AutoMax™
Distributed Power System
Overview

Instruction Manual S-3005-3

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.

The thick black bar shown at the margin of this paragraph will be used throughout this manual to indicate new or revised text or figures.

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.

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

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CHAPTER 1

Introduction

This manual is intended to provide an introduction to the AutoMax™ Distributed Power System. It begins with a description of how the Distributed Power System (DPS) instruction manuals are organized. It then provides an overview of the hardware components that comprise AC and DC Distributed Power systems and a short introduction to Distributed Power System programming. A glossary of terms used in Distributed Power systems and other AC and DC drive systems can be found in Appendix A.

Figures 1.1 to 1.5 illustrate the components of typical Distributed Power SD/SF3000, SA500, SA3000, and SA3100 drive systems. The instruction manuals that describe the various parts of each system are listed in table 1.1.

This manual is not intended to provide operational instructions. Be sure to study the appropriate Rockwell Automation instruction manuals before installing, operating, or maintaining the equipment described in this overview.

1.1 Distributed Power System (DPS) Manual Organization

The documentation that describes DPS drives is contained in separate binders. The associated binder part numbers are shown in table 1.1. Regardless of drive type, each binder will contain the following manuals:

- **S-3005 DPS Overview**

  You are reading the DPS Overview manual. Its organization and contents are described in section 1.0.

- **S-3007 Universal Drive Controller Module Instruction Manual**

  The Universal Drive Controller (UDC) module manual provides mechanical and electrical descriptions of the module. Module installation and replacement procedures are also included. This manual does not describe how to configure or program the UDC module.

- **S-3009 Fiber-Optic Cabling Instruction Manual**

  The Fiber-Optic Cabling manual describes the optical serial link between the Universal Drive Controller module and the Power Module Interface. This manual also specifies the types of fiber-optic cables and connectors to be used along with the recommended cable installation guidelines. Fiber-optic testing/troubleshooting procedures are also provided.

  The following manuals are also included in the binders, however, each manual is tailored to describe the hardware and/or software features in detail for each drive type. Table 1.1 shows the associated document part number for each drive type.

- **Drive Configuration and Programming Instruction Manual**

  The Drive Configuration and Programming manual describes how to configure the drive and Universal Drive Controller (UDC) module using the AutoMax Programming Executive software. This manual also describes how to configure the UDC dual port registers, how to create UDC tasks, and how to use the Programming Executive software on-line for drive control applications. It describes how to load the operating systems to the UDC modules in the AutoMax rack(s), how to load UDC tasks to the rack(s), and how to communicate with an AutoMax rack on-line to monitor or modify variable values and start or stop UDC tasks.

- **Power Module Interface Instruction Manual**

  The Power Module Interface manual describes the PMI and provides mechanical and electrical descriptions of the modules that it contains for SD3000/SF3000 and SA3000 drives: the Power Supply, the PMI Processor module, the Resolver & Drive I/O module, the appropriate Power Technology module, and Gate Driver Interface modules, if used. Rack installation and replacement guidelines are included. The SA3100 PMI is a replaceable modular circuit board assembly that is mounted within the Power Module. For SA500 drives, the PMI is part of the power structure and is described in the Power Module instruction manual.

- **Power Module Instruction Manual**

  The Power Module manual describes the available Power Modules and their operation in the AC or DC Drive system. For SA500 drives, this manual also describes the Power Module Interface.

- **Drive Diagnostics, Troubleshooting, and Start-Up Guidelines**

  This manual provides information about system-wide diagnostics, troubleshooting, and start-up guidelines.

- **DC Bus Supply**

  The DC Bus Supply manual is unique to the SA500 drive. This manual provides mechanical and electrical descriptions of the bus power supply as well as installation and troubleshooting guidelines.

- **Information Guide**

  The Information Guide is provided to help you locate specific DPS information quickly.

Table 1.1 – DPS Documentation

Document	Document Part Number			
	SD/SF3000 Binder S-3000	**SA500 Binder S-3002**	**SA3000 Binder S-3001**	**SA3100 Binder S-3053**
DPS Overview	S-3005	S-3005	S-3005	S-3005
UDC Module	S-3007	S-3007	S-3007	S-3007
Fiber-Optic Cabling	S-3009	S-3009	S-3009	S-3009
Configuration & Programming	S-3006[1] S-3036[2]	S-3044	S-3042	S-3056
Power Module Interface	S-3008	S-3018	S-3019	S-3057
Power Module	S-3037	S-3018	S-3020[3] S-3029[4]	S-3058
Diagnostics, Troubleshooting & Start-Up Guidelines	S-3011	S-3022	S-3021	S-3059
D-C Bus Supply	N/A	S-3017	N/A	N/A
Information Guide	S-3012	S-3024	S-3023	S-3054

1. SD3000 2. SF3000 3. Medium Power 4. High Power

1.2 1567 Power Max™ Documentation

1567 Power Max medium voltage AC drives also operate under the control of the AutoMax DPS system. In addition to the manuals described in section 1.1, the 1567 Power Max binder (S-3040) contains the following manuals:

Rectifier Maintenance Manual

- The Rectifier Maintenance manual is unique to the Power Max drive. This manual provides mechanical and electrical descriptions of the 3-phase liquid cooled rectifier housed in the first cabinet of the drive lineup. Maintenance and troubleshooting procedures are also provided.

Inverter Maintenance Manual

- The Inverter Maintenance manual is unique to the Power Max drive. This manual provides mechanical and electrical descriptions of the 3-phase liquid cooled inverter housed in the third cabinet of the drive lineup. Maintenance and troubleshooting procedures are also provided.

Liquid Cooling System Maintenance Manual

- The Liquid Cooling System Maintenance manual is unique to the Power Max drive. This manual provides a mechanical description of the liquid cooling system pump cabinet as well as maintenance and troubleshooting procedures.

The 1567 Power Max documentation is listed in table 1.2.

Table 1.2 – 1567 Power Max Documentation (Binder S-3040)

Document	Document Part Number
DPS Overview	S-3005
UDC Module	S-3007
Fiber-Optic Cabling	S-3009
Medium Voltage Inverter	S-3041
12-Pulse Diode Rectifier	S-3048
PMI Subsystem	S-3049
Drive Configuration & Programming	S-3050
Liquid Cooling System	S-3051
Installation Guidelines	S-3052
Drive Information Guidelines	S-3046

1.3 AutoMax Programming Executive Software Manuals

The documentation that describes the AutoMax Programming Executive and AutoMax programming is contained in two binders, J2-3104 and J2-3092.

Binder J2-3104 (AutoMax System Operation) contains the following instruction manuals:

- J-3650 AutoMax Processor Module
- J-3669 AutoMax Pocket Reference
- J2-3102 AutoMax Programming Executive
- J2-3103 AutoMax Executive Software Loading Instructions

The AutoMax Programming Executive manual describes the software used to configure an AutoMax system (including DPS drive systems) and to create the application tasks that will run on AutoMax Processors. This manual also describes how to load the operating systems to the AutoMax Processors and UDC modules in the AutoMax rack(s), how to load AutoMax and UDC tasks to the rack(s), and how to communicate with an AutoMax rack on-line to monitor or modify variable values and start or stop AutoMax and UDC tasks.

Binder J2-3092 (AutoMax Programming Reference) contains the following instruction manuals:

- J-3675 Enhanced BASIC Language
- J-3676 Control Block Language
- J2-3093 AutoMax Enhanced Ladder Diagram Editor
- J2-3094 AutoMax Enhanced Ladder Language Reference

The AutoMax Enhanced BASIC Language manual (J-3675), AutoMax Enhanced Ladder Diagram Editor manual (J2-3093), AutoMax Enhanced Ladder Language Reference manual (J2-3094), and AutoMax Control Block Language manual (J-3676) are contained in the AutoMax Programming Reference binder (J2-3092). Application tasks that run on the AutoMax Processor can be created using any of these three programming languages. UDC tasks can only be created using the Control Block language (with a subset of BASIC language functions).

1.4 Standard Engineering Documentation (Instruction Book)

Rockwell Automation provides a set of standard documentation, referred to as an Instruction Book, for all engineered drive systems. The Instruction Book provides a record of the equipment supplied.

Multiple sets of the Instruction Book are usually shipped to the customer by Rockwell within two to six weeks after final equipment shipment. The quantity of books sent and the recipients are determined by agreement between Rockwell Automation and the customer.

After drive start-up, drawings and software listings are revised with any changes made during start-up. Prints of all revised drawings and listings are re-issued to update the Instruction Book.

The following is a list of the contents of the Instruction Book. The abbreviation used in Rockwell documentation follows each title. For a more detailed description of the standard engineering documentation provided with each engineered system, refer to instruction manual D2-3115, Installing, Operating and Maintaining Engineered Drive Systems.

- Bill of Material (B/M) - A list of parts and instructions to manufacture and assemble them.
- Dimension Sheet (D/S) - Drawing providing outline dimensions, mounting information, and other mechanical information about a part or an assembly.
- Wiring Diagram (W/D) - Reference drawing, including schematic diagrams, for standard assemblies included in a drive system.
- Elementary Diagram (W/E) - Schematic diagram showing electrical connections of electronic and electrical devices in the drive system.
- Flow Diagram (W/F) - Diagram showing the relationship between the drive sections, motors, and mechanical regulation schemes in block format. This drawing type may also show the network and remote I/O arrangement, as well as any other communication lines, in a single line diagram format.

- Interconnection Diagram (W/I) - Diagram showing all interconnecting field wiring between individual assemblies or components provided by Rockwell or others. These diagrams are provided optionally in place of the special cabling instructions in the elementary diagrams (W/E).
- Panel Layout Diagram (W/L) - Diagram showing the physical arrangement of the electrical devices on each control panel, including customer connection terminals with wire numbers.
- Motor Control Center Diagram (W/M) - Diagram showing the physical location of the units or compartments within each Motor Control Center and the elementary diagram (W/E) for each unit.
- Note Sheet (W/N) - Wiring instructions and definitions of the standard notes and nomenclature used in the drawings. The notes also indicate the location of the components or subassemblies that may be separately mounted.
- Operator's Station Diagram (W/O) - Diagram showing the arrangement of the devices on an operator's station and the location of field terminals with wire numbers.
- Program Documentation (W/P) - Graphic diagrams of Control Block application tasks.
- Construction Drawing (W/S) - Drawing that provides the information required for the installation of Class A or Class B open Mill Control or for Mill Control Houses. These drawings show the overall dimensions of each assembly, the mounting details, and conduit entry locations.
- Index Sheet (W/X) - Sheet listing the description, last revision date, drawing number, sheet number, and sub order for all drawings in the sales order. This sheet provides a means of identifying which drawings comprise a complete and up-to-date set of prints.
- Printouts of BASIC and PC (Ladder) language application tasks.
- Instruction manuals, performance data, and a list of replacement parts.

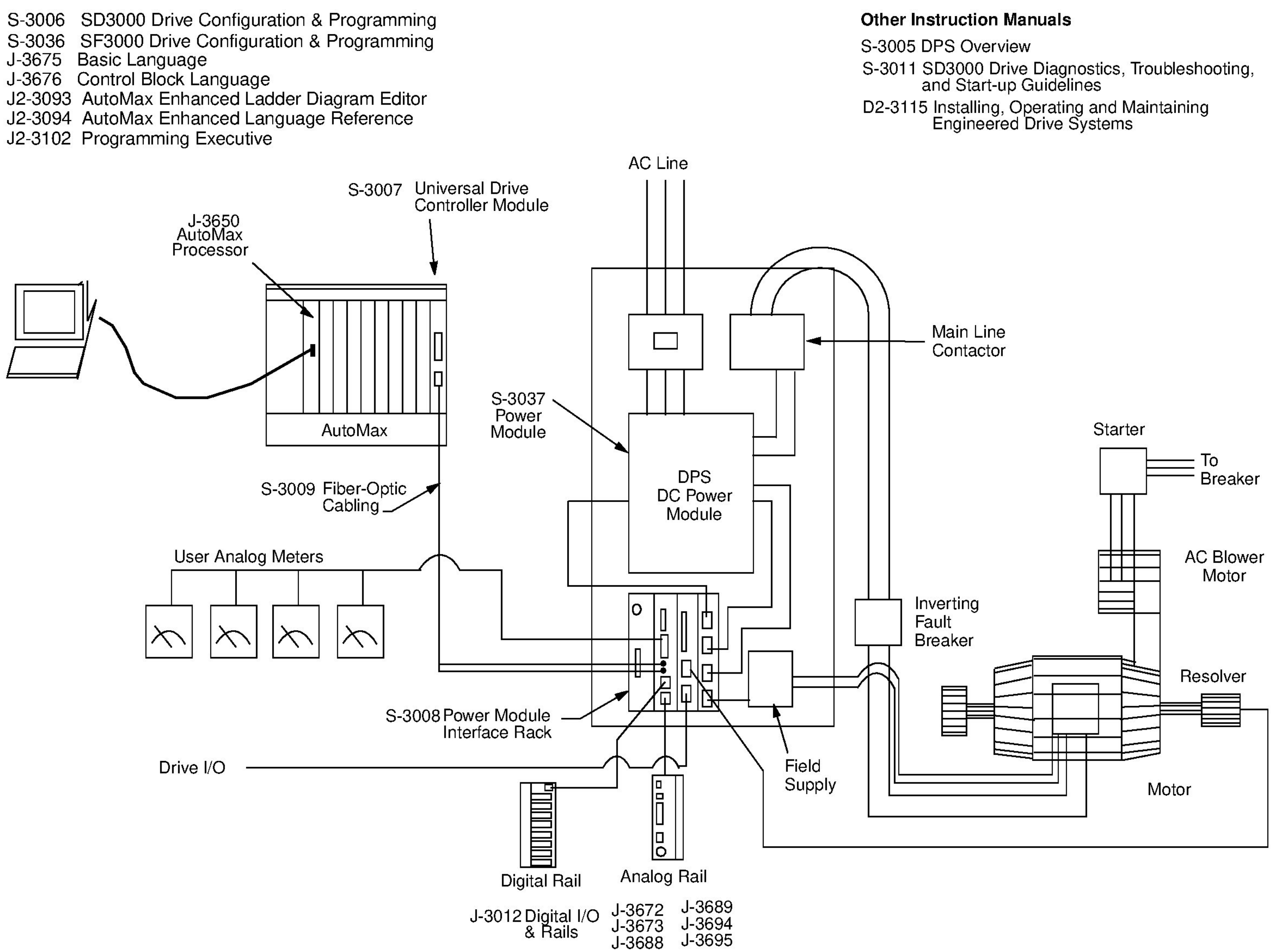


Figure 1.1 – Distributed Power System SD3000/SF3000 Drive Manual Map

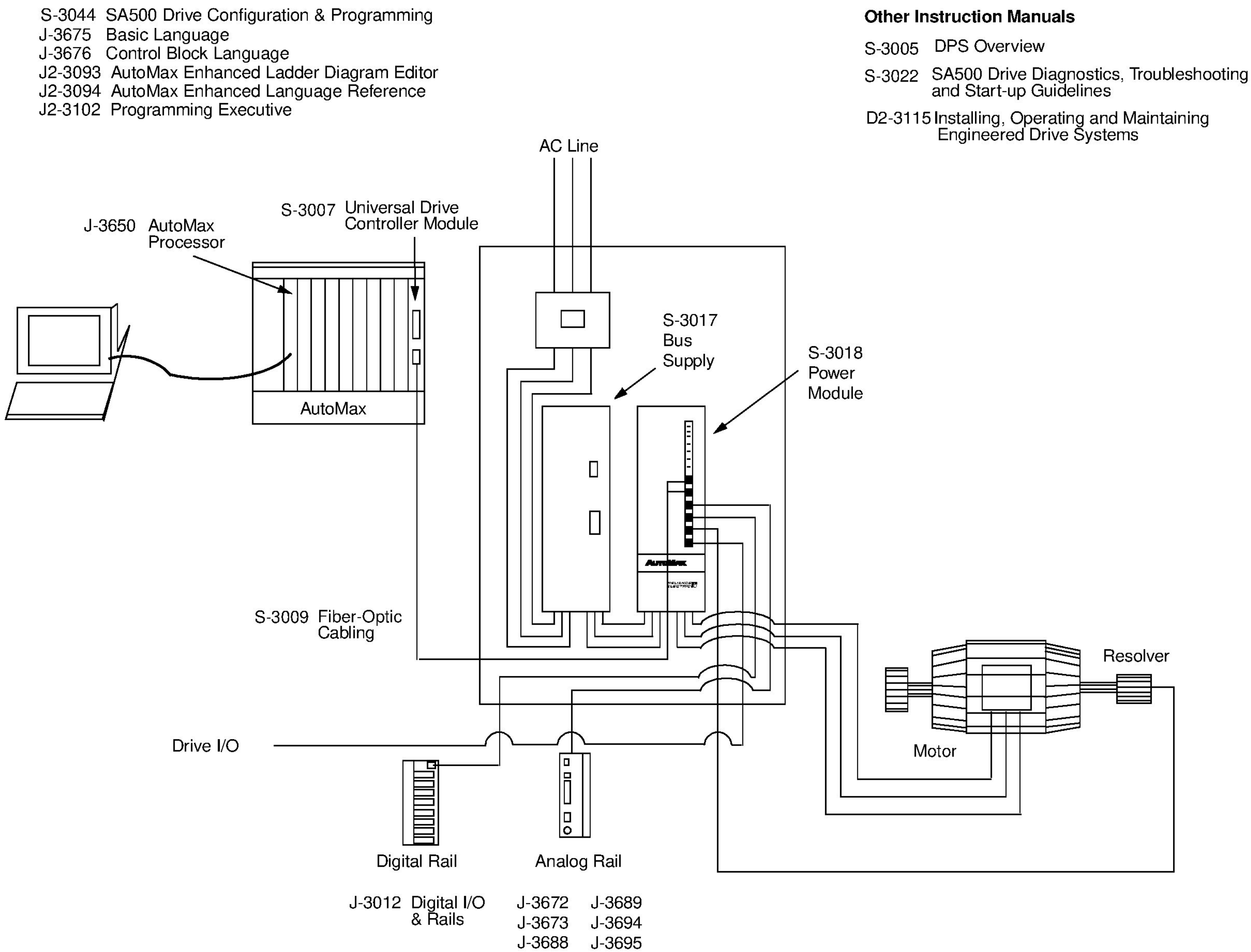
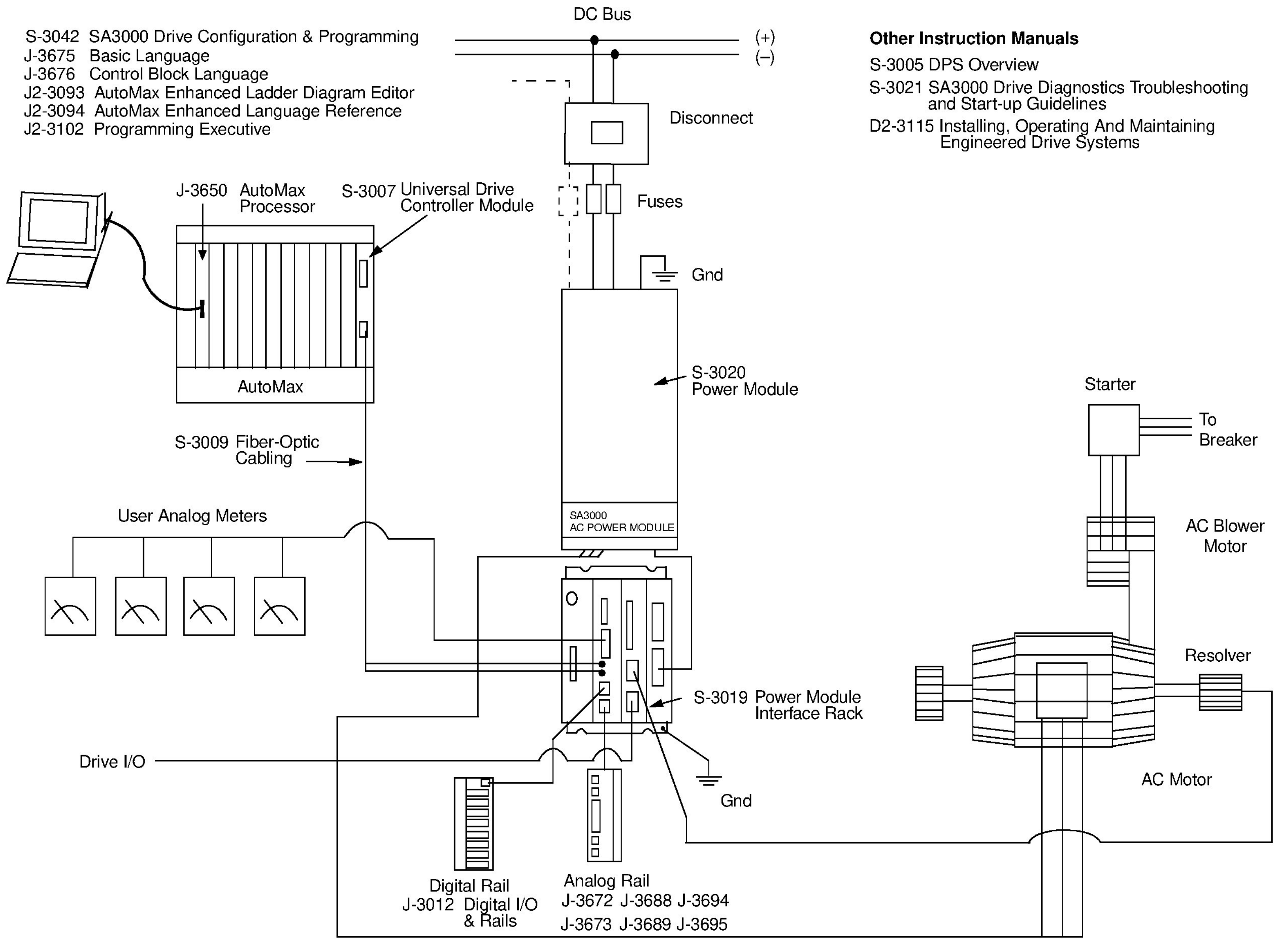


Figure 1.2 – Distributed Power System SA500 Drive Manual Map



NOTE: The dotted line represents additional circuitry when input power is 3-phase AC instead of a DC bus.

Figure 1.3 – Distributed Power System Medium Power SA3000 Drive Manual Map

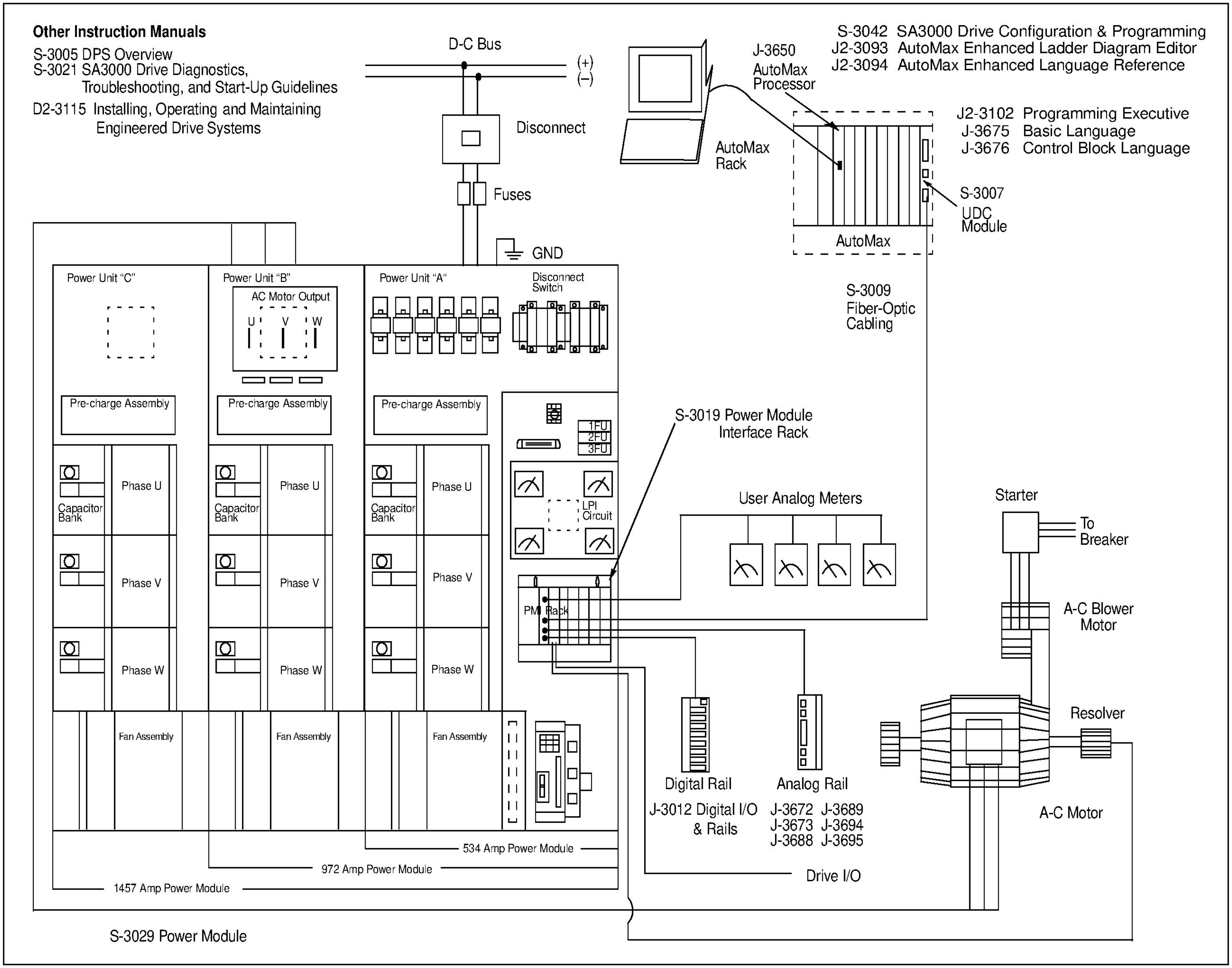
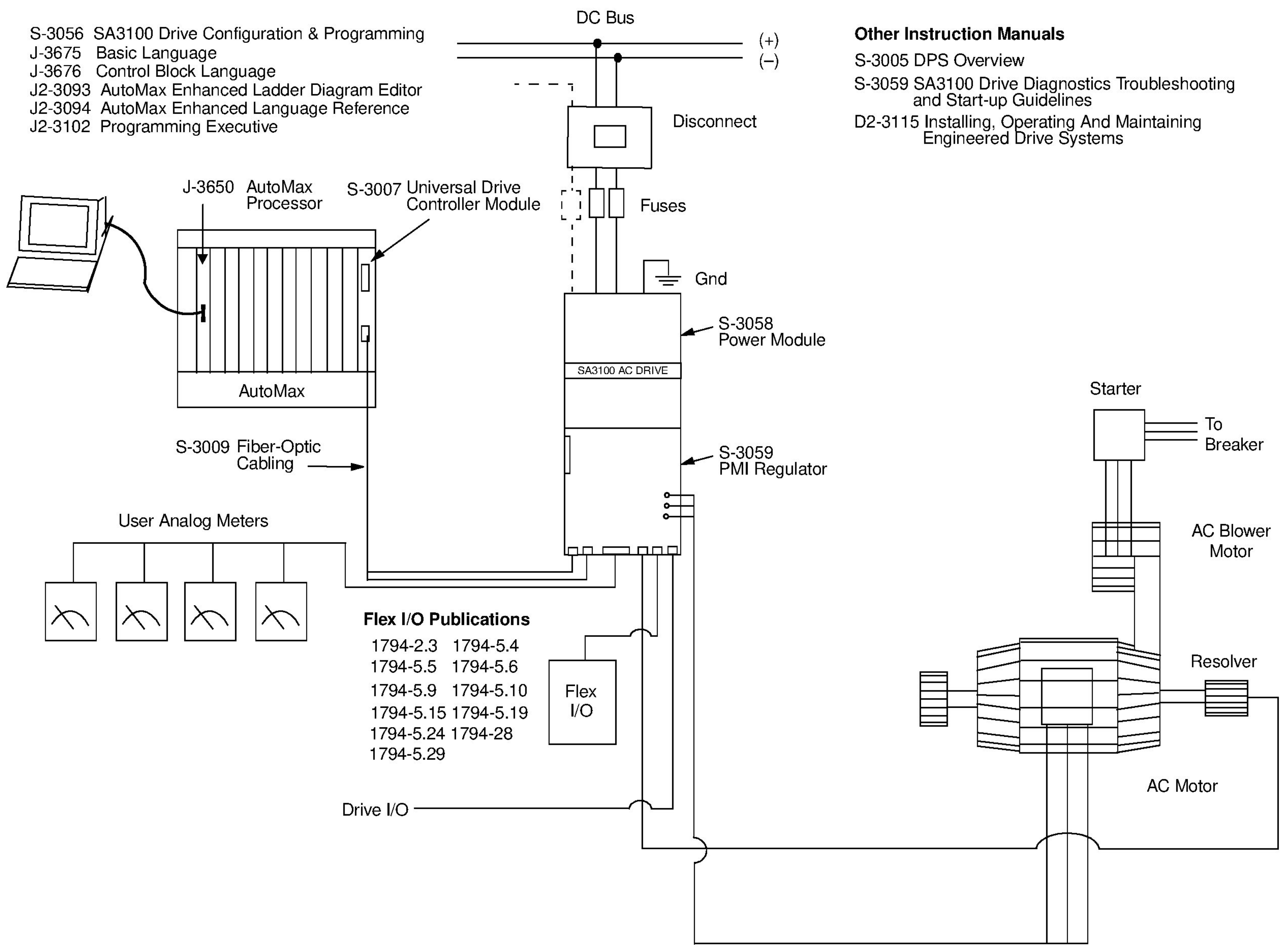


Figure 1.4 – Distributed Power System High Power SA3000 Drive Manual Map



NOTE: The dotted line represents additional circuitry when input power is 3-phase AC instead of a DC bus.

Figure 1.5 – Distributed Power System SA3100 Drive Manual Map

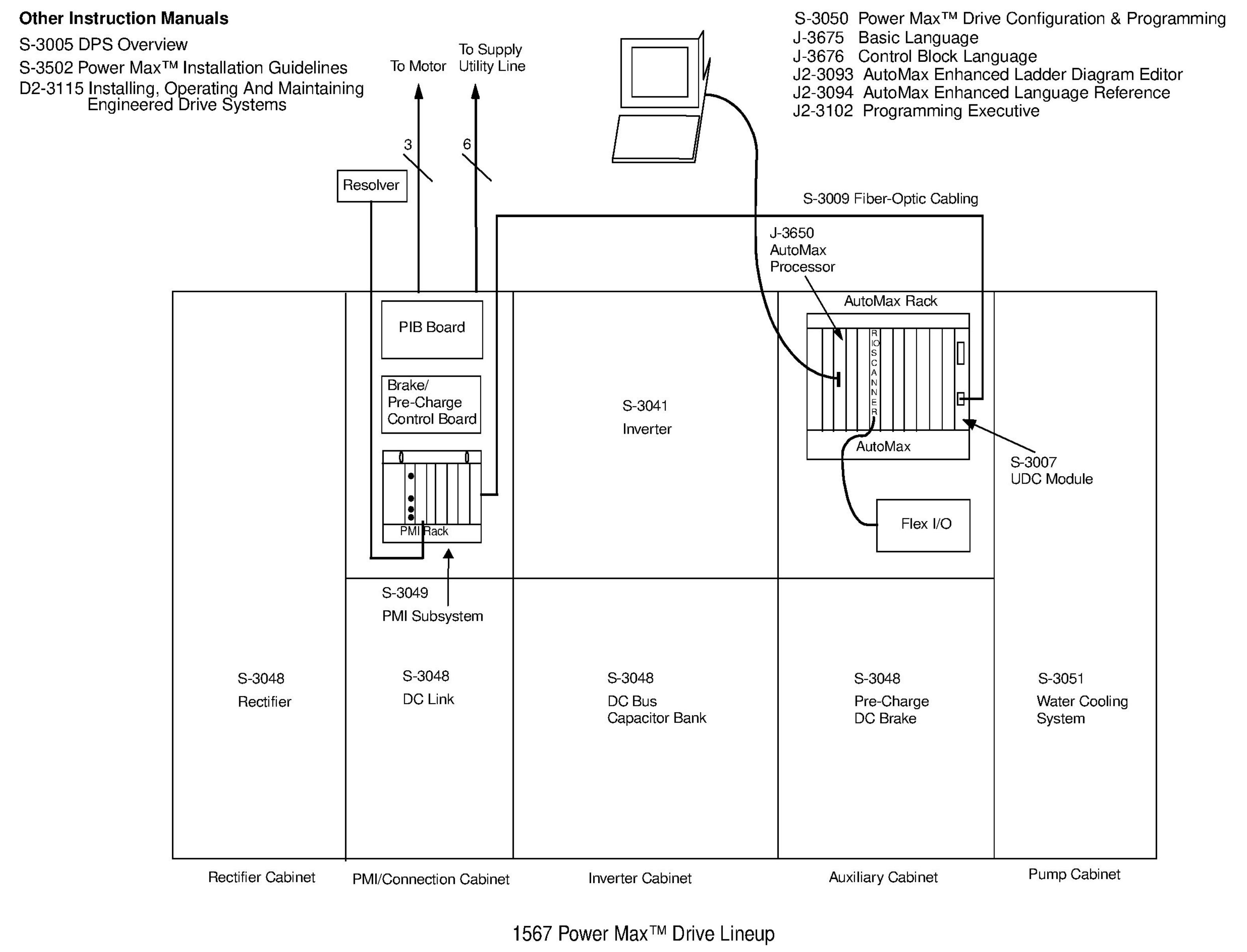


Figure 1.6 – Distributed Power system 1567 Power Max™ Drive Manual Map

CHAPTER 2

Overview of the AutoMax Distributed Power System

The AutoMax Distributed Power System is based on a distributed approach to task processing and to control of power conversion for AC and DC drive control. The benefits of this distributed architecture are:

- Improved performance through the use of modular components and high-speed RISC microprocessors
- Greater application flexibility
- Faster installation/commissioning
- Lower installed cost

Separation of high level control from power conversion is the chief hallmark of the Distributed Power drive architecture. A distributed approach makes it possible to divide the control scheme into different levels, using the existing AutoMax Processor module for higher level control algorithms and drive coordination, the Universal Drive Controller module for outer control loop processing, and the Power Module Interface for real-time control of the Power Module.

The Universal Drive Controller (UDC) module in the AutoMax rack is used to control one or two drives. Both AC and DC drives can be controlled from one UDC module. Up to 10 UDC modules can be mounted in an AutoMax rack permitting control of up to 20 drives from a single rack. Drive types can be mixed throughout the process allowing each section to be customized with the most appropriate power technology. A common software interface makes the different power technologies transparent to the user. Table 2.1 illustrates this distributed architecture for all drive types.

A noise-immune fiber-optic link is used for all communications between the UDC module and the Power Module Interface (PMI) located at the Power Module up to 750 meters (2500 feet) away allowing tight synchronization of the UDC and PMI. The control type (i.e., current for DC, vector and brushless for AC) is determined by the operating system contained in the PMI. The PMI runs the regulation algorithm; collects and sends diagnostic data, performance data and I/O data to the UDC module; and produces firing signals for the power devices.

Hardware in the Distributed Power System incorporates precise diagnostics and clear LED fault displays to pinpoint failures. Comprehensive fault reporting makes it possible to detect errors systematically through application programming. The modular design of most system components permits rapid hardware replacement when malfunctions do occur.

Because power conversion hardware can be located near the motor (and the process) at a significant distance from control equipment, PMIs and Power Modules can be clustered like motor control centers, substantially reducing field wiring requirements. AutoMax racks can be mounted in a location that provides a clear view of the process.

Modular design ensures upward and downward compatibility of most system components. Retrofits to existing installations are easy to do because UDC modules are compatible with all AutoMax Processors and can even be mixed with existing Reliance drive control modules in the same rack. In most cases, the AutoMax Distributed Power System can be used to upgrade existing drives from other manufacturers.

Table 2.1 – Distributed Power Drive Architecture

Drive Type	AutoMax Software Interface	AutoMax Hardware Interface	UDC/PMI Commun-ication	PMI Type	Regulator Type	Power Module	Motors
DC SD3000 (3-Phase Armature) SF3000 (3-Phase Field)	AutoMax Program-ming Executive Software	Universal Drive Controller Module in the AutoMax Rack	Fiber-Optic Cable	4-Slot PMI Rack: 1. Power Supply 2. PMI Processor 3. Resolver/Drive I/O 4. DC Power Technology	Current	S6/S6R 1/2 to 1000 HP (single units) S12 1000 to 5000 HP (parallel units)	DC
AC SA500				PMI/Power Module	Vector or Brushless	14 Amp 28 Amp 35 Amp 48 Amp	Induction and Brushless
AC SA3000 Medium Power				4-Slot PMI Rack: 1. Power Supply 2. PMI Processor 3. Resolver/ Drive I/O 4. AC Power Technology	Vector, Vector with Constant Power, or Volts/Hertz	70 Amp 140 Amp 240 Amp	Induction
AC SA3000 High Power				8-Slot PMI Rack: 1. Power Supply 2. PMI Processor 3. Resolver/ Drive I/O 4. AC Power Technology 5. Parallel Interface 6. Gate Driver Interface		534 Amp 972 Amp 1457 Amp	
AC SA3100				Power Module/ Motherboard & Resolver/Drive I/O board		1 to 800 HP (4.5 to 900 Amps)	

Table 2.1 – Distributed Power Drive Architecture

Drive Type	AutoMax Software Interface	AutoMax Hardware Interface	UDC/PMI Commun-ication	PMI Type	Regulator Type	Power Module	Motors
1567 PowerMax Medium Voltage AC Drive	AutoMax Program-ming Executive Software	Universal Drive Controller Module in the AutoMax Rack	Fiber-Optic Cable	8-Slot PMI Rack: 1. Power Supply 2. PMI Processor 3. Resolver/ Drive I/O 4. Med Voltage Power Technology 5. Gate Driver 1 6. Gate Driver 2 7. Gate Driver 3 8. Gate Driver 4	Voltage Source Neutral Point Clamped 3-Level Inverter	1500 to 5500 HP	Induction

2.1 Software Interface

All Distributed Power System drive types share a common software interface: the AutoMax Programming Executive. Drive parameter configuration is done via graphical forms (screens) displayed on the programming terminal. The easy-to-use forms display parameters in the appropriate engineering units. The programmer can fill in the blanks and configure the drive using only nameplate data from the motor, the Power Module, current transformer (if used), and resolver or other feedback device.

All features currently found in the Windows-based AutoMax Programming Executive software, such as downloading application tasks and monitoring from any drop on the DCS-Net network, can be used in DPS drive control applications. See figure 2.1 for a sample configuration screen.

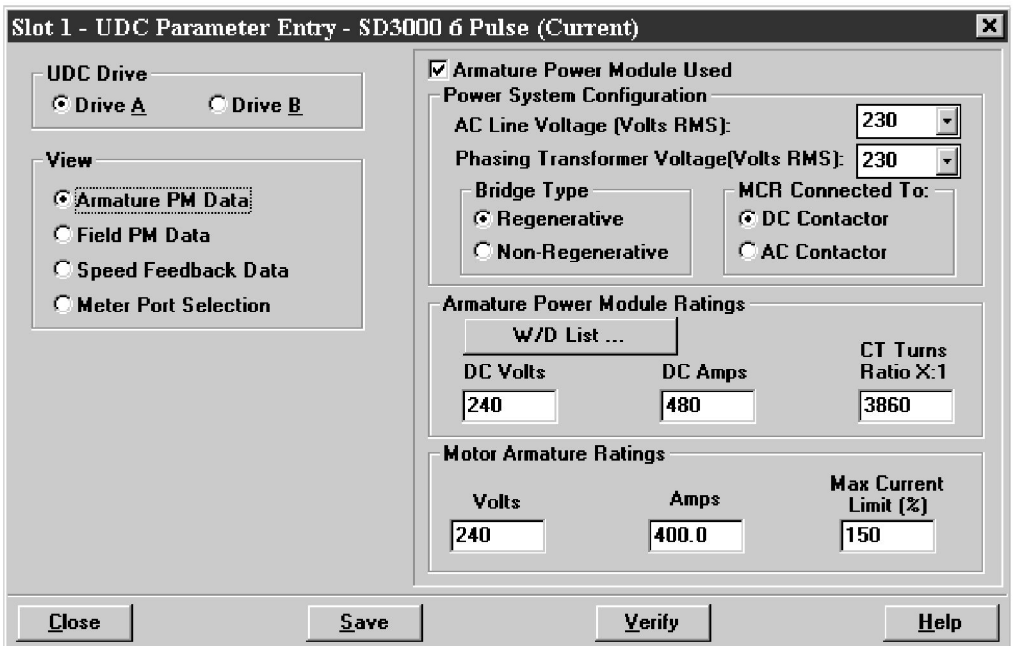


Figure 2.1 – Sample Drive Parameter Configuration Screen (DPS SD3000)

After rack and drive configuration has been completed, the programmer can load an operating system and special rack and drive configuration files to AutoMax Processors and UDC modules in the system. The UDC operating system contains within it the operating systems for the PMIs connected to it. The appropriate PMI operating system is automatically loaded to each PMI.

The PMI operating system executes the selected regulation algorithm which uses the motor's actual electrical characteristics for precise control.

Chapter 3 of this manual describes the AutoMax Programming Executive software interface in more detail. It also provides an overview of how application programming is developed using the AutoMax Executive software.

2.2 DPS Hardware Components Common to All Drive Types

There are two hardware components common to all Distributed Power drive systems: the Universal Drive Controller (UDC) module in the AutoMax rack and the fiber-optic link which is used to connect the UDC module to the Power Module Interface (PMI). The PMI/Power Module hardware will vary depending on the drive type. The two sections that follow describe the UDC module and the fiber-optic link in more detail.

2.2.1 Universal Drive Controller (UDC) Module

The Universal Drive Controller (UDC) module is a special high-speed slave processor module located in the same rack as an AutoMax Processor. The RISC-based UDC module contains non-volatile flash memory to store the operating systems for the UDC module and the PMI, the drive configuration information, and the UDC tasks (one for each drive). The UDC module also contains dual port memory which is used as a storage buffer for exchanging data with the AutoMax Processors in the AutoMax rack.

The faceplate of the UDC module contains transmit and receive ports for two channels of fiber-optic cable and four software-programmable D/A output ports for connection to chart recorders or meters. LEDs on the faceplate indicate the status of the communication link between the UDC module and the Power Module Interface as well as UDC module and drive status.

2.2.2 Fiber-Optic Link

Fiber-optic cables provide a point-to-point serial link between the UDC module and the Power Module Interface. This link allows the UDC module to transfer the PMI operating system, configuration data, and command data to the PMI. The PMI in turn sends feedback and status data to the UDC module.

Data is Manchester-encoded and transmitted over the fiber-optic links at a rate of 10M bits per second. The fiber-optic cables are immune to electromagnetic interference (EMI) and prevent ground loops.

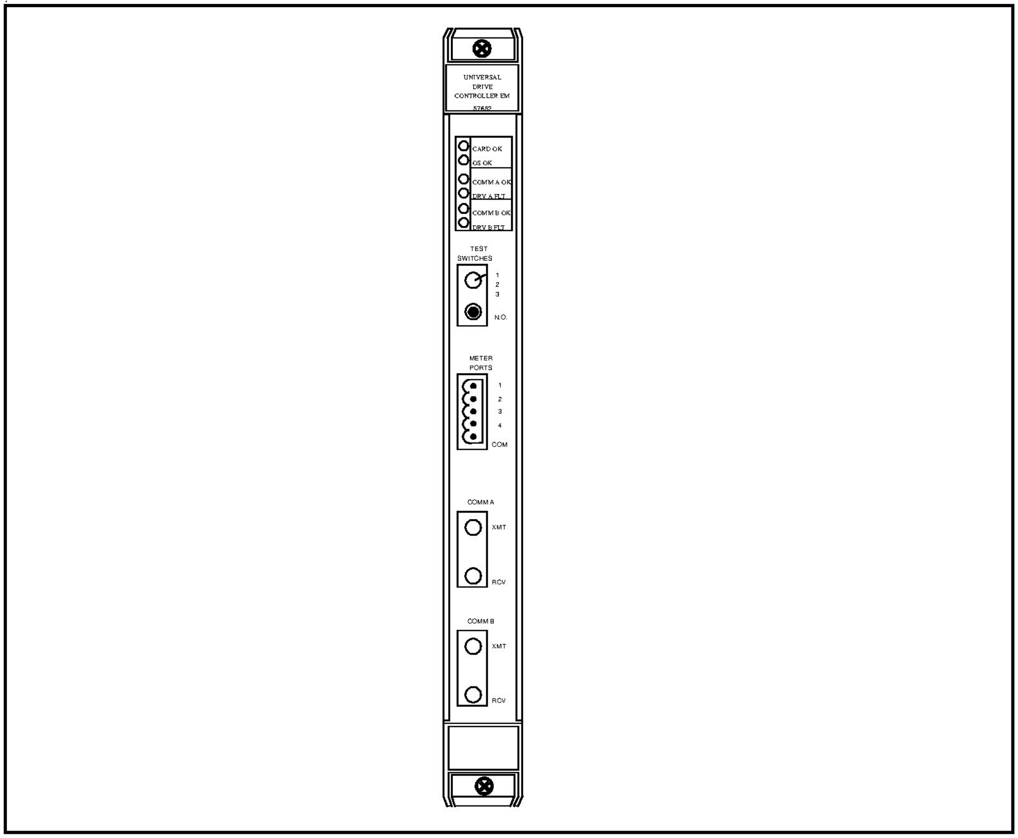


Figure 2.2 – UDC Module Faceplate

2.3 DC Drive Hardware Components

For SD3000 and SF3000 DC drives, the PMI is a four-slot rack containing the same Power Supply module, PMI Processor module, and Resolver & Drive I/O module that is used for Medium Power SA3000 AC drives. The hardware components that are unique to a DPS DC drive system are the DC Power Technology module in the PMI rack and the DC Power Modules. These are described in the following sections. See figure 1.1.

2.3.1 Four-Slot PMI Rack and Modules

The PMI rack is designed to be mounted in the same cabinet or within 3.5 meters (12 feet) of the DC Power Module. The PMI rack contains a Power Supply module, a PMI Processor module, a Resolver and Drive I/O module, and a DC Power Technology module as shown in figure 2.3.

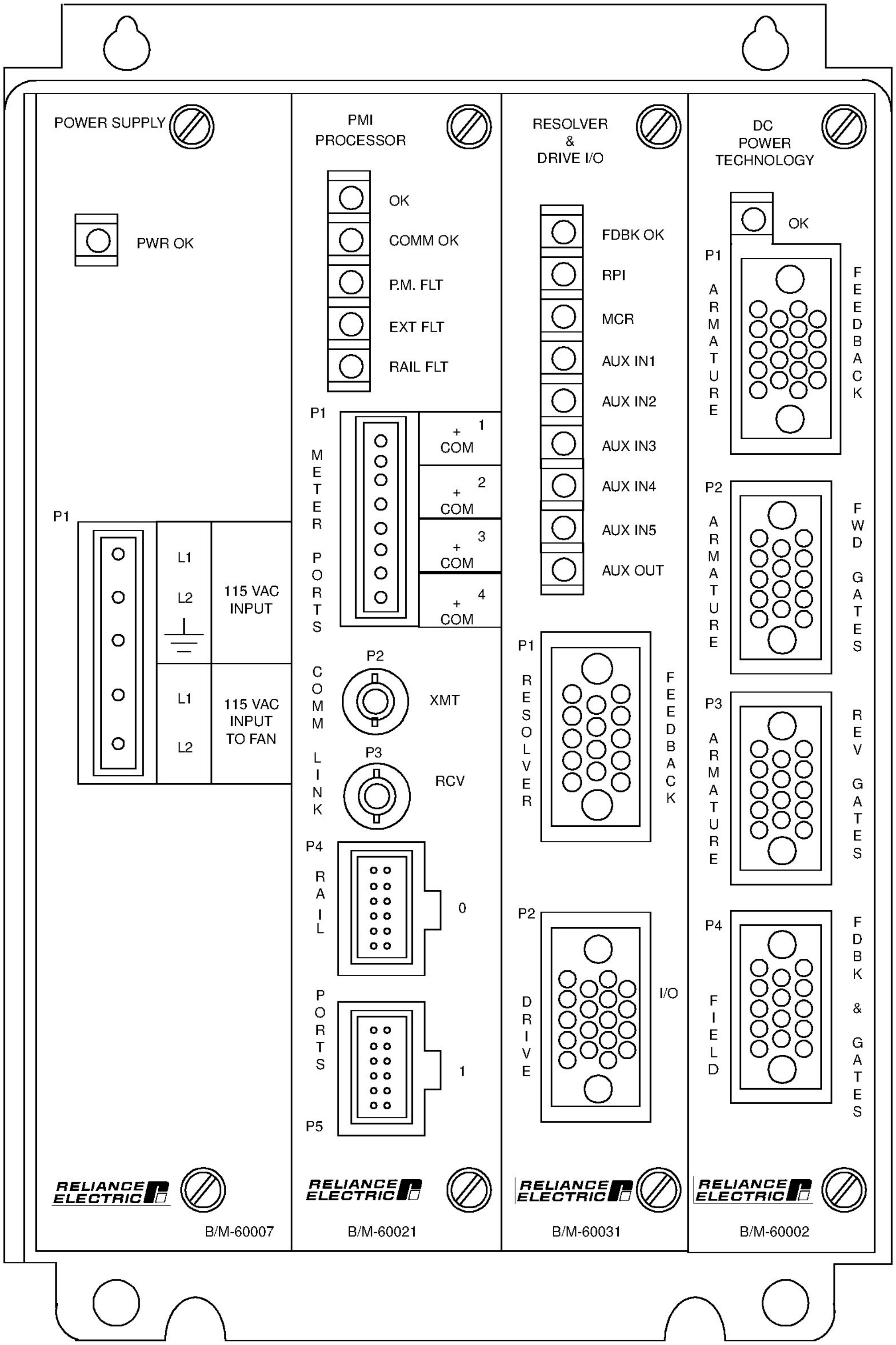


Figure 2.3 – Four-Slot PMI Rack and Modules (SD300/SF3000 Drives)

The Power Supply module provides the power necessary for the operation of the modules in the PMI rack. Connections are provided for 115VAC single-phase input power, a ground terminal, and 115VAC output terminals to power a rack fan, if required. Power supply status is indicated by an LED on the faceplate.

The RISC-based PMI Processor controls all communication within the PMI rack. It executes the inner control algorithm and provides feedback and diagnostic information to the UDC module. The PMI Processor has two rail ports for connection to AutoMate digital and analog rails, as well as four software-programmable meter ports. The faceplate of the PMI Processor module also contains transmit and receive ports for one channel of fiber-optic cable and five LEDs to reflect the status of the PMI rack and the connected DC Power Module.

The Resolver & Drive I/O module provides 12- or 14-bit resolution of external resolver signals to the PMI Processor, as well as connections for an analog input and drive I/O. The module's resolver-to-digital converter can be automatically tuned for wire length and cable characteristics up to 150 meters (500 feet). The resolver feedback connector on the faceplate is shared by an analog input. The analog input can be an analog tachometer, which can be used as an alternate speed feedback device for DC drives. The faceplate also provides a connector for drive I/O. Nine LEDs on the faceplate indicate I/O and drive status.

The DC Power Technology module digitizes all armature and field signals related to the DC Power Modules for use in the field and current regulation algorithms. Four connectors are provided on the faceplate for monitoring feedback signals (e.g., armature current and voltage, AC line voltage) and for driving power devices. One LED on the faceplate indicates the status of the gate driver circuits.

2.3.2 DC Power Modules

The DC Armature Power Modules include a full range of DCS S6 and S6R DC Power Modules from 1 to 1000HP with higher horsepowers available by paralleling Power Modules. These Power Modules provide continuous duty, adjustable-voltage armature power to DC motors by SCR rectification of 3-phase power. Both non-regenerative versions (S6) and regenerative versions (S6R) are available. Lower horsepower versions (below 60HP) of these DC Power Modules are available as assemblies. These assemblies contain integral PMI racks, armature SCR bridges, fans, fuses, field SCR bridges (optional), etc.

The DC Field Power Modules allow tight regulation of field current and programmable field economy, field weakening, and field loss protection. These Power Modules provide continuous duty, adjustable voltage, current-regulated power to DC motor fields by rectification of single-phase power. Both regenerative (S2R) and non-regenerative (S2) versions are available.

2.4 AC Drive Hardware Components

There are three different types of Power Module Interface hardware configurations depending upon the type of AC Power Modules being used. These configurations are described in the following sections.

2.4.1 SA500 Drives (14-48 Amp)

The hardware components of the SA500 drive consist of the DC Bus Supply and the AC Power Module which contains the PMI. These components are shown in figure 1.2 and are described in the following sections. The same hardware is used for vector or brushless control. The control type is determined by the programmer.

2.4.1.1 DC Bus Supply

The SA500 DC Bus Supply rectifies three-phase AC supply voltage to a constant DC bus voltage. The DC Bus Supply shown in figure 2.4 can supply DC power to as many as six AC Power Modules. The DC Bus Supply requires no adjustments and has built-in diagnostics. Bus supplies use either internal or external braking resistors to control the bus voltage during motor regeneration.

2.4.1.2 SA500 Power Module

The SA500 Power Module provides control and power for either permanent magnet motors or squirrel-cage induction motors. It contains transistors to switch power to the motor and also supplies power to the PMI regulator board. The PMI combines the functions of the PMI Processor module and Resolver & Drive I/O module from the PMI rack as described in section 2.3.1 with the exception that no analog meter ports are provided. See figure 2.4.

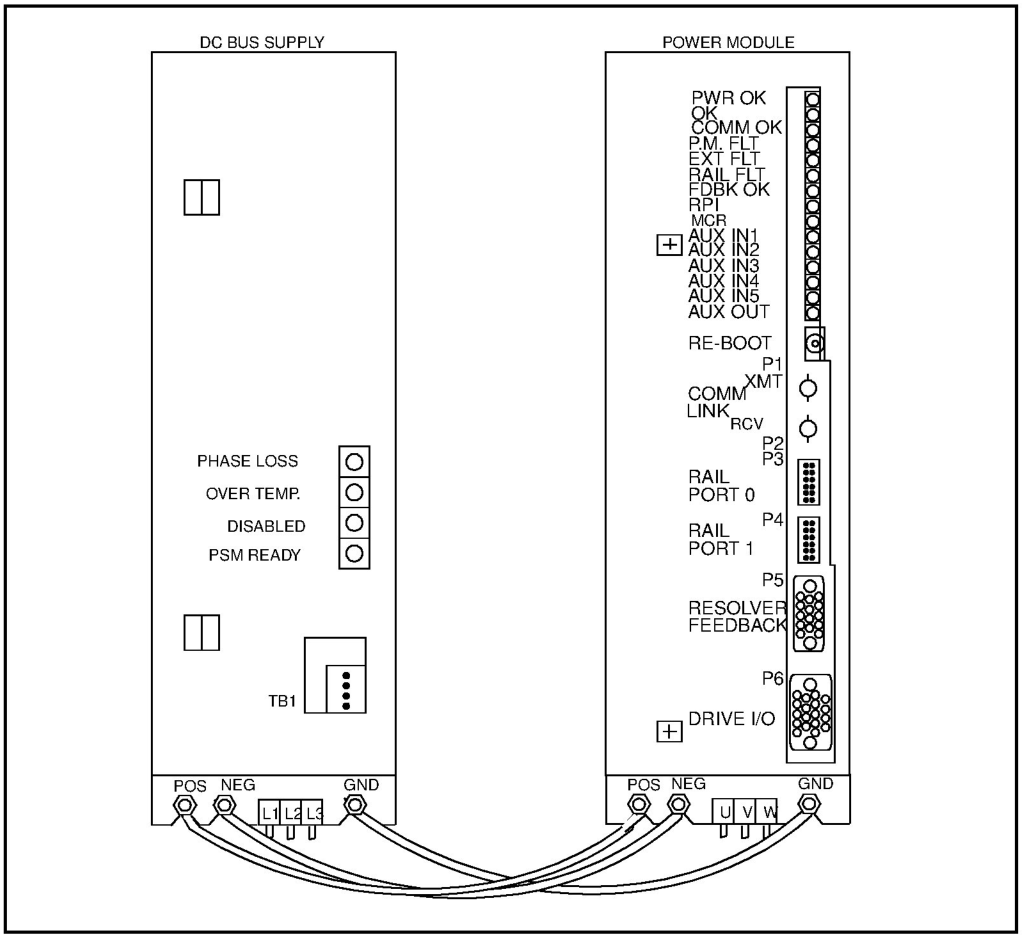


Figure 2.4 – SA500 DC Bus Supply and Power Module

The faceplate contains transmit and receive ports for one channel of fiber-optic cable and 15 LEDs to indicate the status of the PMI and inverter circuitry, the feedback device, the drive I/O, and the communication link to the UDC module. The resolver feedback connector is shared by the resolver interface and the analog input in the same manner as on the Resolver & Drive I/O module in the PMI rack. The faceplate also provides a connector for drive I/O. Two rail ports on the module's faceplate provide connection to AutoMate digital and analog rails.

2.4.2 SA3000 Medium Power Drives (70-240 Amp)

The hardware components of a SA3000 Medium Power drive are the four-slot PMI rack and the Medium Power SA3000 AC Power Modules. These are shown in figure 1.3 and are described in detail in the following sections.

2.4.2.1 SA3000 Four-Slot PMI Rack and Modules

The same four-slot PMI rack is used for Medium Power SA3000 drives that is used for SD3000/SF3000 DC drives. The first three slots contain the same Power Supply module, PMI Processor module, and Resolver & Drive I/O module found in the DC PMI rack. For AC drive control, however, the rightmost slot contains an AC Power Technology module. Refer to figure 2.5.

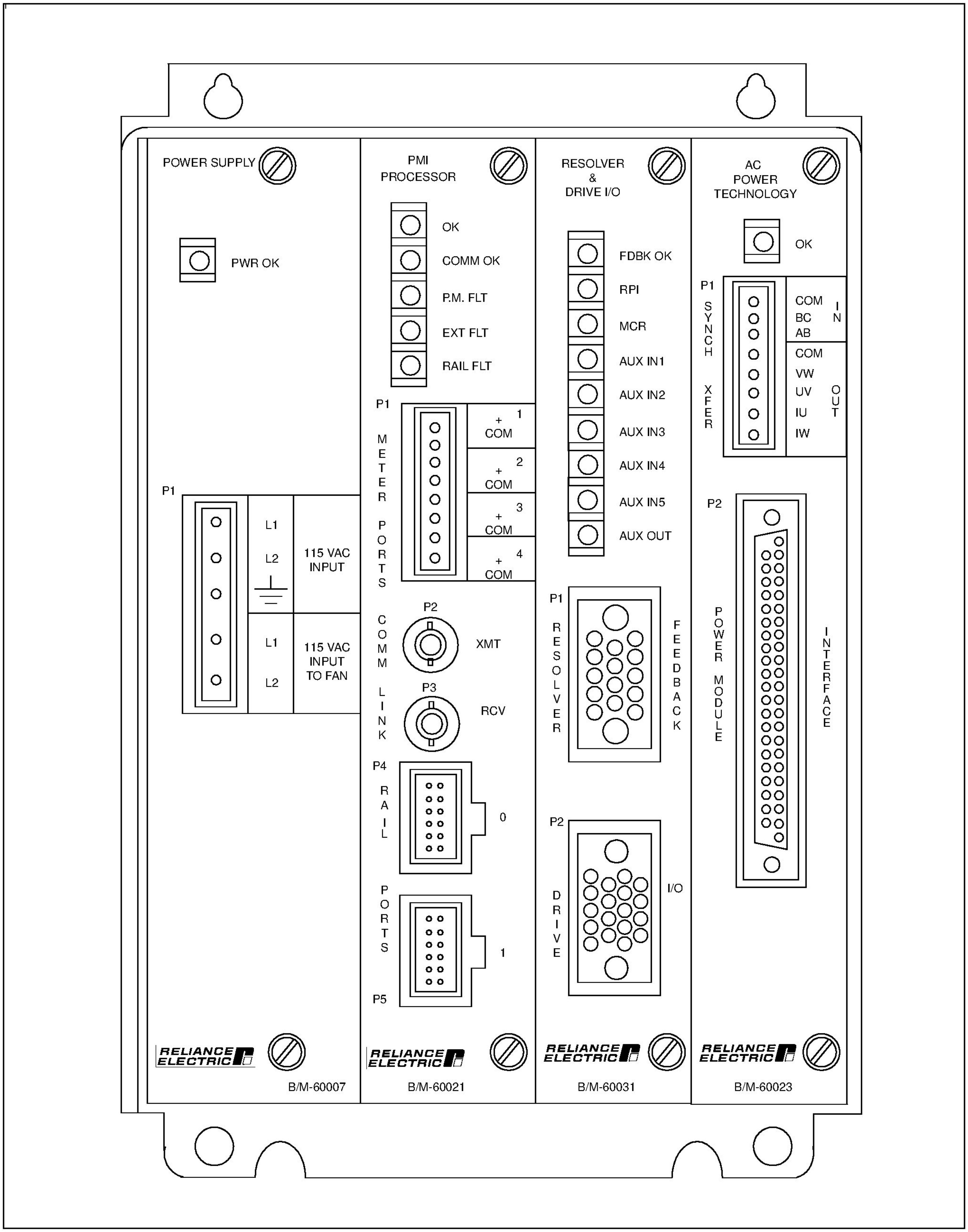


Figure 2.5 – Four-Slot PMI Rack and Modules (SA3000 Medium Power Drives)

The AC Power Technology module performs the calculations required to generate the pulse-width modulated (PWM) signals that fire the power devices in the AC Power Module based on the required feedback inputs and the inner loop reference values received from the UDC module and the PMI Processor.

The Power Module Interface port on the faceplate of the AC Power Technology module provides direct connection to the AC Power Module and is used to receive all drive feedback signals and transmit gate driver signals. One LED on the faceplate indicates all conditions have been met to allow the output of firing signals to the power devices.

2.4.2.2 Medium Power SA3000 AC Power Modules

The Medium Power SA3000 AC Power Modules incorporate state-of-the-art IGBT (insulated gate bipolar transistor) technology for variable speed control of induction motors. The modules can operate from either 3-phase AC input or DC bus power.

Rectified, filtered DC voltage is fed from the rectifier (internal diode rectifier or external DC bus) circuitry to the inverter bridge, which consists of three replaceable Intelligent Power Modules and their snubber circuitry. Pulse-width modulation (PWM), a control technique which results in a relatively smooth, synthesized AC sine wave, is used to produce variable voltage/variable frequency output to the motor.

The Power Modules contain built-in diagnostics to provide warning and fault detection. Diagnostics are run continuously by the PMI to detect problems like over temperature, DC bus overvoltage/undervoltage, excess ground currents, IGBT overcurrent, and communication faults.

2.4.3 SA3000 High Power Drives (534-1457 Amp)

The hardware components of the High Power SA3000 drive are an eight-slot PMI rack, the Local Power Interface module, and the High Power AC Power Module all contained in a floor-mounted cabinet. The High Power AC Power Modules consist of one to three power units connected in parallel to obtain higher current output, as required. These components are shown in figure 1.4 and are described in the sections that follow.

2.4.3.1 SA3000 Eight-Slot PMI Rack and Modules

An eight-slot version of the PMI rack houses the additional modules necessary for firing and paralleling the power units.

The first three slots contain the same Power Supply module, PMI Processor module, and Resolver & Drive I/O module as described in section 2.3.1. The remaining slots contain an AC Power Technology module, a Parallel Interface module, and up to three Gate Driver Interface modules (one for each power unit). Refer to figure 2.6.

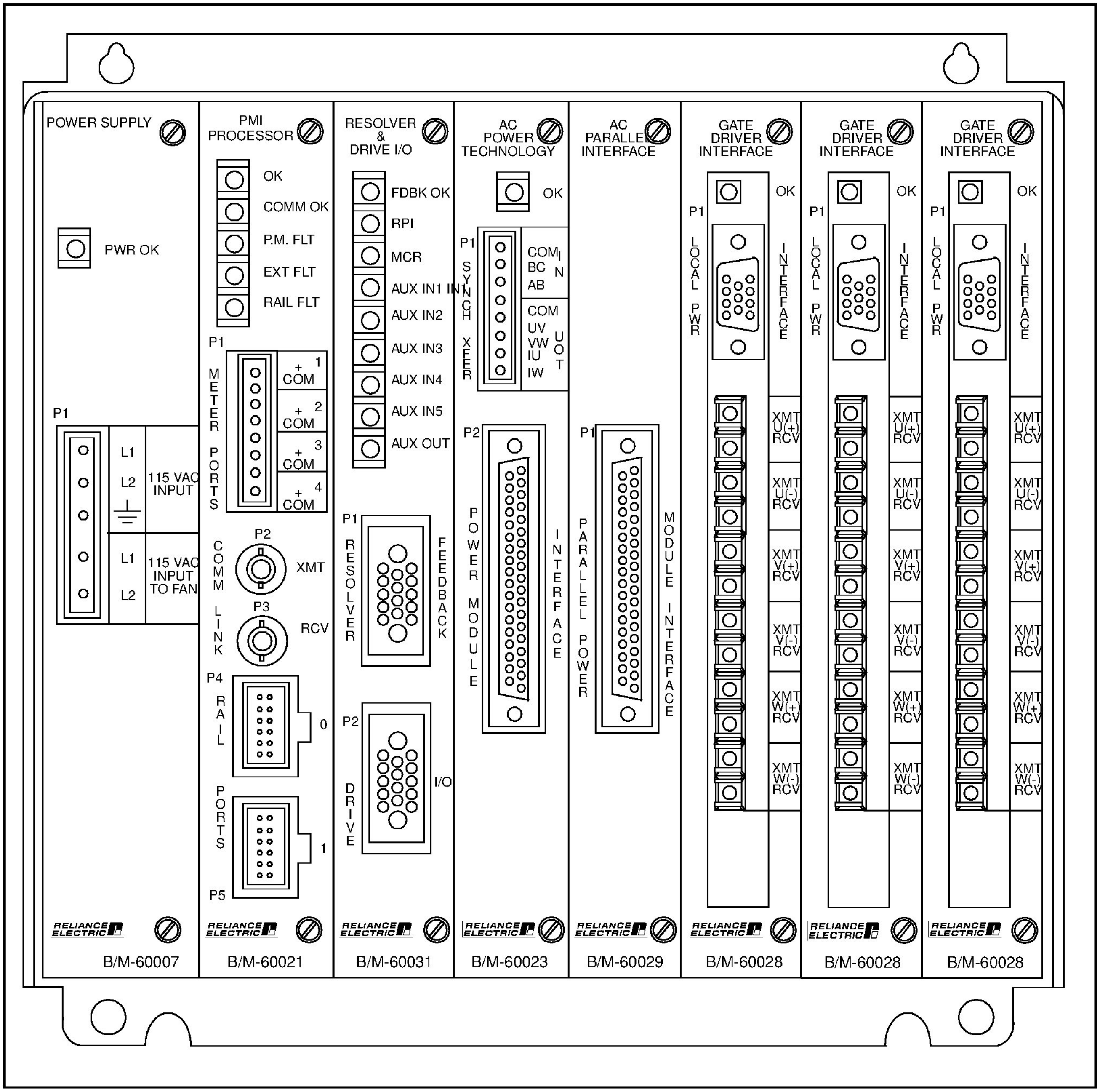


Figure 2.6 – Eight-Slot PMI Rack and Modules (SA3000 High Power Drives)

The AC Power Technology module provides the same functions for the High Power SA3000 Drives as it does for the Medium Power SA3000 Drives. However, when it is used in the eight-slot rack, the module does not connect directly to the AC Power Module, but instead connects to the Parallel Interface module located in the next slot to the right.

The Parallel Interface module (PIM) enables the AC Power Technology module to communicate with up to three Gate Driver Interface (GDI) modules, each connected to a separate power unit. The PIM does the necessary signal splitting and conditioning to make the parallel units behave as if they were a single Power Module. A single connector on the Parallel Interface module faceplate provides the connection to the AC Power Technology module.

The Gate Driver Interface (GDI) module conditions the Power Module feedback signals (received indirectly through the Local Power Interface (LPI) module, described below), and sends this data to the Parallel Interface module via the rack backplane.

The GDI module contains transmit and receive ports for six channels of fiber-optic cable which connect directly to each of the six IGBT gate drivers in the Power Unit. The GDI module transmits the gate driver signals (received from the AC Power Technology module) to the Power Module over the noise-immune fiber-optic link. The GDI module also receives gate fault signals from the Power Module over the fiber-optic link.

The connector on the GDI module faceplate provides the connection to the Local Power Interface module mounted above the PMI rack. One LED on the faceplate indicates the status of the on-board power supplies.

2.4.3.2 Local Power Interface (LPI) Module

The Local Power Interface (LPI) module is mounted above the PMI rack. The module conditions and isolates feedback signals from the power unit(s) for the Gate Driver Interface module(s). A single LPI module services up to three GDI modules.

2.4.3.3 High Power AC Power Modules

The High Power AC Power Modules consist of one to three power units connected in parallel. They are similar to the Medium Power AC Power Modules except that they accept higher input power and produce more output power. They use IGBT technology and pulse-width modulation to produce variable frequency/variable voltage output power. These inverter modules are designed to operate only from a DC bus which can be regenerative or non-regenerative.

The 534 amp Power Module is housed in a stand-alone cabinet which includes the eight-slot PMI rack and modules. The 972 amp and 1457 amp Power Modules each consist of one 534 amp Power Module and PMI rack, plus one or two additional power units connected in parallel in order to supply the higher current.

The High Power AC Power Modules are protected by integral fusing and snubber circuitry, as well as diagnostics to provide warning and fault detection. For parallel Power Modules, the PMI output reactors mounted within the cabinet are provided to ensure load sharing among the IGBT devices.

2.4.4 SA3100 Drives

SA3100 drives are rated from 1 to 800 HP with input voltages from 230 to 575 VAC or from 310 to 775 VDC (common bus). They are supplied in an enclosure for stand-alone operation or open-chassis for mounting within a suitable user-supplied enclosure. Several types of Encoder/Resolver feedback devices are available. An interface for Flex I/O is also provided. The SA3100 drive system is shown in figure 1.5.

On SA3100 drives the PMI Regulator is mounted inside the Power Module. The PMI Regulator contains both the drive's regulator circuitry and its communication interface to the UDC module. The SA3100 PMI Regulator consists of a large motherboard and a smaller Resolver & Drive I/O board that mounts on top of the motherboard. The motherboard contains the PMI processor, AC power technology circuitry, UDC interface, metering ports, status LEDs, and Flex I/O interface. See figure 2.7.

As with other DPS drives, the SA3100 operating system contains built-in diagnostics to provide warning and fault detection. Diagnostics are run continuously by the PMI to detect problems like over temperature, DC bus overvoltage/undervoltage, excess ground currents, IGBT overcurrent, and communication faults.

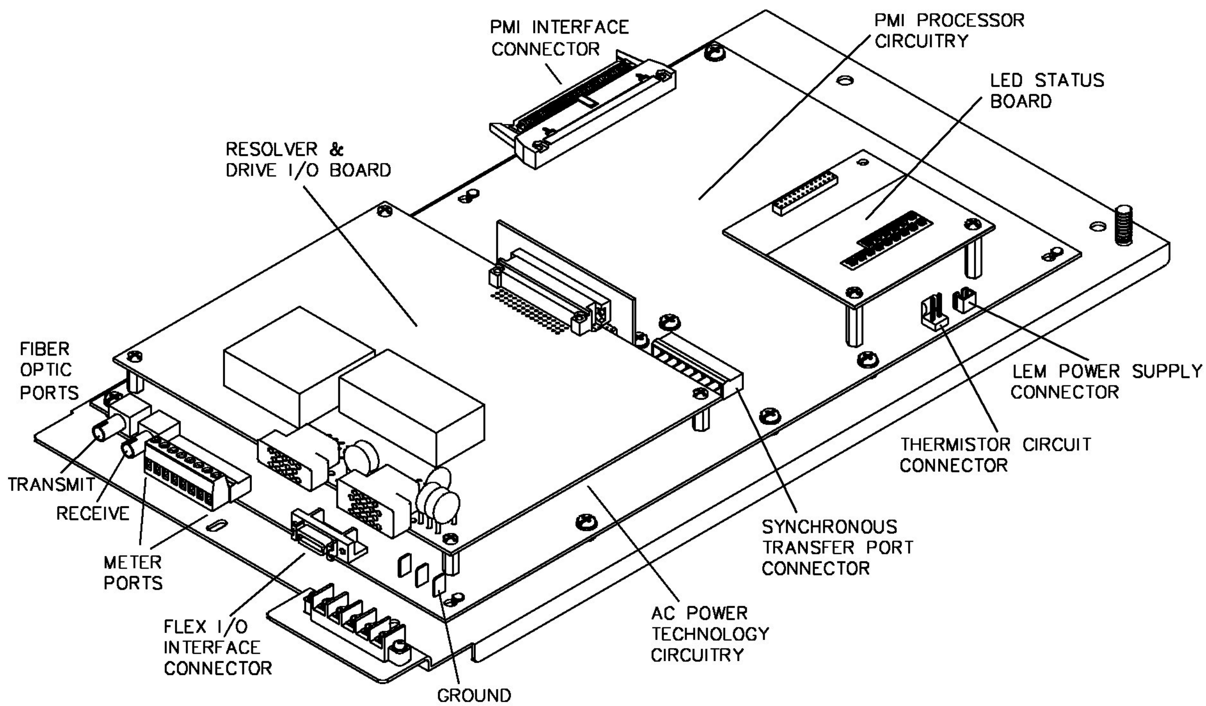


Figure 2.7 – SA3100 PMI Regulator

2.4.5 1567 Power Max™ Drive

The 1567 Power Max™ drive is made up of two main systems, the Rectifier and the Inverter. Together the Rectifier and Inverter convert fixed frequency, fixed voltage from the AC line to variable frequency, variable voltage power for driving an AC induction motor. The drive is mounted in a lineup of five NEMA 1 general purpose enclosures, housing the rectifier, PMI subsystem and DC/Link, three-phase inverter, AutoMax rack and DC brake, and liquid cooling system.

The AutoMax™ Processor coordinates and controls the entire drive system. The Universal Drive Controller (UDC) module in the AutoMax rack runs the drive's major control loop and communicates over a fiber-optic link with the Power Module Interface (PMI) subsystem. The PMI runs the Inverter's control algorithm, commands gate firing of the Inverter's GTOs, and monitors operation of the drive.

The Inverter is a voltage source GTO-based power bridge, with neutral point clamped topology to achieve three-level operation. It is designed to drive induction motors at variable speeds using pulse-width-modulation (PWM). The Inverter is available in power ratings up to 3500 HP (for overload capabilities, check with the factory).

The Inverter's PMI subsystem includes an eight-slot PMI rack and modules (figure 2.8), the Power Interface Board (PIB), a DC Brake/Pre-Charge Control board, and LEM power supplies. The first four slots of the PMI rack contain the Power Supply module, the PMI Processor module, the Resolver & Drive I/O module, and the Medium Voltage Technology module. The remaining four slots contain Gate Driver Interface modules, one for each level of the three-level Inverter and a fourth for the DC brake and auxiliary circuits.

The Power Interface Board (PIB) is the interconnect hub for electrical signals into and out of the Inverter PMI rack. It provides isolation and signal conditioning for PMI feedback signals. Current and voltage feedback from the motor and the DC bus, AC line voltage feedback, RPI, encoder signals, and various analog and digital I/O signals are conditioned by the PIB before being sent to the PMI for processing.

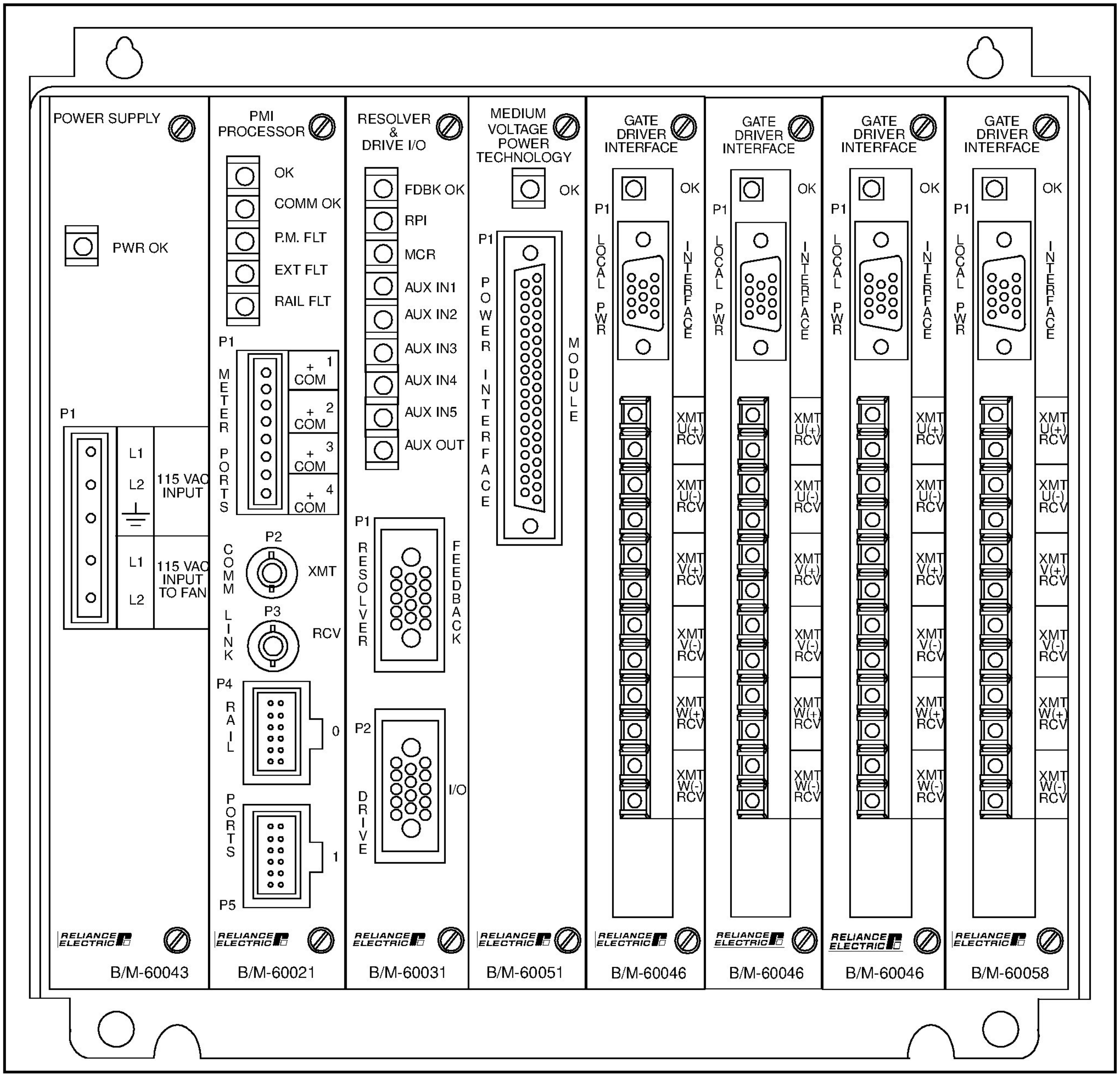


Figure 2.8 – Eight-Slot PMI Rack and Modules (1567 Power Max™ Drives)

CHAPTER 3

Distributed Power System Programming

All Distributed Power Drive application programming is done in the AutoMax environment. This means that the programming tools are incorporated into the AutoMax Programming Executive and that the “master” module in the rack is the AutoMax Processor module.

Also required is the DPS drive software which contains the operating systems for the Universal Drive Controller modules and the Power Module Interface hardware. The software for each unique drive type is a separate product:

- 57C651 SD3000 DPS Software
- 57C652 SF3000 DPS Software
- 57C653 SA3000 DPS Software
- 57C654 SA500 DPS Software
- 57C655 SB3000 DPS Software
- 57C657 SA3100 DPS Software
- 57C650 Shared-User License for DPS Software (5 Users)

3.1 AutoMax Programming Executive Overview

The AutoMax Programming Executive software uses Microsoft™ Windows to provide a graphic environment for all the software functions necessary to configure the hardware in your application and to create, organize, document, and troubleshoot application tasks on a personal computer.

The AutoMax Executive off-line functions are contained within a set of four Windows-based applications:

- **System Configurator** - The System Configurator is used to create, copy, edit, and delete systems, sections, and racks.
- **Rack Configurator** - The Rack Configurator is used to configure AutoMax racks (i.e., place modules in a rack, put racks on a remote I/O network, etc.). For drive control applications, the Rack Configurator is also used to configure drives and enter drive parameters.
- **Variable Configurator** - The Variable Configurator is used to “map” names to I/O and other variables.
- **Task Manager** - The Task Manager is used to create AutoMax user application programs, called tasks. These tasks run on either an AutoMax Processor or, for drive control applications, on a UDC module.

Figure 3.1 shows the AutoMax Executive off-line programming applications.

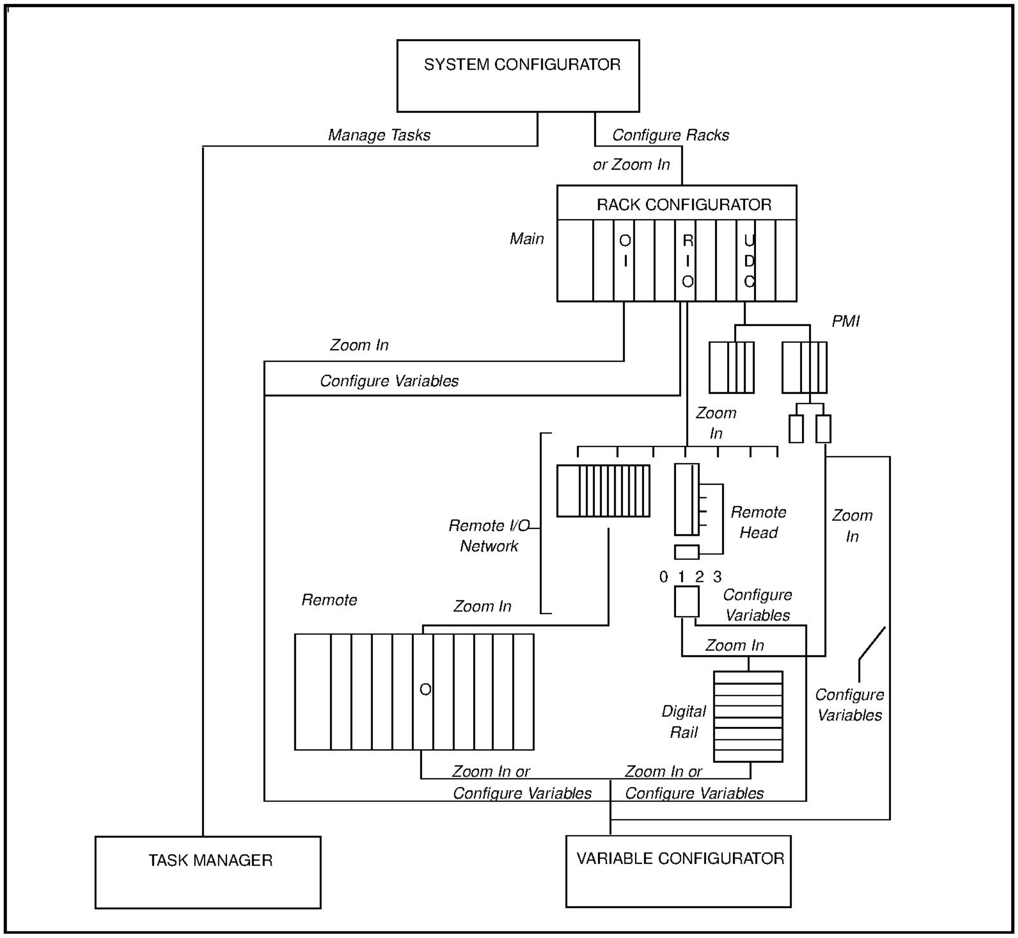


Figure 3.1 – AutoMax Executive Off-Line Programming Applications

3.2 DPS Application Programming

The application programming required for each engineered system is developed in response to each customer’s specifications. Information in this section is general enough to apply to most engineered systems; however, implementation details may vary. Always refer to your wiring diagrams for specific information about your engineered system.

3.2.1 Creating Systems, Sections, and Racks

Before you can begin creating application tasks, you must first define the organization of the hardware in your system using the System Configurator. The System Configurator allows you to define systems, sections, and racks. A system is a name for a project, such as a winder, for example. A section is a group of racks that perform a similar function, such as entry section. Typically, a section represents a network of racks. A rack represents an actual physical rack, with all its I/O and Processor modules.

3.2.2 Configuring Racks and Variables

Once you have documented the system/section/rack structure of your application via the System Configurator, you can begin to configure the hardware in your installation. Hardware configuration consists of adding modules to each rack (including network and remote racks, UDC modules, PMI rail hardware, and drive parameters) to reflect the actual installation.

The AutoMax Executive software checks that modules are added properly. For example, a second AutoMax Processor module can be added only after a Common Memory Module (M/N 57C413 or 57C423) has been added. See figure 3.2.

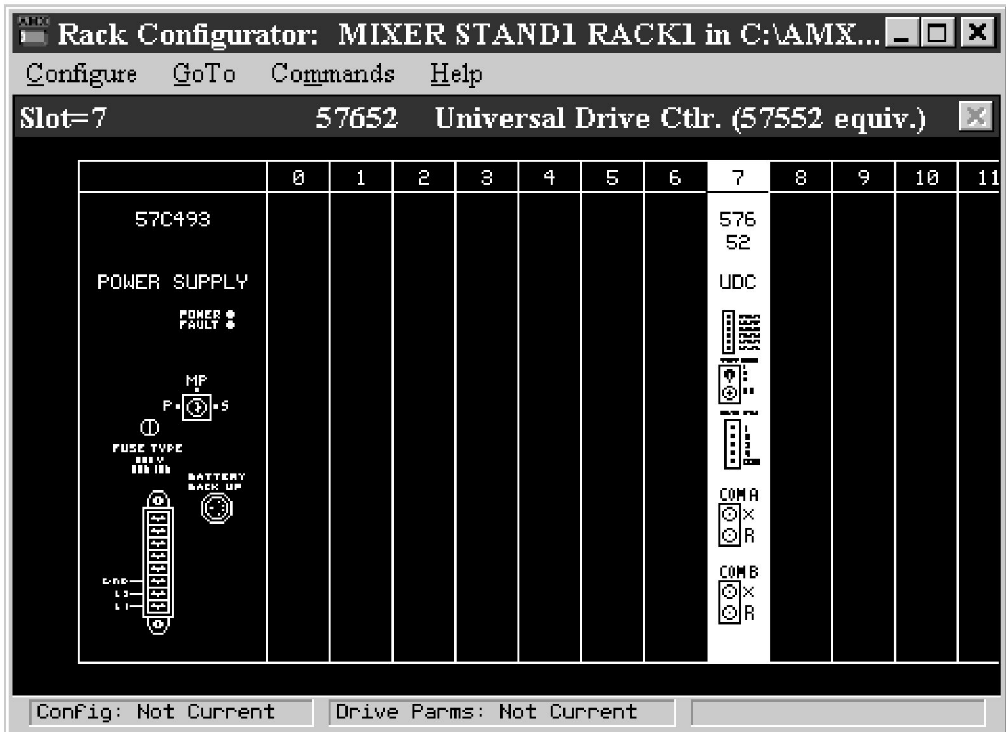


Figure 3.2 – Adding a Module

After you have added a module, you can map variables to I/O points or common memory on that module using one of four types of “forms,” tailored as required for the specific register organization on each module. See figure 3.3. This variable configuration “map,” along with information about the application tasks for the rack, is downloaded to the rack along with application tasks before application tasks can run in the rack.

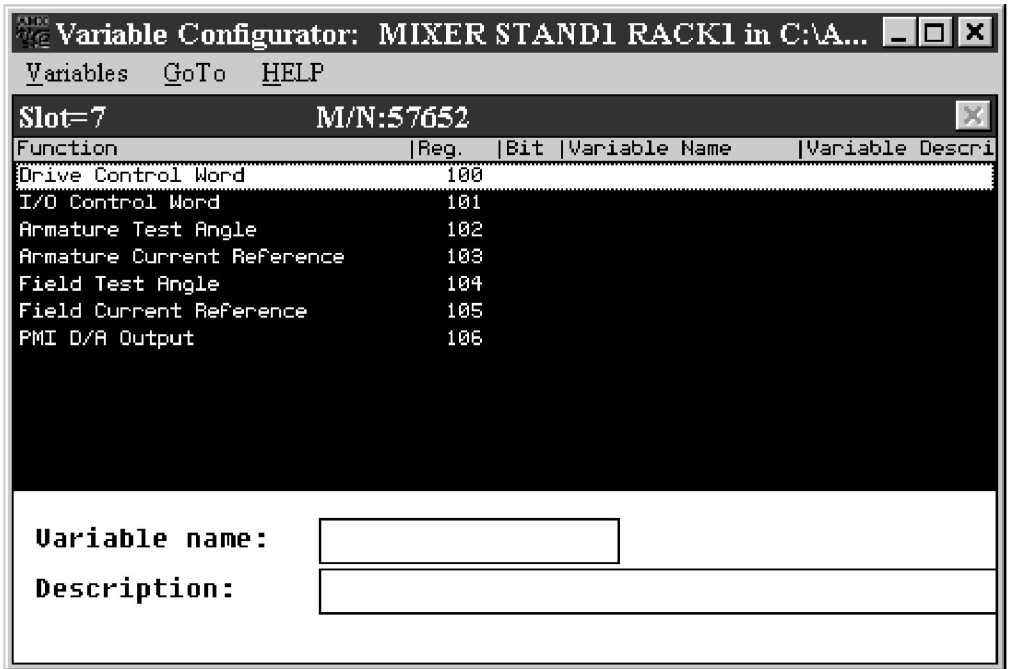


Figure 3.3 – Configuring Variables

After you have completed the physical configuration of your system, you can generate a bill-of-material which lists all of the racks, heads, rails, and modules used in the system along with the needed batteries, cables, and optional hardware and software.

3.2.3 Creating Application Tasks

After you have configured I/O points and common memory using variable names, you can create programs, called application tasks in the AutoMax environment. You can create three types of tasks, BASIC, Control Block, and Ladder Logic tasks. Control Block and BASIC tasks must be compiled before being loaded to the rack.

Application tasks are executed on the AutoMax Processor or UDC module as described below. Each rack is limited to 32 tasks total, distributed among AutoMax Processors and UDC modules. UDC modules are limited to two tasks each.

BASIC Tasks

BASIC tasks are created using the same text editor included with the Programming Executive software. BASIC tasks can be run on the AutoMax Processor.

Control Block Tasks

Control Block tasks are created using the same text editor used for BASIC tasks. Control Block tasks can be run on both the AutoMax Processor and the UDC module. However, Control Block tasks written for the UDC module are restricted to a pre-defined set of blocks within the language. A number of BASIC statements can also be used in Control Block tasks to facilitate inter-task communication.

Ladder Logic Tasks

Ladder Logic tasks are created using a custom editor included with the Programming Executive software. These tasks can run on the AutoMax Processor.

In addition to the language in which they are written, tasks can also be classified by where they execute. Tasks that run on AutoMax Processors (written in any of the three languages) are called **AutoMax tasks**. In DPS systems, AutoMax tasks are generally used for higher-level control, coordination of multiple drives, and sequencing of application tasks in the UDC module.

UDC modules are used to control DPS drives. Each UDC can contain up to two tasks, each independently controlling one drive. Tasks that run on UDC modules (only Control Block tasks) are called **UDC tasks**.

AutoMax tasks can operate on all I/O and common memory variables defined in the rack, including the variables defined in the dual-port memory of all UDCs in the rack. UDC tasks can operate on the variables defined in their own dual-port memory. Both AutoMax and UDC Control Block tasks can be created, compiled, loaded, and monitored in the same way.

3.2.4 On-Line Operations

The on-line functions in AutoMax Executive software enable you to download the object code files (and the operating systems) to the UDC modules in the local rack and to the AutoMax Processors in the local rack as well as over the network. You can run tasks, monitor task status, force or set variables, and view error logs for tasks. Note that before you can go on-line to any rack, the operating systems, or runbases, for the AutoMax Processor module(s) and UDC module(s) must be loaded to the rack. The operating systems are stored in non-volatile memory.

3.3 PMI Software

The PMI operating system executes the control algorithms. It also executes a number of other software routines:

- collects feedback, status, and diagnostic data from the PMI
- manages communication with the UDC module
- when requested by the programmer, determines motor and resolver cabling characteristics

The programmer does not explicitly control the PMI operating system. All of the data and commands that it requires are found in the AutoMax rack configuration and in the UDC task. The programmer provides this information in three ways:

- Drive parameters

  This information describes the type of hardware and electrical characteristics found in the application. It is entered during UDC module configuration.

- Command data

  This information consists of data stored in the UDC dual port memory. The UDC task or an AutoMax task writes to these registers to enable or disable the control algorithm, to request self-tuning of certain system characteristics, and to specify the reference to the control algorithm.

- Pre-defined variables

  This information consists of the pre-defined variables used to store data such as minor loop gain data, resolver calibration data, and diagnostic data. These variables, which vary by drive type, must be defined in every UDC task.

3.4 UDC/PMI Communication

When the UDC module and PMI are first connected over the fiber-optic link, the PMI will request its operating system from the UDC module. As long as the UDC module has its own operating system and the drive parameters are loaded, it will download the appropriate operating system to the PMI.

Communication between the two PMIs (drives A and B) and the UDC module running the corresponding UDC tasks consists of synchronized command and feedback messages sent over the fiber-optic link.

A command message is sent to the PMI by the UDC module at the end of every scan of the UDC task. Each message contains the command data, rail data, and the values of the pre-defined variables that have changed.

A feedback message is sent to the UDC module by the PMI immediately before the beginning of every scan of the UDC task. Each message contains the feedback data, as well as any rail data that has changed from the last message.

APPENDIX A

Glossary

AC contactor: a contactor designed for the specific purpose of establishing and interrupting an AC power circuit.

AC current: current that reverses direction of flow at regular intervals; the measure of the intervals is the frequency (60Hz in US, 50Hz in Europe); available in single phase and three-phase.

AC motor: a motor designed to operate on alternating current; there are two primary types, induction and synchronous.

A/D converter: Analog to Digital converter; a circuit which converts an analog voltage or current to a digital word (series of bits).

adaptive gain: in DC drives, this is a function of the CML. When a drive is in discontinuous conduction, there are periods of low current demand; the SCRs (silicon controlled rectifiers) provide pulses of current instead of continuously flowing current for the armature. Adaptive gain changes the gains based on feedback signals from the Power Module. This allows the drive to maintain optimum control of armature current when current demand is low.

adjustable speed control: the ability to control the operating speed of a motor within a predetermined range.

ambient temperature: the temperature of the air in the area where equipment is stored or operated.

amplitude: the magnitude of a signal or waveform, usually measured zero-to-peak, peak-to-peak, or RMS.

anti-parallel: for Reliance drives, this term defines the configuration of a DC drive Power Module that allows both motoring and regeneration. Also referred to as back-to-back converter configuration.

application task: see **task**.

armature (motors): the rotating, current-carrying part of a DC motor.

armature control: varying the speed of a DC motor (0 to motor base speed) by varying the amount of DC voltage applied to the armature; also called armature voltage control.

armature current: the flow of electrons through the armature windings of a DC motor which produces torque to turn a load.

armature inductance: the inductance of the motor armature circuit in millihenries.

armature resistance: amount of opposition to current flow from the armature circuit. Measured in ohms on a cold motor.

armature voltage feedback: signal proportional to armature voltage. Used to regulate Power Module output.

attenuation: signal reduction inherent in a transmission line or cable over a given distance. The amount of loss is usually stated in decibels per kilometer at a specific wavelength.

back-to-back converter: see **anti-parallel.**

bandwidth (fiber-optic communications): the maximum frequency that can be supported by an optical fiber. This is expressed in Mhz per km of length.

base speed: the speed (RPM) of a DC motor when operating at rated field current, rated armature voltage, and rated armature current.

bend loss (fiber-optic communications): increased attenuation caused by bending a fiber cable at a radius smaller than the recommended bend radius.

bend radius, minimum (fiber-optic communications): radius that a fiber cable can be bent to without damaging the cable.

B/M (Bill of Material): a list of parts, drawings, and instructions to manufacture and assemble them.

braking: retardation and/or dissipation of the kinetic energy of a motor and driven machinery. Braking is required in the following conditions:

1. speed reference change or change in direction of motor
2. overhauling load (the driven load attempts to exceed the reference speed)
3. stopping the motor

Braking can be accomplished in several ways:

dynamic braking: for DC drives, slowing the motor by applying a resistive load across the armature leads after disconnection from the DC supply. This must be done while the motor field is energized. The motor then acts as a generator until the energy of the rotating armature is dissipated.

regenerative braking: returning generated power to the line through the reverse bridge. This provides linear deceleration and is the fastest method of stopping.

motor-mounted or separately-mounted brake: a positive action mechanical friction device. Normal configuration is such that when the power is removed, the brake is set. This can be used as a holding brake. A separately mounted brake is one which is located on some part of the mechanical drive train other than the motor.

breakout cable: a tightly-buffered multifiber fiber-optic cable.

bridge: For Reliance drives, used to describe the entire package of power devices in a Power Module.

buffer (fiber-optic communications): the protective coating over an optical fiber.

buffer (software): a temporary data storage location.

burst (thyristor or gate control): in IEEE usage, a waveform composed of a pulse train.

bus: a conductor, or pair of conductors, used as a path over which information or signals are exchanged.

cascaded loops: a multiple series of nested control loops.

CCLK: the constant clock signal on the AutoMax rack backplane that provides a timing source for modules in the rack. This signal must be driven by only one module in the rack. The constant clock signal on the AutoMax rack backplane is used to synchronize hardware interrupts to AutoMax Processors. This signal is required for the UDC module to be able to execute its tasks.

CEMF: abbreviation for "counter electromotive force," which is the product of a motor armature rotating in a magnetic field. This generating action takes place whenever a motor is rotating. Under stable motoring conditions, this generated voltage (CEMF) is equal to the voltage supplied to the motor minus IR drop. The polarity of the CEMF is opposite to that of the power being supplied to the armature.

channel, fiber-optic: consists of two ports and a transmit cable and a receive cable. The UDC module and PMI provide two channels of fiber-optic communication: COMM A and COMM B.

cladding (fiber-optic cabling): the material that surrounds the fiber-optic cable's core. The cladding has a lower refractive index than the core which optically isolates the core during data transmissions.

closed loop: refers to a control algorithm in which the actual value of the controlled variable (e.g., speed) is sensed and a feedback signal proportional to this value is compared with a reference signal. The difference between these signals (signal error) causes the actual value to change in the direction that will reduce the difference in signals to zero.

CML: see **loop**.

coast to stop: interrupting power and control to the drive, resulting in the drive slowing to a stop due to windage and load friction.

COMMON (variable): a variable that is defined in the rack configuration and is therefore accessible to all AutoMax application tasks in the rack. UDC tasks cannot automatically access common variables. UDC tasks can access only their own dual port memory.

constant HP range: the range of speeds within which a motor produces constant horsepower. In this range, torque is inversely proportional to speed.

constant torque range: the range of speeds within which a motor can maintain rated torque. Horsepower varies directly with speed.

contactor: a two-state (on-off) device for establishing and interrupting an electrical power circuit. Interruption is obtained by introducing a gap or a very large impedance.

continuous conduction: the point at which there is an uninterrupted flow of current to the motor.

control algorithm: In general, software that regulates a quantity such as voltage, power, speed, etc., at a set value or between certain close limits. Also called regulator.

converter: used generally to mean a machine or device for changing AC to DC, or vice versa, or from one frequency to another. See also **rectifier**.

core (fiber-optic cabling): the center of a cable which carries optical signals. The core has a higher refractive index than the cladding.

CURRENT (in BASIC language LOCAL statement): when shown in uppercase, this refers to the parameter in the Local Tunable BASIC statement. The CURRENT value is the value the Local Tunable variable will have for the next scan.

current limiting: an electronic method of limiting the maximum current applied to the motor; can also be preset as a protective measure to protect both the motor and control from extended overloads.

current minor loop (CML): See **loop**.

D/A converter: digital to analog converter; a circuit which converts a digital word (series of bits) to an analog voltage or current.

damping: the reduction or suppression of the oscillation of a system.

dead time: the time interval between initiation of an input and the start of the resulting response.

decibel (dB): a unit for measuring the relative power of a signal.

di/dt: the change in current versus a change in time.

dielectric: a non-metallic, non-conducting substance; insulation.

discontinuous conduction: the region in which current to the motor does not flow continuously, but flows intermittently.

dispersion (fiber-optic cabling): the spreading of optical pulses in a single-mode fiber.

DPS: Distributed Power System.

drive: the means or apparatus for transmitting motion to a machine or machine part; for Distributed Power Systems, the combination of a PMI and a Power Module.

drive regulator group: sometimes used to mean DCS Drive Regulator. This consists of the Drive Controller module (B/M O-57406), Drive Analog I/O module (B/M O-57405), Drive Digital I/O module (B/M O-57401), and Power Module Interface module (B/M O-57408).

D/S (Dimension Sheet): drawings providing outline dimensions, mounting information, and other mechanical information about a part or an assembly.

dual port memory: memory accessible to two or more microprocessors. The UDC module has dual port memory that can be accessed by the UDC microprocessor and AutoMax Processors in the rack.

duty cycle: a description of the variation of load with time.

dv/dt: the change in voltage versus the change in time.

dynamic braking: see braking.

EMF: electromotive force; voltage or potential difference. In DC adjustable speed drives, voltage applied to the motor armature from the power supply is the EMF, and the opposing voltage generated by the speed of the motor is the counter-EMF (CEMF).

E-stop: emergency stop.

feeder: the power lines "feeding" power to drive; one feeder may send power to more than one drive.

fiber (fiber-optic cabling): a single optical element which is composed of a core and a cladding.

fiber optics: light pulse transmission through optical fibers.

field (winding): a stationary electrical winding of a DC motor; wired in parallel (shunt) or in series with the armature.

field control: method of controlling the speed and torque of a DC motor by means of a change in the magnitude of the field current.

field minor loop (FML): see **loop**.

field reversing: one method of producing reverse torque for regeneration or reverse rotation; it is accomplished by changing the direction of current through the motor field, which reverses the polarity of the motor CEMF to account for generator action.

field weakening: the action of reducing the current applied to a DC motor shunt field. This action weakens the strength of the magnetic field while decreasing the available motor torque.

firing angle: a point in time where the SCR is triggered into conduction.

flash (memory): a type of memory that does not require battery back-up. Used in the UDC module.

FML (field minor loop): see loop.

four-quadrant operation: See quadrant, Form D - Type IV.

full-load current: the armature current of a DC motor at full torque rating at full field.

full-load speed: motor base speed.

full-wave rectification: rectifying the positive half-cycle of the AC sine wave and the negative half-cycle of the AC sine wave (by inversion) so that the output voltage contains two positive half-sine pulses for each AC input voltage cycle.

gain: ratio of output to input. In Distributed Power systems, gain values are held in pre-defined Local Tunable variables. Values can be generated by the PMI via self-tuning commands.

gate: the control element of a power device. When a small positive voltage is applied to the gate momentarily, a power device will conduct a current.

half-wave rectification: rectification of one-half of the AC input waveform, typically the positive half. See also full-wave rectification.

horsepower (HP): a measure of the amount of work that a motor can perform in a given period of time.
1 HP = 0.746 KW = [Torque (lb.-ft.) x Speed (RPM)] / 5250.

IGBT (insulated gate bipolar transistor): a high-frequency switching device controlled by voltage applied to the gate terminal.

induction motor: An alternating current motor in which the primary winding on one member (usually the stator) is connected to the power source. A secondary winding on the other member (usually the rotor) carries the induced current. There is no physical electrical connection to the secondary winding, its current is induced.

integrator: a device which provides an output which is a summation of inputs over time.

IR compensation: a circuit used to compensate for the voltage drop across the resistance of the AC or DC motor circuit and reduce or eliminate the resultant reduction in speed with loading; also provides a way to improve the speed regulation characteristics of the motor. Drives that use a tachometer-generator for speed feedback do not use an IR compensation circuit because the speed regulator, via the tachometer, will inherently compensate for the loss in speed.

IR drop (motor): the voltage drop equal to the product of the armature current passing through the motor and the armature resistance of the motor. Expressed in percent of rated voltage.

jacket: in cabling, a layer of plastic insulation surrounding the wires comprising the cable.

jog: in drive control, non-maintained, momentary low speed operation of a drive in order to accomplish a small movement of the driven machine.

LED (light emitting diode): a semiconductor device that produces diffused light. The LED’s light intensity is proportional to the amount of current flowing through it.

light detector: a fiber-optic component that converts light energy into electrical energy. Light detectors can be semiconductor photodiodes or phototransistors.

light source: a fiber-optic component that converts electrical energy into light energy. Light sources can be light emitting diodes (LEDs) or injection laser diodes.

linearity: a measurement of how closely a ratio (e.g., output/input) follows a straight line.

link (fiber-optic): in Distributed Power systems, the fiber-optic cabling which connects a UDC module to a PMI.

LOCAL (variable): a variable that is not defined in the rack configuration and is therefore accessible only to the application task in which it is defined.

loop: a control scheme in which a reference input to a device is compared to a feedback signal from the device for purpose of regulation. Any error is amplified to affect the input to the device to reduce the error. All other “functions” in the loop can be viewed as gain functions.

> **inner loop**; a control loop between the major and minor loops.
>
> **major loop**; also called **outer loop**: For Distributed Power drive systems, refers to the application task that provides reference values to the control algorithms in the PMI. The major loop(s) execute on the UDC module or AutoMax Processor. If they execute on the UDC module, they are called UDC tasks.
>
> **minor loop**: synonym for control algorithm. Executes on the PMI.

Manchester encoding: a means by which separate data and clock signals can be combined into a single, self-synchronizable data stream, suitable for transmission on a serial channel.

maximum recommended pulling tension (fiber-optic cabling): the maximum load which can be applied along the axis of a cable without breaking the fibers.

M-contactor: a contactor used to switch power to/from the motor and/or drive.

megohmmeter (megger): a direct-reading instrument, scaled in megohms, for measuring electric resistance.

microbend loss: attenuation caused by excessive cable bending or manufacturing flaws.

micron: one-millionth of a meter (10^{-6})

minimum loaded bend radius (fiber-optic cabling): the smallest radius to which a cable can be bent during installation.

minimum bend radius: the smallest radius that cable can be bent to without damaging the fiber; usually 10% of the loaded bend radius.

mode (DPS drive control): a PMI operating state.

mode field diameter (fiber-optic cabling): the actual diameter of a single-mode fiber through which light travels.

motoring: mode of operation wherein the motor is delivering power to a mechanical load. Motor rotation and torque are both in the same direction.

motor load: the horsepower (speed and torque) required to drive a machine.

multimode (fiber-optic cabling): a type of light propagation in which all of the light rays do not travel in parallel with the axis of the fiber. Since the light rays follow different paths in the fiber, their transit times will differ. The difference in transit times results in a specific bandwidth that the multimode fiber can support.

nanometer: one-billionth of a meter (10^{-9}).

NEC: National Electrical Code; the recommendations of the National Fire Protection Association, revised every three years. City or state regulations may differ from NEC recommendations and take precedence over them.

NEMA: National Electrical Manufacturers Association; a non-profit organization whose members include manufacturers of electrical equipment and supplies. Some of the standards NEMA specifies are: HP ratings, speeds, frame sizes and dimensions, torques, and enclosures.

numerical aperture (of optical fiber): the range of angles at which a light beam must enter a fiber cable in order to be reflected and transmitted; a measure of the angular acceptance of a fiber; the light-gathering capability of the fiber.

operating system (OS): sometimes called “runbase.” In DPS, all Processors, UDC Modules, and PMIs require operating systems.

optical power: the power emitted from a light source into a fiber-optic cable; defined in watts but usually expressed in decibels.

optical power budget: the total amount of optical power available from the fiber-optic transmitter less the losses present in the fiber-optic link.

OS: see operating system.

overshoot: the amount that a controlled variable exceeds the desired value after a change of input.

overspeed: a speed greater than rated or desired maximum speed (RPM).

parameter (Distributed Power drives): a value used to represent a drive or motor characteristic, such as “maximum motor RPM” or “current transformer turns ratio.” Also, in BASIC language LOCAL tunable statements, a value that defines one of the limits within which a variable can be adjusted, for example, the “HIGH” limit.

phase angle: the displacement between periodic waves of the same frequency.

phase control: in rectifier circuits, the process of varying the point (firing angle) within the cycle at which forward conduction is permitted to begin through the rectifier circuit element.

phase-crossover frequency: the frequency at which the phase angle reaches 180 degrees.

phase lag (delay) or **phase lead**: phase angle of the input wave relative to the output wave.

phase sequence: the order in which the AC line voltages (line to neutral) successively reach their positive maximum values.

phase sequence reversal: a reversal of the normal phase sequence of the AC power supply. Can be accomplished by the interchange of any two lines on a three-phase system.

phase shift: the phase angle difference between two sinusoidal signals of the same frequency. Also, the displacement between corresponding points in similar wave shapes, expressed in degrees lead or lag.

phase, single (AC circuits): a circuit energized by a single AC source. Usually supplied through two wires; the currents in these two wires counted outward from the source differ by 180 degrees, or a half cycle.

phase, three (AC circuits): a combination of three AC signals which differ in phase by one-third of a cycle (120 degrees). Usually supplied through three or four wires.

polyphase (AC circuits): an AC circuit consisting of more than two intentionally inter-related conductors.

quadrant: in power rectification, used to designate the functional characteristics of converters. There are four types:

> Form A - Type I: single converter unit in which the DC current can flow in one direction and is incapable of “inverting” energy from the load to the supply; operates in 1 quadrant.
>
> Form B - Type II: double converter unit in which the DC current can flow in either direction but which is not capable of inverting energy from the load to the AC supply; operates in quadrants 1 and 3 only.
>
> Form C - Type III: single converter unit in which the DC current can flow in one direction only and which is capable of inverting energy from the load to the AC supply; operates in quadrants 1 and 4.
>
> Form D - Type IV: a double converter unit in which the DC current can flow in either direction and which is capable of inverting energy from the load back to the AC supply; operates in all four quadrants.

rectification: the process by which electrical energy is converted from an alternating-current circuit to a direct-current.

rectifier: a type of converter that changes AC to DC. Usually consists of an anode and a cathode; conducts current in one direction only.

regeneration: the characteristic of a motor to act as a generator when the CEMF is larger than the drive’s applied voltage (DC drives) or when the rotor synchronous frequency is greater than the applied frequency (AC).

regenerative braking: see braking.

regulator: in general, a piece of hardware or software that regulates a quantity such as voltage, power, speed, etc., at a set value or between certain close limits.

resolution: the least value of a measured quantity which can be detected.

reversing: changing the direction of rotation of the motor armature or rotor. An AC motor is reversed by swapping two of the three motor leads. A DC motor is reversed by changing either the polarity of the voltage applied to the field or the armature, but not both. The reversing function is performed in one of the following ways:

> **contactor reversing** changes the polarity of the voltage applied to a DC motor armature with switching contactors. The contactors are operated by momentary push-buttons and/or limit switches to stop the motor and change directions. A zero speed (anti-plugging) circuit is associated with this system to protect the motor and control.
>
> **field reversing** changes the DC polarity applied to the motor shunt field. This type of reversing can be accomplished with DC-rated contactors or by means of an electronically controlled solid-state field supply.
>
> **manual reversing** is reversing the polarity to the DC motor armature by manually changing the position of a multi-pole switch.
>
> **static reversing** is reversing the polarity of the motor with no mechanical switching. This is accomplished electronically. Only regenerative drives are capable of static reversing.

RISC: Reduced Instruction Set Computer, a type of high-speed microprocessor.

runbase: see **operating system**.

S2: Reliance name for a single-phase field Power Module.

S2R: Reliance name for a single-phase regenerative field Power Module.

S6: Reliance name for a three-phase armature Power Module.

S6R: Reliance name for a three-phase regenerative armature Power Module.

scan: a single run-through (execution) of an application task.

SCAN_LOOP: a Control Block statement that is used to specify how often a Control Block task should run.

Scans-Per-Interrupt (SPI%): the name of a register (2001) in the UDC module that specifies how many scans of the UDC task should elapse between updates of application registers in the dual port, and optionally, between interrupts to an AutoMax Processor.

scan time: how often an application task in an AutoMax Processor or UDC module should execute. The scan time is calculated by multiplying how often the task should execute (in ticks) by the tick rate (Ticks x Tick Rate).

SCR: see **silicon controlled rectifier**.

series-wound: DC motor in which field excitation is supplied by a winding connected in series with the armature.

service factor: how much over the nameplate rating the motor can be run without overheating. The number is a multiplier of the horsepower, or a percentage of the horsepower in addition to 100% horsepower.

shunt: usually refers to a calibrated meter shunt that produces a low-voltage signal proportional to the current flow through it.

shunt wound: a DC motor or generator in which field excitation is supplied by a winding which may be connected in parallel with the armature, but is normally separately excited.

silicon controlled rectifier (SCR): a solid-state switch, sometimes referred to as a thyristor. The SCR has an anode, cathode, and control element called the gate. The device provides controlled rectification. The SCR can rapidly switch large currents at high voltages.

skeleton file: in AutoMax Programming Executive software, a template file that provides the required statements for each type of AutoMax or UDC task or documentation file. The appropriate skeleton file can be copied into a new task to provide a starting point for developing the task. The Programming Executive contains skeleton files for the following: the BASIC language Include task (SKELETON.INC), AutoMax Control Block (SKELETON.BLK), PC/Ladder Logic (SKELETON.PC), UDC Control Block (SKELETON.UDC), BASIC (SKELETON.BAS), and documentation files (SKELETON.DOC).

snubber: auxiliary circuit element used to modify transient voltage or current of a semiconductor device. There are three types: shunt, series, and polarized.

speed loop: an outer control loop using a speed-sensing device to provide speed feedback for comparison to the speed reference.

speed range: all the speeds that can be obtained in a stable manner by action of the control equipment governing the performance of a motor. The speed range is generally expressed as the ratio of the maximum to the minimum operating speed.

speed regulation: the numerical measure in percent of how accurately the motor speed can be maintained. It is the percentage of change in speed between full load and no load.

squirrel-cage motor: a type of induction motor. See **induction motor**.

starting torque: the torque produced by the motor during the starting period.

surge protection: a form of electrical protection in which an abnormal condition causes disconnection or inhibits connection of the protected equipment in accordance with the rate of change of current, voltage, or power.

surge suppressor: a device that operates to limit the surge of current, voltage or power to limit the rise of such quantity (usually voltage) above a predetermined level.

synchronize: to establish a common time base; in DPS communications, the term is also used to mean to establish communication between the UDC module and PMI such that feedback messages arrive at the UDC module just before it executes the UDC task.

task: an application program that runs on an AutoMax Processor or UDC module.

> **AutoMax task**: an application task that runs on an AutoMax Processor; AutoMax tasks are executed on a priority basis, and share all system data. Application tasks on different AutoMax Processors in the rack are run asynchronously.

UDC task: an application task written in Control Block language that runs on a UDC (Universal Drive Controller) module. This task usually consists of an outer control loop and associated logic.

thermal overload relay: an overload relay that functions (trips) in response to the temperature rise in the sensing element caused by excessive current.

thyristor: device controlling the current through the Power Module. Synonymous with silicon controlled rectifier in Reliance documentation.

thyristor assembly: an electrical and mechanical assembly of thyristors which includes additional components such as heat sinks.

tick: for AutoMax Processors, a unit of time ranging from 0.5 milliseconds to 10 milliseconds (in.5 millisecond increments). The programmer assigns a tick rate to the AutoMax Processor. The Universal Drive Controller operates at a fixed tick rate of 0.5 milliseconds.

tunable (variable): a local variable whose value can be tuned, i.e., changed within limits, by the operator through the use of the AutoMax Executive software. The value of a tunable variable cannot be changed by application tasks.

undershoot: the amount that a controlled variable is less than the desired value after a change of input.

velocity of propagation: the transmission speed of optical energy in a length of fiber-optic cable compared to the speed of light in free space.

watchdog: a device or routine which continuously verifies that a microprocessor is running.

W/D (Wiring Diagram): reference drawing, including schematic diagrams, component locations, rating tables, and replacement parts tables for standard assemblies included in a drive system.

W/E (Elementary Diagram): schematic diagram showing electrical connections of electronic and electrical devices in a drive system.

W/F (Flow Diagram): diagram showing the relationship between the drive sections, motors, regulation schemes, and mechanical components in block format. This drawing type may also show the network and remote I/O arrangement, as well as any other communication lines, in a single line diagram format.

W/I (Interconnection Diagram): diagram showing all interconnecting field wiring between individual assemblies or components provided by Reliance. These diagrams are provided optionally in place of the special cabling instructions in the elementary diagrams (W/E).

W/L (Panel Layout Diagram): diagram showing the physical arrangement of the electrical devices on each control panel, including customer connection terminals with wire numbers.

W/M (Motor Control Center Diagram): diagram showing the physical location of the units or compartments within each motor control center and the reference elementary diagram (W/E) for each unit.

W/N (Note Sheet): installation wiring instructions and definitions of the standard notes and nomenclature used in the drawings. The notes indicate the location of the components or subassemblies that may be separately mounted.

W/O (Operator's Station Diagram): diagram showing the arrangement of the devices on an operator's station and the location of field terminals with wire numbers.

W/P (Program Documentation): block diagrams of application tasks.

W/S (Construction Drawing): drawings that provide the information required for the installation of Class A or Class B open Mill Control or for Mill Control Houses. These drawings show the overall dimensions of each assembly, the mounting details, and conduit entry locations.

W/X (Index Sheet): sheet that lists the description, last revision date, drawing number, and sheet number for all drawings in the sales order. This sheet provides a means of identifying the date of (or on) all prints.

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