# Distributed Power System SA500 Drive Diagnostics, Troubleshooting, and Start-Up Guidelines

Instruction Manual S-3022-1

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 on the outside margin of this page will be used throughout this instruction manual to signify 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.

**ATTENTION:** DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power from the DC bus supply, wait five (5) minutes and then measure the voltage at the POS and NEG terminals of the DC bus supply and each Power Module 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:** For brushless motor applications, changing any resolver wiring, breaking the resolver coupling, replacing the resolver, or replacing the motor and resolver for any reason requires that the shaft alignment test be performed again. Resolver wiring changes always affect shaft alignment. A resolver change and/or a new motor/resolver combination will affect the shaft alignment. Improper shaft alignment can cause motor overspeed when the motor is started. Failure to observe this precaution could result in bodily injury.

**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:** Inserting or removing a module or its connecting cables may result in unexpected machine motion. Turn off power to the rack before removing a module or its connecting cables. Failure to observe these precautions could result in bodily injury.

**ATTENTION:** Only qualified Rockwell personnel or other trained personnel who understand the potential hazards involved may make modifications to the rack configuration, variable configuration, and application tasks. Any modifications may result in uncontrolled machine operation. Failure to observe these precautions could result in damage to equipment and bodily injury.

**ATTENTION:** Registers and bits in the UDC module that are described as "read only" or for "system use only" must not be written to by the user. Writing to these registers and bits may result in improper system operation. 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 user's manual is subject to change without notice.

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# CHAPTER 1

# Introduction

This instruction manual is divided into two sections: 1) a description of SA500 drive diagnostics and troubleshooting, 2) start-up guidelines. This manual is intended for users of SA500 drives who have training and experience in AC drive control and who are familiar with all other SA500 drive documentation.

The diagnostics and troubleshooting chapters (chapters 2-3) describe the error checking built into the PMI Regulator operating system and how to use warning and fault registers, LEDs, and the error log to diagnose drive problems.

Chapter 4 provides guidelines on starting up Distributed Power SA500 AC drives. Although initial start-up services are usually provided by Rockwell personnel, it is recommended that the user become familiar with the general guidelines in this chapter in order to be better prepared to work with the Rockwell service engineer.

This manual does not describe specific applications of the standard SA500 hardware and software. Always refer to the wiring diagrams supplied with your system for information specific to your installation.

## 1.1 Related Publications

You user must become familiar with the other instruction manuals that describe the SA500 drive system. The documentation that describes the SA500 drive is listed in table 1.1.

Table 1.1 – SA500 Documentation (Binder S-3002)

| Document | Document Part Number |
|---|---|
| DPS Overview | S-3005 |
| Universal Drive Controller Module | S-3007 |
| Fiber Optic Cabling | S-3009 |
| SA500 DC Bus Supply | S-3017 |
| SA500 AC Power Modules | S-3018 |
| SA500 Diagnostics, Troubleshooting, & Start-Up Guidelines | S-3022 |
| SA500 Information Guide | S-3024 |
| SA500 Drive Configuration & Programming | S-3044 |

Additional information about using the SA500 drive is found in the prints and other documentation shipped with each drive system. Always consult the prints and other documents shipped with your drive system for specific information about installing, operating, and maintaining your drive.

## 1.2 Typographical Conventions

The following typographical conventions are used in this manual:

- Variable names

  Variables names are shown in all capital letters followed by the appropriate terminating character. The variable names shown in this manual are suggested names only and may vary from the names used in your application.

  Example: MCR@

- Register names

  Register names are shown with the initial letters capitalized followed by the corresponding register number for both drive A and drive B. The drive A register number is shown first followed by the drive B register number (A/B).

  Example: Drive Fault register (202/1202)

- Bit names

  Individual bit names are shown with the initial letters capitalized. Also shown, in parentheses, is the bit's register number, bit number, and suggested variable name.

  Example: Fault Reset bit (register 100/1100, bit 8, FLT_RST@)

- Parameter entry screen titles

  Parameter entry screen titles and the parameters themselves are shown with the initial letters capitalized.

  Example: Feedback Data parameter entry screen

# CHAPTER 2

# Diagnostics and Troubleshooting

The Distributed Power System contains built-in comprehensive diagnostics. In order to diagnose and correct problems quickly, it is important to understand the types of diagnostics that are performed, when they are performed, and how the results are reported. This chapter describes the different types of diagnostics performed by the system's modules and how the results of these diagnostics are reported. This chapter also describes how the system reacts if an error is detected.

An overview of these modes is shown in figure 2.1. The Distributed Power System provides diagnostics at each level of operation as shown in figure 3.1.

Use these figures as a reference to quickly identify the system's requirements for entering and operating in each mode. These figures also refer to specific sections in the manual that provide additional information.

## 2.1 Definition of Terms Used in Diagnostics and Troubleshooting

For the purpose of describing diagnostics and troubleshooting, this instruction manual will use specific terms to refer to the types of errors that can be detected by the PMI and the response of the PMI and UDC module to those errors.

A **diagnostic** is a software routine specifically designed to check for error conditions. There are three types of diagnostics in SA3100 drives: power-up diagnostics, interlock diagnostics, and run-time diagnostics.

A **drive fault** is an error specifically checked for by the PMI operating system that will shut the drive down. Faults are reported in the Drive Fault register (202/1202) of the UDC module and in the error log for the UDC task in which the fault occurred.

A **drive shut-down** occurs when any fault reported in the Drive register (202/1202) occurs.

A **drive warning** is an error specifically checked for by the PMI operating system that indicates the drive is not operating in an optimum manner. Drive warnings will not shut the drive down.

An **error** is any condition other than the desired condition.

**Interlock diagnostics** are those diagnostics performed by the PMI operating system in response to a drive control request from the programmer, e.g., PMI_RUN@, in register 100/1100 of the UDC module dual port memory.

**Power-up diagnostics** consist of the initial tests for basic functionality performed by all printed circuit board modules.

**Run-time diagnostics** are those diagnostics performed continuously by the PMI as a background task after it has received its operating system from the UDC module.

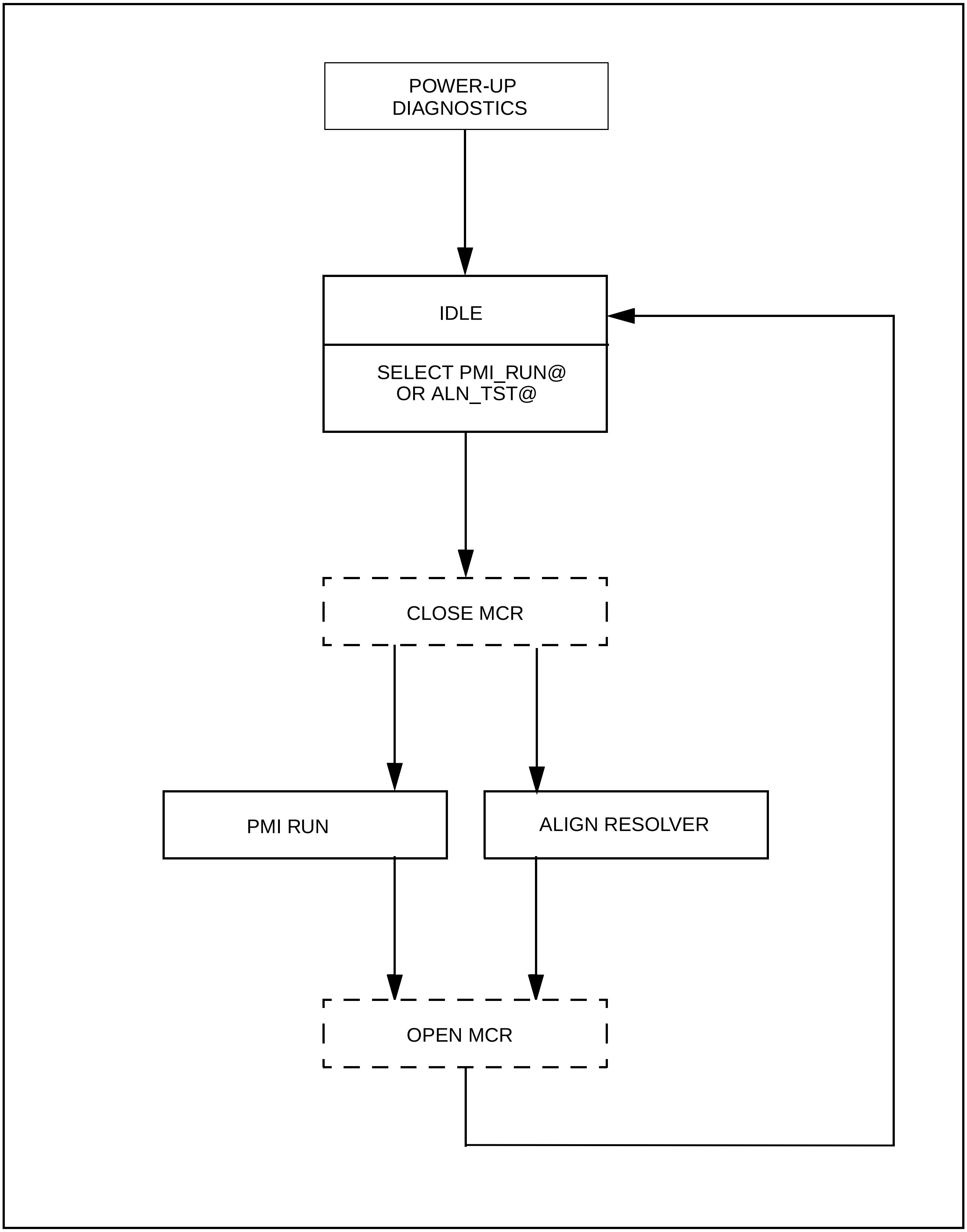


Figure 2.1 – PMI Operating Modes Overview

## 2.2 Power-up Diagnostics in the UDC Module and PMI

Power-up diagnostics execute in the UDC module in the AutoMax™ rack and in the PMI in the Power Module. When power is applied to the AutoMax rack, the UDC module performs a series of self-tests. When all of the tests are successfully completed, the CARD OK LED on the UDC module's faceplate will turn on. If a failure occurs, the OS OK LED will flash rapidly.

When power is applied to the Power Module, the PMI performs a series of self-tests. When all of the tests are successfully completed, the OK LED on the Power Module's faceplate will turn on. If a failure occurs, the P.M. FLT LED on the Power Module will flash rapidly.

If a UDC module or a Power Module does not pass its power-up tests, it must be replaced. After all of the power-up tests are passed, the system continues its power-up routine. The PMI requests the appropriate operating system from the UDC module. The UDC module downloads the operating system and the parameter configuration data, if available, to the PMI. The PMI then runs under the control of its operating system and begins performing the run-time diagnostics. Run-time diagnostics are described in section 2.4.

## 2.3 Interlock Tests

Interlock tests are performed by the PMI whenever one of the PMI's operating modes is selected by the programmer through the Drive Control register (100/1100). These diagnostics verify that all conditions required for the operating mode selected are satisfied. If the interlock tests are completed successfully, then the operating mode requested by the programmer can be entered. If any of the interlock diagnostics fails, the PMI will latch a bit in the Interlock register (205/1205) corresponding to the first diagnostic test that failed, and the requested operating mode will not be entered (i.e., the PMI will remain in the idle mode).

If an interlock test failure occurs, follow the procedure below:

Step 1. Reset the command bit that is currently set in the Drive Control register (100/1100).

Step 2. Correct the condition that caused the test failure.

Step 3. Set the desired command bit in the Drive Control register (100/1100).

The PMI will perform the interlock tests each time a rising edge is detected on the command bits. The results of subsequent interlock tests will overwrite the previous test's results.

## 2.4 Run-time Diagnostics

Run-time diagnostics are performed continuously by the PMI after its operating system has been downloaded by the UDC module. These diagnostics test the status of the PMI and the connected hardware and also check the integrity of the communication link between the UDC module and the PMI.

The results of the diagnostics are stored in either the Drive Warning register (203/1203) or the Drive Fault register (202/1202) in the UDC module's dual port memory. How drive faults and drive warnings are indicated and how they affect the operation of the drive is described in the following sections.

## 2.4.1 Drive Faults

When the PMI detects any of the conditions identified in the Drive Fault register, it will shut down the drive as described below. To determine the cause of a drive shutdown, the following indicators are provided:

- Drive Fault register (202/1202)

The PMI will set a bit in the Drive Fault register to indicate the condition that caused the shutdown. The interlock tests check this register for fault conditions that have occurred. Refer to Appendix A for a complete description of the Drive Fault Register.

- Drive Status Register (200/1200)

The PMI will set the Fault Detected bit (bit 8, FLT@) of the Drive Status register when a drive fault has been detected.

- LEDs on the UDC module

If either LED (DRV FLT A or DRV FLT B) is on, a drive fault has been detected for the drive using that communication channel.

- LEDs on the Power Module

The Power Module's faceplate contains 15 status/fault LED board. Refer to Appendix E for LED definitions.

- Error log for the UDC task

The error log for the task in which the fault occurred is accessed through the ON LINE menu of the AutoMax Programming Executive. A list of the drive fault error codes can be found in Appendix D. Refer to appropriate AutoMax Programming Executive instruction manual for more information regarding the Programming Executive and the ON LINE menu.

### 2.4.1.1 How the System Reacts to Drive Faults

As described in section 2.4.1, if the PMI detects any of the conditions identified by the Drive Fault register, it will shut down the drive. This means that the PMI responds by immediately disabling the gates of the power devices, causing the motor to begin a coast-to-rest stop. The PMI will wait 100 msec after the fault before turning off the MCR output.

Note that the UDC task is not stopped automatically is a drive fault causes a shut-down of the drive. The user must ensure that the application task(s) test the Drive Fault register (202/1202) and takes any appropriate action if a fault is detected.

#### 2.4.1.2 MCR Output Control

The MCR output on the Power Module is used to control an output contactor. This output contactor, sometimes referred to as an M-contactor, disconnects power from the motor. This option is selected during UDC module parameter configuration. If the programmer selects to connect the MCR output to an output contactor, auxiliary contacts from this device must be wired to the AUX IN1/MFDBK input as feedback. The PMI operating system will wait for AUX IN1/MFDBK to turn on before executing any operating mode.

The Run Permissive input (RPI) on the Power Module and the MCR output are interlocked in hardware. The MCR output can be turned on only when the RPI is asserted. The MCR output itself is under the control of the PMI. Application tasks have no direct control of the MCR output. RPI is controlled by the user. When RPI is off, MCR cannot be activated.

The following conditions will cause the MCR output to turn off:

- Absence of the RPI signal
- Occurrence of a drive fault
- Control algorithm is turned off (PMI_RUN@ = 0)

When any of the above conditions occurs, the PMI will disable the power device gates and the motor will begin a coast-to-rest stop. The PMI will wait 100 msec and then turn off the MCR output.

In addition, if the RPI signal is removed, the MCR output and gate power will be removed under hardware control within approximately 0.5 seconds of the removal of the RPI signal to provide an additional interlock. This is done regardless of the actions taken by the PMI.

### 2.4.2 Drive Warnings

The PMI will check for conditions that are not serious enough to shut down the drive, but may affect its performance. If the PMI detects any of the conditions described in the Drive Warning register, it will set the appropriate bit but will NOT shut down the drive. The user must ensure that the application task tests the Drive Warning register (203/1203) and takes any appropriate action if a warning condition is detected.

The PMI will also set the Warning Detected bit (register 200/1200, bit 9, WRN@) if a drive warning has been detected.

Appendix B provides a complete description of the Drive Warning register. Except for rail faults, drive warnings are not indicated by LEDs (a rail fault will turn on the RAIL FLT LED on the Power Module). Drive warnings are not displayed in the UDC task's error log.

### 2.4.3 How to Clear the Drive Fault and Drive Warning Registers

After a drive fault has been detected, the programmer must do the following before the drive can be restarted:

Step 1. Reset the command bit that is currently set in the Drive Control register (100/1100).

Step 2. Correct the fault.

Step 3. Set and reset the Fault Reset bit (register 100/1100, bit 8, FLT_RST@) to clear the Drive Fault register (200/1200). (Note that the Fault Reset bit is edge sensitive.)

Step 4. Set the desired command bit in the Drive Control register (100/1100).

After a drive warning has been detected, the programmer can clear the entire Drive Warning register by setting and resetting the Warning Reset bit (register 100/1100, bit 9, WRN_RST@). (Note that the Warning Reset bit is edge sensitive.)

# CHAPTER 3

# PMI Operating Modes

The PMI's default operating mode is idle. All other operating modes are selected by the programmer in the Drive Control register (100/1100). Table 3.1 shows the available operating modes. Note that the operating modes are mutually exclusive, i.e., only one mode may be enabled at a time (this is checked by the interlock tests).

The PMI's operating modes are shown in figure 3.1 and are described in the following sections.

Table 3.1 – PMI Operating Modes

| Operating Mode | Drive Control Register Bit | Mode Description |
|---|---|---|
| Idle | N/A | The PMI’s default operating mode during which no algorithms are running. |
| PMI Run | 0 | Executes the torque, speed, or position control algorithm. |
| Alignment Test | 1 | Enables the resolver alignment procedure for brushless drives. |

## 3.1 Idle Mode

The PMI's default operating mode after passing the power-up diagnostics is idle. When in idle mode, the PMI is waiting for a command from the Drive Control register (100/1100) to change operating modes.

In order for the PMI to enter the requested operating mode, the Interlock tests must be passed. If any of the Interlock tests fails, or if any fault is latched in the Drive Fault register (202/1202), the PMI will remain in the idle mode.

The PMI will return to the idle mode when it exits any of the other operating modes.

## 3.2 PMI Run Mode

To execute the control algorithm(s), the programmer sets:

- the PMI Run Enable bit (register 100/1100, bit 0, PMI_RUN@) for the torque minor loop

  and, if required,

- the Speed Loop Enable bit (register 100/1100, bit 3, SPD_ON@) for the speed minor loop
- the Position Loop Enable bit (register 100/1100, bit 4, POS_ON@) for the position minor loop.

Before the control algorithm(s) can be executed, all of the following conditions must be met:

- The interlock tests, register 205/1205, must be passed successfully. See section 2.3.
- The M-contactor must be closed, if configured. See section 2.4.1.2.
- The UDC task in the AutoMax rack must be running. The status of the UDC task is indicated by the UDC Task Running bit (register 100/1100, bit 15, UDC_RUN@).

If any of these requirements are not met or if a fault is latched in the Drive Fault register (202/1202), the PMI will remain in the idle mode.

If these requirements are met, the PMI will execute the torque minor loop, and if selected, the speed and position minor loops. At this time, the PMI will set the PMI On bit (200/1200, bit 0, PMI_ON@) to indicate that the torque minor loop is executing.

**Important:** Note that if a brushless motor is being used, the resolver and rotor shafts must be aligned before the torque minor loop is executed or the motor may not run properly. This is not tested by the Interlock tests as a requirement to enter the PMI run mode. See section 3.3 for description of this procedure.

The torque minor loop executes until one of the following occurs:

- The PMI Run Enable bit (register 100/1100, bit 0, PMI_RUN@) is reset by the application task.
- A drive fault is detected. Refer to Appendix A for a description of the Drive Fault register.
- The RPI signal (register 201/1201, bit 0) is removed.

The speed minor loop executes until one of the following occurs:

- The Speed Loop Enable bit (register 100/1100, bit 3, SPD_ON@) is reset by the application task.
- The PMI Run Enable bit (register 100/1100, bit 0, PMI_RUN@) is reset by the application task.
- A drive fault is detected. Refer to Appendix A for a description of the Drive Fault register.
- The RPI signal (register 201/1201, bit 0) is removed.

The position minor loop executes until one of the following occurs:

- The Position Loop Enable bit (register 100/1100, bit 4, POS_ON@) is reset by the application task.
- The Speed Loop Enable bit (register 100/1100, bit 3, SPD_ON@) is reset by the application task.
- The PMI Run Enable bit (register 100/1100, bit 0, PMI_RUN@) is reset by the application task.

- A drive fault is detected. Refer to Appendix A for a description of the Drive Fault register.
- The RPI signal (register 201/1201, bit 0) is removed.

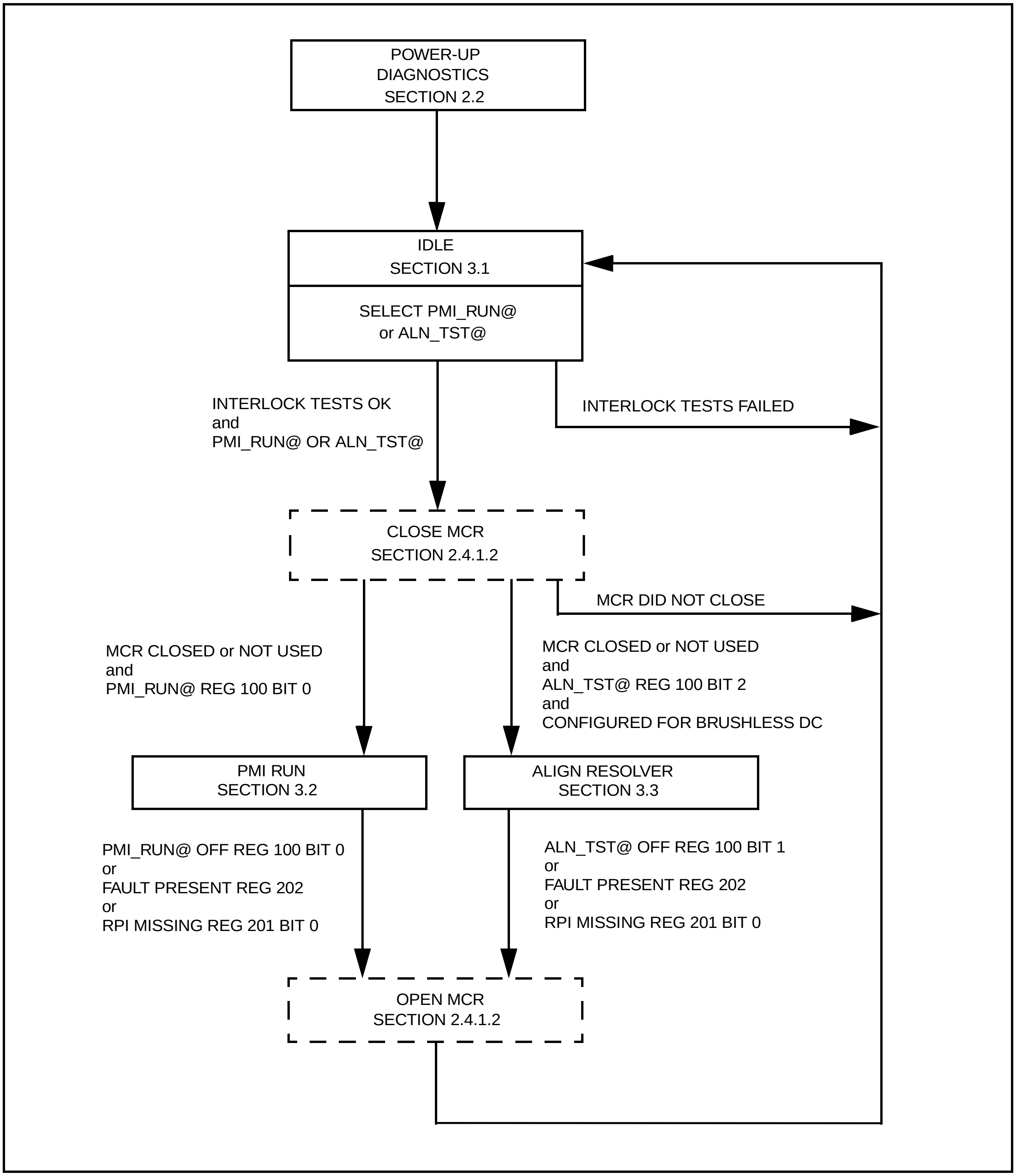


Figure 3.1 – PMI Operating Modes and Diagnostics

## 3.3 Alignment Test Mode

For SA500 drives controlling brushless DC motors, the resolver shaft and the rotor shaft must be aligned in order to ensure that maximum torque is generated. Therefore, an alignment procedure must be performed before the torque, speed, and position minor loops are executed. The alignment procedure automatically determines the offset required to bring the rotor and the stator fields 90° apart. This procedure must be performed whenever the resolver has been disconnected from the motor for any reason, including reversing cosine leads to the resolver.

**ATTENTION:** For brushless motor applications, changing any resolver wiring, breaking the resolver coupling, replacing the resolver, or replacing the motor and resolver for any reason requires that the shaft alignment test be performed again. Resolver wiring changes always affect shaft alignment. A resolver change and/or a new motor/resolver combination will affect the shaft alignment. Improper shaft alignment can cause motor overspeed when the motor is started. Failure to observe this precaution could result in bodily injury.

**Important:** This procedure will cause the motor to move less than one revolution in both forward and reverse direction for under three minutes. Uncouple the motor from the load to run this test if this motion would be harmful to your machine.

The programmer sets the Enable Resolver Alignment Test bit (register 100/1100, bit 1, ALN_TST@) to request the PMI to execute the alignment procedure. Before the alignment test can be executed, all of the following conditions are required:

- The interlock tests (described in section 2.3) must be passed successfully.
- The M-contactor, if configured, must be closed (described in section 2.4.1.2).

If any of the requirements are not met of if a fault is latched in the Drive Fault register (202/1202), the PMI will remain in the idle mode.

If these requirements are met, the PMI will execute the alignment procedure.

When the alignment procedure is successfully completed, the PMI will set the Alignment OK bit (register 200/1200, bit 1, ALN_OK@). The programmer can then turn off the Enable Resolver Alignment Test bit. This will also turn off the Alignment OK bit. The result of this test is written to the tunable variable RES_ALN% by the PMI. If a problem is detected during the alignment procedure (e.g., the incorrect number of motor poles or resolver type was entered during configuration), the Tuning Aborted Warning bit (register 203/1203, bit 5, WRN_TUN@) is set. When the alignment procedure is turned off, the PMI returns to the idle state.

# CHAPTER 4

# Installation and Start-Up Guidelines

> **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:** 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.

This section describes general guidelines that should be followed when verifying the correct installation of the drive hardware and in performing the drive start-up. For more information regarding installation guidelines, refer to instruction manual D2-3115 (Installing, Operating, and Maintaining Engineered Drive Systems).

As part of the start-up procedure, the AutoMax Programming Executive software is used to verify the status of drive I/O and to make drive adjustments. Section 4.1 describes some of the restrictions imposed by the AutoMax Programming Executive software.

## 4.1 Using the AutoMax Programming Executive to Access the Rack

The AutoMax Programming Executive enables four users to access and work in the same rack simultaneously. However, certain restrictions exist when more than one user is working in a rack.

- The maximum number of users is four (4) per rack (one user connected directly to the rack and three users connected via the DCS/AutoMax Network, or four users connected via the DCS/AutoMax Network).
- Data access is required for the user to Set/Force COMMON variables. All users must assure that variable values are not written over by other users working in the rack.
- Task access is required for the user to load a single task and to Set/Tune/Force LOCAL variables in a task. Only one user will be granted Task access for each task in the rack.
- Rack access is required to load the rack configuration and to load all application tasks (AutoMax tasks and UDC tasks).
- If a user has Rack access, no other user can make changes in that rack. All other users will be limited to monitoring tasks and variables.

- Each user can monitor up to 16 COMMON and/or LOCAL variables.
- A maximum of 32 LOCAL variables per UDC module can be monitored, regardless of the number of users.
- A maximum of 16 variables per rack can be forced.

Appendix G describes the type of access required by the user in order to carry out common Programming Executive operations. Refer to the AutoMax Programming Executive instruction manual for more specific information.

## 4.2 Installation Requirements

The installation must meet the following requirements:

**Ambient Temperature**

- Power Modules: 0 to 60° C (32 to 140° F)

**Cooling**

- Air for cooling must be of sufficient quality and flow to avoid recycling the heated exhaust air back into the drive air inlets.

**Relative humidity**

- 5 - 95%, non-condensing

**Altitude**

- Maximum 1000 meters (3300 feet) above sea level.
  Refer to instruction manual S-3018 for derating information when operating above 1000 meters.

**Air Quality**

- Clean
  No flammable vapors, chemical fumes, or oil vapor.

**Clearances**

- Must allow access to the equipment within the cabinet for inspection, maintenance, and replacement.
- Must provide non-restricted air flow to and from the intake and exhaust openings.

See the following instruction manuals for more detailed information about installation requirements:

- S-3018 SA500 Power Modules
- S-3017 SA500 DC Bus Supplies

## 4.3 Installing the Motor

The motor should be installed in accordance with its own installation instructions. Refer to the instruction manual that was provided for the motor (in the Instruction Book) for specific instructions.

## 4.4 Installing the Drive

The drive is most often supplied in its own NEMA 1 enclosure. It is also available in NEMA 4 and NEMA 12 cabinets, in free standing floor-mounted cabinets, in an open panel configuration for mounting in the customer's enclosure, or in a custom-built control room.

### 4.4.1 Cabinet-Enclosed Wall-Mounted Drives

The drive in a wall-mounted NEMA 1 enclosure is force ventilated by means of its own internal cooling fan(s) and additional cabinet fans. Air is drawn into the enclosure through slots in the cabinet bottom and in the lower portion of the cabinet sides. Air is forced out through internally shielded slots near the top of the cabinet sides. Air intake and exhaust openings are unfiltered.

NEMA 4 and NEMA 12 cabinet enclosures are unventilated. Although an internal circulating fan is employed to move air around within the confines of the cabinet to better utilize the cabinet skin for heat dissipation and reduce internal hot spots, there is no air exchange with the atmosphere outside of the enclosure.

### 4.4.2 Floor-Mounted Drives

NEMA 1 free-standing floor-mounted cabinets draw cooling air from slots in the lower portion of the cabinet door and force air through slots near the door's top, if a cabinet fan is supplied. NEMA 4 and NEMA 12 floor-mounted cabinet enclosures are unventilated.

### 4.4.3 Panel-Mounted Drives

The drive is available as a panel-mounted assembly where mounting of the drive within a customer-supplied enclosure is desired. In these instances, the user is responsible for ensuring that the maximum temperature within this enclosure remains at or below the rated ambient temperature under worst-case operating conditions. Note that the same fan-cooling as described in the previous two sections will be provided for the Power Module.

## 4.5 Wiring the Power Module

Verify that the input power to the DC bus supply is of the correct voltage and sufficient ampacity to support the Power Module's input current requirements. Note that the maximum available current from the DC bus supply must be less than the Power Module's short circuit current rating (RMS). Refer to the drive cabinet and motor nameplates for correct current ratings and input power information.

## 4.6 Basic Drive Interconnections

**ATTENTION:** If your drive cabinet is mounted in such a way that the cabinet itself is not grounded, a ground wire must be connected to the drive cabinet to provide safety for personnel. Also the motor frame should be grounded by solidly connecting a ground wire to a screw in the conduit box. Failure to observe these precautions could result in severe bodily injury or loss of life.

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

The SA500 drive requires interconnecting wiring per applicable codes between the drive and the following:

- motor
- operator's control station (if used)
- resolver
- UDC module
- earth ground

Refer to the Elementary Diagram (W/E) (and the Interconnection Diagram (W/I) if provided) supplied with your drive for these interconnections. Be sure that the W/E number corresponds to that on the drive's cabinet or Power Module nameplate. All interconnecting wiring must be sized and installed in conformance with the National Electrical Code and applicable local or other codes.

Unless a standard pre-built fiber-optic cable was included with your system, the fiber-optic cabling that links the UDC module(s) in the AutoMax rack with the Power Module(s) containing the PMI(s) must be installed by someone experienced in installing fiber-optic cables. Unless you have in-house expertise in installing fiber-optic cable, it is recommended that you contact an experienced contractor to perform the installation. Information regarding the selection and installation of fiber-optic cabling is contained in the Distributed Power System Fiber-Optic Cabling instruction manual (S-3009).

## 4.7 Drive Inspection and Start-up Guidelines

**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 from the DC bus supply, wait five (5) minutes and then measure the voltage at the POS and NEG terminals of the DC bus supply and each Power Module 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.

Use the procedures that follow to locate any shipping damage to the drive, to verify proper installation and field wiring, and to start the drive.

**Recommended Start-Up Sequence**

1. Physical inspection of equipment
2. Motor checks
3. Preliminary inspection with power off
4. Inspection with power on
5. I/O verification

Before attempting to perform this start-up procedure, you should be familiar with the general arrangement and function of the drive equipment and should verify that it has been installed and wired as described in the following documents, which are included in the Instruction Book provided with your drive system: Wiring Diagrams (W/Ds), Elementary Diagrams (W/Es), Panel Layout Diagrams (W/Ls), Operator's Station Diagrams (W/Os), and Interconnection Diagrams (W/Is) if supplied.

## 4.7.1 What To Do After Unexpected Test Results

If it is not possible to obtain the correct meter reading or proper operation during any of the tests or adjustment procedures described in the following sections, perform the following steps:

Step 1. Stop the drive.

Step 2. Turn off and lock out all incoming power.

> **ATTENTION:** DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power from the DC bus supply, wait five (5) minutes and then measure the voltage at the POS and NEG terminals of the DC bus supply and each Power Module 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. Wait five minutes to allow the DC bus voltage to dissipate.

Step 4. Measure the voltage at the POS and NEG terminals on the DC bus supply and each Power Module before working on any unit. Refer to figure 4.1. When the DC bus potential is down to less than 5 volts, touch a 50 ohm, 50 W or larger resistor to each unit’s POS and NEG terminals for 20 seconds to allow any remaining voltage to dissipate.

Remove the resistor and re-measure the DC bus potential to ensure the DC bus capacitors are completely discharged.

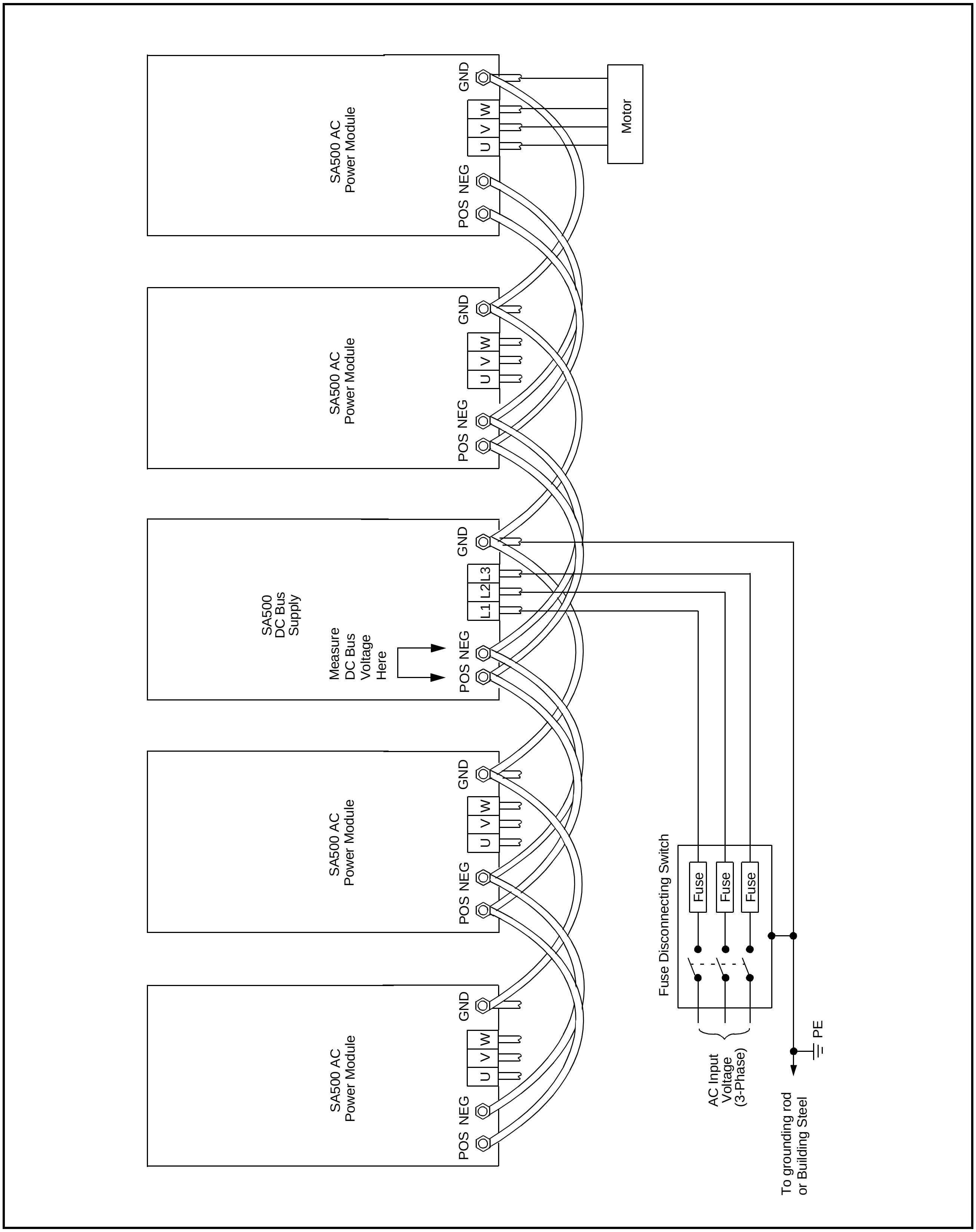


Figure 4.1 – POS and NEG Terminals on the DC Bus Supply

Step 5. Verify the following:

a. All connections are in strict conformance to the wiring diagrams.

b. There are no loose or broken connections.

c. There are no damaged components.

Step 6. Repeat the original test that failed.

### 4.7.2 Recommended Test Equipment

Rockwell recommends the following test equipment:

- Isolated oscilloscope with a current probe and x100 probe for DC bus measurements. An isolation transformer is needed to isolate the oscilloscope and any other equipment.
- AC and DC clamp-on ammeters
- Isolated multimeter having a sensitivity of 20KΩ/volt
- Chart recorder
- Isolated voltmeter
- 50 ohm, 50W resistor for discharging bus capacitors
- Appropriate safety equipment, e.g., safety glasses and safety gloves

A megohmmeter (megger) may be used to reliably verify the absence of inadvertent grounding of the motor. Failure to follow proper procedure when using a megger may cause damage to the drive.

> ⚠ **ATTENTION:** If a megohmmeter is used, disconnect all leads between the rotating equipment and the drive cabinet. This will prevent damage to electronic circuitry (Power Modules and their associated circuits, etc.) due to the high voltage generated by the megger. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

### 4.7.3 Physically Inspecting the Equipment

Before operating the equipment, DISCONNECT AND LOCK OUT ALL INCOMING LINE POWER AND CONTROL POWER TO THE DRIVE and perform the following steps:

Step 1. Carefully inspect the Power Module and other drive components for physical damage. Verify free operation of all switch relays, auxiliary contacts, and contactors.

Step 2. Visually inspect internal wiring for loose or broken connections or damaged wires.

Step 3. Visually check for damaged components.

Step 4. Check fuses.

Step 5. Verify that all shutdown interlocks around the machine are operational.

### 4.7.4 Physically Inspecting the Motor

Carefully read and understand the instruction manual that describes your motor. Then make the following motor inspection. Refer to section 4.7.1, What to Do After Unexpected Test Results, for more information.:

Step 1. Disconnect and lockout all incoming line power and control power to the drive.

Step 2. Check that the motor is installed according to the motor's instruction manual.

Step 3. If possible, uncouple the motor from the driven machinery.

Step 4. Rotate the motor shaft by hand to check that the motor is free from any binding or mechanical load problem.

Step 5. Check that no loose items such as shaft keys, couplings, etc., are present.

Step 6. Check all connections for tightness and proper insulation.

Step 7. Check that the interior of the motor is clean and dry.

> **ATTENTION:** Before starting the motor, remove all unused shaft keys and loose rotating parts to prevent them from flying off. Replace all covers and protective devices. Failure to observe these precautions could result in damage to equipment and bodily injury.

### 4.7.5 Checking the Installation with Power Off

Perform the following tests to verify that:

- Correct power is being supplied to the drive
- Wiring has been done properly
- There are no grounds in the magnetic control circuits or rotating equipment
- All safety devices are in place and functional.

Step 1. If the drive is powered up, disconnect and lock out all incoming line power and control power to the drive. Refer to section 4.7.1 for additional information on measuring and discharging DC bus voltage.

If the drive is not under power, proceed to step 2.

> **ATTENTION:** DC bus capacitors retain hazardous voltages after input power has been disconnected. After disconnecting input power from the DC bus supply, wait five (5) minutes and then measure the voltage at the POS and NEG terminals of the DC bus supply and each Power Module 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 2. Visually check that the AC supply to the DC bus supply is of the correct voltage and frequency and that the plant supply branch from which the drive is to be operated is of sufficient ampacity to supply drive input current requirements.

Step 3. Verify that all drive components have been properly installed and interwired per the instructions provided in the wiring diagrams (W/Ds, W/Es, W/Ls, W/Os, and W/Is).

Step 4. Rotate the 1/4 turn cover fasteners securing the Power Module cover. Remove the cover. Inspect the Power Module for cables that may have come loose during shipping. Replace and re-secure the Power Module cover.

Step 5. Check for grounds in the magnetic control circuits. Always use an ohmmeter to check for grounds in resolver circuits.

Step 6. Check rotating equipment for grounds.

Step 7. Check for tight connections on all wiring.

Step 8. Check circuit breaker trip settings.

Step 9. Verify that all safety devices are in place.

Step 10. Check fuses.

### 4.7.6 Testing Power Modules with Power On

**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:** This procedure is performed with power on. Exercise extreme caution as hazardous voltage exists. Failure to observe this precaution could result in severe bodily injury or loss of life.

**ATTENTION:** Before proceeding, make sure that you can quickly stop the drive if necessary. If the input power disconnect and/or stop push-button are out of your reach, have an associate stationed to operate them in the event of drive malfunction during these initial power checks and drive adjustment. Failure to observe this precaution could result in damage to equipment and bodily injury.

The following steps are required to test SA500 Power Modules before they can be put into service.

Perform the following steps before attempting to start the drive:

Step 1. Check the DC bus supply's DC power levels.

a. Verify that DC input power to the Power Module is off.

b. Connect a DC voltmeter to the POS and NEG terminals on the Power Module.

c. Apply power to the drive and verify that the DC voltage level is correct.

Step 2. If the motor uses 3-phase AC to power its blower motor, verify proper blower motor rotation. Check to see that air is being forced into the motor. If air flow is reversed (air is being pulled out of the motor), remove AC input power from the blower motor and interchange any two AC line power wires feeding the blower motor. Note that the blower motor must be wired to a fixed AC power source and not to the Power Module.

## 4.7.7 I/O Verification

I/O verification consists of ensuring that all physical I/O is properly connected and functional, and that all critical registers and bits can be accessed in the UDC dual port memory. Before verifying the I/O, ensure that the following have been loaded to the AutoMax rack. Note that the application tasks should not be put into run before you have verified all I/O.

- AutoMax Processor and UDC operating systems
- Rack configuration
- Drive parameters
- All application tasks

The procedures described in the following sections are performed using the Monitor I/O function in the AutoMax Programming Executive software.

### 4.7.7.1 Testing UDC/PMI Communication Status

This section describes how to test the UDC/PMI communication status registers. Use the AutoMax Programming Executive software I/O Monitor function to display the UDC/PMI Communication Status registers in the format listed in table 4.1.

Table 4.1 – UDC/PMI Communication Status Register Formats

| Drive A / B | Register Name (format) |
|---|---|
| 80 / 1080 | UDC Module Ports A/B Status (binary) |
| 81 / 1081 | UDC Module Ports A/B Receive Count (decimal) |
| 82 / 1082 | UDC Module Ports A/B CRC Error Count (decimal) |
| 83 / 1083 | UDC Module Ports A/B Format Error Count (decimal) |
| 84 / 1084 | PMI A/B Status (binary) |
| 85 / 1085 | PMI A/B Receive Count (decimal) |
| 86 / 1086 | PMI A/B CRC Error Count (decimal) |
| 87 / 1087 | PMI A/B Format Error Count (decimal) |
| 88 / 1088 | UDC Module Ports A/B Fiber-Optic Link Status (hexadecimal) |
| 89 / 1089 | UDC Module Ports A/B Transmitted Message Count (decimal) |

Step 1. Examine registers 80/1080 and 84/1084 for any errors reported to the UDC module and PMI related to UDC/PMI communication. If any bits in these registers are on, try to determine what caused the error.

Step 2. Examine registers 81/1081 and 85/1085 for the number of messages received by the UDC module and PMI. Over time, this 16-bit value should increase to its maximum value (32767) and then roll over.

Step 3. Examine registers 82/1082 and 83/1083 (and 86/1086 and 87/1087) for the number of CRC and format errors received on the UDC module (and PMI). If either of these values is incrementing, it indicates a problem.

Step 4. Examine register 88/1088 for the status of the fiber-optic ports on the UDC module. If the operating systems are loaded and no tasks are running, the lower byte should be equal to xx03H (UDC module and PMI are exchanging data). The upper byte should be equal to 02xxH (communication between the UDC module and PMI is unsynchronized). Note that “xx” in the byte descriptions indicates “not used.”

Step 5. Examine register 89/1089 for the number of messages transmitted by the UDC module. Over time, this 16-bit value should increase to its maximum value (32767) and then roll over.

#### 4.7.7.2 Testing Rail I/O Registers

This section describes how to test the rail I/O registers if used in your system configuration. Use the AutoMax Programming Executive software I/O Monitor function to display the Rail I/O registers in the format listed in table 4.2.

Display these registers in decimal format if they are used for analog I/O. Display them in binary format if they are used for digital I/O.

Table 4.2 – Rail I/O Register Formats

| Drive A / B | Register Name |
|---|---|
| 0 / 12 | PMI Port 0, Channel 0 |
| 1 / 13 | PMI Port 0, Channel 1 |
| 2 / 14 | PMI Port 0, Channel 2 |
| 3 / 15 | PMI Port 0, Channel 3 |
| 4 / 16 | PMI Port 0, Faults (display in binary format) |
| 5 / 17 | PMI Port 0, Check Bit Fault Counter (display in decimal format) |
| 6 / 18 | PMI Port 1, Channel 0 |
| 7 / 19 | PMI Port 1, Channel 1 |
| 8 / 20 | PMI Port 1, Channel 2 |
| 9 / 21 | PMI Port 1, Channel 3 |
| 10 / 22 | PMI Port 1, Faults (display in binary format) |
| 11 / 23 | PMI Port 1, Check Bit Fault Counter (display in decimal format) |

Step 1. Test each analog current or voltage output channel being used by writing a value between 0 and 4095 to the appropriate register and measuring with an ammeter or voltmeter to verify the signal on the terminal points (4-20mA or 0-10V) is proportional to the register value.

Step 2. Test each analog current or voltage input channel being used by measuring with an ammeter or voltmeter to verify the signal on the terminal points (4-20mA or 0-10V) is proportional to the value displayed in appropriate register.

Step 3. Test each digital input by initiating the input and verifying that the appropriate bit (displayed on the screen) turns on.

Step 4. Test each digital output by forcing the bit on and verifying that the signal is present on the terminal points.

### 4.7.7.3 Testing Feedback Registers and Bits

This section describes how to test the feedback registers and bits. Feedback information provided by the fault, warning, and interlock registers is described in Appendices A, B, and C. Use the AutoMax Programming Executive software I/O Monitor function to display the registers and bits in the format listed in table 4.3.

Table 4.3 – Feedback Registers and Bits

| Drive A/B | Variable Name | Description |
|---|---|---|
| 200 / 1200<br>Bit 15 | <br>(PMI_OK@) | Drive Status Register<br>PMI Operating System Loaded |
| 201 / 1201<br>Bit 0<br>Bit 1<br><br>Bit 2<br>Bit 3<br>Bit 4<br>Bit 5<br>Bit 8 | <br>(RPI@)<br>(M_FDBK@)<br>(AUX_IN1@)<br>(AUX_IN2@)<br>(AUX_IN3@)<br>(AUX_IN4@)<br>(AUX_IN5@)<br>(STR_DET@) | I/O Status Register<br>Run Permissive Input<br>M-Contactor Feedback Input or<br>115VAC Auxiliary Input 1<br>115VAC Auxiliary Input 2<br>115VAC Auxiliary Input 3<br>115VAC Auxiliary Input 4<br>115VAC Auxiliary Input 5<br>External Strobe Detected |
| 203 / 1203<br>Bit 13 | <br>(WRN_RAL@) | Drive Warning Register<br>Rail I/O Communication Error |
| 206 / 1206 | (SPD_FB%) | Speed Feedback (-4095 to +4095) |
| 207 / 1207 | (TRQ_FB%) | Torque Feedback (-4095 to +4095) |
| 208 / 1208 | (POS_FB%) | Position Feedback (-32768 to +32767) |
| 209 / 1209 | (POS_REG_OUT%) | Position Loop Output (-4095 to +4095) |
| 211 / 1211 | (I_FBN%) | Current Feedback (normalized) (-4095 to +4095) |
| 213 / 1213 | (SPD_ERR%) | Speed Error (-4095 to +4095) |
| 214 / 1214 | (USER_AIN%) | Analog Input (-2048 = -10 V to +2047 = +10V) |
| 215 / 1215 | (RES_SCN_POS%) | Resolver Scan Position (-32768 to +32767) |
| 216 / 1216 | (RES_STR_POS%) | Resolver Strobe Position (-32768 to 32767) |
| 217 / 1217 | (RPM%) | Revolutions Per Minute |
| 218 / 1218 | (POS_ERR%) | Position Error (-4095 to +4095) |
| 219 / 1219 | (SPI_OUT%) | Speed Loop P+I Output (-4095 to +4095) |
| 220 / 1220 | (WR2_COMP%) | Speed Loop Feedforward Output (-4095 to +4095) |
| 221 / 1221 | (SLP_RPM%) | RPM Slip |

Step 1. Verify that register 200/1200, bit 15 is on. This bit is on when PMI operating system has been successfully downloaded from the UDC module to the PMI.

Step 2. Check each of the inputs identified by bits 1 through 5 of register 201/1201 by applying 115V to the appropriate pins on the Drive I/O connector on the Resolver and Drive I/O module and verifying that the appropriate bit is on. Refer to the SA500 Power Modules instruction manual (S-3018) for the pinout description.

Step 3. You may want to create a separate monitor screen for registers 206/1206 through 221/1221 and save it. This will allow you to recall the screen later, without having to enter the entire list each time you need to monitor feedback registers. (Note that registers 210/1210 and 212/1212 are not used.)

Step 4. Check the User Analog Input (register 214/1214) by applying an input signal to the appropriate pins on the Resolver Feedback connector on the Resolver and Drive I/O module and verifying that register 214/1214 displays an appropriate value. Refer to instruction manual S-3018 for additional information.

Step 5. Test the resolver. Be sure the resolver's sine/cosine wires are connected per the W/E diagrams. Monitor the value displayed in the Resolver Scan Position register (215/1215). The value in this register can range from -32768 to 32767.

Rotate the resolver by hand (by turning the motor shaft if the resolver is mounted/coupled), first in one direction, then in the other direction. The value in the register should steadily increase in one direction and steadily decrease in the other direction. If the value in the register does not change at all or if the value does not increase/decrease smoothly, a problem may exist with the resolver and/or its wiring.

Step 6. Test the external strobe, if used, as follows. Note that the resolver and external strobe must be connected.

Force register 101, bit 8 (STR_ENA@, Enable External Strobe) on. Verify that register 201/1201, bit 8 (STR_DET@, External Strobe Detected) is on. Check the values displayed for registers 215/1215 (RES_SCN_POS%) and 216/1216 (RES_STR_POS%). The values displayed for these two registers should be very close, if not identical, if the resolver has not turned. After you have finished, unforce register 101, bit 8.

#### 4.7.7.4 Testing the UDC Module Test Switch Register

This section describes how to test the UDC module test switch register. Use the AutoMax Programming Executive software I/O Monitor function to display register 1000 in binary format.

Register 1000 reflects the status of the test switches and LED indicators on the UDC module.

Step 1. Verify the function of the UDC push-button. When the push-button is pressed, register 1000, bit 0 should be on. When the push-button is released, this bit should be off.

Step 2. Verify the function of the UDC Test Switch. When the switch is in the up-position, register 1000, bit 1 should be on. When the switch is in the down-position, register 1000, bit 2 should be on. When the switch is in the center position, both of these bits should be off.

#### 4.7.7.5 Testing UDC Module Meter Ports

This section describes how to test the UDC module meter ports. Use the AutoMax Programming Executive software Monitor Setup UDC/PMI screen. Check each UDC Meter Port being used as follows:

Step 1. Map registers that you want to display to UDC meter ports 1, 2, 3, and 4. Set the desired maximum and minimum values.

Step 2. Using the Monitor I/O screen, force a value within the range configured to each UDC register being output on the meters.

Step 3. Use a voltmeter to verify that the signal on the terminal points (-10V to +10V) of each meter port is proportional to the value in the corresponding register.

Step 4. Unforce the registers being output on the meter ports to zero.

### 4.7.8 Performing Uncoupled Motor Tests

The following tests are performed with the motor uncoupled from the load. Ensure that the limit values entered through the parameter entry screens are correct.

Step 1. Verify that the parameter screen information (Power Module data, motor data, speed feedback data, and meter port setup) is correct.

Step 2. Perform the resolver gain calibration procedure. This procedure is described in the SA500 Power Modules instruction manual (S-3018). The Resolver Gain Calibration Completed bit (register 201/1201, bit 6, RES_GAN@) will be set to indicate the procedure is complete. Check the value in the local tunable RES_GAN%. Large gain values (close to 255) may indicate a problem with the resolver wiring or connections. Refer to the SA500 Drive Configuration and Programming instruction manual (S-3044) for a list of the resolvers that may be used with SA500 drives.

Step 3. Perform the resolver alignment procedure if you are using a brushless motor. Refer to section 3.3. note that this procedure can be performed with the motor coupled to the load. However, it will cause the motor to move less than one revolution in both the forward and reverse directions. If this motion would be harmful to your machine, uncouple the motor from the load before performing this procedure.

Step 4. The Power Module’s AC output phase rotation must match the resolver’s orientation. Output phase rotation (UVW or UWV) is determined by setting the Output Rotation parameter, assuming the motor leads are correctly connected. Resolver orientation is determined by the cosine lead connections.

a. Place a value of zero in the External Torque Reference register (register 102/1102, TRQ_REF%). Turn on the drive.

b. Slowly increase the value in register 102/1102.

c. If the motor begins turning, verify that the motor shaft is turning in a clockwise direction. Examine the contents of the Resolver Scan Position register (register 215/1215, RES_SCN_POS%). The value in the register should be increasing.

If the motor does not turn, place a value of zero in register 102/1102 and turn off the drive. Change the Output Rotation parameter. Regenerate the parameter object file and reload it to the rack. Restart the drive. Slowly increase the value in register 102/1102 and verify that the motor is turning.

d. If the motor shaft is turning in a counter-clockwise direction and the application requires that a clockwise shaft rotation be identified as “forward” (i.e., the value in register 215/1215 is increasing), perform the following:

Turn the drive off and switch the resolver’s cosine wires. Change the Output Rotation parameter. Regenerate the parameter object file and reload it to the rack.

**ATTENTION:** For brushless motor applications, changing any resolver wiring, breaking the resolver coupling, replacing the resolver, or replacing the motor and resolver for any reason requires that the shaft alignment test be performed again. Resolver wiring changes always affect shaft alignment. A resolver change and/or a new motor/resolver combination will affect the shaft alignment. Improper shaft alignment can cause motor overspeed when the motor is started. Failure to observe this precaution could result in bodily injury.

e. If a brushless motor is used and the resolver has been removed, replaced, or had its cosine wires changed, the resolver alignment test must be performed as described in section 3.3.

f. Verify the motor shaft rotation is in the desired direction by repeating steps a and b.

Step 5. Verify that the motor speed can be regulated. The method used to verify speed regulation will depend upon your application.

Step 6. Perform the resolver balance calibration procedure. This procedure is also described in the SA500 Power Modules instruction manual (S-3018). The Resolver Balance Calibration Completed bit (register 201/1201, bit 7, RES_BAL@) will be on when the procedure is complete. The result of this procedure is stored in local tunable RES_BAL%.

If the Tuning Aborted Warning bit (register 203/1203, bit 5, WRN_TUN@) is also on, it indicates that the procedure was unsuccessful (caused by leaving the resolver uncoupled during the procedure or using longer than recommended cable runs) or yielded unusual results (sine/cosine magnitudes are not within 5% of each other).

### 4.7.9 Running Dynamic Motor Tests

The dynamic motor tests complete the drive start-up. The drive is tuned by running the single drive section under test in order to adjust motor tracking, maximum speeds, vernier adjustments, and machine section speed adjustments.

The driven machine is then run under actual operating conditions with a load in order to adjust gain values, feedback devices, limit switches, etc., as required, to obtain the specified performance.

### 4.7.10 Updated Drawings and Software Listings

When start-up is performed by Rockwell personnel, the W/E, W/M, W/P drawings, and all software listings are updated after start-up and are re-issued as revised pages of the Instruction Book. Refer to Installing, Operating and Maintaining Engineered Drive Systems (D2-3115) for more information.

# APPENDIX A

# Drive Fault Register

## Drive Fault Register — 202/1202

The bits in the Drive Fault register indicate the cause of a drive shutdown. The bits in this register are latched until they are reset by setting the Fault Reset bit (bit 8) of the Drive Control register (100/1100, bit 8). After turning the Fault Reset bit on, the drive may be re-started after turning the desired command bit in register 100/1100 off and then back on again. If the fault condition still exists, the identifying bit in this register will immediately be set again.

The fault conditions reported in this register result in turning off the drive. The UDC task is not stopped automatically if a drive fault occurs unless it is specifically instructed to do so in the application task. The user must ensure that the AutoMax application task tests register 202/1202 and takes appropriate action if a fault occurs.

Note that the status of this register is also reported in the error log for the task in which the error occurred.

### Power Module Overtemperature Fault — Bit 0

The Power Module Overtemperature Fault bit is set if either of the following conditions occurs:

| | |
|---|---|
| **Hex Value:** | 0001H |
| **Sug. Var. Name:** | FLT_OT@ |
| **Access:** | Read only |
| **UDC Error Code:** | 1016 |
| **LED:** | P.M. FLT |

- The PMI detects that motor current exceeds 100% of the Power Module's continuous capacity at maximum current for a pre-determined amount of time. At maximum rated current, this trip will occur in 0.5 second.
- Hardware detects that the temperature of the Power Module's heatsink exceeds the configured maximum rating.

### Instantaneous Overcurrent Fault — Bit 1

The Instantaneous Overcurrent Fault bit is set if any of the three motor feedback currents (Iu, Iv, Iw) exceeds 133% of maximum RMS current.

| | |
|---|---|
| **Hex Value:** | 0002H |
| **Sug. Var. Name:** | FLT_IOC@ |
| **Access:** | Read only |
| **UDC Error Code:** | 1017 |
| **LED:** | EXT FLT |

### DC Bus Overvoltage Fault — Bit 2

The DC Bus Overvoltage Fault bit is set if the DC bus voltage exceeds 400 VDC.

| | |
|---|---|
| **Hex Value:** | 0004H |
| **Sug. Var. Name:** | FLT_OV@ |
| **Access:** | Read only |
| **UDC Error Code:** | 1018 |
| **LED:** | P.M. FLT |

| Vcc Power Supply Undervoltage Fault | Bit 3 |
| --- | --- |
| The Vcc Power Supply Undervoltage Fault bit is set if the input to the +5V supply on the PMI drops below the necessary voltage to maintain regulation. | **Hex Value:** 0008H<br>**Sug. Var. Name:** FLT_VCC@<br>**Access:** Read only<br>**UDC Error Code:** 1019<br>**LED:** P.M. FLT |

| Position Error Fault | Bit 4 |
| --- | --- |
| The Position Error Fault bit is set if the position error exceeds the value set in the PMI Tach Loss Maximum Position Error register (register 166/1166). | **Hex Value:** 0010H<br>**Sug. Var. Name:** FLT_SPD@<br>**Access:** Read only<br>**UDC Error Code:** N/A<br>**LED:** N/A |

| Speed Error | Bit 5 |
| --- | --- |
| The Speed Error Fault bit is set if the maximum velocity error exceeds the value set in the PMI Tach Loss Maximum Velocity Error register (register 156/1156). | **Hex Value:** 0020H<br>**Sug. Var. Name:** FLT_SPD@<br>**Access:** Read only<br>**UDC Error Code:** N/A<br>**LED:** N/A |

| Resolver Broken Wire Fault | Bit 8 |
| --- | --- |
| The Resolver Broken Wire Fault bit is set if a sine or cosine signal from the resolver is missing due to a broken wire or if the resolver gain tunable (RES_GAN%) has been set too low. | **Hex Value:** 0100H<br>**Sug. Var. Name:** FLT_TBW@<br>**Access:** Read only<br>**UDC Error Code:** 1008<br>**LED:** FDBK OK |

| Overspeed Fault | Bit 10 |
| --- | --- |
| The Overspeed Fault bit is set if the motor's velocity exceeds the value entered as the Overspeed Trip (RPM) configuration parameter. | **Hex Value:** 0400H<br>**Sug. Var. Name:** FLT_OSP@<br>**Access:** Read only<br>**UDC Error Code:** 1010<br>**LED:** EXT FLT |

| PMI Power Supply Fault | Bit 12 |
| --- | --- |
| The PMI Power Supply Fault bit is set if the PMI power supply is not working correctly | **Hex Value:** 1000H<br>**Sug. Var. Name:** FLT_PS@<br>**Access:** Read only<br>**UDC Error Code:** 1012<br>**LED:** PWR OK |

| PMI Bus Fault | Bit 13 |
|---|---|

The PMI Bus Fault bit is set if a problem is detected with the address and data bus on the PMI regulator board in the Power Module

| | |
|---|---|
| **Hex Value:** | 2000H |
| **Sug. Var. Name:** | FLT_BUS@ |
| **Access:** | Read only |
| **UDC Error Code:** | 1013 |
| **LED:** | N/A |

| UDC Run Fault | Bit 14 |
|---|---|

The UDC Run Fault bit is set if the UDC task stops while the minor loop is running in the PMI.

| | |
|---|---|
| **Hex Value:** | 4000H |
| **Sug. Var. Name:** | FLT_RUN@ |
| **Access:** | Read only |
| **UDC Error Code:** | 1014 |
| **LED:** | N/A |

| Communication Lost Fault | Bit 15 |
|---|---|

The Communication Lost Fault bit is set if the fiber-optic communication between the PMI Processor and the UDC module is lost due to two consecutive errors of any type.

| | |
|---|---|
| **Hex Value:** | 8000H |
| **Sug. Var. Name:** | FLT_COM@ |
| **Access:** | Read only |
| **UDC Error Code:** | 1015 |
| **LED:** | COMM OK |

This bit is set only after communication between the PMI Regulator and UDC module has been established. This bit should be used in the run permissive logic for the drive. Also refer to the CCLK Synchronized bit (register 200/1200, bit 14).

# APPENDIX B

# Drive Warning Register

## Drive Warning Register — 203/1203

The warnings indicated by the Drive Warning register cause no action by themselves. Any resulting action is determined by the application task. The user must ensure that the AutoMax application task monitors register 203/1203 and takes appropriate action if any of these conditions occurs. If a warning condition is detected, the corresponding bit is latched until the Warning Reset bit (bit 9) of the Drive Control register (register 100/1100) is set.

### Ground Current Warning — Bit 0

The Ground Current Warning bit is set if ground current exceeds the value stored in local tunable GIT_E1%.

**Hex Value:** 0001H
**Sug. Var. Name:** WRN_GND@
**Access:** Read only
**UDC Error Code:** N/A
**LED:** N/A

### Reference In Limit Warning — Bit 4

The Reference in Limit Warning bit is set if the PMI torque reference value (register 102/1102) exceeds the maximum value permitted (+/- 4095) and is being limited by the system.

**Hex Value:** 0010H
**Sug. Var. Name:** WRN_RIL@
**Access:** Read only
**UDC Error Code:** N/A
**LED:** N/A

### Tuning Aborted Warning — Bit 5

The Tuning Aborted Warning bit is set if any of the automatic tuning procedures (e.g., resolver balance and gain calibration) is not successful.

**Hex Value:** 0020H
**Sug. Var. Name:** WRN_TUN@
**Access:** Read only
**UDC Error Code:** N/A
**LED:** N/A

### Volatile Gain Limit Warning — Bit 10

The Volatile Gain Limit bit is set if a speed or position loop volatile gain value is out of limit. This bit will only be set if the position or speed loops are enabled.

**Hex Value:** 0400H
**Sug. Var. Name:** WRN_VGN@
**Access:** Read only
**UDC Error Code:** N/A
**LED:** N/A

| Rail Communication Warning | | Bit 13 |
|---|---|---|
| The Rail Communication Warning bit is set if a rail communication problem is detected and logged in registers 4, 10, 16, or 22. | **Hex Value:** | 2000H |
| | **Sug. Var. Name:** | WRN_RAL@ |
| | **Access:** | Read only |
| | **UDC Error Code:** | N/A |
| | **LED:** | I/O FLT |

| CCLK Not Synchronized Warning | | Bit 14 |
|---|---|---|
| The CCLK Not Synchronized Warning bit is set if the CCLK counters in the PMI Regulator and the UDC module are momentarily not synchronized. | **Hex Value:** | 4000H |
| | **Sug. Var. Name:** | WRN_CLK@ |
| | **Access:** | Read only |
| | **UDC Error Code:** | N/A |
| | **LED:** | N/A |

| PMI Communication Warning | | Bit 15 |
|---|---|---|
| The PMI Communication Warning bit is set if a fiber-optic communication error is detected between the PMI Processor module and the UDC module. | **Hex Value:** | 8000H |
| | **Sug. Var. Name:** | WRN_COM@ |
| | **Access:** | Read only |
| | **UDC Error Code:** | N/A |
| | **LED:** | N/A |

Communication errors in two consecutive messages will result in a drive fault.

# APPENDIX C

# Interlock Register

## Interlock Register — 205/1205

Interlock tests are executed whenever bit 0 or 1 of register 100/1100 is set. The first problem detected will be indicated by the identifying bit in this register. Note that these bits will prevent the vector or brushless minor loop from running.

### Configuration Parameters Not Loaded — Bit 0

The Configuration Parameters Not Loaded bit is set if:

| | |
|---|---|
| **Hex Value:** | 0001H |
| **Sug. Var. Name:** | IC_CNF@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

- the configuration parameters have not been downloaded into the UDC module from the Programming Executive, or
- the alignment test has been enabled (register 100/1100, bit 1) when an induction motor has been configured.

### Gains Not Loaded — Bit 1

The Gains Not Loaded bit is set if the required pre-defined local tunables are zero or if a UDC task containing these tunables has not been loaded to the PMI.

| | |
|---|---|
| **Hex Value:** | 0002H |
| **Sug. Var. Name:** | IC_GAIN@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

### RPI Missing — Bit 2

The RPI Missing bit is set if the Run Permissive input on the Power Module is not on.

| | |
|---|---|
| **Hex Value:** | 0004H |
| **Sug. Var. Name:** | IC_RPI@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

### Faults Need Reset — Bit 3

The Faults Need Reset bit is set if previous faults (register 202/1202) have not been cleared.

| | |
|---|---|
| **Hex Value:** | 0008H |
| **Sug. Var. Name:** | IC_FLT@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

### Rising Edge Required — Bit 4

The Rising Edge Required bit is set if a rising edge is required on any command bit in register 100/1100.

| | |
|---|---|
| **Hex Value:** | 0010H |
| **Sug. Var. Name:** | IC_RISE@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

This bit will be set if the application task has set the Fault Reset bit (register 100/1100, bit 8) but has not cleared and then re-set any command bits.

### More Than One Request — Bit 5

The More Than One Request bit is set if more than one operating mode is requested at a time in register 100/1100 (bits 0 and 1).

| | |
|---|---|
| **Hex Value:** | 0020H |
| **Sug. Var. Name:** | IC_MORE@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

### MCR Did Not Close — Bit 7

The MCR Did Not Close bit is set if the optional output contactor did not close when commanded to do so.

| | |
|---|---|
| **Hex Value:** | 0080H |
| **Sug. Var. Name:** | IC_MCR@ |
| **Access:** | Read only |
| **UDC Error Code:** | N/A |
| **LED:** | N/A |

# APPENDIX D

# Summary of UDC Module Drive Fault Indicators

**Status/Fault LEDs**

**CARD OK** (green) - The CARD OK LED will turn on after the UDC module's power-up self tests have been successfully completed. The LED will remain on unless there is a watchdog time-out or until power is cycled.

**OS OK** (green) - The OS (operating system) OK LED will turn on after the UDC operating system is loaded into the module. It will remain on until power is cycled. On subsequent power-ups, the LED will turn on to indicate that the OS is still resident in the module. Note that this LED is also used to indicate any failure that may occur during the power-up diagnostics. If the UDC module fails any of its power-up diagnostics, the module must be replaced.

**COMM A OK** and **COMM B OK** (green) - The Communication Status LEDs will turn on after the UDC module has established communication with the PMI rack(s) over the fiber-optic link(s). COMM A indicates the status of communication link A. COMM B indicates the status of communication link B. When an LED is lit, it indicates that messages are being received over that channel. Each channel operates independently of the other. If a channel is not being used, its LED will remain off. If communication errors are detected in two consecutive messages, the COMM OK LED will turn off and the DRV FLT LED will turn on. If the next message received by the UDC module is correct, the COMM OK LED will turn back on. The Communication Fault bit (register 202/1202, bit 15, FLT_COM@ ) will remain latched.

**DRV FLT A** and **DRV FLT B** (red) - The Drive Fault LEDs are normally off. If a Drive Fault LED is lit, it indicates the a Drive Shutdown fault has been detected for the indicated drive. When a drive fault is detected, a bit is set in register 202 for drive A or register 1202 for drive B in the UDC module's dual port memory. Bit 8 of the Drive Status register (200/1200) is also set.

### Drive Fault Error Codes

Drive faults are reported in the error log for the task in which the error occurred. The drive fault error codes are defined below:

| | |
|---|---|
| 1008 | Broken wire in resolver |
| 1009 | Not used |
| 1010 | Overspeed fault |
| 1011 | Not used |
| 1012 | PMI power supply fault |
| 1013 | PMI bus fault |
| 1014 | UDC run fault |
| 1015 | Fiber-optic link communication fault |
| 1016 | Power Module overtemperature fault |
| 1017 | Instantaneous overcurrent fault |
| 1018 | DC bus overvoltage fault |
| 1019 | Vcc power supply undervoltage |

### Error Codes

The UDC module can generate three error codes which will be displayed on the leftmost AutoMax Processor:

**Error 38** indicates that the UDC module has generated a Stop All. If this error occurs, refer to the UDC task error log for additional information regarding the error.

**Error 39** indicates a UDC module interrupt allocation has failed. In this case, try to cycle power to the rack and reload the rack configuration and application tasks.

**Error 3A** indicates the UDC module's operating system and the AutoMax operating system are not compatible. If this error occurs, reload the most current operating systems.

# APPENDIX E

# Power Module LED Summary

The following table summarizes the LEDs on the SA500 Power Module. Refer to the SA500 Power Modules instruction manual (S-3018) for more information regarding the Power Module. Refer to the SA500 Drive Configuration and Programming instruction manual (S-3044) for more information regarding the UDC module's dual port registers.

| | Name | Description |
|---|---|---|
| LED | **PWR OK** | When lit, all power supply voltages for the PMI are at acceptable operating levels. |
| Related Reg/Bit | 202/1202 bit 12<br>FLT_PS@ | PMI Power Supply Fault |
| LED | **OK** | When lit, indicates the PMI has passed its internal power-up diagnostics and the on-board watchdog timer is being updated. |
| LED | **COMM OK** | When lit, indicates messages are being received correctly from the UDC module over the fiber-optic link. |
| LED | **P.M. FLT** | When lit, indicates one of the following fault conditions has been detected by the PMI: |
| Related Reg/Bit | 202/1202 bit 2<br>FLT_OV@ | DC Bus Overvoltage |
| Related Reg/Bit | 202/1202 bit 3<br>FLT_VCC@ | Vcc Power Supply Undervoltage |
| Related Reg/Bit | 202/1202 bit 0<br>FLT_OT@ | Power Module Overtemperature |
| LED | **EXT FLT** | When lit, indicates one of the following external fault conditions has been detected by the PMI: |
| Related Reg/Bit | 202/1202 bit 1<br>FLT_IOC@ | Instantaneous Overcurrent |
| Related Reg/Bit | 202/1202 bit 10<br>FLT_OSP@ | Overspeed |
| Related Reg/Bit | 101/1101 bit 2<br>EXT_LED@ | User-programmed |
| LED | **RAIL FLT** | When lit, indicates communication between a rail and the PMI has been disrupted, or that a rail is configured but is not plugged in. |
| Related Reg/Bit | 203/1203 bit 13<br>WRN_RAL@ | Rail Communication Warning |
| LED | **FDBK OK** | When lit, indicates that the PMI is receiving feedback from the resolver and no resolver feedback faults have been detected. |
| Related Reg/Bit | 202/1202 bit 8<br>FLT_TBW@ | Resolver Feedback Broken Wire |

| | Name | Description |
|---|---|---|
| LED | **RPI** | When lit, indicates the run permissive input signal has been detected. |
| Related Reg/Bit | 201/1201 bit 0<br>RPI@ | RPI Input Status |
| LED | **MCR** | When lit, indicates that the MCR output signal is being driven on. |
| LED | **AUX IN1** | When lit, indicates the presence of a 115V signal on this input. |
| Related Reg/Bit | 201/1201 bit 1<br>M_FDBK@ | Aux Input 1/MFDBK Status |

# APPENDIX F

# Status of Data in the AutoMax Rack After a STOP_ALL Command or STOP_ALL Fault

| | AutoMax Processor | UDC Module | PMI Processor |
|---|---|---|---|
| LOCAL tunable variables | retained | retained | retained |
| LOCAL variables | retained | reset to 0 | N/A |
| COMMON memory variables | non-volatile are retained;<br>others are reset to 0 | N/A | N/A |
| I/O variables<br>(including UDC dual port memory) | inputs retained and updated;<br>outputs are reset to 0 | see below? | all I/O is reset to 0 |
| Input values, including:<br>Feedback registers<br>UDC/PMI communication status registers<br>UDC Error Log info | retained | retained | N/A |
| Output values, including:<br>Command registers<br>Application registers<br>ISCR registers<br>Scan-per-interrupt register<br>Scans-per-interrupt counter | reset to 0 | reset to 0 | N/A |
| Parameter configuration variables | N/A | retained | N/A |
| UDC test switch information | N/A | retained | N/A |
| D/A setup configuration | N/A | retained | N/A |
| Operating system | retained | retained | retained |

# APPENDIX G

# AutoMax Programming Executive Access Levels

| | Rack Power Supply Keyswitch Position | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Any Position | PROTECT | SETUP | | | PROGRAM | | |
| | User's Access Level | | | | | | | |
| Action | None | Any Level | Data | Task | Rack | Data | Task | Rack |
| Force Common | No | No | No | No | No | Yes | Yes | Yes |
| Force Local | No | No | No | No | No | No | Yes | Yes |
| Force I/O | No | No | No | No | No | Yes | Yes | Yes |
| Set Common | No | No | No | No | No | Yes | Yes | Yes |
| Set Local | No | No | No | No | No | No | Yes | Yes |
| Set I/O | No | No | No | No | No | Yes | Yes | Yes |
| Set/Tune Tunable | No | No | No | Yes | Yes | No | Yes | Yes |
| Load Normal Config | No | No | No | No | No | No | No | Yes |
| Load Debug Config | No | No | No | No | No | No | No | Yes |
| Load Single POB File | No | No | No | No | No | No | Yes[1] | Yes |
| Load Single Task | No | No | No | No | No | No[2] | Yes | Yes |
| Delete Task | No | No | No | No | No | No | Yes | Yes |
| Start Task | No | No | No | No | No | No | Yes | Yes |
| Stop Non-Critical Task | No | No | No | No | No | No | Yes | Yes |
| Save Task from Rack | No | Yes[3] | No | Yes | Yes | No | Yes | Yes |
| Load All POB Files | No | No | No | No | No | Yes | Yes | Yes |
| Load All | No | No | No | No | No | No | No | Yes |
| Delete All Tasks | No | No | No | No | No | No | Yes[4] | Yes |
| Start All Tasks | No | No | No | No | No | No | Yes[4] | Yes |
| Stop All Tasks | No | No | No | No | No | No | Yes[4] | Yes |
| Load AutoMax OS | No | No | No | No | No | No | No | Yes |
| Load Single UDC OS | No | No | No | No | No | No | Yes[1] | Yes |
| Load All UDC OS | No | No | No | No | No | No | Yes[1] | Yes |
| Modify PC Task | No | No | No | No | No | No | Yes | Yes |
| Auto Run | No | No | No | No | No | Yes | Yes | Yes |
| Monitor | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note that a user with privileged (Data, Task, or Rack) access may relinquish this privilege by timing out after two minutes off-line, or by selecting to relinquish access on-line. Functions not listed in the table do not require privileged access.

1. Must have Task access to both tasks in the UDC
2. A single task may be loaded with only Data access if the task does not already exist on the AutoMax Processor or UDC module.
3. Requires Task or Rack access.
4. Must have Task access to all tasks.

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# DIF

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