Distributed Power System
High Power SA3000
AC Power Modules

850020 – 11xxx, 21xxx (534 Amp)

850020 – 12xxx, 22xxx (972 Amp)

850020 – 13xxx, 23xxx (1457 Amp)

Instruction Manual S-3038

Rockwell Automation

Throughout this manual, the following notes are used to alert you to safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

Important: Identifies information that is critical for successful application and understanding of the product.

ATTENTION: Only qualified personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: The user must provide an external, hardwired emergency stop circuit outside of the drive circuitry. This circuit must disable the system in case of improper operation. Uncontrolled machine operation may result if this procedure is not followed. Failure to observe this precaution could result in bodily injury.

ATTENTION: The user is responsible for conforming with all applicable local, national, and international codes. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

The information in this users manual is subject to change without notice.

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CHAPTER 1
Introduction

The High Power SA3000 Power Modules are variable-voltage, variable-frequency power inverters for Distributed Power System (DPS) drives. They are designed to operate from a separate converter (diode bridge, phase-controlled rectifier, SB3000 Synchronous Rectifier, or a common DC bus supply) to drive induction motors at variable speeds using pulse-width modulation (PWM) technology.

The SA3000 Power Modules are configured in three output current ratings: 534 amp, 972 amp, and 1457 amp when used at a 2 kHz carrier frequency. They have a range of AC Input voltage ratings. See table 1.1. Nominal DC bus voltage may range from 300 to 800 VDC.

4 kHz operation requires a derating of the AC input current and DC output load current when compared with operation at 2 kHz. See table 1.1.

The SA3000 Power Module output current ratings given are 100% continuous with no overload. They may be derated for lower current ratings with overload capability.

Table 1.1 – SA3000 Power Module Configurations

Base Part Number	Cabinet Type	DC Bus Input Volts	Output Amps (2 KHz)	Output Amps[1] (4 KHz)	Peak Amps[2]	AC Input Volts
850020-11xxx 850020-21xxx	One Bay	250-820V[3]	534A	445A	700A	230-460V
850020-12xxx 850020-22xxx	Two Bays	250-820V	972A	890A	1275A	230-460V
850020-13xxx 850020-23xxx	Three Bays	250-820V	1457A	1335A	1900A	230-460V

1. Output current ratings at 40° C (104° F) ambient air temperature and 60 Hz. Reduce all output current ratings by 5% when the Power Module blowers are operated from a 50 Hz power source.
2. Contact Rockwell Automation for duty cycle ratings.
3. 800 VDC if an SA3000/SA3100 unit is used to supply 575 VAC output to the motor.

1.1 Standard Features

High Power SA3000 Power Modules have the following standard features:

- IGBT power semiconductor bridge
- Carrier switching frequencies from 2 to 4 kHz
- Input and output short-circuit protection
- Fiber-optic communication with the DPS host, the Universal Drive Controller (UDC) module

- Auto-tuning
- Standard cabinet paint

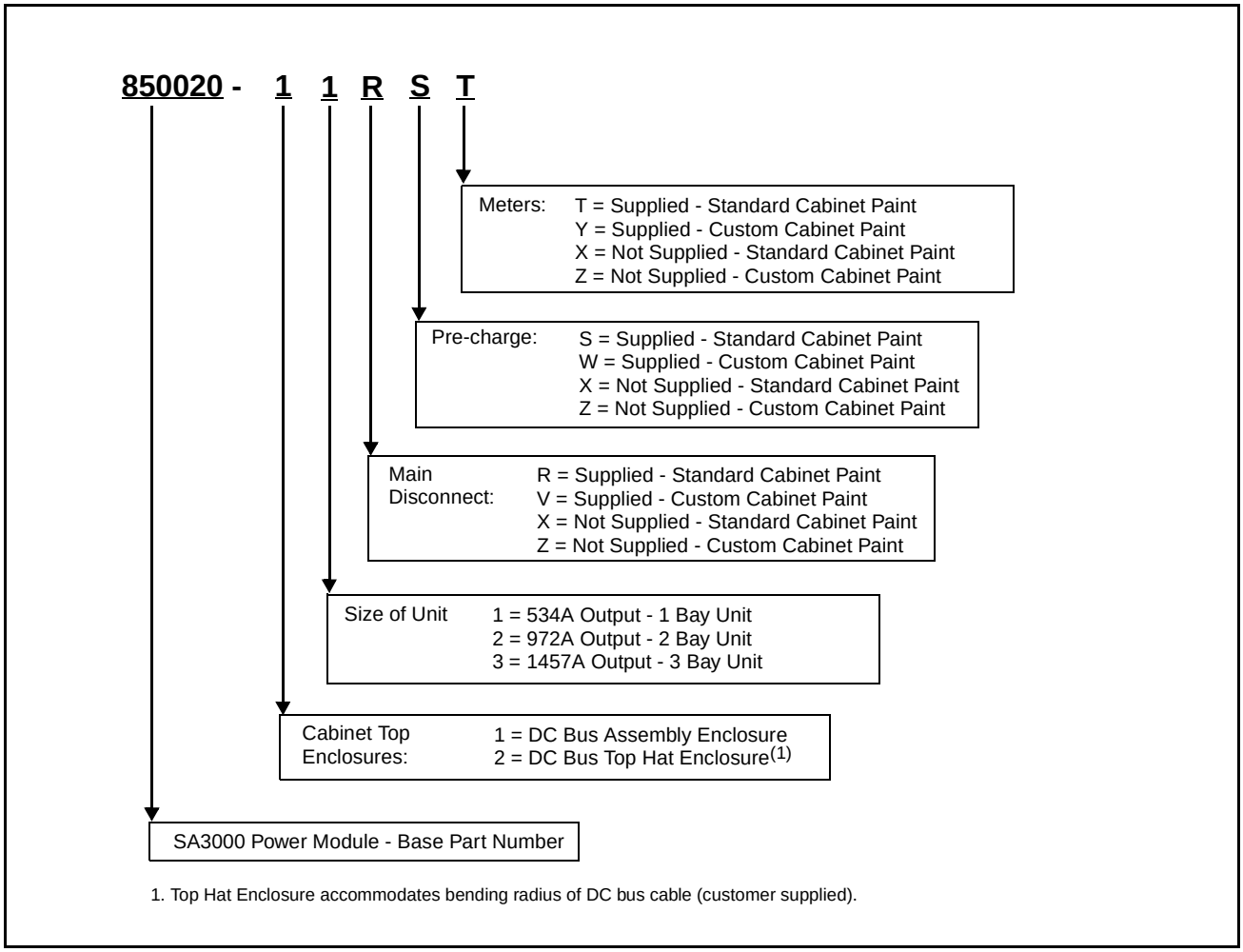
1.2 Optional Features

The following optional features are available for High Power SA3000 Power Modules

- DC bus voltage meter
- Motor ammeter
- Motor voltmeter
- Motor torque meter
- Motor frequency meter
- Main disconnect
- Pre-charge
- Separation of critical and non-critical 115 VAC control power
- DC bus top hat enclosure
- Custom cabinet paint

1.3 Power Module Part Numbers

SA3000 Power Module part numbers are organized by the number of cabinet bays, i.e., single (534A), double (972A), or triple (1457A) cabinet bay configurations, in combination with the supplied options. See figure 1.1.



1. Top Hat Enclosure accommodates bending radius of DC bus cable (customer supplied).

Figure 1.1 – SA3000 Power Module Part Numbering Scheme

1.4 Related Publications

This manual describes the hardware components of the SA3000 Inverter Power Module. The other instruction manuals in binder S-3001 describe the SA3000 software, regulator, and communications. Table 1.1 lists the document part numbers.

Table 1.2 – SA3000 Documentation (Binder S-3001)

Document	Document Part Number
SA3000 Information Guide	S-3023
Drive System Overview	S-3005
Universal Drive Controller Module	S-3007
Fiber Optic Cabling	S-3009
SA3000 Drive Configuration & Programming	S-3016
SA3000 Power Module Interface Rack and Modules	S-3019
Medium Power SA3000 Power Modules	S-3020
SA300 Diagnostics, Troubleshooting, & Start-Up Guidelines	S-3021
High Power SA3000 Power Modules	S-3038

SA3000 Power Modules are designed to be operated from a common DC bus, which can be supplied by a Distributed Power System SB3000 Synchronous Rectifier. Refer to the following manuals for information on the SB3000 Synchronous Rectifier system:

- S-3034 SB3000 Synchronous Rectifier Configuration and Programming
- S-3043 High Power SB3000 Power Modules

1.5 Related Hardware and Software

The following related hardware may be purchased separately:

- P/N 613613-xxS Fiber-optic cable (cable length xx is specified in meters)
- B/M O-57552 Universal Drive Controller (UDC) module
- B/M O-57652 Universal Drive Controller (UDC) module EM

CHAPTER 2

Mechanical/Electrical Description

This chapter provides an overview the SA3000 Power Module's main components and their mechanical and electrical characteristics.

2.1 Mechanical Description

The High Power SA3000 Power Modules are variable-voltage, variable-frequency inverters that are housed in protective sheet metal enclosures. The Power Modules are supplied in single, double, and triple bay cabinet configurations, depending upon the current rating. See figures 2.1 to 2.3. Power Module dimensions are shown in figures 3.1 to 3.3.

2.1.1 Power Module Components

The Power Modules have the following main components:

Phase modules

Each Phase module contains four semiconductor IGBTs (insulated gate bi-polar transistors). IGBT pairs are switched on and off by the integrated Snubber/Gate Driver module to provide modulated phase voltages (U,V,W) to the motor. Fuses and thermostats are provided to protect the IGBT modules.

Snubber/Gate Driver Module

Each Snubber/Gate Driver module, mounted on the IGBT phase module, receives gating signals via fiber-optic cabling from the GDI module(s) in the PMI rack and translates the signals into the appropriate voltage and current levels to turn the IGBTs on and off. Feedback, indicating the integrity of the phase module and IGBTs, is then sent back to the GDI module(s).

This module also provides snubber circuitry (resistors, diodes, and capacitors) to control voltage overshoot and undershoot when the IGBTs are switching.

Fiber-Optic Communication

Fiber-optic cabling is used to transmit gate driver signals from the Gate Driver Interface (GDI) module.These signals are used to turn the IGBTs on and off. IGBT module feedback status information is sent via the fiber-optic cabling back to the GDI module(s) in the PMI rack. Fiber-optic cabling is immune to electromagnetic and radio frequency interference (EMI/RFI) and eliminates ground loops. For more information on fiber-optic cabling refer to the Distributed Power System Fiber-Optic Cabling instruction manual (S-3009).

Local Power Interface module (LPI)

The LPI module is the interface between the SA3000 Power Module and the PMI rack. It is through this module that information is sent to the SA3000 Power Module and feedback data is sent back to the PMI rack.

Capacitor Bank Assembly

The capacitor bank's electrolytic capacitors store power locally for the IGBTs.

115 VAC Power Supply Assembly

Power Supply Assembly P/N 850100-3S allows for the separation of critical (PMI rack, 25 KHz power supply, DC power supplies) and non-critical (blower motors) 115 VAC power via two 115 VAC terminal boards and two 25A circuit breakers. Removing the jumper wires between the two terminal boards provides the separation of critical and non-critical power. The circuit breakers can be locked in either the ON or OFF position when the optional locking mechanism is used.

Power Supply Assembly P/N 850100-3R provides one 115 VAC terminal board and one 25A circuit breaker. This assembly distributes 115 VAC power to the DC power supplies, the 25 KHz power supply, the PMI rack, and the Power Module blowers. See figure 4.5.

25 KHz Power Supply Assembly

The 25 KHz Power Supply Assembly provides power to the six IGBT gate drivers in each Power Module. 25KHz AC power is used for transformer isolation and noise immunity. Input power is provided by the 115 VAC power supply. See figure 4.6.

DC Bus Voltage Meter (Option)

The DC Bus Voltage meter, which is connected directly across the DC bus, measures the DC bus voltage being applied to the power module.

Output Meters (Option)

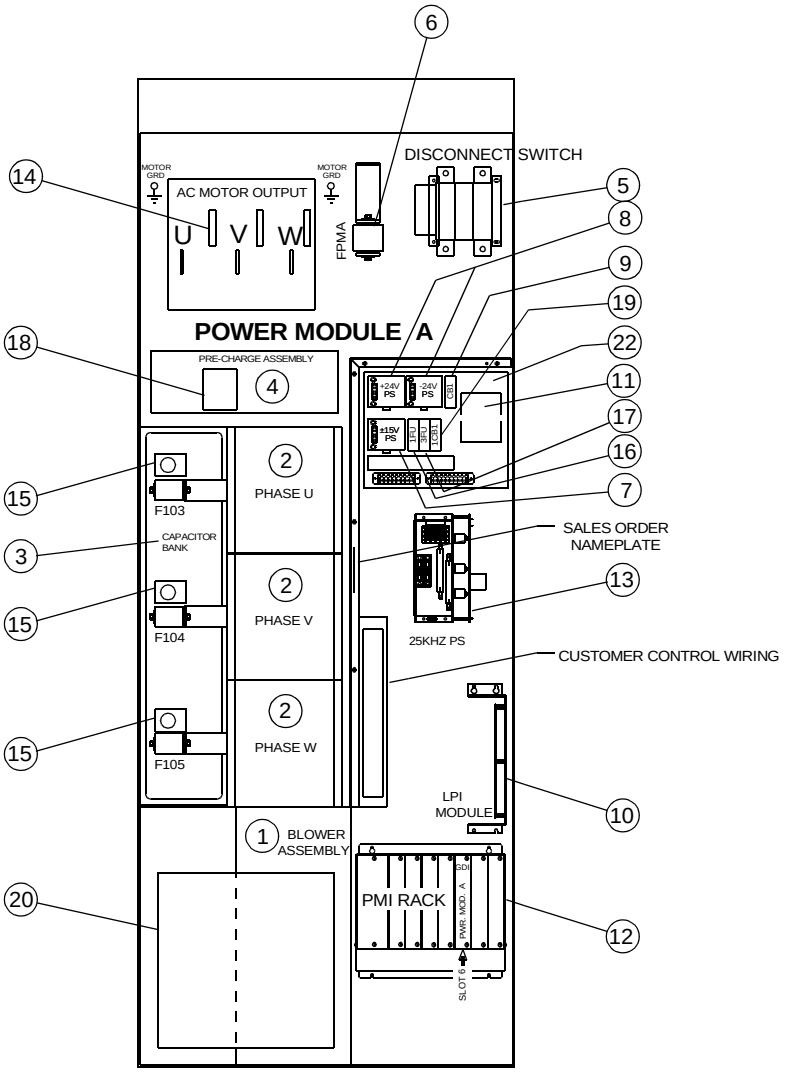
These meters measure the AC voltage (0-600V), current (0-200 percent of full load), torque (200-0-200 percent of full load), and frequency (120-0-120Hz) being applied to the motor. These meters are connected to the PMI Processor’s meter ports, which are under software control.

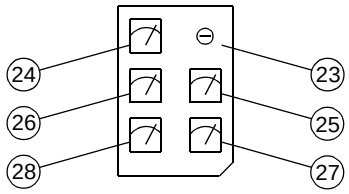
Main Disconnect (Option)

Depending on system requirements, a DC input disconnect may be provided. Note that if a disconnect is supplied, the pre-charge assembly option must also be used if the Power Module is operating from a constant potential DC bus supply.

Pre-charge Assembly (Option)

The Pre-charge Assembly consists of a contactor, pre-charge resistors, and a printed circuit board assembly. The contactor bypasses the pre-charge resistor after the bus voltage reaches a programmable threshold value. A pre-charge control module communicates with the LPI module and controls the pre-charge contactor.



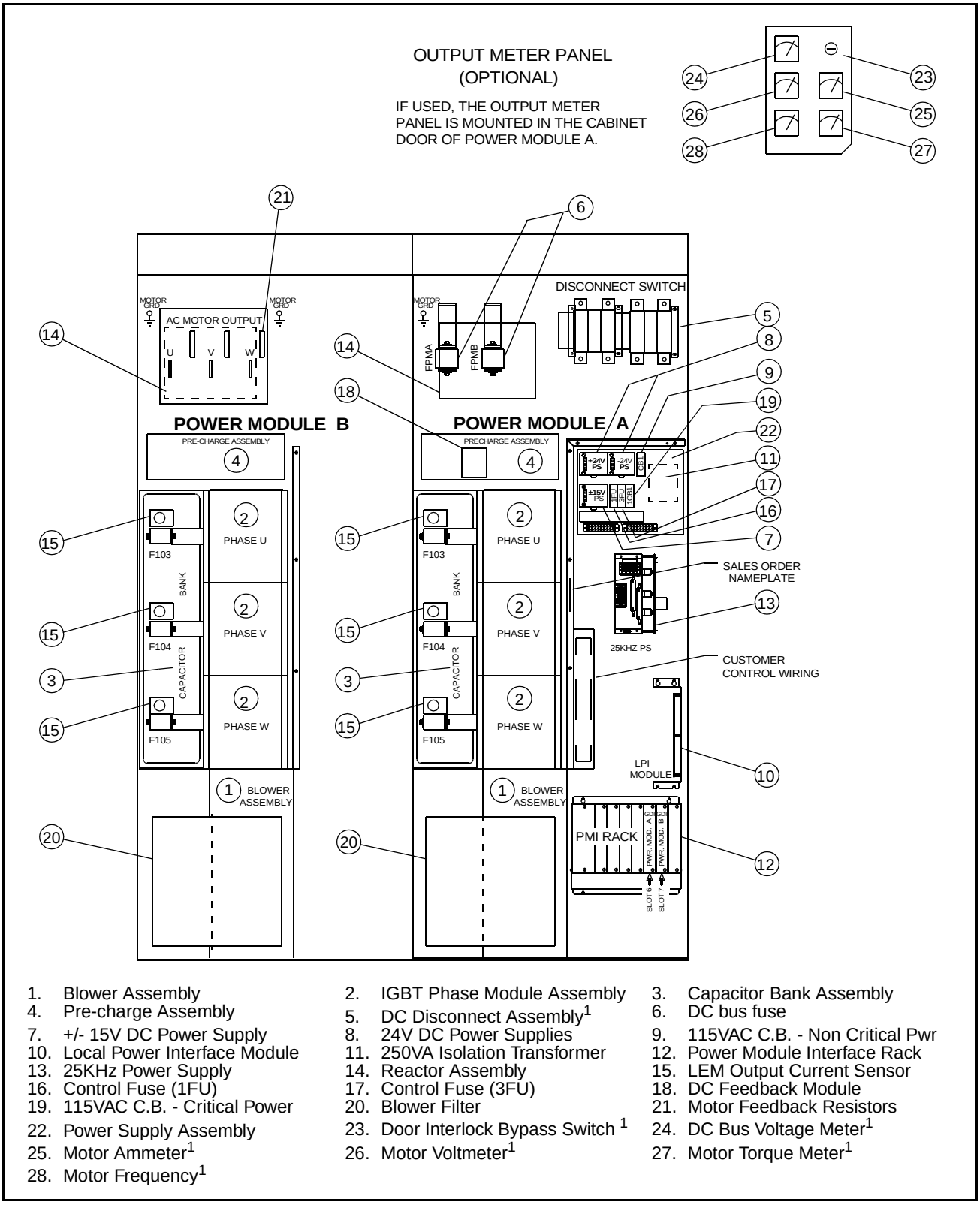


IF USED, THE OUTPUT METER PANEL IS MOUNTED IN THE CABINET DOOR OF POWER MODULE A.

1. Blower Assembly
2. IGBT Phase Module Assembly
3. Capacitor Bank Assembly
4. Pre-charge Assembly
5. DC Disconnect Assembly[1]
6. DC bus fuse
7. +/- 15V DC Power Supply
8. 24V DC Power Supplies
9. 115VAC C.B. - Non Critical Pwr
10. Local Power Interface Module
11. 250VA Isolation Transformer
12. Power Module Interface Rack
13. 25KHz Power Supply
14. Reactor Assembly
15. LEM Output Current Sensor
16. Control Fuse (1FU)
17. Control Fuse (3FU)
18. DC Feedback Module
19. 115VAC C.B. - Critical Power
20. Blower Filter
21. Motor Feedback Resistors
22. Power Supply Assembly
23. Door Interlock Bypass Switch [1]
24. DC Bus Voltage Meter[1]
25. Motor Ammeter[1]
26. Motor Voltmeter[1]
27. Motor Torque Meter[1]
28. Motor Frequency[1]

Figure 2.1 – 534A SA3000 Power Module Components

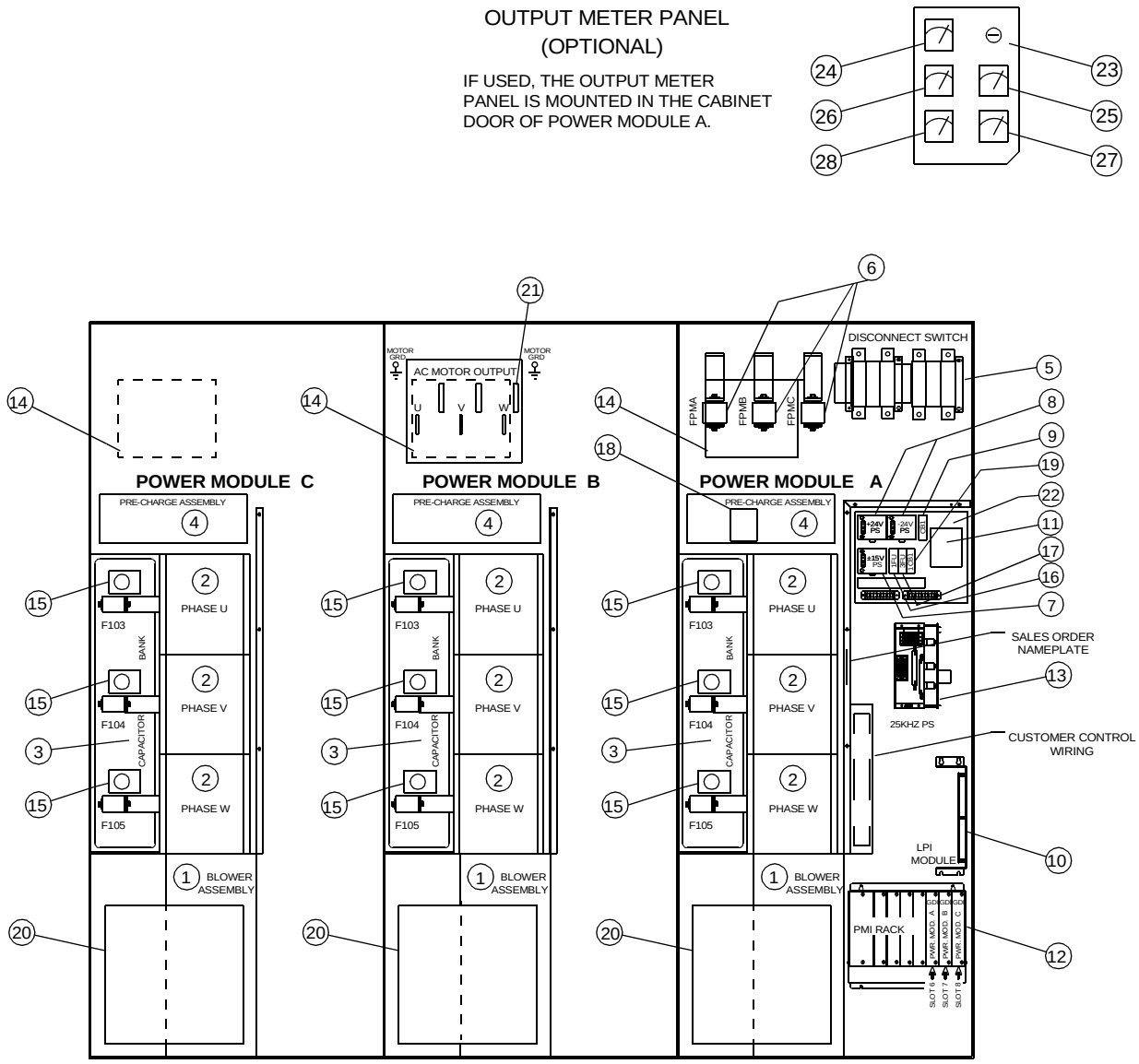
1. Optional



1. Blower Assembly
2. IGBT Phase Module Assembly
3. Capacitor Bank Assembly
4. Pre-charge Assembly
5. DC Disconnect Assembly[1]
6. DC bus fuse
7. +/- 15V DC Power Supply
8. 24V DC Power Supplies
9. 115VAC C.B. - Non Critical Pwr
10. Local Power Interface Module
11. 250VA Isolation Transformer
12. Power Module Interface Rack
13. 25KHz Power Supply
14. Reactor Assembly
15. LEM Output Current Sensor
16. Control Fuse (1FU)
17. Control Fuse (3FU)
18. DC Feedback Module
19. 115VAC C.B. - Critical Power
20. Blower Filter
21. Motor Feedback Resistors
22. Power Supply Assembly
23. Door Interlock Bypass Switch [1]
24. DC Bus Voltage Meter[1]
25. Motor Ammeter[1]
26. Motor Voltmeter[1]
27. Motor Torque Meter[1]
28. Motor Frequency[1]

Figure 2.2 – 972A 3000A Power Module Components

1. Optional



1. Blower Assembly
2. IGBT Phase Module Assembly
3. Capacitor Bank Assembly
4. Pre-charge Assembly
5. DC Disconnect Assembly[1]
6. DC bus fuse
7. +/- 15V DC Power Supply
8. 24V DC Power Supplies
9. 115VAC C.B. - Non Critical Pwr
10. Local Power Interface Module
11. 250VA Isolation Transformer
12. Power Module Interface Rack
13. 25KHz Power Supply
14. Reactor Assembly
15. LEM Output Current Sensor
16. Control Fuse (1FU)
17. Control Fuse (3FU)
18. DC Feedback Module
19. 115VAC C.B. - Critical Power
20. Blower Filter
21. Motor Feedback Resistors
22. Power Supply Assembly
23. Door Interlock Bypass Switch [1]
24. DC Bus Voltage Meter[1]
25. Motor Ammeter[1]
26. Motor Voltmeter[1]
27. Motor Torque Meter[1]
28. Motor Frequency[1]

Figure 2.3 – 1457A SA3000 Power Module Components

1. Optional

2.2 Electrical Description

DC bus input power is applied to the Power Module through terminals 45 (–) and 47 (+), passes through the optional DC bus disconnect and in-line fuses, and is then fed to the optional pre-charge circuitry. See figures 2.4 to 2.7.

When pre-charge circuitry is present and DC input power is applied, the internal DC bus begins charging through the pre-charge resistors. Once the DC bus capacitors are fully charged (per the programmable threshold value) and all pre-charge criteria are met, the internal pre-charge contactor closes and bypasses the pre-charge resistors. If the DC bus disconnect option is not used, the bus supply is responsible for the charging operation. Refer to Appendix B for additional information on SA3000 internal DC bus control.

The DC bus voltage is filtered and stored by the electrolytic capacitors. Discharge resistors are designed to discharge the capacitors down to 50 VDC within 5 minutes after power is removed from the input terminals. However, if a DC bus fuse has blown, it is possible for a charge to be stored on the DC bus capacitors without being indicated on the DC bus voltmeter. Wait 10 minutes before working on the unit. Be sure to measure the DC bus potential of each Power Module capacitor bank before touching any internal circuitry. See figure 4.1 for test point locations.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

When the DC bus operating voltage is reached, the connected Inverter Power Modules may be operated. Note that if an SB3000 Power Module is used to supply the DC bus, the SB3000 Power Module cannot support the loading of SA3000 Inverter Power Modules when the soft-charge resistors in the SB3000 are limiting the bus charging current.

ATTENTION: When used with an SB3000 bus supply, the SA3000 Power Module must be in standby or in regeneration whenever the SB3000 Power Module' s pre-charge contactor opens. The SB3000 Power Module's soft-charge resistors may fail if this interlocking restriction is not observed. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

The SA3000 inverter power circuitry uses the filtered DC bus voltage to provide the variable-voltage, variable-frequency output to the motor (terminals U, V, W). The 972 Amp and 1457 Amp units have reactors for load sharing on their outputs. The IGBTs are switched by the gate drivers on the IGBT phase module under the control of the PMI rack. A LEM sensor is located on each output phase (U,V,W) of each SA3000 Inverter Power Module (A,B, or C) to provide output current feedback for overcurrent protection.

Each SA3000 Inverter Power Module connected to an SB3000 Power Module supplied DC bus must have a separate pre-charge resistor and contactor to limit the current into its capacitor bank. It is the responsibility of the application tasks to make sure that the SB3000 Power Module is in run before the SA3000 Inverter Power Module is put into run.

ATTENTION: When used with an SB3000 Power Module, the SB3000 Power Module must be in run before the SA3000 Inverter Power Module is put into run. If the pre-charge contactor supplying the SB3000 Power Module is not closed, running the SA3000 Power Module will damage the SB3000 pre-charge resistors. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

If the SB3000 Power Module is not in run, the DC bus voltage will not be high enough to support the full rating of the SA3000 Inverter Power Module. If the SB3000 Power Module is shut down due to a fault condition, controlled shutdown of the SA3000 Power Module is the responsibility of the application program running in the SA3000 UDC module.

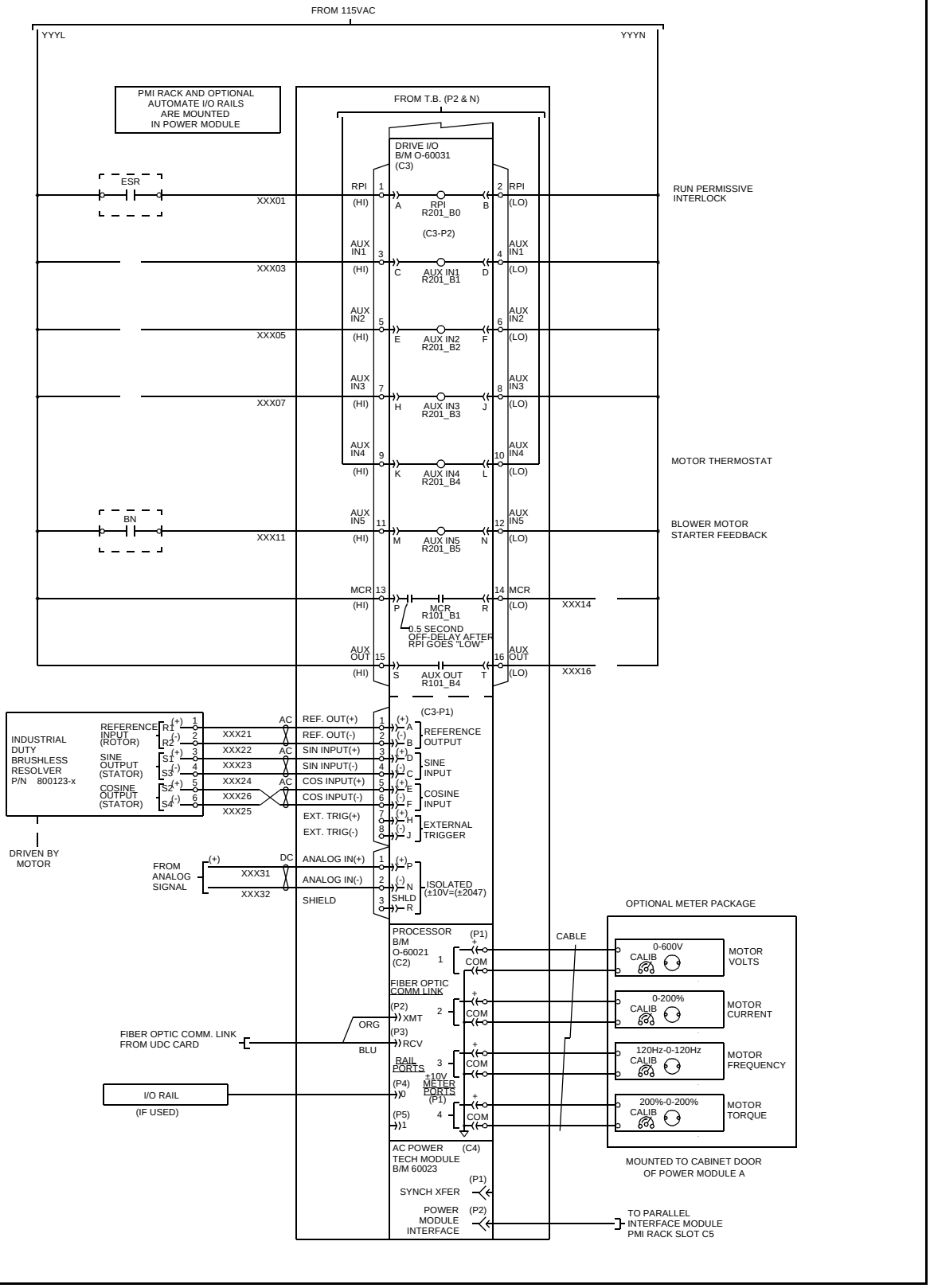


Figure 2.4 – Drive I/O and Processor Card Detail

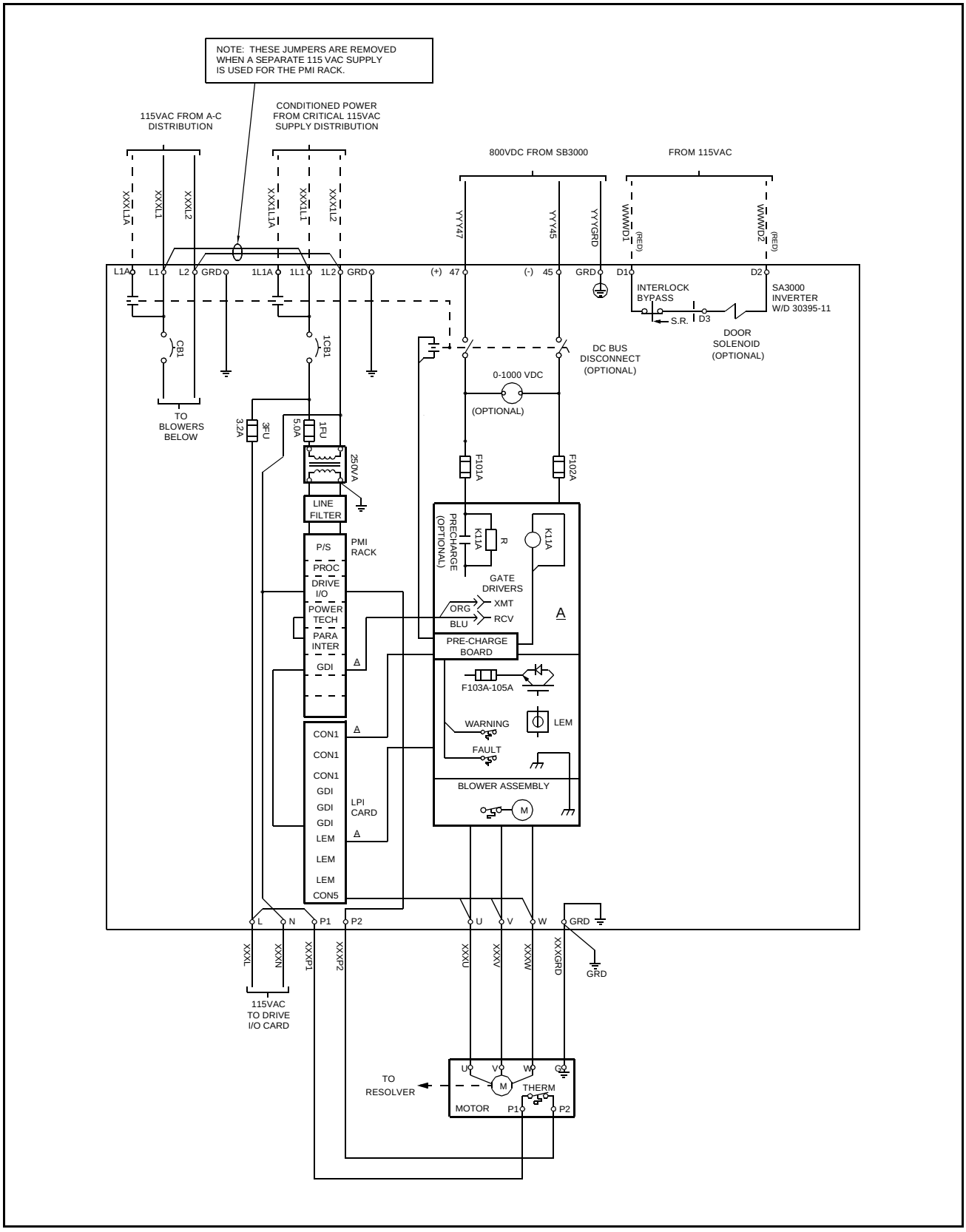


Figure 2.5 – 534A SA3000 Power Module Circuitry

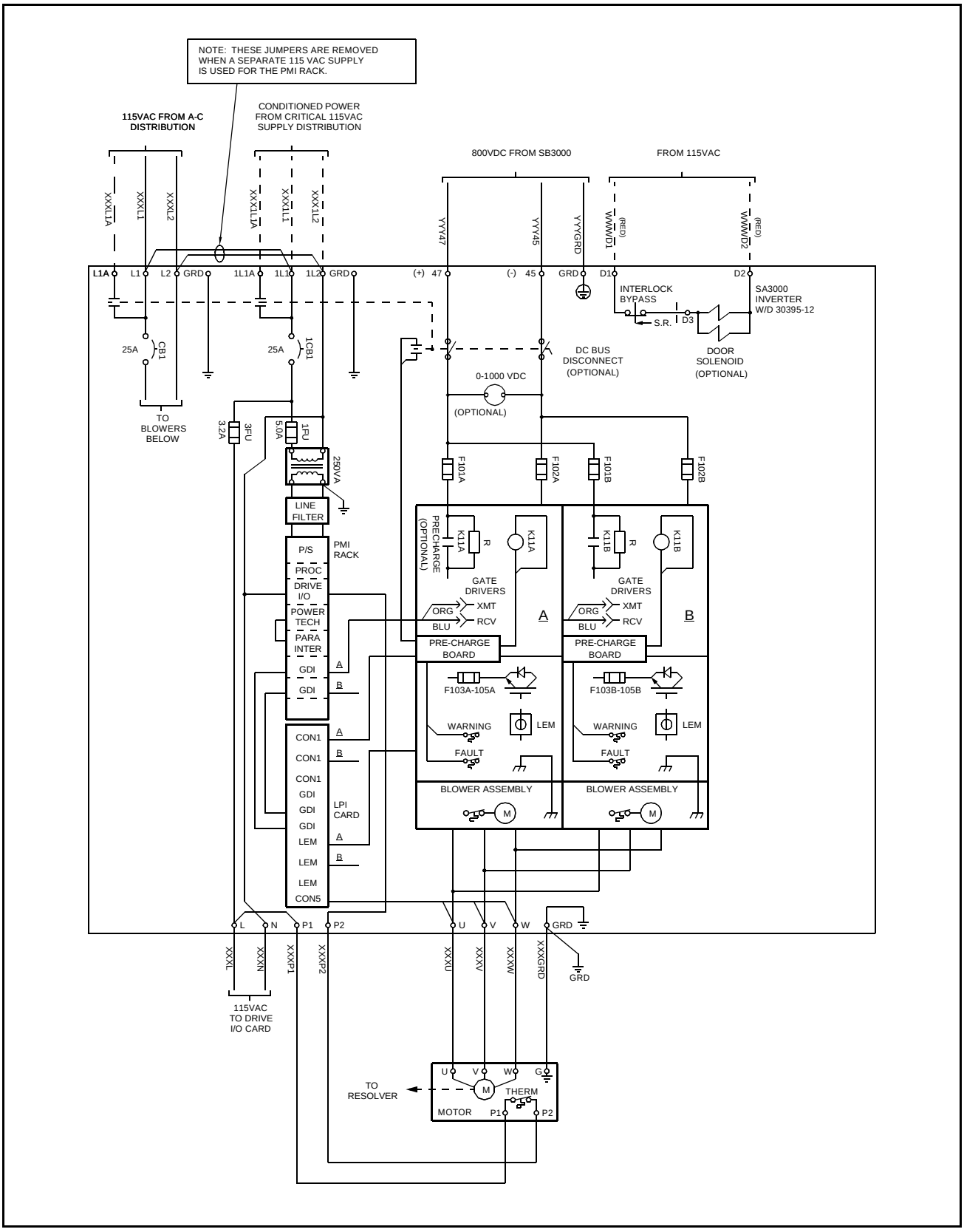


Figure 2.6 – 972A SA3000 Power Module Circuitry

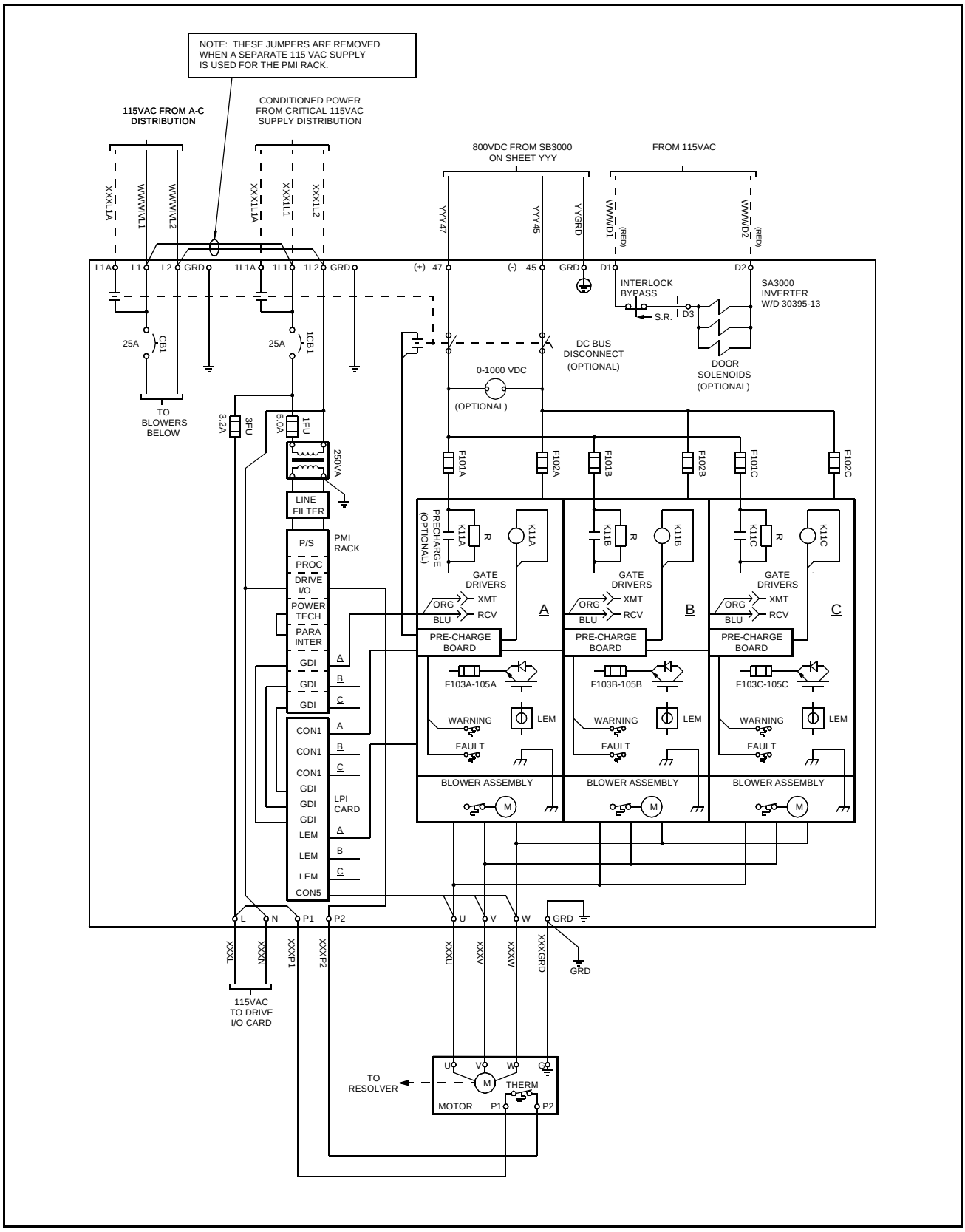


Figure 2.7 – 1457A SA3000 Power Module Circuitry

CHAPTER 3
Installation Guidelines

This chapter describes the guidelines and wiring recommendations to be followed when installing High Power SA3000 Power Modules. Installation and replacement procedures are included for the 534A, 972A, and 1457A Power Modules.

ATTENTION: The user is responsible for conforming with all applicable local, national, and international codes. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

3.1 Installation Planning

SA3000 Power Module current ratings are dependent upon inlet air temperature. Ratings are given at 40° C (104° F) ambient. Refer to table 1.1 for output current ratings.

Internal Power Module conditions are monitored by two thermal switches on the heatsink. One switch is used to indicate a warning condition (register 203/1203, bit 7, WRN_OT@); the other is used to indicate a fault condition (register 202/1202, bit 7, FLT_OT@). The thermal warning switch closes at 78° C (172.4° F); the thermal fault switch closes at 85°C (185° F). Refer to the SA3000 Configuration and Programming instruction manual (S-3042) for more information on faults and warnings.

Use the following guidelines when planning your SA3000 Power Module installation:

- The relative humidity around the SA3000 Power Module must be kept between 5 and 90% (non-condensing).
- Do not install above 1000 meters (3300 feet) without derating. For every 91.4 meters (300 feet) above 1000 meters (3300 feet), the SA3000 Power Module's current rating is derated 1%.
- Locate the SA3000 Power Module in a clean, cool, and dry area. Follow the recommendations given in IEC 68 concerning environmental operating conditions.
- Be sure surrounding equipment does not block service access to the SA3000 Power Module.
- Allow adequate clearance for air ventilation. SA3000 Power Modules pull in air from the bottom of the cabinet and exhaust it through the top of the cabinet. Each cabinet bay of the SA3000 Power Module has one fan. Allow at least 30 cm (12") above and 2 m (6.6') in front of the SA3000 Power Module for adequate air clearance.
- Individual motor lead lengths cannot exceed 100 meters (328 feet).
- Refer to the Drive System Installation manual (D2-3115) for more information.

3.2 Wiring

ATTENTION: The user is responsible for conforming with all applicable local, national, and international codes. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

System wiring is to be done according to the supplied wiring diagrams (W/Es), which are application-specific. Sections 3.2.1 through 3.2.3 provide additional information on fuses and recommended wiring.

3.2.1 Fuses

ATTENTION: The NEC/CEC requires that upstream branch circuit protection be provided to protect input power wiring. Install the fuses recommended in table 3.1. Do not exceed the fuse ratings. Failure to observe this precaution could result in damage to, or destruction of the equipment.

Fuses are provided to protect the Power Module's DC bus, 115 VAC control power input lines, and individual IGBT phase modules. See table 3.1 for the fuse values.

Table 3.1 – Fuse Ratings

Fuse	Circuit	Fuse Current Rating	Fuse Voltage Rating	Rockwell P/N
FPM A,B,C	DC Bus	1000 A	1000 VAC	64676-80P
F103 A,B,C F104 A,B,C F105 A,B,C	IGBT Phase Modules	630 A	1000 VAC	64676-79AZ
1FU	115 VAC	5 A	600 VAC	64676-29R
3FU	115 VAC	3.2 A	600 VAC	64676-29P

3.2.2 Wire Sizes

Input wiring should be sized according to applicable codes to handle the SA3000 Power Module's continuous-rated input current. Output wiring should be sized according to applicable codes to handle the SA3000 Power Module's continuous-rated output current. Recommended wire sizes are shown in table 3.2. Terminals should be tightened to the torque values provided in table 3.3.

Table 3.2 – Recommended DC Bus Input and AC Output Wire Sizes

SA3000 Output Rating	Size of Wire[1]
534A	2 x 600 Kc Mil (304 mm^2)
972A	3 x 600 Kc Mil (304 mm^2)
1457A	4 x 1000 Kc Mil (507 mm^2)

1. NEC-recommended cable types: 40^oC (104^oF) copper wire.

Table 3.3 – Terminal Tightening Torques

Terminals	Tightening Torque
DC Bus Input Power: 45, 47	41 Nm (30 lb-ft)
Output Power: U, V, W	41 Nm (30 lb-ft)
115 VAC Input Power: L1, L2	3.5 Nm (2.6 lb-ft)

3.2.3 Wire Routing

Ac output wiring is routed through the top of the cabinet, above terminals 181, 182 and 183. DC input wiring is also routed through the top of the cabinet. DC input wiring is usually connected to the DC bus in the overhead enclosure that distributes the DC power to the common DC bus Inverter Power Modules. A DC input disconnect switch is provided to disconnect DC bus power, providing safe access to the inside of the SA3000 Power Module cabinet.

3.3 Grounding

ATTENTION: Ungrounded equipment represents a shock hazard. Connect the power module's ground terminals to earth ground using properly-sized ground wires. Failure to observe this precaution could result in severe bodily injury or loss of life.

System grounding is to be done according to the supplied wiring diagrams (W/Es) in accordance with applicable codes. To prevent noise interference and possible malfunction of this equipment, it is imperative that a good cabinet ground be provided. The grounding conductor must be as short as possible and be run directly from the control panel ground terminal to a solid earth ground. It is recommended that the grounding conductor be the same size conductor as the power wiring. Multi-cabinet grounding wires should not be daisy-chained but should be run separately to the common point of earth ground.

3.4 Installing the Power Module Cabinet

Use the following procedure to install the SA3000 Power Module cabinet:

Step 1. Ensure that DC input power leading to the SA3000 Power Module is off.

Step 2. Position the SA3000 Power Module on a level mounting surface. See figures 3.1, 3.2, and 3.3 for cabinet dimensions. Floor mounting dimensions are included for applications in which the cabinet is to be attached to the floor.

Step 3. Connect the DC bus to terminals 45 (-) and 47(+). See the W/Es. Connect the GND terminal to earth ground.

Step 4. If used, connect the optional output contactor to the U, V, and W terminals.

Step 5. Connect the motor leads to the output contactor. If an output contactor is not used, connect the motor leads directly to the U, V, and W terminals. See the W/Es and figure 3.4.

Step 6. Connect the GND terminal to earth ground.

Step 7. Connect the AC control power input line (two-wire 115 VAC with ground) to terminals L1 (L), L2 (N), and GND on the control wiring terminal board. See the W/Es and figure 3.4.

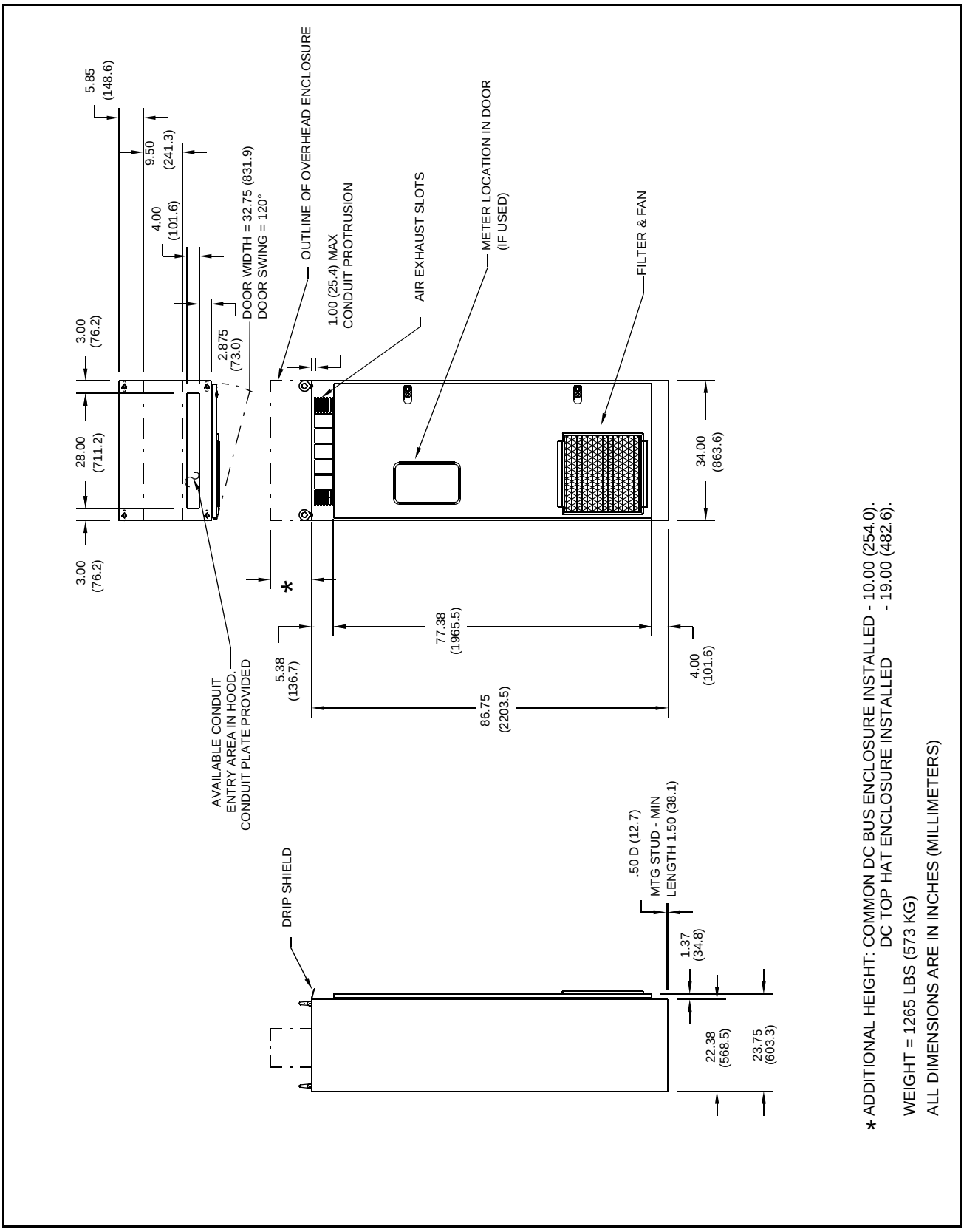


Figure 3.1 – 534A Power Module Mounting Dimensions (Single-Bay)

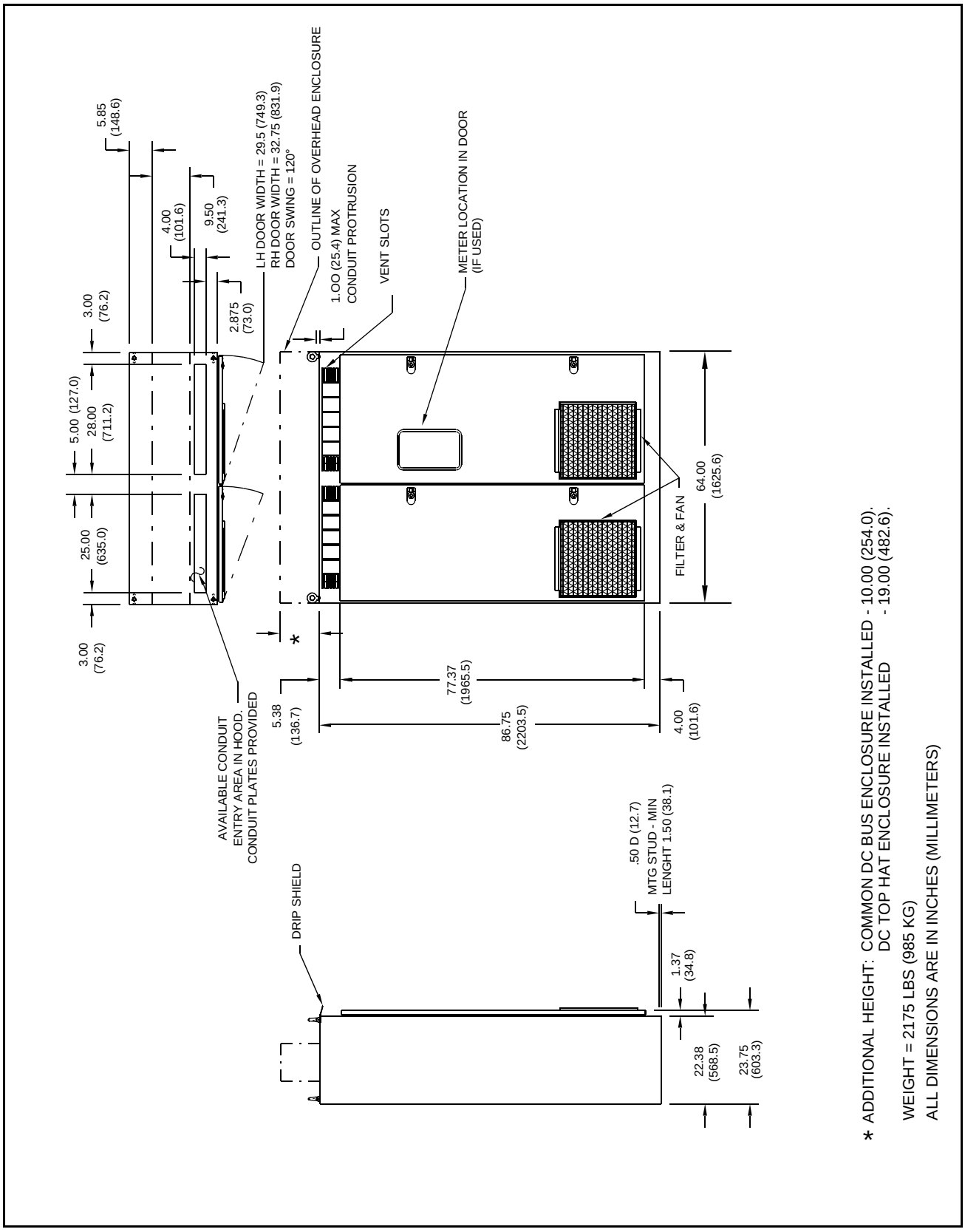


Figure 3.2 – 972A Power Module Mounting Dimensions (Double-Bay)

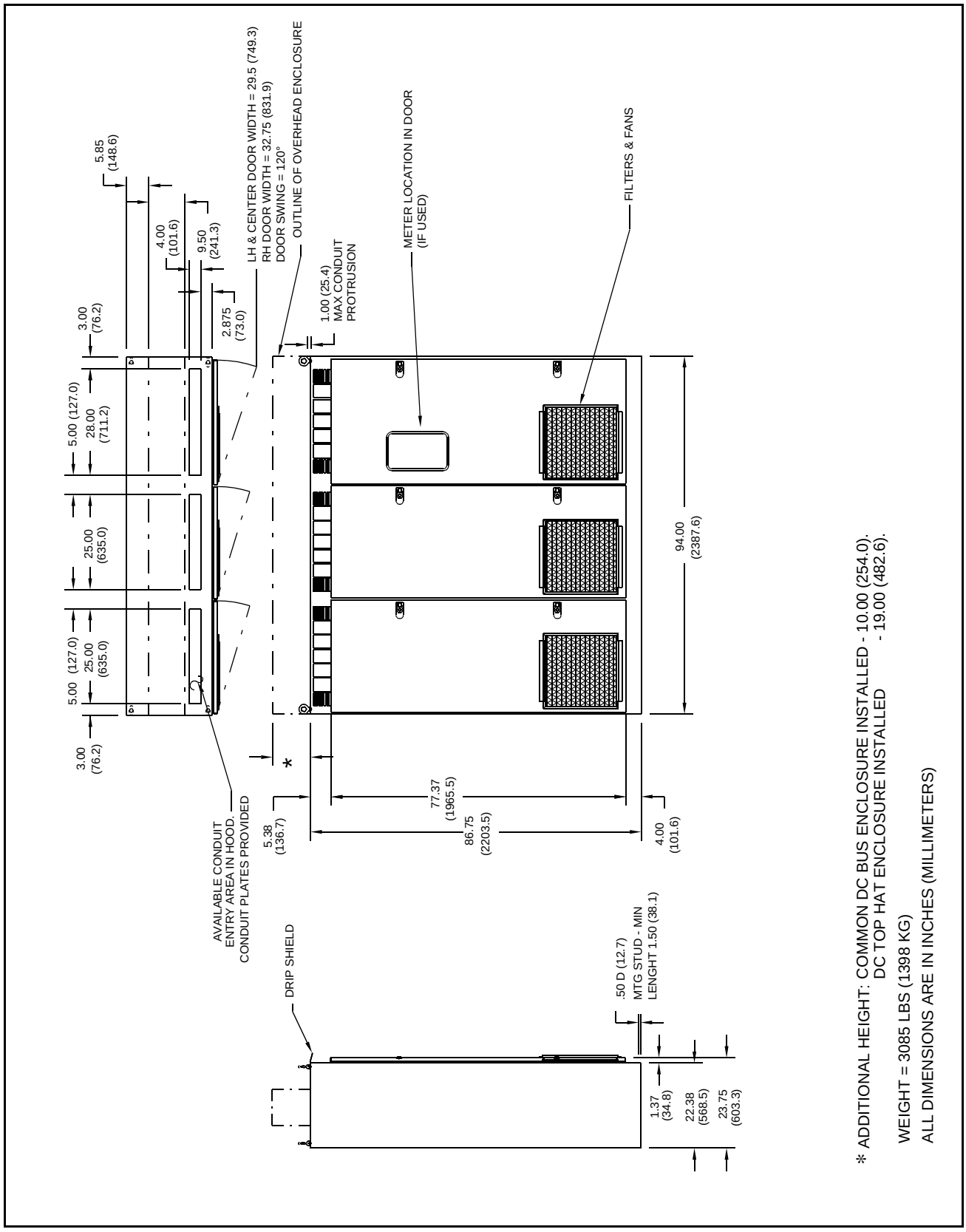


Figure 3.3 – 1457A Power Module Mounting Dimensions (Triple-Bay)

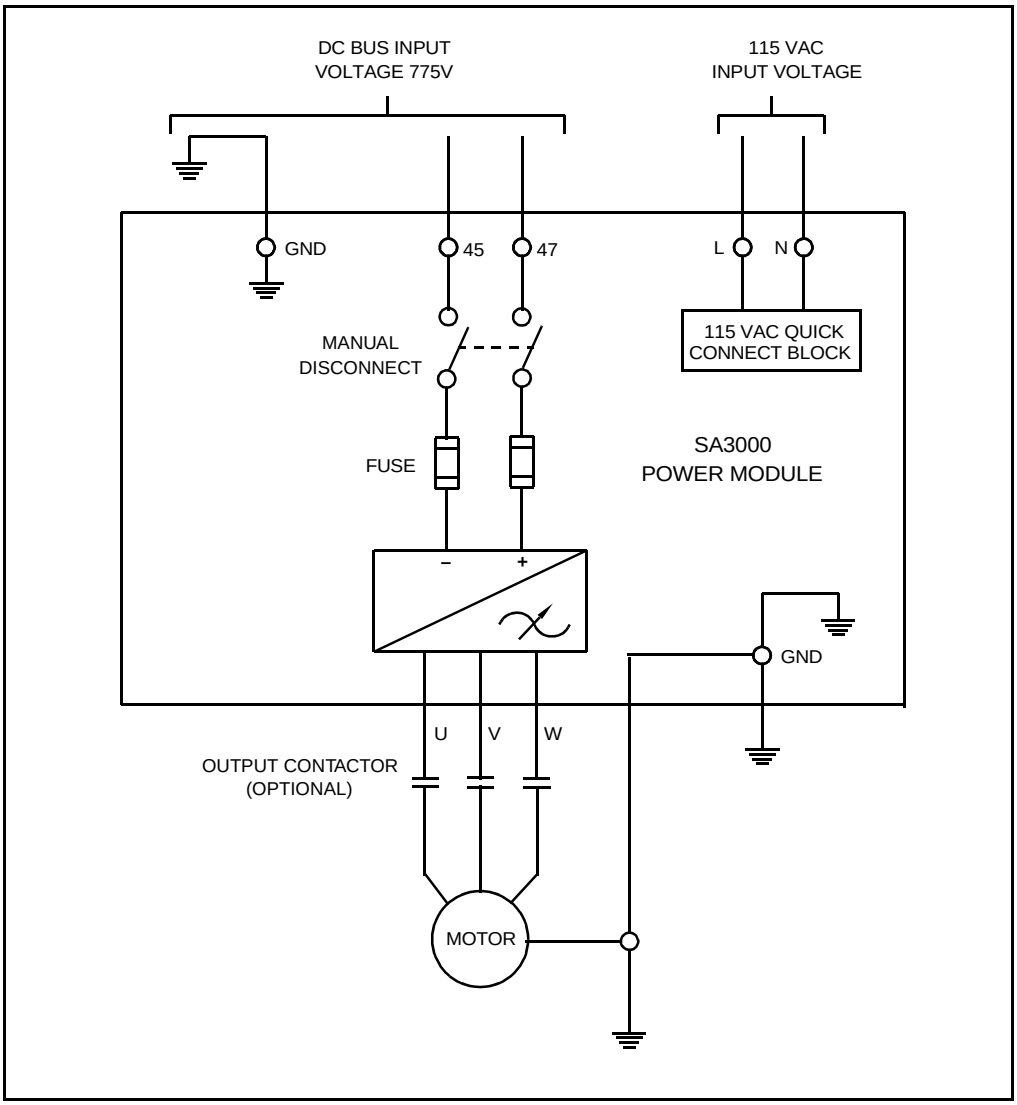


Figure 3.4 – SA3000 Power and Ground Connections

CHAPTER 4

Diagnostics and Troubleshooting

This chapter describes the equipment needed to check the operation of the Power Module and the tests to be performed. Included are descriptions of the Power Module faults and warnings monitored by the Distributed Power System software. Procedures are also provided for replacing Power Module cabinets, sub-assemblies, and fuses.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: The SA3000 Power Module contains printed circuit boards that are static sensitive. Do not touch the boards' components, connectors, or leads. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

4.1 Required Test Equipment

The following equipment is required when servicing the SA3000 Power Module:

- an oscilloscope with an impedance of at least 8 megohms
- a 10:1 probe
- an isolated voltmeter (1000V DC)
- a clamp-on ammeter (1500A)

Note that all measuring devices-meters-oscilloscopes that are AC line-powered must be connected to the AC line through an ungrounded isolation transformer.

ATTENTION: The Power Module is not isolated from earth ground. AC line powered test instruments used to measure Power Module signals must be isolated from ground through an isolation transformer. This is not necessary for battery-powered test instruments. Failure to observe this precaution could result in bodily injury.

ATTENTION: If a megohmmeter (megger) is used to verify an inadvertent ground internal to the motor, make certain that all leads are disconnected between the rotating equipment and the Power Module cabinet. This will prevent damage to electronic circuitry (Power Modules and their associated circuitry) due to the high voltage generated by the megger. Failure to observe this precaution could result in damage to or destruction of the equipment.

4.2 Power Module Tests with Input Power Off

Use the following procedure to perform the SA3000 Power Module tests:

Step 1. Turn off and lock out DC input power.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

> **ATTENTION:** DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the Power Module's cabinet doors and measure the voltage across each pair of DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. See figure 4.1.

Step 4. Disconnect the motor from the Power Module.

Step 5. Check the DC bus fuses.

Be sure to check the DC bus fuses for continuity if an IGBT phase module or fuse fails in a 972A or 1457A Power Module. Excessive current may have damaged the DC bus fuses. It is recommended that the DC bus fuses be replaced whenever an IGBT phase module or fuse fails due to a fault current. If the DC bus fuses have opened in Power Module A, a bus fault will be generated. If the DC bus fuses have opened in Power Modules B or C, a bus fault will not be generated, but an Instantaneous Overcurrent (IOC) fault will be indicated. This may be the only indication of a blown fuse in Power Modules B and C.

Step 6. If a fuse is blown, use a multimeter to check the DC bus, bus capacitors, output terminals, and the output IGBTs. See tables 4.1 and 4.2.

Step 7. If a capacitor is defective, replace the capacitor bank assembly as described in section 4.4.5. If an IGBT is defective, refer to section 4.4.2.

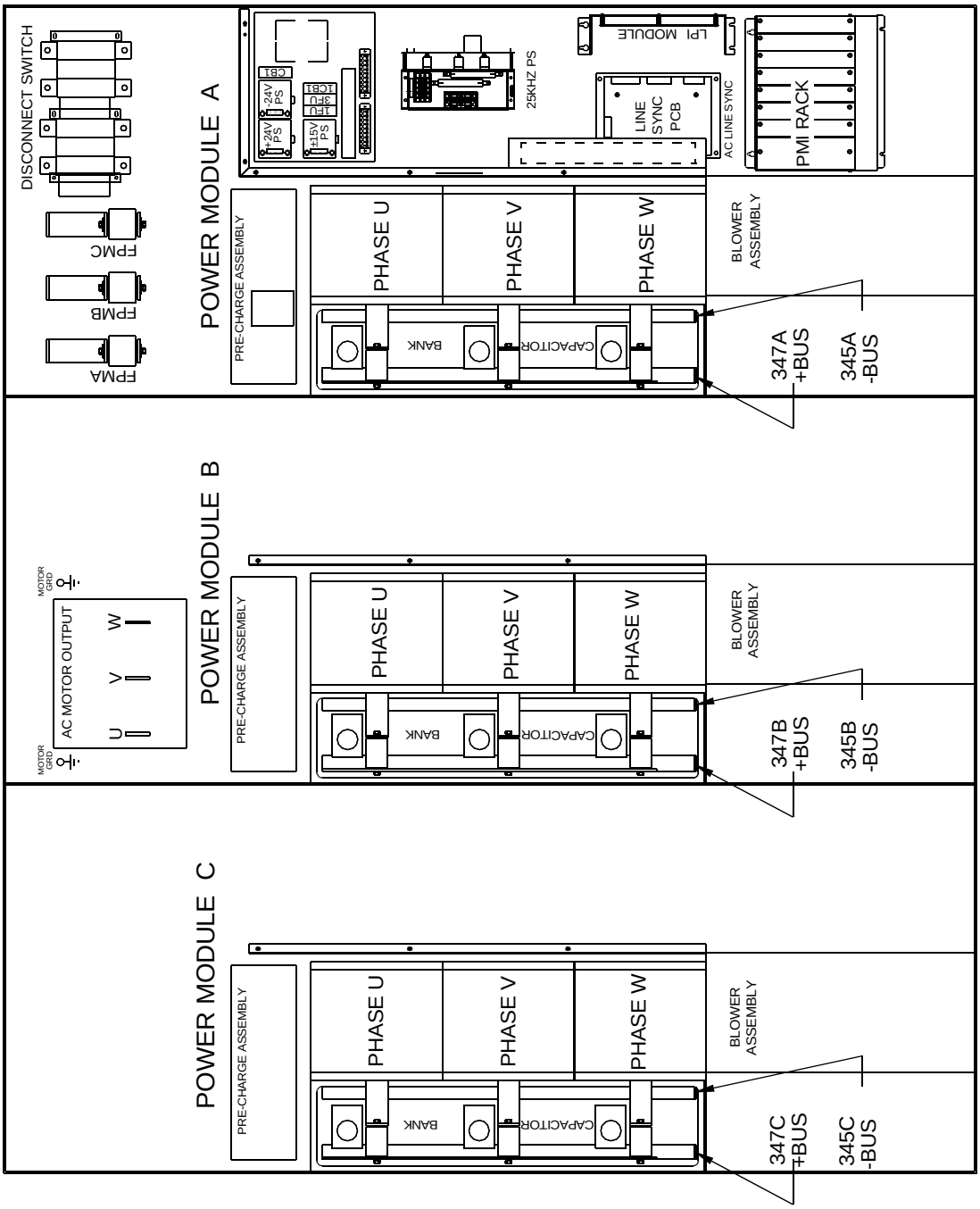


Figure 4.1 – DC Bus Voltage Measuring Points

Table 4.1 – DC Bus and Terminal Tests[1]

	Meter Connections +	-	Scale	Expected Test Results
DC Bus	- Bus (45)	+ Bus (47)	X10	Capacitor Effect (0 to 50 ohms)
	+ Bus (47)	- Bus (45)		Capacitor Effect (0 to 200 ohms)
Bus Capacitors	+	349 A,B,C	X10	Capacitor Effect (0 to 500 ohms)
	-	349 A,B,C		
	U	+	X1	2 ohms
	V	+		
	W	+		
	+	U	X10	Capacitor Effect (0 to 2k ohms)
	+	V		
	+	W		
Output Terminals	U	V	X1000	4k to 6k ohms
	U	W		
	V	W		

1. With the motor disconnected

Table 4.2 – IGBT Tests[1]

	Meter Connections +	-	Scale	Expected Test Results (+/- 10%)
W Phase (lower) +	W	+347 A,B,C	2k Ω/diode	0.300 ohms
V Phase (lower) +	V	+347 A,B,C	2k Ω/diode	0.300 ohms
U Phase (lower) +	U	+347 A,B,C	2k Ω/diode	0.300 ohms
W Phase (upper) -	-345 A,B,C	W	2k Ω/diode	0.300 ohms
V Phase (upper) -	-345 A,B,C	V	2k Ω/diode	0.300 ohms
U Phase (upper) -	-345 A,B,C	U	2k Ω/diode	0.300 ohms

1. With the motor disconnected

4.3 Power Module Faults and Warnings

The PMI Processor continually runs diagnostics which check for errors that may affect system operation. Warnings are errors which indicate that the SA3000 Power Module is not operating in an optimum manner. Warnings will not shut down the SA3000. Faults are severe errors which will shut down the SA3000. See tables 4.3 and 4.4.

Refer to the SA3000 Drive Configuration and Programming instruction manual (S-3042) for more information about the Fault and Warning registers.

4.3.1 Power Module Faults

The Power Module faults listed in table 4.3 will cause the SA3000 Power Module to shut down. In a fault situation, the PMI Processor will command zero current and will stop firing the Power Module's IGBTs. Faults must be reset before the SA3000 Power Module can be restarted.

Table 4.3 – SA3000 Power Module Faults (Register 202/1202)

Bit	Suggested Variable Name	UDC Error Code	Description Summary
0	FLT_OV@	1018	The DC Bus Overvoltage bit is set if the DC bus voltage exceeds 925 VDC.
1	FLT_DCI@	1020	The DC Bus Overcurrent bit is set if the DC bus current exceeds 125% of the rated SA3000 Power Module current.
2	FLT_GND@	1021	The Ground Current Fault bit is set if the ground current exceeds the hardware trip point. See section 4.3.1.3.
3	FLT_IOC@	1017	The Instantaneous Overcurrent Fault bit is set if an overcurrent is detected in one of the power devices.
4	FLT_LPI@	1022	The Local Power Interface bit is set if the power supply voltage on the LPI module is not within tolerance.
6	FLT_CHG@	1024	The Charge Bus Timeout Fault bit is set if the DC bus is not fully charged within 10 seconds of being enabled, if the drive is on and feedback indicates the pre-charge contactor has opened, or if DC bus voltage is less than the Power Loss Fault Threshold tunable variable (PLT_FLT%).
7	FLT_OT@	1016	The Overtemperature Fault bit is set if the fault level thermal switch (85^{o} C (185^{o} F)) in the SA3000 Power Module opens.

4.3.1.1 DC Bus Overvoltage Fault

The DC Bus Overvoltage bit (bit 0) is set in the Fault register (202/1202) if the DC bus voltage exceeds 925 VDC. Error code 1018 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.2 DC Bus Overcurrent Fault

The DC Bus Overcurrent bit (bit 1) is set in the Fault register (202/1202) if the DC bus current exceeds 125% of the rated SA3000 Power Module current. Error code 1020 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.3 Ground Current Fault

The Ground Current Fault bit (bit 2) is set in the Fault register (202/1202) if the ground current exceeds the hardware trip point value of 100 Amps. Error code 2021 will also be displayed in the error log of the UDC task in which the fault occurred.

Note that the Ground Current Fault bit (register 202/1202, bit 2) is not enabled on SA3000 Power Modules using AC Technology modules, B/M 60023-5 and later. Error code 2021 will not be displayed as the ground current hardware trip detector was removed from the AC Technology modules, B/M 60023-5 and later.

4.3.1.4 Instantaneous Overcurrent Fault

The Instantaneous Overcurrent Fault bit (bit 3) is set in the Fault register (202/1202) if an overcurrent is detected in one of the power devices (IGBTs). Register 204/1204, bits 0-5, indicates which power device experienced the overcurrent. When 972A and 1457A SA3000 Power Modules are being used, registers 220/1220 and 221/1221 indicate the status of the B and C Power Modules. Error code 1017 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.5 Local Power Interface Fault

The Local Power Interface Fault bit (bit 4) is set in the Fault register (202/1202) if the power supply voltage on the LPI module is not within tolerance. Error code 1022 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.6 Charge Bus Time-Out Fault

The Charge Bus Fault bit (bit 6) is set in the Fault register (202/1202) if one of the following occurs:

- the internal DC bus is not fully charged within 10 seconds after the bus enable bit (register 100/1100, bit 4) is set.
- the drive is on and feedback indicates that the pre-charge contactor has opened
- DC bus voltage is less than the value stored in the Power Loss Fault Threshold (PLT_E0%) tunable variable.

If this bit is set, verify that the incoming DC bus power is at the appropriate level. If the power level is correct the problem is in one of the SA3000 Power Modules. Bit 8 in register 204/1204, 220/1220, or 221/1221 will be set to indicate which Power Module is caused the fault. Error code 1024 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.7 Overtemperature Fault

The Overtemperature Fault bit (bit 7) is set in the Fault register (202/1202) if the fault level thermal switch (85^{o} C (185^{o} F)) in the Power Module opens. Bit 12 in register 204/1204, 220/1220, or 221/1221 will be set to indicate which SA3000 Power Module is caused the fault. Error code 1016 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.2 Power Module Warnings

The following warnings indicate conditions which are not serious enough to shut down the SA3000 Power Module but may affect its performance. See table 4.4. Warnings cause no action by themselves. Any response to a warning condition is the responsibility of the application task.

Table 4.4 – SA3000 Warning Register 203 /1203

Bit	Suggested Variable Name	Description Summary
0	WRN_OV@	The DC Bus Overvoltage fault bit is set if the DC bus voltage exceeds the overvoltage threshold value stored in local tunable OVT_E0%.
1	WRN_UV@	The DC Bus Undervoltage bit is set if the DC bus voltage drops below the under voltage threshold value stored in local tunable UVT_E0%.
2	WRN_GND@	The Ground Current Warning bit is set if the ground current exceeds the ground fault current level stored in local tunable GIT_EI%.
6	WRN_SHR@	The Load Sharing Warning bit is set if a current sharing problem develops between parallel SA3000 Power Modules.
7	WRN_OT@	The Overtemperature Warning bit is set if the warning level thermal switch (78° C (172.4^{o} F)) in the SA3000 Power Module opens.

4.3.2.1 DC Bus Overvoltage Warning

The DC Bus Overvoltage bit (bit 0) is set in the Warning register (203/1203) if the DC bus voltage exceeds the overvoltage threshold value stored in local tunable OVT_E0%.

4.3.2.2 DC Bus Undervoltage Warning

The DC Bus Undervoltage bit (bit 1) is set in the Warning register (203/1203) if the DC bus voltage drops below the under voltage threshold value stored in local tunable UVT_E0%.

4.3.2.3 Ground Current Warning

The Ground Current Warning bit (bit 2) is set in the Warning register (203/1203) if the ground current exceeds the ground fault current level stored in local tunable GIT_EI%.

4.3.2.4 Load Sharing Warning

The Load Sharing Warning bit (bit 6) is set in the Warning register (203/1203) if a current sharing problem develops between parallel SA3000 Power Modules. Bits 13, 14, or 15 in registers 204/1204, 220/1220, or 221/1221 will be set to indicate the Power Module and phase that caused the warning.

4.3.2.5 Overtemperature Warning

The Overtemperature Warning bit (bit 7) is set in the Warning register (203/1203) if the warning level thermal switch (78^{o} C (172.4^{o} F)) in the SA3000 Power Module opens. Bit 12 in register 204/1204, 220/1220, or 221/1221 will be set to indicate which SA3000 Power Module caused the warning.

4.4 Replacing Power Module Fuses and Sub-Assemblies

Follow the procedures given in sections 4.4.1 to 4.4.5 to replace the SA3000 Power Module's fuses and sub-assemblies.

4.4.1 Replacing Fuses

Use the following procedure to replace a fuse that has blown:

Step 1. Turn off and lock out the AC input power.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. See figure 4.1.

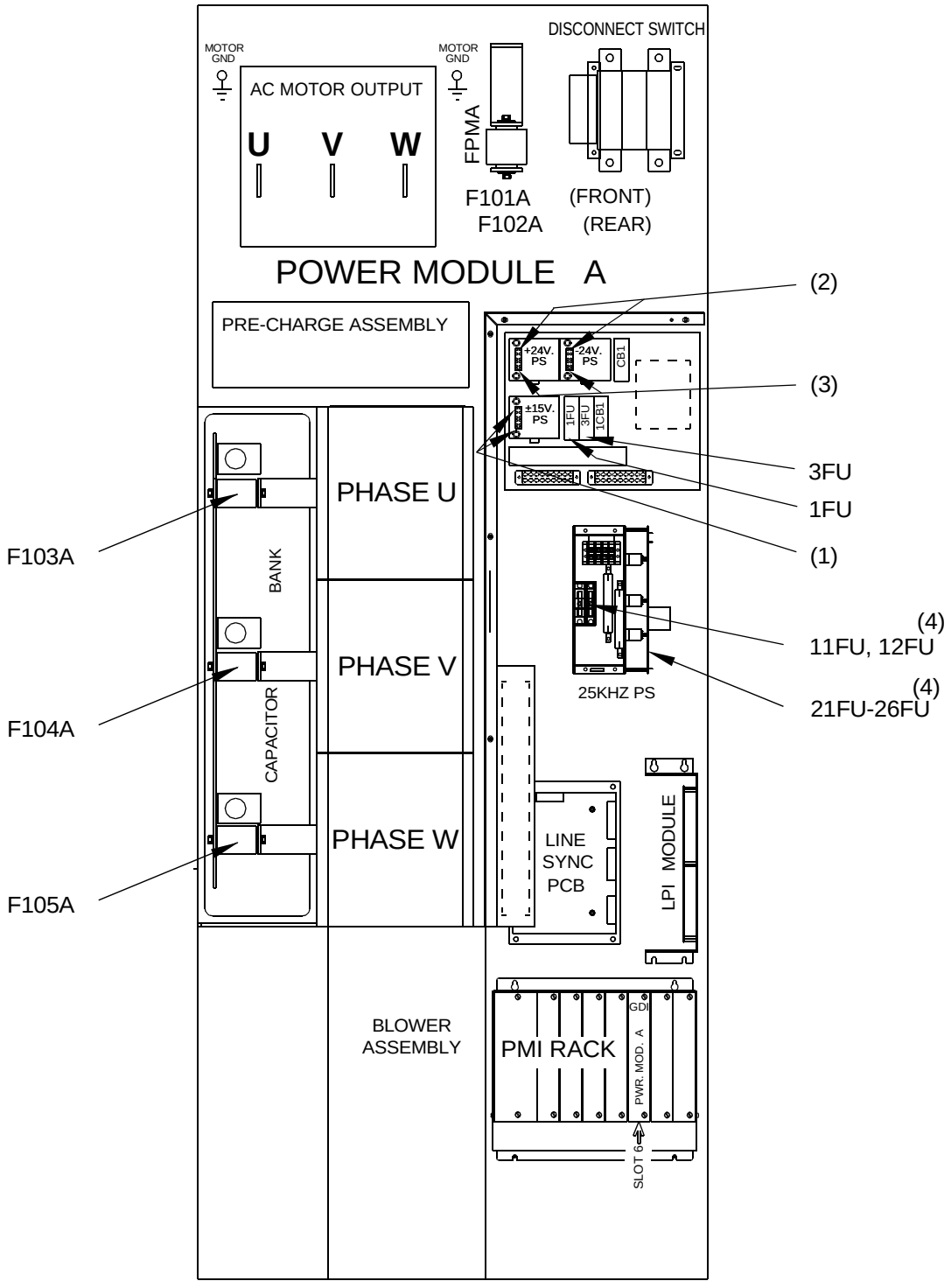
Step 4. Remove the blown fuse and install the replacement fuse. Figures 4.2 to 4.6 show the locations of the fuses in the 534A, 972A, and 1457A SA3000 Power Modules. Table 4.5 provides fuse specifications.

Step 5. Close the cabinet doors and reapply power to the SA3000 Power Module.

Table 4.5 – Power Module Replacement Fuse Specifications

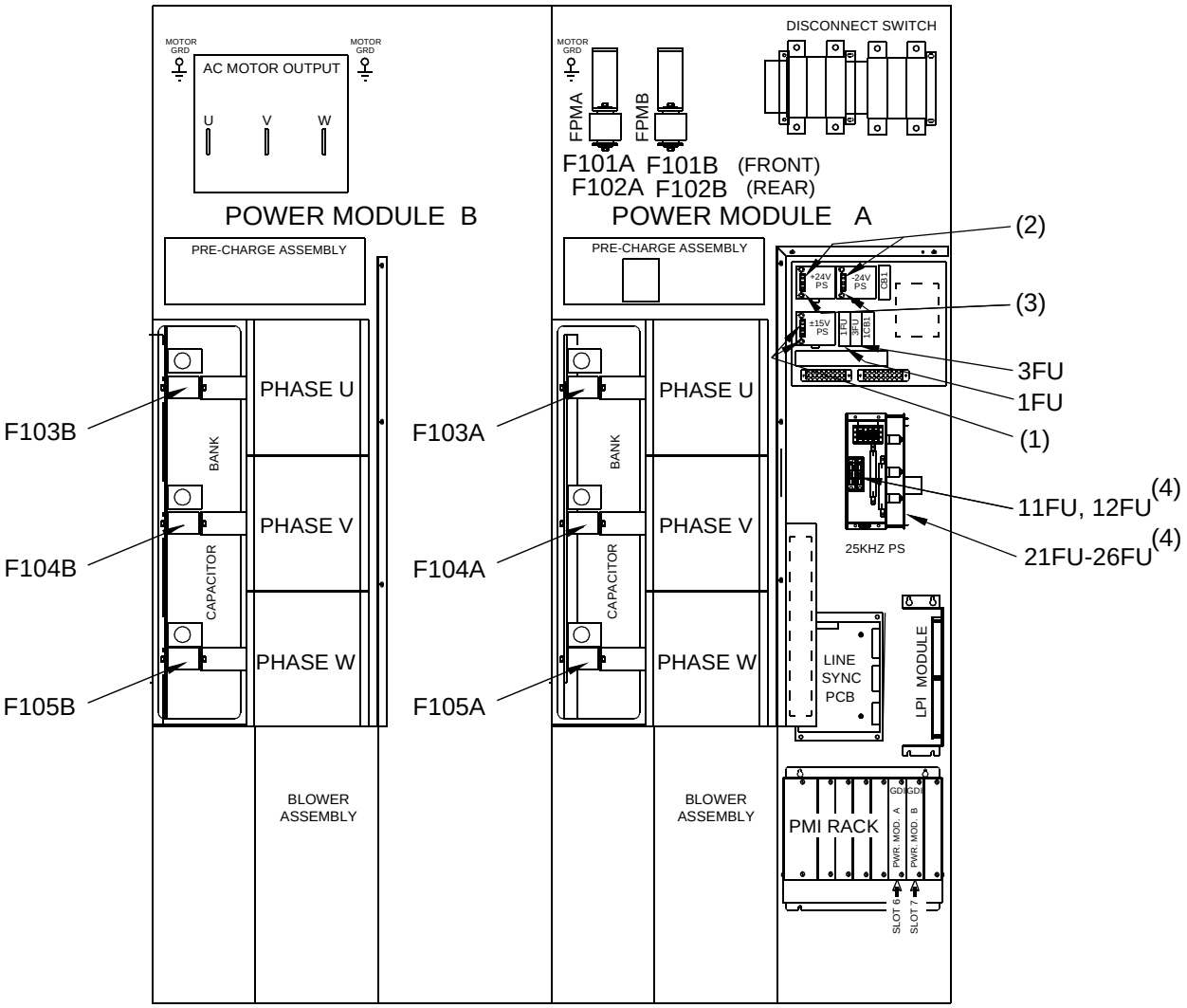
Fuse	Volts	Class	Type	Rating	Rockwell Part Number	Torque Specifications
1FU	600	CC	KLDR	5 A	64676-29R	--
3FU	600	CC	KLDR	3.2 A	64676-29P	--
FPM A,B,C	1000	Semiconductor		1000 A	64676-80P	41 Nm (30 lb-ft)
F103 A,B,C	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
F104 A,B,C	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
F105 A,B,C	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
+/-15V PS[1]	250		F	1.8 A	Replace with 1.6A 64676-82U	--
+/-24V PS[2]	250		T	2.5 A	64676-71P	--
+/-24V PS[3]	600	--	F	2.0 A	64676-82V	--
25 KHz PS[4] 11FU 12FU	250	--	--	8 A	64676-30H	--
25 KHz PS[4] 21FU 26FU	250	--	F	2 A	64676-66C	--

1,2,3. Fuse locations shown in figures 4.2, 4.3, 4.4, and 4.5.
4. Fuse locations shown in figures 4.2, 4.3, 4.4, and 4.6.



Notes 1,2,3. See table 4.5 and figure 4.5
Note 4. See table 4.5 and figure 4.6.

Figure 4.2 – 534A SA3000 Power Module Fuse Locations



Notes 1,2,3. See table 4.5 and figure 4.5
Note 4. See table 4.5 and figure 4.6.

Figure 4.3 – 972A SA3000 Power Module Fuse Locations

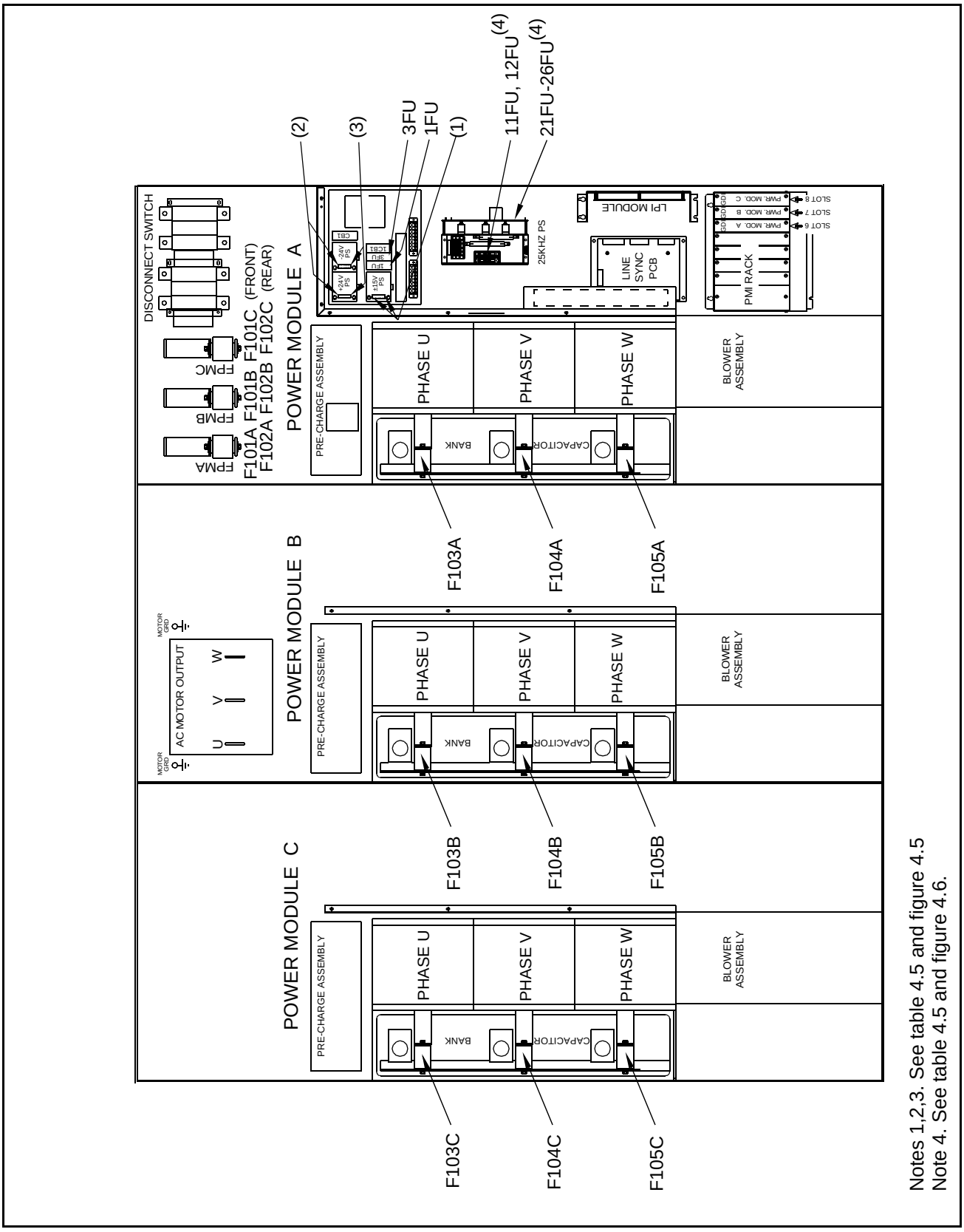
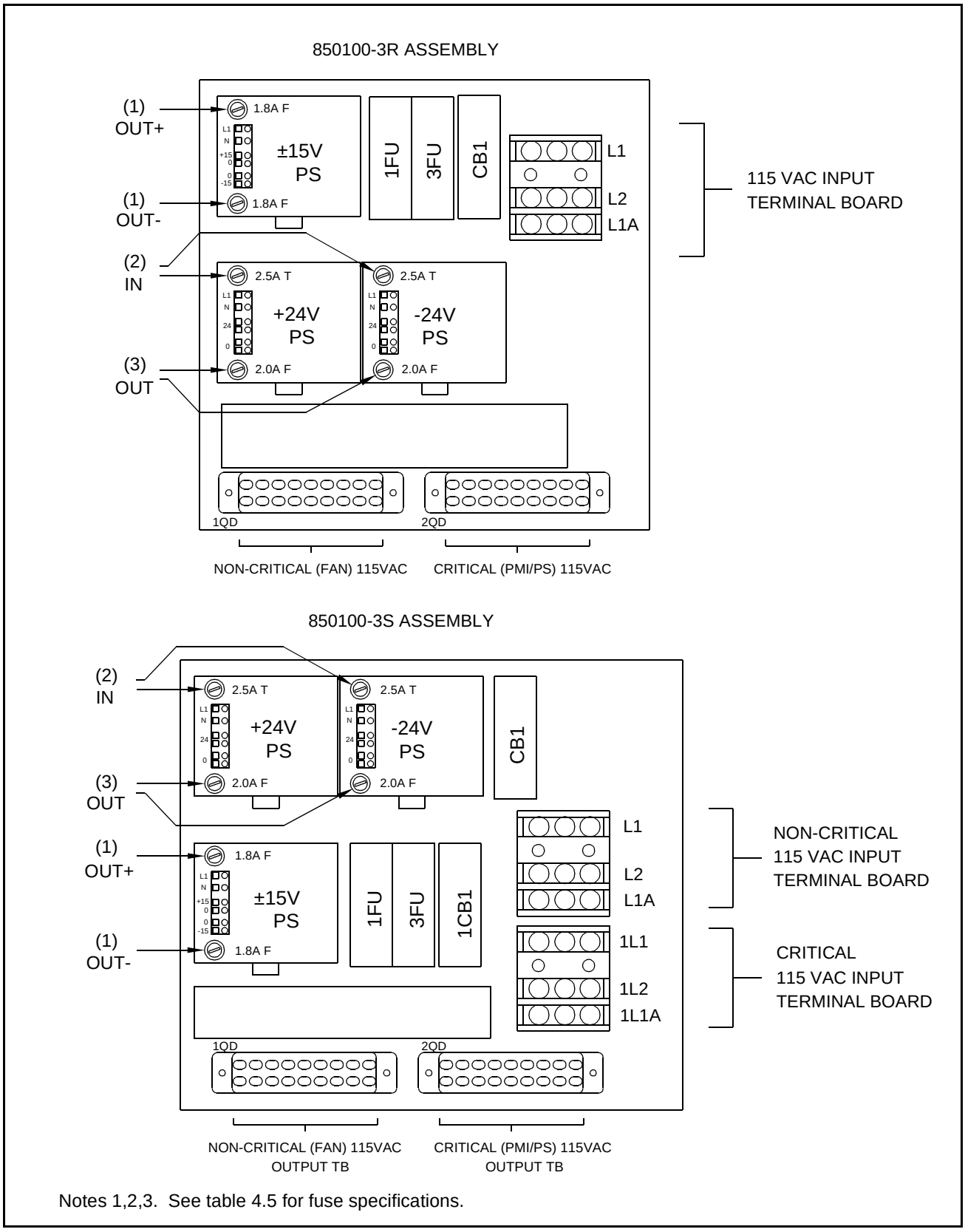


Figure 4.4 – 1457A SA3000 Power Module Fuse Locations



Notes 1,2,3. See table 4.5 for fuse specifications.

Figure 4.5 – 115VAC Control Power Supply Assemblies

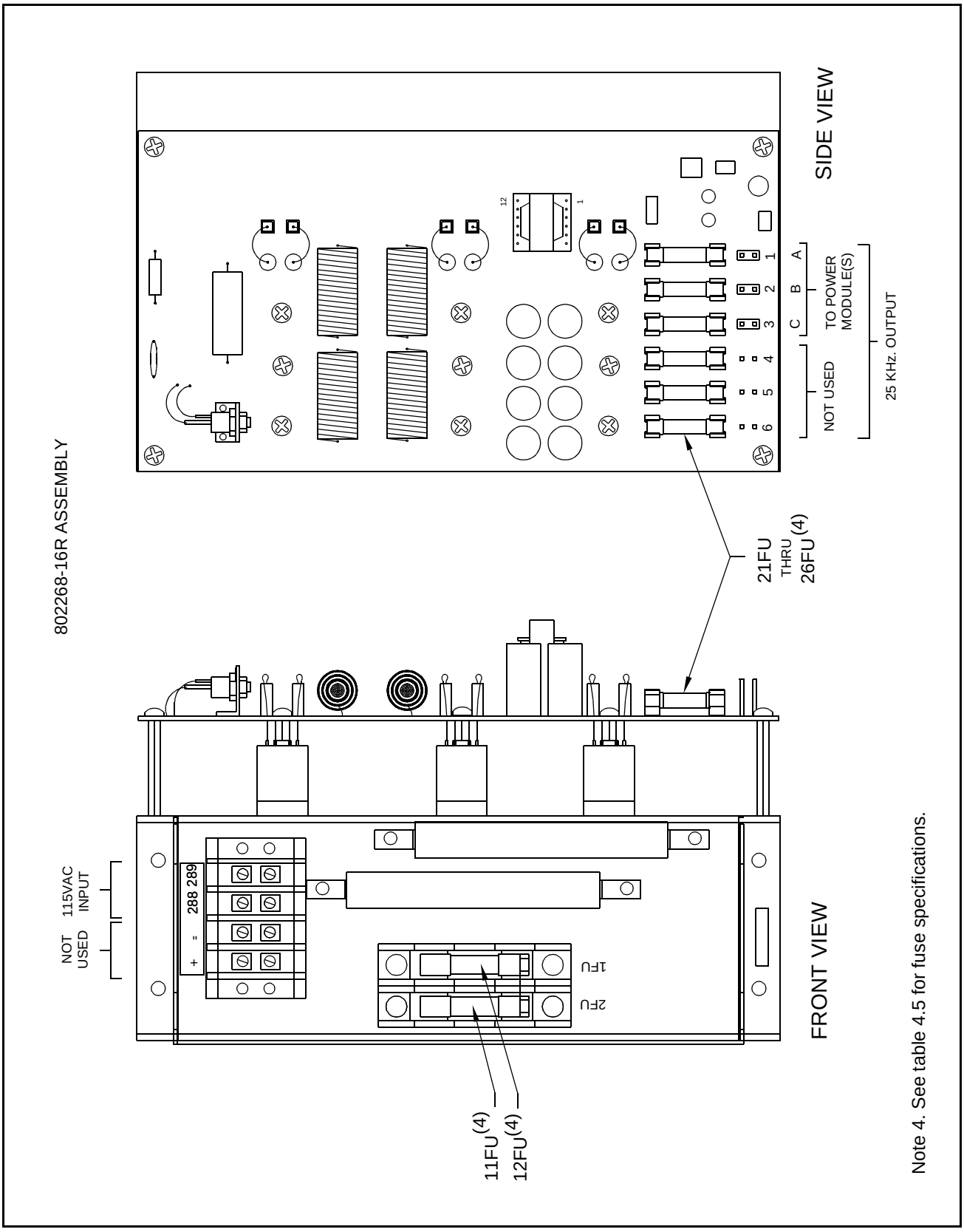


Figure 4.6 – 25 KHz. Power Supply

4.4.2 Replacing an IGBT Phase Module Assembly

Important: When replacing an IGBT phase module assembly be sure to re-install, position, and tighten the hardware in the proper sequence. The IGBT phase module must be aligned correctly to prevent damage to the components.

If all three IGBT phase modules are to be replaced, it will be easier to remove them by starting at the top and working down, i.e., begin by removing module U, continue with module V, and then finish by removing module W. Be sure to re-install the IGBT phase modules in reverse order, beginning by installing module W, continuing with module V, and finishing by installing module U.

Use the following procedure to replace an IGBT phase module assembly (U, V, or W):

Step 1. Turn off and lock out AC input power.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. See figure 4.1.

Step 4. Remove all wires, connectors, and harnesses from the IGBT Phase module assembly to be replaced. Label all of the wires to aid in re-installation. Refer to the wiring diagrams supplied with your system.

Step 5. Remove the right M8 bolt from the fuse. See figure 4.7, callout 2. Note that if you are only replacing the fuse, remove both M8 bolts as shown in figure 4.7, callouts 1 and 2. Remove the fuse without disturbing the alignment of the IGBT Phase module.

Step 6. Remove the two M8 bolts from the AC LEM bus bar. The bolts are located above the fuse and under the LEM device. See figure 4.7, callout 3.

Step 7. Remove the two M6 hex nuts from the negative bus bar. See figure 4.7, callout 4.

Step 8. Remove the two 5/16” x 1” cap screws, flat washers, and lock washers from the heatsink. One cap screw is located on each side of the heatsink. See figure 4.7, callout 5.

Step 9. Remove the IGBT Phase module assembly from the Power Module.

Step 10. Install the new IGBT Phase module assembly by aligning the module's mounting holes with the studs. Push the module into place and hold it in position.

Step 11. Start and finger-tighten the two M6 hex nuts on the negative bus bar. See figure 4.7, callout 4.

Step 12. Start and finger-tighten the two 5/16” cap screws, flat washers, and lock washers on the heatsink. One cap screw is located on each side of the heatsink. See figure 4.7, callout 5.

Step 13. Start and finger-tighten the two M8 bolts on the AC bus bar. See figure 4.7, callout 3. Tighten the bolts evenly.

Step 14. Loosen the M8 bolt on the left side of the fuse. See figure 4.7, callout 1. This allows the fuse some movement.

Step 15. Start and finger-tighten the M8 bolt with a lockwasher and a flat washer on the positive bus bar on the left side of the fuse. See figure 4.7, callout 2.

Note that the fuse ends should be in contact with the left and right bus bars. If the fuse does not touch the bus bars, adjust the horizontal position of the IGBT Phase Module Assembly until the fuse ends are contacting the bus bars. In some cases, the positive bus bar may have to be moved to allow the fuse to make contact.

Step 16. Pull the fuse forward in the slots. Hold the fuse with its back side parallel to the middle AC bus bar.

Note that the fuse must be mounted with the label facing forward, e.g., the top of the label should be to the right. The auxiliary connection tabs on the fuse endplates should be facing down. Do not install the fuse with the tabs facing up or toward the rear.

Step 17. Tighten the right and left fuse bolts to 20.5 Nm (15 lb-ft). Be sure the fuse does not rotate while the bolts are being tightened.

Step 18. Tighten the two M6 hex nuts on the negative bus bar to 5 Nm (45 lb-in). See figure 4.7, callout 4.

Step 19. Tighten the two M8 bolts on the AC bus bar to 9.5 Nm (84 lb-in). See figure 4.7, callout 3.

Step 20. Tighten the two 5/16” cap screws on the heatsink to 9.5 Nm (84 lb-in). See figure 4.7, callout 5.

Step 21. Ensure that all nuts and bolts are tightened to the rated torque. Re-torque the nuts and bolts as necessary.

Step 22. Re-connect the wires, connectors, and harnesses to the IGBT Phase module assembly that were removed in step 4.

Step 23. Close the cabinet doors.

Step 24. Reapply power to the Power Module.

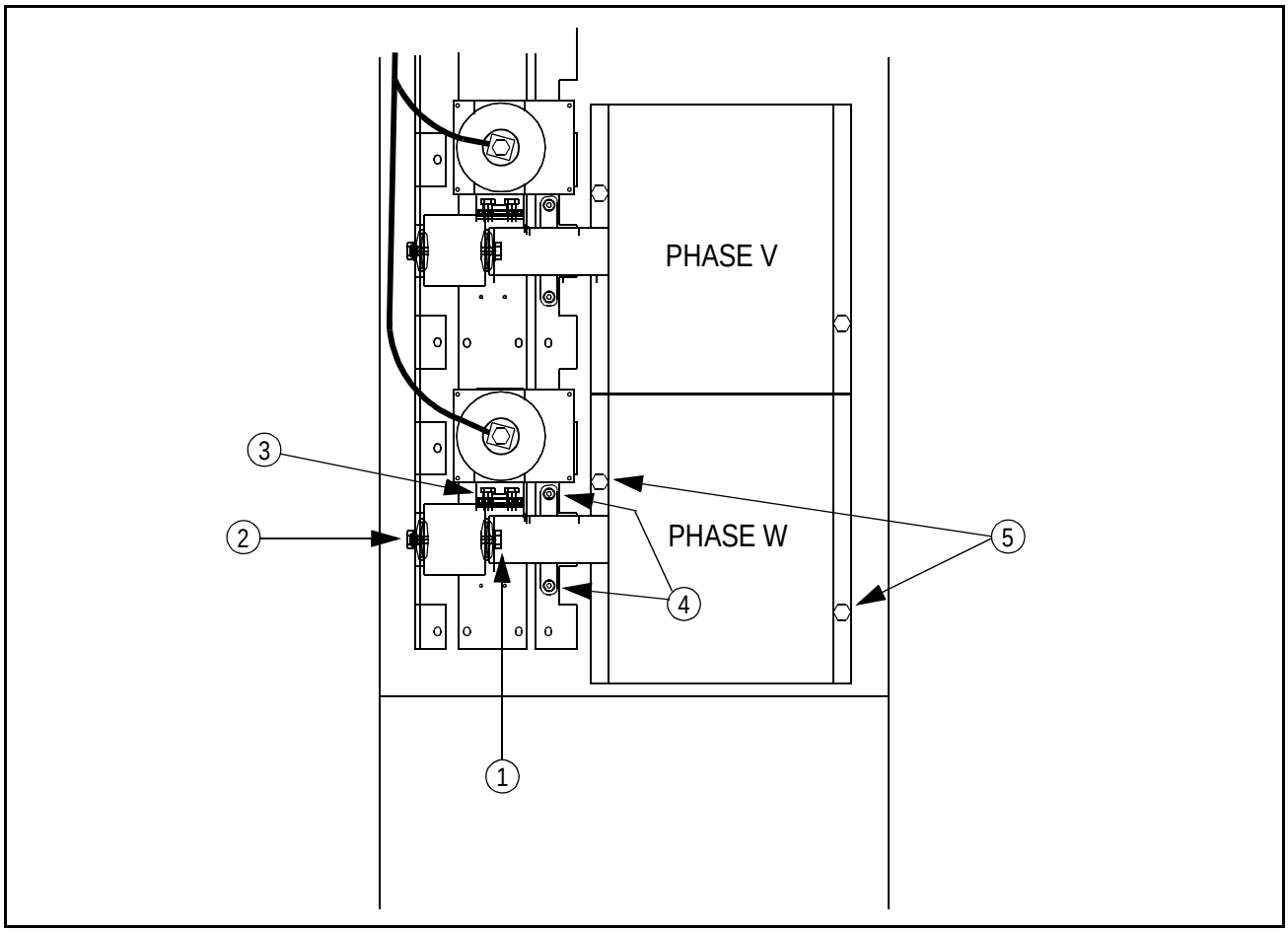


Figure 4.7 – IGBT Module Assembly Mounting Bolt Locations

4.4.2.1 Replacing an IGBT

If an IGBT needs to be replaced, it is recommended that the IGBT module be returned to an authorized Rockwell repair facility.

4.4.3 Replacing the Pre-charge Assembly

Use the following procedure to replace the optional pre-charge assembly:

Step 1. Turn off and lock out DC input power.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the Power Module cabinet's doors and measure the DC bus potential across each pair of DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter before working on the unit. See figure 4.1.

Step 4. Remove the bracket that is fastened across the cabinet in front of the pre-charge assembly. The bracket is attached to the cabinet with two screws.

Step 5. Remove the two power cables marked with a red band from the pre-charge assembly.

Step 6. Remove the wiring control harnesses. Do not remove the CN104 cable on the pre-charge module itself.

Step 7. Remove the power cables marked with a gray band from the DC bus capacitors.

Step 8. Remove the control wiring that connects to the capacitor bank.

Step 9. Remove the four screws that fasten the pre-charge assembly to the back panel of the cabinet.

Step 10. Remove the pre-charge assembly.

Step 11. Install the new pre-charge assembly by following steps 1 through 10 in reverse order.

Step 12. Close the cabinet doors.

Step 13. Reapply power to the Power Module.

4.4.4 Replacing a Blower Assembly

Use the following procedure to replace a blower assembly:

Step 1. Turn off and lock out the AC input power.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. See figure 4.1.

Step 4. Turn off the AC power to the blower by turning the circuit breaker in the power supply panel off.

Step 5. Disconnect the wires from the right side of the blower assembly. The wire connectors are keyed.

Step 6. Remove the blower from the cabinet by sliding it out.

Step 7. Install the new blower assembly by performing steps 1 through 6 in reverse order.

Step 8. Close the cabinet doors and reapply power to the SA3000 Power Module.

4.4.4.1 Replacing a Blower Filter

To replace a blower filter:

Step 1. Remove the old filter by sliding it out.

Step 2. Slide the new filter in.

4.4.5 Replacing a Bus Capacitor Assembly

Use the following procedure to replace a DC bus capacitor assembly:

Step 1. Turn off and lock out the AC input power.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. See figure 4.1.

Step 4. Remove all three IGBT assemblies (U, V, and W). Refer to section 4.4.2 for information on IGBT assembly removal.

Step 5. Remove the AC input power wiring by removing the bolt from the LEM stud spacer. This wiring consists of three insulated, tinned-copper straps which have color-coded bands (orange, yellow, and purple).

Step 6. Remove the LEM device control wiring. Needle-nose pliers may be useful in removing the three wire connectors.

Step 7. Remove the three LEM devices. Four screws attach each LEM device to the capacitor bank.

Step 8. Remove the three insulator blocks. Each insulator block is secured by two hex nuts.

Step 9. Remove the power cable wiring harnesses from the top of the capacitor bank. The two wiring harnesses have color-coded bands. The positive bus bar cable has a red band while the negative bus bar cable has a gray band.

Step 10. Remove the control wiring from the top of the capacitor bank.

Step 11. Remove the capacitor bank's four mounting screws. Two are located at the top of the capacitor bank and two at the bottom.

Step 12. Slide the capacitor bank out of the cabinet.

Step 13. Install the new capacitor bank assembly by performing steps 1 through 12 in reverse order.

Step 14. Close the cabinet doors and reapply power to the SA3000 Power Module.

4.5 Replacing the Power Module Cabinet

Use the following procedure to replace the SA3000 Power Module cabinet:

Step 1. Turn off and lock out the AC input power to the DC bus supply control cabinet.

Step 2. Wait ten minutes to allow the DC bus voltage to dissipate.

ATTENTION: DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power, wait ten (10) minutes for the DC bus capacitors to discharge. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. Failure to observe this precaution could result in severe bodily injury or loss of life.

Step 3. Open the cabinet doors and check the voltage across the DC bus bars, 347 A,B,C (+ bus) and 345 A,B,C (- bus), with an external voltmeter to ensure the DC bus capacitors are discharged before touching any internal components. See figure 4.1.

Step 4. Disconnect the DC bus leads from terminals 45 (-) and 47 (+). Disconnect the GND wire from the ground terminal. See figure 3.4.

Note that if an overhead DC bus assembly was supplied, disassembly of the overhead assembly is required. The assembly may be remounted on the replacement cabinet, if required.

Step 5. Disconnect the AC input line (two-wire 115 VAC with ground) from the L1 (L), L2 (N), and GND terminals on the control power board. See figure 3.4.

Step 6. Disconnect the AC output leads (U, V, W) from the motor and the motor ground wire(s) from the GND terminal(s). See figure 3.4.

Step 7. Remove the SA3000 Power Module cabinet.

Step 8. Install the replacement SA3000 Power Module cabinet by performing these steps in reverse order.

APPENDIX A

Technical Specifications

Ambient Conditions

- Operating Temperature: 0 to +40^{o} C (32 to +104^{o} F)
- Storage Temperature: -25 to +55^{o} C (-13 to +131^{o} F)
- Humidity: 5 to 95%, non-condensing.
- Altitude: Do not install above 1000 meters (3300 feet) without derating output current. For every 91.4 meters (300 feet) above 1000 meters (3300 feet), derate the output current by 1%.
- Vibration: Sine Wave: 1g., 10-500 Hz., all 3 axes.
  Shock: 15g., over 6 msec., half sine wave.

Dimensions (534A SA300 Power Module)

- Height: 2204 mm (86.8 inches)[1]
- Depth: 603 mm (23.8 inches)
- Width: 864 mm (34.0 inches)
- Weight: 573 kg (1265 pounds)

Dimensions (972A SA3000 Power Module)

- Height: 2204 mm (86.8 inches)[1]
- Depth: 603 mm (23.8 inches)
- Width: 1626 mm (64.0 inches)
- Weight: 985 kg (2175 pounds)

Dimensions (1457A SA3000 Power Module)

- Height: 2204 mm (86.8 inches)[1]
- Depth: 603 mm (23.8 inches)
- Width: 2387.6 mm (94.0 inches)
- Weight: 1398 kg (3085 pounds)

Type of Enclosure

- NEMA 1

1. Additional height: DC Bus Assembly Enclosure installed: 254 mm (10.0 inches)
   DC Bus Top Hat Enclosure installed: 482.6 mm (19.0 inches)

DC Bus Specifications

- Pre-charge Time: 1 second
- Discharge time (below 50V): less than 5 minutes
- Pre-charge resistance/bus capacitance: 534A Unit: 7.6 Ω / 32.4 µF
  972A Unit: 3.8 Ω / 64.8 µF
  1457A Unit: 2.5 Ω / 97.2 µF

DC Bus Input Power

- Nominal Maximum DC Voltage: 800 VDC
- Input Voltage Range: 300 - 850 VDC
- Overvoltage Trip: 925 VDC
- Maximum DC Input Current: 534A Unit: 600A
  972A Unit: 1000A
  1457A Unit: 1500A

Use the following equation to calculate the approximate DC input current as a function of the connected horsepower:

$$\text{DC Amps} = \frac{\text{horsepower} \times 746}{\text{motor efficiency} \times \text{inverter efficiency} \times \text{bus voltage}}$$

115 VAC Control Power

- AC Input Voltage: 115 VAC, Single-phase (Critical and Non-critical supplies)
- AC Input Frequency: 50/60 Hz[1]
- Maximum Symmetrical Short Circuit Current: 5 KA

115 VAC Input Power Ratings

115 VAC Power Supply Part Number	534 Amp Power Module	972 Amp Power Module	1457 Amp Power Module
850100-3R[1]	10.6 A	16.5 A	21.6 A
850100-3S (Non-Critical Power)	5.5 A	11.0 A	16.5 A
850100-3S (Critical Power)	1.5 A (Min) 5.1 A (Max)	1.5 A (Min) 5.1 A (Max)	1.5 A (Min) 5.1 A (Max)
850100-3S (Critical and Non-Critical Power)	10.6 A (Max)	16.5 A (Max)	21.6 A (Max)

1. May be replaced by 850100-3S 115VAC Power Supply Assembly.

1. Derate Power Module output current by 5% for 50 Hz blower motor operation.

Output Power

- Output Voltage: 575 VAC, maximum
- Modulation: Sine Wave, Pulse Width Modulation (PWM)
- Short Circuit Rating: 65 KA
- Power Dissipation: 534A Unit: 7500 W
  972A Unit: 15000 W
  1457A Unit: 22500 W
- Output Inductor: 7.5 µH per phase (972A and 1457A units only)

Output Current Ratings at 40° C (104° F) with 2 KHz Carrier Frequency:

Power Module Part Number	Power Module Description	Output Current Rating[1]
850020-11xxx, -21xxx	One Bay Cabinet	534 A
850020-12xxx, -22xxx	Two Bay Cabinet	972 A
850020-13xxx, -23xxx	Three Bay Cabinet	1457 A

1. Derate Power Module output current by 5% for 50 Hz blower motor operation.

Output Current Ratings[1] Based on Carrier Frequencies at 575 VAC Output

Power Module Part Number	Carrier Frequency	
	2 KHz	4 KHz[2]
850020-11xxx, -21xxx	534 A	445 A / 534 A
850020-12xxx, -22xxx	972 A	890 A / 972 A
850020-13xxx, -23xxx	1457 A	1335 A / 1457 A

1. Derate Power Module output current by 5% for 50 Hz blower motor operation.
2. The current limit is the continuous, maximum current rating and is duty cycle-dependent. The drive can be operated at the overload (maximum) current for up to five minutes with a 10% duty cycle.

Typical Power Module Current[1] and Motor Ratings

Part Number	230V Motor			380V Motor			460V Motor			575V Motor		
	Amps	KW	HP	Amps	KW	HP	Amps	KW	HP	Amps	KW	HP
850020-11xxx 850020-21xxx	534	168	225	534	277	371	534	336	451	534	419	561
850020-12xxx 850020-22xxx	972	305	409	972	505	677	972	611	819	972	765	1025
850020-13xxx 850020-23xxx	1457	459	615	1457	757	1015	1457	918	1230	1457	1146	1536

1. 100% rated output current ratings at 40° C (104° F) ambient air temperature at 2 KHz. Reduce all output current ratings by 5% when the Power Module blowers are operated from a 50 Hz power source.

- Rail I/O Current Load: Power supply constraints dictate that any combination of analog and digital I/O rails may be used as long as current consumption does not exceed 1.5 A.

APPENDIX B

SA3000 Internal DC Bus Control

Each DC input High Power SA3000 Power Module contains a capacitor bank which must be charged before the Power Module can produce current. Because the capacitor bank acts like a DC bus, i.e., it supplies DC power to the inverter section of the Power Module, the capacitor bank is referred to as an “internal” DC bus.

An external DC bus, which can be used to supply DC voltage to the Power Module, is provided by the user. This external DC bus is not under the control of the SA3000 drive.

The internal DC bus in each Power Module consists of the capacitor bank and discharge/voltage sharing resistors. In addition, an optional pre-charge contactor and resistor may be part of this system. Note that if an optional disconnect switch is used, the pre-charge option must also be used. See figure B.1 for a simplified internal DC bus schematic.

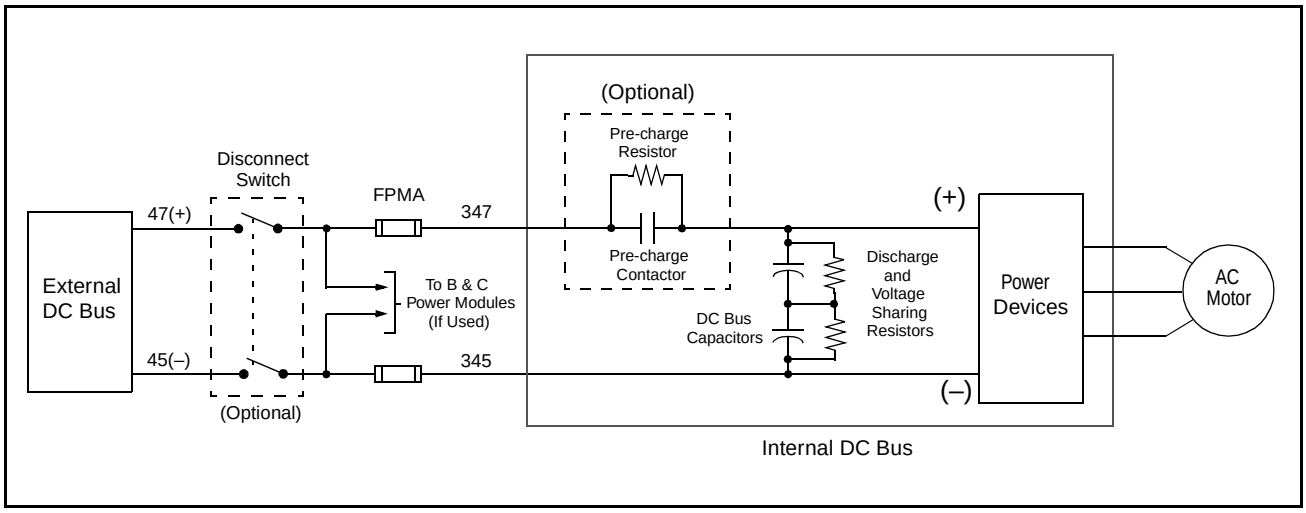


Figure B.1 – Internal DC Bus Schematic

If the pre-charge option is present, DC input power can be turned on either before or at the same time that bus control is enabled. Because the pre-charge contactor is initially open, bus charging actually begins as soon as power is turned on to the Power Module, regardless of whether or not bus control has been enabled by the programmer. In the absence of explicit control by the programmer, current to the bus is limited by the pre-charge resistors. Note that if the pre-charge option is not present, the external bus is responsible for controlling the charging of the inverter’s internal DC bus capacitors.

The programmer initiates control of the charging process by setting the BUS_ENA@ bit (register 100/100, bit 4). Normally, the PMI processor waits for the rising edge of this bit to start the process. However, if this bit is ON at power-up, the PMI processor will interpret this as a positive transition. The DC bus controller, though, will inhibit the system's state machine until valid configuration and gain data is received.

Note that the BUS_ENA@ bit must be turned on before the programmer enables the bridge test or the inner control loop in the PMI processor in register 100/1100. If BUS_ENA@ is not enabled first, an interlock error will occur (register 205.1205, bit 6, IC_BUS@) and the drive will not be permitted to execute either the bridge test or the control loop.

In response to the rising edge of the BUS_ENA@ bit, the PMI processor will allow the bus voltage to rise above the undervoltage threshold and then close the pre-charge contactor. This will short out the pre-charge resistors. The PMI processor will set BUS_RDY@ (bit 4 in register 200/1200) when all of the following conditions have occurred:

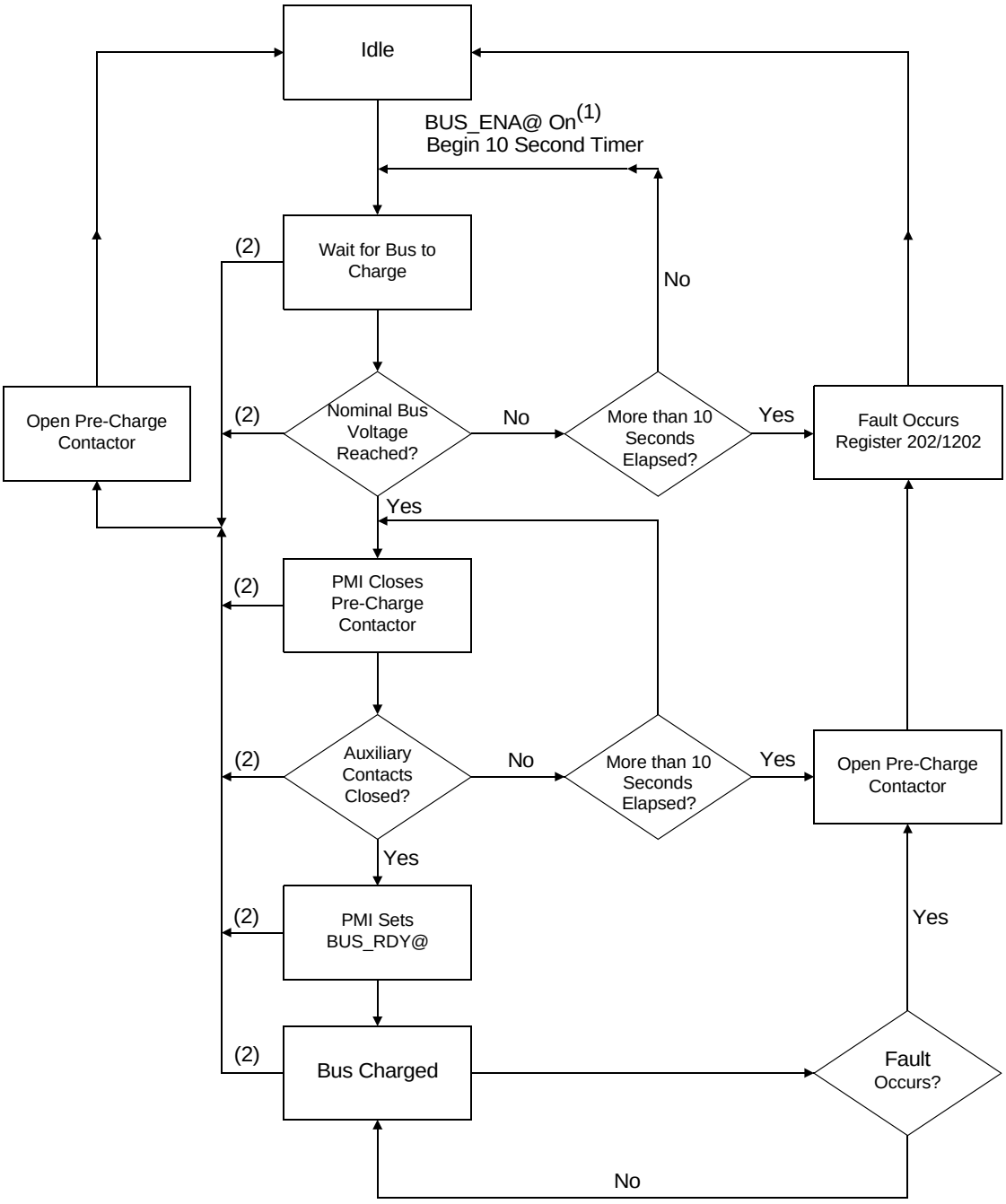
- the internal DC bus has been enabled via the BUS_ENA@ input
- the internal DC bus voltage has reached the level specified in the tunable variable UVT_E0%
- the internal DC bus voltage is at a steady state
- the pre-charge contactor has closed

Important: The BUS_ENA@ bit must remain on during the bridge test or the execution of the control algorithm in the PMI processor, or the pre-charge contactor will open and the drive will shut down.

If BUS_ENA@ is turned off at any time, power to the power device gates is shut off. Approximately one second later, the pre-charge contactor is opened. If the pre-charge contactor closes when it is not commanded to do so by the PMI processor, register 202/1202, bit 6 (FLT_CHG@) is set and the drive is shut down. (Auxiliary contacts on the pre-charge contactor are used to verify that the pre-charge contactor is open or closed. These auxiliary contacts are pre-wired and require no connection by the user.)

There is a time limit of 10 seconds from the time when the rising edge of the BUS_ENA@ input is detected to the time when the bus voltage must reach the steady state voltage specified in the tunable variable UVT_E0% and the auxiliary contact is required to close. (See the following section for more information on tunable variable UVT_E0%.) If this time limit is exceeded, the pre-charge contactor is opened and the FLT_CHG@ bit (register 202/1202, bit 6) is set. If the bus voltage recovers to the appropriate level within 10 seconds, the pre-charge contactor will be closed and the drive will resume operation.

Refer to figure B.2, the internal DC bus control state diagram (with pre-charge option supplied), for more detailed information.



1. BUS_ENA@ must transistion from off to on to start the bus charging process.
2. BUS_ENA@ must remain on during the drive operation

Figure B.2 – Internal DC Bus Control State Diagram

B.1 Modifying Internal DC Bus Voltage Thresholds

The programmer can use three different pre-defined tunable variables to specify three bus voltage thresholds:

- OVT_E0% overvoltage threshold
- UVT_E0% undervoltage threshold
- PLT_E0% power loss threshold

These thresholds define the boundaries for specific operating levels. Figure B.3 shows the relative bus voltage operating ranges and how the tunable variables can affect these ranges.

Important: The three tunable variables listed above should be tuned before enabling the execution of the control algorithm in the PMI Processor to ensure that internal DC bus voltage warning thresholds are set to levels appropriate for the application. See instruction manual S-3042, SA3000 Drive Configuration and Programming, for the acceptable value ranges.

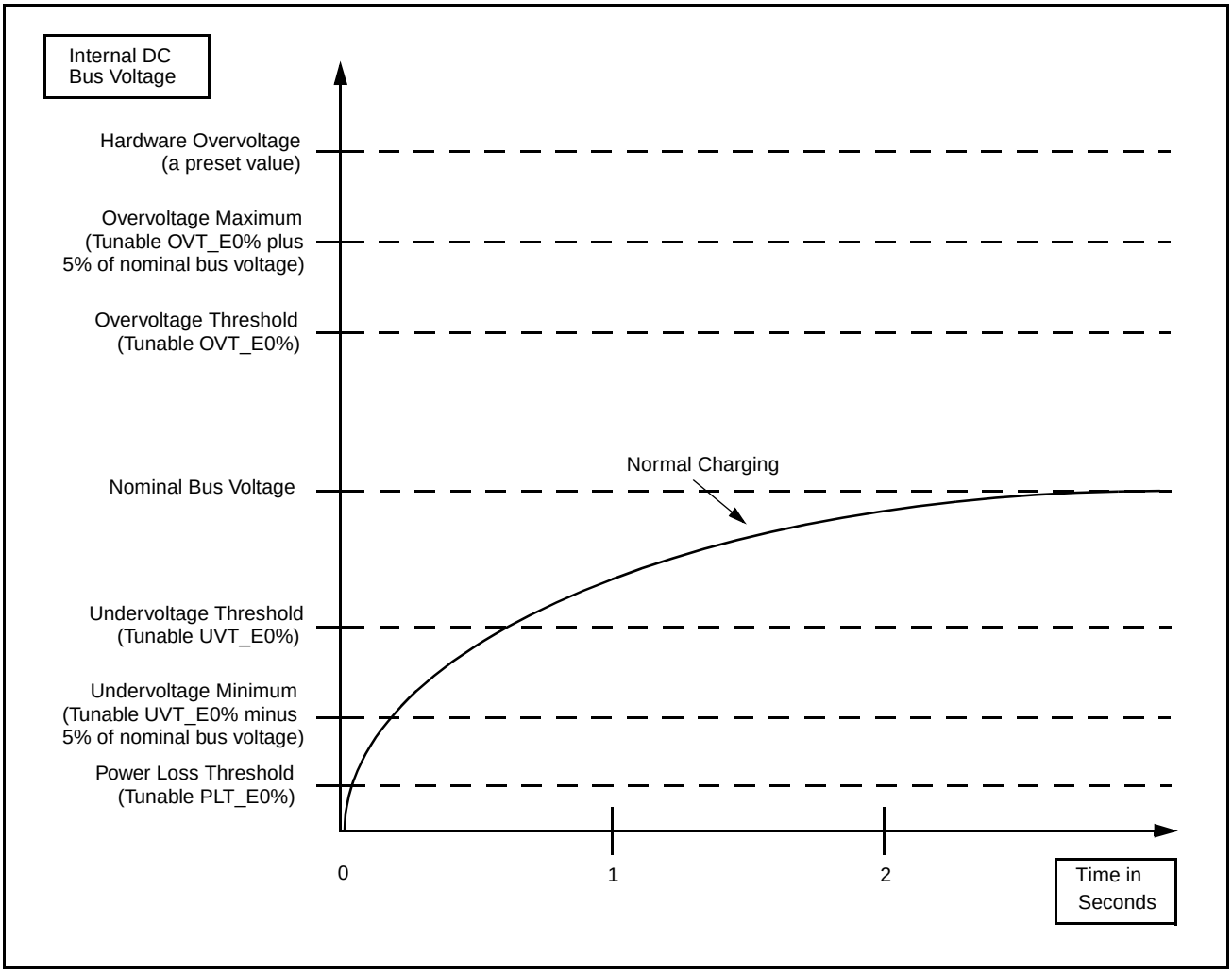


Figure B.3 – Internal DC Bus Operating Range

B.2 Internal DC Bus Protection

The PMI Processor will modify the regeneration or motoring torque limit set by the programmer during parameter entry (calculated from the maximum current and overload ratio parameters) to prevent bus voltage from rising (in the case of regeneration) or falling (in the case of motoring).

During regeneration, if bus voltage reaches the overvoltage threshold, the regeneration torque limit will be reduced, and will be set to zero if the overvoltage maximum is reached. During motoring, if bus voltage reaches the undervoltage threshold, the motoring torque limit will reduced, and will be set to zero if the undervoltage minimum is reached. The PMI processor will set register 203/1203, bit 4 (WRN_RIL@), to indicate that torque is being limited in either direction.

Note that the PMI processor does not modify the reference provided by the UDC task to the PMI processor via register 102/1202, TRQ_REF%. If required, the UDC task can include logic to begin regenerating when DC bus voltage is low.

Refer to Appendix A for specifications on the capacitance, resistance, and charging time of the bus pre-charge circuitry for the High Horsepower SA3000 Power Modules.

APPENDIX C

Replacement Parts

534 Amp SA3000 Power Module

Table C.1 – 534A SA3000 Power Module

Part Description[1]	Quantity	Rockwell Part Number
Blower Assembly	1	850011-R
IGBT Phase Module Assembly	3	803430-8S
Capacitor Bank Assembly	1	803430-6S
Pre-charge Assembly	1	850022-3_
115 VAC Power Supply Assembly	1	850100-3_
Disconnect Switch (Optional) (600A, 1000 VAC)	1	65242-8B
Fuse (FPM A, F101A/F102A) (1000A,1000VAC)	2	64676-80P
Local Power Interface Module	1	0-60027
250VA Isolation Transformer (250 VA, 110 VAC)	1	417155-16B
PMI Rack Assembly	1	805401-5R
25KHz Power Supply (2A) (115 VAC input, 60 VDC output)	1	802268-16R
LEM Sensor (1000A, 5000:1)	3	600595-18A
Motor Feedback Resistors (40KΩ, 90 W)	3	63481-102TFB
DC Feedback Module	1	0-55350-10
Motor Ammeter (Optional)	1	708208-20R
Motor Voltmeter (Optional)	1	708208-18R
Torque Meter (Optional)	1	708208-17R
Frequency Meter (Optional)	1	708208-19R
Blower Filter	1	69470-3RM

1. Components are identified in figure 2.2.

Table C.2 – Capacitor Bank Assembly (803430-6S)

Part Description	Quantity	Rockwell Part Number
Capacitor (7200µF, 500 VDC)	18	600442-30SX

Table C.3 – Blower Assembly (850011-R)

Part Description	Quantity	Rockwell Part Number
Blower (115 VAC)	1	69739-47R
Starter Capacitor (40µF, 240 VAC)	1	69932-24QQ

534 Amp SA3000 Power Module (Continued)

Table C.4 – Pre-charge Assembly (850022-3)

Part Description	Quantity	Rockwell Part Number
Discharge Resistors (1KΩ, 200W)	10	63481-6V
Contactor (230A, 600 VAC)	1	705310-39BX
Pre-charge Module	1	0-55350-4
Pre-charge Capacitor (4700µH, 50 VDC)	1	600442-31TS
Pre-charge Resistors (3.819Ω)	2	48627-G
Voltage Feedback Module	1	O-55350-10

Table C.5 – 115 VAC Power Supply Assembly (850100-3R, -3S)

Part Description	Quantity	Rockwell Part Number
+/- 15 VDC Power Supply (1A)	1	704323-33K
115 VAC Circuit Breaker (25A, 600 VAC)	1 or 2	91212-4RA
24 VDC Power Supply (2A)	2	704323-32G
Fuse (1FU) (5A, 600 VAC)	1	64676-29R
Fuse (3FU) (3.2A, 600 VAC)	1	64676-29P

Table C.6 – IGBT Phase Module Assembly (803430-8S)

Part Description	Quantity	Rockwell Part Number
IGBT Transistor (600A, 1200 VDC)	4	423402-4S
Warning Thermostat	1	66012-16A
Fault Thermostat	1	66012-16B
Gate Driver/Snubber Module	1	0-55350-15
Fuse (F103A, F104A, F105A) (630A, 1000 VAC)	3	64676-79AZ

Table C.7 – PMI Rack Assembly (805401-5)

Part Description	Quantity	Rockwell Part Number
Power Supply	1	0-60007-2
Processor Module	1	0-60021-1
Resolver Module	1	0-60031-4
AC Technology Module	1	0-60023-3
AC Parallel Interface Module	1	0-60029-1
Gate Driver Interface Module	1	0-60028-1

972 Amp SA3000 Power Module

Table C.8 – 972A SA3000 Power Module

Part Description[1]	Quantity	Rockwell Part Number
Blower Assembly	2	850011-R
IGBT Phase Module Assembly	6	803430-8S
Capacitor Bank Assembly	2	803430-6S
Pre-charge Assembly	2	850022-3_
115 VAC Power Supply Assembly	1	850100-3_
Disconnect Switch (Optional) (600A, 1000 VAC)	1	65242-8B
Fuse (FPM A,B) (F101A,B / F102A,B) (1000A,1000VAC)	4	64676-80P
Local Power Interface Module	1	0-60027
250VA Isolation Transformer (250 VA, 110 VAC)	1	417155-16B
PMI Rack Assembly	1	805401-5R
25KHz Power Supply (2A) (115 VAC input, 60 VDC output)	1	802268-16R
LEM Sensor (1000A, 5000:1)	6	600595-18A
Reactor Assembly (600A, 7.5mH)	2	850022-5R
Motor Feedback Resistors (40KΩ, 90 W)	3	63481-102TFB
DC Feedback Module	1	0-55350-10
Motor Ammeter (Optional)	1	708208-20R
Motor Voltmeter (Optional)	1	708208-18R
Torque Meter (Optional)	1	708208-17R
Frequency Meter (Optional)	1	708208-19R
Blower Filter	2	69470-3RM

1. Components are identified in figure 2.3.

Table C.9 – Capacitor Bank Assembly (803430-6S)

Part Description	Quantity	Rockwell Part Number
Capacitor (7200µF, 500 VDC)	18	600442-30SX

Table C.10 – Blower Assembly (850011-R)

Part Description	Quantity	Rockwell Part Number
Blower (115 VAC)	1	69739-47R
Starter Capacitor (40µF, 240 VAC)	1	69932-24QQ

972 Amp SA3000 Power Module (Continued)

Table C.11 – Pre-charge Assembly (850022-3_)

Part Description	Quantity	Rockwell Part Number
Discharge Resistors (1KΩ, 200W)	10	63481-6V
Contactor (230A, 600 VAC)	1	705310-39BX
Pre-charge Module	1	0-55350-4
Pre-charge Capacitor (4700µH, 50 VDC)	1	600442-31TS
Pre-charge Resistors (3.819Ω)	2	48627-G
Voltage Feedback Module	1	O-55350-10

Table C.12 – 115 VAC Power Supply Assembly (850100-3R, -3S)

Part Description	Quantity	Rockwell Part Number
+/- 15 VDC Power Supply (1A)	1	704323-33K
115 VAC Circuit Breaker (25A, 600 VAC)	1 or 2	91212-4RA
24 VDC Power Supply (2A)	2	704323-32G
Fuse (1FU) (5A, 600 VAC)	1	64676-29R
Fuse (3FU) (3.2A, 600 VAC)	1	64676-29P

Table C.13 – IGBT Phase Module Assembly (803430-8S)

Part Description	Quantity	Rockwell Part Number
IGBT Transistor (600A, 1200 VDC)	4	423402-4S
Warning Thermostat	1	66012-16A
Fault Thermostat	1	66012-16B
Gate Driver/Snubber Module	1	0-55350-15
Fuse (F103A, F104A, F105A) (630A, 1000 VAC)	3	64676-79AZ

Table C.14 – PMI Rack Assembly (805401-5)

Part Description	Quantity	Rockwell Part Number
Power Supply	1	0-60007-2
Processor Module	1	0-60021-1
Resolver Module	1	0-60031-4
AC Technology Module	1	0-60023-3
AC Parallel Interface Module	1	0-60029-1
Gate Driver Interface Module	2	0-60028-1

1457 Amp SA3000 Power Module

Table C.15 – 1457A SA3000 Power Module

Part Description[1]	Quantity	Rockwell Part Number
Blower Assembly	3	850011-R
IGBT Phase Module Assembly	9	803430-8S
Capacitor Bank Assembly	3	803430-6S
Pre-charge Assembly	3	850022-3_
115 VAC Power Supply Assembly	1	850100-3_
Disconnect Switch (Optional) (600A, 1000 VAC)	1	65242-8B
Fuse (FPM A,B) (F101A,B / F102A,B) (1000A,1000VAC)	6	64676-80P
Local Power Interface Module	1	0-60027
250VA Isolation Transformer (250 VA, 110 VAC)	1	417155-16B
PMI Rack Assembly	1	805401-5R
25KHz Power Supply (2A) (115 VAC input, 60 VDC output)	1	802268-16R
LEM Sensor (1000A, 5000:1)	9	600595-18A
Reactor Assembly (600A, 7.5mH)	3	850022-5R
Motor Feedback Resistors (40KΩ, 90 W)	3	63481-102TFB
DC Feedback Module	1	0-55350-10
Motor Ammeter (Optional)	1	708208-20R
Motor Voltmeter (Optional)	1	708208-18R
Torque Meter (Optional)	1	708208-17R
Frequency Meter (Optional)	1	708208-19R
Blower Filter	3	69470-3RM

1. Components are identified in figure 2.3.

Table C.16 – Capacitor Bank Assembly (803430-6S)

Part Description	Quantity	Rockwell Part Number
Capacitor (7200µF, 500 VDC)	18	600442-30SX

Table C.17 – Blower Assembly (850011-R)

Part Description	Quantity	Rockwell Part Number
Blower (115 VAC)	1	69739-47R
Starter Capacitor (40µF, 240 VAC)	1	69932-24QQ

1457 Amp SA3000 Power Module (Continued)

Table C.18 – Pre-charge Assembly (850022-3_)

Part Description	Quantity	Rockwell Part Number
Discharge Resistors (1KΩ, 200W)	10	63481-6V
Contactor (230A, 600 VAC)	1	705310-39BX
Pre-charge Module	1	0-55350-4
Pre-charge Capacitor (4700µH, 50 VDC)	1	600442-31TS
Pre-charge Resistors (3.819Ω)	2	48627-G
Voltage Feedback Module	1	O-55350-10

Table C.19 – 115 VAC Power Supply Assembly (850100-3R, -3S)

Part Description	Quantity	Rockwell Part Number
+/- 15 VDC Power Supply (1A)	1	704323-33K
115 VAC Circuit Breaker (25A, 600 VAC)	1 or 2	91212-4RA
24 VDC Power Supply (2A)	2	704323-32G
Fuse (1FU) (5A, 600 VAC)	1	64676-29R
Fuse (3FU) (3.2A, 600 VAC)	1	64676-29P

Table C.20 – IGBT Phase Module Assembly (803430-8S)

Part Description	Quantity	Rockwell Part Number
IGBT Transistor (600A, 1200 VDC)	4	423402-4S
Warning Thermostat	1	66012-16A
Fault Thermostat	1	66012-16B
Gate Driver/Snubber Module	1	0-55350-15
Fuse (F103A, F104A, F105A) (630A, 1000 VAC)	3	64676-79AZ

Table C.21 – PMI Rack Assembly (805401-5)

Part Description	Quantity	Rockwell Part Number
Power Supply	1	0-60007-2
Processor Module	1	0-60021-1
Resolver Module	1	0-60031-4
AC Technology Module	1	0-60023-3
AC Parallel Interface Module	1	0-60029-1
Gate Driver Interface Module	2	0-60028-1

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