Distributed Power System
High Power SB3000
AC Power Modules (Rittal)

804300-S (445 Amp)

804300-T (890 Amp)

804300-V (1335 Amp)

Instruction Manual S-3031

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, then look at the built-in DC bus voltage meter. When the voltage is down to zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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.

CONTENTS

List of Figures

List of Tables

CHAPTER 1
Introduction

The High Power SB3000 Power Modules are variable-voltage, limited-frequency, high performance PWM power converters. They are designed to be used with Distributed Power System (DPS) SA3000 and SA3100 PWM inverter drives and other high performance PWM-type inverters that operate from a fixed voltage DC Bus input.

The SB3000 Power Modules operate as two- quadrant, fast-response, synchronous rectifiers converting fixed-frequency AC power to regulated voltage DC power using pulse-width-modulation (PWM) technology. They can operate in both the motoring and regeneration modes in response to the load applied to the DC output. SB3000 Power Modules are capable of full rating regeneration of power to the AC line and feature adjustable power factor operation.

The SB3000 Power Modules operate in conjunction with a separately-mounted input reactor and a separately-supplied power distribution cabinet, which provides AC power protection, disconnect, and soft-charge functionality for the SB3000 Power Modules. Refer to Appendixes C and D for more information on SB3000 theory of operation and interlock sequencing.

The SB3000 Power Modules are available in three output power ratings: 445 amp, 890 amp, and 1335 amp when used at a 4 kHz carrier frequency. They have a range of AC Input voltage ratings. Nominal DC bus voltage may range from 300 to 800 VDC.

Output current with a 2 kHz carrier frequency is 534A, 972A, and 1457A. A 4 kHz carrier frequency is typically used to minimize the size of the AC line reactor. Four kHz operation requires a derating of the AC input current and DC output load current when compared with operation at 2 kHz.

The SB3000 Power Module output current ratings are 100% continuous with no overload. They may be derated for lower current ratings with overload capability. See table 1.1.

Table 1.1 – SB3000 Power Module Current Ratings[1]

SB3000 Part Number	Continuous AC Input Current (460VAC)	Continuous DC Output Current (800VDC)	5 Minute AC Input and DC Output Overload[2]
804300-S	445A (rms)	445A DC	534A (rms)
804300-T	890A (rms)	890A DC	972A (rms)
804300-V	1335A (rms)	1335A DC	1457A (rms)

1. At 460 VAC Input/800 VDC Output/4kHz Carrier Frequency. For use with SA3000 Power Modules operating at a 2 kHz carrier frequency.
2. With a 25% duty cycle

1.1 Standard Features

The SB3000 Power Modules have the following standard features:

- Input power supplied from a separate disconnect/soft-charge cabinet and AC line reactor
- PWM synchronous rectifier converts AC power to DC power for a fixed-voltage PWM inverter DC bus
- IGBT power semiconductor bridge
- PWM output
- 4 kHz carrier switching frequency
- Ability to add or remove drives from the DC bus while the SB3000 Power Module is running
- Input and output short-circuit protection
- Fiber-optic communication with the DPS host, the Universal Drive Controller (UDC) module
- Auto-tuning without an identification test
- NEMA 1 Cabinet
- PMI Rack
- Top Entry of AC Input Power
- Top Exit of DC Output Power
- Standard Paint

1.2 Power Module Part Numbers

SB3000 Power Module part numbers are organized by the number of cabinet bays, e.g., one, two, or three-bay cabinet configurations. See table 1.2.

Table 1.2 – SB3000 Part Numbers

Cabinet Type	SB3000 Part Number	SB3000 B/M Number
One-Bay (445A)	804300-S	101165-190S
Two-Bay (890A)	804300-T	101165-190T
Three-Bay (1335A)	804300-V	101165-190V

1.3 Related Publications

This manual describes the hardware components of the SB3000 Power Module. Refer to the publications listed below for detailed descriptions of the remaining components of the SB3000 system and the configuration and programming necessary to control the SB3000 Synchronous Rectifier.

- S-3005 AutoMax Distributed Power System Overview
- S-3007 DPS Universal Drive Controller Module
- S-3009 DPS Fiber-Optic Cabling
- S-3034 DPS SB3000 Configuration and Programming

Refer to the following manuals for information on Distributed Power System AC Power Modules for use with the SB3000 Synchronous Rectifier:

- S-3038 DPS SA3000 High Power AC Power Modules (binder S-3001)
- S-3058 DPS SA3100 AC Power Modules (binder S-3053)

CHAPTER 2

Power Module Description

This chapter provides an overview the Power Module's main components and their mechanical and electrical characteristics. Refer to Appendix B for a block diagram of the Power Module. The SB3000 theory of operation is described in Appendix C.

2.1 Mechanical Description

High Power SB3000 Power Modules are housed in protective sheet metal enclosures, as shown in figures 2.2 to 2.4. The Power Modules come in single, double, and triple bay cabinet configurations, depending upon the current rating. See figures 3.1 to 3.3 for Power Module dimensions.

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 regulated DC output voltage. Fuses and thermostats are provided to protect the IGBT modules.

Snubber/Gate Driver Module

Each Snubber/Gate Driver 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 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 transients produced 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 SB3000 Power Module and the PMI rack. It is through this module that information is sent to the SB3000 Power Module and feedback data is sent back to the PMI rack.

Capacitor Bank Assembly

The capacitor bank's electrolytic capacitors store DC power from the IGBTs.

DC Bus Voltage Meter

The DC Bus Voltage meter, which is connected directly across the DC bus, measures the DC bus voltage being supplied by the SB3000 Power Module.

AC Input Current Meter and DC Bus Current Meter

The AC Input Current and DC Bus Current meters measure the AC input current being provided to the Power Module and the DC bus output current supplied by the SB3000 Power Module. These meters are connected to the PMI meter ports on the PMI Processor. The meters are calibrated for +/-10V or +10V at full scale. See table 2.1. Note that PMI ports 3 and 4 are not used.

Table 2.1 – Meter Scaling

SB3000 AC Input Current Rating at 4 kHz	PMI Processor Port 1 DC Bus Current Meter Scaling	PMI Processor Port 2 AC Input Current Meter Scaling
445 Amp	-800 to +800A	0 to 600A
890 Amp	-1,200 to +1,200A	0 to 1,000A
1,335 Amp	-1,800 to +1,800A	0 to 1,500A

The AC Input Current meter indicates the RMS line current flowing into or out of the SB3000 Power Module. The current level is derived from the feedback signals coming from the Hall devices on the AC input leads to the phase modules.

The DC Bus Current meter indicates the DC current level produced by the SB3000 Power Module. The value is scaled from the feedback signal coming from the Hall device monitoring the Power Module’s DC output current. Its range is bi-directional. Positive current indicates that current is flowing from the rectifier to the load (motoring) and negative current indicates current flowing into the rectifier from the load (regenerating) to the AC line.

Softcharge Assembly

The Softcharge assembly is mounted separately and consists of pre-charge resistors and a contactor. The contactor bypasses the pre-charge resistors after the bus voltage reaches a programmable threshold value. A pre-charge contactor module communicates with the LPI module and controls the contactor. See figure 2.1.

2.2 Electrical Description

AC power to the SB3000 Power Module is supplied from an AC power distribution/ soft-charge cabinet through the AC input reactor.

> **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, then look at the built-in DC bus voltage meter. When the voltage is down to approximately zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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.

The DC bus voltage is filtered by the electrolytic capacitors. Discharge resistors are designed to discharge the capacitors down to 50V DC within 5 minutes after power is removed from the input terminals. However, the user should wait ten minutes before working on the unit. Be sure to look at the built-in DC Bus Voltage meter and then measure the DC bus potential before touching any circuitry.

When AC power is applied to the SB3000 Power Module's input terminals 181(L1), 182(L2) and 183(L3), the DC bus is charged through the IGBT emitter-collector diodes to the level of the rectified AC line voltage. See figure 2.1 and figures 2.5 to 2.13. Charging current is limited by the separately-mounted soft-charge resistors and the impedance of the AC input line reactor. Upon reaching the programmed level of DC bus voltage, the pre-charge resistors are bypassed by the pre-charge contactor, which places full line voltage across the AC line to the SB3000 Power Module.

The SB3000 Power Module's inner control loop is enabled when the application task sets register 100/1100, bit 0, (VDC_RUN@). When this is done, the PMI Processor checks the interlocks as described in Appendix D. If the interlock conditions are satisfied, the DC bus voltage is ramped from the voltage produced by the diode rectification of the AC line voltage to the voltage reference value provided by the programmed outer control loop. The DC bus voltage is then regulated by the on-board voltage regulator. The ramp rate is 100 volts per second. When the preset reference voltage is reached, register 200/1200, bit 10, (VDC_ON@) is turned on to indicate that the Power Module is operating.

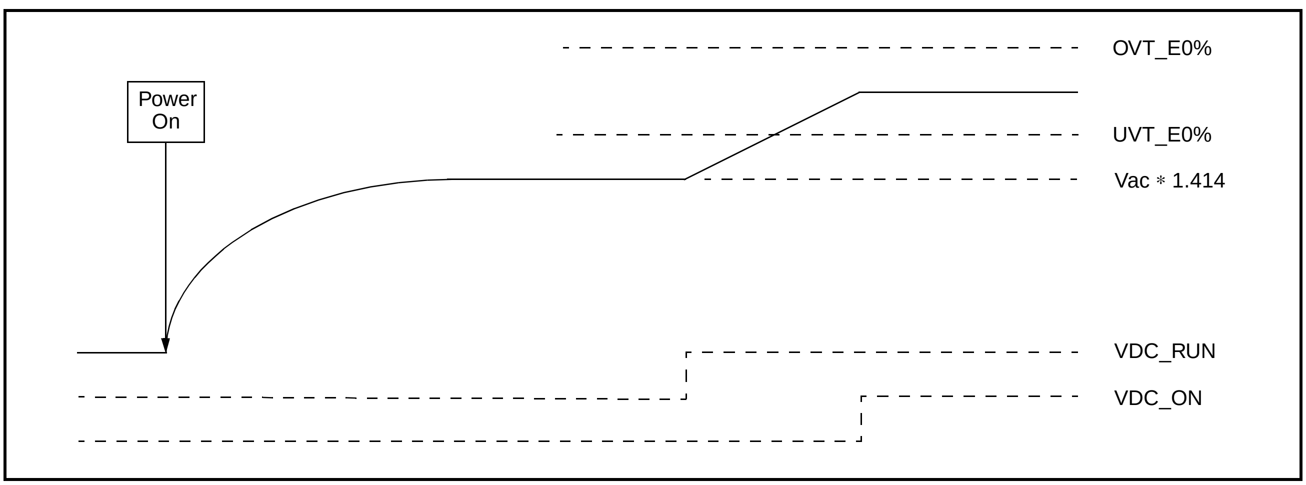


Figure 2.1 – DC Bus Voltage

When the DC bus operating voltage is reached, the connected SA3000/SA3100 Power Modules may be operated. Note that an SB3000 Power Module cannot support the loading of SA3000/SA3100 Power Modules when the soft-charge resistors are limiting the bus charging current.

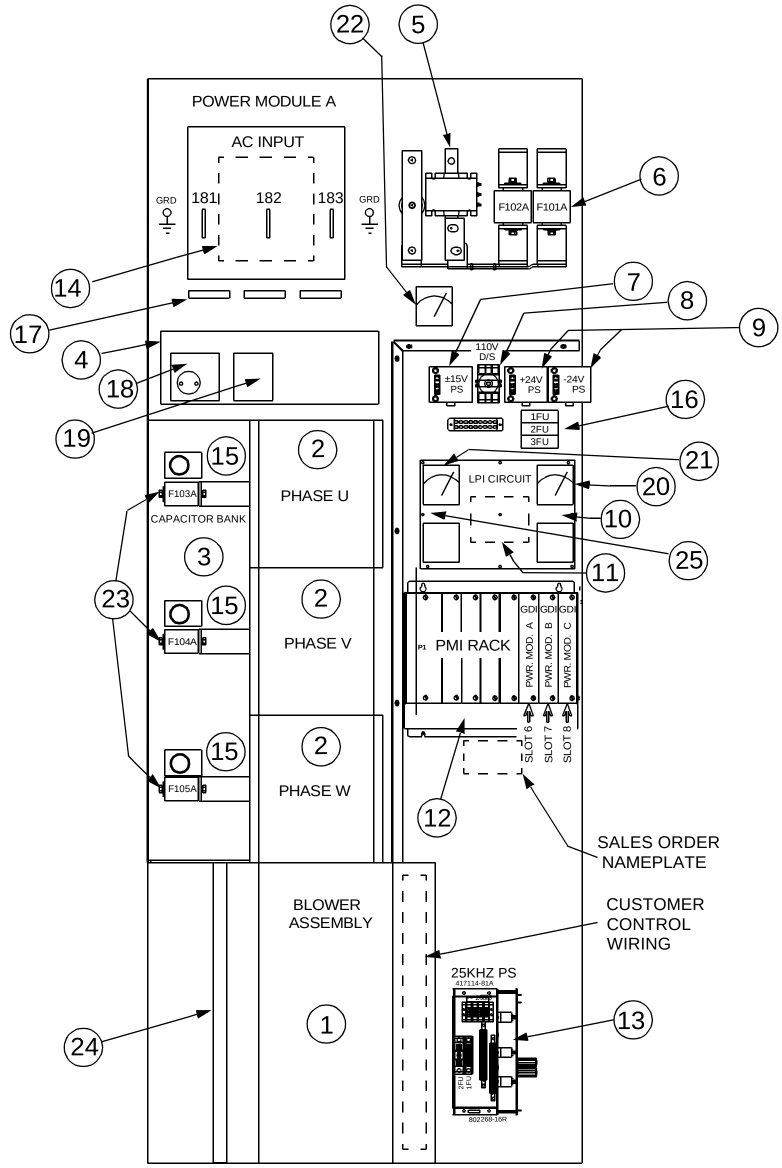
ATTENTION: SA3000/SA3100 Power Modules must be in standby or in regeneration whenever the SB3000 Power Module' s pre-charge contactor opens. The SB3000 Power Module's soft-charge resistors may fail if this interlocking restriction is not observed. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

The filtered SB3000 DC output voltage is then fed to the DC bus inputs of the SA3000/SA3100 Power Module(s). The IGBTs are switched by the Gate Driver Interface module(s) in the PMI rack. Three LEM sensors provide input current feedback, which is used for control and overcurrent protection. One LEM sensor is used to provide DC output current feedback.

Each SA3000/SA3100 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/SA3100 Power Module is put into run.

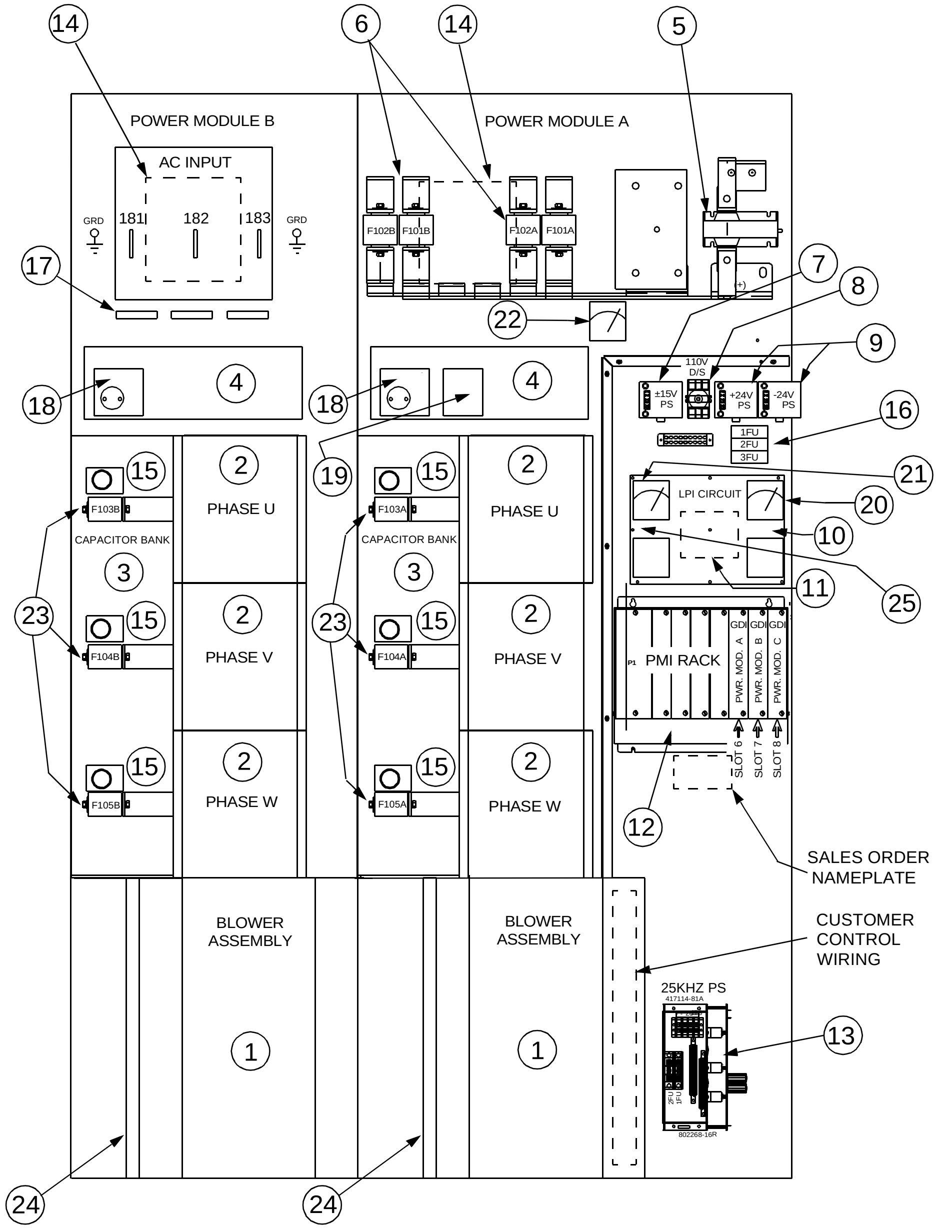
ATTENTION: The SB3000 Power Module must be in run before the SA3000/SA3100 Power Module is put into run. If the pre-charge contactor supplying the SB3000 Power Module is not closed, running the SA3000/SA3100 Power Module will damage the SB3000 pre-charge resistors. Failure to observe this precaution 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/SA3100 Power Module. If the SB3000 Power Module is shut down due to a fault condition, controlled shutdown of the SA3000/SA3100 Power Module is the responsibility of the application program running in the SA3000/SA3100 UDC module.



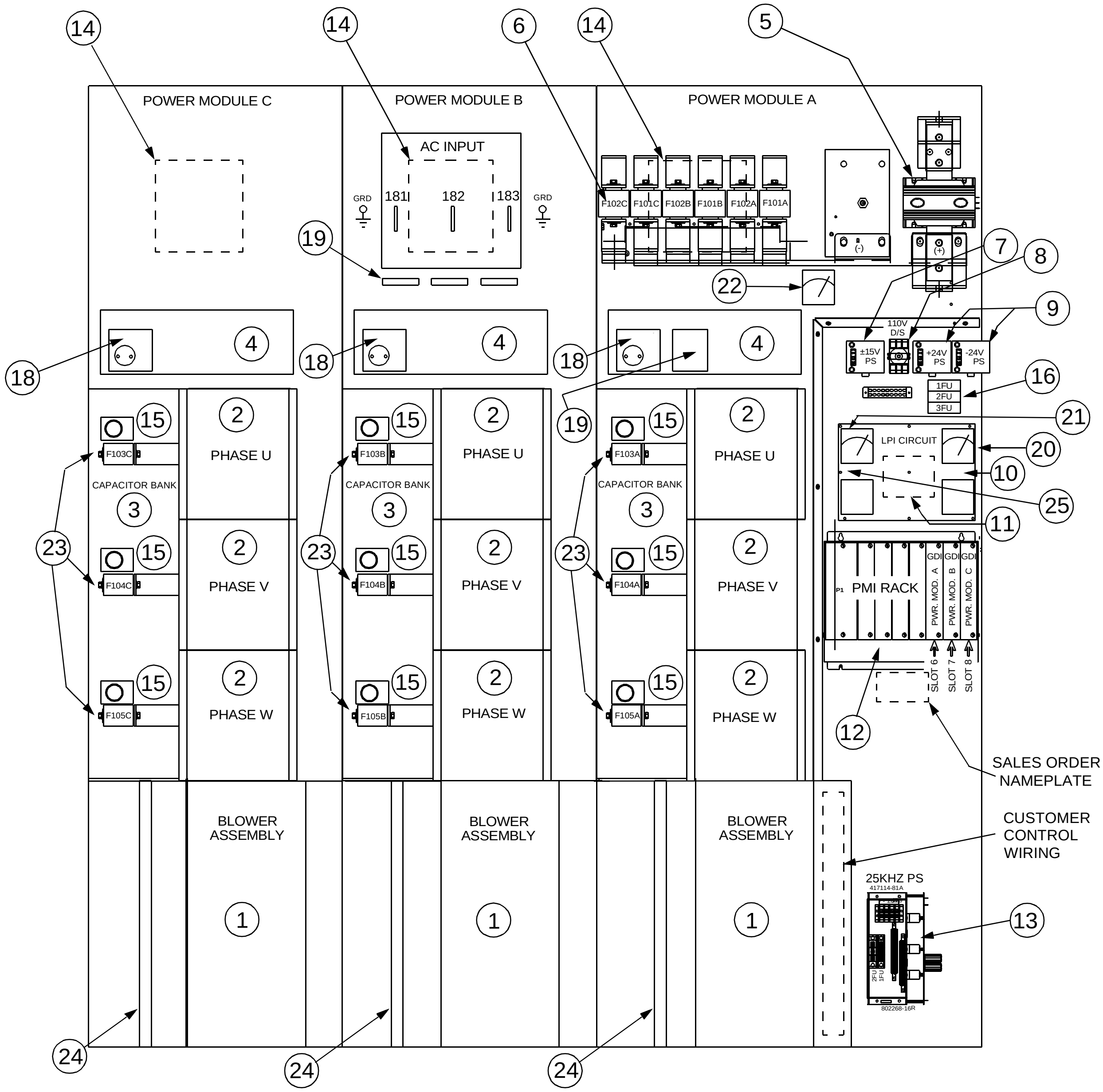
1. Blower Assembly
2. IGBT Phase Module Assembly
3. Capacitor Bank Assembly
4. Pre-charge Assy. Mounting Bracket
5. LEM Sensor - DC Bus Output
6. DC Bus Fuses
7. +/- 15V DC Power Supply
8. 110V AC Disconnect Switch
9. 24V DC Power Supply
10. LPI Module
11. 250VA Isolation Transformer
12. PMI Rack
13. 25KHz Power Supply
14. Reactor Assembly
15. LEM Sensors (3) - AC Input
16. Power Supply Fuses
17. Feedback Resistors
18. Pre-charge Module
19. DC Feedback Module
20. AC Input Current Meter
21. DC Output Current Meter
22. DC Bus Voltage Meter
23. Input Phase Fuses
24. Blower Filter
25. Line Synchronization Module (On the Meter Bracket)

Figure 2.2 – 445A SB3000 Power Module Components



1. Blower Assembly
2. IGBT Phase Module Assembly
3. Capacitor Bank Assembly
4. Pre-charge Assy. Mounting Bracket
5. LEM Sensor - DC Bus Output
6. DC Bus Fuses
7. +/- 15V DC Power Supply
8. 110V AC Disconnect Switch
9. 24V DC Power Supply
10. LPI Module
11. 250VA Isolation Transformer
12. PMI Rack
13. 25KHz Power Supply
14. Reactor Assembly
15. LEM Sensors (3) - AC Input
16. Power Supply Fuses
17. Feedback Resistors
18. Pre-charge Module
19. DC Feedback Module
20. AC Input Current Meter
21. DC Output Current Meter
22. DC Bus Voltage Meter
23. Input Phase Fuses
24. Blower Filter
25. Line Synchronization Module (On the Meter Bracket)

Figure 2.3 – 890A SB3000 Power Module Components



1. Blower Assembly
2. IGBT Phase Module Assembly
3. Capacitor Bank Assembly
4. Pre-charge Assy. Mounting Bracket
5. LEM Sensor - DC Bus Output
6. DC Bus Fuses
7. +/- 15V DC Power Supply
8. 110V AC Disconnect Switch
9. 24V DC Power Supply
10. LPI Module
11. 250VA Isolation Transformer
12. PMI Rack
13. 25KHz Power Supply
14. Reactor Assembly
15. LEM Sensors (3) - AC Input
16. Power Supply Fuses
17. Feedback Resistors
18. Pre-charge Module
19. DC Feedback Module
20. AC Input Current Meter
21. DC Output Current Meter
22. DC Bus Voltage Meter
23. Input Phase Fuses
24. Blower Filter
25. Line Synchronization Module (On the Meter Bracket)

Figure 2.4 – 1335A SB3000 Power Module Components

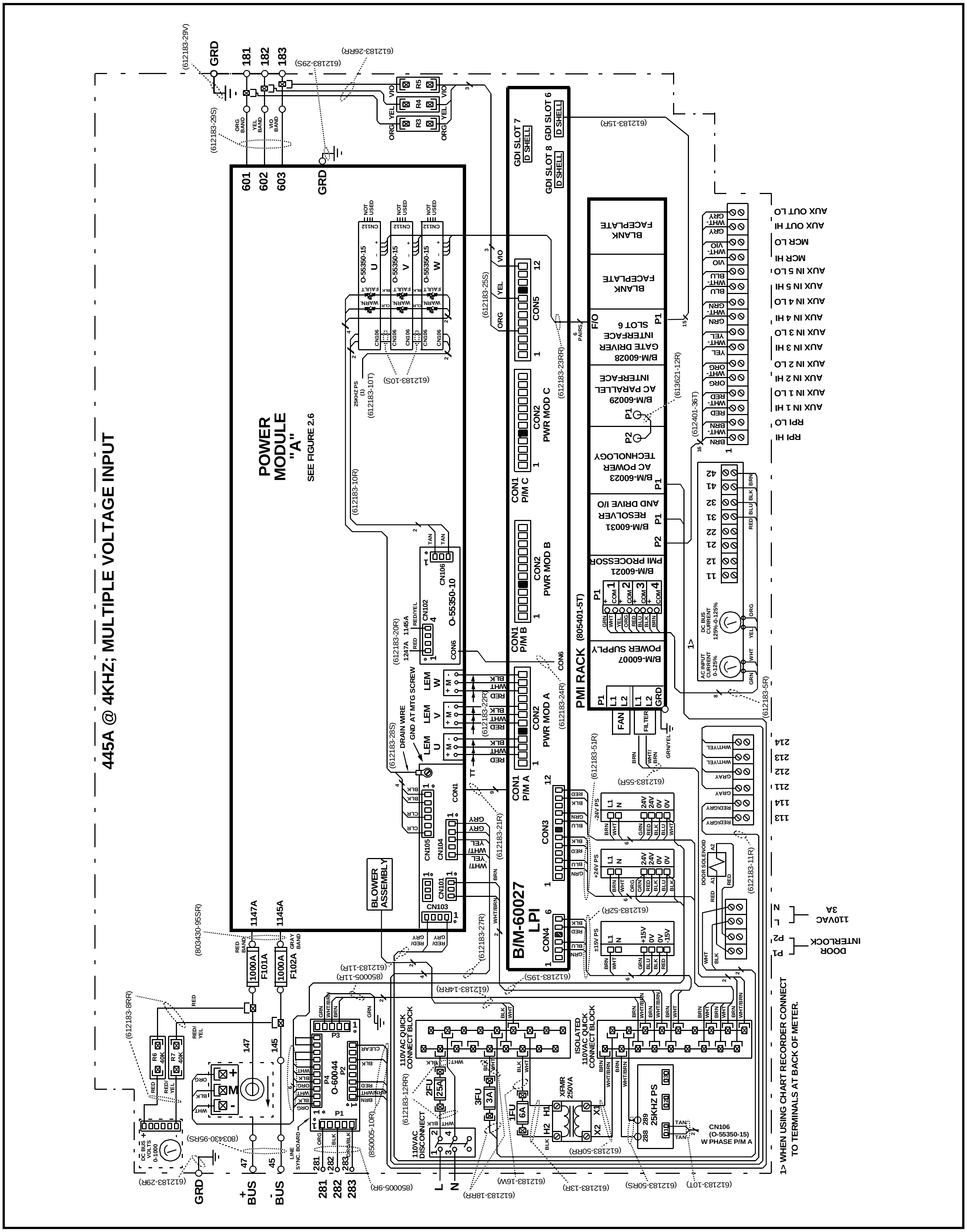


Figure 2.5 – 445A SB3000 Power Module Circuitry

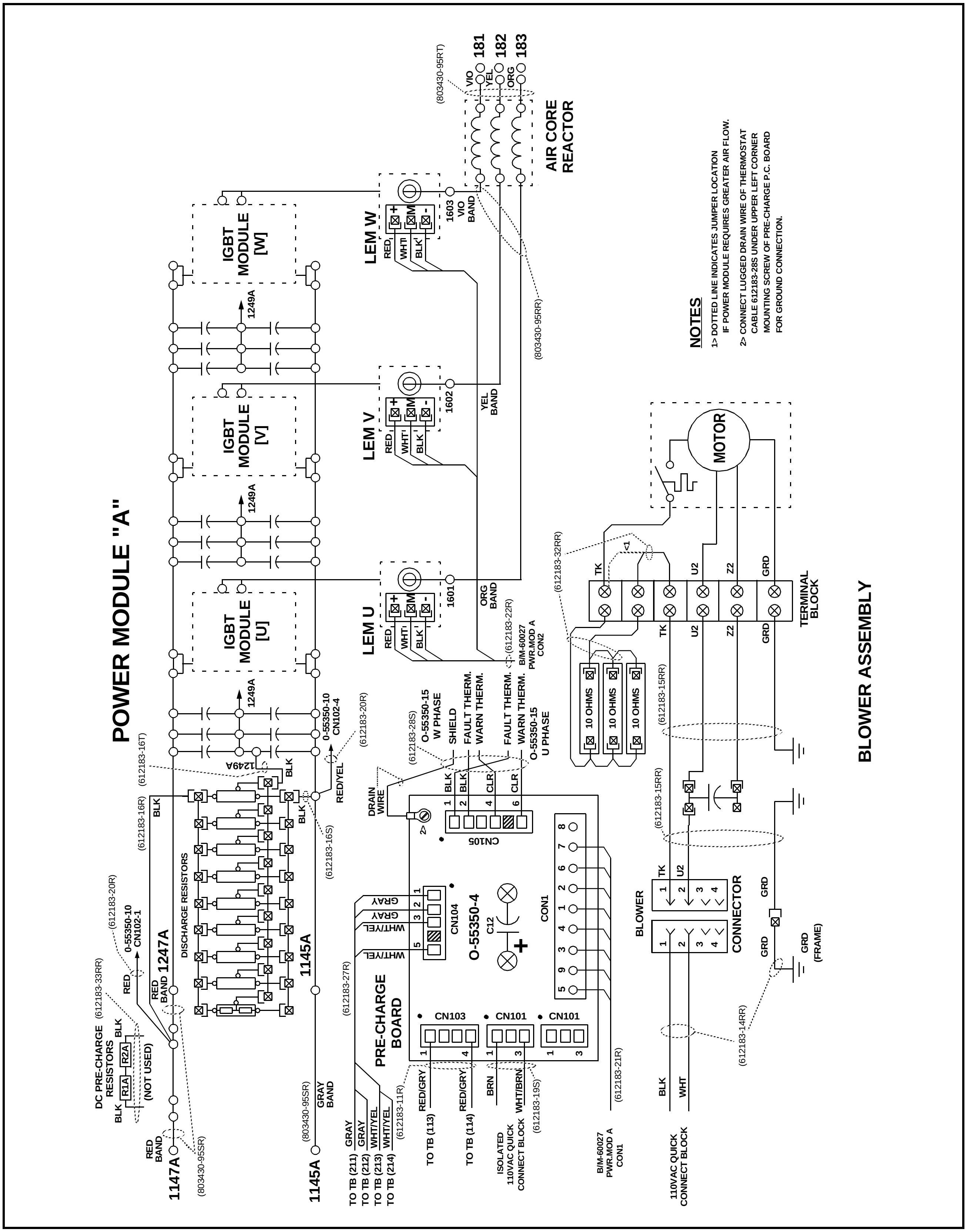


Figure 2.6 – 445A SB3000 Power Module Circuitry (Continued)

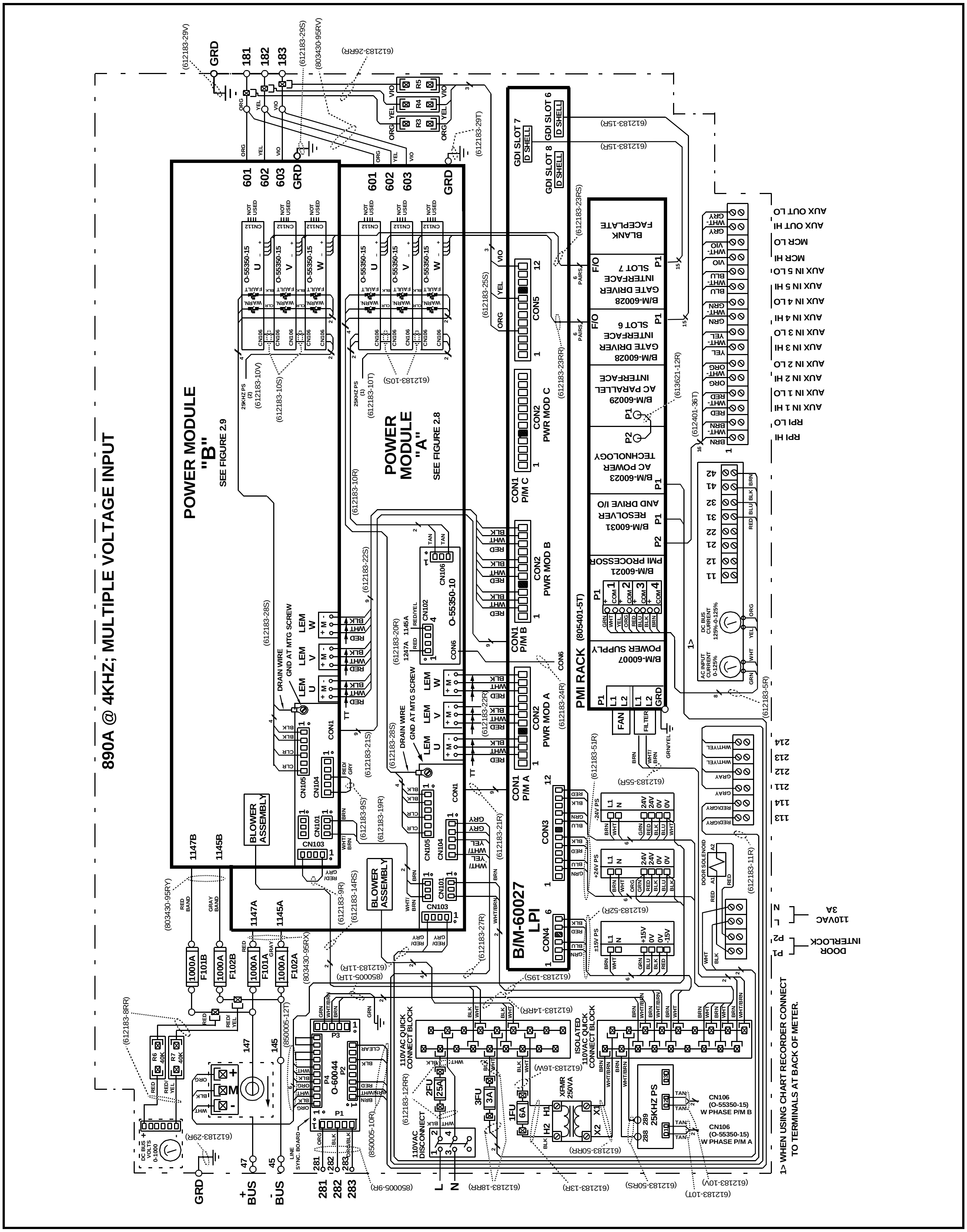


Figure 2.7 – 890A SB3000 Power Module Circuitry

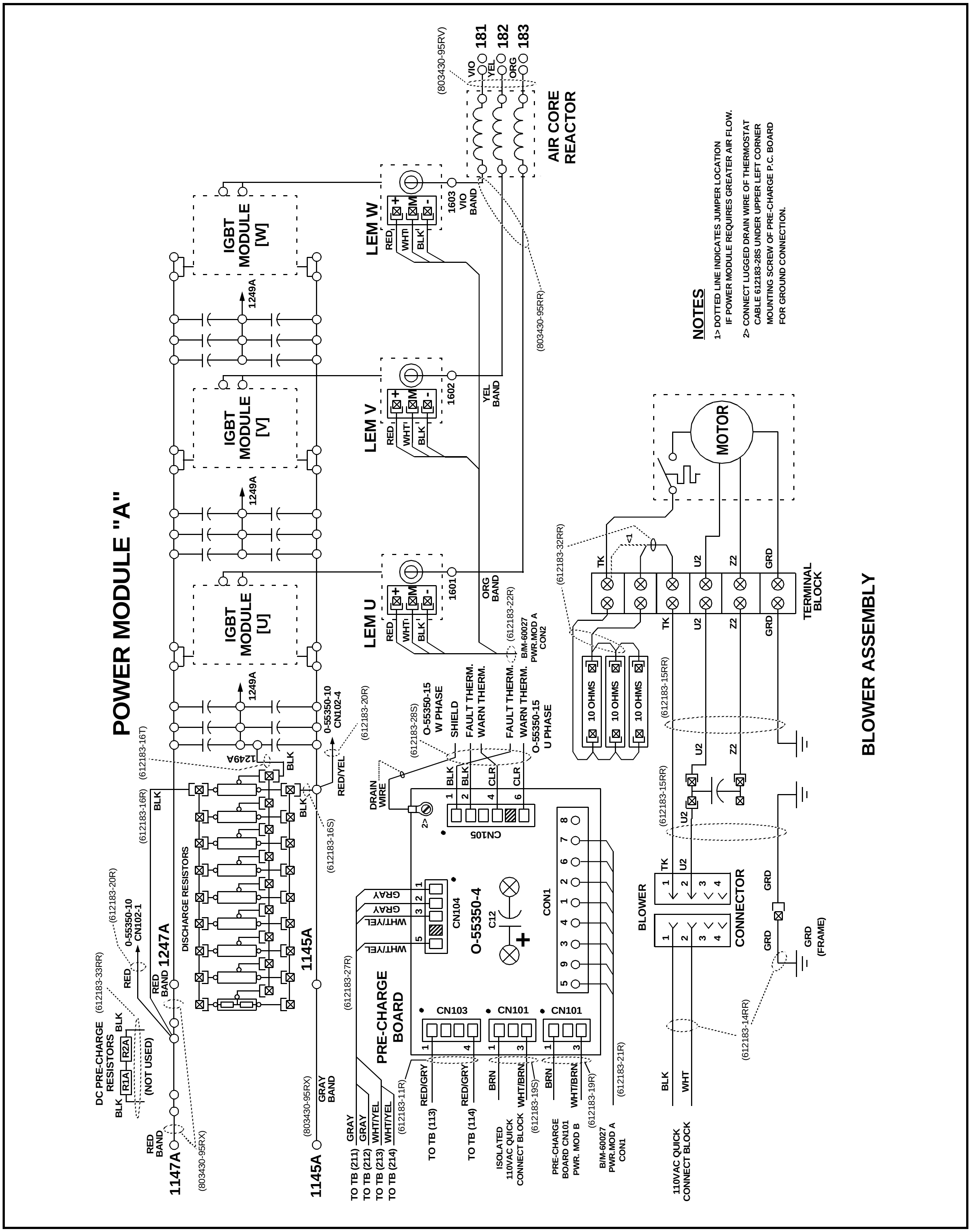


Figure 2.8 – 890A SB3000 Power Module Circuitry (Continued)

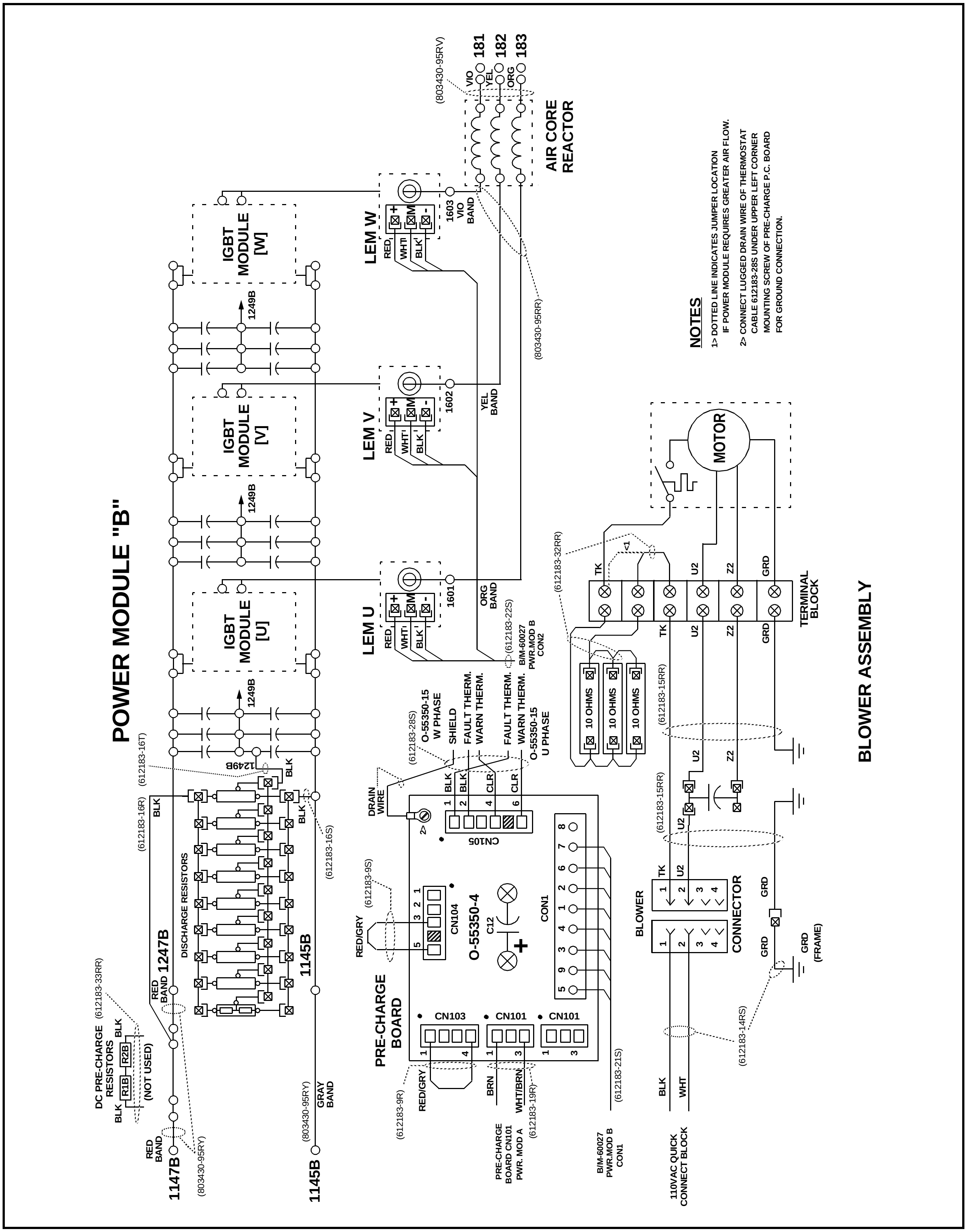


Figure 2.9 – 890A SB3000 Power Module Circuitry (Continued)

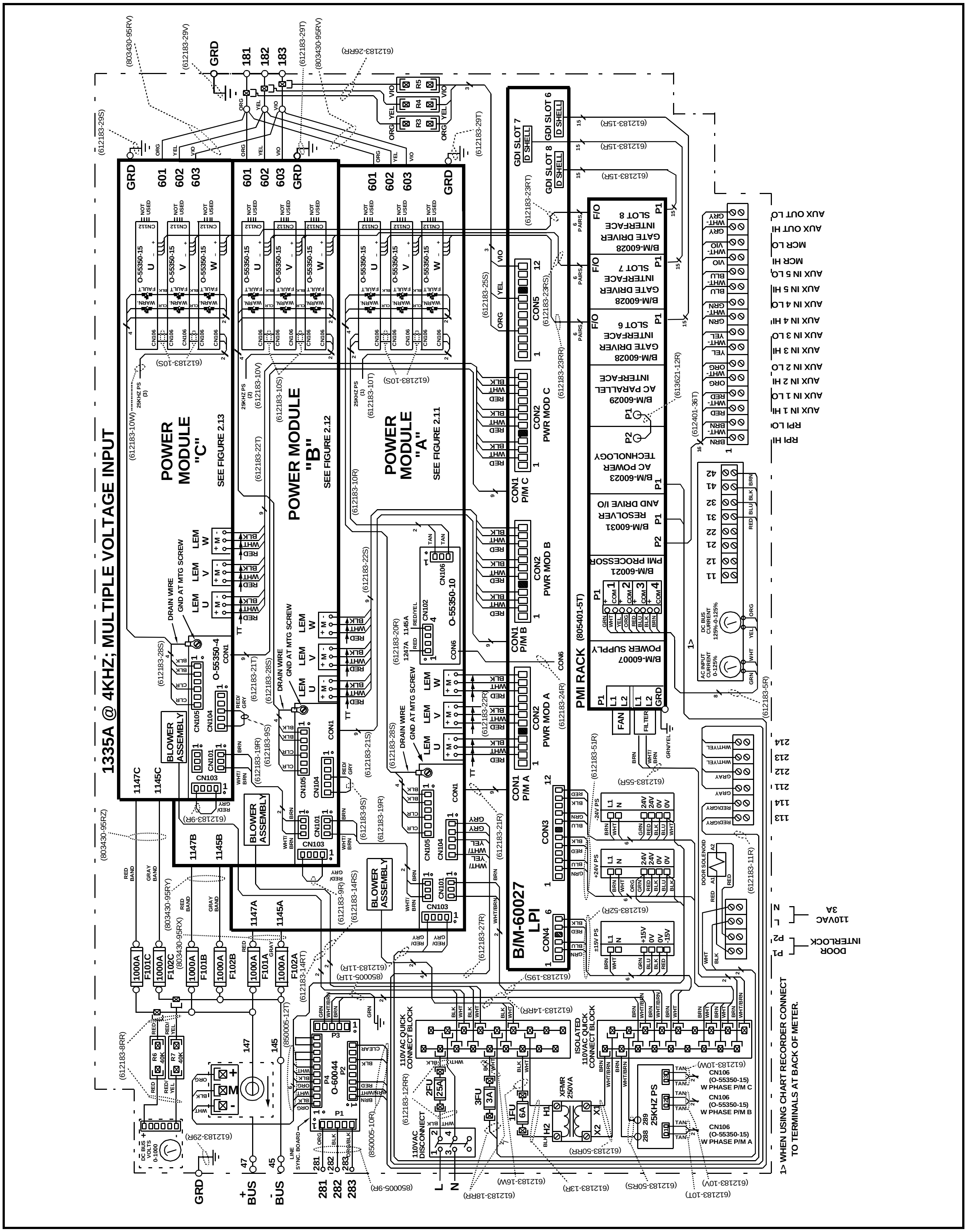


Figure 2.10 – 1335A SB3000 Power Module Circuitry

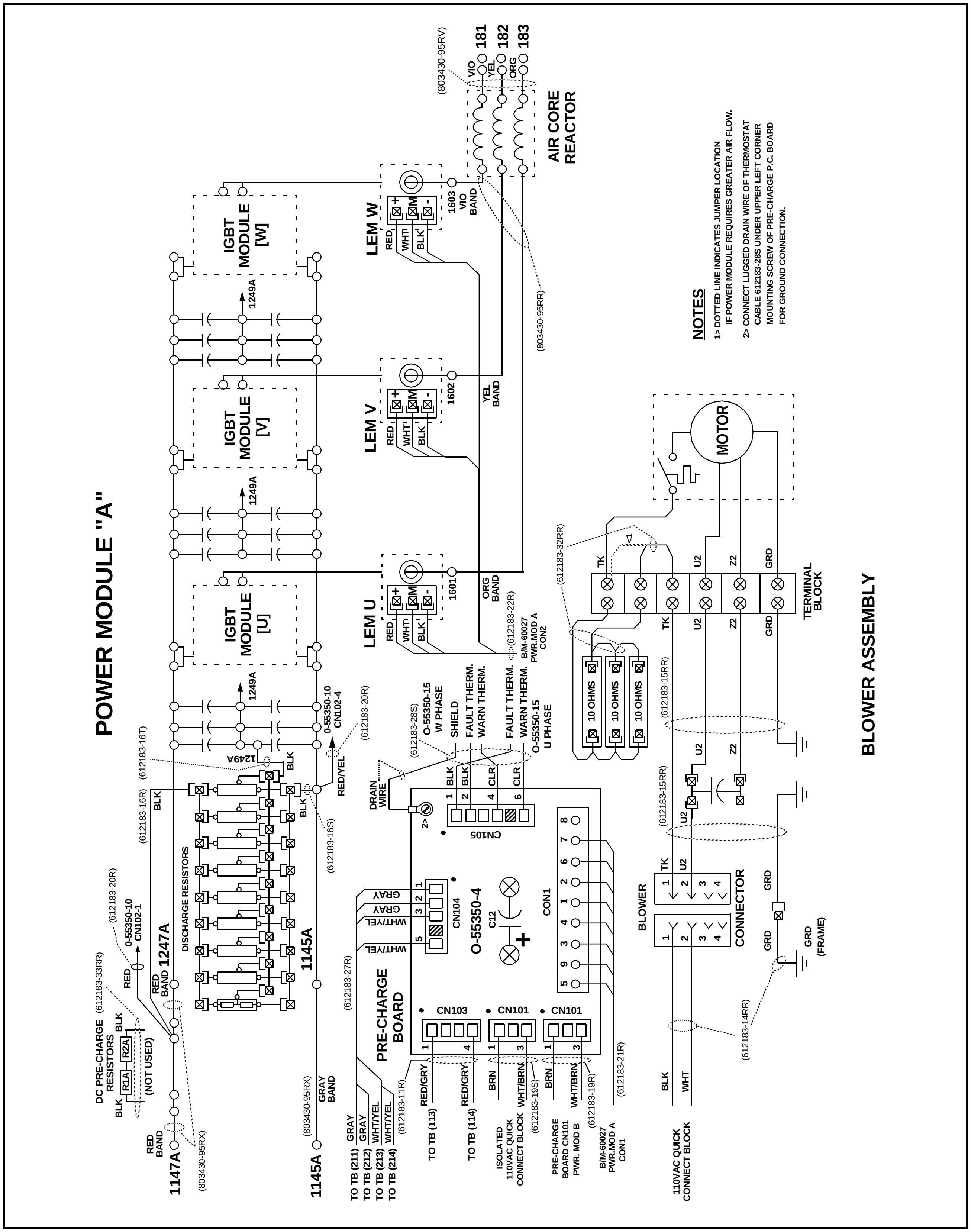


Figure 2.11 – 1335A SB3000 Power Module Circuitry (Continued)

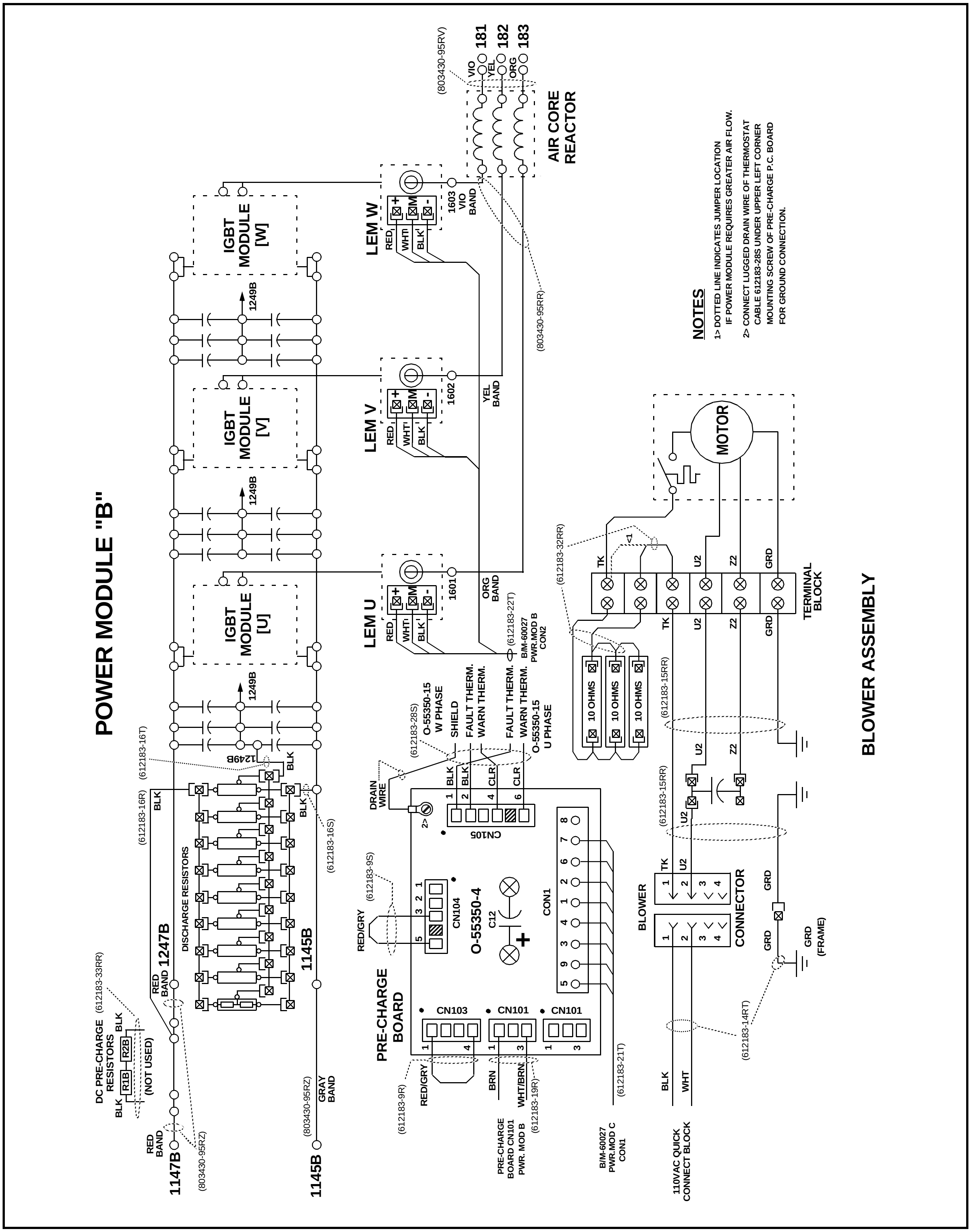


Figure 2.12 – 1335A SB3000 Power Module Circuitry (Continued)

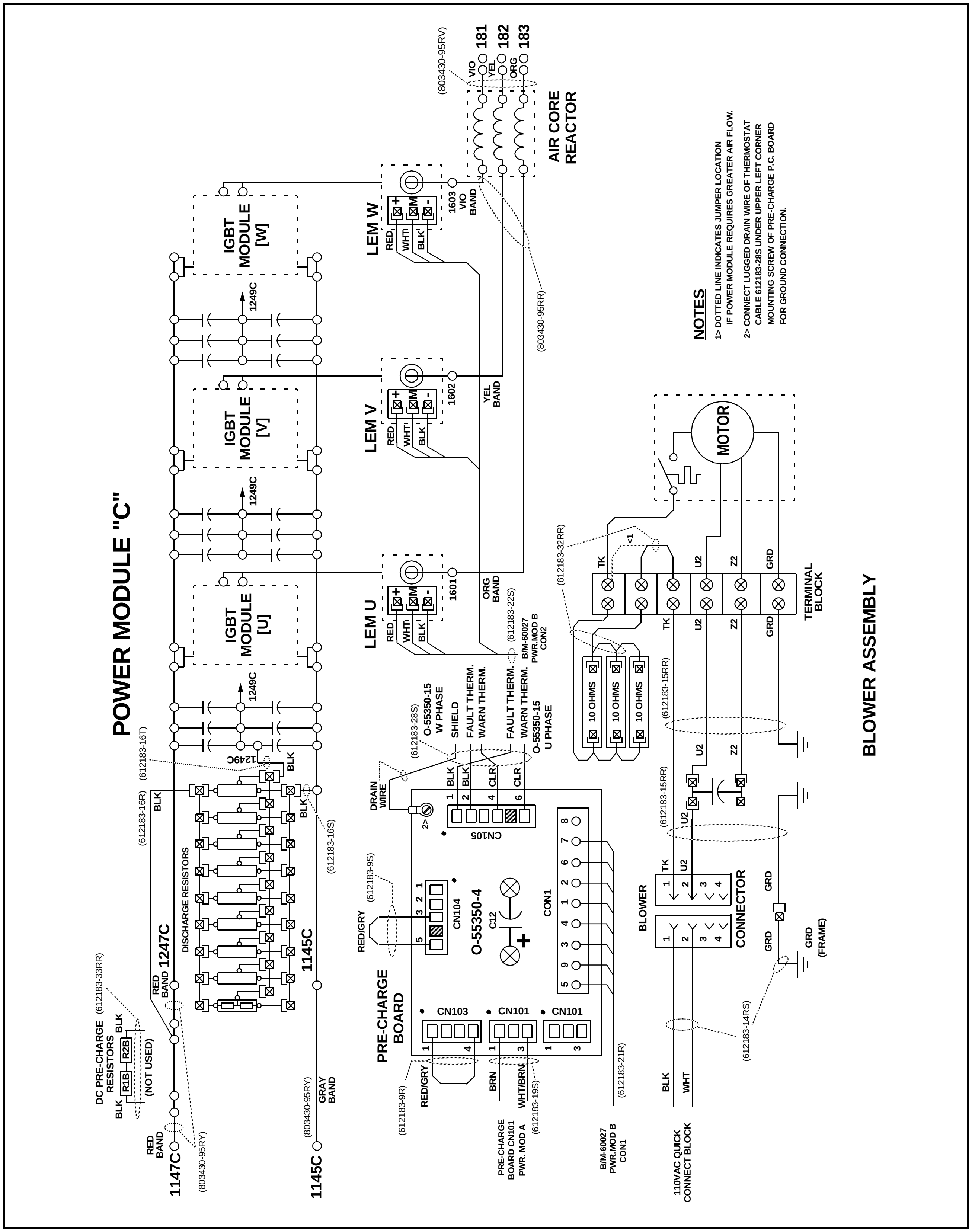


Figure 2.13 – 1335A SB3000 Power Module Circuitry (Continued)

CHAPTER 3

Installation Guidelines

This chapter describes the guidelines and wiring recommendations to be followed when installing High Power SB3000 Power Modules. An installation procedure for the 445A, 890A, and 1335A Power Modules is provided.

⚠ **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

Use the following guidelines when planning your SB3000 Power Module installation:

SB3000 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 thermal switch is used to indicate a warning condition (register 203/1203, bit 7, WRN_OT@) while the other switch 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) while the thermal fault switch closes at 85°C (185° F). Refer to the SB3000 Configuration and Programming Instruction Manual for more information.

- The relative humidity around the SB3000 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 SB3000 Power Module's current rating is derated 1%.
- Locate the SB3000 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 SB3000 Power Module.
- Allow adequate clearance for air ventilation. SB3000 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 SB3000 Power Module has one fan. Allow at least 30 cm (12") above and 2 m (6.6') in front of the SB3000 Power Module for adequate air clearance.
- AC input lead lengths, between the input reactor and the SB3000 Power Module’s AC input terminals, cannot exceed 100 meters (328 feet).

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 3.2.6 provide additional information on input fuses, pre-charge components, AC line reactors, and recommended wire types.

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 SB3000 Power Module's three-phase AC input, DC bus output, and 115V AC input power lines. See table 3.1 for the fuse ratings.

Table 3.1 – AC Input and DC Bus Fuse Ratings

Fuse Number	Circuit	Fuse Current Rating	Fuse Voltage Rating	Rockwell P/N
F101 A,B,C F102 A,B,C	DC Bus	1000 A	1000 VAC	64676-80P
F103 A,B,C F104 A,B,C F105 A,B,C	AC Line Input	630 A	1000 VAC	64676-79AZ
1FU	115V AC	5 Amp	600 VAC	64676-29R
2FU	115V AC	25 Amp	600 VAC	64676-72BB
3FU	115V AC	3.2 Amp	600 VAC	64676-29P

3.2.2 Pre-charge Resistors and Fuses

The pre-charge circuit consists of three AC line resistors with an AC contactor bypass. The pre-charge resistors are protected by fuses in series with each resistor. See table 3.2. The pre-charge circuit is sized to support the charging of the SB3000 Power Module's DC bus capacitors and up to four times the Power Module's capacitance as a load. The pre-charge time is 10 seconds or less.

Table 3.2 – Pre-charge Resistors and Fuses

Power Module Rating	Resistance	Resistor P/N	Fuse Rating	Fuse P/N	3-Phase Fuse Holder P/N
445 Amp	One 3.75Ω Resistor/Phase	402422-3A	15 Amps, 600V RK5 or Equivalent	64676-1BW	49454-21C
890 Amp	Two 1.65Ω Resistors/Phase (3.3Ω/Phase)	402422-3C	20 Amps, 600V RK5 or Equivalent	64676-1BX	49454-21C
1,335 Amp	Two 1.65 Ω Resistors/Phase (3.3Ω/Phase)	402422-3C	20 Amps, 600V RK5 or Equivalent	64676-1BX	49454-21C

The pre-charge circuit is controlled by the PMI rack via the Pre-charge Controller module (B/M O-55350-4). This module is located in the master inverter cabinet and the 24V output is used to drive a pilot relay which in turn drives the pre-charge contactor’s 115 VAC coil.

The pre-charge contactor’s auxiliary contacts are wired back to the Pre-charge Controller Module in the SB3000 Power Module. This module expects to see the pre-charge contactor close after energizing its coil. This condition must be met before the drive can be put into run.

3.2.3 Line Filter Reactors

Three-phase AC line reactors are necessary to isolate the capacitor bank from the AC line and to provide energy storage for the voltage boosting function of the SB3000 Power Module. See table 3.3. The line reactors have iron-cores, copper windings, and 1000V insulation. They are rated at 70° C (158° F) ambient and are convection cooled.

Table 3.3 – Line Filter Reactor Ratings

Power Module	Inductance	Frequency	Harmonic Current at 4kHz
445 Amp	500 µH at 534 Amp	23 to 62 Hz	15%
890 Amp	250 µH at 972 Amp	23 to 62 Hz	15%
1,335 Amp	167 µH at 1457 Amp	23 to 62 Hz	15%

3.2.4 Control Transformers

SB3000 control transformers should not be connected to the same AC power line that supplies the 3-phase power to SB3000 terminals 181, 182, and 183. The SB3000 Power Module, during normal operation, introduces high-frequency line notching in the 3-phase AC line. This type of line disturbance can be coupled through a control transformer into all connected loads and equipment.

SB3000 control transformers that provide power to electronic power supplies, I/O cards, PMI racks, and programmable controllers should be connected to a separate source of AC power that is free of line noise. If a noise-free source of power is not available, a Sola transformer, resonant filter, or a shielded, conditioning transformer must be used.

ATTENTION: The SB3000 Power Module may cause a large variation in the input isolation transformer's neutral-to-ground voltage in ungrounded and high-resistance grounded systems. This type of high frequency, high level line disturbance may cause improper ground fault detector operation or component failure.Failure to observe this precaution could result in damage to, or destruction of the equipment.

During normal operation, the SB3000 Power Module may also cause a large variation in the input isolation transformer's neutral-to-ground voltage in ungrounded and high-resistance grounded systems. This may cause false ground fault detector indications.

This type of high frequency, high level line disturbance can be coupled through standard control transformers into all connected loads, such as electronic power supplies, I/O cards, and programmable controllers. This coupled, high level noise may cause improper operation or component failure.

To ensure proper ground fault detector operation, a ground fault detector with a 60 Hz filter is recommended. Standard magnetic relays and solenoids are not affected by this high frequency line noise.

3.2.5 Wire Sizes

Input wiring should be sized according to applicable codes to handle the SB3000 Power Module's continuous-rated input current. Output wiring should be sized according to applicable codes to handle the SB3000 Power Module's continuous-rated output current. Recommended wire sizes are shown in table 3.4. Terminals should be tightened to the torque values provided in table 3.5.

Table 3.4 – Recommended AC Input and DC Bus Output Wire Sizes

SB3000 Output Rating	Size of Wire[1]
445A	2 x 600 Kc Mil (304 mm^2)
890A	3 x 600 Kc Mil (304 mm^2)
1335A	4 x 1000 Kc Mil (507 mm^2)

1. NEC-recommended cable types: 40^{o}C (104^{o}F) copper wire.

Table 3.5 – Terminal Tightening Torques

Terminals	Tightening Torque
DC Bus Output Power: 45, 47	41 Nm (30 lb-ft)
Ground: GND - Door	11.3 Nm (8.3 lb-ft)
Ground: GND - Hood Access Plate	22.6 Nm (16.5 lb-ft)
Input Power: U, V, W	41 Nm (30 lb-ft)
115 VAC Input Power: L, N	3.5 Nm (2.6 lb-ft)

3.2.6 Wire Routing

AC input wiring is routed through the top of the cabinet, above AC line terminals 181, 182 and 183. DC output wiring is also routed through the top of the cabinet. DC output wiring is usually connected directly to the D-C bus in the overhead enclosure that distributes the DC power to the common DC bus SA3000/SA3100 Power Modules.

The AC power distribution cabinet is mounted separately from the SB3000 Power Module but should be positioned conveniently close by. The AC disconnect is a thermal magnetic circuit breaker or a fused disconnect switch which is rated to protect the power wiring in the SB3000 Power Module. The AC disconnect is mounted such that it can be locked out, providing safe access to the inside of the power distribution cabinet and to the SB3000 Power Module.

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.

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 AC input 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 a Power Module Cabinet

Use the following procedure to install a SB3000 Power Module cabinet.

Step 1. Ensure that AC input power leading to the SB3000 Power Module is off.

Step 2. Position the SB3000 Power Module on a level mounting surface. See figure 3.1, 3.2, or 3.3 for cabinet dimensions. Floor mounting dimensions are included for applications where the cabinet is to be attached to the floor.

Step 3. Connect the AC input leads from the line reactor/pre-charge control directly to the 181 (L1), 182 (L2), and 183 (L3) terminals. Connect the GND terminal to earth ground. See figure 3.4.

Step 4. Connect DC bus terminals 45 and 47 (800V DC) to the SA3000/SA3100 Power Module bus terminals. Connect the GRD terminal to earth ground. See figure 3.4.

Step 5. 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 figure 3.4.

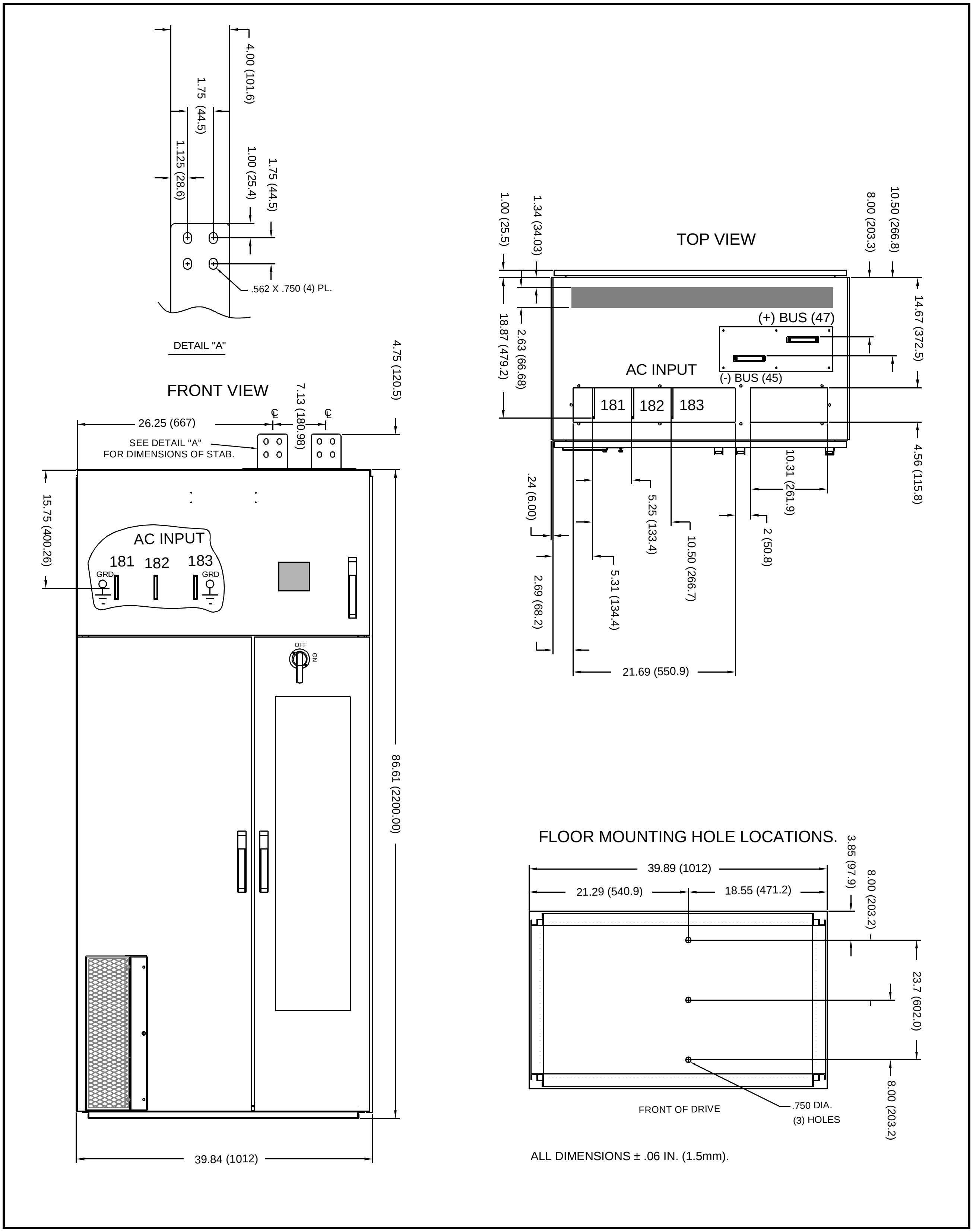


Figure 3.1 – 445A SB3000 Power Module Mounting Dimensions

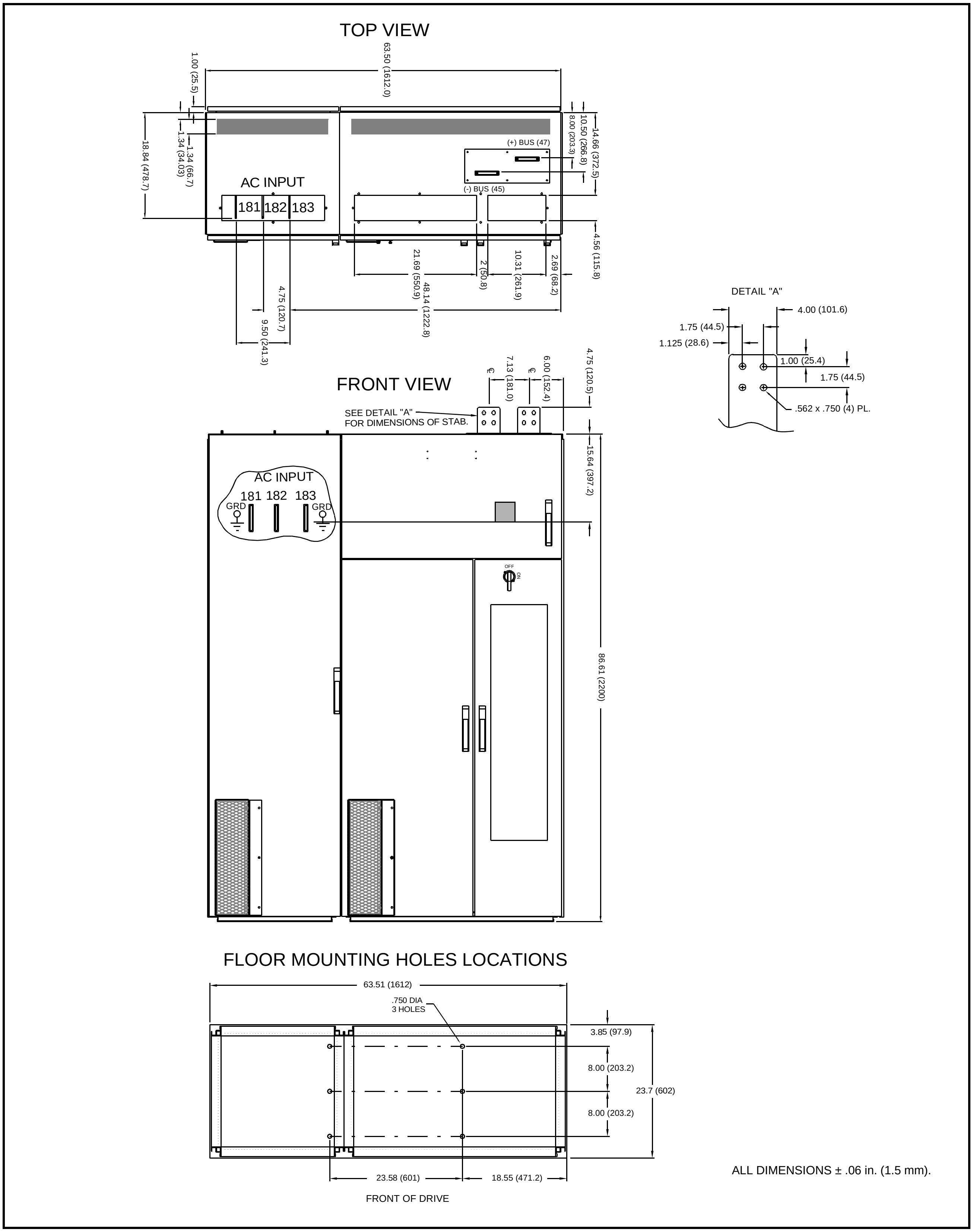


Figure 3.2 – 890A SB3000 Power Module Mounting Dimensions

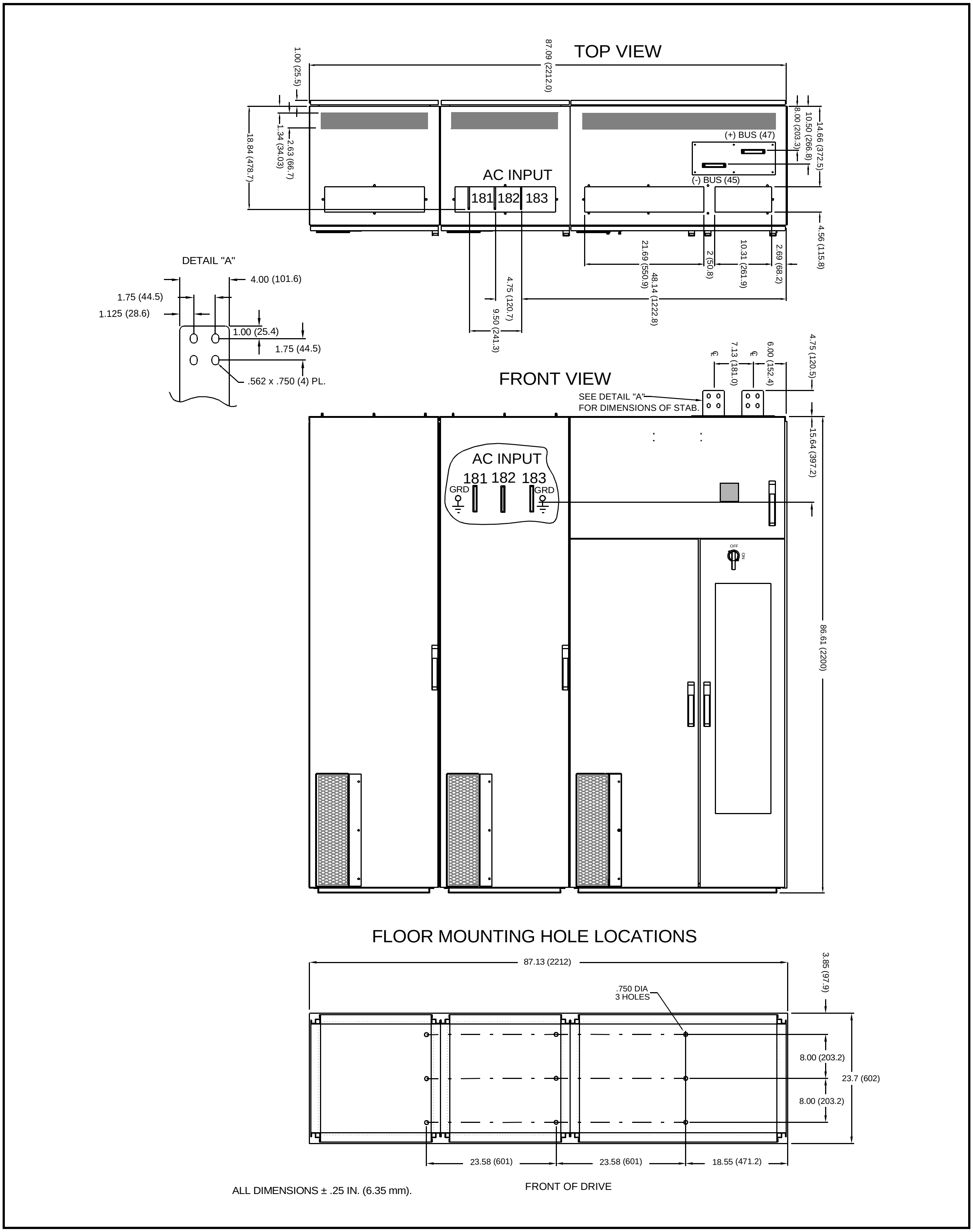


Figure 3.3 – 1335A SB3000 Power Module Mounting Dimensions

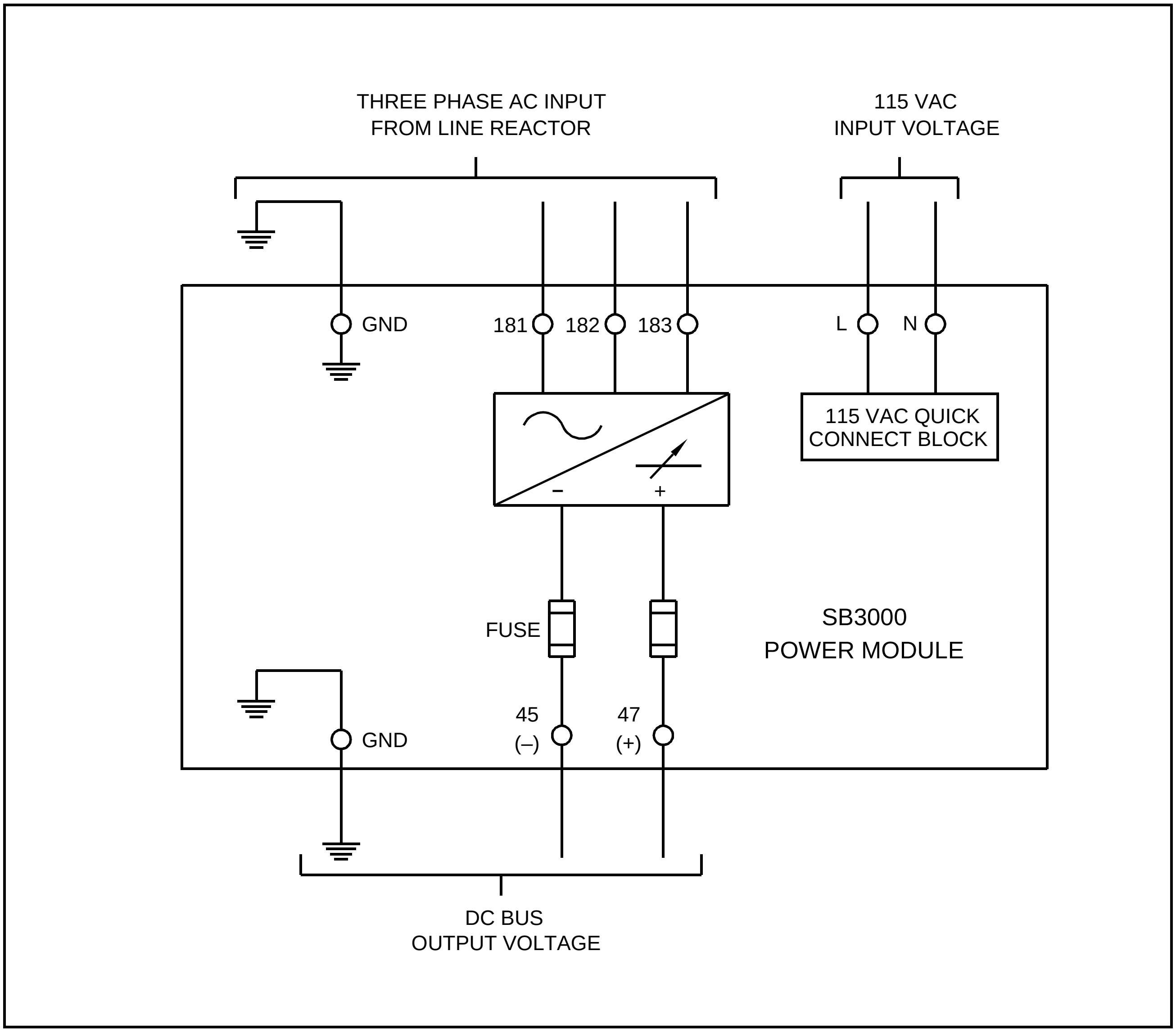


Figure 3.4 – SB3000 Power and Ground Connections

CHAPTER 4

Diagnostics and Troubleshooting

This chapter describes the equipment needed to check the operation of the SB3000 Power Module and the tests to be performed. Also included are descriptions of the SB3000 Power Module faults monitored by the Distributed Power System software. Procedures are provided for replacing fuses and sub-assemblies.

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, then look at the built-in DC bus voltage meter. When the voltage is down to approximately zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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 SB3000 Power Module contains printed circuit boards that are static sensitive. Do not touch any components, connectors, or leads. Failure to observe this precaution could result in damage to equipment.

4.1 Required Test Equipment

The following equipment is required when servicing the SB3000 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. The 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 SB3000 Power Module tests:

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, then look at the built-in DC bus voltage meter. When the voltage is down to approximately zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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. Look at the built-in DC Bus Voltage meter. When the DC bus potential is down to approximately zero volts, open the SB3000 Power Module cabinet's doors and measure the DC bus potential across the DC bus bars, 1247A (+ bus) and 1145A (- bus), with an external voltmeter before working on the unit. See figure 4.1.

Step 4. Check the AC input and DC bus output fuses.

Step 5. If a fuse is blown, use a multimeter to check the DC bus, bus capacitors, AC input terminals, and the input IGBTs. See tables 4.1 and 4.2.

Step 6. If a capacitor is defective, replace the capacitor bank assembly as described in section 4.5.4. If an IGBT is defective, refer to section 4.5.2.

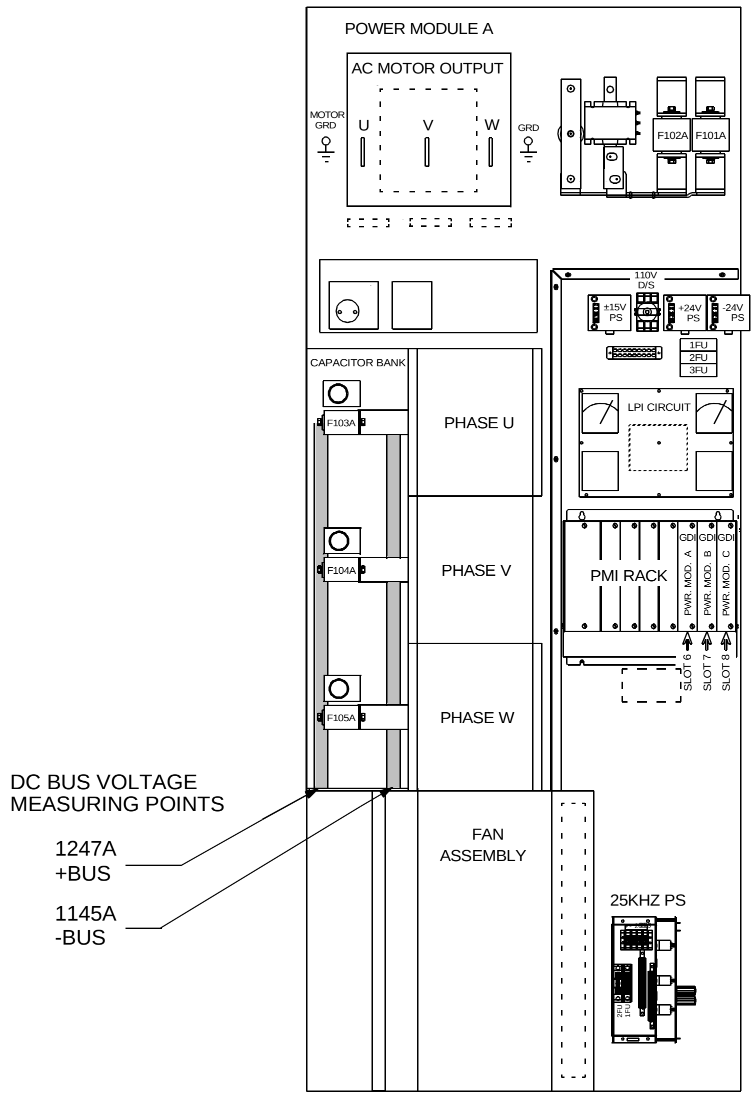


Figure 4.1 – DC Bus Voltage Measuring Points

Table 4.1 – DC Bus and Output 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	+	1249	X10	Capacitor Effect (0 to 500 ohms)
	-	1249		
	601	+	X1	2 ohms
	602	+		
	603	+		
	+	601	X10	Capacitor Effect (0 to 2k ohms)
	+	602		
	+	603		
Input Terminals	181 (601)	182 (602)	X1000	4k to 6k ohms
	181 (601)	183 (603)		
	182 (602)	183 (603		

1. with the AC input lines disconnected

Table 4.2 – IGBT Tests[1]

	Meter Connections +	-	Scale	Expected Test Results (+/- 10%)
W Phase (lower) +	183	+1147	2k Ω/diode	0.300 ohms
V Phase (lower) +	182	+1147	2k Ω/diode	0.300 ohms
U Phase (lower) +	181	+ 1147	2k Ω/diode	0.300 ohms
W Phase (upper) -	1245 -	183	2k Ω/diode	0.300 ohms
V Phase (upper) -	1245 -	182	2k Ω/diode	0.300 ohms
U Phase (upper) -	1245 -	181	2k Ω/diode	0.300 ohms

1. with the AC input lines 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 SB3000 Synchronous Rectifier is not operating in an optimum manner. Warnings will not shut down the SB3000. Faults are severe errors which will shut down the SB3000. See tables 4.3 and 4.4.

Refer to the SB3000 Synchronous Rectifier Configuration and Programming instruction manual (S-3034) for more information about the Fault and Warning registers.

4.3.1 Faults

The following faults will cause the SB3000 Power Module to shut down. See table 4.3. In a fault situation, the PMI Processor will command zero current and will stop firing the IGBTs; however, the IGBT emitter-collector diodes will supply rectified line voltage to the DC bus until AC input power is disconnected. Faults must be reset before the SB3000 Power Module can be restarted.

Table 4.3 – SB3000 Fault 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 900 VDC.
1	FLT_DCI@	1020	The DC Bus Overcurrent bit is set if the DC bus current exceeds 125% of the rated SB3000 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.
5	FLT_GDI@	1023	The Gate Driver Interface Fault bit is set if the power supply voltage on the Gate Driver Interface (GDI) module is not within tolerance.
6	FLT_CHG@	1024	The Charge Fault bit is set if either of the following occurs: the pre-charge contactor does not close when commanded to by the PMI Processor or the contactor opens without being commanded to do so.
7	FLT_OT@	1016	The Overtemperature Fault bit is set if the fault level thermal switch (85^{o} C (185^{o} F)) in the SB3000 Power Module opens.
10	FLT_PWR@	1025	The Power Loss Fault bit is set if AC line power is lost for more than ten seconds while the SB3000 Power Module is running.
11	FLT_PTM@	1011	The Power Technology Fault bit is set if the AC Power Technology module fails.
12	FLT_PS@	1012	The PMI Power Supply Fault bit is set if the PMI rack's power supply fails.
13	FLT_RW@	1013	The PMI Read/Write Fault bit is set if a PMI Processor read or write operation fails.
14	FLT_RUN@	1014	The UDC Run Fault bit is set if the UDC task stops while the voltage loop is running.
15	FLT_COM@	1015	Communication Lost Fault bit is set if fiber-optic communication between the PMI Processor and the UDC module is lost due to two consecutive errors of any type.

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 900 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 SB3000 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. 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 SB3000 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. Register 204/1204, bits 0-5, indicate which power device detected the overcurrent. When 890A and 1335A SB3000 Power Modules are being used, registers 220/1220 and 221/1221 indicate the status of the B and C Power Module cabinets. 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 Gate Driver Interface Fault

The Gate Driver Interface Fault bit (bit 5) is set in the Fault register (202/1202) if the power supply voltage on the Gate Driver Interface (GDI) module is not within tolerance. Error code 1023 will also be displayed in the error log of the UDC task in which the fault occurred.

If SB3000 Power Modules are connected in parallel, bit 7 in register 204/1204, 220/120, or 221/1221 will be set to indicate which GDI module is affected

4.3.1.7 Charge Fault

The Charge Fault bit (bit 6) is set in the Fault register (202/1202) if either of the following occurs: the pre-charge contactor did not close when commanded to by the PMI Processor or the contactor opened without being commanded to do so. Error code 1024 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.8 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 SB3000 Power Module opens. Bit 12 in register 204/1204, 220/1220, or 221/1221 will be set to indicate which SB3000 Power Module is affected. Error code 1016 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.9 Power Loss Fault

The Power Loss Fault bit (bit 10) is set in the Fault register (202/1202) if AC line power is lost for more than ten seconds while the SB3000 Power Module is running.This bit will also be set if one phase of the AC line is lost or if line synchronization is lost. Error code 1025 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.10 Power Technology Fault

The Power Technology Fault bit (bit 11) is set in the Fault register (202/1202) if the AC Power Technology module fails. Error code 1011 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.11 PMI Power Supply Fault

The PMI Power Supply Fault bit (bit 12) is set in the Fault register (202/1202) if the PMI rack's power supply fails. Error code 1012 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.12 PMI Read/Write Fault

The PMI Read/Write Fault bit (bit 13) is set in the Fault register (202/1202) if a PMI Processor read or write operation fails. Error code 1013 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.13 UDC Run Fault

The UDC Run Fault bit (bit 14) is set in the Fault register (202/1202) if the UDC task stops while the voltage loop is running. Error code 1014 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.1.14 Communication Lost Fault

The Communication Lost Fault bit (bit 15) is set in the Fault register (202/1202) if the fiber-optic communication between the PMI Processor and the UDC module is lost due to two consecutive errors of any type. This bit is only set after communication between the PMI Processor and UDC module has been established. This bit should be used in the run permissive logic of the SB3000 Power Module. Error code 1015 will also be displayed in the error log of the UDC task in which the fault occurred.

4.3.2 Warnings

The following warnings indicate conditions which are not serious enough to shut down the SB3000 Synchronous Rectifier 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 – SB3000 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 Under Voltage 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%.
3	WRN_PL@	The Phase Lost Warning bit is set if a phase loss occurs in the AC line.
4	WRN_RIL@	The Reference in Limit Warning bit is set if the UDC reference value (register 102/1102) is less than the minimum value or greater than the maximum value allowed. In the Bridge Test mode, this bit is used to indicate an illegal test code.
6	WRN_SHR@	The Load Sharing Warning bit is set if a current sharing problem develops between parallel SB3000 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 SB3000 Power Module opens.
8	WRN_BGD@	The Bad Gain Warning bit is set when a tunable variable is changed to an illegal value when the UDC task is running.
9	WRN_OL@	The Power Module Overload Warning bit is set if the continuous current rating of the SB3000 Power Module is exceeded for approximately five minutes and does not decrease and maintain the continuous current rating for at least 45 minutes.
10	WRN_PWR@	The Power Lost Warning bit is set if the power dip ride-through feature of the SB3000 Power Module has been enabled.
12	WRN_FAN@	The PMI Fan Loss Warning bit is set if there is no airflow detected through the PMI rack.
13	WRN_RAL@	The Rail Communication Warning bit is set if a rail communication problem occurs and is logged in registers 4, 10, 16, or 22.
14	WRN_CLK@	The CCLK Not Synchronized Warning bit is set if the CCLK counters in the PMI Processor and UDC module are momentarily unsynchronized.
15	WRN_COM@	The PMI Communication Warning bit is set if a fiber-optic communication error occurs between the PMI Processor and the UDC module.

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 Phase Lost Warning

The Phase Lost Warning bit (bit 3) is set in the Warning register (203/1203) if a phase loss occurs in the AC line.

4.3.2.5 Reference in Limit Warning

The Reference in Limit Warning bit (bit 4) is set in the Warning register (203/1203) if the UDC reference value (register 102/1102) is less than the minimum value or greater than the maximum value allowed. In the Bridge Test mode, this bit is used to indicate an illegal test code.

4.3.2.6 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 SB3000 Power Modules. Bits 13, 14, or 15 in registers 204/1204, 220/1220, or 221/1221 will be set to indicate the phase and SB3000 Power Modules affected.

4.3.2.7 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 SB3000 Power Module opens. Bit 12 in register 204/1204, 220/1220, or 221/1221 will be set to indicate which SB3000 Power Module is affected.

4.3.2.8 Bad Gain Data Warning

The Bad Gain Data Warning bit (bit 8) is set in the Warning register (203/1203) if a tunable variable is changed to an illegal value when the UDC task is running. The value will be restored to its previous valid value by the PMI Processor.

4.3.2.9 Power Module Overload Warning

The Power Module Overload Warning bit (bit 9) is set in the Warning register (203/1203) if the continuous current rating of the SB3000 Power Module is exceeded for approximately five minutes and does not decrease and maintain the continuous current rating for at least 45 minutes.

4.3.2.10 Power Loss Warning

The Power Loss Warning bit (bit 10) is set in the Warning register (203/1203) if the power dip ride-through feature of the SB3000 Power Module has been enabled. This will occur if the PMI Processor detects that the AC input voltage is less than 75% or more than 125% of the configured value. When this bit is set, the PMI Processor disables the firing of the IGBTs. If power is restored within 10 seconds, the PMI Processor will resynchronize and resume operation. If power is not restored within 10 seconds, bit 10 in register 202/1202 will be set and the SB3000 Power Module will shut down.

4.3.2.11 PMI Fan Loss Warning

The PMI Fan Loss Warning bit (bit 12) is set in the Warning register (203/1203) if there is no airflow through the PMI rack.

4.3.2.12 Rail Communication Warning

The Rail Communication Warning bit (bit 13) is set in the Warning register (203/1203) if a rail communication problem occurs and is logged in registers 4, 10, 16, or 22.

4.3.2.13 CCLK Not Synchronized Warning

The CCLK Not Synchronized Warning bit (bit 14) is set in the Warning register (203/1203) if the CCLK counters in the PMI Processor and UDC module are momentarily unsynchronized.

4.3.2.14 PMI Communication Warning

The PMI Communication Warning bit (bit 15) is set in the Warning register (203/1203) if a fiber-optic communication error occurs between the PMI Processor and the UDC module. Communication errors in two consecutive messages will result in a fault.

4.4 Replacing the Power Module Cabinet

Use the following procedure to replace an SB3000 Power Module cabinet:

Step 1. Turn off and lock out the AC input power at the input reactor/pre-charge 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, then look at the built-in DC bus voltage meter. When the voltage is down to approximately zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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. Look at the built-in DC Bus Voltage meter. When the DC bus potential is down to approximately zero volts, open the SB3000 Power Module cabinet's doors and measure the DC bus potential across the DC bus bars, 1247 A,B,C (+ bus) and 1145 A,B,C (- bus), with an external voltmeter before working on the unit. See figure 4.1.

Step 4. Disconnect the AC input leads from terminals 181 (L1), 182 (L2), and 183 (L3). Disconnect the GND wire from the ground terminal. See figure 3.4.

Step 5. Disconnect the AC input line (two-wire 110 VAC) from the L and N terminals. See figure 3.4.

Step 6. Disconnect the DC bus from terminals 45 and 47. See figure 3.4.

Step 7. Remove the SB3000 Power Module cabinet.

Step 8. Install the replacement SB3000 Power Module cabinet by following these steps in reverse order.

4.5 Replacing Power Module Sub-Assemblies

Use the procedures in sections 4.5.1 to 4.5.4 to replace the SB3000 Power Module’s fuses and sub-assemblies.

4.5.1 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, then look at the built-in DC bus voltage meter. When the voltage is down to zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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. Look at the built-in DC Bus Voltage meter. When the DC bus potential is down to zero volts, open the SB3000 Power Module cabinet's doors and measure the DC bus potential across the DC bus bars, 1247 A,B,C (+ bus) and 1145 A,B,C (- bus), with an external voltmeter before working on the unit. See figure 4.1.

Step 4. Remove the blown fuse and install the replacement fuse. Figures 4.2, 4.3, and 4.4 show the location of the fuses in the 445A, 890A, and 1335A SB3000 Power Modules. Table 4.5 provides fuse specifications.

Step 5. Close the cabinet doors and reapply power to the SB3000 Power Module.

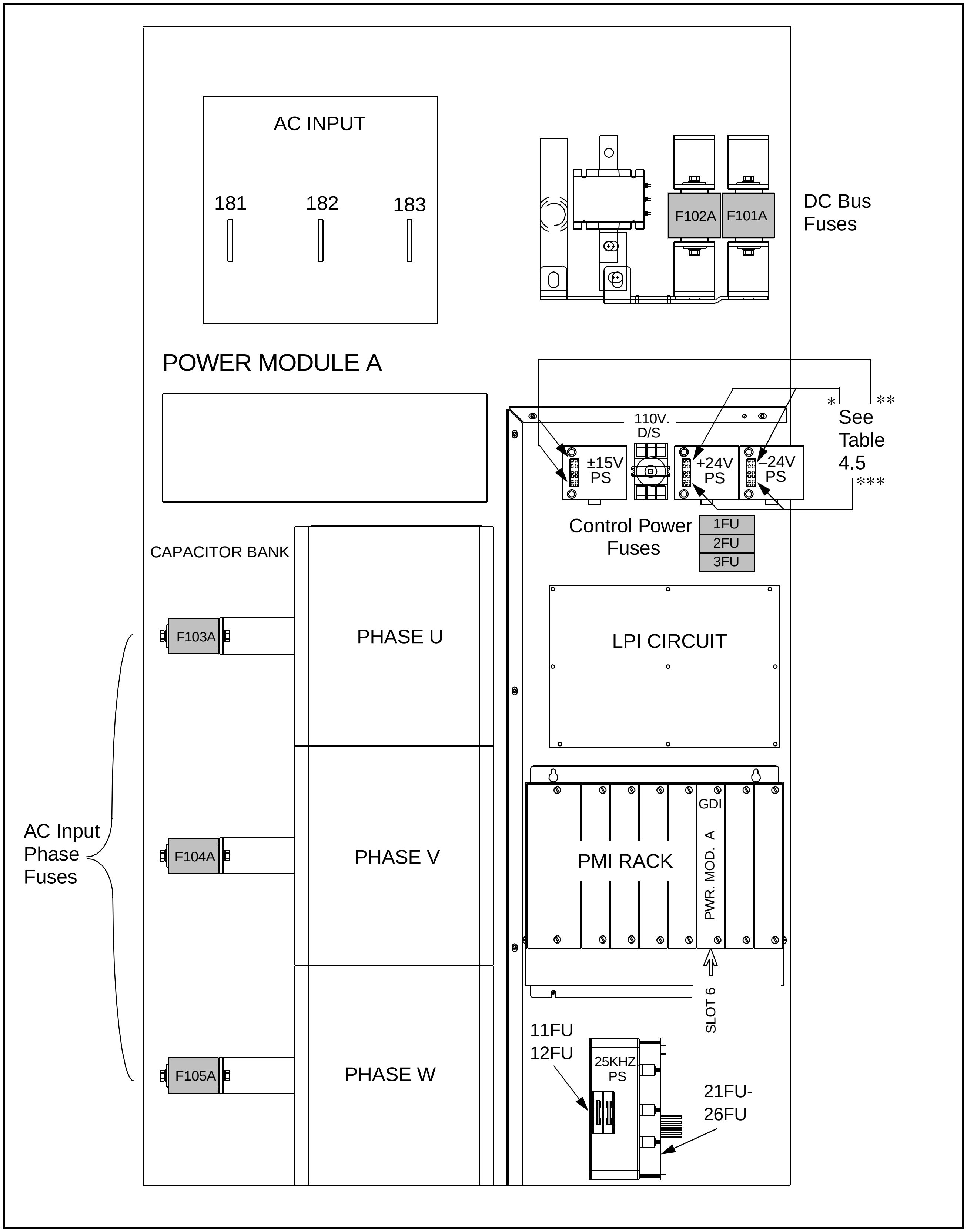


Figure 4.2 – 445A SB3000 Power Module Fuse Locations

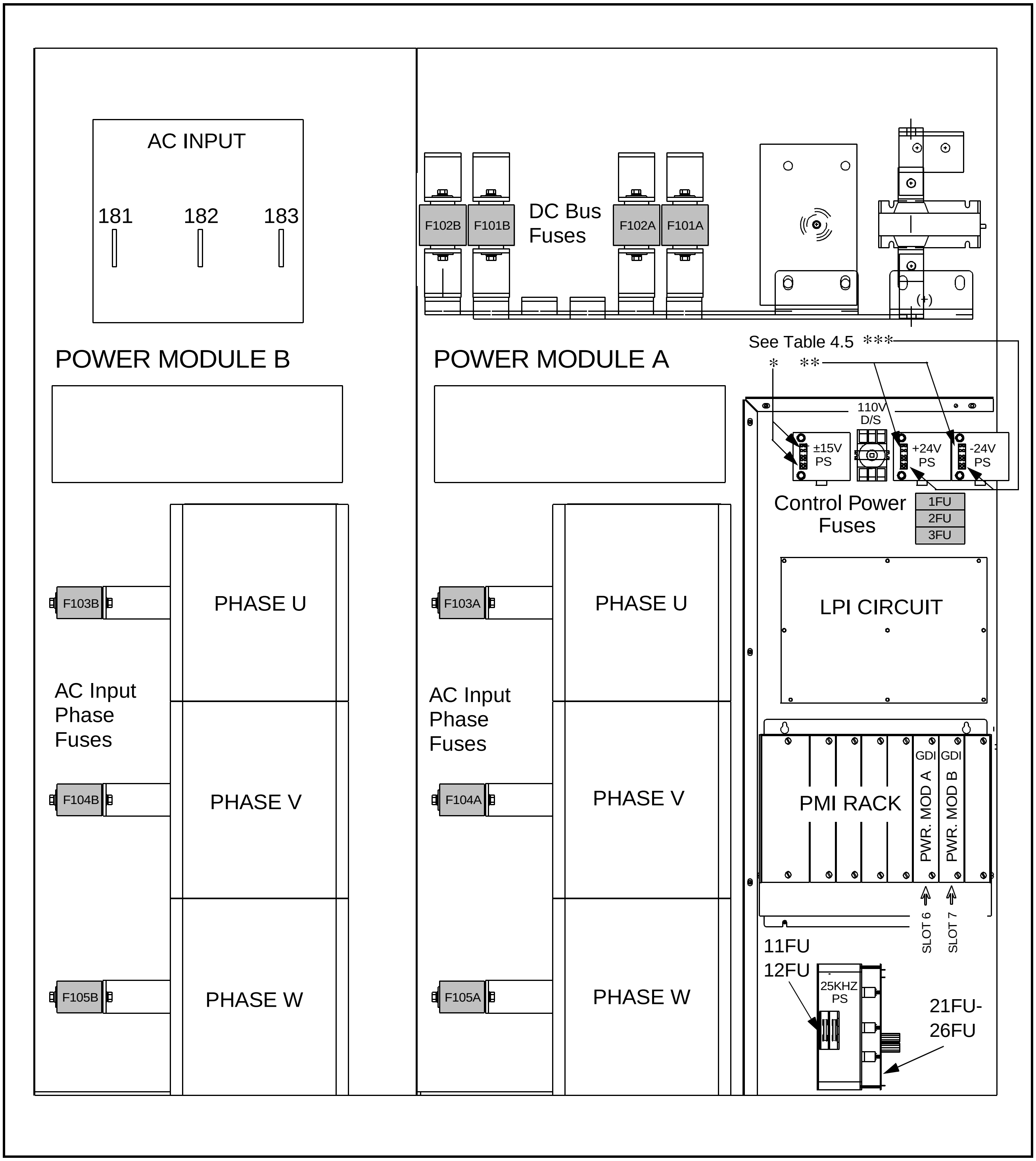


Figure 4.3 – 890A SB3000 Power Module Fuse Locations

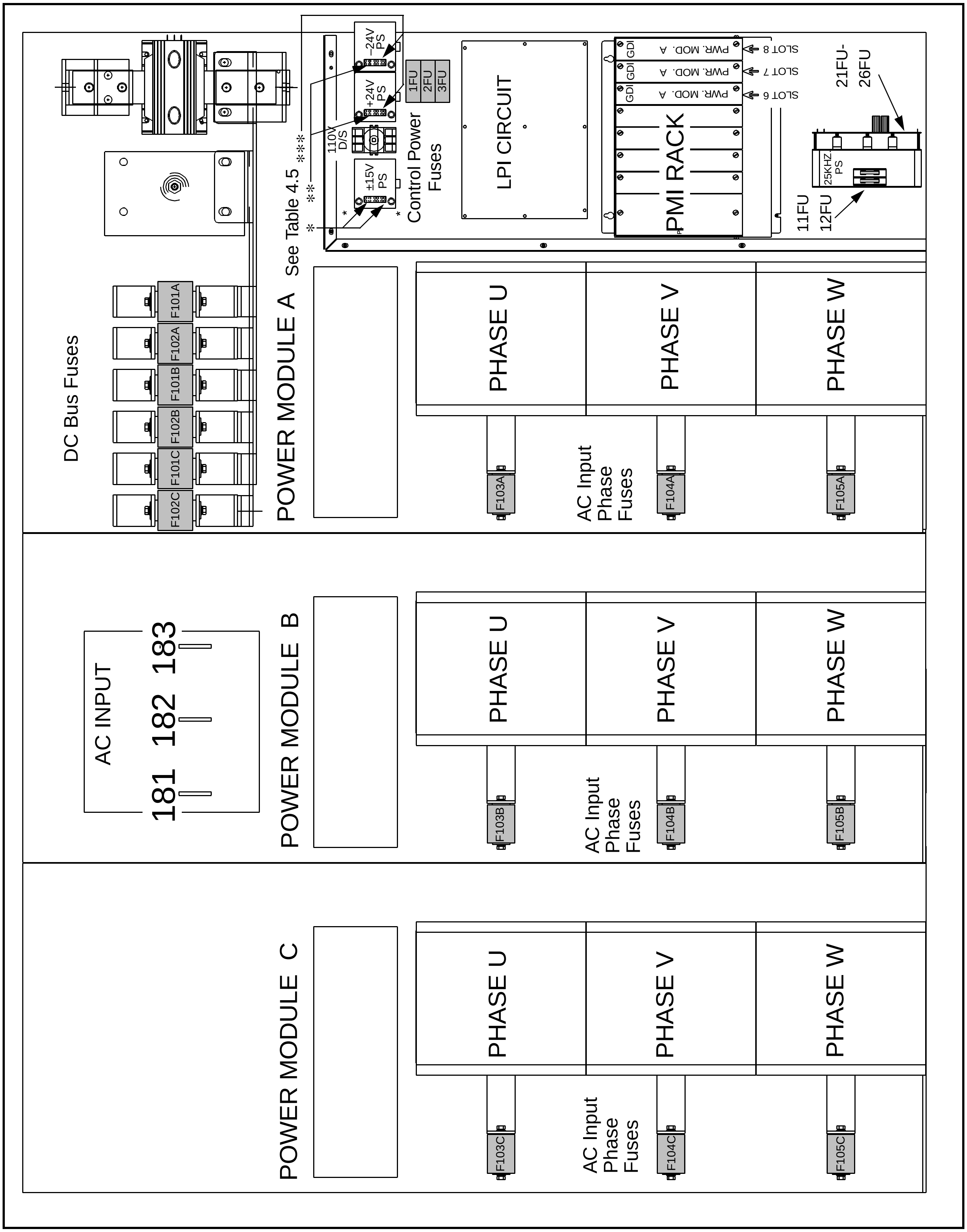


Figure 4.4 – 1335A SB3000 Power Module Fuse Locations

Table 4.5 – Power Module Fuse Specifications[1]

Fuse	Volts	Class	Type	Rating	Rockwell Part Number	Torque Specifications
1FU	600	CC	KLDR	5 A	64676-29R	--
2FU	600	CC	CCMR	25 A	64676-72BB	--
3FU	600	CC	KLDR	3.2 A	64676-29P	--
F101	1000	Semiconductor		1000 A	64676-80P	41 Nm (30 lb-ft)
F102	1000	Semiconductor		1000 A	64676-80P	41 Nm (30 lb-ft)
F103	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
F104	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
F105	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
+/- 15V PS*	250	--	F	1.8 A	Replace with 1.6A 64676-82U	--
+/- 24V PS**	250	--	T	2.5 A	64676-71P	--
+/- 24V PS***	250	--	F	2.0 A	64676-82V	--
25 KHz PS 11FU 12FU	600	CC	--	8 A	64676-30H	--
25 KHz PS 21FU 26FU	250	--	F	2 A	64676-66C	--

1. Fuse locations shown in figures 4.2, 4.3, and 4.4.

4.5.2 Replacing an IGBT Phase Module Assembly

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, then look at the built-in DC bus voltage meter. When the voltage is down to zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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. Look at the built-in DC Bus Voltage meter. When the DC bus potential is down to zero volts, open the SB3000 Power Module cabinet's doors and measure the DC bus potential across the DC bus bars, 1247 A,B,C (+ bus) and 1145 A,B,C (- bus), with an external voltmeter before working on the unit. See figure 4.1.

Step 4. Remove the wiring harnesses from the IGBT Phase module assembly. The wiring includes the power supply wiring, the temperature sensor wiring, and the fiber-optic cables. Remove the fiber-optic cables by pressing the sides of the connectors to release the locking mechanism. Label the harnesses to aid in re-installation. Refer to the wiring diagrams supplied with your system.

Note that due to tight mechanical tolerances, it may be necessary to remove IGBT Phase module assemblies U and/or V, in order to remove assemblies V and/or W.

Step 5. Remove the bolts from the fuses. See figure 4.5, callouts 1 and 2.

Step 6. Remove the 2 bolts from the AC bus bar. The bolts are located below the LEM device and above the fuse. See figure 4.5, callout 3.

Step 7. Remove the 2 hex nuts from the negative bus bar. See figure 4.5, callout 4.

Step 8. Remove the 2 hex nuts from the heatsink. One hex nut is located on each side of the heatsink. See figure 4.5, callout 5.

Step 9. Remove the IGBT module assembly from the SB3000 Power Module.

Step 10. Install the new IGBT module assembly by performing steps 1 through 9 in reverse order.

Step 11. Close the cabinet doors and reapply power to the SB3000 Power Module.

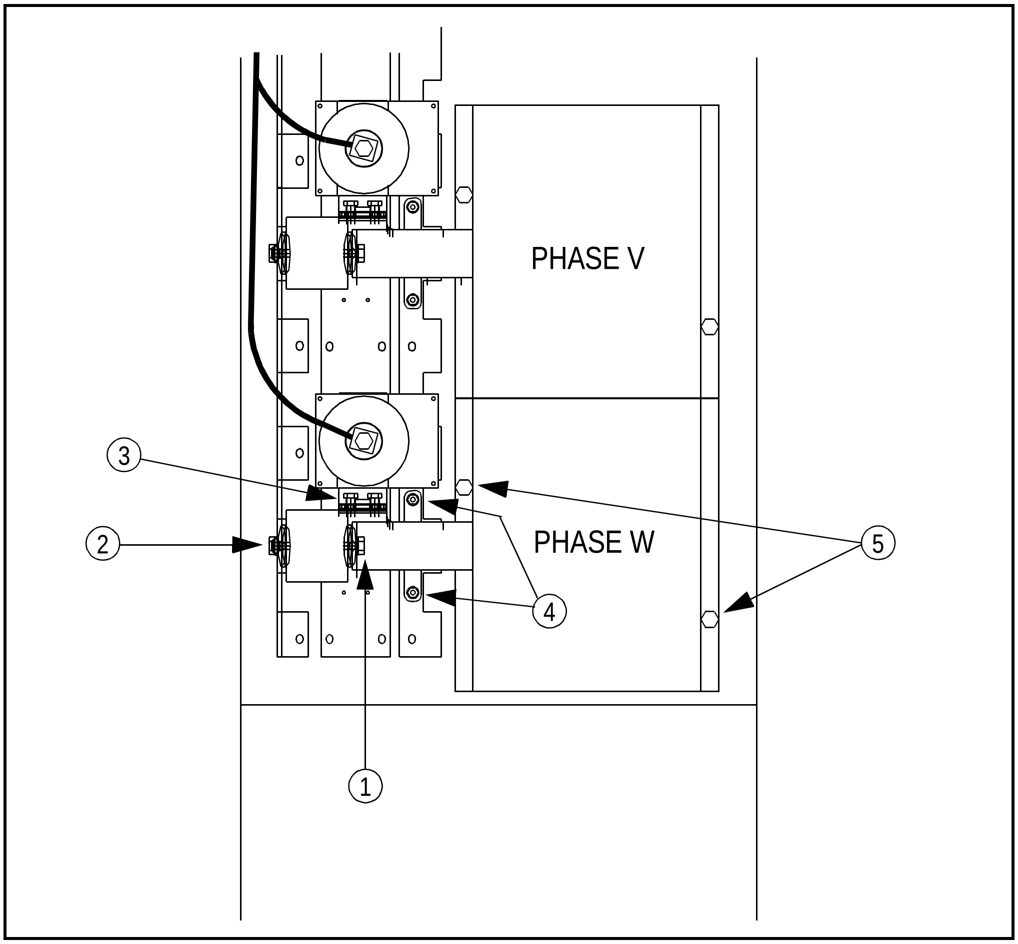


Figure 4.5 – IGBT Module Assembly Mounting Bolt Locations

4.5.2.1 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.

4.5.3 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, then look at the built-in DC bus voltage meter. When the voltage is down to zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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. Look at the built-in DC Bus Voltage meter. When the DC bus potential is down to zero volts, open the SB3000 Power Module cabinet's doors and measure the DC bus potential across the DC bus bars, 1247 A,B,C (+ bus) and 1145 A,B,C (- bus), with an external voltmeter before working on the unit. 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 SB3000 Power Module.

4.5.3.1 Replacing a Blower Filter

Use the following procedure to replace the blower assembly's filter:

Step 1. Remove the filter by sliding it out.

Step 2. Slide the new filter in.

4.5.4 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, then look at the built-in DC bus voltage meter. When the voltage is down to zero (0) volts, open the cabinet doors and check the voltage across the DC bus bars, 1247 A,B,C (+ bus) and 1145 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. Look at the built-in DC Bus Voltage meter. When the DC bus potential is down to zero volts, open the SB3000 Power Module cabinet's doors and measure the DC bus potential across the DC bus bars, 1247 A,B,C (+ bus) and 1145 A,B,C (- bus), with an external voltmeter before working on the unit. See figure 4.1.

Step 4. Remove all three IGBT assemblies (U, V, and W). Refer to section 4.5.2 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 following steps 1 through 12 in reverse order.

Step 14. Close the cabinet doors and reapply power to the SB3000 Power Module.

4.6 Performing the Bridge Test

Important: This test is normally performed at the factory. It should not be necessary to perform it again unless the power devices or fiber-optic cables have been replaced.

The bridge test is used to verify fiber-optic gate cabling connections by test firing the IGBTs one at a time. As the IGBTs fire, the LEDs on the corresponding GDI module in the PMI rack will turn on and off in the following sequence:

1. U- (Lower Power Device)
2. U+ (Upper Power Device)
3. V- (Lower Power Device)
4. V+ (Upper Power Device)
5. W- (Lower Power Device)
6. W+ (Upper Power Device)

If the LEDs do not turn on and off in this order, the fiber-optic gate cables have been connected incorrectly and must be reconnected as shown on the wiring diagrams. Note that three-phase AC input power must be off and the DC bus capacitors must be discharged before the cables can be reconnected.

ATTENTION: Disconnect and lock out three-phase AC input power to the SB3000 Power Module before enabling the bridge test. Ensure that three-phase AC input power cannot be turned on while the bridge test is running. If three-phase AC input power is turned on while the test is running, a line-to-line short circuit will occur. Failure to observe this precaution could result in bodily injury.

Three-phase AC input power to the SB3000 Power Module must be turned off and the inverter must be disconnected before the bridge test can be enabled. When the bridge test is running, the pre-charge contactor will be closed. 115 VAC control power must be applied for the pre-charge contactor. When the bridge test is turned off, the pre-charge contactor will open.

The PMI Processor will prevent the bridge test from executing if the DC bus voltage is greater than 10 VDC. However, the PMI Processor cannot prevent three-phase AC input power from being applied once the bridge test has been started. If three-phase AC input power is turned on while the bridge test is in progress, a line-to-line short circuit will result which may result in bodily injury and damage to the SB3000 Power Module.

Use the following procedure to perform the bridge test:

Step 1. Disconnect, lockout, and tag the three-phase AC input power to the SB3000 Power Module.

Step 2. Ensure that the DC bus is fully discharged. Refer to section 4.2.

Step 3. Enable the bridge test through register 100/1100, bit 2, and bits 10, 11, or 12, as applicable.

Step 4. Verify that the LEDs turn on and off in the order described. If the LEDs do not turn on and off in the proper order, reconnect the fiber-optic gate cables as shown on the wiring diagrams.

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 (445A SB3000 Power Module)

- Height: 2200 mm (86.6 inches)[1]
- Depth: 602 mm (23.7 inches)
- Width: 1012 mm (39.8 inches)
- Weight: 500 kg (1100 pounds)

Dimensions (890A SB3000 Power Module)

- Height: 2200 mm (86.6 inches)[1]
- Depth: 602 mm (23.7 inches)
- Width: 1612 mm (63.5 inches)
- Weight: 910 kg (2002 pounds)

Dimensions (1335A SB3000 Power Module)

- Height: 2200 mm (86.6 inches)[1]
- Depth: 602 mm (23.7 inches)
- Width: 2212 mm (87.1inches)
- Weight: 320 kg (2904 pounds)

1. Does not include upper bus bar connections

AC Input Power

- Minimum AC Line Voltage: 208V nominal
- Maximum AC Line Voltage: 460V nominal
- Maximum AC Line Variation: +/- 10%
- AC Line Frequency: 25, 50, and 60 Hz, +/- 2 Hz
- Frequency Rate of Change: 1Hz/Second
- Maximum AC Line Current: 534A, 972A, 1457A
- Maximum Phase Imbalance: 5%

AC Control Power

- AC Input Voltage: 115 VAC
- AC Input Frequency: 50/60 Hz

DC Output Power

- Minimum Output Voltage: 1.414 x VAC x 1.1 x 1.1
- Maximum Output Voltage: 900V
- Output Voltage Regulation: +/- 1%
- Maximum DC Output Current: (1.70 x E_{Line} x I_{Line} x Power Factor) / VDC
- Maximum Short Circuit Current: 100KA
- Output Voltage Resolution: 0.5V
- Output Voltage Regulation: Less than 5% for +/- 100% current step change
- Voltage Regulator Response: 100 rad/sec.
- VAR/Power Factor Correction: The user can select the maximum amount of SB3000 VAR correction. The SB3000 Power Module will always give the voltage regulator priority over the VAR function. If the output of the SB3000 Power Module is less than its limit, it will attempt to produce VARs up to the limit set by the user. Refer to Appendix C, section C.2.1.

SB3000 Power Module Current Ratings[1]

SB3000 Part Number	Continuous AC Input Current (460VAC)	Continuous DC Output Current (800VDC)	5 Minute AC Input and DC Output Overload[2]
804300-S	445A (rms)	445A DC	534A (rms)
804300-T	890A (rms)	890A DC	972A (rms)
804300-V	1335A (rms)	1335A DC	1457A (rms)

1. At 460 VAC Input/800 VDC Output/4 kHz Carrier Frequency. For use with SA3000/SA3100 Power Modules operating at a 2 kHz carrier frequency.
2. With a 25% duty cycle

TSB3000 Power Module Replacement Fuse Specifications[1]

Fuse	Volts	Class	Type	Rating	Rockwell Part Number	Torque Specifications
1FU	600	CC	KLDR	5 A	64676-29R	--
2FU	600	CC	CCMR	25 A	64676-72BB	--
3FU	600	CC	KLDR	3.2 A	64676-29P	--
F101	1000	Semiconductor		1000 A	64676-80P	41 Nm (30 lb-ft)
F102	1000	Semiconductor		1000 A	64676-80P	41 Nm (30 lb-ft)
F103	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
F104	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
F105	1000	Semiconductor		630 A	64676-79AZ	20.5 Nm (15 lb-ft)
+/- 15V PS*	250	--	F	1.6 A	64676-82U	--
+/- 24V PS**	250	--	T	2.5 A	64676-71P	--
+/- 24V PS***	250	--	F	2.0 A	64676-82V	--
25 KHz PS 11FU 12FU	600	CC	--	8 A	64676-30H	--
25 KHz PS 21FU 26FU	250	--	F	2 A	64676-66C	--

1. Fuse locations shown in figures 4.2, 4.3, and 4.4.

Three-Phase AC Input Voltage

- Voltage Range: 200 to 500 Volts, +/- 10%
- Frequency Range: 25, 50, and 60 Hz (+/- 2 Hz)
- Frequency Rate of Change: 5 Hz per Second
- Maximum Phase Imbalance: 5%

Output Phase Signals (181-182, 182-183)

- Signal Waveform: 10 mA square wave
- Phase Accuracy: < 2%
- Phase Shift versus Frequency: Phase Shift = 0.637 x Input Frequency
- Output Open-Circuit Voltage: 15 Volts
- Short-Circuit Current: < 40 mA

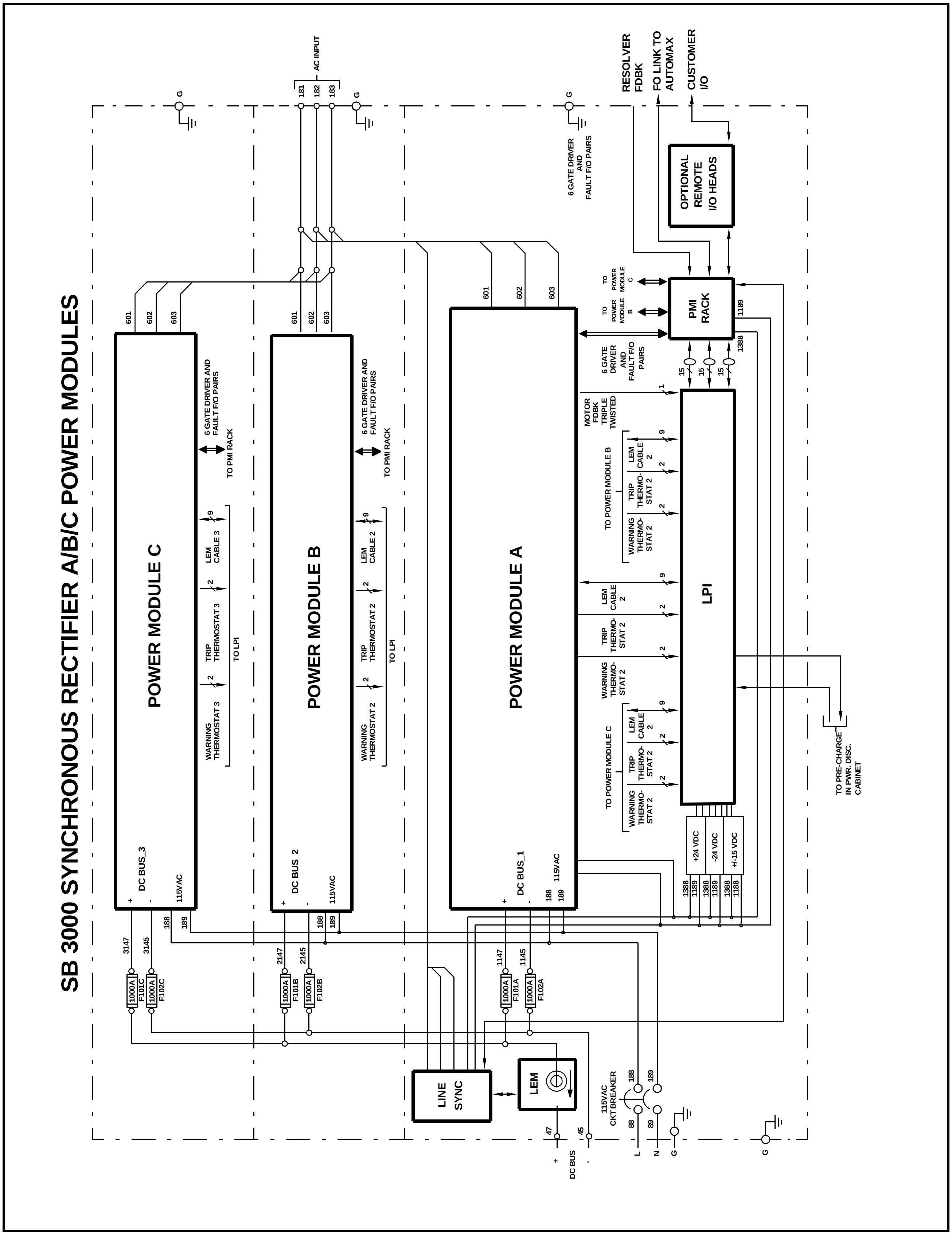
Analog Output Voltage

- Gain: 675 VAC RMS = 10 VDC
- Filter Break Frequency: 23 Hz
- CMRR: 200:1

APPENDIX B

SB3000 Component Block Diagram

The following figure shows an overview of the components of the SB3000 Synchronous Rectifier. Refer to chapter 2 of this manual for detailed diagrams of the 445A, 890A, and 1335A configurations of the SB3000 Synchronous Rectifier.


SB 3000 SYNCHRONOUS RECTIFIER A/B/C POWER MODULES
POWER MODULE C
POWER MODULE B
POWER MODULE A
LPI
PMI RACK
OPTIONAL REMOTE I/O HEADS
LINE SYNC
LEM
AC INPUT
181
182
183
601
602
603
G
RESOLVER FDBK
FO LINK TO AUTOMAX
CUSTOMER I/O
6 GATE DRIVER AND FAULT F/O PAIRS
TO PMI RACK
TO LPI
WARNING THERMOSTAT 3
TRIP THERMOSTAT 3
LEM CABLE 3
WARNING THERMOSTAT 2
TRIP THERMOSTAT 2
LEM CABLE 2
TO POWER MODULE B
TO POWER MODULE C
WARNING THERMO-STAT 2
TRIP THERMO-STAT 2
MOTOR FDBK TRIPLE TWISTED
TO POWER MODULE B
TO POWER MODULE C
6 GATE DRIVER AND FAULT F/O PAIRS
1189
1388
+24 VDC
-24 VDC
+/-15 VDC
TO PRE-CHARGE IN PWR. DISC. CABINET
DC BUS_3
DC BUS_2
DC BUS_1
115VAC
188
189
3147
3145
2147
2145
1147
1145
1000A F101C
1000A F102C
1000A F101B
1000A F102B
1000A F101A
1000A F102A
115VAC CKT BREAKER
88
89
47
45
DC BUS
L
N

APPENDIX C

Theory of Operation

C.1 Typical SB3000 System

SB3000 Power Modules are used to supply regulated common DC bus power to one or more SA3000/SA3100 Power Modules. As illustrated in figure C.1, a typical SB3000 system is made up of the following:

- an AC power disconnect device with overcurrent protection
- a soft-charge assembly which consists of pre-charge resistors and a pre-charge contactor
- an AC line filter reactor
- a power bridge
- a regulator consisting of both hardware and software elements.

The power distribution cabinet is mounted separately from the SB3000 Power Module and typically contains the AC power disconnect/overcurrent protection device, the soft-charge assembly, and the AC line filter reactor.

The AC line filter reactor is an energy storage element that isolates the converter bridge. This reactor limits the current flow between the AC line and the DC bus while providing a voltage boost between the input AC voltage and the output DC voltage.

The pre-charge resistors provide for controlled soft-charging of the DC bus capacitors to an initial voltage from which the SB3000 regulator can be safely started.

The SB3000 power bridges are the same three-phase IGBT inverter bridges that are used in the High Power SA3000 Power Modules, but are connected such that the three-phase AC leads are connected to the AC line, instead of to a motor, and the DC leads are connected as an output to a DC bus designed to feed one or more SA3000/SA3100 Power Modules.

The regulator controls the operation of all the elements in the system and links the SB3000 Power Module to the application level.

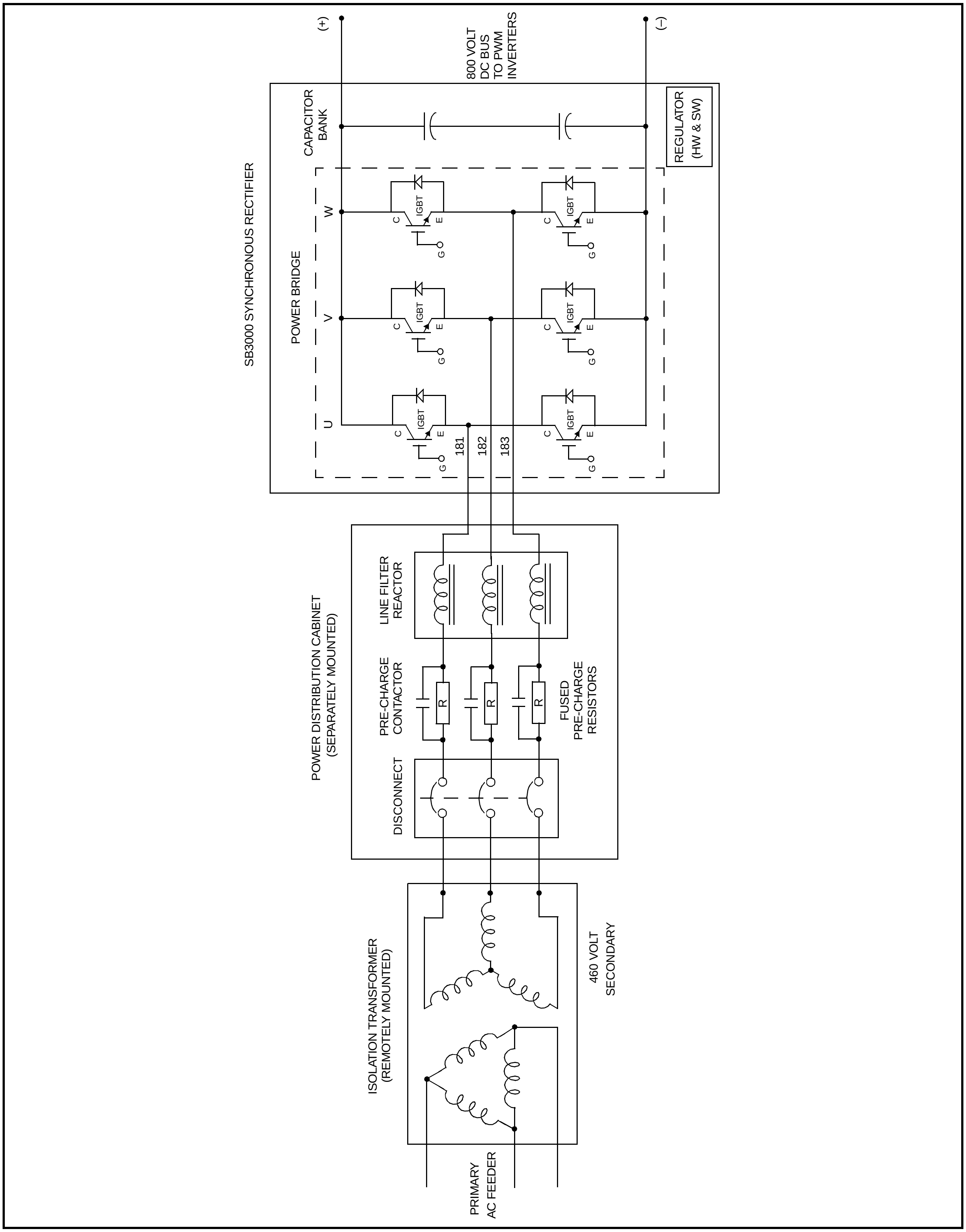


Figure C.1 – SB3000 System

C.2 SB3000 Regulator

The main purpose of the SB3000 regulator is to maintain the proper voltage on the DC bus through the use of a vector algorithm executed in the PMI Processor.

The application task in the UDC module controlling the SB3000 Power Module passes the desired DC bus voltage reference command to the PMI Processor in register 102/1102. The PMI Processor uses proportional-integral-derivative (PID) logic to calculate DC bus current in response to the voltage reference and error values. See figure C.2.

The commanded current is actually made up of two parts: Iq and Id. The Iq current is in phase with the AC line voltage when motoring and is 180 degrees out of phase with the AC line when regenerating. The Id current leads the AC line voltage by 90 degrees. The Iq current is the real current that powers the DC bus. The Id current is the reactive current that produces the leading power factor.

The PMI Processor uses the AC line period to determine the frequency to command. It uses the offset between the zero crossing of the AC line and the commanded zero crossing to determine the angle offset. The AC line frequency may change up to 1 Hz per second.

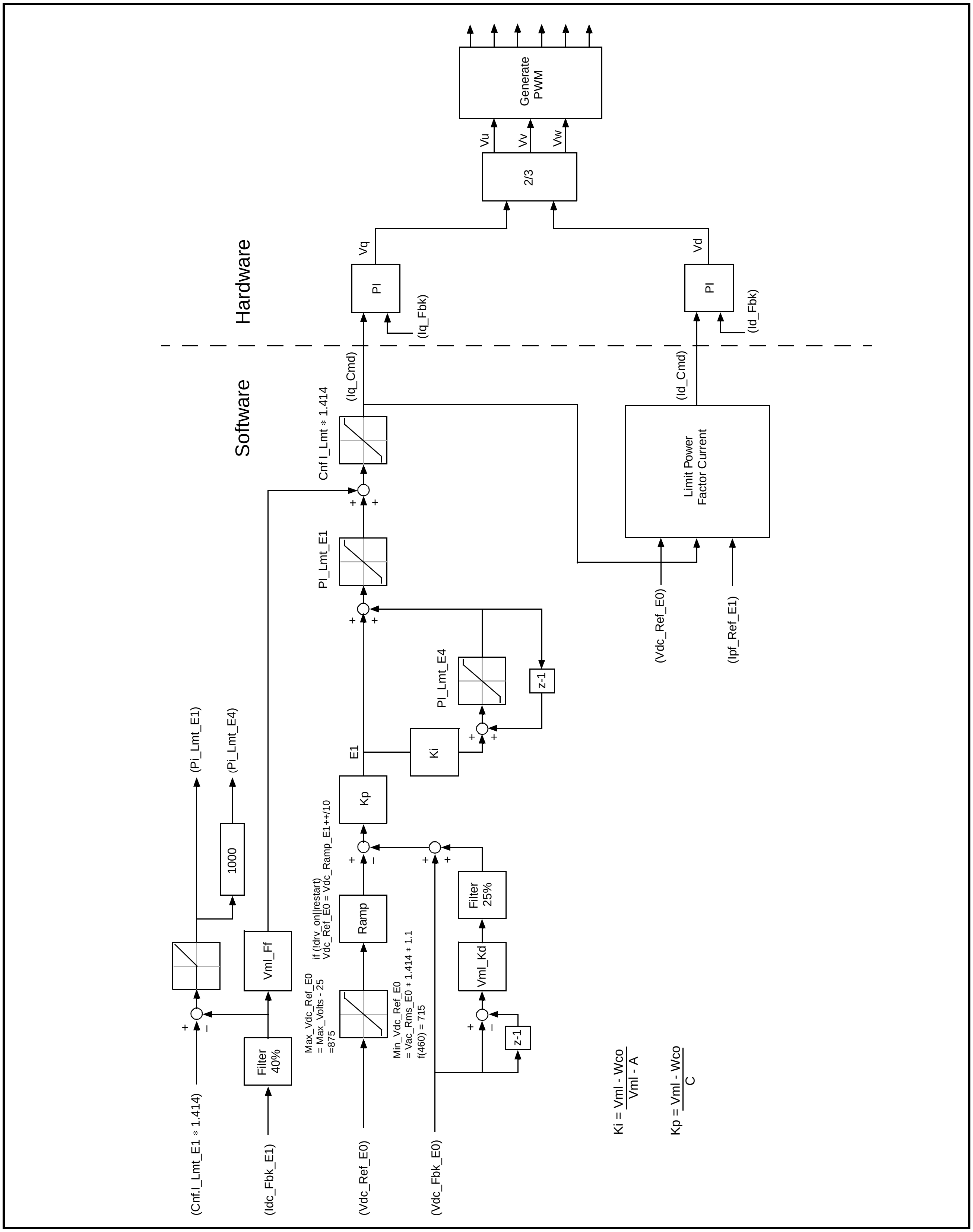


Figure C.2 – Control Structure

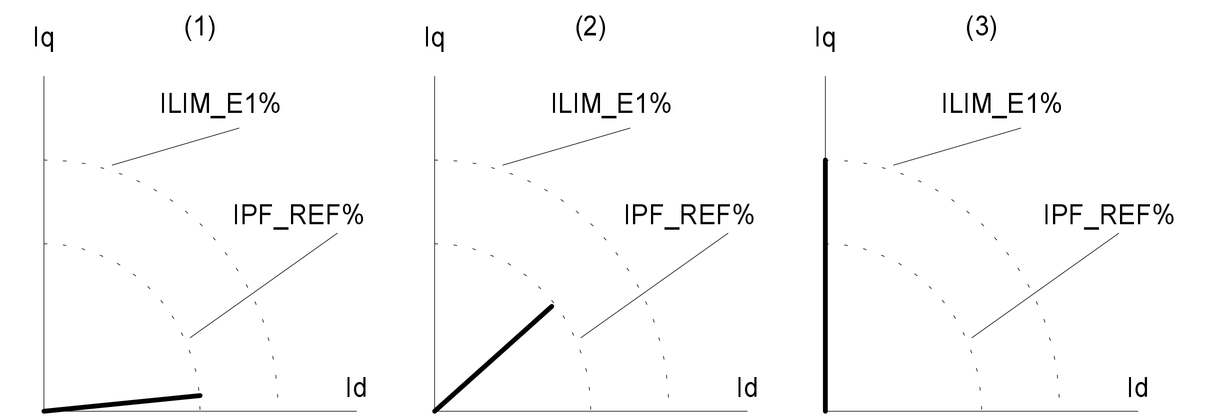
C.2.1 Leading Power Factor Operation

The regulator has the capability to operate with a leading power factor. This allows the regulator to calculate the Id current based on the capacity that is left over in the SB3000 Power Module rating after the Iq current has been determined.

If the UDC application task provides a leading power factor current reference value (IPF_REF%) in register 103/1103, the vector algorithm can compensate for a lagging power factor in the total AC line load with the second component of the current vector (Id). The Id current is calculated based on the value of Iq current and the current reference value in register 103/1103. The leading power factor current reference value is limited to not exceed the SB3000 Power Module's current limit rating. When Id current is near zero, due to a small load on the DC bus, it can approach the reference value. As Iq current increases, Id current decreases. A status bit indicates when the power factor current is being limited.

If capacity is left over after power has been supplied to the inverter load, the vector algorithm can produce VARS (volt-amperes reactive) with a leading power factor to compensate for other machines with lagging power factors on the same AC line. The Id current is limited not to exceed the rectifier rating. The VARS produced will be reported in register 211/1211.

Assuming power factor current is not being limited, Id current is calculated based on the Iq current and IPF_REF%. See figure C.3. The amount of VAR that is produced will be displayed in the feedback data.



When Iq current is near zero because there is negligible load on the DC bus, Id current can be near the full value of IPF_REF%.

When Iq current becomes larger, Id current becomes smaller.

When Iq current becomes greater than IPF_REF, Id current is reduced to zero.

Figure C.3 – Leading Power Factor

C.3 SB3000 DC Bus Charging Sequence

The SB3000 pre-charge circuitry is controlled via a pre-charge contactor which is under the control of the PMI Processor in the SB3000 PMI rack. Any faults relating to pre-charge contactor operation are reported in registers 202/1202 and 205/1205. The closing and opening of the pre-charge contactor is a function of the measured DC bus voltage. See figure C.4.

Note that the RPI signal has no effect on the operation of the pre-charge contactor; however, the RPI input must be present for the voltage loop to be in run. Turning off the RPI signal does not disable output power. If AC input power is on, the diodes in the IGBTs will conduct rectified voltage to the output terminals, independent of the state of the RPI signal.

C.3.1 Pre-charge Contactor Requirements for SA3000/SA3100 Power Modules

ATTENTION: The UDC application task must examine the pre-charge status bit (CHG_FB@) regularly. If the status bit turns off, the SA3000/SA3100 Power Module must be shut down. If the SA3000/SA3100 Power Module is not shut down, the pre-charge resistor may be damaged. Failure to observe this precaution could result in to damage to, or destruction of, the equipment.

The status of the SB3000 pre-charge contactor (CHG_FB@) must be used by the SA3000/SA3100 Power Module's application tasks. The SA3000/SA3100 Power Module must not operate with the pre-charge contactor open. Doing so may damage the pre-charge resistor. It is the responsibility of the application tasks running in the SA3000/SA3100 UDC module to make sure the SB3000 Power Module is in run before the SB3000 Power Module is turned on.

If the SB3000 Power Module is shut down due to a fault condition, the controlled shutdown of the SA3000/SA3100 Power Module is the responsibility of the application.

Each SA3000/SA3100 Power Module must have its own pre-charge resistor and contactor to limit the current into its capacitors.

C.3.2 Pre-charge Sequencing During Normal Operation

When AC power is applied to the SB3000 Power Module, the diodes in the IGBT power devices allow the capacitors to begin charging immediately through the line fuses, input inductors, and pre-charge resistors up to near peak AC line voltage. When the DC bus has reached the close threshold voltage and is at a steady-state condition, the PMI Processor will close the pre-charge contactor if there is no fault. After the contactor is closed, the PMI Processor will turn on status bit CHG_FB@ to indicate this condition to the application task. If there is a fault, the PMI Processor will turn on the IC_FLT@ interlock to indicate that a fault needs to be reset.

C.3.3 Pre-charge Contactor’s Close Threshold Voltage

When control power is first turned on, the pre-charge contactor will be open. This allows the DC bus voltage to increase to near the peak voltage of the AC line. The pre-charge contactor’s close threshold voltage is equal to the following:

Close Threshold Voltage = 1.414 x (Peak Configured AC RMS Line Voltage) - 10%

This threshold voltage allows the SB3000 Power Module to turn on when the AC line is up to 10% low. The pre-charge contactor will stay open until the measured DC bus voltage reaches this threshold. When the pre-charge contactor closes, the PMI Processor will indicate this by turning on register 201/1201, bit 12 (CHG_FB@).

C.3.4 Pre-charge Contactor’s Open Threshold Voltage

The pre-charge contactor’s open threshold voltage is the peak voltage of the configured AC RMS line voltage, times the square root of two, minus 100 volts. The maximum step change on the capacitor is 100 volts. If the DC bus voltage drops below the open threshold voltage, the pre-charge contactor will be opened to protect the capacitors and CHG_FB@ will be turned off. In this case, register 201/1201, bit 12 (CHG_FB@) will be turned off. The pre-charge contactor will remain open until the bus voltage again reaches a steady-state voltage above the close threshold voltage.

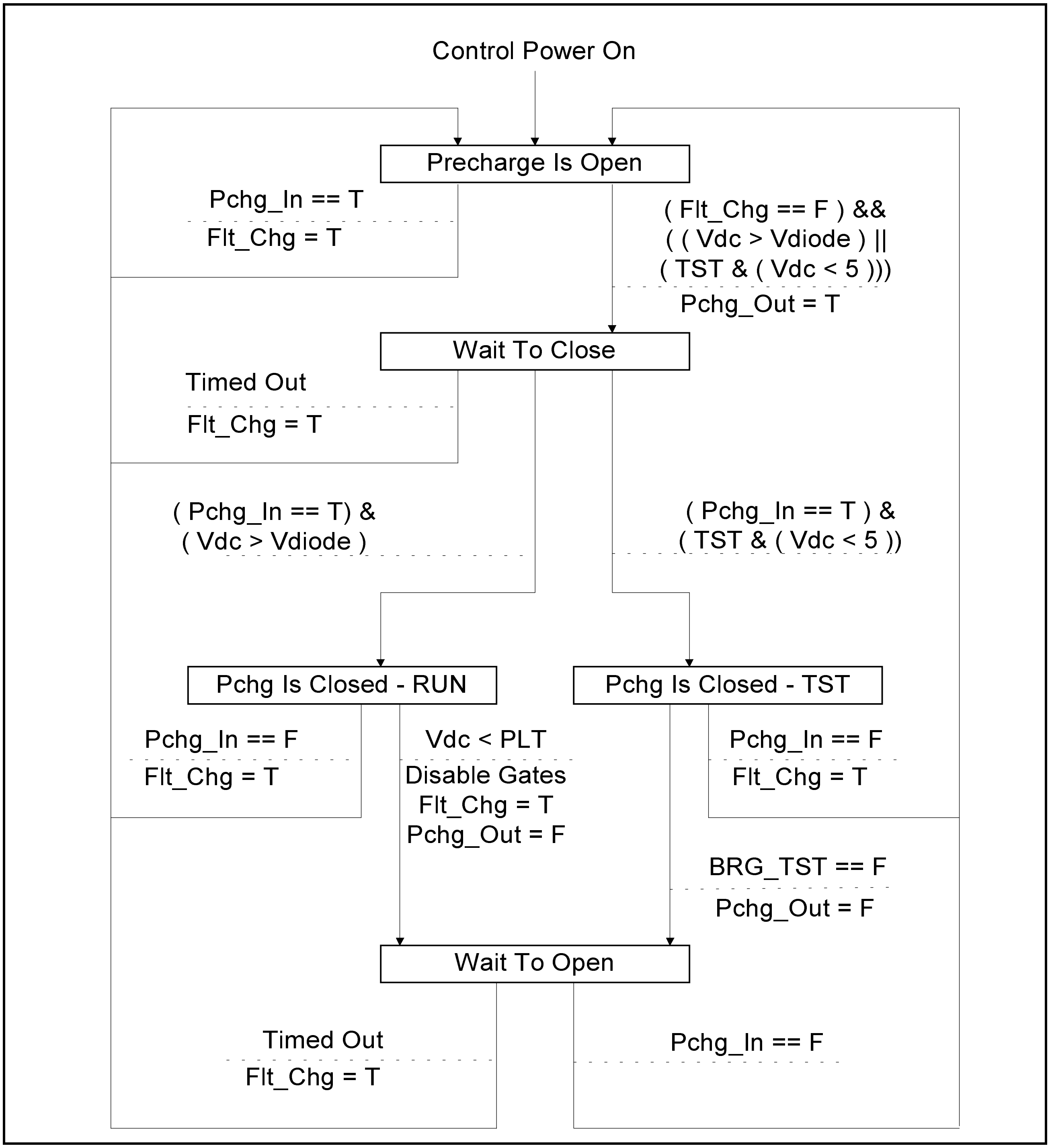


Figure C.4 – Pre-charge State Diagram

C.3.5 Pre-charge Contactor Sequencing During the Bridge Test

When the bridge test is commanded in register 100/1100, bit 2, the SB3000's pre-charge contactor will close. After the results of the test have been displayed on the GDI module(s), the pre-charge contactor will be opened.

C.3.6 Charge Faults

The PMI Processor will generate a Charge Fault (register 202/1202, bit 6) if:

- the pre-charge contactor is closed when it should be open.
- the pre-charge contactor opens without being commanded to open.
- the pre-charge contactor is commanded to open and it does not open within one second.

C.4 Line Synchronization

The motoring operation of the SB3000 Power Module is analogous to the operation of an SA3000 Power Module regenerating power from a large synchronous motor to the DC bus. For the SB3000 Power Module, the AC line acts like a very large synchronous motor operating at a fixed frequency/speed. Whether the SB3000 Power Module is motoring (supplying power to the DC bus from the AC line) or regenerating (returning power to the AC line from the DC bus) is determined by the voltage level of the DC bus which the SB3000 Power Module is regulating. To operate, the SB3000 Power Module must be synchronized, in frequency and phase, with the AC line. Line synchronization specifications are provided in Appendix A.

Phase synchronization is maintained by the PMI and the Line Synchronization module. The period of the AC line is used to determine the frequency to command and the offset between the zero crossing of the AC line and the commanded zero crossing is used to determine the angle offset.

The Line Synchronization module, located in the SB3000 control cabinet, is connected to the +/- 24 and 15 volt power supplies. The AC line synchronization circuit monitors the AC line feeding the SB3000 Power Module and outputs a pair of signals locked in-phase with the AC line to the A-C Power Technology module in the PMI rack. The AC line synchronization circuit also contains the Burden resistor for the Hall device which monitors the DC bus current.

If the PMI detects AC input voltage to be less than 75% of the configured voltage or greater than 125% of the configured voltage, it will latch the WRN_PWR@ warning bit and disable the firing of the IGBTs. If power is restored within ten seconds, the PMI will re-synchronize and resume operation. If power is not restored within ten seconds, the PMI will latch the FLT_PWR@ fault bit and will not automatically restart.

If input voltage is out of tolerance, a bit is set in the UDC Module's memory (VDC_SB@) to indicate that the voltage loop is in standby. The master speed reference task can then optionally begin to decelerate the inverter-driven load, using the inertia in the driven load (motor and machine) to maintain the DC bus voltage until power comes back or the machine is stopped. If any fault is detected while in standby, VDC_SB@ is turned off, and the drive will not automatically restart.

APPENDIX D

SB3000 Interlock Sequencing

When a request is made to turn on the SB3000 Power Module's voltage loop and a required precondition has not been met, a bit will be set in Interlock register 205/1205 indicating the problem. The interlock requirements are described in the following table. If an interlock problem is detected, the voltage loop will not go into run.

Interlock Precondition	Bit Set in Register 205/1205 by the PMI Processor
Valid configuration parameters have not been downloaded into the UDC module from the Programming Executive or the parameters are outside of acceptable limits.	Bit 0 (IC_CNF@)
Pre-defined local tunables are zero or a UDC task containing the variables has not been loaded to the rack.	Bit 1 (IC_GAIN@)
The RPI input is not turned on.	Bit 2 (IC_RPI@)
A fault that shut down the voltage loop has not been reset.	Bit 3 (IC_FLT@)
A rising edge is not detected on a command bit in register 100/1100.	Bit 4 (IC_RISE@)
More than one operating mode is requested at a time.	Bit 5 (IC_MORE@)
The pre-charge contactor has not closed.	Bit 7 (IC_PCHG@)
The number of GDI modules in the PMI rack does not match the number of GDI modules configured or the GDI modules have been incorrectly placed in the PMI rack.	Bit 8 (IC_GDI@)
During the bridge test, a Power Module has not been selected or an incorrect Power Module been selected.	Bit 8 (IC_GDI@)
The PMI rack has an incorrect backplane.	Bit 9 (IC_IPBP@)
The bridge test is requested and the DC bus voltage is greater than 10V.	Bit 11 (IC_VDC@)

APPENDIX E

Replacement Parts

445 Amp SB3000 Synchronous Rectifier

Table E.1 – 445A SB3000 Power Module

Part Description[1]	Quantity	Rockwell Part Number
Blower Assembly	1	803430-9R
IGBT Module Assembly	3	803430-8S
Capacitor Bank Assembly	1	803430-6S
Pre-charge Assembly	1	803430-7R
Fuse (F101A, F102A) (1000A, 1000 VAC)	2	64676-80P
+/- 15 VDC Power Supply (1A)	1	704323-33K
110V AC Disconnect Switch (40A, 600 VAC)	1	65242-10R
24 VDC Power Supply (2A)	2	704323-32G
LPI 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
Reactor (7.5uH, 600A)	3	608895-60A
LEM Sensor (1000A, 5000:1)	3	600595-18A
Fuse (1FU) (6 Amp, 600 VAC)	1	64676-64M
Fuse (2FU) (25 Amp, 600 VAC)	1	64676-72BB
Fuse (3FU) (3 Amp, 600 VAC)	1	64676-64J
Voltage Feedback Resistors (40KΩ, 90 W)	5	63481-102TFB
DC Feedback Module	1	0-55350-10
AC Input Current Meter	1	850012-R
DC Output Current Meter	1	850012-S
Blower Filter	1	69740-10G

1. Components are identified in figure 2.2.

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

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

445 Amp SB3000 Synchronous Rectifier (Continued)

Table E.3 – Pre-charge Assembly (803430-7R)

Part Description	Quantity	Rockwell Part Number
Discharge Resistors (8KΩ, 150 W)	9	612183-36R
Pre-charge Module	1	0-55350-4
Pre-charge Capacitor (4700uH, 50 VDC)	1	600442-31TS

Table E.4 – Blower Assembly (803430-9R)

Part Description	Quantity	Rockwell Part Number
Blower (115 VAC)	1	69739-47R
Starter Capacitor (40uF, 240 VAC)	1	69932-24QQ
Voltage Resistors (10Ω, 90 W)	3	63481-104QAA

Table E.5 – IGBT Module Assembly (803430-8S)

Part Description	Quantity	Rockwell Part Number
IGBT Transistor (600A, 1200 VDC)	4	602909-808AW
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 E.6 – 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

890 Amp SB3000 Synchronous Rectifier

Table E.7 – 890A SB3000 Power Module

Part Description[1]	Quantity	Rockwell Part Number
Blower Assembly	2	803430-9R
IGBT Module Assembly	6	803430-8S
Capacitor Bank Assembly	2	803430-6S
Pre-charge Assembly	2	803430-7R
Fuse (F101, F102) (1000A, 1000 VAC)	4	64676-80P
+/- 15 VDC Power Supply (1A)	1	704323-33K
110V AC Disconnect Switch (40A, 600 VAC)	1	65242-10R
24 VDC Power Supply (2A)	2	704323-32G
LPI Module	1	0-60027
250VA Isolation Transformer (250 VA, 110 VAC)	1	417155-16B
PMI Rack Assembly	1	805401-5S
25KHz Power Supply (2A) (115 VAC input, 60 VDC output)	1	802268-16R
Reactor (7.5uH, 600A)	6	608895-60A
LEM Sensor (1000A, 5000:1)	6	600595-18A
Fuse (1FU) (6A, 600 VAC)	1	64676-64M
Fuse (2FU) (25A, 600 VAC)	1	64676-72BB
Fuse (3FU) (3A, 600 VAC)	1	64676-64J
Voltage Feedback Resistors (40KΩ, 90 W)	3	63481-102TFB
DC Feedback Module	1	0-55350-10
AC Input Current Meter	1	850012-R
DC Output Current Meter	1	850012-S
Blower Filter	2	69740-10G

1. Components are identified in figure 2.3.

Table E.8 – Capacitor Bank Assembly (803430-6S) (2 Required)

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

Table E.9 – Pre-charge Assembly (803430-7R) (2 Required)

Part Description	Quantity	Rockwell Part Number
Discharge Resistors (8KΩ, 150 W)	9	612183-36R
Pre-charge Module	1	0-55350-4
Pre-charge Capacitor (4700uH, 50 VDC)	1	600442-31TS

890 Amp SB3000 Synchronous Rectifier (Continued)

Table E.10 – Blower Assembly (803430-9R) (2 Required)

Part Description	Quantity	Rockwell Part Number
Blower (115 VAC)	1	69739-47R
Starter Capacitor (40uF, 240 VAC)	1	69932-24QQ
Voltage Resistors (10Ω, 90 W)	3	63481-104QAA

Table E.11 – IGBT Module Assembly (803430-8S) (2 Required)

Part Description	Quantity	Rockwell Part Number
IGBT Transistor (600A, 1200 VDC)	4	602909-808AW
Warning Thermostat	1	66012-16A
Fault Thermostat	1	66012-16B
Gate Driver/Snubber Module	1	0-55350-15
Fuse (F103, F104, F105) (630A, 1000 VAC)	3	64676-79AZ

Table E.12 – PMI Rack Assembly (805401-5) (2 Required)

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

1335 Amp SB3000 Synchronous Rectifier

Table E.13 – 1335A SB3000 Power Module

Part Description[1]	Quantity	Rockwell Part Number
Blower Assembly	3	803430-9R
IGBT Module Assembly	9	803430-8S
Capacitor Bank Assembly	3	803430-6S
Pre-charge Assembly	3	803430-7R
Fuse (F101, F102) (1000A, 1000 VAC)	6	64676-80P
+/- 15 VDC Power Supply (1A)	1	704323-33K
110V AC Disconnect Switch (40A, 600 VAC)	1	65242-10R
24 VDC Power Supply (2A)	2	704323-32G
LPI Module	1	0-60027
250VA Isolation Transformer (250 VA, 110 VAC)	1	417155-16B
PMI Rack Assembly	1	805401-5T
25KHz Power Supply (2A) (115 VAC input, 60 VDC output)	1	802268-16R
Reactor (7.5uH, 600A)	9	608895-60A
LEM Sensor (1000A, 5000:1)	9	600595-18A
Fuse (1FU) (6A, 600 VAC)	1	64676-64M
Fuse (2FU) (25A, 600 VAC)	1	64676-72BB
Fuse (3FU) (3A, 600 VAC)	1	64676-64J
Voltage Feedback Resistors (40KΩ, 90 W)	3	63481-102TFB
DC Feedback Module	1	0-55350-10
AC Input Current Meter	1	850012-R
DC Output Current Meter	1	850012-S
Blower Filter	3	69740-10G

1. Components are identified in figure 2.4.

Table E.14 – Capacitor Bank Assembly (803430-6S) (3 Required)

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

Table E.15 – Pre-charge Assembly (803430-7R) (3 Required)

Part Description	Quantity	Rockwell Part Number
Discharge Resistors (8KΩ, 150 W)	9	612183-36R
Pre-charge Module	1	0-55350-4
Pre-charge Capacitor (4700uH, 50 VDC)	1	600442-31TS

1335 Amp SB3000 Synchronous Rectifier (Continued)

Table E.16 – Blower Assembly (803430-9R) (3 Required)

Part Description	Quantity	Rockwell Part Number
Blower (115 VAC)	1	69739-47R
Starter Capacitor (40uF, 240 VAC)	1	69932-24QQ
Voltage Resistors (10Ω, 90 W)	3	63481-104QAA

Table E.17 – IGBT Module Assembly (803430-8S) (3 Required)

Part Description	Quantity	Rockwell Part Number
IGBT Transistor (600A, 1200 VDC)	4	602909-808AW
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 E.18 – PMI Rack Assembly (805401-5) (3 Required)

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	3	0-60028-1

INDEX

P

R

S

T

W

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