Figure 18 - Deadbolt Assembly Mounted to Door



1. Lock out and isolate the drive from medium voltage. Verify with a hot stick that there is no medium voltage present.
2. Determine that the key interlock is correctly aligned by securely bolting the medium voltage doors of the cabinet closed and removing the key from the lock. The key should turn easily; if any force is required to turn the key, the deadbolt alignment requires adjustment.
3. Open the doors of the cabinet and inspect the key assembly. Place high visibility grease on the pins of the deadbolt counterpart. The factory recommends using yellow torque sealant. If that is unavailable, almost any grease will do (Figure 19).

Figure 19 - Deadbolt Counterpart Mounted to Cabinet



4. Bolt the cabinet door closed so the pins on the dead bolt counterpart make contact with the deadbolt assembly. Doing so should leave two marks of torque sealant or grease on the assembly where the pins made contact (see Figure 18 on page 28).
5. Slightly loosen the adjustment bolts on the counterpart and make the necessary movements on the counterpart to ensure that the pins align with the landing plates on the deadbolt assembly. As the amount of counterpart movement required is an estimate, it can take a couple attempts to properly align the assembly.
6. Clean the torque seal/grease from the key interlock once finished aligning the counterpart.

Once properly aligned, the key should turn freely when the cabinet door is fully bolted shut. If the key does not function when the door is tightly bolted closed, adjustments will have to be made to the depth of the counterpart. This can be done by adding shims on the landing plate where the counterpart is mounted.

Control / Cabling Cabinet Components

For converter cabinets, see Converter Cabinet Components on page 55.

For DC link/fan cabinets, see DC Link and Fan Cabinet Components on page 116.

Figure 20 - Cabling Cabinet for AFE Rectifier (Heatsink Model)

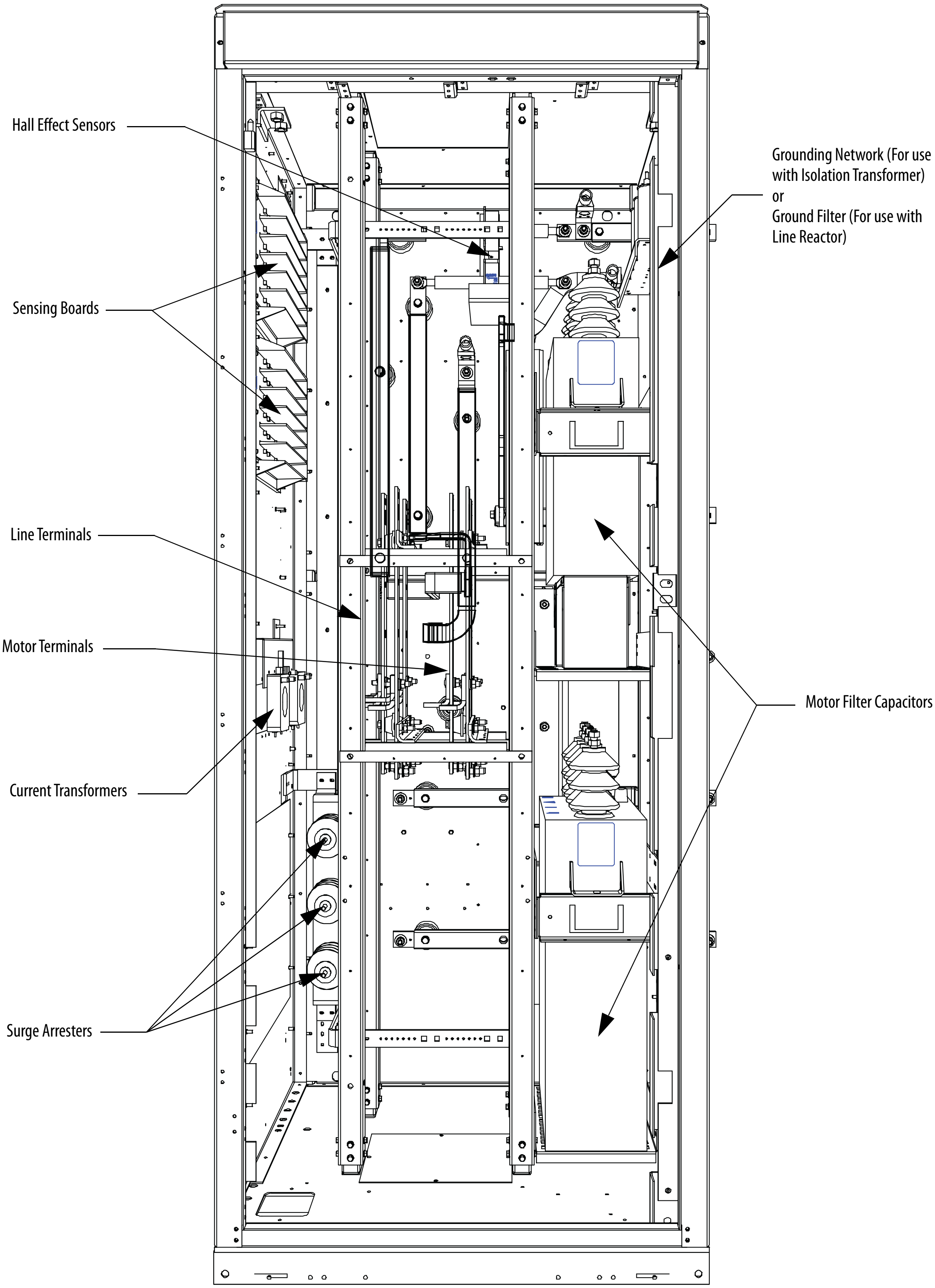


Figure 21 - Cabling Cabinet for AFE Rectifier (Heatpipe Model)

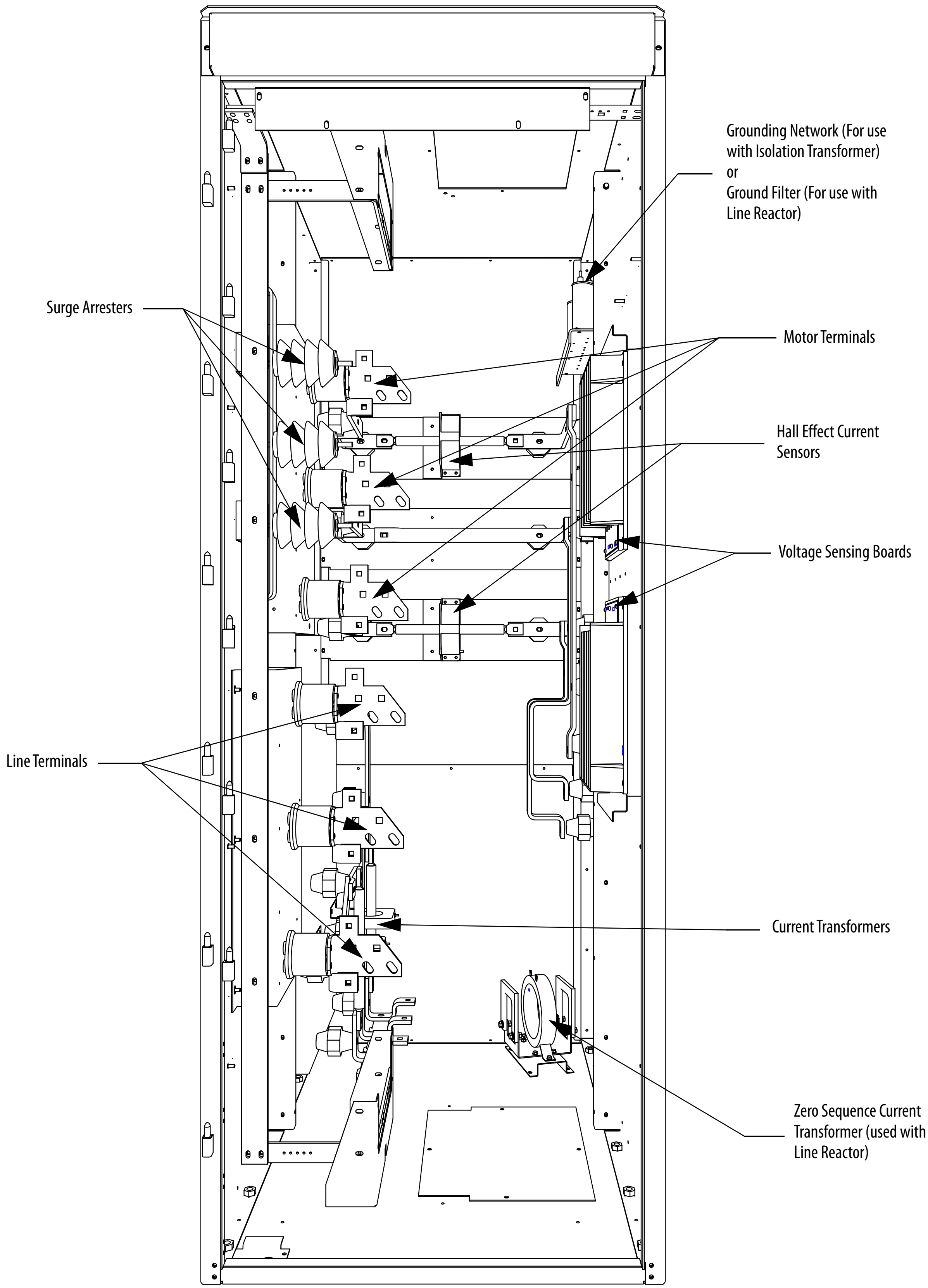


Figure 22 - Cabling Cabinet for AFE Rectifier (6600V Heatpipe Model)

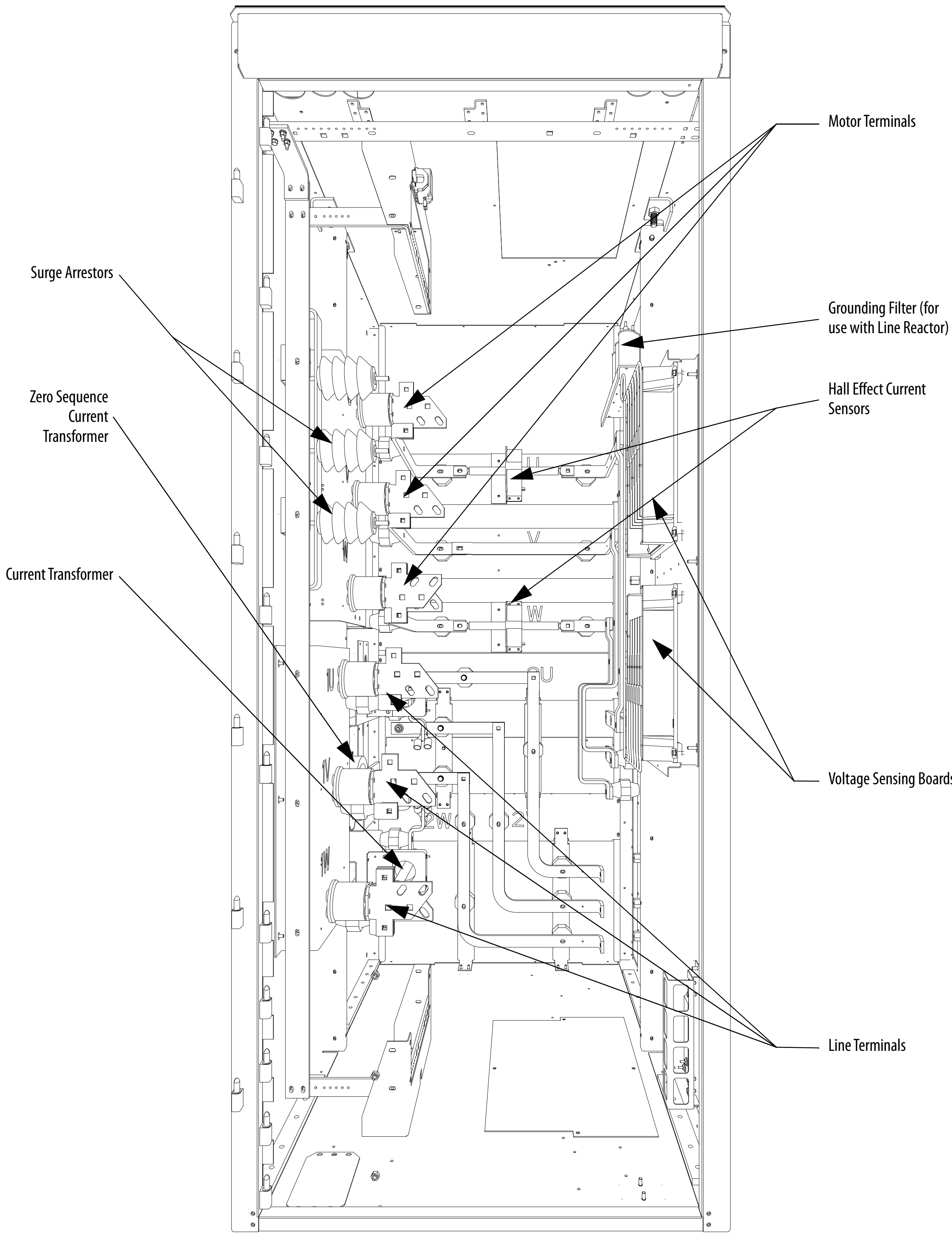


Figure 23 - Cabling Cabinet for 18-pulse Rectifier (Motor Filter Capacitors not shown)

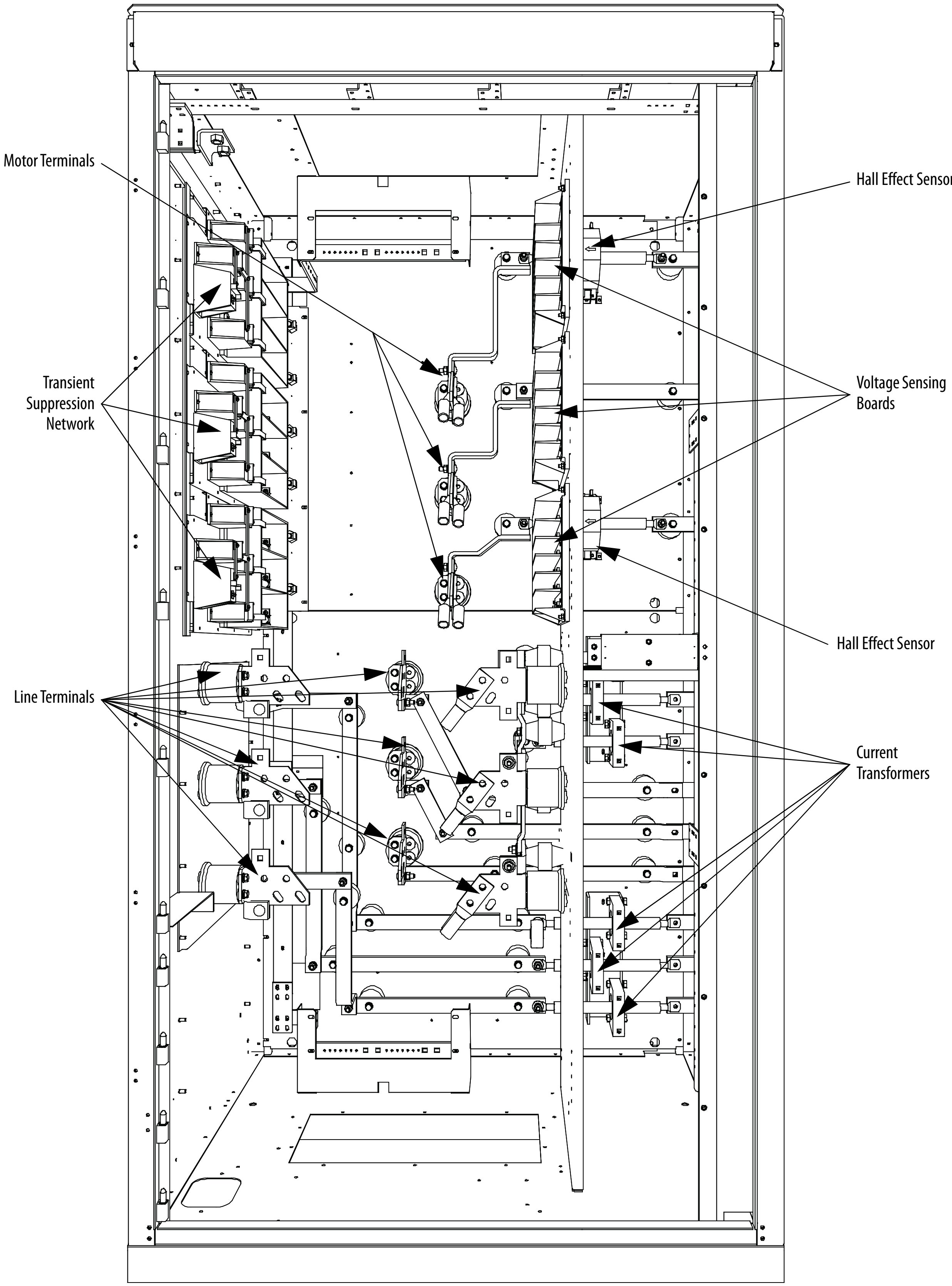


Figure 24 - AC line Reactor Cabinet with Connection Cabinet (Heatsink Model)

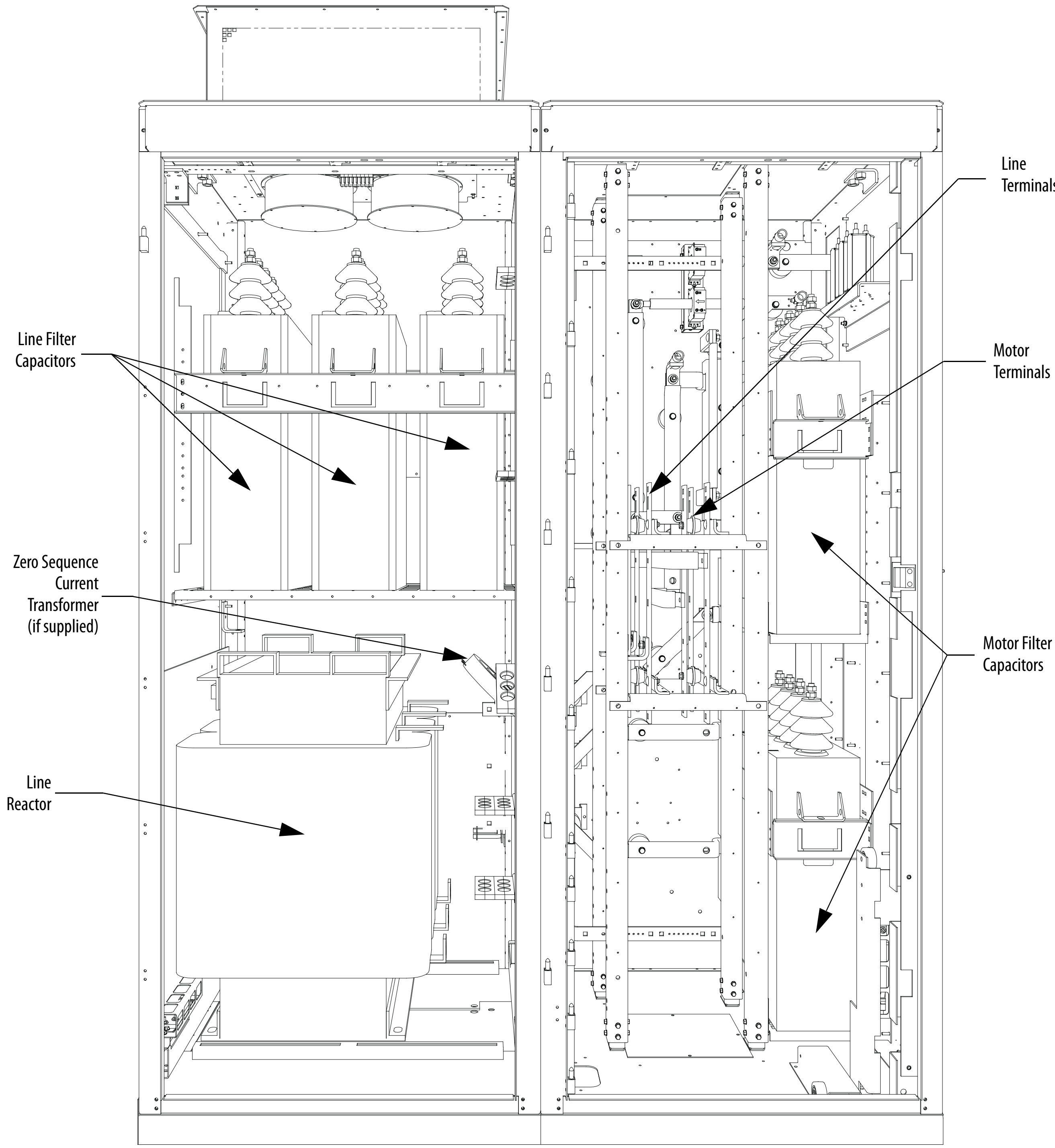


Figure 25 - AC Line Reactor Cabinet (6600V Heatpipe Model)

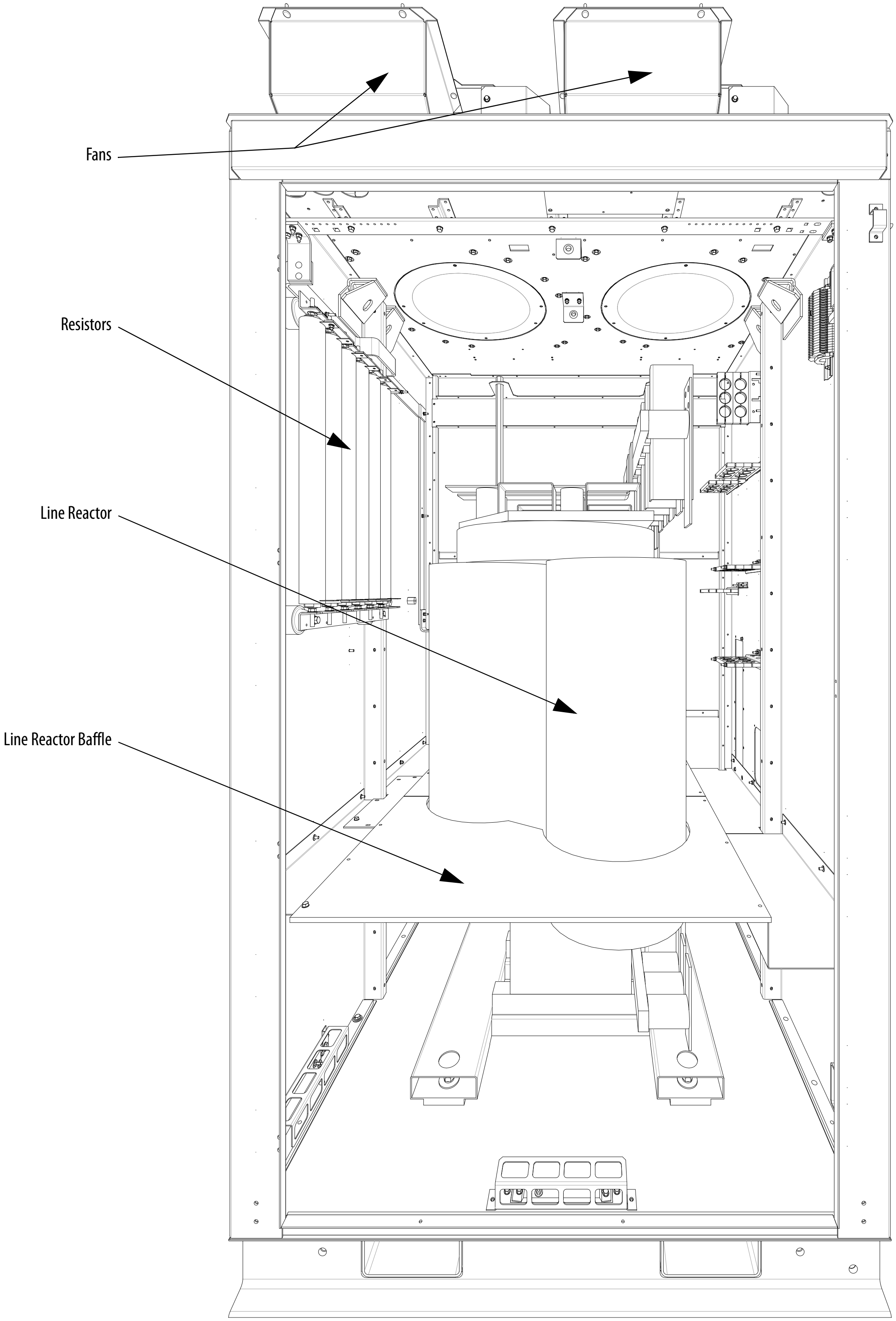
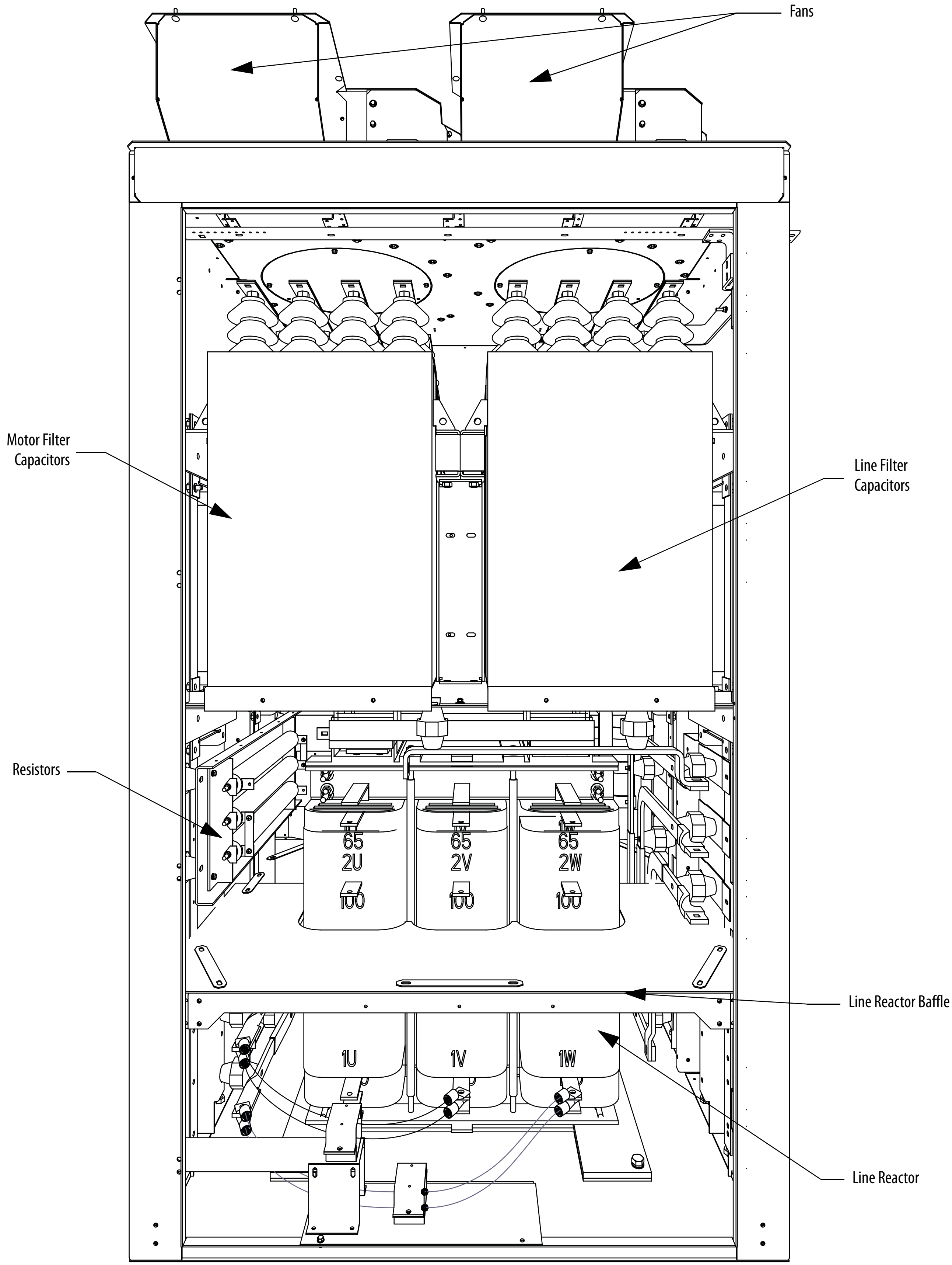


Figure 26 - AC Line Reactor with Connection Cabinet (Heatpipe Model)



Voltage-sensing Assembly

The voltage-sensing assembly consists of the voltage sensing board and the mounting plate. The voltage sensing board has six independent channels that convert voltages as high as 10,800V (7.2 kV x 1.5 pu) down to low voltage levels that the PowerFlex 7000 analog control board (ACB) can use. To measure up to twelve independent voltage channels, link two assemblies together, with one assembly acting as the master assembly and the second as the slave assembly. In linked assemblies, the master assembly sends the twelve voltage signals to the ACB. For drives requiring the synchronous transfer option, use one additional module.

This assembly uses a separate connector to output the transfer voltages directly to the ACB.

Table 2 shows the input voltage ranges for each input terminal on the voltage-sensing board. There are four separate inputs taps for each independent channel. This assembly operates at a nominal input voltage of up to 7200V with a continuous 40% overvoltage. The output voltages scale to provide almost 10V peak for a 140% input voltage at the high end of each of the voltage ranges.

Each channel has four taps that provide a range of input voltages and software to provide a given amount of gain, so that 140% will correspond to the maximum numerical value of the analogue to digital converter.

Table 2 - Nominal Input Voltage Range

Tap	Voltage Range
D	800…1449V
C	1450…2499V
B	2500…4799V
A	4800…7200V

ATTENTION: Reconnect the grounds on the voltage sensing boards. Failure to do so may result in injury, death or damage to equipment.

Replacing the Voltage-Sensing Circuit Board Assembly

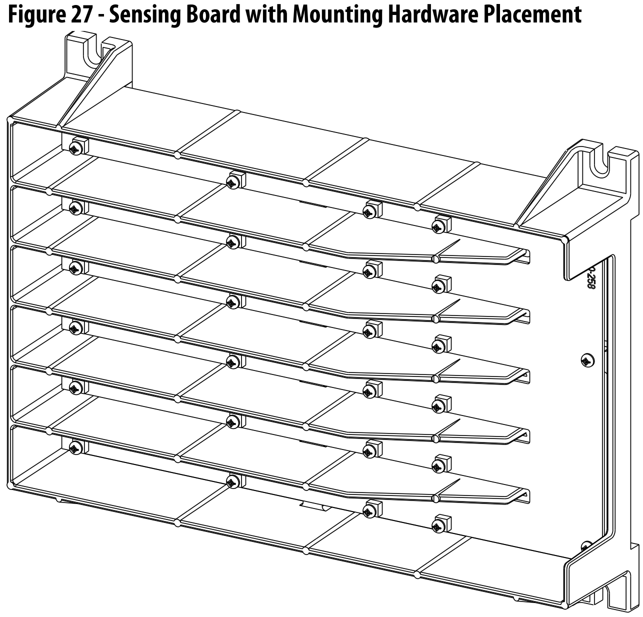
The number of sensing boards is dependent upon the drive rectifier configuration. To access the sensing boards in an arc resistant drive, remove the barriers behind the swing out LV compartment.

1. Verify there is no power to the equipment.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the sensing board. Verify that all circuits are voltage-free, using a hot stick or appropriate high voltage-measuring device. Failure to do so may result in injury or death.

2. Mark the position of the ribbon cables and wires.
3. Remove the screws and lift the ring lugs from the terminals to remove the wires.
4. Release the locking mechanism located on each side of the ribbon cable connector and pull the ribbon cable straight out to prevent bending the pins.
5. Remove the four nuts and washers that secure the assembly to the studs welded to the frame.
6. Remove the old VSB and replace with the new VSB on the studs, using the existing hardware to secure the assembly. Do not over-torque the connections or you may break the studs.
7. Replace ring lugs on terminals. Plug in ribbon cables making sure that cables are positioned properly and fitting is secure (locking mechanism is engaged).
8. For personnel and equipment safety, ensure both grounding connections are re-connected to the sensing board.

Figure 27 - Sensing Board with Mounting Hardware Placement



Input Transient Protection

The drive provides input transient protection in one of two forms:

- Transient suppression network (TSN), or
- Surge arresters

The TSN is optimized for 18-pulse rectifier designs. Surge arresters are optimized for AFE and Direct-to-Drive™ rectifier designs.

Transient Suppression Network (TSN)

The TSN module consists of an assembly of suppressors connected to each of the three phase input lines and the structure ground bus. There are three assemblies for an 18-pulse drive.

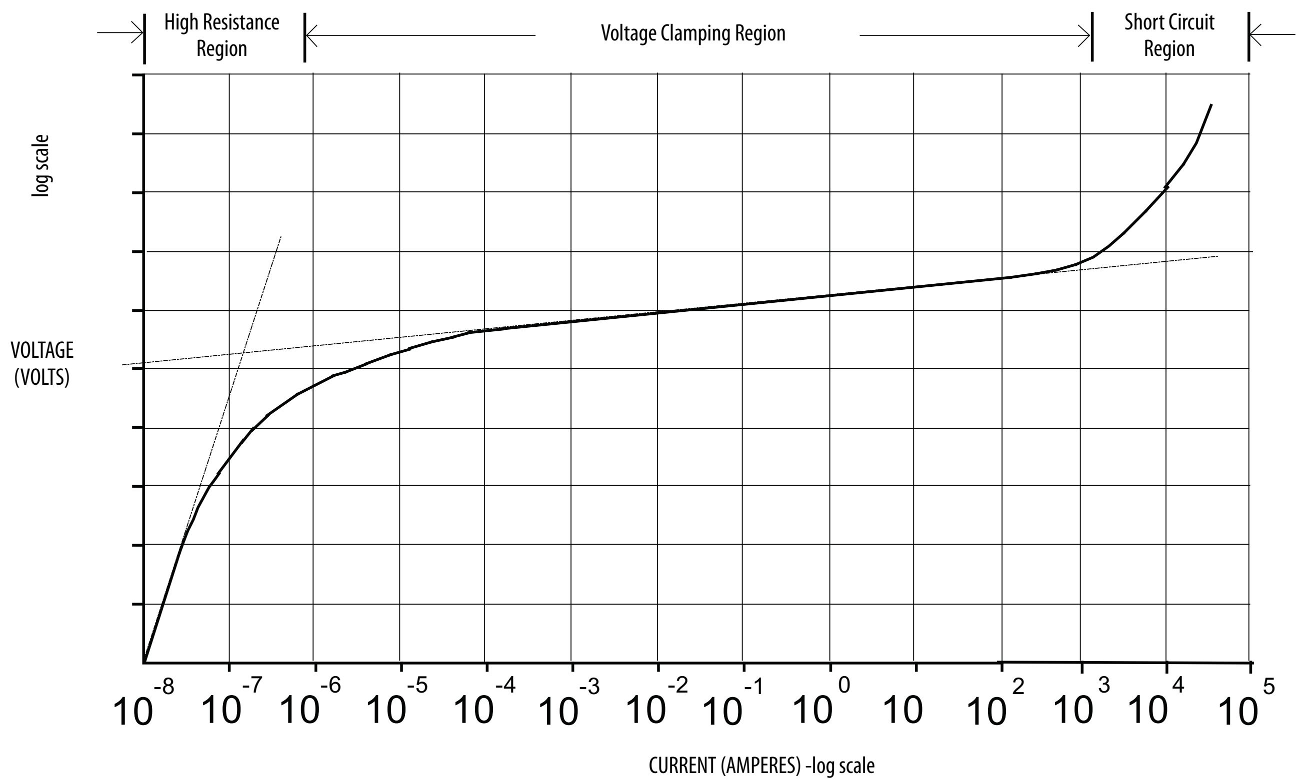
A transient voltage spike in excess of the semiconductor rating will destroy or shorten the lifespan of the device. The TSN module suppresses transient overvoltages on the drive input, and is a standard feature of the drive. The two basic blocks of the TSN module are the MOV suppressor and the MOV fuse.

MOV Suppressor

The transient suppressors used in the module are heavy-duty metal oxide varistors (MOVs). Varistors are voltage dependent, nonlinear resistors. They have symmetrical voltage/current characteristics similar to back-to-back connected Zener diodes. The varistor has very high resistance below its voltage rating and appears as an open circuit.

The leakage current through the device would be very small in this region. When a voltage transient occurs in which the voltage exceeds the ‘knee’ in the curve, the varistor resistance changes from its high state by several orders of magnitude to a very low level. The voltage is clamped for a change in current of several orders of magnitude (Figure 28).

Figure 28 - Typical MOV V-I Characteristic Curve



When the MOV clips the voltage transient, the MOV absorbs the transient energy. The varistor has a limited energy absorbing capability and there is insufficient time to conduct heat out of the device. The MOV size depends on the steady-state voltage rating, the energy in the transient, and the repetition rate of the transients. A critical element in selecting a MOV for protection is the impedance in the line supplying the transient. The isolation transformer or the AC line reactor on the input of the drive provides this impedance, which is why an impedance level is necessary for these input devices.

MOV Fuse

A medium voltage fuse is in series with each of the phase MOVs. As seen in Figure 29 on page 41, these fuses may reside on either the assembly or remote from the assembly (on the line terminal module). Check the part number on your module and the information in this documentation to determine which assembly your drive requires.

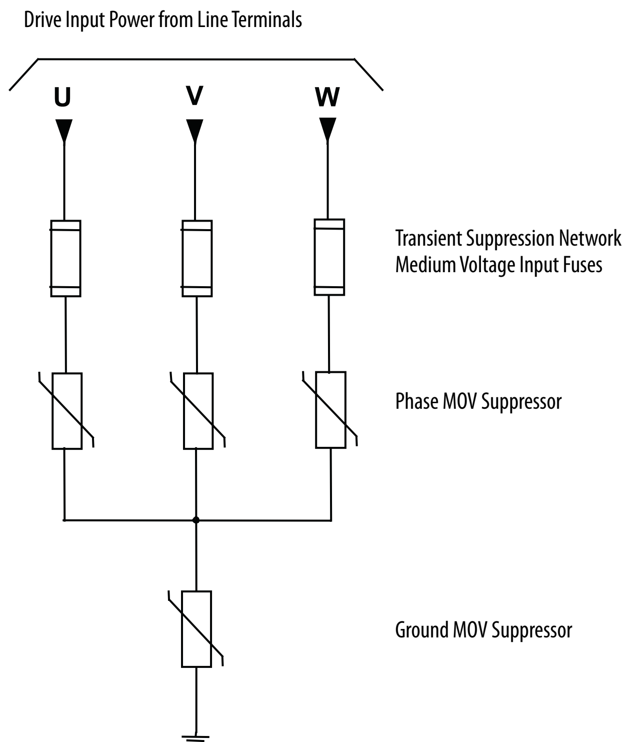
The fuses provide overload protection for the conductors feeding the suppression network (and overturned protection if a short circuit occurs on the downstream side of the fuse.) These conductors will normally have a much smaller current carrying capacity than the drive input conductors; they are not protected by the drive input fuses. The fuses also isolate a failed MOV. Varistors initially fail in a short-circuited condition. The high follow-through current will open the fuse and remove the MOV from the circuit.

The fuses are E-rated, current-limiting fuses with a high interrupting rating. Because they are current-limiting, they limit both the magnitude and duration of fault currents. They are small dimension, ferrule-type fuses with a fiberglass body, and mount in standard fuse clips.

IMPORTANT	Rockwell Automation selects the fuses sent with the transient suppression network based on their characteristics (including internal resistance) for optimum MOV performance and protection. Do not substitute other fuses without contacting the factory first.

IMPORTANT	Voltage sensing occurs after the MOV fuse and will detect open fuses in the drive control as a master or slave undervoltage or unbalance.

Figure 29 - Simplified Wiring Diagram



Replacing Transient Suppression Network Fuses

Two sizes of fuses (5 kV, 7.2 kV) are available within the TSN located inside the connection cabinet. The 18-pulse drive contains three TSNs.

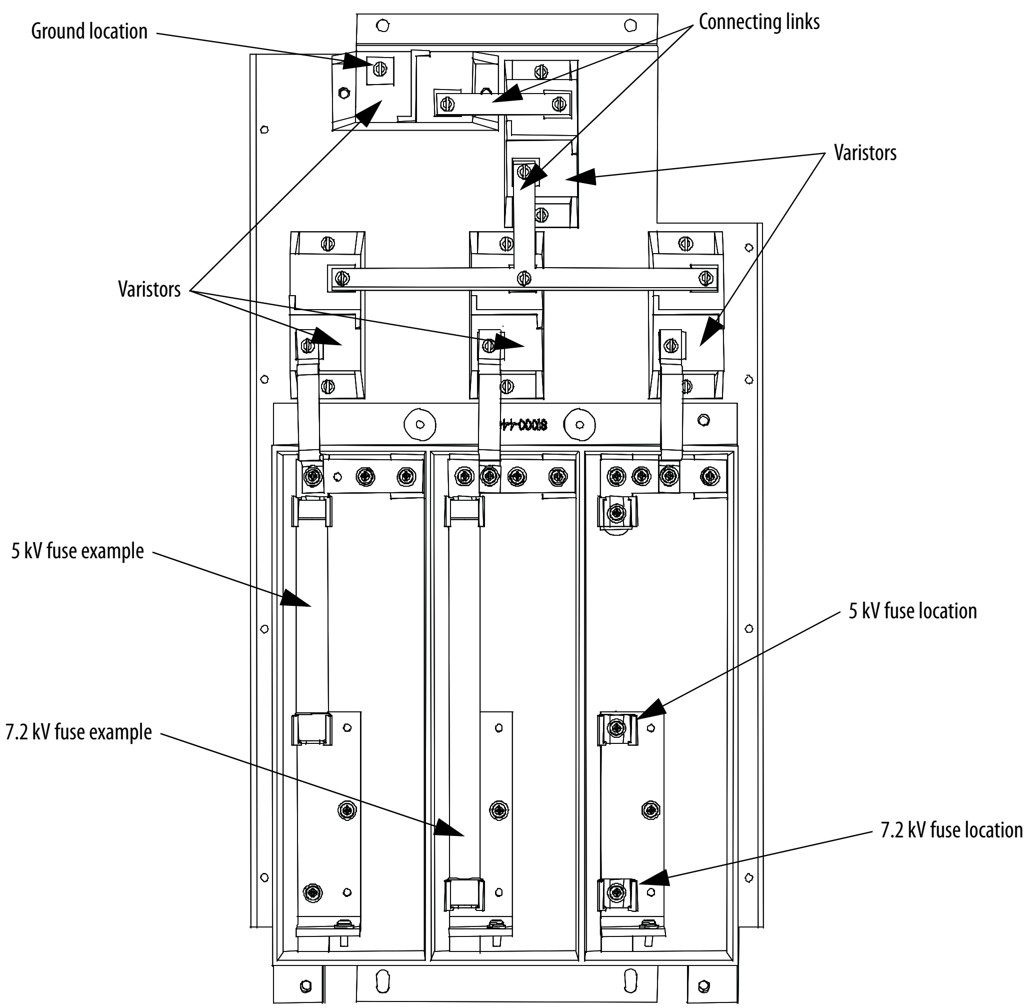
1. Ensure there is no power to the equipment.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Fuses are held in a place with a fuse clip. To remove the fuse pull firmly.
3. To replace the fuse, hold it in position and push firmly until the fuse is seated within the fuse clip. Install fuses so that the rating is visible.

IMPORTANT	Replace the fuse with another of the same rating. See Figure 30 on page 42 for location.

Figure 30 - Transient Suppression Network



Replacing Metal-Oxide Varistors

Metal-oxide varistors (MOV) are part of the TSN located within the connection cabinet.

1. Ensure there is no power to the equipment.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Observe the locations of the connecting links.
3. Detach the connecting links by removing the screws.
4. Using a screwdriver remove the screws at the base.
5. Replace the MOV (polarity is not an issue).
6. Continue by replacing the screws and connecting links.

Each MOV panel is grounded. One MOV (see Figure 30 on page 42 for location) must connect to the grounding lead.

Surge Arresters

The drive uses heavy duty distribution class surge arresters for transient overvoltage protection in the drives with AFE rectifiers. The arresters are certified as per ANSI/IEEE Std C62.11-1993.

The surge arresters are MOVs, with or without an air gap in series, in sealed housing. They provide overvoltage protection similar to that of the TSN module. They differ from the TSN in that fusing is not mandatory for the operation of surge arresters.

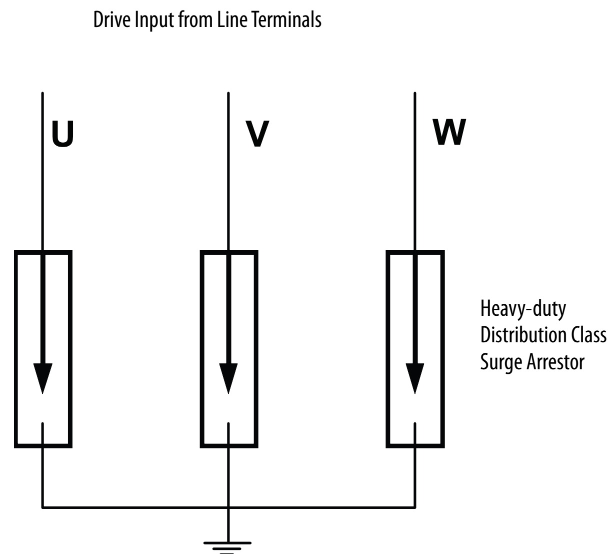
There are three types of surge arresters depending on the voltage class of the drive:

Drive Voltage	2.4 kV	3.3 kV, 4.16 kV, 4.8 kV	6.0…6.9 kV
Arrester rating (RMS)	3 kV	6 kV	9 kV
Arrester MCOV (RMS)	2.55	5.10	7.65

The most severe temporary overvoltage occurs when one phase is grounded in an ungrounded system. The full line-to-line voltage applies to the arrester in this case. The arresters operate under this condition continuously without any problems as indicated by their maximum continuous operating voltage rating.

Three Y-connected surge arresters attach to the incoming MV lines. The neutral point of the arresters connects to the ground bus.

Figure 31 - Surge Arresters on Incoming MV Lines



Operation

Arrester operation without a gap is the same as that of MOVs in the TSN. Depending on design, the arrester may also have a gap. Both gapped and un-gapped arresters provide adequate overvoltage protection.

The arresters can withstand most commonly-seen bus transients within their capability. If there is a harmonic filter on the MV bus connected to the drive, the filter must satisfy relevant international or local standards, such as IEEE Std 1531— Clause 6.4, to avoid high inrush currents.

The surge arrester is certified as per ANSI/IEEE Std C62.11-1993. Certification tests include high current short duration tests, low current long duration tests, and fault current withstand tests. The fault current withstand tests consist of different combinations of kA and number of cycles, including a 20kA 10-cycle test, under which the arresters are non-fragmenting without expelling any internal components.

When the incoming energy exceeds the handling capability of the arrester and causes arrester failure, the housing splits open to vent without causing damage to any adjacent components.

Replacing the Surge Arrester

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

1. Isolate and lock out all power to the drive.

   To access the surge arrestors in an arc resistant drive, remove the barriers behind the swing-out LV compartment.
2. Wait a minimum of ten minutes for the drive to discharge stored energy.
3. Observe the location of the connecting leads.
4. Use proper method to ensure the leads are at ground potential. Use temporary grounding when necessary.
5. Detach the connecting leads.
6. Loosen the bolt that attaches the surge arrester to the ground bus. Remove the arrester. Remove temporary ground when applicable.
7. Replace the surge arrester with an equivalent one (make sure that the voltage rating is the same).
8. Connect the leads to the surge arrester.
9. Torque the surge arrester hardware to 28 N•m (21 lb•ft).

Figure 32 - Surge Arresters (Heatsink Model)

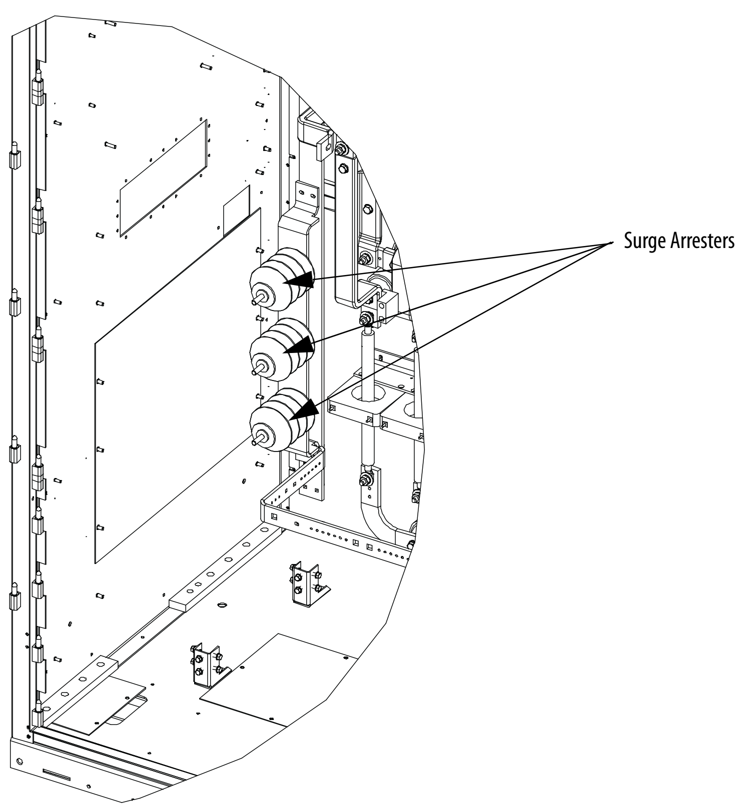
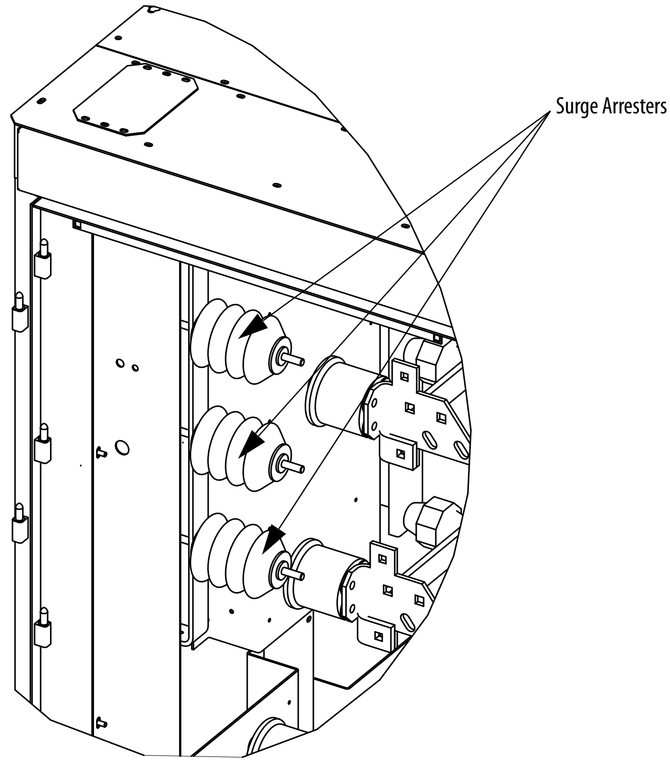


Figure 33 - Surge Arresters (Heatpipe Model)



When you disconnect the surge arrester from drive, the arrester may retain a small amount of static charge. As a precautionary measure, install a temporary ground on the line-end of the arrester and discharge the stored energy. Remove temporary ground before reinstalling the arrester. To avoid electrical shock when removing the arrester from service, treat the arrester as fully energized until you disconnect both the line and ground leads.

Field Test and Care

No field testing is necessary. The arresters do not require special care. At very dusty sites, however, you should clean the arrester when cleaning the entire drive.

Replacing Grounding Network Capacitors

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

PowerFlex 7000 18-pulse and select AFE drives come with an installed grounding network.

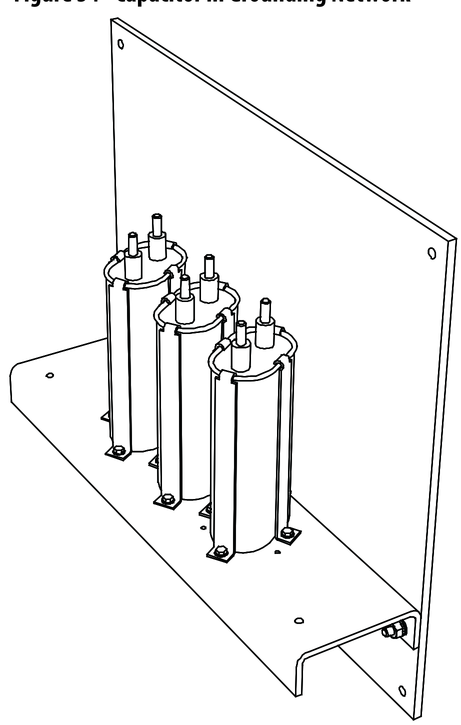
The number of capacitors varies depending on the system voltage.

1. Isolate and lock out all power to the drive.

   To access the grounding network in an arc resistant drive, barriers behind the swing-out LV compartment require removal.
2. Note the position of the leads.
3. Remove the 6.4 mm (¼ in.) hardware and disconnect the leads connected to the terminals.
4. Four brackets secure the capacitor. Loosen the four screws at the base of the brackets and lift the capacitor out.
5. Place the new capacitor and tighten the screws securely.
6. Replace the ring lugs and 6.4 mm (¼ in.) hardware (see Figure 33).

IMPORTANT	The maximum torque for the capacitor terminal is 3.4 N•m (30 lb•in).

Figure 34 - Capacitor in Grounding Network



Replacing the Hall Effect Current Sensor (HECS)

1. Isolate and lock out all power to the drive.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Note the location of all wires and the orientation of the HECS. For quick reference when checking the orientation of the HECS, look for the white arrow.

IMPORTANT	The HECS and wires must be in the proper orientation. Note the position before disassembly.

3. Remove the round bus bar. Remove the M10 hardware and slide the bar out.
4. Remove the output connector. Note the orientation.
5. Remove the four screws on the base and remove the sensor.
6. Insert the new sensor. Orient the arrows as shown in Figure 36.
7. Slide the bus bar back into place and secure with the M10 hardware.
8. Replace the output connector, noting the correct orientation.

Figure 35 - Hall Effect Current Sensor located within Cabinet

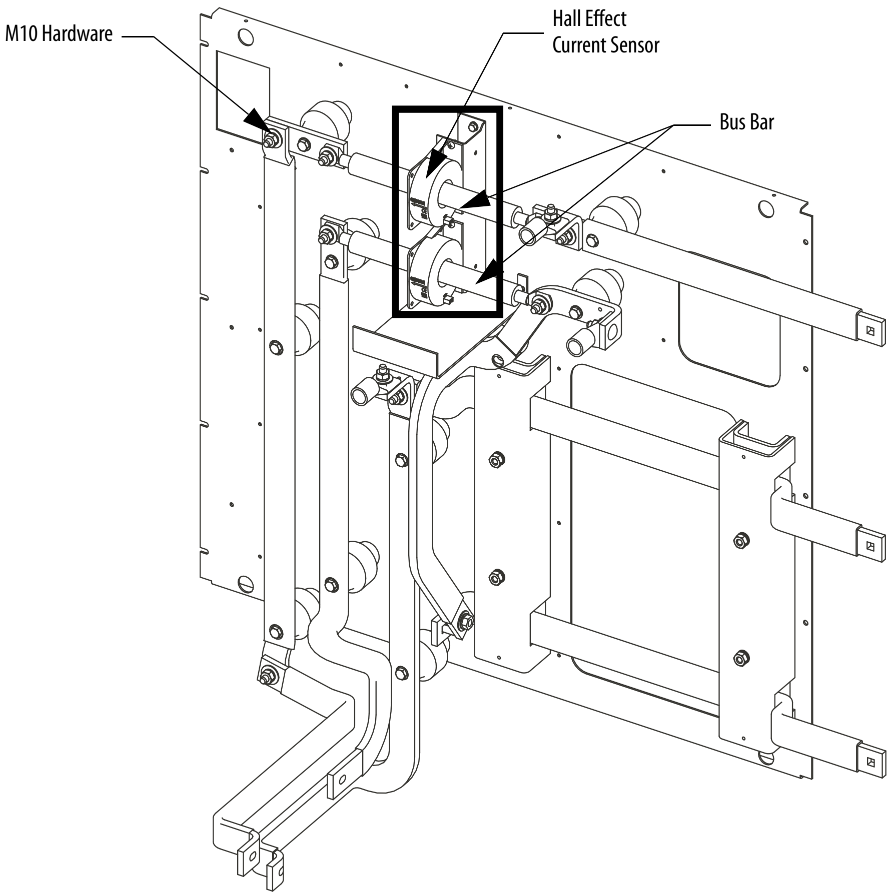
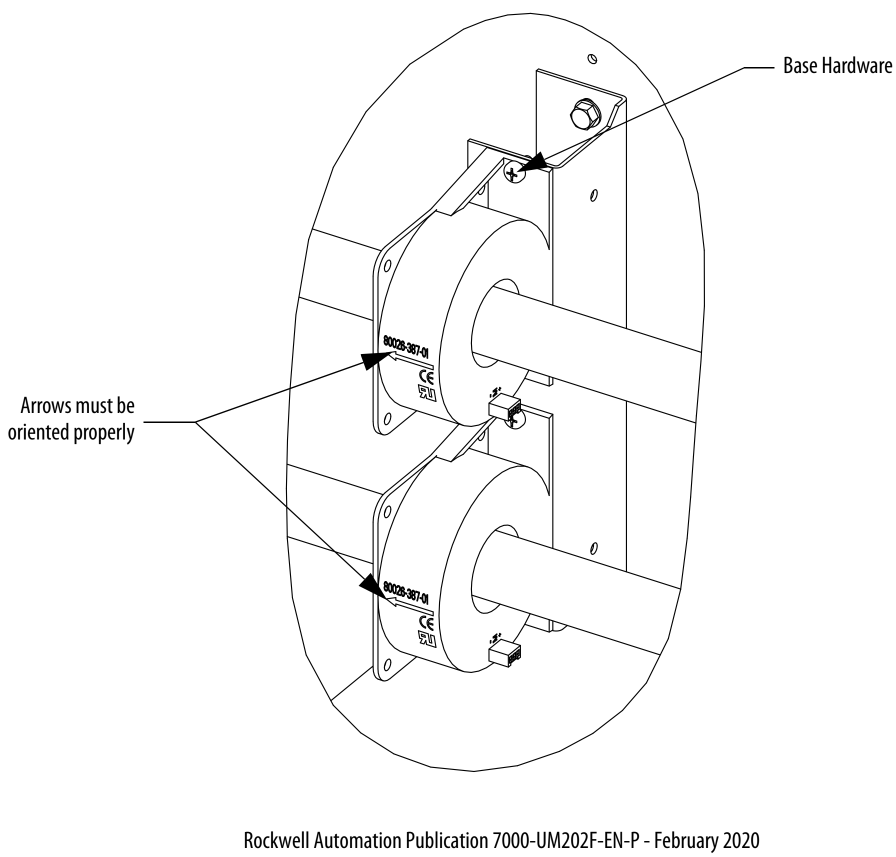


Figure 36 - Hall Effect Current Sensor (detail)



Replacing the Current Transformer (CT)

1. Isolate and lock out all power to the drive.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Note the location of all wires and the orientation of the CT. For quick reference when checking the orientation of the CT, look for the white dot.

IMPORTANT	The CT and wires must be in the proper orientation. Note the position before disassembly.

3. Disconnect the wires.
4. Disassemble the bus bar to remove the CT. Remove the M10 hardware to slide out the bus bar.
5. Remove the four screws located in the base of the CT and remove the CT.
6. Replace the CT, ensuring the proper orientation. Fasten the CT securely with the four screws in the base
7. Reconnect the ring lugs. Do not overtighten or you will break the threaded stud. For torque specifications, see Torque Requirements for Threaded Fasteners on page 195. Replace the bus bar and tighten into place.

Filter Capacitor Cabinet

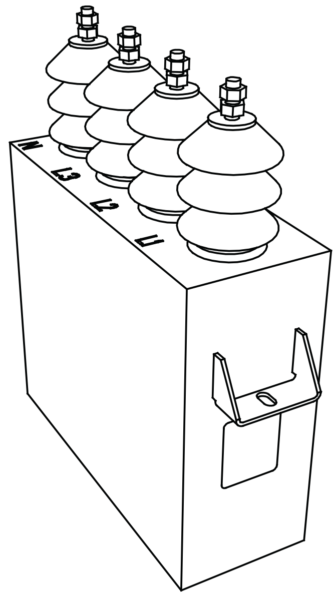
Filter Capacitors

All 'B' frame drives use filter capacitors on the motor side. The AFE rectifier options also include filter capacitors on the line side. See Figure 21 on page 31 (cabling cabinet for AFE rectifier) and Figure 23 on page 33 (cabling cabinet for 18-pulse rectifier).

The filter capacitors are three-phase, oil-filled, four-bushing units. The three-phase capacitors are internal single-phase units connected in a Y configuration. The neutral point of the Y connects to the fourth bushing, which is available to use as a neutral point voltage measurement or other protection/diagnostics purposes. The metal cases of the capacitors are grounded through a stud on the capacitor housing.

The capacitors have internal "bleeding resistors" to discharge the capacitor and reduce its voltage below 50V in five minutes when disconnected. Figure 37 shows a typical three-phase capacitor.

Figure 37 - Motor Filter Capacitor



WARNING: Allow 5…10 minutes for motor capacitors to safely discharge voltage prior to opening cabinet doors.

WARNING: The following fault codes may also indicate a non-operational Motor Filter Capacitor (MFC):

F96 (Motor Overcurrent Fault)
F98 (Motor Neutral Overvoltage Fault)
F99 (Motor Flux Unbalance Fault)
F100 (Motor Current Unbalance Fault)
F103 (Motor Stall Fault)
F113 (DC Link Overcurrent Fault)
F114 (Ground Overcurrent Fault)
F115 (Neutral Resistor Overcurrent Fault)
F145 (Neutral Resistor Overload Fault)

Do not reset these faults until you have determined the root cause of the fault.

Operating a synchronous transfer system (specifically during the 'Transfer to Drive' operation, also known as the de-sync operation) with a non-operational MFC can lead to serious personal injury and/or property damage.

Replacing Filter Capacitors

See Publication 7000-IN010, “Handling, Inspection, and Storage of Medium Voltage Line Filter Capacitors”.

1. Isolate and lock out all power to the drive.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Note the location of all the cables and mark them accordingly.
3. Remove the four power connections to the terminals, and the single ground connector from the drive to the capacitor frame, located at the back top right corner of the capacitor.
4. Remove the front bracket that holds the capacitor in place. At the rear of the capacitor, there is no hardware securing the capacitor. The bracket fits into a slot in the assembly.
5. Remove the capacitor from the drive.

IMPORTANT Capacitors can weigh as much as 100 kg (220 lbs). Use two or more people to remove a capacitor.

ATTENTION: The porcelain bushings are extremely fragile and any force applied to the bushings can damage the seal between the bushing and the body causing potential leaks or chipping.

6. Install the new capacitor, sliding it back until it fits into the slot. Fasten the front bracket.
7. Reconnect all the power cables and the ground connection. These use M14 hardware, but should only be tightened to 30 N•m (22 lb•ft) due to capacitor mechanical constraints. You may want to fasten these connections before fully sliding the capacitor into place depending on the available space.
8. Follow the instruction labels on each capacitor to tighten the terminal connections.
9. Reinstall the removed sheet metal, and complete one final check to ensure connections are secure and correct.

Testing Filter Capacitors

There are two ways to test line filter capacitors. Rockwell Automation recommends the first method as it reduces the chance of re-torque issues because the capacitors are not disconnected. If the readings are unsatisfactory, the second method is more accurate, but involves disconnecting and testing them individually.

First Method

1. Ensure there is no power to the equipment.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

ATTENTION: Verify the load is not running due to process. A freewheeling motor can generate voltage that feeds back to the equipment.

2. Follow appropriate safety steps to isolate the equipment from medium voltage.
3. Verify that there is no voltage present on the capacitor by using a hot stick or any other appropriate voltage-measuring device.
4. Perform visual inspection to verify there is no oil leak or bulge in any of the capacitors.

ATTENTION: Capacitors that appear bulged or are leaking oil indicate potential problems with the internal elements. DO NOT USE. These units must be replaced. Failure to do so may lead to personal injury or death, property damage, or economic loss.

5. Using a digital multimeter, measure the capacitance across each phase-to-neutral of capacitors without removing any connections.

   If the difference between the highest and the lowest readings is below 15%, then all capacitors are in good condition. If the difference between the highest and the lowest readings is off by 15% or more, then you might have a bad capacitor. If more than one capacitor is used in the circuit, then you would need to isolate each of them and check them separately to identify which one is defective.
6. Before disconnecting the capacitors, note the location of all the cables and mark them accordingly.
7. Disconnect power cables from the capacitor terminals on all four bushings and isolate them from the capacitor (see Replacing Filter Capacitors on page 52).
8. Repeat step 5 to check each capacitor separately to confirm which is defective.

Second Method

1. Ensure there is no power to the equipment.

> **ATTENTION:** To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

> **ATTENTION:** Verify the load is not running due to process. A freewheeling motor can generate voltage that feeds back to the equipment.

2. Perform visual inspection to verify there is no oil leak or bulge in any of the capacitors.

> **ATTENTION:** Capacitors that appear bulged or are leaking oil indicate potential problems with the internal elements. DO NOT USE. These units must be replaced. Failure to do so may lead to personal injury or death, property damage, or economic loss.

3. Note the location of all the cables and mark them accordingly.
4. Disconnect power cables from the capacitor terminals on all four bushings and isolate them from the capacitor (see Replacing Filter Capacitors on page 52).
5. Connect a low voltage single-phase test power, for instance 110V or 220V, across a phase and the neutral of the capacitor. Switch on the test power and measure the test voltage and current drawn by the capacitor. Repeat the test for all three phases and note down the test voltage and current.

> **ATTENTION:** The capacitor will charge during this test so take care to prevent a shock or injury. When moving the test connections from one phase to the next, wait five minutes minimum for the capacitor to discharge.

6. Calculate the capacitance from the measured values of test voltage and current. For a good capacitor, the calculated capacitance value for each of the three readings should be within ±15% of the capacitor nameplate micro-Farad. If it is outside this range, the capacitor must be replaced.

Suppose that a capacitor under test is rated at 400 kVAR, 6600V, 50 Hz, 29.2 μF. Assume that you are using 200V, 50 Hz test power with the recorded voltage, and current values for each test as shown in the table below.

Phase - Neutral	L1-N	L2-N	L3-N
Test voltage	200V	200V	200V
Measured current	1.87 A	1.866 A	1.861 A

Calculate the capacitance using the first reading. In this case:

V = 200V, I = 1.87 for L1-N
Xc = V/I = 200/1.87 = 106.95
C= 1/ (2 π *F* Xc)
C= 1/(2 x 3.14 x 50 x 106.95
C=29.7µ *F*

Where:
F = frequency of the applied voltage.

Similarly, you can calculate the capacitance for the remaining two measurements for L2-N and L3-N.

Converter Cabinet Components

This section describes the converter cabinet components of your PowerFlex 7000 'B' frame drive. This section also details a number of regular or recurring maintenance tasks that will keep your drive in peak operating condition.

The converter cabinet contains three rectifier modules and three inverter modules. Isolated gate driver power supplies (IGDPS) are available on the right side sheet of the cabinet.

Thermal sensors are available on the top module of the inverter and rectifier. The exact location depends on the drive configuration. These sensors connect to temperature feedback boards that return signals to the drive control.

For control/cabling cabinets, see Control / Cabling Cabinet Components on page 29. For DC link and fan cabinets, see DC Link and Fan Cabinet Components on page 116.

Figure 38 - Converter Cabinet (Heatsink Model, 2400V)

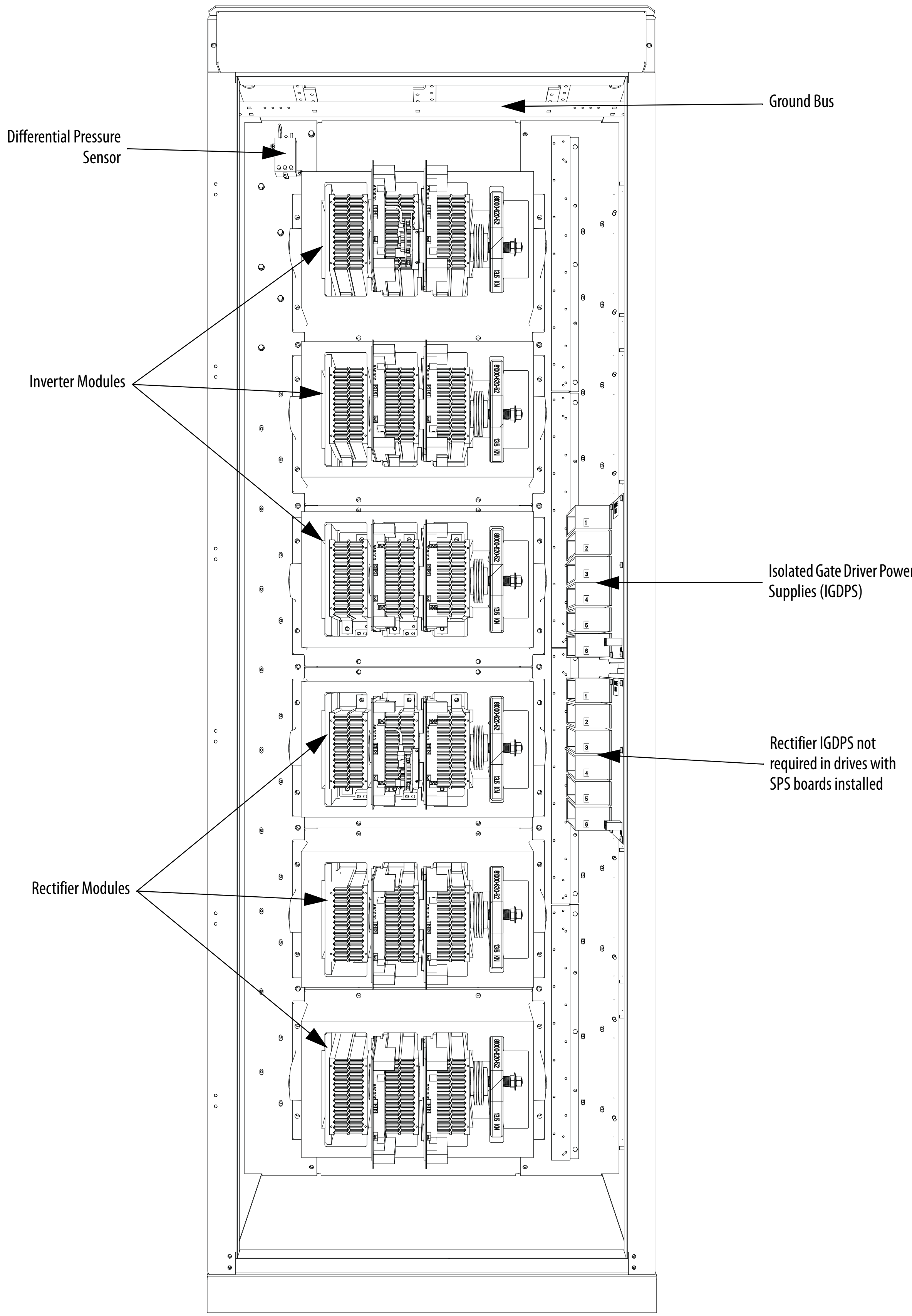


Figure 39 - Converter Cabinet (Heatsink Model, 3300…4160V)

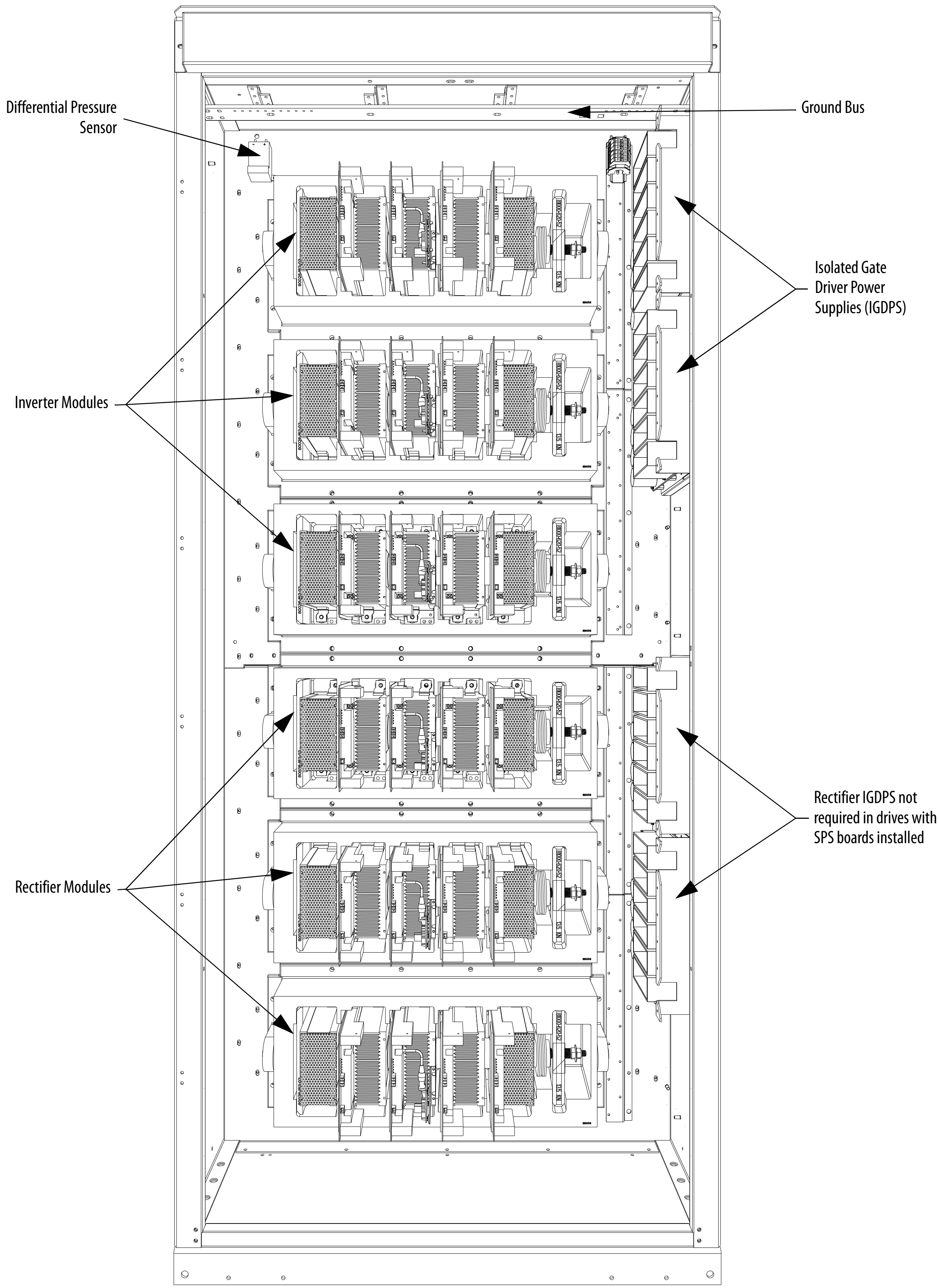


Figure 40 - Converter Cabinet (Heatsink Model, 6600V)

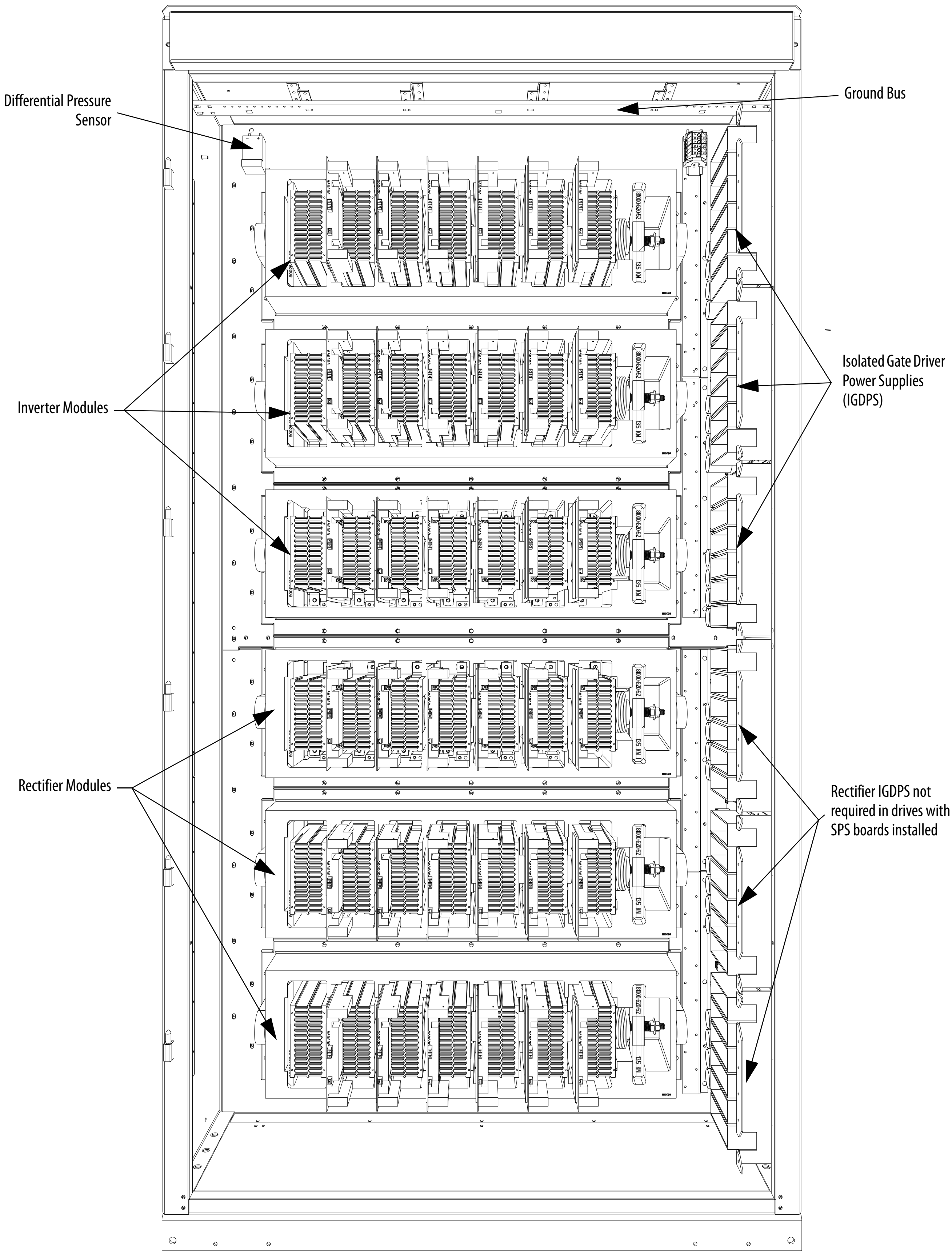


Figure 41 - Converter Cabinet, 3300…4160V (Heatpipe Model)

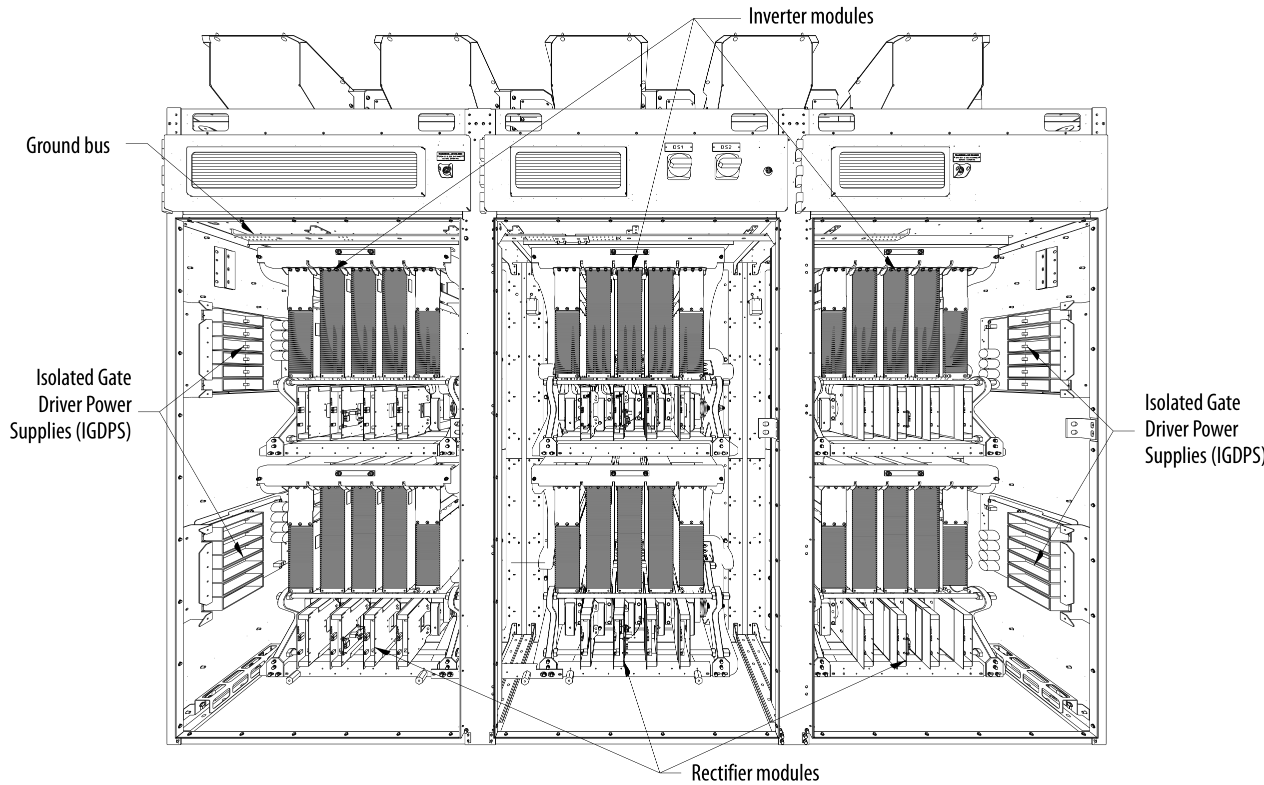
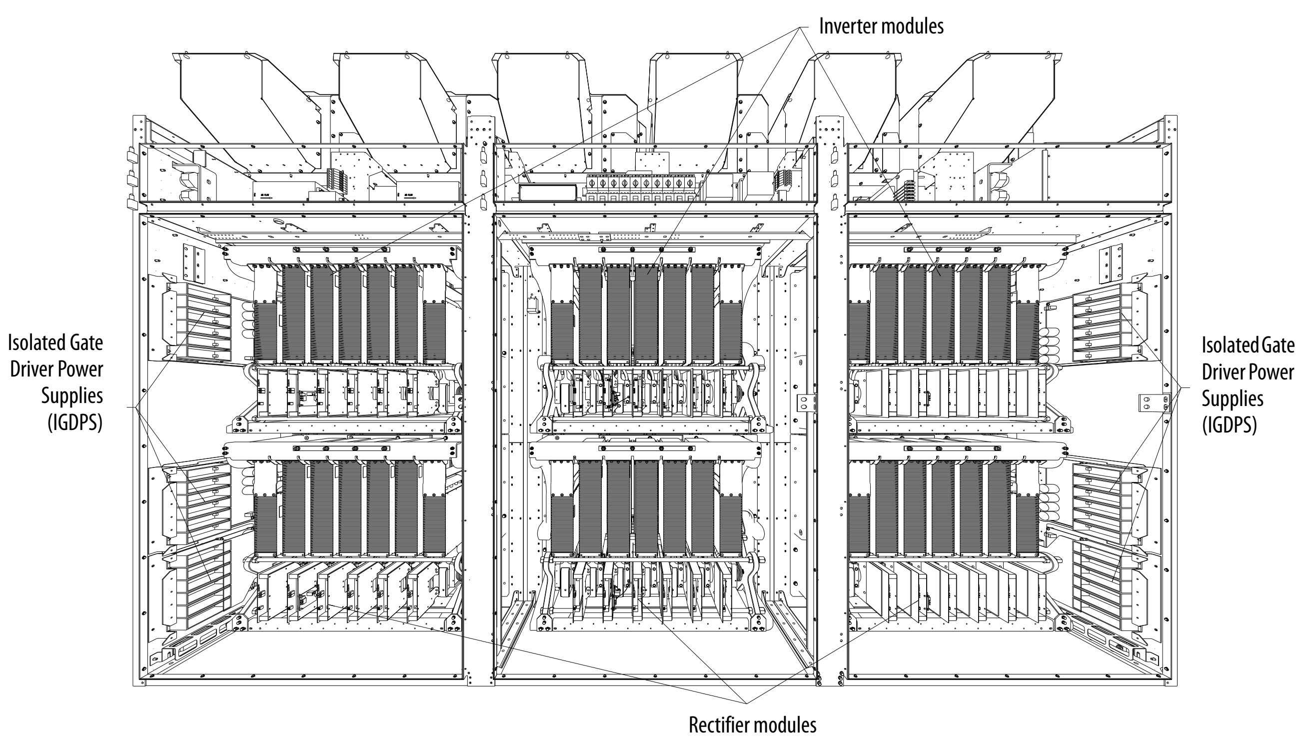


Figure 42 - Converter Cabinet, 6600V (Heatpipe Model)



PowerCage Module Overview

A PowerCage™ module is a converter module, consisting of the following elements:

- Epoxy resin housing
- Power semiconductors with gate driver circuit boards
- Heatsinks or heatpipes
- Clamp
- Snubber resistors
- Snubber capacitors
- Sharing resistors (not applicable for 2400V models)

Each drive consists of three PowerCage rectifier modules and three PowerCage inverter modules. There are two principal classes of rectifiers:

- AFE and 18-pulse
  - AFE type rectifiers use SGCTs
  - 18-pulse rectifiers use SCRs

All inverter modules use SGCTs as semiconductors.

The size of the PowerCage module depends on the system voltage, and the components will also vary in the system current.

This table illustrates power semiconductor usage in the converter section.

Configuration	Rectifier SGCTs	Rectifier SCRs	Inverter SGCTs
2400V, AFE	6	0	6
2400V, 18-pulse	0	18	6
3300/4160V, AFE	12	0	12
3300/4160V, 18-pulse	0	18	12
6600V, AFE	18	0	18
6600V, 18-pulse	0	18	18

Some drive configurations contain self-powered SGCT power supply (SPS) boards. These boards are applicable on all “A” frame drives and all AFE ‘B’ frame drives with heatsinks. See Self-powered SGCT Power Supply - SPS on page 106 for more information

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free, using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

ATTENTION: The PowerCage module can house either SCRs or SGCTs. The SGCT circuit board is sensitive to static charges. Never handle these boards without proper grounding.

ATTENTION: Some circuit boards can be destroyed by static charges. Use of damaged circuit boards may also damage related components. Use a grounding wrist strap when handling sensitive circuit boards.

ATTENTION: If equipped, the SPS circuit board is sensitive to static charges. Do not handle these boards without proper grounding.

Resistance Checks

Prior to applying control power to the drive, power semiconductor and snubber circuit resistance measurements must be taken. Doing so will ensure that no damage has occurred to the converter section during shipment. The instructions provided below detail how to test the following components:

- Inverter or AFE rectifier bridge
  - Anode-to-cathode resistance test (sharing resistor and SGCT)
  - Snubber resistance test (snubber resistor)
  - Snubber capacitance test (snubber capacitor)
- SCR rectifier bridge
  - Anode-to-cathode resistance test (sharing resistor and SCR)
  - Gate-to-Cathode resistance test (SCR)
  - Snubber resistance test (snubber resistor)
  - Snubber capacitance rest (snubber capacitor)

ATTENTION: Before attempting any work, verify that the system has been locked out and tested to have no potential.

Snubber Resistors

Snubber resistors connect in series with the snubber capacitors. Together they form a simple RC snubber that connects across each thyristor (SCR or SGCT). The snubber circuit reduces the dv/dt stress on the thyristors and reduces the switching losses. The snubber resistors connect as sets of various wire-wound resistors connected in parallel. The number of resistors in parallel depends on the type of the thyristor and the configuration and frame size of the drive.

Snubber Capacitors

Snubber capacitors are connected in series with the snubber resistors. Together they form a simple RC snubber that is connected across each thyristor (SGCT). The purpose of the snubber circuit is to reduce the voltage stress (dv/dt and peak) of the thyristor and to reduce the switching loss.

Sharing Resistors

Sharing resistors provides equal voltage sharing when using matched devices in series. SGCT PowerCage modules for 2400V systems do not need matched devices and have no sharing resistor.

SCR PowerCage modules always have sharing resistors even if matched devices are not necessary. Sharing resistors in SCR PowerCage modules provide a diagnostic function.

SGCT and Snubber Circuit

With all power semiconductors or thyristors, the SGCT requires a snubber circuit. The snubber circuit for the SGCT consists of a snubber resistor in series with a snubber capacitor.

Figure 43 shows the snubber circuit. Figure 53 shows the physical locations of the same circuit. Measure the resistance across two adjacent heatsinks. A value between 60 kΩ and 75 kΩ indicates a good sharing resistor.

Figure 43 - Snubber Circuit for SGCT Module

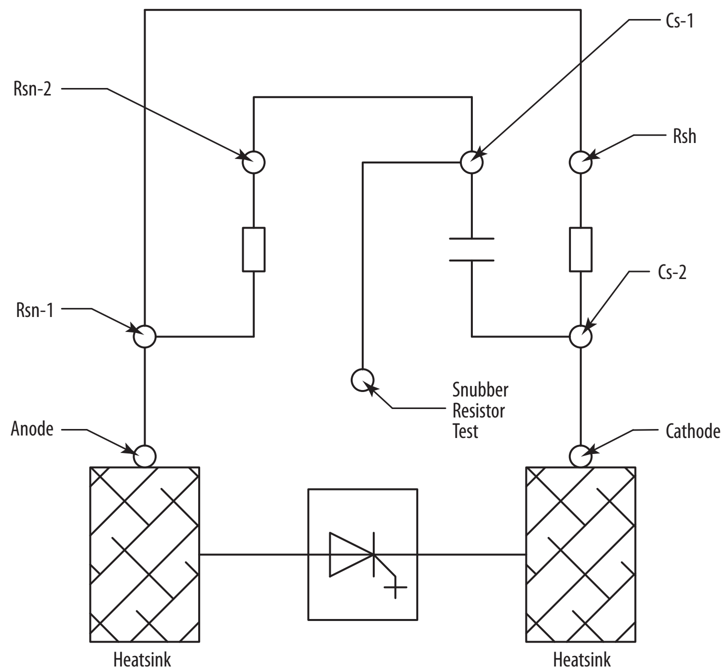


Figure 44 - Snubber Circuit for SGCT module (with SPS board)

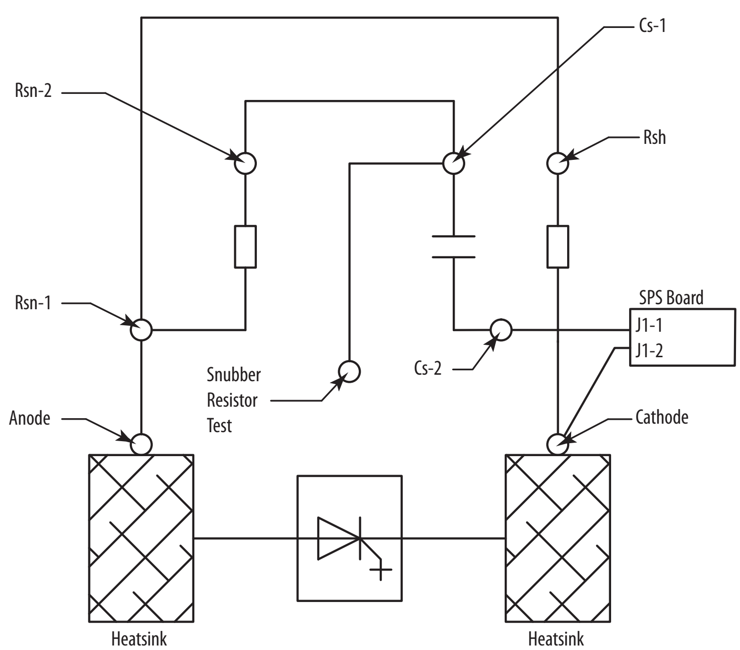


Figure 45 - 2400V Two Device PowerCage Module (Heatsink Model)

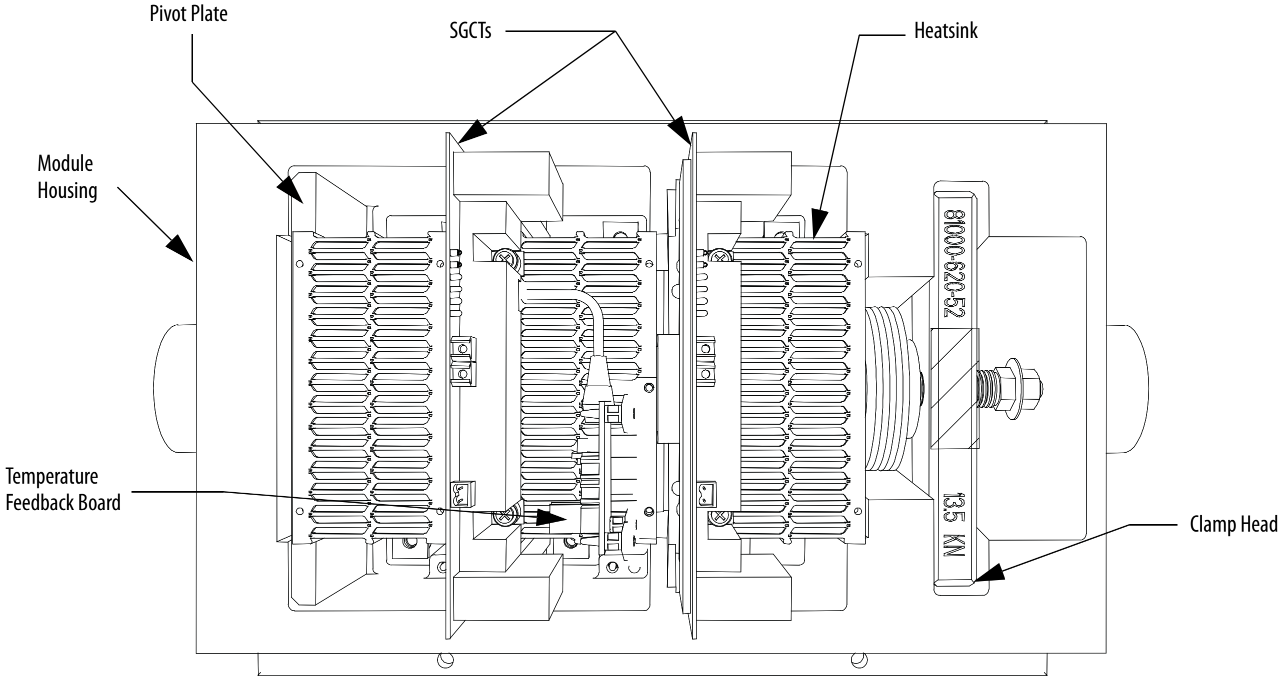


Figure 46 - 2400V Two Device PowerCage Module (with SPS Boards installed)

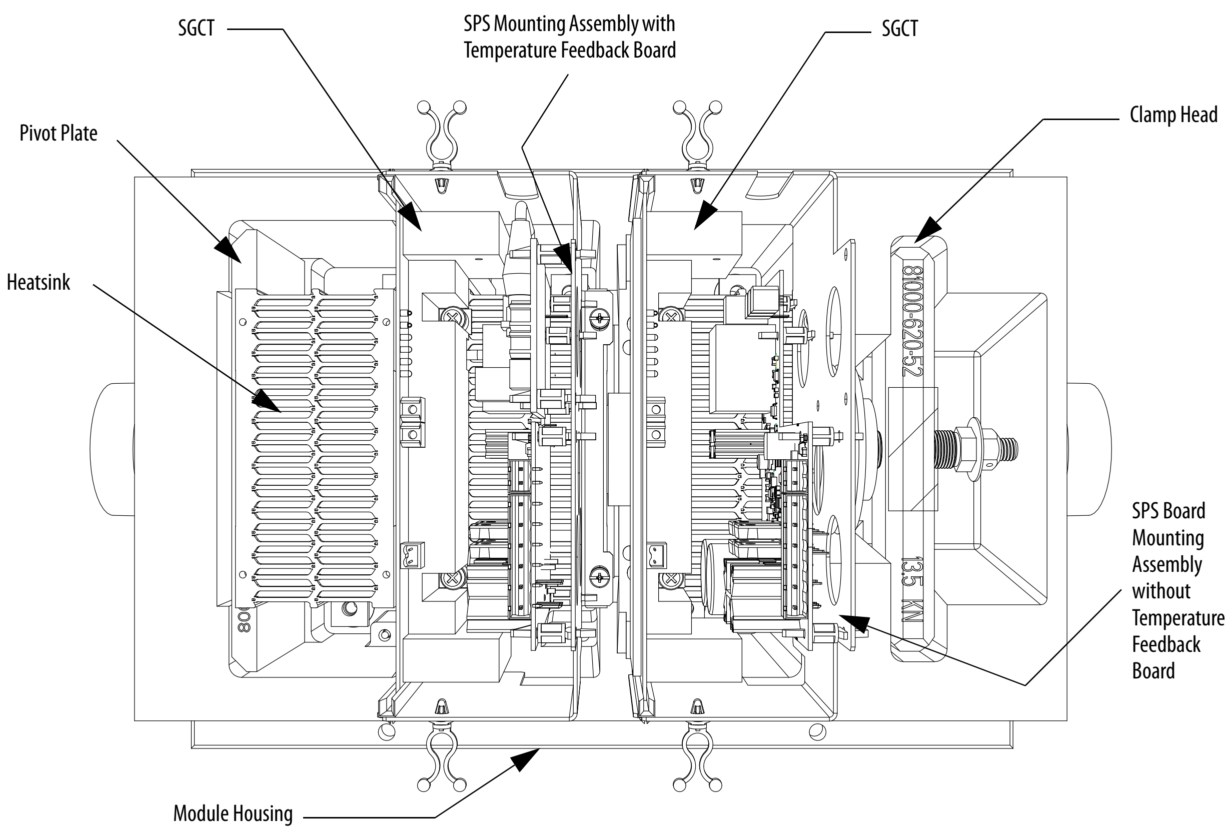


Figure 47 - 3300/4160V Four Device PowerCage Module (heatsink model)

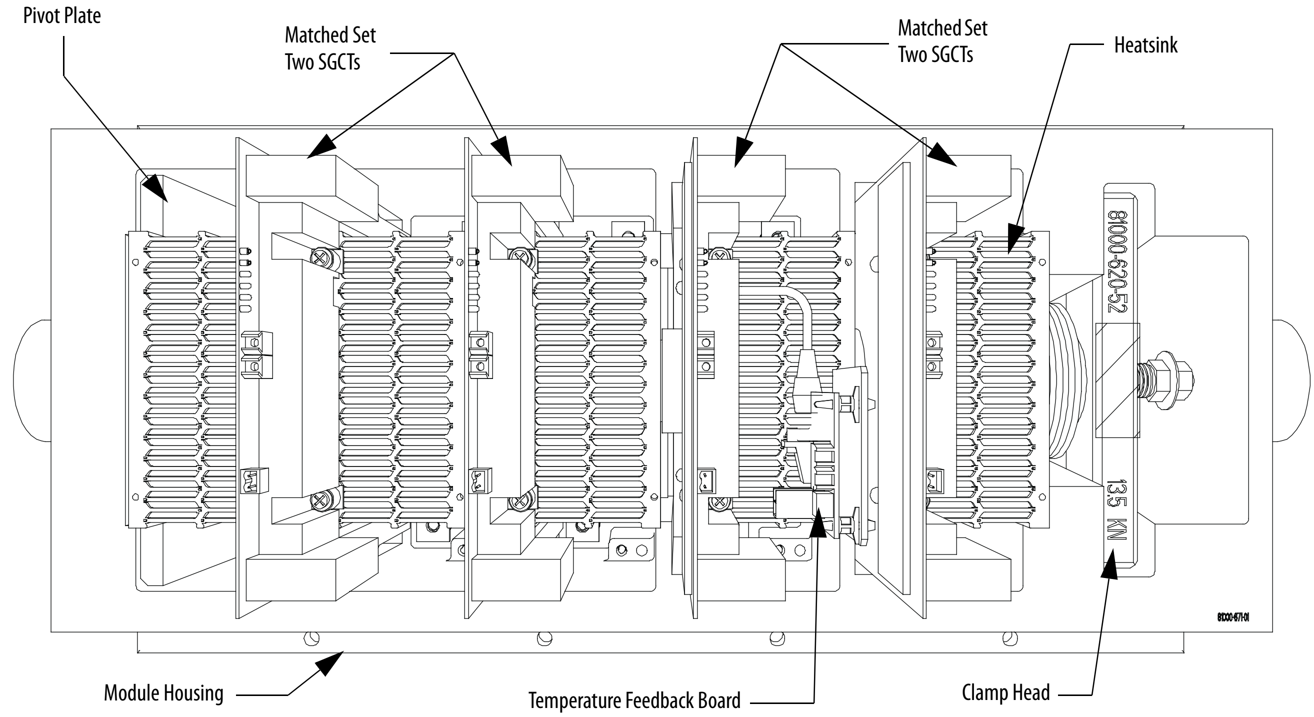


Figure 48 - 3300/4160V Four Device Rectifier PowerCage Module (with SPS Boards installed)

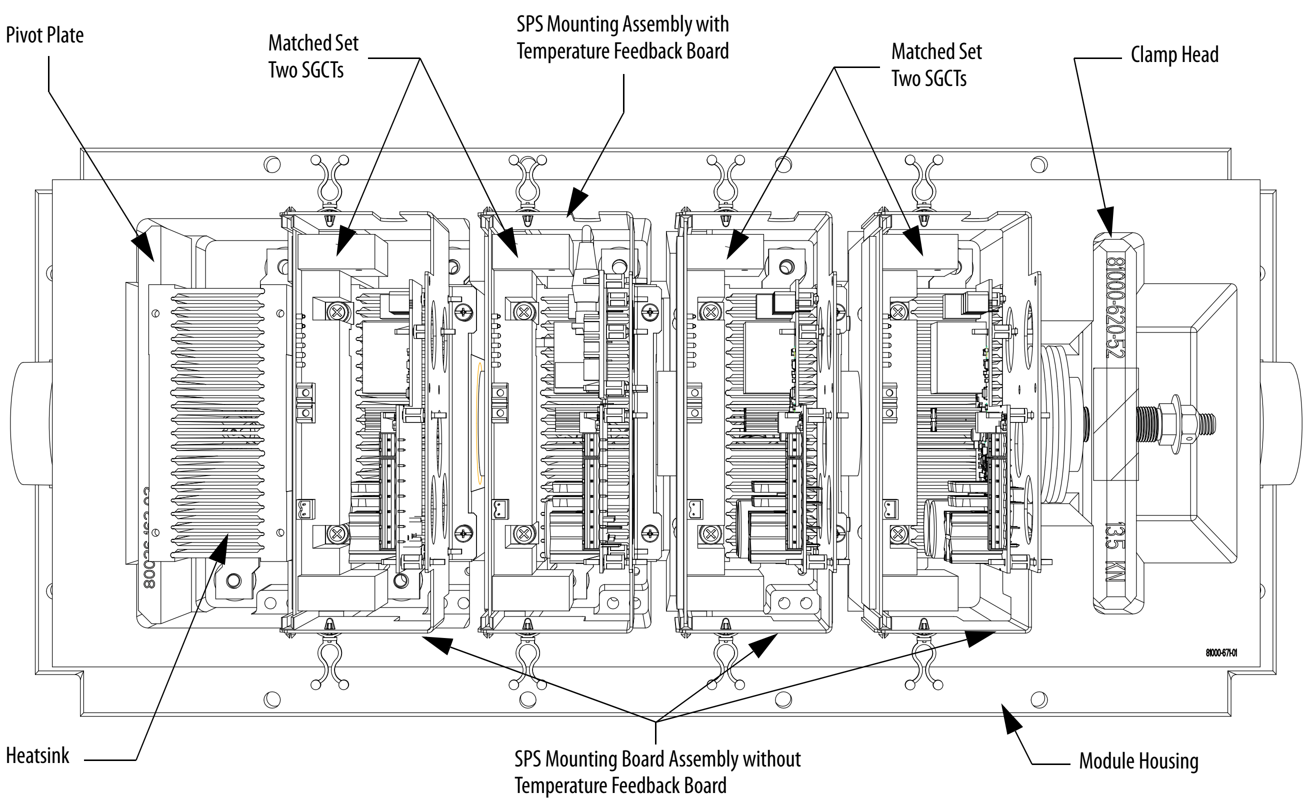


Figure 49 - 6600V Six Device PowerCage Module (heatsink model)

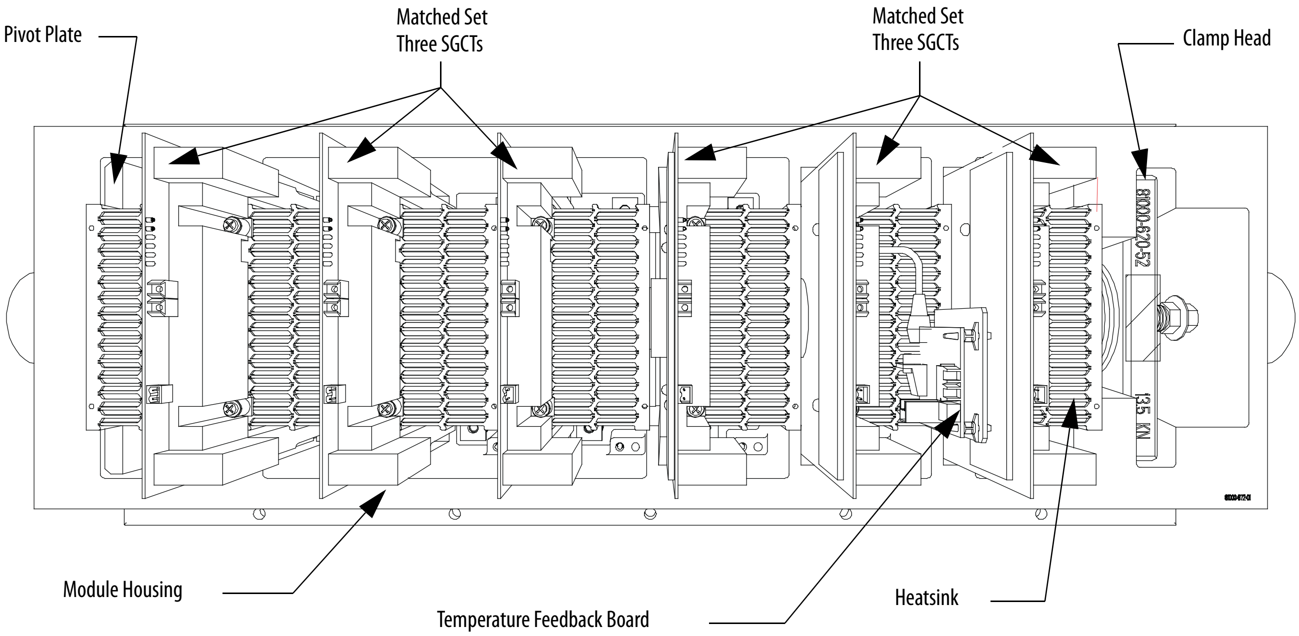


Figure 50 - 6600V Six Device PowerCage Module (with SPS Boards installed)

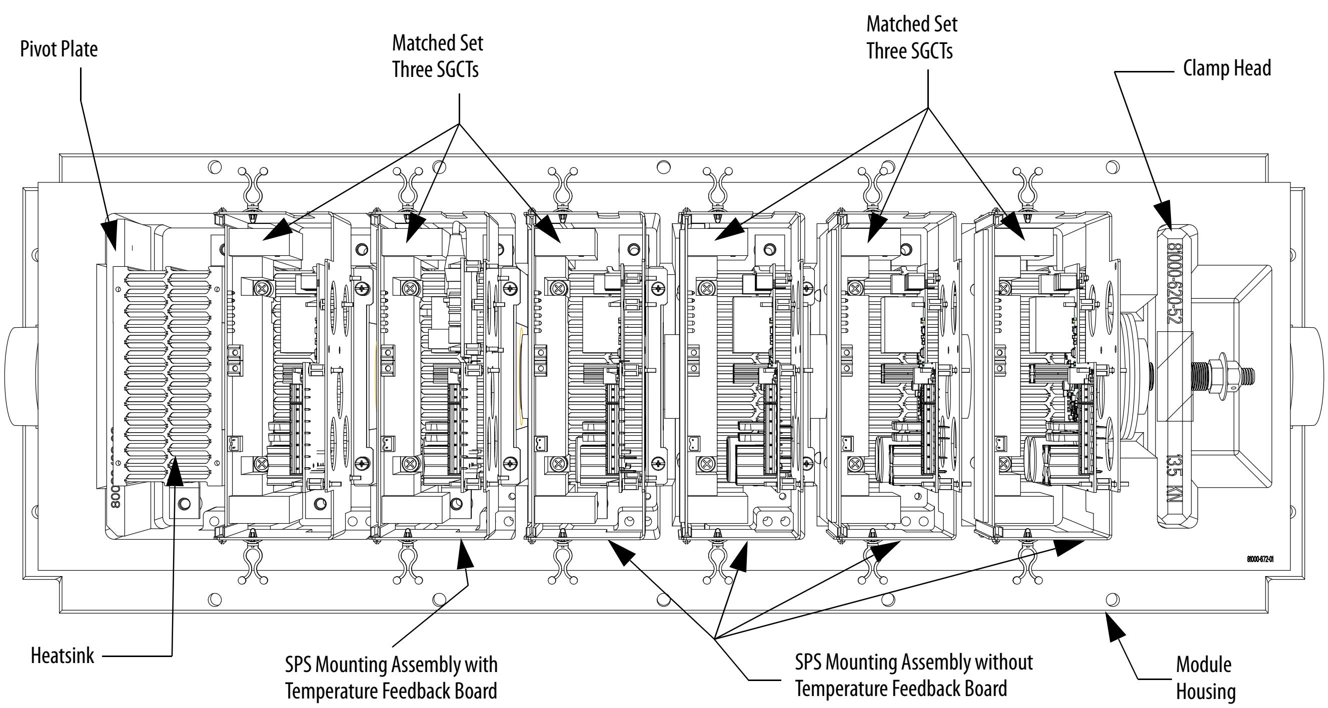


Figure 51 - 3300/4160V Four Device PowerCage Module (Heatpipe Model)

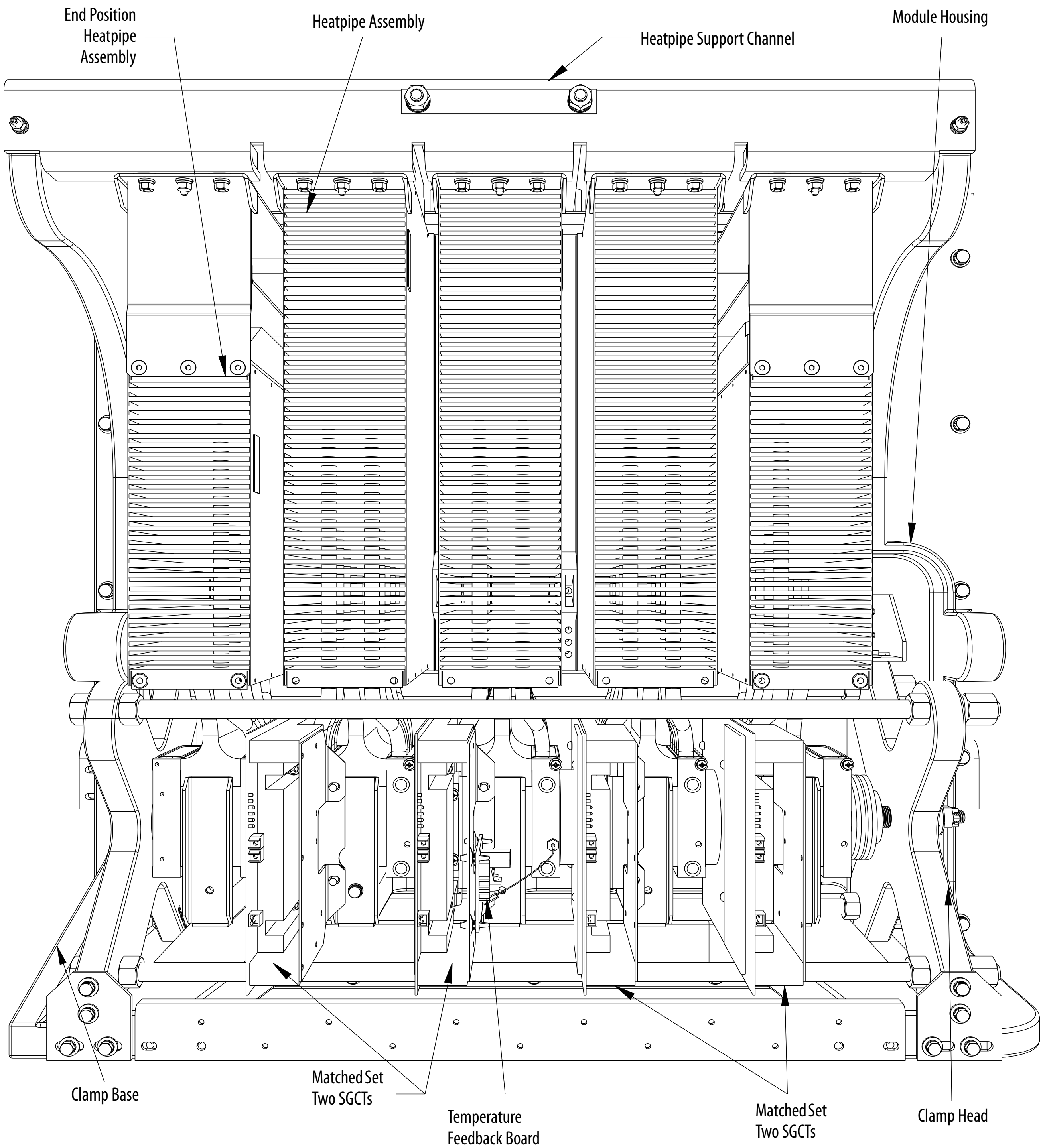


Figure 52 - Snubber Circuit Assembly for SGCT module

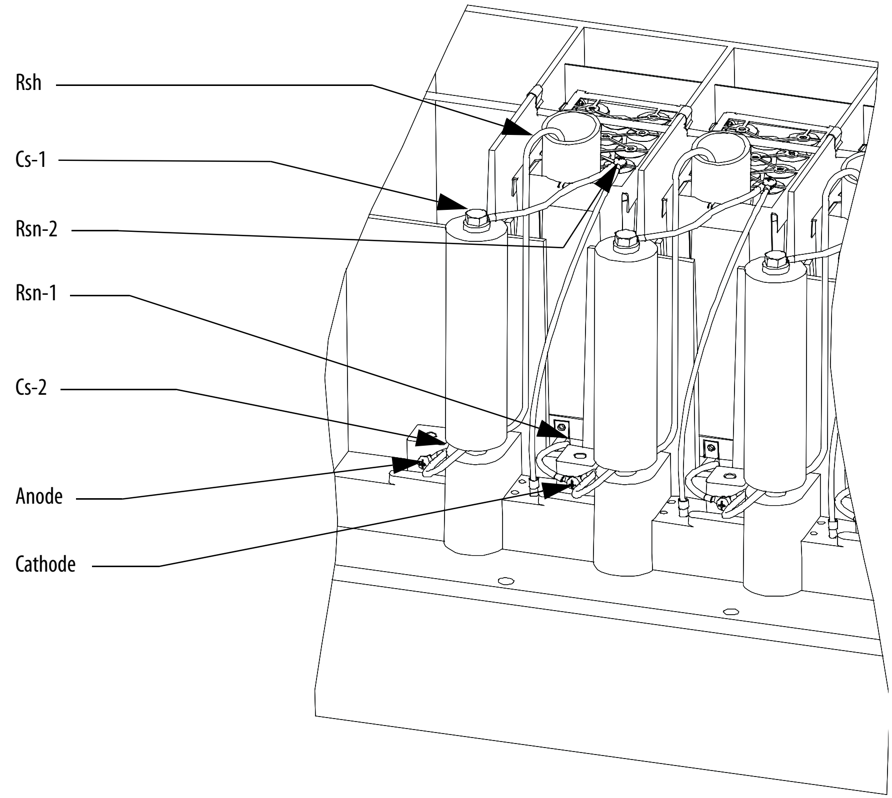
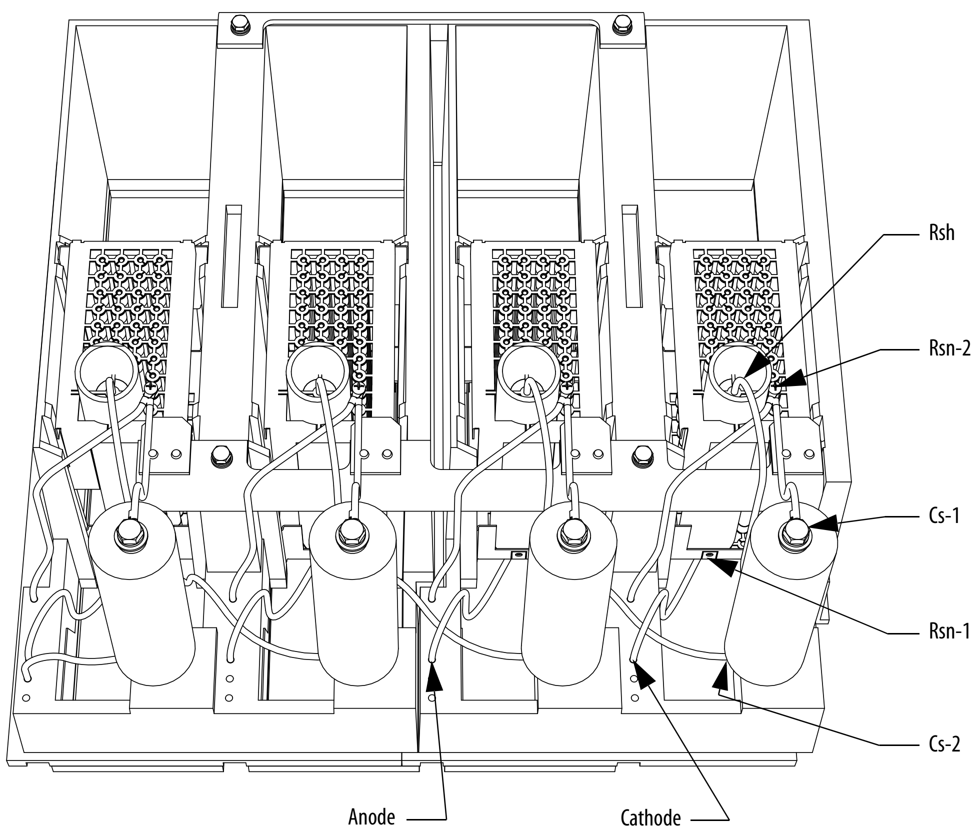


Figure 53 - Snubber Circuit Assembly (Heatpipe Model)



In addition to the snubber circuit, a sharing resistor connects in parallel with the SGCT. The sharing resistor ensures the equal distribution of the voltage among the SGCTs connected in series. Connect SGCTs in series to increase the total reverse voltage blocking (PIV) capacity, as seen by the electrical circuit. A single SGCT has a PIV rating of 6500V. This single device provides sufficient design margin for electrical systems with 2400V medium voltage supply. At 4160V, connect two SGCTs in series to provide a net PIV of 13,000V to achieve the necessary design margin. Similarly, connect three SGCTs in series at 6.6 kV, providing a net PIV of 19,500V to achieve the necessary design margin.

To meet the cooling requirements of the SGCT, place the SGCT between two forced air-cooled heatsinks, one heatsink on the anode and the other heatsink on the cathode. The force on the SGCTs differs with the size of the device. The clamp assembly on the right hand side of the inverter module generates these forces.

The SGCTs require uniform pressure to prevent damage and to ensure low thermal resistance. Achieve uniform pressure by loosening the heatsink mounting bolts, tightening the clamp, then tightening the heatsink bolts.

This design directs external filtered air through the heatsink slots to dissipate heat from the SGCTs. The door filter is designed to keep the heatsink slots free of dust particles.

SGCT Testing

The following sections outline how to verify SGCT semiconductors and all associated snubber components. A quick reference to the expected resistance and capacitance values as well as a simple schematic diagram is located in the table below. A simple schematic diagram in Figure 43 on page 62 shows how the snubber components are connected across an SGCT.

SGCT Rating	Sharing Resistor(1)	Snubber Resistor	Snubber Capacitor
1500 A	80 kΩ	6 Ω (AFE rectifier)	0.2 µf
1500 A	80 kΩ	7.5 Ω (Inverter)	0.2 µf
800 A	80 kΩ	10 Ω	0.1 µf
400 A	80 kΩ	15 Ω (AFE rectifier)	0.1 µf
400 A	80 kΩ	17.5 Ω (Inverter)	0.1 µf

(1) 2400V drives will not have a sharing resistor on devices.

Table 3 - SGCT/snubber resistance values

SGCT Resistance Measurement	Measured Resistance			
	Inverter		Rectifier (AFE only)	
SGCT Anode-Cathode Resistance (heatsink to heatsink) k-Ω				
	(Lowest)	(Highest)	(Lowest)	(Highest)
Snubber Resistance (Test point: heatsink above) Ω				
	(Lowest)	(Highest)	(Lowest)	(Highest)
Snubber Capacitance (Test Point – heatsink on Right) µF				
	(Lowest)	(Highest)	(Lowest)	(Highest)

SGCT Anode-to-Cathode (Sharing) Resistance

The anode-cathode resistance check measures the parallel combination of the sharing resistor and SGCT anode-cathode resistance. The sharing resistor has a resistance much lower than that of a good SGCT, so the measurement will be slightly less than the resistance of the sharing resistor. A measurement between 60 kΩ and 75 kΩ indicates the SGCT is in good condition and that wiring to the SGCT is correct. If the SGCT fails, it will be in the shorted mode, 0 Ω. The anode-to-cathode resistance check will be 0 Ω.

There is a test point inside the PowerCage module to measure the resistance of the snubber resistor and capacitance of the snubber capacitor. The test point is the electrical connection between the snubber resistor and snubber capacitor. Place one probe of the multimeter on the test point and the other probe on the appropriate heatsink to determine the value of the resistor or capacitor. See Figure 54.

Figure 54 - SGCT PowerCage Module

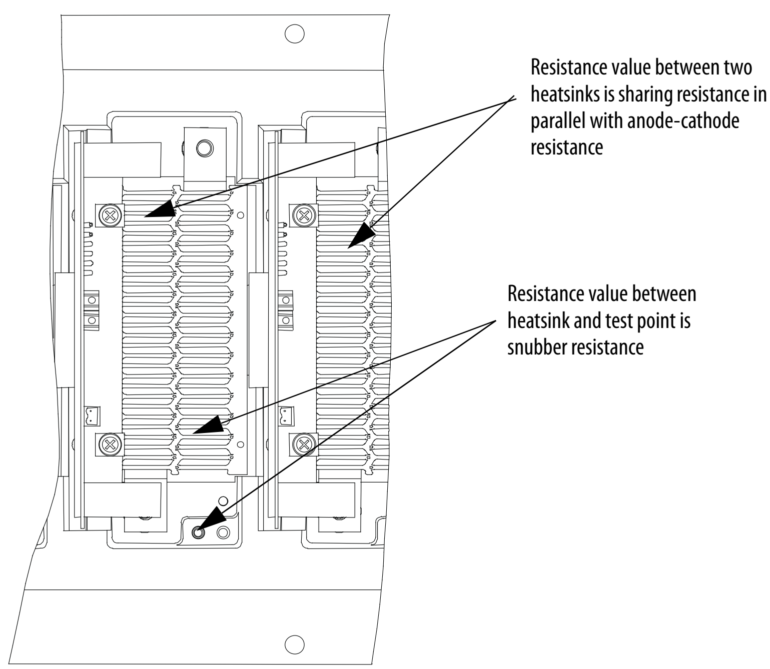


Figure 55 - Resistance Measurements SGCT PowerCage Module (with SPS Board Mounting Assembly)

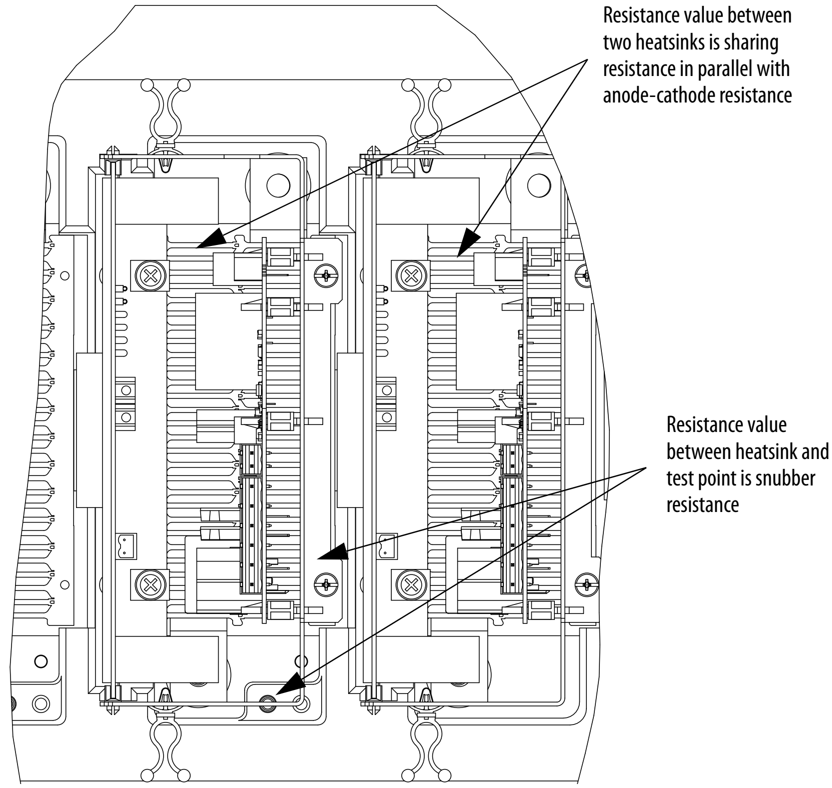
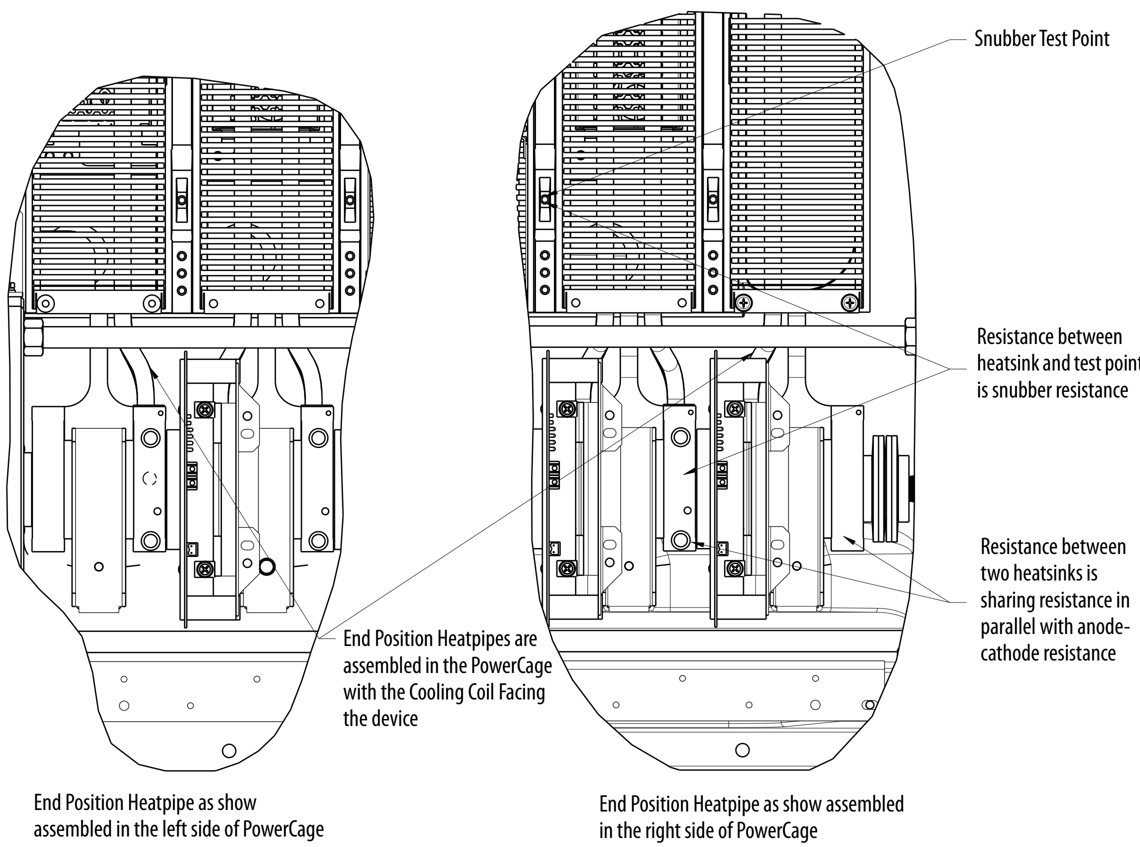


Figure 56 - Resistance Measurements (Heatpipe Model)



Snubber Resistance (SGCT Device)

Access to the snubber resistor is not required to test the resistance. The snubber circuit test point is located within the PowerCage module under the heatsinks. For each device, there is one test point. To verify the resistance, measure the resistance between the test point and the heatsink above.

Figure 57 - Snubber Resistor Test

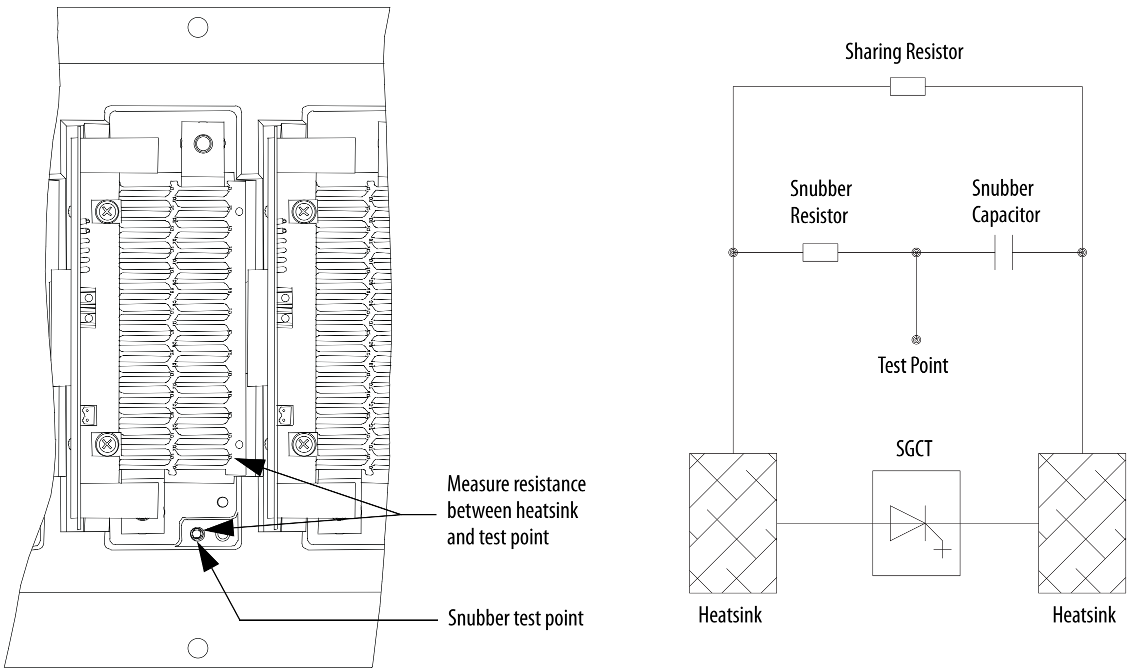
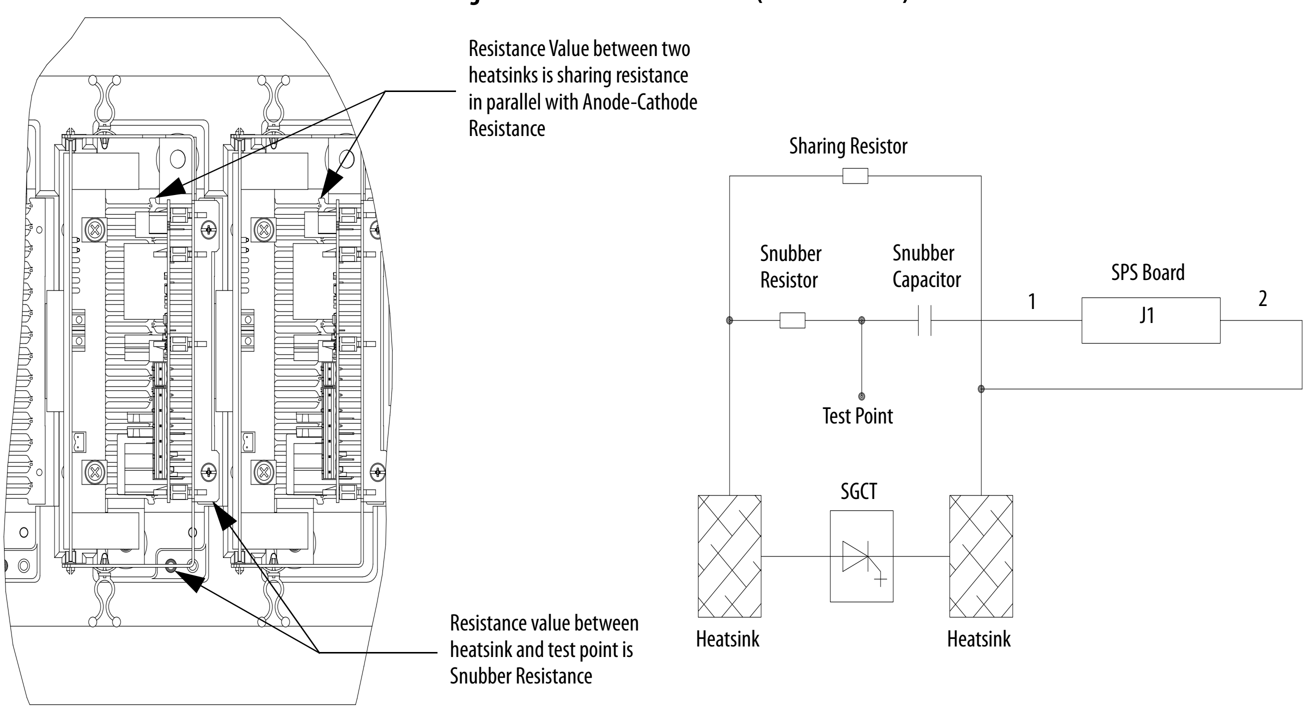


Figure 58 - Snubber Resistor Test (with SPS Board)



See Table 3 on page 69 to determine the appropriate snubber resistance value for the current rating of the SGCT used.

If the resistor is found to be out of tolerance, see page page 77 for detailed instructions on replacing the snubber resistor assembly.

Snubber Capacitance (SGCT Device)

Turn the multimeter from the resistance to capacitance measurement mode. Verify the snubber capacitor by measuring from the test point to the heatsink adjacent to the right for standard rectifiers, or from heatsink to heatsink. For SPS rectifiers, measure from the test point to pin 1 of the Phoenix connector that plugs into J1 of the SPS board (disconnect the J1 connector from the SPS board first).

Figure 59 - Snubber Capacitor Test

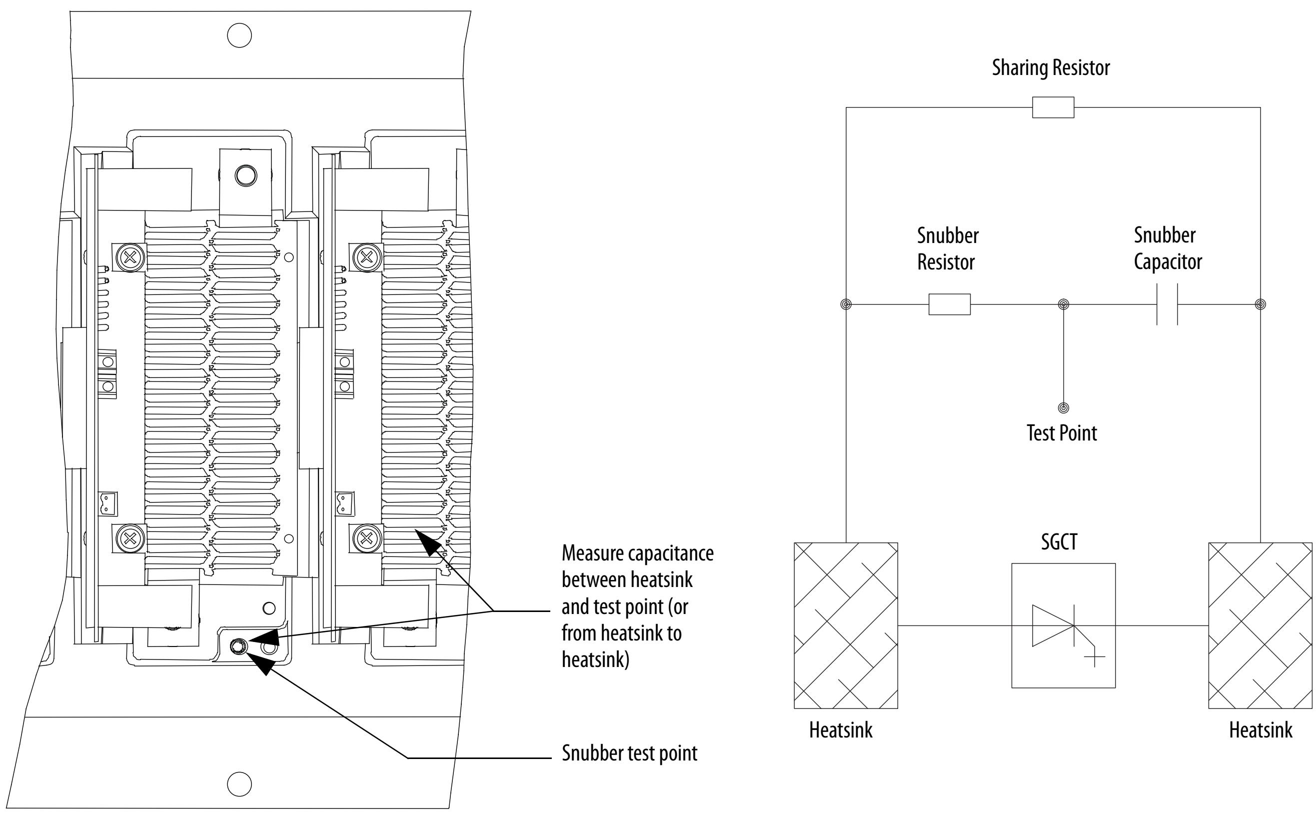
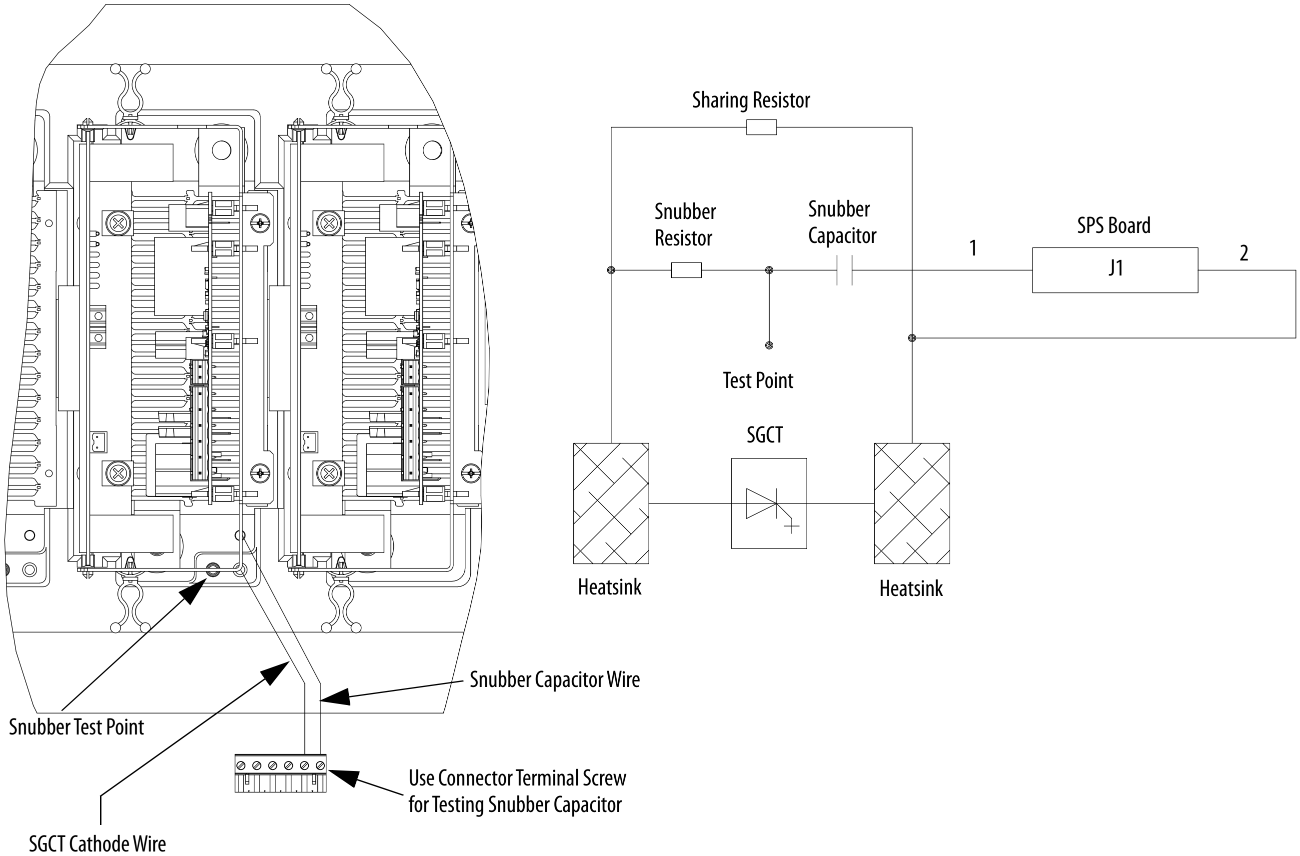


Figure 60 - Snubber Capacitor Test (Shown with SPS Board Installed)



See Table 3 on page 69 to determine the appropriate snubber capacitance value for the current rating of the SGCT used.

The capacitance measured is actually affected by the snubber capacitor and other capacitance in the circuit, including capacitance from the gate driver circuit. You are actually looking for a consistent reading for all devices.

If the capacitor is out of tolerance, see page 82 for detailed instructions on how to replace the snubber capacitor.

Replacing the SGCT

The SGCT ("device") with attached circuit board is located within the PowerCage module assembly. Replace SGCTs in matched sets (two sets for 4160V, three sets for 6600V).

The SGCT and associated control board are a single component. Never change the device or the circuit board individually. This table describes the functions of the four LEDs on the SGCT.

LED 4	Green	Solid Green indicates that the Power Supply to the Card is OK
LED 3	Green	Solid Green indicates that the Gate-Cathode resistance is OK
LED 2	Yellow	LED ON indicates the gate is ON, and Flashes alternately with LED 1 while gating
LED 1	Red	LED ON indicates the gate is OFF, and Flashes alternately with LED 2 while gating

1. Isolate and lock out all power to the drive.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Note the position of the fiber optic cables for assembly.
3. To remove the SGCT, remove the gate driver power cable and fiber optic cables. Exceeding the minimum bend radius (50 mm [2 in.]) of the fiber optic cables may result in damage.

   Remove the SPS snubber connector (J1 on the SPS board) and remove the SPS mounting bracket with the SPS board, if installed.

ATTENTION: You may damage the fiber optic cables if you strike or bend them sharply. The minimum bend radius is 50 mm (2 in.). The connector has a locking feature that requires pinching the tab and gently pulling straight out. Hold the component on the printed circuit board to prevent damage.

IMPORTANT Nylon screws are installed on the 6600V heatpipe model only; these must be removed when replacing the SGCTs. The purpose of these screws is for additional support while in transit and they are not required once the drive is installed on site. They must not be used again when the SGCTs are replaced.

4. Remove the load on the clamp head assembly as described under Checking Clamping Pressure on page 94.
5. Two brackets secure the board to the heatsink. Loosen the captive screws to free the circuit board. If necessary, adjust the position of the heatsinks to move the SGCT freely.

6. Slide the circuit board straight out.

ATTENTION: Static charges can damage or destroy the SGCT. Properly ground yourself before removing the replacement SGCT from the protective anti-static bag. Using damaged circuit boards may also damage related components. Use a grounding wrist strap for handling sensitive circuit boards.

IMPORTANT	SGCTs come in matched sets in systems with more than one device per leg. When replacing the device, you must replace all SGCTs in the set even if only one has failed. Arrange the devices from left to right in sets (that is, set 1+2, 3+4, 5+6).

7. While grounded, remove the SGCT from its anti-static bag.
8. Clean the heatsink with a soft cloth and rubbing alcohol.
9. Apply a thin layer of electrical joint compound (Alcoa EJC No. 2 or approved equivalent) to the contact faces of the new SGCTs. Apply the compound to the pole faces using a small brush, and then gently wipe the pole face with an industrial wipe so that a thin film remains. Examine the pole face before proceeding to ensure that no brush bristles remain.

IMPORTANT	Too much joint compound may result in contamination of other surfaces leading to system damage.

10. Slide the SGCT into place until the mounting brackets contact the surface of the heatsink and tighten the captive screws located in the brackets.
11. Follow procedure Uniform Clamping Pressure on page 93 to clamp the heatsinks to a uniform pressure.

    If equipped, re-install the SPS board and mounting bracket, and reconnect the snubber connection to J1 of the SPS board.
12. Connect the power cable and fiber optic cables (do not exceed the bend radius).

Figure 61 - Replacing the SGCT

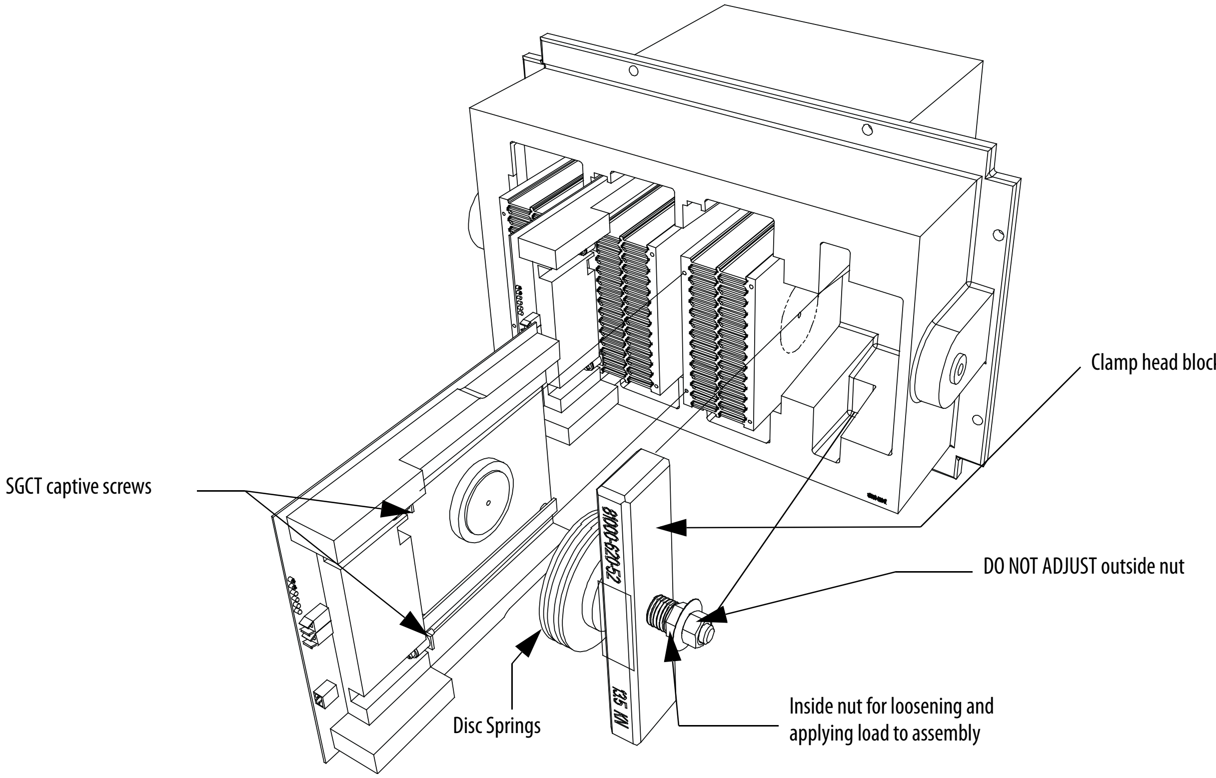


Figure 62 - Replacing the SGCT (if SPS board is installed)

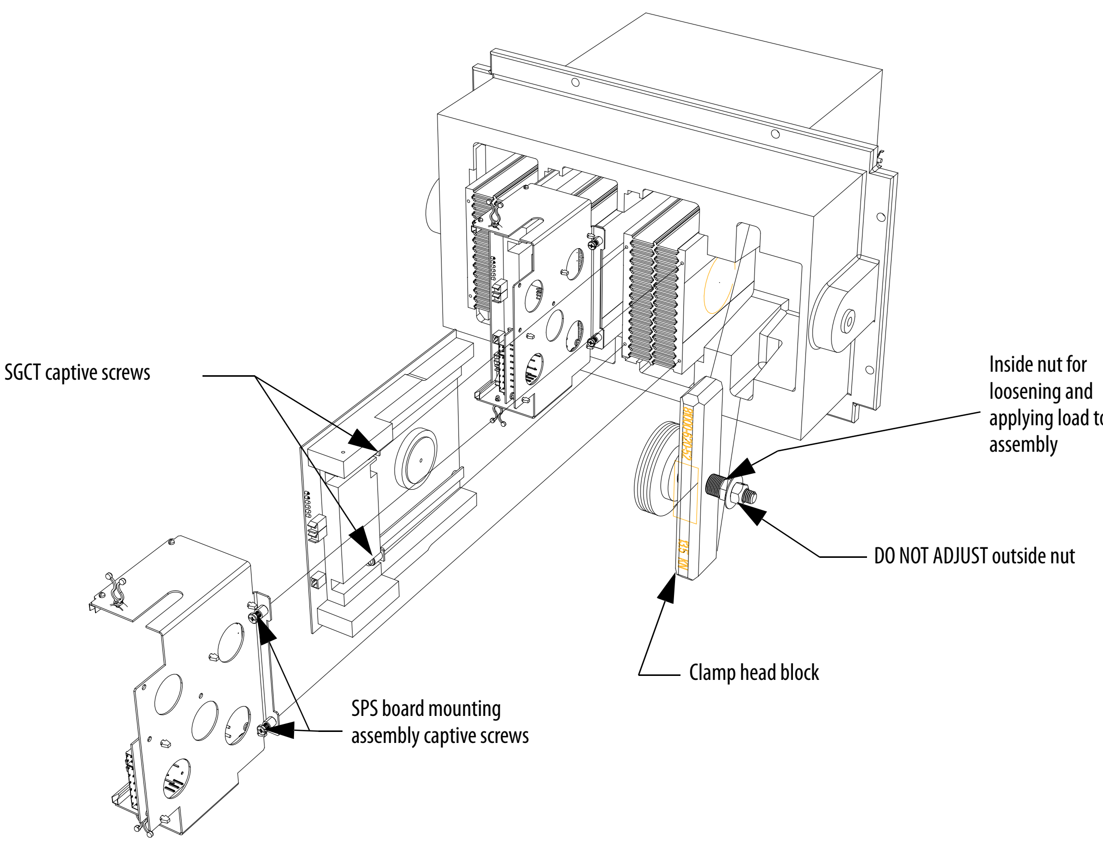
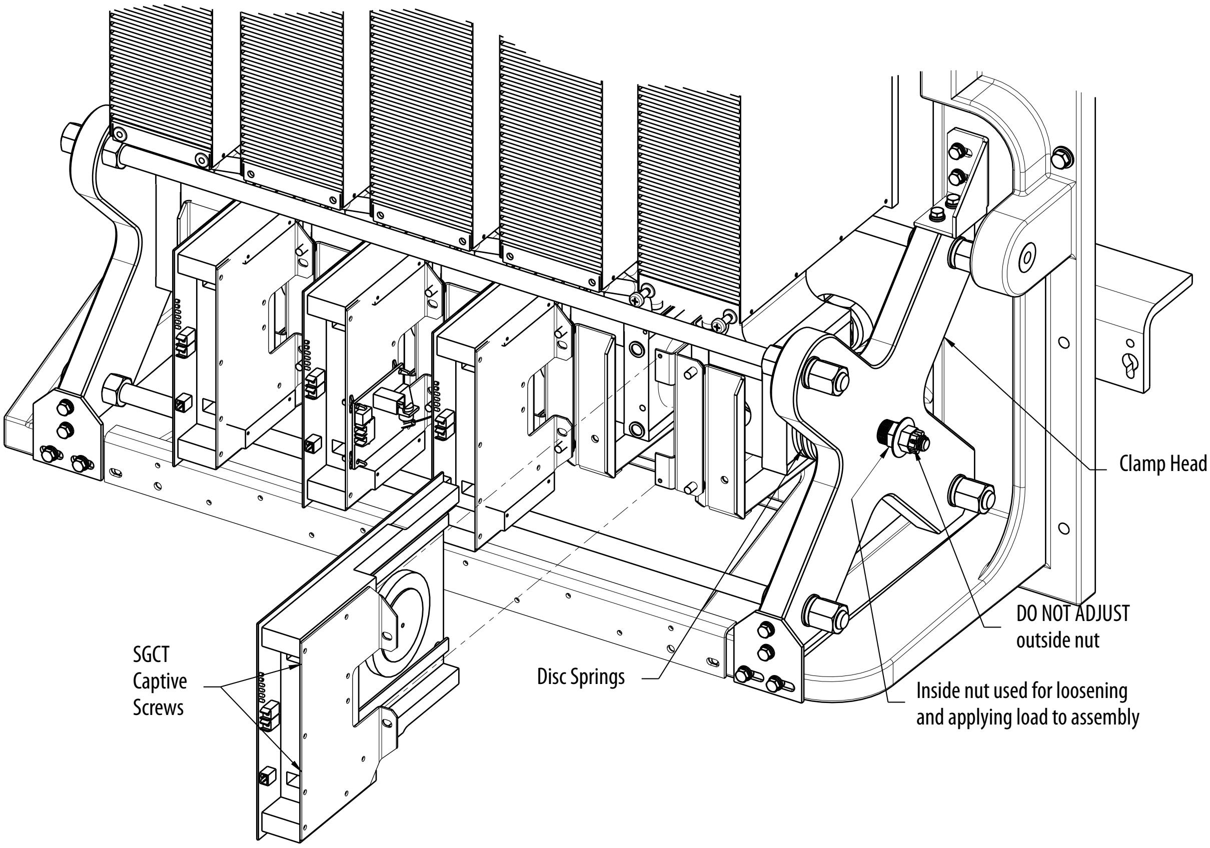


Figure 63 - Replacing the SGCT (Heatpipe Model)



Replacing Snubber and Sharing Resistor

The snubber and sharing resistors are part of the resistor assembly located behind the PowerCage module.

1. Remove the PowerCage module as outlined in Removing the PowerCage Module on page 104.

   Note the connection of the leads for correct replacement.

2. Detach the leads located on the bottom of the resistor assembly.

Figure 64 - PowerCage Module Removal (Heatsink PowerCage)

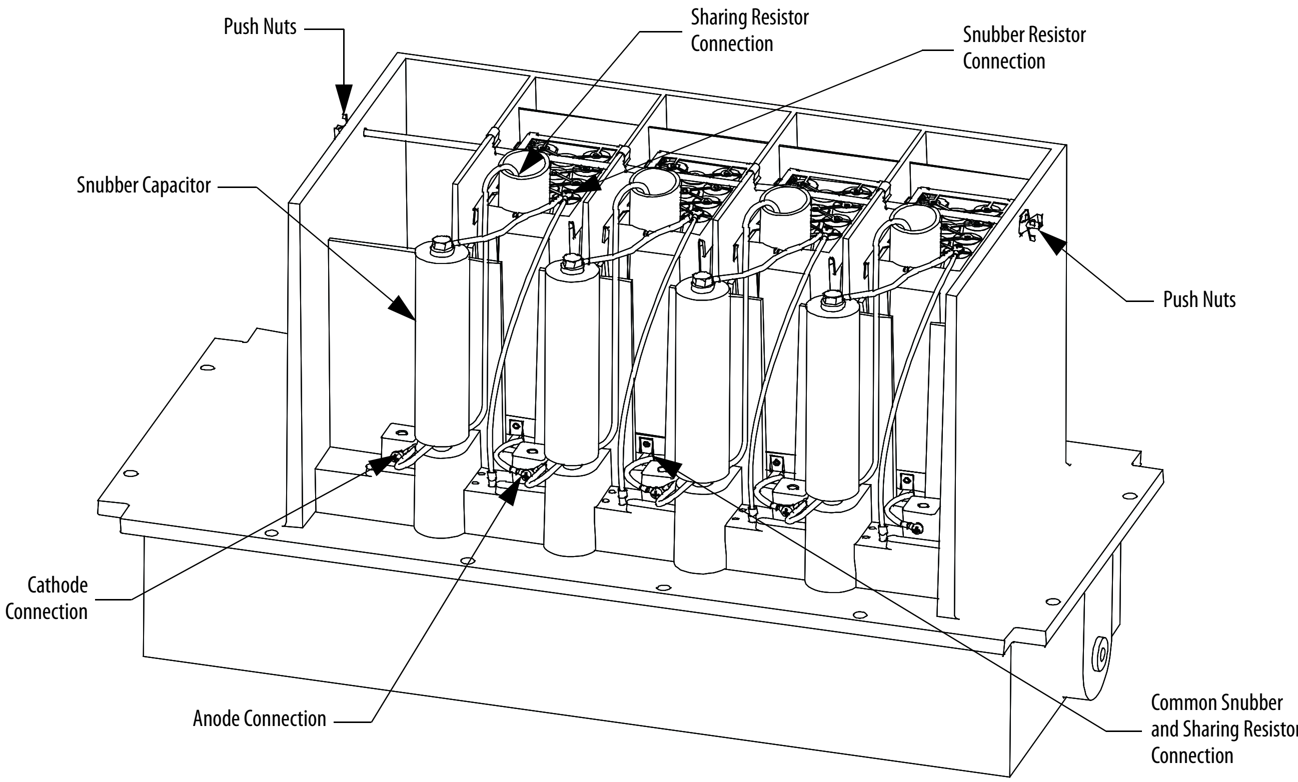
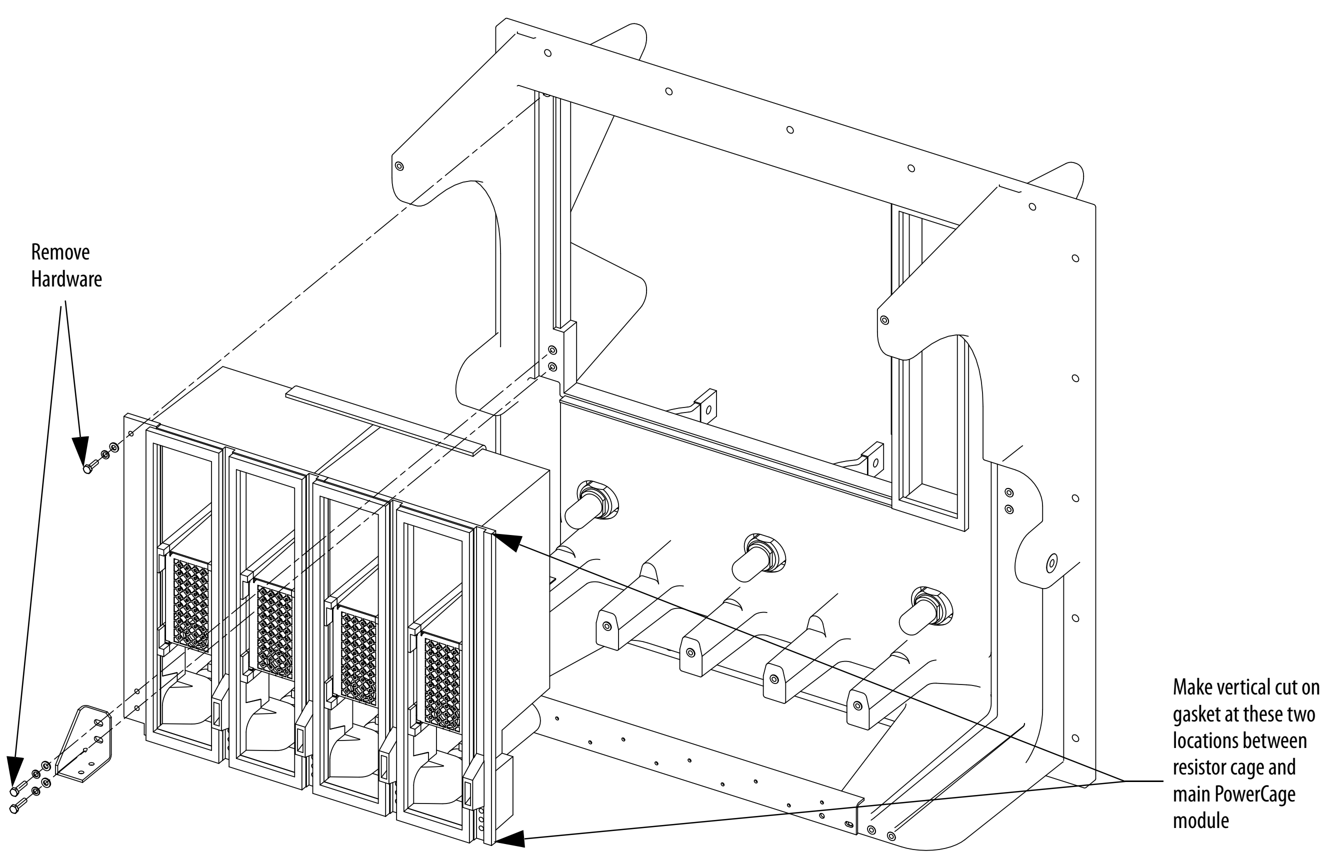


Figure 65 - PowerCage Module Removal (Heatpipe Model)



3. Remove the push nuts on the end of the retaining rod.
4. Pinch the clip together and pull off.
5. Pull out the retaining rod.

Figure 66 - Snubber and Sharing Resistor Replacement (Heatsink Model)

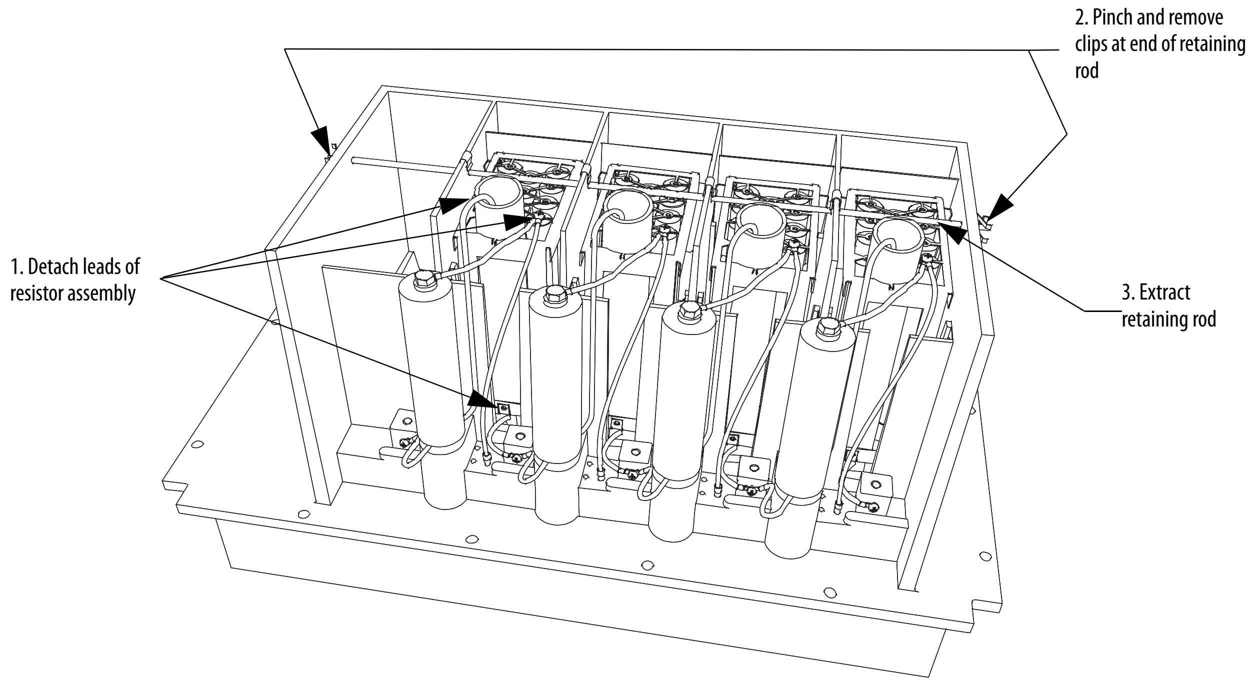
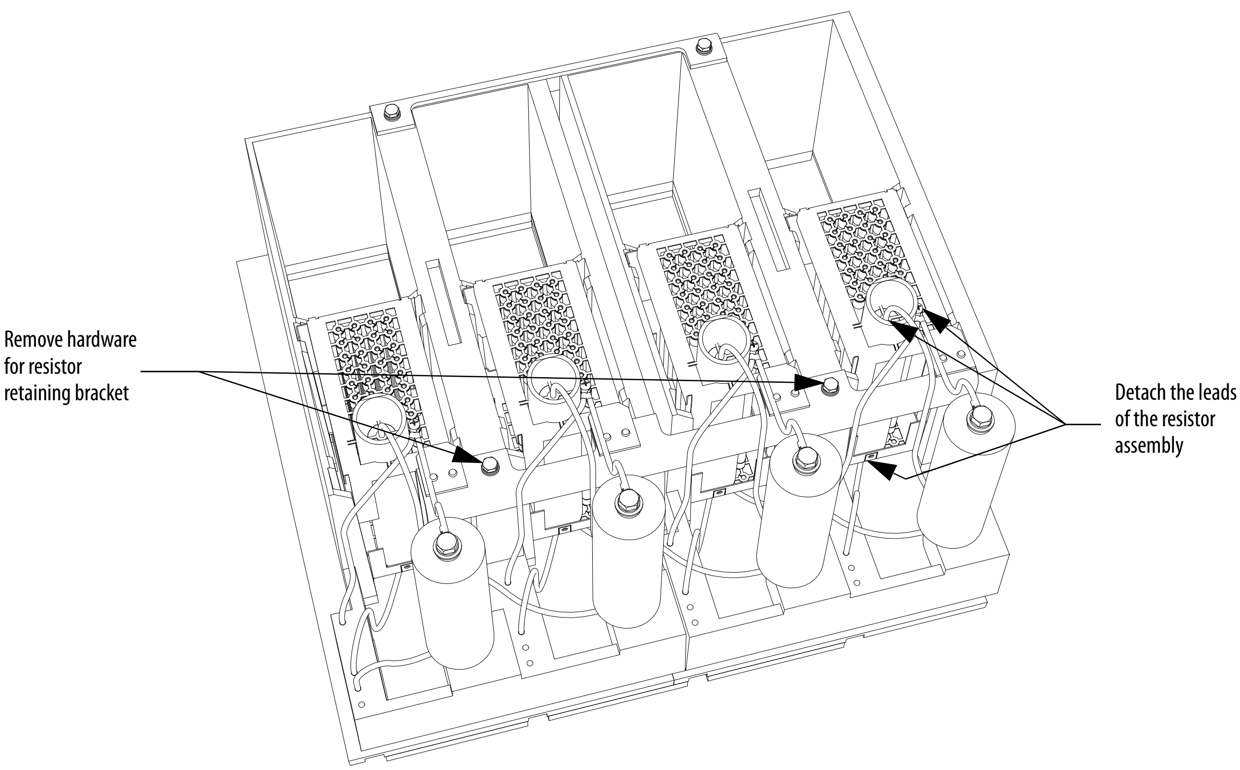


Figure 67 - Snubber and Sharing Resistor Replacement (Heatpipe Model)



6. Use silicone gel to secure the snubber resistor assembly to the PowerCage module. The gel minimizes possible damages to the resistor bank during transportation from the factory. You do not need to reapply any gel when inserting the new resistor bank. Remove the resistor bank from the PowerCage module.

Figure 68 - Removing Resistor Bank from PowerCage Module

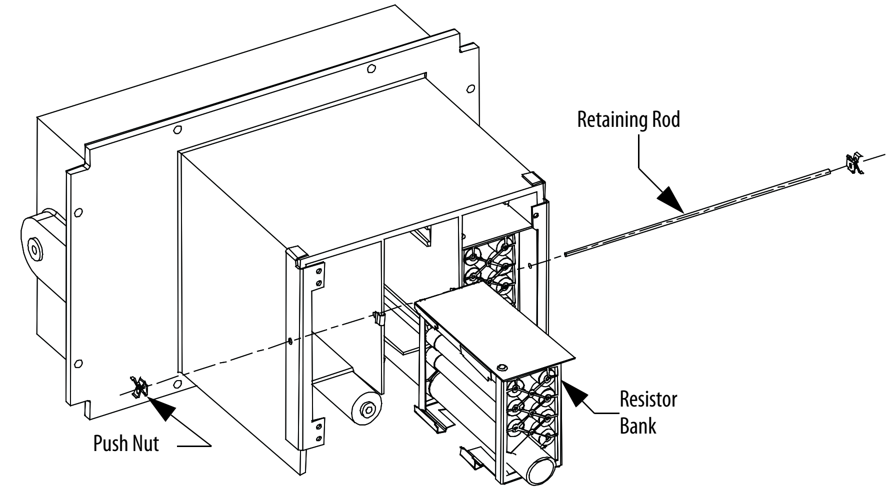
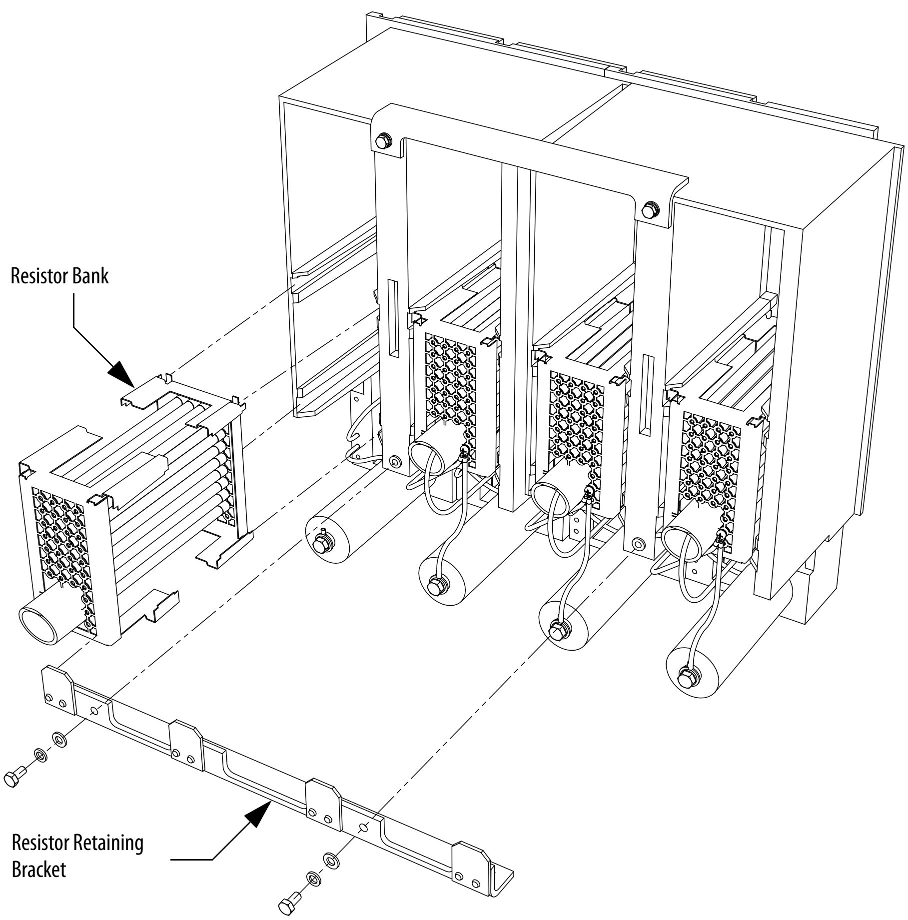


Figure 69 - Removing Resistor Bank from PowerCage Module (Heatpipe Model)



7. Place the new resistor bank assembly back into the PowerCage module.
8. Slide the retaining rod into place and push the clips back into place.
9. Connect the leads to the resistor bank
10. Install the PowerCage module as outlined in Removing the PowerCage Module on page 104.

Replacing Sharing Resistors

Normally the sharing resistor is part of the snubber resistor assembly. Replacing the sharing resistor requires also replacing the snubber resistor.

The sharing and snubber resistors are normally located on the backside of the PowerCage module. See page 77 for removing and replacing snubber resistors.

Replacing Snubber Capacitor

The snubber capacitors are part of the capacitor assembly located behind the PowerCage module.

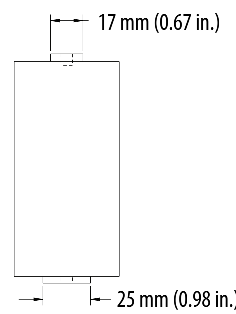
IMPORTANT If the drive can be accessed from the rear, the snubber capacitors can be removed and replaced from the rear, with the PowerCage modules in place.

If the drive cannot be accessed from the rear, the PowerCage modules must be removed to access the snubber capacitors. See Removing the PowerCage Module on page 104.

Replace the capacitors one at a time. Do not remove all at once.

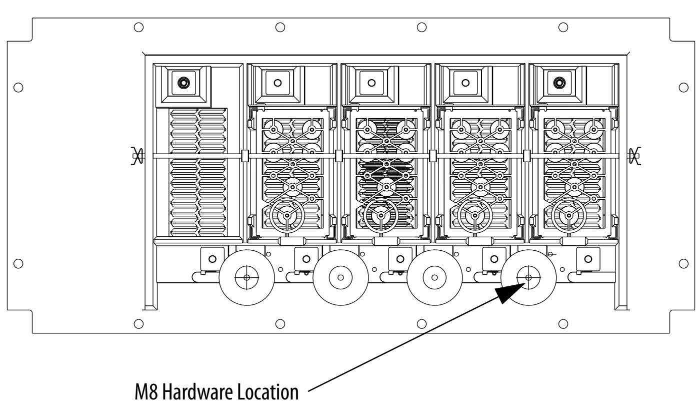
1. Using a 13 mm socket wrench, remove the M8 bolt on the end of the capacitor and retain hardware.
2. Hand rotate the capacitor counter-clockwise to unscrew it from the threaded stud connecting it to the PowerCage module.
3. Apply a drop of Loctite 425 to the thread of the 25 mm flange side of the replacement capacitor.
4. Hand-tighten the replacement capacitor onto the threaded stud.

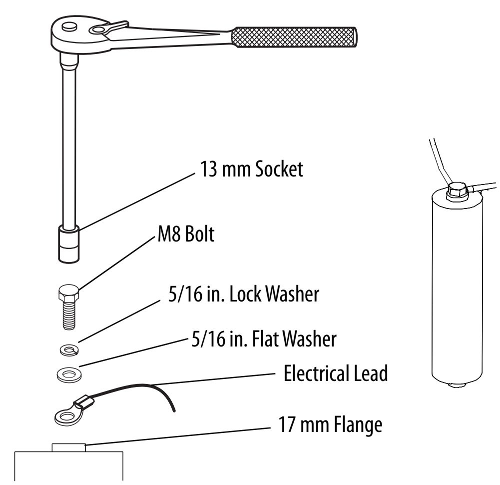
ATTENTION: You must insert the capacitor in the correct orientation.
The 25 mm flange must be connected to the threaded stud on the PowerCage module.



5. Connect the electrical leads and hardware on the 17 mm flange side of the replacement capacitor.

   Torque M8 hardware to 7 N•m (60 lb•in).





6. Bundle and secure the connecting wires using wire ties.

Silicon Controlled Rectifier PowerCage Modules

Figure 70 shows the snubber circuit. Figure 71 shows the physical locations of the same circuit.

Disconnect the 2-pole plug to the gate driver board marked TB1 on the circuit board. Measure the resistance from the point of the plug that connects to the point labeled V.SENSE on the gate driver board to the anode side heatsink. A value of 80 kΩ indicates a good sharing resistor.

Figure 70 - Snubber Circuit for SCR Rectifier Module

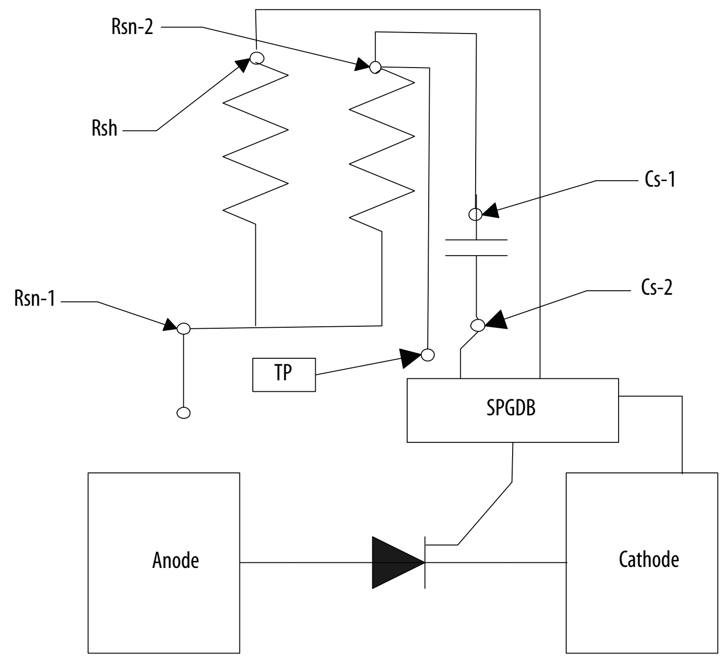
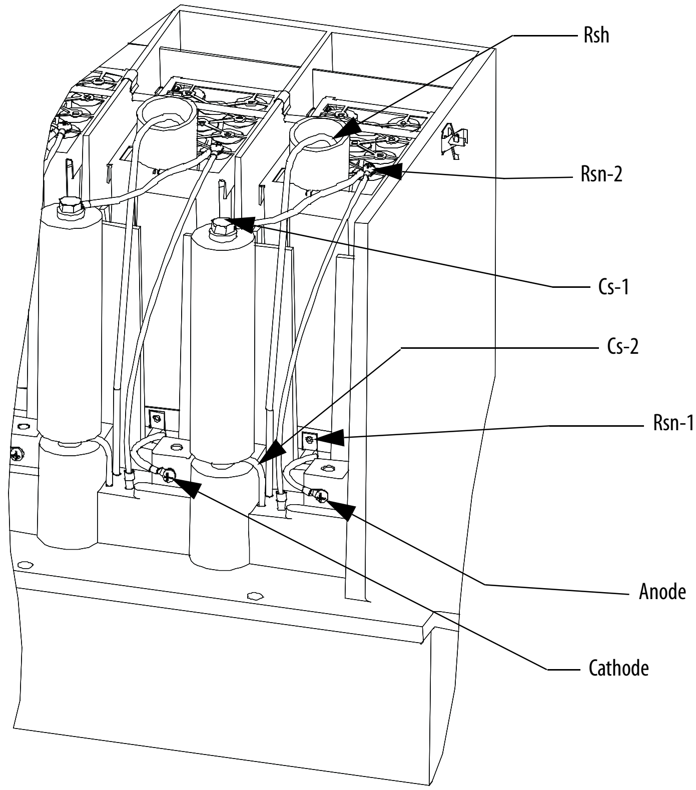


Figure 71 - Snubber Circuit Assembly for SCR Rectifier Module



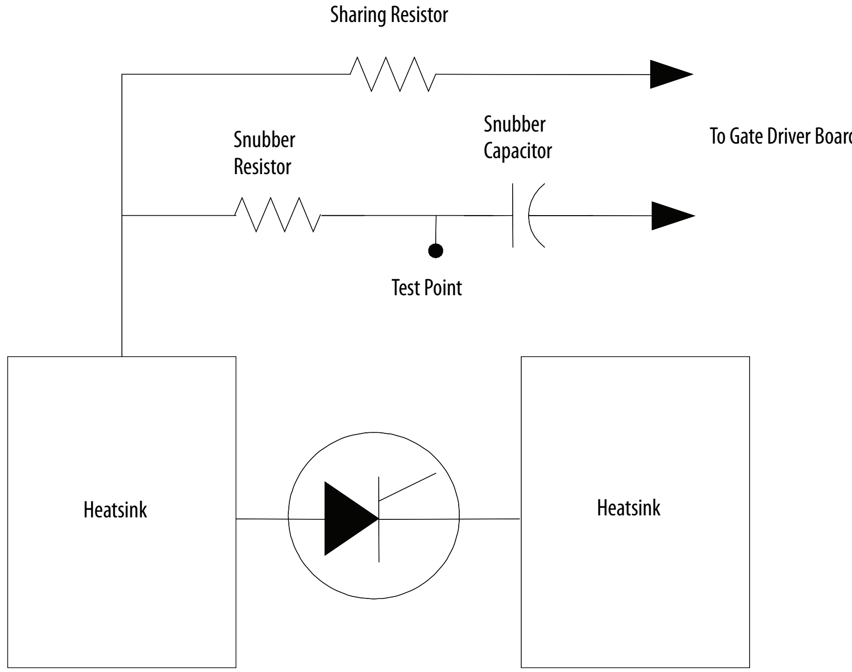
SCR Testing

The following section verifies SCR semiconductors and all associated snubber components. For quick reference to the expected resistance and capacitance values, see Table 4. A simple schematic diagram in Figure 72 shows the snubber component connections across an SGCT.

Table 4 - SCR Snubber Circuit Resistance and Capacitance Values

SCR Rating	Sharing Resistance	Snubber Resistance	Snubber Capacitance
350, 400, 815 A	80 kΩ	60 Ω	0.5 µf

Figure 72 - SCR snubber Circuit Connections



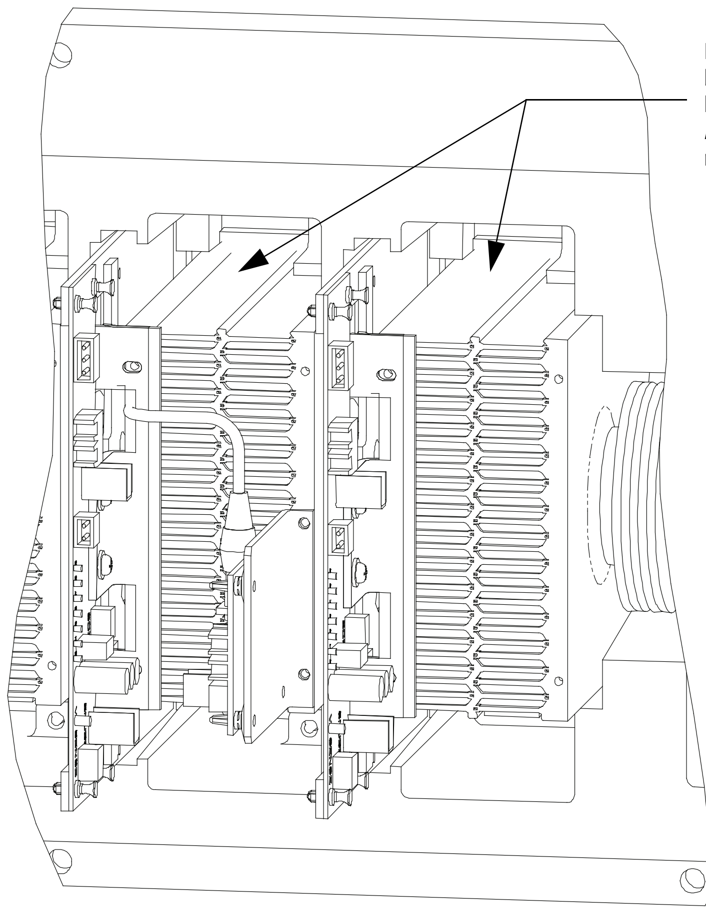
SCR Resistance Measurement	**Measured Resistance**			
	Inverter		**Rectifier (SCR only)**	
SCR Anode-Cathode Resistance (heatsink to heatsink) k-Ω				
	(Lowest)	(Highest)	(Lowest)	(Highest)
SCR Gate-Cathode Resistance (across SCR Phoenix connector) Ω				
Snubber Resistance (Test point: heatsink above) Ω				
	(Lowest)	(Highest)	(Lowest)	(Highest)
Snubber Capacitance (Test Point – heatsink on Right) μF				
	(Lowest)	(Highest)	(Lowest)	(Highest)
Sharing Resistance (Red wire from snubber Phoenix connector—heatsink on left) k-Ω				
	(Lowest)	(Highest)	(Lowest)	(Highest)

SCR Anode-to-Cathode Resistance

Performing an anode-to-cathode resistance test verifies the integrity of the SCR. The SCR uses the snubber circuit to power the self-powered gate driver boards. The resistance measurement taken across each SCR should be constant; an inconsistent value may indicate a damaged sharing resistor, self-powered gate driver board or SCR.

Using an ohmmeter, measure the anode-to-cathode resistance across each SCR in the rectifier bridge, while looking for similar resistance values across each device. Easy access from the anode-to-cathode is available by going from heatsink-to-heatsink (Figure 73).

Figure 73 - Anode-to-Cathode test



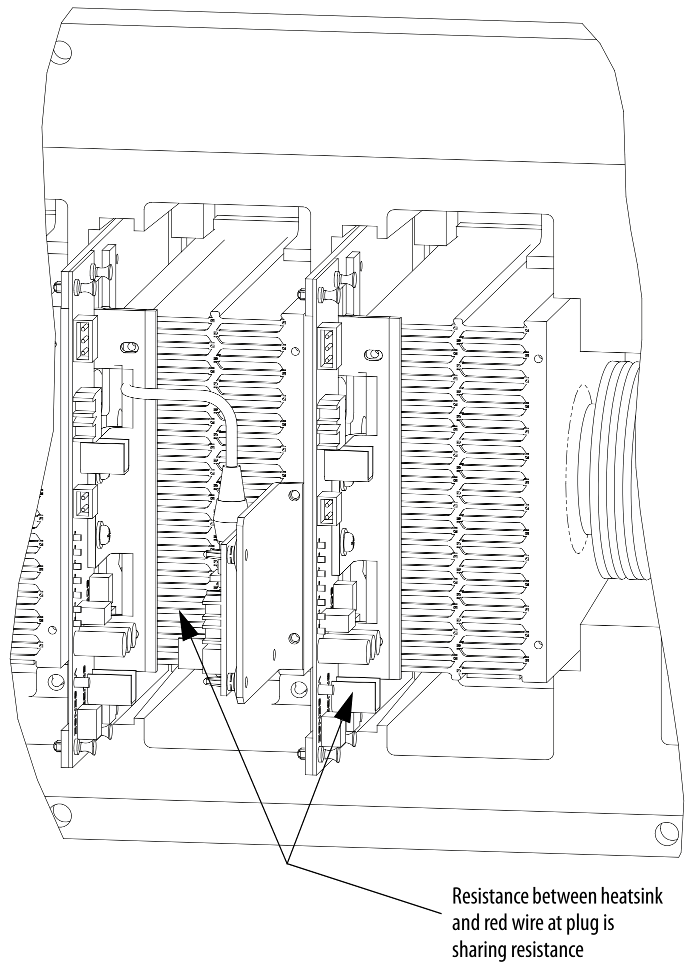
A good SCR and circuit should read between 22 and 24 kΩ.

An SCR that has failed from anode-to-cathode will commonly produce a resistance value of 0 for a shorted device or ∞Ω for an opened device. Unlike the SGCT, it is highly irregular for an SCR to have a partially shorted device. If an SCR is found to be out of tolerance, see page 91 for detailed instructions on how to replace the SCR assembly.

SCR Sharing Resistance Test

To test the sharing resistor of an SCR module, disconnect the 2-pole plug of the self-powered gate driver board labeled SHARING and SNUBBER on the circuit board. The red wire of the plug is the sharing resistor. Measure the resistance between the red wire of the plug and the heatsink to the left. A value of 80 k-ohms indicates a healthy sharing resistor.

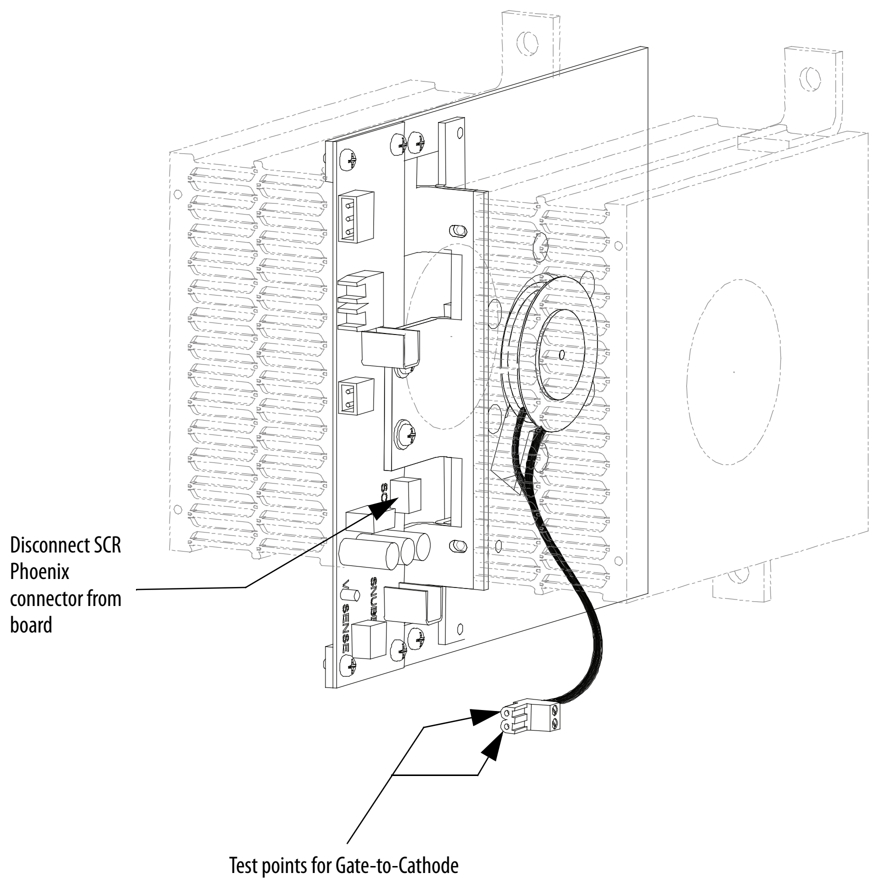
Figure 74 - SCR Sharing Resistance Test



SCR Gate-to-Cathode Resistance

One test that can be performed on SCRs that cannot be performed on SGCTs is a Gate-to-Cathode Resistance Test. Performing a Gate-to- Cathode resistance measurement will identify damage to an SCR by revealing either an open or shorted gate to cathode connection. To test an SCR from gate-to-cathode, disconnect the SCR gate leads from the self powered gate driver board and measure the gate-to-cathode resistance on the SCR firing card Phoenix connector.

Figure 75 - SCR Gate-to-Cathode Test



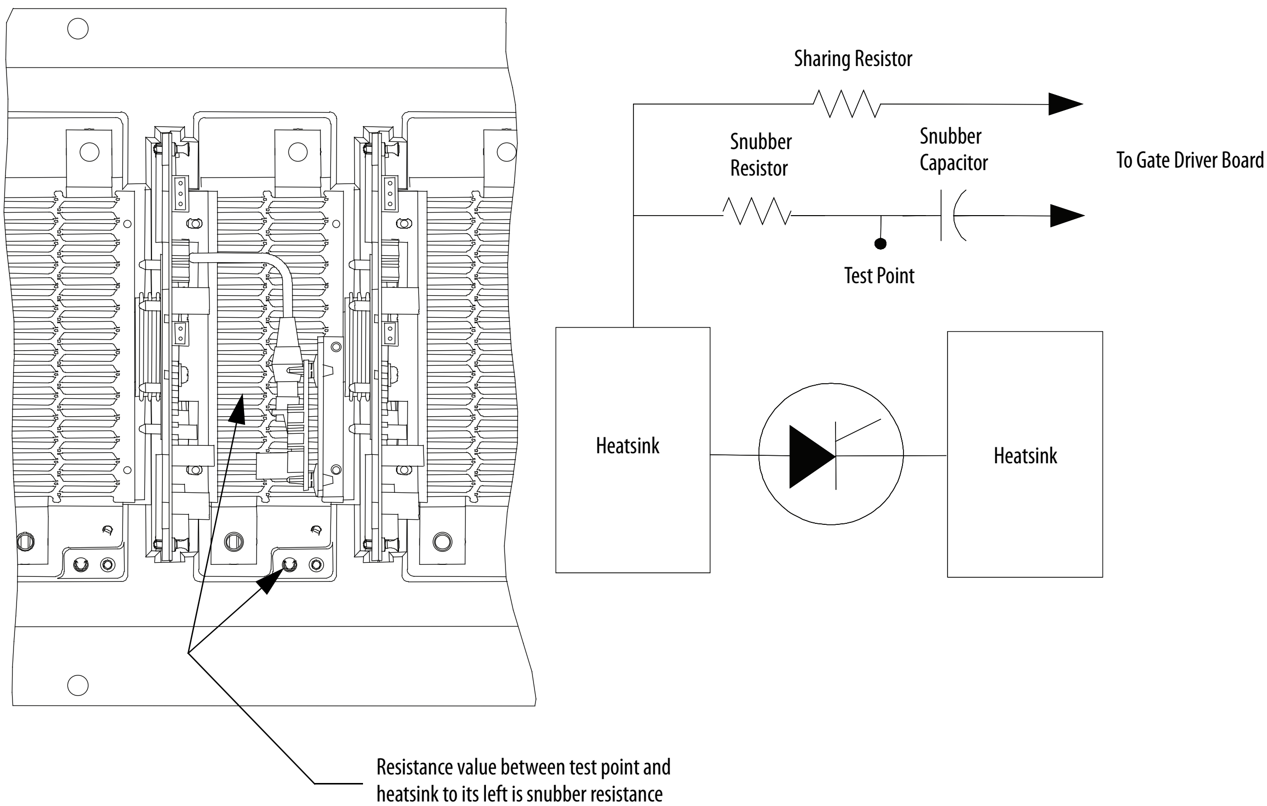
The resistance value from gate-to-cathode should be between 10…20 Ω. A value close to 0 Ω indicates that there is an internal short in the SCR. An extremely high value indicates that the gate connection in the device has broken.

If a Gate-to-Cathode test reveals a damaged SCR, see page 91 for the SCR replacement procedure.

Snubber Resistance (SCR Device)

Access to the snubber resistor is not required to test the resistance. The snubber circuit test point is located within the PowerCage module under the heatsinks. For each device, there is one test point. To verify the resistance, measure the resistance between the test point and the heatsink above.

Figure 76 - Snubber Resistance Test



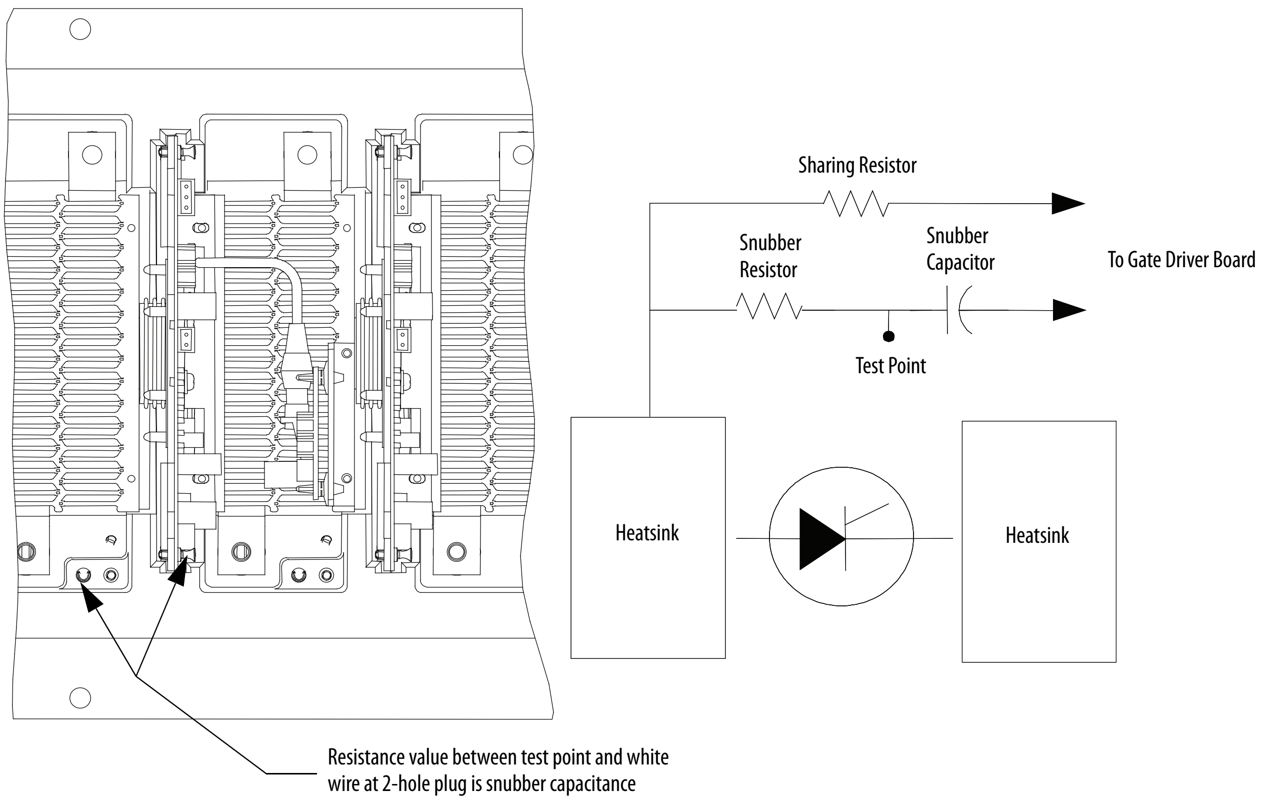
See Table 4 on page 84 to determine the appropriate snubber resistance value for the current rating of the SCR used.

If the resistor is found to be out of tolerance, see page 77 for the snubber resistor assembly replacement procedure.

Snubber Capacitance (SCR Device)

Turn the multimeter from the resistance to capacitance measurement mode. Proceed to verify the snubber capacitor by measuring from the test point and the white wire at the 2-pole device snubber plug (labeled snubber).

Figure 77 - Snubber Capacitance Test



To test the snubber capacitance, disconnect the plug of the self-powered gate driver board labeled SHARING and SNUBBER. The resistance between the white wire of the plug and the Test Point to its left is the snubber capacitance.

See Table 4 on page 84 to determine the appropriate snubber capacitance value for the current rating of the SCR used. Read the actual snubber capacitor value shown in the table.

If the capacitor is out of tolerance, see page 82 for the snubber capacitor replacement procedure.

Replacing SCR and SCR Self-Powered Gate Driver Boards (SPGDB)

Replacing the SCR is similar to replacing the SGCT, except that you can replace the SCR and circuit board independently of one another.

1. Isolate and lock out all power to the drive.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Note the position of the fiber optic cables for reassembly.
3. To remove the SCR and SCR SPGDB, first remove the gate driver power supply connector (from snubber circuit), the fiber optic cable, and the SCR gate-cathode connection. Exceeding the minimum bend radius
(50 mm / 2 in.) of the fiber optic cables may result in damage.

ATTENTION: You may damage the fiber optic cables if you strike or bend them sharply. The minimum bend radius is 50 mm (2 in.). The connector has a locking feature that requires pinching the tab and gently pulling straight out. Hold the component on the printed circuit board to prevent damage.

4. Remove the load on the clamp head assembly as described under Checking Clamping Pressure on page 94.
5. Loosen the 2 captive screws with a long Phillips screwdriver until the circuit board is free. If necessary, adjust the position of the heatsinks to allow free movement of the SCR.
6. Slide the SCR and SCR SPGDB straight out.
7. While grounded, unplug the gate-cathode connector from the SCR SPGD board.

ATTENTION: Static charges can destroy or damage the SCR and SCR SPGD board. Properly ground yourself before removing the replacement SCR and SCR SPGD board from the protective anti-static bag. Using damaged circuit boards may also damage related components. Use a grounding wrist strap for handling sensitive circuit boards.

IMPORTANT Never adjust the orientation of the SCR using the gate and cathode leads. These connections are sensitive; adjust the device orientation by turning the device itself.

To replace the SCR, follow steps 8…11 and 15…18.

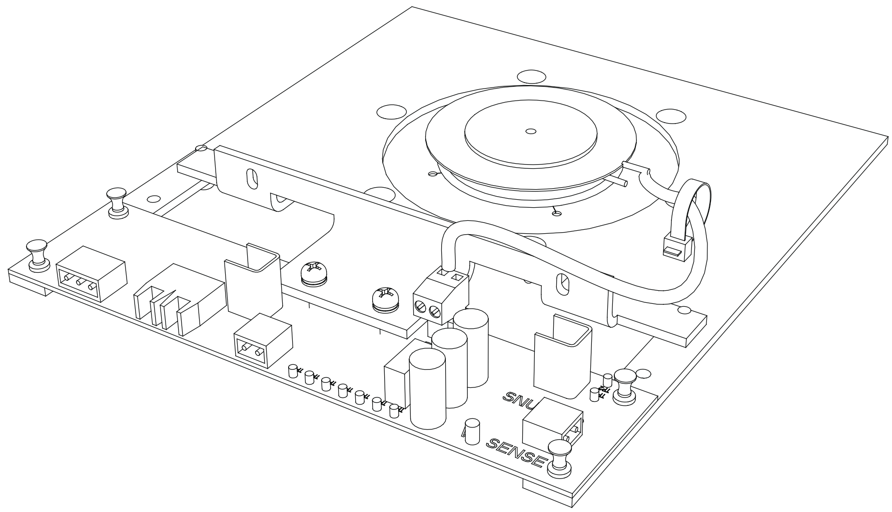
To replace the SCR SPGDB, follow steps 12…18.

8. Loosen the tie wrap holding the gate-cathode wire in place, and remove the device from the assembly.
9. Install the new device in the same position and using the same orientation as the original SCR, and firmly secure the gate-cathode wires with the same tie wrap.
10. Connect the gate-cathode connector to the gate driver board.
11. Apply a thin layer of electrical joint compound (Alcoa EJC No.2 or approved equivalent) to the contact faces of the new SCRs. The recommended procedure is to apply the compound to the pole faces using a small brush and then gently wiping the pole face with an industrial wipe so that a thin film remains. Examine the pole face before proceeding to ensure that no brush bristles remain.

IMPORTANT	Too much joint compound may result in contamination of other surfaces leading to system damage.

12. While grounded, use a long Phillips screwdriver to remove the two screws that hold the SCR SPGDB to the metal bracket on the red glastic assembly. Retain the hardware.
13. Pull the four plastic clips that secure the SCR SPGDB to the glastic assembly. Retain the hardware.
14. Install the new SCR SPGDB in the assembly with the 4 plastic clips and use the screws to secure the board to the metal bracket.
15. Clean the heatsink with a soft cloth and rubbing alcohol.
16. Slide the SCR and SPGDB back into place until the mounting bracket makes contact with the heatsink. Use the Phillips screwdriver to tighten the assembly to the heatsink.
17. Reapply the clamping load as described in Uniform Clamping Pressure on page 93.
18. Connect the control power cable and the fiber optic cables, ensuring that you do not exceed the bend radius.

Figure 78 - SCR and SPGDB Assembly



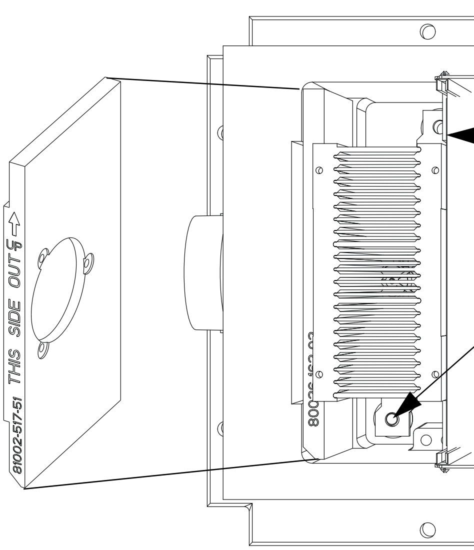
Uniform Clamping Pressure

Always maintain proper pressure on the thyristors. Follow this procedure whenever changing devices or loosening the clamp completely.

1. Apply a thin layer of electrical joint compound (Alcoa EJC No. 2 or approved equivalent) to the clamp head pressure pad face (Figure 80). Apply the compound using a small brush, and gently wipe the pad face with an industrial wipe until a thin film remains. Ensure no brush bristles remain.
2. Torque the heatsink bolts to 13.5 N•m (10 lb•ft.), then loosen each bolt two complete turns.

Figure 79 - Location of Heatsink Bolts

Do NOT remove the pivot plate from the PowerCage when changing devices. If the pivot plate is removed from the PowerCage, install it in the proper orientation per the stamping on the side.



3. Tighten the clamp to the proper force until you can turn the indicating washers by the fingers with some resistance.

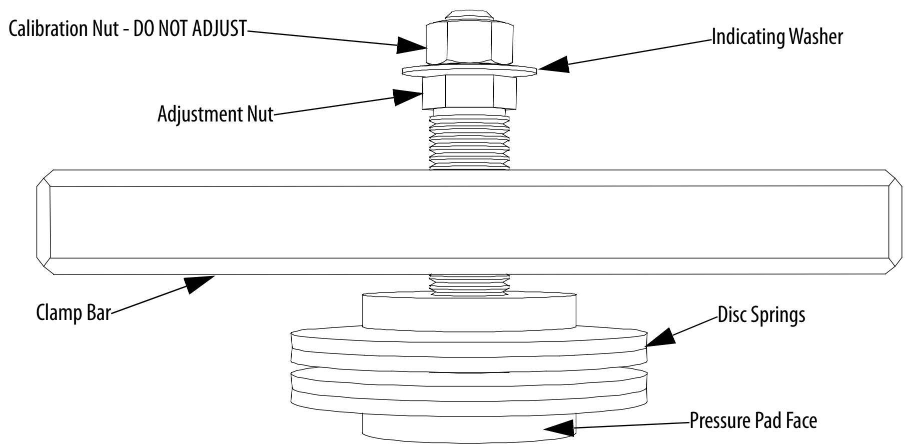
4. Torque the heatsink bolts to 13.5 N•m (10 lb•ft) starting with the center heatsink and moving outward alternating left to right.
5. Check the clamp indicating washer.

Checking Clamping Pressure

Periodically inspect the clamping force in the PowerCage module. Ensure there is no power to the equipment.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

Figure 80 - Clamp Head Illustration



Clamping Pressure Adjustment

1. Disconnect all power to the drive.
2. Do not loosen the adjustment nut. If you loosen the clamping pressure, carry out the assembly procedure to ensure uniform pressure on the thyristors.
3. Tighten with a 21 mm wrench on the adjustment nut (upward motion) until you can turn the indicating washer by fingers with some resistance. The calibration nut should not spin freely.

IMPORTANT	Do not adjust the calibration nut located outside the indicating washer at the end of the threaded rod. The rotation of the calibration nut will affect the torque calibration, which is factory-defined. Only adjust the adjustment nut (see Figure 80).

Temperature Sensing

Thermal sensors are available on one heatsink in the rectifier and one heatsink in the inverter. The thermal sensors are mounted on the heatsink with the temperature feedback board, or on the SPS mounting bracket which is mounted to the heatsink, if equipped.

Replacing the Thermal Sensor

1. Ensure there is no power to the equipment.

> **ATTENTION:** To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Remove the heatsink with the thermal sensor from the PowerCage module. If equipped, first remove the SPS mounting bracket.
3. Remove clamp load (Figure 80 on page 94).
4. Remove the device (SGCT or SCR) from the heatsink with the thermal sensor.
5. Disconnect the fiber optic cable to the temperature feedback board.
6. Remove two M8 screws holding the heatsink in place.
7. Remove the heatsink with the temperature feedback board (may be on the SPS bracket, if equipped) from the PowerCage module.
8. Disconnect the plug connecting the thermal sensor and circuit board.
9. Remove the screw attaching the thermal sensor to the heatsink.
10. Replace with the new thermal sensor and cable assembly.
11. Note there is a small voltage difference between the thermal sensor and its heatsink. For proper function, mount the small insulating pad between the thermal sensor and the heatsink, and the insulating bushing between the thermal sensor mounting screw and the thermal sensor.
12. Reverse the removal order to replace the heatsink with the new thermal sensor.
13. Follow procedure Uniform Clamping Pressure on page 93 to clamp the heatsinks to a uniform pressure.

Figure 81 - Thermal sensor replacement (Heatsink Model)

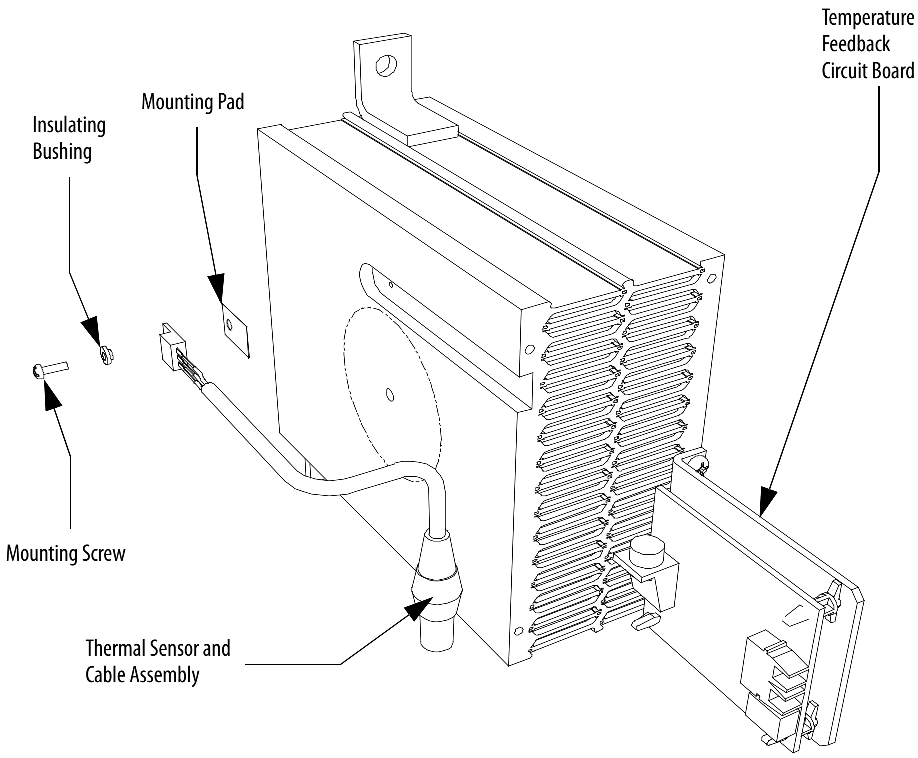


Figure 82 - Thermal Sensor Replacement (SPS Board Model)

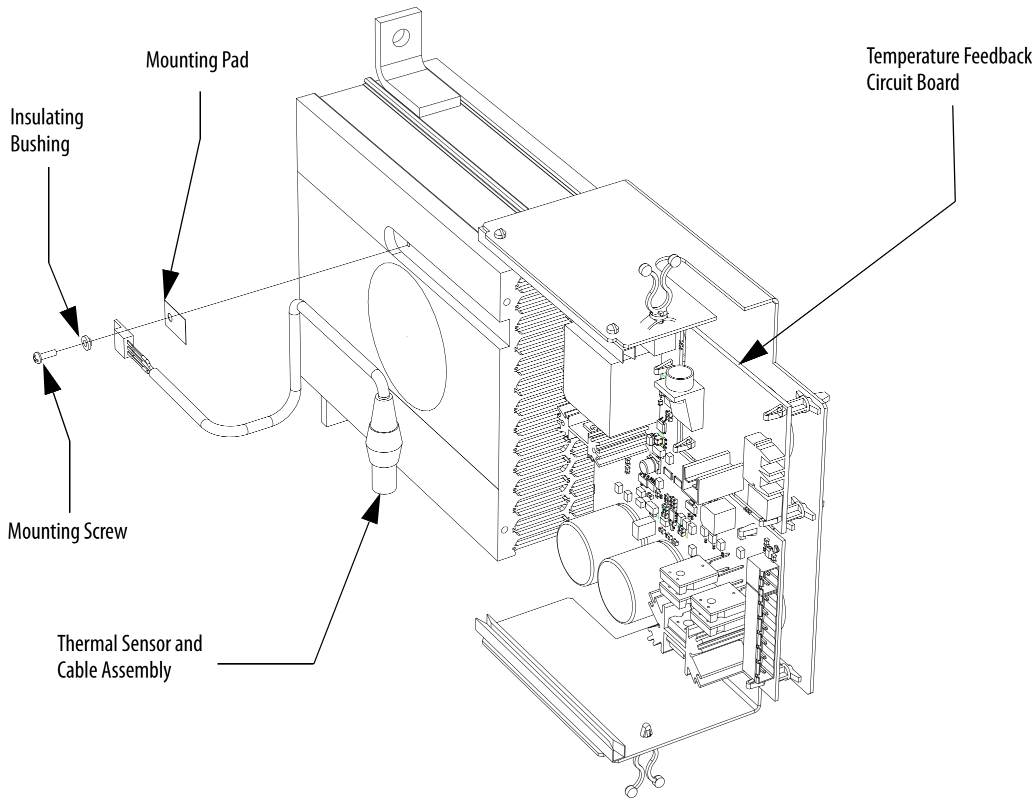
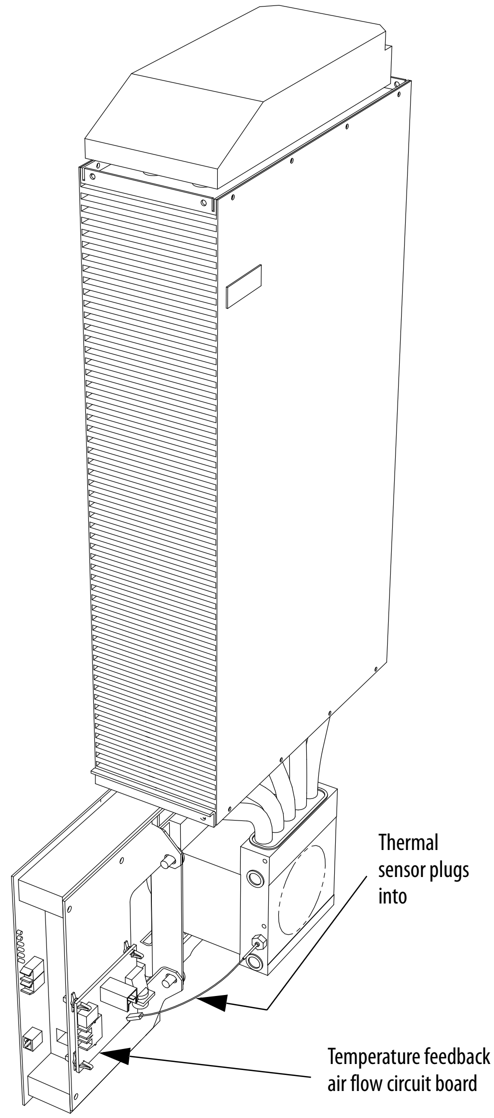


Figure 83 - Thermal Sensor Replacement (Heatpipe Model)

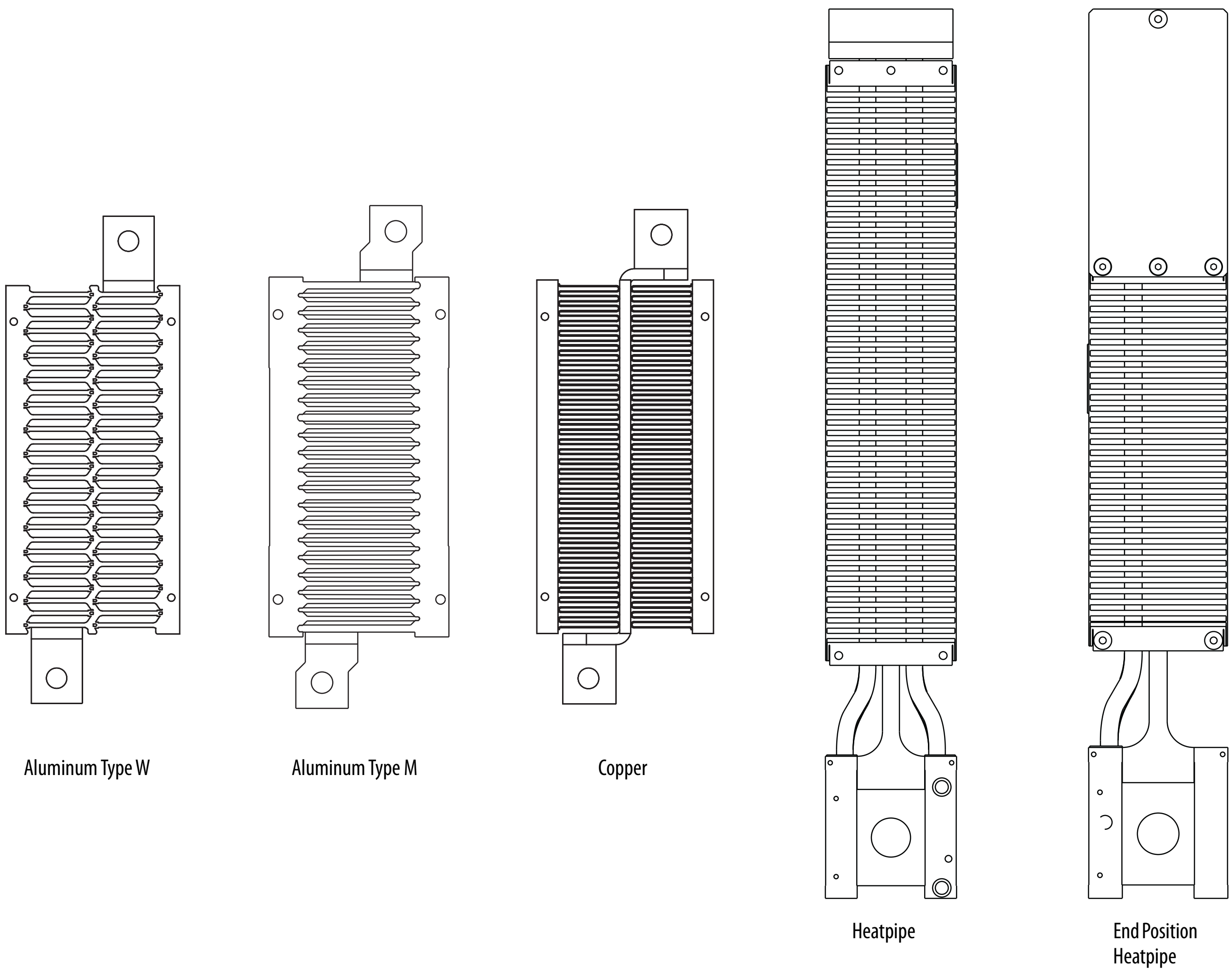


Replacing Heatsinks/ Heatpipes

There are three different styles of heatsinks and one type of heatpipe used in PowerFlex 7000 air-cooled drives, depending on thermal requirements:

- Aluminum type W heatsinks have a plurality of short internal fins along the internal surfaces
- Aluminum type M heatsinks have internal fins with flat surfaces.
- Copper heatsinks have internal fins made from folded copper foil
- Heatpipes have a stack of aluminum fins

Figure 84 - Styles of Heatsinks / Heatpipes



Replacing Heatsinks

The copper heatsinks can weigh about 9 kg (20 lb), while the aluminum heatsinks will weigh approximately 4 kg (9 lb).

1. Isolate and lock out all power to the drive.

> **ATTENTION:** To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Remove the load from the clamp head as described in Checking Clamping Pressure on page 94.
3. Completely remove the SGCT or SCR from the heatsink that is being replaced (see Replacing the SGCT on page 74 or Replacing SCR and SCR Self-Powered Gate Driver Boards (SPGDB) on page 91).
4. There are two bolts that secure the heatsink to the PowerCage module. They are M8 bolts (13 mm socket required), and must be removed using several extenders to get the socket wrench out past all the sensitive gate driver boards.

> **ATTENTION:** Do NOT remove the pivot plate from the PowerCage. The pivot plate is located on the opposite end of the PowerCage from the clamp head. If the pivot plate is removed from the PowerCage, it must be replaced in the original orientation. See Figure 45 through Figure 50 for pivot plate location.

5. Loosen the two bolts and carefully remove the heatsink from the PowerCage module.

> **ATTENTION:** If present, remove plastic film from the heatsink before installation. Failure to remove the film will result in device failure.

6. Install the new heatsink and hand-tighten the bolts.
7. Replace the SGCT or SCR (see Replacing the SGCT on page 74 or Replacing SCR and SCR Self-Powered Gate Driver Boards (SPGDB) on page 91).
8. Follow procedure Uniform Clamping Pressure on page 93 to ensure the heatsinks are clamped to a uniform pressure.

Replacing Heatpipes

For the largest power ratings of AFE rectifiers, heatpipes are used. Heatpipes weigh approximately 13 kg (28 lb). To replace a heatpipe:

1. Loosen heatpipe locking nuts on top of heatpipe horizontal fin support (center nut at each sink).

   On 6600V drives only: Loosen heatsink nylon shipping bolts on the bottom of the white heatsink retaining bracket (Figure 85).
2. Remove the load from the clamp head as described in Checking Clamping Pressure on page 94.
3. Completely remove SGCT from the heatpipe that is being replaced as described in Replacing the SGCT on page 74.
4. Remove snubber resistor lugged connection at front of heatsink block and the thermistor connection if present.
5. Remove top heatsink horizontal fin support.
6. Remove the front white heatpipe retaining bracket at bottom of heatsink block.
7. Remove the top clamp glass rod (Figure 85).
8. Pull heatsink forward, and lift up and out of PowerCage module. **Do not remove the bottom clamp head glass rod.**

   On both the ends and middle heatpipes there will be resistance pulling the heatsink forward due to the pin in the socket power connection is being disconnected as the heatpipe is being pulled forward.

ATTENTION: If present, remove plastic film from the heatsink before installation. Failure to remove the film will result in device failure.

9. Install the new heatpipe.
10. Install top clamp head glass rod.
11. Set bottom clamp head glass rod to:
    - 4160V set to 657.26 mm (+0.5 mm, -0.0 mm)
    - 6600V set to 909.66 mm (+0.5 mm, -0.0 mm)
12. Replace front white heatpipe retaining bracket.
13. Replace top heatsink horizontal fin support.
14. Replace the snubber resistor wire lugged connection and thermistor connection, if present.
15. Replace the SGCT as described in Replacing the SGCT on page 74.
16. Re-apply clamp force to heatpipes:

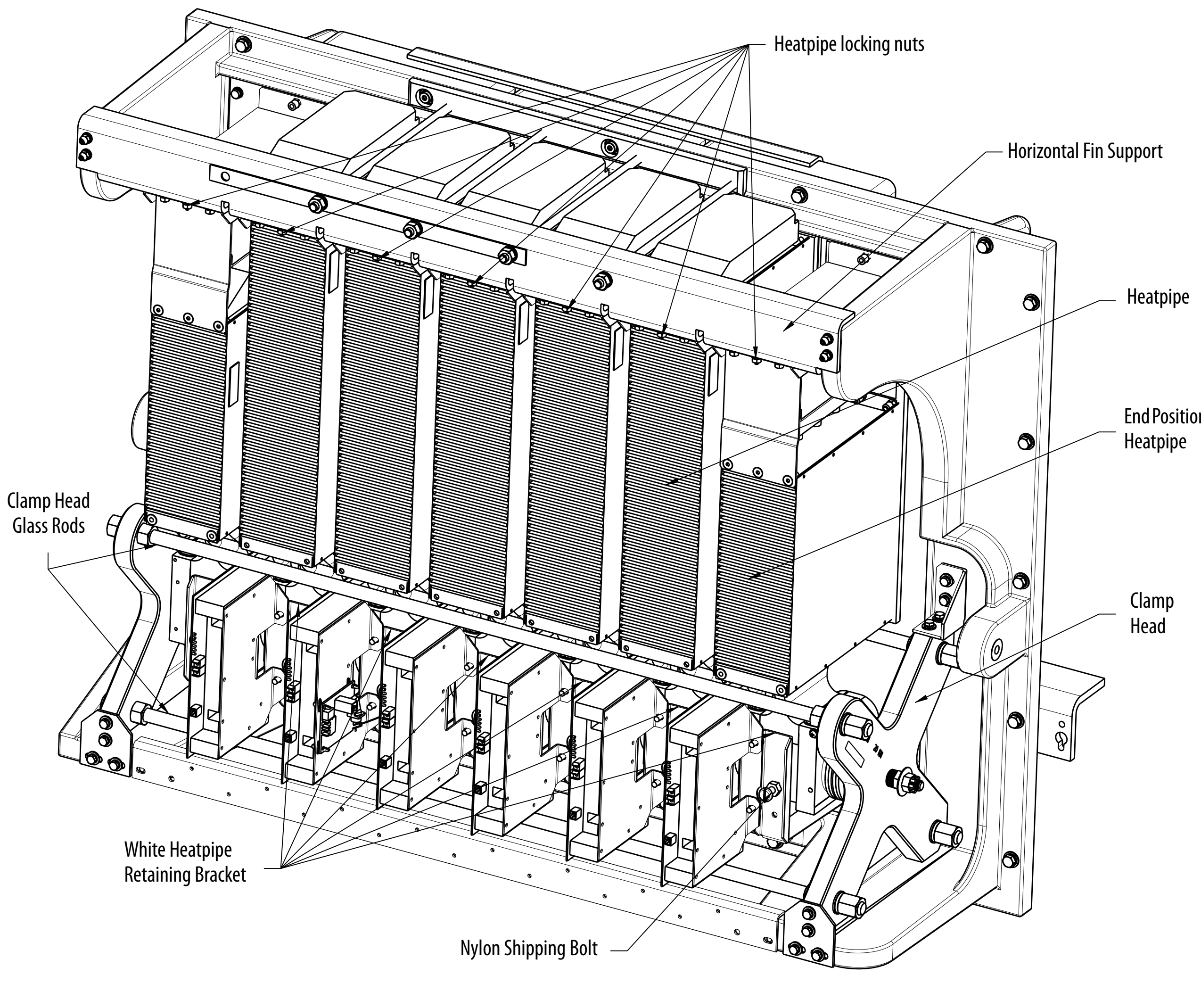
    a. Apply a thin layer of electrical joint compound (Alcoa EJC No.2 or approved equivalent) to the clamp head pressure pad face.

b. Tighten the clamp to the proper force until you can turn the indicating washers by the fingers with some resistance.

17. Once clamp force has been re-applied, tighten heatpipe locking nuts on top of horizontal fin support (center nut at each sink) to 8 N•m (6 lb•ft).

IMPORTANT	Do not re-tighten nylon shipping bolts on 6600V drives. They are for shipping purposes only.

Figure 85 - Heatpipe PowerCage Module



PowerCage Gasket

All possible air leaks are sealed with a rubber gasket between the surface of the PowerCage and heatsink module in order to direct all air movement through the slots of the heatsink. The gasket maintains proper cooling of the SGCTs or SCRs.

Figure 86 - PowerCage Gasket Location (Heatsink Model)

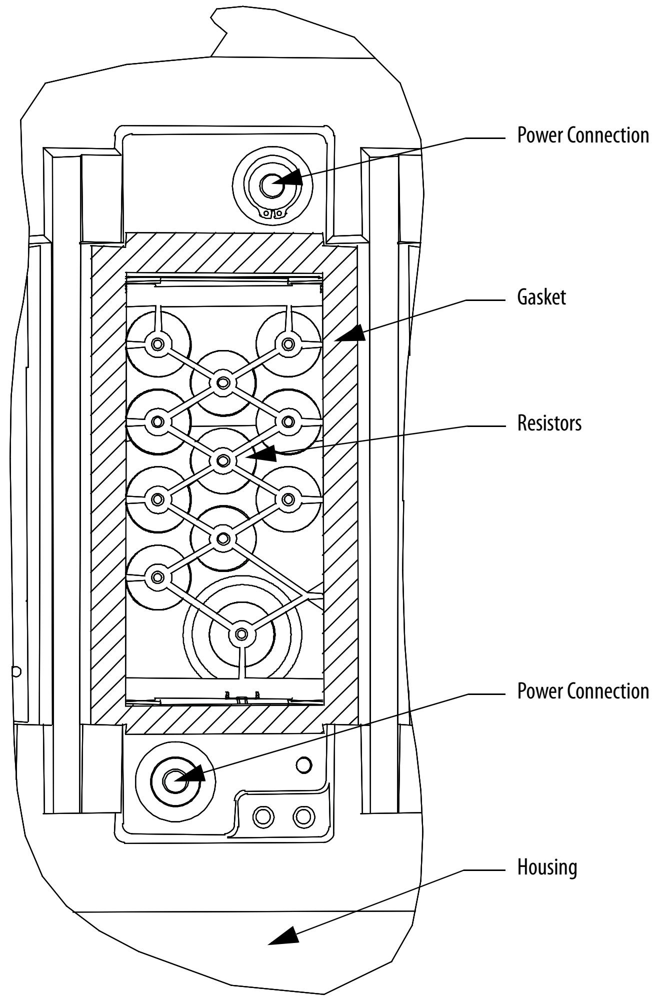
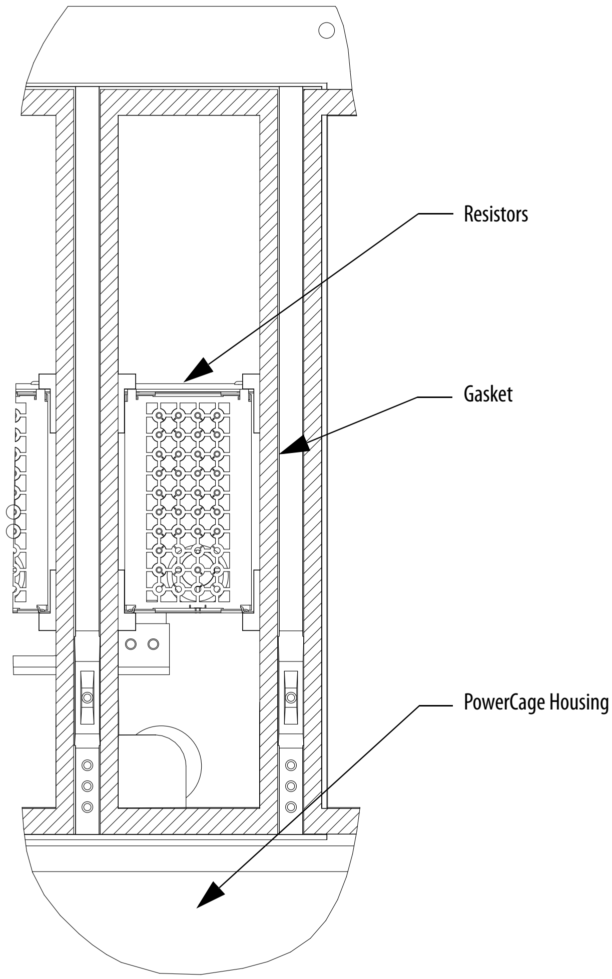


Figure 87 - PowerCage Gasket Location (Heatpipe Model)



Replacing PowerCage Gaskets

The gaskets do not normally require replacement, but in the event that they become damaged, you may have to replace them.

Remove Old Gasket Material

Remove as much material as possible by hand to leave an even, bondable surface. Scrape off as much material as possible with a sharp knife, but avoid scoring the PowerCage module. Clean away any loose pieces of gasket before proceeding with the gasket installation.

Clean the PowerCage module with a general purpose household cleaner. Do not spray onto the PowerCage module as this promotes electrical tracking. Apply the cleaner to a paper towel and wipe the surface of the PowerCage module where you will apply the gasket. Liberally spray the surface with distilled water, then wipe dry with a clean paper towel.

Apply a thin bead of Loctite 454 adhesive to the PowerCage module surface in a zigzag pattern using the original nozzle size. Use the tip to spread the adhesive around to cover at least 50% of the area. There should be sufficient quantity of adhesive to remain wet long enough for the gasket to be applied. The adhesive uses the moisture in the air as it cures. The higher the humidity the faster the adhesive will cure.

IMPORTANT This adhesive will bond anything quickly, including fingers!

Position the gaskets ensuring the gasket is oriented correctly. Center the gasket over the opening for the heatsinks with the narrow end positioned closest to the test points. Apply the porous surface of the gasket to the PowerCage module. The gasket will bond almost immediately. Apply some pressure to the gasket for 15…30 seconds.

After all the gaskets have been placed check to see that the gasket has bonded properly. Repair any loose areas.

Removing the PowerCage Module

1. Ensure there is no power to the equipment.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

2. Remove all the components located within the module to avoid any damage to the components. Consult the required sections to remove clamping pressure, as well as remove the SGCT or SCR, circuit boards, and thermal sensor.

ATTENTION: Static charges can destroy or damage the SCR and SCR SPGD board. Properly ground yourself before removing the replacement SCR and SCR SPGD board from the protective anti-static bag. Using damaged circuit boards may also damage related components. Use a grounding wrist strap for handling sensitive circuit boards.

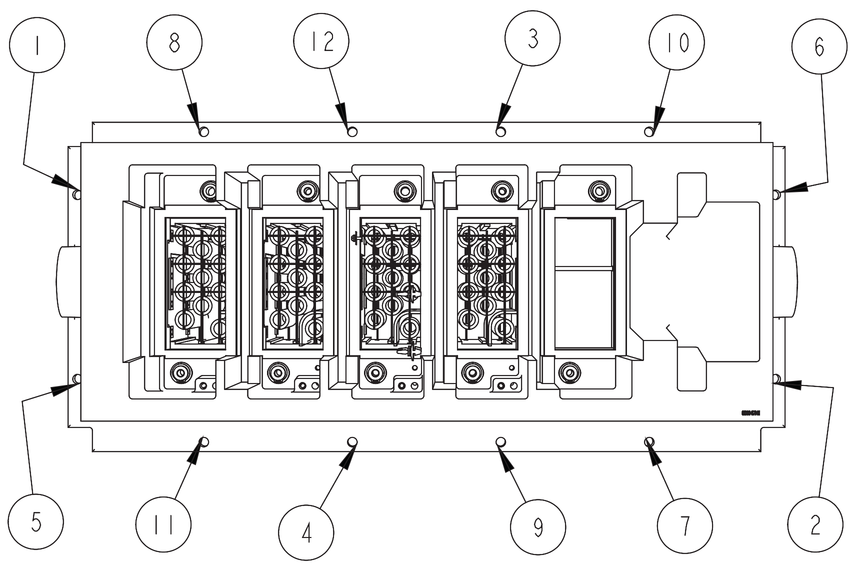
ATTENTION: Do NOT remove the pivot plate from the PowerCage. The pivot plate is located on the opposite end of the PowerCage from the clamp head. If the pivot plate is removed from the PowerCage, it must be replaced in the original orientation. See Figure 45 through Figure 50 for pivot plate location.

3. Remove the M8 bolts (use 13 mm) in the two flanges that connect the heatsink to the PowerCage module, then remove the heatsink. This reduces the weight for easier handling.
4. To detach the PowerCage module, remove the bolts on the outer flange. Carefully lift the module down, placing the forward face down. Do not over-torque these bolts.

IMPORTANT	The module can be heavy. Use two people to extract the module from the drive.

5. See appropriate section for component replacement.
6. Place the bolts on the outer flange in loosely. Torque bolts alternately on one flange and then the opposite flange to ensure even tightening of the module. Use the suggested torquing sequence shown in Figure 88.

Figure 88 - Typical Torque Sequence(1)



7. Replace interior assembly in the reverse order of removal.

IMPORTANT	A heatpipe PowerCage module does not have to be removed to access the snubber resistors. The resistor cage can be removed within a heatpipe PowerCage module (Figure 65).

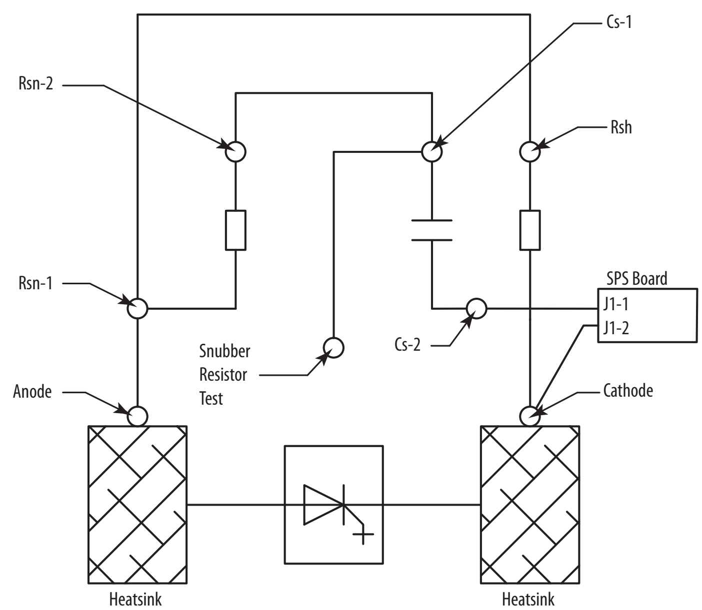
(1) The PowerCage module is shown with switching components, heatsinks, and clamps removed for ease of lifting.

Self-powered SGCT Power Supply - SPS

This board is a component in drives that does not use the IGDPS module to power the rectifier SGCTs. The SPS board extracts energy from the associated SGCT snubber circuitry to provide the 20V DC required to power the SGCT device.

The SPS board has two snubber connection inputs and two 20V DC connection outputs. Snubber connection inputs are derived from opening the to SGCT cathode connection and bringing these connections to the SPS board (Figure 89).

Figure 89 - Snubber Circuit for SGCT Module (with SPS board)



Board Calibration

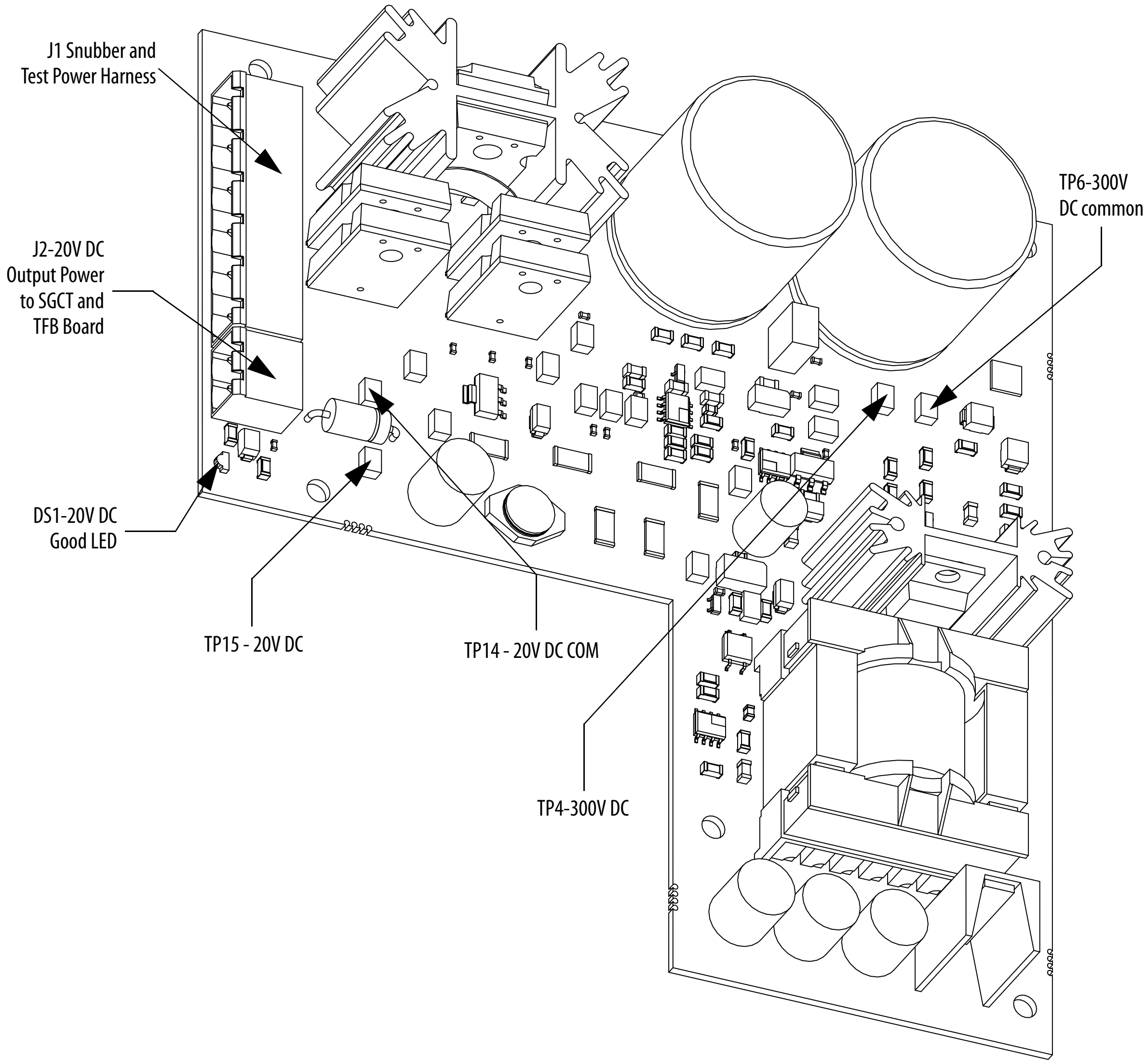
This board requires no field calibration.

Test Points

TP4	300V DC bus
TP6	300V DC bus common
TP15	20V DC output
TP14	20V DC output common

The green LED (DS1) on the SPS board indicates that the 20V DC output is within operating specification range.

Figure 90 - SPS Board Test Points



Terminal	Connections
J1 – 1	Connection to the SGCT snubber capacitor at CS-2 location
J1 – 2	Connection to SGCT cathode terminal
J1 – 3	Connection to input attenuated feedback (Short J1-3 to J1-4 to disable input SCR clamp stage for test power usage)
J1 – 4	Connection to 300V DC common connection (Short J1-3 to J1-4 to disable input SCR clamp stage for test power usage)
J1 – 5	Connection to 300V DC internal bus (Short J1-5 to J1-6 to allow input to operate from 90V AC)
J1 – 6	Connection to TOPSwitch programming resistor (Short J1-5 to J1-6 to allow input to operate from 90V AC)

Testing Equipment

Ensure you have the following equipment available in order to perform testing tasks.

- SPS test power harness (part no. 80018-695-51)
- Digital multimeter

1. Disconnect the snubber connection to J1 of the SPS board.
2. Connect one of the SPS test power harness connectors to the SPS J1 connector.
3. Plug the AC input end of the SPS test power harness into the appropriate drive receptacle.

   The green LED (DS1) at the front of the board should be on.
4. Measure between the TP4 and TP6 on the SPS board. It should be at a level of $\sqrt{2} \times VIN_{RMS}$.

   This can range from 120V (85V input) to 375V (265V input).
5. Measure between TP15 and TP14 on the SPS board. It should be at a level of 20V DC, +/- 400 mV.

   If these readings are not correct, replace the tested SPS board with a new board and return the faulty board to the factory.

WARNING: When the SPS test harness is installed and powered, there are lethal voltages on the SPS board and test harness. Always connect multimeter test leads to the SPS test points before applying input power to the SPS test harness. Do not touch the test harness contacts or the SPS board once input power is applied. Once the test harness is removed, wait 10 seconds before touching the SPS board.

Always connect the SPS test harness connectors to the SPS board before applying input power to the SPS test harness.

Certain shorted components on the SPS board, such as any of the input diode bridge diodes D10, D11, D13 or D14, will cause the input breaker to the SPS test power harness to trip. In this situation, replace with a new unit and return the faulty board to the factory.

WARNING: When testing with the SPS harness is complete, remove the test harness from all of the SPS boards and remove the SPS test harness from the power converter cabinet. Do NOT leave the SPS test harness in the power converter cabinet. Reconnect all of the SGCT snubber connections to the J1 connectors on the SPS boards.

Self-Powered Gate Driver Board – SPGDB

This board is a component in drives using SCRs as the rectifying device on the input of the drive. The SCRs require a gating pulse to turn on, and this is achieved by using the SPGDB.

The SPGDB receives signals from the drive processor via a light signal transmitted through a fiber optic cable. The power source for the SPGDB is from the SCR snubber network, a Rockwell Automation patented design. This unique design gives the SPGDB the ability to conserve the amount of energy that it supplies to the SCR. This reduces the amount of energy required by the drive to operate, thus making the drive more efficient.

This board also determines the health of the SCR. The SPGDB has the hardware necessary to diagnose SCR conditions and relay the status to the processor via a fail-safe light signal along a fiber optic cable.

Board Calibration

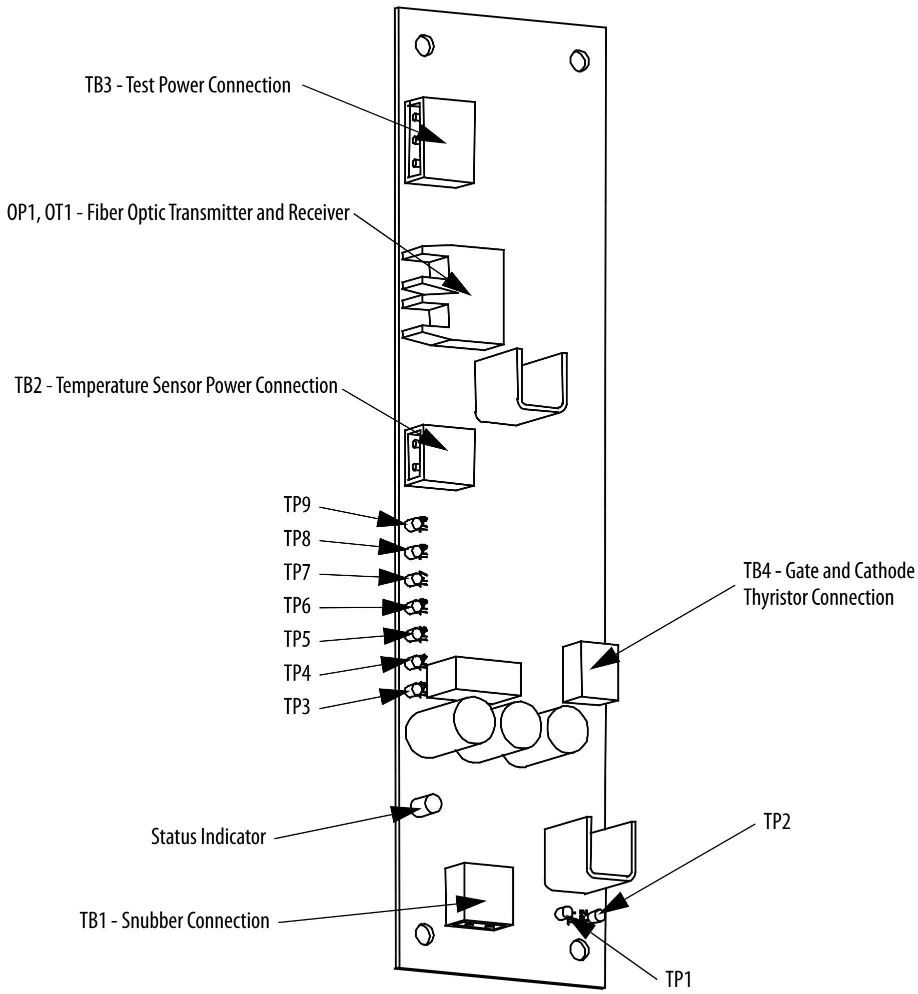
This board requires no field calibration.

Test Points

TP1	SCR gate output (attach oscilloscope between TP1 and TP2 to see gating pulses)
TP2	SCR cathode output
TP3	Common reference point for all other test point measurements, except for TP1, which uses TP2 as its reference point
TP4	The positive 20 V rail used for the SPGDB operation
TP5	The positive 5 V rail used for the SPGDB operation
TP6	The sense voltage taken from the sense resistor across the SCR being controlled
TP7	Trigger signal, which remains active for a fixed period of time after the SCR being controlled, has turned on and the voltage across it has collapsed
TP8	Internal gating signal that indirectly turns on the SCR that is being controlled
TP9	Gating signal received from the commanding drive control board, through the appropriate fiber optic cable

The yellow LED (LED 1) on the SGPDB indicates that the controlled SCR has a gating current flowing, which turns on the SCR.

Figure 91 - Self-Powered Gate Driver Board



Terminal/Connections

TB1-1	Connection to SCR snubber circuit (capacitor connection end) used to extract energy from the snubber for SPGDB operation.
TB1-2	Connection to SCR sensing resistor which indicates conduction status of SCR being operated.
TB2-1	Positive 20V power supply connection to temperature sensor board. Provides power to temperature sensor board.
TB2-2	Common connection of positive 20V power supply to temperature sensor board.
TB3-1	Positive 15V power supply connection for test power used when commissioning drive or testing SPGDB.
TB3-2	Provides artificial sense voltage signal to allow SPGDB to gate the SCR when in test mode. When the appropriate test power cable is used, P/N 80018-298-51, this input is shorted to TB3-1 to obtain the sense voltage.
TB3-3	Common connection of positive 15V power supply used for test power
TB4-2	Cathode connection to SCR being controlled
TB4-1	Gate connection to SCR being controlled
OP1	Blue fiber optic cable receptacle – gating pulse command from the processor
OT1	Grey fiber optic cable receptacle – diagnostic status of the SCR

Testing Procedure for SCR Self-Powered Gate Driver Board

Testing Equipment

Ensure you have the following equipment available in order to perform testing tasks.

- Digital oscilloscope
- Function generator w/duty cycle control
- DC power supply (+15V @ 300 mA required)
- Digital multimeter
- Temperature sensor board (80190-639-02)
- SPS test power harness (80018-695-51)

Procedure

1. Connect a clamped ABB #5STP03D6500 SCR to the gate-cathode leads of the SPGDB board (TB4-1/TB4-2).
2. Attach a temperature sensor board to the TB2-1/TB2-2 terminals.
3. Apply +15V test power to terminals TB3-1 and TB3-3 (TB3-1 is at +15V while TB3-3 is the +15V return). Leave TB3-2 open.
4. Measure TP4 to TP3, which should be +14.4V, +/-100mV.
5. Measure TP5 to TP3, which should be +5.0V, +/- 250mV.
6. Measure TB2-1 to TB2-2, which should be +14.4V, +/-100mV.
7. Measure the voltage at U4-pin2 to COM, which should be +1.0V, +/-100mV.
8. Measure the voltage at U4-pin3 to COM, which should be 0V.
9. Measure the voltage at U4-pin7 to COM, which should be +3.6V, +/-100mV.
10. Verify that the OT1 LED is off.
11. Measure TP7 to TP3, which should be 0V.
12. Measure TP9 to TP3, which should be +5.0V, +/- 250mV.
13. Measure TP8 to TP3, which should be 0V.
14. Measure TP1 to TP2, which should be 0V.
15. Connect a jumper between TB3-1 and TB3-2 and verify that the voltage at TP6 is +2.2V, +/-100mV.
16. Apply a 60Hz, 33% duty cycle signal to the OP1 fiber optic input.
17. Verify that the diagnostics transmitter LED, OT1, is on.
18. Verify that the signals at TP9 and TP8 are as shown in Figure 93 on page 112.
19. Verify that the signal between TP1 and TP2 is as shown in Figure 94 on page 113 and Figure 95 on page 113

20. Remove the jumper between TB3-1 and TB3-2.
21. Apply a constant fiber optic signal to the OP1 input.
22. Apply a 60 Hz, 33% duty cycle signal, at a 0 to +2V level, between the TB1-2 input and COM. Verify the signals as illustrated from Figure 93 to Figure 96 on page 114. In Figure 96 on page 114, there should be a 220 µS, +/-20 µS time between the rising edge of the U4-pin7 pulse and the falling edge of the TP7 signal.

Figure 92 - Gating Pulses

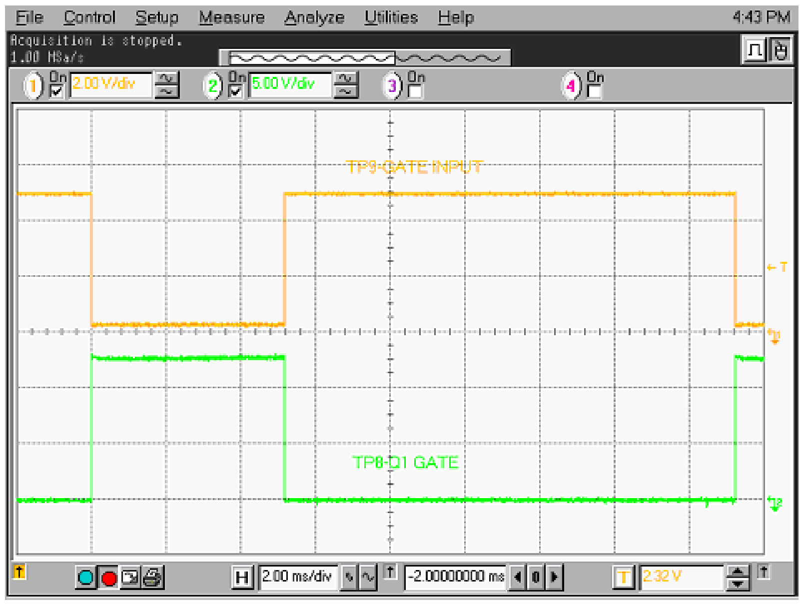


Figure 93 - SCR Gating Pulses

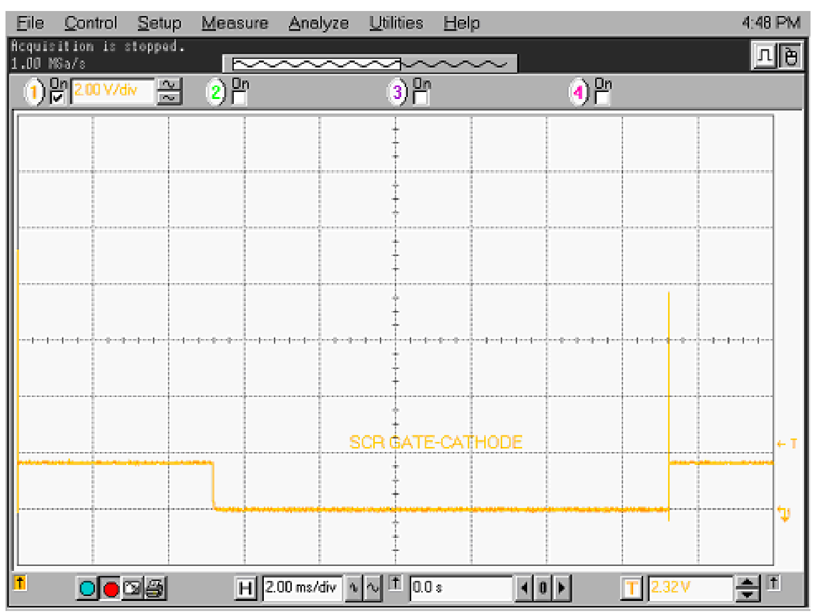


Figure 94 - Expanded SCR Gating Pulse

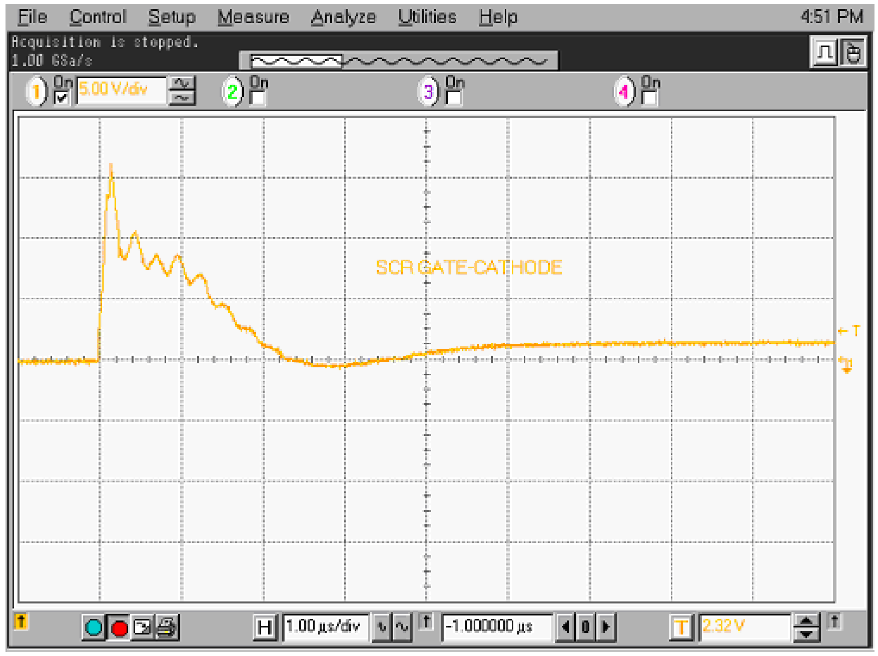


Figure 95 - V-Sense Trigger to SCR Gating Pulse

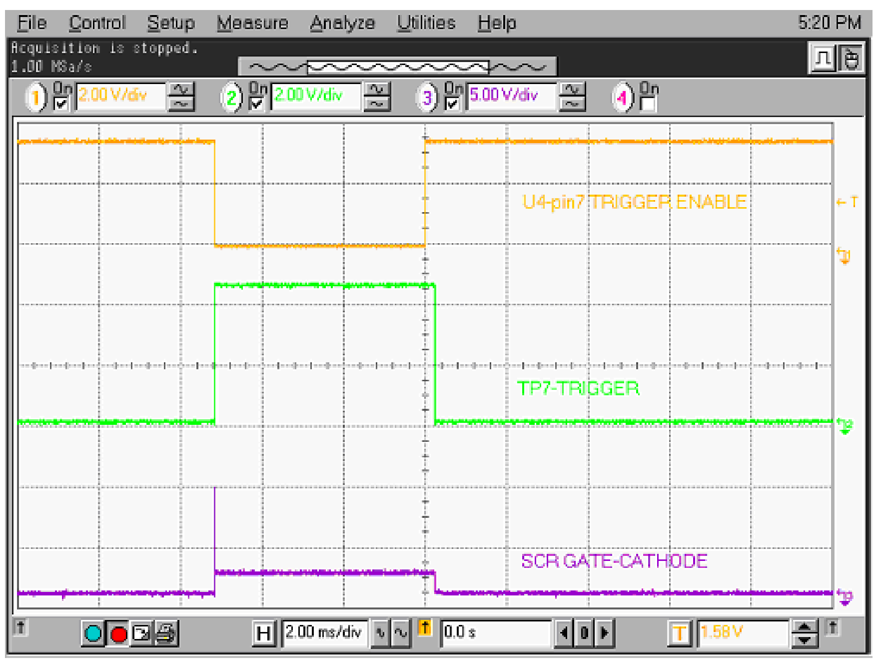
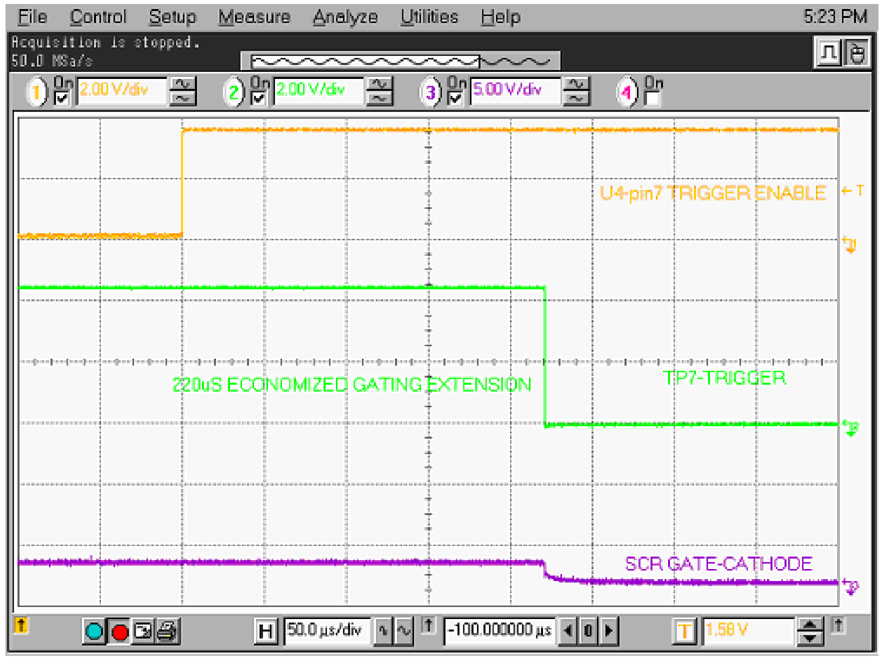


Figure 96 - Expansion of V Sense Trigger to SCR Gating Pulse



Fiber Optic Cabling

The equipment uses fiber optic cabling between the low voltage control and the medium voltage circuits. You should never need to change the routing of the fiber optic cables.

Each end of a fiber optic cable has a connector that plugs and latches into its respective location on a circuit board. To disconnect a fiber optic cable, depress the ridged plastic tab at the end connector and pull. To install a fiber optic cable insert the fiber optic port of the circuit board so that the plastic tab latches into place.

If you must replace fiber optic cables, be careful to prevent the cables from straining or crimping as a resulting loss in light transmission will impact performance.

The minimum bend radius permitted for the fiber optic cables is 50 mm (2.0 in.).

When installing the fiber optic cable, match the connector color at the end of the cable with the connector socket color on the circuit board.

The product uses the following fiber optic cable lengths.

Duplex	Simplex
5.0 m	5.0 m
5.5 m	6.0 m
6.0 m	10.0 m
6.5 m	
7.0 m	

There is one duplex fiber optic for each thyristor, which manages gating and diagnostic functions. The circuitry on the respective driver boards determines the functional status of the thyristor, and sends this information to the main processor via a fail-safe light signal in the fiber optic. The main processor initiates the firing command for the thyristor and transmits the signal to the appropriate gate driver board via the gating fiber optic.

The color codes of the connectors are:

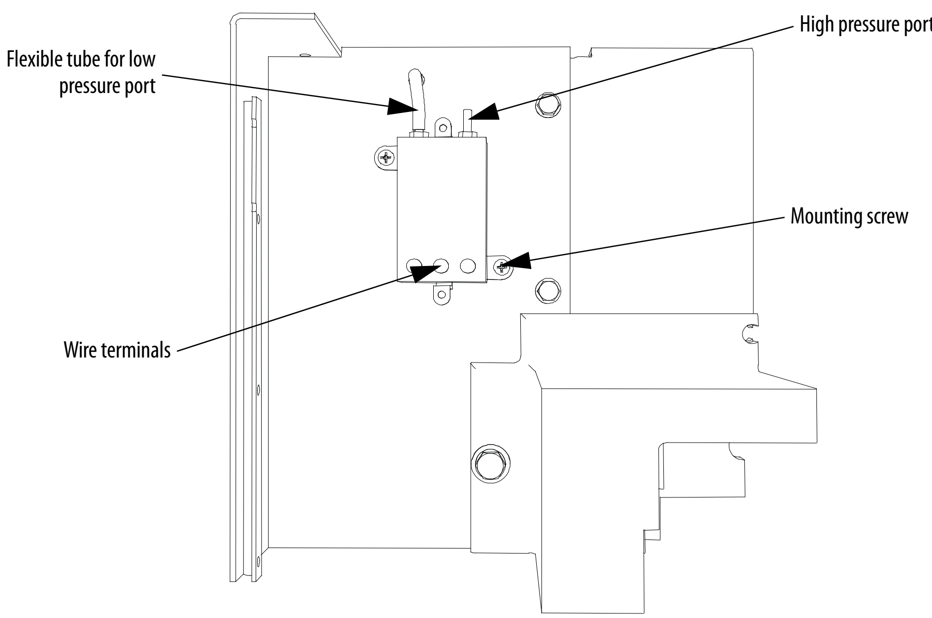
BLACK or GREY – is the transmitting end of the fiber optic.

BLUE – is the receiving end of the fiber optic.

Air Pressure Sensor

An air pressure sensor is located in the converter cabinet. The sensor is located in the upper left area near the uppermost inverter module.

Figure 97 - Air Pressure Sensor



The air pressure sensor measures the difference in air pressure between the front and rear of the converter modules. The sensor sends a small direct current voltage signal to the control circuits.

Rockwell Automation currently uses Ashcroft air pressure sensors. In the event of reduced fan performance or air blockage, the sensor notes the reduced differential pressure and triggers a warning message to the console. One likely cause of such a performance reduction would be partially plugged filters at the air inlet.

If airflow becomes reduced to the point of risking thermal damage, the sensor triggers a fault signal that shuts down the drive. Also, in the event of fan failure, the sensor will detect the pressure change and stop the drive.

Replacing the Air Pressure Sensor

1. Remove the wires at the sensor and note their designation.
2. Disconnect the clear tube on the low pressure port. Remove the two mounting screws of the sensor.
3. Check the integrity of the existing sealant where the clear tubing passes through the sheet metal barrier.
4. Installing the replacement airflow sensor is in the reverse order of its removal.

DC Link and Fan Cabinet Components

This section describes the DC link and fan cabinet components of your PowerFlex 7000 'B' frame drive. This section also details a number of regular or recurring maintenance tasks that will keep your drive in peak operating condition.

For control and cabling cabinets, see Control / Cabling Cabinet Components on page 29.

For converter cabinets, see Converter Cabinet Components on page 55.

Figure 98 - DC Link/Fan Cabinet with Fan Control Panel (Heatsink Model)

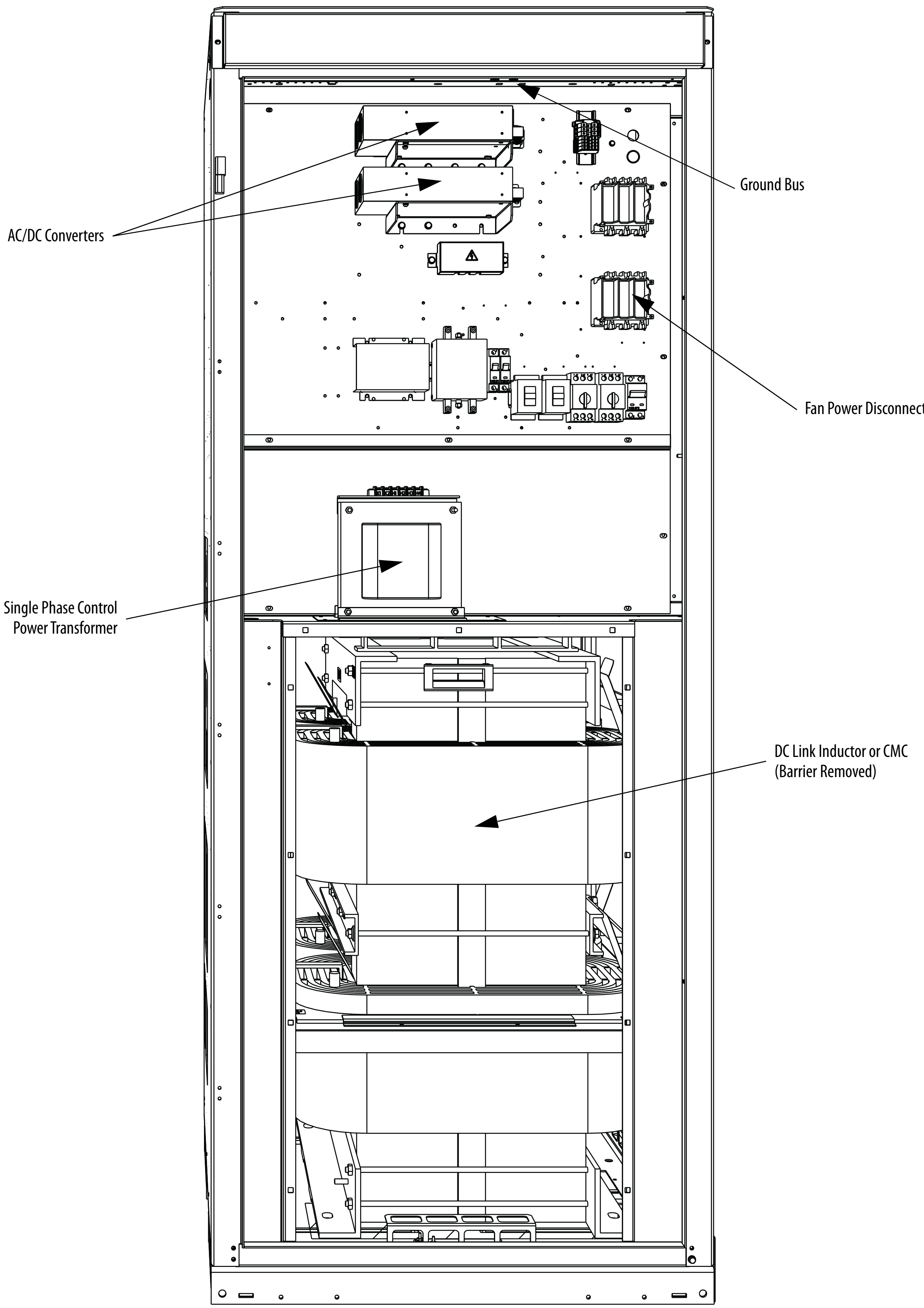


Figure 99 - DC Link/Fan Cabinet with Panel Removed to Show CMC (Heatpipe Model)

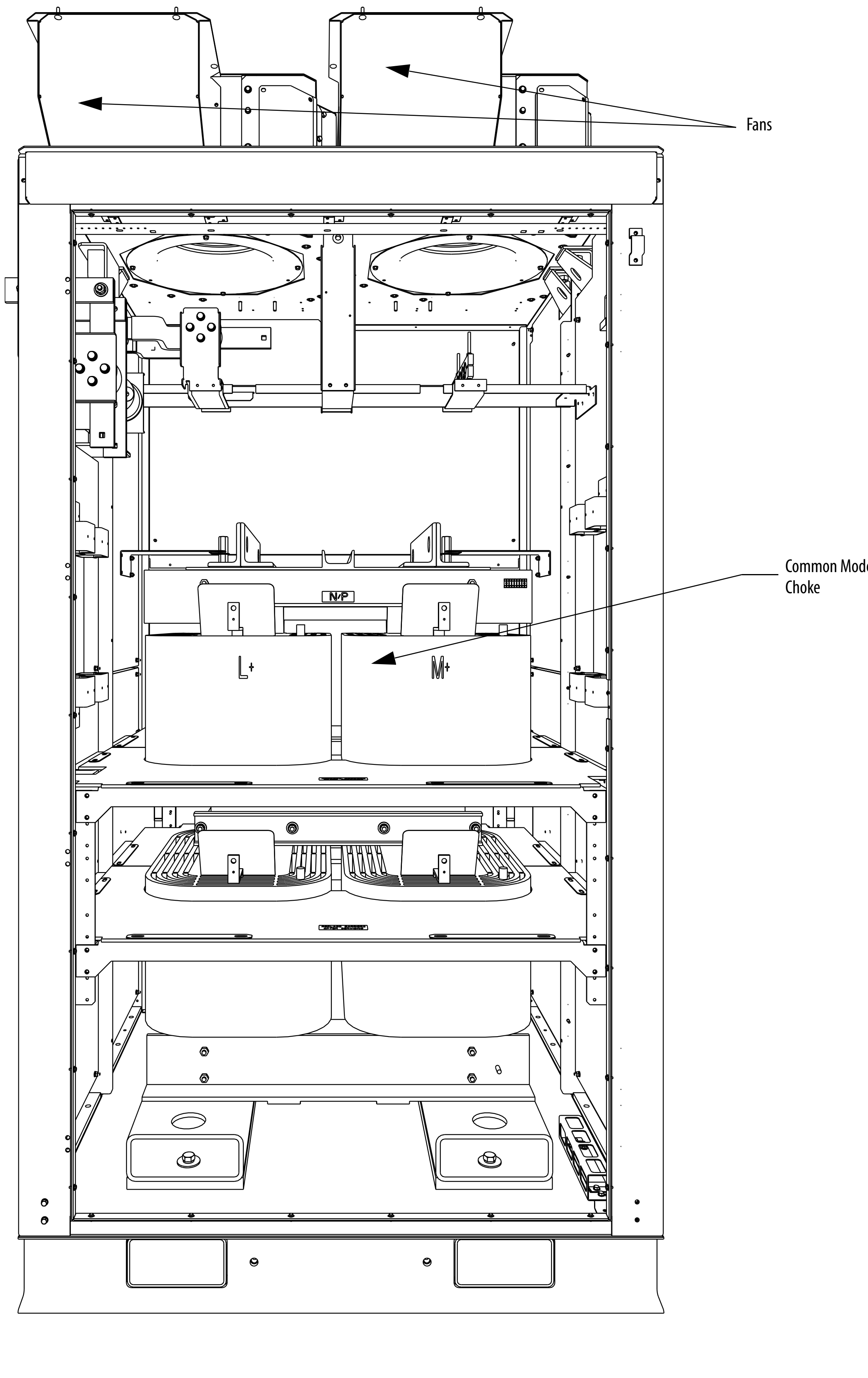
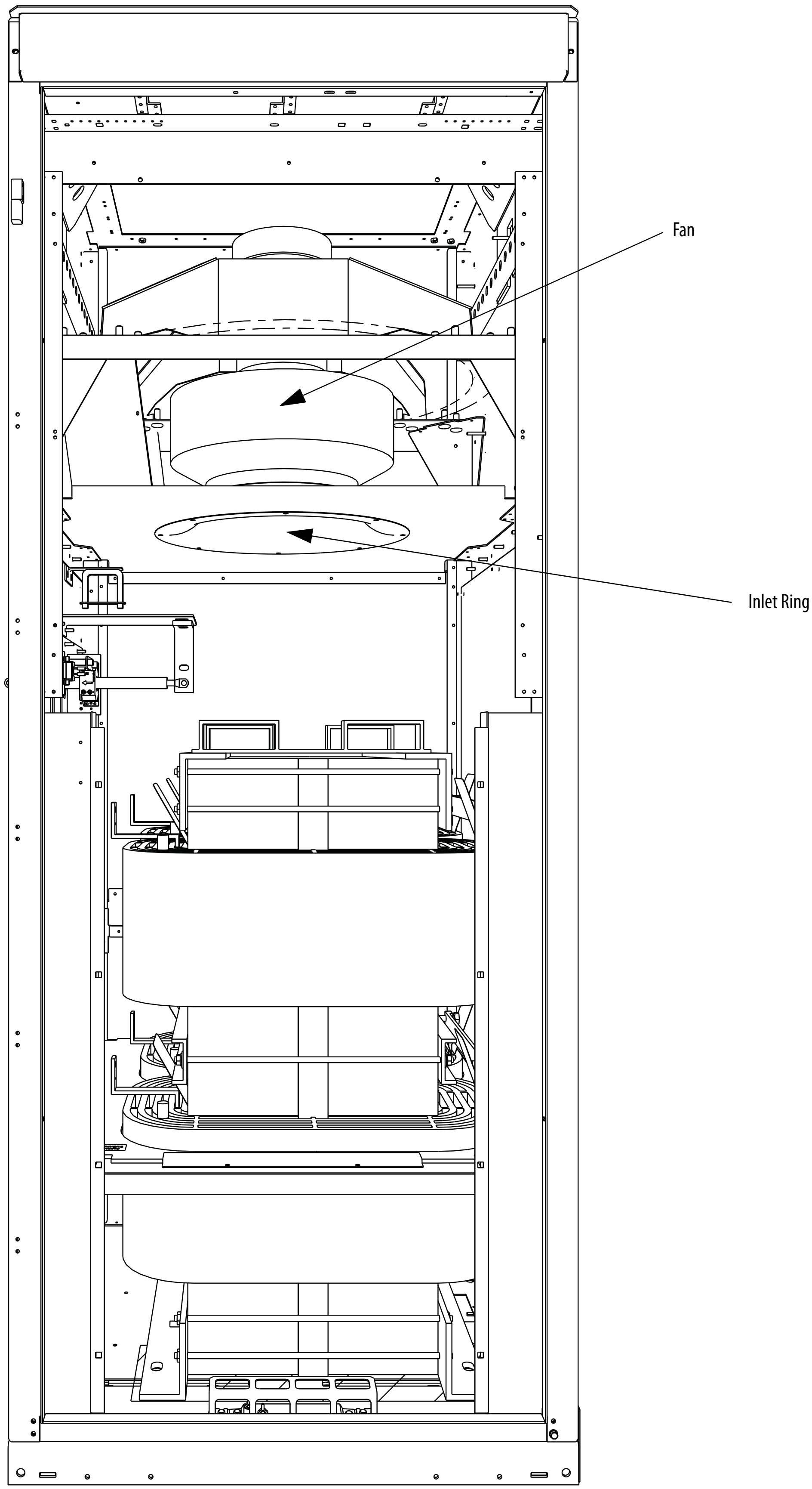


Figure 100 - DC Link/Fan Cabinet with Panel Removed to show Main Cooling Fan



The door of the cabinet interlocks to remain closed until you disconnect the fan power. The fan power disconnect handle is on the right-hand side of the cabinet. The DC link and fan are behind the fixed fan control panels in the medium voltage compartment.

The DC link is on the floor plate of the cabinet. Airflow barriers assembled around the coils of the inductor direct a portion of the cooling air through the inductor.

Power connects to the inductor via flexible leads. There are four power connection points labeled L+, L-, M+, and M-. There is a current sensor on the M+ conductor.

The iron core of the DC link has thermal protection.

Above the DC link is the main drive cooling fan. The primary elements of the fan are the inlet ring, impeller and motor. The inlet ring is stationary and must not contact the rotating impeller.

An air exhaust hood is mounted on top of the cabinet; ensure you install the hood correctly to prevent foreign objects entering the drive. If there is a redundant fan option, the option is mounted on the top of this cabinet, inside an enlarged exhaust hood.

DC Link Reactor

The DC Link maintains a low ripple current between the rectifier and the inverter. The link design ensures that it cools with air drawn through its coils.

The DC link reactor does not normally require service. In the event of its replacement, however, Rockwell Automation must approve the replacement link.

1. Lock out the all source power to the drive.
2. Open the DC link cabinet door and remove the screws holding the vertical sheet metal barrier in front of the DC link.
3. The DC link is equipped with flexible power leads. Disconnect the four power connections.
4. Remove the horizontal barrier around the DC link.
5. Remove the hardware that secures the DC link to the floor channel.
6. Disconnect the ground connection.
7. The DC link is heavy and has provision for lifting with forks of a lift truck.

Figure 101 - DC Link Removal (Heatsink Model)

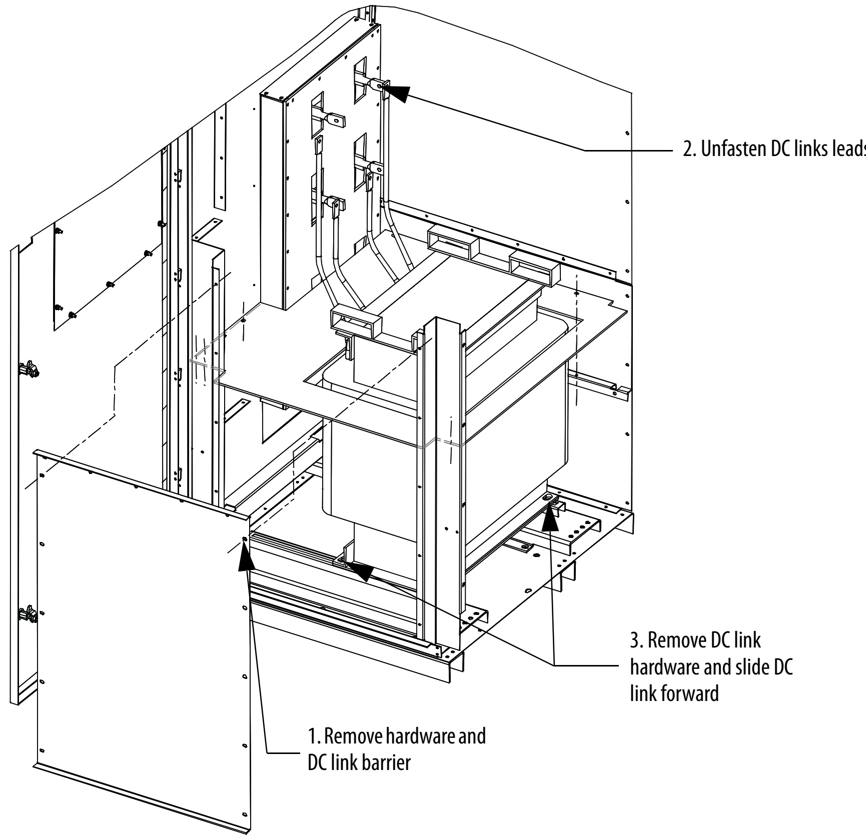
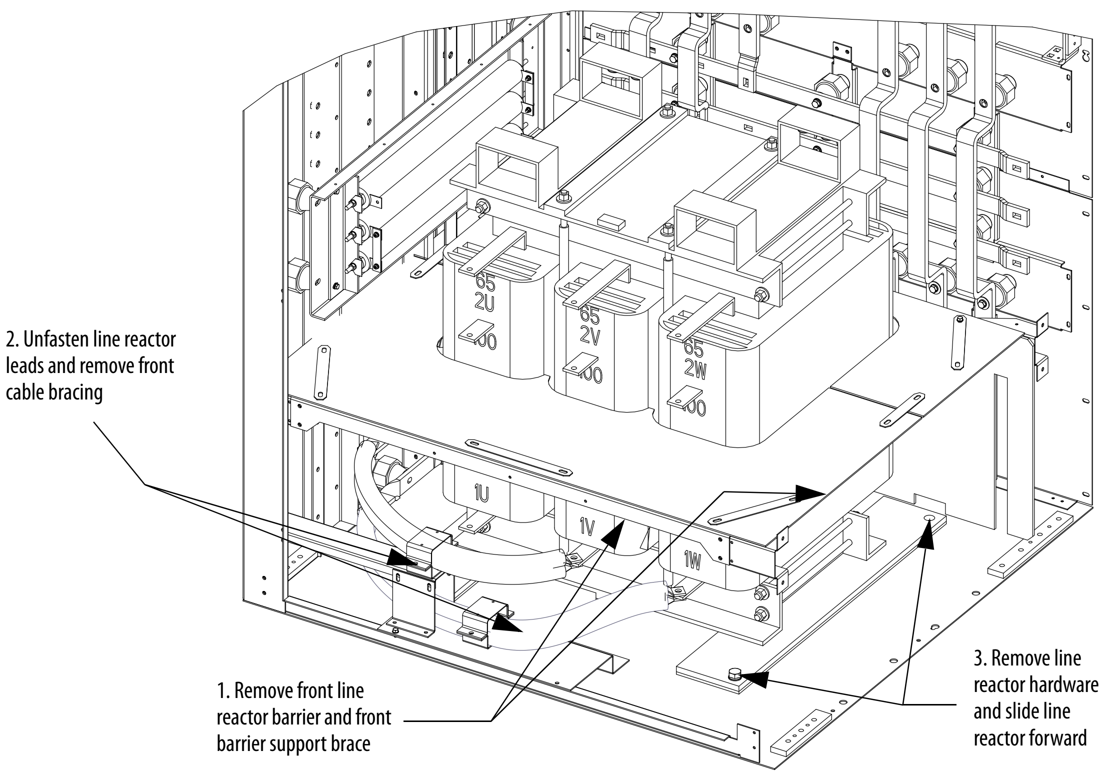


Figure 102 - DC Link Removal (Heatpipe Model)



Install the replacement DC link in the reverse order of its removal.

You must connect the flexible DC link leads to the appropriate terminal and route them to maintain electrical clearances. You must also verify that the nameplate ratings are the same or appropriate for the drive system. A different DC link will require different parameter settings.

The DC link maintains a low ripple current between the line converter and the machine converter. Thermal protection of the DC link reactor is provided by two normally closed contacts wired to the I/O module. These contacts will open at 190°C and cause a fault/alarm message to be displayed.

Removing and Replacing Fans

The fan consists of a motor and impeller assembly. To replace the fan, remove the fan exhaust hood and cabinet top plate.

Safety Notes

- Fan replacement requires working at a significant height from the floor. Be careful to work from a safe, stable platform.
- The fan motor is heavy and requires suitable lifting provision.
- Lock out the fan power during fan maintenance.

Remove the eight nuts that secure the motor frame to the side sheets of the cabinet. Disconnect the power leads to the motor. Note the terminal locations so that proper fan rotation is maintained.

To extract the fan, use lifting hooks in the holes on the motor mounting brackets and draw the assembly vertically from the cabinet. Do not support the assembly on the impeller or you may damage the unit.

Figure 103 - Fan Removal (Heatsink Model)

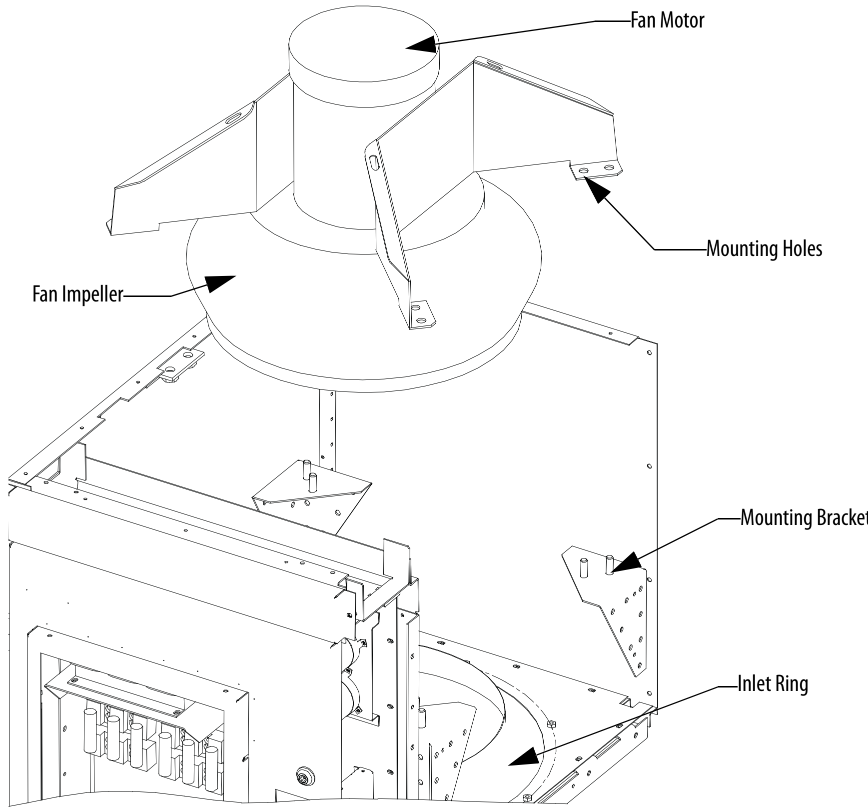
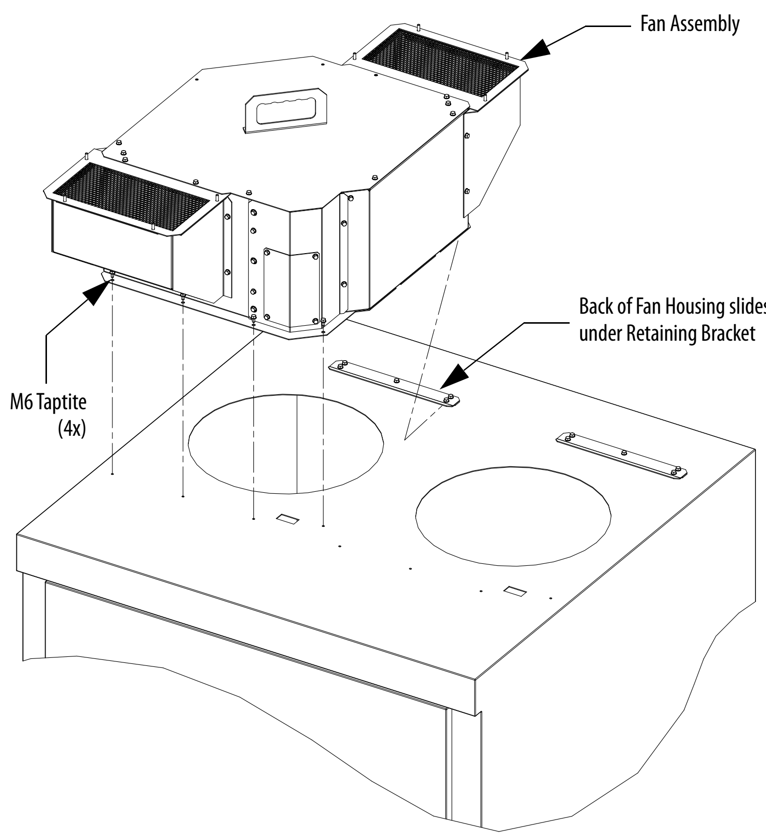


Figure 104 - Fan Removal (Heatpipe Model)



Fan Installation

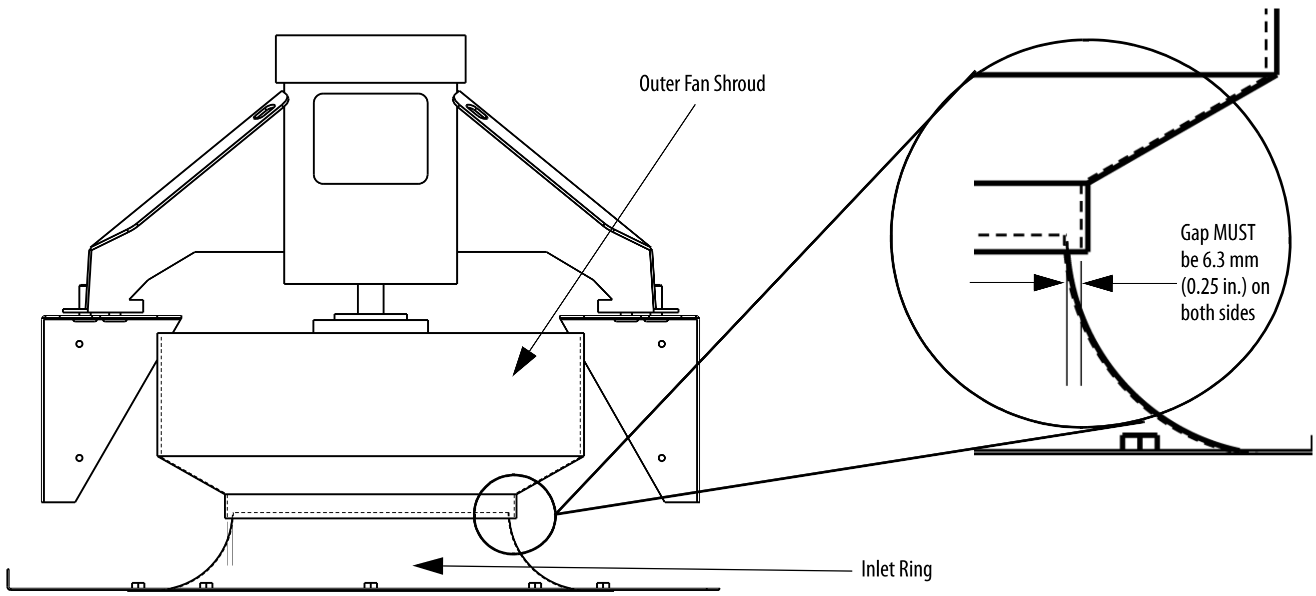
Take care when handling the fan as poor handling can adversely affect its balance.

Install the fan in the reverse order of its removal.

IMPORTANT After installation, rotate the impeller by hand to verify it is clear of the inlet ring.

ATTENTION: The fan assembly must be radially centered. Use a feeler gauge or similar tool to measure the gap between the impeller shroud and inlet ring. The gap must be at least 6.3 mm (0.25 in.). To adjust the gap space, loosen the hardware connecting the inlet ring to the cabinet plate and adjust the inlet ring as necessary.

Figure 105 - Fan Assembly Installation



Impeller Maintenance

The fan impeller connects to the motor shaft with a split tapered bushing. This bushing is positioned on the motor shaft and through the center of the impeller. Two cap screws, when tightened to 10.2 N•m (7.5 lb•ft), lock the bushing onto the motor shaft and the impeller to the bushing.

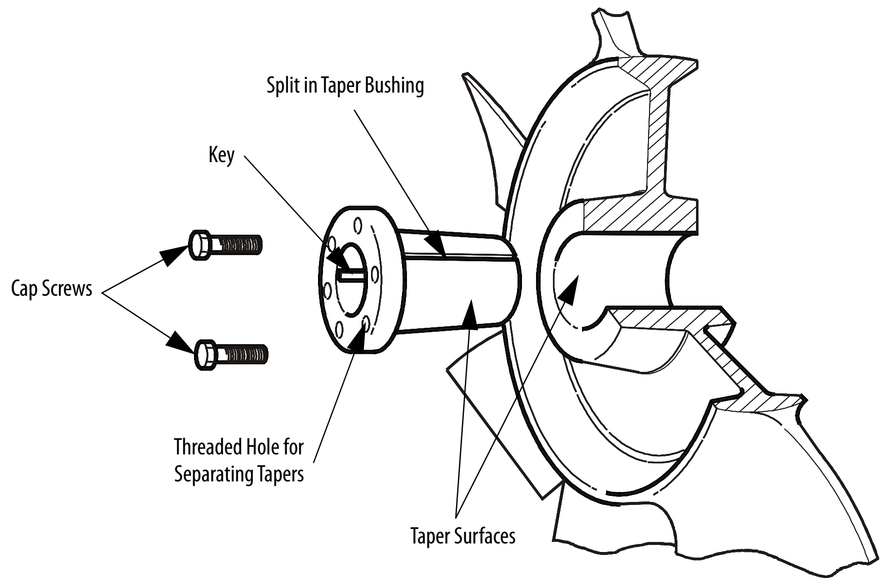
Impeller Removal from Motor Shaft

Safety Notes

The impeller is not designed to support the weight of the motor.

If vertical, the impeller and bushing may fall when loosening cap screws. Physical injury or component damage may result.

Figure 106 - Impeller Removal



1. Record the distance from the end of the motor shaft to the bushing. The new impeller must be installed in the same location. Failure to do so will result in gaps between the impeller and the intake ring resulting in loss of air flow, or rubbing of the impeller against the inlet ring or motor assembly during operation.
2. Remove both cap screws from the bushing. The impeller or bushing may fall as screws are loosened.
3. Thread the cap screws by hand into the two threaded holes in the bushing flange.

4. Tighten each bolt part of a turn successively, to push the impeller off the bushing. Screwing down the cap screws into these holes will force the bushing away from the impeller hub, releasing the compression on the shaft. Be careful that the impeller does not fall as the clamping force is released.
5. Pull the bushing off the shaft and remove the impeller. If the assembly has been in place for some time, it may be necessary to use a wheel puller to remove the bushing. Do not use a wheel puller on the impeller.

ATTENTION: Do not lubricate capscrews, bore, or bushing barrel, as this will hinder clamping force of the bushing on the shaft and the impeller bore.

Installing Impeller Assembly onto Motor Shaft

The bushing barrel and the bore of the impeller are tapered which assures concentric mounting and keeps the impeller running evenly.

The cap screws, when tightened, lock the bushing in the impeller and over the motor shaft.

The bushing is split down the middle, so that when the locking cap screws force the bushing into the tapered bore in the impeller assembly, the bushing will grip the shaft with a positive clamping fit.

The impeller and bushing assembly have keyways that line up with the shaft and are held in place with compression.

To assemble:

1. The shaft and keyway are clean and smooth. Clean the shaft and bore with rubbing alcohol or non oily solvent. Check the key size with both the shaft and bushing keyways.
2. Put the cap screws through the clearance holes in the bushing, and put the bushing loosely into the impeller, lining up the screws with the threaded holes on the impeller hub. Do not press, drive, or hammer the bushing into the bore.
3. Start the cap screws by hand, turning them just enough to engage the threads. Do not use a wrench at this time. The bushing should be loose enough in the impeller to move freely.
4. Slide the impeller and bushing assembly onto the motor shaft, ensuring the same distance from the end of the shaft to the bushing as in step 1 of impeller removal.
5. Fit the key into keyway. Do not force impeller and bushing onto shaft. If they do not fit easily, check the shaft, bushing and key sizes.

6. Tighten the cap screws progressively with a wrench. Do this evenly as though mounting an automobile wheel. Turn one a quarter turn, then the next a quarter turn, then go back and turn the other a quarter turn and so on. Torque to 10.2 N•m (7.5 lb•ft).
7. Peen the end of the motor shaft at the keyway with a chisel or center punch to prevent the key from falling out of position.

Fan Balance

Fan impellers are statically and dynamically balanced within acceptable tolerances at the factory. Damage in shipping or from poor handling or installation may upset the fan balance. An impeller that is not properly balanced can lead to excessive vibration causing undue wear on the entire unit.

If vibration is excessive, shut down the fan and determine the cause.

Some common causes of excessive vibration include:

- support structure not sufficiently rigid or level. Vibration amplified by resonance in duct work or support structure.
- bearing locking collar or mounting bolts loose. Impeller or bushing loose.
- material accumulation on impeller.
- wheel rubbing on inlet ring.

The inlet ring is the large circular part located on the underside of a horizontal barrier beneath the fan impeller. The position enables the impeller to sit inside without touching the ring. The ring sits inside the impeller 10 mm (0.40 inches).

Safety Notes

This procedure requires contact with the internal electrical connectors and devices. Disconnect all power to the drive before beginning the work. Failing to do so may result in serious injury or death.

Ensure you can prevent the inlet ring from falling after you have removed all of the bolts.

ATTENTION: To prevent electrical shock, disconnect the main power before working on the drive. Verify that all circuits are voltage-free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

If rear panel access is possible, remove rear middle panel of the DC link/fan portion of the cabinet and remove the inlet ring from the back.

If rear panel access is not possible, follow this procedure:

1. Remove the DC Link barrier and impeller access panel (Figure 103 on page 123). Remove electrical components in front of the inlet ring access panel.
2. Remove bolts from the inlet ring; do not to allow the ring to fall.
3. Remove inlet ring via the bottom access panel by moving it around the DC link and diagonally out the door. You may have to shift the DC link.
4. To install the new ring, reverse the above procedure. Rotate the fan impeller by hand to check clearance inside the inlet ring.

   Move the ring and retighten bolts to eliminate interference.

IMPORTANT The fan must not make contact with the inlet ring.

5. Replace access panels and electrical components.

Replacing Air Filters

Air filters are located at the cooling air intake grill mounted on the door in front of the converter, line reactor, and transformer cabinets.

You must periodically remove and clean, or remove and replace, the filter material. The frequency with which you renew the filters depends on the cleanliness of the available cooling air.

ATTENTION: For arc resistant drives, equipment is not rated as arc resistant while the filter covers are open. Filter covers must be bolted closed to maintain arc resistant structural integrity.

You can replace filters in an operational drive, but the procedure is easier to perform while the drive is shut down.

Procedure (see Figure 107 on page 129):

1. Using an 8 mm Hex key, loosen the ¼ turn fasteners and swing open the hinged grill assembly.
2. Remove filter material. If the drive is running, you must replace the filter as soon as possible to prevent foreign material from falling into the drive.

Be careful when removing the filter to prevent accumulated dirt on the inlet side of the filter from being sucked into the drive. The filter may be difficult to remove the filter material without tearing it due to the suction at the air inlet.

Recommended cleaning method of filters:

- Vacuum – A few passes of a vacuum cleaner on the inlet side of the filter will remove accumulated dust and dirt in seconds.
- Blow with compressed air – point compressed air nozzle in opposite direction of operating air flow (Blow from exhaust side toward intake side)
- Cold water rinse – Under normal conditions the foam media used in the filters, require no oily adhesives. Collected dirt is washed away quickly and easily using just a standard hose nozzle with plain water. (Ensure filter is completely dry before reinstalling)
- Immersion in warm, soapy water – Where stubborn air-borne dirt is present, the filter may be dipped in a solution of warm water and mild detergent. Then simply rinse in clear clean water, let stand until completely dry and free of moisture, and return to service.

Use only Rockwell Automation supplied or approved replacement filters. Replace the filters in the reverse order of its removal. Check that there are no openings to allow foreign matter to enter the drive.

Figure 107 - Filter replacement

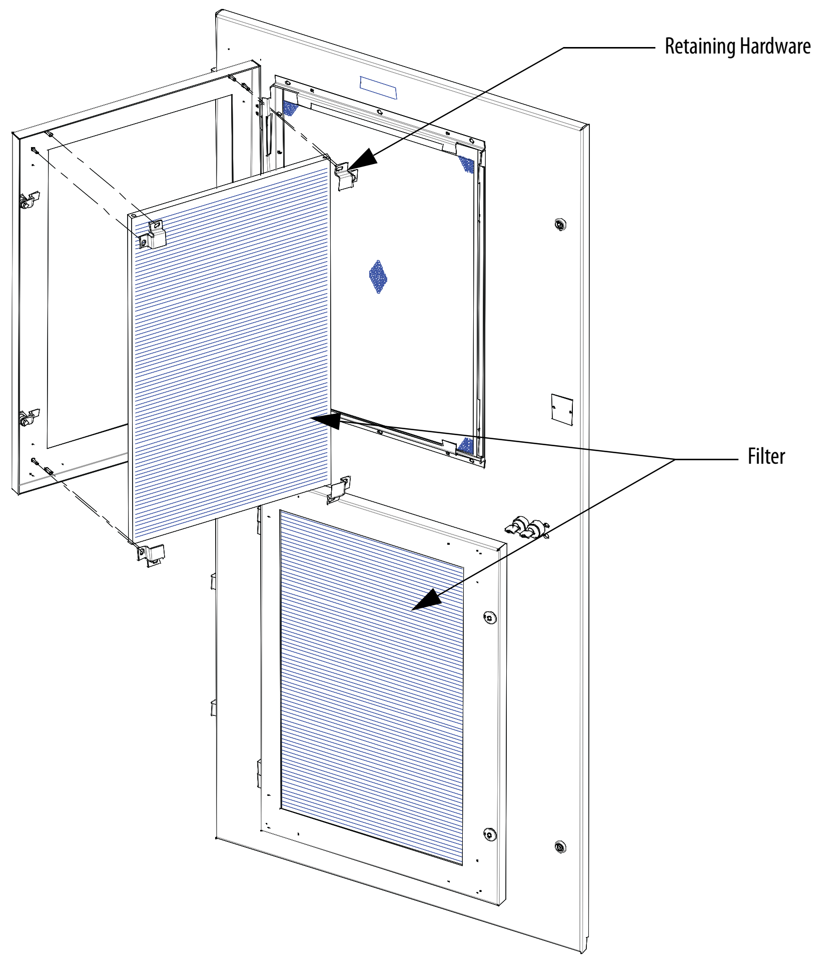


Figure 108 - Air Flow Pattern for Snubber Cooling

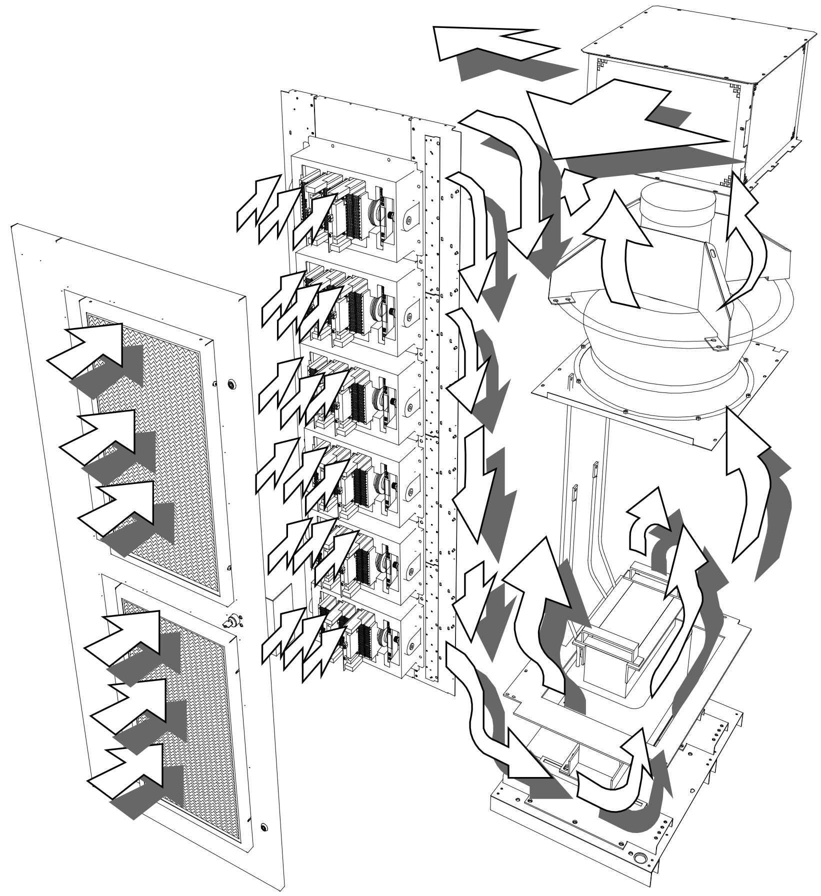
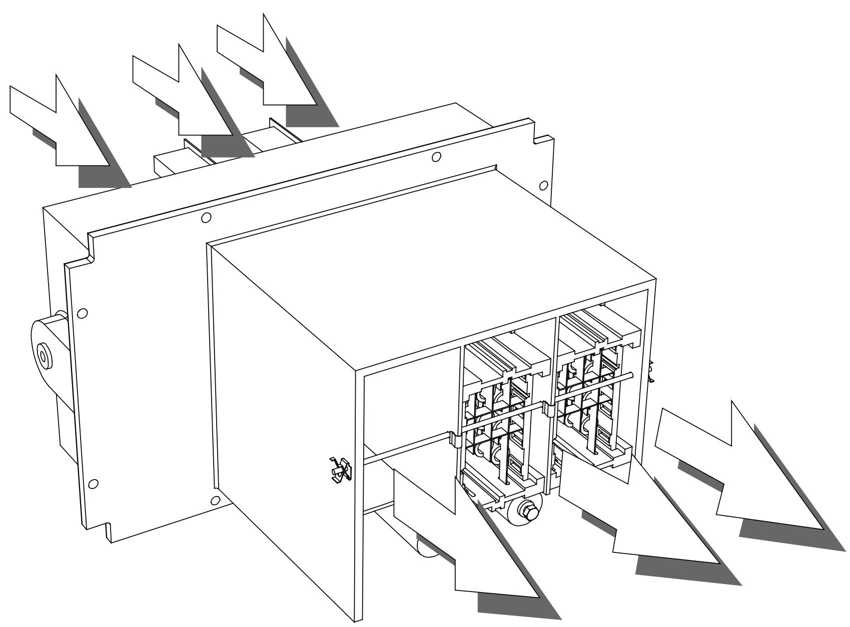


Figure 109 - Air Flow through PowerCage Module



Notes:

Control Component Definition and Maintenance

Control Power Components

There are two configurations for distributing control power for the drive, dependent on your selected drive option.

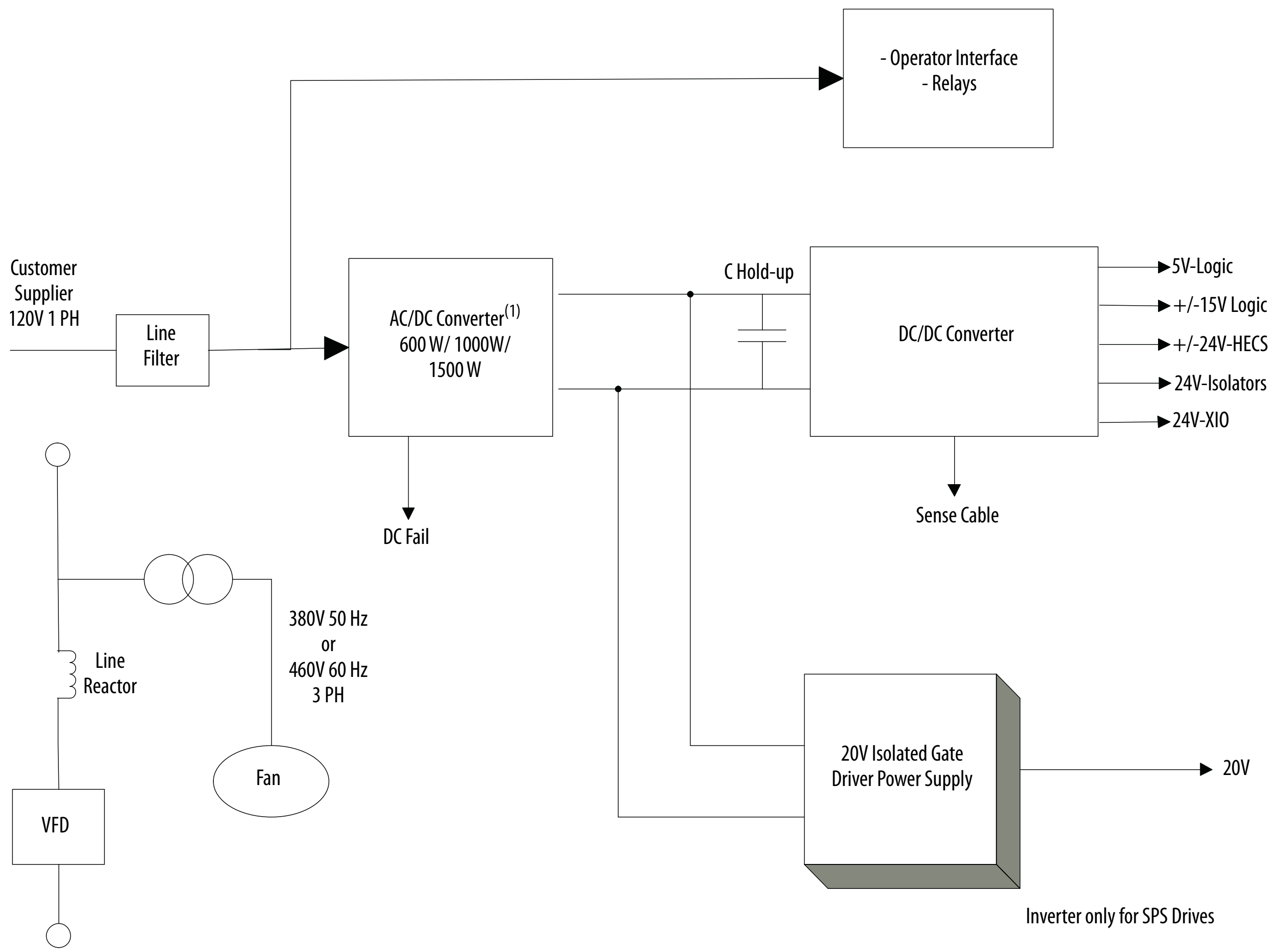
- Direct-to-Drive™ (transformerless AFE rectifier) (see Figure 110)
- AFE/18-pulse rectifier with separate isolation transformer (see Figure 111 on page 135)

Ride-through

Standard controls with 5 cycle ride-through: The drive main control boards will remain energized for a total of 5 cycles after control power interruption. If you cannot restore control power during the 5 cycles, the drive performs a controlled shutdown.

Figure 110 illustrates the control power distribution for AFE drives with integral starter and/or line reactor.

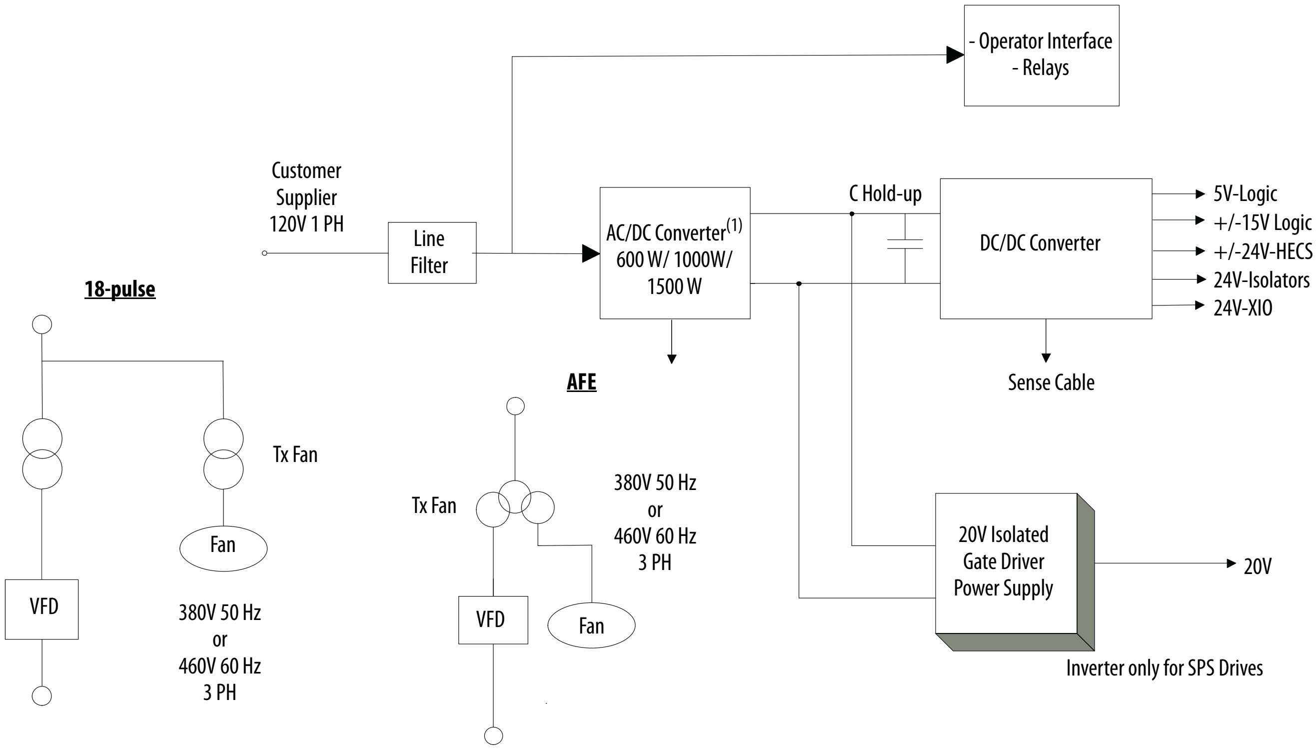
Figure 110 - Direct-to-Drive (transformerless AFE Rectifier)



(1) Cosel power supply output is 57V DC, Pioneer power supply (Heatpipe drives only) output is 56V DC.

Figure 111 illustrates the control power distribution for AFE drives with remote transformer/starter or integrated line reactor with remote starter.

Figure 111 - AFE/18-pulse Remote Transformer / Starter



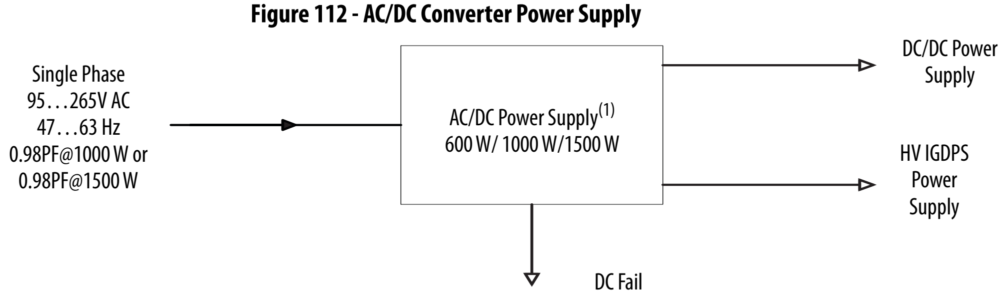
(1) Cosel power supply output is 57V DC, Pioneer power supply output (Heatpipe drives only) is 56V DC.

AC/DC Power Supply

The load demands on the AC/DC converters are the DC/DC converter and up to six IGDPS modules (up to three IGDPS modules for SPS drives). The DC/DC is a fixed load; however, the quantity of IGDPS modules will vary depending upon the drive configuration and whether SPS modules are used.

The AC/DC power supply accepts single phase voltage and produces a regulated 57V DC(1) output for the DC/DC power supply and the HV IGDPS modules that power the SGCTs. The input and output voltages are monitored and fail signals are annunciated upon either voltage going below a pre-set level.

Figure 112 - AC/DC Converter Power Supply



(1) Cosel Power Supply output is 57V DC, Pioneer Power Supply output is 56V DC

DC FAIL: Upon loss of DC output (V outputs ≤ 49V DC) this output goes from low to high. The AC/DC power supply is located in the low voltage panel at the top right-hand section of the drive. A typical low voltage compartment is shown in Figure 113.

(1) Cosel power supply output is 57V DC, Pioneer power supply output (Heatpipe drives only) is 56V DC.

Figure 113 - Location of AC/DC Pioneer Power Supply on LV Panel (Heatsink Model)

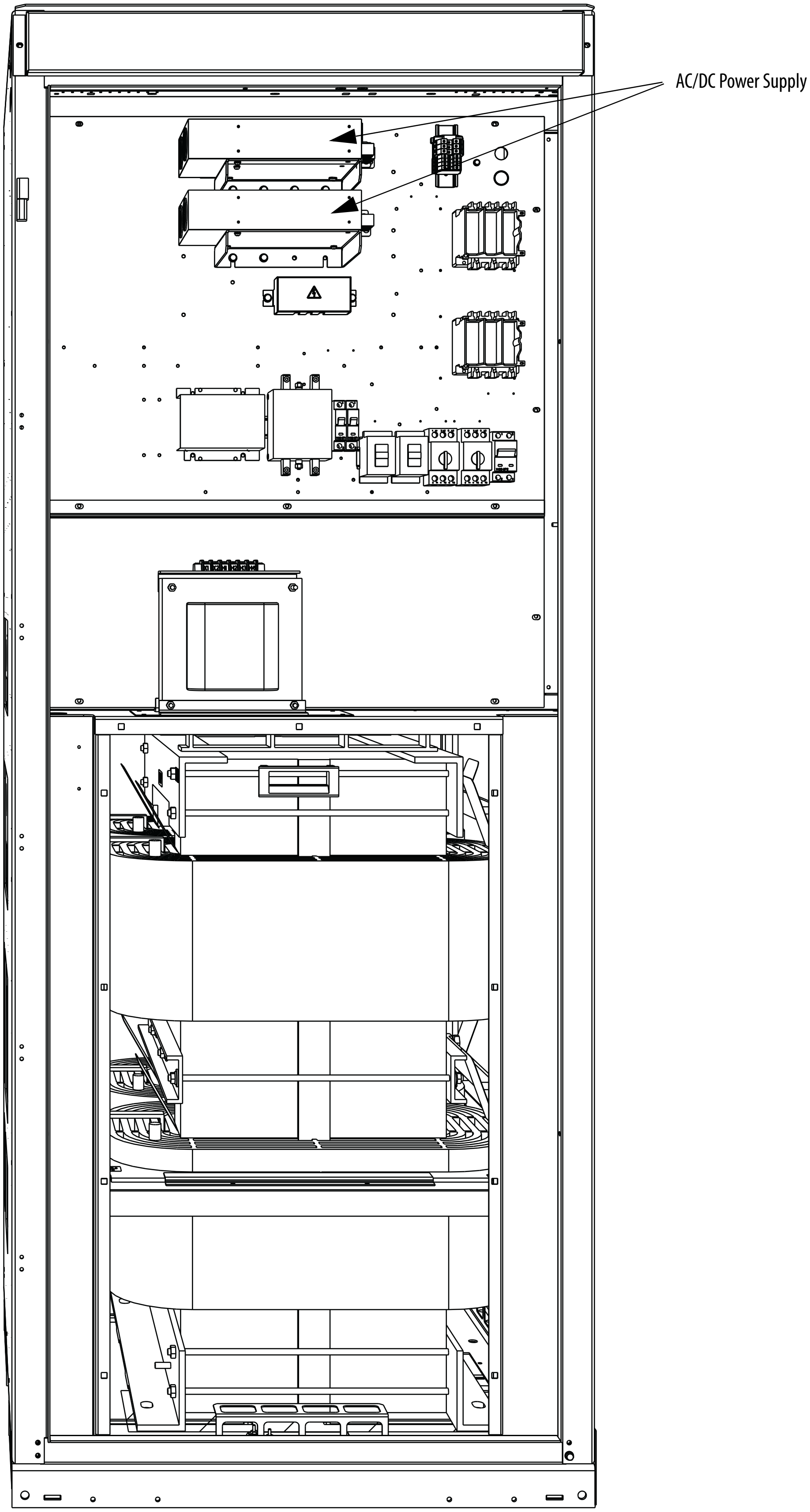
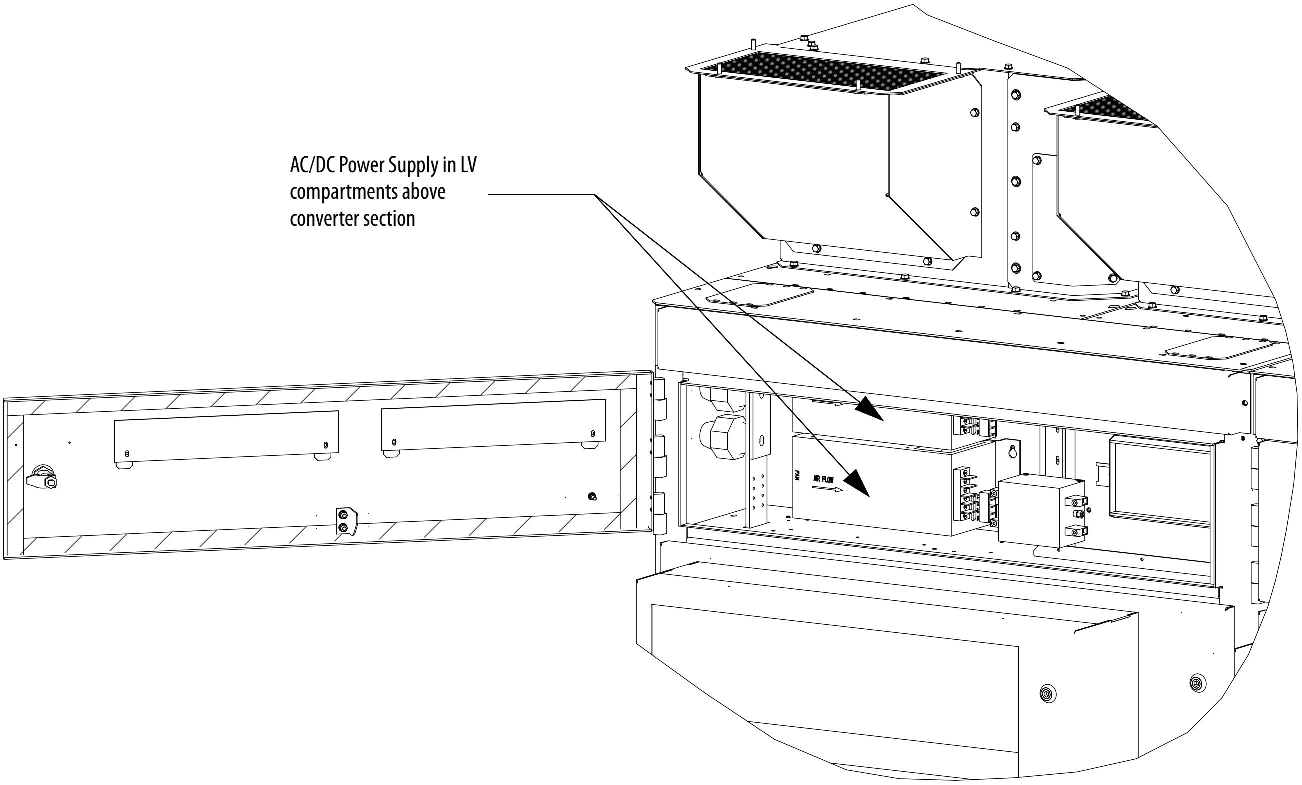


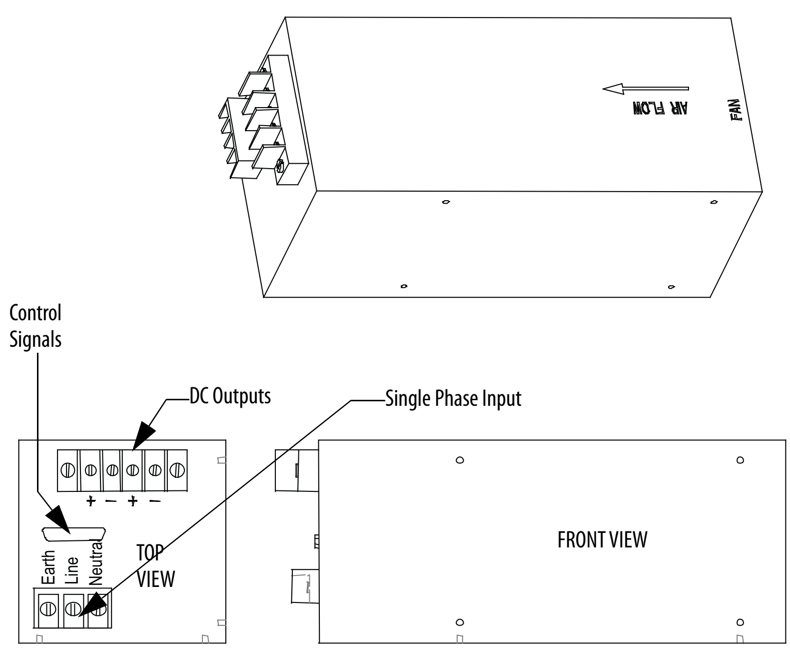
Figure 114 - Location of AC/DC Power Supply on LV Panel (Heatpipe Model)



Terminal / Connections Descriptions (Pioneer Power Supply)

The terminal connections are shown in Figure 115.

Figure 115 - Terminal Locations on AC/DC (Pioneer) Power Supply



	PIN#	LABEL
P1-AC input	1	EARTH
	2	LINE
	3	NEUTRAL
P2-DC output	1	+56V
	2	+56V COMM
	3	+56V
	4	+56V COMM
P3-FAIL output	3	DC POWER FAIL (OUTPUT POWER GOOD)
	15	CURRENT SHARING
	14	DC POWER FAIL COMMON

Terminal / Connections Descriptions (Cosel Power Supply)

The terminal connections are shown in Figure 116.

Figure 116 - Terminal Locations on 1000W AC/DC Power Supply (Cosel)

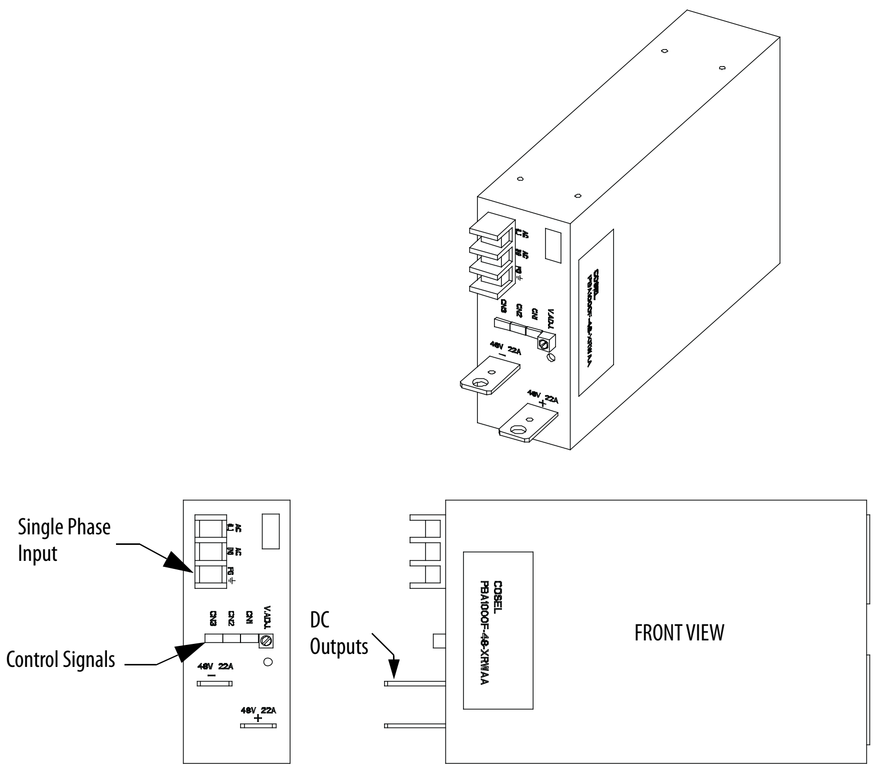
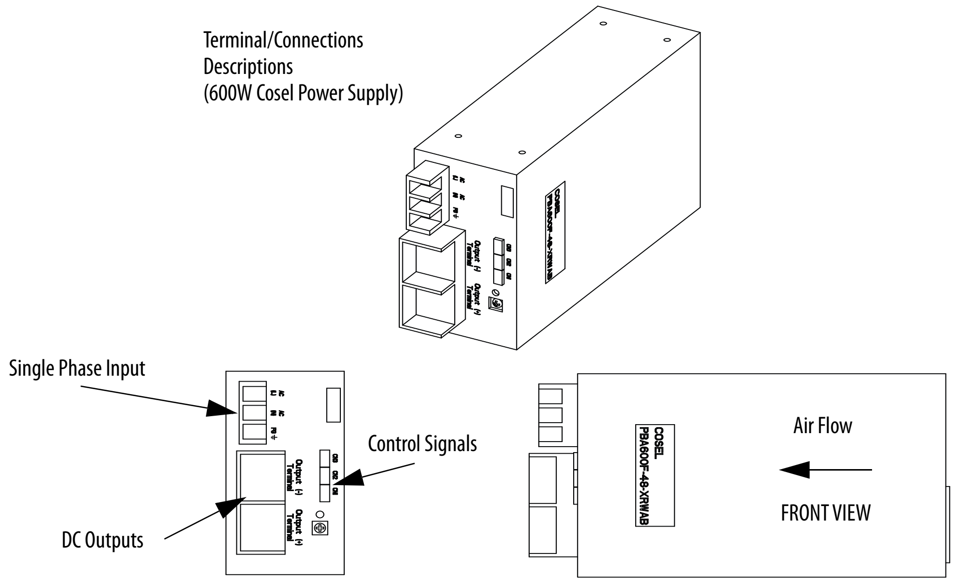


Figure 117 - Terminal Locations on 600W AC/DC Power Supply (Cosel)



P1-AC Input	PIN#	LABEL
	AC (L)	Live
	AC (N) (1500 W only)	Neutral (1500 W only)
	NC	No Connection
	FG	Earth
P2-DC Output	**PIN#**	**LABEL**
	+	+56V
	–	+56V COMM
P3-Fail Output	**PIN#**	**LABEL**
	CN1	1-2 Connected 3-4 Connected 5, 6, 7, 8, 9, 10 N/C
	CN2	N/C
	CN3	7 - Alarm 8 - Alarm GND

Output Calibration

Ensure the output of the supply is 56V DC(1).

There is a potentiometer on the top of the power supply that adjusts the 56V DC(1) output for the power supply. Isolate the output of the power supplies; multiple supplies in series will affect your measurements. With the control power on and the output of the AC/DC Converter isolated from the drive control, adjust the potentiometer until the output equals 56V DC(1). Perform this test on each power supply. When all adjustments are complete, reconnect the power supply to the circuit and re-measure the output. Readjust if necessary.

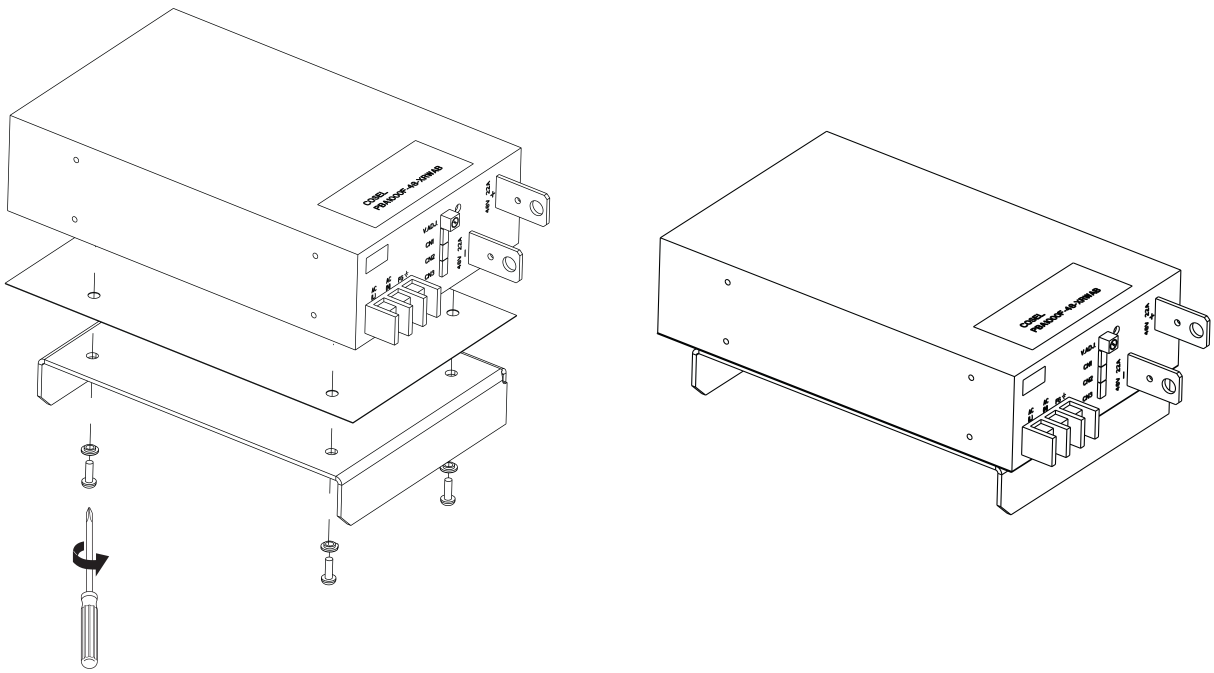
If it is not possible to maintain 56V DC(1), the power supply may be faulty.

(1) 56V DC for Pioneer and Cosel model numbers -XRWAC and earlier. 57V DC for Cosel model numbers -XRWAD and newer.

Power Supply Replacement

Follow these steps to replace a power supply.

1. Ensure control power is isolated and locked out.
2. Disconnect all the wiring terminals from the power supply unit.
3. Remove the four M6 bolts (Figure 118).
4. Extract the power supply complete with bracket from the drive.
5. Remove the bracket(s) from the failed power supply (four M4 screws and nylon shoulder washers).
6. Attach bracket to replacement power supply. Confirm the black polypropylene insulation is between the AC/DC power supply and the mounting plate(s).



7. Install the new power supply to the drive (Figure 118).
8. Reconnect the terminals to the unit.
9. Reapply control power and verify voltage levels.

Figure 118 - Replacing AC/DC Power Supply on LV Panel (Heatsink Model)

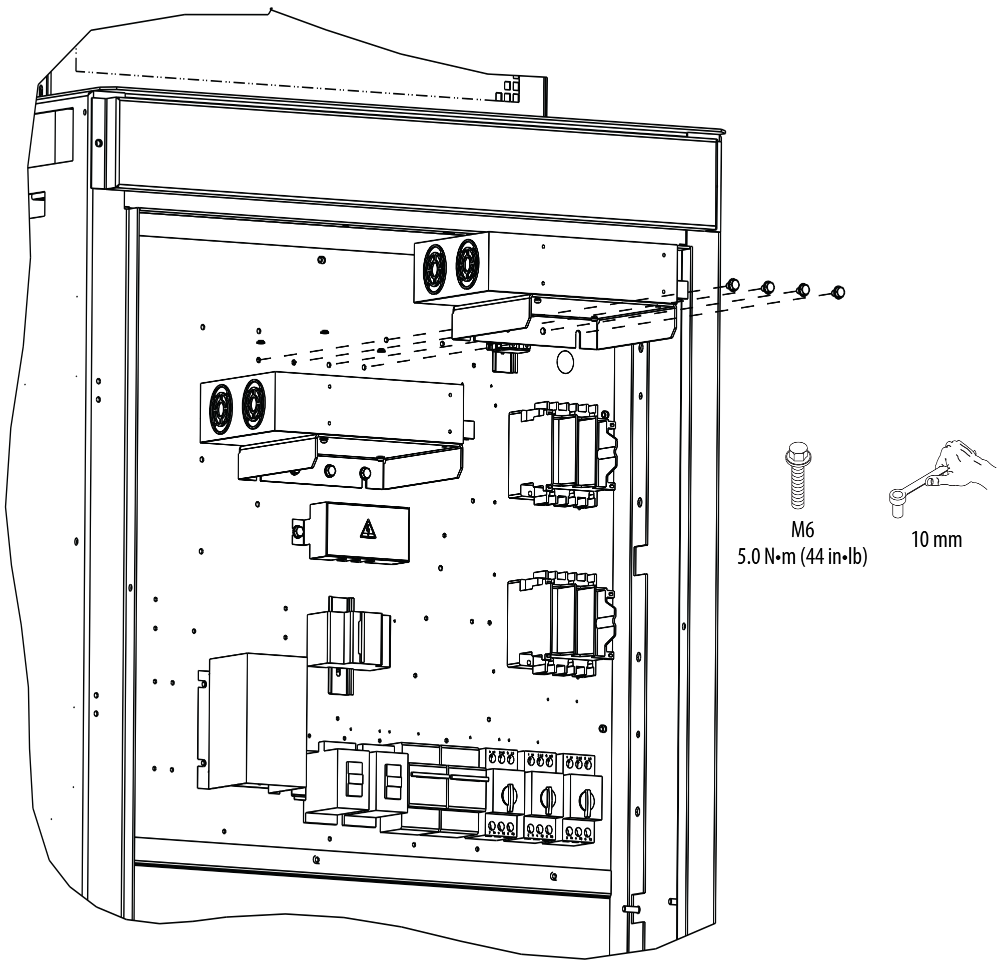
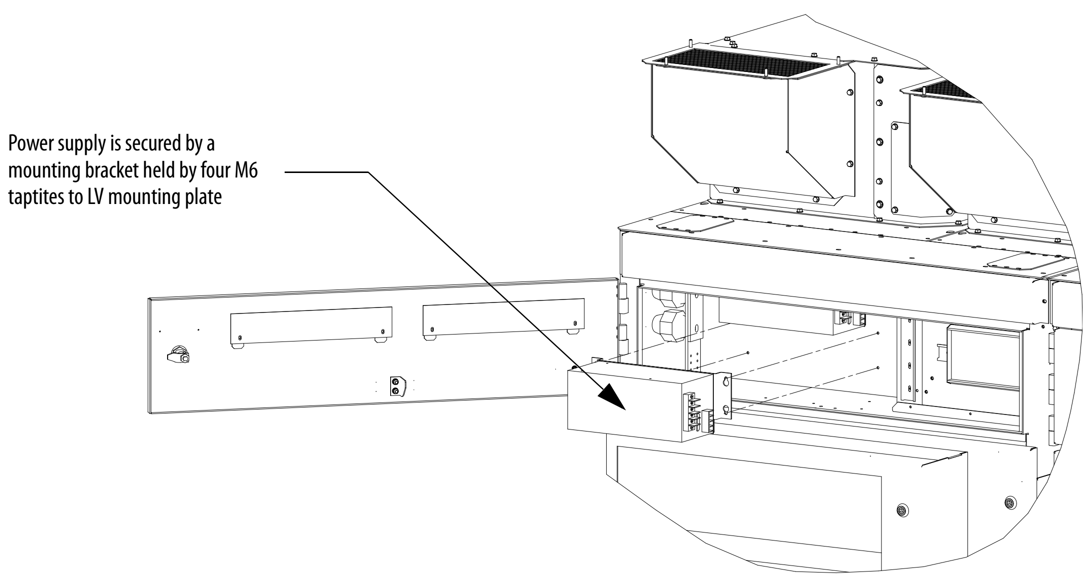


Figure 119 - Replacing AC/DC Power Supply on LV Panel (Heatpipe Model)



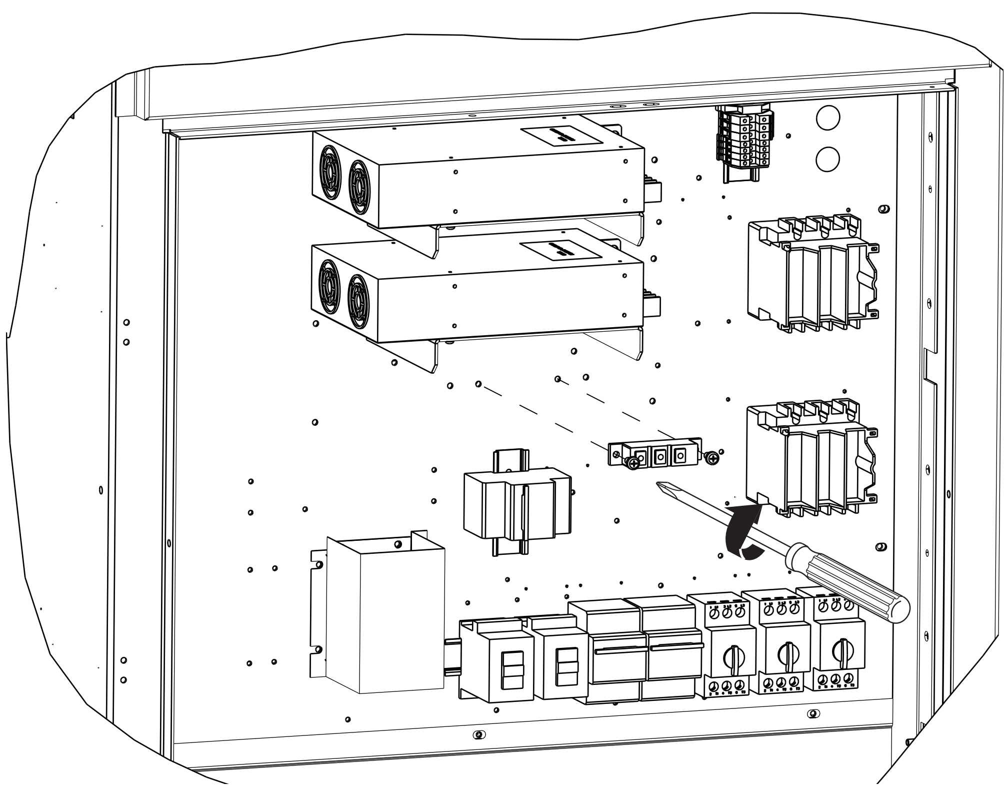
Power Supply Diode Replacement

IMPORTANT	If there are at least two power supplies, the drive is equipped with a power supply diode.

IMPORTANT	Depending on watt rating and number of power supplies, the location of the diode will differ depending on your configuration. The replacement procedure is the same.

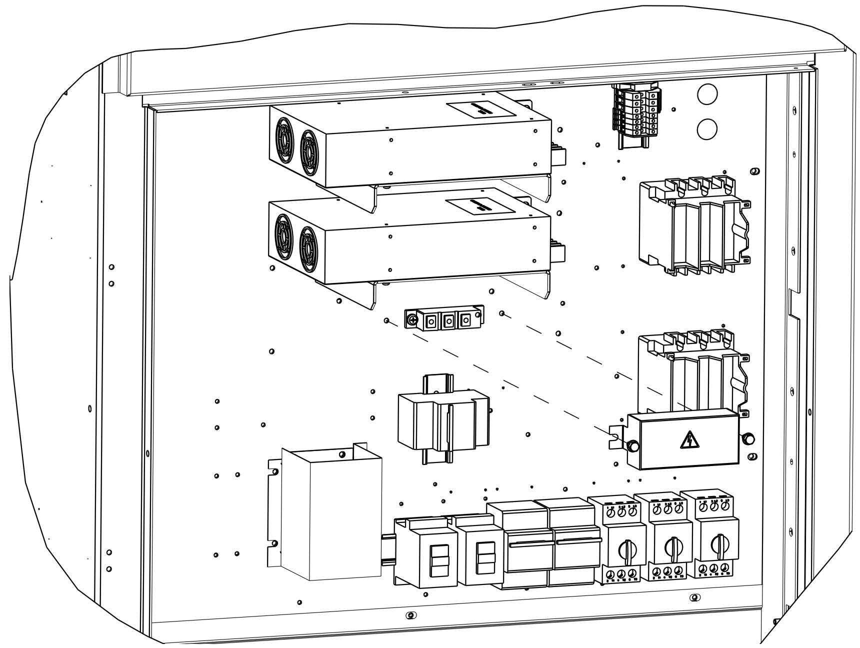
Follow these steps to replace the power supply diode.

1. Ensure control power is isolated and locked out.
2. Remove the diode cover and disconnect the wiring terminals on the diode.
3. Remove the power supply diode.
4. Clean any old thermal grease from the panel using isopropyl alcohol and allow the area to dry completely.
5. Apply thermal grease to the diode.
6. Install new power supply diode.



7. Reconnect the diode wiring removed in step 2.

8. Install the new power supply diode cover.



UPS Option

The drive has the option for internal and external UPS power to keep the control power active within the drive in the event of a control power loss. Figure 120 shows the current configuration of the internal UPS option.

Figure 120 - 300W AC/DC Power Supply (Heatsink)

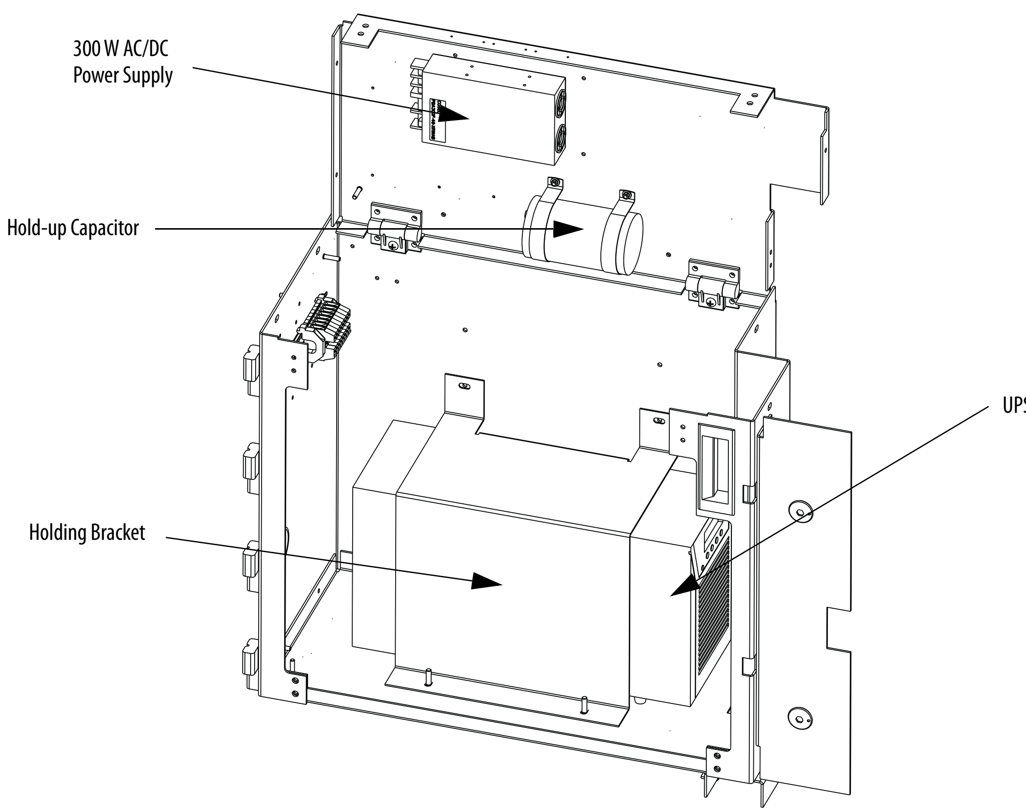
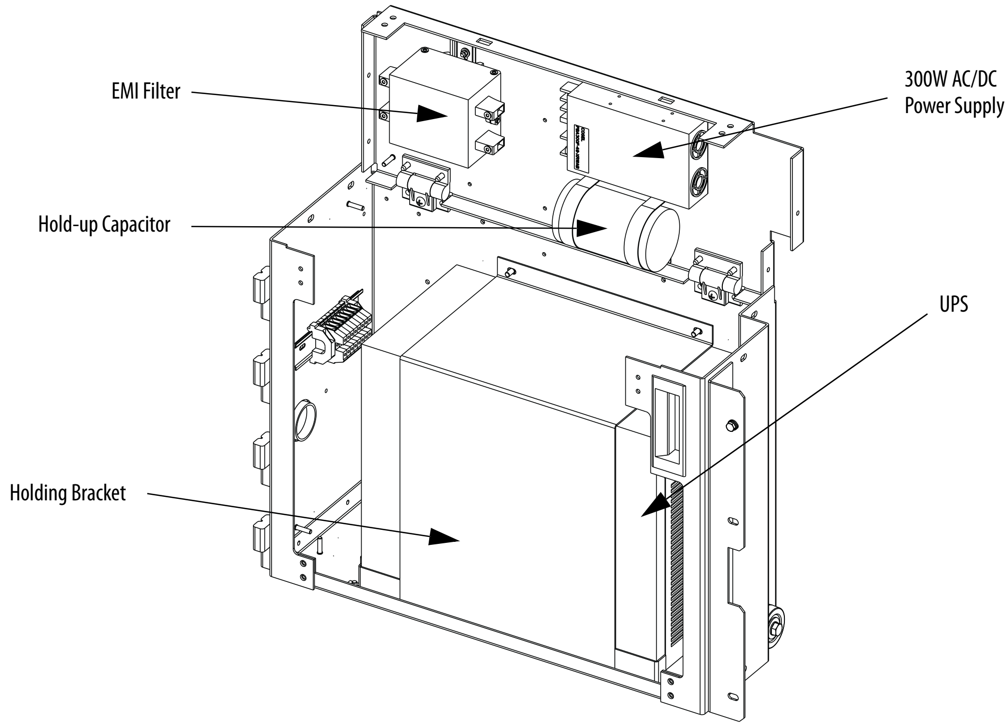


Figure 121 - 300W AC/DC Power Supply (Heatpipe Model)



The UPS is installed in the incoming cabling section, below the LV control section.

The UPS will maintain control power to all the critical 120VAC loads and an extra AC/DC power supply that feeds the DC/DC power supply for powering all the drive control components. The main drive cooling fan, and the AC/DC power supply that feeds the IGDPS boards are not powered from this UPS.

The UPS uses the AS400 communication protocol, and feeds several status signals back to the ACB to control responses to various conditions including low batteries, loss of input power, UPS on bypass, etc.

If you have an external UPS, the firmware will not expect any of the signals mentioned in the above section, and will not display any information relating to the UPS status. The firmware will operate in the same manner with respect to the operation of the drive with an internal or external UPS.

The output of the UPS feeds a 300W AC/DC power supply. This is 20% of the standard AC/DC power Supply used in the drive because the load represented by the DC/DC power Supply is much smaller than the load of the IGDPS boards, and we are able to reduce the size accordingly. We still use the standard AC/DC power supply to feed the IGDPS boards. The 300W AC/DC power supply has its AC input monitored by the UPS, and the DC output is monitored by the ACB board for fault conditions.

There is also a hold-up capacitor on the output of the 300W AC/DC power supply to maintain the 56VDC(1) in the event of a failure of the power supply.

(1) 56V DC for Pioneer and Cosel model numbers -XRWAC and earlier. 57V DC for Cosel model numbers -XRWAD and newer.

Replacing the UPS

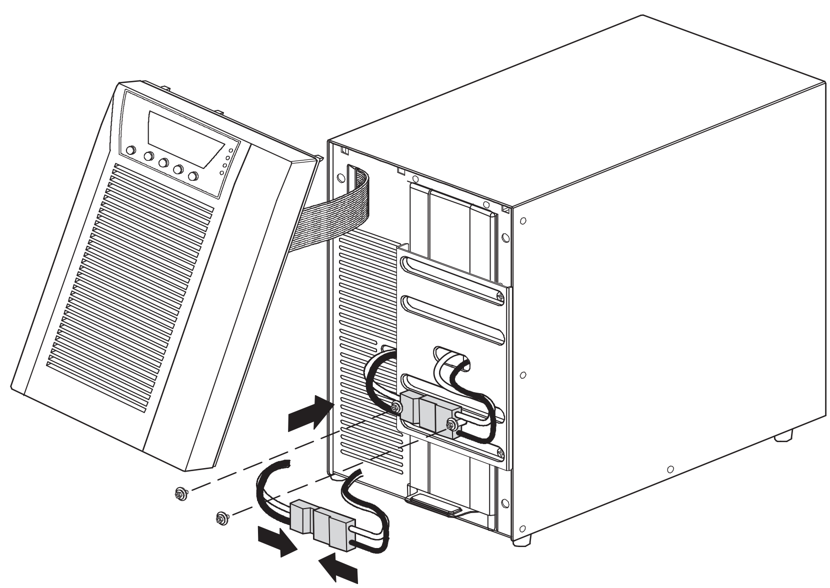
IMPORTANT	To replace the UPS battery, see the UPS user manual that was shipped with the drive.

1. Isolate and lock out the control power.
2. Remove the hardware that fastens the holding bracket to the cabinet assembly and remove the holding bracket.
3. Disconnect the input and output wiring connected to and from the UPS.
4. Disconnect the 15-pin status plug and remove the UPS.

ATTENTION: Before installing the new UPS, check the battery recharge date on the shipping carton label. If the date has passed and the batteries were never recharged, do not use the UPS. Contact Rockwell Automation.

5. Before installing the new UPS, the internal battery must be connected.(1)
   a. Remove the UPS front cover. Push down on the top of the cover and pull the cover towards you to unclip it from the cabinet.
   b. Connect the white connectors together, connecting red to red, and black to black. Verify there is a proper connection.
   c. Remove and retain the two screws from the screw mounts.
   d. Place the battery connector between the screw mounts. Reinstall the two screws to hold the connector in place.
   e. Replace the UPS front cover.

Figure 122 - Connect the internal UPS battery



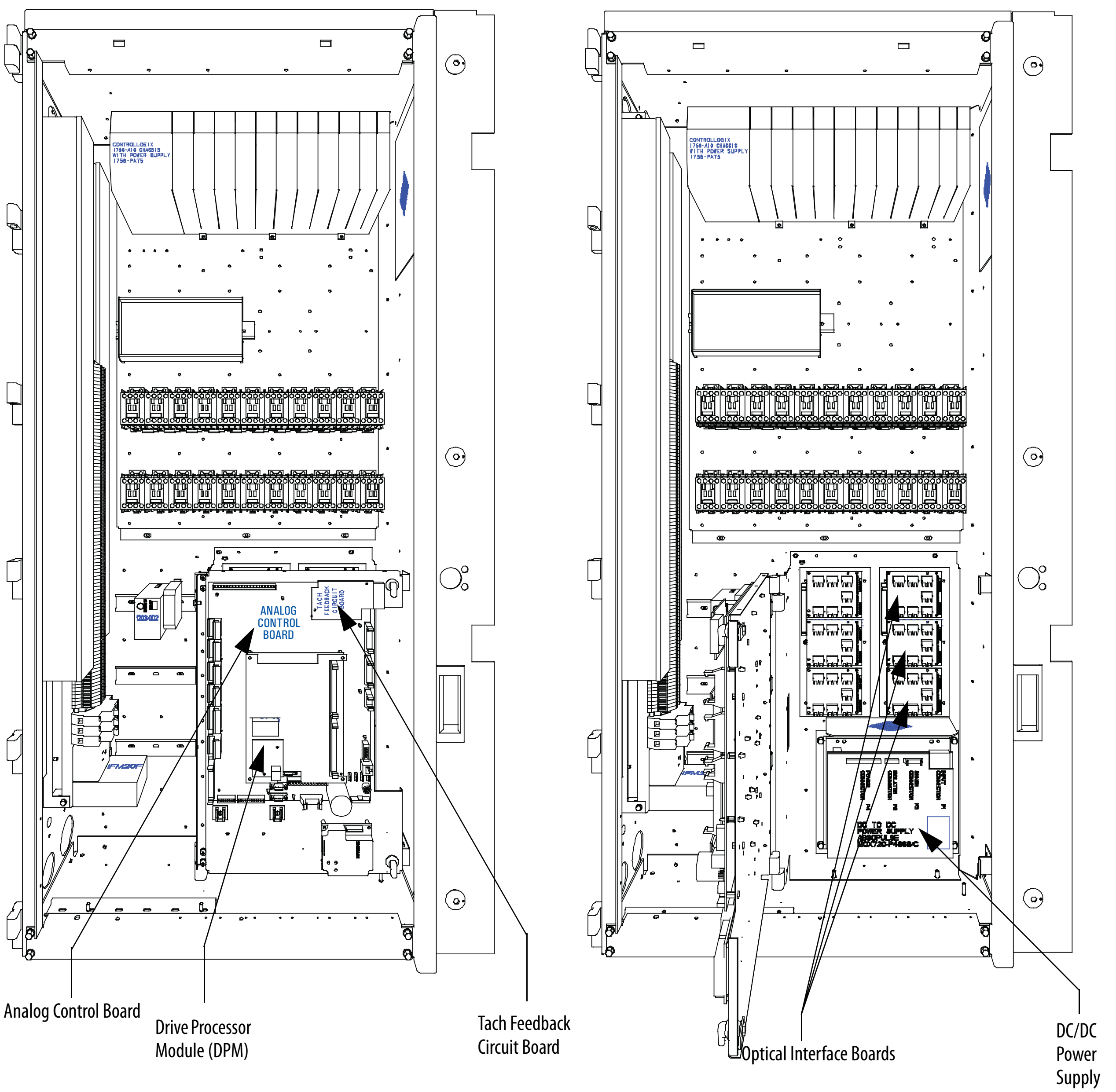
(1) Reprinted from 700-3000 VA User Manual by permission of Eaton Corporation.

6. Reconnect all the connections removed in the previous steps.
7. Before reconnecting the mounting bracket, apply control power to the unit and ensure the UPS is configured for the AS400 communication protocol. See the manual that comes with the UPS for instructions.
8. Once this has been confirmed, install the mounting bracket.

Low Voltage Control Section

The low voltage control section houses all of the control circuit boards, relays, operator interface terminal, DC/DC power supply, and most other low voltage control components. See Figure 123 for a generic representation of a low voltage tub arrangement.

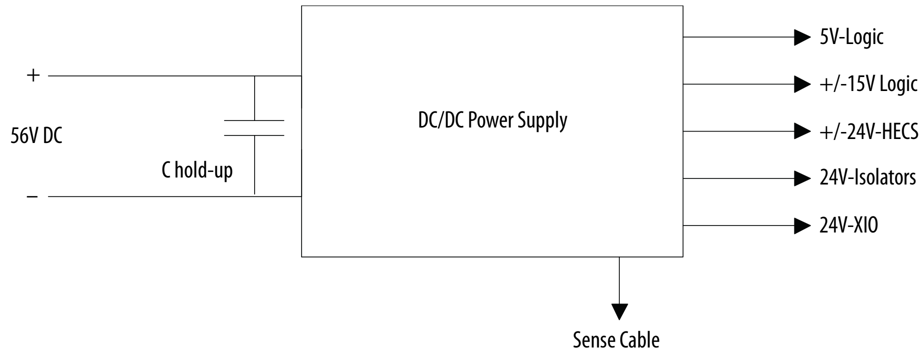
Figure 123 - Low Voltage Tub Compartment



DC/DC Power Supply

The DC/DC power supply provides a source of regulated DC voltages for various logic control boards and circuits., using a regulated 56V DC source.

Figure 124 - DC/DC Converter Power Supply



The capacitor at the input terminals enables the equipment to ride through power dips. If the capacitor (C hold-up) loses the 56V[1] input, it maintains the voltage level for a period of time to enable a controlled shut-down. This component is not required in all configurations.

Due to the critical nature of the ACB/DPM Logic power source, the DC/DC power supply provides redundancy for the 5V rail. There are two separate 5V outputs, each capable of powering the logic boards. In the event of one failing, the drive switches to the other power supply automatically to provide the output power.

(1) 56V DC for Pioneer and Cosel model numbers -XRWAC and earlier. 57V DC for Cosel model numbers -XRWAD and newer.

Terminal/Connections Descriptions

P1 – DC Input	PIN NO.	LABEL	DESCRIPTION ONLY
	1	+56V	+56V input
	2	+56V COMM	+56V common
	3	EARTH	earth ground

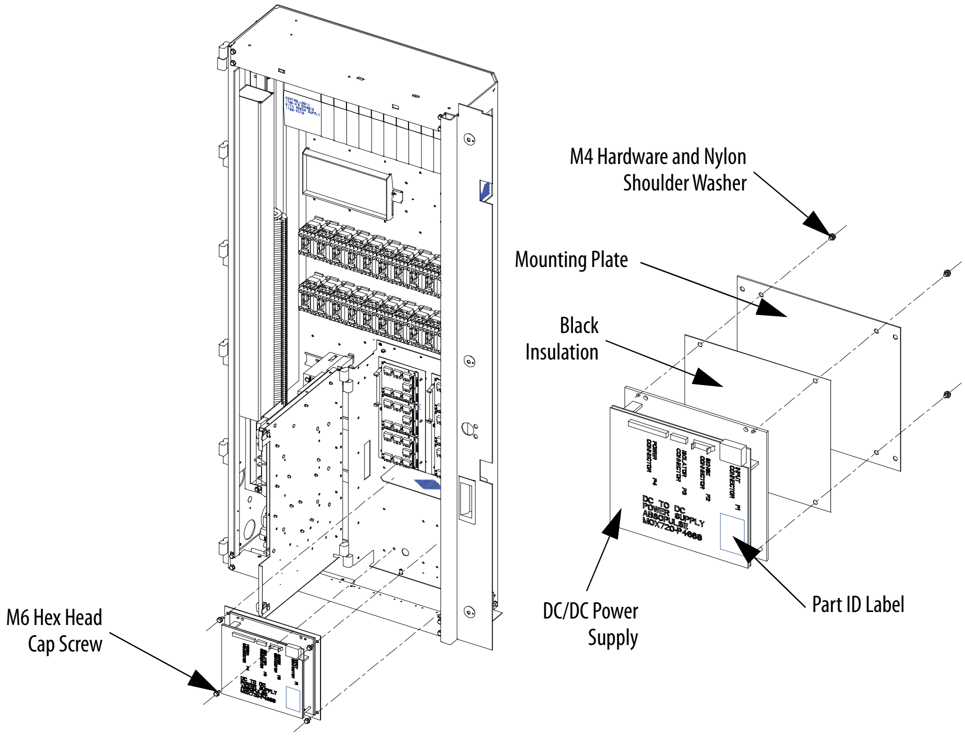
P2 – SENSE (To ACB)	PIN NO.	LABEL	DESCRIPTION ONLY
	1	+56V	+56V input supply
	2	+56V RTN	+56V input supply return
	3	NC	Not connected
	4	NC	Not connected
	5	+24V	Isolated +24V supply
	6	+24V RTN	Isolated +24V supply return
	7	NC	Not connected
	8	NC	Not connected
	9	+5VA	Primary +5V supply, before OR'ing diode
	10	DGND(com1)	+5V, +/-15V common
	11	+5VB	Secondary +5V supply, before OR'ing diode
	12	DGND(com1)	+5V, +/-15V common
	13	ID0	Power supply ID Pin 0
	14	ID1	Power supply ID Pin 1

P3 – ISOLATOR (To Isolator Modules)	PIN NO.	LABEL	DESCRIPTION ONLY
	1	ISOLATOR (+24V,1A)	+24V,1A/com4
	2	ISOL_COMM (com4)	0V/com4
	3	EARTH	EARTH

P4 – PWR (To ACB)	PIN NO.	LABEL	DESCRIPTION ONLY
	1	+24V_XIO (+24V,2A)	+24V,2A/com3
	2	XIO_COMM (com3)	0V/com3
	3	+HECSPWR (+24V,1A)	+24V,1A/com2
	4	LCOMM (com2)	0V/com2
	5	–HECSPWR (-24V,1A)	-24V,1A/com2
	6	+15V_PWR (+15V,1A)	+15V,1A/com1
	7	ACOMM (com1)	0V/com1
	8	–15V_PWR (-15V,1A)	-15V,1A/com1
	9	+5V_PWR (+5V,5A)	+5V,5A/com1
	10	DGND (com1)	0V/com1
	11	EARTH	earth ground

Replacing a DC/DC Power Supply

Figure 125 - Replacing a DC/DC Power Supply



1. With the drive energized, check that all output voltages are present (view 1).
2. De-energize the drive, isolate and lock out the control power, and remove all wire connections from the unit (view 1).
3. Remove four M6 (H.H.T.R.S.) so you can remove the DC/DC power supply assembly from the low voltage panel (view 1).
4. Remove four M4 (P.H.M.S.) and nylon shoulder washers from the back of the mounting plate (view 2).
5. Install the new DC/DC power supply. Ensure you replace the black insulation between the DC/DC power supply and the mounting plate. Repeat steps 4, 3, 2, 1 in this order to replace unit (view 2).
6. Reconnect the P4 plug ground wire to the ground by the M10 bolt.

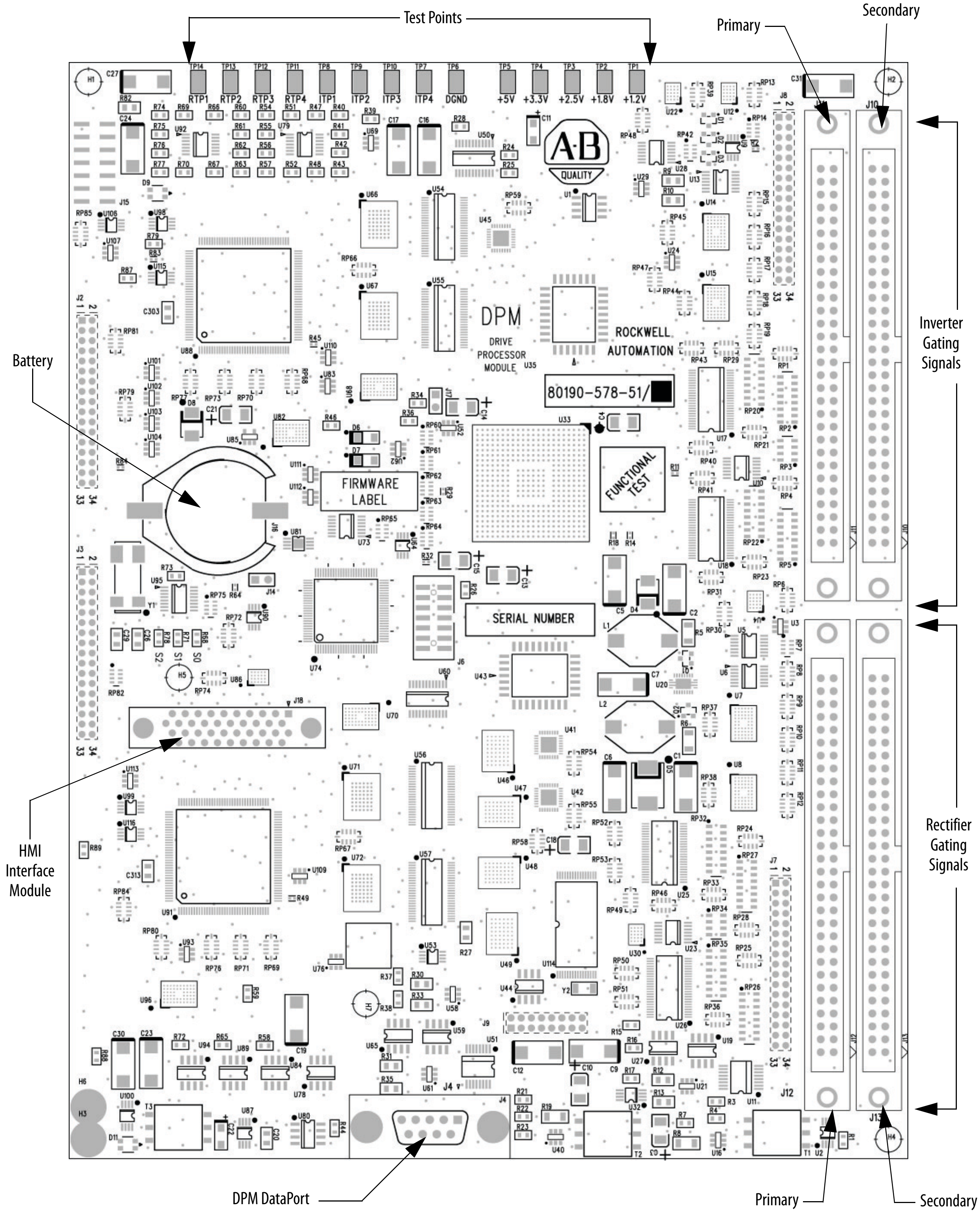
Take the following precaution when replacing printed circuit boards.
- Disconnect all drive power.
- Leave the replacement board in the anti-static bag until needed.
- Use an anti-static wrist strap, grounded in the low voltage control section.

There are no direct screw/terminal connections on any of the low voltage circuit boards. All wire/terminal connections plug into the circuit boards. This means that changing boards only requires the removal of the plugs, minimizing the chance of mistakes when reconnecting all of the wiring.

Drive Processor Module

This board contains control processors, which are responsible for all the drive control processing and stores the parameters used for the drive control.

Figure 126 - Drive Processor Module (DPM)



Diagnostic test points on the DPM have a voltage output range of -5…+5V. Table 5 identifies test points on the DPM.

Table 5 - Test Points on Drive Processor Module

Test points	Name	Description
DPM-TP1	+1.2V	+1.2V DC power supply
DPM-TP2	+1.8V	+1.8V DC power supply
DPM-TP3	+2.5V	+2.5V DC power supply
DPM-TP4	+3.3V	+3.3V DC power supply
DPM-TP5	+5V	+5V DC power supply
DPM-TP6	DGND	Digital ground
DPM-TP7	ITP1	Digital to analog output – Assignable diagnostic test point
DPM-TP8	ITP2	Digital to analog output – Assignable diagnostic test point
DPM-TP9	ITP3	Digital to analog output – Assignable diagnostic test point
DPM-TP10	ITP4	Digital to analog output – Assignable diagnostic test point
DPM-TP11	RTP1	Digital to analog output – Assignable diagnostic test point
DPM-TP12	RTP2	Digital to analog output – Assignable diagnostic test point
DPM-TP13	RTP3	Digital to analog output – Assignable diagnostic test point
DPM-TP14	RTP4	Digital to analog output – Assignable diagnostic test point

This table defines the states of LEDs D9 and D11 on the DPM board, which uses D9 for the inverter side processor, and D11 for the rectifier side processor. The other two LEDs (D6 and D7) are the watchdogs for the inverter and rectifier code respectively.

Table 6 - Description of D6 and D7 Function

Color	Rate or Count (Pulse)	Meaning
Green	Solid	Application firmware is running

Table 7 - Description of D9 and D11 Function: Boot Code Status

Color	Rate or Count (Pulse)	Meaning
Green	10 count	Pre-execution OK
Red	.25 Hz	No bootcode
Green	.25 Hz	No application
Green	.5 Hz	Downloading via serial port
Green	2 Hz	Serial port active – terminal
Green	1 Hz	Waiting/loading application
Green	Solid	Application running
Red	Solid	Operation failed
Red	2 count	POST – RAM failed
Red	3 count	POST – NVRAM failed
Red	4 count	POST – DPRAM failed

Table 7 - Description of D9 and D11 Function: Boot Code Status (Continued)

Color	Rate or Count (Pulse)	Meaning
Red	8 count	FPGA Loading failed
Red	9 count	POST – USART failed: 1 Green Count = Port 1 2 Green Count = Port 2
Red	10 count	End of code reached
Red	11 count	Download – CRC error
Red	14 count	Download – Overflow error

If the application is running, there are two other possible states for D9 and D11, described below.

Table 8 - Alternate D9 and D11 Descriptions

LED	State	Meaning
D9 (Inv)	Off	Parameter load timeout
D11(Rect)	Red	FPGA real-time clock failed

Replacing the Drive Processor Module

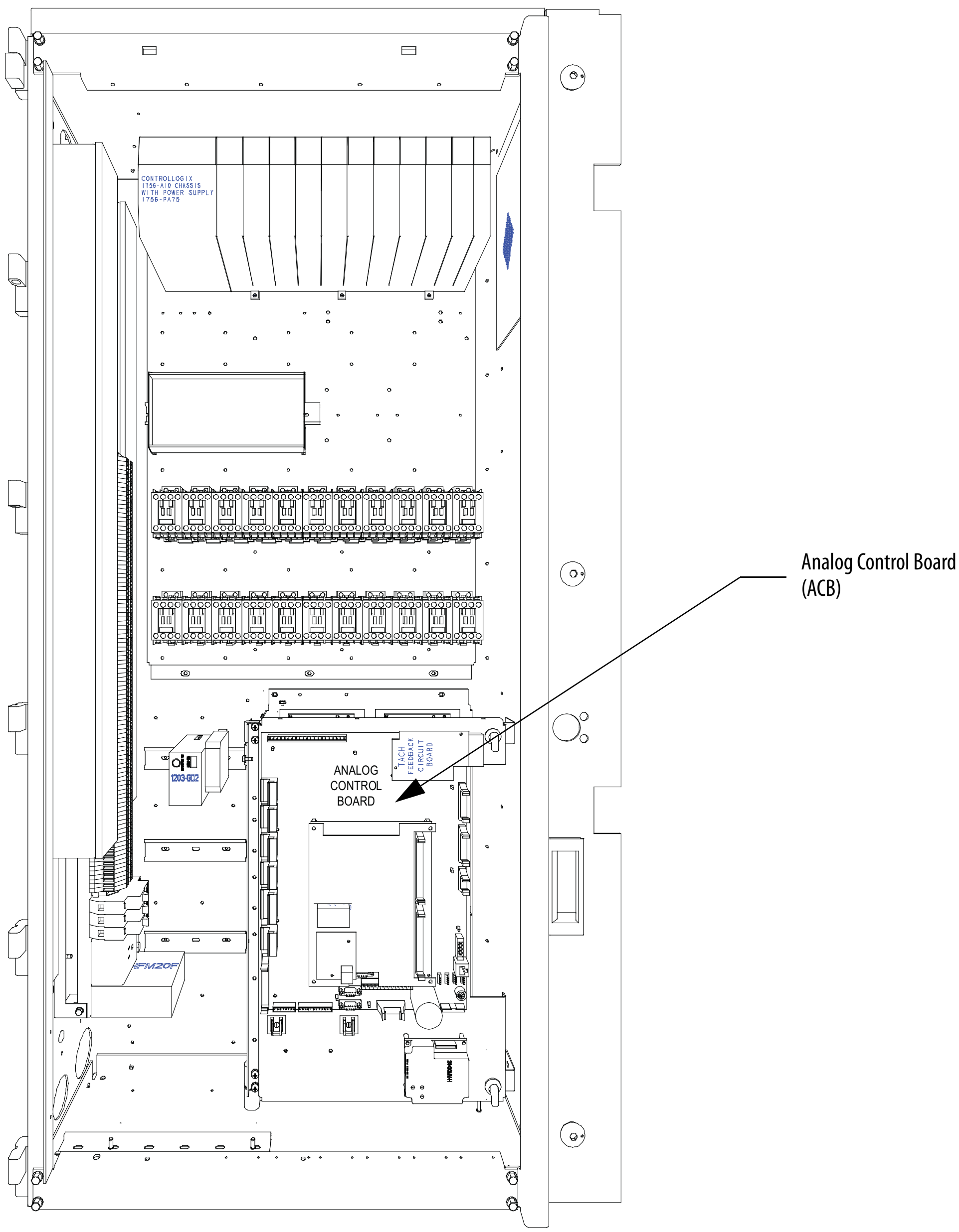
Before replacing the drive processor module, record all of the programmed drive parameters and settings; specifically, the parameters, fault masks, fault descriptions, and PLC links. This information resides in NVRAM on each board, and as a result you may lose your settings with a new board. Save parameters in the terminal memory. Other options include a flashcard, HyperTerminal, the door-mounted printer, or DriveTools™ software to record the parameters to a file. The printer and HyperTerminal options enable you to print configuration information. Otherwise, record information by hand. If a board fails, you likely cannot save parameters after the failure.

Save all parameters after commissioning or servicing the drive. If you do not have a copy of the initial configuration or current parameters, contact your Rockwell sales or service representative or Product Support to check if they have a copy.

1. Record all drive configuration using one of the options above.
2. Isolate and lock out all medium voltage and control voltage power to the drive.
3. Remove the transparent sheet on top of the drive processor module by removing the four screws.
4. Use a grounding static strap before removing any connectors.
5. Remove the connectors J4, J11 and J12 after proper identification and marking if necessary. Use the electrical drawing as the reference.
6. Remove the four screws on the corners of the board fastening the board to the standoffs on the analog control board.

7. Remove the drive processor module from the four, 34-pin female connectors and one, 16-pin female connector on the ACB.
8. Remove the DIM module from the DPM and plug it on the new DPM before replacing the DPM.
9. Reverse steps 7 – 3 to re-install the boards into the low voltage control cabinet.
10. Apply control power to the drive. The DPMs ship without installed firmware, so the drive will shift into download mode. Install firmware in the drive by following the guidelines the installation manual.
11. Program the drive. See publication 7000-TD002. Save the parameters to NVRAM and externally, using the options described earlier in this section.

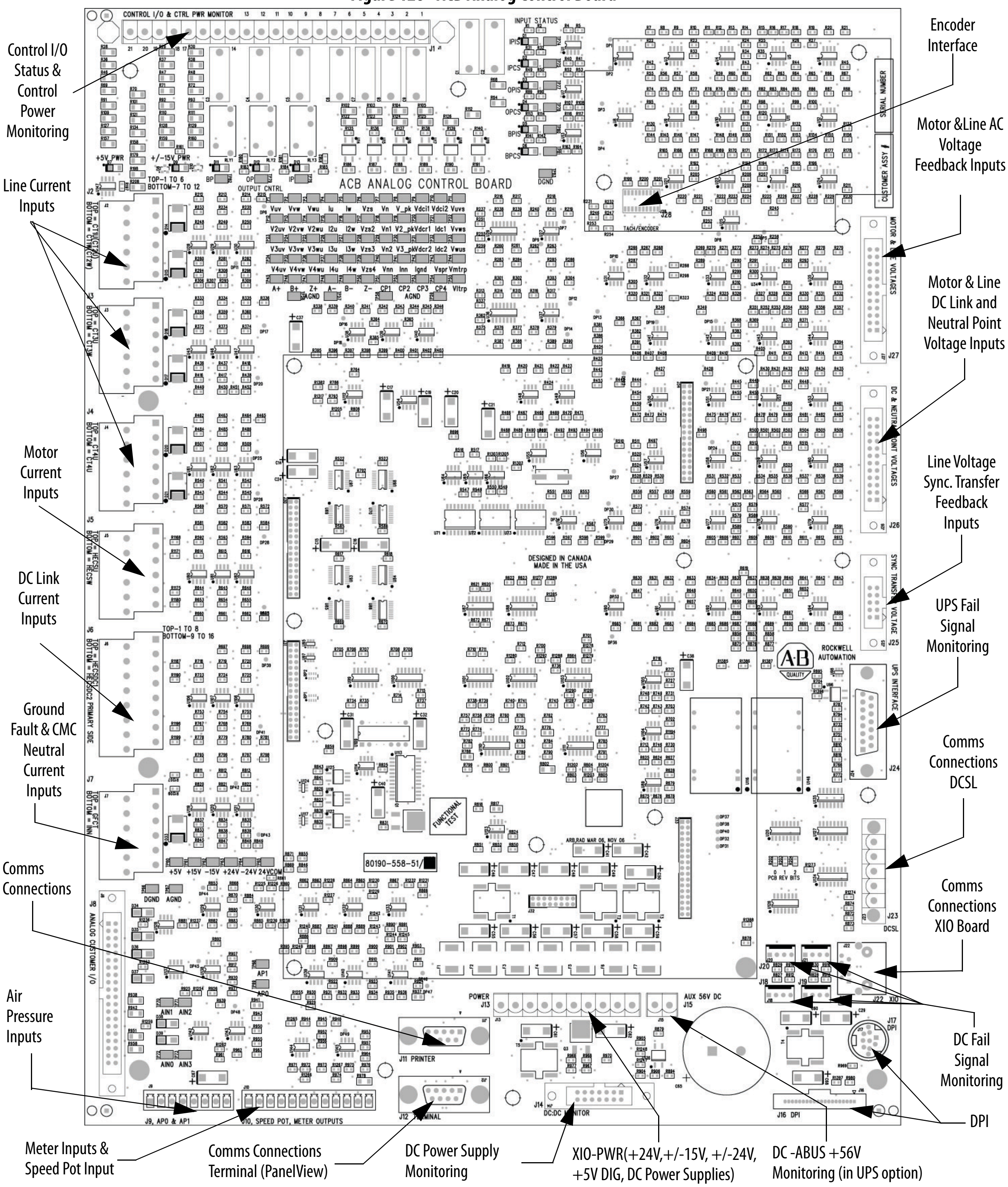
Figure 127 - ACB and DPM Replacement



Analog Control Board (ACB)

The ACB is the hub for all control-level signals external to the drive. The drive routes analog I/O, external fault signals (through the XIO board), DPI communication modules, remote I/O, terminal interface, printers, modem, and other external communication devices through this board.

Figure 128 - ACB Analog Control Board



The analog control board receives all of the analog signals from the internal components of the drive. This includes the current and voltage feedback signals. The board also has isolated digital I/O for e-stops, contactor control and status feedback. All of the test points for the currents, system voltages, control voltages, and flux are on these boards.

Table 9 - Connectors on Analog Control Board

ACB Connectors	Description
ACB-J1	Control I/O and control power monitor
ACB-J2	Line current inputs, CT2U, CT2W
ACB-J3	Line current inputs, CT3U, CT3W
ACB-J4	Line current inputs, CT4U, CT4W
ACB-J5	Motor current inputs, HECSU, HECSW
ACB-J6	DC Link current inputs, HECSDC1, HECSDC2
ACB-J7	Ground fault and CMC neutral current inputs, GFCT, INN
ACB-J8	Isolated and non-isolated analog inputs, AIN1, AIN2, AIN3 and non-isolated outputs, AOUT1, AOUT2, AOUT3, AOUT4
ACB-J9	Air pressure inputs, AP0,AP1
ACB-J10	Meter outputs, AOUT5, AOUT6, AOUT7, AOUT8 and speed pot input, AIN0
ACB-J11	Communication connections, printer outputs
ACB-J12	Communication connections, terminal
ACB-J13	DC power supplies, XIO(+24V),+/-15V,+/-24V,+5V
ACB-J14	DC power supply monitoring, 5V1,5V2, DC-BUS
ACB-J15	DC-ABUS +56V output monitoring (UPS option)
ACB-J16	DPI interface
ACB-J17	Communication connections, scan port
ACB-J18	DC fail signal monitoring
ACB-J19	DC fail signal monitoring
ACB-J20	DC fail signal monitoring
ACB-J21	DC fail signal monitoring
ACB-J22	Communication connection, XIO link CAN interface
ACB-J23	Communication connection, parallel drive
ACB-J24	UPS fail signal monitoring
ACB-J25	Line voltage synchronous transfer feedback voltage inputs VSA,VSB,VSC
ACB-J26	Motor & line DC link and neutral point voltage inputs
ACB-J27	AC motor and line voltage feedback inputs
ACB-J28	Encoder interface
ACB-J30	DPM connection, A/D SUB system
ACB-J31	DPM connection, DACs serial data
ACB-J32	DPM power supply, +5V
ACB-J33	DPM connection, faults, and other I/O
ACB-J34	DPM connection, encoder

Table 10 - Test Points on Analog Control Board

Test points	Name	Description
ACB-TP1	Vuv	Motor voltage feedback, UV
ACB-TP2	Vvw	Motor voltage feedback, VW
ACB-TP3	Vwu	Motor voltage feedback, WU
ACB-TP4	Iu	Motor current, HECSU
ACB-TP5	Iw	Motor current, HECSW
ACB-TP6	Vzs	Zero sequence generation motor side, VZS
ACB-TP7	Vn	Motor side filter CAP neutral voltage, MFCN
ACB-TP8	V_pk	Motor over voltage detection for UVW
ACB-TP9	Vdci1	Motor side DCLINK voltage for bridge #1, VMDC1
ACB-TP10	Vdci2	Motor side DCLINK voltage for bridge #2, VMDC2
ACB-TP11	Vuvs	Line voltage synchronous feedback, VSAB
ACB-TP12	V2uv	Line voltage feedback, 2UV
ACB-TP13	V2vw	Line voltage feedback, 2VW
ACB-TP14	V2wu	Line voltage feedback, 2WU
ACB-TP15	I2u	Line current, CT2U
ACB-TP16	I2w	Line current, CT2W
ACB-TP17	Vzs2	Zero sequence generation line side, VZS2
ACB-TP18	Vn1	Line filter CAP neutral voltage for bridge #1, LFCN1
ACB-TP19	V2_pk	AC over voltage detection for 2UVW
ACB-TP20	Vdcr1	Line side DCLINK voltage for bridge#1, VLDC1
ACB-TP21	Idc1	DCLINK current, HECSDC1
ACB-TP22	Vvws	Line voltage synchronous feedback, VSBC
ACB-TP23	V3uv	Line voltage feedback, 3UV
ACB-TP24	V3vw	Line voltage feedback, 3VW
ACB-TP25	V3wu	Line voltage feedback, 3WU
ACB-TP26	I3u	Line current, CT3U
ACB-TP27	I3w	Line current, CT3W
ACB-TP28	Vzs3	Zero sequence generation line side, VZS3
ACB-TP29	Vn2	Line filter CAP neutral voltage for bridge #2, LFCN2
ACB-TP30	V3_pk	AC over voltage detection for 3UVW
ACB-TP31	Vdcr2	Line side DCLINK voltage for bridge#2, VLDC2
ACB-TP32	Idc2	DCLINK current, HECSDC2
ACB-TP33	Vwus	Line voltage synchronous feedback, VSCA
ACB-TP34	V4uv	Line voltage feedback,4UV
ACB-TP35	V4vw	Line voltage feedback,4VW
ACB-TP36	V4wu	Line voltage feedback,4WU
ACB-TP37	I4u	Line current,CT4U
ACB-TP38	I4w	Line current, CT4W
ACB-TP39	Vzs4	Zero sequence generation line side,VZS4 (spare one)

Table 10 - Test Points on Analog Control Board (Continued)

Test points	Name	Description
ACB-TP40	Vnn	CMC neutral voltage, VNN
ACB-TP41	Inn	CMC neutral current, INN
ACB-TP42	Ignd	Ground fault current, GFCT
ACB-TP43	Vspr	Spare channel for inputs
ACB-TP44	Vmtrp	Motor over voltage detection set point
ACB-TP45	A+	Encoder A+ input
ACB-TP46	B+	Encoder B+ input
ACB-TP47	Z+	Encoder Z+ input
ACB-TP48	A-	Encoder A- input
ACB-TP49	B-	Encoder B- input
ACB-TP50	Z-	Encoder Z- input
ACB-TP51	CP1	Control power monitoring for channel 1
ACB-TP52	CP2	Control power monitoring for channel 2
ACB-TP53	CP3	Control power monitoring for channel 3
ACB-TP54	CP4	Control power monitoring for channel 4
ACB-TP55	Vltrp	AC over voltage detection set point for 2UVW & 3UVW
ACB-TP56	AGND	Analog ground
ACB-TP57	AGND	Analog ground
ACB-TP58	AGND	Analog ground
ACB-TP59	AGND	Analog ground
ACB-TP60	+5V	+5V DC power supply
ACB-TP61	+15V	+15V DC power supply
ACB-TP62	-15V	-15V DC power supply
ACB-TP63	+24V	+24V DC power supply
ACB-TP64	-24V	-24V DC power supply
ACB-TP65	24VCOM	+/- 24V common
ACB-TP66	DGND	Digital ground
ACB-TP67	AGND	Analog ground
ACB-TP68	AP1	Analog control inputs, air pressure input, AP1
ACB-TP69	AP0	Analog control inputs, air pressure input, AP0
ACB-TP70	AIN1	Analog control input, AIN1
ACB-TP71	AIN2	Analog control input, AIN2
ACB-TP72	AIN0	Analog control input, AIN0
ACB-TP73	AIN3	Analog control input, AIN3
ACB-TP74	IPIS	Input isolating switch
ACB-TP75	IPCS	Input contactor status
ACB-TP76	IP	Input contactor command
ACB-TP77	OPIS	Output isolating switch
ACB-TP78	OPCS	Output contactor status

Table 10 - Test Points on Analog Control Board (Continued)

Test points	Name	Description
ACB-TP79	OP	Output contactor command
ACB-TP80	BPIS	Bypass isolating switch
ACB-TP81	BPCS	Bypass contactor status
ACB-TP82	BP	Bypass contactor command
ACB-TP83	DGND	Digital ground return

Status Indicators

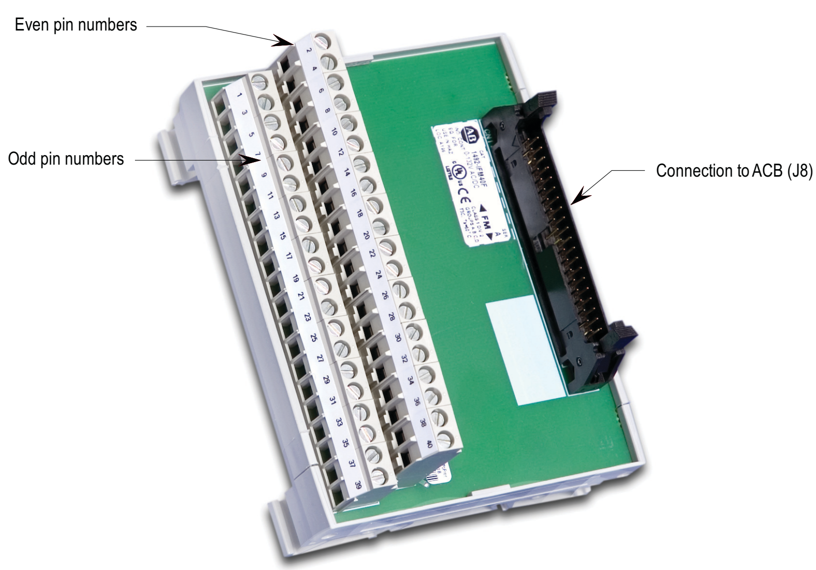
There are two power status indicators on the ACB labeled D7 and D9:

- D9 is the ±15V DC voltage-OK signal
- D7 is the +5V DC voltage present signal.

Interface Module (IFM)

The interface module makes all your connections to the ACB. The pin numbers listed on the following pages refer to the IFM pin numbers.

Figure 129 - Interface Module (IFM)



Analog Inputs and Outputs

The PowerFlex™ 7000 drive offers one isolated process current loop transmitter and three isolated process current loop receivers, embedded into the control. These are accessible on the ACB.

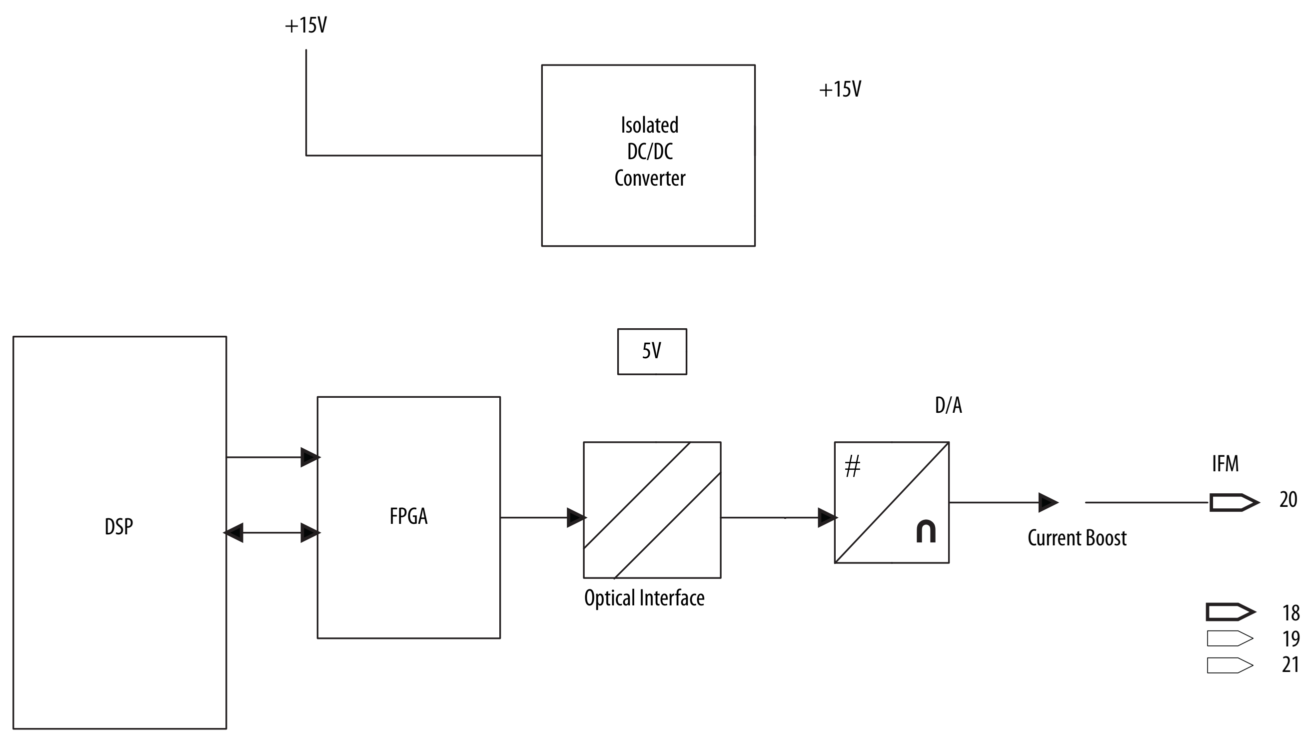
The isolated process output is configured as 4-20 mA. The three isolated process inputs are individually configurable for either a range of -10/0/+10V or 4-20 mA.

The following information details the connections for each input and output.

Current Loop Transmitter

The current loop transmitter sends a 4-20 mA output to an external receiver. The loop compliance on the transmitter is 12.5V. Loop compliance is the maximum voltage at which a transmitter can generate to achieve the maximum current and is usually a function of the power supply voltage. Therefore, the PowerFlex 7000 transmitter can drive a receiver with an input resistance up to 625 Ω. Figure 130 shows a block diagram of the transmitter.

Figure 130 - Process Loop Transmitter block diagram



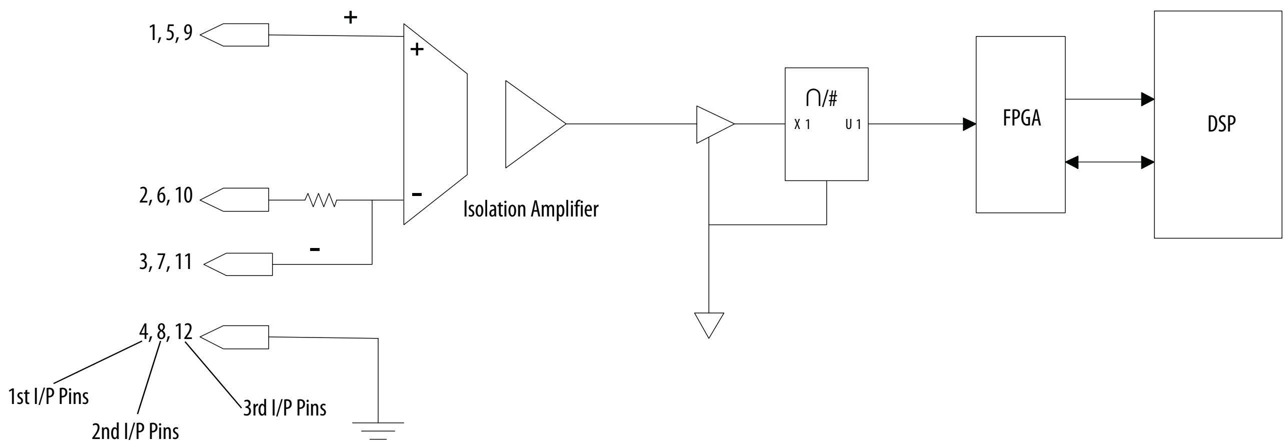
This type of transmitter is known as a 4-wire transmitter, and will "sink" current from a receiver. The receiver is connected by two wires only from pins 20 (+ connection) and either pins 18, 19, 21 (- connection).

The recommended connection is shown above. The type of shielded cable used is application specific and is determined by the length of the run, the characteristic impedance and the frequency content of the signal.

Isolated Process Receiver

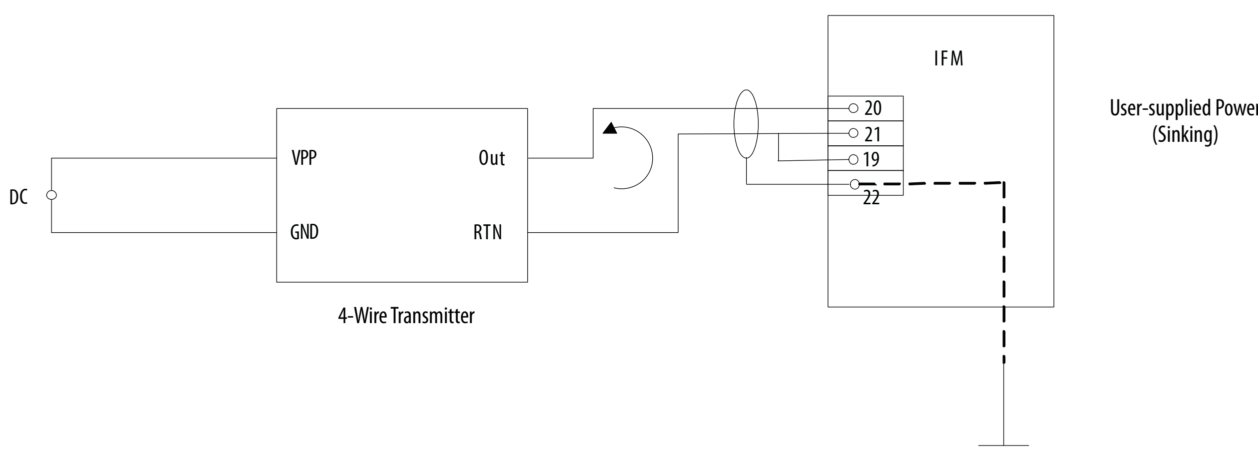
These inputs are individually configurable to accept either a -10/0/+10V input signal or a 4-20 mA signal. When configured for voltage input, each channel has an input impedance of 75 K Ω. When used as a current loop input, the transmitter must have a minimum loop compliance of 2V to satisfy the 100 Ω input impedance. Regardless of input configuration, each input is individually isolated to ± 100V DC or 70V RMS AC.

Figure 131 - Process Loop Receiver block diagram



The receiver can accept 4-wire transmitters. The figure below shows the recommended connections. Again, the type of shielded cable used is application specific as per the transmitter.

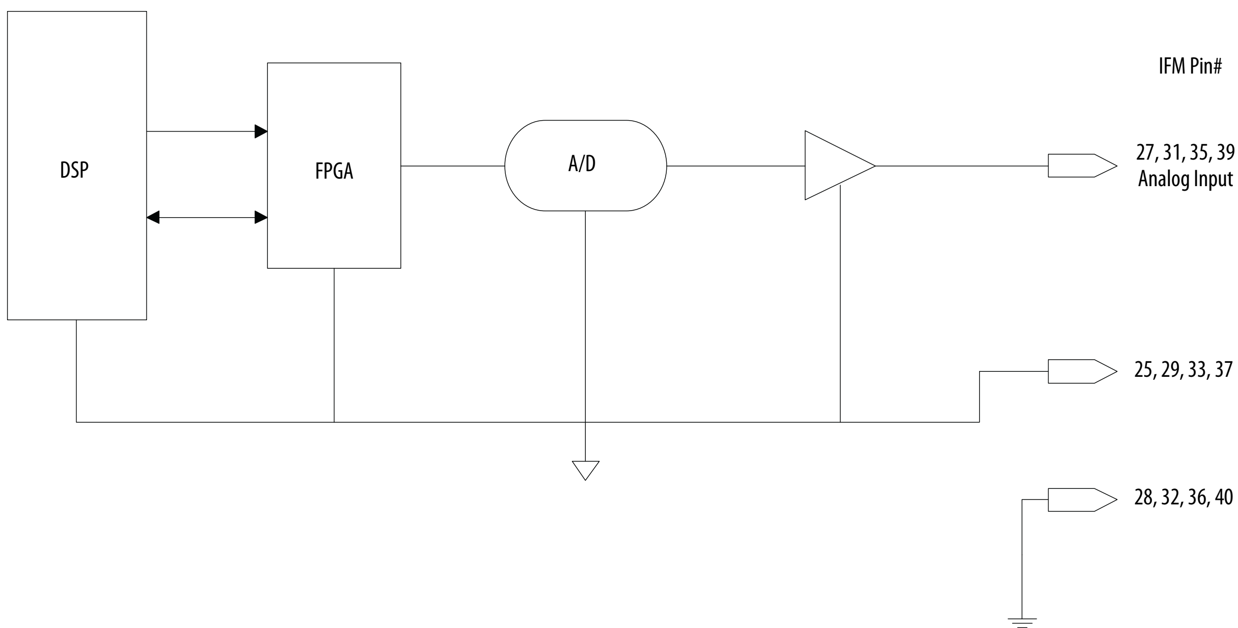
Figure 132 - Process Loop Receiver connections



Non-Isolated Process Outputs

The drive supplies four non-isolated -10/0/+10 V outputs for your use. These outputs can drive loads with impedances as low as 600 Ω. These outputs are referenced to the Drive AGND; isolate them if you require them to drive outside the frame enclosure.

Figure 133 - Non-isolated configurable ACB analog outputs



Auxiliary +24V Power Supply

The DC/DC converter has a built-in isolated 24V power supply (Connector P3). Use this supply for any equipment requiring up to 24 W at 24V. You can also use the supply to power any custom drive options, such as isolation modules for additional process control outputs. The health of this power supply is monitored in the drive.

PIN NO.	DESCRIPTION
1	ISOLATOR (+24V, 1 A)
2	ISOL_COMM (com4)
3	EARTH

Replacing the Analog Control Board

To replace the analog control boards:

1. Isolate and lock out all power to the drive.
2. Remove the transparent sheet on top of the drive processor module and the drive processor module itself before removing the ACB. Remove the transparent sheet on top of the DPM by removing the 4 screws.
3. Use static strap before removing any connectors.
4. Remove the connectors J4, J11 and J12 on DPM after proper identification and marking if necessary. Use the electrical drawing as the reference. Remove the four screws holding the DPM on the standoffs above the ACB.
5. Remove the DPM mounted on the four, 34-pin connectors.
6. Remove the screws holding encoder interface board and gently remove the board mounted on the 8-pin connector
7. Remove the connectors J1, J2, J3, J4, J5, J6, J7,J8, J9, J10, J12, J13, J14, J16, J22, J24, J25, J26, J27 on ACB after proper identification and marking if necessary. Use the electrical drawing as the reference.
8. Remove the ACB board by removing the 4 screws, and 6 standoffs screwed to support the DPM and encoder interface board.
9. Reverse steps 8 through 2 reinstall the boards into the low voltage control cabinet.
10. Apply low voltage power and complete both system and medium voltage tests to ensure the new board functions properly.

Encoder Feedback Board

Encoder Options

There are two positional encoder interface boards usable with the drive. The encoder interface boards do not have any user accessible test points; however, buffered and isolated versions of each of the signals A+, A-, B+, B-, Z+ and Z- are available on the ACB at test points TP45-TP50.

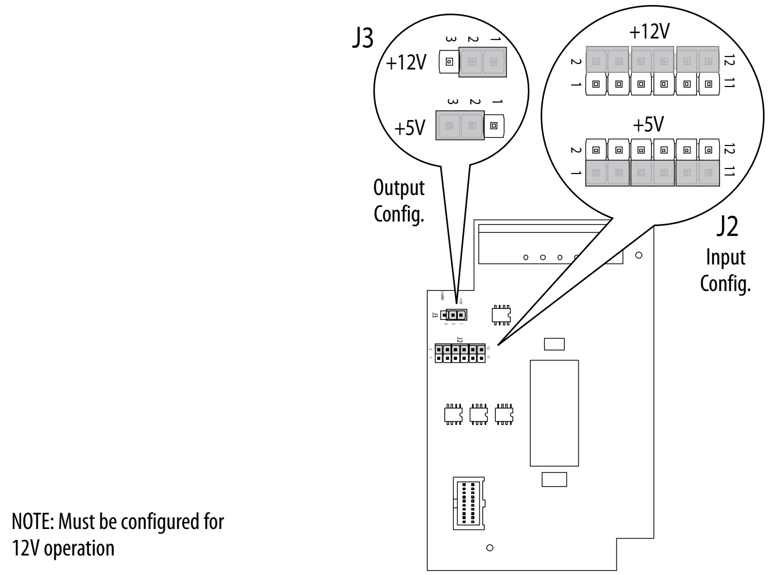
Regardless of the type of encoder board, observe the following conditions.

1. Do not attach encoders with open collector outputs to the drive. Acceptable outputs are analog line driver or push pull.
2. The drive will not operate properly if using single ended quadrature encoders. Rockwell Automation recommends using differential inputs only for these types of encoders. Single ended outputs are only acceptable for positional encoders.

20B-ENC-3 Encoder Interface

This encoder interface enables connecting the drive to a standard quadrature encoder. The 20B-ENC encoder interface provides three optically isolated differential encoder inputs for A and B phases as well as a Z track. You cannot configure these inputs for use with a single ended encoder. The board only supports differential encoders. The board also provides a galvanically isolated 12V/3 W supply to power the attached encoder. You can configure the 20B-ENC-3 encoder interface for 5V operation, however Rockwell Automation recommends operation at 12V.

Figure 134 - 20B-ENC-3 Encoder Interface



Operation at 5V does not support long cable lengths, given the need to regulate power within 5% at the encoder. Cable resistance and capacitance makes it difficult to regulate power at the encoder to 4.75V. Longer cables may decrease voltage below 4.75V, causing encoder malfunction. As a general rule, using 18 Avg cabling with an Rdc of 19.3 Ω/km limits the cable length to 12 m (42 ft) from the board to the encoder.

Input Connections

All encoder interface connections occur at J1, as follows.

J1 Pin 1 A+

J1 Pin 2 A-

J1 Pin 3 B+

J1 Pin 4 B-

J1 Pin 5 Z+

J1 Pin 6 Z-

J1 Pin 7 encoder power return

J1 Pin 8 encoder power (+12V @ 3 W)

80190-759-01, 80190-759-02 Universal Encoder Interface

The universal encoder interface enables connections between the drive and to an absolute position encoder or a standard quadrature encoder, providing the option for dual or redundant quadrature encoders. The universal encoder interface provides 12 single ended or 6 differential, optically isolated inputs as well as a 12V/3W galvanically isolated encoder power source.

When using absolute encoders, use the 12 single ended inputs. For quadrature encoders, use the six differential inputs.

Either encoder with frequencies up to 200 kHz connects to the universal encoder interface.

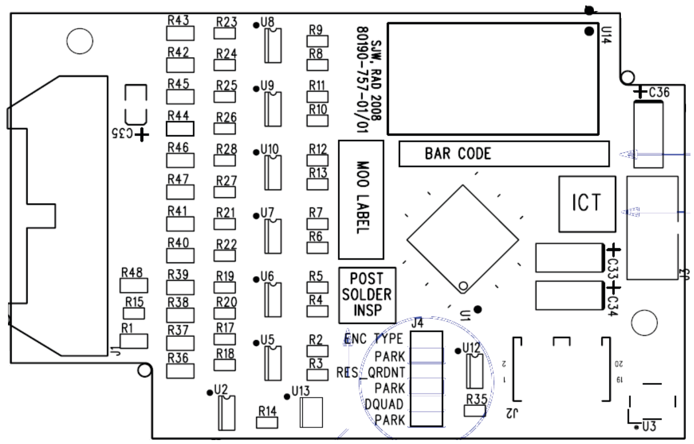
The 80190-759-02 universal encoder interface is functionally identical to the 80190-759-01 with the addition of conformal coating. The universal encoder interface is configured via jumpers installed on the 12-position header J4. The header has three positions labeled ‘Park’ and used to store the jumpers when indicated as “Removed” in the table below. Each function is selected by moving its corresponding jumper from the ‘park’ location to the selected function location if labeled “Installed”. Table 11 describes the functions available.

ATTENTION: Removing the Universal Encoder Interface with active control power may damage the board. Disconnect the control power before removing the board.

Table 11 - Encoder Configurations

ENC_TYPE	POL_QRDNT	CD_DQUAD	CONFIGURATION
Installed	Installed	Installed	Single quadrature encoder option (Factory Default)
Installed	Installed	Removed	Dual quadrature encoder option without redundancy
Installed	Removed	Removed	Dual quadrature encoder option with redundancy
Installed	Removed	Installed	Single quadrature option (CDSEL/DQUAD) must be removed for redundancy
Removed	Installed	Installed	Gray code absolute encoder low true
Removed	Installed	Removed	Natural binary absolute encoder low true
Removed	Removed	Installed	Gray code absolute encoder high true
Removed	Removed	Removed	Natural binary absolute encoder high true

Figure 135 - Universal Encoder Board

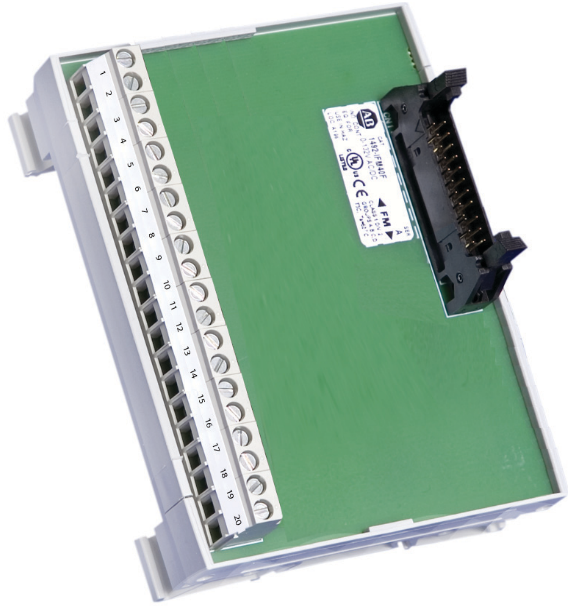


Connections to the universal encoder interface occur via a 1492-IFM20F interface module. The connections to the IFM are detailed below.

Table 12 - Encoder Functions

IFM Pin #	Quadrature Encoder Function	Absolute Encoder Function
1	A1+	E0
2	A1-	E1
3	B1+	E2
4	B1-	E3
5	ENC_COM	ENC_COM
6	Z1+	E4
7	Z1-	E5
8	A2+ (redundant or dual ENC)	E6
9	A2- (redundant or dual ENC)	E7
10	ENC_COM	ENC_COM
11	B2+ (redundant or dual ENC)	E8
12	B2- (redundant or dual ENC)	E9
13	Z2+ (redundant or dual ENC)	E10
14	Z2- (redundant or dual ENC)	E11
15	ENC_COM	ENC_COM
16	ENC_COM	ENC_COM
17	ENC_COM	ENC_COM
18	ENC PWR (+12V)	ENC PWR (+12V)
19	ENC PWR (+12V)	ENC PWR (+12V)
20	ENC PWR (+12V)	ENC PWR (+12V)

Figure 136 - 20-pin Interface Module (IFM)



Quadrature Encoder Operation

The universal encoder interface accepts either single or dual quadrature encoders. Configure the board to accept the encoders through jumpers on J4.

Boards shipped from the factory come default to single quadrature encoder configuration. For dual encoder configurations, the primary encoder wires to pins 1… 7 on the 1492-IFM20 module.

To select the dual encoder option, remove the CD_QUAD jumper and place it in PARK. This configures the board to accept two individual quadrature encoders. In this mode, the drive can switch between encoders for applications such as Synchronous Transfer between two motors with each having their own encoder.

For the redundant encoder option, remove both the CD_QUAD and POL_QRDNT jumpers and place them in PARK. With this configuration, the drive will switch over to the redundant encoder when it detects a problem with the primary encoder.

IMPORTANT	Consult the factory for availability of dual quadrature encoder options.

When the drive switches over to the redundant encoder, it cannot switch back without recycling control power.

Positional Encoder Operations

Besides quadrature encoders, the universal encoder interface also accepts positional (absolute) encoders. The interface converts parallel positional data to a serial stream and transmits it to the DPM. The board also generates "pseudo" quadrature differential signals, including a zero position mark, derived from the binary data to the DPM.

IMPORTANT	Consult the factory for availability of Positional Encoder options.

There are three different positional encoder configurations available. For all of these configurations remove the ENC_TYPE jumper. The other jumpers configure the board for the type of positional data (gray code or natural binary) set by CD_DQUAD and high or low true data set by POL_QRDNT.

- Gray code, low true. In this configuration the board inverts the incoming gray code data then converts it to binary for transmission to the DPM.
- Natural binary, low true. The board does not convert incoming data but does invert it.
- Gray code, high true. The board converts incoming gray code data to binary without inverting the input data.
- Natural binary, high true. The board converts positional data to the serial stream without inverting or converting it.

Positional Encoder Guidelines

When selecting a positional encoder, follow these guidelines for optimal performance.

1. Code Selection: Purchase absolute encoders with either Gray code or Binary output format. Gray code is a form of binary code, where only a single bit changes at a time for each sequential number or position. The fact that only a single bit changes at a time makes it easier for the Universal Encoder Interface to read valid positional data and not ambiguous data. If we compare the Natural Binary code to Gray code for the transition from 255 to 256, we see:

	Binary Code	Gray Code
255	011111111	010000000
256	100000000	110000000

All nine bits changed in the Binary Code, while only the MSB of the Gray code changed. In the Universal Encoder Interface, the frequency filter components and input hysteresis create delays. Differences in these delays could cause errors due to reading a bit as ON when switching to OFF or vice versa. In the case of Gray code, since only one bit ever changes, the ambiguity error is never more than one count. For this reason, and to reduce inrush currents, Rockwell Automation recommends using Gray code Positional Encoders.

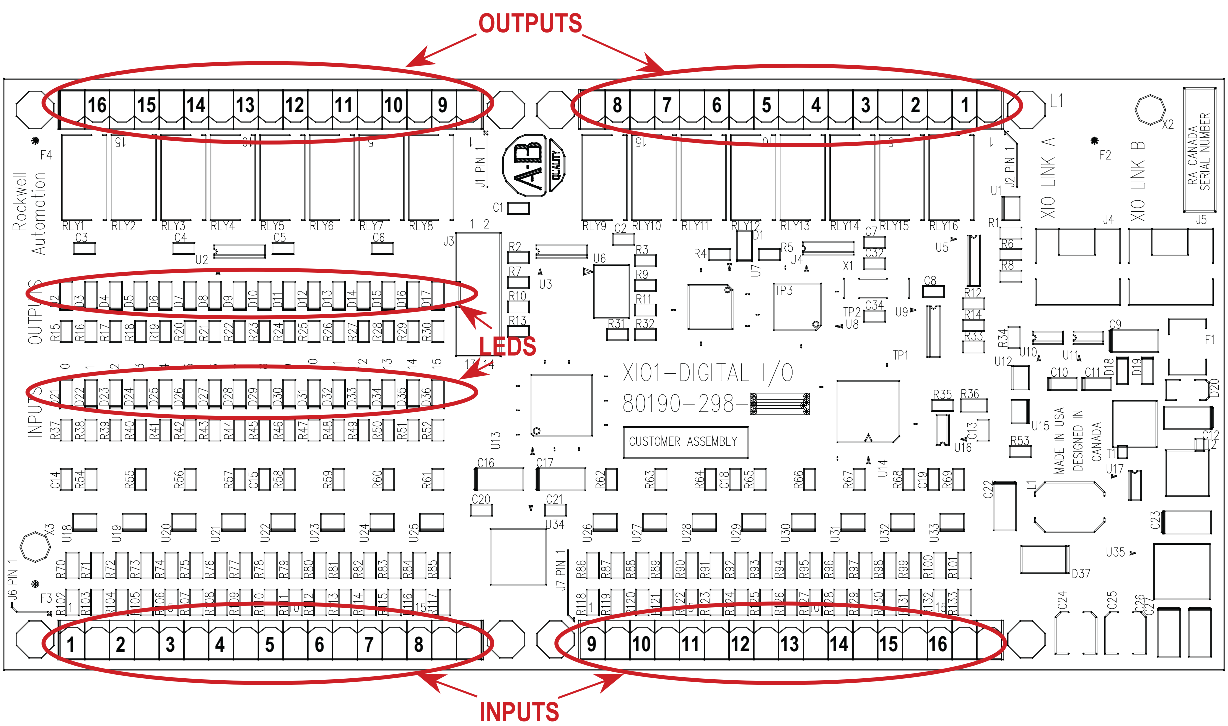
2. Data Polarity: Absolute encoders typically have a High True output. If the encoder model does not have a High/True (or Non Inverted/ Inverted) option, you should assume it to be High True. In the case of a 10bit High True encoder, the zero position is represented by 0000000000. In a Low/True encoder, the zero position is 1111111111. On the Universal Encoder Interface, the position data is inverted in hardware. That is, a '1' will turn on an optocoupler producing a '0'. Therefore, a High True encoder would produce 1111111111 for the zero position. With the POL_QRDNT jumper, you can control the polarity of the input. With the jumper installed (factory default), it is set to accept High True encoders, and an extra inversion is done in the Universal Encoder Interface. If you are using a Low True encoder, then this jumper needs to be removed so that the zero position is inverted by the optocouplers alone.

   The other role of the POL_QRDNT jumper is to correct the data in the event the encoder was mounted so that a CCW rotation produced decreasing counts. If this is the case, the POL_QRDNT jumper should be configured to the opposite of what it should normally be for the data polarity. For example, if the Universal Encoder Interface is configured to operate with High True encoders (POL_QRDNT installed), remove it to correct for encoder mounting.

External Input/Output Boards

The external input/output (XIO) boards connect through a network cable (CAN Link) to the analog control board (ACB). You can connect this cable to either XIO Link A (J4) or XIO Link B (J5). The XIO board handles all external digital input and output signals and sends them to the ACB through the cable. There are 16 isolated inputs and 16 isolated outputs on the card, used for Runtime I/O including Start, Stop, Run, Fault, Warning, Jog, and External Reset signals. The boards also handle the standard drive fault signals (transformer/line reactor overtemperature, DC link overtemperature, etc.) and several spare configurable fault inputs. There is a software option to assign each XIO a specific function (general IO, external IO, or liquid cooling).

Figure 137 - XIO Board



The standard drive comes with one XIO board; additional boards (up to five) can be daisy chained together from XIO Link B (J5) on the first board to XIO Link A (J4) on the second board, for a total of six XIO cards. However, at this time the drive only supports the use of addresses 1 to 3, depending on the features and application of the drive. U6 on the XIO board displays the address of the board which is automatically calculated from its position in the network.

XIO link A and B ports are interchangeable but it may make wiring easier to follow if you use Link A for “upstream” (closest to the ACB), and Link B for “downstream” (farthest from the ACB).

LED D1 and display U6 indicate the status of the board. Table 13 illustrates the possible states for D1.

Table 13 - Color Status Explanation for LED D1

LED Status	Description
Solid Green	Normal operation
Solid Red	Board failure
Alternate Flashing of Red and Green	No communication available to ACB board (normal at power on, during firmware download and with unprogrammed drive)

Table 14 - Status of U6 Display

Display	Description	Explanation
—	No valid address found	– More than six XIO cards on network – XIO cable failure – XIO card failure – ACB failure
0	Card in "Master" mode	– Rockwell Automation use only – Remove connection to J3 and recycle power
1 – 6	Valid address	Normal
Decimal point ON	Indicates network activity	Normal
Decimal point OFF	No activity on the network	Normal at power on, during firmware download and with unprogrammed drive

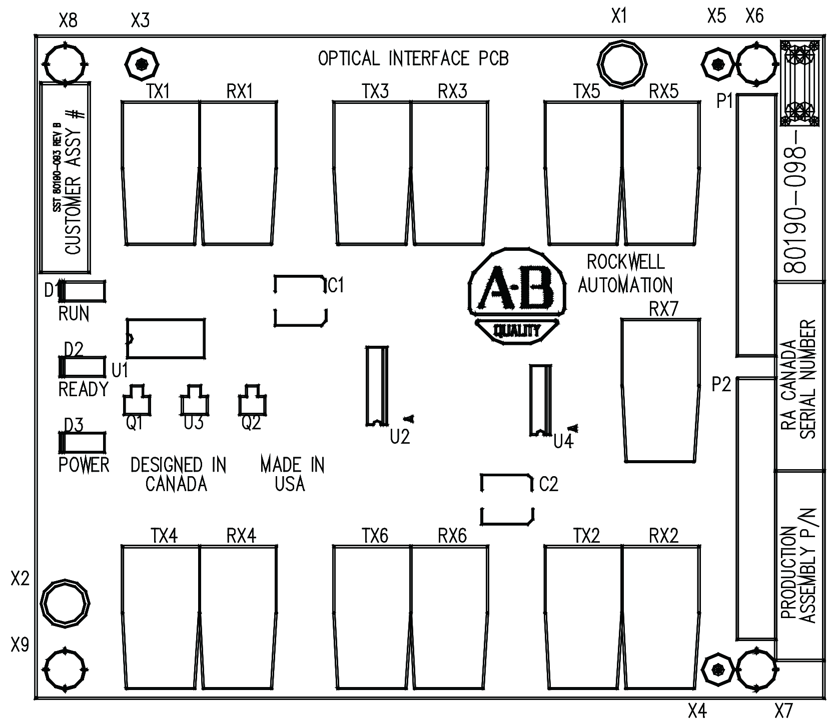
Replacing the External Input/Output Board

1. Disconnect and lock out all medium voltage and control voltage power to the drive.
2. Mark the location and orientation of all the plugs, cables, and connectors into the XIO board. Use the electrical drawing as a reference.
3. Ground your static strap, and disconnect all of the power connections.
4. Remove the XIO board assembly from the low voltage control cabinet. The XIO board mounts on a DIN rail, so a special 3-piece assembly secures the board. The assembly does not come with the new board, so you must remove the old board from the assembly and install the new board in its place.
5. Install the new XIO board assembly in the low voltage control cabinet.
6. Reconnect all connections and verify the locations.
7. Apply low voltage power and complete both system and medium voltage tests to ensure the new board functions properly.

Optical Interface Boards (OIB)

The optical interface boards are the interface between the DPM and the gate driver circuitry. The drive control decides which device to fire, and signals the OIB boards. The OIB board converts that electrical signal to an optical signal that it transmits via fiber optics to the gate driver cards. Typically, the transmit ports are gray and the receive ports are blue. The gate driver accepts that signal and turns the device on and off accordingly. The diagnostic fiber optic signals work the same way, but the source is the gate driver boards and the destination is the drive control boards. Each OIB contains one extra fiber optic receiver (RX7), which is used for temperature measurement.

Figure 138 - Optical Interface Board



The OIB boards mount directly onto the optical interface base board (OIBB) using two parallel 14-pin connectors for the electrical connection, and plastic clips to provide the mechanical strength. There is one OIBB for the inverter, and one OIBB for the rectifier device. The OIBB interface to the DPM using two ribbon cables to connect to J11 and J12.

Each OIB board can handle the firing and diagnostic duplex fiber optic connector for six devices, whether they are SCRs or SGCTs. Physically, on the OIBBs, there is provision for 18 devices for the inverter and the rectifier. The top OIB board on the OIBB is for the 'A' devices, the middle OIB board on the OIBB is for the 'B' devices, and the bottom OIB board on the OIBB is for the 'C' devices. Test points for the OIB gating diagnostic and temperature feedback signals are on the OIBB.

Each OIB board also has input RX7 for a signal from a temperature feedback board. The quantity and location of thermistor connections is dependent on the drive configuration. Typically, there is one temperature sensor from the line converter and one temperature sensor from the machine converter, each going into the respective OIB board in the 'A' position. However, some drive configurations only require one thermistor feedback connection. The temperature feedback connection on OIBC is not implemented on the OIBB and is never used. For more information, see the drawings supplied with your drive. The alarm and trip set points for each of these signals are programmable in software.

There are three LEDs on the OIB. Table 15 illustrates the status and description for the LED states.

Table 15 - Color Explanation for OIB LEDs

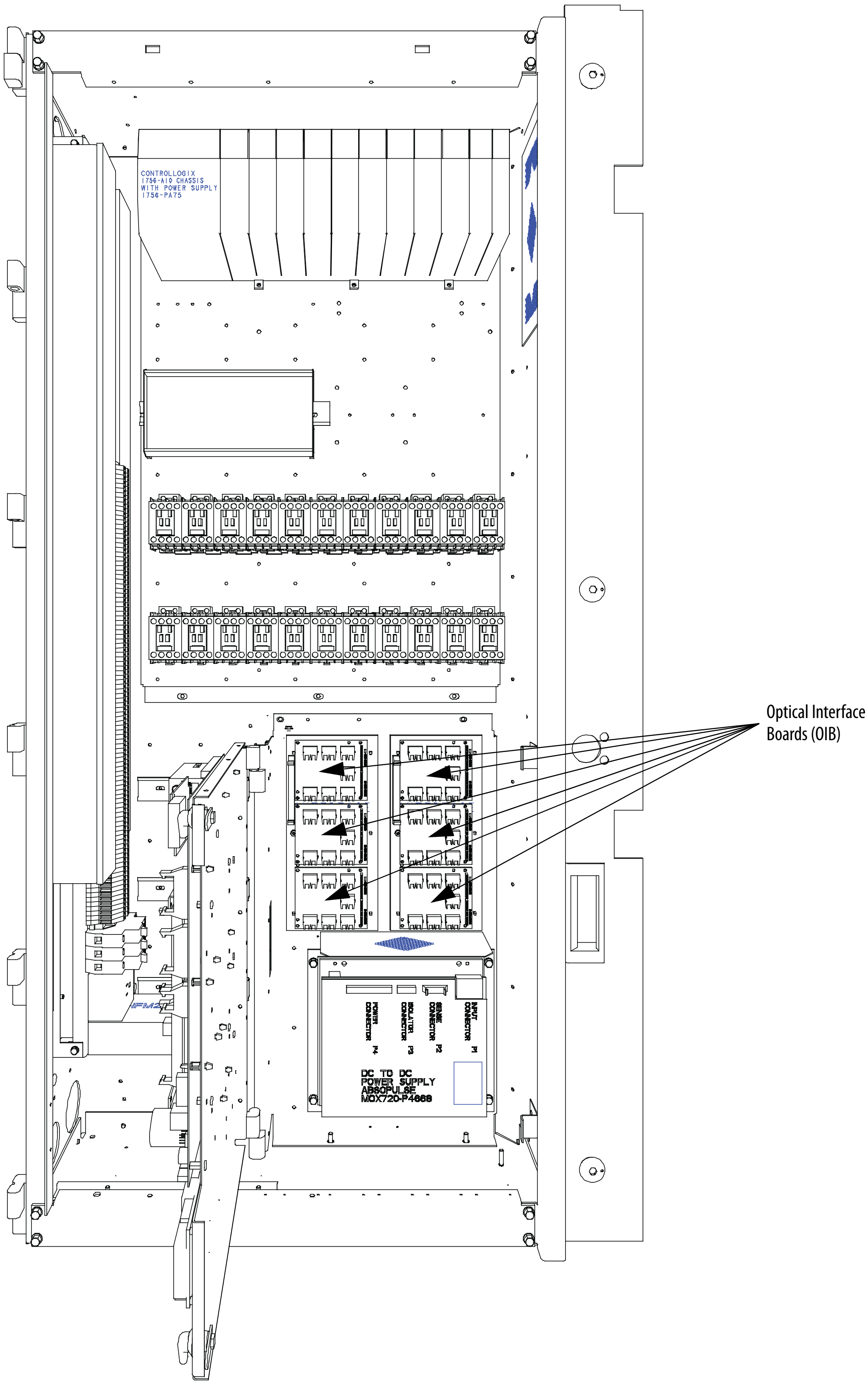
LED	Status	Description
D1	Red – On	Run – The OIB has received an enable signal. The drive control software is in control of all gating.
D2	Yellow – On	Ready – The OIB power supply is sufficient for proper operation.
D3	Green – On	Power – The OIB has received a voltage signal greater than 2V.

Replacing the Optical Interface Board

IMPORTANT If the drive is equipped with the Safe Torque Off option, the drive will use OIB2 boards. See publication 7000-UM203 to replace the OIB2 boards.

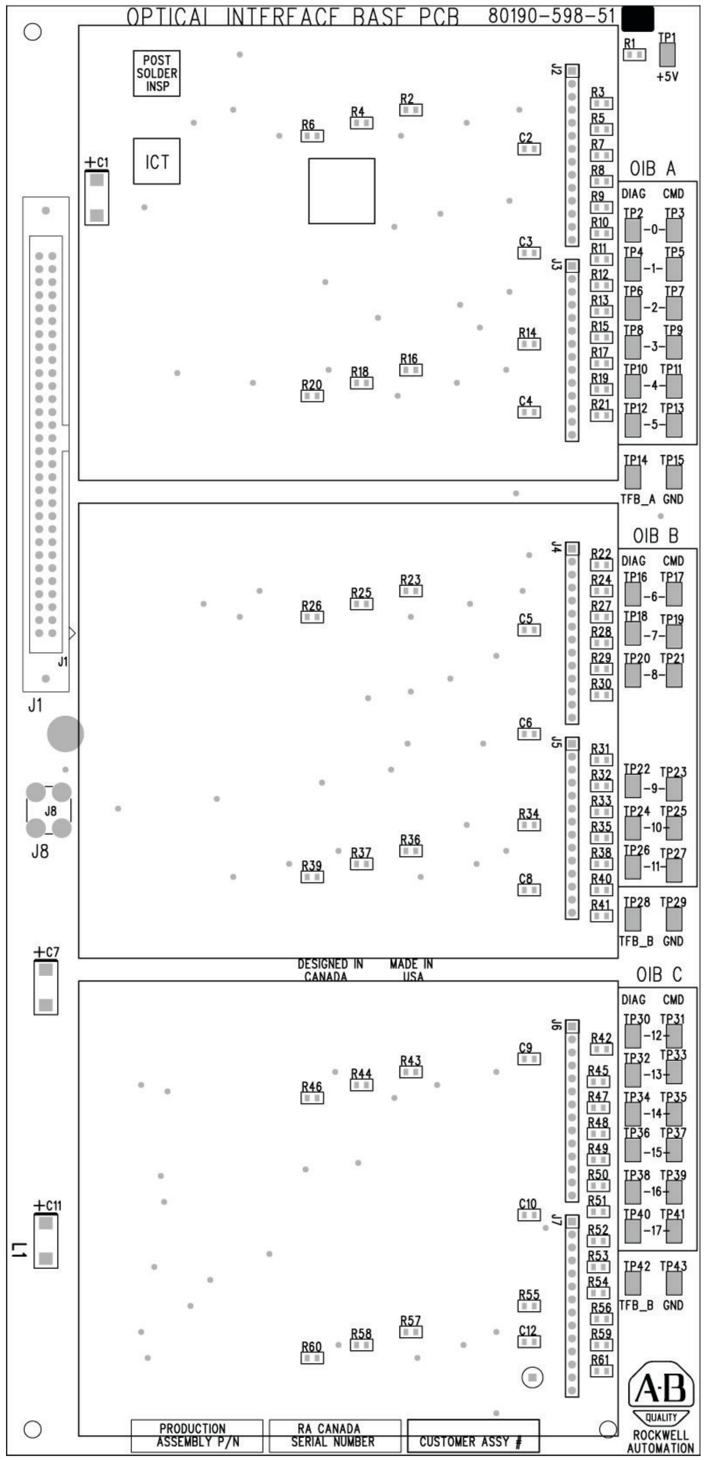
1. Isolate and lock out all power to the drive.
2. Mark the location and orientation of all the fiber optic cables. Use the electrical drawing for reference.
3. Ground your static strap, and disconnect all of the connections. You may need to remove the 60 core cable connectors on the Optical interface base and the ground connection for access to the standoffs
4. Remove the OIB board from the OIBB. There are four standoffs that snap into place on the OIB, and they need to be carefully handled when disconnecting the boards. There is also the 28-pin connection between the boards, and this connection should be handled carefully as you do not want to bend the pins.
5. Install the new OIB on the OIBB. Ensure the standoffs snap into place.
6. Reconnect all fiber optic connections and verify the locations.
7. Apply low voltage power and complete gating, system, and medium voltage tests to confirm board performance.

Figure 139 - OIB Replacement (Mounting Plate Accessible)



This board provides the mechanical and electrical interconnections between the OIBs and the DPM. The board connects to either J11 or J12 on the DPM via a 60-conductor shielded-ribbon cable. Attach the cable drain wire to the screw terminal J8. The remaining connectors on the board complete the electrical connection of the installed OIBs to the DPM. Each OIB can support from one to three OIBs.

Figure 140 - Optical Interface Base Board (OIBB)



Replace the Optical Interface Base Board

IMPORTANT	If the drive is equipped with the Safe Torque Off option, the drive will use OIBBS boards. See publication 7000-UM203 to replace the OIBBS.

1. Isolate and lock out all power to the drive.

IMPORTANT	Use a static strap when performing this procedure.

2. If the OIB boards are also being replaced, note and mark the location and orientation of all fiber optic cables.
3. Remove the OIB boards from the OIBB. There are four standoffs that are secured in place on the OIB boards. There is also the 28-pin connection between the boards, and this connection should be handled carefully. Do not bend the pins.
4. Remove the 60-pin cable connector on the OIBB and the ground connection.
5. Remove the ground nut holding in the OIBB. There are five standoffs that snap into place on the OIBB. They must be carefully handled when removing the boards.
6. Install the new OIBB and reinstall the ground nut.
7. Plug in the OIB boards and reconnect all the cables.

ATTENTION: Reconnect the fiber optic cables in their proper location. Use the electrical drawing for reference. Failure to do so may result in injury or damage to equipment.

Optical Interface Base Board Test Points

In addition to the command and diagnostic test points, there are three ground reference test points. These reference points are electrically identical, but their locations facilitate oscilloscope or chart recorder test leads connections.

Table 16 - Test Points on Optical Interface Base Board (OIBB)

Test Point	Signal Name	Description
TP1	+5V	Positive 5V Power Supply
TP2	DIAG_0	OIB A, RX1 Diagnostic Feedback
TP3	CMD_0	OIB A, TX1 Firing Command Signal
TP4	DIAG_1	OIB A, RX2 Diagnostic Feedback
TP5	CMD_1	OIB A, TX2 Firing Command Signal
TP6	DIAG_2	OIB A, RX3 Diagnostic Feedback
TP7	CMD_2	OIB A, TX3 Firing Command Signal

Test Point	Signal Name	Description
TP8	DIAG_3	OIB A, RX4 Diagnostic Feedback
TP9	CMD_3	OIB A, TX4 Firing Command Signal
TP10	DIAG_4	OIB A, RX5 Diagnostic Feedback
TP11	CMD_4	OIB A, TX5 Firing Command Signal
TP12	DIAG_5	OIB A, RX6 Diagnostic Feedback
TP13	CMD_5	OIB A, TX6 Firing Command Signal
TP14	TFB_A	OIB A Temperature Feedback Signal
TP15	GND	Ground Reference for TP1 – TP14
TP16	DIAG_6	OIB B, RX1 Diagnostic Feedback
TP17	CMD_6	OIB B, TX1 Firing Command Signal
TP18	DIAG_7	OIB B, RX2 Diagnostic Feedback
TP19	CMD_7	OIB B, TX2 Firing Command Signal
TP20	DIAG_8	OIB B, RX3 Diagnostic Feedback
TP21	CMD_8	OIB B, TX3 Firing Command Signal
TP22	DIAG_9	OIB B, RX4 Diagnostic Feedback
TP23	CMD_9	OIB B, TX4 Firing Command Signal
TP24	DIAG_10	OIB B, RX5 Diagnostic Feedback
TP25	CMD_10	OIB B, TX5 Firing Command Signal
TP26	DIAG_11	OIB B, RX6 Diagnostic Feedback
TP27	CMD_11	OIB B, TX6 Firing Command Signal
TP28	TFB_B	OIB B Temperature Feedback Signal
TP29	GND	Ground Reference for TP16 – TP28
TP30	DIAG_12	OIB C, RX1 Diagnostic Feedback
TP31	CMD_12	OIB C, TX1 Firing Command Signal
TP32	DIAG_13	OIB C, RX2 Diagnostic Feedback
TP33	CMD_13	OIB C, TX2 Firing Command Signal
TP34	DIAG_14	OIB C, RX3 Diagnostic Feedback
TP35	CMD_14	OIB C, TX3 Firing Command Signal
TP36	DIAG_15	OIB C, RX4 Diagnostic Feedback
TP37	CMD_15	OIB C, TX4 Firing Command Signal
TP38	DIAG_16	OIB C, RX5 Diagnostic Feedback
TP39	CMD_16	OIB C, TX5 Firing Command Signal
TP40	DIAG_17	OIB C, RX6 Diagnostic Feedback
TP41	CMD_17	OIB C, TX6 Firing Command Signal
TP42	TFB_C	OIB C Temperature Feedback Signal – There is no provision in the drive for the use of this signal, it is only provided for Rockwell internal testing.
TP43	GND	Ground Reference for TP30 – TP42

Specifications

ATTENTION: See the customer drawings if there is a discrepancy between the generic manual specifications and the specific design or electrical drawings.

'B' Frame Drive Specifications

Table 17 - General Design Specifications

Description	
Motor Type	Induction or Synchronous
Input Voltage Rating	2400V, 3300V, 4160V, 6600V
Input Voltage Tolerance	± 10% of Nominal
Voltage Sag(1)	-30%
Control Power Loss Ride-through	5 Cycles (Standard) > 5 Cycles (Optional UPS)
Input Protection(2)	Surge Arrestors (AFE/Direct-to-Drive) Metal Oxide Varistor (MOV) (18-pulse)
Input Frequency	50/60 Hz, ±5%
Power Bus Input Short-circuit Current Withstand (2400…6600V(3))	25 kA rms SYM, 5 Cycle
Basic Impulse Level(4)	45 kV (0…1000 m)
Power Bus Design	Copper - Tin plated
Ground Bus	Copper - Tin plated 6 x 51 mm (¼ x 2 in.)
Customer Control Wire Way	Separate and Isolated
Input Power Circuit Protection(5)	Vacuum Contactor with Fused Isolating Switch or Circuit Breaker
Output Voltage	0…2400V 0…3300V 0…4160V 0…6000V, 0…6300V, 0…6600V
Inverter Design	PWM
Inverter Switch	SGCT
Inverter Switch Failure Mode	Non-rupture, Non-arc
Inverter Switch Failure Rate (FIT)	100 per 1 Billion Hours Operation
Inverter Switch Cooling	Double Sided, Low Thermal Stress
Inverter Switching Frequency	420…440 Hz

Table 17 - General Design Specifications (Continued)

Description			
Number of Inverter SGCTs	**Voltage**	**SGCTs (per phase)**	
	2400V 3300V 4160V 6600V	2 4 4 6	
Inverter PIV Rating (Peak Inverse Voltage)	**Voltage**	**PIV (each device)**	**Total PIV**
	2400V 3300V 4160V 6600V	6500V 6500V 6500V 6500V	6500V 13,000V 13,000V 19,500V
Rectifier Designs	Direct-to-Drive™ (transformerless AFE rectifier) AFE with separate isolation transformer 18-pulse with separate isolation transformer		
Rectifier Switch	SCR (18-pulse), SGCT (AFE Rectifier)		
Rectifier Switch Failure Mode	Non-rupture, Non-arc		
Rectifier Switch Failure Rate (FIT)	50 (SGCT) 100 (SCR) per 1 Billion Hours Operation		
Rectifier Switch Cooling	Double Sided, Low Thermal Stress		
Number of Rectifier Devices per phase	**Voltage**	**AFE**	**18-pulse**
	2400V 3300V 4160V 6600V	2 4 4 6	6 6 6 6
Output Current Harmonics (1^{st}…49^{th})	< 5% (full load, full speed)		
Output Waveform to Motor	Sinusoidal Current / Voltage		
Medium Voltage Isolation	Fiber Optic		
Modulation techniques	SHE Synchronous Trapezoidal PWM Asynchronous or Synchronous SVM (Space Vector Modulation)		
Control Method	Digital Sensorless Direct Vector Full Vector Control with Encoder Feedback (Optional)		
Tuning Method	Auto Tuning via Setup Wizard		
Speed Regulator Bandwidth	1…10 rad/s with standard control 1…20 rad/s with HPTC (optional)		
Torque Regulator Bandwidth	15…50 rad/s with standard control 80…100 rad/s with HPTC (optional)		
Torque Accuracy with HPTC (optional)	+/- 5%		
Speed Regulation	0.1% without Encoder Feedback 0.01…0.02% with Encoder Feedback		
Acceleration/Deceleration Range	Independent Accel/Decel – 4 x 30 s		
Acceleration/Deceleration Ramp Rates	4 x Independent Accel/Decel		
S Ramp Rate	Independent Accel/Decel – 2 x 999 s		
Critical Speed Avoidance	3 x Independent with Adjustable bandwidth		

Table 17 - General Design Specifications (Continued)

Description		
Stall Protection	Adjustable time delay	
Load Loss Detection	Adjustable level, delay, speed set points	
Control Mode	Speed or Torque	
Current Limit	Adjustable in Motoring and Regenerative	
Output Frequency Range	0.2…75 Hz (Standard) 75 Hz…90 Hz (Optional - need specific Motor Filter Capacitor [MFC])	
Service Duty Rating	**Normal Duty**	**Heavy Duty**
	110% Overload for 1 min. every 10 min. (Variable Torque Load)	150% Overload for 1 min. every 10 min. (Constant Torque Load)
Typical VFD Efficiency	> 97.5% (AFE) > 98% (18-pulse) Contact Factory for Guaranteed Efficiency of Specific Drive Rating	
Input Power Factor	**AFE Rectifier**	
	0.95 minimum, 10…100% Load	
IEEE 519 Harmonic Guidelines(6)	IEEE 519 - 1992 Compliant	
VFD Noise Level	< 85 dB (A)) per OSHA Standard 3074	
Regenerative Braking Capability	Inherent – No Additional Hardware or Software Required	
Flying Start Capability	Yes – Able to Start into and Control a Spinning Load in Forward or Reverse Direction	
Operator Interface	10" Color Touchscreen – Cat# 2711P-T10C4A9 (VAC) Built-in PDF viewer Redesigned PanelView Plus 6 Logic Module with 512 Mb of memory	
Languages	English, French, Spanish, Portuguese, German, Chinese, Italian, Russian, and Polish	
Control Power	220/240V or 110/120V, Single phase - 50/60 Hz (20 A)	
External I/O	16 Digital Inputs, 16 Digital Outputs	
External Input Ratings	50…60 Hz AC or DC 120…240V – 1 mA	
External Output Ratings	50…60 Hz AC or DC 30…260V – 1 A	
Analog Inputs	Three Isolated, 4…20 mA or 0…10V (250 Ω)	
Analog Resolution	Analog input 12 Bit (4…20 mA) Internal parameter 32 Bit resolution Serial Communication 16 Bit resolution (0.1Hz) (Digital Speed Reference)	
Analog Outputs	1 isolated, 8 non-isolated, 4…20 mA or 0…10V (600 Ω)	
Communication Interface	EtherNet/IP DPI	
Scan Time	Internal DPI – 2 ms min, 4 ms max	

Table 17 - General Design Specifications (Continued)

Description		
Communication Protocols (Optional)	DeviceNet®	ControlNet®
	Ethernet I/P™	Lon Works
	Dual-port Ethernet I/P	Can Open
	PROFIBUS	RS485 HVAC
	Modbus	RS485 DF1
	Interbus	RS232 DF1
	USB	
Enclosure	Type 1 IP21 (with door gaskets)	
	IP42 (optional)	
Lifting Device	Standard / Removable	
Mounting Arrangement	Mounting Sill Channels	
Structure Finish	Epoxy Powder – Paint Exterior Sandtex Light Grey (RAL 7038) – Black (RAL 8022) Internal – Control Sub Plates – High Gloss White (RAL 9003)	
Interlocking	Key provision for customer input Disconnecting Device	
Corrosion Protection	Unpainted Parts (Zn chromate)	
Ambient Temperature	0…40 °C (32…104 °F) / 0…50 °C (32…122 °F) - optional	
Fiber Optic Interface	Rectifier – Inverter – Cabinet (Warning / Trip)	
Door Filter	Painted Defuser with Matted Filter Media	
Door Filter Blockage	Air Flow Restriction Trip / Warning	
Storage and Transportation Temperature Range	-40…+70 °C (-40…+158 °F)	
Relative Humidity	Max. 95%, non-condensing	
Altitude (Standard)	0…1000 m (0…3300 ft)	
Altitude (Optional)	1001…5000 m (3300…16,400 ft)	
Seismic (UBC Rating)	1, 2, 3, 4	
Standards	NEMA, IEC, CSA, UL, ANSI, IEEE	

(1) Voltage Sag tolerance is reduced to -25% when control power is supplied from medium voltage via CPT.
(2) MOVs are used for 18-pulse. Surge arrestors are used for AFE/Direct-to-Drive configurations.
(3) Short-circuit fault rating based on input protection device (contactor or circuit breaker).
(4) BIL rating based on altitudes < 1000 m (3300 ft) Refer to factory for derating on altitudes >1000 m.
(5) Optional.
(6) Under certain conditions, power system analysis will be required.

Catalog Number Explanation

			Position			
1	*2*	*3*	*4*	*5*	*6*	*7*
7000	**A**	**40**	**D**	**A**	**RPDTD**	**1–…etc.**
a	*b*	*c*	*d*	*e*	*f*	

a

Bulletin Number

Code	Description
7000A	'A' frame (Air-cooled)
7000	'B' frame (Air-cooled)
7000L	'C' frame (Liquid-cooled)

b

Service Duty/Altitude Code

Code	Description
A	Normal Duty, 0…1000 m Altitude. Maximum 40 °C Ambient
B	Normal Duty, 1001…5000 m Altitude Reduced Ambient (from 40 °C offering) 1001…2000 m = 37.5 °C 2001…3000 m = 35 °C 3001…4000 m = 32.5 °C 4001…5000 m = 30 °C
C	Heavy Duty, 0…1000 m Altitude. Maximum 40 °C Ambient
D	Heavy Duty, 1001…5000 m Altitude. Reduced Ambient (from 40 °C offering) – same as 'B' code above
E	Normal Duty, 0…1000 m Altitude. Maximum 35 °C Ambient
F	Normal Duty, 1001…5000 m Altitude Reduced Ambient (from 35 °C offering) 1001…2000 m = 32.5 °C 2001…3000 m = 30 °C 3001…4000 m = 27.5 °C 4001…5000 m = 25 °C
G	Heavy Duty, 0…1000 m Altitude. Maximum 35 °C Ambient
J	Normal Duty, 0…1000 m Altitude. Maximum 50 °C Ambient
L	Heavy Duty, 0…1000 m Altitude. Maximum 50 °C Ambient
N	Normal Duty, 0…1000 m Altitude. Maximum 20 °C Ambient
Z	Custom Configuration (Contact Factory)

c

Drive Current Rating(1)

Code	Description	Code	Description
40	40 A	215	215 A
46	46 A	250	250 A
53	53 A	285	285 A
61	61 A	325	325 A
70	70 A	375	375 A
81	81 A	430	430 A
93	93 A	495	495 A
105	105 A	575	575 A
120	120 A	625	625 A
140	140 A	657	657 A
160	160 A	720	720 A
185	185 A		

(1) Not all amperages are available at all ambient/altitude configurations.

d

Enclosure Type

Code	Description
D	Type 1 w/gasket (IP21)
T	Type 1 w/gasket (IP21) – Seismic rated
K	IP42
U	IP42 – Seismic rated

Position

1	2	3	4	5	6	7
7000	**A**	**40**	**D**	**A**	**RPDTD**	**1–…etc.**
a	*b*	*c*	*d*	*e*	*f*	

e

Supply Voltage/Control Voltage/Frequency/CPT Selection

Frame Size	Voltage: Nominal Line	Voltage: Control	Frequency (Hz)	Code: With a C.P.T(1)	Code: Without a C.P.T(2)
'A' Frame	2400	120	60	A	AD
		120…240		AA	—
	3300	110	50	CY	CDY
		220		CP	CDP
	4160	110	50	EY	EDY
		220		EP	EDP
		120	60	E	ED
		120…240		EA	—
	6600	110	50	JY	JDY
		220		JP	JDP
		110…220		JAY	—
		120	60	J	JD
		240		JA	—
'B' and 'C' Frames(3)	2400	208	60	AHD	
		480		ABD	
		600		ACD	
	3300	230	50	CPD	
		380		CND	
		400		CKD	
	4160	230	50	EPD	
		380		END	
		400		EKD	
		208	60	EHD	
		480		EBD	
		600		ECD	
	6600	230	50	JPD	
		380		JND	
		400		JKD	
		208	60	JHD	
		480		JBD	
		600		JCD	

(1) A Control Power Transformer modification must be selected (6, 6B, and so on) to size the transformer.
(2) Control Circuit Power is supplied from separate/external source.
(3) Three-phase Control Circuit Power is supplied from separate/external source.

f

Rectifier Configuration/Line Impedance Type

Code	Description
RPDTD	AFE Rectifier with Integral Line Reactor and Direct-to-Drive™ DC Link
RPTX	AFE Rectifier with provision for connection to separate Isolation Transformer (standard DC Link)
RPTXI	AFE Rectifier with integral Isolation Transformer (standard DC Link)(1)
R18TX	18-pulse Rectifier with provision for connection to separate Isolation Transformer (standard DC Link)(2)

(1) RPTXI configuration is only available for 'A' frame configurations.
(2) R18TX configuration is only available for 'B' and 'C' frame configurations.

PowerFlex 7000 Drive Selection Explanation

The PowerFlex 7000 medium voltage AC drive selection tables are based on two types of drive service duty ratings:

1. **Normal Duty (110% overload for one minute, once every ten minutes)** – used for variable torque (VT) applications only.

   Drives with this rating are designed for 100% continuous operation, with 110% overload for one minute, once every ten minutes.

2. **Heavy Duty (150% overload for one minute, once every ten minutes)** – used for constant torque (CT) applications only.

   Drives with this rating are designed for 100% continuous operation with 150% overload for one minute, once every ten minutes.

Service Duty Rating, Continuous Current Rating and Altitude Rating Code

There are different codes that define service duty and altitude in the drive catalog number (see Catalog Number Explanation on page 181).

Catalog number 7000 – A160DED-RPDTD, has a continuous current rating of 160 A, with a "normal duty" service rating up to 1000 m altitude.

Catalog number 7000 – D185TEDY-RPDTD has a continuous rating of 185 A with a "heavy duty" service rating up to 5000 m altitude.

The ambient temperature rating of the drive is reduced at higher altitudes. If 40 °C ambient is required at 1001…5000 m altitude, a rating code of Z is required.

Notes:

Preventative Maintenance Schedule

Preventative Maintenance Checklist

The preventive maintenance activities on the PowerFlex™ 7000 air-cooled drive can be broken down into two categories:

- Operational maintenance – can be completed while the drive is running.
- Annual maintenance – should be completed during scheduled downtime.

Refer to the Tools/Parts/Information requirements at the end of this section for a list of documentation and materials needed to properly complete the preventive maintenance documents.

Operational Maintenance

This process really involves only one task: changing or cleaning the air filters. The PowerFlex 7000 drive requires consistent, unrestricted airflow to keep the power devices cool. The air filter is the main source of blockage in the air path.

The drive will provide an air filter alarm whenever the pressure differential across the devices drops to a drive-specific level. Referring to the Air Filter Block parameter, this can be anywhere from 7…17% blocked, depending on the heatsink and device configuration. This may seem like a small number, but it takes significant blockage to begin to lower the voltage from the pressure sensor. The percentage is a measure of voltage drop, and should not be viewed as a percentage of the opening that is covered. They are not related linearly.

Once you receive an air filter warning, you should immediately make plans to change or clean the filter. You could still have days or weeks until the drive reaches an air filter fault, but this is dependent on site-specific particle conditions.

Annual Maintenance

These maintenance tasks should be performed on an annual basis. These are recommended tasks, and depending on the installation conditions and operating conditions, you may find that the interval can be lengthened. For example, we do not expect that torqued power connections will require tightening every year. Due to the critical nature of the applications run on MV drives, the key word is preventive. Investing approximately 8.0 hr/yr on these tasks is time well spent in adding insurance against unexpected downtime.

Initial Information Gathering

Some of the important information to be recorded includes:

- Print drive setup
- Print fault/warning queues
- Save parameters to NVRAM
- Save parameters to operator interface
- Circuit board part numbers / serial numbers / revision letters (this only needs to be recorded if parts have been modified or changed since the last preventive maintenance activities)

WARNING: To prevent electrical shock, ensure the main power has been disconnected before working on the drive. Verify that all circuits are voltage free using a hot stick or appropriate voltage-measuring device. Failure to do so may result in injury or death.

Physical Checks (NO Medium Voltage and NO Control Power)

1. Power connection inspection
   - Inspect PowerFlex 7000 drive, input/output/bypass contactor sections, and all associated drive components for loose power cable connections and ground cable connections: torque them to the required torque specifications.
   - Inspect the bus bars and check for any signs of overheating / discoloration and tighten the bus connections to the required torque specifications.
   - Clean all cables and bus bars that exhibit dust build-up.
   - Use torque sealer on all connections.
2. Carry out the integrity checks on the signal ground and safety grounds.
3. Check for any visual/physical evidence of damage and/or degradation of components in the low voltage compartments.
   - This includes relays, contactors, timers, terminal connectors, circuit breakers, ribbon cables, control wires, and so one. Causes could be corrosion, excessive temperature, or contamination.
   - Clean all contaminated components using a vacuum cleaner (DO NOT use a blower), and wipe clean components where appropriate.
4. Check for any visual/physical evidence of damage and/or degradation of components in the medium voltage compartments (inverter/rectifier, cabling, DC Link, contactor, load break, harmonic filter, etc).
   - This includes main cooling fan, power devices, heatsinks, circuit boards, insulators, cables, capacitors, resistors, current transformers, potential transformers, fuses, wiring, and so on. Causes could be corrosion, excessive temperature, or contamination.

- Verify torque on heatsink bolts (electrical connections to bullet assemblies) is within specifications (13.5 N•m).
- Clean all contaminated components using a vacuum cleaner and wipe clean components where appropriate.

IMPORTANT	Do not use a blower.

- Note: An important component to check for contamination is the heatsink. The fine grooves in the aluminum heatsinks can capture dust and debris.

5. Carry out the physical inspection and verification for the proper operation of the contactor/isolator interlocks, and door interlocks.
   - Carry out the physical inspection and verification for the proper operation of the key interlocks.
   - Physical verification of the additional cooling fans mounted in the AC line reactor cabinet, Harmonic filter cabinet for mounting and connections.
   - Carry out the cleaning of the fans and ensure that the ventilation passages are not blocked and the impellers are freely rotating without any obstruction.
   - Carry out the insulation resistance testing of the drive, motor, isolation transformer/line reactor, and the associated cabling.
   - Refer to page 197 for insulation resistance testing procedure.
   - Check clamp head indicator washers for proper clamp pressure, and adjust as necessary.

     Refer to page 93 for details on proper clamp pressure.

Control Power Checks (No Medium Voltage)

1. Apply control power to the drive, and test power to all of the vacuum contactors (input, output, and bypass) in the system, verifying all contactors can close and seal in.
2. See publication 1502-UM050 for a detailed description of all contactor maintenance.
3. Verify all single-phase cooling fans for operation.
4. This includes the cooling fans in the AC/DC Power supplies and the DC/DC converter.
5. Verify the proper voltage levels at the CPT (if installed), AC/DC power supplies, DC/DC converter, isolated gate power supply boards.
   - See 7000-IN012 for appropriate procedures/voltage levels for the above checks.

6. Verify the proper gate pulse patterns using gate test operating mode.

   For drives with SPS boards installed, use the test power harness (80018-695-51) to power the rectifier SGCT boards.

7. If there have been any changes to the system during the outage, place the drive in system test operating mode and verify all functional changes.

Final Power Checks before Restarting

1. Ensure all cabinets are cleared of tools, and all component connections are back in place and in the running state.
2. Put all equipment in the normal operating mode, and apply medium voltage.
3. If there were any input or output cables removed, verify the input phasing, and bump the motor for rotation.
4. If there were any changes to the motor, input transformer, or associated cabling, you will have to retune the drive to the new configuration using autotuning.
5. Save all parameter changes (if any) to NVRAM.
6. Run the application up to full speed/full load, or to desired satisfaction.
7. Capture the drive variables while running, in the highest access level if possible.

Additional Tasks During Preventive Maintenance

1. Investigation of concerns relating to drive performance
   - Relate any problems found during above procedures to customer issues.
2. Informal instruction on drive operation and maintenance for plant maintenance personnel
   - Reminder of safety practices and interlocks on MV equipment, and on specific operating concerns
   - Reminder of the need to properly identify operating conditions
3. Recommendation for critical spare parts which should be stocked in-plant to reduce production downtime
   - Gather information on all spare parts on site, and compare that with factory-recommended critical spares to evaluate whether levels are sufficient.
   - Contact MV spare parts group for more information.
4. Vacuum bottle integrity testing using a vacuum checker or AC Hi-pot
   - Refer to publication 1502-UM050 for a detailed description of all contactor maintenance.

Final Reporting

1. A complete, detailed report on all steps in the Preventive Maintenance procedures should be recorded to identify changes.
   - A completed copy of this checklist should be included.
   - A detailed description of all adjustments and measurements that were taken during the process should be included in an addendum (interlock adjustments, loose connections, voltage readings, insulation resistance results, parameters, and so on).
2. This information should be communicated to MV product support so future support activities have the latest site information available.
   - This can be faxed to (519) 740-4756 or e-mailed to MVSupport_Technical@ra.rockwell.com.

Time Estimations

Operational Maintenance	0.5 hours per filter
Annual Maintenance	
• Initial Information Gathering	0.5 hours
• Physical Checks	
– Torque Checks	2.0 hours
– Inspection	2.0 hours
– Cleaning(1)	2.5 hours(1)
– Insulation Resistance Testing	1.5 hours
• Control Power Checks	
– Contactor Adjustments(1)	2.0 hours(1)
– Voltage Level Checks	1.0 hour
– Firing Check	0.5 hours
– System Test(1)	2.0 hours(1)
• Medium Voltage Checks	
– Final Inspection	0.5 hours
– Phasing Check(1)	1.5 hours(1)
– Autotuning(1)	2.0 hours(1)
– Operation to Maximum Load	Site Dependent
• Additional Tasks(1)	
– Investigation	Varies with nature of Problem
– Informal Training/Refresher	2.0 hours
– Spare Parts Analysis	1.0 hour
– Vacuum Bottle Integrity Check	3.0 hours
• Final Report	3.0 hours

(1) Time may not be required depending on the nature of the maintenance and the condition of the drive system. These times are only estimations.

Tool / Parts / Information Requirements

The following is a list of the tools recommended for proper maintenance of the PowerFlex 7000 drive. Not all of the tools may be required for a specific drive preventive procedure, but to complete all of the tasks listed above the following tools would be required.

Tools

- 100 MHz oscilloscope with minimum 2 Channels and memory
- 5 kV DC insulation resistance tester
- Digital multimeter
- Torque wrench
- Laptop computer with relevant software and cables

- Assorted hand tools (screwdrivers, open-ended metric wrenches, metric sockets, and so on)
- 8 mm Allen keys
- Speed wrench
- Feeler gauge
- Vacuum bottle checker or AC Hi-pot
- Minimum of 15 kV hotstick / potential indicator
- Minimum of 10 kV safety gloves
- Vacuum cleaner with anti-static hose
- Anti-static cleaning cloth
- No. 30 Torx driver

Documentation

- PowerFlex 7000 Technical Data (Parameters, Troubleshooting) – Publication 7000-TD002
- PowerFlex 7000 MV Drives Transportation and Handling Procedures – Publication 7000-IN008
- MV 400A Vacuum Contactor, Series D User Manual – publication 1502-UM050
- MV 400A Vacuum Contactor, Series E User Manual – publication 1502-UM052
- Operator Interface Guide: HMI Offering with Enhanced Functionality publication 7000-UM201
- Drive-specific electrical and mechanical prints
- Drive-specific spare parts list

Materials

- Torque sealer (yellow) part number RU-6048
- Electrical joint compound EJC No. 2 (part number 80159-701-51) or approved equivalent (for power devices)
- Aeroshell no. 7 part number 40025-198-01 (for vacuum contactors)

Overview

Rockwell Automation recognizes that following a defined maintenance schedule improves drive performance and operational lifespan. By following this maintenance schedule, you can expect the highest possible uptime. Annual maintenance includes a visual inspection of all drive components visible from the front of the unit, resistance checks on the power components, power supply voltage level checks, general cleaning and maintenance, checking of all accessible power connections for tightness, and other tasks.

I – Inspection	This indicates that the component should be inspected for signs of excessive accumulation of dust/dirt/etc. or external damage (for example, looking at filter capacitors for bulges in the case, inspecting the heatsinks for debris clogging the air flow path).
M – Maintenance	This indicates a maintenance task that is outside the normal preventative maintenance tasks, and can include the inductance testing of line reactors/DC links, or the full testing of an isolation transformer.
R – Replacement	This indicates that the component has reached its mean operational life, and should be replaced to decrease the chance of component failure. It is very likely that components will exceed the design life in the drive, and that is dependent on many factors such as usage or heating.
C – Cleaning	This indicates the cleaning of a part that can be reused, and refers specifically to the door-mounted air filters in the liquid-cooled drives and some air-cooled drives.
Rv – Review	This refers to a discussion with Rockwell Automation to determine whether any of the enhancements/changes made to the drive hardware and control would be valuable to the application.
RFB/R – Refurbishment/Replacement	The parts can be refurbished at lower cost OR the parts can be replaced with new ones.

Rockwell Automation PowerFlex 7000 Drive Preventative Maintenance Schedule

Period Interval (Years)		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Air-Cooling System	Door Mounted Air Filters(1) (2)	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R
	Main Cooling Fan Motor		I	I	I	I	I	I	RFB/R	I	I	I
	Redundant Cooling Fan Motor (if supplied)		I	I	I	I	I	I	RFB/R	I	I	I
	Small Aux. Cooling Fans "Caravel"		I	I	I	I	R	I	I	I	I	R
Power Switching Components	Power Devices (SGCTs/SCRs)		I	I	I	I	I	I	I	I	I	I
	Snubber Resistors/Sharing Resistors/ HECS		I	I	I	I	I	I	I	I	I	I
	Rectifier Snubber Capacitors(3)(4)		I	I	I	I/R (4)	I	I	I	I/R(4)	I	Rv/R(4)
	Inverter Snubber Capacitors(5)(6)		I	I	I	I	I	I	I	I	I	R
	Integrated Gate Driver Power Supply		I	I	I	I	RFB/R	I	I	I	I	RFB/R
	Self-Powered SGCT Power Supply (SPS)		I	I	I	I	RFB/R	I	I	I	I	RFB/R
Integral Magnetics/Power Filters	Isolation Transformer/Line Reactor		I	I	I	I	M	I	I	I	I	M
	DC Link/CMC		I	I	I	I	M	I	I	I	I	M
	Line/Motor Filter Capacitors		I	I	I	I	M	I	I	I	I	M
Control Cabinet Components	AC/DC and DC/DC Power Supplies		I	I	I	I	RFB/R	I	I	I	I	RFB/R
	Control Boards		I	I	I	I	I	I	I	I	I	I
	Batteries (DCBs and CIB)		I	I	R	I	I	R	I	I	R	I
	Battery Module (UPS)(7)		I	I	I	I	R	I	I	I	I	R
Connections	Low Voltage Terminal Connections/ Plug-in Connections		I	I	I	I	I	I	I	I	I	I
	Medium Voltage Connections		I	I	I	I	I	I	I	I	I	I
	Heatsink Bolted Connections		I	I	I	I	I	I	I	I	I	I
	Medium Voltage Connections (Rectifier)(3)		–	–	–	I(3)	–	–	–	I(3)	–	I(3)
	Medium Voltage Connections (Inverter)(5)		–	–	–	–	–	–	–	–	–	I
Enhancements	Firmware		–	–	Rv	–	–	Rv	–	–	Rv	–
	Hardware		–	–	Rv	–	–	Rv	–	–	Rv	–
Operational Conditions	Parameters		I	I	Rv	I	I	Rv	I	I	Rv	I
	Variables		I	I	Rv	I	I	Rv	I	I	Rv	I
	Application Concerns		I	I	Rv	I	I	Rv	I	I	Rv	I
Spare Parts	Inventory/Needs		I	I	Rv	I	I	Rv	I	I	Rv	I

(1) If filter supplied is not a washable type, replace filter. If filter supplied is a washable type, wash or replace (depending on state of filter).
(2) These components may be serviced while the VFD is running.
(3) When rectifier snubber capacitors are replaced, the MV connections for the rectifier need to be inspected.
(4) A 4-year rectifier snubber capacitor replacement interval applied only to drives with 6-pulse or 18-pulse rectifiers shipped before 2012 (rectifier snubber capacitors are blue). However, current enhanced replacement rectifier snubber capacitors extend this to a 10-year replacement interval (replacement rectifier snubber capacitors are black). A 10-year rectifier snubber capacitor replacement interval has always applied to drives with AFE rectifiers.
(5) When inverter snubber capacitors are replaced, the MV connections for the inverter need to be inspected.
(6) A 10-year inverter snubber capacitor replacement interval applies to all drive configurations.
(7) Replace UPS batteries annually for 50°C rated VFDs.

Rockwell Automation PowerFlex 7000 Drive Preventative Maintenance Schedule

Period Interval (Years)		**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Air-Cooling System	Door Mounted Air Filters(1) (2)	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R	C/R
	Main Cooling Fan Motor	I	I	I	RFB/R	I	I	I	I	I	I
	Redundant Cooling Fan Motor (if supplied)	I	I	I	RFB/R	I	I	I	I	I	I
	Small Aux. Cooling Fans "Caravel"	I	I	I	I	R	I	I	I	I	I
Power Switching Components	Power Devices (SGCTs/SCRs)	I	R	I	I	I	I	I	I	I	I
	Snubber Resistors/Sharing Resistors/ HECS	I	I	I	I	I	I	I	I	I	I
	Rectifier Snubber Capacitors(3)(4)	I	I/R (4)	I	I	I	I/R (4)	I	I	I	I
	Inverter Snubber Capacitors(5)(6)	I	I	I	I	I	I	I	I	I	I
	Integrated Gate Driver Power Supply	I	I	I	I	RFB/R	I	I	I	I	I
	Self-Powered SGCT Power Supply (SPS)	I	I	I	I	RFB/R	I	I	I	I	I
Integral Magnetics/Power Filters	Isolation Transformer/Line Reactor	I	I	I	I	M	I	I	I	I	I
	DC Link/CMC	I	I	I	I	M	I	I	I	I	I
	Line/Motor Filter Capacitors	I	I	I	I	M	I	I	I	I	I
Control Cabinet Components	AC/DC and DC/DC Power Supplies	I	I	I	I	RFB/R	I	I	I	I	I
	Control Boards	I	I	I	I	I	I	I	I	I	I
	Batteries (DCBs and CIB)	I	R	I	I	R	I	I	R	I	I
	Battery Module (UPS)(7)	I	I	I	I	R	I	I	I	I	I
Connections	Low Voltage Terminal Connections/ Plug-in Connections	I	I	I	I	I	I	I	I	I	I
	Medium Voltage Connections	I	I	I	I	I	I	I	I	I	I
	Heatsink Bolted Connections	I	I	I	I	I	I	I	I	I	I
	Medium Voltage Connections (Rectifier)(3)	–	I(3)	–	–	–	I(3)	–	–	–	–
	Medium Voltage Connections (Inverter)(5)	–	–	–	–	–	–	–	–	–	–
Enhancements	Firmware	–	Rv	–	–	Rv	–	–	Rv	–	–
	Hardware	–	Rv	–	–	Rv	–	–	Rv	–	–
Operational Conditions	Parameters	I	Rv	I	I	Rv	I	I	Rv	I	–
	Variables	I	Rv	I	I	Rv	I	I	Rv	I	–
	Application Concerns	I	Rv	I	I	Rv	I	I	Rv	I	–
Spare Parts	Inventory/Needs	I	Rv	I	I	Rv	I	I	Rv	I	–

(1) If filter supplied is not a washable type, replace filter. If filter supplied is a washable type, wash or replace (depending on state of filter).
(2) These components may be serviced while the VFD is running.
(3) When rectifier snubber capacitors are replaced, the MV connections for the rectifier need to be inspected.
(4) A 4-year rectifier snubber capacitor replacement interval applied only to drives with 6-pulse or 18-pulse rectifiers shipped before 2012 (rectifier snubber capacitors are blue). However, current enhanced replacement rectifier snubber capacitors extend this to a 10-year replacement interval (replacement rectifier snubber capacitors are black). A 10-year rectifier snubber capacitor replacement interval has always applied to drives with AFE rectifiers.
(5) When inverter snubber capacitors are replaced, the MV connections for the inverter need to be inspected.
(6) A 10-year inverter snubber capacitor replacement interval applies to all drive configurations.
(7) Replace UPS batteries annually for 50°C rated VFDs.

Torque Requirements

Torque Requirements for Threaded Fasteners

Unless otherwise specified, use the following values of torque in maintaining the equipment.

Diameter	Pitch	Material	Torque (N•m)	Torque (lb•ft)
M2.5	0.45	Steel	0.43	0.32
M4	0.70	Steel	1.8	1.3
M5	0.80	Steel	3.4	2.5
M6	1.00	Steel	6.0	4.4
M8	1.25	Steel	14	11
M10	1.50	Steel	29	21
M12	1.75	Steel	50	37
M14	2.00	Steel	81	60
1/4 in.	20	Steel S.A.E. 5	12	9.0
5/16 in.	18	Steel S.A.E. 2	15	12
3/8 in.	16	Steel S.A.E. 2	27	20

Notes:

Insulation Resistance Test

Overview

When a ground fault occurs, there are three zones in which the problem may appear: input to the drive, the drive, output to the motor. The ground fault condition indicates a phase conductor has found a path to ground. Depending on the resistance of the path to ground, a current with magnitude ranging from leakage to fault level exists. The highest probability for the source of the fault exists in either the input or output zones. The drive itself is rarely a source of a ground fault when properly installed. This is not to say there will never be any ground fault problems associated with the drive, but the chances are the fault is outside of the drive. Also, testing the drive is more complex than testing outside the drive.

With these two factors, it is recommended to first test the input and output zones when encountering a ground fault. If the location of the ground fault can not be located outside the drive, the drive will need to be tested. This procedure must be performed with due care as the hazards to drive exist if the safety precautions in the procedure are not followed. This is due to the fact the insulation resistance procedure applies high voltage to ground: all the control boards in the drive have been grounded and if not isolated, they will have high potential applied to them causing immediate damage.

Insulation Resistance Test

ATTENTION: Use caution when performing an insulation resistance test. High voltage testing is potentially hazardous and may cause severe burns, injury or death. Where appropriate, connect the test equipment to ground.

Ensure you check the insulation levels before energizing power equipment. Insulation resistance tests provide a resistance measurement from the phase-to-phase and phase-to-ground by applying a high voltage to the power circuitry. Perform this test to detect ground faults without damaging any drive equipment.

This test involves “floating” the drive and all connected equipment to a high potential while measuring the leakage current to ground. Floating the drive means to temporarily remove any existing paths to ground necessary for normal operation of the drive.

ATTENTION: There are risks of serious or fatal injury to personnel if you do not follow safety guidelines.

Follow this procedure to perform insulation resistance tests on the drive. Failure to comply with this procedure may result in poor test readings and damage to drive control boards.

Insulation Resistance Test Procedure

Required Equipment

- Torque wrench and an 10 mm socket[1]
- Phillips screwdriver
- 2500/5000V insulation resistance tester

Procedure

1. Isolate and lock out the drive system from any high voltage source.

   Disconnect any incoming power sources, medium voltage sources should be isolated and locked out and all control power sources should be turned off at their respective circuit breaker(s).

   Verify with a potential indicator that power sources have been disconnected, and that the control power in the drive is de-energized.

2. Isolate the power circuit from system ground.

   You must remove the grounds on the following components within the drive (refer to the electrical diagrams provided with the equipment to assist in determining the points to disconnect):
   - Voltage sensing boards (VSB)
   - Grounding network (GN)

Voltage Sensing Boards

a. Remove all ground connections from all of the VSBs in the drive. Do this at the screw terminals on the VSB rather than the ground bus. There are two grounds on each board marked “GND 1”, and “GND 2”.

IMPORTANT	Disconnect the terminals on the boards rather than from the ground bus, as the grounding cable is only rated for 600V. Injecting a high voltage on the ground cable will degrade the cable insulation. Do not disconnect the white medium voltage wires from the VSBs. They must be included in the test.

The number of VSBs installed in each drive varies depending on the drive configuration.

(1) Capacitor terminals of the grounding network require a 7/16 in. hex tool.

Grounding Network

b. Remove the ground connection on the GN (if installed). Lift this connection at the GN capacitor rather than the grounding bus, as the grounding cable is only rated for 600V.

IMPORTANT	Injecting a high voltage on the ground cable during an insulation resistance test will degrade the cable insulation.

3. Disconnect connections between power circuit and low voltage control.

Voltage Sensing Boards

The connections between the low voltage control and the power circuit are made through ribbon cable connectors. The cables are plugged into connectors on the voltage sensing board marked "J1", "J2", and "J3", and terminate on the signal conditioning boards. Every ribbon cable connection made on the VSBs should be marked for identification from the factory.

a. Confirm the marking matches the connections, and disconnect the ribbon cables and move them clear of the VSB. If you do not remove these ribbon cables from the VSB, then high potential applies directly to the low voltage control through the ACBs, causing immediate damage to those boards.

IMPORTANT	The VSB ribbon cable insulation is not rated for the potential applied during an insulation resistance test. You must disconnect the ribbon cables at the VSB rather than the ACB to avoid exposing the ribbon cables to high potential.

Potential Transformer Fuses

An insulation resistance test may exceed the rating of potential transformer fusing. Removing the primary fuses from all potential and control power transformers in the system will not only protect them from damage but removes a path from the power circuit back to the drive control.

Transient Suppression Network

A path to ground exists through the TSN network as the network has a ground connection to dissipate high energy surges in normal operation. If this ground connection is not isolated, the insulation resistance test will indicate a high leakage current reading through this path, falsely indicating a problem in the drive. To isolate this ground path, all fuses on the TSN must be removed before proceeding with the test.

4. Test the drive.

IMPORTANT	Verify the drive and any connected equipment is clear of personnel and tools prior to commencing the insulation resistance test. Barricade off any open or exposed conductors. Conduct a walk-around inspection before commencing the test

All three phases on the line and machine sides of the drive connect through the DC Link and snubber network. Therefore a test from any one of the input or output terminals to ground will provide all the sufficient testing required for the drive.

ATTENTION: Discharge the insulation resistance tester prior to disconnecting it from the equipment.

a. Connect the insulation resistance tester to the drive, following the specific instructions for that model.
b. If the test has a lower voltage setting (normally 500V or 1000V), apply that voltage for 5 seconds as a precursor for the higher voltage rating. This may limit the damage if you forgot to remove any grounds. If the reading is very high, apply 5kV from any drive input or output terminal to ground.
c. Perform an insulation resistance test at 5 kV for 1 minute and record the result.
The test should produce a reading greater than the minimum values listed below. If the test results produced a value lower than these values start segmenting the drive system down into smaller components and repeat the test on each segment to identify the source of the ground fault. This implies isolating the line side of the drive from the machine side by removing the appropriate cables on the DC Link reactor.

You may need to completely isolate the DC Link reactor from the drive, at which point you must disconnect all four power cables. You must ensure that you have electrically isolated all electrical components to be tested from ground.

Items that may produce lower than expected readings are surge capacitors at the motor terminals, motor filter capacitors at the output of the drive. The testing procedure must follow a systematic segmentation of electrical components to isolate and locate a ground fault.

Type of Drive	Minimum Insulation Resistance Value
Liquid-cooled drive	200 M Ω
Air-cooled drive	1k M Ω

Type of Drive	Minimum Insulation Resistance Value
Drive with input/output capacitors disconnected	5k M Ω
Isolation transformer	5k M Ω
Motor	5k M Ω

The motor filter capacitors and line filter capacitors (if applicable) may result in the test results being lower than expected. These capacitors have internal discharge resistors designed to discharge the capacitors to ground. If you are uncertain of the test results, disconnect the output capacitors.

IMPORTANT Humidity and dirty standoff insulators may also cause leakage to ground because of tracking. You may have to clean a 'dirty' drive prior to commencing the test.

5. Reconnect connections between power circuit and low voltage control.
   a. Reconnect the ribbon cables “J1”, “J2”, and “J3” in all the VSBs. Do not cross the cable connections. Mixing the feedback cables may result in serious damage to the drive.
6. Reconnect the power circuit to the system ground.

Voltage Sensing Boards

a. Securely reconnect the two ground conductors on the VSBs.

The two ground connections on the VSB provide a reference point for the VSB and enable the low voltage signal to be fed to the ACBs. If you do not connect the ground conductor, the monitored low voltage signal could then rise up to medium voltage potential, which is a serious hazard to avoid at all times. Always ensure the ground conductors on the VSB are securely connected before applying medium voltage to the drive.

Failure to connect both ground connections on the voltage sensing board will result in high potential in the low voltage cabinet within the drive that will damage the drive control, and possible cause injury or death to personnel.

Grounding Network

b. Reconnect the ground connection on the GN capacitor. The bolt connection should torque down to 3.4 N•m (30 lb•in). Exceeding the torque rating of this connection may result in damage to the capacitor.

Failure to reconnect the GN ground may result in impressing the neutral voltage offset on the motor cables and stator, which may result in equipment damage. For drives that did not originally have the GN connected (or even installed), this is not a concern.

Transient Suppression Network

c. Re-install the fuses on the TSN.

Notes:

Line and Load Cable Sizes

Maximum Line Cable Sizes

The data provided in Table 18 and Table 19 is for informational purposes only. Final design criteria should not be based solely on this data. National and local installation codes, industry best practices, and cable manufacturer recommendations must be followed.

Table 18 - Maximum Line Cable Sizes

Product			Input (Line Side)			
Voltage/Frequency/ Rectifier	Drive Rating (A)	Drive Structure Code	Line Cable Conduit Opening [in. (mm)](1)	No. and Max. Size of Incoming Cables (NEMA) (2)(3)(4)(5)(6)(7)	No. and Max. Size of Incoming Cables (IEC)(2)(3)(4)(5)(6)(7)	Space for Stress Cones [in. (mm)]
2400V / 60 Hz / RPDTD	46…375	70.40C, 70.41C, 7.44C(8)	5.61 x 7.19 (142 x 183)	One 500 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV)	34.4 (874)
3300V / 50 Hz / RPDTD	46…430	70.43, 70.44, 70.45, 70.47	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
3300V / 50 Hz / RPDTD	E495…E625, G285, G325, N720	70.32	11.81 x 16.22 (300 x 412) (1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
3300V / 50 Hz / RPDTD	46…375	70.43C, 70.44C, 70.45C, 70.47C (8)	5.61 x 7.19 (142 x 183)	One 500 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV)	34.4 (874)
4160V / 50 Hz / RPDTD	46…375	70.43, 70.44, 70.45, 70.47	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
4160V / 50 Hz / RPDTD	46…375	70.43C, 70.44C, 70.45C, 70.47C(8)	5.61 x 7.19 (142 x 183)	One 500 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV)	34.4 (874)
4160V / 60 Hz / RPDTD	46…430	70.43, 70.44, 70.45, 70.47	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	28.5 (725)
4160V / 60 Hz / RPDTD	E495…E625, G285, G325, N720	70.32	11.81 x 16.22 (300 x 412)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
4160V / 60 Hz / RPDTD	46…375	70.43C, 70.44C, 70.45C, 70.47C(8)	5.61 x 7.19 142 x 183)	One 500 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (8 kV or 15 kV)	34.4 (874)
6600V / 50 Hz / RPDTD	40…285	70.46, 70.47, 70.48, 70.49	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	28.5 (725)
6600V / 50 Hz / RPDTD	E325…E575, G215, G250, N625, N625	70.34, 70.35	12.79 x 19.68 (325 x 500)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.5 (421)
6600V / 50 Hz / RPDTD	40…285	70.46C, 70.47C, 70.49C(8)	5.61 x 7.19 (142 x 183)	One 500 MCM / phase (8 kV or 15 kV)	One 253 mm^2 / phase (8 kV or 15 kV)	34.4 (874)
6600V / 60 Hz / RPDTD	40…285	70.46, 70.47, 70.48, 70.49	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
6600V / 60 Hz / RPDTD	40…285	70.46C, 70.47C, 70.49C(8)	5.61 x 7.19 (142 x 183)	One 500 MCM / phase (8 kV or 15 kV)	One 253 mm^2 / phase (5 kV or 8 kV)	34.4 (874)
2400V / 60 Hz / RPTX	46…430	70.1, 70.2, 70.25, 70.26	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
3300V / 50 Hz / RPTX	46…430	70.10, 70.27, 70.28, 70.30	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
3300V / 50 Hz / RPTX	E495…E625, G285, G325, N720	70.32	11.81 x16.22 (300 x 412) (1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)

Table 18 - Maximum Line Cable Sizes (Continued)

Product			Input (Line Side)			
Voltage/Frequency/ Rectifier	**Drive Rating (A)**	**Drive Structure Code**	**Line Cable Conduit Opening [in. (mm)]**(1)	**No. and Max. Size of Incoming Cables (NEMA)** (2)(3)(4)(5)(6)(7)	**No. and Max. Size of Incoming Cables (IEC)**(2)(3)(4)(5)(6)(7)	**Space for Stress Cones [in. (mm)]**
4160V / 50 Hz / RPTX	46…430	70.10, 70.27, 70.29, 70.30	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
4160V / 60 Hz / RPTX	46…430	70.2, 70.26, 70.27, 70.28, 70.29, 70.31	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	28.5 (725)
4160V / 60 Hz / RPTX	E495…E625, G285, G325, N720	70.32	11.81 x 16.22 (300 x 412) (1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
6600V / 50 Hz / RPTX	40…285	70.11, 70.28, 70.30. 70.31	9.79 x 10.97 (249 x 279)(1)	Two 250 MCM / phase (15 kV)	Two 127 mm^2 / phase (15 kV)	28.5 (725)
6600V / 50 Hz / RPTX	E325…E575, G215, G250, N625	70.36, 70.37	12.79 x 19.68 (325 x 500) (1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253mm^2 / phase (8 kV or 15 kV)	16.5 (421)
2400V / 60 Hz / RP18TX(9)	46…430	70.8	9.79 x 21.06 (249 x 535)(1)	Two 500 MCM / secondary winding (5 kV or 8 kV)	Two 253 mm^2 / secondary winding (5 kV or 8 kV)	17.7 (449)
3300V / 50 Hz / RP18TX(9)	46…430	70.9	9.79 x 21.06 (249 x 535)(1)	Two 500 MCM / secondary winding (8 kV or 15 kV)	Two 253 mm^2 / secondary winding (8 kV or 15 kV)	17.7 (449)
4160V / 50 Hz / RP18TX(9)	46…430	70.9, 70.18	9.79 x 21.06 (249 x 535)(1)	Two 500 MCM / secondary winding (8 kV or 15 kV)	Two 253 mm^2 / secondary winding (8 kV or 15 kV)	17.7 (449)
4160V / 60 Hz / RP18TX(9)	46…430	70.8, 70.9	9.79 x 21.06 (249 x 535)(1)	Two 500 MCM / secondary winding (8 kV or 15 kV)	Two 253 mm^2 / secondary winding (8 kV or 15 kV)	17.7 (449)
6600V / 50 Hz / RP18TX(9)	40…215	70.9	9.79 x 21.06 (249 x 535)(1)	Two 350 MCM / secondary winding (15 kV)	Two 177 mm^2 / secondary winding (15 kV)	17.7 (449)
6600V / 50 Hz / RP18TX(9)	250…430	70.18	9.79 x 21.06 (249 x 535)(1)	Two 350 MCM / secondary winding (15 kV)	Two 177 mm^2 / secondary winding (15 kV)	17.7 (449)
6600V / 60 Hz / RP18TX(9)	40…215	70.9	9.79 x 21.06 (249 x 535)(1)	Two 350 MCM / secondary winding (15 kV)	Two 177 mm^2 / secondary winding (15 kV)	17.7 (449)
6600V / 60 Hz / RP18TX(9)	250…430	70.18	9.79 x 21.06 (249 x 535)(1)	Two 350 MCM / secondary winding (15 kV)	Two 177 mm^2 / secondary winding (15 kV)	17.7 (449)

(1) Most PowerFlex 'B' frame drives have a single enclosure opening provision for both line and load cables. Most 'B' frames have separate opening provisions for line and load cables. All cabling capacities shown in this table are "worst case" conditions when both line and load cabling enters and exits in the same direction.

(2) Cable sizes are based on overall dimensions of compact-stranded three-conductor shielded cable (common for industrial cable tray installations). Maximum sizing stated accounts for minimum rated cable insulation requirements and the next higher-rated cable (for example, 8 kV is not commercially available in many areas of the world, therefore Rockwell Automation provides an 8 kV (minimum rating) as well as a 15 kV rating, when applicable. Enclosure openings will accommodate the thicker insulation on the higher-rated cable. IEC ratings show the equivalent to the NEMA sizes. The exact cable mm^2 size shown is not commercially available in many cases; use the next smaller standard size.

(3) Minimum cable bend radius recommendations vary by national codes, cable type, and cable size. Consult local codes for guidelines and requirements. General relationship of cable diameter to bend radius is typically between 7…12x (for example, if the cable diameter is 1 in. [2.54 cm] the minimum bend radius could range between 7…12 in. [18.8…30.48 cm]).

(4) For minimum cable insulation requirements, see the PowerFlex 7000 user manual for your particular frame. Stated voltages are peak line-to-ground. Some cable manufacturers rate cabling based on RMS line-to-line.

(5) Ground lug capabilities: up to ten mechanical range lugs for ground cable connections are available, typically these frames supply four. Mechanical range lugs can accommodate cable size #6-250MCM (13.3…127 mm^2).

(6) Maximum cable size for 'B' Frame (two per phase) is 500 MCM (253 mm^2), limited by lug pad assembly size and clearance requirements.

(7) As cabling methods can vary widely, maximum cable sizes shown do not account for the size of the conduit hub. Verify size of conduit hub(s) against the line cable conduit openings shown.

(8) With a close-coupled starter.

(9) 18-pulse drives have nine line-side connections (from the secondary windings of the isolation transformer) which enter the drive. Lug pads are provided for each connection. The lug pad and enclosure opening can generally accommodate two cables per connection (18 cables total).

Maximum Load Cable Sizes

Table 19 - Maximum Load Cable Sizes

Product			Output (Motor Side)			
Voltage/Frequency/ Rectifier	**Drive Rating (A)**	**Drive Structure Code**	**Load Cable Conduit Opening [in. (mm)]**(1)	**No. and Max. Size of Outgoing Cables (NEMA)** (2)(3)(4)(5)(6)(7)	**No. and Max. Size of Outgoing Cables (IEC)**(2)(3)(4)(5)(6)(7)	**Space for Stress Cones [in. (mm)]**
2400V / 60 Hz / RPDTD	46…430	70.40, 70.41, 70.44, 70.45	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
2400V / 60 Hz / RPDTD	46…375	70.40C, 70.41C, 7.44C(8)	6.52 x 9.88 (168 x 251)	One 500 MCM / phase (5 kV) *or* Two 250 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV) *or* Two 127 mm^2 / phase (5 kV or 8 kV)	16.2 (411)
3300V / 50 Hz / RPDTD	46…430	70.43, 70.44, 70.45, 70.47	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
3300V / 50 Hz / RPDTD	E495…E625, G285, G325, N720	70.32	11.81 x 16.22 (300 x 412)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
3300V / 50 Hz / RPDTD	46…375	70.43C, 70.44C, 70.45C, 70.47C(8)	6.52 x 9.88 (168 x 251)	One 500 MCM / phase (5 kV) *or* Two 250 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV) *or* Two 127 mm^2 / phase (5 kV or 8 kV)	16.2 (411)
4160V / 50 Hz / RPDTD	46…375	70.43, 70.44, 70.45, 70.47	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
4160V / 50 Hz / RPDTD	46…375	70.43C, 70.44C, 70.45C, 70.47C (8)	6.52 x 9.88 (168 x 251)	One 500 MCM / phase (5 kV) *or* Two 250 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV) *or* Two 127 mm^2 / phase (5 kV or 8 kV)	16.2 (411)
4160V / 60 Hz / RPDTD	46…430	70.43, 70.44, 70.45, 70.47	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
4160V / 60 Hz / RPDTD	E495…E625, G285, G325, N720	70.32	11.81 x 16.22 (300 x 412)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
4160V / 60 Hz / RPDTD	46…375	70.43C, 70.44C, 70.45C, 70.47C(8)	6.52 x 9.88 (168 x 251)	One 500 MCM / phase (5 kV) *or* Two 250 MCM / phase (5 kV or 8 kV)	One 253 mm^2 / phase (5 kV or 8 kV) *or* Two 127 mm^2 / phase (5 kV or 8 kV)	16.2 (411)
6600V / 50 Hz / RPDTD	40…285	70.46, 70.47, 70.48, 70.49	9.79 x 10.97 (249 x 279) (1)	Two 500 MCM / phase (8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
6600V / 50 Hz / RPDTD	40…285	70.46C, 70.47C, 70.49C(8)	6.52 x 9.88 (168 x 251)	One 500 MCM / phase (5 kV) *or* Two 250 MCM / phase (8 kV or 15 kV)	One 253 mm^2 / phase (8 kV or 15 kV) *or* Two 127 mm^2 / phase (8 kV or 15 kV)	16.2 (411)
6600V / 50 Hz / RPDTD	E325…E575, G215, G250, N625, N625	70.34, 70.35	12.79 x 19.68 (325 x 500)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.5 (421)
6600V / 60 Hz / RPDTD	40…285	70.46, 70.47, 70.48, 70.49	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
6600V / 60 Hz / RPDTD	40…285	70.46C, 70.47C, 70.49C (8)	6.52 x 9.88 (168 x 251)	One 500 MCM / phase (5 kV) *or* Two 250 MCM / phase (8 kV or 15 kV)	One 253 mm^2 / phase (8 kV or 15 kV) *or* Two 127 mm^2 / phase (8 kV or 15 kV)	16.2 (411)
2400V / 60 Hz / RPTX	46…430	70.1, 70.2, 70.25, 70.26	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
3300V / 50 Hz / RPTX	46…430	70.10, 70.27, 70.28, 70.30	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
3300V / 50 Hz / RPTX	E495…E625, G285, G325 N720	70.32	11.81 x 16.22 (300 x 412)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
4160V / 50 Hz / RPTX	46…430	70.10, 70.27, 70.29, 70.30	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
4160V / 60 Hz / RPTX	46…430	70.2, 70.26, 70.27, 70.28, 70.29, 70.31	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	28.5 (725)
4160V / 60 Hz / RPTX	E495…E625, G285, G325, N720	70.32	11.81 x 16.22 (300 x 412)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.5 (421)
6600V / 50Hz / RPTX	40…285	70.11, 70.28, 70.30. 70.31	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	28.5 (725)

Table 19 - Maximum Load Cable Sizes

Product			Output (Motor Side)			
Voltage/Frequency/ Rectifier	**Drive Rating (A)**	**Drive Structure Code**	**Load Cable Conduit Opening [in. (mm)]**(1)	**No. and Max. Size of Outgoing Cables (NEMA)** (2)(3)(4)(5)(6)(7)	**No. and Max. Size of Outgoing Cables (IEC)**(2)(3)(4)(5)(6)(7)	**Space for Stress Cones [in. (mm)]**
6600V / 50 Hz / RPTX	E325…E575, G215, G250, N625	70.36, 70.37	12.79 x 19.68 (325 x 500)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.5 (421)
2400V / 60Hz / RP18TX(9)	46…430	70.8	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.4 (415)
3300V / 50Hz / RP18TX(9)	46…430	70.9	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.4 (415)
4160V / 50Hz / RP18TX(9)	46…430	70.9, 70.18	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.4 (415)
4160V / 60Hz / RP18TX(9)	46…430	70.8, 70.9	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (5 kV or 8 kV)	Two 253 mm^2 / phase (5 kV or 8 kV)	16.4 (415)
6600V / 50Hz / RP18TX(9)	40…215	70.9	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.4 (415)
6600V / 50Hz / RP18TX(9)	250…430	70.18	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.4 (415)
6600V / 60Hz / RP18TX(9)	40…215	70.9	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.4 (415)
6600V / 60Hz / RP18TX(9)	250…430	70.18	9.79 x 10.97 (249 x 279)(1)	Two 500 MCM / phase (8 kV or 15 kV)	Two 253 mm^2 / phase (8 kV or 15 kV)	16.4 (415)

(1) Most PowerFlex 'B' frame drives have a single enclosure opening provision for both line and load cables. Most 'B' frames have separate opening provisions for line and load cables. All cabling capacities shown in this table are "worst case" conditions when both line and load cabling enters and exits in the same direction.

(2) Cable sizes are based on overall dimensions of compact-stranded three-conductor shielded cable (common for industrial cable tray installations). Maximum sizing stated accounts for minimum rated cable insulation requirements and the next higher-rated cable (for example, 8 kV is not commercially available in many areas of the world, therefore Rockwell Automation provides an 8 kV (minimum rating) as well as a 15 kV rating, when applicable. Enclosure openings will accommodate the thicker insulation on the higher-rated cable. IEC ratings show the equivalent to the NEMA sizes. The exact cable mm^2 size shown is not commercially available in many cases; use the next smaller standard size.

(3) Minimum cable bend radius recommendations vary by national codes, cable type, and cable size. Consult local codes for guidelines and requirements. General relationship of cable diameter to bend radius is typically between 7…12x (for example, if the cable diameter is 1 in. [2.54 cm] the minimum bend radius could range between 7…12 in. [18.8…30.48 cm]).

(4) For minimum cable insulation requirements, see the PowerFlex 7000 user manual for your particular frame. Stated voltages are peak line-to-ground. Some cable manufacturers rate cabling based on RMS line-to-line.

(5) Ground lug capabilities: up to ten mechanical range lugs for ground cable connections are available, typically these frames supply four. Mechanical range lugs can accommodate cable size #6-250MCM (13.3…127 mm^2).

(6) Maximum cable size for 'B' Frame (two per phase) is 500 MCM (253 mm^2), limited by lug pad assembly size and clearance requirements.

(7) As cabling methods can vary widely, maximum cable sizes shown do not account for the size of the conduit hub. Verify size of conduit hub(s) against the load cable conduit openings shown.

(8) With a close-coupled starter.
(9)18-pulse drives have nine line-side connections (from the secondary windings of the isolation transformer) which enter the drive. Lug pads are provided for each connection. The lug pad and enclosure opening can generally accommodate two cables per connection (18 cables total).

Environmental Considerations

Air Quality Requirements

Air cleanliness for PowerFlex™ 7000 drives is important for two reasons.

1. Airborne particulate that settles on heatsinks and heat-producing components increases the thermal resistance of the components, resulting in an increase in the temperature of the part. The internal fins of the thyristor heatsinks must be kept clean; the dust on the surface of the heatsinks interferes with the boundary layer air flow which inhibits cooling of the part.
2. Particulate can decrease the tracking insulation of electrical insulation materials within the drive. Electrically conductive dusts (such as coal dust and metallic dusts) can be severe, however other particulates such as cement dust moist from high ambient relative humidity may prove destructive as well. Dust coating low voltage circuit boards can also cause failures.

Air presented to the PowerFlex 7000 drive must be of a cleanliness expected in a typical industrial control room environment. The drive is intended to operate in conditions with no special precautions to minimize the presence of sand or dust, but not in close proximity to sand or dust sources. This is defined by IEC 60721(1) as being less than 0.2 mg/m3 of dust.

If outside air does not meet the conditions described above (0.2 mg / m3), the site air handling system must filter the air to ASHRAE (American Association of Heating, Refrigeration and Air-Conditioning Engineers) Standard 52.2 MERV 11 (Minimum Efficiency Reporting Value). This filtration eliminates from 65…80% of the particulate in Range 2 (1.0…3.0 μm) and 85% of the particulate in Range 3 (3.0…10.0 μm). This filter system must be cleaned or changed regularly.

This environment is accomplished by placing the drive in a pressurized room with adequate air conditioning to maintain the ambient temperature. The drive exhaust air is circulated within the control room. Five to ten percent cooled/heated and filtered make-up air is usually provided to keep the room pressurized.

(1) IEC 60721-3-3 "Classification of Environmental Conditions - Part 3: Classification of Groups of Environmental Parameters and their Severities - Section 3: Stationary Use at Weather Protected Locations".

Hazardous Materials

Environmental protection is a top priority for Rockwell Automation. The facility that manufactured this medium voltage drive operates an environmental management system that is certified to the requirements of ISO 14001. As part of this system, this product was reviewed in detail throughout the development process to ensure that environmentally inert materials were used wherever feasible. A final review has found this product to be substantially free of hazardous material.

Rockwell Automation is actively seeking alternatives to potentially hazardous materials for which no feasible alternatives exist today in the industry. In the interim, the following precautionary information is provided for your protection and for the protection of the environment. Please contact the factory for any environmental information on any material in the drive or with any general questions regarding environmental impact.

Capacitor Dielectric Fluid

The fluids used in the filter capacitors and the snubber capacitors are generally considered very safe and are fully sealed within the capacitor housings. Shipping and handling of this fluid is typically not restricted by environmental regulations. In the unlikely event that capacitor fluid leaks out, avoid ingestion or contact with skin or eyes as slight irritation could result. Rubber gloves are recommended for handling.

To clean up, soak into an absorbent material and discard into an emergency container, or, if significant leakage occurs, pump fluid directly into the container. Do not dispose into any drain or into the environment in general or into general landfill refuse. Dispose of according to local regulations. If disposing of an entire capacitor, the same disposal precautions should be taken.

Printed Circuit Boards

Printed circuit boards may contain lead in components and materials. Circuit boards must be disposed of according to local regulations and must not be disposed of with general landfill refuse.

Lithium Batteries

This drive contains four small lithium batteries. Three are mounted on the printed circuit boards and one is located in the PanelView™ user interface. Each battery contains less than 0.05g of lithium, which is fully sealed within the batteries. Shipping and handling of these batteries is typically not restricted by environmental regulations, however, lithium is considered a hazardous substance. Lithium batteries must be disposed of according to local regulations and must not be disposed of with general landfill refuse.

Chromate Plating

Some sheet steel and fasteners are plated with zinc and sealed with a chromate-based dip. Shipping and handling of the chromate plating parts is typically not restricted by environmental regulations, however, chromate is considered a hazardous substance. Dispose of chromate plated parts according to local regulations, not with general landfill refuse.

In Case Of Fire

This drive is highly protected against arcing faults and is therefore unlikely the cause of a fire. In addition, the materials in the drive are self-extinguishing (that is, they will not burn without a sustained external flame). If, however, the drive is subjected to a sustained fire from some other source, some of the polymer materials in the drive will produce toxic gases. As with any fire, individuals involved in extinguishing the fire or anyone in close proximity should wear a self-contained breathing apparatus to protect against any inhalation of toxic gases.

Disposal

When disposing of the drive, it should be disassembled and separated into groups of recyclable material as much as possible. These materials should then be sent to local recycling facilities. In addition, all disposal precautions mentioned above must also be taken for those particular materials.

Notes:

Encoder Use and Torque Capabilities

When to use an Encoder

An encoder is required under any of the following conditions:

- When speed regulation accuracy must be between 0.01…0.02% of nominal speed.
- When the zero speed breakaway torque needed is greater than 90% of continuous running torque.
- When continuous running speed is greater than or equal to 0.1 Hz, but less than 6 Hz.
- For minimizing restart times using the flying start capability in forward or reverse direction.
- At any time when HPTC is enabled.

Table 20 - PowerFlex Speed Regulation

Encoder	Frequency Output		
	<6 Hz	6…15 Hz	>15 Hz
Without Encoder	Not applicable	0.1%	0.1%
With Encoder	0.02%	0.01%	0.01%
With Encoder and HPTC mode enabled	0.01%	0.01%	0.01%

Notes:

- Speed regulation is based on a percentage of motor synchronous speed.
- Encoder to be mounted on the AC machine
- Operational 15V DC power supply mounted in drive to power the Encoder as a standard option with the encoder feedback card.
- You are responsible for providing and mounting of encoder
- Sleeve bearing motors require the encoder to have an axial movement tolerance.
- Recommended encoders are shaft mounting type, examples are the Avtron 685 or the NexGen RIM Tach 8500, 12…15V models or equivalent. Magneto resistive models are more adaptable to harsh environments.
- If possible, use encoders without Marker, Index, Z, or sig. C signals, as these are not used on the PowerFlex 7000 drive.
- When installing, the encoder body and electronics must be isolated from ground (options available from the encoder manufacturer to accomplish this).
- When cable lengths exceed 305 m (1000 ft) for the Northstar or 610 m (2000 ft) for the Avtron, consult the factory.

Table 21 - Encoder Selection

HPTC Mode	Motor RPM	Minimum Tach PPR	Recommended Tach PPR
	3600	1024	1024
	3000	1024	1024
	1800	1024	2048
	1500	1024	2048
	1200	2048	2048
	1000	2048	2048
	900	2048	4096
	720	4096	4096
	600	4096	4096
	450	4096	8192
	360	8192	8192
	300	8192	8192
Standard Control Mode	3600	—	600
	3000	—	600
	1800	—	1024
	1500	—	1024
	1200	—	2048
	1000	—	2048
	900	—	2048
	720	—	2048
	600	—	2048

PowerFlex 7000 Drive Performance (Torque Capabilities)

PowerFlex™ 7000 drives have been tested on a dynamometer to verify performance under locked rotor, accelerating, and low speed-high torque conditions. Table 22 shows the PowerFlex 7000 drive torque capabilities as a percent of motor rated torque, independent of the momentary overload conditions of the drive.

Table 22 - PowerFlex 7000 Drive Torque Capabilities

Parameter	Torque Capability without Encoder (% of Motor Rated Torque)	Torque Capability with Encoder (% of Motor Rated Torque)	Torque Capability with Encoder and HPTC
Breakaway Torque	90%	150%	150%
Accelerating Torque	90% (0…8 Hz)	140% (0…8 Hz)	150% (0…75 Hz)
	125% (9…75 Hz)	140% (9…75 Hz)	
Steady State Torque(1)	125% (9…75 Hz)(3)	100% (1…2 Hz)	150% (0…60 Hz) (3)
		140% (3…60 Hz)(3)	
Max. Torque Limit(2)	150%	150%	150%

(1) Continuous operating torque required to control the load, without instability.
(2) An electronic method of limiting the maximum torque available from the motor. The software in a drive typically sets the torque limit to 150% of motor rated torque.
(3) Drive will require over-sizing to achieve greater than 100% continuous torque.

Table 23 - Typical Application Load Torque Profiles

Application	Load Torque Profile	Load Torque as Percent of Full-Load Drive Torque			Required Drive Service Duty Rating	Encoder Required for Extra Starting Torque?
		Break-away(1)	Accelerating (2)	Peak Running		
AGITATORS						
Liquid	CT	100	100	100	Heavy	Yes
Slurry	CT	150	100	100	Heavy	Yes
BLOWERS (centrifugal)						
Damper closed	VT	30	50	40	Normal	No
Damper opened	VT	40	110	100	Normal	No
CHIPPER (WOOD)—starting empty	CT	50	40	200	Contact factory	No
COMPRESSORS						
Axial-vane, loaded	VT	40	100	100	Normal	No
Reciprocating, starting unloaded	CT	100	100	100	Contact factory	Yes
CONVEYORS						
Armored Face	CT	175	150	200	Contact factory	Yes
Belt type, loaded	CT	150	130	100	Heavy	Yes
Drag type	CT	175	150	100	Contact factory	Yes
Screw type, loaded	CT	200	100	100	Contact factory	Yes
DRAG LINE	CT	100	200	200	Contact factory	Yes
EXTRUDERS (rubber or plastic)	CT	150	150	100	Contact factory	Yes
FANS (centrifugal, ambient)						
Damper closed	VT	25	60	50	Normal	No
Damper open	VT	25	110	100	Normal	No
FANS (centrifugal, hot gases)						
Damper closed	VT	25	60	100	Normal	No
Damper open	VT	25	200	175	Contact factory	No
FANS (propeller, axial flow)	VT	40	110	100	Normal	No
GRINDING MILL (Ball/Sag Mill)	CT	175	180	100	Contact factory	Yes
HOISTS	CT	100	200	200	Contact factory	Yes
KILNS (rotary, loaded)	CT	250	125	125	Contact factory	Yes

Table 23 - Typical Application Load Torque Profiles (Continued)

Application	Load Torque Profile	Load Torque as Percent of Full-Load Drive Torque			Required Drive Service Duty Rating	Encoder Required for Extra Starting Torque?
		Break-away(1)	Accelerating (2)	Peak Running		
MIXERS						
Chemical	CT	175	75	100	Contact factory	Yes
Liquid	CT	100	100	100	Heavy	Yes
Slurry	CT	150	125	100	Heavy	Yes
Solids	CT	175	125	175	Contact factory	Yes
PULPER	VT	40	100	150	Contact factory	No
PUMPS						
Centrifugal, discharge open	VT	40	100	100	Normal	No
Oil field Flywheel	CT	150	200	200	Contact Factory	Yes
Propeller	VT	40	100	100	Normal	No
Fan Pump	VT	40	100	100	Norma	No
Reciprocating / Positive Displacement	CT	175	30	175	Contact factory	Yes
Screw type, started dry	VT	75	30	100	Normal	No
Screw type, primed, discharge open	CT	150	100	1000	Heavy	Yes
Slurry handling, discharge open	CT	150	100	100	Heavy	Yes
Turbine, Centrifugal, deep-well	VT	50	100	100	Normal	No
Vane-type, positive displacement	CT	150	150	175	Contact factory	Yes
SEPARATORS, AIR (fan type)	VT	40	100	100	Normal	No

(1) Torque required to start a machine from standstill.

(2) Torque required to accelerate a load to a given speed, in a certain period of time. Calculate the average torque to accelerate a known inertia (WK^2):
$T = (WK^2 \text{ x change in RPM}) / 308t$
where:
T = acceleration torque in N•m (lb•ft)
W = force N or kg*f* (lb)
K = gyration radius m (ft)
WK^2 = total system inertia (kg*f* x m^2 [lb•ft^2]) that the motor must accelerate, including motor, gear box, and load
t = time (s) to accelerate total system load

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	https://rockwellautomation.custhelp.com/
Local Technical Support Phone Numbers	Locate the phone number for your country.	http://www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	http://www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	http://www.rockwellautomation.com/global/literature-library/overview.page
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