# DriveBlok™

## Owner's Manual

MTS Systems Corporation
Automation Division

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0101

Part Number 0A-0028-03 Version 1.3

# Safety Overview

Before designing a system or machine that will contain a DriveBlok module or before installing and operating a DriveBlok module, it is extremely important that you read this section very thoroughly and carefully. The DriveBlok module will deliver years of reliable, trouble-free, and safe operation if the cautions and warnings outlined in this section are heeded and the subsequent instructions in the remainder of this manual are followed.

Throughout this manual *three* unique symbols will be used to identity hazardous and potentially dangerous situations. The symbols are described here:

**THE ELECTRICAL SHOCK SYMBOL SHOWN TO THE LEFT IS USED TO INDICATE SITUATIONS WHERE ELECTRICAL SHOCK HAZARDS MAY EXIST.** Follow these warnings to avoid electrocution of the user or other serious potential issues that could result in serious injury or death.

DANGER

**THE DANGER SYMBOL SHOWN TO THE LEFT IS USED TO INDICATE SITUATIONS (OTHER THAN ELECTRICAL HAZARDS), WHICH ARE CLEARLY DANGEROUS TO EITHER YOU OR TO THE PRODUCT.** Follow these warnings to avoid serious injury to you and damage to the product.

CAUTION

**THE CAUTION SYMBOL SHOWN TO THE LEFT IS USED TO INDICATE SITUATIONS WHERE THE CHANCE OF MINOR OR MODERATE INJURY TO YOURSELF OR THE PRODUCT EXISTS.** Follow these warnings to avoid injury to you and damage to the product.



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Document 0A-0028-03

# General Safety Precautions

The following indicates a partial list of warnings, precautions, and points of concern that must be addressed to ensure safe operation of the DriveBlok module and the machine it is installed in. Other more specific precautions are indicated in the appropriate sections of this manual. As you read through the manual, pay particularly close attention to these cautions and warnings as they could save the life of the user!

**Dangerous voltages, currents, temperatures, and energy levels** exist within this unit, on certain accessible terminals, and at the motor. **NEVER** operate the unit with its protective cover removed! Exercise caution when installing and applying this product. Only qualified personnel should attempt to install and/or operate this product. It is essential that proper electrical practices, applicable electrical codes, common sense and suggestions in this manual be strictly adhered to.


**AC motors can develop high torque and speed.** Use extreme caution during development of applications and integration into the system. Sudden motor motion may occur during execution of software programs. All software should be verified for proper operation before integration into your system. The motor may continue to rotate upon removal of power to the unit. It is your responsibility to ensure that no dangerous motion occurs due to gravity loading or free-running motors upon unit shutdown. Fail-safe brakes may be interfaced to the unit to prevent such dangerous conditions.


**Rotating machinery can cause serious injury or death.** Use extreme caution when near any rotating machine. Never wear loose clothing (e.g., neck ties) nor allow hands and feet anywhere near a rotating shaft. Always wear safety glasses when you operate rotating equipment. Refer to OSHA rules and regulations, as well as the CE Machinery (IEC 204-1), when designing a mechanical system that includes a motor and drive to ensure that the user is protected.


**AC motors can have surface temperatures of up to or exceeding 130°C,** and can store heat for some time. Use caution when handling the motor or anything mounted directly to the motor or its shaft, as they can be hot enough to cause potentially serious injury even after the unit has been de-energized for some time.

Dangerous high voltages exist in this product. Be certain the power has been removed for at least 5 minutes before any service work or circuit board configuration changes are performed.


**DriveBlok products are not suitable for use in explosive atmosphere,** or in a "Hazardous (Classified) Location". See Article 500 of the National Electric Code.

Temperature of the heatsink can exceed 60 °C, which could cause discomfort or injury to an operator. The end user should be protected from casual contact with DriveBlok heat exchangers. During diagnostic testing and machine development, exercise caution when determining the temperature or when touching the heat exchanger hardware.

Secure mounting and proper grounding of both the DriveBlok and the AC or BLDC motor is essential for proper operation of the system. Pay particular attention to the suggested wiring diagrams, as noise currents injected into the motor frame must be returned to the drive chassis, and the loop area must be minimized to meet applicable EMC standards.

It is your responsibility to follow the appropriate federal, state, and local electrical and occupational safety codes in the application of this product.

**NEVER wire the unit with the power on!** Serious injury as well as damage to the unit may result.

**NONE of the inputs to the unit are to be used as EMERGENCY STOP** in *any* application. These inputs go to a microprocessor-input port, where software determines the proper action - activation of these inputs will discontinue motion or disable motor current. However, these inputs are **NOT** designed as fail-safe E-STOP inputs. Relying exclusively on inputs of the unit to cease motion, which could cause dangerous conditions, is a violation of Machine Safety Codes (ref. IEC 204-1). Other measures such as mechanical stops and fail-safe brakes must be used in these situations.



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**All electronic equipment is susceptible to damage from static discharge.** Static control precautions are required when crating and uncrating, storing (in inventory at your factory), moving to the factory floor, installing, testing and servicing the DriveBlok product. Component damage may result if good static control procedures are ignored. When installing the module, connect the ground wire as soon as possible. Keep hands and tools away from the electronic circuits as much as possible. Non-conductive materials (paper, plastic, Styrofoam, tape, etc.) should not be used on or around the module as they can generate a high static charge.

**Printed circuit boards are not field repairable.** Attempting to modify or repair these components will invalidate the warranty and could negate the solid state protection features designed and tested into the DriveBlok family of products, which could cause serious collateral damage if an impaired system is powered up.



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# Introduction

The DriveBlok is a complete family of Integrated Drive Modules (IDMs) that provide AC Induction Motor (AC) and Brushless Synchronous Permanent Magnet DC (BLDC) motor speed or torque control in a wide variety of industrial and commercial applications. Models are available for 1 to 20 Hp (0.75 - 15 kW) applications.

This manual provides a checklist, drawings, specifications and pre-installation information to help select the right equipment, design the machine that will house the unit, and properly install the DriveBlok Module.

To ensure success, thoroughly read and understand the material presented in each section before you attempt to integrate a DriveBlok into your equipment. If this is your first design or installation, read each section in the sequence presented since it is assumed that you know the material presented previously. Once experience with the DriveBlok family has been gained, use the manual as a reference source to look up the information needed.

DriveBloks are designed to provide precise speed control of three phase motors. The microprocessor based pulse width modulated (PWM) modules have a very general-purpose I/O and functional feature set, which can be programmed to tailor the unit's performance and behavior. The manual describes how to go about this customization of hardware and software. These sections are important to read and understand before this task is started.

If there are any questions or comments, please contact MTS Automation through any of the following method.


**Tel:** 507 354 1616
800 967 1785

**Fax:** 507 354 1611

**Web:** http://www.mtsautomation.com/

# Quick Start

The "Quick Start" is written for a user who is familiar with *installing*, *configuring*, and *operating* motion control products. The following directions assume that the user is familiar with motors, motor drives, any related electrical connections, and use of Windows95 or WindowsNT based software.

## I. SHIPPING CONTENT

Verify that you have the following items:

[Required]

❖ **DriveBlok**

ADM- 10 05 E- CS- XXXXX

**Assembled Drive Configurations**
(with Heatsink and Filter Capacitors)

**Optional CapBlok™**
- CS – Standard
- CH – Rated for single-phase inputs to *1 and 2 hp drive modules*
- 00 – No capacitor assembly

**AC Line Voltage**
- D – 200/240 V
- E – 380/460 V

**Power Rating**
- 01 – 1 hp
- 02 – 2 hp
- …
- 20 – 20 hp

**Module Type & Footprint**
- 10 – 1-5 hp
- 20 – 7.5-20 hp

**Control Type**
- ADM – Sensorless Flux Vector (SFV) AC drive module
- BDM – Brushless DC drive module

*Drive Module Only*
The first 8 digits of the ordering part numbers identify the basic drive module

*Drive Module with* **CapBlok** *DC Bus Filter Capacitor*
By including the additional capacitor assembly part number to the drive module ordering number, the drive module would be supplied with the appropriately rated electrolytic filter **CapBlok** capacitor assembly. Each capacitor assembly has its own specifications. The capacitor assembly and drive module are shipped together in the same box; however, final assembly is required.

*Assembled Drive Configurations*
MTS Automation offers standard assembled drive configurations that include the **CapBlok**, heatsink, fan, and other options. Refer to the **DriveBlok** Owner's Manual specifying a guide for sizes and options.

❖ Capacitor Assembly (MTS Automation offers the **CapBlok**)
❖ Heatsink (MTS Automation offers a heatsink)
❖ Computer with Windows95 or WindowsNT operating system
❖ RJ-12 6-P Cable (for RS-485 serial communication between the drive and the computer)
❖ RS-232/RS-485 converter (MTS Automation offers this item under the B&B Electronics part number **485SD9TB**). See **Figure 1**.



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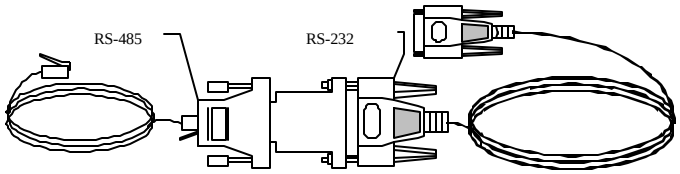



**Figure 1**

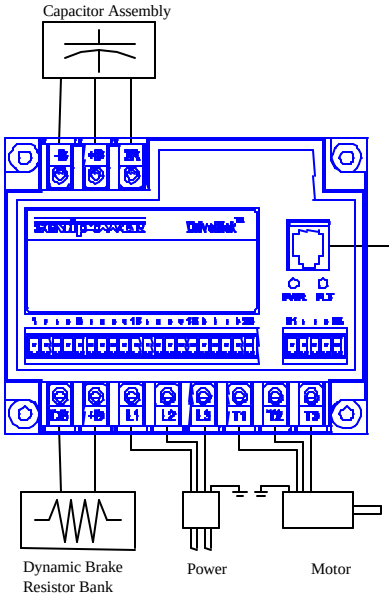
- ❖ RS-232 serial communication cable
- ❖ Motor (AC or Brushless DC) and its appropriate cables
- ❖ Power Cables

[Optional]

- ❖ Dynamic Brake Resistor Bank (Consult factory for resistor values based upon application)

## II. INSTALLING THE DriveBlok

| Pin | Function |
|---|---|
| 1 | ILOOP (*Torque Reference*) |
| 2 | AGND |
| 3 | VIN (*Speed Reference*) |
| 4 | AOUT1 (*Speed*) |
| 5 | AOUT2 (*Torque*) |
| 6 | AOUT3 (*Null Function*) |
| 7 | +5V |
| 8 | DIGCOM |
| 9 | DIN1 (*Run-Enable*) |
| 10 | DIN2 (*Run*) |
| 11 | DIN3 (*Jog*) |
| 12 | DIN4 (*Direction*) |
| 13 | DIN5 (*Preset Speed Bit 0*) |
| 14 | DIN6 (*Preset Speed Bit 1*) |
| 15 | DIN7 (*External Fault*) |
| 16 | DIN8 (*Fault Clear*) |
| 17 | FANRTN |
| 18 | +12V |
| 19 | TERM1 |
| 20 | TERM2 |




| Pin | Function |
|---|---|
| 21 | RLY1 NO (*Fault*) |
| 22 | RLY1 COM |
| 23 | RLY2 NC |
| 24 | RLY2 COM |
| 25 | RLY2 NO (*Run*) |

[Note: All digital and analog I/O are configurable.]

**Figure 2**



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1. Mount the drive module to the HEATSINK *if not already mounted*.
2. Mount the CAPACITOR ASSEMBLY *if not already mounted*.
3. Connect the Dynamic Brake Resistor Bank *if appropriate.*
4. Connect the COMPUTER.
5. Connect the MOTOR.
6. Connect the POWER CABLES.

Without a proper cooling system (e.g., heatsink, fan), the drive module will not operate reliably. Visit the following website address, www.mtsautomation.com , for information and tools to design an appropriate cooling system.

Without a proper capacitor assembly, the drive module will not operate reliably. Please visit the following website address, www.mtsautomation.com , for information and tools to design a proper capacitor assembly.

Output Current, Wire Size, Circuit Breaker, Fuse Information Table

| HP | 1 | 2 | 3 | 5 | 7.5 | 10 | 15 | 20[CT] | 25[VT] |
|---|---|---|---|---|---|---|---|---|---|
| 220V - 240V, 3-ϕ | | | | | | | | | |
| • Drive FLA | 3.6 | 6.8 | 9.6 | 15.2 | 22 | 28 | n/a | n/a | n/a |
| • Min Wire Size[1] (AWG) | 14 | 14 | 12 | 8 | 8 | 6 | n/a | n/a | n/a |
| • Circuit Breaker Rating, A | 20 | 20 | 25 | 40 | 50 | 60 | n/a | n/a | n/a |
| • Fuse Rating[2], A | 20 | 20 | 25 | 40 | 50 | 60 | n/a | n/a | n/a |
| • Fuse Class | KTK | KTK | KTK | T | T | T | n/a | n/a | n/a |
| 440V - 480V, 3-ϕ | | | | | | | | | |
| • Drive FLA | 1.8 | 3.4 | 4.8 | 7.6 | 11 | 14 | 21 | 27 | 34 |
| • Min Wire Size[1] (AWG) | 14 | 14 | 14 | 14 | 12 | 10 | 8 | 6 | 6 |
| • Circuit Breaker Rating, A | 15 | 15 | 15 | 20 | 25 | 35 | 40 | 60 | 60 |
| • Fuse Rating[2], A | 10 | 10 | 15 | 20 | 25 | 35 | 50 | 60 | 60 |
| • Fuse Class | KTK | KTK | KTK | KTK | T | T | T | T | T |

**Table 1**

1. Based on 90°C rated copper wire in a 30°C ambient. Adjust per NEC or applicable code or different conditions.
2. Fuses must be current limiting type, Gould Shawmut ATM, A3T, or A6T or equivalent.
3. CT = Continuous Torque
4. VT = Variable Torque

**DO *NOT* APPLY POWER UNTIL ALL ELECTRICAL CONNECTIONS ARE COMPLETED!.**

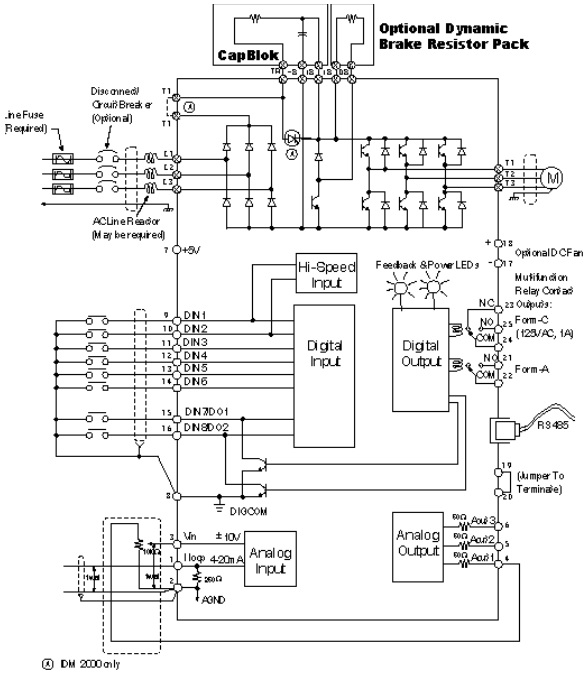


**Figure 3**

After all the mounts and connections have been completed, the drive module is ready to be powered up and configured.



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## III. CONFIGURING THE DriveBlok

The configuration of the **DriveBlok** will be done via the software program, *wInControl*, using the **Motor Wizard**, **Application Wizard**, and **Regulator Wizard**.

1. Apply appropriate power to the drive module. The green PWR LED on the drive module will turn on and remain on.

2. Open the *wInControl* software program. The following dialog box will appear


**Figure 4**

3. Click on the **Reset Drive Fault** button. [Note: This fault will normally appear when power to the drive module is cycled.] The following drive workspace will appear

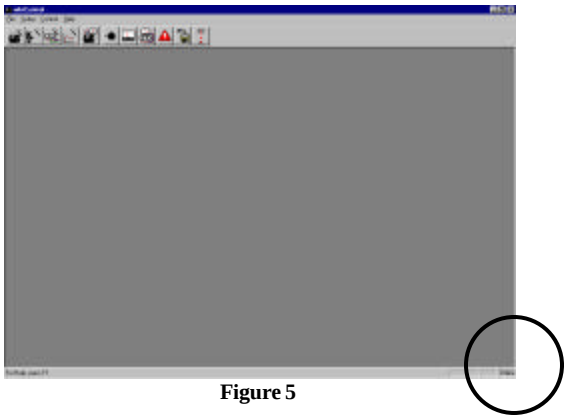

**Figure 5**

4a. To verify that communication between the drive module and the computer is set up properly, check the lower right corner for the word, **Online**.

4b. *If* communication between the drive module and the computer is not online, then click on the Communications sub-menu under Setup menu from the original window. The following dialog box will appear


**Figure 6**

4c. Configure the Communications Setup to the proper Baud Rate, Port Selection, and IDM address until communication between the drive module and the computer is online.

4d. Click the **OK** button.

4e. *If* communication between the drive module and the computer is STILL not online, check the physical connection between the two items until communication between the drive module and the computer is online.

5. Click the **Motor Wizard** icon. The following dialog box will appear

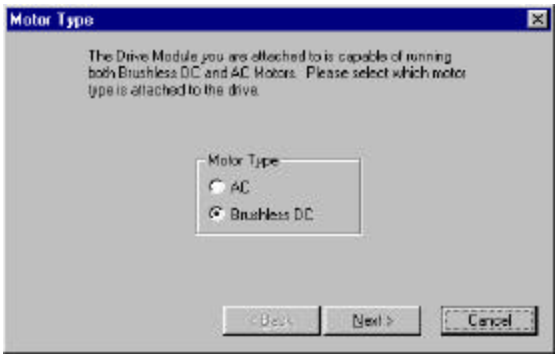


**Figure 7**

The above dialog box will only appear if the computer is connected to a **BDM** type drive module; otherwise, the dialog box that will appear is shown in **Figure 8**.



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6. Select the Motor Type.

   *If AC* is selected, follow directions 7a to 7c.

   *If Brushless DC* is selected, follow directions 8a to 8e.

7a. Click the **Next>** button. The following dialog box will appear

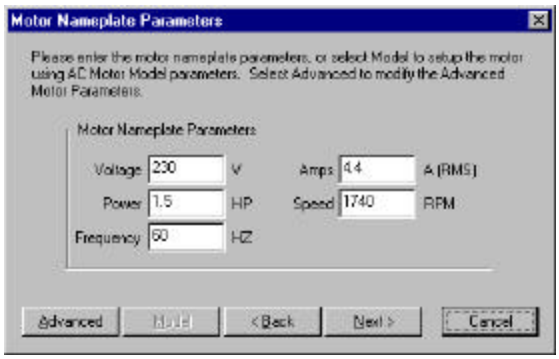


**Figure 8**

7b. Enter values for each Motor Nameplate Rating.

7c. Go to Step 9.

8a. Click the **Next>** button. The following dialog box will appear

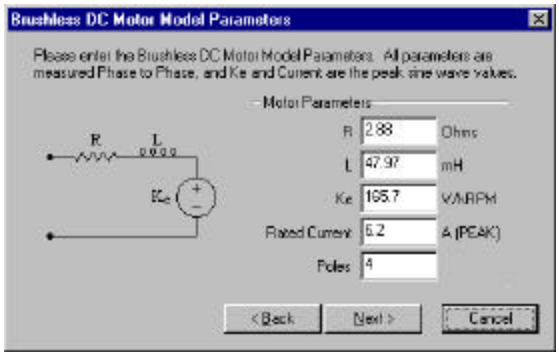


**Figure 9**

*All* the values entered for these motor parameters must be based upon measured or calculated phase-to-phase (i.e., line-to-line) values for optimum performance. Also, the back EMF constant, $K_e$, and the *Rated Current* must be based upon peak sine values. Consult factory for further technical support.

8b. Enter values for each Motor Parameter.

8c. Click the **Next>** button. The following dialog box will appear

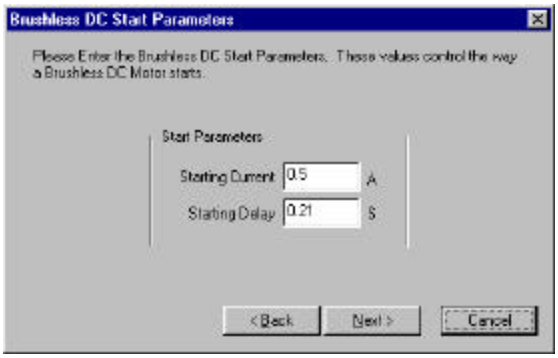


**Figure 10**

Recommended values for the *Starting Current* and *Starting Delay*:

For lightly loaded motors, use 25% of *Rated Current*.
For highly loaded motors, use 50% or more of *Rated Current*.

For low inertia loads, use 0.25 s for *Starting Delay*.
For high inertia loads, use 1.00 s for *Starting Delay*.



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8d. Enter values for the Starting Current and Starting Delay.

8e. Go to Step 9.

9. Click the **Next>** button. The following dialog box will appear


**Figure 11**

[Note: Prior to commissioning the drive module, ensure that a jumper is connected from digital input pin 8 (i.e., DIGCOM) to digital input pin 9 (i.e., Run-Enable) on the I/O terminal connector.]

*Commissioning* is a process in which the drive module sends current to the motor to fine tune the drive module with respect to the entered motor parameters (e.g, $K_e$ for a Brushless DC motor).

10. Click the **Commission** button. The following dialog box will appear


**Figure 12**

After the drive module has been commissioned, the original window will appear. The drive module is ready for operation.

## IV. OPERATING THE DriveBlok

The operation of the drive module, which includes controlling and monitoring, can be done via the software program, *wInControl.*

The user can monitor feedback, I/O status, and faults by clicking on the **Feedback View** icon, **I/O View** icon, and **Fault View** icon, respectively. By clicking on the **Control View** icon, the user can start, stop, change direction, and change speed of the motor. If all three icons are clicked, the original window will appear with the following dialog boxes

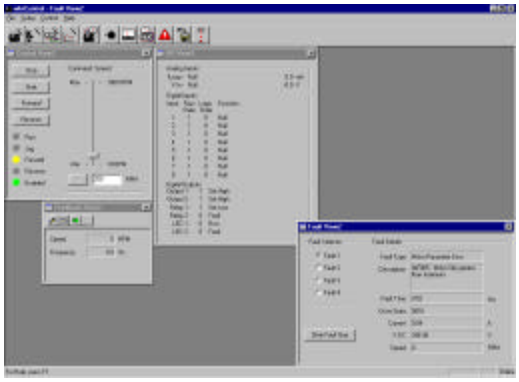

**Figure 13**



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Example 1:

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | | √ |
| Jog | | √ |
| Forward | D | |
| Reverse | | D |
| Online | √ | |

1. Select the desired direction of the motor rotation by clicking the **Forward** or **Reverse** button.

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | | √ |
| Jog | √ | |
| Forward | D | |
| Reverse | | D |
| Online | √ | |

2. Adjust the command speed to 0 RPM by
   - using the Scroll Bar or
   - entering a value and clicking the **Set** button.

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | | √ |
| Jog | | √ |
| Forward | D | |
| Reverse | | D |
| Online | √ | |

3. Click the **Start** Button.

*The motor will not rotate. However, there will be current injected to the motor (due to a zero commanded speed) to counter any externally forced rotation.*

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | √ | |
| Jog | | √ |
| Forward | D | |
| Reverse | | D |
| Online | √ | |

4. Adjust the command speed to a value that is appropriate to the application by
   - using the Scroll Bar or
   - entering a value and clicking the **Set** button.

*The motor will rotate at the desired speed.*

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | √ | |
| Jog | | √ |
| Forward | D | |
| Reverse | | D |
| Online | √ | |

*If the application allows motor rotation that is opposite of the desired direction, follow the next instruction. Otherwise, go to instruction number 6.*

5. Select the desired direction of the motor rotation by clicking the **Forward** or **Reverse** button.

*The motor will rotate in the desired direction at the last commanded speed.*

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | √ | |
| Jog | | √ |
| Forward | | D |
| Reverse | D | |
| Online | √ | |

6. Click the **Stop** button.

*The motor will stop rotating.*

*The following is the current LED Status on the* **Control View** *dialog box*

| LED | Active | Inactive |
|---|---|---|
| Run | | √ |
| Jog | | √ |
| Forward | | D |
| Reverse | D | |
| Online | √ | |



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D = Set per commanded direction





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# Installation

This section of the DriveBlok Owner's Manual provides pre-installation information, an installation checklist, drawings [See **Appendix C**.], and specifications to help select the right equipment and properly install the DriveBlok module.

To ensure successful installation, thoroughly read and understand the material presented in this section before attempting to design the module into the equipment. If this is the first opportunity to use the DriveBlok, read this section in the sequence it is presented. Once experience with designing the DriveBlok into machines has been gained, use this section as a reference source.

## A. Pre-Installation

This part of the **Installation** section provides guidelines to consider before designing in or installing the drive module:

- Handling of drive assembly or drive module after delivery
- Where to locate the drive module in the machine
- Application Considerations
- Input Line Considerations
- Output Wiring Considerations
- Analog and Digital I/O Signal Considerations

### 1. Handling of drive *assembly* or drive *module* after delivery

Although every precaution is taken to ensure that every unit shipped will be in good condition, inspect the drive.

*If* a complete open-frame drive assembly (i.e., DriveBlok and CapBlok on a heatsink) was received:

- Inspect the shipping container for evidence of rough handling immediately after the unit arrives. Report all damage to the freight carrier and MTS Automation or your MTS Automation sales representative.
- Carefully unpack the drive, taking care to save the shipping container and any packing material should you need to return the unit at a later date. Verify that the items on the packing list agree with your order.
- If you are not installing the drive right away, store the drive in a clean, dry area where the ambient temperature is between 0 to 160°F (-20° to 70°C) and less than or equal to 95% humidity (non-condensing). Ensure that the drive is not subject to corrosive atmosphere (such as $H_2S$).

*If* a drive module (and associated CapBlok Capacitor Assembly) were received:

- Inspect the shipping container for evidence of rough handling immediately after the unit arrives. Report all damage to the freight carrier and MTS Automation or your MTS Automation sales representative.
- Carefully open the shipping container and remove the packing list (i.e., 1-page summary of content form). Inspect these documents to ensure that you have received exactly what you ordered - paying special attention to any special product configuration (the last 3 digits of the model number).
- Carefully preserve the shipping container, antistatic bags, etc. Do not destroy or misplace these materials.
- If you are planning to inventory these assemblies, it is strongly recommended that you do so in the original shipping containers in which you received them from MTS Automation. These boxes not only hold all associated materials (screws, covers, mating connectors, etc.), but they are clearly labeled and provide significant mechanical and antistatic protection for your DriveBlok modules.
- A DriveBlok module should be uncrated and removed from its protective antistatic bag only immediately prior to assembly into your equipment.


Large drive assemblies or multi-axis assemblies, once mounted to their heat exchanger system, may require more than one person to move from one location to another. Observe proper lifting techniques to avoid injury when handling heavy electrical equipment.

### 2. Where to locate the drive module in the machine

Consider the following:

- Since the drive module is IP-20 (1 - 5Hp) or an Open-Frame (7 - 20Hp) enclosure, the unit is not suitable for standalone operation. It is intended to be mounted in a panel, which provides the primary safety enclosure to protect the operator of the machine from the hazards of electrical shock that these drives would otherwise expose the user to.

  If the panel can be opened while power is applied to the unit, then provide a separate safety barrier (such as a Plexiglas sheet) to make it impossible for the casual user to contact potentially lethal voltages with the cover off. The possible exception is the 1 - 5Hp frame size modules, coupled with MTS Automation's CapBlok housing. These units are IP-20 compliant, and reduce the hazard of casual contact with lethal voltages. Only YOU can decide if this alone is sufficient protection for your equipment.



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- Standard Open-Frame DriveBlok-based drives are rated for an application at a maximum ambient temperature of 122°F (50°C) for 1 - 5Hp ratings, and 108°F (40°C) for 7.5 - 20Hp ratings, up to 3,300 feet (1000 meters) above sea level. If the drive is installed in a larger enclosure, the maximum ambient temperature must not be exceeded.

In addition, for every 1000 feet (300 meters) above the rated altitude, the DriveBlok current ratings must be de-rated by 2%.

- Drive modules are rated based on a baseplate temperature not to exceed 90°C under worst case operating conditions. The UL Recognition is only valid if you keep the substrate temperature less than 90°C.

  Note: The DriveBlok will trip off due to over temperature at 92±2°C.

  This temperature can be maintained in any number of ways:

  - ❖ At a reasonable ambient temperature (30° - 60°C), an extruded or bonded fin heatsink and suitable Brushless DC fans are sufficient.
  - ❖ At a higher ambient temperature (50° - 70°C), an exotic bonded fin design or water-cooled heat exchanger is probably required.

Please refer to our Application Notes and Heatsink Design Tools that are available on our web site or from your MTS Automation sales representative for more details.

- Refer to the drawings in **Appendix C** for the mounting dimensions of each DriveBlok, CapBlok, and Open-Frame Drive.
- If air will be used to cool the DriveBlok, ensure that there is plenty of ventilating space surrounding the drive, so that its fan has an unobstructed area to draw from. Refer to the drawings in **Appendix C** for ventilation clearances.

### 3. Application Considerations

When designing a DriveBlok in to a machine, consider how the drive will be used and what you will expect from it. Different applications, such as industrial process control and HVAC system control, require different drive options, different motors or motor types, and special software configuration. Plan how the DriveBlok will be used in order to be satisfied with the end results.

- An input line impedance of at least 1% and not over 5% is required for proper drive operation. If you need to operate at temperatures exceeding these values, you must de-rate the unit as follows:

  - ❖ For every 9°F (5°C) over the rated temperature you must de-rate the DriveBlok current ratings by 10%. However, do not exceed a maximum temperature of 149°F (65°C) for 1 - 5Hp units or 131°F (55°C) for 7.5 - 20Hp units under any circumstances.

  Calculate the input line impedance to determine whether an input reactor is required. Refer to the discussion on Input Line Considerations later in this section for more details on determining line impedance.
- Order a 3% or 5% input line reactor to improve input line harmonic distortion as required. Refer to the discussion on Input Line Characteristics later in this section for more details on harmonic distortions.
- A circuit breaker is usually required for disconnecting the motor from the power source.


- An input line fuse is **ALWAYS** required to limit the current available to a failed semiconductor device. The fuse limits or eliminates the collateral damage that can occur when a drive fails catastrophically, and the possibility of fire that could occur. While this is a remote circumstance, it is important that all reasonable precaution should be taken to avoid the chance of consequential damages. Refer to the discussion on *Input Line Considerations* later in this section for more details on determining the correct fuse type and rating for your application.

#### a. Motor Selection

Careful consideration of the proper motor is essential to obtain optimum performance from the DriveBlok. Contact your MTS Automation sales representative or distributor for additional assistance and/or literature regarding motor Selection and other aspects of drive applications.

- When using an *ADM* type DriveBlok, it is designed to be connected directly to a single, NEMA design B, three phase AC induction motor. When using a *BDM* type DriveBlok, it is designed to be connected directly to a single, three phase Permanent Magnet Brushless DC motor. The motor must be selected and applied so that the average operating motor current and horsepower do not exceed the continuous current and horsepower ratings of the drive. The intermittent operating current must not exceed the intermittent current rating of the drive.



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- Consider the effect of speed on the cooling capacity of the motor. As you slow down some types of motors (such as a Totally Enclosed Fan Cooled [TEFC]), the fan turns slower which reduces airflow to the motor. These types of motors may overheat if you operate them for extended periods of time at their rated torque and a reduced speed (typically something less than 50% of full rated speed). Choose a motor that matches the expected duty, torque range, and speed.
- For an *ADM* type DriveBlok, multiple motors may be operated *if*:
  - ❖ Total current from all motors does not exceed the current rating of the DriveBlok.
  - ❖ Individual motor overload protection is supplied by some means external to the drive (winding thermostat in each motor, etc.).
  - ❖ The application is such that all motors will start and change speed together.


DANGER

If the drive is configured to operate above 60 Hz, the motor may operate above its nameplate rated speed. **Personal injury or equipment damage may occur when you operate a motor and driven machines above their rated speed.** Make certain that you **do not exceed the rated maximum operating speed of any component in your motion system.** Refer to the motor manufacturer's datasheet to verify safe motor speed.

**ALWAYS** use mechanical guards and shields to protect the user before operating at any speed.

**b. Heatsinking and Thermal Design - Cooling the DriveBlok Module**

The total energy delivered from the motor shaft has to flow through the drive module - and the more rugged the application is the more heat the DriveBlok will generate. Keep the DriveBlok mounting surface below 90ºC under absolute worst case conditions. Internal device temperatures are guaranteed to be at safe levels if you do not exceed maximum rated RMS output current and maintain the baseplate at or below 90ºC. **Failure to follow this guideline will cause nuisance over temperature trip and may degrade the life of the DriveBlok module.**

There is a more information on MTS Automation's web site concerning this critical issue. Find and evaluate the Application Notes and software tools provided to calculate the required device heatsinking and airflow to maintain a reliable design margin.

**4. Input Line Considerations**

All wiring must comply with the requirements of the National Electric Code (NEC) and/or other codes as required by the authority having jurisdiction over the installation or machine in which the drive module is installed. The installer or system integrator must ensure that the electrical connections at the site conform to the connection diagrams provided in this manual.

[Note: Ensure that the most recent version of the codes is used when installing the drive module.]



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**Table 2** provides an overview of the DriveBlok's electrical specifications

| Module Type | Nominal Hp | Input | | | Output | | | Wire Size | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Voltage 3-ϕ, VAC | Freq, Hz | $I_{RMS}$, amps | Voltage 3-ϕ, VAC | Freq, Hz | $I_{RMS}$, amps | 100m or less | 500m | 1000m or more |
| **A**DM1001D/ **B**DM1001D | 1 | 200-240 | 50/60 | 4.0 | 0-240 | 0-400 | 3.6 | 14 | 10 | 8 |
| **A**DM1002D/ **B**DM1002D | 2 | 200-240 | 50/60 | 7.5 | 0-240 | 0-400 | 6.8 | 14 | 8 | 6 |
| **A**DM1003D/ **B**DM1003D | 3 | 200-240 | 50/60 | 10.6 | 0-240 | 0-400 | 9.6 | 14 | 6 | 4 |
| **A**DM1005D/ **B**DM1005D | 5 | 200-240 | 50/60 | 16.7 | 0-240 | 0-400 | 15.2 | 12 | 6 | 4 |
| **A**DM2007D/ **B**DM2007D | 7.5 | 200-240 | 50/60 | 24 | 0-240 | 0-400 | 22 | 10 | 4 | 2 |
| **A**DM2010D/ **B**DM2010D | 10 | 200-240 | 50/60 | 31 | 0-240 | 0-400 | 28 | 8 | 2 | 1 |
| **A**DM1001E/ **B**DM1001E | 1 | 380-480 | 50/60 | 2.5 (for 380 VAC)<br>2.0 (for 460 VAC) | 0-480 | 0-400 | 1.8 | 14 | 14 | 12 |
| **A**DM1002E/ **B**DM1002E | 2 | 380-480 | 50/60 | 4.7 (for 380 VAC)<br>3.7 (for 460 VAC) | 0-480 | 0-400 | 3.4 | 14 | 12 | 10 |
| **A**DM1003E/ **B**DM1003E | 3 | 380-480 | 50/60 | 6.7 (for 380 VAC)<br>5.3 (for 460 VAC) | 0-480 | 0-400 | 4.8 | 14 | 10 | 8 |
| **A**DM1005E/ **B**DM1005E | 5 | 380-480 | 50/60 | 10.7 (for 380 VAC)<br>8.4 (for 460 VAC) | 0-480 | 0-400 | 7.6 | 14 | 8 | 6 |
| **A**DM2007E/ **B**DM2007E | 7.5 | 380-480 | 50/60 | 15.0 (for 380 VAC)<br>12.1 (for 460 VAC) | 0-480 | 0-400 | 11 | 14 | 6 | 4 |
| **A**DM2010E/ **B**DM2010E | 10 | 380-480 | 50/60 | 20.0 (for 380 VAC)<br>15.0 (for 460 VAC) | 0-480 | 0-400 | 14 | 12 | 6 | 4 |
| **A**DM2015E/ **B**DM2015E | 15 | 380-480 | 50/60 | 30.0 (for 380 VAC)<br>23.0 (for 460 VAC) | 0-480 | 0-400 | 21 | 10 | 4 | 2 |
| **A**DM2020E/ **B**DM2020E | 20 | 380-480 | 50/60 | 37.0 (for 380 VAC)<br>30.0 (for 460 VAC) | 0-480 | 0-400 | 27 | 8 | 2 | 1 |

**Table 2**

**a. Input Line Conductor and Circuit Overload Protection Selection**

- The input line conductors must be made of copper with a temperature rating of at least 167° F (75° C). Use a conductor of at least the size specified in **Table 2** above.
- Note: Verify that the input line conductor size and branch circuit overload protection are in accordance with applicable local code requirements.
- The input line and branch circuit overload protection must be rated for the input voltage and current stated on the nameplate of the drive, and repeated here in **Table 2**.
- In addition, consider the wire size capacity of the integral module input line terminals:

❖ For IDM1000 type modules maximum wire size is #8 AWG
❖ For IDM2000 type modules maximum wire size is #4 AWG

Use a short length of wire of this size, spliced onto a larger wire if your cable run length is sufficient to warrant a larger wire size as indicated in the Table. The power terminal tightening torque range is 16-18 in. lbs. on these power terminals (including L1, L2, L3, T1, T2, T3, and the ground lugs).



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- Input Line Fuses are required for safe application of the drive module or open-frame drive. These fast acting fuses are designed to limit the let-through current by disconnecting the drive from the power line in the event of a catastrophic failure of the power semiconductors in the drive; and to reduce or eliminate the chance of consequential damage to the drive and any associated equipment in the machine. Fuse recommendations are listed in **Table 3**.

| Module Type | Nominal Hp | Voltage 1-ϕ or 3-ϕ, VAC | $I_{input}$ 3-ϕ, amps | 3-ϕ Line Fuse (Bussman types shown) | Fuse Class | Branch Circuit Breaker |
|---|---|---|---|---|---|---|
| ADM1001D/ BDM1001D | 1 | 200-240 | | KTK-20 | KTK | 15 |
| ADM1002D/ BDM1002D | 2 | 200-240 | | KTK-20 | KTK | 15 |
| ADM1003D/ BDM1003D | 3 | 200-240 | | KTK-25 | KTK | 20 |
| ADM1005D/ BDM1005D | 5 | 200-240 | | JJN-40 | 300V T | 30 |
| ADM2007D/ BDM2007D | 7.5 | 200-240 | | JJN-50 | 300V T | 40 |
| ADM2010D/ BDM2010D | 10 | 200-240 | | JJN-60 | 300V T | 60 |
| ADM1001E/ BDM1001E | 1 | 380-480 | | KTK-10 | KTK | 15 |
| ADM1002E/ BDM1002E | 2 | 380-480 | | KTK-10 | KTK | 15 |
| ADM1003E/ BDM1003E | 3 | 380-480 | | KTK-15 | KTK | 15 |
| ADM1005E/ BDM1005E | 5 | 380-480 | | KTK-20 | KTK | 15 |
| ADM2007E/ BDM2007E | 7.5 | 380-480 | | JJS-25 | 600V T | 20 |
| ADM2010E/ BDM2010E | 10 | 380-480 | | JJS-35 | 600V T | 30 |
| ADM2015E/ BDM2015E | 15 | 380-480 | | JJS-50 | 600V T | 40 |
| ADM2020E/ BDM2020E | 20 | 380-480 | | JJS-60 | 600V T | 60 |

**Table 2**

Input Branch Protection - a circuit breaker or equivalent - may be required for your application. In addition, some suitable means of safety power disconnect is almost certainly required so that the DriveBlok and the machine may be safely serviced. Ensure that the correct methods applied are in conformance to any and all machinery directives and the National Electric Code or your local electrical codes.

**b. Grounding Connections**

For personal safety and reliable equipment operation, *firmly* connect each chassis to earth ground as shown in the connection diagrams in the *Drawings* section of this manual.


The DriveBlok chassis ground conductor should be the same size as the input line conductors or sized according to electrical code requirements. Use a copper or aluminum conductor. **Connection to a grounded conduit does not provide an adequate equipment ground. Ensure that all operator's control stations and motor frames are adequately grounded.**

**c. Input Line Impedance**

Ensure that the input line power has an impedance of at least 1% and less than or equal to 5% relative to the DriveBlok nominal rating for proper operation. Damage to the drive may occur if the source impedance is less than 1%. If the source impedance is more than 5%, the drive may not provide rated output voltage.

Actual input current varies considerably in response to the load on the motor connected to the DriveBlok and the impedance of the power source. Since power source



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impedance has an effect on the harmonic content of the input current, the amount of impedance affects the value of the input line current and the input current harmonic distortion.

The value of source impedance is expressed as a percent of the effective impedance of the drive. To determine the source impedance of a drive, you must know:

- The short circuit capacity of the power source at the drive's input power terminals.
- The full load (output) current rating of the drive (found on the nameplate).

The following calculation provides the source impedance as a percent of the effective impedance of the drive:

*Full Load Current * 100 = Source Impedance * Short Circuit Capacity*

The short circuit capacity must be at least 20 times the full load current rating (5% input impedance) and no more than 100 times the full load current rating (1% input impedance).

*For example*, if the full load (output) current of your DriveBlok drive is 22 amps and the short circuit current capacity of the power source is 2200 amps, the source impedance is:

*(22 * 100) / 2200 = 1%*

Since the design of a power distribution system often includes a short circuit capacity study, power distribution system drawings or other distribution system documentation may show the short circuit capacity at various points. In **Table 4**, the proper line reactance (i.e, inductor value) at varying impedance levels for all drive models is shown.

| Module Type | Voltage $_{rated}$, VAC | Current$_{rated}$, A | Inductance$_{1\%\ impedance}$, mH | Inductance$_{3\%\ impedance}$, mH | Inductance$_{5\%\ impedance}$, mH |
|---|---|---|---|---|---|
| ADM1001D/BDM1001D | 230 | 3.6 | 0.978 | 2.940 | 4.890 |
| ADM1002D/BDM1002D | 230 | 6.8 | 0.518 | 1.550 | 2.590 |
| ADM1003D/BDM1003D | 230 | 9.6 | 0.367 | 1.100 | 1.830 |
| ADM1005D/BDM1005D | 230 | 15.2 | 0.232 | 0.700 | 1.160 |
| ADM2007D/BDM2007D | 230 | 22 | 0.160 | 0.480 | 0.800 |
| ADM2010D/BDM2010D | 230 | 28 | 0.126 | 0.380 | 0.630 |
| ADM1001E/BDM1001E | 460 | 1.8 | 3.914 | 11.740 | 19.570 |
| ADM1002E/BDM1002E | 460 | 3.4 | 2.072 | 6.220 | 10.360 |
| ADM1003E/BDM1003E | 460 | 4.8 | 1.468 | 4.400 | 7.340 |
| ADM1005E/BDM1005E | 460 | 7.6 | 0.927 | 2.780 | 4.630 |
| ADM2007E/BDM2007E | 460 | 11 | 0.640 | 1.920 | 3.200 |
| ADM2010E/BDM2010E | 460 | 14 | 0.503 | 1.510 | 2.520 |
| ADM2015E/BDM2015E | 460 | 21 | 0.335 | 1.010 | 1.680 |
| ADM2020E/BDM2020E | 460 | 27 | 0.261 | 0.780 | 1.300 |

**Table 4**

### d. Harmonic Distortion

As previously stated, Input Line source impedance can affect the harmonic content of the input line current. As source impedance increases, line current harmonic content decreases.

The relationship between Input Line impedance and harmonic voltage distortion is just the opposite: as source impedance increases, so does harmonic voltage distortion.

*For example*, if the source impedance is 1%, you will cause less than 5% harmonic voltage distortion when you connect a single DriveBlok to an undistorted power source. If the source impedance increases to 5%, the resulting harmonic voltage distortion is less than 10%.

Contact your MTS Automation sales representative or distributor for assistance in estimating harmonic distortion in multiple drive installations. We can also provide assistance in selecting a means of harmonic reduction such as line reactors.

### e. Input Line Routing



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- *If* conduit is used, use a separate conduit for input line conductors and output power conductors. **NEVER** route analog and digital wiring from any equipment in the same conduit as input or output power wiring.
- *If* cable trays are used, use a separate cable tray for input line conductors and output line conductors. **NEVER** route analog and digital wiring from any equipment in the same cable tray as input or output power wiring.
- **ALWAYS** route the Input and Output Grounding conductors in the same conduit or cable tray as the respective Input or Output power leads. Preferably, these conductors should be bundled.
- *If* multi-conductor wiring is used, a separate multi conductor cable must be used for the input line wiring for each drive.

**f. Isolation Transformers**

Isolation transformers can be used with drive modules. Remember that the input line impedance must be at least 1% and not over 5% with the drive running. See the previous discussion on Input Line Impedance.

**g. Power Factor Correction**

The displacement power factor at the input terminals of the drive is approximately 0.95 at all operating speeds and loads. Power factor correction capacitors are not required. Furthermore, they cannot alone improve Power Factor and should not be installed. If capacitors for correcting the power factor of other equipment are installed too close to the drive, nuisance tripping of the drive may be experienced.

**h. Standby Power Generation**

Three phase standby power generators can be used with drive modules as long as the input line impedance is within the 1% to 5% range.

**5. Output Wiring Considerations**

To comply with local and nationally recognized codes, such as the NEC, consider proper output power wire sizing and layout when planning the machine design and DriveBlok installation.

Note: Use the most recent version of the codes when installing the DriveBlok.

**a. Output Power Conductor and Ground Conductor Sizing**

These conductor-sizing issues were discussed in the previous section and **Table 3**. Refer to that section for details.

**b. Output Power Conductor Routing**

Long output cable runs from multiple drives in the same conduit cable tray present a unique safety concern. Since the output leads are electrically coupled when share the same cable tray, the PWM action of the inverter power stage in one unit can couple sufficient energy into the DC link of another unpowered drive to present an electrical shock hazard.

**NEVER** work on a drive when other drives are energized in the system.

Although the input power has been opened, **NEVER** assume the drive is intrinsically safe.

Verify that the DC link is below 30 VDC with a voltmeter before commencing service.

- *If* conduit is used, use a separate conduit for input line conductors and output power conductors. **NEVER** route analog and digital wiring from any equipment in the same conduit as input or output power wiring.
- *If* cable trays are used, use a separate cable tray for input line conductors and output line conductors. **NEVER** route analog and digital wiring from any equipment in the same cable tray as input or output power wiring.
- **ALWAYS** route the Input and Output Grounding conductors in the same conduit or cable tray as the respective Input or Output power leads. Preferably, these conductors should be bundled.
- *If* multi-conductor wiring is used, a separate multi conductor cable must be used for the input line wiring for each drive.



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### c. Overcurrent Protection

Drive modules are designed to automatically provide overcurrent protection for the output power circuit if only one motor is connected to the drive and sized to match the drive.

If more than one motor is connected to the drive, each motor must have its own overcurrent protection. In addition, the combined current rating on the nameplate of each motor must not exceed the output current rating of the drive.

### d. Power Factor Correction

Power factor correction capacitors must **NEVER** be connected to the output of the drive. They will cause severe damage to the drive and would not serve any useful purpose.

## 6. Analog and Digital I/O Signal Considerations

Comply with local and nationally recognized codes when designing and installing the DriveBlok in the equipment. Consider proper analog and digital signal wiring practices carefully when you planning the application.

### a. Analog and Digital Signal Wiring

- 18 AWG wire size is recommended. Minimum wire size is 20 AWG; maximum is 14 AWG.
- *One* conductor per terminal for 14 AWG conductors. *Two* conductors per terminal at 18 AWG. *Three* conductors per terminal at 20 AWG.
- Maximum length is 500 feet.
- Use shielded cable for the analog signal conductors where indicated on the terminal block connection diagram. Typically, shielding is required for all analog input and output runs.
- All digital signal runs should be shielded.
- Ground the shield conductor of shielded cable at both ends of the terminal block of the drive for input signals only. Output signals should not be grounded at the drive end of the cable but should be grounded at the device.
- The analog and digital signal conductors must be made of copper with a temperature rating of at least 167°F (75°C).

### b. Analog and Digital Conductor Routing

If conduit is used, use separate conduit for input and output power and DriveBlok control wiring, up to the drive. If cable trays are used, **NEVER** route analog and digital wiring from any equipment in the same cable tray as input or output power wiring.

Separate analog and digital wiring for the DriveBlok from other control equipment wiring by using a metal tray divider or by bundling to keep the conductors at least 2 inches apart.

Trays containing analog and digital wiring should be separated from trays containing low voltage (up to 120 volts) power wiring.

Trays containing analog and digital wiring should be separated from trays containing medium voltage (between 230 VAC and 480 VAC) power wiring.

### c. Analog Input Connections

There are two analog inputs: 1) a ±10 V input with 10-bit plus sign resolution and 2) a 4 – 20 mA current loop with 10-bit resolution. The inputs are protected from continuous overload $V_{in}$ ±25V, $I_{in}$ to +25/-5 VDC. There is no isolation from internal logic supply is provided.

The current loop input is intended to interface to a 0 - 20 mA signal, usually from a process feedback sensor. The DriveBlok does not power the current loop - you must provide this source externally if one is required.

The voltage input (Vin) accepts a -10 to +10 V signal, which may come from any low impedance source including a potentiometer. The DriveBlok does not provide -10V, so if you do not have it available an external supply must be provided. For a potentiometer reference, it is recommended that one of the analog outputs be programmed to +5 or +10V and used to drive the top of the speed pot.

The inputs are configurable from a list of functions. [See **Appendix E**.]

[See **Figure 14**.]



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**d. Analog Output Connections**

There are thee analog outputs. The outputs have 8-bit resolution and produce an output voltage of 0 – 10 volts. The outputs are protected from continuous overload of up to +25/-5 VDC. There is no isolation from internal logic supply.

The outputs are configurable from a list of functions. [See **Appendix E**.]

[See **Figure 15**.]

**e. Digital Input Connections**

There are eight digital inputs. The inputs are intended for dry contact closure application. The contact closure activates configured inputs. The logic threshold is 2.5 V. The inputs are protected from continuous overload of up to +25/-5 VDC (where shared I/O PIN 15 and 16 require a minimum external impedance of 750Ω due to their dual functions). There is no isolation from internal logic supply.

The six digital input pins (i.e., PIN 9 through 14) may be configured to be all PULLED UP or PULLED DOWN.

The two digital input/output pins (i.e., PIN 15 and 16) are PULLED UP only.

Two of the digital inputs (i.e., DIN1 and DIN2) are high-speed inputs that have the capacity of measuring duty cycle and frequency. These measurements can be used as references for speed and torque.

The outputs are configurable from a list of functions. [See **Appendix E**.]

[See **Figure 16**.]

**f. Digital Output Connections**

There are two open-collector outputs. The outputs can be externally pulled up to +5VDC, +12 VDC, or +24 VDC and are rated at 50 mA. The outputs are internally pulled up to +5V through 4.7kΩ. The response time is 2 msec.

The outputs are configurable from a list of functions. [See **Appendix E**.]

[See **Figure 17**.]



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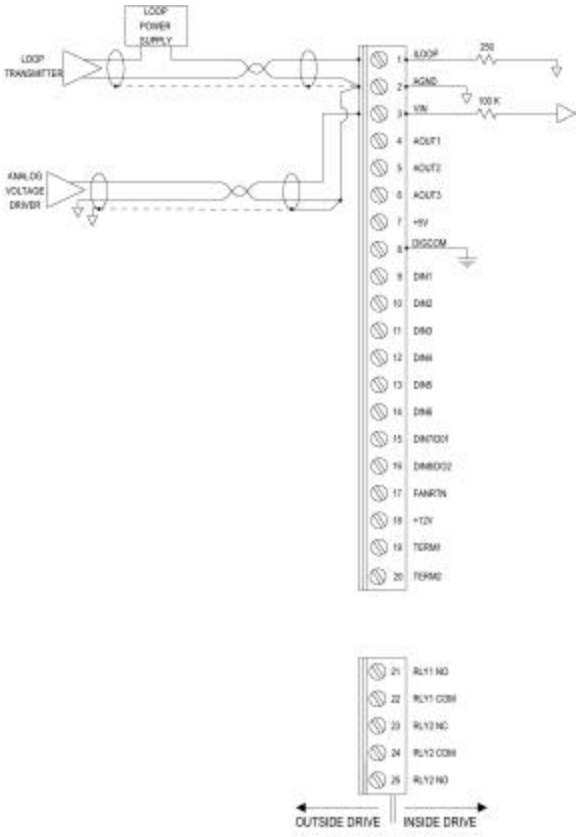


**Figure 14**

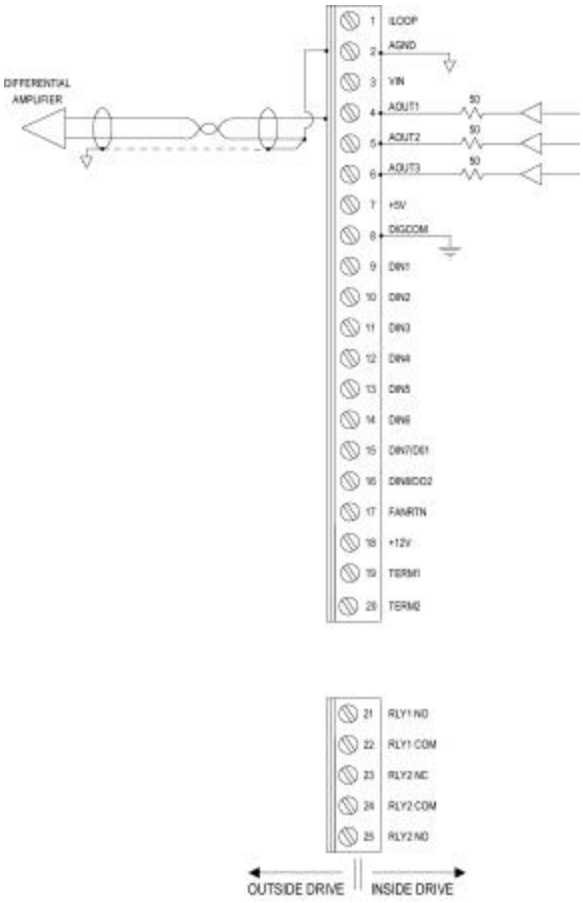


**Figure 15**



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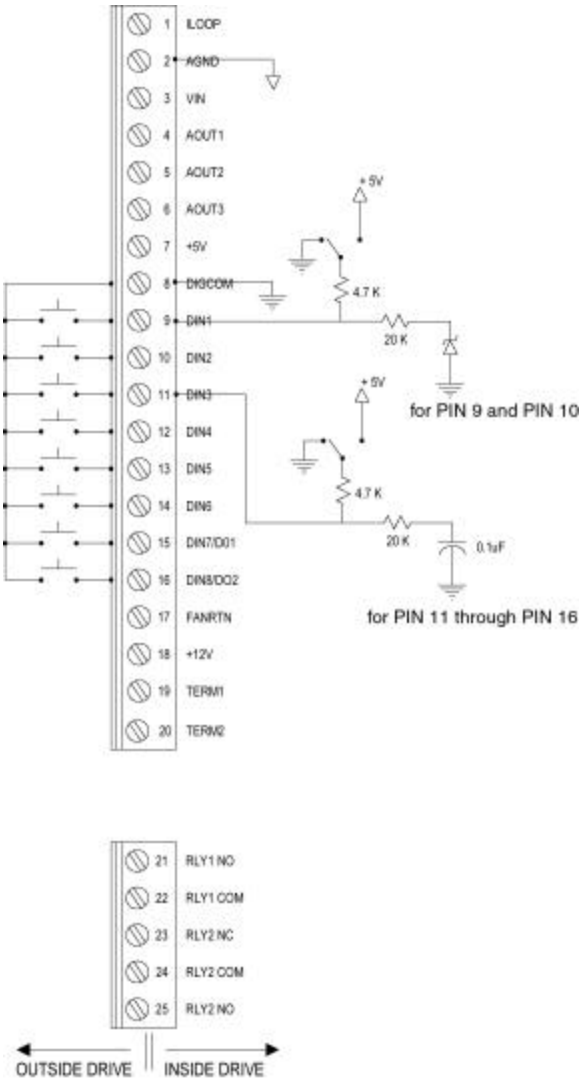


**Figure 16**

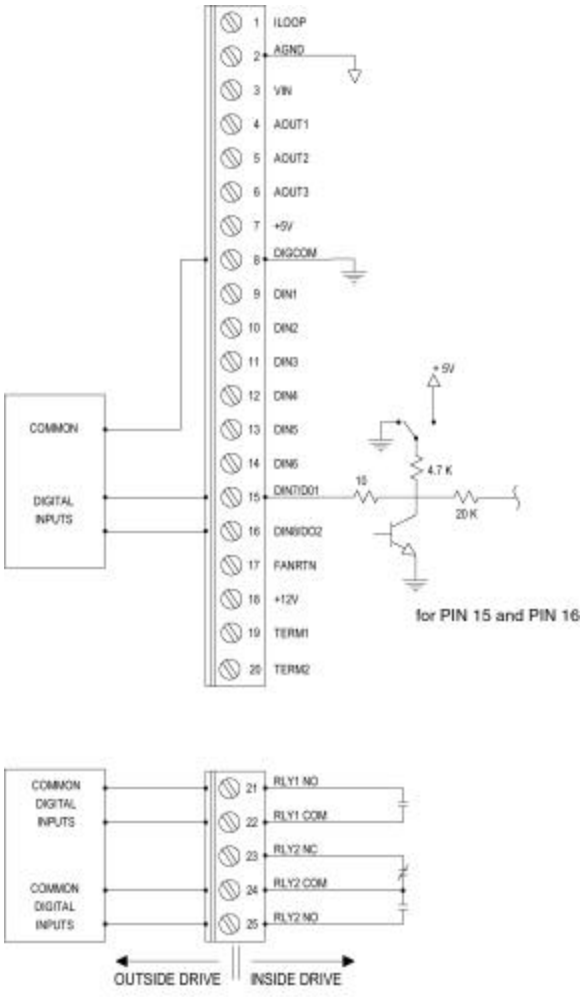


**Figure 17**



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### 7. Braking Resistor

Provisions are made for the connection of an external braking resistor when braking is required. There is no provision for an internal braking resistor. The braking transistor is protected from ground fault and short circuit via internal circuits. When no braking resistor is provided, braking torque is limited to the power consumed by the internal and external losses. Braking transistor duty cycle and frequency vary depending on the required braking torque, the total bus capacitance, the line voltage, and the brake circuit inductance. The braking circuit activates at a DC bus voltage of 410 VDC for 200/240 VAC drives and 820 VDC for 380/480 VAC drives. The braking resistor value can be no lower than the minimum specified value. The inductance of the braking resistor (and associated wiring) can be no larger than the maximum value specified.

| Module Type | Voltage Class, VAC | Braking Resistance $_{minimum}$, W | Inductance $_{maximum}$ of Braking Resistor, mH (including wiring) |
|---|---|---|---|
| **A**DM1001D/**B**DM1001D | 200-240 | 50 | 2.3 |
| **A**DM1002D/**B**DM1002D | 200-240 | 50 | 2.4 |
| **A**DM1003D/**B**DM1003D | 200-240 | 35 | 1.5 |
| **A**DM1005D/**B**DM1005D | 200-240 | 20 | 0.9 |
| **A**DM2007D/**B**DM2007D | 200-240 | 15 | 0.6 |
| **A**DM2010D/**B**DM2010D | 200-240 | 10 | 0.5 |
| **A**DM1001E/**B**DM1001E | 380-480 | 200 | 9.0 |
| **A**DM1002E/**B**DM1002E | 380-480 | 200 | 9.0 |
| **A**DM1003E/**B**DM1003E | 380-480 | 140 | 6.0 |
| **A**DM1005E/**B**DM1005E | 380-480 | 80 | 3.6 |
| **A**DM2007E/**B**DM2007E | 380-480 | 60 | 2.4 |
| **A**DM2010E/**B**DM2010E | 380-480 | 40 | 1.8 |
| **A**DM2015E/**B**DM2015E | 380-480 | 30 | 1.2 |
| **A**DM2020E/**B**DM2020E | 380-480 | 20 | 0.9 |

**Table 5**

Power resistors are specified by four characteristic ratings: *Resistance*, *Power* (average power rating in Watts), *Peak Power* or *Energy* (maximum short duration power handling in Joules), and *Rated Working Voltage* (rated operating terminal voltage in Volts). In addition, the thermal time constant of the resistor must be known to properly evaluate its suitability as a braking resistor and to protect it in the application.

#### a. Resistor Value

First, in selecting the correct braking resistor, the required resistance value must be solved. The required resistance value is relatively easy to solve based upon basic motor, drive, and application setup information. The motor torque rating (given by horsepower and speed for an AC motor or current and BEMF for a BLDC motor), braking load limit (the percentage value set in wInControl), and the maximum speed in this application must be known. Motor torque rating and braking load limit will provide the maximum braking torque. Maximum braking torque times maximum speed will provide the peak braking power. The maximum resistance value that we can use is:

$$Resistance_{maximum} = Voltage_{braking}^2 / Power_{maximum\ braking}, \text{ where}$$

$$Power_{maximum\ braking} = Torque_{rated\ motor} * (Load\ Limit_{braking}/100) * Speed_{maximum}$$

[Note: For $Voltage_{braking}$, use 375 VDC for a 230 VAC drive and 750 VDC for a 480 VAC drive.]



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Remember that this value is a maximum resistance when hot. Therefore, select a convenient value less than this calculated, but not less than about half this value. Also, in order to protect the drive, never select a resistor value smaller than the minimum braking resistor value from the **Table 5**.

If you think that a smaller value resistor is necessary for a particular drive module type, then the next larger drive module for this application is recommended.

There is one complication in the resistance calculation for AC motors. If maximum speed exceeds the speed at which the motor enters field weakening, then the speed at which the motor enters field weakening should be used in place of the actual "maximum speed" to calculate the resistor value. Typically, this speed is 1.2x the motor rated speed.

**b. Average Power Rating**

Next, braking resistor's power rating must be determined. The power rating of the resistor can *only* be calculated if the *frequency* of how often the drive brakes and the *time duration* of how long the braking should be is known. The average power during braking the load from maximum speed to zero speed is equal to half the peak power that you calculated above for linear or S-curve ramps. If the application brakes in $Time_{stop}$ seconds and does this every $Time_{repeat}$ seconds then, the duty cycle is:

Duty Cycle = $Time_{stop}/Time_{repeat}$

$Power_{minimum\ rating}$ = Duty Cycle * ($Power_{maximum\ braking}/2$)

Example 1:

A drive configured for 150% $Load\ Limit_{braking}$ is running a 5 Hp, 4 pole, 230 VAC motor. The motor is to decelerate from 1800 RPM to 0 RPM in 1 sec and repeats this deceleration five times per minute. What is the required resistance and power rating of the braking resistor for this application?

$Torque_{rated\ motor}$ = ($Power_{rated\ motor}$)/($Speed_{rated\ motor}$)
= (5 Hp * 746 Watts/Hp)/(1800 RPM * 2π rad/rev * (1 min/60 sec))
= 19.8 N-m
~ 20 N-m

$Power_{maximum\ braking}$ = $Torque_{rated\ motor}$ * ($Load\ Limit_{braking}/100$) * $Speed_{maximum}$
= 20 N-m * (150/100) * (1800 RPM * 2π rad/rev * (1 min/60 sec))
= 5595 Watts

$Resistance_{maximum}$ = $Voltage_{braking}^2/Power_{maximum\ braking}$
= $(375\ VDC)^2/5595$ Watts
= 25 Ohms. Select a 20 Ω resistor, which is the next smaller standard resistance rating.

In order to understand how hot the resistor will get, $Power_{average\ resistor}$ must be determined.

Duty Cycle = $Time_{stop}/Time_{repeat}$
= 1 sec/(60 sec/5)
= 0.0833

$Power_{minimum\ rated}$ = Duty Cycle * ($Power_{maximum\ braking}/2$)
= 0.0833 * (5595 Watts/2)
= 233 Watts. Select a 250-Watt resistor, which is the next larger standard power rating.



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Example 2:

A drive configured for 200% Load $Limit_{braking}$ is running a BLDC motor rated at a $K_e$ of 80 Volts/kRPM (line-to-$line_{peak}$), $Speed_{rated\ motor}$ of 4000 RPM, and a $Current_{rated\ motor}$ (0-to-peak) of 5 Amps. The drive runs from 4000 RPM to -4000 RPM and back to 4000 RPM continuously as often as possible. What is the required resistance and power rating of the braking resistor for this application?

$Torque_{motor\ rating}$ = (0.00827) * $K_e$ * $Current_{rated\ motor}$
= (0.00827) * (80 Volts/kRPM)) * (5 Amps)
= 3.308 N-m

$Power_{maximum\ braking}$ = $Torque_{rated\ motor}$ * (Load $Limit_{braking}$/100) * $Speed_{maximum}$
= 2.208 N-m * (200/100) * (4000 RPM* 2π rad/rev * (1 min/60 sec))
= 2771 Watts

$Resistance_{maximum}$ = $Voltage_{braking}^2$/$Power_{maximum\ braking}$
= (375 VDC)$^2$/2771 Watts
= 50.7 Ω. Select a 40 Ω resistor, which is the next smaller standard resistance rating.

In order to understand how hot the resistor will get, $Power_{average\ resistor}$ must be determined.

Duty Cycle = $Time_{stop}$/$Time_{repeat}$
= 0.50 since the motor is accelerating one half of the time and decelerating on the other half of the time.

$Power_{minimum\ rated}$ = Duty Cycle * ($Power_{maximum\ braking}$/2)
= 0.50 * (277 Watts/2)
= 693 Watts. Select a 1000-Watt resistor, which is the next larger standard power rating.



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For most applications, sizing can stop right here – there is enough information to order a braking resistor. However, there are several additional things to be aware of.

**c. Special Consideration - Resistor Construction and Energy Ratings**

First, the Peak Power or Energy ratings of a resistor depend on its internal construction. A typical power wire-wound resistor consists of a resistance wire wound on a hollow ceramic core and welded to the electrical terminations (e.g., wiring lugs or leads) at each end. If this type of resistor is hit with a large pulse of power, despite a short duration, mechanical stresses at these terminations will be produced that will cause the resistor to fail prematurely in your machine. Typically, a wire-wound resistor can tolerate 3:1 to 5:1 peak to average power for very short power pulses.

In Example 1, a wire-wound resistor would be a poor choice. Peak to average power is 5595/250 = 22.4:1. In example 2, a wire-wound is a good candidate because peak to average power is 2771/1000 = 2.77:1. If the wire-wound resistor can be used, buy it. It is usually less expensive and more readily available.

$$Energy_{minimum\ rated} = Time_{stop} * (Power_{maximum\ braking}/2)$$

In example 1, a ceramic resistor capable of at least 1 sec * 5595/2 = 2800 J in addition to the 250 W average power rating would be needed. This is a hefty resistor. [Note: Remember that 1 J of energy raises 1gm of water 1° C. Therefore, this resistor if it had the same density as water and was 2.5 x 12.5 cm (1in dia x 5in long) would heat up to 89.6° C every time you stopped the motor - WOW!]

**d. Working Voltage**

Normally, the working voltage is not a problem. By the time, a resistor is large enough to handle the power of a large motor is obtained, it can easily support the voltages applied. However, for smaller drives this may not be the case. It is recommended that a resistor is rated as follows:

So what do you do when a higher ratio of peak to average power is needed? First, speak with the wire-wound resistor vendor. Several vendors make specially constructed wire-wound resistors that have a higher Peak Power rating, but it is unlikely that these resistors will be found in the catalog. Contact technical support of the resistor manufacturer.

The other alternative is to choose a resistor constructed to handle high Peak Power. Several vendors specialize in resistors constructed specifically for pulse power applications. Carborundum, and HVR Advanced Power Components are two of the best vendors. Each vendor manufactures a line of solid ceramic resistance elements that heat uniformly during the power pulse, thus eliminating the termination problem inherent in wire-wound resistor construction. These resistors can handle basically ANY peak power, as long as it does not overheat the entire resistive element; and, therefore, typically rate themselves in Joules (i.e., the number of Watt-seconds that can be delivered without raising the temperature too high in a single pulse).
The energy rating required of our application, assuming $Time_{stop}$ is short with respect to the thermal time constant of the resistor, is:

| **Drive Voltage $_{rated}$, VAC** | **Voltage $_{applied}$ (typical), VDC** | **Working Voltage $_{minimum\ rated}$ (recommended), VDC** |
|---|---|---|
| 240 | 375 | 500 |
| 380/480 | 750 | 1000 |

**Table 6**

Failure to do so could conceivably lead to insulation failure or could be a fire hazard. BE CAREFUL!

**e. Using wInControl to protect the braking resistor**

wInControl has a dialog box in which the following brake settings (i.e., *Load Limit*, *Power*, and *Time Constant*) are entered. With an accurate thermal model, the DriveBlok can keep track of how much energy has been dissipated in the braking resistor and estimate its operating temperature in real time, protecting itself from an overload that would damage it.



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By default, wInControl assumes that the braking resistor has a load limit of 150%, power rated at zero Watts (i.e., there is no braking resistor; and, no attempt to perform braking will take place) and a thermal time constant of 60 sec.

The power (i.e., average power rating) of the braking resistor must be entered. Any non-zero value enables the dynamic braking function.

If the thermal time constant data from the resistor manufacturer is known, enter it. Unfortunately, this data is generally not available; therefore, the time constant must be estimated, either analytically or empirically, or measured directly. Measuring or analytically determining the correct value is relatively difficult and beyond the scope of this owner's manual; however, the time constant can be estimated within the ballpark by looking at the construction of the resistor:

- If a wire-wound resistor that is designed to be bolted to a heatsink and cooled by conduction is used, then the thermal time constant is usually very short - in the 5 - 10 second range.
- If the more common wire-wound resistor style (i.e., constructed by winding the resistance element about a hollow ceramic core and finishing with a vitreous enamel or epoxy dip) is used, then the thermal time constant is relatively long - in the 60 - 180 second range. In general, keeping the default setting is the most conservative approach.
- If a solid ceramic resistor like the ones described previously by HVR or Carborundum is used, then the thermal time constant is typically in the middle - in the 30 - 60 second range.
- In the absence of any more concrete data from the manufacturer, use the default setting.

Once brake settings have been entered, the DriveBlok will ensure that it will not damage the braking resistor, even if it has been undersized for the application.

## 8. Fan

Provision is made to power external 12 VDC fan(s) to provide forced air cooling of the heat sink the DriveBlok is mounted on. See **Table 7** for the maximum allowable current. See **Figure 8** for the wiring diagram of the fan(s) the drive.

| Module Type | Allowable Fan Start Current, A | Allowable Fan Run Current, A | Voltage, VDC |
|---|---|---|---|
| **A**DM1001D/**B**DM1001D | 0.6 | 0.3 | 12 |
| **A**DM1002D/**B**DM1002D | 0.6 | 0.3 | 12 |
| **A**DM1003D/**B**DM1003D | 0.6 | 0.3 | 12 |
| **A**DM1005D/**B**DM1005D | 0.6 | 0.3 | 12 |
| **A**DM2007D/**B**DM2007D | 1.2 | 0.6 | 12 |
| **A**DM2010D/**B**DM2010D | 1.2 | 0.6 | 12 |
| **A**DM1001E/**B**DM1001E | 0.6 | 0.3 | 12 |
| **A**DM1002E/**B**DM1002E | 0.6 | 0.3 | 12 |
| **A**DM1003E/**B**DM1003E | 0.6 | 0.3 | 12 |
| **A**DM1005E/**B**DM1005E | 0.6 | 0.3 | 12 |
| **A**DM2007E/**B**DM2007E | 1.2 | 0.6 | 12 |
| **A**DM2010E/**B**DM2010E | 1.2 | 0.6 | 12 |
| **A**DM2015E/**B**DM2015E | 1.2 | 0.6 | 12 |
| **A**DM2020E/**B**DM2020E | 1.2 | 0.6 | 12 |

**Table 7**



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### 9. Capacitor Assembly

MTS Automation offers an electrolytic filter capacitor coupled with the appropriate module type or as a separate item altogether. In **Table 8**, the capacitance is given for the *standard* CapBlok for the respective module type.

In the event that *more* capacitance CapBlok is desired for a given drive module, a higher capacitance CapBlok can be used. However, there are few restrictions:

- The higher capacitance CapBlok must have the same voltage rating as the CapBlok it is replacing.
- A CapBlok used on an ADM100xx/BDM100xx module type can only be used on another ADM100xx/BDM100xx module type. For example, a CapBlok used on an ADM1005D/BDM1005D module type can be used on an ADM1001D/BDM1001D module type.
- A CapBlok used on an ADM2010x/BDM2010x module type can only be used on the ADM2010x/BDM2010x and ADM2007x/BDM2007x module types.
- A CapBlok used on an ADM2020E/BDM2020E module type can only be used on the ADM2020E/BDM2020E and ADM2015E/BDM2015E module types.

| Module Type | Capacitance of CapBlok™$_{standard}$, ■F |
|---|---|
| **A**DM1001D/**B**DM1001D | 540 |
| **A**DM1002D/**B**DM1002D | 1080 |
| **A**DM1003D/**B**DM1003D | 1080 |
| **A**DM1005D/**B**DM1005D | 1620 |
| **A**DM2007D/**B**DM2007D | 3000 |
| **A**DM2010D/**B**DM2010D | 3000 |
| **A**DM1001E/**B**DM1001E | 135 |
| **A**DM1002E/**B**DM1002E | 270 |
| **A**DM1003E/**B**DM1003E | 270 |
| **A**DM1005E/**B**DM1005E | 405 |
| **A**DM2007E/**B**DM2007E | 750 |
| **A**DM2010E/**B**DM2010E | 750 |
| **A**DM2015E/**B**DM2015E | 1350 |
| **A**DM2020E/**B**DM2020E | 1350 |

**Table 8**



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# Appendix A: Performance Specifications

**A. ADM Version**

| Parameter | Rating | Conditions |
|---|---|---|
| Output Frequency Range | 0 - 434 Hz | In sensorless vector mode |
| Constant Torque Speed Range | 100:1 | From 18 RPM to 1800 RPM can achieve 100% motor rated torque |
| Speed Regulation | 0.2% | Maximum change in actual motor speed with change in steady-state load as a % of motor rated speed. Motor no load to motor rated torque, above 25RPM |
| Speed Accuracy | ±0.5% | Actual motor speed vs. Command motor speed as a % of motor rated speed. Motor no load to motor rated torque, above 25 RPM |
| Starting Torque | up to 250% | Start into locked rotor - controlled by load limit parameter with appropriate motor |
| Speed Drop Response | 60 RPM typical | Transient speed drop from, no-load to motor rated torque step with motor running at 1000 RPM (driving 1 rotor inertia) |
| Speed Response Time | 100 ms typical | Speed drop recovery time to steady-state value, conditions same as above |
| Torque Response | 1.5 ms typical | Time to respond to 90% of command value - drive in torque mode, running at 1000 RPM |

**Table 9**

[Note: Specifications are guaranteed only when running at an input line voltage ≥ 230 VAC (for 220/240 VAC product) and at ≥ 460 VAC(for 380/480 VAC product). Ratings for operation with a 4 pole, 60 Hz NEMA B motor of the same rated power as the drive, with suitable tuning of the motor parameters. Rated torque is motor rated power divided by motor rated speed.]

**B. BDM Version**

| Parameter | Rating | Conditions |
|---|---|---|
| Output Frequency Range | 0 - 434 Hz | In sensorless vector mode |
| Constant Torque Speed Range | 100:1 | From 1% - 5% of rated speed to rated speed. Call factory for details. |
| Minimum Speed | 1% - 5% of no load speed | Actual results based on motor type and construction. Call factory for details. |
| Maximum Speed | 26,000 RPM | For a 2-pole motor. |
| Speed Regulation | ±2 RPM | Maximum change in actual motor speed with change in steady-state load as a % of motor rated speed. Motor no load to motor rated torque, above MINIMUM speed. |
| Speed Accuracy | ±0.1% | Actual motor speed vs. Command motor speed as a % of motor rated speed. Motor no load to motor rated torque, above MINIMUM speed. |
| Starting Torque | Consult Factory | Start into locked rotor. |
| Velocity Bandwidth | >100Hz typical | With 3 inch diameter motor. |
| Torque Response | 1.5 ms typical | Time to respond to 90% of command value - drive in torque mode. |

**Table 10**



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# Appendix B: Common Specifications

## A. Environmental

| Parameter | Rating | Conditions |
|---|---|---|
| Enclosure 1-5Hp | IP-20 | Module CapBlok, Assembled Drive Configurations |
| 15-20Hp | IP-20 | Module Only |
| 7.5-20Hp | Open Frame | CapBlok and Assembled Drive Configurations |
| Max Operating Ambient Temperature | -10 to +70°C | Module with Sufficient Heat Sinking 1 - 5Hp |
| | -10 to +50°C | Assembled Drive Configurations 1 - 5Hp |
| | -10 to +40°C | Assembled Drive Configurations 7.5 - 20Hp |
| Max SubstrateTemp | -20 to +90°C | All |
| StorageTemperature | -20 to +100°C | All |
| Humidity | 10 to 95% | Non-Condensing |
| Altitude | 1000m (3300 ft.) | Maximum for Full Rating |
| Altitude Derating | 2% for every 330m (1000 ft.) | Not Rated for Use Above 4000m (13200 ft.) |
| Vibration IEC68-2 | IEC68-2 | |

**Table 11**

## B. Electrical

| Parameter | Rating | Conditions |
|---|---|---|
| AC Line Input Freq | 47 to 66Hz | |
| Efficiency | 97% | 5-20Hp Ratings |
| | 95% | 1-3Hp Ratings |
| Line Drop-Out Ride-Through Time | 2 (Sec)[1] | Short Term Power Interruption with Unloaded Motor Running at Rated Speed |
| PWM Frequency | 3-5 kHz | Motor PWM Noise Reduction Through Efficiency Optimization. Consult Factory for Details. |
| Protection Functions | Instantaneous Overcurrent, Ground Fault, Short Circuit, Over Voltage, Under Voltage, Substrate Over Temp, Motor $I^2T$, AC Input Phase Loss, Motor Fault, Brake Overload | |

**Table 12**

[1] Typical for AC motor. Actual time depends on Motor and Load Inertia, Bus Capacitance, Motor Speed and External Load.



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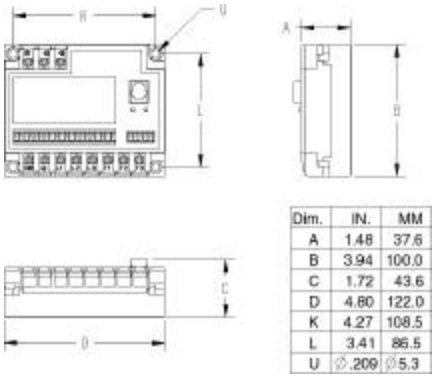
# Appendix C: Product Dimensions

## A. SERIES 1000 DIMENSIONS

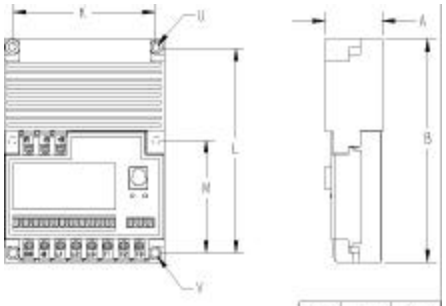
### 1. DriveBlok Module



| Dim. | IN. | MM |
|---|---|---|
| A | 1.48 | 37.6 |
| B | 3.94 | 100.0 |
| C | 1.72 | 43.6 |
| D | 4.80 | 122.0 |
| K | 4.27 | 108.5 |
| L | 3.41 | 86.5 |
| U | ∅.209 | ∅5.3 |

**Figure 20**

### 2. DriveBlok Module with CapBlok



| Dim. | IN. | MM |
|---|---|---|
| A | 1.70 | 43.3 |
| B | 6.77 | 172.0 |
| C | 1.72 | 43.6 |
| D | 4.80 | 122.0 |
| K | 4.27 | 108.5 |
| L | 6.43 | 163.3 |
| M | 3.41 | 86.5 |
| U | ∅.209 | ∅ 5.3 |
| V | ∅.209 | ∅5.3 |

**Figure 21**



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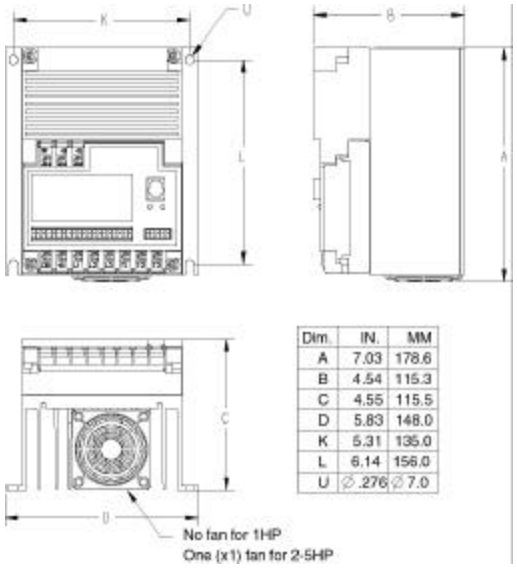
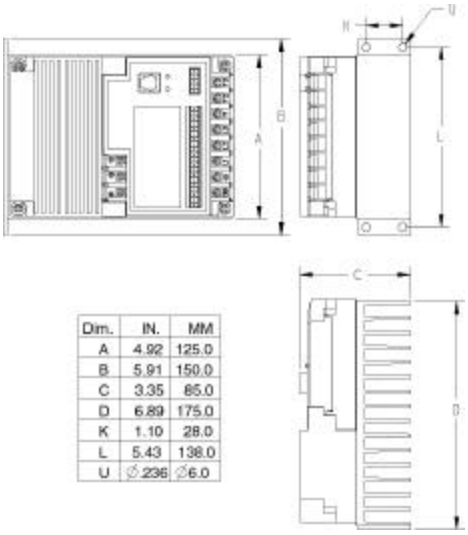
**3. ADM 1xxX-CS-WC00S**




| Dim. | IN. | MM |
|---|---|---|
| A | 7.03 | 178.6 |
| B | 4.54 | 115.3 |
| C | 4.55 | 115.5 |
| D | 5.83 | 148.0 |
| K | 5.31 | 135.0 |
| L | 6.14 | 156.0 |
| U | ∅.276 | ∅7.0 |

**Figure 22**

**4. ADM 10xxX-CS-BB00S**




| Dim. | IN. | MM |
|---|---|---|
| A | 4.92 | 125.0 |
| B | 5.91 | 150.0 |
| C | 3.35 | 85.0 |
| D | 6.89 | 175.0 |
| K | 1.10 | 28.0 |
| L | 5.43 | 138.0 |
| U | ∅.236 | ∅6.0 |

**Figure 23**



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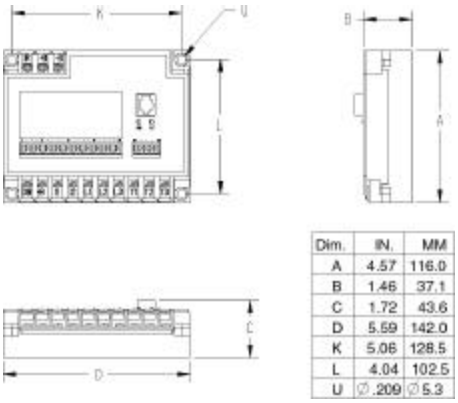
## B. SERIES 2000 DIMENSIONS

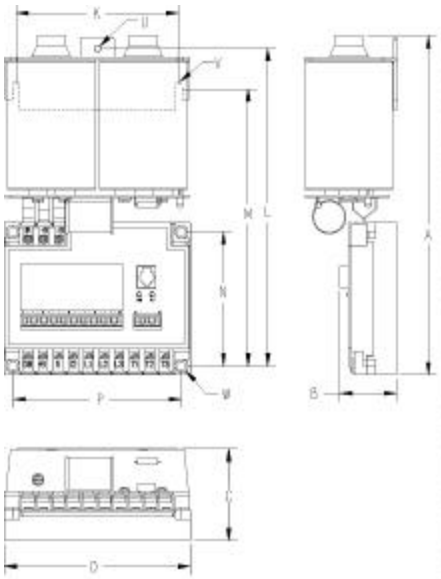
### 1. DriveBlok Module




| Dim. | IN. | MM |
|---|---|---|
| A | 4.57 | 116.0 |
| B | 1.46 | 37.1 |
| C | 1.72 | 43.6 |
| D | 5.59 | 142.0 |
| K | 5.06 | 128.5 |
| L | 4.04 | 102.5 |
| U | Ø .209 | Ø 5.3 |

**Figure 24**

### 2. DriveBlok Module with CapBlok




For 7.5-10 HP

| Dim. | IN. | MM |
|---|---|---|
| A | 8.98 | 228.0 |
| B | 1.72 | 43.6 |
| C | 2.76 | 70.0 |
| D | 5.59 | 142.0 |
| K | 4.88 | 124.0 |
| L | 8.34 | 211.8 |
| M | 7.12 | 180.8 |
| N | 4.04 | 102.5 |
| P | 5.06 | 128.5 |
| U | Ø .197 | Ø 5.0 |
| V | Ø .197 | Ø 5.0 |
| W | Ø .209 | Ø 5.3 |

For 15-20 HP

| Dim. | IN. | MM |
|---|---|---|
| A | 10.52 | 267.2 |
| B | 1.72 | 43.6 |
| C | 2.76 | 70.0 |
| D | 5.59 | 142.0 |
| K | 4.88 | 124.0 |
| L | 9.88 | 250.9 |
| M | 8.66 | 219.9 |
| N | 4.04 | 102.5 |
| P | 5.06 | 128.5 |
| U | Ø .197 | Ø 5.0 |
| V | Ø .197 | Ø 5.0 |
| W | Ø .209 | Ø 5.3 |

**Figure 25**



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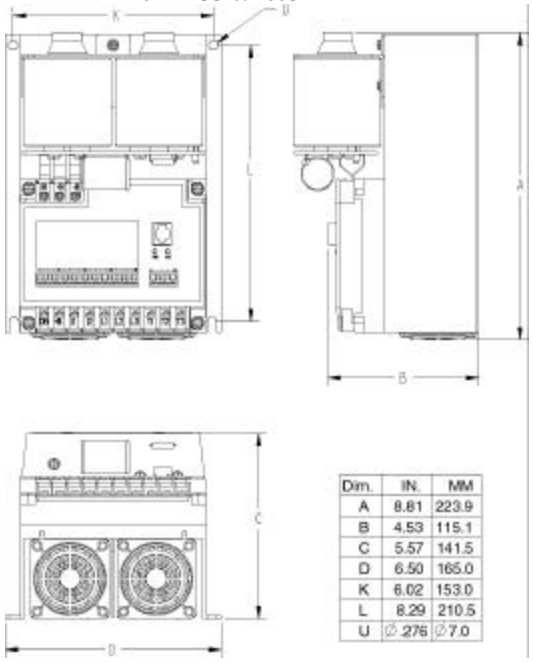
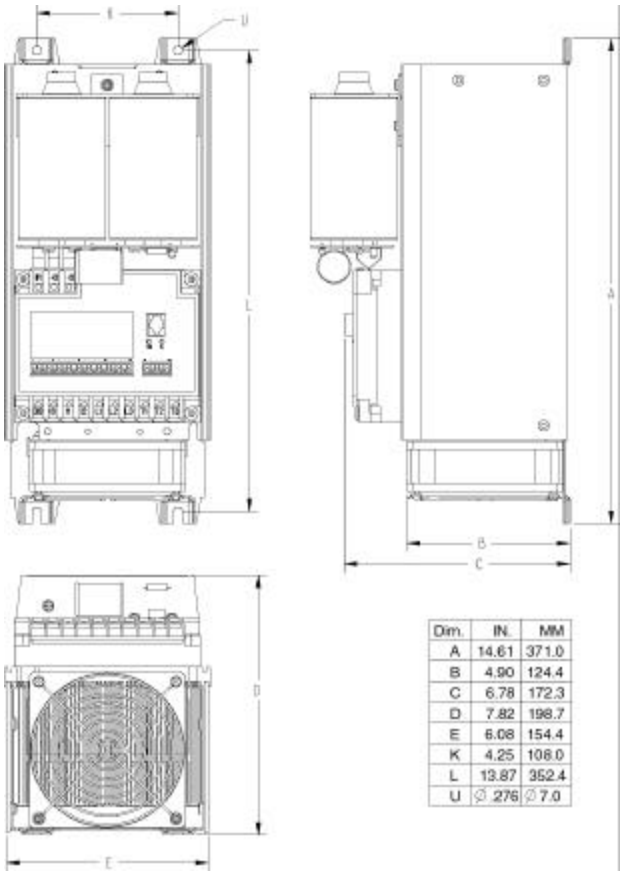
**3. ADM 20xxX-CS-WE00S**



| Dim. | IN. | MM |
|---|---|---|
| A | 8.81 | 223.9 |
| B | 4.53 | 115.1 |
| C | 5.57 | 141.5 |
| D | 6.50 | 165.0 |
| K | 6.02 | 153.0 |
| L | 8.29 | 210.5 |
| U | Ø .276 | Ø7.0 |

**Figure 26**

**4. ADM 20xxX-CS-WG00S**



| Dim. | IN. | MM |
|---|---|---|
| A | 14.61 | 371.0 |
| B | 4.90 | 124.4 |
| C | 6.78 | 172.3 |
| D | 7.82 | 198.7 |
| E | 6.08 | 154.4 |
| K | 4.25 | 108.0 |
| L | 13.87 | 352.4 |
| U | Ø .276 | Ø 7.0 |

**Figure 27**



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# Appendix D: EMC Installation

**Instructions for Compliance with the European Standards**

EMC Directive

An Integrated Drive Module does not generally function independently. It is a component designed to be integrated into a machine control system, and is generally intended to be installed within another enclosure with other control equipment and devices. It is therefore assumed that the DriveBlok is installed in such a manner, and to assure compliance with the EMC Directive the unit is tested in this configuration.

**Suggested Installation for EMC Directive Compliance**

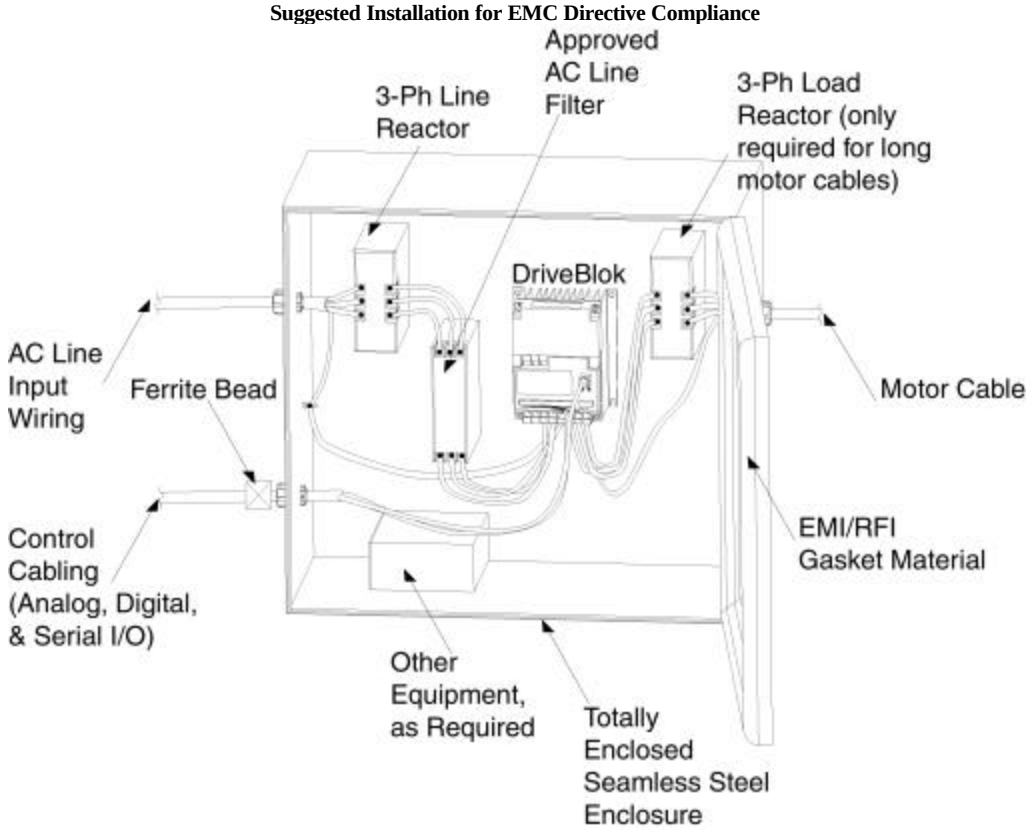


**Figure 28**

**A. Outline of Installation Requirements**

1. Install the DriveBlok and EMC components within a totally enclosed seamless steel enclosure. A standard NEMA or IEC enclosure is adequate for this purpose.
2. Run AC Line Input wiring through a rigid or flexible metal-jacketed conduit, as required by applicable Electrical Code. Rigidly couple the conduit to the enclosure with a low impedance electrical connection (removing paint from the steel enclosure surface as required).
3. Run a separate Ground conductor with the 2- or 3-wire AC Line input wires inside the conduit, and bond this separate conductor directly to a Ground Bonding stud on the enclosure surface.
5. Install a 1-ph or 3-ph 1% (minimum) line reactor, as required, in series with the incoming AC Line.



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5. Install an appropriately rated 1-ph or 3-ph European Standard-compliant noise filter between the line reactor and the input terminals of the drive. See the table in the Operator's Manual for recommended representative noise filters.
6. Run a separate Ground conductor from the provided Open-Frame Drive Ground bonding screw (or in the case of an IDM module installation from immediately adjacent to the mounted DriveBlok module) to the enclosure Ground bonding stud.
7. If required, install a 3-ph 1% (minimum) line reactor in series with the outgoing Motor Cable. This is normally only required for motor cables over 10m in length, but should be tested in your application.
8. Use a shielded cable for wiring between the drive and motor (Motor Cable). Run a separate Ground conductor in the Motor Cable, connected directly to the DriveBlok heatsink Ground bonding screw on one end, and the motor Ground bonding screw in the motor junction box at the motor end. This cable may be run in a rigid conduit, but better EMC suppression is provided by a shielded cable with a braided shield.
9. Clamp a ferrite bead around all analog and digital control I/O and / or serial I/O cables as they exit the enclosure.

It is useful to note that the DriveBlok has passed all EMC emissions and susceptibility tests outside the enclosure described here, with the sole exception of the ESD directive. If the DriveBlok is protected from casual contact and therefore ESD susceptibility testing is not required, it should be possible with shielded cables to pass all other EMC Directives outside a sealed secondary enclosure.

## Low Voltage Directive

A power electronic system is quite unique in its safety concerns and the methods used to ensure the safety of people, animals, plant and equipment. The applicable Standard for this product family is prEN50178-1995: Electronic Equipment for use in Power Installations. This Standard details the design requirements and verification testing required for power electronic systems, including motor drive products, and we have self-certified compliance to the Low Voltage Directive according to this Standard.

To ensure that your installation is safe, we recommend that the DriveBlok be installed in the following manner:

- The DriveBlok and CapBlok come in two voltage classes. The 230V class units achieve full rating at 230VAC ±10% 3-phase 50/60Hz. Operation at 200V must be derated – the drive current rating cannot be increased at 200V and so can deliver less total output power under this condition. The 400V class units carry a dual rating – they are rated to deliver full power at 400VAC ±10% 3-phase 50/60Hz and 480VAC ±10% 3-phase 50/60Hz. This means that you can deliver higher output current at 380 / 400V operation to deliver the same shaft power from an appropriately rated motor. The CE Mark applies to all 230V class applications, but for the 400V class only applications at 380 / 400VAC.
- On an Open-Frame Drive model, connect the heatsink Ground bonding terminals to Earth as shown in the wiring diagram above. Module customers must bond the Earthing conductor as close to the mounted module as possible so as to provide a return path for currents injected into the IDM module baseplate. Even if EMC compliance is not required, the drive must be bonded to Ground with a suitable conductor rated for continuous current of at least the input current rating of the drive itself. Wire these connections separately – do not daisy chain Ground connections.
- Do not use an Earth leakage circuit breaker as an electric shock protector.
- Install current-limiting fuses on the incoming AC Line power leads to prevent damage to equipment and people in the event of a catastrophic failure of the power electronic circuits.
- While not normally required, it is generally good practice to install a surge suppressor assembly at the input terminals of the drive. These assemblies are available from many sources – recommended assemblies are listed in the Operator's Manual.
- The operating rating of the Relay Outputs provided for control I/O is 30V 0.5A for the purpose of a CE compliant installation. UL considers them acceptable for 120VAC 1A, but they are not rated at that voltage according to EN50178.



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# Appendix E: Input/Output Description

## A. Analog Input

The drive has 2 analog inputs. Their functions and scaling are modified through the **I/O Wizard** in wInControl or by configuring the internal drive parameters **ILOOP INPUT FCN** (M10**)** and/or **VIN FCN** (M11**)** via the Serial Communication Protocol. These inputs are individually scaled and may range from 0 to 20 mA for ILOOP and +10 to –10 V for VIN.

- In order to use the analog inputs, the *Setpoint Control* must be configured for *Analog*. This mode can be configured through the **I/O Wizard** in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.
- *If* the analog inputs are not used, the input functions may be set to the *Null* function.
- *If* the Current Loop Input and the Voltage Input are set to the same function, the Current Loop Input will always take precedence.

### 1. 4 – 20 mA Current Loop (i.e., ILOOP)

| Function | M10 Internal Drive Parameter Value | Function Description |
|---|---|---|
| Null Function | 0 | This function ignores the 4 - 20 mA input.<br><br>This function disables fault on loss of current loop regardless of mode setting. |
| Speed Reference | 1 | This function controls the speed.<br><br>Four parameters control the speed reference. **MIN I REF** (M25) corresponds to **MIN SPEED** (F00), **MAX I REF** (M26) corresponds to **MAX SPEED** (F07). The speed command is linear in between.<br><br>If the Start/Stop Mode is configured as Analog, then a signal transition through **MIN I REF** (M25) will be the start and stop control.<br><br>If power-on start is enabled, the drive will start on power-on if the input is above **MIN I REF** (M25) and the drive is enabled to run. |
| Torque Reference | 2 | This function controls the torque.<br><br>Four parameters control the torque reference. **MIN I REF** (M25) corresponds to **MIN TORQUE** (F0E), **MAX I REF** (M26) corresponds to **MAX TORQUE** (F0F). The torque command is linear in between. |
| Load Limit Reference | 3 | This function controls the load limit %.<br><br>The load limit is scaled as **MIN I REF** (M25) gives 0 and **MAX I REF** (M26) gives **LOAD_LIM_MOTOR** (G12). The output is linear between. **MIN I REF** (M25) and **MAX I REF** (M26) are unsigned numbers. |
| Null Function | > 3 | This function ignores the 4 - 20 mA input.<br><br>This function disables fault on loss of current loop regardless of mode setting. |

**Table 13**

[Note: The scale parameters **MIN I REF** (M25) and **MAX_I_REF** (M26) are used to scale the speed, torque and load limit references. The scaling on these parameters is 0 ≡ 0 mA, $2^{16}$ ≡ 20 mA.]



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**2. ±10 V Input (i.e., VIN)**

| Function | M11 Internal Drive Parameter Value | Function Description |
|---|---|---|
| Null Function | 0 | This function ignores the ±10V input. |
| Speed and Direction Reference | 1 | This function controls the speed and the direction.<br><br>The sign of the analog input sets the direction.<br><br>The magnitude is scaled as MIN V REF (M23) gives **MIN SPEED** (F00) and **MAX V REF** (M24) gives **MAX SPEED** (F07). The output is linear in between.<br><br>**MIN V REF** (M23) and **MAX V REF** (M24) are signed numbers.<br><br>Note:<br>• Although negative numbers are allowed for **MIN V REF** (M23) and **MAX V REF** (M24), only positive numbers should be used.<br>• If **MAX V REF** (M24) < **MIN V REF** (M23), then at 0+ volts, the drive will be commanded **MAX SPEED** (F07) forward and at 0- volts, the drive will be commanded **MAX SPEED** (F07) reverse.<br><br>If the Start/Stop mode is configured for Analog, the drive will start when the calculated speed command exceeds **MIN SPEED** (F00) and will stop when the calculated speed equals **MIN SPEED** (F00). |
| Speed Reference | 2 | This function controls the speed.<br><br>The magnitude is scaled as **MIN V REF** (M23) gives **MIN SPEED** (F00) and **MAX V REF** (M24) gives **MAX SPEED** (F07). The output is linear in between.<br><br>**MIN V REF** (M23) and **MAX V REF** (M24) are signed numbers. |
| Torque Reference | 3 | This function controls the torque.<br><br>The magnitude is scaled as **MIN V REF** (M23) gives **MIN TORQUE** (F0E) and **MAX V REF** (M24) gives **MAX TORQUE** (F0F). The output is linear in between.<br><br>**MIN V REF** (M23), **MAX V REF** (M24), **MAX TORQUE** (F0E), and **MAX TORQUE** (F0F) are signed numbers.<br><br>Note:<br>The motor torque is limited by the **LOAD_LIM_MOTOR** (G12), **LOAD_LIM_BRAKE** (G13), and **MAX_SLIP/LOAD_LIM_MOTOR** (G14) even when the torque command exceeds these values. |
| Load Limit Reference | 4 | This function controls the load limit %.<br><br>The load limit is scaled as **MIN V REF** (M23) gives 0 and **MAX V REF** (M24) gives **LOAD_LIM_MOTOR** (G12). The output is linear between. **MIN V REF** (M23) and **MAX V REF** (M24) are signed numbers. |
| Null Function | > 4 | This function ignores the ±10V input. |

**Table 14**

Note: The scale parameters **MIN V REF** (M23) and **MAX V REF** (M24) are used to scale the speed, torque and load limit references. The scaling on these parameters is $0 \equiv 0$ volts, $2^{15} \equiv +10$ V. Negative numbers are two's complement of positive numbers.

**B. Analog Output**

The drive has 3 analog outputs. Their functions and scaling are modified through the **I/O Wizard** in wInControl or by configuring the value of the internal drive parameters **ANALOG OUTPUT 1 FCN** (M0D), **ANALOG OUTPUT 2 FCN** (M0E), and **ANALOG OUTPUT 3 FCN** (M0F) via the Serial Communication Protocol.



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These outputs are individually scaled and range from 0 to 10 V output.

| Function | M0D – M0F Internal Drive Parameter Value | Function Description |
|---|---|---|
| Null Function | 0 | Ignore 0 – 10 V output |
| Current | 1 | Current (0 - peak) scaled to **AO_X_SCALE**. |
| Torque | 2 | Torque scaled to **AO_X_SCALE**. |
| Torque set-point | 3 | Torque set point scaled to **AO_X_SCALE**. |
| Speed | 4 | Speed scaled to **AO_X_SCALE**. |
| Speed set-point | 5 | Speed set point scaled to **AO_X_SCALE**. |
| Frequency | 6 | Frequency scaled to **AO_X_SCALE**. |
| Vout | 7 | Output voltage scaled to **AO_X_SCALE**. |
| Heat sink temperature | 8 | Heat sink temperature scaled to **AO_X_SCALE**. |
| DC Link Voltage | 9 | DC Link voltage scaled to **AO_X_SCALE**. |
| Feedback Pointer | 10 | Value at feedback pointer (D16) scaled to **AO_X_SCALE**. |
| Null Function | > 10 | Ignore 0 – 10V output |

**Table 15**

[Note: User must define the scale of analog outputs. The scaling of analog outputs is defined by parameters **ANALOG OUT 1 SCALE** (M27), **ANALOG OUT 2 SCALE** (M28) and **ANALOG OUT 3 SCALE** (M29). The value of the **AO_X_SCALE** parameters defines the 10 V output value of the analog output. The scaling of the internal parameters is defined in **Appendix G**.]

### C. Digital Input

The drive may have up to 8 digital inputs. Their functions are modified through the **I/O Wizard** in wInControl or by configuring the value of the internal drive parameters **DIGITAL INPUT 1 FCN** (M00) through **DIGITAL INPUT 8 FCN** (M07) via the Serial Communication Protocol.

- All the digital inputs may be configured with any of the functions, up to the number of pins available.
- The digital input pins 9 – 14 may be pulled up or down, depending on the configuration of the *Pull-Up/Pull-Down* mode. This mode can be modified through the **I/O Wizard** in wInControl or by configuring the value of the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 10) via the Serial Communication Protocol. Changes to this mode will not take affect until the next power cycle.
- The polarity of digital inputs may be configured to asserted low or asserted high. The polarity can be modified through the **I/O Wizard** in wInControl or by configuring the value of the internal drive parameter **DIGITAL INPUT POLARITY** (M08) via the Serial Communication Protocol. Each of the first 8 low-order bits corresponds to a digital input; (e.g., Bit0 = DIN1, Bit1 = DIN2, etc.). The bit set corresponds to positive acting polarity; the input is asserted when the input is high. Changing of the polarity of inputs will not result in transitions that are acted on by the control.
- Digital pins 15 and 16 are programmable as inputs or outputs These pins can be modified from digital inputs to digital outputs through the **I/O Wizard** in wInControl or by configuring the value of the internal drive parameters **DIGITAL INPUT 7 FCN** (M06) and/or **DIGITAL INPUT 8 FCN** (M07) as *Null* function and **DIGITAL INPUT 1 FCN** (M09) and/or **DIGITAL INPUT 2 FCN** (M0A) as a desired digital output function via the Serial Communication Protocol. These pins are always Pulled-Up.
- *Only* digital pins 1 and 2 may be configured as high-speed inputs.

| Function | M00 - M07 Internal Drive Parameter Value | Description |
|---|---|---|
| Null | 0 | This function ignores the digital input pin. |
| Run Enable | 1 | This function enables the drive to run.<br><br>All digital input pins defined as Run Enable must be asserted to run a motor.<br><br>If any Run Enable pin is de-asserted while the motor is running, it will stop.<br><br>The drive is automatically enabled to run if no digital input pin is configured as Run |



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| | | |
|---|---|---|
| | | Enable. |
| Run | 2 | This function starts the drive when a transition from de-asserted to asserted on the digital input pin. |
| Start / Stop | 3 | This function starts the drive when a transition from de-asserted to asserted on the digital input pin.<br><br>This function stops the drive when a transition in the opposite direction is asserted on the digital input pin. |
| External Fault | 4 | This function puts the drive in an External Fault condition when the digital input pin is asserted.<br><br>This state remains until the External Fault digital input pin is de-asserted.<br><br>The drive will trip off and record a fault if it is commanded to run while in the External Fault condition state or if the External Fault digital input pin is asserted while the drive is running. |
| Jog | 5 | This function runs the motor at the specified Jog Speed when the digital input pin is asserted.<br><br>When the digital input pin is de-asserted, the motor stops. |
| Direction | 6 | This function controls the direction of the motor.<br><br>The drive is automatically set to run in one direction if no digital input pin is configured as Direction.<br><br>This function does not operate if the Speed and Direction Reference function is selected for the Analog Input for voltage. |
| Digital Pot Accelerate | 7 | This function causes the Speed Setpoint to increase at the current acceleration rate when the digital input pin is asserted.<br><br>This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. Furthermore, no Preset Speed Bit digital inputs or the Preset Teach digital input can be asserted.<br><br>Digital Pot Decelerate takes precedence over Digital Pot Accelerate. |
| Digital Pot Decelerate | 8 | This function causes the Speed Setpoint to decrease at the current acceleration rate when the digital input pin is asserted.<br><br>This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. Furthermore, no Preset Speed Bit digital inputs or the Preset Teach digital input can be asserted.<br><br>Digital Pot Decelerate takes precedence over Digital Pot Accelerate. |
| Accel/Decel Select | 9 | This function causes the drive to use Accel/Decel Set 2 when the digital input pin is asserted.<br><br>This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. |
| Preset Speed Bit 0 | 10 | This function provides a means via Preset Speed Bits 0, 1, and 2 that make up a binary numbers used to select to select a Preset Speed.<br><br>If one of these inputs is not defined, a value of 0 is used for that bit.<br><br>This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. |



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| | | |
|---|---|---|
| Preset Speed Bit 1 | 11 | See above. |
| Preset Speed Bit 2 | 12 | See above. |
| Preset Teach | 13 | This function provides a method to program a Preset Speed without using the serially configured Setpoint Control.<br><br>To set a Preset Speed:<br>• Select the Preset Speed to program via the Preset Speed Bit.<br>• Assert the Preset Teach digital input.<br>• Use Digital Pot Accelerate or Digital Pot Decelerate to adjust the motor to the desired speed.<br>• De-assert Preset Teach.<br><br>This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. |
| Local Mode | 14 | This function switches the current Start/Stop Control and Setpoint Control to Local when the digital input pin is asserted.<br><br>When the digital input is de-asserted, the Start/Stop Control and Setpoint Control will return to its original mode. |
| Commission | 15 | This function commissions the drive when the digital input pin has made a transition from de-asserted to asserted. |
| Open Loop Control | 16 | This function switches the drive's Control Method from Sensorless Flux Vector to Volts per Hertz when the digital input pin is asserted.<br><br>When the digital input pin is de-asserted, the drive Control Method returns to its original mode. |
| Undefined | 17 | Reserved |
| Coast Stop Mode | 18 | This function switches the Stop Mode from Ramp to Coast when the digital input pin is asserted.<br><br>When the digital input pin is de-asserted, the Control Method returns to its original mode. |
| Undefined | 19 | Reserved |
| Torque Mode | 20 | This function switches the Regulator Mode from Speed to Torque when the digital input is asserted.<br><br>When the digital input pin is de-asserted, the Regulator Mode returns to its original mode. |
| Analog Setpoint Source | 21 | This function switches the current Setpoint Control to Analog when the digital input pin is asserted.<br><br>When the digital input pin is de-asserted, the Setpoint Control returns to its original mode. |
| Undefined | 22 | Reserved |
| Fault Clear | 23 | *This function clears any current faults when the digital input pin makes a transition from de-asserted to asserted.* |

**Table 16**

### 1. High Speed Inputs

The scale parameters **MIN HSI1 REF** (M2A), **MAX HSI1 REF** (M2B), **MIN HSI2 REF** (M2C), and **MAX HSI2 REF** (M2D) are used to scale the speed, torque and load limit references. The scaling on these parameters depends on whether the function is set to measure duty cycle or frequency. The scaling for frequency functions is Hz. The scaling for duty-cycle functions is 0 ≡ 0%, 0xffff (65535) ≡ 100%.

| Function | | M00 - M01 Internal Drive Parameter Value | Description |
|---|---|---|---|
| Frequency | Null | 101 | This function provides the Frequency result available for monitoring under the internal |



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| | | |
|---|---|---|
| Function | | drive parameters, **HIGH SPEED INPUT 1 RESULT** (D1F) or **HIGH SPEED INPUT 2 RESULT** (D20). |
| Duty Cycle Null Function | 102 | This function provides the Duty Cycle result available for monitoring under the internal drive parameters, **HIGH SPEED INPUT 1 RESULT** (D1F) or **HIGH SPEED INPUT 2 RESULT** (D20). |
| Frequency Speed Reference | 103 | This function allows the digital input pin to translate a high speed frequency for speed reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>The usable frequency range is 40 Hz to 65535 Hz. If the frequency falls below 40 Hz, 40 Hz is used.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Duty Cycle Speed Reference | 104 | This function allows the digital input pin to translate a high speed duty cycle for speed reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Frequency Torque Reference | 105 | This function allows the digital input pin to translate a high speed frequency for torque reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>The usable frequency range is 40 Hz to 65535 Hz. If the frequency falls below 40 Hz, 40 Hz is used.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Duty Cycle Speed Reference | 106 | This function allows the digital input pin to translate a high speed duty cycle for torque reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Reserved | 107 | |
| Reserved | 108 | |
| Reserved | 109 | |
| Reserved | 110 | |
| Null Function | > 110 | |

**Table 17**

### D. Digital Outputs

The drive has 2 digital outputs, 2 relay outputs, and a tri-state FBK LED. Their functions are modified through the **I/O Wizard** in wInControl or by configuring the value of the internal drive parameters M09 through M0C via the Serial Communication Protocol.

- The tri-state FBK LED has two configurable states. Third state's configuration is based upon the configuration of the other two states. In other words, the third state is active when the other two states are *both* active. The color scheme of each of the FBK LED states is as follows:

| FBK LED State | Color |
|---|---|
| 1 | Red |



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| | |
|---|---|
| 2 | Orange |
| 3 | Yellow |

**Table 18**

| Function | M09 - M0C Internal Drive Parameter Value | Description |
|---|---|---|
| Set High | 0 | This function asserts the digital output to go High.<br><br>This function is considered de-asserted. |
| Set Low | 1 | This function asserts the digital output to go Low. |
| At Speed | 2 | This function asserts the digital output when the motor speed is within a specified At Speed Range. |
| Undefined | 3 | Reserved |
| Run | 4 | This function asserts the digital output when the drive's output electronics are active. |
| Fault | 5 | This function asserts the digital output when the drive is faulted. |
| Reverse | 6 | This function asserts the digital output when the motor is running in the reverse direction. |
| Overload Alert | 7 | This function asserts the digital output when the $I^2T$ accumulator exceeds the specified Overload Alert value. |
| Over Temperature Alert | 8 | This function asserts the digital output when the drive's substrate temperature exceeds the specified Over Temperature Alert value. |
| Speed Detect Low | 9 | This function asserts the digital output when the motor speed is below the Speed Detect Low value.<br><br>This function de-asserts the digital output when the motor speed is above the Speed Detect Low value + hysteresis.<br><br>Hysteresis is fixed at 1% of $speed_{motor\_max}$. |
| Speed Detect High | 10 | This function asserts the digital output when the motor speed is above the Speed Detect High value.<br><br>This function de-asserts the digital output when the motor speed is below the Speed Detect Low value + hysteresis.<br><br>Hysteresis is fixed at 1% of $speed_{motor\_max}$. |
| Torque Detect Low | 11 | This function asserts the digital output when the motor torque is below the Torque Detect Low value.<br><br>This function de-asserts the digital output when the motor speed is above the Torque Detect Low value + hysteresis.<br><br>Hysteresis is fixed at 1% of $torque_{motor\_max}$. |
| Torque Detect High | 12 | This function asserts the digital output when the motor torque is above the Torque Detect High value.<br><br>This function de-asserts the digital output when the motor speed is above the Torque Detect High value + hysteresis.<br><br>Hysteresis is fixed at 1% of $torque_{motor\_max}$. |
| Commission | 13 | This function asserts the digital output when the drive is commissioning. |
| Brake Actuate | 14 | This function asserts the digital output when an external brake should be released.<br><br>This function asserts the digital output when an external brake should be applied.<br><br>This function only applies to a drive running a BLDC motor. |

**Table 19**



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# Appendix F: Serial Communication Protocol

This section describes the serial communication capabilities of the DriveBlok including the following:

- Connection of an external computer to monitor and control the DriveBlok.
- Description of how to establish a network of DriveBloks.
- How to communicate with the DriveBlok using the serial communication protocol.

## A. Hardware Protocol

### 1. RS-485 Serial Port Specifications

#### a. Overview

An external computer can be used to remotely setup, monitor, and control the operation of the DriveBlok module by connecting them over the included serial link. As many as 30 drives can be linked together in a network, allowing coordination of integrated systems by a host computer. Standard EIA RS-485 serial connection (up to 30 drives) allows reliable communication over relatively long distances. The communication protocol is industry standard ANSI-x3.28-2.5-A4.

#### b. RS-485 Connections

The DriveBlok has one RS-485 serial connection that utilizes a standard 6-pin RJ-11 phone connector. The RS485 differential connections provide greater noise immunity than single-ended RS-232 or RS-422 connections. You can connect an RS-232 device using an RS-485 to RS-232 converter/adapter. Consult the factory for more information on this orderable option.

**RS-485 Specifications**

| Baud Rate | 1200 - 19200 |
|---|---|
| Data Length | 8 bits |
| Stop Bits | 1 bit |
| Parity | none |

**Table 20**

**Serial Connections**

| Pin | Name | Description |
|---|---|---|
| 1 | +12V | +12V Auxiliary Power |
| 2 | COM | Power Common |
| 3 | A | RS485 Signal |
| 4 | B | RS-485 Signal |
| 5 | SCOM | Signal Common |
| 6 | NC | No Connection |

**Table 21**

When daisy chaining drives only pins 2,3 and 4 should be used. A standard RJ-11 tee can be used for daisy chaining drives. The cable length between the tee and the drive should be minimized. However, up to 300m of twisted pair cable can be used. The power ground/return connection should not be made via the RJ-11 connector; a separate return cable is required.

## B. Communication Protocol

The host acts as the master and initiates the transmissions. The protocol has two basic commands, read or write. The read command allows the host to read the value of *any* parameter. The write command allows the host to write to a parameter that is *write accessible.*

The typical transmission sequence to the drive is as follows:

- The host transmits a command to the drive, which includes the drive addressing.
- The host should receive a response within 400 msec. If it does not receive a response the host should resend the command. *If* this is tried for ten (10) times and no response is received, the host should indicate a transmission error.
- The drive that is addressed in the command sends a response to the host.
- After a proper reply was received, the host should wait approximately 1 msec before sending another message.

### 1. Issuing a Read Command

The read command consists of 6 characters in the following order: a dollar sign (the read command character); a one-character address; a three-character parameter number, in hex; and a checksum character. The address can be 1-9, A-Z. The list of available parameters, and their hex addresses, are provided in *Table 8.1*. The checksum is a calculated value and will be discussed later. The format of the transmission is: **$WXXXC<CR>**

| Read Command | Address | Param Char1 | Param Char2 | Param Char3 | Checksum | Carriage Return |
|---|---|---|---|---|---|---|
| $ | W | X1 | X2 | X3 | C | <CR> |

**Table 22**



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Note that the DriveBlok uses a half-duplex serial communications protocol. This means that one twisted pair of wires is used for transmit and receive. A host (computer, PLC, etc.) is required to originate all communications. When a drive detects a communication which includes its assigned address the drive responds with an acknowledgement that the message was received and the instructions carried out, or with an error message to indicate the message was not received correctly. If the host needs to monitor some drive data the host must poll the drive asking for the data. The drive will send the information every time it is requested, but only when it is specifically requested.

After a Read Request the DriveBlok responds with the requested message. The message is preceded with the % character, denoting this as a response to a query, followed by W the address of the DriveBlok, XXX the parameter in hex, YYYY the data stored in that parameter in hex, and C the checksum: **%WXXXYYYYC<CR>**

| Read Command | Address | Param Char1 | Param Char2 | Param Char3 | Data Char1 | Data Char2 | Data Char3 | Data Char4 | Checksum | Carriage Return |
|---|---|---|---|---|---|---|---|---|---|---|
| % | W | X1 | X2 | X3 | Y1 | Y2 | Y3 | Y4 | C | <CR> |

**Table 23**

### 2. Issuing a Write Command

The write command is used to send setup or command and control data to the drive. The host can only send data to a parameter that is write accessible. If the parameter is not write accessible, the drive will respond with an error. The write command has the same format as that of the response from a read command, but is preceded by the & write command character. The format for the data string is: **&WXXXYYYYC<CR>**

| Write Command | Address | Param Char1 | Param Char2 | Param Char3 | Data Char1 | Data Char2 | Data Char3 | Data Char4 | Checksum | Carriage Return |
|---|---|---|---|---|---|---|---|---|---|---|
| & | W | X1 | X2 | X3 | Y1 | Y2 | Y3 | Y4 | C | <CR> |

**Table 24**

If the checksum and the command are valid, the drive will write the data to the Parameter indicated and then respond back to the host that it has completed the command. The response that is sent is prefaced with the # acknowledgement character (ACK), followed by the address of the responding DriveBlok and the message checksum: **#XC<CR>**.

| ACK character | Address | Checksum | Carriage Return |
|---|---|---|---|
| # | X | C | <CR> |

**Table 25**

### 3. Drive Transmitted Serial Errors

If the DriveBlok receives a command that is addressed to it but that it does not understand (an invalid command) or for which the checksum is incorrect, the module will respond with an error message. The message is preceded with the ? error character, the drive address, and the checksum: **?XYC<CR>**

| Error character | Address | Error Code | Checksum | Carriage Return |
|---|---|---|---|---|
| ? | X | Y | C | <CR> |

**Table 26**



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The error codes are:

| Error Code | Description |
|---|---|
| 1 | Bad Checksum |
| 2 | Bad Hex Character |

**Table 27**

*For example*, if a checksum is calculated incorrectly by the host and addressed for drive 1, the drive will respond with: **?11A<CR>**

### 4. Communication Error Detection

The communication protocol includes a method of detecting errors in the transmission of information. These errors may be caused by electrical interference corrupting the data, by intermittent electrical contact, or by two or more DriveBloks responding to the same message. The first line of defense for detecting these errors is using a message checksum. A checksum of all the information to be transmitted is calculated by the host and added to the message as the last character sent before the end of transmission (carriage Return character). The module receives the transmitted information and calculates a checksum on the message it captured, then compares it to the checksum it received from the host. If the two agree the data is accepted as good. If they are not the same the drive transmits an error message which should cause the host to retransmit the data.

### 5. Checksum Calculation

The checksum is calculated as follows:

- Perform an 8-bit **ADD** of the hex values of each of the ASCII characters that are to be sent. Do not include the checksum byte or the carriage return character.
- Take the sum and **AND** it with **7Fh**. This will limit the calculated number to the first 128 ASCII characters.
- Now take the above result and **OR** it with **40h**. This will shift the characters by 40 hex characters, effectively shifting the result to one of the printable characters.
- Now look up the 8-bit Hex value in a standard ASCII table to determine the character that is to be used as the checksum.

Let's assume you wanted to send the message **$1006**. The ASCII character "**$**" is represented by the Hex value **24h**. The ASCII character "**1**" is represented by the Hex character **31h**, "**0**" by **30h** (two times in this example), and lastly "**6**" by **36h**. Adding these values gives the 8-bit result **EBh**. **AND** with **7Fh** yields **6Bh**. **OR** with **40h** yields the final result **6Bh**, which is the ASCII character lower case "**k**". The final transmitted string would then be: **$1006k<CR>**.

*If* the command and the checksum are valid, the drive will respond with the appropriate response, as described previously.

*If* the checksum or the command is *not* valid, the drive will respond with an error message.



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# Appendix G: Internal Drive Parameters

The Internal Drive Parameters are parameters that characterize the drive with respect to configuration, operation, and monitoring. These parameters are only accessible via the serial communication protocol. [See **Appendix F**.] The parameters are divided into 18 different categories. Some of the parameters have reserved access (i.e., these parameters should not be modified without consulting the factory).

**Group A: Drive Identification**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| A00 | **EEPROM_VALID** | Valid code = A5A5h | Read Only | Indicates that the EEPROM was initialized with data, and passed verification. |
| A01 | **EE_VERSION** | TBRR<br>T = 0 (Release)<br>T = 1 (Beta)<br><br>B = 1 (SSI/Gen 2)<br>B = 2 (Future)<br><br>RR = Release number in hex. | Read Only | EEPROM Version |
| A02 | **EE_REVISION** | 0 - ffffh | Read Only | TBA |
| A03 | **CODE_VERSION** | TBRR<br>T = 0 (Release)<br>T = 1 (Beta)<br><br>B = 1 (SSI/Gen 2)<br>B = 2 (Future)<br><br>RR = Release number in hex. | Read Only | Code Version |
| A04 | **DRIVE_SN_LO** | TBA | Read Only | Drive serial number low |
| A05 | **DRIVE_SN_MID** | TBA | Read Only | Drive serial number mid |
| A06 | **DRIVE_SN_HI** | TBA | Read Only | Drive serial number high |
| A07 | **DRIVE_VOLTS** | Volts | Read Only | Drive voltage rating |
| A08 | **DRIVE_HP** | 10 * HP | Read Only | Drive horsepower rating |
| A09 | **KI_IMAG** | I (amps) = i_mag/drive_ki | Read Only | KI: Drive nominal current scaling factor |
| A0A | **KV** | Output Voltage (volts) = vout/drive_kv | Read Only | KV: Drive volts scale factor |
| A0B | **DRIVE_KW** | ω(radians/sec) = ω * drive_kw | Read Only | KW: Drive frequency scale factor |
| A0C | **PRODUCT_ID** | TBA | Read Only | Product ID |
| A0D | **COMPATABILITY INDEX** | Compatibility index | Read Only | TBA |
| A0E | **PRODUCT TYPE** | Bit 0 set HW I/O available<br><br>Bit 1 set BLDC available<br><br>Bit 2 - 15 Not used | Reserved | TBA |

**Table 28**

**Group B: Serial Communications**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| B00 | **DRIVE_ADDRESS** | 1 - 9, A - Z | Read/Write | The address of this drive.<br><br>There are 35 possible values. |
| B01 | **BAUD_RATE** | 300, 600, 1200, 2400, 4800, 9600, 19200 | Read/Write | TBA |

**Table 29**



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**Group C: Drive Command**

| Parm # | Name | Scaling | | Access | Description |
|---|---|---|---|---|---|
| C00 | **DRIVE_COMMAND** | Bit 0 | Stop request | Read/Write | This parameter is bit defined. |
| | | Bit 1 | Start request | | Sending a command to the drive is accomplished by setting this parameter with the appropriate bit cleared. |
| | | Bit 2 | Commission request | | |
| | | Bit 3 | Reserved (always write as 1) | | The command is acknowledged when the corresponding bit is set. |
| | | Bit 4 | Clear External fault | | |
| | | Bit 5 | External fault | | |
| | | Bit 6 | Clear the fault queue. | | |
| | | Bit 7 | Reset serial communications. | | |
| | | Bit 8 | Set Factory Default Autotune Parameters | | |
| | | Bit 9 | Jog Start Request | | |
| | | Bit 10 | Not Defined | | |
| | | Bit 11 | I/O Reset | | |
| | | Bit 12 | Calc Motor | | |
| | | Bit 13 | Not defined | | |
| | | Bit 14 | Not defined | | |
| | | Bit 15 | Processor Reset | | |
| C01 | **DRIVE_MODE** | Bit 0 set | Use parameter C07 | Read/Write | This parameter is bit defined. |
| | | Bit 0 clr | Coast to stop. | | Set and Clear the appropriate bits to set the drive in the desired mode. |
| | | Bit 1 set | Speed regulator mode. Hold speed to value pointed to by speed command source. The torque command source has no effect. | | This parameter should be read to determine which bits are currently set. |
| | | Bit 1 clr | Run in torque regulator mode. Hold torque to value pointed to by torque command source. The speed command source has no effect. This is limited to a two-quadrant torque controller. The direction of rotation is fixed by the start command. | | The current value should be modified by setting or clearing the desired bits, then the new value written to the drive. |
| | | Bit 2 set | Flying starts disabled. | | |
| | | Bit 2 clr | Flying starts enabled. | | |
| | | Bit 3 set | Efficiency optimization disabled. | | |
| | | Bit 3 clr | Efficiency optimization enabled | | |
| | | Bit 4 set | Calc motor parms from | | |



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| | | | | |
|---|---|---|---|---|
| | | nameplate data | | |
| | | Bit 4 clr Do not calc motor parms | | |
| | | Bit 5 set Forward direction.<br>Bit 5 clr Reverse direction. | | |
| | | Bit 7 set Normal comm mode<br>Bit 7 clr Comm ignore check-sum | | |
| | | Bit 8 set No enhanced commission<br>Bit 8 clr Enhanced commission | | |
| | | Bit 9 set AC Mode<br>Bit 9 clr BLDC Mode | | |
| | | Bit 10 set Closed Loop Mode<br>Bit 10 clr Open Loop Mode | | |
| | | Bit 11 Not Defined | | |
| | | Bit 12 Not Defined | | |
| | | Bit 13 Not Defined | | |
| | | Bit 14 Not Defined | | |
| | | Bit 15 Not Defined | | |
| C02 | **OMEGA_CMD_SAVE (RAM ONLY)** | RPM | TBA | Commanded speed. |
| C03 | **TORQUE_CMD (RAM ONLY)** | N-m * 100.0 | TBA | Commanded torque. |
| C04 | **OMEGA_CMD_SAVE (EEPROM AND RAM)** | RPM | TBA | TBA |
| C05 | **TORQUE_CMD (EEPROM AND RAM)** | N-m * 100.0 | TBA | TBA |
| C06 | **EXTENDED DRIVE MODE** | Bit 0 set Serial Set-point<br>Bit 0 clr Local Set-point<br><br>Bit 1 set Digital Set-point<br>Bit 1 clr Analog Set-point<br><br>Bit 2 set Not Defined<br>Bit 2 clr Not Defined<br><br>Bit 3 set Serial Start/Stop<br>Bit 3 clr Local Start/Stop<br><br>Bit 4 set Digital Start/Stop<br>Bit 4 clr Analog Start/Stop<br><br>Bit 5 set Power-up Start disabled<br>Bit 5 clr Power-up Start enabled<br><br>Bit 6 set Follower loss fault disabled<br>Bit 6 clr Follower loss fault enabled<br><br>Bit 7 set Not Defined<br>Bit 7 clr Not Defined<br><br>Bit 8 set Not Defined<br>Bit 8 clr Not Defined | Read/Write | This parameter is bit defined.<br><br>Set and Clear the appropriate bits to set the drive in the desired mode.<br><br>This parameter should be read to determine which bits are currently set.<br><br>The current value should be modified by setting or clearing the desired bits, then the new value written to the drive. |



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| | | | | | |
|---|---|---|---|---|---|
| | | Bit 9 set<br>Bit 9 clr | Not Defined<br>Not Defined | | |
| | | Bit 10 set<br>Bit 10 clr | Digital inputs pulled up<br>Digital inputs pulled down | | |
| | | Bit 11 set<br>Bit 11 clr | Not Defined<br>Not Defined | | |
| | | Bit 12 set<br>Bit 12 clr | Not Defined<br>Not Defined | | |
| | | Bit 13 set<br>Bit 13 clr | Not Defined<br>Not Defined | | |
| | | Bit 14 set<br>Bit 14 clr | Not Defined<br>Not Defined | | |
| | | Bit 15 set<br>Bit 15 clr | Not Defined<br>Not Defined | | |
| C07 | **STOP MODE** | 0<br><br>1 | Ramp Stop<br><br>Reserved for future use | Read/Write | When Bit 0 of parameter C01 is set, the **STOP MODE** is selected based on the value in stop mode.<br><br>If the value is out of range, ramp stop is used. |

**Table 30**

**Group D: Drive Feedback**

| Parm # | Name | Scaling | | Access | Description |
|---|---|---|---|---|---|
| D00 | **DRIVE_STATE** | Byte 0<br><br>Byte 1 | State machine location (0-ffh)<br><br>Feedback bit indicating status.<br><br>Bit 0 set Reverse direction<br><br>Bit 1 set Stopping<br><br>Bit 2 set Running<br><br>Bit 3 set Reversing<br><br>Bit 4 set Commissioning<br><br>Bit 5 set Closed Loop<br><br>Bit 6 set Jogging<br><br>Bit 7 set Speed Mode | Read Only | This parameter consists of 2 bytes. The low byte is the drive control state.<br><br>The second byte is used to provide feedback to the user as to the mode that the drive is in. |
| D01 | **DRIVE_STATUS_SAVE** | Bit 0 clr<br><br>Bit 1 clr<br><br>Bit 2 clr<br><br>Bit 3 clr | System faulted. Always clear when any other bit is clear.<br><br>Inverter interrupt sat fault.<br><br>DB overload.<br><br>Phase over current. | Read Only | When the system is not faulted, this parameter will be read as 0ffffh. |



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| | | | | |
|---|---|---|---|---|
| | | Bit 4 clr Single phase input detected. | | |
| | | Bit 5 clr DC Link under voltage. | | |
| | | Bit 6 clr DC Link over voltage. | | |
| | | Bit 7 clr Base drive fault. | | |
| | | Bit 8 clr A/D offsets out of tolerance. | | |
| | | Bit 9 clr Motor fault. | | |
| | | Bit 10 clr Heat sink overtemp. | | |
| | | Bit 11 clr Motor thermal overload. | | |
| | | Bit 12 clr Communications Fault. | | |
| | | Bit 13 clr External Fault | | |
| | | Bit 14 clr EEPROM fault | | |
| | | Bit 15 clr Motor Parameter Fault | | |
| D02 | **LIMIT_FLAG** | Bit 0 set Flux D est. on high limit<br>Bit 1 set Flux D est. on low limit<br>Bit 2 set Flux Q est. on high limit<br>Bit 3 set Flux Q est. on low limit<br>Bit 4 set PLL on high limit<br>Bit 5 set PLL on low limit<br>Bit 6 set Speed reg. on high limit.<br>Bit 7 set Speed reg. on low limit.<br>Bit 8 set Flux reg. on limit<br>Bit 9 set vd_cmd on limit<br>Bit 10 set vq_cmd on limit<br>Bit 11 set vmag_cmd on limit<br>Bit 12 set id_reg on high limit<br>Bit 13 set id_reg on low limit<br>Bit 14 set iq_reg on high limit<br>Bit 15 set iq_reg on low limit | Read/Write | Bits set in this parameter indicate that the corresponding limit was hit.<br>All bits are latched and may be cleared by the user. |
| D03 | **I_MAG** | I (amps 0 - peak) * drive_ki | Read Only | Output current magnitude. |
| D04 | **ID** | $I_d$ (amps 0 - peak) * drive_ki/2 | Read Only | d-axis current magnitude. |
| D05 | **IQ** | $I_q$ (amps 0 - peak) * drive_ki/2 | Read Only | q-axis current magnitude. |
| D06 | **VOUT** | Motor Volts (volts 0 - peak) * drive_kv | Read Only | Output voltage |
| D07 | **VDC** | VDC (volts) * drive_kv | Read Only | DC link voltage |
| D08 | **OMEGA_DSP** | 10 * Hz | Read Only | Electrical frequency. |
| D09 | **OMEGA_M_DSP** | RPM | Read Only | Mechanical speed. |
| D0A | **HEATSINK TEMP** | 0.1 °C | Read Only | Heat sink temperature |
| D0B | **TORQUE** | N-m * 100 | Read Only | TBA |



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| | | | | |
|---|---|---|---|---|
| D0C | **POWER_OUT** | 0 - 10 HP drives: Watts<br>> 10 HP drives: tbd | Read Only | TBA |
| D0D | **POWER_IN** | Watts | Read Only | TBA |
| D0E | **ELAPSED_LO** | 0.01 hours | Read/Write | Incremented every 1/100 hour when the drive is running. |
| D0F | **ELAPSED_HRS** | hours | Read/Write | Incremented each time **ELAPSED_LO** reaches 100. |
| D10 | **WATT_HR** | TBA | Read/Write | TBA |
| D11 | **WATT_HR_HI** | TBA | Read/Write | TBA |
| D12 | **TBA** | TBA | TBA | TBA |
| D13 | **DB_PT** | $DB\_PT = P * (1 - e^{-t/TC})$ | Read/Write | Current status of dynamic brake power accumulator.<br><br>The accumulator value behaves according to the expression given on the left<br><br>$T_C$ is defined by parameter J12.<br><br>P is the power into the braking resistor. |
| D14 | **INVRS_LM** | TBA | Reserved | TBA |
| D15 | **I_SQR_T** | TBA | Read Only | TBA |
| D16 | **FEEDBACK_PTR** | TBA | Reserved | TBA |
| D17 | **FEEDBACK_VALUE** | TBA | Reserved | TBA |
| D18 | **FLUXR_FF** | TBA | Reserved | TBA |
| D19 | **EXTENDED FAULT CODE** | TBA | Read Only | TBA |
| D1A | **SPEED SET-POINT** | RPM | Read Only | TBA |
| D1B | **TORQUE SET-POINT** | 100 * N-m | Read Only | The current internal torque set-point. |
| D1C | **DIGITAL OUTPUTS** | TBA | Read Only | The current value in the digital output register. |
| D1D | **DIGITAL INPUTS** | TBA | Read Only | The current value in the digital input register. |
| D1E | **DIGITAL INPUT ASSERTION** | TBA | Read Only | The current assertion level of the digital inputs.<br><br>Bit set = asserted<br>Bit clr = de-asserted. |
| D1F | **HIGH SPEED INPUT 1 RESULT** | Frequency: Hz<br><br>Duty Cycle: 0 = 0%, 0ffffh = 100% | Read Only | If digital input pin 9 is configured as High Speed Inputs, the raw result is available by reading this parameter. |
| D20 | **HIGH SPEED INPUT 2 RESULT** | Frequency: Hz<br><br>Duty Cycle: 0 = 0%, 0ffffh = 100% | Read Only | If digital input pin 10 has been configured as High Speed Input 2, the raw result is available by reading this parameter. |
| D21 | **VIN RESULT** | Signed 16 bit word<br>0 = 0 volts<br>8001h = -10 volts<br>7fffh = 10 volts | Read Only | TBA |
| D22 | **ILOOP RESULT** | 0 = 0 milliamps<br>0ffffh = 20 milliamps | Read Only | TBA |
| D23 | **STATE FLAGS** | Bit 0 set Drive disabled<br><br>Bit 1 set Digital Start Disabled<br><br>Bit 6 set Preset Teach Mode<br><br>Bit 7 set Digital Pot accel<br><br>Bit 8 set Digital Pot Decel | Read Only | TBA |
| D24 | **PRESET INDEX** | integer 0 – 8 | Read Only | Indicates the currently active preset speed. |
| D25 | **ANALOG SPEED COMMAND** | RPM | Read Only | TBA |



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| | | | | |
|---|---|---|---|---|
| D26 | **ANALOG TORQUE COMMAND** | 100 * N-m | Read Only | TBA |

**Table 31**

**Group E: Fault Queue**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| E00 | **FAULT_CUE_FULL** | 0 - 1<br><br>0 indicates cue not full<br>1 indicates cue full | Read Only | Zero when no faults have been recorded since the queue was last reset, or the fault cue has not rolled over. Indicates that there are 4 or fewer faults in the cue.<br><br>When the fault cue rolls over (from 4 back to 1), this index is set to 1. This indicates that the cue is full.<br><br>The last fault recorded will be **LAST_FAULT_INDEX**. |
| E01 | **LAST_FAULT_INDEX** | 0 - 4<br><br>0 indicates no faults.<br>1 indicates fault 1.<br>2 indicates fault 2.<br>3 indicates fault 3.<br>4 indicates fault 4. | Read Only | Zero when no faults have been recorded since the queue was last reset.<br><br>If **FAULT_CUE_FULL** is 0, there are 4 or fewer faults in the cue.<br><br>If **FAULT_CUE_FULL** is 1, there are 4 faults in the cue.<br><br>The most recent fault is **LAST_FAULT_INDEX**.<br><br>The previous fault is **LAST_FAULT_INDEX** -1, etc.<br><br>The fault cue is circular; therefore, the cue rolls from 1 back to 4, when reading the cue. |
| E02 | **FIRST_FAULT_STATUS** | drive_status_save | Read Only | TBA |
| E03 | **FIRST_FAULT_TIME_LO** | elapsed_time_lo | Read Only | TBA |
| E04 | **FIRST_FAULT_TIME_HI** | elapsed_time_hi | Read Only | TBA |
| E05 | **FIRST_FAULT_DRIVE_STATE** | drive_state | Read Only | TBA |
| E06 | **FIRST_FAULT_I** | i_mag | Read Only | TBA |
| E07 | **FIRST_FAULT_VDC** | vdc | Read Only | TBA |
| E08 | **FIRST_FAULT_SPEED** | $\omega_m$ | Read Only | TBA |
| E09 | **FIRST_FAULT_EXT_ERROR** | first_fault_ext_error | Read Only | TBA |
| E0A | **TBA** | TBA | Reserved | TBA |
| E0B | **FAULT_1_STATUS** | drive_status_save | Read Only | TBA |
| E0C | **FAULT_1_TIME_LO** | elapsed_time_lo | Read Only | TBA |
| E0D | **FAULT_1_TIME_HI** | elapsed_time_hi | Read Only | TBA |
| E0E | **FAULT_1_DRIVE_STATE** | drive_state | Read Only | TBA |
| E0F | **FAULT_1_I** | i_mag | Read Only | TBA |
| E10 | **FAULT_1_VDC** | vdc | Read Only | TBA |
| E11 | **FAULT_1_SPEED** | $\omega_m$ | Read Only | TBA |
| E12 | **FAULT_1_EXT_ERROR** | fault_1_ext_error | Read Only | TBA |



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|---|---|---|---|---|
| E13 | **TBA** | TBA | Reserved | TBA |
| E14 | **FAULT_2_STATUS** | drive_status_save | Read Only | TBA |
| E15 | **FAULT_2_TIME_LO** | elapsed_time_lo | Read Only | TBA |
| E16 | **FAULT_2_TIME_HI** | elapsed_time_hi | Read Only | TBA |
| E17 | **FAULT_2_DRIVE_STATE** | drive_state | Read Only | TBA |
| E18 | **FAULT_2_I** | i_mag | Read Only | TBA |
| E19 | **FAULT_2_VDC** | vdc | Read Only | TBA |
| E1A | **FAULT_2_SPEED** | $\omega_m$ | Read Only | TBA |
| E1B | **FAULT_2_EXT_ERROR** | fault_2_ext_error | Read Only | TBA |
| E1C | **TBA** | TBA | Reserved | TBA |
| E1D | **FAULT_3_STATUS** | Drive_status_save | Read Only | TBA |
| E1E | **FAULT_3_TIME_LO** | Elapsed_time_lo | Read Only | TBA |
| E1F | **FAULT_3_TIME_HI** | Elapsed_time_hi | Read Only | TBA |
| E20 | **FAULT_3_DRIVE_STATE** | Drive_state | Read Only | TBA |
| E21 | **FAULT_3_I** | i_mag | Read Only | TBA |
| E22 | **FAULT_3_VDC** | vdc | Read Only | TBA |
| E23 | **FAULT_3_SPEED** | $\omega_m$ | Read Only | TBA |
| E24 | **FAULT_3_EXT_ERROR** | fault_3_ext_error | Read Only | TBA |
| E25 | **TBA** | TBA | Reserved | TBA |
| E26 | **FAULT_4_STATUS** | Drive_status_save | Read Only | TBA |
| E27 | **FAULT_4_TIME_LO** | Elapsed_time_lo | Read Only | TBA |
| E28 | **FAULT_4_TIME_HI** | Elapsed_time_hi | Read Only | TBA |
| E29 | **FAULT_4_DRIVE_STATE** | Drive_state | Read Only | TBA |
| E2A | **FAULT_4_I** | i_mag | Read Only | TBA |
| E2B | **FAULT_4_VDC** | vdc | Read Only | TBA |
| E2C | **FAULT_4_SPEED** | $\omega_m$ | Read Only | TBA |
| E2D | **FAULT_4_EXT_ERROR** | fault_4_ext_error | Read Only | TBA |

**Table 32**

**Group F: Drive Parameters**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| F00 | **MIN SPEED** | RPM | Read/Write<br>Run locked | Minimum allowed commanded speed.<br><br>Commanded speeds will be limited to this minimum value.<br><br>To disable jump speeds, set them to **MAX SPEED**. |
| F01 | **JUMP_SPD_L_LO** | RPM | Read/Write<br>Run locked | Lower bound of lowest jump speed range.<br><br>Set to **MAX SPEED** to disable jump speed 1 |
| F02 | **JUMP_SPD_1_HI** | RPM | Read/Write<br>Run locked | Upper bound of lowest jump speed range.<br><br>Set to **MAX SPEED** to disable jump speed 1 |
| F03 | **JUMP_SPD_2_LO** | RPM | Read/Write<br>Run locked | Lower bound of second jump speed range.<br><br>Set to **MAX SPEED** to disable jump speed 2 |
| F04 | **JUMP_SPD_2_HI** | RPM | Read/Write<br>Run locked | Upper bound of second jump speed range.<br><br>Set to **MAX SPEED** to disable jump speed |



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| F05 | **JUMP_SPD_3_LO** | RPM | Read/Write<br>Run locked | Lower bound of highest jump speed range.<br><br>Set to **MAX SPEED** to disable jump speed 3 |
| F06 | **JUMP_SPD_3_HI** | RPM | Read/Write<br>Run locked | Upper bound of highest jump speed range.<br><br>Set to **MAX SPEED** to disable jump speed 3 |
| F07 | **MAX SPEED** | RPM | Read/Write<br>Run locked | Maximum allowed commanded speed. |
| F08 | **ACCEL_RATE_1** | RPM/sec | Read/Write | Speed increase rate limit 1. |
| F09 | **DECEL_RATE_1** | RPM/sec | Read/Write | Speed decrease rate limit 1. |
| F0A | **ACCEL_RATE_2** | RPM/sec | Read/Write | Speed increase rate limit 2. |
| F0B | **DECEL_RATE_2** | RPM/sec | Read/Write | Speed decrease rate limit 2. |
| F0C | **W12_SWITCH** | RPM | Read/Write | Speed at which to switch between **ACCEL_RATE_1**/ **DECEL_RATE_1**and **ACCEL_RATE_2**/ **DECEL_RATE_2**.<br><br>At speeds above **W12_SWITCH**, rates 2 are used.<br><br>At speeds below **W12_SWITCH**, rates 1 are used. |
| F0D | **S_CRV_W_DT** | $-1 * 2^{16} * 0.01/T_c$ (sec)<br><br>$T_c$ is the time constant for the curved portion of the ramp. | Read/Write | Sets the time constant for the curved portion of an S curve ramp.<br><br>Setting this -32768 (8000h) disables the S curve feature.<br><br>**S_CRV_W_DT** must always be negative. |
| F0E | **MIN TORQUE** | 100 * N-m | Read/Write | Used only in the scaling of analog torque command. |
| F0F | **MAX TORQUE** | 100 * N-m | Read/Write | Used only in the scaling of analog torque command. |

**Table 33**

**Group G: Motor Parameters**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| G00 | **MOTOR RATED VOLTAGE** | name plate volts | Read/Write | Only required for induction motor nameplate mode. |
| G01 | **MOTOR RATED HP** | 100 * HP | Read/Write | Only required for induction motor nameplate mode. |
| G02 | **MOTOR RATED SPEED** | RPM | Read/Write | Only required for induction motor nameplate mode. |
| G03 | **MOTOR RATED AMPS** | 10 * RMS amps | Read/Write | Required for all motors |
| G04 | **MOTOR RATED FREQ** | Hz | Read/Write | Only required for induction motor nameplate mode. |
| G05 | **TORQUE LOSS %** | 0 - 200 | Reserved | TBA |
| G06 | **TBA** | TBA | Reserved | TBA |
| G07 | **INDUCTANCE RATIO** | $Ll/(L_l+L_m)$* 1000 | Read/Write | Applies only to induction motors. |
| G09 | **FLUX COMMAND** | Rated line to neutral BEMF (0 - peak volts) at 60 Hz * drive_kv | Read/Write | For an induction motor, this parameter is the commanded rotor flux level. It is calculated in nameplate mode, otherwise it must be provided.<br><br>For a BLDC, this parameter is the initial magnet flux estimate. It is automatically |



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| | | | | tuned in enhanced commission. An initial estimate should be provided. |
| G0A | **RATED IQ** | Amps (0-pk) * ki_i_mag/2.0 | Read/Write | Rated torque producing current.<br><br>For an induction motor, this parameter is calculated in nameplate mode. Otherwise it must be provided. This is used in the load limit and slip limit calculations.<br><br>For a BLDC, this parameter should be the same as rated current although it is used for load limit calculations while rated current is used only for overload protection calculations. |
| G0B | **RATED ID** | Amps (0 - pk) * ki_i_mag/2.0 | Read Only | Rated magnetizing current.<br><br>It applies to induction motors only.<br><br>It is automatically tuned in enhanced commissioning. |
| G0C | **STATOR RESISTANCE** | $R_s$ * 754 * (drive_kw/1000) * ($L_r$/$L_m$) * (drive_kv/ki_i_mag i)<br><br>$R_s$ is line to neutral stator resistance in ohms.<br><br>$L_m$ is line to neutral stator magnetizing inductance in henrys.<br><br>$L_r$ is line to neutral rotor total inductance reflected to the stator in henrys.<br><br>$L_s$ is line to neutral stator total inductance in henrys.<br><br>$R_r$ is line to neutral rotor resistance reflected to the stator in ohms. | Read/Write | TBA |
| G0D | **ROTOR RESISTANCE** | $R_r$ * ($L_m$/$L_r$) * 754 * (drive_kw/1000) * drive_kv/ki_i_mag | Read/Write | Motor rotor resistance (reflected to stator).<br><br>Must be set to zero for BLDC motors. |
| G0E | **INVRS_LM_NOM** | TBA | Read Only | Motor magnetizing reactance.<br><br>Applies only to induction motors. |
| G0F | **INDUCTANCE** | BLDC Inductance = 6177 * $L_{line-line}$/2 * Kv/Ki_imag | Read/Write | Stator leakage inductance.<br><br>Auto calculated for induction motors.<br><br>Must be provided for BLDC motors. |
| G10 | **HALF_POLES** | (Number of Poles)/2 | Read/Write | TBA |
| G12 | **LOAD_LIM_MOTOR** | 0 - 200 | Read/Write | Torque limit during motoring as a percent of rated torque.<br><br>For an induction motor this limit is superseded by **MAX_SLIP/LOAD_LIM_LIM** when the torque limit requires more slip than **MAX_SLIP/LOAD_LIM_LIM** allows. |
| G13 | **LOAD_LIM_BRAKE** | 0 - 200 | Read/Write | TBA |
| G14 | **MAX_SLIP/LOAD_LIM_LIM** | 0 - 500 | Run Locked | For an induction motor, this parameter is the maximum allowed slip as a percent of rated slip.<br><br>For a BLDC, this parameter is an upper |



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| | | | | limit on **LOAD_LIM_BRAKE.** |
| G15 | **ROTOR_WDT** | | Read Only | |
| G16 | **VOLT_GAIN** | (drive_kw/1000) * ($L_r/L_m$) * 426.6 * vdc_gain/2 [16]<br><br>kv_raw = 130.94 (230 VAC)<br><br>kv_raw = 65.472 (460 VAC) | Read/Write | Voltage scale factor |
| G17 | **SLIP_GAIN** | 0 - 200 | Read/Write | TBA |
| G18 | **LOAD_LIM_GAIN** | 0 - 200 | Read/Write | TBA |
| G19 | **KRS** | TBA | Reserved | TBA |
| G1A | **RS_MAX** | 3000 | Reserved | TBA |
| G1B | **RS_GAIN** | 0 - 200 | Reserved | TBA |
| G1C | **MAX_RATED_SLIP** | 10 * % | Read/Write | Maximum slip allowed to be entered by the user without generating a motor parameter fault.<br><br>Example: A setting of 100 corresponds to a maximum of 10% maximum rated slip. Applies only in nameplate mode. |
| G1D | **K_RS** | TBA | Read/Write | Set during commissioning by the drive.<br><br>$r_s = (VDC^2/HP_{motor}) * \mathbf{K\_RS} /100$. $HP_{motor}$ is in units of 100 * $HP_{motor}$.<br><br>Applies only to induction motors in nameplate mode. |
| G1E | **K_ID** | 0 – 100 % | Read/Write | d-axis current as percent of rated current.<br><br>This is auto tuned during enhanced commissioning.<br><br>Applies only to induction motors. |
| G1F | **MIN_EFF_FLUX** | 10 * % | Read/Write | Percentage of rated flux at zero torque. Applies only to induction motors. |
| G20 | **DEFAULT_K_RS** | TBA | Reserved | **K_RS** is set to this when the command Set Factory Default Autotune occurs. |
| G21 | **DEFAULT_K_ID** | TBA | Reserved | **K_ID** is set to this when the command Set Factory Default Autotune occurs. |
| G22 | **I_BLDC_START** | TBA | TBA | TBA |
| G23 | **BLDC_LOCK_RTR_WAIT** | TBA | TBA | TBA |
| G24 | **BLDC_START_OMEGA** | TBA | TBA | TBA |

**Table 34**

**Group H: Braking Parameters**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| H00 | **DC INJECTION TIME** | DC injection duration (sec)/0.0524 | Read/Write | Duration of DC injection.<br><br>DC injection is applied when the control system has detected the drive has stopped. |
| H01 | **DC INJECTION LEVEL** | DC injection current (amps) * ki_i_mag/2 | Read/Write | DC injection current level. |

**Table 35**

**Group I: Current and Voltage Feedback Parameters**



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| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| I00 | **VDC_GAIN** | $2^{16}$ * drive_kv/raw_kv<br><br>32533 (230 VAC)<br>33032 (460 VAC) | Read Only | DC link scale factor, used in calculating **VOLT_GAIN**.<br><br>raw_kv = 130.94 (230 VAC)<br>raw_kv = 65.472 (460 VAC) |
| I01 | **OFFSET WDT** | TBA | | TBA |
| I02 | **IB SKEW** | TBA | Reserved | TBA |
| I03 | **IC SKEW** | TBA | Reserved | TBA |
| I04 | **IB_GAIN** | TBA | Reserved | TBA |
| I05 | **IB_OFFSET_NOM** | TBA | Reserved | TBA |
| I06 | **IB_OFFSET** | TBA | Reserved | TBA |
| I07 | **IC_GAIN** | TBA | Reserved | TBA |
| I08 | **IC_OFFSET_NOM** | TBA | Reserved | TBA |
| I09 | **IC_OFFSET** | TBA | Reserved | TBA |
| I0A | **OFFSET_ERROR** | TBA | Reserved | TBA |

**Table 36**

**Group J: Protection**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| J00 | **ZERO_CRNT** | I (amps) * ki_i_mag | Read/Write | Zero current detect level |
| J01 | **I_SQR_T_WDT** | TBA | Read/Write | $I^2T$ time constant for thermal protection |
| J02 | **I_SQR_T_LIM** | TBA | Read/Write | $I^2T$ trip point for thermal protection |
| J03 | **SNGL_PH_TRIP** | TBA | Read/Write | TBA |
| J04 | **TBA** | TBA | Reserved | TBA |
| J05 | **COMM_TIMER_MAX** | 0 - 65535<br><br>Time (sec) = comm_timer_max * 0.052 sec | Read/Write | Communications timeout setting.<br><br>0 disables time-out checking. |
| J06 | **ZERO_POWER_THRESHHOLD** | TBA | Reserved | TBA |
| J07 | **ILOOP_LOSS_REF** | 0 = 0 milliamps<br>$2^{15}$ = 20 milliamps | Read/Write | When follower-loss fault is enabled, the drive will fault running or asked to run and iloop current is less than this value. |
| J08 | **PASSWORD** | 0 - 65535 | Read/Write | Allows writes to read-only locations when set.<br><br>This value set by the factory. |
| J09 | **FAN_ON_TEMP** | 0.1 °C | Reserved | Fan on temp |
| J0A | **TEMP_HYS** | 0.1 °C | Reserved | Hysteresis used in fan control |
| J0B | **HEATSINK_HOT** | 0.1 °C | Reserved | Over temperature trip point |
| J0C | **I_SQR_T_OK_DRV** | TBA | Reserved | TBA |
| J0D | **VDC_DELTA_MAX** | 0 - 255<br>volts * Kv * volt_gain/vdc_gain | Reserved | Delta volts above **VDC_NOM** or below **VDC_RIDE_THRU** that trips the drive on over or under volts. |
| J0E | **VDC_RIDE_THRU** | volts * Kv * volt_gain/vdc_gain | Reserved | Value at which the dc bus is regulated during ride thru.<br><br>Drive undervoltage trip point at **VDC_RIDE_THRU** - **VDC_DELTA_MAX**. |
| J0F | **VDC_NOM** | volts * Kv * volt_gain/vdc_gain | Reserved | Drive overvoltage trip point at **VDC_NOM** + **VDC_DELTA_MAX** |
| J10 | **VDC_BRAKING** | volts * Kv * volt_gain/vdc_gain | Reserved | Value at which the dc bus is regulated during braking. |
| J11 | **IABC_MAX** | I (amps) * drive_ki | Reserved | Overcurrent trip point. |
| J12 | **DB_PT_WDT** | $2^{16}$ * 0.052/$T_c$ (sec)<br>$T_c$ = Thermal time constant of DB | TBA | Time constant for DB protection. |



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| | | resistor in seconds.<br><br>TripTime = -ln((P-DBLim)/P)*$T_c$<br><br>P = power into DB<br><br>If P <= DBLim, TripTime = ∞<br>If P = 1.582*DBLim, Trip Time = $T_c$ | | |
| J13 | **DB_PT_LIM** | Watts | TBA | DB resistor power rating |
| J14 | **OUT_OF_REG_CNT** | TBA | TBA | TBA |

**Table 37**

**Group K: Regulator Gains**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| K00 | **KP_TRQ** | TBA | Read/Write | TBA |
| K01 | **KI_TRQ** | TBA | Read/Write | TBA |
| K02 | **KP_FLX\|SPEED REG GN** | TBA | Read/Write | TBA |
| K03 | **IQ_WDT_SPEED** | TBA | Read/Write | TBA |
| K04 | **IQ_WDT_TRQ** | TBA | TBA | TBA |
| K05 | **KI_FLUXR** | TBA | Reserved | TBA |
| K06 | **OMEGA_TORQ_START** | TBA | Reserved | TBA |
| K07 | **VDC_RGN_GAIN** | Kp ride thru/Kp regen override | Reserved | TBA |
| K08 | **KP_BRAKE** | TBA | Reserved | TBA |
| K09 | **KI_BRAKE** | TBA | Reserved | TBA |
| K0A | **MAX_BRAKING** | TBA | Reserved | TBA |
| K0B | **KP_I_NOM** | TBA | Reserved | TBA |
| K0C | **KI_OMEGA** | TBA | Reserved | TBA |
| K0D | **PLL_DT_W** | TBA | TBA | TBA |

**Table 38**

**Group L: Internal Parameters**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| L00 | **I_SQR_WAVE** | TBA | Reserved | Lockout correction |
| L01 | **W_FF_W_DT** | TBA | Reserved | TBA |
| L02 | **OMEGA_LO_LIM** | TBA | Reserved | TBA |
| L03 | **TRQ_CNVRT** | (2/3) * (drive_ki/2) * drive_kv * ($L_r/L_m$) * $W_b$<br><br>$W_b$ = 377<br><br>$L_r/L_m$ = 1.028 | Reserved | Torque conversion factor.<br><br>Converts internal units to 0.01 N-m |
| L04 | **PWR_IN_CNVRT** | (2/3) * (drive_ki/2) * drive_kv * √(3/4)/0.98<br><br>$L_r/L_m$ = 1.028 | Reserved | Power conversion factor.<br><br>Converts internal units to Watts (1 - 10 HP drives). |
| L05 | **PWR_OUT_CNVRT** | (2/3) * (drive_ki/2) * drive_kv * ($L_r/L_m$) * $W_b$ * 12.016 * $2^{16}$<br><br>$W_b$ = 377<br><br>$L_r/L_m$ = 1.028 | Reserved | Power conversion factor.<br><br>Converts internal units to Watts (1 - 10 HP drives). |
| L06 | **DSP_WDT** | TBA | Reserved | Display filter time-constant. |
| L07 | **SAMPLE_ADVANCE** | TBA | Reserved | TBA |
| L08 | **CHECK_TIME** | TBA | Reserved | Delay time used in measuring resistance |



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| | | | | during commissioning. |
| L09 | **FLX_RATE_LIM_LO** | TBA | Reserved | TBA |
| L0A | **FLX_RATE_LIM_HI** | TBA | Reserved | TBA |
| L0B | **COMMISSION_STARTS** | 0 - ffffh | Read/Write | TBA |
| L0C | **COMMISSION_ANGLE** | 0 - 1440 | Reserved | TBA |
| L0D | **WATT_HR_NUM** | TBA | Reserved | TBA |
| L0E | **WATT_HR_CNTR** | TBA | Reserved | TBA |
| L0F | **LOSSES_ON** | Watts | Reserved | TBA |
| L10 | **LOSSES_OFF** | Watts | Reserved | TBA |
| L11 | **INVRS_LM_DELTA_MAX** | TBA | Reserved | TBA |
| L12 | **INVRS_LM_W_MIN** | TBA | Reserved | TBA |
| L13 | **INVRS_LM_W_RANGE** | TBA | Reserved | TBA |
| L14 | **HALF_PWM_NOM** | 1000/(Hz * 4 * π * 0.8e-6 * kW) | Reserved | Unsynchronized PWM frequency. |
| L15 | **HALF_PWM_MIN** | 1000/(Hz * 4 * π * 0.8e-6 * kW) | Reserved | Minimum PWM period (max frequency). |
| L16 | **HALF_PWM_MAX** | 1000/(Hz * 4 * π * 0.8e-6 * kW) | Reserved | Maximum PWM period (min frequency). |
| L17 | **SYNC_OMEGA_MIN** | Hz * kW * 2 * π /1000 | Reserved | Switch point from unsynchronized to synchronized PWM. |
| L18 | **COSINE_PTR** | TBA | Read Only | TBA |
| L19 | **VQ_SKEW_THETA** | TBA | Reserved | TBA |
| L1A | **VD_SKEW_THETA** | TBA | Reserved | TBA |
| L1B | **VQ_SKEW_MAG** | TBA | Reserved | TBA |
| L1C | **VD_SKEW_MAG** | TBA | Reserved | TBA |
| L1D | **DEAD_TIME** | TBA | TBA | Write bits 0 - 7 as 0s.<br><br>Write bit 8 as a 1 for SSI drives.<br><br>Write bits 9 - 11 as 0s. (Read Only bits)<br><br>Write bits 12 - 15 as needed for dead-time. Minimum dead-time is 0.1 µsec, and increments by 0.2 µsec for each integer increment.<br>0 = 0.1 µ-sec.<br>1 = 0.3 µ-sec<br>2 = 0.5 µ-sec, etc.<br><br>Example: Write<br><br>5100H for 1.1 µ-sec dead-time on an SSI drive.<br>8100H for 1.7 µ-sec dead-time on an SSI drive. |
| L1E | **EXT_COMMISSION_W** | TBA | TBA | TBA |
| L1F | **CLOSE_LOOP_PER** | TBA | TBA | TBA |

**Table 39**

**Group M: I/O Setup**

| Parm # | Name | Scaling | Access | Description |
|---|---|---|---|---|
| M00 | **DIGITAL INPUT 1 FCN** | TBA | Read/Write | TBA |
| M01 | **DIGITAL INPUT 2 FCN** | TBA | Read/Write | TBA |
| M02 | **DIGITAL INPUT 3 FCN** | TBA | Read/Write | TBA |



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| M03 | **DIGITAL INPUT 4 FCN** | TBA | Read/Write | TBA |
| M04 | **DIGITAL INPUT 5 FCN** | TBA | Read/Write | TBA |
| M05 | **DIGITAL INPUT 6 FCN** | TBA | Read/Write | TBA |
| M06 | **DIGITAL INPUT 7 FCN** | TBA | Read/Write | TBA |
| M07 | **DIGITAL INPUT 8 FCN** | TBA | Read/Write | TBA |
| M08 | **DIGITAL INPUT POLARITY** | TBA | Read/Write | TBA |
| M09 | **DIGITAL OUTPUT 1 FCN** | TBA | Read/Write | TBA |
| M0A | **DIGITAL OUTPUT 2 FCN** | TBA | Read/Write | TBA |
| M0B | **RELAY 1 FCN** | TBA | Read/Write | TBA |
| M0C | **RELAY 2 FCN** | TBA | Read/Write | TBA |
| M0D | **ANALOG OUTPUT 1 FCN** | TBA | Read/Write | TBA |
| M0E | **ANALOG OUTPUT 2 FCN** | TBA | Read/Write | TBA |
| M0F | **ANALOG OUTPUT 3 FCN** | TBA | Read/Write | TBA |
| M10 | **ILOOP INPUT FCN** | TBA | Read/Write | TBA |
| M11 | **VIN FCN** | TBA | Read/Write | TBA |
| M12 | **JOG SPEED** | TBA | Read/Write | TBA |
| M13 | **PRESET SPEED 1** | TBA | Read/Write | TBA |
| M14 | **PRESET SPEED 2** | TBA | Read/Write | TBA |
| M15 | **PRESET SPEED 3** | TBA | Read/Write | TBA |
| M16 | **PRESET SPEED 4** | TBA | Read/Write | TBA |
| M17 | **PRESET SPEED 5** | TBA | Read/Write | TBA |
| M18 | **PRESET SPEED 6** | TBA | Read/Write | TBA |
| M19 | **PRESET SPEED 7** | TBA | Read/Write | TBA |
| M1A | **OVERLOAD ALERT LEVEL** | TBA | Read/Write | TBA |
| M1B | **OVERTEMP ALERT** | TBA | Read/Write | TBA |
| M1C | **SPEED DETECT LOW** | TBA | Read/Write | TBA |
| M1D | **SPEED DETECT HIGH** | TBA | Read/Write | TBA |
| M1E | **AT SPEED RANGE** | TBA | Read/Write | TBA |
| M1F | **TORQUE DETECT LOW** | TBA | Read/Write | TBA |
| M20 | **TORQUE DETECT HIGH** | TBA | Read/Write | TBA |
| M21 | **LED 1 FCN** | TBA | Read/Write | TBA |
| M22 | **LED 2 FCN** | TBA | Read/Write | TBA |
| M23 | **MIN V REF** | TBA | Read/Write | TBA |
| M24 | **MAX V REF** | TBA | Read/Write | TBA |
| M25 | **MIN I REF** | TBA | Read/Write | TBA |
| M26 | **MAX I REF** | TBA | Read/Write | TBA |
| M27 | **ANALOG OUT 1 SCALE** | TBA | Read/Write | TBA |
| M28 | **ANALOG OUT 2 SCALE** | TBA | Read/Write | TBA |
| M29 | **ANALOG OUT 3 SCALE** | | Read/Write | |
| M2A | **MIN HSI1 REF** | Frequency: Hz<br>Duty Cycle: 0 = 0%, 0ffffh = 100% | Read/Write | |
| M2B | **MAX HSI1 REF** | Frequency: Hz<br>Duty Cycle: 0 = 0%, 0ffffh = 100% | Read/Write | |
| M2C | **MIN HSI2 REF** | Frequency: Hz | Read/Write | |



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| | | | |
|---|---|---|---|
| M2D | **MAX HSI2 REF** | Duty Cycle: 0 = 0%, 0ffffh = 100%<br>Frequency: Hz<br>Duty Cycle: 0 = 0%, 0ffffh = 100% | Read/Write |

**Table 40**



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# Appendix H: wInControl™ Owner's Manual

## 1. Introduction

Welcome to the wInControl Owner's Manual! The wInControl application was developed by MTS Automation Systems, Inc. to aid in configuration and customization of the DriveBlok product line. It provides an easy to use operator interface with complete access to the DriveBlok capabilities.

This manual covers the use of **wInControl v2.5** and its integration with the DriveBlok product line.

## 2. Installation

wInControl is a 32-bit program that can be run on Windows 95®, Windows 98®, or Windows NT ®.

wInControl comes as a self-extracting executable. The file name indicates the version of wInControl being installed. For example, the file wInControl25.exe will install wInControl version 2.5.

To install:

- Select Run from the Start menu
- In the dialog box, type the path to and executable name of wInControl. For example, if wInControl version 2.5 is being installed from a floppy, type A:\wInControl25.exe.
- Next, select the **OK** button to begin the installation.
- *After temporary files are unzipped, the Welcome screen is displayed.*
- Press the **Next** to continue or **Cancel** to exit the installation program.
- *The Choose Destination Location dialog box now allows the wInControl installation directory to be modified.*
- Click the **Browse** button and select a new installation directory if desired. Otherwise, press the **Next** button to continue.
- Finally, a Program Folder must be selected. The default folder is MTS Automation Systems. If a different Program Folder is desired, enter that information now.
- Once the Program Folder is selected, press the **Next** button to complete the installation.
- *The files are now copied to the selected destination and a program folder is added to the target computer.*
- *A final dialog box is displayed indicating the destination location of wInControl.*
- Press the **OK** button and allow the self-extraction utility to exit.

You are now ready to use wInControl!!!

## 3. First Time Instructions

wInControl is executed by selecting Start, Programs, MTS Automation Systems, wInControl from the Windows Toolbar.

The first time wInControl is run, it needs to know about DriveBlok communications.

The default values for Baud Rate and IDM Address match a drive shipped from the factory.

The Port Selection must be configured before communications with the DriveBlok can occur. Select the Communications Port to use and press the **OK** button. These communication settings may be changed at any time as described in **Section 6.2.1**.

wInControl must be connected to a powered DriveBlok in order to work properly. If a DriveBlok is not connected, many of the features of wInControl will be unavailable for use.

## 4. DriveBlok Setup Wizards

Four Setup Wizards exist in wInControl that allow the user to select and control all features of the DriveBlok. These Wizards are: Motor Wizard, Application Wizard, I/O Wizard, and Regulator Wizard.

- *Motor Wizard* is used to configure the drive for a new motor or modify the drive's configuration for a current motor.



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- *Application Wizard* is used to configure the drive for application specific parameters. These parameters include Acceleration Rates, Jump Speeds, or the Maximum Speed Setting.
- *I/O Wizard* is used to configure the drive's inputs and outputs. These include Analog Inputs, Analog Outputs, Digital Inputs, and Digital Outputs.
- *Regulator Wizard* is used to tune the drive's Speed Regulator for peak application performance.

### 4.1 Motor Wizard

Motor Wizard is initialized by pressing the Motor Wizard Button on the wInControl Toolbar. This button is shown in **Figure 27**.

**Figure 27**

In order to achieve the optimum performance from the DriveBlok, it is important to match the drive size to the motor size. For *AC motors*, stay within one power level of the DriveBlok rating. In other words, a 2 Hp DriveBlok can span the range from 1 Hp to 3 Hp. However, it is important to note that if the application requires 3 Hp continuous output power, then a 3Hp DriveBlok should be used. For *Brushless DC motors*, the Back EMF constant, $K_e$, should be above 40 V/kRPM and the motor current rating should be within 25% of the DriveBlok's current rating.

#### 4.1.1 Motor Wizard Initialization

While the Motor Wizard is being initialized, the dialog box shown in **Figure 28** is shown


**Figure 28**

This dialog box is shown while wInControl is determining the current motor configuration of the DriveBlok. Pressing the **Cancel** button causes the DriveBlok communications to cease and terminates Motor Wizard. Under normal operation, this dialog box is shown for less than one second.

#### 4.1.12 Motor Type

During Motor Wizard initialization, wInControl determines the Control Type of the DriveBlok. The ADM product is capable of driving AC Motors while the BDM product is capable of driving both AC and Brushless DC Motors. If wInControl detects the DriveBlok is a BDM, then the dialog box shown in **Figure 29** shown. If an ADM module is detected, then the dialog box in **Figure 30** is shown.

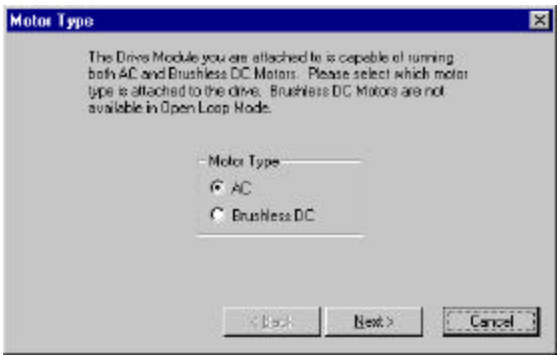


**Figure 29**

The desired motor type should be selected.

To continue with motor configuration, press the **Next >** button. Pressing the **Cancel** button causes Motor Wizard to be exited and all modified data to be restored to their settings before Motor Wizard was run. For *AC* motor configuration, continue to **Section 4.1.3**. For *BLDC* motor configuration, proceed to **Section 4.1.5**.

#### 4.1.3 Motor Nameplate Parameters

If an *AC* motor is selected, the Motor Nameplate Parameters dialog box shown in **Figure 30** is shown. This dialog box allows entry of the motor nameplate parameters. These parameters are self-explanatory and are not described here.

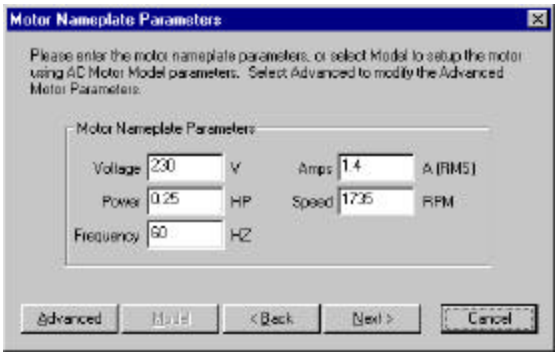


**Figure 30**

At any time, the **< Back** button takes the user to the previous configuration dialog box.

If there is need to modify the Advanced Motor Parameters, pressing the **Advanced** button opens the dialog box shown in **Figure 31**. Selecting the **Next >** button proceeds to the final dialog box described in **Section 4.1.7**.

#### 4.1.4 Advanced Motor Parameters

The Advanced Motor Parameters dialog box allows adjustment of DriveBlok parameters that normally would not need to be modified.

The *Service Factor* parameter is used for $I^2T$ protection of the motor. This parameter defines the output capabilities of the motor.



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For example, a service factor of 1.15 indicates the motor can be run at 115% rated output power continuously.

*Inductance Ratio* allows the amount of Leakage Inductance to be adjusted for the motor. The parameter is defined as:

Leakage Inductance = Inductance Ratio * (Leakage Inductance + Magnetizing Inductance)

When these parameters have been adjusted to their appropriate values, select the **Next >** to proceed to the dialog box described in **Section 4.1.7**.

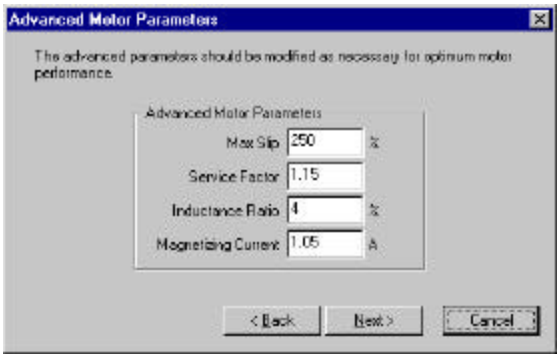


**Figure 31**

### 4.1.5 Brushless DC Motor Model Parameters

The Brushless DC Motor Model Parameters are entered from the dialog box shown in **Figure 32**. A diagram describing the motor model used is part of the dialog box.

Enter the information based upon the shown motor model and select the **Next >** button to proceed to the dialog box in **Section 4.1.6**.

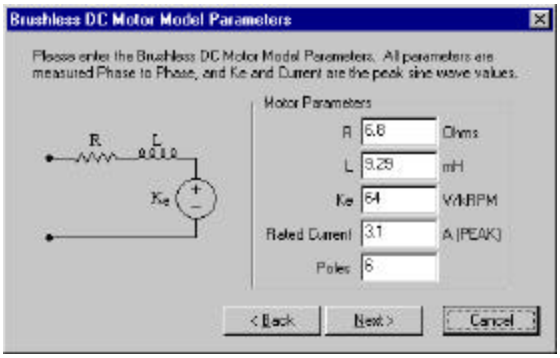


**Figure 32**

### 4.1.6 Brushless DC Starting Parameters

The Brushless DC Starting Parameters control how much current is applied to the motor when the drive is starting. The dialog box is shown in **Figure 33**.


**Figure 33**

Selecting the **Next >** button proceeds to the dialog box in **Section 4.1.7**.

### 4.1.7 Commission Drive

**Figure 34** shows the Commission Motor dialog box. Two methods of drive commissioning (Normal and Enhanced) are available; however, only the Normal commissioning is available from this dialog box.

See **Section 4.5** for more information on the Commissioning process.

In the Commission Motor dialog box, select the **Commission** button to initiate a Normal commission. The dialog box shown in **Figure 35** is shown while the Commissioning process is executing.


**Figure 34**

Pressing the **Finish** button exits the Motor Wizard and returns to the main display.


**Figure 35**

Pressing the **Cancel** button causes the commissioning process to stop. The Drive Commissioning dialog box closes automatically when the drive finishes commissioning.



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## 4.2 Application Wizard

Application Wizard is initialized by pressing the Application Wizard Button on the wInControl Toolbar. This button is shown in **Figure 36**.

**Figure 36**

During the initialization of Application Wizard, the dialog box shown in **Figure 37** is shown. This initialization should take approximately one second to complete at which time the dialog box shown in **Figure 38** is shown.


**Figure 37**

**Sections 4.2.1** and **4.2.2** describe the Control Method and Regulator Mode of the DriveBlok. **Table 41** describes the information required for each mode and the dialog boxes used for gathering that information.

| Volts per Hertz Mode | Sensorless Flux Vector Mode | |
|---|---|---|
| | *Speed Mode* | *Torque Mode* |
| 0 - 4.2.3 Start and Stop Modes | 0 - 4.2.3 Start and Stop Modes | 0 - 4.2.3 Start and Stop Modes |
| 0 - 4.2.6 Acceleration Parameters | 0 - 4.2.4 Speed Mode Limits | 0 - 4.2.5 Torque Mode Limits |
| 0 - 4.2.7 Jump Speed Settings | 0 - 4.2.6 Acceleration Parameters | 0 - 4.2.8 Brake Settings |
| | 0 - 4.2.7 Jump Speed Settings | |
| | 0 - 4.2.8 Brake Settings | |
| | 0 - 4.2.9 Efficiency Mode Settings | |

**Table 41**

### 4.2.1 Control Method

The Control Method Dialog box is shown in **Figure 38**. The user selects if the drive should run in *Sensorless Flux Vector Mode* or *Volts per Hertz* control mode. If the application is using a Brushless DC motor, *Volts per Hertz* mode is not available and the Control Method Dialog box does not appear. If this is the case, wInControl proceeds directly to the dialog box described in **Section 4.2.2**. *Sensorless Flux Vector* mode provides the best motor control and should be used in most applications. *Volts per Hertz* mode can be used if precise control is not required or if an undersized motor is connected to the DriveBlok.


**Figure 38**

### 4.2.2 Regulator Mode

From the Regulator Mode dialog box shown in **Figure 39**, the user configures the DriveBlok to operate in *Speed* or *Torque* (Four-quadrant) mode.

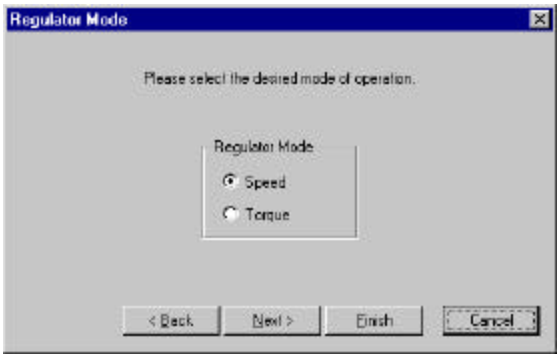


**Figure 39**

### 4.2.3 Start and Stop Modes

The Start and Stop Modes dialog box shown in **Figure 40** allows the user to control how the DriveBlok handles starting and stopping. The Start Mode parameter configures whether the control system assumes a motor is stopped when starting or if it determines the current motor speed before starting control. If the *Flying Start* mode is selected, a slight delay will be noticeable while the DriveBlok is finding the current motor speed. This delay is not present in *Normal* start mode.

The Stop Mode can be configured to *Coast* or *Ramp*.



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If Stop Mode is configured to *Coast*, a stop command causes the drive to shut down all power output stages. The motor is left to coast to a stop. In this mode, the DC Hold parameters have no effect.

If Stop Mode is configured to *Ramp*, a Stop command will cause the drive to decelerate at the pre-programmed rate until zero speed is reached. At that time the DriveBlok will apply a DC Hold current to the motor as specified by the DC Hold *Level* parameter for the time specified by the DC Hold *Time* parameter.

When the DriveBlok is commanded to less than the minimum operating speed, it will apply DC Hold current to the motor. This mode will continue until a stop command is sent to the drive or the speed command exceeds the minimum operating speed. If a stop command is sent to the drive, the DC Hold current will continue for the time specified by the DC Hold Time parameter.

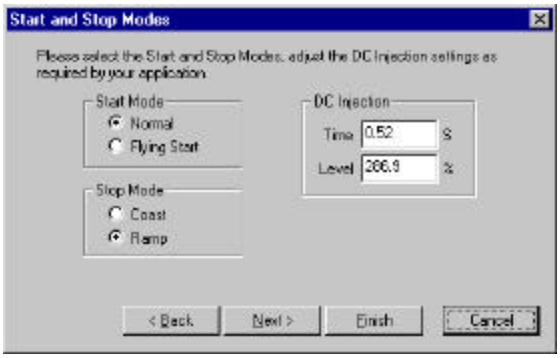


**Figure 40**

### 4.2.4 Speed Mode Limits

The Speed Mode Limits dialog box is shown in **Figure 41**. *Min Speed* is the slowest speed the DriveBlok can be commanded to. It is not necessarily the slowest speed the drive can run at. The speed range of a DriveBlok is from 1% of Rated Speed to Rated Speed. Any speed commands below 1% Rated Speed cause the drive to enter a DC Hold mode. For AC Motors this means the DriveBlok outputs zero frequency with a magnitude equal to the Starting Magnetizing Current of the motor (See section 0). For a Brushless DC motor, DriveBlok outputs zero frequency with a magnitude equal to the Starting Current of the motor (See section 0).

The *Max Speed* is the highest speed the drive is allowed to run. Speed commands above this value will cause the drive to run at the specified Maximum Speed. The DriveBlok can operate at up to 400 Hz output frequencies. This corresponds to a synchronous speed of 24,000 RPM for a 2 pole motor. If the drive output exceeds 410 Hz as a result of a commanded speed, the drive will trip off with an Overspeed Fault.

The *Max Speed* and *Min Speed* settings are also used to scale analog inputs. See **Sections 4.3.5** and **4.3.6** for more details about analog input scaling.

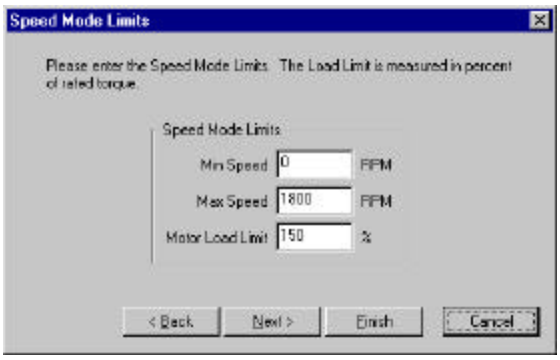


**Figure 41**

*Motor Load Limit* is the percentage of rated torque the motor is allowed to output. In **Figure 41** the *Motor Load Limit* is configured to 150%. This means the drive will produce up to 150% of rated motor torque, if necessary, to keep the motor operating at the commanded speed.

### 4.2.5 Torque Mode Limits

The Torque Mode Limits dialog box is shown in **Figure 42**. *Overspeed Trip Pt.* is a parameter that specifies where the drive will trip off on an Overspeed Fault. The actual trip point is above the parameter value and is calculated as:

Actual Trip Point = *Overspeed Trip Pt.* + 1200 / Motor Poles

For a four pole motor with an *Overspeed Trip Pt.* of 1800 RPM, the actual trip point would be 1800 + 1200 / 4 = 2100 RPM.

The *Motor Load Limit* in this dialog box is the same as in the Speed Mode Limits dialog box shown in **Figure 41**.

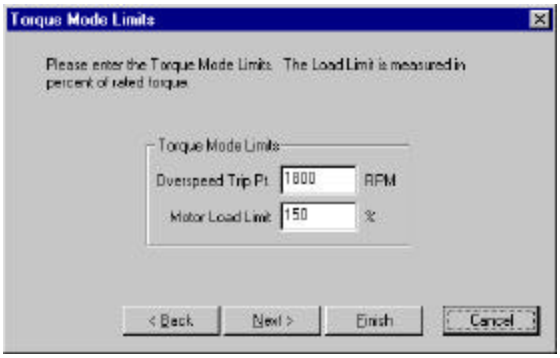


**Figure 42**

### 4.2.6 Acceleration Parameters

The Acceleration Parameters dialog box is shown in **Figure 43**. This dialog box allows the adjustment of the acceleration profile of the DriveBlok while operating in *Speed* regulator mode. The DriveBlok has two acceleration/deceleration sets. *Accel/Decel Set 1* is used when the motor is operating at speeds below the Configured *Set 1/2 Switch Speed*. *Accel/Decel Set 2* is used above that value. If the *Set 1/2 Switch Speed* parameter is configured to



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the same value as the *Max Speed* parameter, then *Accel/Decel Set 1* is always used.

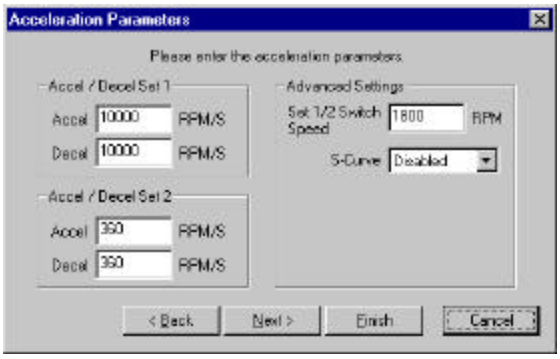


**Figure 43**

In addition, *Accel/Decel Set 2* can be selected through the use of a Digital Input. See **Section 4.3.9** for more information about the Digital Inputs.

The *S-Curve* parameter controls the acceleration of the drive. When *S-Curve* parameter is enabled, it calculates the necessary parameters for an *S-Curve* acceleration profile based upon the *Accel/Decel Set 1* parameters.

### 4.2.7 Jump Speed Settings

The DriveBlok features three independent *Jump Speeds* as shown in **Figure 44**. These *Jump Speeds* work to keep the motor from continuously operating within a specified range.

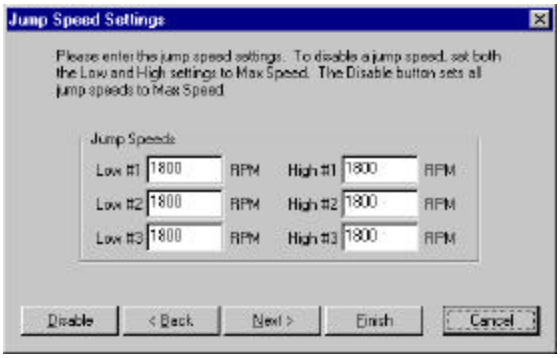


**Figure 44**

The effect of the *Jump Speed* parameters is shown in **Figure 45**. *Jump Speeds* can be used to control a mechanical resonance problem by not allowing the motor to continuously operate within that range. In this example, one Jump Speed was within the Low value of 400 RPM, and the High value of 600 RPM. As can be seen, the motor will not remain in the speed range from 400 to 600 RPM.

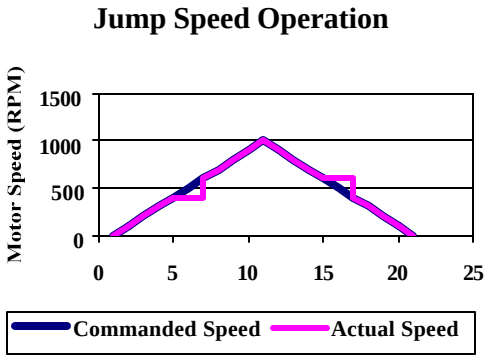


**Figure 45**

### 4.2.8 Brake Settings

The Brake Settings dialog box shown in **Figure 46** allows the amount of braking torque the DriveBlok will produce to be controlled. If the *Load Limit* parameter is configured to 0, the drive will be unable to regulate speed accurately.

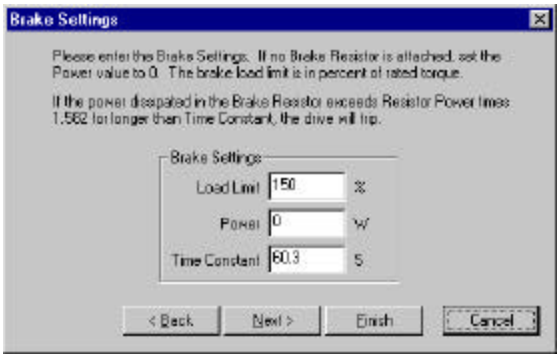


**Figure 46**

The *Load Limit* parameter configures how much braking torque is allowed. As braking torque is applied, energy is removed from the motor system. This energy must be dissipated by the Brake Resistor. If no Brake Resistor is present, the DriveBlok dissipates power as fast as it can and the motor deceleration rate is reduced to that level. The parameters for configuring the external Braking Resistor are part of this dialog box. Resistor *Power* is specified in Watts.

As stated in the dialog box, if the power dissipated by the Braking Resistor equals the resistor *Power* times 158%, the drive will trip after the time specified as the *Time Constant*. If we have a 300 Watt Resistor with a 60 second Time Constant, we can dissipate 474 Watts in the resistor for 60 seconds before the drive will trip with a Dynamic Brake Overload Fault. If less power is dissipated by the resistor, the drive will operate longer before faulting. If more power is dissipated, the drive will not operate as long.

### 4.2.9 Efficiency Mode Settings



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Efficiency Mode Settings are modified from the dialog box shown in **Figure 47**. Efficiency Mode allows the DriveBlok to reduce the amount of flux or magnetic field strength applied to the motor when not required by the load. When the Efficiency Mode is *Enabled* on an application requiring less than full load torque, the applied flux is reduced, which causes power and noise to be reduced. Changes in motor flux are limited by the rotor time constant. Therefore, Efficiency Mode is best suited for applications where the torque does not change rapidly.

Full load torque applies full motor flux; and, No load or zero torque applies the amount of flux specified by the *Min Efficiency Flux* parameter. Linear interpolation is used to determine the amount of flux to apply between no load and full load. The drive must flux the motor before the torque can be increased.


**Figure 47**

### 4.3 I/O Wizard

I/O Wizard is initialized by pressing the I/O Wizard button on the wInControl Toolbar. This button is shown in **Figure 48**.

**Figure 48**

#### 4.3.1 I/O Wizard Initialization

While the I/O Wizard is being initialized, the dialog box shown in **Figure 49** is shown.


**Figure 49**

This dialog box is shown while wInControl is determining the current I/O configuration of the DriveBlok. Pressing the **Cancel** button causes the DriveBlok communications to cease and terminates I/O Wizard. Under normal operation, this dialog box is shown for about 1.5 seconds.

#### 4.3.2 I/O Wizard Mode

The dialog box shown in **Figure 50** allows the Setup Mode to be selected. From here the user can choose to *Modify Current I/O Settings* of the DriveBlok or *Select a Preset I/O Theme*. Choosing to *Modify Current I/O Settings* proceeds to the dialog box shown in **Figure 50** while choosing *Select a Preset I/O Theme* navigates to **Section 4.3.3**.


**Figure 50**

#### 4.3.3 Preset I/O Themes

The Preset I/O Themes are designed to assist the user in configuring the DriveBlok I/O. These themes can be used as is or can be used as a basis for I/O modifications. If one of the themes meets the I/O requirements of the target system, select that theme and press the **Finish** button. However, if a theme is not sufficient, but is close to the target system requirements, select the **Modify** button. The I/O Wizard will navigate to the dialog box shown in **Figure 52** and begin target system modification.

At any time the **Cancel** button may be pressed to exit the I/O Wizard without saving any of the modified configuration to the drive.

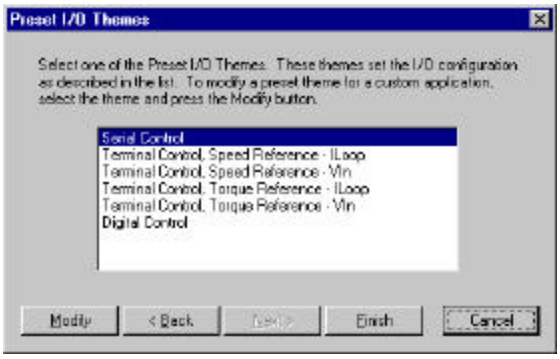


**Figure 51**

#### 4.3.4 I/O Control

The I/O Control dialog box shown in **Figure 52** allows adjustment of the I/O Control selectors. The Start/Stop Control governs where Start and Stop commands originate. If *Serial* is selected then Start and Stop commands must come from the DriveBlok RS-485 Serial Port. If *Local* is selected, then Start and Stop commands can originate from either an analog source if the *Analog* button is



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selected or a digital source if the *Digital* button is selected. The Local Mode Start/Stop sources are shown in **Table 57**.

| Mode | Start / Stop Control |
|---|---|
| *Digital* | Run |
| | Start / Stop |
| | Jog |
| *Analog* | Current Loop |
| | Voltage Input |
| | High Speed Input #1 |
| | High Speed Input #2 |

**Table 4.3.4-1**


**Figure 52**

The DriveBlok can be configured for Power On Starts that occur if the Start/Stop Control is *Local* and the DriveBlok I/O is in a run configuration (i.e., commanded to run).

The Enable Communications Timeout Fault may be either enabled or disabled from this dialog box. When the checkbox is checked, the Enable Communications Timeout is enabled. Now, the drive that is running must communicate over the RS-485 serial port at least once every five seconds or else it will trip off with a Communications Fault. The Enable Communications Timeout Fault should be disabled if the DriveBlok is being configured to run from the I/O.

Any time the DriveBlok receives a Serial stop command the Start/Stop Mode is reset to Serial.

### 4.3.5 Current Loop Input

The Current Loop Input dialog box shown in **Figure 53** gives control of the DriveBlok via a current loop input. The user must first choose a *Function*. Null is the factory default value. The Current Loop Input functions are listed in **Table 43**. If the Current Loop Input and the Voltage Input are configured as the same function, the Current Loop Input will always take precedence.

| Function | Description |
|---|---|
| Null | Ignore the Current Loop Input. |
| Speed Reference | Use the Current Loop Input to command Motor Speed. |
| Torque Reference | Use the Current Loop Input to command Motor Torque. |
| Load Limit Reference | Use the Current Loop Input to control Motor Load Limit. |

**Table 43**

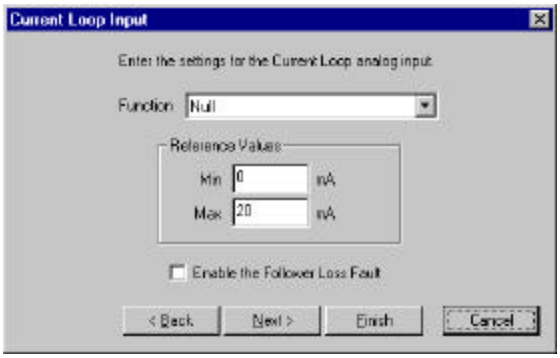


**Figure 53**

The *Min* and *Max* reference values are used for scaling based upon the *Function*. These reference values can range from 0 mA to 20 mA.

If Speed Reference is selected, a current loop input equal to the *Min* reference value will cause the motor to run at the *Min Speed* as configured in **Section 4.2.4**. A current loop input equal to the *Max* reference value will cause the motor to run at the *Max Speed* also adjusted in **Section 4.2.4**.

If Torque Reference is selected, the *Min* and *Max* Torque Scale values are adjusted in the dialog box shown in **Figure 55**.

If Load Limit Reference is selected, the function scales from 0% to *Motor Load Limit* configured in **Section 4.2.4**. In order for the Load Limit Reference Function to operate, the DriveBlok must be in *Local* Setpoint Control.

The *Enable Follower Loss Fault* will cause the drive to trip off if the current loop input ever drops below 2mA. If the checkbox is checked, the feature is enabled.



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### 4.3.6 Voltage Input

The Voltage Input dialog box shown in **Figure 54** gives control of the DriveBlok voltage input. The user must choose an input function. Null is the factory default value. The Voltage Input functions are listed in **Table 44**. If the Voltage Input and the Current Loop Input are configured to the same function, the Current Loop Input will always take precedence.

| Function | Description |
|---|---|
| Null | Ignore the Voltage Input. |
| Speed and Direction Reference | Use the Voltage Input for both Motor Speed command, and Motor Direction. |
| Speed Reference | Use the Voltage Input to command Motor Speed. |
| Torque Reference | Use the Voltage Input to command Motor Torque. |
| Load Limit Reference | Use the Voltage Input to control Motor Load Limit. |

**Table 44**

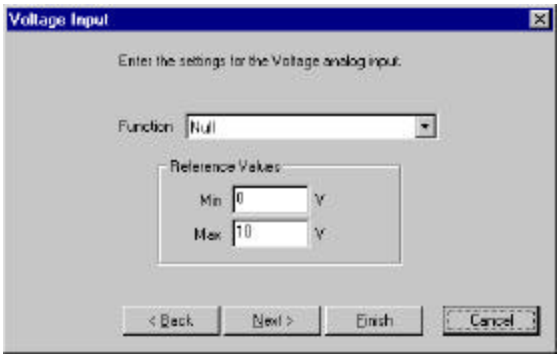


**Figure 54**

The scaling used for the Voltage Input is identical to that of the Current Loop Input described in Section 0, however the Voltage Input Reference Value range is from –10V to +10V. When configuring the function as *Speed and Direction*, the minimum and maximum voltage setting should only be configured with *positive* values. The minimum voltage setting will reference the minimum speed. The maximum voltage will reference the maximum speed. Positive voltage causes the motor to operate forward. Negative voltage causes the motor to operate in the reverse direction.

### 4.3.7 Torque Setpoint Scale

The Torque Setpoint Scale dialog box shown in **Figure 55** will only appear if at least one of the analog input functions is configured to Torque Reference. It allows the minimum and maximum values used to scale analog inputs to be entered. For convenience, the Maximum Torque for the current configuration is shown in the dialog box.

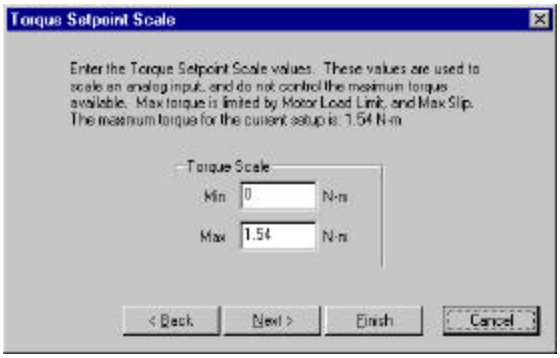


**Figure 55**

### 4.3.8 Digital Inputs

The Digital Inputs dialog box shown in **Figure 56** and **Figure 57** provide complete control over the DriveBlok digital input lines and their associated functions. The digital input functions are listed in **Table 45**.

| Function | Description |
|---|---|
| Null | This function ignores the digital input pin. |
| Run Enable | This function enables the drive to run.<br><br>All digital input pins defined as Run Enable must be asserted to run a motor.<br><br>If any Run Enable pin is de-asserted while the motor is running, it will stop.<br><br>The drive is automatically enabled to run if no digital input pin is configured as Run Enable. |
| Run | This function starts the drive when a transition from de-asserted to asserted on the digital input pin. |
| Start / Stop | This function starts the drive when a transition from de-asserted to asserted on the digital input pin. |



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| | |
|---|---|
| | This function stops the drive when a transition in the opposite direction is asserted on the digital input pin. |
| External Fault | This function puts the drive in an External Fault condition when the digital input pin is asserted. |
| | This state remains until the External Fault digital input pin is de-asserted. |
| | The drive will trip off and record a fault if it is commanded to run while in the External Fault condition state or if the External Fault digital input pin is asserted while the drive is running. |
| Jog | This function runs the motor at the specified Jog Speed when the digital input pin is asserted. |
| | When the digital input pin is de-asserted, the motor stops. |
| Direction | This function controls the direction of the motor. |
| | The drive is automatically set to run in one direction if no digital input pin is configured as Direction. |
| | This function does not operate if the Speed and Direction Reference function is selected for the Analog Input for voltage. |
| Digital Pot Accelerate | This function causes the Speed Setpoint to increase at the current acceleration rate when the digital input pin is asserted. |
| | This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. Furthermore, no Preset Speed Bit digital inputs or the Preset Teach digital input can be asserted. |
| | Digital Pot Decelerate takes precedence over Digital Pot Accelerate. |
| Digital Pot Decelerate | This function causes the Speed Setpoint to decrease at the current acceleration rate when the digital input pin is asserted. |
| | This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. Furthermore, no Preset Speed Bit digital inputs or the Preset Teach digital input can be asserted. |
| | Digital Pot Decelerate takes precedence over Digital Pot Accelerate. |
| Accel/Decel Select | This function causes the drive to use Accel/Decel Set 2 when the digital input pin is asserted. |
| | This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. |
| Preset Speed Bit 0 | This function provides a means via Preset Speed Bits 0, 1, and 2 that make up a binary numbers used to select to select a Preset Speed. |
| | If one of these inputs is not defined, a value of 0 is used for that bit. |
| | This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. |
| Preset Speed Bit 1 | See above. |
| Preset Speed Bit 2 | See above. |
| Preset Teach | This function provides a method to program a Preset Speed without using the serially configured Setpoint Control. |
| | To set a Preset Speed:<br>Select the Preset Speed to program via the Preset Speed Bit.<br>Assert the Preset Teach digital input.<br>Use Digital Pot Accelerate or Digital Pot Decelerate to adjust the motor to the desired speed.<br>De-assert Preset Teach. |
| | This function requires the Setpoint Control configured for Digital. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be set. |
| Local Mode | This function switches the current Start/Stop Control and Setpoint Control to Local when the digital input pin is asserted. |
| | When the digital input is de-asserted, the Start/Stop Control and Setpoint Control will return to its original mode. |
| Commission | This function commissions the drive when the digital input pin has made a transition from de-asserted to asserted. |
| Open Loop | This function switches the drive's Control Method from Sensorless Flux Vector to Volts per Hertz when the digital input |



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| | |
|---|---|
| Control | pin is asserted.<br><br>When the digital input pin is de-asserted, the drive Control Method returns to its original mode. |
| Undefined | Reserved |
| Coast Stop Mode | This function switches the Stop Mode from Ramp to Coast when the digital input pin is asserted.<br><br>When the digital input pin is de-asserted, the Control Method returns to its original mode. |
| Undefined | Reserved |
| Torque Mode | This function switches the Regulator Mode from Speed to Torque when the digital input is asserted.<br><br>When the digital input pin is de-asserted, the Regulator Mode returns to its original mode. |
| Analog Setpoint Source | This function switches the current Setpoint Control to Analog when the digital input pin is asserted.<br><br>When the digital input pin is de-asserted, the Setpoint Control returns to its original mode. |
| Undefined | Reserved |
| Fault Clear | This function clears any current faults when the digital input pin makes a transition from de-asserted to asserted. |

**Table 45**

Digital Inputs 1 and 2 (PIN 9 and PIN 10) are also the High Speed Input lines. These two inputs support the Frequency and Duty Cycle Functions listed in **Table 46**. In order to use a High Speed Input as a Reference Command, the Setpoint Control must be configured to *Local Analog*.

| **Function** | **Description** |
|---|---|
| Frequency Null Function | This function provides the Frequency result available for monitoring under the internal drive parameters, **HIGH SPEED INPUT 1 RESULT** (D1F) or **HIGH SPEED INPUT 2 RESULT** (D20). |
| Duty Cycle Null Function | This function provides the Duty Cycle result available for monitoring under the internal drive parameters, **HIGH SPEED INPUT 1 RESULT** (D1F) or **HIGH SPEED INPUT 2 RESULT** (D20). |
| Frequency Speed Reference | This function allows the digital input pin to translate a high speed frequency for speed reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>The usable frequency range is 40 Hz to 65535 Hz. If the frequency falls below 40 Hz, 40 Hz is used.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Duty Cycle Speed Reference | This function allows the digital input pin to translate a high speed duty cycle for speed reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Frequency Torque Reference | This function allows the digital input pin to translate a high speed frequency for torque reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>The usable frequency range is 40 Hz to 65535 Hz. If the frequency falls below 40 Hz, 40 Hz is used.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |
| Duty Cycle Speed Reference | This function allows the digital input pin to translate a high speed duty cycle for torque reference.<br><br>This function requires the Setpoint Control configured for Analog. This mode can be configured through the I/O Wizard in wInControl or by configuring the internal drive parameter **EXTENDED DRIVE MODE** (C06 Bit 1) via the Serial Communication Protocol. The bit must be clear.<br><br>This function over-writes any other Analog Input configured for Speed Reference. |



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**Table 46**

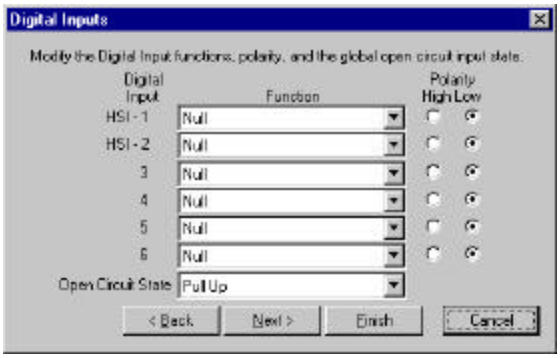


**Figure 56**

In addition to *Function*, two other properties are adjusted from the dialog box shown in **Figure 56**: *Polarity and Open Circuit State*.

*Input Polarity* controls whether asserted implies a high or low voltage on the input pin. The case shown in **Figure 56** indicates that asserted is a low voltage on the input.

*Open Circuit State* refers to the state of the digital input when the digital input is not connected to anything. The DriveBlok can be configured to either Pull Up or Pull Down the input. This parameter does not take effect until after a power cycle. Furthermore, this configuration affects only digital inputs 1 through 6.

### 4.3.9 Digital Inputs/Outputs

The pins used by digital inputs 7 (PIN 15) and 8 (PIN 16) are shared with digital outputs 1 and 2. The open circuit state of these pins is always High. **Figure 57** shows the dialog box used to change the settings for these I/O Lines.

When the I/O Line is configured as an input, it performs like the inputs described in **Section 4.3.8**. When the I/O Line as an output, it performs like the outputs described in **Section 4.3.10**. When the I/O Line is configured as an input, wInControl automatically configures the pin's output function to set High. This keeps the digital output function of the pin from interfering with the digital input function of the pin. Likewise, wInControl configures the input function to Null when the I/O Line is configured as an output.

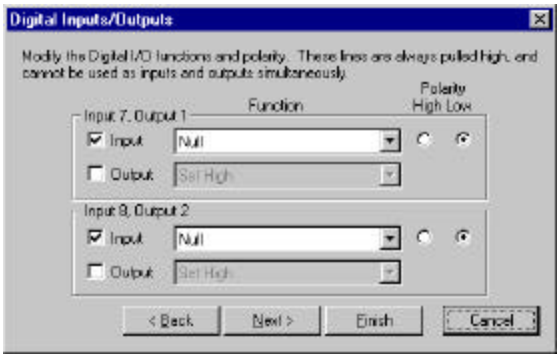


**Figure 57**

### 4.3.10 Digital Outputs

The DriveBlok has a total of six adjustable digital outputs. The two digital outputs described in **Section 4.3.9** are open collector outputs. There are two digital outputs that are relays and the final two digital outputs are inputs to the three-color FBK LED indicator. All of these digital outputs are programmed from the same list of output functions. The output functions are listed in **Table 47**.

| Function | Description |
|---|---|
| Set High | This function asserts the digital output to go High.<br><br>This function is considered de-asserted. |
| Set Low | This function asserts the digital output to go Low. |
| At Speed | This function asserts the digital output when the motor speed is within a specified At Speed Range. |
| Undefined | Reserved |
| Run | This function asserts the digital output when the drive's output electronics are active. |
| Fault | This function asserts the digital output when the drive is faulted. |
| Reverse | This function asserts the digital output when the motor is running in the reverse direction. |
| Overload Alert | This function asserts the digital output when the $I^2T$ accumulator exceeds the specified Overload Alert value. |
| Over Temperature Alert | This function asserts the digital output when the drive's substrate temperature exceeds the specified Over Temperature Alert value. |
| Speed Detect Low | This function asserts the digital output when the motor speed is below the Speed Detect Low value.<br><br>This function de-asserts the digital output when the motor speed is above the Speed Detect Low value + hysteresis.<br><br>Hysteresis is fixed at 1% of $speed_{motor\_max}$. |
| Speed Detect High | This function asserts the digital output when the motor speed is above the Speed Detect High value. |



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|---|---|---|
| | | This function de-asserts the digital output when the motor speed is below the Speed Detect Low value + hysteresis.<br><br>Hysteresis is fixed at 1% of $speed_{motor\_max}$. |
| Torque Low | Detect | This function asserts the digital output when the motor torque is below the Torque Detect Low value.<br><br>This function de-asserts the digital output when the motor speed is above the Torque Detect Low value + hysteresis.<br><br>Hysteresis is fixed at 1% of $torque_{motor\_max}$. |
| Torque High | Detect | This function asserts the digital output when the motor torque is above the Torque Detect High value.<br><br>This function de-asserts the digital output when the motor speed is above the Torque Detect High value + hysteresis.<br><br>Hysteresis is fixed at 1% of $torque_{motor\_max}$. |
| Commission | | This function asserts the digital output when the drive is commissioning. |
| Brake Actuate | | This function asserts the digital output when an external brake should be released.<br><br>This function asserts the digital output when an external brake should be applied. |

**Table 47**

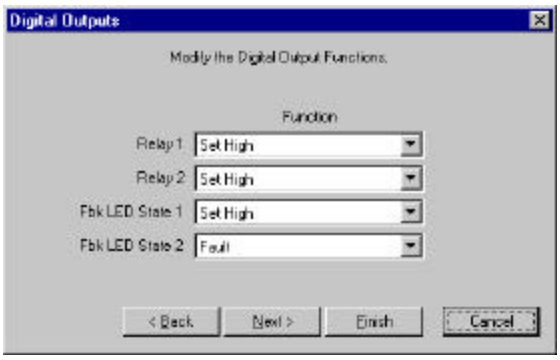


**Figure 58**

The state of the three-color FBK LED indicator is defined by the information in **Table 48**.

| State 1 | State 2 | Output |
|---|---|---|
| De-asserted | De-asserted | Off |
| Asserted | De-asserted | Red |
| De-asserted | Asserted | Yellow |
| Asserted | Asserted | Orange |

**Table 48**

### 4.3.11 High Speed Input Reference

The High Speed Input Reference dialog box shown in **Figure 59** allows the high speed inputs to be scaled as necessary for the target application. Like the Analog Inputs, the *Min* and *Max* values (i.e., Hz or %) refer to the *Min Speed* and *Max Speed* values covered in **Section 4.2.4**.

If a High Speed Input is configured for a Torque Command Reference, the Torque Command is scaled using the Minimum and Maximum Torque Scale parameters discussed in Section 0.

The DriveBlok can detect Frequency Inputs from 40 Hz to 65535 Hz and Duty Cycle Inputs from 0% to 100%. If a Duty Cycle Input is being used as a Reference Command, it must stay above 50 Hz. Otherwise the DriveBlok assumes the signal has been lost and the drive trips off with a Motor Fault. Furthermore, the minimum pulse width of the frequency input must be 0.8µsec.

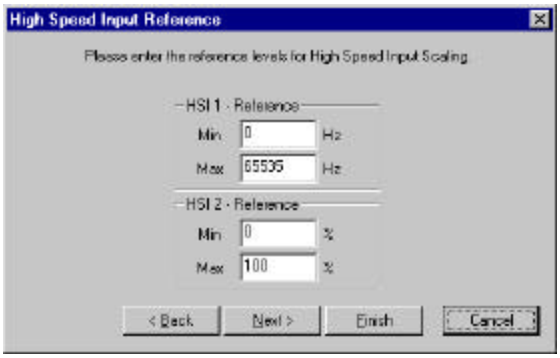


**Figure 59**

### 4.3.12 Digital Output Levels

The Digital Output Levels dialog box shown in **Figure 60** allows output levels to be selected for each of the digital outputs. These output levels are referenced in **Section 4.3.10**.



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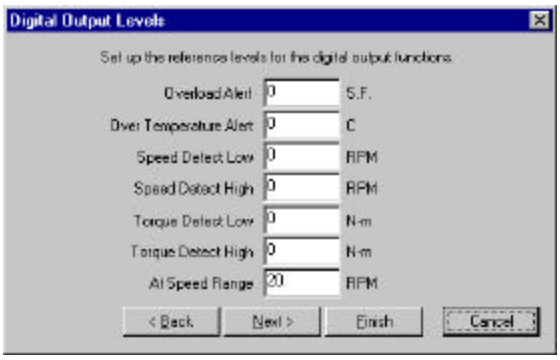


**Figure 60**

### 4.3.13 Speed Settings

The Speed Settings dialog box shown in **Figure 61** allows modification of the *Preset Speeds* and the *Jog Speed*. The *Preset Speeds* and the *Jog Speed* are discussed in **Section 4.3.8**.

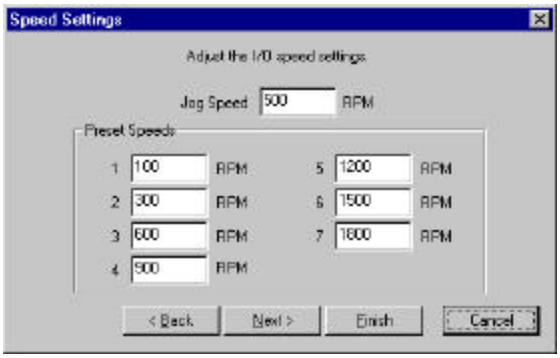


**Figure 61**

### 4.3.14 Analog Outputs

The DriveBlok has three analog outputs. Their functions and scalings are modified through the dialog box shown in **Figure 62**. These outputs are individually scaled and range from 0 – 10 VDC output. The example shown in **Figure 62** has the output functions configured as Speed, Torque, and Frequency. The Max Output parameter configures the 10 VDC output level. In the example, Output 1 will equal 10 VDC when the Motor Speed is at 1800 RPM. Likewise, Output 2 will equal 10 VDC when the Motor Torque equals 1.25 N-m.

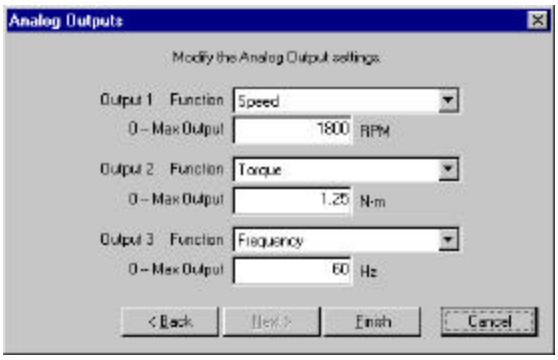


**Figure 62**

## 4.4 Regulator Wizard

Regulator Wizard is initialized by pressing the Regulator Wizard button on the wInControl Toolbar. This button is shown in **Figure 63**.

**Figure 63**

### 4.4.1 Regulator Wizard Initialization

While the Regulator Wizard is being initialized, the dialog box in **Figure 64** is shown.


**Figure 64**

This dialog box is shown while wInControl is determining the current speed regulator configuration of the DriveBlok. Pressing the **Cancel** button causes the DriveBlok communications to cease and terminates Regulator Wizard. Under normal operation this dialog box is shown for less than one second.

### 4.4.2 Inertia Adjustment

The system inertia is one of the parameters necessary for optimal tuning of the speed regulator. This is entered into wInControl as the *Rotor Inertia* and the *Load Inertia Ratio*. The only number that matters, however, is the *Total Inertia* value shown in **Figure 65**. If the total system inertia is known, enter that value at the *Rotor Inertia* and enter a 0 for the *Load Inertia Ratio*. If the load inertia to rotor inertia ratio is known, enter the rotor inertia and the ratio.

If the rotor inertia is unknown, the Inertia Assistant can be used to determine the approximate values. See **Section 4.4.3** for more information.

If the total system inertia is configured too low, the system will have a slow oscillation as it tries to maintain the commanded speed. This oscillation is most evident when starting the motor. If



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the total system inertia is configured too high, the system will have a high frequency chatter while maintaining the commanded speed. If either of these symptoms occur, modify the *Total Inertia* to compensate.

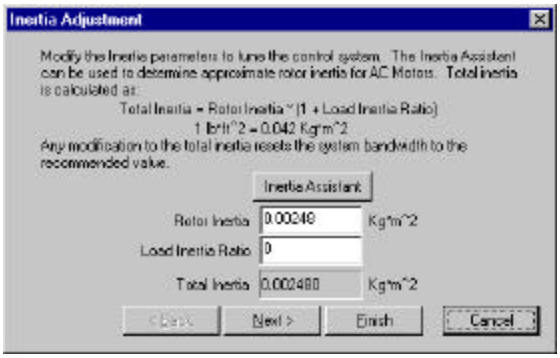


**Figure 65**

### 4.4.3 Inertia Assistant

The Inertia Assistant shown in **Figure 66** aids in determining the approximate inertia of the rotor for a given *NEMA Frame Size*. Selecting a *NEMA Frame Size* in the list box causes the calculated inertia value to be shown in the *Rotor Inertia* box. Pressing the **Use Result** button causes the Inertia Assistant to be closed and the value to be put into the *Rotor Inertia* box and to return to the Inertia Adjustment dialog box. Pressing the **Cancel** causes the dialog box to close and to return to the Inertia Adjustment dialog box.

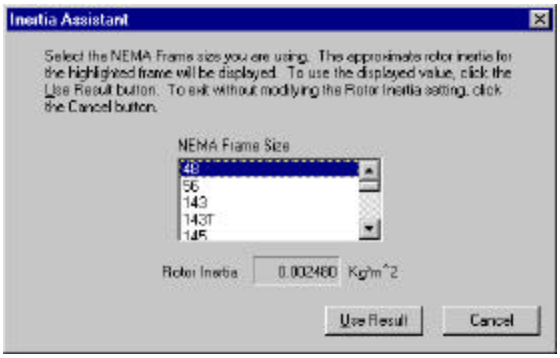


**Figure 66**

### 4.4.4 System Bandwidth

The System Bandwidth adjustment is accomplished through the dialog box shown in **Figure 67**. A low *System Bandwidth* setting causes the DriveBlok speed regulator to respond more slowly to changing input commands. A high *System Bandwidth* causes the Speed Regulator to respond more rapidly to input command changes. Some response characteristics like overshoot magnitude do not change as the System Bandwidth is modified.

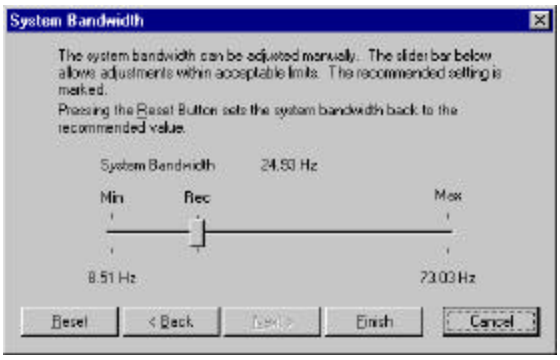


**Figure 67**

Any change to the total system inertia from causes the *System Bandwidth* to be reset to the recommended value. In addition, the *System Bandwidth* can be easily reset to the recommended value by pressing the **Reset** button. Small changes to the bandwidth can be made by selecting the scroll bar (single click) and using the Cursor Right and Cursor Left keys. The *System Bandwidth* indicator above the scroll bar reflects the changes.

Pressing the **Finish** button sends all Speed Regulator parameters to the DriveBlok and exits Regulator Wizard.

## 4.5 Commission Motor

To commission a motor, press the Toolbar button shown in Figure . This opens the dialog box shown in **Figure 68**.

**Figure 68**

The Commission Motor Dialog box allows the user to commission a motor using either the *Normal* or the *Enhanced* commission methods by selecting the desired mode and pressing the **Commission** button.

Both *Normal* and *Enhanced* commissioning determine the stator resistance of the motor.

*Enhanced Commissioning* for AC Motors determines the *Magnetizing Current* used when the motor is operating below 1.5% of motor rated *Speed*. Above this speed, the DriveBlok continuously optimizes the *Magnetizing Current*.

Enhanced Commissioning for Brushless DC Motors tunes the Back EMF of the motor.



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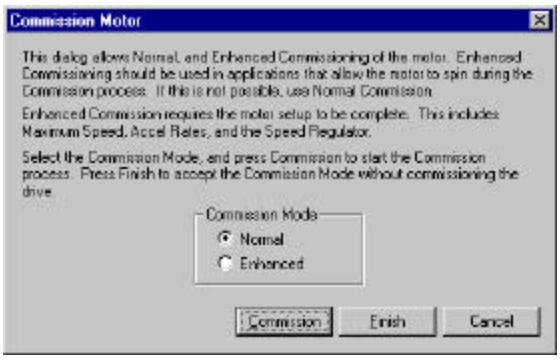


**Figure 69**

It is important to note that **Enhanced Commissioning causes the motor to spin**. If the application is not compatible with this requirement, then Normal Commissioning should be used. In addition, the DriveBlok's Maximum Speed parameter, the Acceleration Rates, and the Speed regulator must be configured in order for Enhanced Commission to work properly. These parameters are adjusted through the Application Wizard, and the Regulator Wizard respectively.

Pressing the Commission button begins either a Normal Commission, or an Enhanced Commission based upon the selected Commission Mode. The Drive Commissioning dialog box shown in **Figure 35** is shown. When the Commissioning process has completed, the Drive Commissioning dialog box will automatically close.

## 5. wInControl Views

Once the DriveBlok is configured using the Wizards, its operation can be controlled and monitored using the Views. The six Views available are *Control View*, *Feedback View*, *I/O View*, *Fault View*, *Log Communications*, and *Broadcast View*. They are described in the following sections.

### 5.1 Control View

To access the Control View, press the Toolbar button shown in **Figure 70**. This will open the View shown in **Figure 71**. If a Control View window is already open, pressing the button will bring that window to the foreground.

**Figure 70**

The Control View is responsible for *Serial* Start/Stop and *Serial* Setpoint Control of the DriveBlok. There are three groups of controls in the Control View. The first controls group is the buttons at the top left of the view. The **Stop** button sends a serial stop command to the DriveBlok at any time it is pressed. If the DriveBlok is in *Local* Start/Stop Control, pressing the **Stop** button sends a serial stop command to the DriveBlok and causes the DriveBlok to revert to *Serial* Start/Stop Control. This button is always available.

The **Start** button sends a serial start command to the DriveBlok at any time it is pressed. This command only has an effect when the DriveBlok is in *Serial* Start/Stop Control and is only available in that case.

The **Forward** button sends a command to the DriveBlok instructing it to run the motor in the forward direction. This command is only effective when the DriveBlok is in *Serial* Setpoint Control and when *Torque* Regulator Mode is not selected. The control is available only in these cases.

The **Reverse** button sends a command to the DriveBlok instructing it to run the motor in the Reverse direction. This command is only effective when the DriveBlok is in *Serial* Setpoint Control and when *Torque* Regulator Mode is not selected. The control is available only in these cases.

The second controls group in the Control View window is the Setpoint Control. This consists of a vertical slider bar and a direct edit box. If the DriveBlok is in *Speed* Regulator Mode or *Volts per Hertz* Control Method, this control allows speed commands to be sent to the drive. If the DriveBlok is in *Torque* Regulator Mode, torque commands can be adjusted. In either case, the DriveBlok must be in *Serial* Setpoint Control for this controls group to be available.

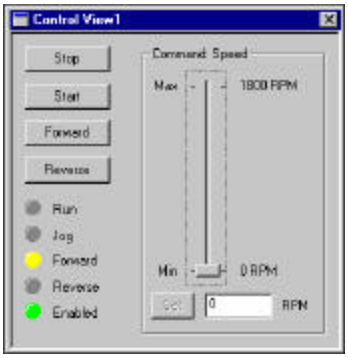


**Figure 71**

The last controls group are the status indicator LEDs. These simulated LEDs display the current DriveBlok status.

The *Run* LED indicates if the DriveBlok's output devices are active.

The *Jog* LED indicates if the DriveBlok is Jogging.



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The *Forward* LED is bright yellow as shown in **Figure 71** if the drive is running in that direction. The *Forward* LED is Dark Yellow if the drive is commanded to run in the Forward direction, but is not currently doing so.

The *Reverse* LED is bright yellow if the drive is running in that direction. The *Reverse* LED is Dark Yellow if the drive is commanded to run in the Reverse direction, but is not currently doing so.

The *Enabled* LED indicates if a Start command will cause the DriveBlok to run. This LED is off if any *Run Enable* digital input is de-asserted or if any other setting is preventing the DriveBlok from starting.

### 5.2 Feedback View

To access the Feedback View, press the Toolbar button shown in **Figure 72**. This will open the View shown in **Figure 73**. If a Feedback View window is already open, pressing the button will bring that window to the foreground.

**Figure 72**

The Feedback View is responsible for displaying and recording any DriveBlok feedback needed by the user. From this view, the type of feedback desired can be selected and recorded to disk.

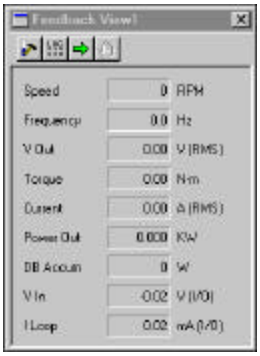


**Figure 73**

Pressing the **Setup** button (i.e., the first button on the Feedback View Toolbar) brings up the dialog box shown in **Figure 74**. This dialog box allows the user to select which data to display in the Feedback View. Check the box next to the descriptive text to display an item. Finally, press the **OK** button. The Feedback View will be updated to display the selected items.

The Feedback View can also be used to log feedback data to disk. This is accomplished in two steps. First, the Datalog Setup should be initialized. Press the **Datalog Setup** button (i.e., the second button on the Feedback Toolbar) to bring up the setup dialog box shown in **Figure 75**. The Datalog Setup consists of two parameters. The *Datalog Filename* parameter controls where the feedback data is stored. The second parameter is the *Minimum Time Between Samples (ms)*. To have the feedback data written to a datalog file at maximum rate, set this parameter to zero. If a delay of five seconds is desired between samples, set this parameter to 5000 as in **Figure 75**. wInControl will capture new feedback data as soon as it can after the delay time has expired.

Once the datalog feature is activated, it records all information in the feedback view to the datalog file. At the top of the datalog file is a header describing the file's content. The data is in the format Time, Data, Time, Data, etc. and can be directly imported into a spreadsheet as a comma delimited file. The timestamp on all data is in milliseconds from when the datalog was started.

To start the Datalog, press the **Start Datalog** button (i.e., the green arrow on the Feedback View Toolbar). While the datalog is running, the **Stop Datalog** button (i.e., the white hand) will be enabled. To stop the datalog, press the **Stop Datalog** button. At any time the datalog is started, the datalog file is rewritten.

The performance of the Datalog can be enhanced by reducing the number of feedback items recorded, as well as reducing the number of views open in wInControl. The datalog is recorded at the maximum rate allowed by the serial channel.


**Figure 74**


**Figure 75**

### 5.3 I/O View

To access the I/O View, press the Toolbar button shown in **Figure 76**. This will open the View shown in **Figure 77**. If an I/O View window is already open, pressing the button will bring that window to the foreground.



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**Figure 76**

The I/O View is responsible for displaying the current state of the DriveBlok inputs and outputs. The information is presented in three sections: *Analog Inputs*, *Digital Inputs*, and *Digital Outputs*.

The Analog Inputs section displays the function and current input value for both the Current Loop Input and the Voltage Input.

The Digital Inputs section contains three pieces of information: *Raw State*, *Logic State*, and *Function*. The *Raw State* display is simply the state of the input at the terminal. However, the polarity of the input can be adjusted and so one additional piece of information is necessary, the *Logic State*. When the polarity is configured *Low*, a 1 shown in the Logic State column indicates the digital input is asserted and a 0 shown in the Logic State column indicates the digital input is de-asserted. Finally, the *Function* display allows easy correlation between the input number and the function assigned to it. Since the rate in which the state of the High Speed Input (e.g., Frequency Speed Reference) may be too fast for wInControl to capture, the Logic State should be considered inaccurate.

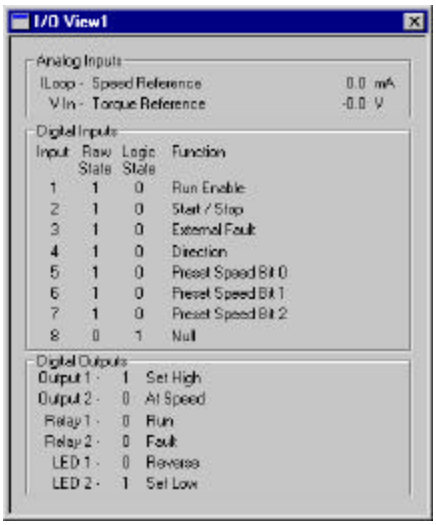


**Figure 77**

The Digital Outputs section of the I/O View displays the current output state as well as the output function. A 1 in the Output State indicates the output is asserted and a 0 indicates the output is de-asserted.

### 5.4 Fault View

To access the Fault View, press the Toolbar button shown in **Figure 78**. This will open the View shown in **Figure 79**. If a Fault View window is already open, pressing the button will simply bring that window to the foreground.

**Figure 78**

The Fault View displays the contents of the DriveBlok fault queue. The Fault Selector group allows the desired fault to be shown. The Fault Details group displays all the information about the selected fault: *Fault Type* and *Description* fully categorize the DriveBlok Fault that occurred. The remaining information specifies the state of the drive when the fault occurred. *Fault Time* is the DriveBlok Run Time when the fault occurred. *Drive State* contains information on the state of the drive when it faulted. *Current* is the unfiltered amount of output current when the DriveBlok faulted. *V DC* is the DC Bus Voltage when the fault occurred. Finally, *Speed* is the unfiltered speed of the motor when the fault occurred.

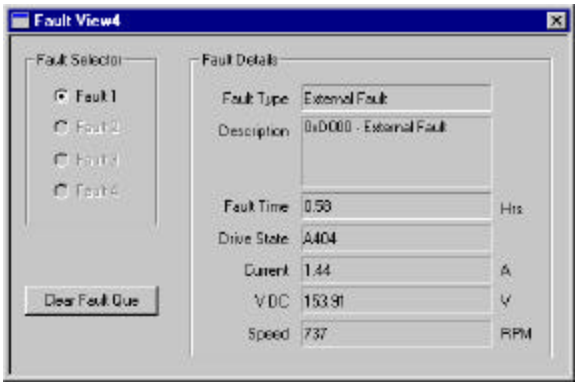


**Figure 79**

The Fault Types and their Descriptions are listed in **Table 49**.

Pressing the **Clear Fault Que** button clears all faults in the DriveBlok. The faults in the Fault Selector group will be disabled.

Fault 1 is always the most recent fault and Fault 4 is always the oldest.

| Fault Number (hex) | Description |
|---|---|
| 1000h | Sat fault |
| 2000h | DB Overload |
| 3000h | Phase Overcurrent |
| 4000h | Single-phase input detected |
| 5000h | DC link undervoltage |
| 6000h | DC link overvoltage |
| 6001h | VDC>vdc_braking and positive power |
| 7000h | 12 VDC supply low |



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| | |
|---|---|
| 7001H | Current Loop Loss |
| 8000h | A/D offset out of range |
| 9000h | Motor did not stop within 10 seconds |
| 9001h | Motor overspeed |
| 9002h | Zero current detect |
| 9003h | Motor pull out fault (BLDC only) |
| 9004h | *Out of speed regulation fault* |
| 9005h | Duty Cycle Input Lost |
| A000h | Heatsink overtemp |
| B000h | Motor thermal overload |
| C000h | Communications loss |
| D000h | External fault |
| E000h | EEPROM read error |
| E001h | EEPROM write error |
| E002h | init parms fault (!EEPROM_valid, code_version != EEPROM_version) |
| E003h | Wrong FPGA version. |
| F000h | A low jump speed is greater than its hi jump speed. |
| F001h | omega_m_min>omega_m_max |
| F002h | poles>12 |
| F003h | voltage*current/HP<431 |
| F004h | voltage*+current/HP>1293 |
| F005h | slip>max slip (max slip stored in EEPROM) |
| F006h | Did not reach omega_cmd during enhanced commission. |
| F007h | Invrs_lm out of range in enhanced commission. |
| F008h | Flux_cmd_nom out of range in enhanced commission. |

**Table 49**

### 5.5 Log Communications

To access the Communications Log View, press the Toolbar button shown in **Figure 80**. This will open the View shown in **Figure 81**. If a Communications Log View window is already open, pressing the button will bring that window to the foreground.

**Figure 80**

The Communications Log View allows RS-485 serial communications between wInControl and the DriveBlok to be recorded to disk. This feature is added to assist the user communicating directly with the DriveBlok and using his/her own serial communications routines. Pressing the **Start Comm Log** button (i.e., Green Arrow) causes wInControl to begin writing to the specified file. The **Start Comm Log** button becomes disabled and the **Stop Comm Log** button becomes enabled. The Communications Log continues until the **Stop Comm Log** button is pressed.


**Figure 81**

Communications between wInControl and the DriveBlok occur at the maximum rate the serial channel is capable of. At 9600 Baud, the practical communications limit is about 30 messages per second. Therefore, the Communications Log datafile will be written at that rate. The Communications Log datafile will quickly become large.

### 5.6 Broadcast View

To access the Broadcast View, press the Toolbar button shown in **Figure 82**. This will open the View shown in **Figure 83**. If a Broadcast View window is already open, pressing the button will simply bring that window to the foreground.

**Figure 82**

The DriveBlok RS-485 Serial Communications System is designed for a multi-drive network. The Communications System was designed with messages that could be broadcast to all DriveBloks on the serial network. The Broadcast View gives the user two controls that affect all drives connected to the RS-485 network. The **Start All** button sends a serial start broadcast command onto the network. All drives configured for *Serial* Start/Stop Control will process this command, and start as configured. The **Stop All** button sends a serial stop broadcast command onto the network. All drives respond to this command whether they are configured for *Serial* Start/Stop Control or not. Furthermore, as described in **Section 5.1**, all drives will revert to *Serial* Start / Stop Control once a serial stop command is given.



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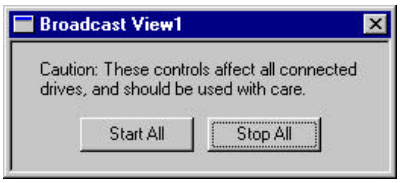


**Figure 83**

## 6. wInControl Menus

Several key functions of wInControl can be accessed only through the menus. This section covers all of wInControl's menu based functions.

### 6.1 File Menu

The wInControl File menu contains functions relating to disk access.

#### 6.1.1 Store Drive to Disk

The Store Drive to Disk feature writes all internal DriveBlok parameters to a Drive Definition File (.DEF). This file can be used to replicate the configuration of a drive. In addition, it can be used to document the state of the drive in case the need arises to restore a DriveBlok to a stored configuration.

When the Store Drive to Disk menu item is selected, the standard file Save As dialog box is opened allowing the user to select the destination filename. Once the file is selected, the dialog box shown in **Figure 84** is shown. This dialog box indicates the status of the drive information transfer. At any time during this process, the **Cancel** button may be pressed. This stops the parameter transfer and closes the destination file.

After the last parameter is transferred, the Status display will indicate Data Transfer complete and the **Ok** button will be enabled. All drive data has now been stored to the specified file. Press the **Ok** button to finish the operation.


**Figure 84**

#### 6.1.2 Restore Drive from Disk

The Restore Drive from Disk menu item causes wInControl to read a drive definition File (.DEF) from disk and writes all application parameters to the DriveBlok. Selecting this menu causes the standard file Open dialog box to be shown. From here, the desired drive definition file must be selected. Pressing the **Open** button starts the restore process that brings up the dialog box shown in **Figure 85**.

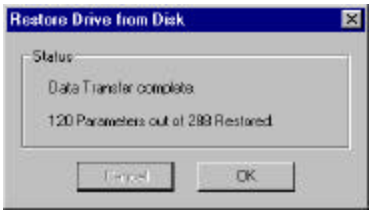


**Figure 85**

This Restore Drive from Disk dialog box indicates the status of the restore process. Pressing the **Cancel** button at any time will abort the Restore process. Once all the application data in the drive definition file has been transferred, the Status display will indicate Data Transfer complete. Pressing the **OK** button completes the restore process.

#### 6.1.3 Save Workspace

wInControl allows the user interface setup to be captured for automatic restoration the next time it is run. The Save Workspace menu causes wInControl to store the placement and sizing of all currently open views. When wInControl is run the next time, the views will be restored in the same position and with the same size as when the workspace was saved.

#### 6.1.4 Restore Factory Workspace

The Restore Factory Workspace feature causes wInControl to clear all view placement and sizing information. This is the default state of wInControl.

#### 6.1.5 Exit

Selecting the Exit menu item causes the wInControl application to be shut down. The serial port is released for use by other applications.

### 6.2 Setup Menu

The Setup Menu provides for configuration of both wInControl and DriveBlok settings.

#### 6.2.1 Communications



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The Communications menu item allows modification to the wInControl serial port settings. Selecting this item opens the dialog box shown in **Figure 86**.

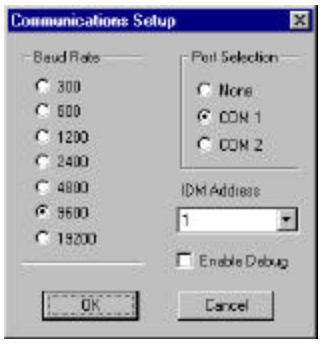


**Figure 86**

The Communications Setup dialog box allows selection of the *Baud Rate*, *Port Selection*, and *IDM Address* used by wInControl. A DriveBlok will come from the factory configured for 9600 Baud, with a IDM Address of 1. These settings should be adjusted to meet the needs of the current application.

### 6.2.2 Drive Address

The Drive Address menu allows modification of the *Drive Address* parameter. Selecting this menu opens the dialog box shown in **Figure 87**. The current *Drive Address* is shown in the list box. To select a new address, navigate the list box until the desired address is selected. Then, press the **OK** button. If the Drive Address has not been modified, this feature will exit the dialog box. However, if the address is changing, wInControl will display the warning shown in **Figure 88**.

The DriveBlok can be configured to any of 35 addresses. These are the numbers 0 through 9 or the letters A through Z.


**Figure 87**

The warning shown in **Figure 88** indicates that continuing with the drive address modification will cause wInControl to no longer be able to communicate with the drive. This means the DriveBlok Address discussed in **Section 6.2.1** must be configured to the new address in order to restore communications. Press the **OK** button if you wish to change the address. Otherwise, press the **Cancel** button.


**Figure 88**

### 6.2.3 Drive Baud Rate

The Drive Baud Rate menu allows modification of the *Baud Rate* parameter. Selecting this menu opens the dialog box shown in **Figure 89**. The radio button of the current *Baud Rate* is selected. To select a new *Baud Rate*, select the radio button of the desired *Baud Rate* and press the **OK** button. If the *Baud Rate* has not been modified, this feature will exit the dialog box. However, if the *Baud Rate* is changing, wInControl will display the warning shown in **Figure 88**.


**Figure 89**

The warning shown in Figure indicates that continuing with the *Baud Rate* modification will cause wInControl to no longer be able to communicate with the drive. This means the *Baud Rate* discussed in **Section Error! Not a valid link.** must be configured to the new *Baud Rate* in order to restore communications. Press the **OK** button if you wish to change the *Baud Rate*. Otherwise, press the **Cancel** button.

### 6.2.4 Access Level

Selecting the Access Level menu causes the dialog box in **Figure 90** to be shown.


**Figure 90**

wInControl has a provision for feature access restriction. By default the *Password* is "BASIC" which provides Basic Level



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feature access. wInControl does not require a password for Basic Level Access. Although the provision has been made for additional features, none are accessible at this time. Any future password restricted features will be noted in this section.

### 6.3 Control Menu

The Control Menu gives keyboard access to the open views and to stop the drive.

#### 6.3.1 Stop Drive

This menu can be used to stop the drive. Selecting the Stop Drive menu item causes a Serial Stop command to be sent to the DriveBlok. This causes the DriveBlok to revert to Serial Start/Stop Control as described in **Section 4.3.4**.

#### 6.3.2 Open View List

The Open View List is not a menu item, but rather is the list of currently open views. This menu allows direct access to the views by selecting the view from the list.

### 6.4 Help Menu

The Help Menu provides information about both wInControl and the DriveBlok under control.

#### 6.4.1 About wInControl

This dialog box contains the version number of wInControl and the disclaimer. It is necessary to know the version of wInControl before receiving technical support from MTS Automation.

#### 6.4.2 About Drive

The About Drive Dialog box displays several key pieces of information about the connected DriveBlok. The data shown is: *DriveBlok Serial Number*, *Code Version*, *Compatibility Index*, *Product ID*, Voltage Rating, and *Horsepower Rating*. This information is required receiving technical support from MTS Automation.





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# Appendix I: Troubleshooting

The following tables will assist the user to isolate, understand, and solve a problem with the drive based upon the fault number generated. The generated fault number can be found under the **Fault View** in wInControl or by requesting the internal drive parameters E0B, E14, E1D, or E26 via the Serial Communication Protocol.

### A. Sat faults

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 1000h | Sat fault | TBA | TBA |

**Table 50**

### B. DB Overload Faults

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 2000h | DB Overload | TBA | TBA |

**Table 51**

### C. Phase Overcurrent

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 3000h | Phase Overcurrent | 1. Excessive starting torque or high peak torque transients. | Check the Motor Load Limit in the Application Wizard of wInControl. Decrease value. |
| | | 2. Rapid large increases in load (impact) | Check the Rotor Inertia and Load Inertia in the Regulator Wizard of wInControl. Increase the value to dampen the speed regulator response, which will all the motor speed to drop during sudden large load changes. |
| | | 3. Attempting to start a spinning motor in Flying Start start mode | Check the Start Mode in the Application Wizard of wInControl. Select Flying Start. |
| | | 4. Rapid accel and/or decel | Increase acceleration and/or deceleration values in the Application Wizard of wInControl.. |

**Table 52**

### D. Single Phase

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 4000h | Single-phase input detected | 1. Drive is receiving single-phase input and is operating above specified power level. | Correct single-phase input condition for 3-ϕ application.<br>Verify branch circuit devices (i.e., fuses or circuit breakers) operate properly and have not failed.<br>Verify terminations are not loose nor corroded. |

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### E. DC Link Undervoltage

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 5000h | DC link undervoltage | 1. The bus voltage is below the specified undervoltage trip point.<br><br>Undervoltage trip point is 200 VDC for 230 VAC rated modules and 400 VDC for 460 VAC rated modules<br><br>An undervoltage condition will not harm the drive. | Increase the bus voltage above the undervoltage trip point. |

**Table 54**

### F. DC Link Overvoltage

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 6000h | DC link overvoltage | 1. The bus voltage is above the specified overvoltage trip point.<br><br>Overvoltage trip point is 380 VDC for 230 VAC rated modules and 760 VDC for 460 VAC rated modules. | Decrease the bus voltage below the overvoltage trip point. |
| 6001h | VDC>vdc_braking and positive power | TBA | TBA |

**Table 55**

### G. Hardware Fault

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 7000h | 12 VDC supply low | TBA | TBA |
| 7001H | Current Loop Loss | TBA | TBA |

**Table 56**

### H. A/D Offset Fault

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 8000h | A/D offset out of range | TBA | TBA |

**Table 57**



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### I. Motor Fault

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| 9000h | Motor did not stop within 10 seconds | TBA | TBA |
| 9001h | Motor overspeed | TBA | TBA |
| 9002h | Zero current detect | TBA | TBA |
| 9003h | Motor pull out fault (BLDC only) | TBA | TBA |
| 9004h | Out of speed regulation fault | TBA | TBA |
| 9005h | Duty Cycle Input Lost | TBA | TBA |

**Table 58**

### J. Heat Sink Overtemp

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| A000h | Heatsink overtemp | 1. Fan malfunction. | Verify that the airflow is not blocked.<br><br>Verify that the fan is wired properly. [See Figure ???.]<br><br>Verify that the fan operates properly. |
| | | 2. Excessive ambient temperature. | Verify that the ambient temperature is not exceeding the maximum ambient temperature for a given horsepower and drive assembly. [See Appendix B.] |

**Table 59**

### K. Motor Thermal O verload

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| B000h | Motor thermal overload | TBA | TBA |

**Table 60**

### L. Communication Loss

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| C000h | Communications loss | 1. Serial communication between drive and computer is lost. | Verify that the physical connections between the drive and the computer is sound.<br><br>Verify that the serial communication cable and components are sound.<br><br>Disable the Enable Communications Timeout Fault feature in the I/O Wizard of wInControl. |

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### M. External Fault

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| D000h | External fault | 1. A digital input configured as an External Fault has been activated. | De-activate the digital input configured as an External Fault. |

**Table 62**

### N. EEPROM Fault

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| E000h | EEPROM read error | TBA | TBA |
| E001h | EEPROM write error | TBA | TBA |
| E002h | init parms fault (!EEPROM_valid, code_version != EEPROM_version) | TBA | TBA |
| E003h | Wrong FPGA version. | TBA | TBA |

**Table 63**

### O. Motor Parameter Error

| Fault Number (hex) | Description | Explanation | Solution |
|---|---|---|---|
| F000h | A low jump speed is greater than it's hi jump speed. | TBA | TBA |
| F001h | omega_m_min> omega_m_max | TBA | TBA |
| F002h | poles>12 | TBA | TBA |
| F003h | voltage*current/ HP<431 | TBA | TBA |
| F004h | voltage*+current/HP>1293 | TBA | TBA |
| F005h | slip>max slip (max slip stored in EEPROM) | TBA | TBA |
| F006h | Did not reach omega_cmd during enhanced commission. | TBA | TBA |
| F007h | Invrs_lm out of range in enhanced commission. | TBA | TBA |
| F008h | Flux_cmd_nom out of range in enhanced commission. | TBA | TBA |

**Table 64**



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# Terms and Conditions

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B. **Payments Terms:** Subject to approval of Buyer's credit, the full net amount of each invoice is due and payable in cash within thirty (30) days of shipment. No payment discounts are offered, and minor inadvertent administrative errors contained in an invoice are subject to correction and shall not constitute reason for untimely payment.

If, in the judgement of the Seller, the financial credit of Buyer at any time does not justify continuance of production or shipment of any product(s) on the payment terms herein specified, Seller may require full or partial payment prior to completion of production or shipment, or may terminate any order, or any part thereof, then outstanding.

C. **Transportation:** Shipments are F.O.B. shipping point. The Buyer must claim any transportation damaged and the Buyer must submit a claim to the carrier.

D. **Prices:** Published prices and discounts schedules are subject to change without notice. They are prepared for the purpose of furnishing general information and are not quotations or offers to sell on the part of the company.

E. **Minimum Billing:** Minimum billing will be $250.00.

F. **Order Scheduled:** For all standard products, shipping schedules for the next 30-day period are firm and cannot be rescheduled. Scheduled beyond 30 days may be rescheduled without penalty.

G. **Delays:** MTS Automation Systems shall not be liable for any defaults, damaged, or delays in fulfilling any order caused by conditions beyond MTS Automation's control, including, but not limited to, acts of God, strike, lockout, boycott, or other labor troubles, war, riot, flood, governments regulations, or delays of MTS Automation's subcontractors or suppliers on furnishing materials or supplies due to one or more of the foregoing clauses.

H. **Cancellations:** By written notice given at any time prior to delivery, Buyer may terminate, for his convenience, any or all of the order. Buyer will be liable for all costs incurred by Seller in performance of the order that is canceled on the actual date of receipt of the written notice of termination. Termination charges may be up to and including 100% of the price of the products.

I. **Product Warranty:** All products are warranted for two years from date of manufacture as determined by the date code on the product label. The date code consists of four digits; the first two are the year and the second two are the week.

J. **Taxes:** Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational, or like taxes which may be imposed by any taxing authority upon the manufacture, sales or delivery of the items sold hereunder. If the Seller must pay any such taxes or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may assessed if the items are held to be taxable.



MTS Automation Division
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# Warranty and RMA Policy

The warranty and limitation of liability statement apply to all goods sold and appear on all MTS Automation "acknowledgement and order status" reports.

**A. Warranty Repair**

1. Prior to returning any products for repair, authorization must first be received from customer service.

2. Products that have been modified or damaged by the customer are excluded from this warranty repair policy. Examples are damage from miswiring and improper settings on controls.

3. If a product is returned for warranty repair and is found to contain out-of-warranty damage, MTS Automation will:

   - Within thirty (30) days, notify the customer via fax or phone classification change and associated non-warranty conditions and repair charges.
   - If the customer does not respond within 5 working days, MTS Automation will return the Drive(s) unrepaired.

4. Warranty repairs made during the first year of warranty are warranted to the end of the original two-year warranty. Warranty repairs made during the second year of warranty are warranted for one year after the repair and therefore extend beyond the original two-year warranty. In the latter case, only those parts that are replaced or repaired are warranted.

5. A repair label is fixed to repaired products and shows the repair date expressed in four digits (year-week) and the **R**eturn **M**aterial **A**uthorization number (**RMA**).

6. A repair report is furnished to the customer contact established under the return procedure.

**B. Return Procedure**

1. All returns must be authorized by the customer service department. Efficient and timely handling requires that the customer provide the following (when available) during the customer service phone call:

   - Model type, serial number and date code of the product(s) to be returned.
   - Reason for return including conditions/symptoms of product failure.
   - The person to be contacted for questions and their phone number.
   - The address to send invoices.
   - The address to send the repaired product(s) and the preferred carrier.

2. After receiving the above information, customer service will issue a **R**eturn **M**aterial **A**uthorization number (**RMA**) which must be included on the packing slip and on the outside of the shipping container of the returned products. Returns without a valid RMA will not be accepted.

   **RETURN TO:**

   Attn: Customer Service
   RMA#_____
   MTS Automation
   2307 Bering Drive
   San Jose, California, 95131

3. All products to be repaired must be returned freight prepaid. All returns are on consignment. They remain the customer's property with no debit to MTS Automation. MTS Automation returns to the customer as follows:

   - Warranty repairs are returned freight prepaid, surface. Shipping methods other than surface are at the customer's expense.

**C. RMA Processing**

1. All standard control warranty returns will be processed through the factory in 30 working days from the date of receipt.



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# Warranty Limitation and Liability

MTS Automation warrants its drive ("Product(s)") to the original purchaser (the "Customer"), and in case of original equipment manufacturers or distributors, to their original consumer (the "Customer") to be free from defects in material and workmanship and to be made in accordance with Customer's specifications which have been accepted in writing by MTS Automation. In no event, however, shall MTS Automation be liable or have any responsibility under such warranty if the Products have been improperly stored, installed, used or maintained, or if customer has permitted any unauthorized modifications, adjustments and/or repairs to such Products. MTS Automation's obligation hereunder is limited solely to repairing replacing (at its option), at its factory any Products, or parts thereof, which prove to MTS Automation's satisfaction to be defective as a result of defective materials or workmanship, in accordance with MTS Automation stated warranty, provided, however, that written notice of claimed defects shall have been given to MTS Automation within two (2) years after the date of the product date code that is affixed to the Product, and within thirty (30) days from the date any such defect is first discovered. The products or parts claimed to be defective must be returned to MTS Automation, transportation prepaid by Customer, with written specifications of the claimed defect. Evidence acceptable to MTS Automation must be furnished that the claimed defects were not caused by misuse, abuse, or neglect by anyone other than MTS Automation.

MTS Automation also warrants that each of the MTS Automation Motion Control Software Programs ("Program(s)") will, when delivered, conform to the specifications therefore set forth in MTS Automation's specifications manual. Customer, however, acknowledges that these Programs are of such complexity and that the Programs are used in such diverse equipment and operating environments that defects unknown to MTS Automation may be discovered only after the Programs have been used by Customer. Customer agrees that as MTS Automation's sole liability, and as Customer's sole remedy, correct documented failures of the Programs to conform to MTS Automation's specifications manual. **MTS AUTOMATION DOES NOT SEPERATELY WARRANT THE RESULTS OF ANY SUCH CORRECTION OR WARRANT THAT ANY OR ALL FAILURES OR ERRORS WILL BE CORRECTED OR WARRANT THAT THE FUNCTIONS CONTAINED IN MTS AUTOMATION'S PROGRAMS WILL MEET CUSTOMER'S REQUIREMENTS OR WILL OPERATE IN THE COMBINATIONS SELECTED BY CUSTOMER.** This warranty for Programs is contingent upon proper use of the Programs and shall not apply to defects or failure due to: (i) accident, neglect or misuse; (ii) failure of Customer's equipment; (iii) the use of software or hardware not provided by MTS Automation; (iv) unusual stress caused by Customer's equipment; or (v) any party other than MTS Automation who modifies, adjusts, repairs, adds to, deleted from or services the Programs. This warranty for Programs is valid for a period of ninety (90) days from the date MTS Automation first delivers the Program to Customer.

**THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES (EXCEPT AS TO TITLE), WHETHER EXPRESSED OR IMPLIED. INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR ANY PARTICULAR PURPOSE, AND ARE IN LIEU OF ALL OTHER OBLIGATIONS OR LIABILITIES ON THE PART OF MTS AUTOMATION. MTS AUTOMATION MAXIMUM LIABILITY WITH RESPECT TO THESE WARRANTIES, ARISING FROM ANY CAUSE WHATSOEVER, INCLUDING WITHOUT LIMITATION, BREACH OF CONTRACT, NEGLIGENCE, STRICT LIABILITY, TORT WARRANTY, PATENT OR COPYRIGHT INFRINGEMENT, SHALL NOT EXCEED THE PRICE SPECIFIED OF THE PRODUCTS OR PROGRAMS GIVING RISE TO THE CLAIM, AND IN NO EVENT SHALL MTS AUTOMATION BE LIABLE UNDER THESE WARRANTIES OR OTHERWISE, EVEN IF MTS AUTOMATION HAS BEEN ADVISED OF THE POSSIBILITY IF SUCH DAMAGES, FOR SPECIAL, INCEDENTAL OR CONSQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, DAMAGE OR LOSS RESULTING FROM INABILITY TO USE THE PRODUCTS OR PROGRAMS, INCREASED OPERATING COSTS RESULTING FROM A LOSS OF THE PRODUCTS OR PROGRAMS, LOSS OF ANTICIPATED PROFITS, OR OTHER SPECIAL INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER SIMILAR OR DISSIMILAR, OF ANY NATURE ARISING OR RESULTING FROM THE PURCHASE, INSTALLATION, REMOVAL, REPAIR, OPERATION, USE OR BREAKDOWN OF THE PRODUCTS OR PROGRAMS, OR ANY PTHER CAUSE WHATSOEVER, INCLUDING NEGLIGENCE.**

The foregoing shall also apply to Products, Programs, or parts for the same which have been repaired or replaced pursuant to such warranty, and within the period of time, in accordance with MTS Automation's date of warranty.

No person, including any agent, distributor, or representative of MTS Automation, is authorized to make any representation or warranty on behalf of MTS Automation concerning any Products or Programs manufactured by MTS Automation, except to refer purchasers to this warranty.



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