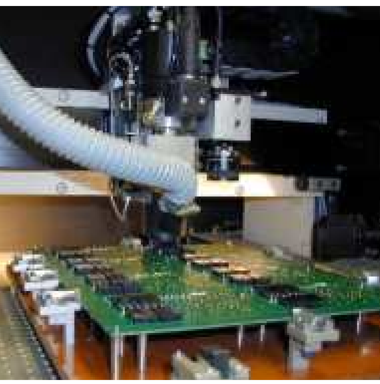
ADVANCED MOTION CONTROLS




Everything's possible.

M/V™ DigiFlex® Performance™ Motor Controllers CANopen Communication

for Electric Mobility and Vehicular Applications

Hardware Installation Manual

www.a-m-c.com
MNDVDCIN-02

Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the most recent software, the latest revisions of this manual, and copies of compliance and declarations of conformity, visit the company's website at ***www.a-m-c.com***. Otherwise, contact the company directly at:

ADVANCED Motion Controls 3805 Calle Tecate Camarillo, CA 93012-5068 USA

Agency Compliances

The company holds original documents for the following:

- UL 508c, file number E140173
- Electromagnetic Compatibility, EMC Directive - 2014/30/EU
  EN61000-6-2:2005
  EN61000-6-4:2007/A1:2011
- Electrical Safety, Low Voltage Directive - 2014/35/EU
  EN 60204-1:2006/A1:2009
- Reduction of Hazardous Substances (RoHS III), 2015/863/EU

Trademarks

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Related Documentation

- Product datasheet specific for your drive, available for download at www.a-m-c.com
- DriveWare Software Guide, available for download at www.a-m-c.com
- CANopen Communication Manual, available for download at www.a-m-c.com

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.

Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.

Notice - Required instruction necessary to ensure successful completion of a task or procedure.

Caution - Instructs and directs you to avoid damaging equipment.

Warning - Instructs and directs you to avoid harming yourself.

Danger - Presents information you must heed to avoid serious injury or death.

Revision History

Document ID	Revision #	Date	Changes
MNDVDCIN-01	1	7/2014	DVC Install Manual First Release
MNDVDCIN-02	2	5/2024	Added STO Operation Test

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1 Safety

This section discusses characteristics of your DVC Digital Drive to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

1.1 General Safety Overview

In order to install a DVC drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Notice

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.

Warning

Keep clear of all exposed power terminals (motor, DC Bus, shunt, DC power, transformer) when power is applied to the equipment. Follow these safety guidelines:

- **Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.**
- **Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative.**
- **Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.**
- **Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.**
- **Do not make any connections to the drive while power is applied.**

Caution

- **Do not reverse the power supply leads! Severe damage will result!**
- **If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.**

Caution

Use sufficient capacitance!

Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Caution

Make sure minimum inductance requirements are met!

Pulse Width Modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 H.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2 Products and System Requirements

This document is intended as a guide and general overview in selecting, installing, and operating an ADVANCED Motion Controls M/V™ series DigiFlex Performance™ digital motor controller. This manual specifically focuses on motor controllers, referred to herein as DVC drives, that use a CANopen interface for networking. Contained within this manual are instructions on system integration, wiring, setup, and standard operating methods.

2.1 DVC Drive Family Overview

The M/V series DVC motor controller family can power three phase brushless (servo, closed loop vector, closed loop stepper) or single phase (brushed, voice coil, inductive load) motors for use in electric mobility and vehicular applications. The command source can be generated externally or can be supplied internally. A digital controller can be used to command and interact with DVC motor controllers, and a number of dedicated and programmable digital and analog input/output pins are available for parameter observation and configuration. DVC motor controllers are capable of operating in Current (Torque), Velocity, or Position Mode, and utilize Space Vector Modulation, which results in higher bus voltage utilization and reduced heat dissipation compared to traditional PWM. DVC motor controllers provide high power from battery supplies, and also offer a variety of feedback options.

DVC motor controllers offer CANopen communication for multiple drive networking, and feature a single USB interface for drive configuration and setup. Commissioning is accomplished using DriveWare 7, the setup software from ADVANCED Motion Controls, available for download at www.a-m-c.com.

2.1.1 Drive Datasheet

Each DVC motor controller has a separate datasheet that contains important information on the options and product-specific features available with that particular model. The datasheet is to be used in conjunction with this manual for system design and installation.

Caution

In order to avoid damage to equipment, only after a thorough reading and understanding of this manual and the specific datasheet of the DVC motor controller being used should you attempt to install and operate the product.

2.2 Products Covered

The products covered in this manual adhere to the following part numbering structure. However, additional features and/or options are readily available for OEM's with sufficient ordering volume. Feel free to contact ADVANCED Motion Controls for further information.

FIGURE 2.1 DVC Part Numbering Structure

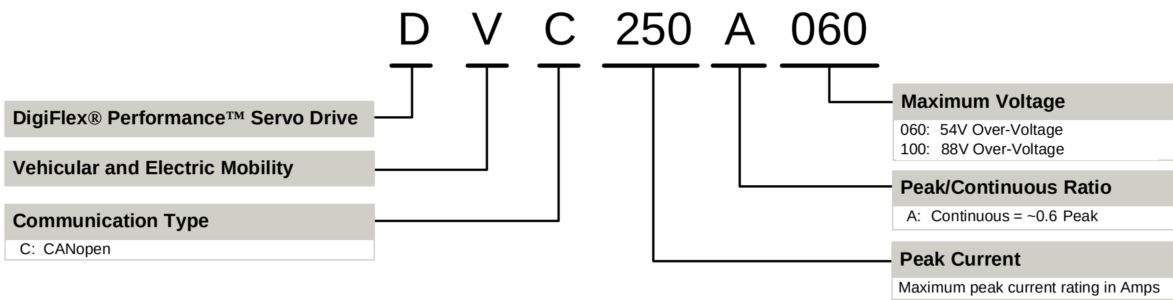


TABLE 2.1 Control Specifications

Description	DVC
Network Communication	CANopen (USB for Configuration)
Command Sources	± 10V Analog, Over the Network, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Profile Current, Profile Velocity, Profile Position, Interpolated Position Mode (PVT)
Motors Supported	Three Phase Brushless (Servo, Closed Loop Vector, Closed Loop Stepper), Single Phase (Brushed, Voice Coil, Inductive Load)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	4 Inputs, 4 Outputs
Programmable Analog I/O	2 Inputs
Primary I/O Logic Level	24 VDC

TABLE 2.2 Feedback Options

Description	DVC
Hall Sensors	
Incremental Encoder	
± 10 VDC Position	
Tachometer (± 10VDC)	

TABLE 2.3 Power Specifications - DC Input DVC Drives

Description	Units	250A060	200A100
DC Supply Voltage Range	VDC	20-54	20-80
DC Bus Over Voltage Limit	VDC	60	92
DC Bus Under Voltage Limit	VDC	18	16
Logic Supply Voltage (Keyswitch)	VDC	20-54	20-80
Maximum Peak Output Current	A (A_{RMS})	250 (176.8)	200 (141.4)
Maximum Continuous Output Current	A (A_{RMS})	150 (150)	125 (125)
Max. Continuous Output Power	W	7695	9500
Max. Continuous Power Dissipation	W	405	500
PWM Switching Frequency	kHz	14	14
Internal Bus Capacitance	F	12600	6000
Minimum Load Inductance (Line-To-Line)	H	200	250

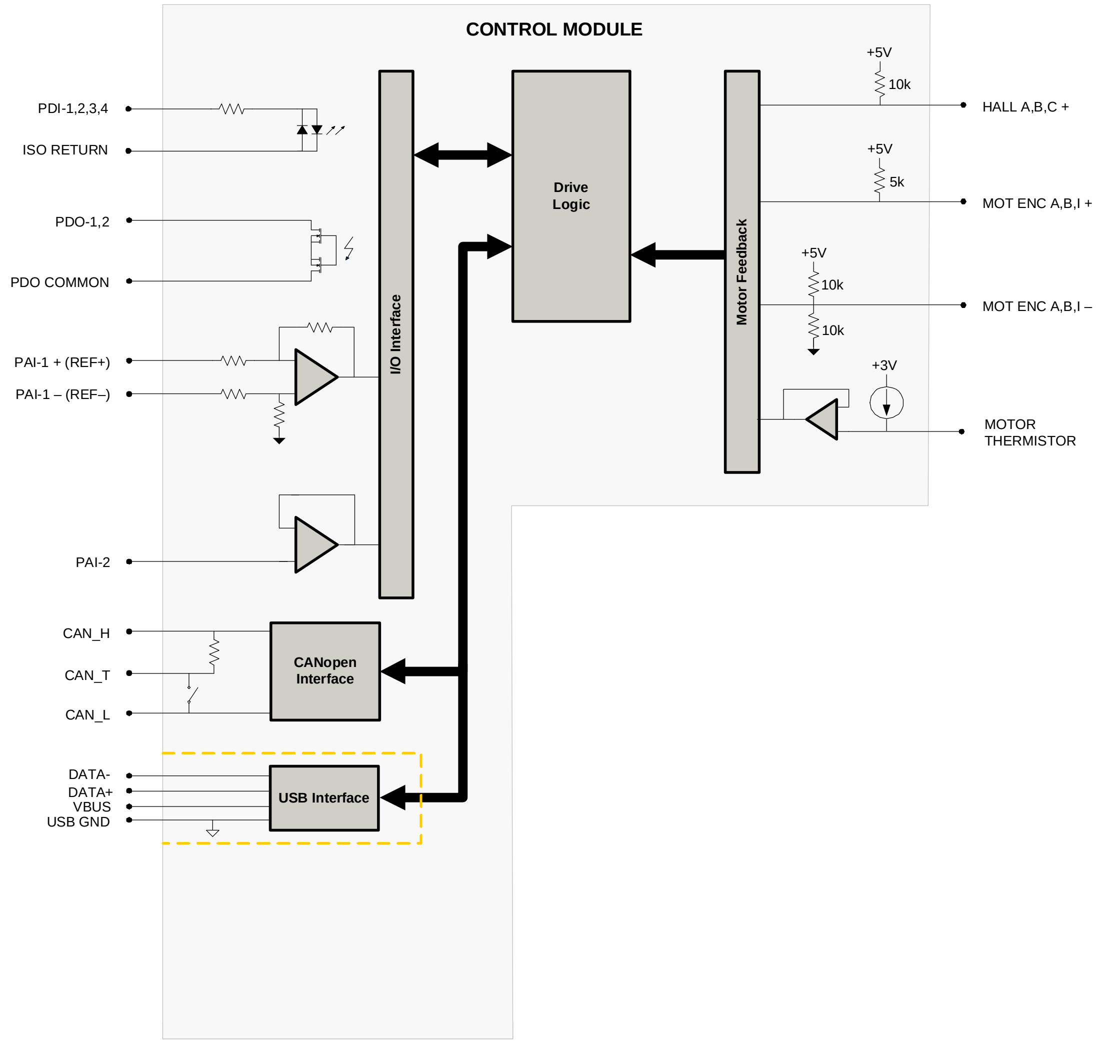
2.2.1 Control Module

The DVC control module is shown in Figure 2.2. For complete pinouts, consult the datasheet.

DVC

- CANopen Communication
- Hall Sensor, Incremental Encoder, ±10 VDC Position, Tachometer (±10 VDC)
- 24 VDC Primary I/O Logic Level
- ±10 V Analog, Sequencing, Indexing, Jogging, or Over the Network
- Drives Three Phase and Single Phase Motors
- 4 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 2 Programmable Analog Inputs (PAIs)

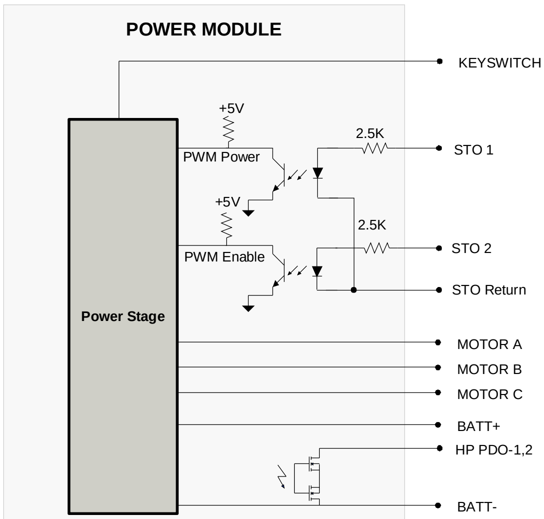
FIGURE 2.2 DVC Control Module



2.2.2 DC Power Modules

There are 2 DC power modules in the DVC motor controller family, each with a unique current output and supply voltage rating. The same general block diagram is used for each DC power module:

FIGURE 2.3 DVC Power Module



250A060

- **20 - 54 VDC Supply Voltage Range**
- **250 Amps Peak Output Current**
- **150 Amps Cont. Output Current**
- **7695 W Maximum Continuous Output Power**
- **20 - 54 VDC Logic Supply Voltage (Keyswitch)**

200A100

- **20 - 80 VDC Supply Voltage Range**
- **200 Amps Peak Output Current**
- **125 Amps Cont. Output Current**
- **9500 W Maximum Continuous Output Power**
- **20 - 80 VDC Logic Supply Voltage (Keyswitch)**

2.3 Communication Protocol

DVC motor controllers offer networking capability through the CANopen communication protocol. DVC motor controllers include an auxiliary USB interface used for configuring the drive through DriveWare.

2.3.1 CANopen

CANopen is an open standard embedded machine control protocol that operates through the CAN communication interface on DVC digital motor controllers. The CANopen protocol is developed for the CAN physical layer. The CAN interface for ADVANCED Motion Controls' DVC motor controllers follows the CiA (CAN in Automation) 301 communications profile and the CiA 402 device profile. CiA is the non-profit organization that governs the CANopen standard. More information can be found at www.can-cia.org.

CAN communication works by exchanging messages between a CANopen "host" and CANopen "nodes". The messages contain information on specific drive functions, each of which is defined by a group of objects. An object is roughly equivalent to a memory location that holds a certain value. The values stored in the drive's objects are used to perform the drive functions (current loop, velocity loop, position loop, I/O functions, etc.). See "Communication and Commissioning" on page 44 for information on how to correctly setup and wire a CANopen network using DVC motor controllers.

For more detailed information on CANopen communication and a complete list of CAN objects, consult the ADVANCED Motion Controls' CANopen Communication Manual, available for download at www.a-m-c.com.

2.4 Control Modes

DVC digital motor controllers operate in either Profile Current (Torque), Profile Velocity, Profile Position, Cyclic Synchronous Current, Cyclic Synchronous Velocity, or Cyclic Synchronous Position Mode. The setup and configuration parameters for these modes are commissioned through DriveWare 7. See the ADVANCED Motion Controls' CANopen Communication Manual for mode configuration information.

2.4.1 Profile Modes

In Profile Modes, the trajectory is limited by the drive, using the Command Limiter values to limit the maximum command rate. If the host sends a large command step, the drive spreads the demand over some period of time to stay equal to or below the maximum defined rate.

Profile Current (Torque) In Current (Torque) Mode, the input command voltage controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored in DriveWare through the digital oscilloscope function. DriveWare also offers configuration of maximum and continuous current limit values.

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

Profile Velocity In Velocity Mode, the input command voltage controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. DVC motor controllers allow velocity control with either Hall Sensors or an encoder as the feedback element. The motor velocity and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for velocity control must be specified in DriveWare, which also offers configuration of velocity limits. See "Feedback Supported" on page 10 for more information on feedback devices.

Profile Position In Position Mode, the input command voltage controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. DVC motor controllers allow position control with an encoder. The motor position and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for position control must be specified in DriveWare, which also offers configuration of position limits. See "Feedback Supported" on page 10 for more information on feedback devices.

2.4.2 Interpolated Position Mode

Interpolated Position Mode (PVT) is typically used to stream motion data between multiple axes for coordinated motion. Arbitrary position and velocity profiles can be executed on each axis. A PVT command contains the position, velocity, and time information of the motion profile's segment end points. The drive performs a third order interpolation between segment end points, resulting in a partial trajectory generation where both host controller and drive generate a specific portion of the overall move profile trajectory. The host controller calculates position and velocity of intermittent points on the overall trajectory, while the drive interpolates between these intermittent points to ensure smooth motion. The actual position loop is closed within the drive. This reduces the amount of commands that need to be sent from host controller to drive, which is critical in distributed control systems. For more information on how to operate a DVC drive in PVT mode, consult the DriveWare Software Manual.

2.5 Feedback Supported

There are a number of different feedback options available in the DPC family of digital drives. The feedback element can be any device capable of generating a signal proportional to current, velocity, position, or any parameter of interest. Such signals can be provided directly by a potentiometer or indirectly by other feedback devices such as Hall Sensors or encoders. For information on the functional operation of the feedback devices, see "Feedback Operation" on page 40.

Feedback Polarity The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. The feedback element must be connected for negative feedback. Connecting the feedback element for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. The correct feedback polarity will be determined and configured during commissioning of the drive. Otherwise, to correct this, either change the order that the feedback lines are connected to the drive, or use DriveWare to reverse the internal velocity feedback polarity setting.

2.5.1 Hall Sensors

DVC motor controllers can use single-ended Hall Sensors for commutation and/or velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. With Hall Sensors being used as the feedback element, the input command controls the motor velocity, with the Hall Sensor frequency closing the velocity loop.

Note

Hall velocity mode is not optimized for relatively high or relatively low Hall frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.

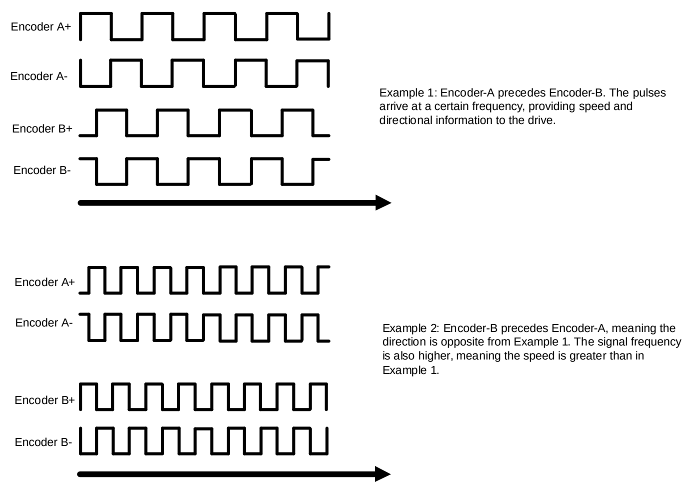
For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 45.

2.5.2 Incremental Encoder

DVC motor controllers can utilize incremental encoder feedback for velocity or position control, with the option of also using the encoder to commutate the motor. The encoder provides incremental position feedback that can be extrapolated into very precise velocity or position information. With an encoder being used as the feedback element, the input command controls the motor velocity or motor position, with the frequency of the encoder pulses closing the velocity and/or position loop. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor's speed, position and direction of rotation. Based on the speed and order in which these pulses are received from the encoder, the drive can interpret the motor velocity and physical location. The actual motor speed and physical location can be monitored within the configuration software, or externally through network commands.

Figure 2.5 below represents differential encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated. By keeping track of the number of encoder "pulses" with respect to a known motor "home" position, DVC motor controllers are able to ascertain the actual motor location.

FIGURE 2.5 Encoder Feedback Signals



Note

The high resolution of motor mounted encoders allows for excellent velocity and position control and smooth motion at all speeds. Encoder feedback should be used for applications requiring precise and accurate velocity and position control, and is especially useful in applications where low-speed smoothness is the objective.

2.5.3 Tachometer (±10 VDC)

DVC motor controllers support the use of a tachometer for velocity feedback. The tachometer measures the rotary speed of the motor shaft and returns an analog voltage signal to the drive

for velocity control. DVC motor controllers provide a Programmable Analog Input that is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

2.5.4 ±10 VDC Position

DVC motor controllers accept an analog ±10 VDC Position Feedback, typically in the form of a load-mounted potentiometer. The feedback signal must be conditioned so that the voltage does not exceed ±10 V, and is connected through the Programmable Analog Input. In DriveWare, the connection method that is used must be selected under the Position Loop Feedback options.

2.6 Command Sources

The input command source for DVC motor controllers can be configured for one of the following options.

2.6.1 ±10V Analog

DVC motor controllers accept a single-ended or differential analog signal with a range of ±10 V from an external source. The input command signals should be connected to the differential programmable analog input, PAI-1. See "Programmable Analog Inputs" on page 39 for more information.

2.6.2 0-5 V / 0-5 kohm

DVC motor controllers accept 0-5 V or 0-5 kohm potentiometer analog command input. The input command signal should be connected to the single-ended analog input, PAI-2. A +5V, 5 mA supply output is featured on DVC motor controllers for use with an external 5k potentiomter.

2.6.3 Sequencing

DVC motor controllers allow configuration of up to 16 separately defined Sequences in DriveWare. Sequences are sets of steps that are Motion Tasks and Control Functions linked together and executed in a sequential order.

2.6.4 Indexing

DVC motor controllers allow configuration of up to 16 separately defined Index tasks in DriveWare. Indexes can be either Absolute (commands a pre-defined move to an absolute position) or Relative (commands a pre-defined move relative to the current position).

2.6.5 Jogging

DVC motor controllers allow configuration of two separate Jog velocities in DriveWare, commanding motion at a defined constant velocity with infinite distance.

2.6.6 Over the Network

DVC motor controllers can utilize network communication as a form of input command through the CAN interface. In order to send commands to the drive over the CAN bus, the command source must be set to 'Communication Channel' in the Configuration window in DriveWare. For more information on commanding the drive with CANopen, see "Communication and Commissioning" on page 44.

2.7 System Requirements

To successfully incorporate a DVC digital motor controller into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance.

2.7.1 Specifications Check

Before selecting a DVC digital motor controller, a user should consider the requirements of their system. This involves calculating the voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with. Before attempting to install or operate a DVC motor controller, be sure all the following items are available:

- DVC Motor Controller
- DVC Datasheet (specific to your model)
- DVC Series Digital Hardware Installation Manual
- DriveWare Software Guide

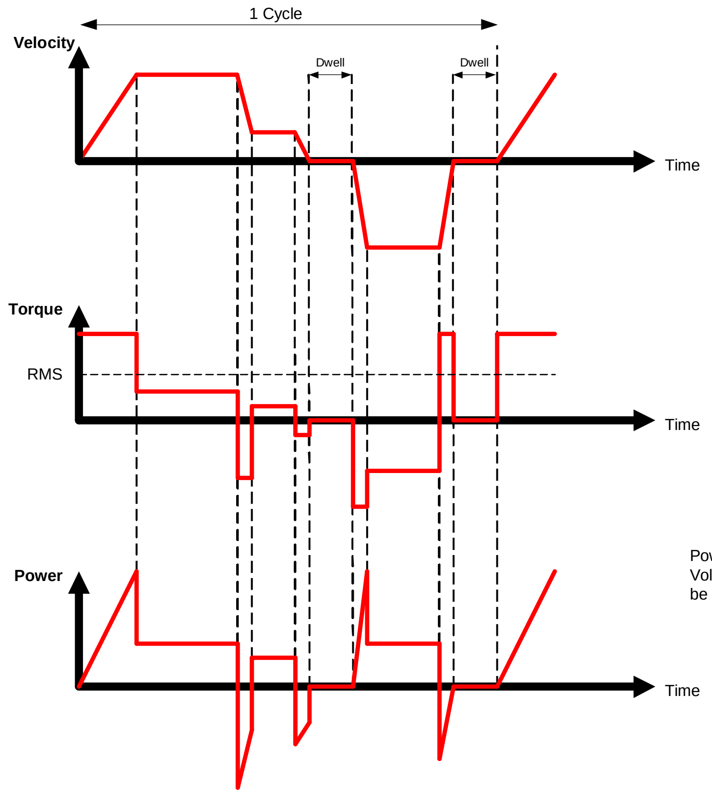
2.7.2 Motor Controller Selection and Sizing

DVC motor controllers have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a model may be selected that will best suit the motor capabilities.

A motor controller should be selected that will meet the peak and continuous current requirements of the application, and operate within the voltage requirements of the system.

Motor Current and Voltage Motor voltage and current requirements are determined based on the maximum required torque and velocity. These requirements can be derived from the application move profiles (Figure 2.6).

FIGURE 2.6 Example Velocity, Torque, and Power Curves



Power is equal to Torque x Velocity. Motor Voltage (V_m) and Motor Current (I_m) should be chosen where power is at a maximum.

The motor current I_M is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T -motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile.

The continuous torque is the average torque required by the system during the move profile, including dwell times. Both peak torque and continuous, or RMS (root mean square) torque

need to be calculated. RMS torque can be calculated by plotting torque versus time for one move cycle.

$$T_{RMS} = \sqrt{\frac{\sum_i T_i^2 t_i}{\sum_i t_i}}$$

Here T is the torque and t is the time during segment i. In the case of a vertical application make sure to include the torque required to overcome gravity.

The system voltage requirement is based on the motor properties and how fast and hard the motor is driven. The system voltage requirement is equal to the motor voltage, V_M, required to achieve the move profile. In general, the motor voltage is proportional to the motor speed and the motor current is proportional to the motor shaft torque. Linear motors exhibit the same behavior except that in their case force is proportional to current. These relationships are described by the following equations:

$$V_m = I_m R_m + E$$

$$E = K_e S_m$$

for rotary motors $T = K_t I_m$

for linear motors $F = K_f I_m$

Where:

V	-motor voltage
I	-motor current (use the maximum current expected for the application)
R	-motor line-to-line resistance
E	-motor back-EMF voltage
T	-motor torque
F	-motor force
K	-motor torque constant
K	-motor force constant
K	-voltage constant
S	-motor speed (use the maximum speed expected for the application)

The motor manufacturer's data sheet contain K (or K) and K constants. Pay special attention to the units used (metric vs. English) and the amplitude specifications (peak-to-peak vs. RMS, phase-to-phase vs. phase-to-neutral).

The maximum motor terminal voltage and current can be calculated from the above equations. For example, a motor with a K = 10V/Krpm and required speed of 3000 RPM would require 30V to operate. In this calculation the IR term (voltage drop across motor winding resistance) is disregarded. Maximum current is maximum torque divided by K . For example, a motor with K = 0.5 Nm/A and maximum torque of 5 Nm would require 10 amps of current. Continuous current is RMS torque divided by K .

Motor Inductance The motor inductance is vital to the operation of motor controllers, as it ensures that the DC motor current is properly filtered.

A motor that does not meet the rated minimum inductance value of the drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary. See "Inductive Filter Cards" on page 27 for more information.

A minimum motor inductance rating for each specific motor controller can be found in the DVC datasheet. If the motor controller is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

In the above equations the motor inductance is neglected. In brushless systems the voltage drop caused by the motor inductance can be significant. This is the case in high-speed applications if motors with high inductance and high pole count are used. Please use the following equation to determine motor terminal voltage (must be interpreted as a vector).

$$V_m = \quad R_m + j \quad L \; I_m + E$$

Where:

L -phase-to-phase motor inductance
-maximum motor current frequency

2.7.3 Power Supply Selection and Sizing

There are several factors to consider when selecting a power supply for a DVC motor controller.

- Power Requirements
- Isolation
- Regeneration
- Voltage Ripple

Power Requirements refers to how much voltage and current will be required by the motor controller in the system. Isolation refers to whether the power supply needs an isolation

transformer. Regeneration is the energy the power supply needs to absorb during deceleration. Voltage Ripple is the voltage fluctuation inherent in unregulated supplies.

Power Supply Current and Voltage **The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one motor controller, then the current requirements for each drive should be added together. Due to the nature of motor controllers, the current into the drive does not always equal the current out of the drive. However, the power in is equal to the power out. Use the following equation to calculate the power supply output current, I_{PS}, based on the motor voltage and current requirements.**

$$I_{PS} = \frac{V_M \; I_M}{V_{PS} \; 0.98}$$

Where:

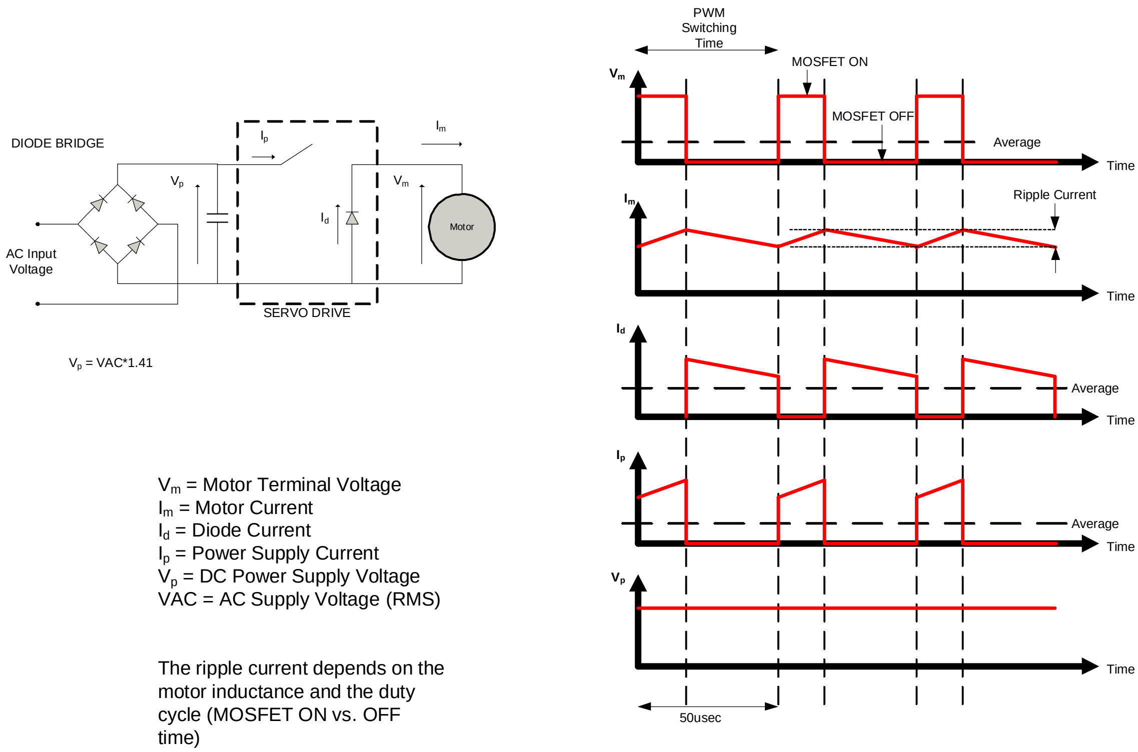
V_{PS}	-nominal power supply voltage
I_M	-motor current
V_M	-motor voltage

Use values of V and I at the point of maximum power in the move profile, Figure 2.6 (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.

The power supply current is a pulsed DC current (Figure 2.7): when the MOSFET switch is on, it equals the motor current; when the MOSFET is off it is zero. Therefore, the power supply current is a function of the PWM duty cycle and the motor current (e.g. 30% duty cycle and 12 amps motor current will result in 4 amps power supply current). 30% duty cycle also means that the average motor voltage is 30% of the DC bus voltage. Power supply power is approximately equal to drive output power plus 3 to 5%.

The only time the power supply current needs to be as high as the drive output current is if the move profile requires maximum current at maximum velocity. In many cases however, maximum current is only required at start up and lower currents are required at higher speeds.

FIGURE 2.7 **Unregulated DC Power Supply Current**



A system will need a certain amount of voltage and current to operate properly. If the power supply has too little voltage/current the system will not perform adequately. If the power supply has too much voltage the drive may shut down due to over voltage, or the motor controller may be damaged.

To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the ideal system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

- DVC motor controller over voltage
- External shunt regulator turn-on voltage (see "Regeneration and Shunt Regulators" on page 20)

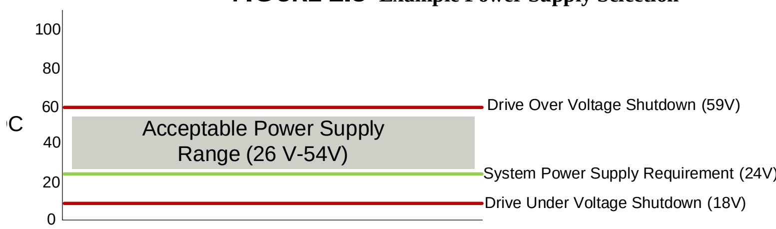
These percentages also account for the variances in K and K , and losses in the system external to the motor controller. The selected margin depends on the system parameter variations.

Do not select a supply voltage that could cause a mechanical over-speed in the event of a drive malfunction or a runaway condition.

Brushed Motors may have voltage limitations due to the mechanical commutators. Consult the manufacturer's data sheets.

Figure 2.8 provides one possible example of an appropriate system power supply voltage for a DVC250A060 motor controller. The over voltage and under voltage shutdown levels can be found on the drive datasheet. The system power supply requirement is based on the motor properties and how much voltage is needed to achieve the application move profile (see "Motor Current and Voltage" on page 14). Keep in mind that the calculated value for V is the minimum voltage required to complete moves at the desired speed and torque. There should be at least 10% headroom between the calculated value and the actual power supply voltage to allow for machine changes such as increased friction due to wear, change in load, increased operating speed, etc.

FIGURE 2.8 Example Power Supply Selection



Isolation

In systems where an AC line is involved, isolation is required between the AC line and the signal pins on the motor drive. This applies to all systems except those that use a battery as a power supply. There are two options for isolation:

1. The motor controller can have built in electrical isolation.
2. The power supply can provide isolation (e.g. a battery or an isolation transformer).

The system must have at least one of these options to operate safely.

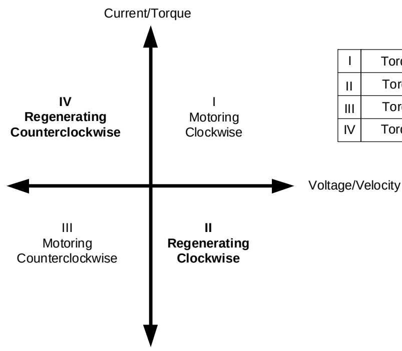
Power Supply with Isolation

An isolated power supply is either a battery or a power supply that uses an isolation transformer to isolate the AC line voltage from the power supply ground. This allows both the power ground on an isolated power supply and the signal ground on a non-isolated drive to be safely pulled to earth ground. Always use an isolated power supply if there is no isolation in the drive.

Regeneration and Shunt Regulators

Use of a shunt regulator is necessary in systems where motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply.

FIGURE 2.9 Four Quadrant Operation - Regeneration occurs when Torque and Velocity polarity are opposite



I	Torque +	Velocity +	No Regen
II	Torque -	Velocity +	Regen
III	Torque -	Velocity -	No Regen
IV	Torque +	Velocity -	Regen

This regenerated energy can charge the power supply capacitors to levels above that of the motor controller over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. Shunt regulators are essentially a resistor placed in parallel with the DC bus. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The voltage rise on the power supply capacitors without a shunt regulator, can be calculated according to a simple energy balance equation. The amount of energy transferred to the power supply can be determined through:

$$E_i = E_f$$

Where:

E	-initial energy
E	-final energy

These energy terms can be broken down into the approximate mechanical and electrical terms - capacitive, kinetic, and potential energy. The energy equations for these individual components are as follows:

$$E_c = \frac{1}{2} C V_{nom}^2$$

Where:

E	-energy stored in a capacitor (joules)
C	-capacitance
V	-nominal bus voltage of the system

$$E_r = \frac{1}{2}J\ \ ^2$$

Where:

E	**-kinetic (mechanical) energy of the load (joules)**
J	**-inertia of the load (kg-m)**
	-angular velocity of the load (rads/s)

$$E_p = mgh$$

Where:

E	**-potential mechanical energy (joules)**
m	**-mass of the load (kg)**
g	**-gravitational acceleration (9.81 m/s)**
h	**-vertical height of the load (meters)**

During regeneration the kinetic and potential energy will be stored in the power supply's capacitor. To determine the final power supply voltage following a regenerative event, the following equation may be used for most requirements:

$$E_c\ \ E_r\ \ E_p\ _i = \ E_c\ \ E_r\ \ E_p\ _f$$

$$\frac{1}{2}CV_{nom}^2 + \frac{1}{2}J\ \ _i^2 + mgh_i = \frac{1}{2}CV_f^2 + \frac{1}{2}J\ \ _f^2 + mgh_f$$

Which simplifies to:

$$V_f = \sqrt{V_{nom}^2 + \frac{J}{C}\ \ _i^2 - \ \ _f^2\ \ + \frac{2mg\ \ h_i - h_f}{C}}$$

The V calculated must be below the power supply capacitance voltage rating and the drive over voltage limit. If this is not the case, a shunt regulator is necessary. A shunt regulator is sized in the same way as a motor or controller, i.e. continuous and RMS power dissipation must be determined. The power dissipation requirements can be determined from the application move profile (see Figure 2.6).

ADVANCED Motion Controls offers a variety of shunt regulators for motor controllers. When choosing a shunt regulator, select one with a shunt voltage that is greater than the DC bus voltage of the application but less than the over voltage shutdown of the drive. Verify the need

for a shunt regulator by operating the motor controller under the worst-case braking and deceleration conditions. If the drive shuts off due to over-voltage, a shunt regulator is necessary.

Continuous Regeneration

In the special case where an application requires continuous regeneration (more than a few seconds) then a shunt regulator may not be sufficient to dissipate the regenerative energy. Please contact ADVANCED Motion Controls for possible solutions to solve this kind of application. Some examples:

- Web tensioning device
- Electric vehicle rolling down a long hill
- Spinning mass with a very large inertia (grinding wheel, flywheel, centrifuge)
- Heavy lift gantry

Voltage Ripple

For the most part, ADVANCED Motion Controls DVC motor controllers are unaffected by voltage ripple from the power supply. The current loop is fast enough to compensate for 60 Hz fluctuations in the bus voltage, and the components in the drive are robust enough to withstand all but the most extreme cases. Peak to peak voltage ripple as high as 25 V is acceptable.

There are some applications where the voltage ripple can cause unacceptable performance. This can become apparent where constant torque or force is critical or when the bus voltage is pulled low during high speed and high current applications. If necessary, the voltage ripple from the power supply can be reduced, either by switching from single phase AC to three phase AC, or by increasing the capacitance of the power supply.

The voltage ripple for a system can be estimated using the equation:

$$V_R = \frac{I_{PS}}{C_{PS}} F_f$$

Where:

V	-voltage ripple
C	-power supply capacitance
I	-power supply output current
F	-frequency factor (1/hertz)

The power supply capacitance can be estimated by rearranging the above equation to solve for the capacitance as:

$$C_{PS} = \frac{I_{PS}}{V_R} F_f$$

The frequency factor can determined from:

$$F_f = \frac{0.42}{f}$$

where f is the AC line frequency in hertz. Note that for half wave rectified power supplies, f = f/2.

The power supply output current, if unknown, can be estimated by using information from the output side of the motor controller as given below:

$$I_{PS} = \frac{V_M \quad I_M}{V_{PS} \quad 0.98}$$

Where:

I	-current through the motor
V	-nominal power supply voltage
V	-motor voltage (see “Motor Current and Voltage” on page 14)

2.7.4 Environment

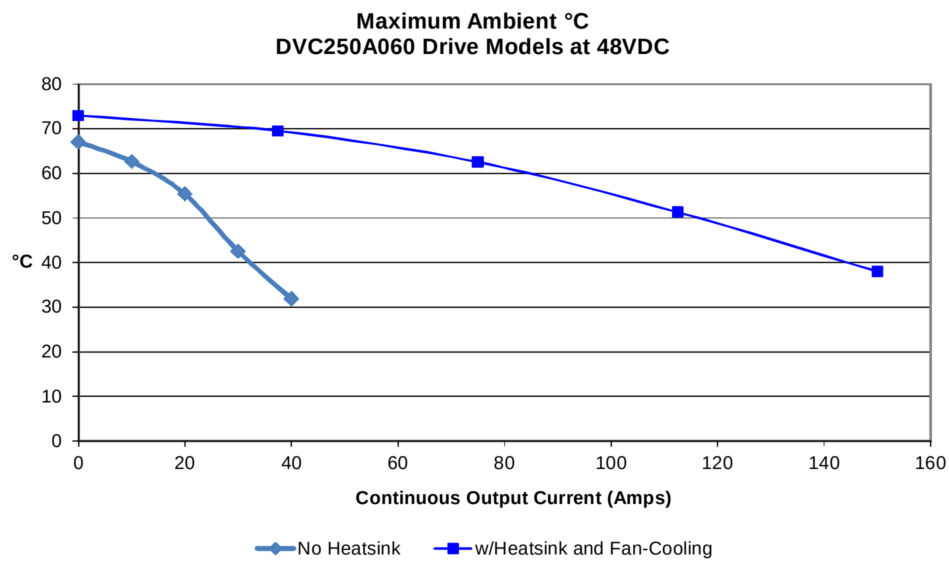
To ensure proper operation of a DVC motor controller, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.4 Environmental Specifications

Environmental Specifications	
Parameter	Description
Baseplate Temperature Range	0 - 75 °C (32 - 167 °F)
Humidity	90%, non-condensing
IP Rating	65

Baseplate Temperature Range DVC drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above 75°C. For a specific continuous output current and DC supply voltage, Figure 2.10 below specifies an upper limit to the ambient temperature range DVC motor controllers can operate within while keeping the baseplate temperature below 75°C. Additional cooling and/or heatsinking are required to achieve rated performance. It is also recommended to apply thermal grease between the motor controller baseplate and external heatsink.

FIGURE 2.10 DVC Ambient Temperature Range



1. Heatsink used is a 15" x 22" x 0.65" aluminum plate.
2. Fan used is a 118 CFM NMB-MAT Model: 4715KL-05W-B40 - blowing directly up underneath the motor controller on the underside of the heatsink.
3. Consult ***ADVANCED*** Motion Controls for DVC200A100 thermal data.

Shock/Vibrations

While DVC motor controllers are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to. The best way to secure the drive against mechanical vibration is to use screws to mount the DVC motor controller against its baseplate. For information on mounting options and procedures, see "Mounting Dimensions" on page 49 and the dimensional drawings and information on the datasheet.

Caution

Care should be taken to ensure the drive is securely mounted in a location where no moving parts will come in contact with the drive.

3 Integration in the Servo System

This chapter will give various details on incorporating a DVC motor controller into a system, such as how to properly ground the motor controller along with the entire system, and how to properly connect motor wires, power supply wires, feedback wires, communication cables, and inputs into the DVC drive.

3.1 LVD Requirements

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the servo drives must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

Contact the factory for assistance in determining the type of drive in use.

General

1. **Shielded cables must be used for all interconnect cables to the drive and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.**
2. **The drive's metal enclosure must be grounded to the closest ground point with the least amount of resistance.**
3. **The drive must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.**

Analog Input Drives

4. **A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.**

PWM Input Drives

5. **A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.**

MOSFET Switching Drives

6. **A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.**
7. **An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.**

IGBT Switching Drives

8. **An appropriately rated Cosel Tac series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.**
9. **A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.**

Fitting of AC Power Filters

10. **It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be**

adversely affected by the noise. AC power filters can filter this noise and keep it from getting on the AC power signal. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power filter enters the enclosure as possible. Also, the AC power cable on the load end of the filter should be routed far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

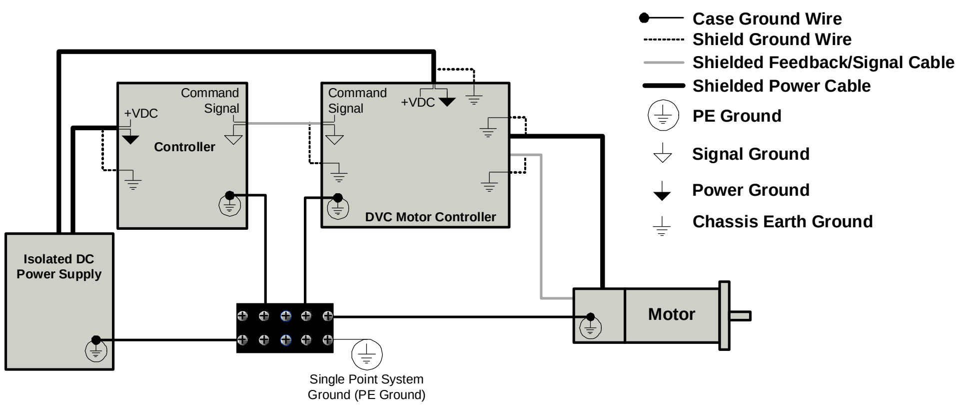
Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines.

3.3 Grounding

In most servo systems the case grounds of all the system components should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point through a single low resistance wire reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

- Motor chassis
- Controller chassis
- Power supply chassis
- DVC drive chassis

FIGURE 3.1 System Grounding



Ground cable shield wires at the drive side to a chassis earth ground point.

The DC power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the DVC motor controller to avoid picking up noise due to the "floating" differential servo drive input. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed. As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

The main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card or a noise suppression device is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of larger diameter wire rather than too thin. This becomes more critical as the cable length increases. The following table provides recommendations for selecting the appropriate wire size for a specific current. These values should be used as reference only. Consult any applicable national or local electrical codes for specific guidelines.

Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518
15	#18	0.823
20	#16	1.31
35	#14	2.08
45	#12	3.31

Current (A)	Minimum Wire Size (AWG)	mm^2
60	#10	5.26
80	#8	8.37
120	#6	13.3
150	#0	53.5
200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

- For a single phase motor or voice coil, twist the two motor wires together as a group.

- **For a three phase motor, twist all three motor wires together as a group.**

Caution

DO NOT use wire shield to carry motor current or power!

Ground the motor power cable shield at one end only to the drive chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

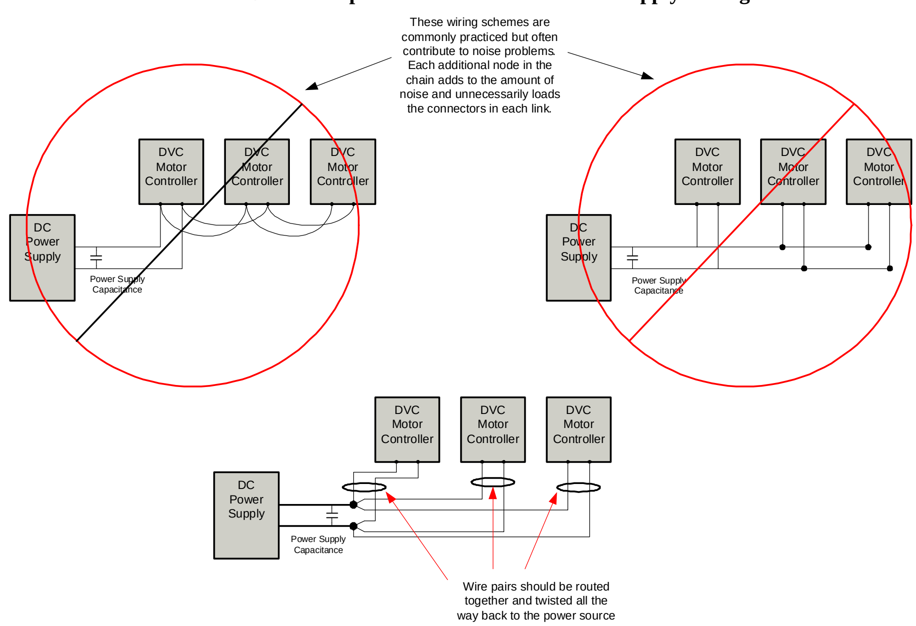
3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the drive chassis ground.

When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. **Run separate power supply leads to each drive directly from the power supply filter capacitor.**
2. **Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.**

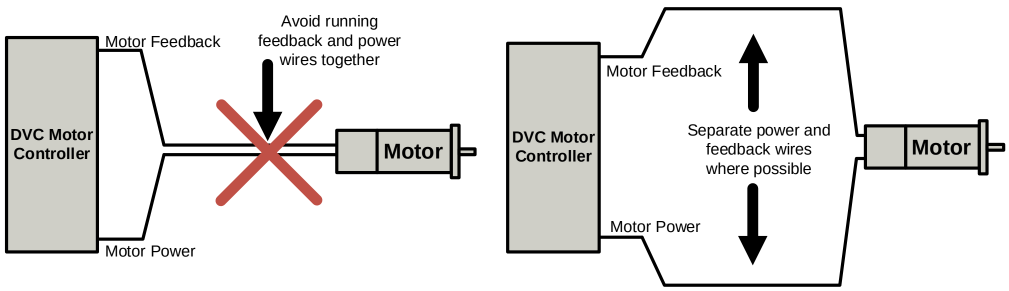
FIGURE 3.2 Multiple Motor Controllers Power Supply Wiring



3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the drive chassis ground. Also make sure that the feedback connector preserves the shield continuity. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.3 Feedback Wiring



3.4.5 I/O and Signal Wires

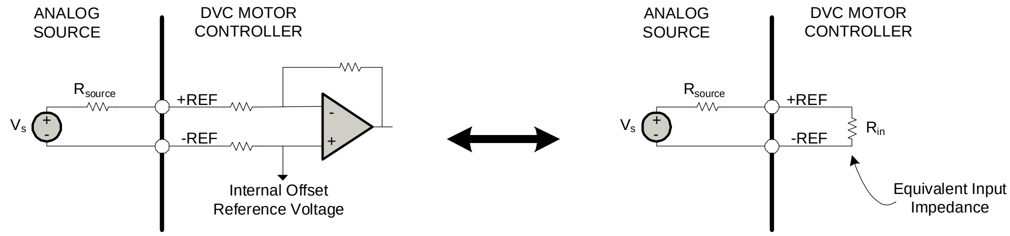
Use of a twisted, shielded pair for the I/O and Signal wires is recommended. Connect the shield to the drive chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds.

In case of a single-ended reference signal when using ±10V as the input command source, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

Analog Input When using an analog signal for an input command, it is important to consider the output impedance of the analog source when interfacing to input circuitry. A poorly designed analog input interface can lead to undesired command signal attenuation. Figure 3.4 shows an external analog source connected to an analog input. The ideal voltage delivered to the input is V_S. However, the voltage drop across R_{source} will reduce the signal being delivered to the drive input. This voltage drop is dependent on the value of R_{source} and the drive's input impedance.

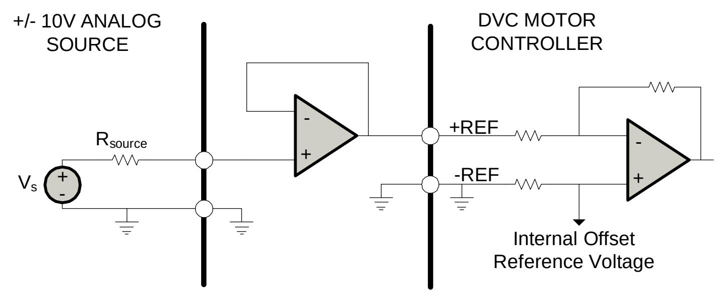
FIGURE 3.4 Analog Source and Drive Input



The DVC motor controller's analog input can be simplified to a single impedance, R_{in}, as shown in Figure 3.4. If the impedance of R_{source} is of the same magnitude or larger than R_{in}, there will be a significant voltage drop across R_{source}. Reduced values of R_{source} cause a lower voltage drop that increases signal integrity. In order to avoid a voltage drop of more than 5% between the source and the drive, it is recommended to use an R_{source} value of less than or equal to 2kohm.

If there is a large output impedance from the analog source, it is recommended to use a buffer circuit between the analog source output and the drive input. A unity gain op-amp circuit as shown in Figure 3.5 will ensure low output impedance with minimal voltage drop.

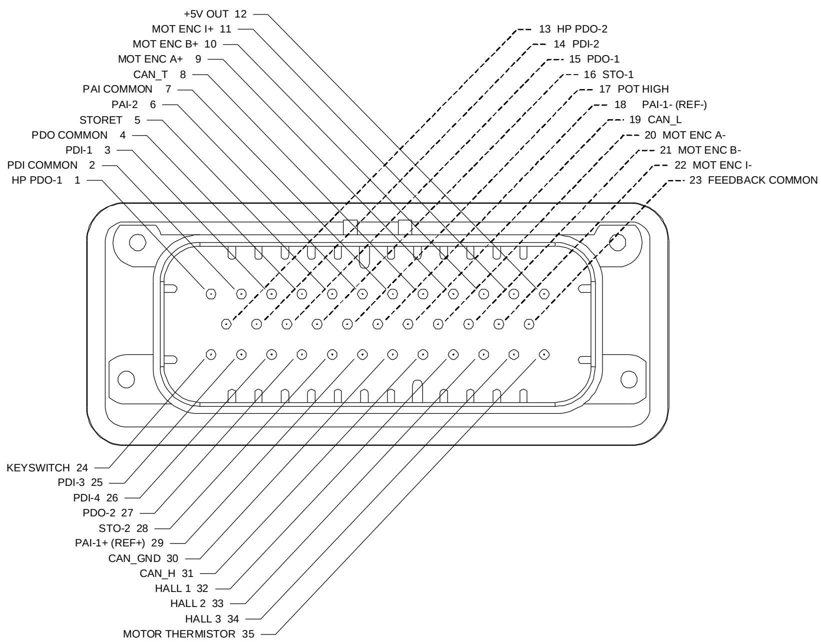
FIGURE 3.5 Optimized Low Impedance Interface



3.5 Connector Types

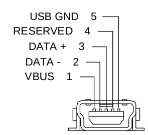
The different types of connectors used on DVC motor controllers are shown in the tables below.

I/O Signal Connector		
Connector Information		35-pin, AMPSEAL connector
Mating Connector	Details	TE Connectivity: Housing P/N 776164-1; Socket Contacts P/N 770854-3 (loose); Seal Plug P/N 770678-1; Crimp Tool P/N 58529-1
	Included with Drive	No



Mating connector housing, socket contacts, and seal plugs can be ordered as a kit using ADVANCED Motion Controls' part number KC-35AMPSEAL01. Crimp tool not included with mating connector kit. Circuit cavities remain sealed until pierced. Seal plugs are included to reseal pierced circuit cavities that will not be used. Seal plugs should be inserted into the circuit cavity as far as possible, large end first.

USB Connector		
Connector Information		5-pin, Mini USB B Type port
Mating Connector	Details	TE Connectivity: 1496476-3 (2-meter STD-A to MINI-B ASSY)
	Included with Drive	No



MOTOR POWER Connectors		
Connector Information		Three individual M6 threaded terminals
Mating Connector	Details	M6 screw or bolt with washer
	Included with Drive	Yes

POWER Connectors		
Connector Information		Two individual M6 threaded terminals
Mating Connector	Details	M6 screw or bolt with washer
	Included with Drive	Yes

4 Operation and Features

This chapter will present a brief introduction on how to test and operate a DVC motor controller. Read through this entire section before attempting to test the drive or make any connections.

4.1 Features and Getting Started

To begin operation with your DVC motor controller, be sure to read and understand the previous chapters in this manual as well as the product datasheet and the DriveWare Software Guide. Ensure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the DVC motor controller. Also, be aware of the "Troubleshooting" section at the end of this manual for solutions to basic operation issues.

Warning

Do not install the DVC motor controller into the system without first determining that all chassis power has been removed for at least 10 seconds.

Never remove a motor controller from an installation with power applied!

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up!

4.1.1 Initial Setup and Configuration

For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- **DVC Motor Controller**
- **Motor**
- **DC Power Supply and Logic Power Supply (Keyswitch) for supplying power to system**
- **DriveWare Setup Software and Software Guide for detailed instructions on how to setup, tune and configure a DVC motor controller in DriveWare**

The following steps outline the general procedure to follow when commissioning a DVC motor controller for the first time. The DriveWare Software Guide contains more detailed information on each step.

1. Check System Wiring: Before beginning, check the wiring throughout the system to ensure proper connections and that all grounding and safety regulations have been followed appropriately for the system.

Caution

Do not apply power to the system until certain all wiring and grounding has been setup safely and properly!

2. Apply Power: Power must be applied to the motor controller before any communication or configuration can take place. Turn on the Logic (Keyswitch) supply, then turn on the main Power supply. Use a multimeter or voltmeter to check that both power supply levels are within their specified ranges.
3. Establish Connection: Open DriveWare 7 on the PC. The DVC motor controller should be connected to the PC with a USB cable. Choose the "Connect to a drive" option when DriveWare starts, and enter the appropriate communication settings in the options window that appears. See the DriveWare Software Guide for more information on connecting to a drive. For connection issues, see "Connection Problems" on page 51.
4. Configure the drive in DriveWare: DriveWare allows the user to manually configure user units, motor and feedback information, system parameters and limits, tune the Current, Velocity and Position Loops, commutate the motor, and assign drive and software "actions" to specific events. Consult the DriveWare Software Guide for detailed instructions.
5. Connect to the Controller (optional): Once the drive has been properly commissioned, if an external controller is going to be used to command an input signal to the drive, the controller wiring and setup should follow the safety and grounding guidelines and conventions as outlined in "Grounding" on page 29.

4.1.2 Input/Output Pin Functions

DVC motor controllers provide a number of various input and output pins for parameter observation and drive configuration options.

Programmable Digital I/O The single-ended Programmable Digital I/O can be assigned to over 40 different functions in DriveWare. The polarity of the signals can be set to active HIGH or active LOW depending on the preference of the user.

24VDC Digital I/O Specification

The 24VDC Digital I/O is designed to be compatible with controllers that interface with 24VDC signals, using optical isolation that separates the drive signal ground from the controller signal ground. Isolation increases a system's noise immunity by helping to eliminate current loops and ground currents.

- Inputs - The Isolated Digital Inputs use bi-directional optical isolators to detect signals from the controller. Dual LED's in the optical isolator allow current to flow in either direction. Current flow through the LED activates the transistor, and the drive responds depending on whether the transistor is active or not. The presence or absence of current in the LED determines the logic level, not the direction of current. This flexibility allows the Isolated Digital Inputs to be compatible with a wide range of controllers.

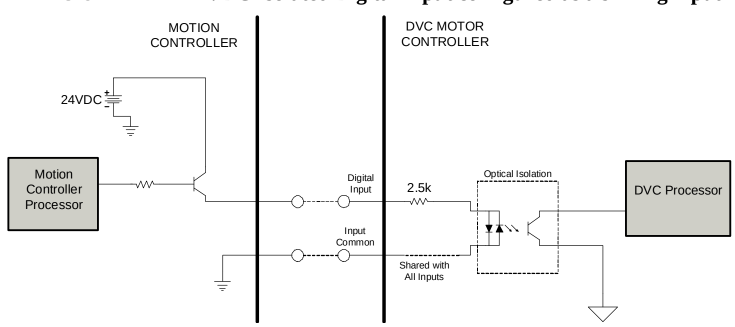
TABLE 4.1 24VDC Isolated Digital Input

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

When current flows into the digital input it is acting as a sinking input. When current flows out of the digital input it is acting as a sourcing input. Since current is allowed to flow in either direction, the inputs can either sink or source. The voltage at the Input Common pin determines whether the inputs sink or source. The Input Common pin is common to all of the inputs, but is isolated from the drive signal ground.

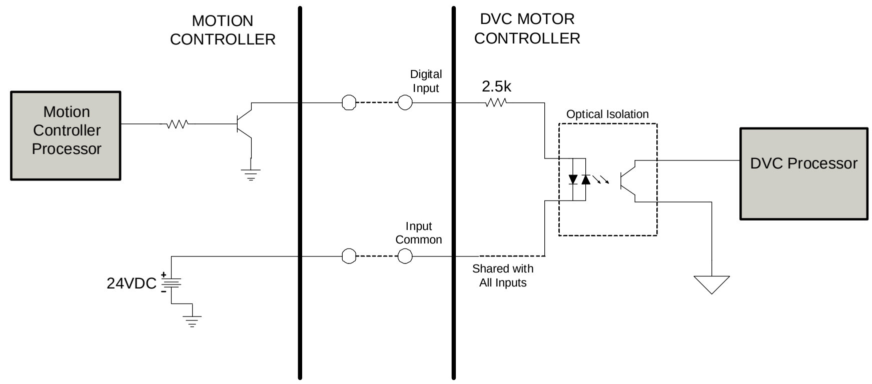
To configure the Isolated Digital Inputs as sinking, the 24V ground is applied to the Input Common and 24V is modulated at the digital input. Figure 4.1 shows a sourcing output from the motion controller feeding the sinking input at the drive. In this example the external motion controller uses a transistor to control the 24V to the drive input. A mechanical switch, relay or other voltage-controlling device can be used in place of the transistor.

FIGURE 4.1 24VDC Isolated Digital Input configured as a sinking input



To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.2 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides a transistor.

FIGURE 4.2 24VDC Isolated Digital Input configured as a sourcing input.



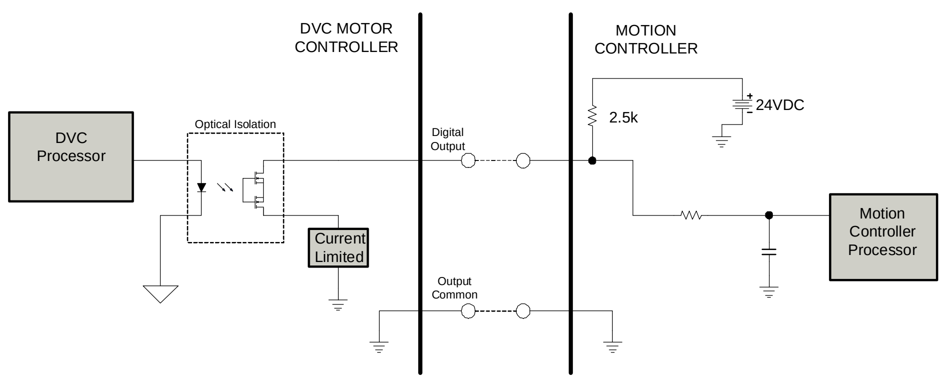
- Outputs - The Isolated Digital Outputs have a common grounding point labeled Output Common, and are +24VDC single-ended outputs.

TABLE 4.2 24VDC Isolated Digital Output

24VDC Isolated Digital Output (Sinking)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA

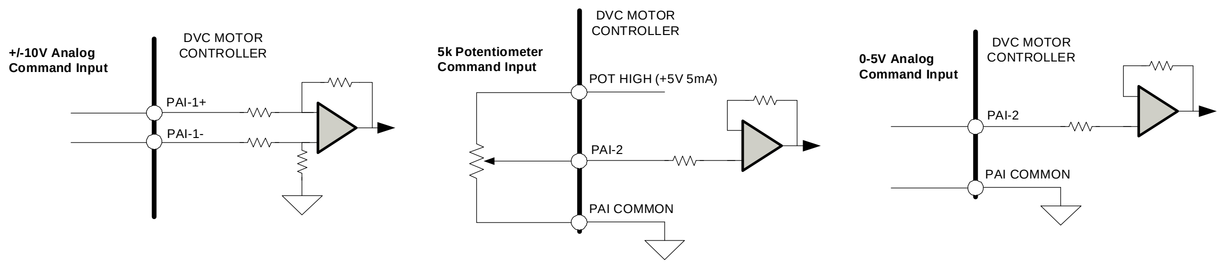
A transistor controls the voltage at each sinking digital output. The output pin is pulled to 24V and the 24V ground goes to the output common, as shown in Figure 4.3. A transistor controls the voltage at the digital output. When the transistor is open the voltage at the digital output is HIGH. When the transistor is closed the voltage is pulled to ground, which causes the output to go LOW.

FIGURE 4.3 24VDC Isolated Digital Output configured as a sinking output.



Programmable Analog Inputs The Programmable Analog Inputs can be assigned to drive functions in DriveWare or used as analog input commands. PAI-1 is used for a ±10V analog input command, and PAI-2 is used for 0-5V or 0-5kohm command options. DVC motor controllers provide a +5V, 5mA supply output for use with an external 5kohm potentiometer. For both ±10V and 0-5V / 0-5k, the command source in DriveWare should be set to Analog Input, and the correct analog input should be selected depending on the command type.

FIGURE 4.4 Programmable Analog I/O Commands



High Powered Programmable Digital Outputs DVC motor controllers feature two High Powered Programmable Digital Outputs (HPDOs) that are DIP Switch selectable for 24, 36, 48, or 72 V and can sink up to 3 A. A user-supplied load can be connected between the Keyswitch input and the HPDO.

Warning

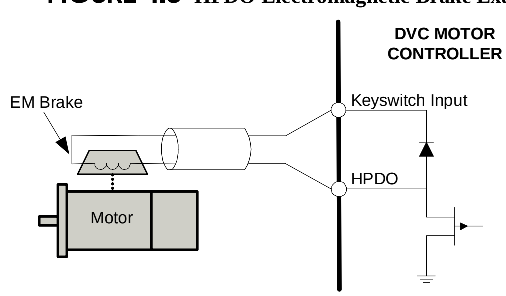
HPDOs are designed to work only with the Keyswitch voltage. Using a separate power supply for the HPDOs other than the Keyswitch voltage will apply power to the drive even when the Keyswitch voltage is off.

TABLE 4.3 HPDO DIP Switch Settings

HPDO Voltage	Switch	
	SW8	SW9
24V	OFF	OFF
36V	ON	OFF
48V	OFF	ON
72V	ON	ON

Figure 4.5 shows an example of an electromagnetic holding brake used with one of the HPDOs. When activated, the HPDO will energize the external user-supplied holding brake and release the motor. The electromagnetic holding brake is normally engaged to lock the motor shaft and keep the rotor from turning when the vehicle is stopped.

FIGURE 4.5 HPDO Electromagnetic Brake Example

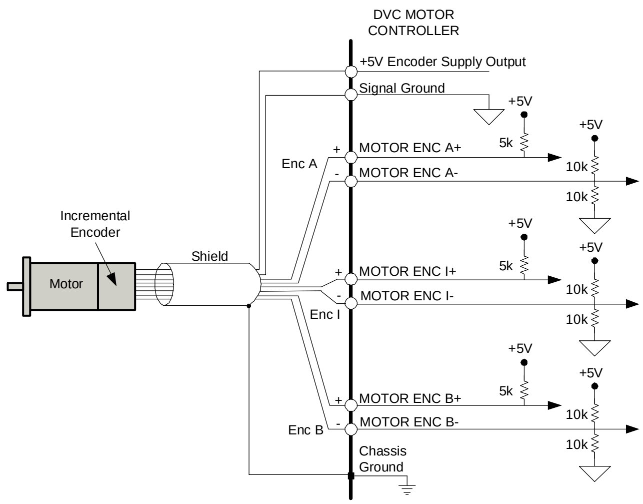


4.1.3 Feedback Operation

The functional operation of the feedback devices supported by DVC motor controllers is described in this section. For more information on feedback selection, see "Feedback Supported" on page 10.

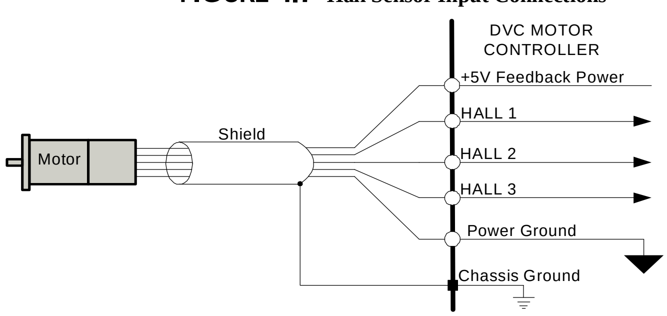
Incremental Encoder DVC motor controllers support incremental encoder feedback. The drive allows inputs for differential and single-ended inputs. For single-ended encoder inputs, leave the negative terminal open. Both the "A" and "B" channels of the encoder are required for operation. DVC motor controllers also accept an optional differential "index" channel that can be used for synchronization and homing. A +5V Encoder Supply Output pin is provided to supply power to the encoder. If using the +5V, 250mA low voltage power supply output from the motor controller, verify that the supply output voltage and current rating is sufficient for the encoder specifications

FIGURE 4.6 Incremental Encoder Connections



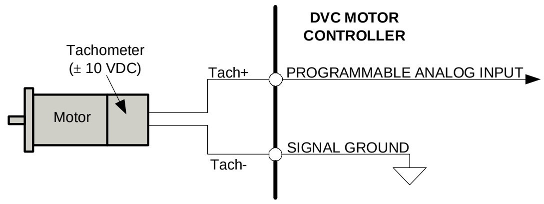
Hall Sensors DVC motor controllers accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive allows differential or single-ended Hall Sensor inputs. For single-ended Hall signals leave the negative terminals open. Verify on the motor datasheet that the voltage and current rating of the +5V, 250mA supply output will work with the Hall Sensors before connecting.

FIGURE 4.7 Hall Sensor Input Connections



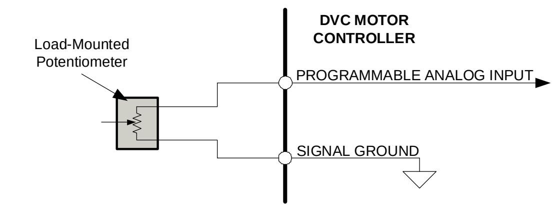
Tachometer (±10 VDC) DVC motor controllers support the use of a tachometer for velocity feedback. The differential Programmable Analog Input is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

FIGURE 4.8 Tachometer Input Connections



±10 VDC Position DVC motor controllers support the use of ±10 VDC position feedback, typically through the use of a load-mounted potentiometer. The differential Programmable Analog Input is available for ±10 VDC position feedback.

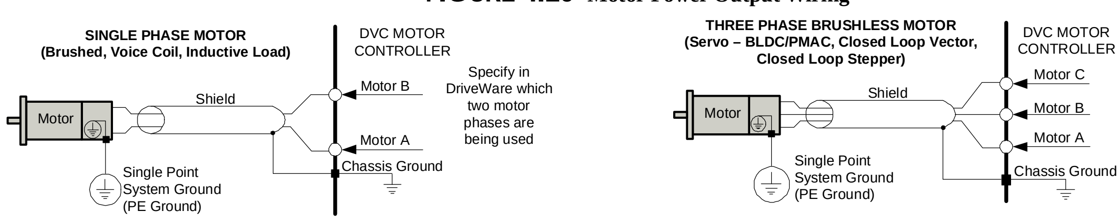
FIGURE 4.9 ±10 VDC Position Feedback Connections



4.1.4 Motor Connections

The diagrams below show how a DVC motor controller connects to single phase and three phase motors. Notice that the motor wires are shielded, and that the motor housing is grounded to the single point system ground (PE Ground). The cable shield should be grounded at the drive side to chassis ground.

FIGURE 4.10 Motor Power Output Wiring

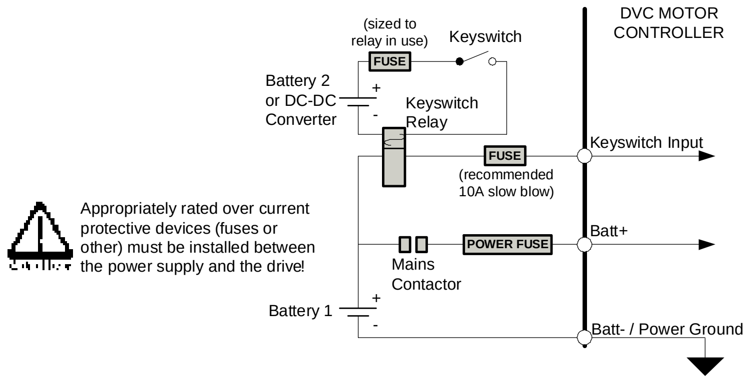


If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

4.1.5 Keyswitch Input

The Keyswitch input on DVC motor controllers provides logic power to the motor controller, and functions as the master switch. The Keyswitch must be on in order for the motor controller to function.

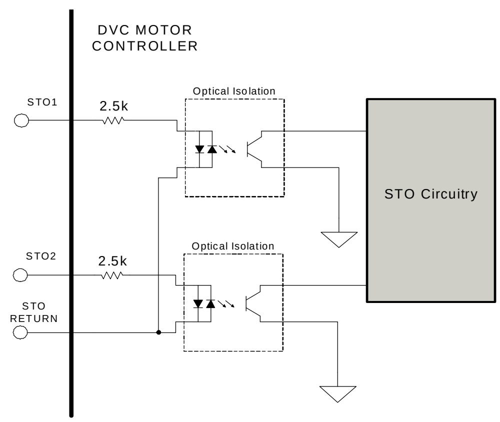
FIGURE 4.11 Keyswitch Input



4.1.6 STO (Safe Torque Off)

DVC drives feature dedicated +24VDC sinking single-ended inputs for STO functionality. Both STO1 and STO2 must be active (HIGH) to allow torque output at the DVC motor outputs.

FIGURE 4.12 STO Connections



STO Operation Test

The operation of the STO monitoring circuit (STO1 and STO2) must be verified at least once per month. The following procedure provides an example of a method to verify correct STO functionality. Note that it is the responsibility of the system operator to ensure all personal and machine safety requirements for the system are properly enforced during the proof test.

1. **Power on the drive.**
2. **Verify the drive is in an Enabled state (by monitoring via a digital controller or network commands).**

3. Remove the voltage signal from the STO1 input pin via a digital controller signal, network command.
4. Verify that the drive is in a Disabled state (via network commands or through the setup software).
5. Re-apply the voltage signal to the STO1 pin. Verify that the drive is once again in an Enabled state (by monitoring via a digital controller or network commands).
6. Repeat the above steps for the STO2 signal.

Note

End-product certification may require a different interval test schedule or test requirements. It is the responsibility of the end-user to determine the required test interval and requirements for certifications other than stated above.

4.1.7 LED Functionality

DVC motor controllers feature LED status indicators for bridge status and USB connection status.

Status LED The Status LED indicates whether the drive power bridge is enabled or disabled.

Status LED	
State	Description
GREEN	Power output bridge is enabled
RED	Power output bridge is disabled

4.1.8 Communication and Commissioning

DVC motor controllers include a CANopen interface for networking and a USB interface for drive configuration and setup. The CANopen node ID is set by DIP Switches under the DVC access panel. The DIP Switch settings take effect after the drive is power cycled. Table 4.4 shows the CANopen node ID DIP Switch information.

TABLE 4.4 CANopen Node ID Dip Switch Settings

Switch	Description	Setting	
		On	Off
1	Bit 0 of binary CANopen node ID.	1	0
2	Bit 1 of binary CANopen node ID.	1	0
3	Bit 2 of binary CANopen node ID.	1	0
4	Bit 3 of binary CANopen node ID.	1	0
5	Bit 4 of binary CANopen node ID.	1	0
6	Bit 5 of binary CANopen node ID.	1	0

The default CANopen bit rate is set in the DVC EEPROM at 1000 kbits/sec.

CANopen Interface

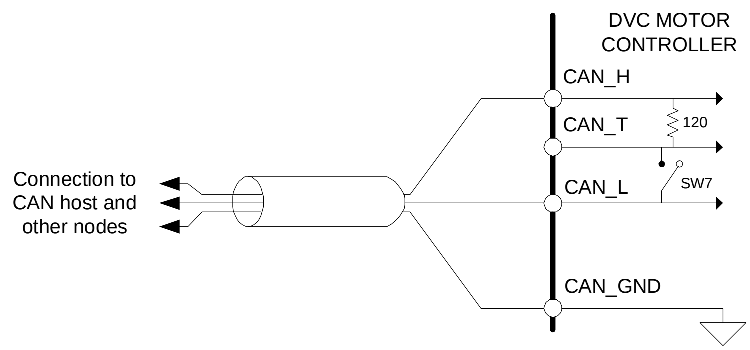
Note that in order to send commands to the drive over the CAN bus, the command source must be set to Communication Channel in the Command Source tab in DriveWare. If the drive is the last node on the CANopen network, there are two options for CAN termination:

- Connect CAN_T pin (P-8) to CAN_L (P-19)

  or:

- Set DIP Switch #7 to ON

FIGURE 4.13 CANopen Interface



USB Interface

For drive commissioning, the DVC motor controller must be connected to a PC running ADVANCED Motion Controls' DriveWare software. The mini type-b USB port on the DVC motor controller should be used with a STD-A to MINI-B USB cable for connection to a USB port on a PC.

FIGURE 4.14 USB Connectors

MINI TYPE-B USB Connector

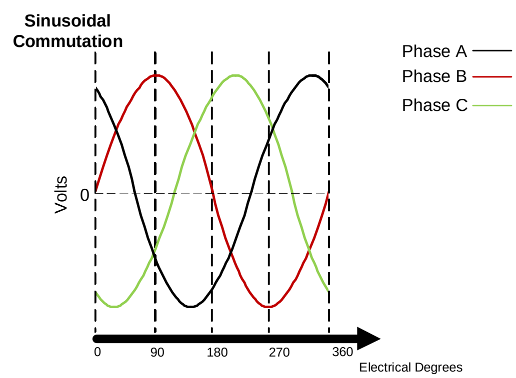
4.1.9 Commutation

Motor commutation is the process that maintains an optimal angle between the magnetic field created by the permanent magnets in the motor and the electromagnetic field created by the currents running through the motor windings. This process ensures optimal torque or force generation at any motor position. Single phase (brushed) motors accomplish this process with internal commutators built into the motor housing. Three phase (brushless) motors require a correctly configured drive to commutate properly, however.

See the DriveWare Software Guide for more information on AutoCommutation, Manual Commutation, and Phase Detect. DVC motor controllers allow either sinusoidal or trapezoidal commutation.

Sinusoidal Commutation Sinusoidal commutation provides greater performance and efficiency than trapezoidal commutation. DVC motor controllers can commutate sinusoidally when connected to a motor-mounted encoder. Sinusoidal Commutation works by supplying current to each of the three motor phases smoothly in a sinusoidal pattern. The flow of current through each phase is shifted by 120 degrees. The sum of the current flowing through all three phases adds up to zero. Figure 4.15 shows one electrical cycle of the motor phase currents.

FIGURE 4.15 Sinusoidal Commutation Motor Phase Currents

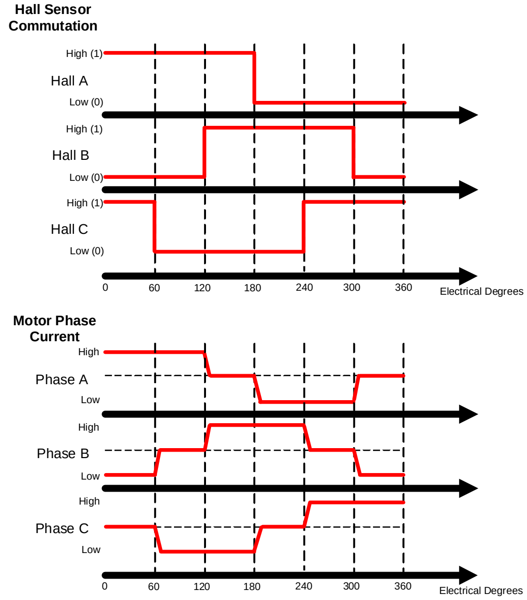


Trapezoidal Commutation Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DVC motor controllers can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at a time with trapezoidal commutation. The Hall Sensors each generate a square wave with a certain phase difference (either 120- or 60-degrees) over one electrical cycle of the motor. This results in six distinct Hall states for each electrical cycle. Depending on the motor pole count, there may be more than one electrical cycle per motor revolution. The number of electrical cycles in one motor revolution is equal to the number of motor poles divided by 2. For example:

- a 6-pole motor contains 3 electrical cycles per motor revolution
- a 4-pole motor contains 2 electrical cycles per motor revolution
- a 2-pole motor contains 1 electrical cycle per motor revolution

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 4.16.

FIGURE 4.16 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing



Note: Not all ADVANCED Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

Table 4.5 shows the default commutation states for 120-degree and 60-degree phasing. Depending on the specific setup, the sequences may change after running Auto Commutation.

TABLE 4.5 Digital Drive Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

4.1.10 Homing

DVC motor controllers can be configured in DriveWare to "home" to a certain reference signal. This reference signal can be any number of different signal types, such as limit switches, home switches, or encoder index pulses. See the DriveWare Software Guide for more information on Homing.

4.1.11 Firmware

DVC motor controllers are shipped with the latest version of firmware already stored in the drive. Periodic firmware updates are posted on ADVANCED Motion Controls' website, www.a-m-c.com. See the DriveWare Software Guide for information on how to check the drive's firmware version, and how to download new firmware into the drive when necessary.

A Specifications

A.1 Specifications Tables

TABLE A.1 Power Specifications - DC Input DVC Drives

Description	Units	250A060	200A100
DC Supply Voltage Range	VDC	20-54	20-80
DC Bus Over Voltage Limit	VDC	59	92
DC Bus Under Voltage Limit	VDC	18	16
Logic Supply Voltage (Keyswitch)	VDC	20-54	20-80
Maximum Peak Output Current	A	250	200
Maximum Continuous Output Current	A	150	125
Max. Continuous Output Power	W	7695	9500
Max. Continuous Power Dissipation	W	405	500
PWM Switching Frequency	kHz	14	14.6
Internal Bus Capacitance	F	12600	6000
Minimum Load Inductance (Line-To-Line)	H	200	250

TABLE A.2 Control Specifications

Description	DVC
Network Communication	CANopen (USB for Configuration)
Command Sources	± 10V Analog, Over the Network, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Profile Current, Profile Velocity, Profile Position, Interpolated Position Mode (PVT)
Motors Supported	Three Phase Brushless (Servo, Closed Loop Vector, Closed Loop Stepper), Single Phase (Brushed, Voice Coil, Inductive Load)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	4 Inputs, 4 Outputs
Programmable Analog I/O	2 Inputs
Primary I/O Logic Level	24 VDC

TABLE A.3 Environmental Specifications

Environmental Specifications	
Parameter	Description
Baseplate Temperature Range	0 - 75 °C (32 - 167 °F)
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m
IP Rating	65

TABLE A.4 Feedback Specifications

Feedback Specifications	
Parameter	**Value**
Maximum Incremental Encoder Input Frequency	20MHz (5 pre-quadrature)
Maximum Sin/Cos Encoder Input Frequency	200kHz
Maximum Hall Sensor Input Frequency	0.15 x PWM Switching Frequency
Maximum Tachometer Voltage	±10VDC

TABLE A.5 24 VDC Digital I/O Specifications

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

24VDC Isolated Digital Output	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA sinking, 8mA sourcing

A.2 Mounting Dimensions

DVC motor controllers provide mounting hole locations on the baseplate allowing either vertical or horizontal mounting configurations. Motor controllers can be mounted to a heatsink or other plane surface

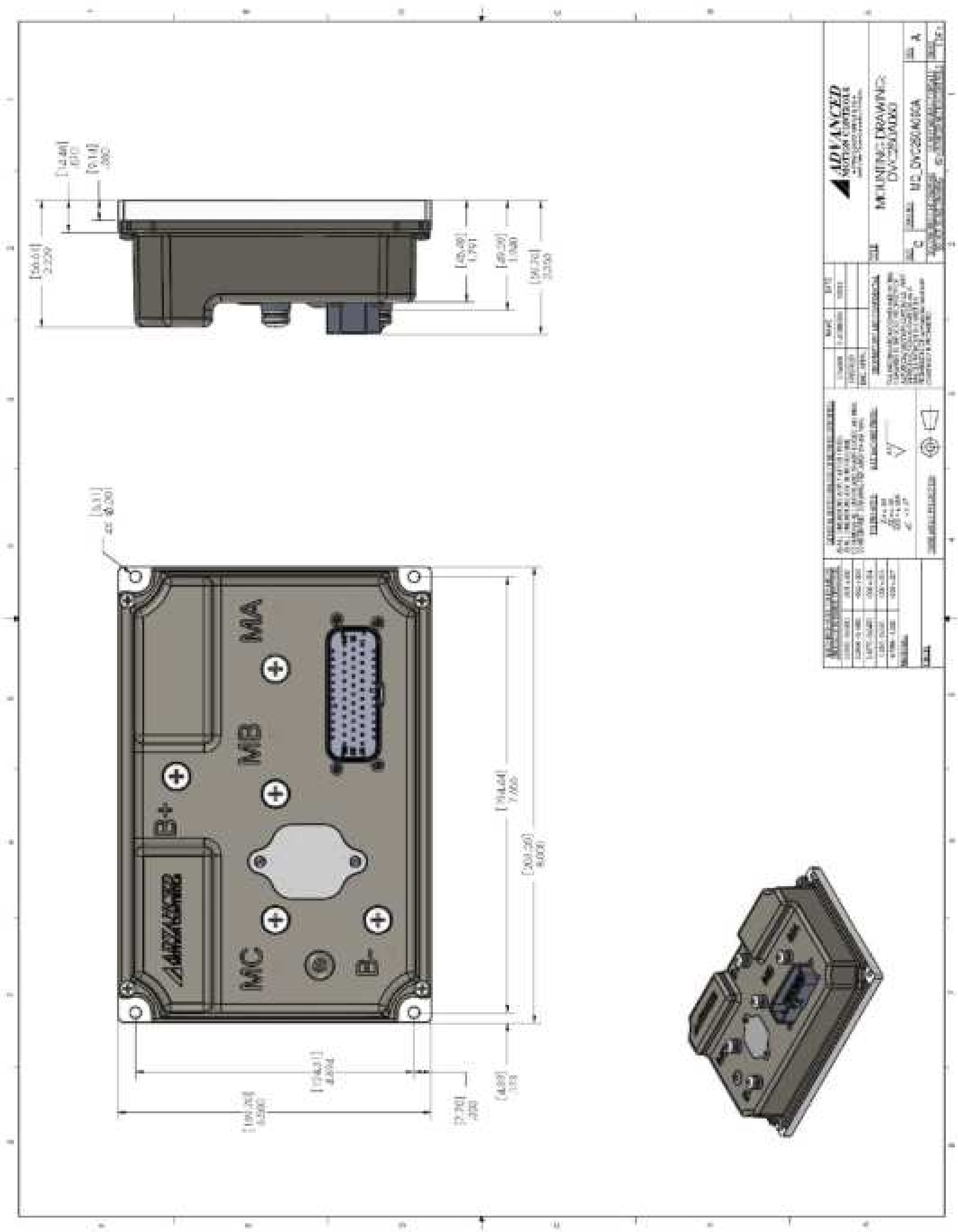


FIGURE A.1 DVC Mounting Dimensions

B Troubleshooting

This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

B.1 Fault Conditions and Symptoms

A fault condition can either be caused by a system parameter in excess of software or hardware limits, or by an event that has been user-configured to disable the drive upon occurrence.

To determine whether the drive is in a fault state, use the Drive Status function in DriveWare to view active and history event items and drive fault conditions. See the DriveWare Software Guide for more information on reading the Drive Status window. Some common fault conditions caused by hardware issues are listed below.

Over-Temperature Verify that the baseplate temperature is less than the drive Baseplate Temperature value. The drive remains disabled until the temperature at the drive baseplate falls below this threshold. See "Baseplate Temperature Range" on page 24 or consult the drive datasheet for the allowable temperature range.

Over-Voltage Shutdown

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Power Supply Selection and Sizing" on page 17 for more information.

Under-Voltage Shutdown Verify power supply voltage for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply cannot provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing, power ground, and also phase-to-phase. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

Invalid Hall Sensor State

See the "Commutation Sequence" table in "Commutation" on page 45 for valid commutation states. If the drive is disabled check the following:

1. Check the voltage levels for all the Hall sensor inputs.
2. Make sure all Hall Sensor lines are connected properly.

B.1.1 Software Limits

Because DriveWare allows user configuration of many system parameters such as current, velocity, and position limits, as well as an associated "event action" for DriveWare to take when the system reaches this limit, it is possible for a drive to appear to be inoperative when in actuality it is simply in an assigned disable state.

For example, the motor velocity can be limited by giving a value to the Motor Over Speed selection in DriveWare. An "event action", such as "Disable the Power Bridge", can also be assigned for this particular limiting event for DriveWare to take if the motor reaches this speed. If the motor does happen to reach this velocity limit, DriveWare will automatically cut power to the drive's output in this particular case, and the drive will be disabled. In the Drive Status window, "Motor Over Speed" will be shown as a "history" event, and "Commanded Disable" will be shown as an "Action" event.

Depending on each specific system and application, there are many different options available for assigning system limits and associated actions. See the DriveWare Software Guide for more information.

B.1.2 Connection Problems

Connection problems are oftentimes caused by incorrect communication settings in DriveWare. The default factory setting for DVC motor controllers is a Drive Address of 63. When connecting to the drive with DriveWare for the first time, the default factory settings will have to be used. Once the connection has been established, the Drive Address may be changed. Check all communications settings to be sure that the Drive Address is correct.

Faulty connection cables are also a possible cause of connection problems. Check all cables for any shorts or intermittent connections. Also check that all port hardware (USB-to-serial, etc.) is properly installed and configured.

B.1.3 Overload

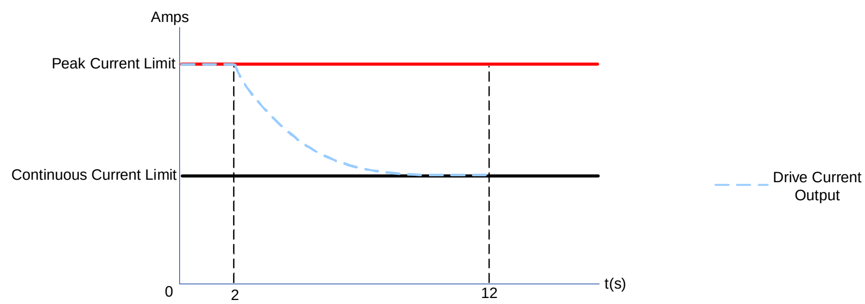
Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip.

Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive datasheets for minimum inductance requirements.

B.1.4 Current Limiting

All drives incorporate a “fold-back” circuit for protection against over-current. This “fold-back” circuit uses an approximate “I t” algorithm to protect the drive. All drives can run at peak current for a maximum of 2 seconds (each direction). Currents below this peak current but above the continuous current can be sustained for a longer time period, and the drive will automatically fold back at an approximate rate of "I t" to the continuous current limit within a time frame of less than 10 seconds. An over-current condition will not cause the drive to become disabled unless configured to do so in DriveWare.

FIGURE B.1 Peak Current Fold-Back



B.1.5 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, or by using DriveWare to reverse the internal velocity feedback polarity setting.

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper motor commutation or poor loop tuning. Follow the steps in the DriveWare Software Guide to properly commutate and tune the motor.

B.1.6 Causes of Erratic Operation

- Improper grounding (i.e., drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive voltage spikes on bus.

B.2 Technical Support

For help from the manufacturer regarding drive set-up or operating problems, please gather the following information:

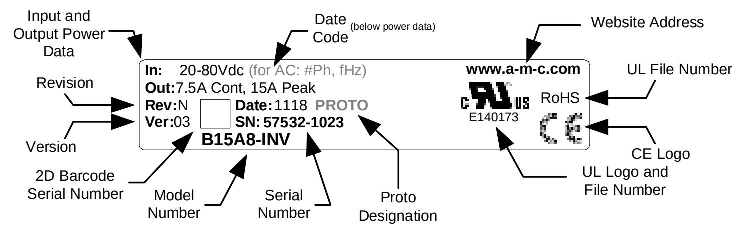
B.2.1 Drive Model Information

- DC bus voltage and range.
- Motor type, including inductance, torque constant, and winding resistance.
- Length and make-up of all wiring and cables.
- If brushless, include Hall sensor information.
- Type of controller, plus full description of feed back devices.
- Description of problem: instability, run-away, noise, over/under shoot, or other description.
- Complete part number and serial number of the product. Original purchase order is helpful, but not necessary.

B.2.2 Product Label Description

The following is a typical example of a product label as it is found on the drive:

FIGURE B.2 Product Label



1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with the same model number and revision letter ('01' is the earliest release of any revision).
4. Proto Designation: When included, indicates that the model is a prototype unit and model number will also begin with an 'X' designator.
5. Serial Number: The serial number consists of a 5-digit lot number followed by a 4-digit sequence number. Each product is assigned a unique serial number to track product life cycle history.
6. Date Code: The date code is a 4-digit number signifying the year and week of manufacture. The first two digits designate the year and the second two digits designate the week (e.g. the drive label shown would have been built in the year 2011 during the 18th week).
7. Input and Output Power Data: Includes basic power parameters of the product.
8. General Information: Displays applicable agency approvals, UL file reference number, and compliance approvals. More complete product information is availabe by following the listed website.

B.2.3 Warranty Returns and Factory Help

Seller warrants that all items will be delivered free from defects in material and workmanship and in conformance with contractual requirements. The Seller makes no other warranties, express or implied and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Seller's exclusive liability for breach of warranty shall be limited to repairing or replacing at the Seller's option items returned to Seller's plant at Buyer's expense within one year of the date of delivery. The Seller's liability on any claim of any kind, including negligence, for loss or damage arising out of, connected with or resulting from this order, or from the performance or breach thereof or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under this order shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim and in the event Seller fails to manufacture or deliver items other than standard products that appear in Seller's catalog. Seller's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. IN NO EVENT SHALL THE SELLER BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Buyer will take all appropriate measures to advise users and operators of the products delivered hereunder of all potential dangers to persons or property, which may be occasioned by such use. Buyer will indemnify and hold Seller harmless from all claims of any kind for injuries to persons and property arising from use of the products delivered hereunder. Buyer will, at its sole cost, carry liability insurance adequate to protect Buyer and Seller against such claims.

All returns (warranty or non-warranty) require that you first obtain a Return Material Authorization (RMA) number from the factory.

Request an RMA number by:

web	www.a-m-c.com/download/form/form_rma.html
telephone	(805) 389-1935
fax	(805) 389-1165

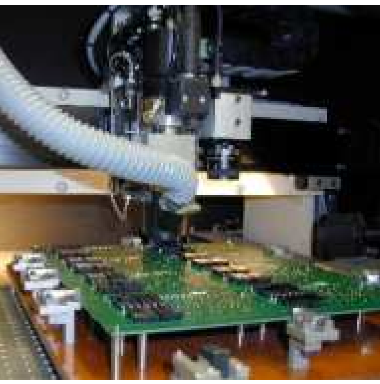
Index

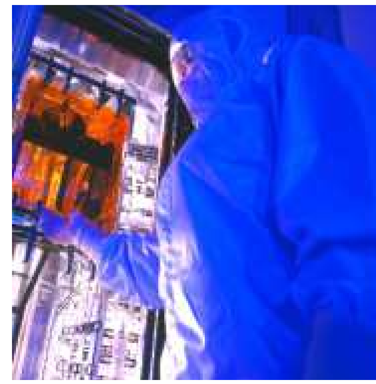
DVC Motor Controllers
Hardware Installation Manual
MNDVDCIN-02

ADVANCED MOTION CONTROLS

3805 Calle Tecate Camarillo, CA 93012-5068
Tel: (805) 389-1935 Fax: (805) 389-1165 www.a-m-c.com

ADVANCED MOTION CONTROLS





Everything's possible.

DigiFlex® Performace™ DPR Drives

RS485 and Modbus RTU Communication

Hardware Installation Manual

www.a-m-c.com

ORIGINAL INSTRUCTIONS

MNDGDRIN-12

Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the most recent software, the latest revisions of this manual, and copies of compliance and declarations of conformity, visit the company's website at www.a-m-c.com. Otherwise, contact the company directly at:

ADVANCED Motion Controls • 3805 Calle Tecate Camarillo, CA • 93012-5068 USA

Agency Compliances

The company holds original documents for the following:

- UL 508c, file number E140173
- Electromagnetic Compatibility, EMC Directive - 2014/30/EU
  EN61000-6-2:2005
  EN61000-6-4:2007/A1:2011
  Electrical Safety, Low Voltage Directive - 2014/35/EU
  EN 60204-1:2006/A1:2009
- Reduction of Hazardous Substances (RoHS III), 2015/863/EU
- Functional Safety Type Approved, TUV Rheinland

Trademarks

ADVANCED Motion Controls®, the combined isosceles trapezoid/right triangle logo, **DIGIFLEX®, DIGIFLEX® Performance™** and DriveWare® are either registered trademarks or trademarks of *ADVANCED* Motion Controls in the United States and/or other countries. All other trademarks are the property of their respective owners.

Related Documentation

- Product datasheet specific for your drive, available for download at www.a-m-c.com
- DriveWare Software Guide, available for download at www.a-m-c.com
- Serial Communication Manual, available for download at www.a-m-c.com
- Modbus Communication Manual, available for download at www.a-m-c.com

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.

Note	Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.
Notice	Notice - Required instruction necessary to ensure successful completion of a task or procedure.
Caution	Caution - Instructs and directs you to avoid damaging equipment.
Warning	Warning - Instructs and directs you to avoid harming yourself.
DANGER	Danger - Presents information you must heed to avoid serious injury or death.

Revision History

Document ID	Revision #	Date	Changes
MNDGDRIN-01	1	6/2009	DPR Install Manual First Release
MNDGDRIN-02	2	3/2010	- Removed DPRNLIR control module
MNDGDRIN-03	3	3/2011	- Added DPRxxxx-015S400 drive model information
MNDGDRIN-04	4	9/2012	- Updated for DriveWare 7 information - Updated for RMS Charge-Based Limiting Capabilities
MNDGDRIN-05	5	10/2013	- Added DPRxxxx-C060A400 and DPRxxxx-C100A400 drive model information
MNDGDRIN-06	6	10/2014	- Added STO wiring recommendation
MNDGDRIN-07	7	2/2015	- Removed DPRAHIA, DPRAHIR, DPRNLIE control modules
MNDGDRIN-08	8	3/2015	- Added Modbus RTU Support
MNDGDRIN-09	9	1/2016	- Removed DPRxxxx-015A400 drive model information (reserved)
MNDGDRIN-10	10	3/2017	- Added DPRxxxx-040A400 drive model information
MNDGDRIN-11	11	11/2017	- Added DPRxxxx-100B080 drive model information
MNDGDRIN-12	12	5/2018	- Added 2-Phase Stepper Motor Information - Added PDO power-up delay information

Contents

1 Safety

This section discusses characteristics of your DPR Digital Drive to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

1.1 General Safety Overview

In order to install a DPR drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Caution

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Notice

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.

Warning

Keep clear of all exposed power terminals (motor, DC Bus, shunt, DC power, transformer) when power is applied to the equipment. Follow these safety guidelines:

- When using a separate logic supply, turn on the logic power supply first before turning on the main power supply.
- Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.
- Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative.
- Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.
- Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.
- Do not make any connections to the drive while power is applied.

Caution

- Do not reverse the power supply leads! Severe damage will result!
- If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

Use sufficient capacitance!

Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Caution

Make sure minimum inductance requirements are met!

Pulse Width Modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 ∝H.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2 Products and System Requirements

This document is intended as a guide and general overview in selecting, installing, and operating *ADVANCED* Motion Controls DigiFlex Performance™ digital servo drives that use RS-485 or Modbus RTU for networking. These specific drives are referred to herein and within the product literature as DPR drives. Other drives in the DigiFlex Performance product family that utilize other methods of network communication such as CANopen , EtherCAT , or POWERLINK / Modbus TCP / Ethernet are discussed in separate manuals that are available at www.a-m-c.com. Contained within each DigiFlex Performance product family manual are instructions on system integration, wiring, drive-setup, and standard operating methods.

2.1 DPR Drive Family Overview

The DPR ddrive family can power three phase or single phase brushless or brushed servomotors, two phase or three phase closed loop stepper motors, and closed loop vector AC induction motors. The command source can be generated externally or can be supplied internally. A digital controller can be used to command and interact with DPR drives, and a number of dedicated and programmable digital and analog input/output pins are available for parameter observation and drive configuration. DPR drives are capable of operating in Current (Torque), Velocity, or Position Mode, and utilize Space Vector Modulation, which results in higher bus voltage utilization and reduced heat dissipation compared to traditional PWM. DPR drives also offer a variety of feedback options.

DPR drives offer RS-485 or Modbus RTU communication for multiple drive networking, and feature an RS-232 serial communication interface for drive configuration and setup. Drive commissioning is accomplished using DriveWare 7, the setup software from *ADVANCED* Motion Controls, available for download at www.a-m-c.com.

2.1.1 Drive Datasheet

Each DPR digital drive has a separate datasheet that contains important information on the options and product-specific features available with that particular drive. The datasheet is to be used in conjunction with this manual for system design and installation.

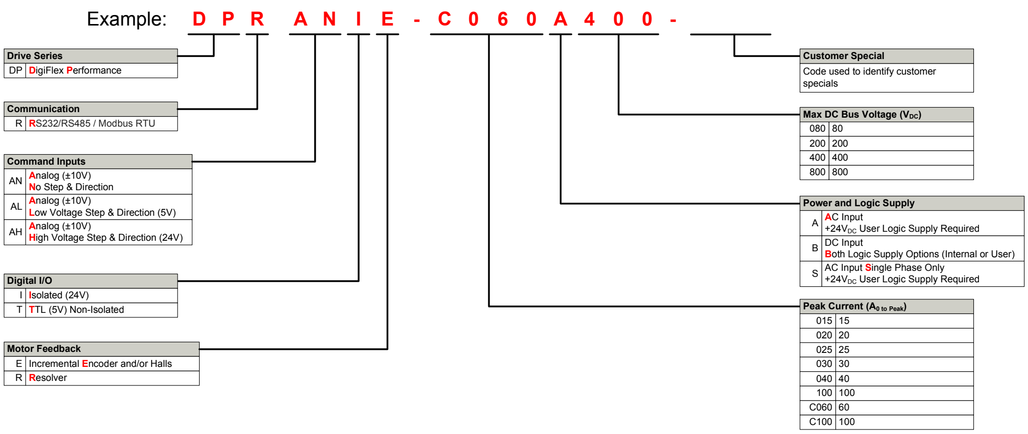
Caution

In order to avoid damage to equipment, only after a thorough reading and understanding of this manual and the specific datasheet of the DPR drive being used should you attempt to install and operate the drive.

2.2 Products Covered

The products covered in this manual adhere to the following part numbering structure. However, additional features and/or options are readily available for OEM's with sufficient ordering volume. Feel free to contact *ADVANCED* Motion Controls for further information.

FIGURE 2.1 DPR Part Numbering Structure*



* Note that not all possible part number combinations are offered as standard drives. For a list of standard drives, see "Drive Models" on page 7.

When selecting a DPR drive, follow the part numbering structure above to determine the Digital I/O, Motor Feedback, and Power Module choices that are applicable for the end application. The tables below outline the features and specifications that are available for standard DPR drive models.

TABLE 2.1 Control Specifications

Description	Control Specifications: DPRAHIx	DPRANIx	DPRALTx
Network Communication	RS-485 or Modbus RTU		
Command Sources	±10V Analog, 24V Step and Direction, Encoder Following, Over the Network, PWM and Direction, Sequencing, Indexing, Jogging	±10V Analog, Encoder Following, Over the Network, PWM and Direction, Sequencing, Indexing, Jogging	±10V Analog, 5V Step and Direction, Encoder Following, Over the Network, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal		
Control Modes[1]	Current (Torque), Velocity, Hall Velocity, Position		
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)		
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage		
Programmable Digital I/O	10/4		6/4
Programmable Analog I/O	4/0	4/1	3/2
Primary I/O Logic Level	24 VDC		5V TTL

1. Hall Velocity mode may not be supported on certain drives. Check the drive datasheet to see if Hall Sensors are supported.

TABLE 2.2 Feedback Options

Description	Feedback Supported DPRxxxE	DPRxxxR
Hall Sensors		
Incremental Encoder		
Auxiliary Incremental Encoder		
Resolver		
1Vp-p Sine/Cosine Encoder		
±10 VDC Position		
Tachometer (±10 VDC)		

TABLE 2.3 Power Specifications - AC Input DPR Drives

		Power Specifications						
Description	Units	015S400	030A400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	264	528	528
AC Input Phases[2]	-	1	3	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	123-373	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	429	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	30 (21.2)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	15 (15)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[2]	W	2415	4831	6441	9662	16103	6840	13680
Max. Continuous Power Dissipation @ Rated Voltage	W	127	254	339	509	848	360	720
Internal Bus Capacitance	∝F	540	1410	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	20	25	20	20	note 3	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	600	3000	3000

1. Certain 3-phase drive models can operate on single-phase VAC if peak/cont. current ratings are reduced by at least 30%.
2. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
3. Contact factory before using an external shunt resistor with this power module

TABLE 2.4 Power Specifications - DC Input DPR Drives

		Power Specifications					
Description	Units	020B080	040B080	060B080	100B080	025B200	015B200
DC Supply Voltage Range	VDC	20-80	20-80	20-80	20-80	20-190	40-190
DC Bus Over Voltage Limit	VDC	86	86	86	88	198	198
DC Bus Under Voltage Limit	VDC	17	17	17	17	17	35
Maximum Peak Output Current	A (Arms)	20 (14.1)	40 (28.3)	60 (42.4)	100 (70.7)	25 (17.7)	15 (10.6)
Maximum Continuous Output Current	A (Arms)	10 (10)	20 (20)	30 (30)	60 (60)	12.5 (12.5)	7.5 (7.5)
Max. Continuous Output Power	W	760	1520	2280	4560	2256	1354
Max. Continuous Power Dissipation	W	40	80	120	230	118	71
PWM Switching Frequency	kHz	20	20	20	20	20	20
Internal Bus Capacitance	∝F	33	500	500	500	50	20
Minimum Load Inductance (Line-To-Line)	∝H	250	250	250	250	300	250

2.3 Drive Models

The standard drive models in the below tables are formed by combining a power module and a control module that will best suit the end application and system requirements.

TABLE 2.5 AC Drive Models

Drive Number	VAC (Nominal)	Peak Current (A)	Continuous Current (A)
DPRAHIE-015S400	100-240	15	7.5
DPRAHIE-030A400	100-240	30	15
DPRAHIE-040A400	100-240	40	20
DPRAHIE-C060A400	200-240	60	30
DPRAHIE-C100A400	200-240	100	50
DPRAHIE-030A800	200-480	30	15
DPRAHIE-060A800	200-480	60	30
DPRANIE-015S400	100-240	15	7.5
DPRANIE-030A400	100-240	30	15
DPRANIE-040A400	100-240	40	20
DPRANIE-C060A400	200-240	60	30
DPRANIE-C100A400	200-240	100	50
DPRANIE-030A800	200-480	30	15
DPRANIE-060A800	200-480	60	30
DPRANIR-015S400	100-240	15	7.5
DPRANIR-030A400	100-240	30	15
DPRANIR-040A400	100-240	40	20
DPRANIR-C060A400	200-240	60	30
DPRANIR-C100A400	200-240	100	50
DPRANIR-030A800	200-480	30	15
DPRANIR-060A800	200-480	60	30

TABLE 2.6 DC Drive Models

Drive Number	VDC (Nominal)	Peak Current (A)	Continuous Current (A)
DPRALTE-020B080	20-80	20	10
DPRALTE-040B080	20-80	40	20
DPRALTE-060B080	20-80	60	30
DPRALTE-015B200	40-190	15	7.5
DPRALTE-025B200	20-190	25	12.5
DPRALTR-020B080	20-80	20	10
DPRALTR-040B080	20-80	40	20
DPRALTR-060B080	20-80	60	30
DPRALTR-015B200	40-190	15	7.5
DPRALTR-025B200	20-190	25	12.5
DPRANIE-100B080	20-80	100	60

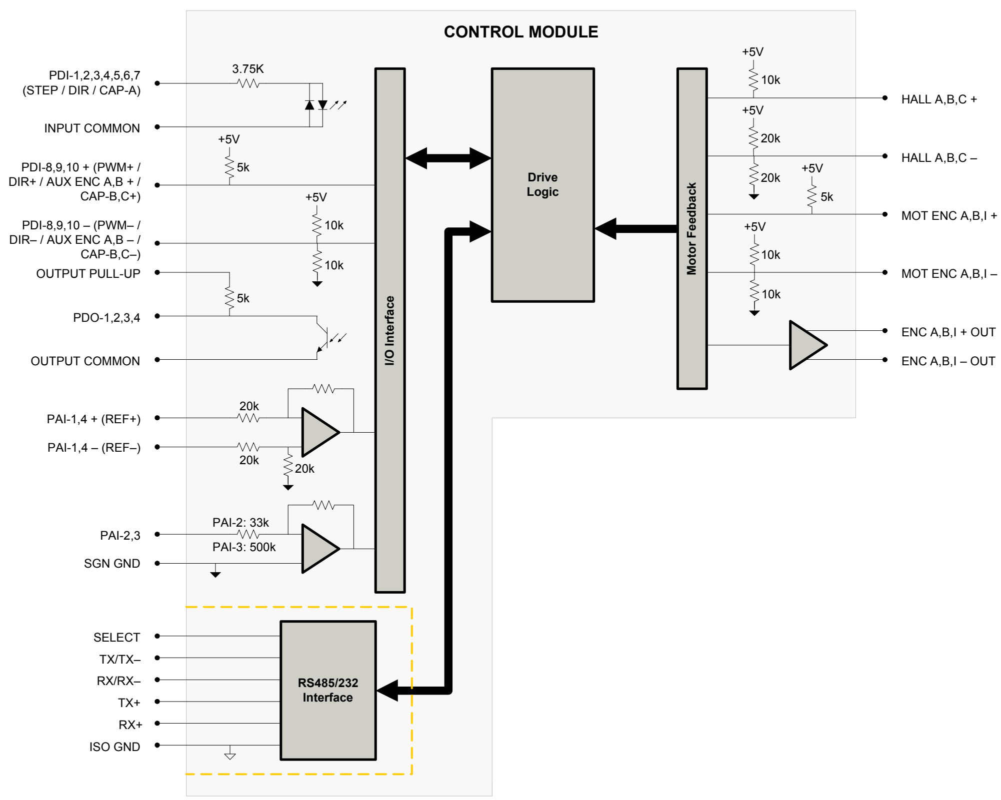
2.3.1 Control Modules

The DPR drive family consists of 5 different control modules. They are primarily differentiated by the method of command, the type of feedback allowed, and the primary I/O logic level. The diagrams in this section show the general block diagrams for the different control modules. For complete pinouts, consult the specific drive's datasheet.

DPRAHIE

- RS-485 or Modbus RTU Communication
- ±10 VDC Position, Incremental Encoder, Hall Sensor, Auxiliary Incremental Encoder, Tachometer (±10 VDC) Feedback
- ±10 V Analog, 24V Step and Direction, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources
- Drives Three Phase and Single Phase Motors
- 10 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 4 Programmable Analog Inputs (PAIs)
- 24 VDC Primary I/O Logic Level

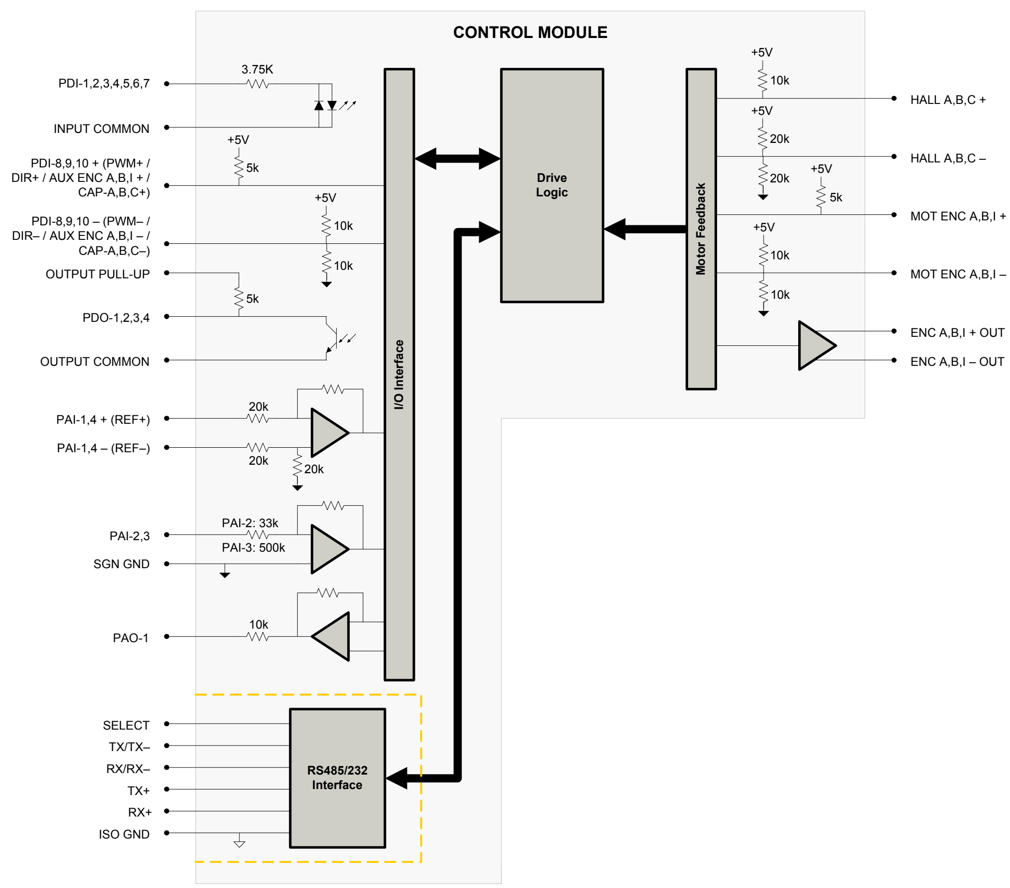
FIGURE 2.2 DPRAHIE Control Module



DPRANIE

- RS-485 or Modbus RTU Communication
- ±10 VDC Position, Auxiliary Incremental Encoder, Hall Sensor, Incremental Encoder, Tachometer (±10 VDC) Feedback
- ±10 V Analog, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources
- Drives Three Phase and Single Phase Motors
- 10 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 4 Programmable Analog Inputs (PAIs)
- 1 Programmable Analog Output (PAO)
- 24 VDC Primary I/O Logic Level

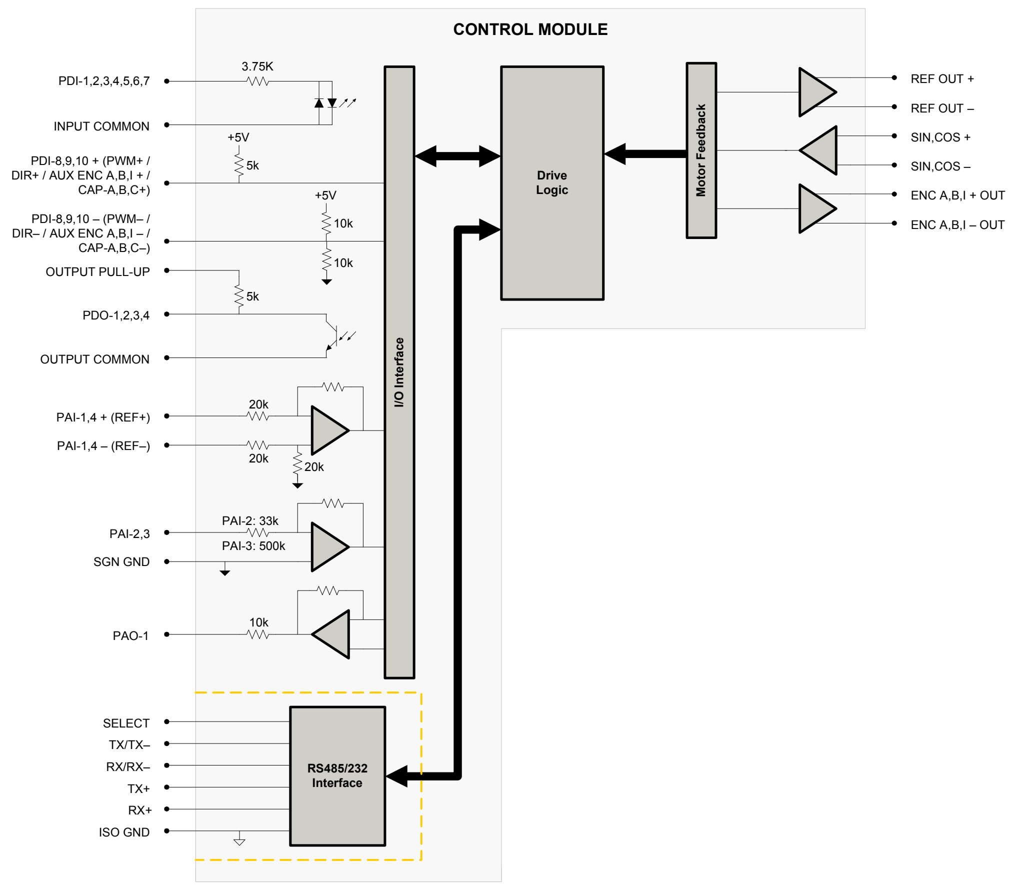
FIGURE 2.3 DPRANIE Control Module



DPRANIR

- **RS-485 or Modbus RTU Communication**
- **±10 VDC Position, Auxiliary Incremental Encoder, Resolver, Tachometer (±10 VDC) Feedback**
- **±10 V Analog, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources**
- **Drives Three Phase and Single Phase Motors**
- **10 Programmable Digital Inputs (PDIs)**
- **4 Programmable Digital Outputs (PDOs)**
- **4 Programmable Analog Inputs (PAIs)**
- **1 Programmable Analog Output (PAO)**
- **24 VDC Primary I/O Logic Level**

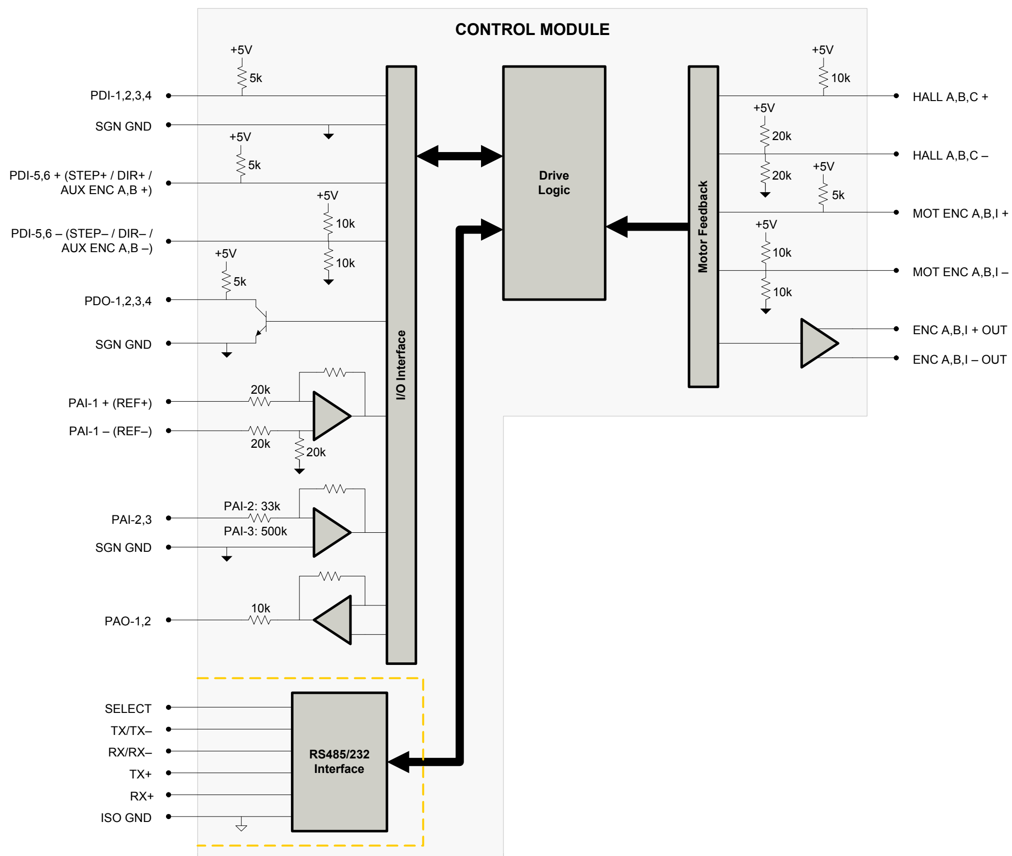
FIGURE 2.4 **DPRANIR Control Module**



DPRALTE

- RS-485 or Modbus RTU Communication
- ±10 VDC Position, Auxiliary Incremental Encoder, Halls, Incremental Encoder, Tachometer (±10 VDC) Feedback
- ±10 V Analog, 5V Step and Direction, Encoder Following, Sequencing, Indexing, Jogging, or Network Command Sources
- Drives Three Phase and Single Phase Motors
- 6 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 3 Programmable Analog Inputs (PAIs)
- 2 Programmable Analog Outputs (PAOs)
- 5V TTL Primary I/O Logic Level

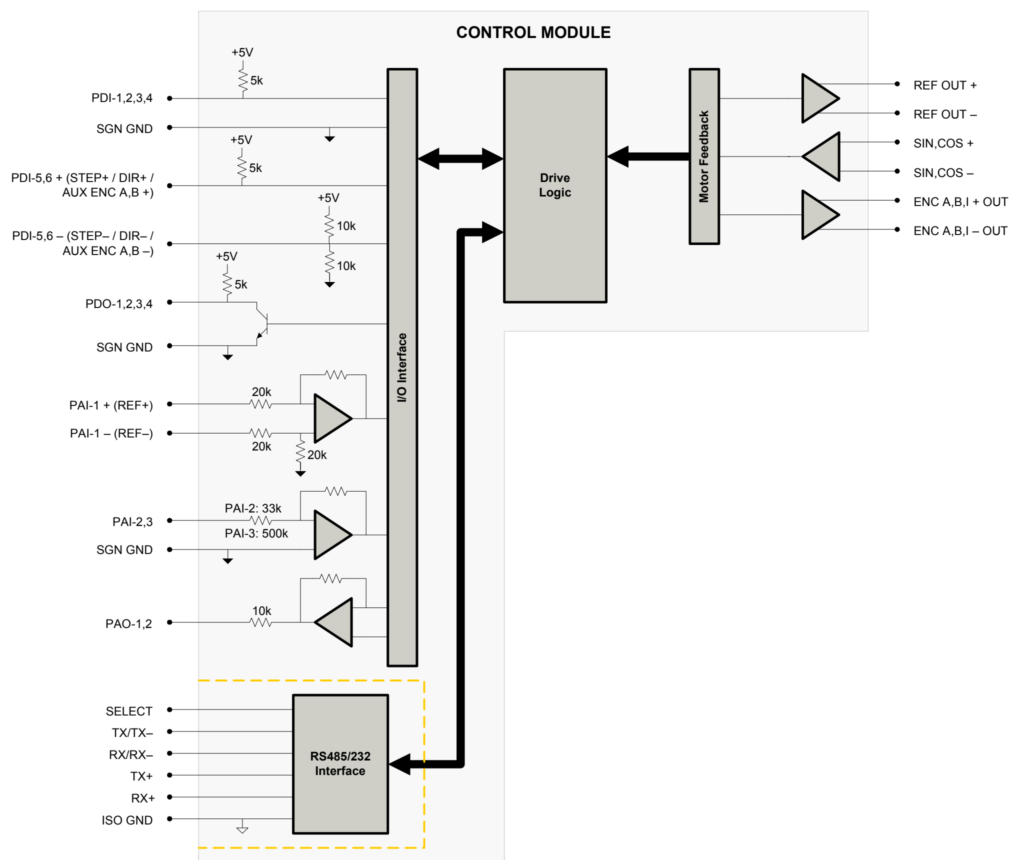
FIGURE 2.5 DPRALTE Control Module



DPRALTR

- RS-485 or Modbus RTU Communication
- ±10 VDC Position, Auxiliary Incremental Encoder, Resolver, Tachometer (±10 VDC) Feedback
- ±10 V Analog, 5V Step and Direction, Encoder Following, Sequencing, Indexing, Jogging, or Network Command Sources
- Drives Three Phase and Single Phase Motors
- 6 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 3 Programmable Analog Inputs (PAIs)
- 2 Programmable Analog Outputs (PAOs)
- 5V TTL Primary I/O Logic Level

FIGURE 2.6 DPRALTR Control Module



2.3.2 AC Power Modules

There are 6 AC power modules in the DPR drive family, providing a wide variety of current output and supply voltage selections.

015S400

- 15 A Peak Output Current
- 7.5 A Cont. Output Current
- 20 - 30 VDC Logic Supply Voltage
- 240 VAC (339 VDC) Rated Supply Voltage
- 1-Phase 100 - 240 VAC (127 - 373 VDC) Supply Voltage Range
- 2415 W Maximum Continuous Output Power at Rated Voltage.
- Internal Shunt Regulator
- External Shunt Resistor Connections

030A400

- 30 Amps Peak Output Current
- 15 Amps Continuous Output Current
- 20 - 30 VDC Logic Supply Voltage
- 240 VAC (339 VDC) Rated Supply Voltage
- 3-Phase 100 - 240 VAC (127-373 VDC) Supply Voltage Range
- 4831 W Max. Continuous Output Power at Rated Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

040A400

- 40 Amps Peak Output Current
- 20 Amps Continuous Output Current
- 20 - 30 VDC Logic Supply Voltage
- 240 VAC (339 VDC) Rated Supply Voltage
- 3-Phase 100 - 240 VAC (127-373 VDC) Supply Voltage Range
- 6441 W Max. Continuous Output Power at Rated Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

C060A400

- 60 Amps Peak Output Current
- 30 Amps Continuous Output Current
- 240 VAC (339 VDC) Rated Supply Voltage
- 3-Phase 200 - 240 VAC (255 - 373 VDC) Supply Voltage Range
- 9662 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

C100A400

- 100 Amps Peak Output Current
- 50 Amps Continuous Output Current
- 240 VAC (339 VDC) Rated Supply Voltage
- 20 - 30 VDC Logic Supply Voltage
- 3-Phase 200 - 240 VAC (255 - 373 VDC) Supply Voltage Range
- 16103 W Max. Continuous Output Power at Rated Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

030A800

- 30 Amps Peak Output Current
- 15 Amps Continuous Output Current
- 480 VAC (678 VDC) Rated Supply Voltage
- 3-Phase 200 - 480 VAC (255 - 747 VDC) Supply Voltage Range
- 6840 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Resistor
- Internal Shunt Regulator
- External Shunt Resistor Connections

060A800

- 60 Amps Peak Output Current
- 30 Amps Continuous Output Current
- 480 VAC (678 VDC) Rated Supply Voltage
- 3-Phase 200 - 480 VAC (255 - 747 VDC) Supply Voltage Range
- 13680 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

2.3.3 DC Power Modules

There are 5 DC power modules in the DPR drive family, each with a unique current output and supply voltage rating.

020B080

- **20 Amps Peak Output Current**
- **10 Amps Cont. Output Current**
- **20 - 80 VDC Supply Voltage Range**
- **760 W Maximum Continuous Output Power**
- **20 - 80 VDC Logic Supply Voltage (optional)**

040B080

- **40 Amps Peak Output Current**
- **20 Amps Cont. Output Current**
- **20 - 80 VDC Supply Voltage Range**
- **1520 W Maximum Continuous Output Power**
- **20 - 80 VDC Logic Supply Voltage (optional)**

060B080

- **60 Amps Peak Output Current**
- **30 Amps Cont. Output Current**
- **20 - 80 VDC Supply Voltage Range**
- **2280 W Maximum Continuous Output Power**
- **20 - 80 VDC Logic Supply Voltage (optional)**

100B080

- **100 Amps Peak Output Current**
- **60 Amps Cont. Output Current**
- **20 - 80 VDC Supply Voltage Range**
- **4560 W Maximum Continuous Output Power**
- **20 - 80 VDC Logic Supply Voltage (optional)**

015B200

- **15 Amps Peak Output Current**
- **7.5 Amps Cont. Output Current**
- **40 - 190 VDC Supply Voltage Range**
- **1354 W Maximum Continuous Output Power**
- **40 - 190 VDC Logic Supply Voltage (optional)**

025B200

- **25 Amps Peak Output Current**
- **12.5 Amps Cont. Output Current**
- **20 - 190 VDC Supply Voltage Range**
- **2256 W Maximum Continuous Output Power**
- **40 - 190 VDC Logic Supply Voltage (optional)**

2.4 Communication Protocol

DPR digital drives offer networking capability through either RS-485 or Modbus RTU communication.

2.4.1 RS-485 Communication

ADVANCED Motion Controls' proprietary serial protocol is a byte-based, binary, master-slave standard to access drive "commands" used on DPR drives. The drive commands provide read or write access to drive parameters, with each command containing one or more parameters. Each command is assigned a unique index number, and parameters within a command are given offset values. As a result, parameters are referenced using a combination of the command index and parameter offset values. The serial protocol utilizes variable length commands to access one or more parameters within an index.

On DPR drives, the RS-485 interface is provided through a transmit pin and a receive pin. These pins should be connected to the appropriate locations on a serial cable connector, as specified by the serial protocol. The reference point for the RS-485 signals is common with the signal ground of the drive. See "Communication and Commissioning" on page 56 for information on how to correctly setup and wire a RS-485 network using DPR drives.

For more detailed information on RS-485 communication, consult the *ADVANCED* Motion Controls Serial Communication Manual, available for download at www.a-m-c.com.

2.4.2 Modbus RTU Communication

Modbus is an open standard, master slave system developed for communication between multiple devices using a single wire. The Modbus protocol uses a defined message structure, regardless of the physical layer of the network used to communicate. A master device initiate a "query", and slave devices return a "response", supplying the requested data or taking the requested action. The query can be made to individual devices or broadcast to all connected devices. For more detailed information on Modbus RTU communication with DPR drives and a complete list of register definitions, consult the *ADVANCED* Motion Controls' Modbus Communication Manual available for download at www.a-m-c.com.

The Modbus RTU protocol for *ADVANCED* Motion Controls' DPR drives follows the Modbus Application Protocol Specification V1.1b. More information can be found at www.Modbus-IDA.org.

2.5 Feedback Supported

There are a number of different feedback options available in the DPR family of digital drives. The feedback element can be any device capable of generating a signal proportional to current, velocity, position, or any parameter of interest. Such signals can be provided directly by a potentiometer or indirectly by other feedback devices such as Hall Sensors or encoders. For information on the functional operation of the feedback devices, see "Feedback Operation" on page 48.

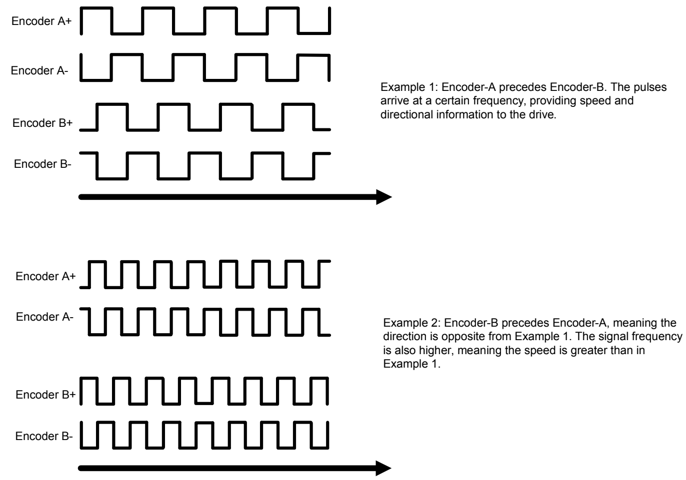
Feedback Polarity The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. The feedback element must be connected for *negative* feedback. Connecting the feedback element for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. The correct feedback polarity will be determined and configured during commissioning of the drive. Otherwise, to correct this, either change the order that the feedback lines are connected to the drive, or use DriveWare to reverse the internal velocity feedback polarity setting. For more information on how to properly connect the feedback element, see "Feedback Wires" on page 31.

2.5.1 Incremental Encoder

DPRxxxE drive models can utilize incremental encoder feedback for velocity or position control, with the option of also using the encoder to commutate the motor. The encoder provides incremental position feedback that can be extrapolated into very precise velocity or position information. With an encoder being used as the feedback element, the input command controls the motor velocity or motor position, with the frequency of the encoder pulses closing the velocity and/or position loop. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor's speed, position and direction of rotation. Based on the speed and order in which these pulses are received from the encoder, the drive can interpret the motor velocity and physical location. The actual motor speed and physical location can be monitored within the configuration software, or externally through network commands.

Figure 2.7 below represents differential encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated. By keeping track of the number of encoder "pulses" with respect to a known motor "home" position, DPR drives are able to ascertain the actual motor location.

FIGURE 2.7 Encoder Feedback Signals



Note

The high resolution of motor mounted encoders allows for excellent velocity and position control and smooth motion at all speeds. Encoder feedback should be used for applications requiring precise and accurate velocity and position control, and is especially useful in applications where low-speed smoothness is the objective.

2.5.2 Auxiliary Incremental Encoder

The auxiliary encoder input pins can be used as a command source for encoder following mode, or as a secondary feedback device input for closing the position loop. The particular function is configured in DriveWare.

2.5.3 Hall Sensors

DPRxxxE drive models allow Hall Sensors for commutation and/or velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. With Hall Sensors being used as the feedback element, the input command controls the motor velocity, with the Hall Sensor frequency closing the velocity loop. For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 58.

Note

Hall velocity mode is not optimized for relatively high or relatively low frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.

2.5.4 Resolver

DPRxxxR drives support resolver feedback for both velocity and position feedback. A resolver functions similar to a rotary transformer, in that when the resolver rotor winding is excited with an AC signal, the resolver stator windings then produce an AC voltage output that varies in amplitude according to the sine and cosine of the resolver shaft position. The AC voltage output is then read through a specialized converter as the velocity or position feedback signal. DPRxxxR drives support resolvers with a carrier frequency of 5kHz, an excitation voltage of 4Vrms, and a 0.5 transformation ratio. The drive configuration software allows the user to determine the interpolation for 12-bit (high speeds) or 14-bit (high precision) resolution. In general, resolvers are less common and more expensive than encoders, and are typically used in harsh physical environments.

Note

Resolvers using the inductive (brushless) method to couple the stator and rotor windings are very reliable in hostile industrial environments, as they are resilient to vibration and dirt and have a longer lifetime than brush type resolvers.

2.5.5 ±10 VDC Position

DPR drives accept an analog ±10 VDC Position Feedback, typically in the form of a load-mounted potentiometer. The feedback signal must be conditioned so that the voltage does not exceed ±10 V, and is connected through the Programmable Analog Input. In DriveWare, the connection method that is used must be selected under the Position Loop Feedback options.

2.5.6 Tachometer (±10 VDC)

All DPR drives support the use of a tachometer for velocity feedback. The tachometer measures the rotary speed of the motor shaft and returns an analog voltage signal to the drive for velocity control. DPR drives provide a Programmable Analog Input on the motor Feedback Connector that is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

2.6 Control Modes

The DPR family of digital drives operate in either Current (Torque), Velocity, or Position Mode. The setup and configuration parameters for these modes are commissioned through DriveWare. See the DriveWare Software Guide for mode configuration information.

The name of the mode refers to which servo loop is being closed in the drive, not the end-result of the application. For instance, a drive operating in Current (Torque) Mode may be used for a positioning application if the external controller is closing the position loop. Oftentimes, mode selection will be dependent on the requirements and capabilities of the controller being used with the drive as well as the end-result application.

2.6.1 Current (Torque)

In Current (Torque) Mode, the input command controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored within the configuration software, or externally through network commands.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

2.6.2 Velocity

In Velocity Mode, the input command controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. The motor velocity and other parameters can be monitored within the configuration software, or externally through network commands. See "Feedback Supported" on page 17 for more information on velocity feedback devices.

2.6.3 Position

In Position Mode, the input command controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. The motor position and other parameters can be monitored within the configuration software, or externally through network commands. See "Feedback Supported" on page 17 for more information on position feedback devices.

2.7 Command Sources

The input command source for DPR drives can be configured for one of the following options.

2.7.1 PWM and Direction

All DPRxxIx drives support PWM and Direction as a command source for current, velocity or position control. The drive can be configured for standard PWM and Direction, using two inputs, or for Single Input PWM Control, using only a single input for bi-directional control. Additionally, scaling, offset and command inversion may be configured for customized control. The PWM and Direction command source supports broken wire detection for cases when the PWM command reaches 0% or 100% duty cycle. The frequency range of the PWM and Direction command input is 1kHz - 125kHz.

2.7.2 Step and Direction

Most DPR drives support a differential or single-ended Step and Direction input command to control the motor in a simulated stepper motor configuration. The Direction input commands the direction of rotation, while each pulse of the Step input commands the motor to "step" in the specified direction based on a scaling value that is entered in DriveWare. Since the input is directly controlling the actual position of the motor, the physical motor location can be determined without any other feedback element. DPRAHxx drives offer +24V Step and Direction, and DPRALxx drives offer +5V Step and Direction.

2.7.3 ±10V Analog

DPRAxxx drives accept a single-ended or differential analog signal with a range of ±10 V from an external source. The input command signals should be connected to the programmable input on the I/O Signal Connector. See “Programmable Analog I/O” on page 47 for more information.

2.7.4 Encoder Following

DPR drives can utilize Encoder Following as a form of input command. In Encoder Following mode, an auxiliary encoder signal can be used to command the drive in a master/slave configuration. The gearing ratio (input counts to output counts ratio) can be configured in DriveWare by the user. Encoder Following is only a valid option when the DPR drive is operated in position mode.

2.7.5 Indexing and Sequencing

DPR drives allow configuration of up to 16 separately defined Index tasks in DriveWare. Indexes can be either Absolute (commands a pre-defined move to an absolute position) or Relative (commands a pre-defined move relative to the current position). Indexes can be combined with Homing routines and other control functions to form up to 16 different Sequences. Sequences can be configured to initiate on power-up, via a digital input, or by using an external network command.

2.7.6 Jogging

DPR drives allow configuration of two separate Jog velocities in DriveWare, commanding motion at a defined constant velocity with infinite distance.

2.7.7 Over the Network

DPR drives can utilize RS485/232 or Modbus RTU network communication as a form of input command through the serial interface. In order to send commands to the drive using Modbus RTU, the command source in DriveWare must be set to Interface Input 1. For more information on using serial communication to command the drive, see "Communication Protocol" on page 16.

2.8 System Requirements

To successfully incorporate a DPR digital servo drive into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance.

2.8.1 Specifications Check

Before selecting a DPR digital servo drive, a user should consider the requirements of their system. This involves calculating the voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with. Before attempting to install or operate a DPR servo drive, be sure all the following items are available:

- DPR Digital Servo Drive
- DPR Drive Datasheet (specific to your model)
- DPR Series Digital Hardware Installation Manual
- DriveWare Software Guide

2.8.2 Motor Specifications

DPR digital servo drives have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a DPR drive may be selected that will best suit the motor capabilities. Some general guidelines that are useful when pairing a DPR servo drive with a motor:

- The motor current I_M is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T -motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile. The continuous torque is the average torque required by the system during the move profile, including dwell times.

- The system voltage requirement is based on the motor properties and how fast and hard the motor is driven. The system voltage requirement is equal to the motor voltage, V_M, required to achieve the move profile.

$$V_M = (K_E \cdot S_M) + (I_M \cdot R_M)$$

Where:

K -motor back EMF constant

S -motor speed (use the maximum speed expected for the application)

I -motor current (use the maximum current expected for the application)

R -motor line-to-line resistance

- The motor inductance is vital to the operation of DPR servo drives, as it ensures that the DC motor current is properly filtered.

Caution

A motor that does not meet the rated minimum inductance value of the DPR drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary.

A minimum motor inductance rating for each specific DPR drive can be found in the drive datasheet. If the drive is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

2.8.3 Power Supply Specifications

Depending on the drive model, a DPR servo drive operates off either an AC Power Supply or an isolated DC Power Supply. To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

- Drive over voltage
- External shunt regulator turn-on voltage

Use of a shunt regulator is necessary in systems where motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply. This regenerated energy can charge the power supply capacitors to levels above that of the DPR drive over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one drive, then the current requirements for each drive should be added together. Due to the nature of servo drives, the current into the drive does not always equal the current out of the drive. However, the *power* in is equal to the *power* out. Use the following equation to calculate the power supply output current, I_{PS}, based on the motor current requirements.

$$I_{PS} = \frac{V_M \cdot I_M}{V_{PS} \cdot (0.98)}$$

Where:

V_{PS} -nominal power supply voltage

I_M -motor current

V_M -motor voltage

Use values of V and I at the point of maximum power in the move profile (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.

2.8.4 Environment

To ensure proper operation of a DPR servo drive, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.7 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m

Baseplate Temperature Range **DPR drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above a certain value. Table 2.8 below shows the maximum allowable temperature range for standard drive power modules. It is recommended to mount the baseplate of the DPR drive to a heatsink for best thermal management results. For mounting instructions see** **“Mounting” on page 38****.**

TABLE 2.8 Baseplate Temperature Ranges

Baseplate Maximum Allowable Temperature	
Power Board	**Temperature Range**
015S400	0 - 75 °C
030A400	0 - 75 °C
040A400	0 - 75 °C
C060A400	0 - 75 °C
C100A400	0 - 75 °C
030A800	0 - 75 °C
060A800	0 - 75 °C
020B080	0 - 65 °C
040B080	0 - 75 °C
060B080	0 - 75 °C
100B080	0 - 75 °C
015B200	0 - 65 °C
025B200	0 - 75 °C

Shock/Vibrations **While DPR drives are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to. The best way to secure the drive against mechanical vibration is to use screws to mount the DPR drive against its baseplate. For information on mounting options and procedures, see** **“Mounting” on page 38.**

Caution

Care should be taken to ensure the drive is securely mounted in a location where no moving parts will come in contact with the drive.

3 Integration in the Servo System

This chapter will give various details on incorporating a DPR servo drive into a system, such as how to properly ground the DPR drive along with the entire system, and how to properly connect motor wires, power supply wires, feedback wires, communication cables, and inputs into the DPR drive.

3.1 LVD Requirements

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the servo drives must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

Contact the factory for assistance in determining the type of drive in use.

General

1. Shielded cables must be used for all interconnect cables to the drive and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.
2. The drive's metal enclosure must be grounded to the closest ground point with the least amount of resistance.
3. The drive must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.

Analog Input Drives

4. A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.

PWM Input Drives

5. A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.

MOSFET Switching Drives

6. A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.
7. An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.

IGBT Switching Drives

8. An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.
9. A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.

Fitting of AC Power Filters

10. It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be

adversely affected by the noise. AC power filters can filter this noise and keep it from getting on the AC power signal. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power filter enters the enclosure as possible. Also, the AC power cable on the load end of the filter should be routed far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

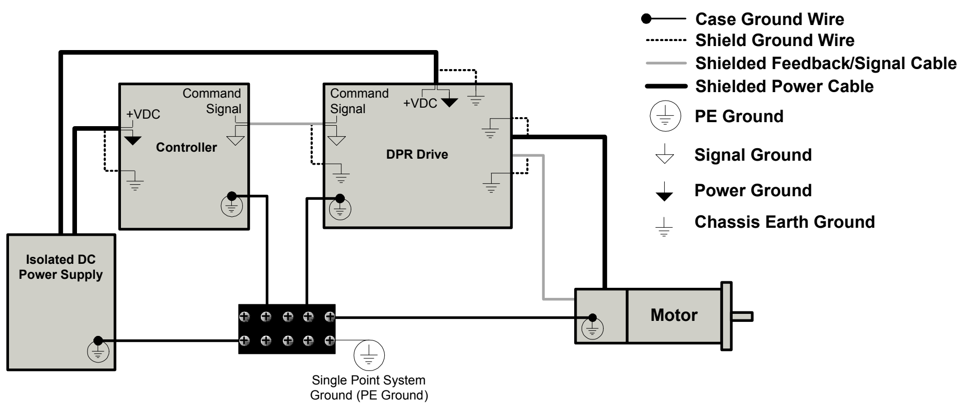
Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines. This means they can be used in place of the suppression cores mentioned above.

3.3 Grounding

In most servo systems the case grounds of all the system components should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point through a single low resistance wire reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

- Motor chassis
- Controller chassis
- Power supply chassis
- DPR drive chassis

FIGURE 3.1 System Grounding



Ground cable shield wires at the drive side to a chassis earth ground point.

The DC power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the DPR drive to avoid picking up noise due to the "floating" differential servo drive input. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

Warning

Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed. As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

The main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card or a noise suppression device is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

ADVANCED Motion Controls recommends using the following hand crimp tools for the appropriate I/O and Feedback cable and wire preparation. Consult the drive datasheet to see which connectors are used on a specific drive.

Drive Connector	Hand Crimp Tool Manufacturer and Part Number
6-pin, 3.96 mm spaced, friction lock header	Tyco: P/N 770522-1
High Density D-sub headers	Tyco: P/N 90800-1

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of larger diameter wire rather than too thin. This becomes more critical as the cable length increases. The following table provides recommendations for selecting the appropriate wire size for a specific current. These values should be used as reference only. Consult any applicable national or local electrical codes for specific guidelines.

Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518
15	#18	0.823
20	#16	1.31
35	#14	2.08
45	#12	3.31

Current (A)	Minimum Wire Size (AWG)	mm^2
60	#10	5.26
80	#8	8.37
120	#6	13.3
150	#0	53.5
200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

- For a single phase motor or voice coil, twist the two motor wires together as a group.
- For a three phase motor, twist all three motor wires together as a group.

Ground the motor power cable shield at one end only to the drive chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

Caution

DO NOT use wire shield to carry motor current or power!

3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the drive chassis ground.

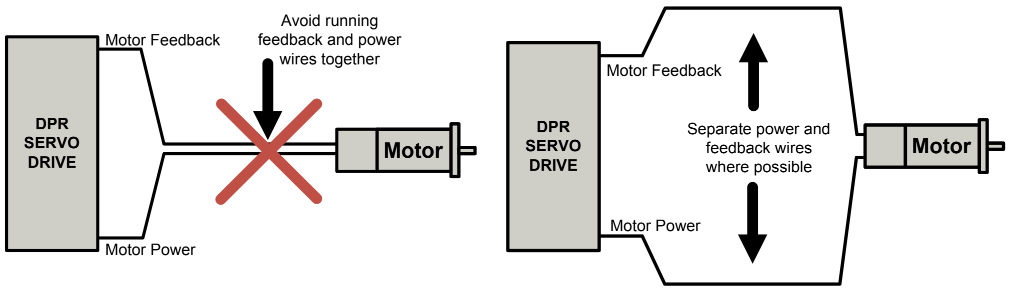
When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each drive directly from the power supply filter capacitor.
2. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the drive chassis ground. Also make sure that the feedback connector and D-sub shell preserve the shield continuity. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.2 Feedback Wiring



3.4.5 I/O and Signal Wires

Use of a twisted, shielded pair for the I/O and Signal wires is recommended. Connect the shield to the drive chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds.

Notice

In case of a single-ended reference signal when using ±10V command input, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

3.5 Connector Types

Depending on the specific drive model, typically a DPR drive connection interface will consist of:

- Power Connectors - used for Logic, Motor, and AC or DC Power, as well as optional external shunt regulator connections
- Feedback Connectors - used for primary and auxiliary feedback connections, programmable inputs and outputs, and other drive functions
- RS-485/232 Communication Connector - used for RS-485 networking, and necessary for RS-232 commissioning with DriveWare
- I/O Signal Connector - used for programmable inputs and outputs as well as some feedback connections.
- STO Connector - used for Safe Torque Off (STO) functionality.

The different types of connectors used in the DPR drive series are shown in the sections below. Consult the specific drive datasheet for the actual connectors and pin labels used on the drive.

3.5.1 Power Connectors

TABLE 3.1 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 5.08 mm spaced, enclosed, friction lock header with threaded flange
Mating Connector	Details	Phoenix Contact: P/N 1777808
	Included with Drive	Yes

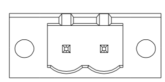


TABLE 3.2 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1757019
	Included with Drive	Yes

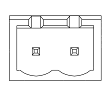


TABLE 3.3 POWER / MOTOR POWER / BRAKE LOGIC - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		4-contact, 13 mm spaced, dual-barrier terminal block
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

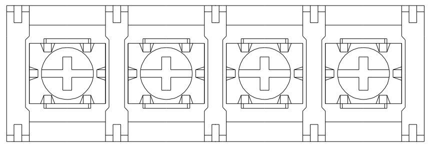


TABLE 3.4 POWER / MOTOR POWER / DC BUS / BRAKE RESISTOR - Power Connector

DC BUS / BRAKE RESISTOR - Power Connector		
Connector Information		5-contact, 13 mm spaced, dual-barrier terminal block
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

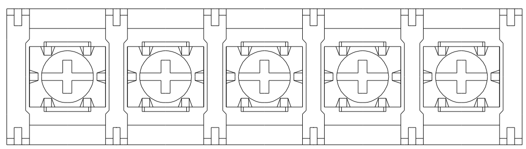


TABLE 3.5 POWER - DC Power Connector

POWER - DC Power Connector		
Connector Information		8-contact, 11.10 mm spaced, dual-barrier terminal block
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

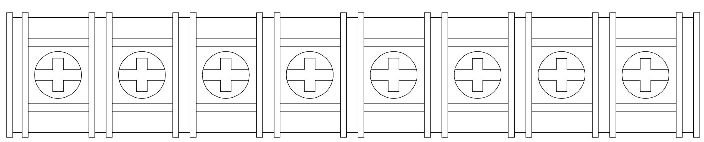


TABLE 3.6 POWER - DC Power Connector

POWER - DC Power Connector		
Connector Information		6-pin, 3.96 mm spaced, friction lock header
Mating Connector	Details	AMP: Plug P/N 770849-6; Terminals P/N 770522-1 (loose) or 770476-1 (strip)
	Included with Drive	Yes

TABLE 3.7 MOTOR POWER - Motor Power Connector

MOTOR POWER - Motor Power Connector		
Connector Information		3-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804917
	Included with Drive	Yes

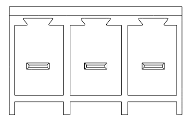


TABLE 3.8 POWER - Power Connector

POWER - DC Power Connector		
Connector Information		8-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1767067
	Included with Drive	Yes

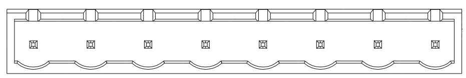


TABLE 3.9 POWER - Power Connector

POWER - Power Connector		
Connector Information		10-port,5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1781069
	Included with Drive	Yes

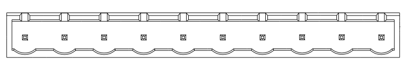


TABLE 3.10 POWER / MOTOR POWER / DC BUS - Power Connector

DC BUS - Power Connector		
Connector Information		4-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804920
	Included with Drive	Yes

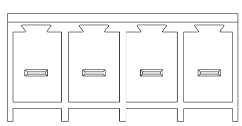


TABLE 3.11 AC POWER / MOTOR POWER / DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 10.16 mm spaced, enclosed, friction lock header
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

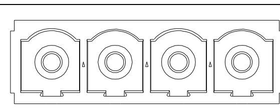


TABLE 3.12 AC POWER / MOTOR POWER - Power Connector

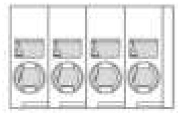
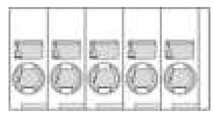
AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	No
		

TABLE 3.13 DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		5-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	Not applicable
		

3.5.2 Feedback Connectors

TABLE 3.14 FEEDBACK - Feedback Connector

FEEDBACK - Feedback Connector		
Connector Information		15-pin, high-density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 748364-1; Housing P/N 5748677-1; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No

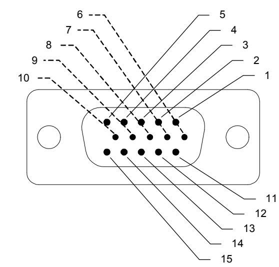
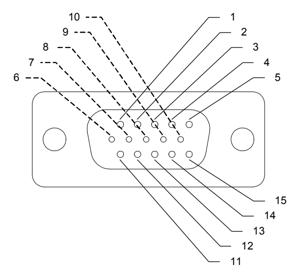


TABLE 3.15 AUX ENCODER - Auxiliary Feedback Connector

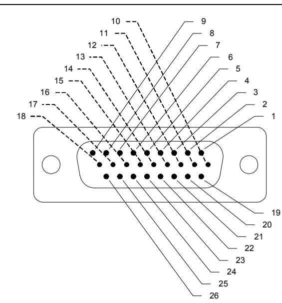
AUX ENCODER - Auxiliary Feedback Connector		
Connector Information		15-pin, high-density, male D-sub
Mating Connector	Details	TYCO: Plug P/N 1658681-1; Housing P/N 5748677-1; Terminals P/N 1658686-2 (loose) or 1658686-1 (strip)
	Included with Drive	No



3.5.3 I/O Connectors

TABLE 3.16 I/O - Signal Connector

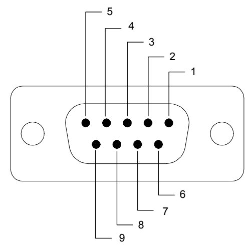
I/O - Signal Connector		
Connector Information		26-pin, high density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 1658671-1; Housing P/N 5748677-2; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No



3.5.4 Communication Connectors

TABLE 3.17 COMM - RS232/RS485 Communication Connector

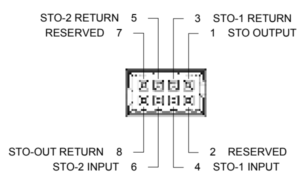
COMM - RS232/RS485 Communication Connector		
Connector Information		9-pin, female D-sub
Mating Connector	Details	TYCO: Plug P/N 205204-4; Housing P/N 5748677-1; Terminals P/N 1658540-5 (loose) or 1658540-4 (strip)
	Included with Drive	No



3.5.5 STO Connector

TABLE 3.18 Safe Torque Off (STO) connector

STO Connector		
Connector Information		8-port, 2.00 mm spaced, enclosed, friction lock header
Mating Connector	Details	Molex: P/N 51110-0860 (housing); 50394-8051 (pins)
	Included with Drive	No



3.6 Mounting

DPR drives provide a number of mounting configuration options. The drive baseplate includes perimeter mounting screwholes allowing different mounting arrangements depending on the requirements or space limitations of the system. See the drive datasheet for specific mounting dimensions and screwhole locations.

4 Operation and Features

This chapter will present a brief introduction on how to test and operate a DPR servo drive. Read through this entire section before attempting to test the drive or make any connections.

4.1 Features and Getting Started

To begin operation with your DPR drive, be sure to read and understand the previous chapters in this manual as well as the drive datasheet and the DriveWare Software Guide. Ensure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the DPR drive. Also, be aware of the "Troubleshooting" section at the end of this manual for solutions to basic operation issues.

4.1.1 Initial Setup and Configuration

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up. For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- DPR Servo Drive
- Motor
- AC or DC Power Supply and Logic Power Supply for supplying power to system
- DriveWare Setup Software and Software Guide for detailed instructions on how to setup, tune and configure a DPR drive in DriveWare

The following steps outline the general procedure to follow when commissioning a DPR drive for the first time. The DriveWare Software Guide contains more detailed information on each step.

1. **Check System Wiring:** Before beginning, check the wiring throughout the system to ensure proper connections and that all grounding and safety regulations have been followed appropriately for the system.

Caution

Do not apply power to the system until certain all wiring and grounding has been setup safely and properly!

For drives using a separate logic power supply, turn on the logic supply first before turning on the main power supply.

2. **Apply Power:** Power must be applied to the drive before any communication or configuration can take place. Turn on the Logic supply first for drives using a separate logic supply, then turn on the main Power supply. Use a multimeter or voltmeter to check that both power supply levels are within their specified ranges.
3. **Establish Connection:** Open DriveWare on the PC. The DPR drive should be connected to the PC with a serial cable. Choose the "Connect to a drive" option when DriveWare starts, and enter the appropriate communication settings in the options window that appears. See the DriveWare Software Guide for more information on connecting to a drive. For connection issues, see "Connection Problems" on page 64.
4. **Configure the drive in DriveWare:** DriveWare allows the user to manually configure user units, motor and feedback information, system parameters and limits, tune the Current, Velocity and Position Loops, commutate the motor, and assign drive and software "actions" to specific events. Consult the DriveWare Software Guide for detailed instructions.
5. **Connect to the Controller:** Once the drive has been properly commissioned, use an external controller to command an input signal to the drive. The controller wiring and setup should follow the safety and grounding guidelines and conventions as outlined in "Grounding" on page 29.

4.1.2 Input/Output Pin Functions

DPR drives provide a number of various input and output pins for parameter observation and drive configuration options. Consult the drive datasheet to see which input/output pin functions are available for each drive.

Programmable Digital I/O The single-ended and differential Programmable Digital I/O can be assigned to over 40 different functions in DriveWare. The polarity of the signals can be set to active HIGH or active LOW depending on the preference of the user. The differential high speed inputs can also be used as command source inputs with an Auxiliary Encoder (see "Auxiliary Encoder Input" below) or for PWM and Direction input (see PWM and Direction below). They also may be used as a High Speed Capture input (see "Capture Inputs" below). DPR drives offer both isolated and non-isolated Programmable Digital I/O.

Note: Depending on the configuration, digital outputs will be pulled either low or high for a period of time after a power cycle or drive reset. The delay period for each control module is given below.

FIGURE 4.1 Programmable Digital Output Power-up Delay

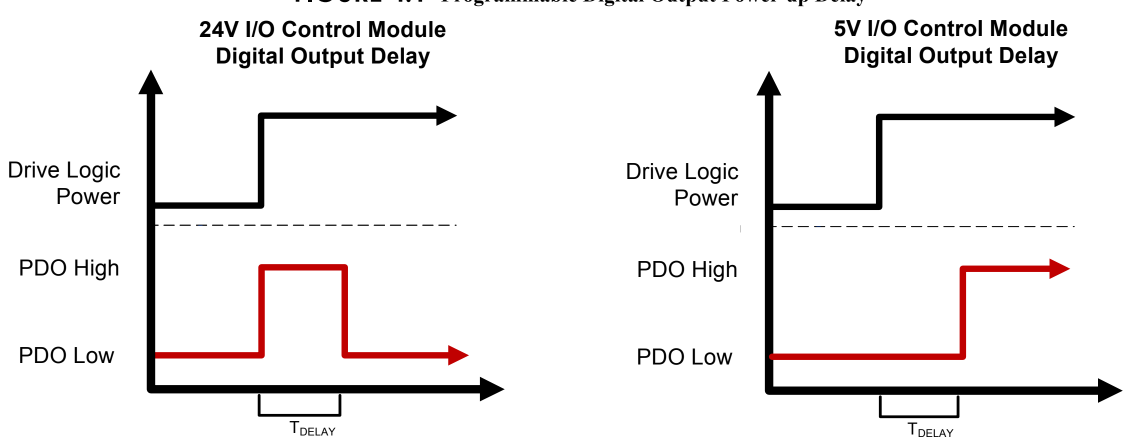


TABLE 4.1 Programmable Digital Output Power-up Delays

		Active High		Active Low	
		Power Cycle Delay (ms)	Reset Delay (ms)	Power Cycle Delay (ms)	Reset Delay (ms)
24V I/O Control Modules	DPRAHIE	350	100	-	-
	DPRANIE	200	100	-	-
	DPRANIR	300	100	-	-
5V I/O Control Modules[1]	DPRALTE	-	60	250	100
	DPRALTR	-	60	200	100

1. 5V I/O control modules exhibit an ~100mV voltage spike when set to Active High when a drive reset is commanded.

24VDC Digital I/O Specification

The 24VDC Digital I/O is designed to be compatible with controllers that interface with 24VDC signals, using optical isolation that separates the drive signal ground from the controller signal ground. Isolation increases a system's noise immunity by helping to eliminate current loops and ground currents.

- **Inputs** - The Isolated Digital Inputs use bi-directional optical isolators to detect signals from the controller. Dual LED's in the optical isolator allow current to flow in either direction. Current flow through the LED activates the transistor, and the drive responds depending on whether the transistor is active or not. The presence or absence of current in the LED determines the logic level, not the direction of current. This flexibility allows the Isolated Digital Inputs to be compatible with a wide range of controllers.

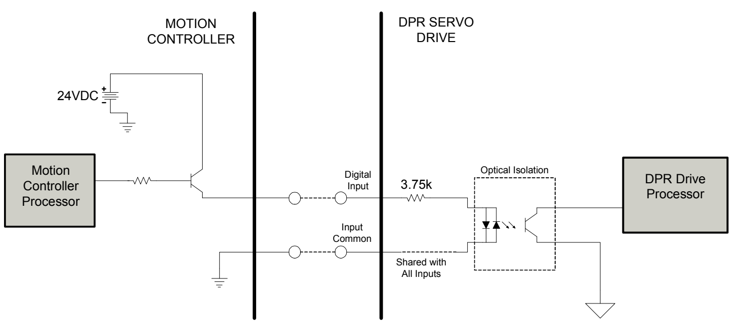
TABLE 4.2 24VDC Isolated Digital Input

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

When current flows into the digital input it is acting as a sinking input. When current flows out of the digital input it is acting as a sourcing input. Since current is allowed to flow in either direction, the inputs can either sink or source. The voltage at the Input Common pin determines whether the inputs sink or source. The Input Common pin is common to all of the inputs, but is isolated from the drive signal ground.

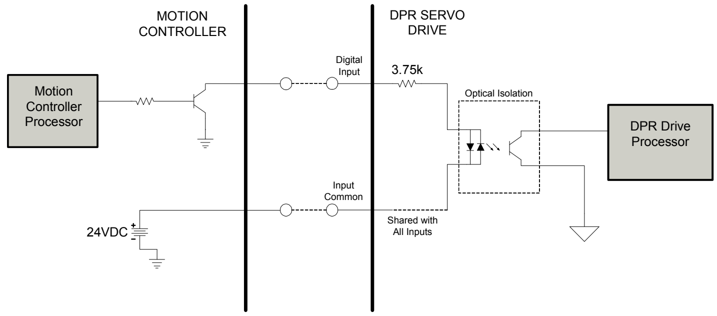
To configure the Isolated Digital Inputs as sinking, the 24V ground is applied to the Input Common and 24V is modulated at the digital input. Figure 4.2 shows a sourcing output from the motion controller feeding the sinking input at the drive. In this example the controller uses a transistor to control the 24V to the drive input. A mechanical switch, relay or other voltage-controlling device can be used in place of the transistor.

FIGURE 4.2 24VDC Isolated Digital Input configured as a sinking input



To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.3 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides a transistor.

FIGURE 4.3 24VDC Isolated Digital Input configured as a sourcing input.



- **Outputs** - The Isolated Digital Outputs are pulled up with a 2.5k resistor via the pin labeled Output Pull-Up and have a common grounding point labeled Output Common.

TABLE 4.3 24VDC Isolated Digital Output (Sinking)

24VDC Isolated Digital Output (Sinking)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA

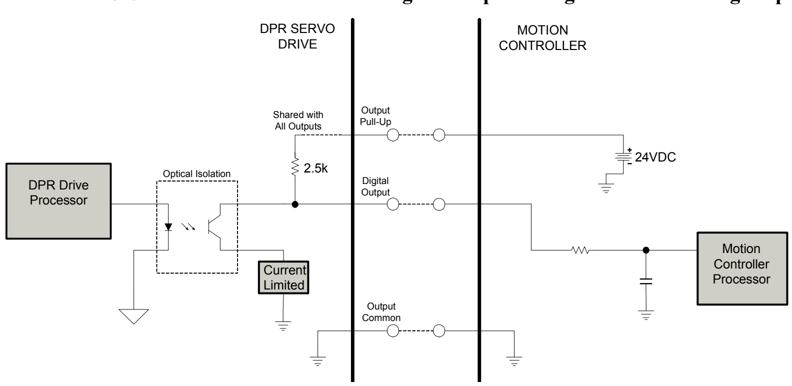
TABLE 4.4 24VDC Isolated Digital Output (Sourcing)

24VDC Isolated Digital Output (Sourcing)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	9.6mA

A transistor controls the voltage at each digital output. The Isolated Digital Output can sink or source depending on how the wiring is configured.

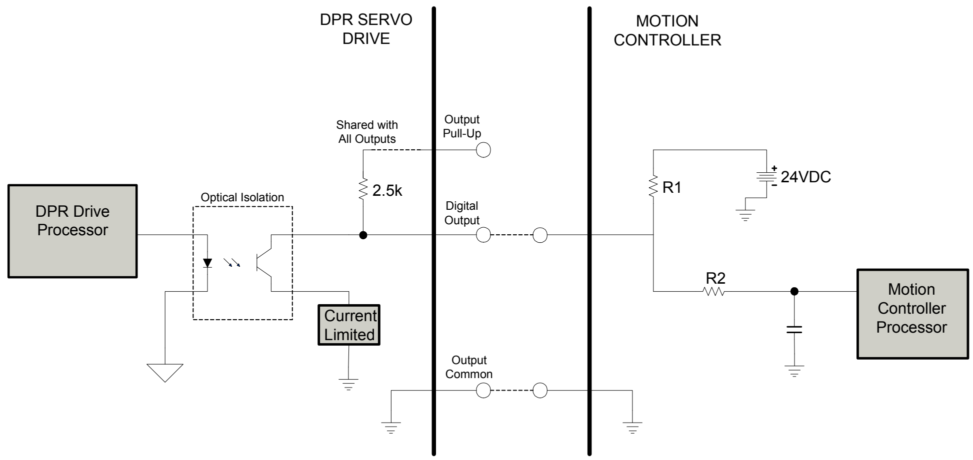
For sourcing outputs the Output Pull-Up pin is pulled to 24V and the 24V ground goes to the output common, as shown in Figure 4.4. A transistor controls the voltage at the digital output. When the transistor is open the voltage at the digital output is HIGH. When the transistor is closed the voltage is pulled to ground, which causes the output to go LOW.

FIGURE 4.4 24VDC Isolated Digital Output configured as a sourcing output.



For sinking outputs the Output Pull-Up pin is not connected and the digital output pin is interfaced as an open collector, as shown in Figure 4.5. 24V is applied to the digital output through a resistor R1 and the 24V ground goes to Output Common. As in the previous example a transistor controls the voltage of the digital output. R1 should be greater than 600Ω to limit the current into the digital output to less than 50mA.

FIGURE 4.5 24VDC Isolated Digital Output configured as a sinking output.



Programmable Limit Switch (PLS) Outputs

When a digital output is configured as a Programmable Limit Switch through the setup software, the maximum frequency of the output will correspond to the table below.

TABLE 4.5 Maximum Digital Output Frequency for PLS Outputs

	Maximum Frequency
24V I/O Control Modules	85 Hz (50% duty cycle)[1]
5V I/O Control Modules	5 kHz (for 20 kHz switching frequency)[2]

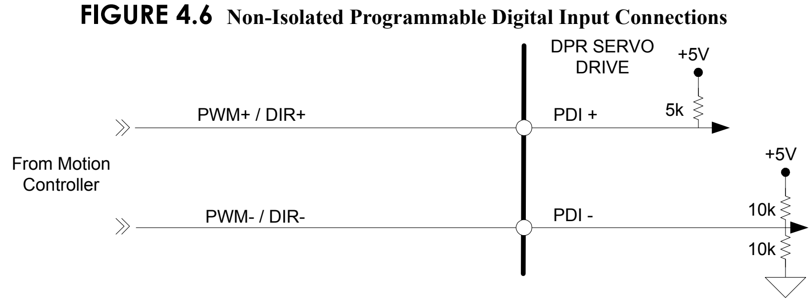
1. Higher duty cycles will result in higher maximum frequencies due to hardware filtering.

2. Lower switching frequencies will result in lower output frequencies due to sampling on 5V I/O control modules..

PWM and Direction Inputs

DPRAHIx, and DPRANIx drives allow configuration of PWM and Direction as a command source using High-Speed digital inputs. When configured for PWM and Direction control these inputs cannot use the Auxiliary Encoder, Step and Direction or Capture features. The command source must be set to PWM and Direction and configured in the Command Source window within DriveWare.

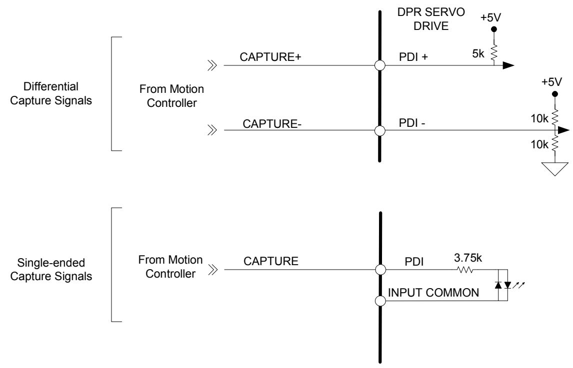
FIGURE 4.6 Non-Isolated Programmable Digital Input Connections



Capture Inputs

DPR drives using an AC power module allow configuration of differential and single-ended Capture inputs using digital inputs. When configured for Capture signals, these inputs cannot be used for Auxiliary Encoder, Step and Direction, or PWM and Direction control. The Capture signals can be used to capture and view internal signals on a designated trigger (rising edge, falling edge, or both). Parameters and options for the Capture signals can be entered and configured in DriveWare.

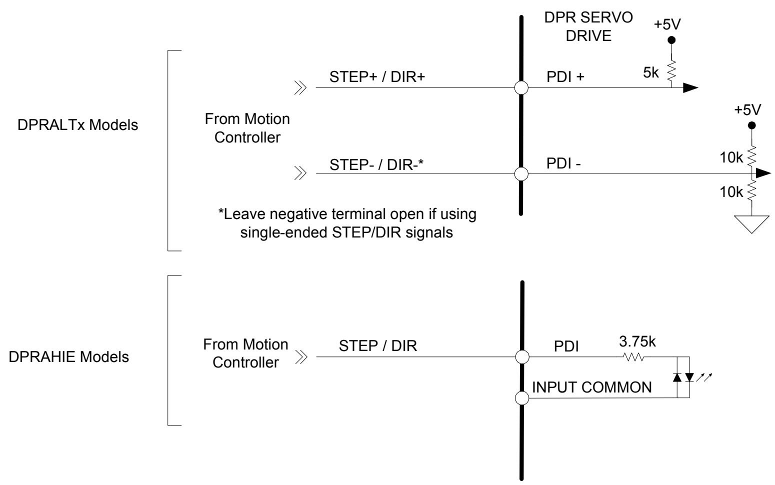
FIGURE 4.7 Capture Input Connections



Step and Direction Inputs

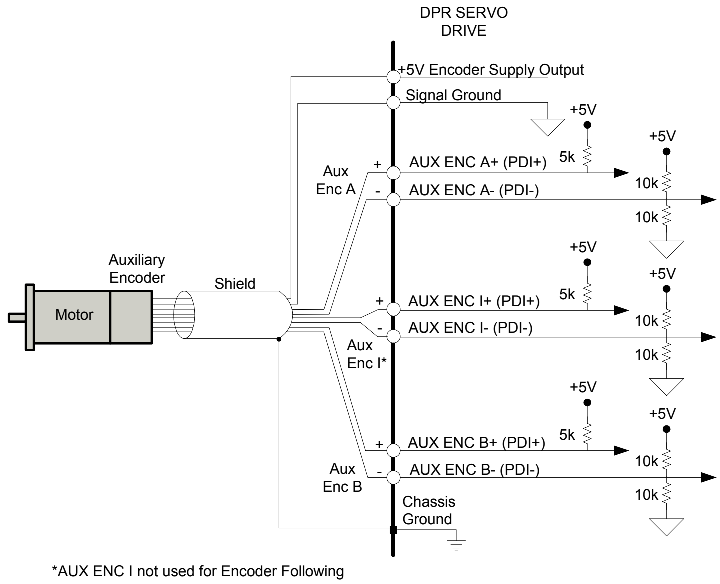
Certain DPR models allow configuration of Step and Direction as a command source using digital inputs. DPRAHIE drives offer +24V Step and Direction, and DPRALTx drives offer +5V Step and Direction. When configured for Step and Direction control these inputs cannot use the Auxiliary Encoder, PWM and Direction, or Capture features. The command source must be set to Step and Direction and configured in the Command Source window within DriveWare.

FIGURE 4.8 Step and Direction Input Connections



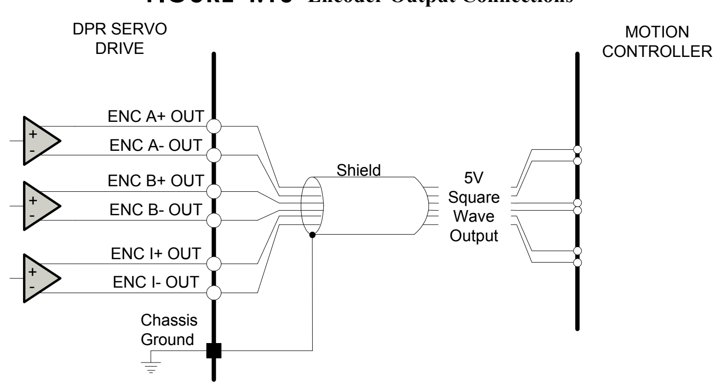
Auxiliary Encoder Input DPR drives accept a differential auxiliary encoder input that can be used for auxiliary position feedback, or for a command source when configured for Encoder Following. The auxiliary encoder signals are connected through High-Speed Programmable Digital Inputs. If using these pins for an auxiliary encoder input, the drive will not be able to utilize the Capture, Step and Direction, or PWM and Direction features. Hardware settings and options for the auxiliary encoder can be entered and configured in DriveWare.

FIGURE 4.9 Auxiliary Encoder Input Connections



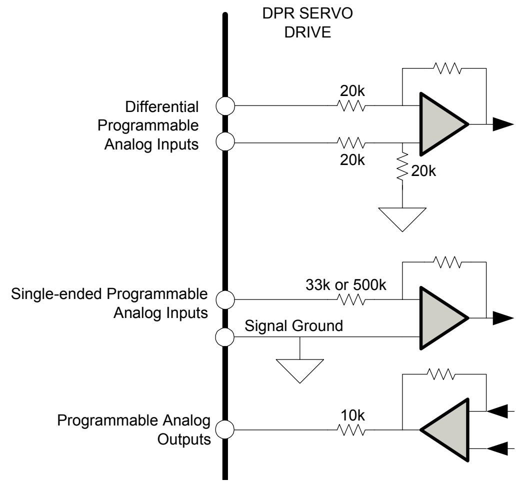
Encoder Output The Encoder Output pins provide a differential encoder output that can be used to synchronize the command to other axes, or to close the position loop. Depending on the type of feedback in use, the drive outputs either a 5V square wave buffered encoder signal (DPRxxxE/S/A drives) or a 5V square wave emulated encoder signal (DPRxxxR/S/A drives). The buffered encoder output has a 1:1 input-to-output ratio, while the emulated encoder input-to-output ratio is configurable within DriveWare (for resolver feedback the emulated output will match the resolver resolution setting). There is a small phase lag between the sinusoidal feedback to the drive and the emulated output due to the time required to process the emulated signal.

FIGURE 4.10 Encoder Output Connections



Programmable Analog I/O **The Programmable Analog I/O can be assigned to drive functions in DriveWare. These can be used to monitor drive signals, and are also useful for troubleshooting unexpected drive behavior. The drive I/O Signal Connector provides a differential programmable analog input that may be used for a ±10V analog input command.**

FIGURE 4.11



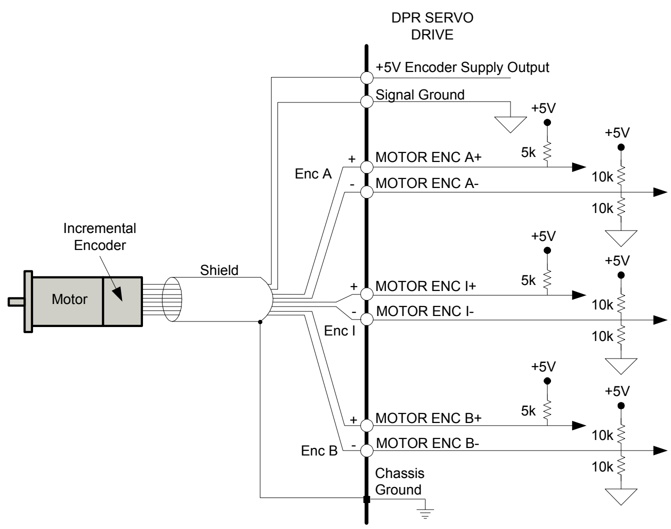
4.1.3 Feedback Operation

The functional operation of the feedback devices supported by DPR drives is described in this section. For more information on feedback selection, see **"Feedback Supported" on page 17****. See the datasheet of the drive in use for specific pin locations.**

Incremental Encoder

DPRxxxE drives support incremental encoder feedback. The drive Feedback Connector allows inputs for differential and single-ended inputs. For single-ended encoder inputs, leave the negative terminal open. Both the "A" and "B" channels of the encoder are required for operation. DPRxxxE drives also accept an optional differential "index" channel that can be used for synchronization and homing. A +5V Encoder Supply Output pin is provided to supply power to the encoder.

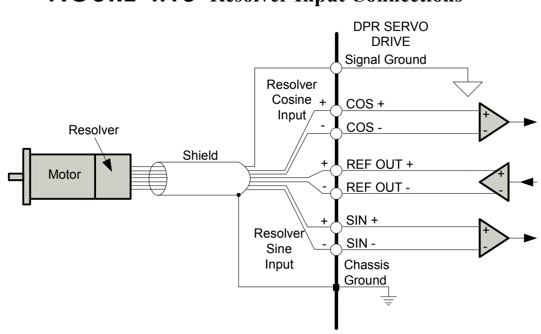
FIGURE 4.12 Incremental Encoder Connections



Resolver

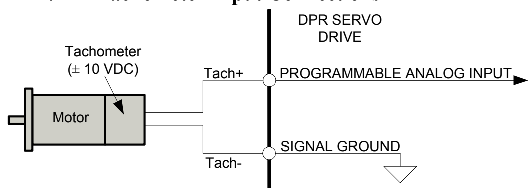
DPRxxxR drives support resolver feedback with a carrier frequency of 5kHz, an excitation voltage of 4Vrms, and a 0.5 transformation ratio. The drive Feedback Connector provides a differential Resolver Reference/Excitation output, and allows differential sine and cosine resolver inputs.

FIGURE 4.13 Resolver Input Connections



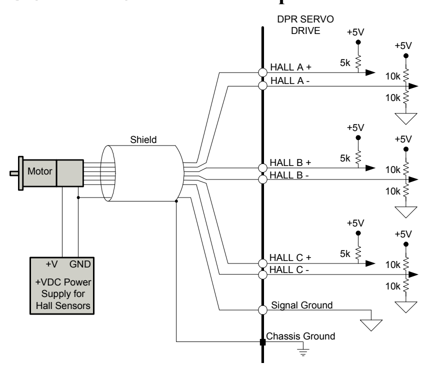
Tachometer (±10 VDC) **All DPR drives support the use of a tachometer for velocity feedback. The Programmable Analog Input on the motor Feedback Connector is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.**

FIGURE 4.14 Tachometer Input Connections



Hall Sensors **DPRxxxE drives accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive Feedback Connector allows differential or single-ended Hall Sensor inputs. For single-ended Hall signals leave the negative terminals open.**

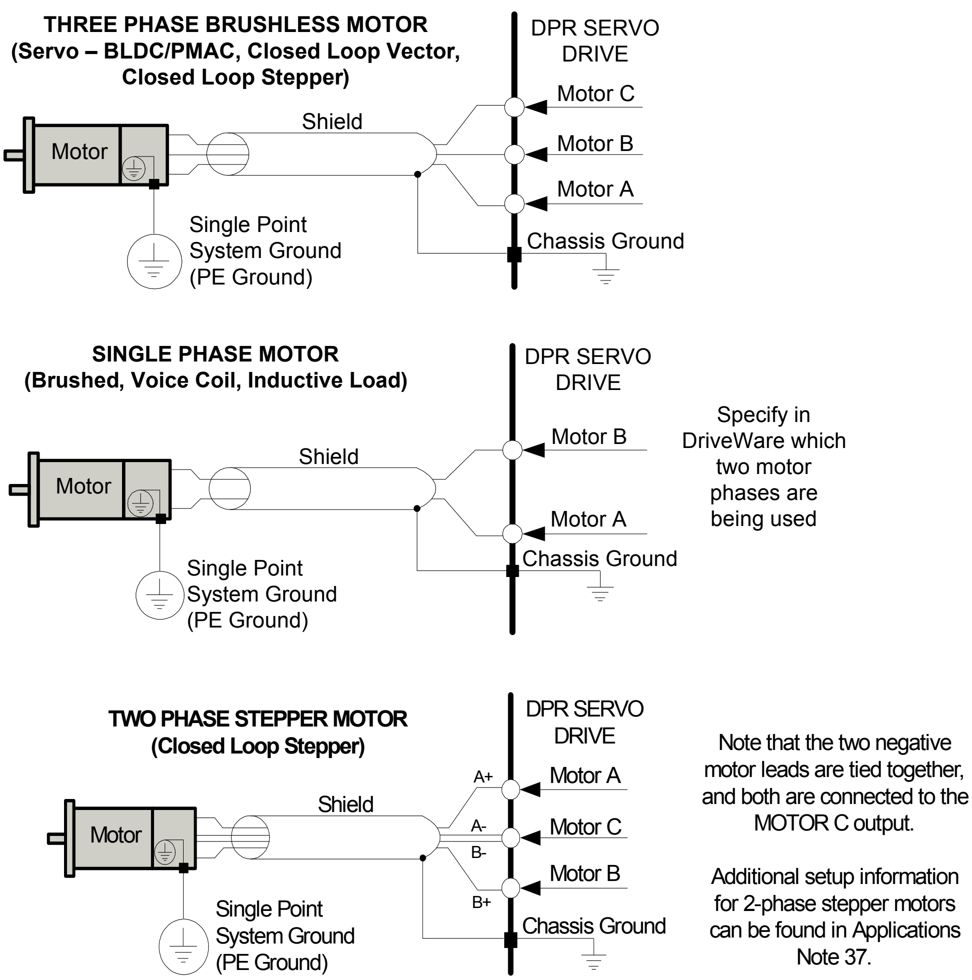
FIGURE 4.15 Hall Sensor Input Connections



4.1.4 Motor Connections

The diagrams below show how a DPR drive connects to various motor types. Notice that the motor wires are shielded, and that the motor housing is grounded to the single point system ground (PE Ground). The cable shield should be grounded at the drive side to chassis ground.

FIGURE 4.16 Motor Power Output Wiring.



Caution

If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

For applications using stepper motors, the maximum motor speed will be limited (typically ~600 RPM max).

4.1.5 STO (Safe Torque Off)

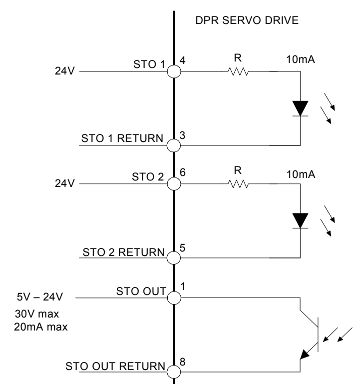
Some models of the DPR drive family feature an external dedicated +24VDC STO safety function designed to monitor an external 24V STO input from the user system and disable the motor output during an STO event. The STO circuit uses +24VDC sinking single-ended isolated inputs for STO functionality. Both STO1 and STO2 must be active (HIGH) to allow torque output at the drive motor outputs.

TABLE 4.6 STO Signal Behavior

STO 1	STO 2	Motor Outputs	STO OUT
Active (HIGH)	Active (HIGH)	Enabled	Open
Active (HIGH)	Not Active (LOW)	Disabled	Closed
Not Active (LOW)	Active (HIGH)	Disabled	Closed
Not Active (LOW)	Not Active (LOW)	Disabled	Closed

The STO circuitry also features an STO status output (STO OUT) that signifies when an STO condition has occurred. This status is also viewable in the setup software as an indicator only. The STO OUT output functions as a switch. When an STO event occurs, the STO OUT switch becomes CLOSED. When the drive is in normal functional operation (STO 1 and STO 2 = 24V), the STO OUT switch is OPEN.

FIGURE 4.17 STO Connections



See “STO Connector” on page 38 for a drawing and description of the physical STO connector and mating hardware. Functional Safety is TÜV Rheinland certified and meets requirements of the following standards:

- EN ISO 13849-1 -- Category 4 / PL e
- EN IEC 61800-5-2 -- STO (SIL 3)
- EN 62061 -- SIL CL3
- IEC 61508 -- SIL 3

The user must verify proper operation of the monitoring circuit (STO 1 and STO2) at least once per month to maintain SIL 3, Cat 4 / PL e certification. The monitoring circuit is required to be examined by an external logic element when STO is incorporated into a complete drive system in order for proper diagnostics to be fully implemented and utilized in the FMEA calculation (see “STO Operation Test” on page 52). The calculation of the safety relevant parameters are based on a proof test interval of one year and have shown that the requirements of up to SIL 3 are fulfilled. The safety relevant parameters are:

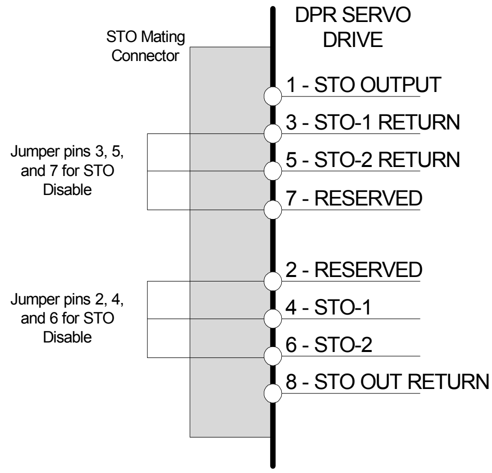
- Safe-Failure-Fraction: SFF = 97%
- Probability of a dangerous failure per hour: PFH = 1.3 x 10 1/h
- Average probability of a dangerous failure on demand (1 year): PFD = 1.7 x 10

Note

The above assessment and safety values defined were assessed with the STO function incorporated into the DigiFlex Performance DPR drive family. Product data for the DPR drive family can be found by visiting www.a-m-c.com.

STO Disable **For applications that do not require Safe Torque Off functionality, disabling of the STO feature is required for proper drive operation. A dedicated STO Disable Key connector is available for purchase and must be installed for applications where STO is not in use. Contact the factory for ordering information. Altenatively, STO may be disabled by installing the included mating connector for the STO connector, and wiring the designated pins together as given below in figure.**

FIGURE 4.18 **STO Disable Connections**



STO Operation Test **To maintain SIL 3, Cat 4 / PL e certification, the operation of the STO monitoring circuit (STO1 and STO2) must be verified at least once per month. The following procedure provides an example of a method to verify correct STO functionality. Note that it is the responsibily of the system operator to ensure all personal and machine safety requirements for the system are properly enforced during the proof test.**

1. **Power on the drive.**
2. **Verify the drive is in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
3. **Remove the voltage signal from the STO1 input pin via a digital controller signal, network command, or by physically removing the STO Connector if safe to do so.**
4. **Verify that the drive is in a Disabled state (by viewing the Status LED is RED, or by verifying the STO OUT switch has closed).**
5. **Re-apply the voltage signal to the STO1 pin. Verify that the drive is once again in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
6. **Repeat the above steps for the STO2 signal.**

Note

End-product certification may require a different interval test schedule or test requirements. It is the responsibility of the end-user to determine the required test interval and requirements for certifications other than stated above.

4.1.6 External Shunt Resistor Connections

Most AC powered DPR drives allow the option of connecting an external shunt resistor to protect against damage that may occur due to over-voltage. Drives that do not include an internal shunt resistor require an external shunt resistor for the internal shunt regulator to operate. The figures below show how an external shunt resistor should be connected to the drive for the different AC Power Modules. The shunt regulator must be enabled and configured in DriveWare in order to operate.

FIGURE 4.19 030A400 Power Module External Shunt Resistor Connection

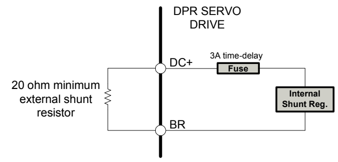


FIGURE 4.20 C060A400 Power Module External Shunt Resistor Connection

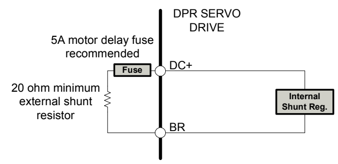


FIGURE 4.21 C100A400 Power Module External Shunt Resistor Connection

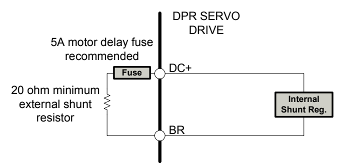


FIGURE 4.22 030A800 Power Module External Shunt Resistor Connection

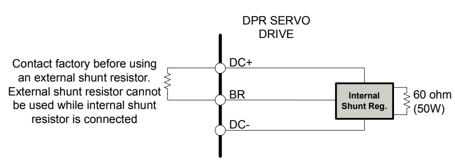
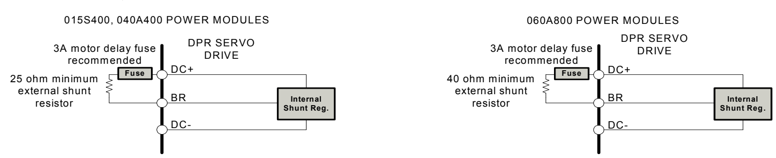


FIGURE 4.23 015S400, 040A400 and 060A800 Power Module External Shunt Resistor Connections



4.1.7 Logic Power Supply

An external +24 VDC logic power supply (850 mA) is required on drives using AC power modules. The logic power supply ground should be referenced to the DPR drive signal ground. The logic power inputs are made through a separate Logic Power connector on the drive.

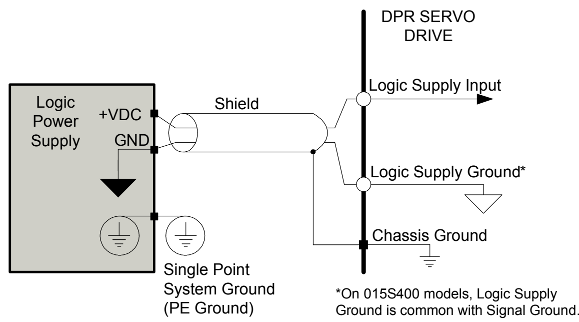
Caution

When using a separate logic power supply, the logic power must be turned on before the main power supply.

TABLE 4.7 AC Power Module Logic Supply Range

AC Power Module	Logic Supply Range (VDC)	Input Current (mA)
015S400, 030A400, 040A400, C060A400, C100A400, 030A800, 060A800	20-30	850

FIGURE 4.24 AC Power Module Logic Power Supply Inputs

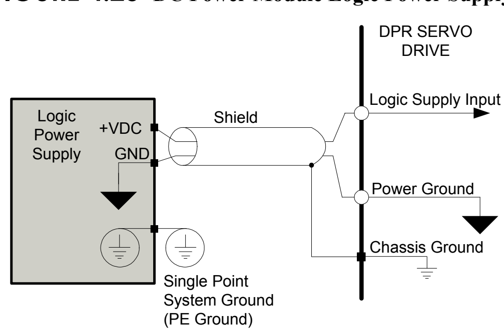


On drives using DC power modules, an external logic supply is optional. If no external logic power supply is connected the drive will use the main DC power supply for logic power. If an external logic power supply is used, the voltage must be below the main DC power value. Table 4.8 shows the different DC power modules and their corresponding logic supply ranges.

TABLE 4.8 DC Power Module Logic Supply Ranges.

DC Power Module	Logic Supply Range (VDC)
020B080	20-80
040B080	20-80
060B080	20-80
100B080	20-80
015B200	40-190
025B200	20-190

FIGURE 4.25 DC Power Module Logic Power Supply Inputs

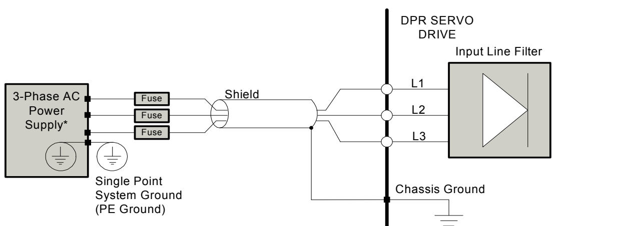


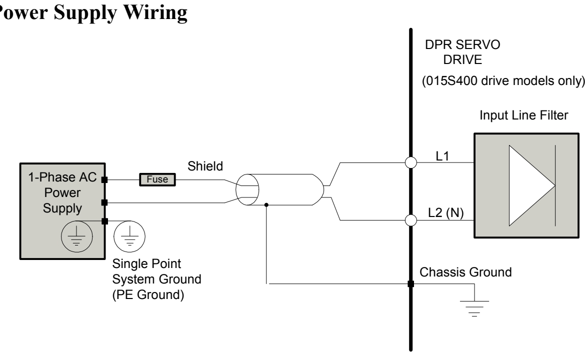
4.1.8 Power Supply Connections

The figures below show how an external power supply should be connected to the DPR drive.

AC or DC Power Modules For drive models designed for a three-phase AC power supply, connect the AC supply to L1, L2, and L3. On certain drive models, a single-phase AC supply can be connected to any two of the three (L1, L2, L3) AC terminals with the result that some drive power de-rating may occur. See Figure 4.26 below or the drive datasheet for the specific model characteristics. For drives designed for a single phase AC supply, connect the AC supply to the L1 and L2 (N) AC terminals for. Figure 4.26 below shows the recommended connections.

FIGURE 4.26 AC Power Supply Wiring





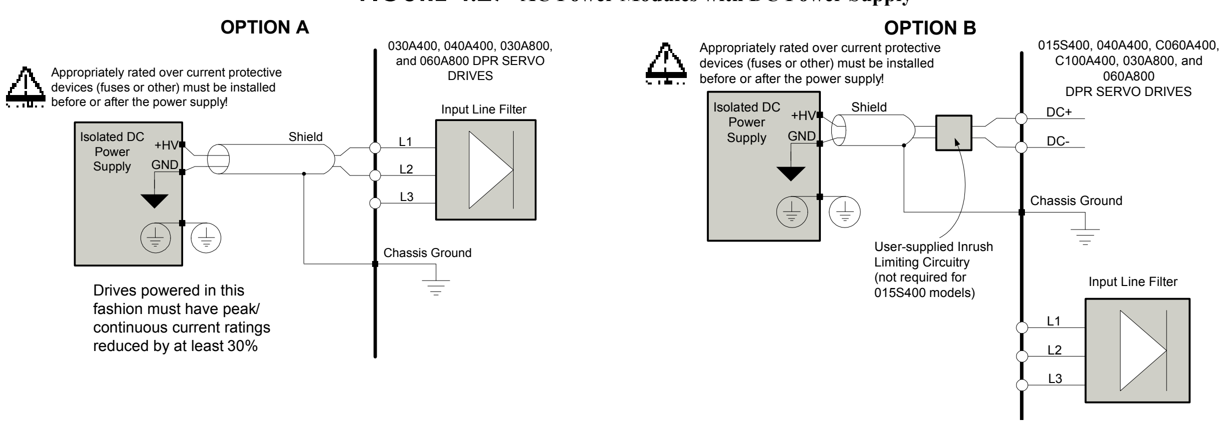
*To use a single-phase AC Supply with a drive designed for a three-phase AC supply, connect AC lines to any two of L1, L2, and L3. Do not connect AC line neutral to ground! See the chart below for specific drive model de-rating information for drives powered by single-phase AC.

Model	Single-Phase AC De-rating Characteristics
030A400	Peak and continuous current ratings will be reduced by 30%
040A400	Peak and continuous current ratings will be reduced by 30%
C060A400	Output power must not exceed 3KW. No current limit de-rating.
C100A400	Output power must not exceed 3kW. Current limits de-rated to 30A cont. / 60A peak.

If using a DC supply to power a drive with an AC power module, follow one of the methods below, depending on the connections available for the specific power module (Figure 4.27 below shows the recommended connections):

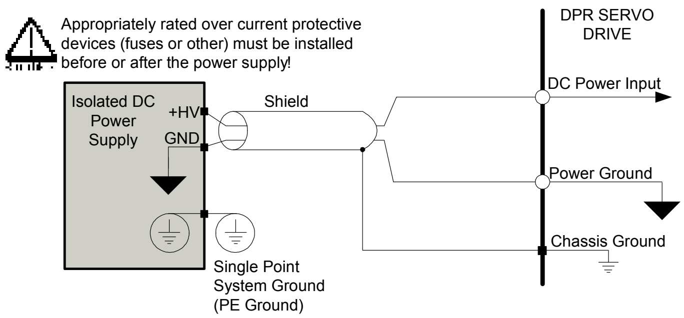
- (Option A) Connect the isolated DC supply between any two of the three (L1, L2, L3) power terminals. Note that drives powered in this fashion must have peak and continuous current ratings reduced by at least 30% and should not be given current commands that exceed this derating.
- (Option B) Some drives feature DC+ and DC- terminals which can be used as DC inputs rather than using L1, L2, or L3. Except for 015S400 power modules, powering the drive in this fashion will require external inrush limiting circuitry that must be properly scaled to the application and drive power requirements.

FIGURE 4.27 AC Power Modules with DC Power Supply



DC Power Modules For drives using a DC power module, connect the isolated DC supply high voltage to the DC Power Input terminal, and the DC supply ground to the power ground terminal, as shown in Figure 4.28 below.

FIGURE 4.28 DC Power Supply Wiring



4.1.9 Communication and Commissioning

DPR drives include a single serial interface for networking and drive configuration and setup. The RS-485 address and baud rate are set by dipswitches on the DPR drive. The dipswitch settings are different from and do not affect the RS-232 connection settings. Table 4.9 shows the RS-485 drive address and baud rate dipswitch information. The RS-485 drive address and baud rate settings will apply when using Modbus RTU.

TABLE 4.9 Binary RS-485 Drive Address and Baud Rate Dipswitch Settings

Switch	Description	Setting	
		On	Off
1	Bit 0 of binary RS-485 drive address	1	0
2	Bit 1 of binary RS-485 drive address	1	0
3	Bit 2 of binary RS-485 drive address	1	0
4	Bit 3 of binary RS-485 drive address	1	0
5	Bit 4 of binary RS-485 drive address	1	0
6	Bit 5 of binary RS-485 drive address	1	0
7	Bit 0 of drive RS-485 baud rate setting	1	0
8	Bit 1 of drive RS-485 baud rate setting	1	0

The drive can be configured to use the RS-485 address and/or baud rate stored in non-volatile memory by setting the address and/or baud rate value to 0. The baud rate settings are given in Table 4.10.

TABLE 4.10 RS-485 Drive Baud Rate Settings

Baud Rate (kbits/sec)	Value For Baud Rate Setting
Load from non-volatile memory	0
9.6	1
38.4	2
115.2	3

Upon connecting to the drive for the first time, the factory default settings for drive address and baud rate must be used. The default drive address and baud rate for both RS-232 and RS-485 is 63 and 115200, respectively. The recommended baud rate setting is 115200 for RS-232, and 115200 or higher for RS-485. If necessary, a baud rate of 9600 can be used to connect to the drive, but the baud rate should be increased prior to commissioning the drive. After connecting to the drive, by setting the RS-485 baud rate dipswitches to 0, the RS-485 baud rate can be configured in DriveWare or by serial commands up to a baud rate of 921600.

RS-485/232 Interface DPR drives include a Communication port for connection to RS-485/232 hardware interface. In order to select between RS-232 and RS-485 communication, the RS-485/232 selection pin SELECT (Pin 1 on Communication port) must be pulled to ground for RS-485, or left open for RS-232. DPR drives support both two wire and four wire RS-485 networks.

FIGURE 4.29 RS-232 Interface

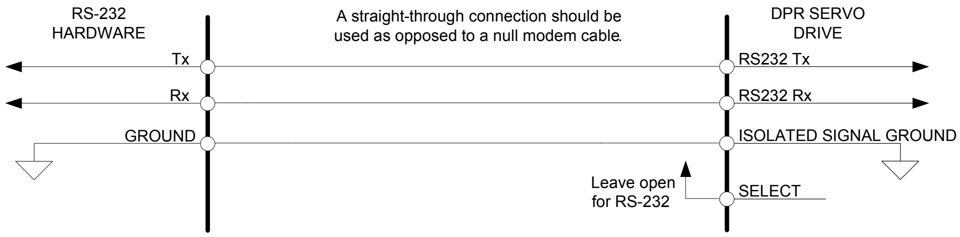
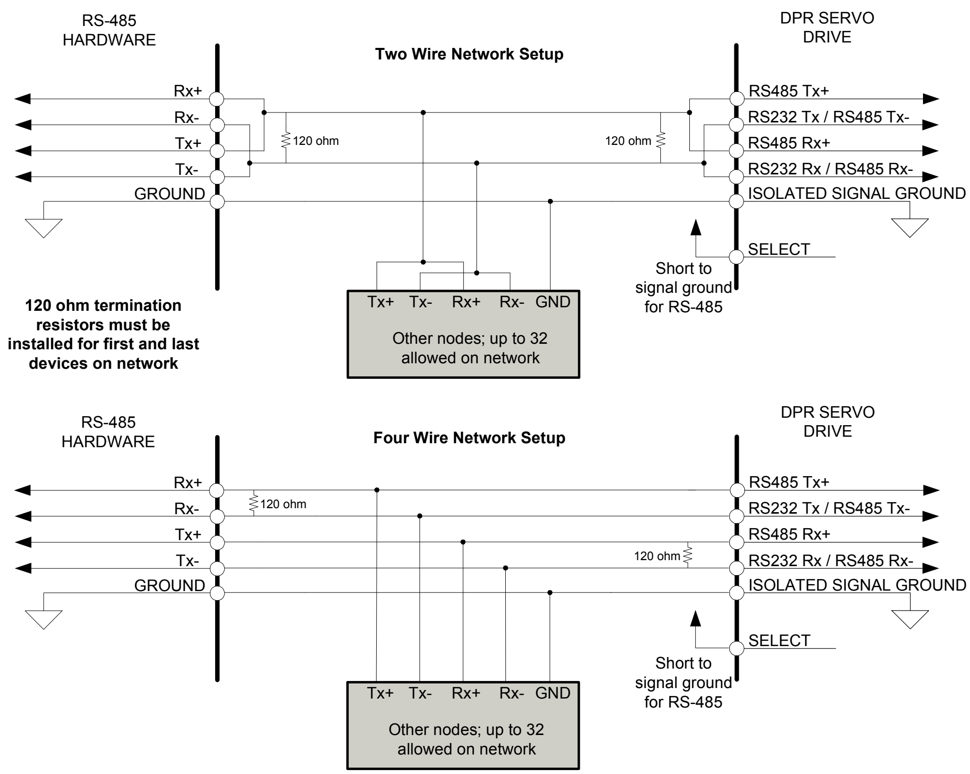


FIGURE 4.30 RS-485 Interface



4.1.10 LED Functionality

DPR drives feature LED status indicators for supply power and power bridge status. Certain models also include an LED to indicate regeneration mode status.

Power LED

The Power LED indicates whether power is being supplied to the drive, as well as shunt regulator operation.

Power LED	
State	**Description**
GREEN	Power is being supplied to the drive
OFF	No power is being supplied to the drive
FLASHING RED	Drive is shunting excess energy through the shunt regulator (may appear as flashing RED/GREEN as the shunt regulator is turning off and on during regeneration)

Status LED

The Status LED indicates whether the drive power bridge is enabled or disabled.

Status LED	
State	**Description**
GREEN	Power output bridge is enabled
RED	Power output bridge is disabled (via inhibit or fault)

4.1.11 Commutation

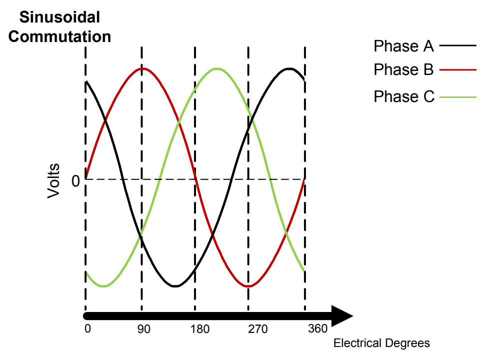
Motor commutation is the process that maintains an optimal angle between the magnetic field created by the permanent magnets in the motor and the electromagnetic field created by the currents running through the motor windings. This process ensures optimal torque or force generation at any motor position. Single phase (brushed) motors accomplish this process with internal commutators built into the motor housing. Three phase (brushless) motors require a correctly configured drive to commutate properly, however.

See the DriveWare Software Guide for more information on AutoCommutation, Manual Commutation, and Phase Detect. DPR drives allow either sinusoidal or trapezoidal commutation.

Sinusoidal Commutation

Sinusoidal commutation provides greater performance and efficiency than trapezoidal commutation. DPR drives can commutate sinusoidally when connected to a motor-mounted encoder. Sinusoidal Commutation works by supplying current to each of the three motor phases smoothly in a sinusoidal pattern. The flow of current through each phase is shifted by 120 degrees. The sum of the current flowing through all three phases adds up to zero. Figure 4.31 shows one electrical cycle of the motor phase currents.

FIGURE 4.31 Sinusoidal Commutation Motor Phase Currents



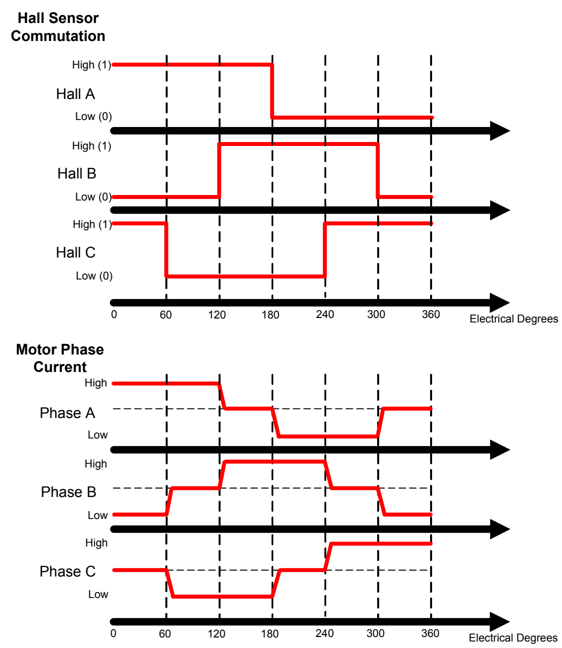
Trapezoidal Commutation

Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DPR drives can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at a time with trapezoidal commutation. The Hall Sensors each generate a square wave with a certain phase difference (either 120- or 60-degrees) over one electrical cycle of the motor. This results in six distinct Hall states for each electrical cycle. Depending on the motor pole count, there may be more than one electrical cycle per motor revolution. The number of electrical cycles in one motor revolution is equal to the number of motor poles divided by 2. For example:

- a 6-pole motor contains 3 electrical cycles per motor revolution
- a 4-pole motor contains 2 electrical cycles per motor revolution
- a 2-pole motor contains 1 electrical cycle per motor revolution

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 4.32.

FIGURE 4.32 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing



Note: Not all *ADVANCED* Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

Table 4.11 shows the default commutation states for 120-degree and 60-degree phasing. Depending on the specific setup, the sequences may change after running Auto Commutation.

TABLE 4.11 Digital Drive Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

4.1.12 Homing

DPR drives can be configured in DriveWare to "home" to a certain reference signal. This reference signal can be any number of different signal types, such as limit switches, home switches, or encoder index pulses. See the DriveWare Software Guide for more information on Homing.

4.1.13 Firmware

DPR drives are shipped with the latest version of firmware already stored in the drive. Periodic firmware updates are posted on the *ADVANCED* Motion Controls' website, www.a-m-c.com. See the DriveWare Software Guide for information on how to check the drive's firmware version, and how to download new firmware into the drive when necessary.

A Specifications

A.1 Specifications Tables

TABLE A.1 Power Specifications - AC Input DPR Drives

Description	Units	Power Specifications 015S400	030A400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	264	528	528
AC Input Phases[2]	-	1	3	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	123-373	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	429	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	30 (21.2)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	15 (15)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[2]	W	2415	4831	6441	9662	16103	6840	13680
Max. Continuous Power Dissipation @ Rated Voltage	W	127	254	339	509	848	360	720
Internal Bus Capacitance	∝F	540	1410	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	20	25	20	20	note 3	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	600	3000	3000

1. Certain 3-phase drive models can operate on single-phase VAC if peak/cont. current ratings are reduced by at least 30%.
2. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
3. Contact factory before using an external shunt resistor with this power module

TABLE A.2 Power Specifications - DC Input DPR Drives

Description	Units	Power Specifications 020B080	040B080	060B080	100B080	025B200	015B200
DC Supply Voltage Range	VDC	20-80	20-80	20-80	20-80	20-190	40-190
DC Bus Over Voltage Limit	VDC	86	86	86	88	198	198
DC Bus Under Voltage Limit	VDC	17	17	17	17	17	35
Maximum Peak Output Current	A (Arms)	20 (14.1)	40 (28.3)	60 (42.4)	100 (70.7)	25 (17.7)	15 (10.6)
Maximum Continuous Output Current	A (Arms)	10 (10)	20 (20)	30 (30)	60 (60)	12.5 (12.5)	7.5 (7.5)
Max. Continuous Output Power	W	760	1520	2280	4560	2256	1354
Max. Continuous Power Dissipation	W	40	80	120	230	118	71
PWM Switching Frequency	kHz	20	20	20	20	20	20
Internal Bus Capacitance	∝F	33	500	500	500	50	20
Minimum Load Inductance (Line-To-Line)	∝H	250	250	250	250	300	250

TABLE A.3 Control Specifications

Description	DPRAHIx	DPRANIx	DPRALTx
	Control Specifications		
Network Communication	RS-485/RS232 or Modbus RTU		
Command Sources	±10V Analog, 24V Step and Direction, Encoder Following, Over the Network, PWM and Direction, Sequencing, Indexing, Jogging	±10V Analog, Encoder Following, Over the Network, PWM and Direction, Sequencing, Indexing, Jogging	±10V Analog, 5V Step and Direction, Encoder Following, Over the Network, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal		
Control Modes[1]	Current (Torque), Velocity, Hall Velocity, Position		
Motors Supported	Three Phase Brushless (Servo, Closed Loop Vector, Closed Loop Stepper), Single Phase (Brushed, Voice Coil, Inductive Load)		
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage		
Programmable Digital I/O	10/4		6/4
Programmable Analog I/O	4/0	4/1	3/2
Primary I/O Logic Level	24 VDC		5V TTL

1. Hall Velocity mode may not be supported on certain drives. Check the drive datasheet to see if Hall Sensors are supported.

TABLE A.4 Environmental Specifications

Parameter	Description
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m

TABLE A.5 Baseplate Temperature Ranges

Power Board	Temperature Range
015S400	0 - 75 °C
030A400	0 - 75 °C
040A400	0 - 75 °C
C060A400	0 - 75 °C
C100A400	0 - 75 °C
030A800	0 - 75 °C
060A800	0 - 75 °C
020B080	0 - 65 °C
040B080	0 - 75 °C
060B080	0 - 75 °C
015B200	0 - 65 °C
025B200	0 - 75 °C

TABLE A.6 Feedback Specifications

Parameter	Value
Maximum Incremental Encoder Input Frequency	20MHz (5 pre-quadrature)
Maximum Sin/Cos Encoder Input Frequency	200kHz
Maximum Hall Sensor Input Frequency	0.15 x PWM Switching Frequency
Resolver Specifications	5kHz, 4Vrms, 0.5 transformation ratio
Maximum Tachometer Voltage	±10VDC

TABLE A.7 24 VDC Digital I/O Specifications

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

24VDC Isolated Digital Output	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA sinking, 8mA sourcing

B Troubleshooting

This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

B.1 Fault Conditions and Symptoms

A fault condition can either be caused by a system parameter in excess of software or hardware limits, or by an event that has been user-configured to disable the drive upon occurrence.

To determine whether the drive is in a fault state, use the Drive Status function in DriveWare to view active and history event items and drive fault conditions. See the DriveWare Software Guide for more information on reading the Drive Status window. Some common fault conditions caused by hardware issues are listed below.

Over-Temperature Verify that the baseplate temperature is less than 65°C (149°F). The drive remains disabled until the temperature at the drive baseplate falls below this threshold.

Over-Voltage Shutdown

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Power Supply Specifications" on page 24 for more information.

Under-Voltage Shutdown Verify power supply voltage for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply cannot provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing, power ground, and also phase-to-phase. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

Invalid Hall Sensor State

See the “Commutation Sequence” table in “Commutation” on page 58 for valid commutation states. If the drive is disabled check the following:

1. Check the voltage levels for all the Hall sensor inputs.
2. Make sure all Hall Sensor lines are connected properly.

B.1.1 Software Limits

Because DriveWare allows user configuration of many system parameters such as current, velocity, and position limits, as well as an associated "event action" for DriveWare to take when the system reaches this limit, it is possible for a drive to appear to be inoperative when in actuality it is simply in an assigned disable state.

For example, the motor velocity can be limited by giving a value to the Motor Over Speed selection in DriveWare. An "event action", such as "Disable the Power Bridge", can also be assigned for this particular limiting event for DriveWare to take if the motor reaches this speed. If the motor does happen to reach this velocity limit, DriveWare will automatically cut power to the drive’s output in this particular case, and the drive will be disabled. In the Drive Status window, "Motor Over Speed" will be shown as a "history" event, and "Commanded Disable" will be shown as an "Action" event.

Depending on each specific system and application, there are many different options available for assigning system limits and associated actions. See the DriveWare Software Guide for more information.

B.1.2 Connection Problems

Connection problems are oftentimes caused by incorrect communication settings in DriveWare. The default factory setting for DPR drives are a Drive Address of 63 and 115200 Baud Rate (some older drives may have a default Baud Rate of 9600). When connecting to the drive with DriveWare for the first time, these default factory settings will have to be used along with the appropriate serial port being used with the PC. Once the connection has been established, the Drive Address and Baud Rate may be changed. Check all communications settings to be sure that the Drive Address, Baud Rate, and serial port are correct. If unable to determine the appropriate settings, the Auto Detect routine will automatically scan for serial port and Baud Rate settings.

Faulty connection cables are also a possible cause of connection problems. Check all cables for any shorts or intermittent connections. Also check that all port hardware (USB-to-serial, etc.) is properly installed and configured.

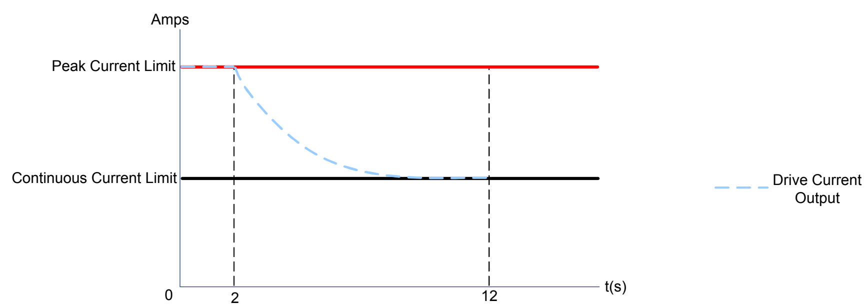
B.1.3 Overload

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip. Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive datasheets for minimum inductance requirements.

B.1.4 Current Limiting

All drives incorporate a “fold-back” circuit for protection against over-current. This “fold-back” circuit uses an approximate “I t” algorithm to protect the drive. All drives can run at peak current for a maximum of 2 second (each direction). Currents below this peak current but above the continuous current can be sustained for a longer time period. The drive will automatically fold back at an approximate rate of "I t" to the continuous current limit, within a time frame of less than 10 seconds. An over-current condition will not cause the drive to become disabled unless configured to do so in DriveWare.

FIGURE B.1 Peak Current Fold-Back



B.1.5 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, or by using DriveWare to reverse the internal velocity feedback polarity setting.

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper motor commutation or poor loop tuning. Follow the steps in the DriveWare Software Guide to properly commutate and tune the motor.

B.1.6 Causes of Erratic Operation

- Improper grounding (i.e., drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive voltage spikes on bus.

B.2 Technical Support

For help from the manufacturer regarding drive set-up or operating problems, please gather the following information:

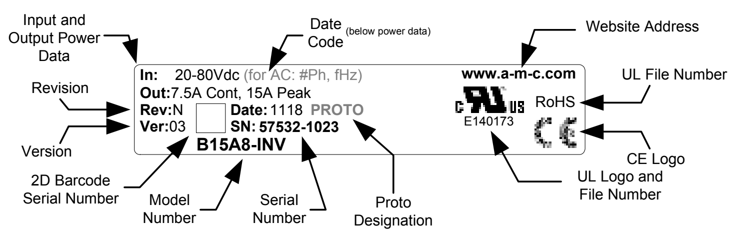
B.2.1 Drive Model Information

- DC bus voltage and range.
- Motor type, including inductance, torque constant, and winding resistance.
- Length and make-up of all wiring and cables.
- If brushless, include Hall sensor information.
- Type of controller, plus full description of feed back devices.
- Description of problem: instability, run-away, noise, over/under shoot, or other description.
- Complete part number and serial number of the product. Original purchase order is helpful, but not necessary.

B.2.2 Product Label Description

The following is a typical example of a product label as it is found on the drive:

FIGURE B.2 Product Label



1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with the same model number and revision letter ('01' is the earliest release of any revision).
4. Proto Designation: When included, indicates that the model is a prototype unit and model number will also begin with an 'X' designator.
5. Serial Number: The serial number consists of a 5-digit lot number followed by a 4-digit sequence number. Each product is assigned a unique serial number to track product life cycle history.
6. Date Code: The date code is a 4-digit number signifying the year and week of manufacture. The first two digits designate the year and the second two digits designate the week (e.g. the drive label shown would have been built in the year 2011 during the 18th week).
7. Input and Output Power Data: Includes basic power parameters of the product.
8. General Information: Displays applicable agency approvals, UL file reference number, and compliance approvals. More complete product information is availabe by following the listed website.

B.2.3 Warranty Returns and Factory Help

Seller warrants that all items will be delivered free from defects in material and workmanship and in conformance with contractual requirements. The Seller makes no other warranties, express or implied and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Seller's exclusive liability for breach of warranty shall be limited to repairing or replacing at the Seller's option items returned to Seller's plant at Buyer's expense within one year of the date of delivery. The Seller's liability on any claim of any kind, including negligence, for loss or damage arising out of, connected with or resulting from this order, or from the performance or breach thereof or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under this order shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim and in the event Seller fails to manufacture or deliver items other than standard products that appear in Seller's catalog. Seller's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. IN NO EVENT SHALL THE SELLER BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Buyer will take all appropriate measures to advise users and operators of the products delivered hereunder of all potential dangers to persons or property, which may be occasioned by such use. Buyer will indemnify and hold Seller harmless from all claims of any kind for injuries to persons and property arising from use of the products delivered hereunder. Buyer will, at its sole cost, carry liability insurance adequate to protect Buyer and Seller against such claims.

All returns (warranty or non-warranty) require that you first obtain a Return Material Authorization (RMA) number from the factory.

Request an RMA number by:

web	www.a-m-c.com/download/form/form_rma.html
telephone	(805) 389-1935
fax	(805) 389-1165

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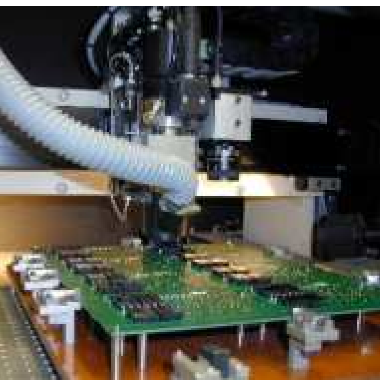
DPR Digital Drives

Hardware Installation Manual

MNDGDRIN-12

3805 Calle Tecate • Camarillo, CA 93012-5068

Tel: (805) 389-1935 Fax: (805) 389-1165 www.a-m-c.com



Everything's possible.

DigiFlex® Performance™ DPP Drives

POWERLINK / Modbus TCP / Ethernet Communication

Hardware Installation Manual

www.a-m-c.com

ORIGINAL INSTRUCTIONS

MNDGDPIN-06

Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the most recent software, the latest revisions of this manual, and copies of compliance and declarations of conformity, visit the company's website at *www.a-m-c.com*. Otherwise, contact the company directly at:

ADVANCED Motion Controls • 3805 Calle Tecate Camarillo, CA • 93012-5068 USA

Agency Compliances

The company holds original documents for the following:

- UL 508c, file number E140173
- Electromagnetic Compatibility, EMC Directive - 2014/30/EU
  EN61000-6-2:2005
  EN61000-6-4:2007/A1:2011
- Electrical Safety, Low Voltage Directive - 2014/35/EU
  EN 60204-1:2006/A1:2009
- Reduction of Hazardous Substances (RoHS III), 2015/863/EU
- Functional Safety Type Approved, TUV Rheinland

Trademarks

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Related Documentation

- Product datasheet specific for your drive, available for download at www.a-m-c.com
- DriveWare Software Guide, available for download at www.a-m-c.com
- POWERLINK Communication Manual, available for download at www.a-m-c.com
- Modbus Communication Manual, available for download at www.a-m-c.com
- Ethernet Communication Manual, available for download at www.a-m-c.com

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.

Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.

Notice - Required instruction necessary to ensure successful completion of a task or procedure.

Caution - Instructs and directs you to avoid damaging equipment.

Warning - Instructs and directs you to avoid harming yourself.

Danger - Presents information you must heed to avoid serious injury or death.

Revision History

Document ID	Revision #	Date	Changes
MNDGDPIN-01	1	3/2015	DPP Install Manual First Release
MNDGDPIN-02	2	10/2015	Added Ethernet POWERLINK as a supported network communication type
MNDGDPIN-03	3	3/2016	Added -040A400 power module information
MNDGDPIN-04	4	4/2017	Added -030A800 and -060A800 power module information
MNDGDPIN-05	5	11/2017	Added -100B080 power module information
MNDGDPIN-06	6	5/2018	- Added 2-Phase Stepper motor information - Added PDO power-up delay information

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1 Safety

This section discusses characteristics of your DPP digital drive to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

1.1 General Safety Overview

In order to install a DPP drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Caution

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Notice	High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.
Warning	Keep clear of all exposed power terminals (motor, DC Bus, shunt, DC power, transformer) when power is applied to the equipment. Follow these safety guidelines: • When using a separate logic supply, turn on the logic power supply first before turning on the main power supply. • Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive. • Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative. • Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive. • Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed. • Do not make any connections to the drive while power is applied.
Caution	• Do not reverse the power supply leads! Severe damage will result! • If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.
Caution	Use sufficient capacitance! Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Caution

Make sure minimum inductance requirements are met!

Pulse Width Modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 ∝H.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2 Products and System Requirements

This document is intended as a guide and general overview in selecting, installing, and operating *ADVANCED* Motion Controls DigiFlex Performance™ digital servo drives that use POWERLINK / Modbus TCP / Ethernet for networking. These specific drives are referred to herein and within the product literature as DPP drives. Other drives in the DigiFlex Performance product family that utilize other methods of network communication such as CANopen, EtherCAT , or RS-485 / Modbus RTU are discussed in separate manuals that are available at www.a-m-c.com. Contained within each DigiFlex Performance product family manual are instructions on system integration, wiring, drive-setup, and standard operating methods.

2.1 DPP Drive Family Overview

The DPP drive family can power three phase or single phase brushless or brushed servomotors, two phase or three phase closed loop stepper motors, and closed loop vector AC induction motors. The command source can be generated externally or can be supplied internally. A digital controller can be used to command and interact with DPP drives, and a number of dedicated and programmable digital and analog input/output pins are available for parameter observation and drive configuration. DPP drives are capable of operating in current (torque), velocity, or position modes, and utilize Space Vector Modulation, which results in higher bus voltage utilization and reduced heat dissipation compared to traditional PWM. DPP drives also offer a variety of firmware-dependent feedback options.

DPP drives offer POWERLINK, Modbus TCP or Ethernet communication for multiple drive networking, and feature a USB interface for drive configuration and setup. Drive commissioning is accomplished using DriveWare, the setup software from *ADVANCED* Motion Controls, available for download at www.a-m-c.com.

2.1.1 Drive Datasheet

Each DPP digital drive has a separate datasheet that contains important information on the options and product-specific features available with that particular drive. The datasheet is to be used in conjunction with this manual for system design and installation.

Caution

In order to avoid damage to equipment, only after a thorough reading and understanding of this manual and the specific datasheet of the DPP drive being used should you attempt to install and operate the drive.

2.2 Products Covered

The products covered in this manual adhere to the following part numbering structure. However, additional features and/or options are readily available for OEM's with sufficient ordering volume. Feel free to contact *ADVANCED* Motion Controls for further information.

FIGURE 2.1 DPP Part Numbering Structure

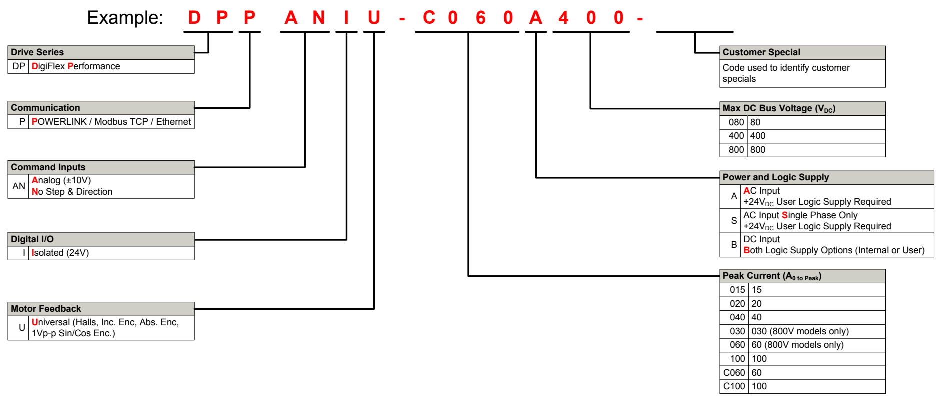


TABLE 2.1 Power Specifications - AC Power Modules

Description	Units	Power Specifications 015S400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	528	528
AC Input Phases	-	1	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[1]	W	2415	6441	9662	16103	6830	13650
Max. Continuous Power Dissipation @ Rated Voltage	W	127	339	509	848	360	720
Internal Bus Capacitance	∝F	540	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	25	20	20	note 2	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	3000	3000

1. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
2. Contact factory before using an external shunt resistor with this power module

TABLE 2.2 Power Specifications - DC Power Modules

Description	Units	Power Specifications 020B080	100B080
DC Supply Voltage Range	VDC	20-80	20-80
DC Bus Over Voltage Limit	VDC	88	88
DC Bus Under Voltage Limit	VDC	17	17
Maximum Peak Output Current	A (Arms)	20 (14.1)	100 (70.73)
Maximum Continuous Output Current	A (Arms)	10 (10)	60 (60)
Max. Continuous Output Power @ Rated Voltage[1]	W	760	4560
Max. Continuous Power Dissipation @ Rated Voltage	W	40	240
Internal Bus Capacitance	∝F	33	500
PWM Switching Frequency	kHz	20	20
Minimum Load Inductance (Line-To-Line)	∝H	600	250

TABLE 2.3 Control Specifications

Description	DPPANIU
Network Communication	POWERLINK / Modbus TCP / Ethernet (USB for Configuration)
Command Sources	± 10V Analog, Over the Network, Encoder Following, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	11/7
Programmable Analog I/O	2/0
Primary I/O Logic Level	24 VDC

TABLE 2.4 Feedback Options

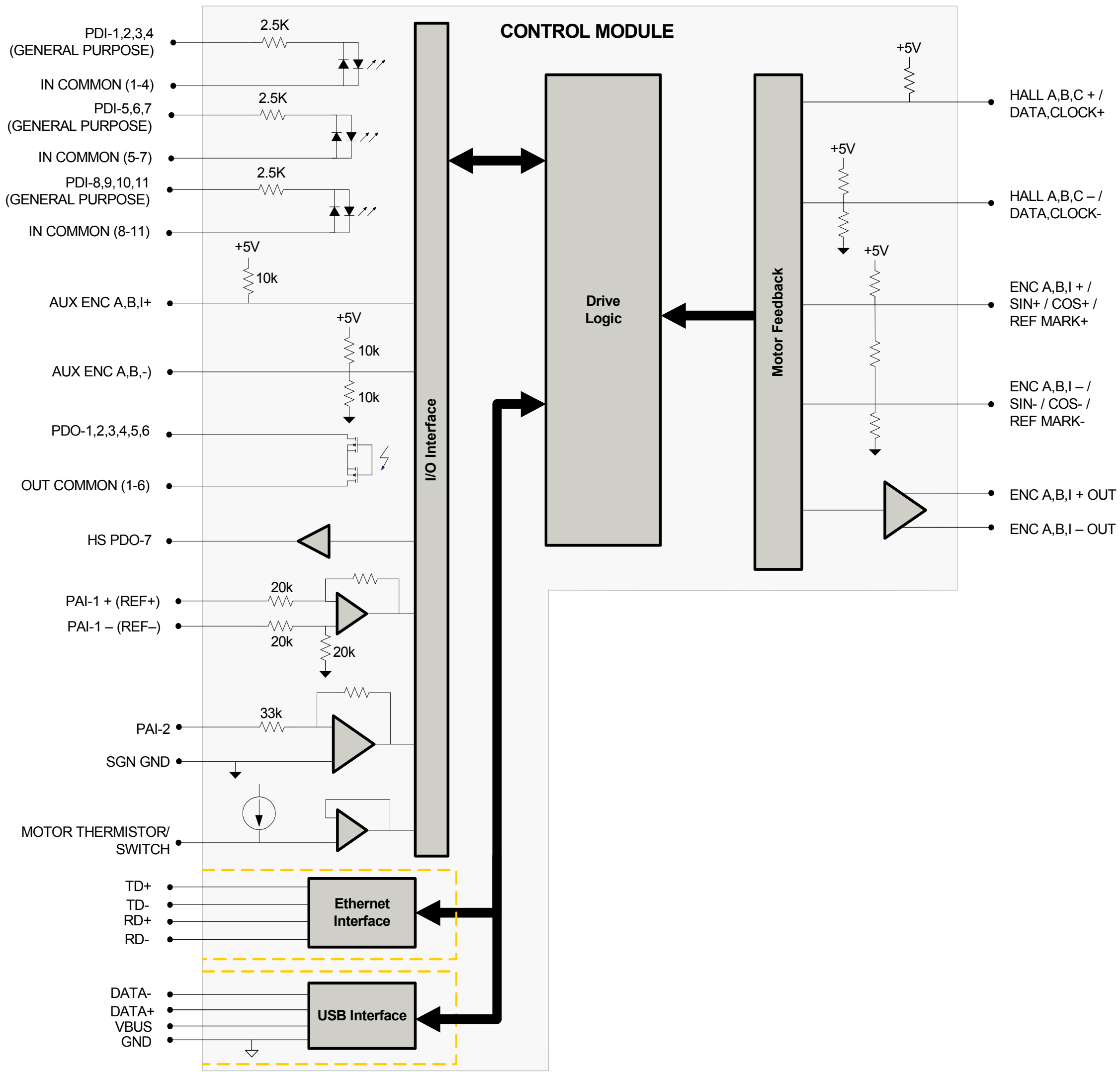
Description	DPPANIU
Hall Sensors	
Incremental Encoder	
Auxiliary Incremental Encoder	
Absolute Encoder (Hiperface®, EnDat®, BiSS C-Mode)	
1Vp-p Sine/Cosine Encoder	
Tachometer (10 ±VDC)	
±10 VDC Position	

Note: Drive will support either Incremental Encoder, Absolute Encoder, or 1Vp-p Sine/Cosine Encoder depending on drive firmware

2.2.1 Control Module

The diagram below shows the general block diagram for the DPPANIU control module. For complete pinouts, consult the drive's datasheet.

FIGURE 2.2 DPPANIU Control Module



2.3 Communication Protocol

DPP digital drives offer networking capability through POWERLINK, Modbus TCP or Ethernet communication. An auxiliary USB port is featured for configuring the drive through DriveWare.

Ethernet POWERLINK is an open-source real-time industrial Ethernet protocol created by B&R Automation. POWERLINK expands upon Ethernet according to the IEE 802.3 standard with a mixed polling and time slicing mechanism. The POWERLINK communication profile is based on CANopen communication profiles DS301 and DS302. POWERLINK is developed and maintained by the Ethernet POWERLINK Standardization Group (EPSG). For more detailed information on POWERLINK communication with DPP drives and a complete list of register definitions, consult the *ADVANCED* Motion Controls' POWERLINK Communication Manual available for download at www.a-m-c.com.

For more information on POWERLINK visit www.ethernet-powerlink.org.

Modbus is an open standard, master slave system developed for communication between multiple devices using a single wire. The Modbus protocol uses a defined message structure, regardless of the physical layer of the network used to communicate. A master device initiate a "query", and slave devices return a "response", supplying the requested data or taking the requested action. The query can be made to individual devices or broadcast to all connected devices. For more detailed information on Modbus TCP communication with DPP drives and a complete list of register definitions, consult the *ADVANCED* Motion Controls' Modbus Communication Manual available for download at www.a-m-c.com.

The Modbus TCP protocol for *ADVANCED* Motion Controls' DPP drives follows the Modbus Application Protocol Specification V1.1b. More information can be found at www.Modbus-IDA.org.

2.4 Control Modes

DPP digital drives operate in a variety of operating modes. The setup and configuration parameters for these modes are commissioned through DriveWare. See the DriveWare Software Manual for mode configuration information.

2.4.1 Profile Modes

In Profile Modes, the trajectory is limited by the drive, using the Command Limiter values to limit the maximum command rate. If the host sends a large command step, the drive spreads the demand over some period of time to stay equal to or below the maximum defined rate.

Profile Current (Torque) **In Current (Torque) Mode, the input command voltage controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored in DriveWare through the digital oscilloscope function. DriveWare also offers configuration of maximum and continuous current limit values.**

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

Profile Velocity **In Velocity Mode, the input command voltage controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. DPC drives allow velocity control with either Hall Sensors, an encoder, a resolver, or a tachometer as the feedback element. The motor velocity and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for velocity control must be specified in DriveWare, which also offers configuration of velocity limits. See** **"Feedback Supported" on page 11** **for more information on feedback devices.**

Profile Position **In Position Mode, the input command voltage controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. DPC drives allow position control with either an encoder, a resolver, or ±10V Position feedback. The motor position and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for position control must be specified in DriveWare, which also offers configuration of position limits. See** **"Feedback Supported" on page 11** **for more information on feedback devices.**

2.4.2 Cyclic Synchronous Modes

Cyclic Synchronous Modes give responsibility of trajectory control to the host. The drive interpolates between command points, defining the rate by dividing the change in command

by the interpolation time period. This allows the drive to respond smoothly to each step in command.

Cyclic Synchronous Current In Cyclic Synchronous Current Mode, the drive closes the current loop. The host is allowed more control by having the ability to instantly add current feedforward values. This allows for gain compensation in applications with varying loads.

Cyclic Synchronous Velocity In Cyclic Synchronous Velocity Mode, the drive closes two control loops: velocity and current. The host is allowed more control by having the ability to instantly add velocity and current feedforward values. This allows for gain compensation in applications with varying loads.

Cyclic Synchronous Position In Cyclic Synchronous Position Mode, the drive closes three control loops: position, velocity, and current. The host can send target position, velocity feedforward, and current feedforward values to the drive. This allows for gain compensation in applications with varying loads.

2.4.3 Current (Torque)

In Current (Torque) Mode, the input command controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored within the configuration software, or externally through network commands.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

2.4.4 Velocity

In Velocity Mode, the input command controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. The motor velocity and other parameters can be monitored within the configuration software, or externally through network commands. See “Feedback Supported” on page 11 for more information on velocity feedback devices.

2.4.5 Position

In Position Mode, the input command controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. The motor position and other parameters can be monitored within the configuration software, or externally through network commands. See “Feedback Supported” on page 11 for more information on position feedback devices.

2.5 Feedback Supported

DPP drives feature the ability to support a variety of primary feedback devices by downloading the appropriate firmware into the drive. Compatible firmware-dependent devices are Incremental Encoders, Absolute Sin/Cos Encoders (Hiperface®, EnDat®, and BiSS C-Mode), and 1Vp-p Sin/Cos Encoders. Consult the DriveWare Software Manual for instructions on how to download firmware into a digital servo drive.

Other supported feedback types that do not require a firmware change are Hall Sensors, Auxiliary Incremental Encoder, Tachometer, and ±10 VDC Position feedback.

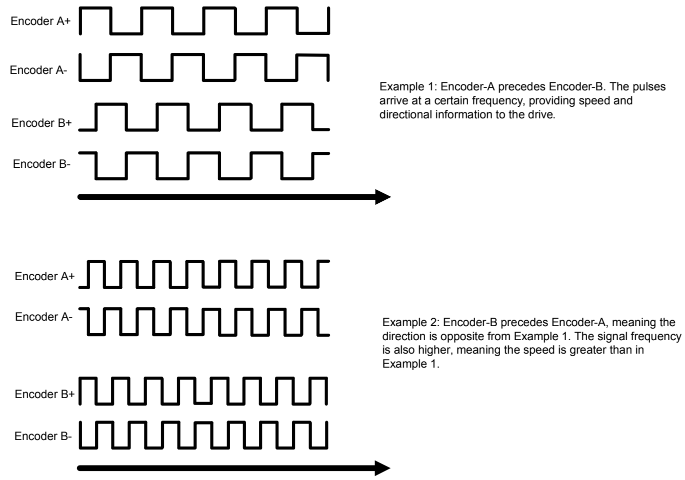
Feedback Polarity The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. The feedback element must be connected for *negative* feedback. Connecting the feedback element for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. The correct feedback polarity will be determined and configured during commissioning of the drive. Otherwise, to correct this, either change the order that the feedback lines are connected to the drive, or use DriveWare to reverse the internal velocity feedback polarity setting.

2.5.1 Incremental Encoder

DPP drive models can utilize incremental encoder feedback for velocity or position control, with the option of also using the encoder to commutate the motor. The encoder provides incremental position feedback that can be extrapolated into very precise velocity or position information. With an encoder being used as the feedback element, the input command controls the motor velocity or motor position, with the frequency of the encoder pulses closing the velocity and/or position loop. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor’s speed, position and direction of rotation. Based on the speed and order in which these pulses are received from the encoder, the drive can interpret the motor velocity and physical location. The actual motor speed and physical location can be monitored within the configuration software, or externally through network commands.

Figure 2.3 below represents differential encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated. By keeping track of the number of encoder "pulses" with respect to a known motor "home" position, DPP drives are able to ascertain the actual motor location.

FIGURE 2.3 Encoder Feedback Signals



Note

The high resolution of motor mounted encoders allows for excellent velocity and position control and smooth motion at all speeds. Encoder feedback should be used for applications requiring precise and accurate velocity and position control, and is especially useful in applications where low-speed smoothness is the objective.

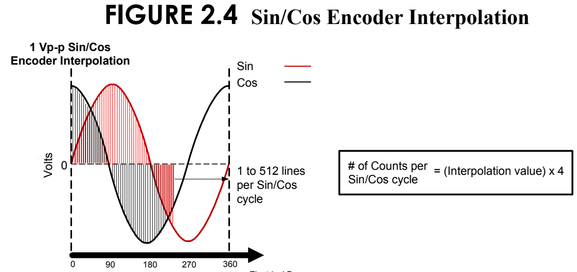
2.5.2 Absolute Encoder

DPP drives support Hiperface®, EnDat® (2.1/2.2 command set), or BiSS C-Mode absolute encoders for velocity and absolute position feedback. The encoder resolution and other options can be configured within the drive configuration software. The drive breaks down the signals from the encoder into individual reference points (counts). For feedback devices that accept 1 Vp-p signals, the interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.4. This allows for very high interpolated encoder resolution (4-2048 counts).

Note

The absolute position feedback eliminates the need for a homing routine when the drive is powered on.

FIGURE 2.4 Sin/Cos Encoder Interpolation



2.5.3 1Vp-p Sin/Cos Encoder

DPP drives support 1Vp-p Sin/Cos encoders for position and velocity feedback. The drive breaks down the 1 Vp-p sinusoidal signals from the encoder into individual reference points (counts). The interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.4. This allows for very high interpolated encoder resolution (4-2048 counts per Sin/Cos cycle).

2.5.4 Hall Sensors

DPP drives can use single-ended or differential Hall Sensors for commutation and/or velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. With Hall Sensors being used as the feedback element, the input command controls the motor velocity, with the Hall Sensor frequency closing the velocity loop.

Note

Hall velocity mode is not optimized for relatively high or relatively low Hall frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.

For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 48.

2.5.5 Auxiliary Incremental Encoder

The auxiliary encoder input pins can be used as a command source for encoder following mode, or as a secondary feedback device input for closing the position loop. The particular function is configured in the configuration software.

2.5.6 Tachometer (±10 VDC)

DPP drives support the use of a tachometer for velocity feedback. The tachometer measures the rotary speed of the motor shaft and returns an analog voltage signal to the drive for velocity control. DPP drives provide a Programmable Analog Input on the motor Feedback Connector that is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

2.5.7 ±10 VDC Position

DPP drives accept an analog ±10 VDC Position feedback, typically in the form of a load-mounted potentiometer. The feedback signal must be conditioned so that the voltage does not exceed ±10 V, and is connected to the drive through the Programmable Analog Input. In DriveWare, the connection method that is used must be selected under the Position Loop Feedback options. See the DriveWare Software Guide for more information.

2.6 Command Sources

The input command source for DPP drives can be configured for one of the following options.

2.6.1 ±10V Analog

DPP drives accept a single-ended or differential analog signal with a range of ±10 V from an external source. The input command signals should be connected to the programmable input on the I/O Signal Connector. See "Programmable Analog I/O" on page 36 for more information.

2.6.2 Encoder Following

DPP drives can utilize Encoder Following as a form of input command. In Encoder Following mode, an auxiliary encoder signal can be used to command the drive in a master/slave configuration. The gearing ratio (input counts to output counts ratio) can be configured in DriveWare by the user. Encoder Following is only a valid option when the DPP drive is operated in position mode.

2.6.3 Indexing and Sequencing

DPP drives allow configuration of up to 16 separately defined Index tasks in DriveWare. Indexes can be either Absolute (commands a pre-defined move to an absolute position) or Relative (commands a pre-defined move relative to the current position). Indexes can be combined with Homing routines and other control functions to form up to 16 different Sequences. Sequences can be configured to initiate on power-up, via a digital input, or by using an external network command.

2.6.4 Jogging

DPP drives allow configuration of two separate Jog velocities in DriveWare, commanding motion at a defined constant velocity with infinite distance.

2.6.5 Over the Network

DPP drives can utilize Modbus TCP or Ethernet network communication as a form of input command through the Ethernet interface. In order to send commands to the drive, the command source in DriveWare must be set to Interface Input 1. For more information on commanding the drive with Modbus TCP, see "Communication and Commissioning" on page 46.

2.7 System Requirements

To successfully incorporate a DPP digital servo drive into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance.

2.7.1 Specifications Check

Before selecting a DPP digital servo drive, a user should consider the requirements of their system. This involves calculating the voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with. Before attempting to install or operate a DPP servo drive, be sure all the following items are available:

- DPP Digital Servo Drive
- DPP Drive Datasheet (specific to your model)
- DPP Series Digital Hardware Installation Manual
- DriveWare Software Guide

2.7.2 Motor Specifications

DPP digital servo drives have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a DPP drive may be selected that will best suit the motor capabilities. Some general guidelines that are useful when pairing a DPP servo drive with a motor:

- The motor current I_M is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T -motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile. The continuous torque is the average torque required by the system during the move profile, including dwell times.

- The system voltage requirement is based on the motor properties and how fast and hard the motor is driven. The system voltage requirement is equal to the motor voltage, V_M, required to achieve the move profile.

$$V_M = (K_E \cdot S_M) + (I_M \cdot R_M)$$

Where:

K -motor back EMF constant

S -motor speed (use the maximum speed expected for the application)

I -motor current (use the maximum current expected for the application)
R -motor line-to-line resistance

- The motor inductance is vital to the operation of DPP servo drives, as it ensures that the DC motor current is properly filtered.

Caution

A motor that does not meet the rated minimum inductance value of the DPP drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary.

A minimum motor inductance rating can be found in the drive datasheet. If the drive is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

2.7.3 Power Supply Specifications

DPP servo drives operate off a single-phase AC Power Supply. To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

- Drive over voltage
- External shunt regulator turn-on voltage

Use of a shunt regulator is necessary in systems where motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply. This regenerated energy can charge the power supply capacitors to levels above that of the DPP drive over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one drive, then the current requirements for each drive should be added together. Due to the nature of servo drives, the current into the drive does not always equal the current out of the drive. However, the *power* in is equal to the *power* out. Use the following equation to calculate the power supply output current, I_{PS}, based on the motor current requirements.

$$I_{PS} = \frac{V_M \cdot I_M}{V_{PS} \cdot (0.98)}$$

Where:

V_{PS} -nominal power supply voltage
I_M -motor current
V_M -motor voltage

Use values of V and I at the point of maximum power in the move profile (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.

2.7.4 Environment

To ensure proper operation of a DPP servo drive, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.5 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Baseplate Maximum Allowable Temperature	0 - 75 °C

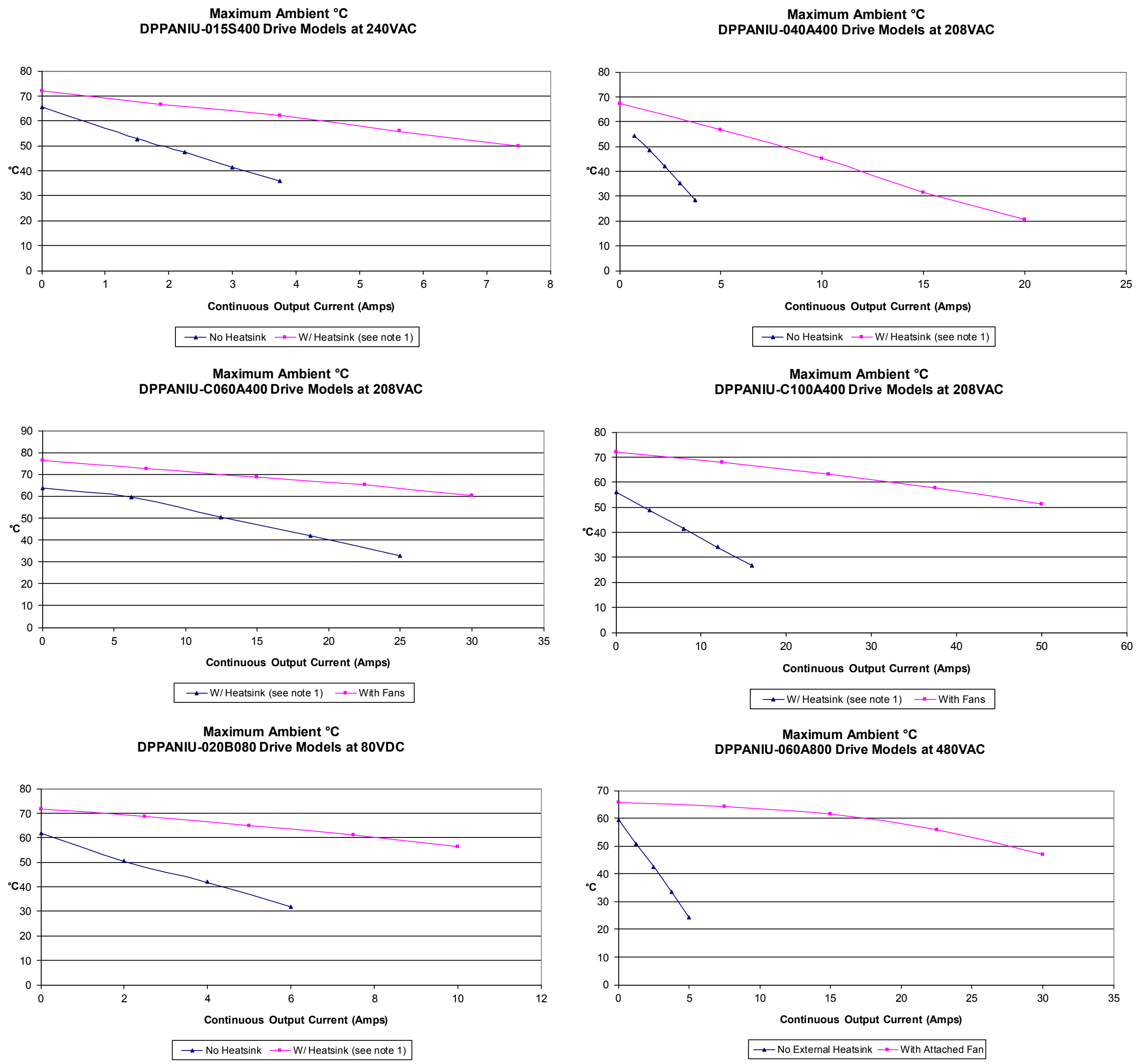
Shock/Vibrations **While DPP drives are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to. The best way to secure the drive against mechanical vibration is to use screws to mount the DPP drive against its baseplate. For information on mounting options and procedures, see** **"Mounting" on page 30.**

Caution

Care should be taken to ensure the drive is securely mounted in a location where no moving parts will come in contact with the drive.

Ambient Temperature Range and Thermal Data **DPP drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above 75 degrees Celsius. For a specific AC supply voltage and a specific output current, Figure 2.5 below specifies an upper limit to the ambient temperature range DPP drives can operate within while keeping the baseplate temperature below the maximum baseplate temperature. It is recommended to mount the baseplate of the DPP drive to a heatsink and/or use fan cooling for best thermal management results. For mounting instructions see** **"Mounting" on page 30****.**

FIGURE 2.5 DPP Drives Maximum Ambient Temperature Range



1.The heatsink used in the above test is a 15" x 22" x 0.65" aluminum plate.
2.Contact the factory for DPPANIU-100B080 thermal data.

3 Integration in the Servo System

This chapter will give various details on incorporating a DPP servo drive into a system, such as how to properly ground the DPP drive along with the entire system, and how to properly connect motor wires, power supply wires, feedback wires, communication cables, and inputs into the DPP drive.

3.1 LVD Requirements

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the servo drives must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

Contact the factory for assistance in determining the type of drive in use.

General

1. Shielded cables must be used for all interconnect cables to the drive and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.
2. The drive's metal enclosure must be grounded to the closest ground point with the least amount of resistance.
3. The drive must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.

Analog Input Drives

4. A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.

PWM Input Drives

5. A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.

MOSFET Switching Drives

6. A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.
7. An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.

IGBT Switching Drives

8. An appropriately rated Cosel Tac series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.
9. A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.

Fitting of AC Power Filters

10. It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be

adversely affected by the noise. AC power filters can filter this noise and keep it from getting on the AC power signal.The above mentioned AC power filters should be mounted flat against the enclosure of the product using the mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power filter enters the enclosure as possible. Also, the AC power cable on the load end of the filter should be routed far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

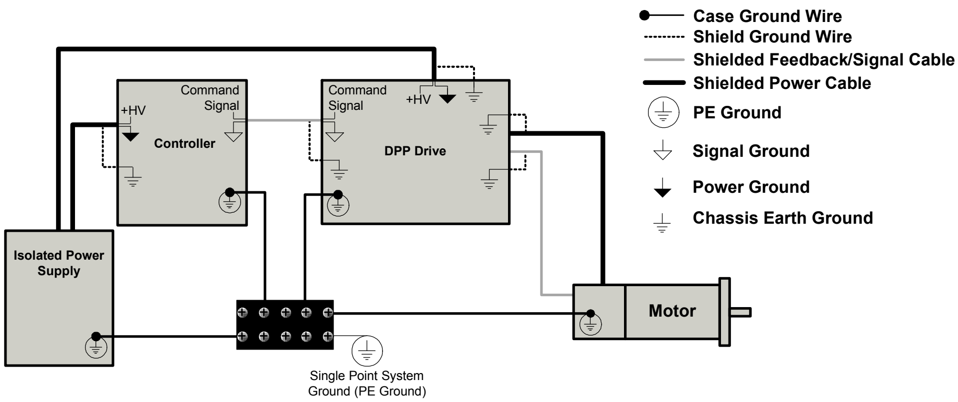
Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines.

3.3 Grounding

In most servo systems the case grounds of all the system components should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point through a single low resistance wire reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

- Motor chassis
- Controller chassis
- Power supply chassis
- DPP drive chassis

FIGURE 3.1 System Grounding



Ground cable shield wires at the drive side to a chassis earth ground point.

The power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the DPE drive to avoid picking up noise due to the "floating" differential servo drive input. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed. As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

The main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card or a noise suppression device is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

ADVANCED Motion Controls recommends using the following hand crimp tools for the appropriate I/O and Feedback cable and wire preparation. Consult the drive datasheet to see which connectors are used on a specific drive.

Drive Connector	Hand Crimp Tool Manufacturer and Part Number
6-pin, 3.96 mm spaced, friction lock header	Tyco: P/N 770522-1
High Density D-sub headers	Tyco: P/N 90800-1

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of larger diameter wire rather than too thin. This becomes more critical as the cable length increases. The following table provides recommendations for selecting the appropriate wire size for a specific current. These values should be used as reference only. Consult any applicable national or local electrical codes for specific guidelines.

Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518
15	#18	0.823
20	#16	1.31
35	#14	2.08
45	#12	3.31

Current (A)	Minimum Wire Size (AWG)	mm^2
60	#10	5.26
80	#8	8.37
120	#6	13.3
150	#0	53.5
200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

- For a single phase motor or voice coil, twist the two motor wires together as a group.
- For a three phase motor, twist all three motor wires together as a group.

Caution

DO NOT use wire shield to carry motor current or power!

Ground the motor power cable shield at one end only to the drive chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the drive chassis ground.

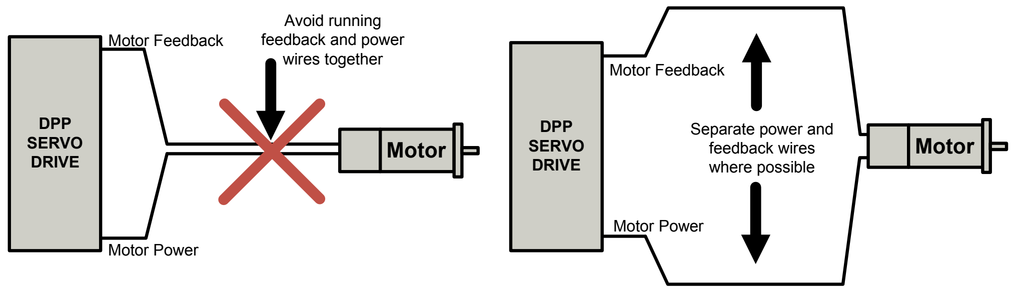
When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each drive directly from the power supply filter capacitor.
2. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the drive chassis ground. Also make sure that the feedback connector and D-sub shell preserve the shield continuity. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.2 Feedback Wiring



3.4.5 I/O and Signal Wires

Use of a twisted, shielded pair for the I/O and Signal wires is recommended. Connect the shield to the drive chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds.

Notice

In case of a single-ended reference signal when using ±10V as the input command source, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

3.5 Connector Types

Depending on the specific drive model, typically a DPP drive connection interface will consist of:

- Power Connectors - **used for Logic, Motor, and AC or DC Power, as well as optional external shunt regulator connections**
- Feedback Connectors - **used for primary and auxiliary feedback connections, programmable inputs and outputs, and other drive functions**
- Ethernet Communication Connector - **used for networking connections**
- Auxiliary USB Communication Connector - **used for USB drive communication necessary for commissioning with DriveWare**
- I/O Signal Connector - **used for programmable inputs and outputs as well as some feedback connections.**
- STO Connector - **used for Safe Torque Off (STO) functionality.**

The different types of connectors used in the DPP drive series are shown in the sections below. Consult the specific drive datasheet for the actual connectors and pin labels used on the drive.

3.5.1 Power Connectors

TABLE 3.1 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 3.5 mm spaced insert connector
Mating Connector	Details	Phoenix Contact: P/N 1840366
	Included with Drive	Yes

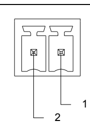


TABLE 3.2 POWER / MOTOR POWER / BRAKE - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		10-port, 5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1781069
	Included with Drive	Yes

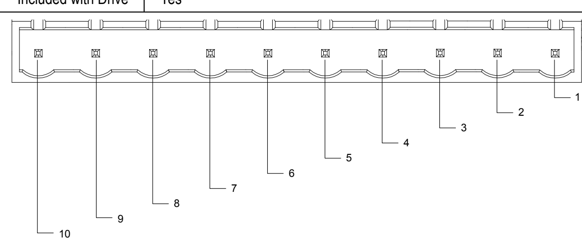


TABLE 3.3 POWER / MOTOR POWER / LOGIC - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		6-pin, 3.96 mm spaced, friction lock header
Mating Connector	Details	AMP: Plug P/N 770849-6; Terminals P/N 770522-1 (loose) or 770476-1 (strip)
	Included with Drive	Yes

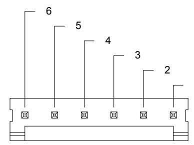


TABLE 3.4 AC POWER / MOTOR POWER / DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 10.16 mm spaced, enclosed, friction lock header
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

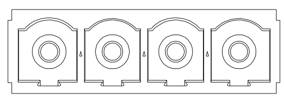


TABLE 3.5 AC POWER / MOTOR POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	No

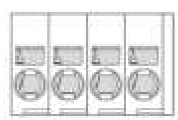


TABLE 3.6 DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		5-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	Not applicable

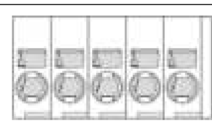


TABLE 3.7 DC POWER / MOTOR POWER - Power Connector

DC POWER / MOTOR POWER - Power Connector		
Connector Information		4-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804920
	Included with Drive	Yes

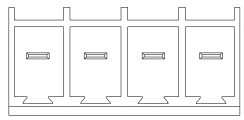
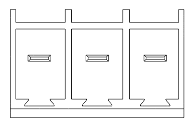


TABLE 3.8 AC POWER - Power Connector

ACPOWER - Power Connector		
Connector Information		3-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804917
	Included with Drive	Yes



3.5.2 Feedback Connectors

TABLE 3.9 FEEDBACK - Feedback Connector

FEEDBACK - Feedback Connector		
Connector Information		15-pin, high-density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 748364-1; Housing P/N 5748677-2; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No

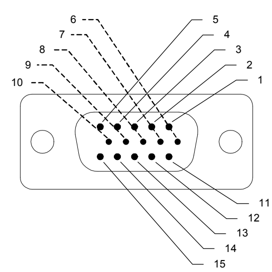
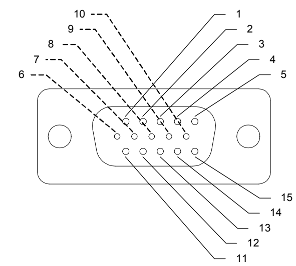


TABLE 3.10 AUX ENCODER - Auxiliary Feedback Connector

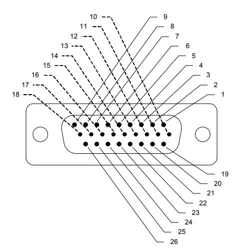
AUX ENCODER - Auxiliary Feedback Connector		
Connector Information		15-pin, high-density, male D-sub
Mating Connector	Details	TYCO: Plug P/N 1658681-1; Housing P/N 5748677-2; Terminals P/N 1658686-2 (loose) or 1658686-1 (strip)
	Included with Drive	No



3.5.3 I/O Connectors

TABLE 3.11 I/O - Signal Connector

I/O - Signal Connector		
Connector Information		26-pin, high density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 1658671-1; Housing P/N 5748677-3; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No



3.5.4 Communication Connectors

TABLE 3.12 COMM - Ethernet Communication Connector

COMM - Ethernet Communication Connector		
Connector Information		Shielded, dual RJ-45 socket with LEDs
Mating Connector	Details	Standard CAT 5e or CAT 6 ethernet cable
	Included with Drive	No

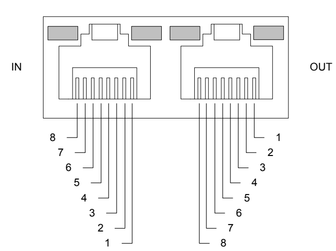
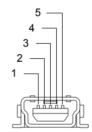


TABLE 3.13 AUX COMM - USB Communication Connector

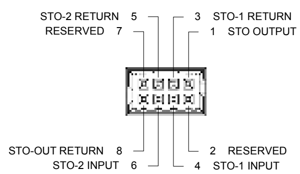
AUX COMM - USB Communication Connector		
Connector Information		5-pin, Mini USB B Type port
Mating Connector	Details	TYCO: 1496476-3 (2-meter STD-A to MINI-B ASSY)
	Included with Drive	No



3.5.5 STO Connector

TABLE 3.14 Safe Torque Off (STO) connector

STO Connector		
Connector Information		8-port, 2.00 mm spaced, enclosed, friction lock header
Mating Connector	Details	Molex: P/N 51110-0860 (housing); 50394-8051 (pins)
	Included with Drive	No



3.6 Mounting

DPP drives provide a number of mounting configuration options. The drive baseplate includes perimeter mounting screwholes allowing different mounting arrangements depending on the requirements or space limitations of the system. See the drive datasheet for specific mounting dimensions and screwhole locations.

4 Operation and Features

This chapter will present a brief introduction on how to test and operate a DPP servo drive. Read through this entire section before attempting to test the drive or make any connections.

4.1 Features and Getting Started

To begin operation with your DPP drive, be sure to read and understand the previous chapters in this manual as well as the drive datasheet and the DriveWare Software Guide. Ensure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the DPP drive. Also, be aware of the "Troubleshooting" section at the end of this manual for solutions to basic operation issues.

4.1.1 Initial Setup and Configuration

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up. For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- DPP Servo Drive
- Motor
- AC Power Supply and Logic Power Supply for supplying power to system
- DriveWare Setup Software and Software Guide for detailed instructions on how to setup, tune and configure a DPP drive in DriveWare

The following steps outline the general procedure to follow when commissioning a DPP drive for the first time. The DriveWare Software Guide contains more detailed information on each step.

1. **Check System Wiring:** Before beginning, check the wiring throughout the system to ensure proper connections and that all grounding and safety regulations have been followed appropriately for the system.

Caution

Do not apply power to the system until certain all wiring and grounding has been setup safely and properly!

For drives using a separate logic power supply, turn on the logic supply first before turning on the main power supply.

2. **Apply Power:** Power must be applied to the drive before any communication or configuration can take place. Turn on the Logic supply first for drives using a separate logic supply, then turn on the main Power supply. Use a multimeter or voltmeter to check that both power supply levels are within their specified ranges.
3. **Establish Connection:** Open DriveWare on the PC. The DPP drive should be connected to the PC with a USB cable. Choose the "Connect to a drive" option when DriveWare starts, and enter the appropriate communication settings in the options window that appears. See the DriveWare Software Guide for more information on connecting to a drive. For connection issues, see "Connection Problems" on page 53.
4. **Configure the drive in DriveWare:** DriveWare allows the user to manually configure user units, motor and feedback information, system parameters and limits, tune the Current, Velocity and Position Loops, commutate the motor, and assign drive and software "actions" to specific events. Consult the DriveWare Software Guide for detailed instructions.
5. **Connect to the Controller:** Once the drive has been properly commissioned, use an external controller to command an input signal to the drive. The controller wiring and setup should follow the safety and grounding guidelines and conventions as outlined in "Grounding" on page 22.

4.1.2 Input/Output Pin Functions

DPP drives provide a number of various input and output pins for parameter observation and drive configuration options. Consult the drive datasheet to see which input/output pin functions are available for each drive.

Programmable Digital I/O The single-ended and differential Programmable Digital I/O can be assigned to over 40 different functions in DriveWare. The polarity of the signals can be set to active HIGH or active LOW depending on the preference of the user. The differential high speed inputs can also be used as command source inputs with an Auxiliary Encoder (see "Auxiliary Encoder Input" below). DPP drives offer both isolated and non-isolated Programmable Digital I/O.

Note

When set to Active High, digital outputs will be pulled high for a period of time after a power cycle or drive reset. The delay period is given below.

FIGURE 4.1 Programmable Digital Output Power-up Delay

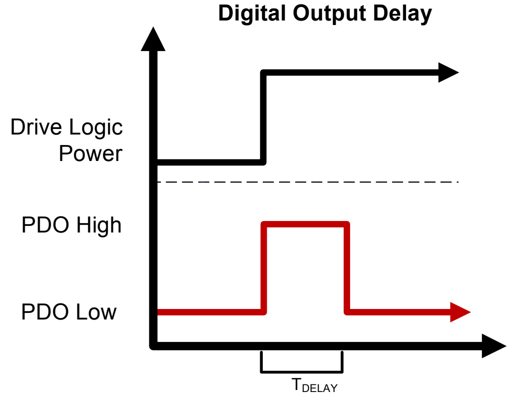


TABLE 4.1 Programmable Digital Output Power-up Delays

Active High		Active Low	
Power Cycle Delay (ms)	Reset Delay (ms)	Power Cycle Delay (ms)	Reset Delay (ms)
1900	1800	-	-

24VDC Digital I/O Specification

The 24VDC Digital I/O is designed to be compatible with controllers that interface with 24VDC signals, using optical isolation that separates the drive signal ground from the controller signal ground. Isolation increases a system's noise immunity by helping to eliminate current loops and ground currents.

- **Inputs** - The Isolated Digital Inputs use bi-directional optical isolators to detect signals from the controller. Dual LED's in the optical isolator allow current to flow in either direction. Current flow through the LED activates the transistor, and the drive responds depending on whether the transistor is active or not. The presence or absence of current

in the LED determines the logic level, not the direction of current. This flexibility allows the Isolated Digital Inputs to be compatible with a wide range of controllers.

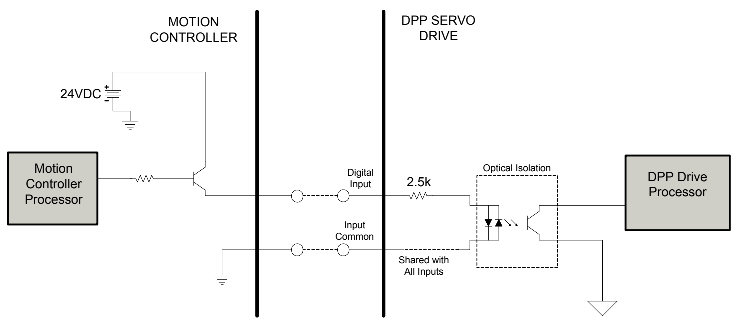
TABLE 4.2 24VDC Isolated Digital Input

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

When current flows into the digital input it is acting as a sinking input. When current flows out of the digital input it is acting as a sourcing input. Since current is allowed to flow in either direction, the inputs can either sink or source. The voltage at the Input Common pin determines whether the inputs sink or source. The Input Common pin is common to all of the inputs, but is isolated from the drive signal ground.

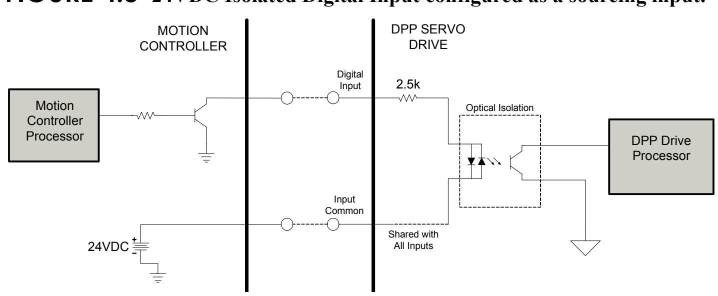
To configure the Isolated Digital Inputs as sinking, the 24V ground is applied to the Input Common and 24V is modulated at the digital input. Figure 4.2 shows a sourcing output from the motion controller feeding the sinking input at the drive. In this example the controller uses a transistor to control the 24V to the drive input. A mechanical switch, relay or other voltage-controlling device can be used in place of the transistor.

FIGURE 4.2 24VDC Isolated Digital Input configured as a sinking input



To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.3 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides a transistor.

FIGURE 4.3 24VDC Isolated Digital Input configured as a sourcing input.



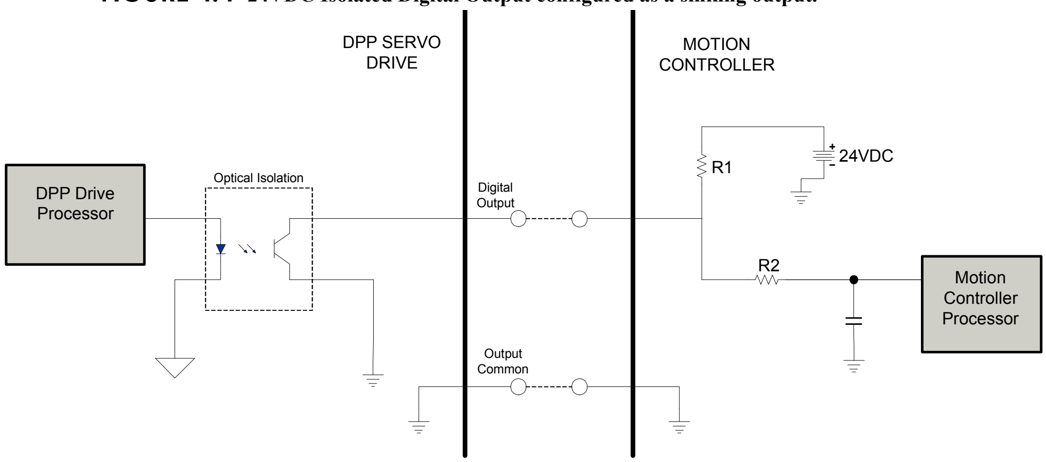
- **Outputs** - The Isolated Digital Outputs have a common grounding point labeled Output Common, and are +24VDC single-ended outputs.

TABLE 4.3 24VDC Isolated Digital Output

24VDC Isolated Digital Output (Sinking)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	120mA

A transistor controls the voltage at each digital output. The output pin is pulled to 24V and the 24V ground goes to the output common, as shown in Figure 4.4. A transistor controls the voltage at the digital output. When the transistor is open the voltage at the digital output is HIGH. When the transistor is closed the voltage is pulled to ground, which causes the output to go LOW.

FIGURE 4.4 24VDC Isolated Digital Output configured as a sinking output.



Programmable Limit Switch (PLS) Outputs

When a digital output is configured as a Programmable Limit Switch through the setup software, the maximum frequency of the output will correspond to the table below.

Maximum Digital Output Frequency for PLS Outputs

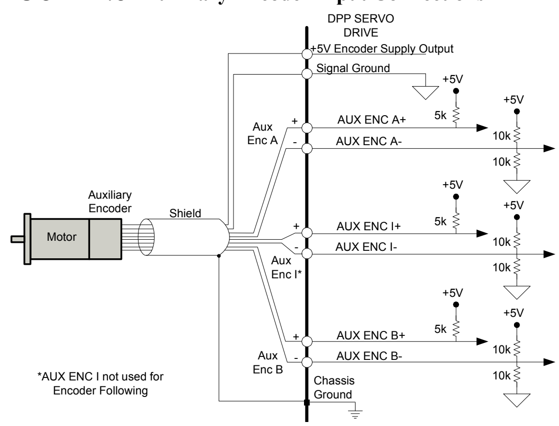
	Maximum Frequency
24V I/O Control Modules	85 Hz (50% duty cycle)[1]

1. Higher duty cycles will result in higher maximum frequencies due to hardware filtering.

Auxiliary Encoder Input

DPP drives accept a differential auxiliary encoder input that can be used for auxiliary position feedback, or for a command source when configured for Encoder Following. Hardware settings and options can be entered and configured in DriveWare.

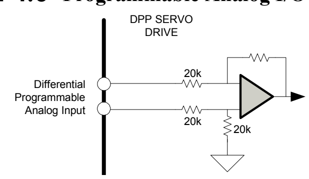
FIGURE 4.5 Auxiliary Encoder Input Connections



Programmable Analog I/O

The Programmable Analog I/O can be assigned to drive functions in DriveWare. These can be used to monitor drive signals, and are also useful for troubleshooting unexpected drive behavior. The drive I/O Signal Connector provides a differential programmable analog input that may be used for a ±10V analog input command.

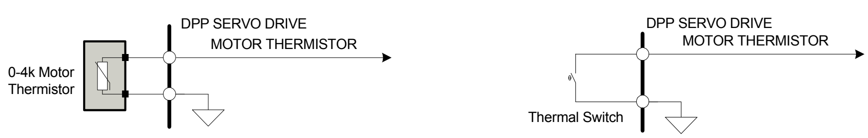
FIGURE 4.6 Programmable Analog I/O



Motor Thermistor

A 0-4 kohm thermistor or thermal switch can be connected between MOTOR THERMISTOR and GROUND. Thermistor/switch behavior can be configured in DriveWare.

FIGURE 4.7 Recommended Motor Thermistor Input

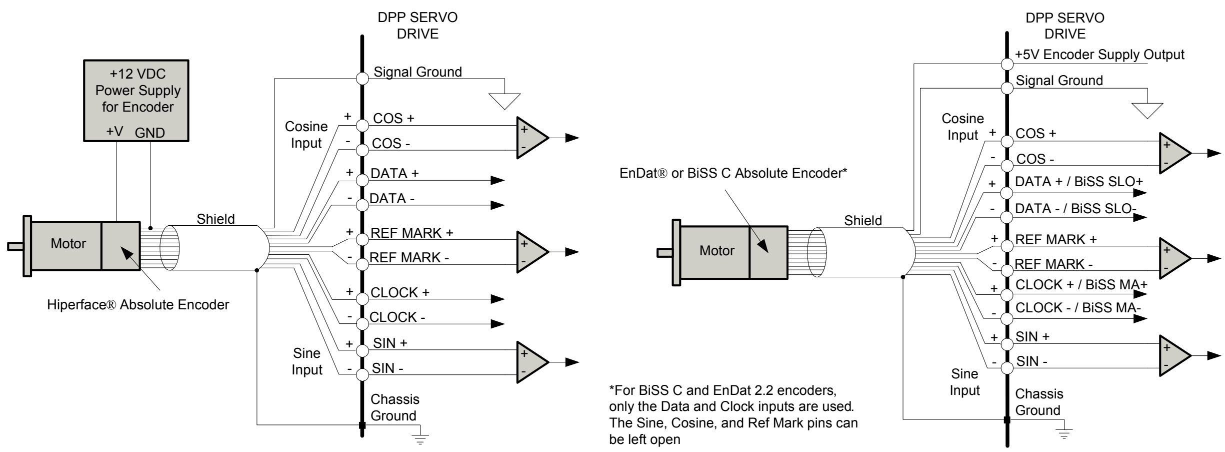


4.1.3 Feedback Operation

The functional operation of the feedback devices supported by DPP drives is described in this section. For more information on feedback selection, see "Feedback Supported" on page 11. See the drive datasheet specific pin locations.

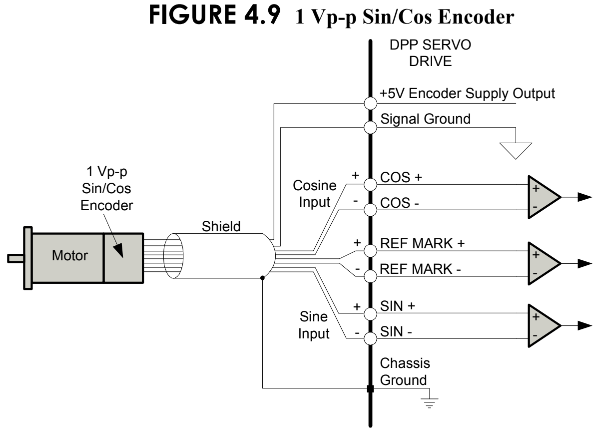
Absolute Encoder DPP drives support Hiperface®, EnDat®, or BiSS C-Mode absolute encoders. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs and differential RS-485 Data and Clock signals. Hiperface® encoders require an external +12 VDC supply for power, while EnDat® and BiSS C encoders can use the +5V Encoder Supply Output pin provided on the DPP drive. For BiSS C-Mode and EnDat 2.2 encoders, only the Data and Clock inputs are used. The Sine, Cosine, and Index pins can be left open.

FIGURE 4.8 Absolute Encoder Connections



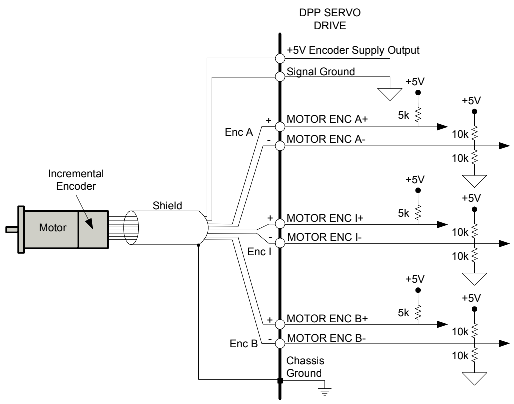
1 Vp-p Sin/Cos Encoder DPP drives support 1 Vp-p Sin/Cos Encoder feedback. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs. A +5V Encoder Supply Output pin is provided to supply power to the encoder.

FIGURE 4.9 1 Vp-p Sin/Cos Encoder



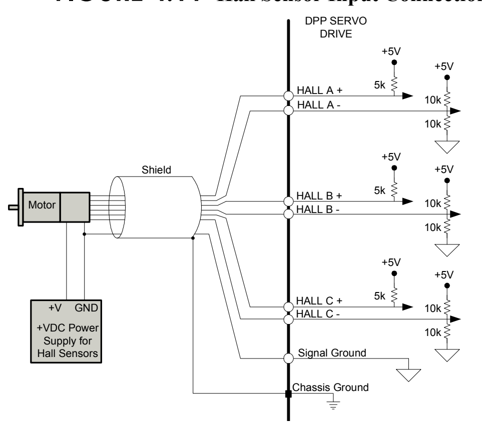
Incremental Encoder **DPP drives support incremental encoder feedback. The drive Feedback Connector allows inputs for differential inputs only. Both the "A" and "B" channels of the encoder are required for operation. DPP drives also accept an optional differential "index" channel that can be used for synchronization and homing. A +5V Encoder Supply Output pin is provided to supply power to the encoder.**

FIGURE 4.10 **Incremental Encoder Connections**



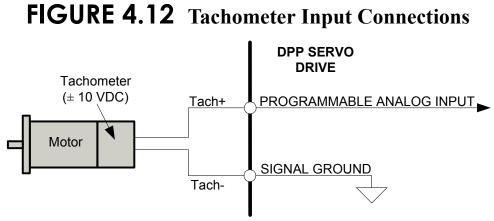
Hall Sensors **DPP drives accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive Feedback Connector allows differential or single-ended Hall Sensor inputs. For single-ended Halls leave the negative terminals open.**

FIGURE 4.11 **Hall Sensor Input Connections**



Tachometer (±10 VDC) **DPP drives support the use of a tachometer for velocity feedback. The Programmable Analog Input on the Auxiliary Feedback Connector is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.**

FIGURE 4.12 **Tachometer Input Connections**



4.1.4 Logic Power Supply

For DPP drives using an external +24 VDC nominal logic power supply (850mA), the logic supply ground should be referenced to the drive signal ground. The logic power inputs are made through a separate Logic Power connector on the drive.

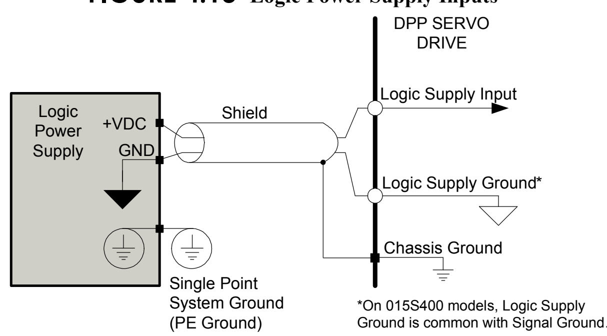
Caution

When using a separate logic power supply, the logic power must be turned on before the main power supply.

TABLE 4.4 AC Power Module Logic Supply Ratings

Logic Supply Range (VDC)	Input Current (mA)
20-30	850

FIGURE 4.13 Logic Power Supply Inputs

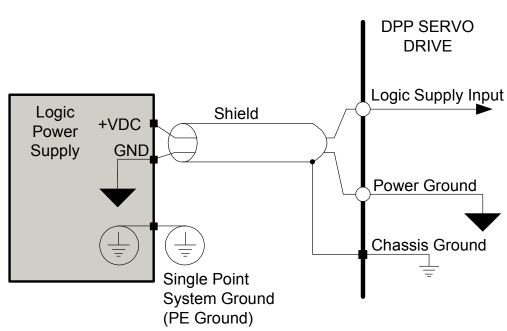


On drives using DC power modules, an external logic supply is optional. If no external logic supply is connected the drive will use the main DC power supply for logic power. If an external logic power supply is used, the voltage must be below the main DC Power Supply value. Table 4.5 shows the different DC power modules and their corresponding logic supply ranges.

TABLE 4.5 DC Power Module Logic Supply Ranges.

DC Power Module	Logic Supply Range (VDC)
020B080, 100B080	20-80

FIGURE 4.14 DC Power Module Logic Power Supply Inputs



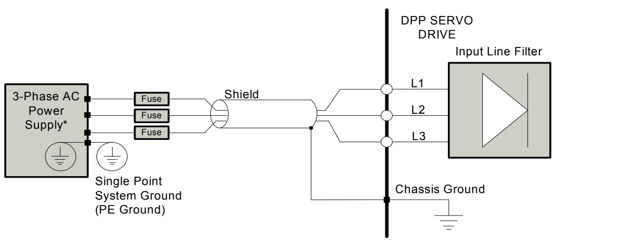
4.1.5 Power Supply Connections

The figures below show how an external power supply should be connected to the DPP drive.

AC or DC Power Modules

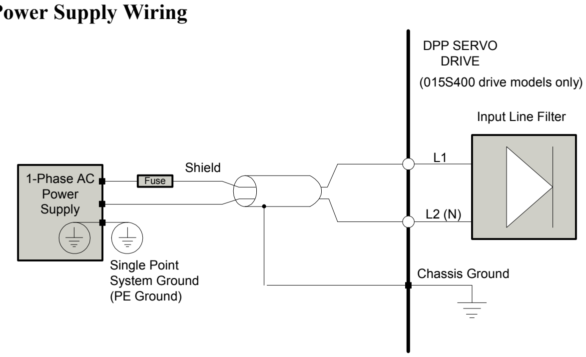
For drive models designed for a three-phase AC power supply, connect the AC supply to L1, L2, and L3. On certain drive models, a single-phase AC supply can be connected to any two of the three (L1, L2, L3) AC terminals with the result that some drive power de-rating may occur. See Figure 4.15 below or the drive datasheet for the specific model characteristics. For drives designed for a single phase AC supply, connect the AC supply to the L1 and L2 (N) AC terminals for. Figure 4.15 below shows the recommended connections.

FIGURE 4.15 AC Power Supply Wiring



*To use a single-phase AC Supply with a drive designed for a three-phase AC supply, connect AC lines to any two of L1, L2, and L3. Do not connect AC line neutral to ground! See the chart below for specific drive model de-rating information for drives powered by single-phase AC.

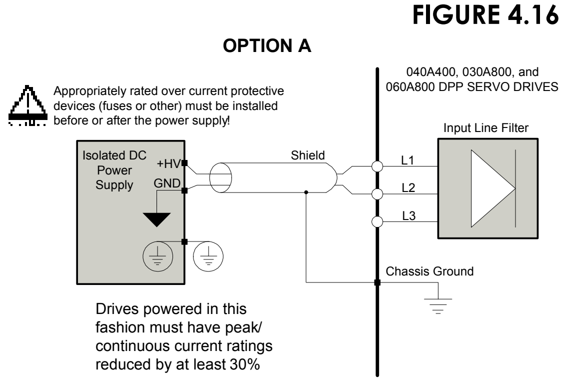
Model	Single-Phase AC De-rating Characteristics
040A400	Peak and continuous current ratings will be reduced by 30%
C060A400	Output power must not exceed 3KW. No current limit de-rating.
C100A400	Output power must not exceed 3kW. Current limits de-rated to 30A cont. / 60A peak.

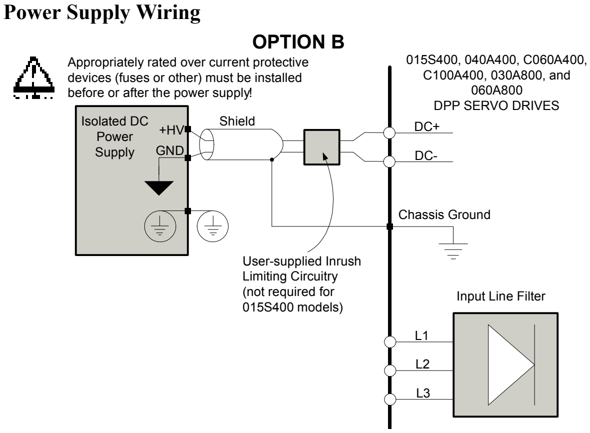


If using a DC supply to power a drive with an AC power module, follow one of the methods below, depending on the connections available for the specific power module (Figure 4.16 below shows the recommended connections).

- (Option A) Connect the isolated DC supply between any two of the three (L1, L2, L3) power terminals. Note that drives powered in this fashion must have peak and continuous current ratings reduced by at least 30% and should not be given current commands that exceed this derating.
- (Option B) Some drives feature DC+ and DC- terminals which can be used as DC inputs rather than using L1, L2, or L3. Except for 015S400 power modules, powering the drive in this fashion will require external inrush limiting circuitry that must be properly scaled to the application and drive power requirements.

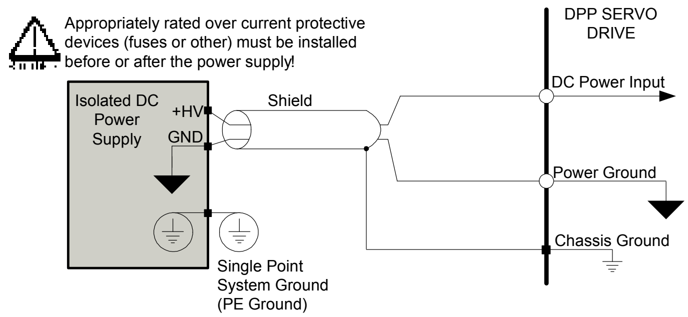
FIGURE 4.16 DC Power Supply Wiring





DC Only Power Modules **For drives using a DC power module, connect the isolated DC supply high voltage to the DC Power Input terminal, and the DC supply ground to the power ground terminal, as shown in Figure 4.17 below.**

FIGURE 4.17 DC Power Module Supply Wiring



4.1.6 Power LEDs Functionality

DPP drives feature LED status indicators for supply power and power bridge status.

Power LED **The Power LED indicates whether power is being supplied to the drive, as well as shunt regulator operation.**

Power LED	
State	**Description**
GREEN	Power is being supplied to the drive
OFF	No power is being supplied to the drive
RED	Drive is shunting excess energy through the shunt regulator (may appear as flashing RED/GREEN as the shunt regulator is turning off and on during regeneration)

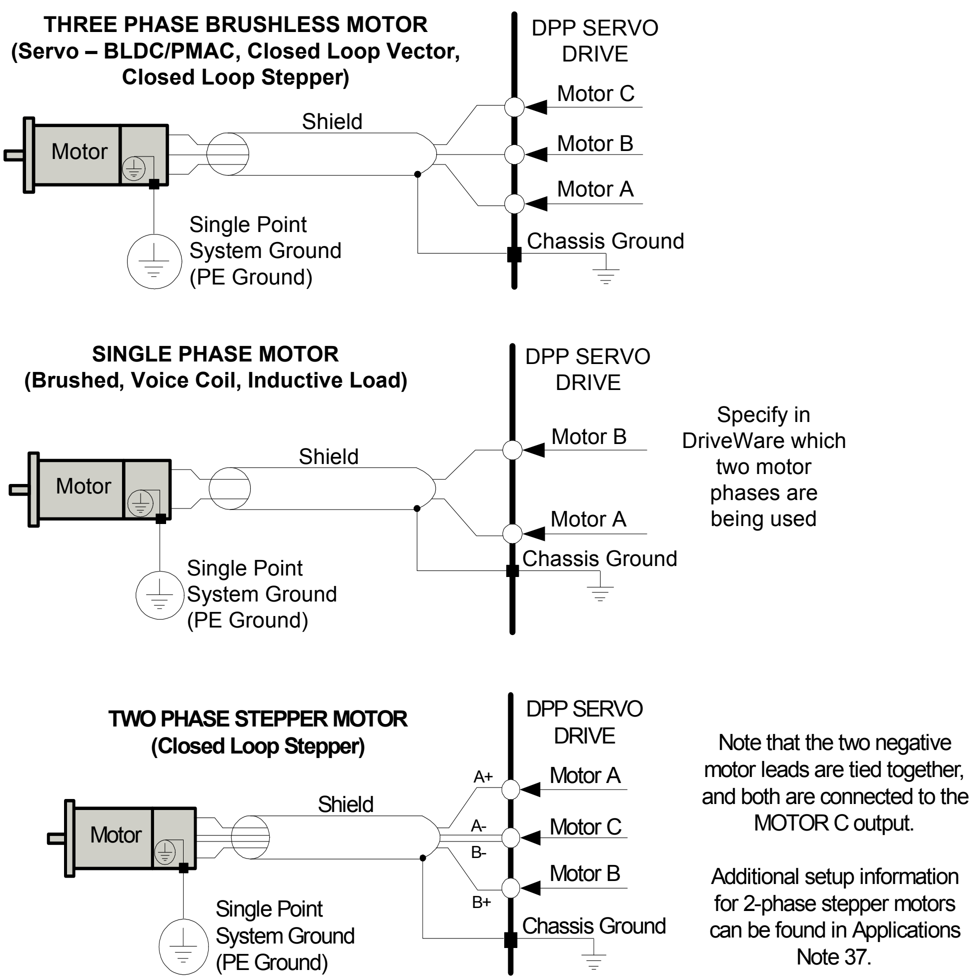
Status LED **The Status LED indicates whether the drive power bridge is enabled or disabled.**

Status LED	
State	**Description**
GREEN	Power output bridge is enabled
RED	Power output bridge is disabled (via inhibit or fault)

4.1.7 Motor Connections

The diagrams below show the connections to single and three phase motors. Notice that the motor wires are shielded, and that the motor housing is grounded to the single point system ground (PE Ground). The cable shield should be grounded at the drive side to chassis ground.

FIGURE 4.18 **Motor Power Output Wiring.**



Caution

If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

For applications using stepper motors, the maximum motor speed will be limited (typically ~600 RPM max).

4.1.8 External Shunt Resistor Connections

Most AC powered DPP drives allow the option of connecting an external shunt resistor to protect against damage that may occur due to over-voltage. Drives that do not include an internal shunt resistor require an external shunt resistor for the internal shunt regulator to operate. The figures below show how an external shunt resistor should be connected to the drive for the different AC Power Modules. The internal shunt regulator must be enabled and configured in DriveWare in order to operate..

FIGURE 4.19 C060A400 Power Module External Shunt Resistor Connection

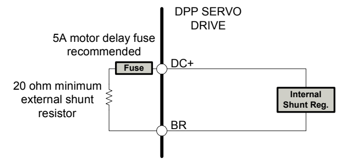


FIGURE 4.20 C100A400 Power Module External Shunt Resistor Connection

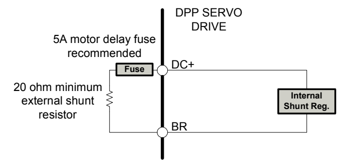


FIGURE 4.21 030A800 Power Module External Shunt Resistor Connection

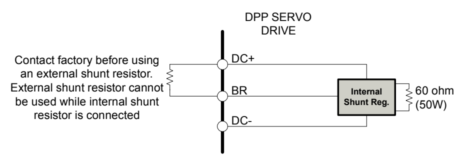


FIGURE 4.22 015S400, 040A400 and 060A800 Power Module External Shunt Resistor Connections

4.1.9 STO (Safe Torque Off)

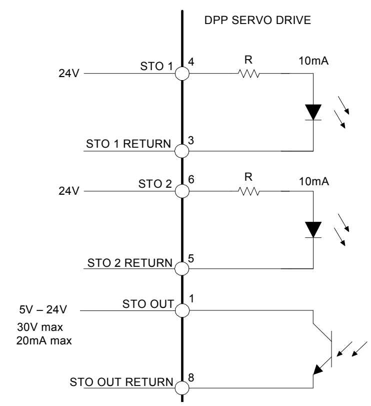
Some models of the DPP drive family feature an external dedicated +24VDC STO safety function designed to monitor an external 24V STO input from the user system and disable the motor output during an STO event. The STO circuit uses +24VDC sinking single-ended isolated inputs for STO functionality. Both STO1 and STO2 must be active (HIGH) to allow torque output at the drive motor outputs.

TABLE 4.6 STO Signal Behavior

STO 1	STO 2	Motor Outputs	STO OUT
Active (HIGH)	Active (HIGH)	Enabled	Open
Active (HIGH)	Not Active (LOW)	Disabled	Closed
Not Active (LOW)	Active (HIGH)	Disabled	Closed
Not Active (LOW)	Not Active (LOW)	Disabled	Closed

The STO circuitry also features an STO status output (STO OUT) that signifies when an STO condition has occurred. This status is also viewable in the setup software as an indicator only. The STO OUT output functions as a switch. When an STO event occurs, the STO OUT switch becomes CLOSED. When the drive is in normal functional operation (STO 1 and STO 2 = 24V), the STO OUT switch is OPEN.

FIGURE 4.23 STO Connections



See the drive datasheet for a drawing and description of the physical STO connector and mating hardware. Functional Safety is TÜV Rheinland certified and meets requirements of the following standards:

- **EN ISO 13849-1 -- Category 4 / PL e**
- **EN IEC 61800-5-2 -- STO (SIL 3)**
- **EN 62061 -- SIL CL3**
- **IEC 61508 -- SIL 3**

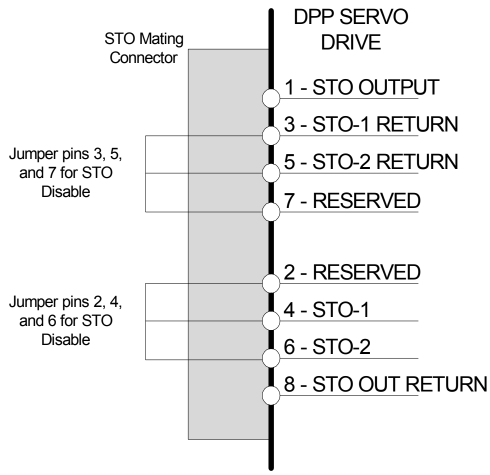
The user must verify proper operation of the monitoring circuit (STO 1 and STO 2) at least once per month to maintain SIL 3, Cat 4 / PL e certification. The monitoring circuit is required to be examined by an external logic element when STO is incorporated into a complete drive system in order for proper diagnostics to be fully implemented and utilized in the FMEA calculation (see "STO Operation Test" on page 45). The calculation of the safety relevant parameters are based on a proof test interval of one year and have shown that the requirements of up to SIL 3 are fulfilled. The safety relevant parameters are:

- **Safe-Failure-Fraction: SFF = 97%**
- **Probability of a dangerous failure per hour: PFH = 1.3 x 10 1/h**
- **Average probability of a dangerous failure on demand (1 year): PFD = 1.7 x 10**

Note: The above assessment and safety values defined were assessed with the STO function incorporated into the DigiFlex Performance DPP drive family. Product data for the DPP drive family can be found by visiting www.a-m-c.com.

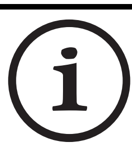
STO Disable **For applications that do not require Safe Torque Off functionality, disabling of the STO feature is required for proper drive operation. A dedicated STO Disable Key connector is available for purchase and must be installed for applications where STO is not in use. Contact the factory for ordering information. Altenatively, STO may be disabled by installing the included mating connector for the STO connector, and wiring the designated pins together as given below in figure.**

FIGURE 4.24 STO Disable Connections



STO Operation Test **To maintain SIL 3, Cat 4 / PL e certification, the operation of the STO monitoring circuit (STO1 and STO2) must be verified at least once per month. The following procedure provides an example of a method to verify correct STO functionality. Note that it is the responsibily of the system operator to ensure all personal and machine safety requirements for the system are properly enforced during the proof test.**

1. **Power on the drive.**
2. **Verify the drive is in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
3. **Remove the voltage signal from the STO1 input pin via a digital controller signal, network command, or by physically removing the STO Connector if safe to do so.**
4. **Verify that the drive is in a Disabled state (by viewing the Status LED is RED, or by verifying the STO OUT switch has closed).**
5. **Re-apply the voltage signal to the STO1 pin. Verify that the drive is once again in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
6. **Repeat the above steps for the STO2 signal.**

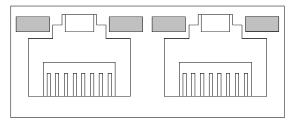

Note

End-product certification may require a different interval test schedule or test requirements. It is the responsibility of the end-user to determine the required test interval and requirements for certifications other than stated above.

4.1.10 Communication and Commissioning

DPP drives include an Ethernet interface for POWERLINK, Modbus TCP or Ethernet networking and a USB interface for drive configuration and setup. A dual RJ-45 socket connector accepts standard CAT 5e or CAT 6 ethernetcables for the Ethernet network connections.

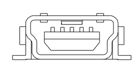
FIGURE 4.25 Ethernet Connectors

IN  OUT

Dual RJ-45 Ethernet Communication Connector

For drive commissioning, the DPP drive must be connected to a PC running *ADVANCED* Motion Controls DriveWare software. The mini type-b USB port on the DPP drive should be used with a STD-A to MINI-B USB cable for connection to a USB port on a PC.

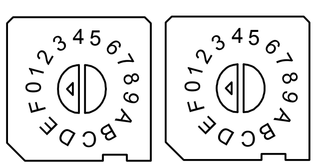
FIGURE 4.26 USB Connectors



MINI TYPE-B USB Connector

Ethernet Node ID/Address **DPP drives include two hexadecimal switches to assign the last octet of the IP address of the drive within the Ethernet network. Note that for POWERLINK, the IP address will always be 192.168.100.xxx. Figure 4.27 shows the hexadecimal switch settings and the corresponding node ID.**

FIGURE 4.27 Ethernet Address Hexadecimal Switches



SW0 SW1

SW1	SW0	Node ID
0	0	Address stored in NVM
0	1	001
0	2	002
...	...	...
F	D	253
F	E	254
F	F	255

Network Communication LEDs Functionality **The LINK/ACT LEDs on the dual RJ-45 communication connector provide network status. Figure 4.28 shows the LED locations, and Table 4.7 below describes typical LED functionality.**

FIGURE 4.28 Network LED Locations

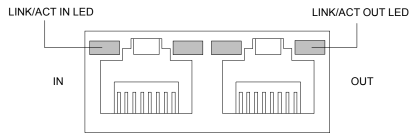


TABLE 4.7 Network Communication LEDs Function Protocol

LINK/ACT LED	
LED State	**Description**
Green - On	Valid Link - No Activity
Green - Flickering	Valid Link - Network Activity
Off	Invalid Link

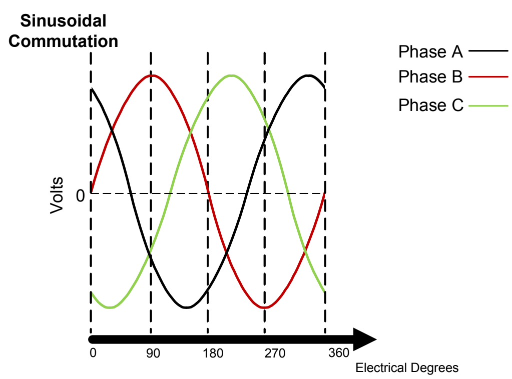
4.1.11 Commutation

Motor commutation is the process that maintains an optimal angle between the magnetic field created by the permanent magnets in the motor and the electromagnetic field created by the currents running through the motor windings. This process ensures optimal torque or force generation at any motor position. Single phase (brushed) motors accomplish this process with internal commutators built into the motor housing. Three phase (brushless) motors require a correctly configured drive to commutate properly, however.

See the DriveWare Software Guide for more information on AutoCommutation, Manual Commutation, and Phase Detect. DPP drives allow either sinusoidal or trapezoidal commutation.

Sinusoidal Commutation Sinusoidal commutation provides greater performance and efficiency than trapezoidal commutation. DPP drives can commutate sinusoidally when connected to a motor-mounted encoder. Sinusoidal Commutation works by supplying current to each of the three motor phases smoothly in a sinusoidal pattern. The flow of current through each phase is shifted by 120 degrees. The sum of the current flowing through all three phases adds up to zero. Figure 4.29 shows one electrical cycle of the motor phase currents.

FIGURE 4.29 Sinusoidal Commutation Motor Phase Currents

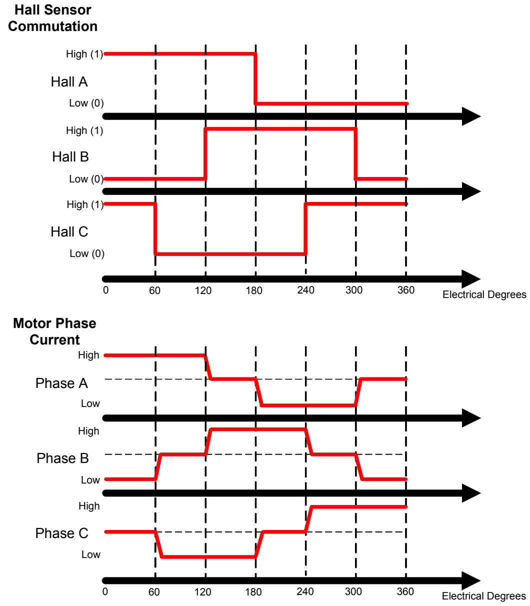


Trapezoidal Commutation Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DPP drives can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at a time with trapezoidal commutation. The Hall Sensors each generate a square wave with a certain phase difference (either 120- or 60-degrees) over one electrical cycle of the motor. This results in six distinct Hall states for each electrical cycle. Depending on the motor pole count, there may be more than one electrical cycle per motor revolution. The number of electrical cycles in one motor revolution is equal to the number of motor poles divided by 2. For example:

- a 6-pole motor contains 3 electrical cycles per motor revolution
- a 4-pole motor contains 2 electrical cycles per motor revolution
- a 2-pole motor contains 1 electrical cycle per motor revolution

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 4.30.

FIGURE 4.30 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing



Note: Not all *ADVANCED* Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

Table 4.8 shows the default commutation states for 120-degree and 60-degree phasing. Depending on the specific setup, the sequences may change after running Auto Commutation.

TABLE 4.8 Digital Drive Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

4.1.12 Homing

DPP drives can be configured in DriveWare to "home" to a certain reference signal. This reference signal can be any number of different signal types, such as limit switches, home switches, or encoder index pulses. See the DriveWare Software Guide for more information on Homing.

4.1.13 Firmware

DPP drives are shipped with the latest version of firmware already stored in the drive. Periodic firmware updates are posted on *ADVANCED* Motion Controls' website, www.a-m-c.com. See the DriveWare Software Guide for information on how to check the drive's firmware version, and how to download new firmware into the drive when necessary.

A Specifications

A.1 Specifications Tables

TABLE A.1 Specifications - AC Power Modules

Description	Units	Power Specifications 015S400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	528	528
AC Input Phases	-	1	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[1]	W	2415	6441	9662	16103	6830	13650
Max. Continuous Power Dissipation @ Rated Voltage	W	127	339	509	848	360	720
Internal Bus Capacitance	∝F	540	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	25	20	20	note 2	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	3000	3000

1. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
2. Contact factory before using an external shunt resistor with this power module

TABLE A.2 Power Specifications - DC Power Modules

Description	Units	Power Specifications 020B080	100B080
DC Supply Voltage Range	VDC	20-80	20-80
DC Bus Over Voltage Limit	VDC	88	88
DC Bus Under Voltage Limit	VDC	17	17
Maximum Peak Output Current	A (Arms)	20 (14.1)	100 (70.73)
Maximum Continuous Output Current	A (Arms)	10 (10)	60 (60)
Max. Continuous Output Power @ Rated Voltage[1]	W	760	4560
Max. Continuous Power Dissipation @ Rated Voltage	W	40	240
Internal Bus Capacitance	∝F	33	500
PWM Switching Frequency	kHz	20	20
Minimum Load Inductance (Line-To-Line)	∝H	600	250

TABLE A.3 Control Specifications

Description	DPPANIU
Network Communication	POWERLINK / Modbus TCP / Ethernet (USB for Configuration)
Command Sources	± 10V Analog, Over the Network, Encoder Following, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	11/7
Programmable Analog I/O	2/0
Primary I/O Logic Level	24 VDC

TABLE A.4 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Mechanical Shock	15g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m
Baseplate Maximum Allowable Temperature	0 - 75 °C

TABLE A.5 Feedback Specifications

Feedback Specifications	
Parameter	**Value**
Maximum Incremental Encoder Input Frequency	20MHz (5 pre-quadrature)
Maximum Sin/Cos Encoder Input Frequency	200kHz
Maximum Hall Sensor Input Frequency	0.15 x PWM Switching Frequency
Maximum Tachometer Voltage	±10VDC

TABLE A.6 24 VDC Digital I/O Specifications

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

24VDC Isolated Digital Output	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA sinking, 8mA sourcing

B Troubleshooting

This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

B.1 Fault Conditions and Symptoms

A fault condition can either be caused by a system parameter in excess of software or hardware limits, or by an event that has been user-configured to disable the drive upon occurrence.

To determine whether the drive is in a fault state, use the Drive Status function in DriveWare to view active and history event items and drive fault conditions. See the DriveWare Software Guide for more information on reading the Drive Status window. Some common fault conditions caused by hardware issues are listed below.

Over-Temperature Verify that the baseplate temperature is less than the drive Baseplate Temperature value. The drive remains disabled until the temperature at the drive baseplate falls below this threshold. See "Ambient Temperature Range and Thermal Data" on page 17 or consult the drive datasheet for the allowable temperature range.

Over-Voltage Shutdown

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Power Supply Specifications" on page 16 for more information.

Under-Voltage Shutdown Verify power supply voltage for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply cannot provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing, power ground, and also phase-to-phase. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

Invalid Hall Sensor State

See the “Commutation Sequence” table in “Commutation” on page 48 for valid commutation states. If the drive is disabled check the following:

1. Check the voltage levels for all the Hall sensor inputs.
2. Make sure all Hall Sensor lines are connected properly.

B.1.1 Software Limits

Because DriveWare allows user configuration of many system parameters such as current, velocity, and position limits, as well as an associated "event action" for DriveWare to take when the system reaches this limit, it is possible for a drive to appear to be inoperative when in actuality it is simply in an assigned disable state.

For example, the motor velocity can be limited by giving a value to the Motor Over Speed selection in DriveWare. An "event action", such as "Disable the Power Bridge", can also be assigned for this particular limiting event for DriveWare to take if the motor reaches this speed. If the motor does happen to reach this velocity limit, DriveWare will automatically cut power to the drive’s output in this particular case, and the drive will be disabled. In the Drive Status window, "Motor Over Speed" will be shown as a "history" event, and "Commanded Disable" will be shown as an "Action" event.

Depending on each specific system and application, there are many different options available for assigning system limits and associated actions. See the DriveWare Software Guide for more information.

B.1.2 Connection Problems

Connection problems are oftentimes caused by incorrect communication settings in DriveWare. Check all communications settings to be sure that the settings assigned in DriveWare are correct.

Faulty connection cables are also a possible cause of connection problems. Check all cables for any shorts or intermittent connections. Also check that all port hardware is properly installed and configured.

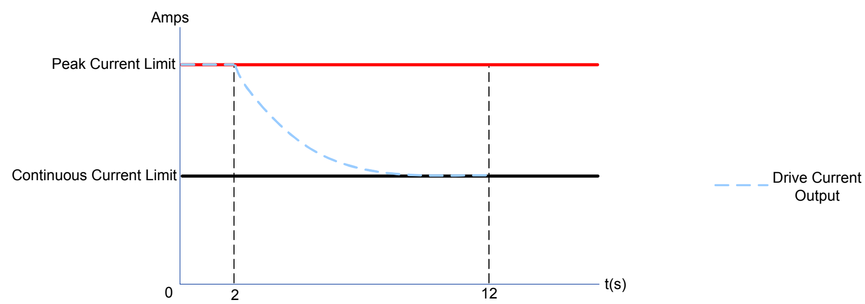
B.1.3 Overload

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip. Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive datasheets for minimum inductance requirements.

B.1.4 Current Limiting

All drives incorporate a “fold-back” circuit for protection against over-current. This “fold-back” circuit uses an approximate “I t” algorithm to protect the drive. All drives can run at peak current for a maximum of 2 seconds (each direction). Currents below this peak current but above the continuous current can be sustained for a longer time period, and the drive will automatically fold back at an approximate rate of "I t" to the continuous current limit within a time frame of less than 10 seconds. An over-current condition will not cause the drive to become disabled unless configured to do so in DriveWare.

FIGURE B.1 Peak Current Fold-Back



B.1.5 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, or by using DriveWare to reverse the internal velocity feedback polarity setting.

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper motor commutation or poor loop tuning. Follow the steps in the DriveWare Software Guide to properly commutate and tune the motor.

B.1.6 Causes of Erratic Operation

- Improper grounding (i.e., drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive voltage spikes on bus.

B.2 Technical Support

For help from the manufacturer regarding drive set-up or operating problems, please gather the following information:

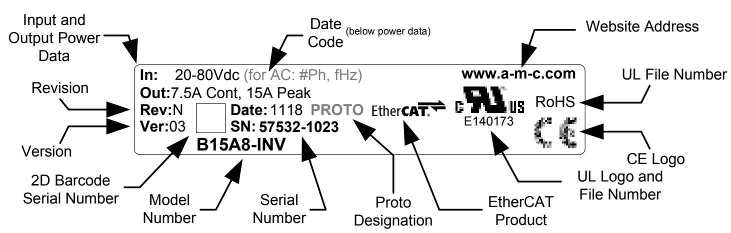
B.2.1 Drive Model Information

- DC bus voltage and range.
- Motor type, including inductance, torque constant, and winding resistance.
- Length and make-up of all wiring and cables.
- If brushless, include Hall sensor information.
- Type of controller, plus full description of feed back devices.
- Description of problem: instability, run-away, noise, over/under shoot, etc.
- Complete part number and serial number of the product. Original purchase order is helpful, but not necessary.

B.2.2 Product Label Description

The following is a typical example of a product label as it is found on the drive:

FIGURE B.2 Product Label



1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with the same model number and revision letter ('01' is the earliest release of any revision).
4. Proto Designation: When included, indicates that the model is a prototype unit and model number will also begin with an 'X' designator.
5. Serial Number: The serial number consists of a 5-digit lot number followed by a 4-digit sequence number. Each product is assigned a unique serial number to track product life cycle history.
6. Date Code: The date code is a 4-digit number signifying the year and week of manufacture. The first two digits designate the year and the second two digits designate the week (e.g. the drive label shown would have been built in the year 2011 during the 18th week).
7. Input and Output Power Data: Includes basic power parameters of the product.
8. General Information: Displays applicable agency approvals, UL file reference number, compliance approvals, and EtherCAT capability. More complete product information is availabe by following the listed website.

B.2.3 Warranty Returns and Factory Help

Seller warrants that all items will be delivered free from defects in material and workmanship and in conformance with contractual requirements. The Seller makes no other warranties, express or implied and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Seller's exclusive liability for breach of warranty shall be limited to repairing or replacing at the Seller's option items returned to Seller's plant at Buyer's expense within one year of the date of delivery. The Seller's liability on any claim of any kind, including negligence, for loss or damage arising out of, connected with or resulting from this order, or from the performance or breach thereof or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under this order shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim and in the event Seller fails to manufacture or deliver items other than standard products that appear in Seller's catalog. Seller's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. IN NO EVENT SHALL THE SELLER BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Buyer will take all appropriate measures to advise users and operators of the products delivered hereunder of all potential dangers to persons or property, which may be occasioned by such use. Buyer will indemnify and hold Seller harmless from all claims of any kind for injuries to persons and property arising from use of the products delivered hereunder. Buyer will, at its sole cost, carry liability insurance adequate to protect Buyer and Seller against such claims.

All returns (warranty or non-warranty) require that you first obtain a Return Material Authorization (RMA) number from the factory.

Request an RMA number by:

web	www.a-m-c.com/download/form/form_rma.html
telephone	(805) 389-1935
fax	(805) 389-1165

Index

DPP Digital Drives

Hardware Installation Manual

MNDGDPIN-06

ADVANCED MOTION CONTROLS

3805 Calle Tecate • Camarillo, CA 93012-5068

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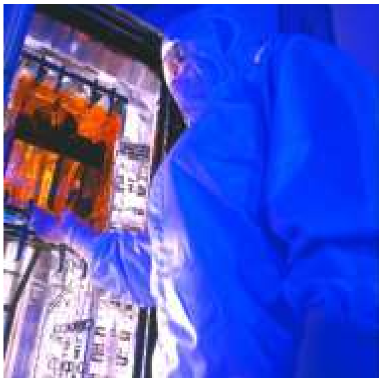
ADVANCED MOTION CONTROLS



Everything's possible.

DigiFlex® Performance™ DPM Drives

Click&Move® Embedded

Hardware Installation Manual

www.a-m-c.com

ORIGINAL INSTRUCTIONS

MNDGDMIN-04

Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the most recent software, the latest revisions of this manual, and copies of compliance and declarations of conformity, visit the company's website at www.a-m-c.com. Otherwise, contact the company directly at:

ADVANCED Motion Controls • 3805 Calle Tecate Camarillo, CA • 93012-5068 USA

Agency Compliances

The company holds original documents for the following:

- UL 508c, file number E140173
- Electromagnetic Compatibility, EMC Directive - 2014/30/EU
  EN61000-6-2:2005
  EN61000-6-4:2007/A1:2011
- Electrical Safety, Low Voltage Directive - 2014/35/EU
  EN 60204-1:2006:A1:2009
- Reduction of Hazardous Substances (RoHS III), 2015/863/EU
- Functional Safety Type Approved, TUV Rheinland

Trademarks

ADVANCED Motion Controls®, the combined isosceles trapezoid/right triangle logo, **DIGIFLEX®, DIGIFLEX® Performance™**, DriveWare®, and Click&Move® are either registered trademarks or trademarks of *ADVANCED* Motion Controls in the United States and/or other countries. All other trademarks are the property of their respective owners.

Related Documentation

- Product datasheet specific for your drive, available for download at www.a-m-c.com
- DriveWare Software Guide, available for download at www.a-m-c.com
- Modbus Communication Manual, available for download at www.a-m-c.com

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.


Note

Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.


Notice

Notice - Required instruction necessary to ensure successful completion of a task or procedure.


Caution

Caution - Instructs and directs you to avoid damaging equipment.


Warning

Warning - Instructs and directs you to avoid harming yourself.


DANGER

Danger - Presents information you must heed to avoid serious injury or death.

Revision History

Document ID	Revision #	Date	Changes
MNDGDMIN-01	1	5/2016	DPM Install Manual First Release
MNDGDMIN-02	2	4/2017	- Added 030A800 and 060A800 power module information
MNDGDMIN-03	3	11/2017	- Added 100B080 power module information
MNDGDMIN-04	4	5/2018	- Added 2-Phase Stepper Motor information - Added PDO power-up delay information

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Index I

1 Safety

This section discusses characteristics of your Click&Move embedded DigiFlex Performance to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

1.1 General Safety Overview

In order to install a drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Caution

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Notice

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.

Warning

Keep clear of all exposed power terminals (motor, DC Bus, shunt, DC power, transformer) when power is applied to the equipment. Follow these safety guidelines:

- When using a separate logic supply, turn on the logic power supply first before turning on the main power supply.
- Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.
- Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative.
- Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.
- Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.
- Do not make any connections to the drive while power is applied.

Caution

- Do not reverse the power supply leads! Severe damage will result!
- If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

Use sufficient capacitance!

Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Caution

Make sure minimum inductance requirements are met!

Pulse Width Modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 ∝H.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2 Products and System Requirements

This document is intended as a guide and general overview in selecting, installing, and operating *ADVANCED* Motion Controls DigiFlex Performance™ digital servo drives that with embedded Click&Move functionality. These specific drives are referred to herein and within the product literature as DPM drives. Other drives in the DigiFlex Performance product family that utilize other methods of network communication such as CANopen, EtherCAT, or RS-485 / Modbus RTU are discussed in separate manuals that are available at www.a-m-c.com. Contained within each DigiFlex Performance product family manual are instructions on system integration, wiring, drive-setup, and standard operating methods.

2.1 DPM Drive Family Overview

The DPM drive family can power three phase or single phase brushless or brushed servomotors, two phase or three phase closed loop stepper motors, and closed loop vector AC induction motors. The command source can be generated externally or can be supplied internally. A digital controller can be used to command and interact with DPM drives, and a number of dedicated and programmable digital and analog input/output pins are available for parameter observation and drive configuration. DPM drives are capable of operating in Current, Velocity, or Position Mode, and utilize Space Vector Modulation, which results in higher bus voltage utilization and reduced heat dissipation compared to traditional PWM. These drives also offer a variety of firmware-dependent feedback options.

Click&Move motion control and automation programs can be executed using this drive. User variables in a Click&Move embedded project can also be stored in non-volatile memory. Click&Move is available for download at www.a-m-c.com.

2.1.1 Drive Datasheet

Each drive has a separate datasheet that contains important information on the options and product-specific features available with that particular drive. The datasheet is to be used in conjunction with this manual for system design and installation.

Caution

In order to avoid damage to equipment, only after a thorough reading and understanding of this manual and the specific datasheet of the DPP drive being used should you attempt to install and operate the drive.

2.2 Products Covered

The products covered in this manual adhere to the following part numbering structure. However, additional features and/or options are readily available for OEM's with sufficient ordering volume. Feel free to contact *ADVANCED* Motion Controls for further information.

FIGURE 2.1 DPM Part Numbering Structure

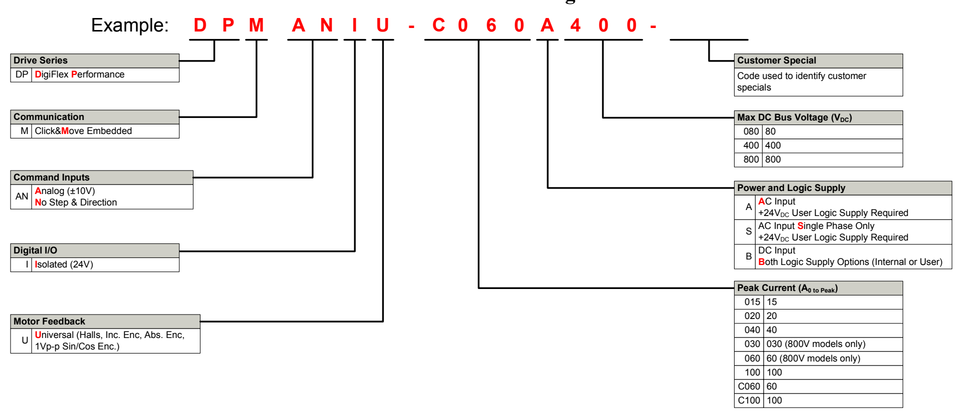


TABLE 2.1 Power Specifications - AC Power Modules

Description	Units	Power Specifications 015S400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	528	528
AC Input Phases	-	1	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[1]	W	2415	6441	9662	16103	6830	13650
Max. Continuous Power Dissipation @ Rated Voltage	W	127	339	509	848	360	720
Internal Bus Capacitance	∝F	540	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	25	20	20	note 2	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	3000	3000

1. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
2. Contact factory before using an external shunt resistor with this power module

TABLE 2.2 Power Specifications - DC Power Modules

Description	Units	Power Specifications 020B080	100B080
DC Supply Voltage Range	VDC	20-80	20-80
DC Bus Over Voltage Limit	VDC	88	88
DC Bus Under Voltage Limit	VDC	17	17
Maximum Peak Output Current	A (Arms)	20 (14.1)	100 (70.73)
Maximum Continuous Output Current	A (Arms)	10 (10)	60 (60)
Max. Continuous Output Power @ Rated Voltage[1]	W	760	4560
Max. Continuous Power Dissipation @ Rated Voltage	W	40	240
Internal Bus Capacitance	∝F	33	500
PWM Switching Frequency	kHz	20	20
Minimum Load Inductance (Line-To-Line)	∝H	600	250

TABLE 2.3 Control Specifications

Description	DPMANIU
Network Communication	Modbus TCP / Ethernet (USB for Configuration)
Command Sources	Embedded Click&Move Program, ± 10V Analog, Over the Network, Encoder Following
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Current, Velocity, Position
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	11/7
Programmable Analog I/O	2/0
Primary I/O Logic Level	24 VDC

TABLE 2.4 Feedback Options

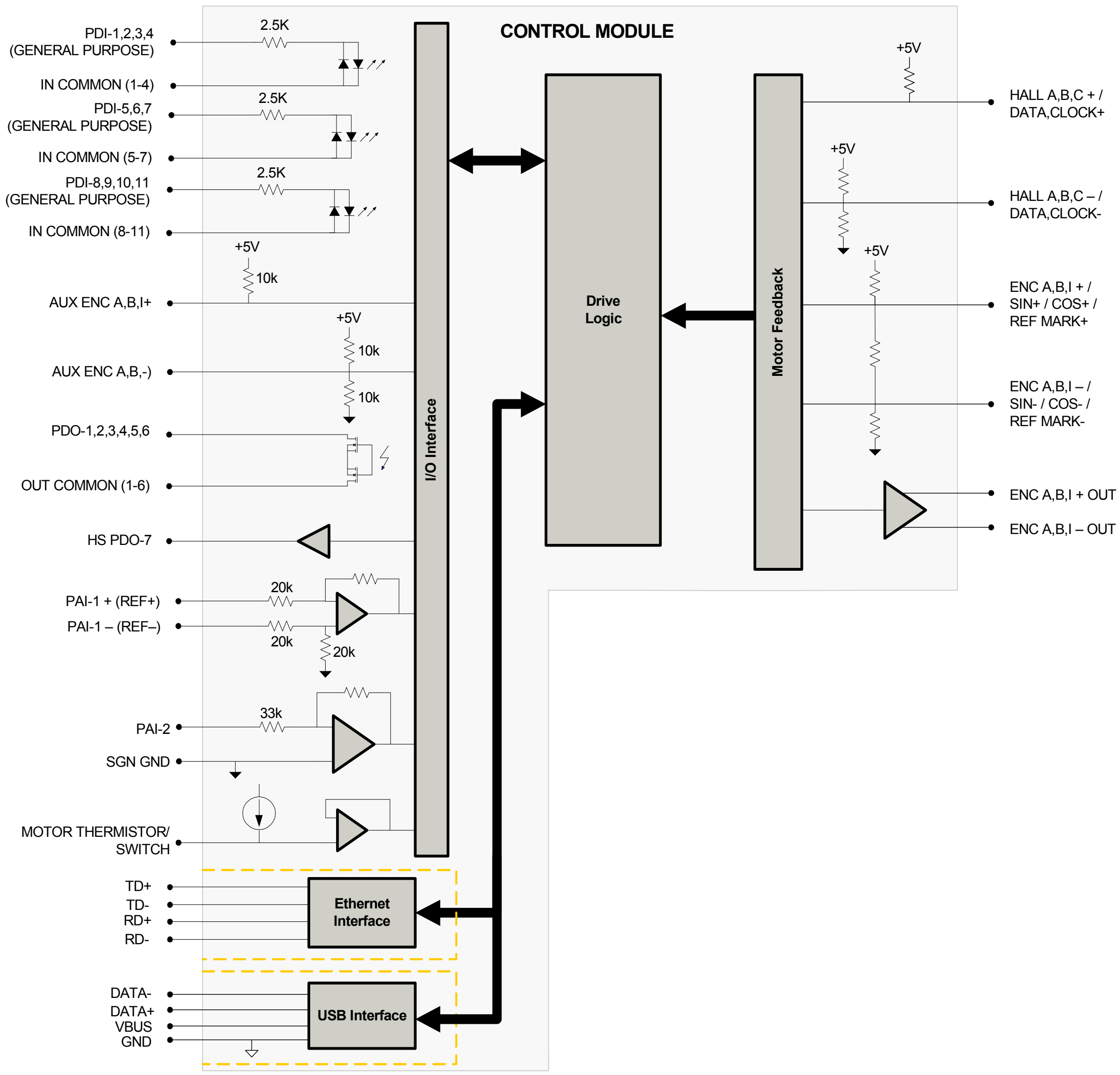
Description	DPPANIU
Hall Sensors	
Incremental Encoder	
Auxiliary Incremental Encoder	
Absolute Encoder (Hiperface®, EnDat®, BiSS C-Mode)	
1Vp-p Sine/Cosine Encoder	
Tachometer (10 ±VDC)	
±10 VDC Position	

Note: Drive will support either Incremental Encoder, Absolute Encoder, or 1Vp-p Sine/Cosine Encoder depending on drive firmware

2.2.1 Control Module

The diagram below shows the general block diagram for the DPMANIU control module. For complete pinouts, consult the drive's datasheet.

FIGURE 2.2 DPMANIU Control Module



2.3 Communication Protocol

DPM drives offer networking capability through Modbus TCP or Ethernet communication. An auxiliary USB port is featured for configuring the drive through DriveWare.

Modbus is an open standard, master slave system developed for communication between multiple devices using a single wire. The Modbus protocol uses a defined message structure, regardless of the physical layer of the network used to communicate. A master device initiate a "query", and slave devices return a "response", supplying the requested data or taking the requested action. The query can be made to individual devices or broadcast to all connected devices. For more detailed information on Modbus TCP communication with DPM drives and a complete list of register definitions, consult the *ADVANCED* Motion Controls' Modbus Communication Manual available for download at www.a-m-c.com.

The Modbus TCP protocol for *ADVANCED* Motion Controls' DPM drives follows the Modbus Application Protocol Specification V1.1b. More information can be found at www.Modbus-IDA.org.

2.4 Control Modes

DPM digital drives operate in either Current, Velocity or Position Mode. The setup and configuration parameters for these modes are commissioned through DriveWare. See the DriveWare Software Manual for mode configuration information.

2.4.1 Current (Torque)

In Current (Torque) Mode, the input command controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored within the configuration software, or externally through network commands.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

2.4.2 Velocity

In Velocity Mode, the input command controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. The motor velocity and other parameters can be monitored within the configuration software, or externally through network commands. See "Feedback Supported" on page 10 for more information on velocity feedback devices.

2.4.3 Position

In Position Mode, the input command controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. The motor position and other parameters can be monitored within the configuration software, or externally through network commands. See "Feedback Supported" on page 10 for more information on position feedback devices.

2.5 Feedback Supported

DPM drives feature the ability to support a variety of primary feedback devices by downloading the appropriate firmware into the drive. Compatible firmware-dependent devices are Incremental Encoders, Absolute Sin/Cos Encoders (Hiperface®, EnDat®, and BiSS C-Mode), and 1Vp-p Sin/Cos Encoders. Consult the DriveWare Software Manual for instructions on how to download firmware into a digital servo drive.

Other supported feedback types that do not require a firmware change are Hall Sensors, Auxiliary Incremental Encoder, Tachometer, and ±10 VDC Position feedback.

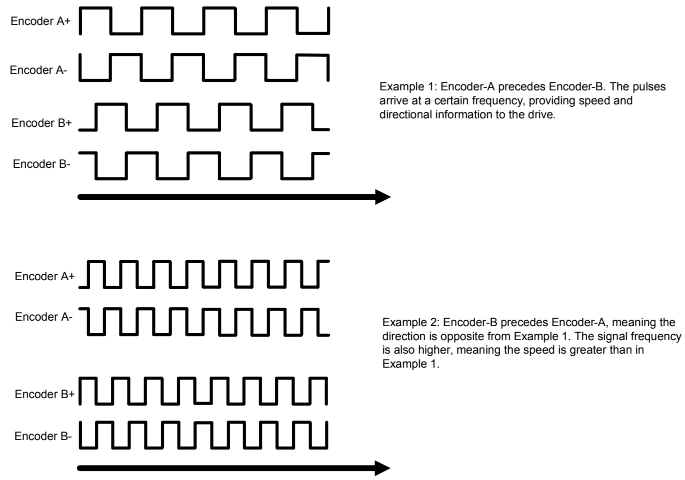
Feedback Polarity The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. The feedback element must be connected for *negative* feedback. Connecting the feedback element for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. The correct feedback polarity will be determined and configured during commissioning of the drive. Otherwise, to correct this, either change the order that the feedback lines are connected to the drive, or use DriveWare to reverse the internal velocity feedback polarity setting.

2.5.1 Incremental Encoder

DPM drive models can utilize incremental encoder feedback for velocity or position control, with the option of also using the encoder to commutate the motor. The encoder provides incremental position feedback that can be extrapolated into very precise velocity or position information. With an encoder being used as the feedback element, the input command controls the motor velocity or motor position, with the frequency of the encoder pulses closing the velocity and/or position loop. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor's speed, position and direction of rotation. Based on the speed and order in which these pulses are received from the encoder, the drive can interpret the motor velocity and physical location. The actual motor speed and physical location can be monitored within the configuration software, or externally through network commands.

Figure 2.3 below represents differential encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated. By keeping track of the number of encoder "pulses" with respect to a known motor "home" position, DPM drives are able to ascertain the actual motor location.

FIGURE 2.3 Encoder Feedback Signals



Note

The high resolution of motor mounted encoders allows for excellent velocity and position control and smooth motion at all speeds. Encoder feedback should be used for applications requiring precise and accurate velocity and position control, and is especially useful in applications where low-speed smoothness is the objective.

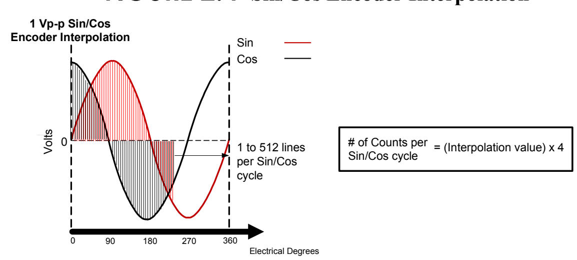
2.5.2 Absolute Encoder

DPM drives support Hiperface®, EnDat® (2.1/2.2 command set), or BiSS C-Mode absolute encoders for velocity and absolute position feedback. The encoder resolution and other options can be configured within the drive configuration software. The drive breaks down the signals from the encoder into individual reference points (counts). For feedback devices that accept 1 Vp-p signals, the interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.4. This allows for very high interpolated encoder resolution (4-2048 counts).

Note

The absolute position feedback eliminates the need for a homing routine when the drive is powered on.

FIGURE 2.4 Sin/Cos Encoder Interpolation



2.5.3 1Vp-p Sin/Cos Encoder

DPM drives support 1Vp-p Sin/Cos encoders for position and velocity feedback. The drive breaks down the 1 Vp-p sinusoidal signals from the encoder into individual reference points (counts). The interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.4. This allows for very high interpolated encoder resolution (4-2048 counts per Sin/Cos cycle).

2.5.4 Hall Sensors

DPM drives can use single-ended or differential Hall Sensors for commutation and/or velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. With Hall Sensors being used as the feedback element, the input command controls the motor velocity, with the Hall Sensor frequency closing the velocity loop.

Note

Hall velocity mode is not optimized for relatively high or relatively low Hall frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.

For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 47.

2.5.5 Auxiliary Incremental Encoder

The auxiliary encoder input pins can be used as a command source for encoder following mode, or as a secondary feedback device input for closing the position loop. The particular function is configured in the configuration software.

2.5.6 Tachometer (±10 VDC)

DPM drives support the use of a tachometer for velocity feedback. The tachometer measures the rotary speed of the motor shaft and returns an analog voltage signal to the drive for velocity control. DPM drives provide a Programmable Analog Input on the motor Feedback Connector that is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

2.5.7 ±10 VDC Position

DPM drives accept an analog ±10 VDC Position feedback, typically in the form of a load-mounted potentiometer. The feedback signal must be conditioned so that the voltage does not exceed ±10 V, and is connected to the drive through the Programmable Analog Input. In DriveWare, the connection method that is used must be selected under the Position Loop Feedback options. See the DriveWare Software Guide for more information.

2.6 Command Sources

The input command source for DPM drives can be configured for one of the following options.

2.6.1 Embedded Click&Move® Program

DPM drives are designed to store and run an embedded Click&Move program. The Click&Move development software is used to create motion code and PLC logic. The code is compiled for the targeted drive platform and then downloaded to the drive via DriveWare. I/O is local to the drive.

2.6.2 ±10V Analog

DPM drives accept a single-ended or differential analog signal with a range of ±10 V from an external source. The input command signals should be connected to the programmable input on the I/O Signal Connector. See “Programmable Analog I/O” on page 35 for more information.

2.6.3 Encoder Following

DPM drives can utilize Encoder Following as a form of input command. In Encoder Following mode, an auxiliary encoder signal can be used to command the drive in a master/slave configuration. The gearing ratio (input counts to output counts ratio) can be configured in DriveWare by the user. Encoder Following is only a valid option when the DPM drive is operated in position mode.

2.7 System Requirements

To successfully incorporate a DPM servo drive into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance.

2.7.1 Specifications Check

Before selecting a DPM servo drive, a user should consider the requirements of their system. This involves calculating the voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with. Before attempting to install or operate a DPM servo drive, be sure all the following items are available:

- DPM Servo Drive
- DPM Drive Datasheet (specific to your model)
- DPM Series Digital Hardware Installation Manual
- DriveWare Software Guide

2.7.2 Motor Specifications

DPM digital servo drives have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a DPM drive may be selected that will best suit the motor capabilities. Some general guidelines that are useful when pairing a DPM servo drive with a motor:

- The motor current I_M is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T -motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile. The continuous torque is the average torque required by the system during the move profile, including dwell times.

- The system voltage requirement is based on the motor properties and how fast and hard the motor is driven. The system voltage requirement is equal to the motor voltage, V_M, required to achieve the move profile.

$$V_M = (K_E \cdot S_M) + (I_M \cdot R_M)$$

Where:

K -motor back EMF constant

S -motor speed (use the maximum speed expected for the application)

I -motor current (use the maximum current expected for the application)

R -motor line-to-line resistance

- The motor inductance is vital to the operation of DPM servo drives, as it ensures that the DC motor current is properly filtered.

Caution

A motor that does not meet the rated minimum inductance value of the DPM drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary.

A minimum motor inductance rating can be found in the drive datasheet. If the drive is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

2.7.3 Power Supply Specifications

DPM servo drives operate off a single-phase AC Power Supply. To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

- Drive over voltage
- External shunt regulator turn-on voltage

Use of a shunt regulator is necessary in systems where motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply. This regenerated energy can charge the power supply capacitors to levels above that of the DPM drive over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one drive, then the current requirements for each drive should be added together. Due to the nature of servo drives, the current into the drive does not always equal the current out of the drive. However, the *power* in is equal to the *power* out. Use the following equation to calculate the power supply output current, I_{PS}, based on the motor current requirements.

$$I_{PS} = \frac{V_M \cdot I_M}{V_{PS} \cdot (0.98)}$$

Where:

V_{PS} -nominal power supply voltage

I_M -motor current

V_M -motor voltage

Use values of V and I at the point of maximum power in the move profile (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.

2.7.4 Environment

To ensure proper operation of a DPM servo drive, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.5 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Baseplate Maximum Allowable Temperature	0 - 75 ºC

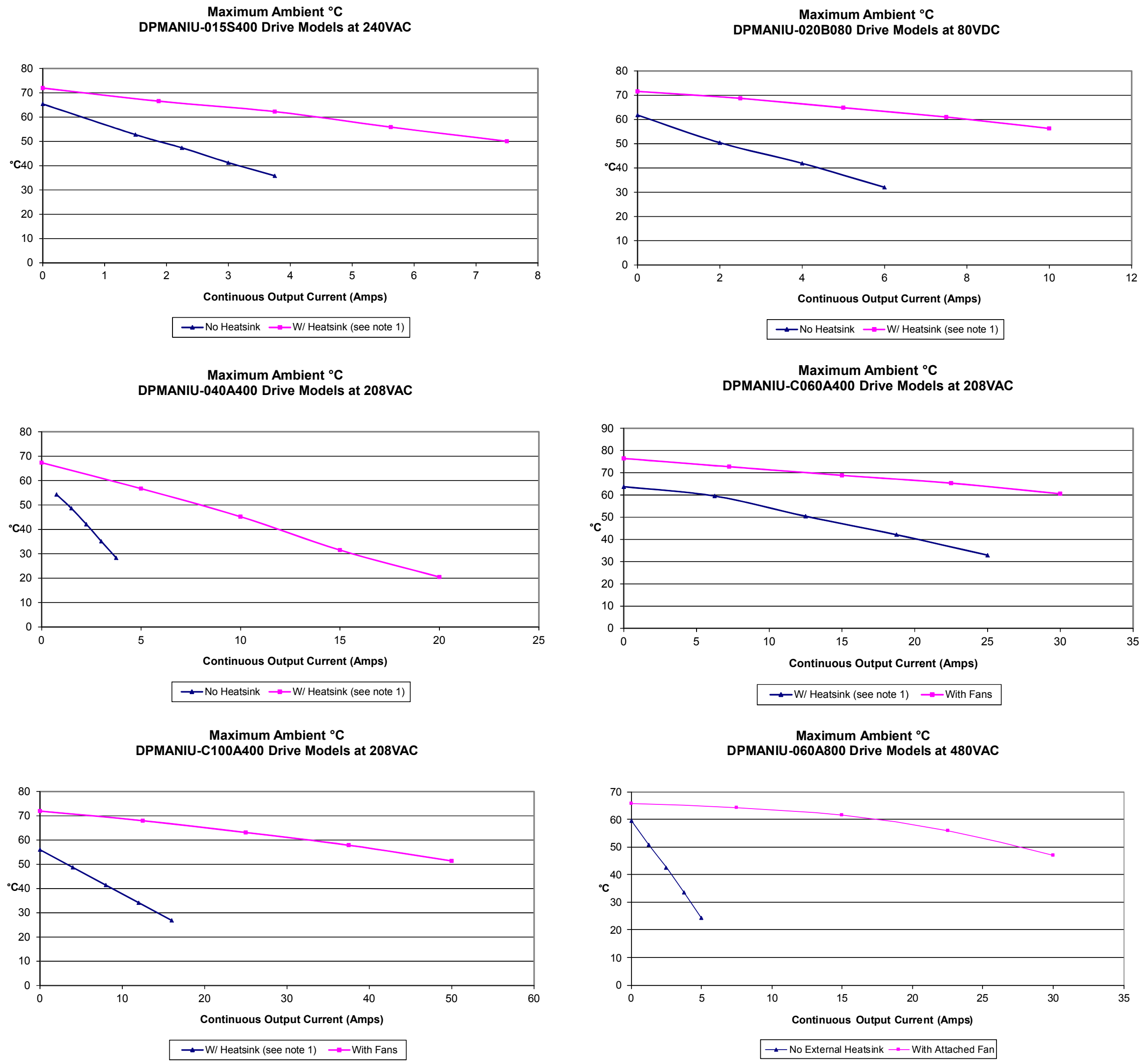
Shock/Vibrations **While DPM drives are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to. The best way to secure the drive against mechanical vibration is to use screws to mount the DPM drive against its baseplate. For information on mounting options and procedures, see** **"Mounting" on page 29.**

Caution

Care should be taken to ensure the drive is securely mounted in a location where no moving parts will come in contact with the drive.

Ambient Temperature Range and Thermal Data **DPM drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above 75 degrees Celsius. For a specific AC supply voltage and a specific output current, Figure 2.5 below specifies an upper limit to the ambient temperature range DPM drives can operate within while keeping the baseplate temperature below the maximum baseplate temperature. It is recommended to mount the baseplate of the DPM drive to a heatsink and/or use fan cooling for best thermal management results. For mounting instructions see** **"Mounting" on page 29.**

FIGURE 2.5 DPM Drives Maximum Ambient Temperature Range



1.The heatsink used in the above test is a 15" x 22" x 0.65" aluminum plate.
2.Contact the factory for DPMANIU-100B080 thermal data.

3 Integration in the Servo System

This chapter will give various details on incorporating a DPM servo drive into a system, such as how to properly ground the DPM drive along with the entire system, and how to properly connect motor wires, power supply wires, feedback wires, communication cables, and inputs into the DPM drive.

3.1 LVD Requirements

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the servo drives must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

Contact the factory for assistance in determining the type of drive in use.

General

1. **Shielded cables must be used for all interconnect cables to the drive and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.**
2. **The drive's metal enclosure must be grounded to the closest ground point with the least amount of resistance.**
3. **The drive must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.**

Analog Input Drives

4. **A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.**

PWM Input Drives

5. **A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.**

MOSFET Switching Drives

6. **A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.**
7. **An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.**

IGBT Switching Drives

8. **An appropriately rated Cosel Tac series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.**
9. **A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.**

Fitting of AC Power Filters

10. **It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be**

adversely affected by the noise. AC power filters can filter this noise and keep it from getting on the AC power signal. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power filter enters the enclosure as possible. Also, the AC power cable on the load end of the filter should be routed far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

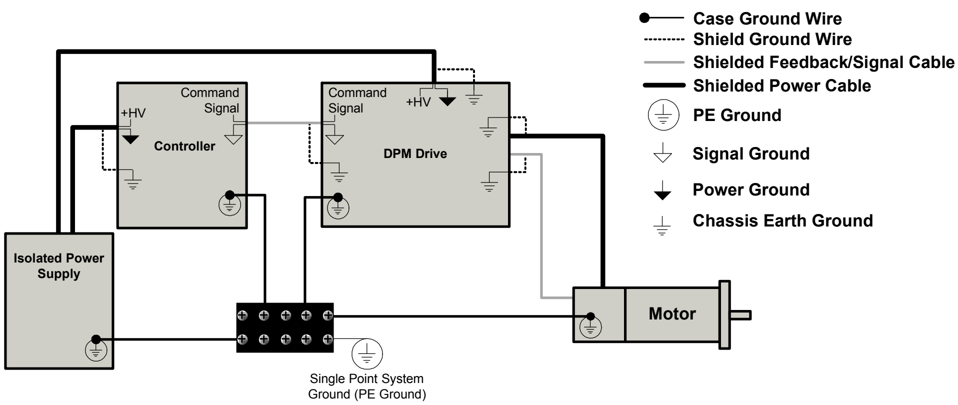
Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines.

3.3 Grounding

In most servo systems the case grounds of all the system components should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point through a single low resistance wire reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

- Motor chassis
- Controller chassis
- Power supply chassis
- DPM drive chassis

FIGURE 3.1 System Grounding



Ground cable shield wires at the drive side to a chassis earth ground point.

The power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the DPM drive to avoid picking up noise due to the "floating" differential servo drive input. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed. As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

The main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card or a noise suppression device is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

ADVANCED Motion Controls recommends using the following hand crimp tools for the appropriate I/O and Feedback cable and wire preparation. Consult the drive datasheet to see which connectors are used on a specific drive.

Drive Connector	Hand Crimp Tool Manufacturer and Part Number
6-pin, 3.96 mm spaced, friction lock header	Tyco: P/N 770522-1
High Density D-sub headers	Tyco: P/N 90800-1

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of larger diameter wire rather than too thin. This becomes more critical as the cable length increases. The following table provides recommendations for selecting the appropriate wire size for a specific current. These values should be used as reference only. Consult any applicable national or local electrical codes for specific guidelines.

Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518
15	#18	0.823
20	#16	1.31
35	#14	2.08
45	#12	3.31

Current (A)	Minimum Wire Size (AWG)	mm^2
60	#10	5.26
80	#8	8.37
120	#6	13.3
150	#0	53.5
200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

- For a single phase motor or voice coil, twist the two motor wires together as a group.
- For a three phase motor, twist all three motor wires together as a group.

Caution

DO NOT use wire shield to carry motor current or power!

Ground the motor power cable shield at one end only to the drive chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the drive chassis ground.

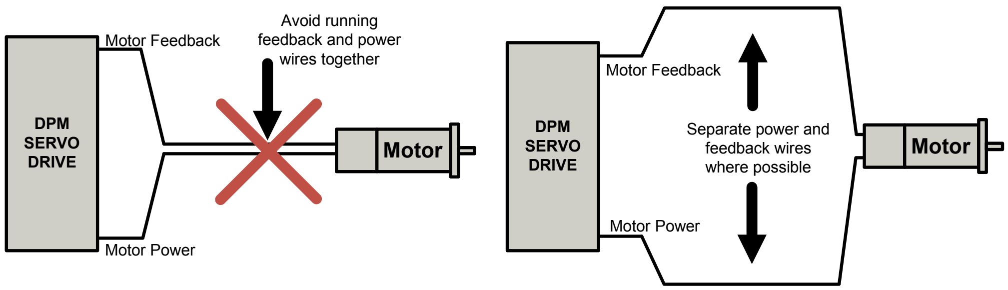
When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each drive directly from the power supply filter capacitor.
2. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the drive chassis ground. Also make sure that the feedback connector and D-sub shell preserve the shield continuity. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.2 Feedback Wiring



3.4.5 I/O and Signal Wires

Use of a twisted, shielded pair for the I/O and Signal wires is recommended. Connect the shield to the drive chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds.

Notice

In case of a single-ended reference signal when using ±10V as the input command source, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

3.5 Connector Types

Depending on the specific drive model, typically a DPM drive connection interface will consist of:

- **Power Connectors - used for Logic, Motor, and AC or DC Power, as well as optional external shunt regulator connections**
- **Feedback Connectors - used for primary and auxiliary feedback connections, programmable inputs and outputs, and other drive functions**
- **Ethernet Communication Connector - used for networking connections**
- **Auxiliary USB Communication Connector - used for USB drive communication necessary for commissioning with DriveWare**
- **I/O Signal Connector - used for programmable inputs and outputs as well as some feedback connections.**
- **STO Connector - used for Safe Torque Off (STO) functionality.**

The different types of connectors used in the DPM drive series are shown in the sections below. Consult the specific drive datasheet for the actual connectors and pin labels used on the drive.

3.5.1 Power Connectors

TABLE 3.1 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 3.5 mm spaced insert connector
Mating Connector	Details	Phoenix Contact: P/N 1840366
	Included with Drive	Yes

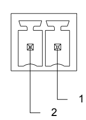


TABLE 3.2 POWER / MOTOR POWER / BRAKE - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		10-port, 5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1781069
	Included with Drive	Yes

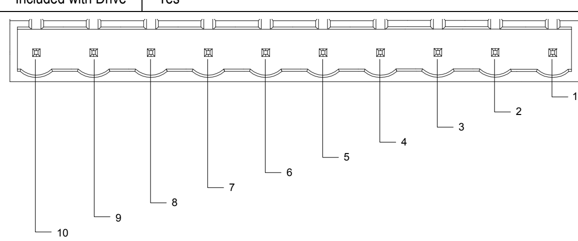


TABLE 3.3 POWER / MOTOR POWER / LOGIC - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		6-pin, 3.96 mm spaced, friction lock header
Mating Connector	Details	AMP: Plug P/N 770849-6; Terminals P/N 770522-1 (loose) or 770476-1 (strip)
	Included with Drive	Yes

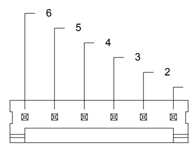


TABLE 3.4 AC POWER / MOTOR POWER / DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 10.16 mm spaced, enclosed, friction lock header
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

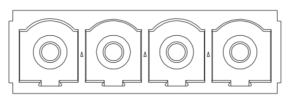


TABLE 3.5 AC POWER / MOTOR POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	No

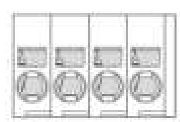


TABLE 3.6 DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		5-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	Not applicable

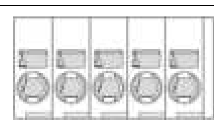


TABLE 3.7 DC POWER / MOTOR POWER - Power Connector

DC POWER / MOTOR POWER - Power Connector		
Connector Information		4-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804920
	Included with Drive	Yes

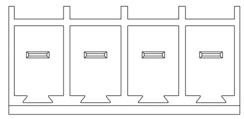
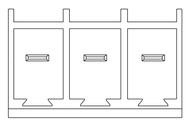


TABLE 3.8 AC POWER - Power Connector

ACPOWER - Power Connector		
Connector Information		3-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804917
	Included with Drive	Yes



3.5.2 Feedback Connectors

TABLE 3.9 FEEDBACK - Feedback Connector

FEEDBACK - Feedback Connector		
Connector Information		15-pin, high-density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 748364-1; Housing P/N 5748677-2; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No

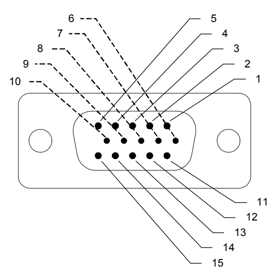
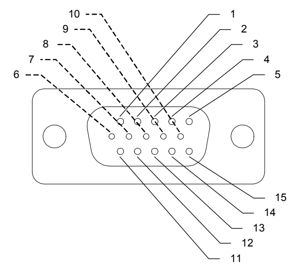


TABLE 3.10 AUX ENCODER - Auxiliary Feedback Connector

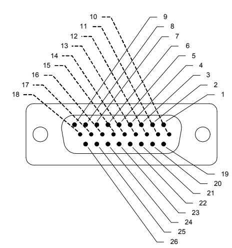
AUX ENCODER - Auxiliary Feedback Connector		
Connector Information		15-pin, high-density, male D-sub
Mating Connector	Details	TYCO: Plug P/N 1658681-1; Housing P/N 5748677-2; Terminals P/N 1658686-2 (loose) or 1658686-1 (strip)
	Included with Drive	No



3.5.3 I/O Connectors

TABLE 3.11 I/O - Signal Connector

I/O - Signal Connector		
Connector Information		26-pin, high density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 1658671-1; Housing P/N 5748677-3; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No



3.5.4 Communication Connectors

TABLE 3.12 COMM - EtherCAT Communication Connector

COMM - EtherCAT Communication Connector		
Connector Information		Shielded, dual RJ-45 socket with LEDs
Mating Connector	Details	Standard CAT 5e or CAT 6 ethernet cable
	Included with Drive	No

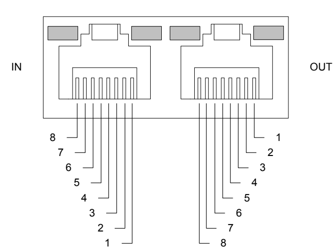
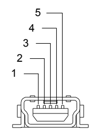


TABLE 3.13 AUX COMM - USB Communication Connector

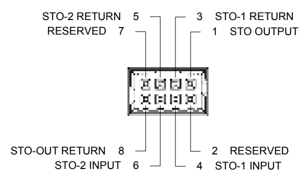
AUX COMM - USB Communication Connector		
Connector Information		5-pin, Mini USB B Type port
Mating Connector	Details	TYCO: 1496476-3 (2-meter STD-A to MINI-B ASSY)
	Included with Drive	No



3.5.5 STO Connector

TABLE 3.14 Safe Torque Off (STO) connector

STO Connector		
Connector Information		8-port, 2.00 mm spaced, enclosed, friction lock header
Mating Connector	Details	Molex: P/N 51110-0860 (housing); 50394-8051 (pins)
	Included with Drive	No



3.6 Mounting

DPM drives provide a number of mounting configuration options. The drive baseplate includes perimeter mounting screwholes allowing different mounting arrangements depending on the requirements or space limitations of the system. See the drive datasheet for specific mounting dimensions and screwhole locations.

4 Operation and Features

This chapter will present a brief introduction on how to test and operate a DPM servo drive. Read through this entire section before attempting to test the drive or make any connections.

4.1 Features and Getting Started

To begin operation with your DPM drive, be sure to read and understand the previous chapters in this manual as well as the drive datasheet and the DriveWare Software Guide. Ensure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the DPM drive. Also, be aware of the "Troubleshooting" section at the end of this manual for solutions to basic operation issues.

4.1.1 Initial Setup and Configuration

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up. For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- DPM Servo Drive
- Motor
- AC Power Supply and Logic Power Supply for supplying power to system
- DriveWare Setup Software and Software Guide for detailed instructions on how to setup, tune and configure a DPM drive in DriveWare

The following steps outline the general procedure to follow when commissioning a DPM drive for the first time. The DriveWare Software Guide contains more detailed information on each step.

1. **Check System Wiring:** **Before beginning, check the wiring throughout the system to ensure proper connections and that all grounding and safety regulations have been followed appropriately for the system.**

Caution

Do not apply power to the system until certain all wiring and grounding has been setup safely and properly!

For drives using a separate logic power supply, turn on the logic supply first before turning on the main power supply.

2. **Apply Power:** **Power must be applied to the drive before any communication or configuration can take place. Turn on the Logic supply first for drives using a separate logic supply, then turn on the main Power supply. Use a multimeter or voltmeter to check that both power supply levels are within their specified ranges.**
3. **Establish Connection:** **Open DriveWare on the PC. The DPM drive should be connected to the PC with a USB cable. Choose the "Connect to a drive" option when DriveWare starts, and enter the appropriate communication settings in the options window that appears. See the DriveWare Software Guide for more information on connecting to a drive. For connection issues, see "Connection Problems" on page 52.**
4. **Configure the drive in DriveWare:** **DriveWare allows the user to manually configure user units, motor and feedback information, system parameters and limits, tune the Current, Velocity and Position Loops, commutate the motor, and assign drive and software "actions" to specific events. Consult the DriveWare Software Guide for detailed instructions.**
5. **Connect to the Controller:** **Once the drive has been properly commissioned, use an external controller to command an input signal to the drive. The controller wiring and setup should follow the safety and grounding guidelines and conventions as outlined in "Grounding" on page 21.**

4.1.2 Input/Output Pin Functions

DPM drives provide a number of various input and output pins for parameter observation and drive configuration options. Consult the drive datasheet to see which input/output pin functions are available for each drive.

Programmable Digital I/O The single-ended and differential Programmable Digital I/O can be assigned to over 40 different functions in DriveWare. The polarity of the signals can be set to active HIGH or active LOW depending on the preference of the user. The differential high speed inputs can also be used as command source inputs with an Auxiliary Encoder (see "Auxiliary Encoder Input" below). DPM drives offer both isolated and non-isolated Programmable Digital I/O.

Note

When set to Active High, digital outputs will be pulled high for a period of time after a power cycle or drive reset. The delay period is given below.

FIGURE 4.1 Programmable Digital Output Power-up Delay

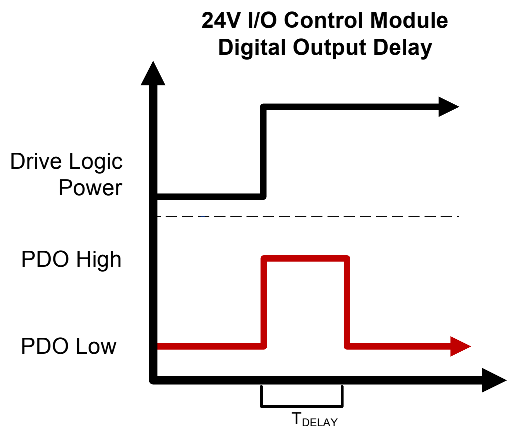


TABLE 4.1 Programmable Digital Output Power-up Delays

Active High		Active Low	
Power Cycle Delay (ms)	Reset Delay (ms)	Power Cycle Delay (ms)	Reset Delay (ms)
1900	1800	-	-

24VDC Digital I/O Specification

The 24VDC Digital I/O is designed to be compatible with controllers that interface with 24VDC signals, using optical isolation that separates the drive signal ground from the controller signal ground. Isolation increases a system's noise immunity by helping to eliminate current loops and ground currents.

- Inputs - The Isolated Digital Inputs use bi-directional optical isolators to detect signals from the controller. Dual LED's in the optical isolator allow current to flow in either direction. Current flow through the LED activates the transistor, and the drive responds depending on whether the transistor is active or not. The presence or absence of current

in the LED determines the logic level, not the direction of current. This flexibility allows the Isolated Digital Inputs to be compatible with a wide range of controllers.

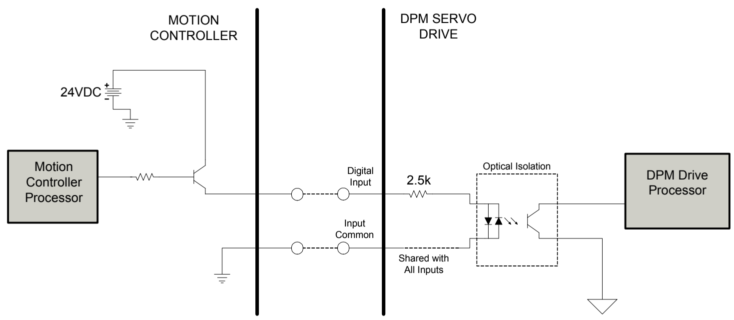
TABLE 4.2 24VDC Isolated Digital Input

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

When current flows into the digital input it is acting as a sinking input. When current flows out of the digital input it is acting as a sourcing input. Since current is allowed to flow in either direction, the inputs can either sink or source. The voltage at the Input Common pin determines whether the inputs sink or source. The Input Common pin is common to all of the inputs, but is isolated from the drive signal ground.

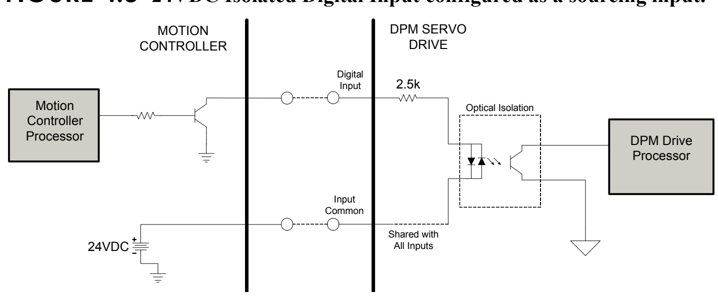
To configure the Isolated Digital Inputs as sinking, the 24V ground is applied to the Input Common and 24V is modulated at the digital input. Figure 4.2 shows a sourcing output from the motion controller feeding the sinking input at the drive. In this example the controller uses a transistor to control the 24V to the drive input. A mechanical switch, relay or other voltage-controlling device can be used in place of the transistor.

FIGURE 4.2 24VDC Isolated Digital Input configured as a sinking input



To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.3 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides a transistor.

FIGURE 4.3 24VDC Isolated Digital Input configured as a sourcing input.



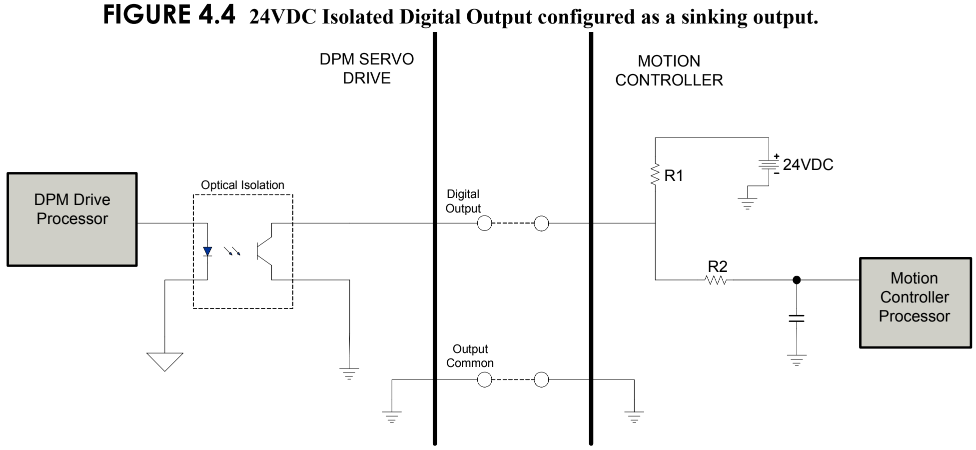
- **Outputs** - The Isolated Digital Outputs have a common grounding point labeled Output Common, and are +24VDC single-ended outputs.

TABLE 4.3 24VDC Isolated Digital Output

24VDC Isolated Digital Output (Sinking)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	120mA

A transistor controls the voltage at each digital output. The output pin is pulled to 24V and the 24V ground goes to the output common, as shown in Figure 4.4. A transistor controls the voltage at the digital output. When the transistor is open the voltage at the digital output is HIGH. When the transistor is closed the voltage is pulled to ground, which causes the output to go LOW.

FIGURE 4.4 24VDC Isolated Digital Output configured as a sinking output.



Programmable Limit Switch (PLS) Outputs

When a digital output is configured as a Programmable Limit Switch through the setup software, the maximum frequency of the output will correspond to the table below.

TABLE 4.4 Maximum Digital Output Frequency for PLS Outputs

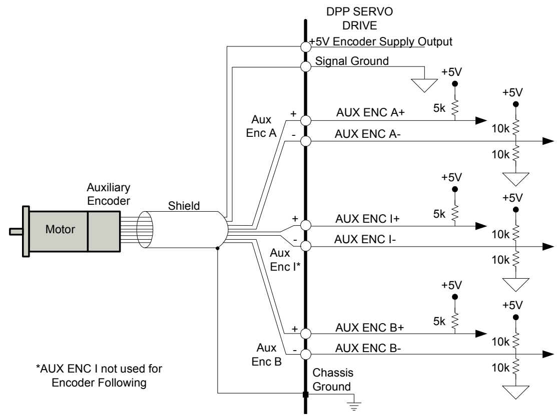
	Maximum Frequency
24V I/O Control Modules	85 Hz (50% duty cycle)[1]

1. Higher duty cycles will result in higher maximum frequencies due to hardware filtering.

Auxiliary Encoder Input

DPM drives accept a differential auxiliary encoder input that can be used for auxiliary position feedback, or for a command source when configured for Encoder Following. Hardware settings and options can be entered and configured in DriveWare.

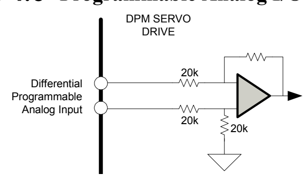
FIGURE 4.5 Auxiliary Encoder Input Connections



Programmable Analog I/O

The Programmable Analog I/O can be assigned to drive functions in DriveWare. These can be used to monitor drive signals, and are also useful for troubleshooting unexpected drive behavior. The drive I/O Signal Connector provides a differential programmable analog input that may be used for a ±10V analog input command.

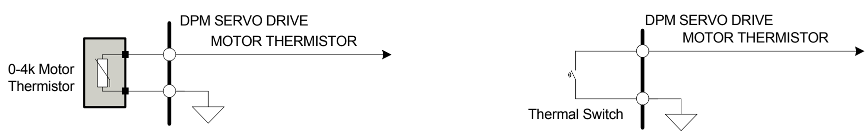
FIGURE 4.6 Programmable Analog I/O



Motor Thermistor

A 0-4 kohm thermistor or thermal switch can be connected between MOTOR THERMISTOR and GROUND. Thermistor/switch behavior can be configured in DriveWare.

FIGURE 4.7 Recommended Motor Thermistor Input

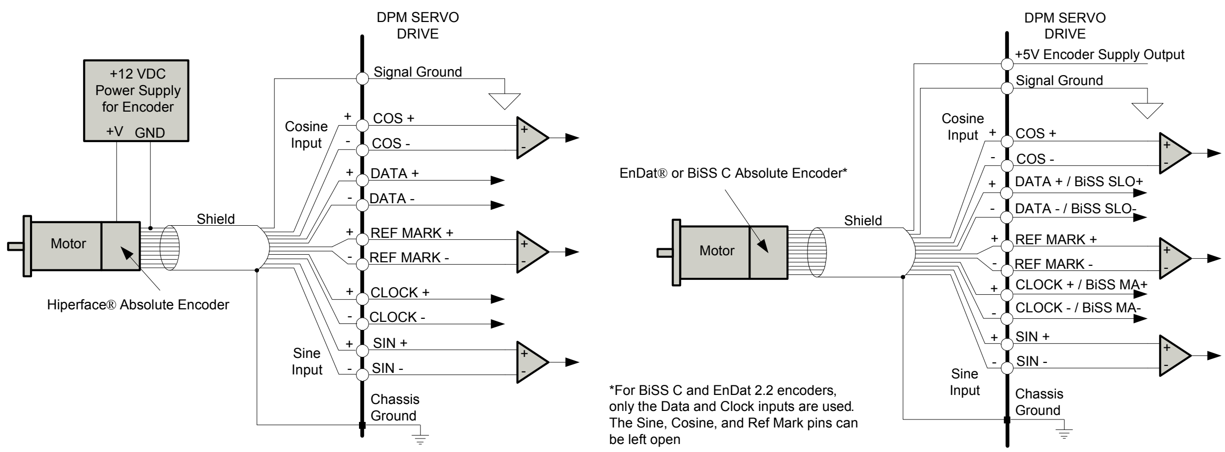


4.1.3 Feedback Operation

The functional operation of the feedback devices supported by DPM drives is described in this section. For more information on feedback selection, see "Feedback Supported" on page 10. See the drive datasheet specific pin locations.

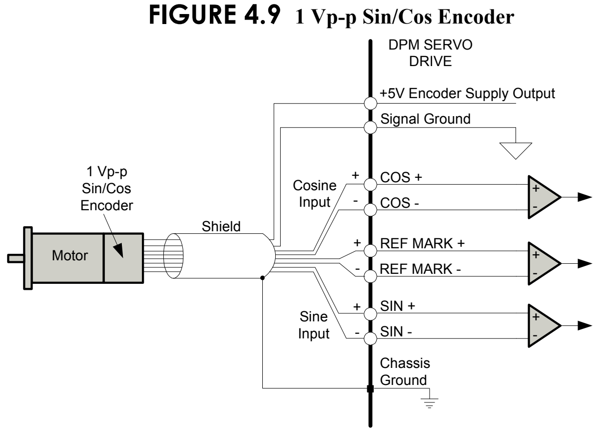
Absolute Encoder **DPM drives support Hiperface®, EnDat®, or BiSS C-Mode absolute encoders. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs and differential RS-485 Data and Clock signals. Hiperface® encoders require an external +12 VDC supply for power, while EnDat® and BiSS C encoders can use the +5V Encoder Supply Output pin provided on the drive. For BiSS C-Mode and EnDat 2.2 encoders, only the Data and Clock inputs are used. The Sine, Cosine, and Index pins can be left open.**

FIGURE 4.8 Absolute Encoder Connections



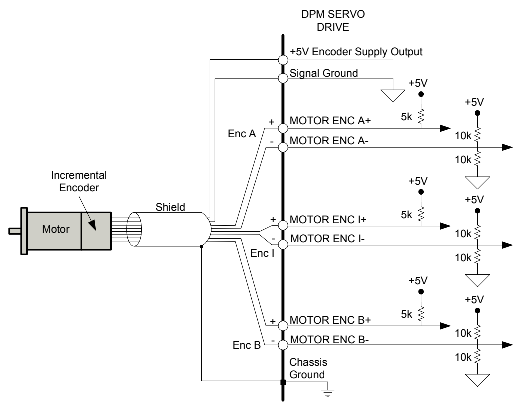
1 Vp-p Sin/Cos Encoder **DPM drives support 1 Vp-p Sin/Cos Encoder feedback. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs. A +5V Encoder Supply Output pin is provided to supply power to the encoder.**

FIGURE 4.9 1 Vp-p Sin/Cos Encoder



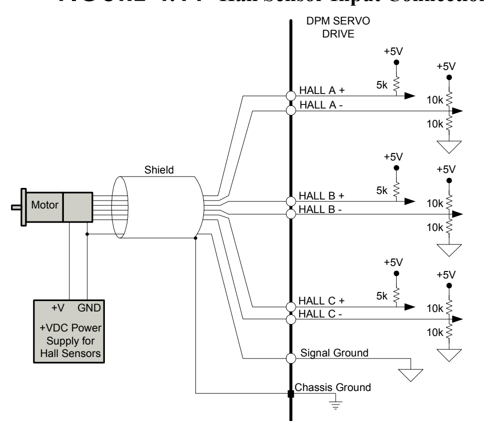
Incremental Encoder **DPM drives support incremental encoder feedback. The drive Feedback Connector allows inputs for differential inputs only. Both the "A" and "B" channels of the encoder are required for operation. DPM drives also accept an optional differential "index" channel that can be used for synchronization and homing. A +5V Encoder Supply Output pin is provided to supply power to the encoder.**

FIGURE 4.10 **Incremental Encoder Connections**



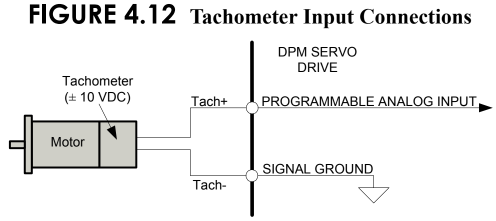
Hall Sensors **DPM drives accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive Feedback Connector allows differential or single-ended Hall Sensor inputs. For single-ended Halls leave the negative terminals open.**

FIGURE 4.11 **Hall Sensor Input Connections**



Tachometer (±10 VDC) **DPM drives support the use of a tachometer for velocity feedback. The Programmable Analog Input on the Auxiliary Feedback Connector is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.**

FIGURE 4.12 **Tachometer Input Connections**



4.1.4 Logic Power Supply

For DPM drives using an external +24 VDC nominal logic power supply (850mA), the logic supply ground should be referenced to the drive signal ground. The logic power inputs are made through a separate Logic Power connector on the drive.

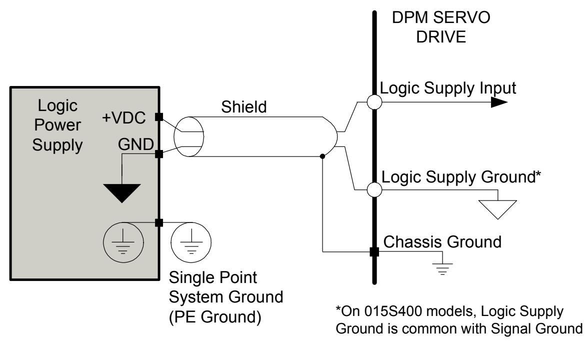
Caution

When using a separate logic power supply, the logic power must be turned on before the main power supply.

TABLE 4.5 AC Power Module Logic Supply Ratings

Logic Supply Range (VDC)	Input Current (mA)
20-30	850

FIGURE 4.13 Logic Power Supply Inputs

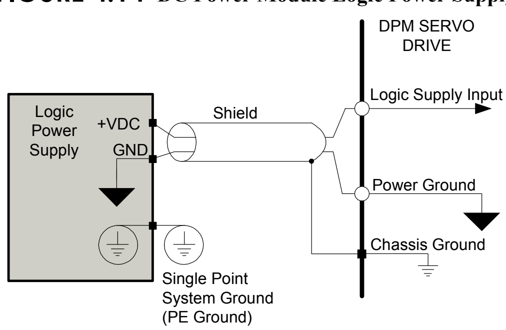


On drives using DC power modules, an external logic supply is optional. If no external logic supply is connected the drive will use the main DC power supply for logic power. If an external logic power supply is used, the voltage must be below the main DC Power Supply value. Table 4.6 shows the different DC power modules and their corresponding logic supply ranges.

TABLE 4.6 DC Power Module Logic Supply Ranges.

DC Power Module	Logic Supply Range (VDC)
020B080, 100B080	20-80

FIGURE 4.14 DC Power Module Logic Power Supply Inputs



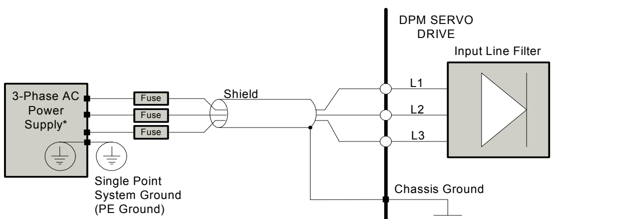
4.1.5 Power Supply Connections

The figures below show how an external power supply should be connected to the DPM drive.

AC or DC Power Modules

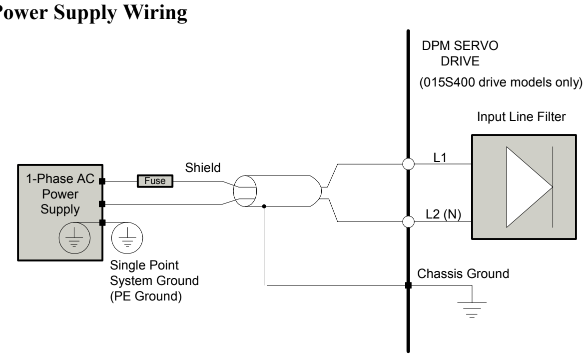
For drive models designed for a three-phase AC power supply, connect the AC supply to L1, L2, and L3. On certain drive models, a single-phase AC supply can be connected to any two of the three (L1, L2, L3) AC terminals with the result that some drive power de-rating may occur. See Figure 4.15 below or the drive datasheet for the specific model characteristics. For drives designed for a single phase AC supply, connect the AC supply to the L1 and L2 (N) AC terminals for. Figure 4.15 below shows the recommended connections.

FIGURE 4.15 AC Power Supply Wiring



*To use a single-phase AC Supply with a drive designed for a three-phase AC supply, connect AC lines to any two of L1, L2, and L3. Do not connect AC line neutral to ground! See the chart below for specific drive model de-rating information for drives powered by single-phase AC.

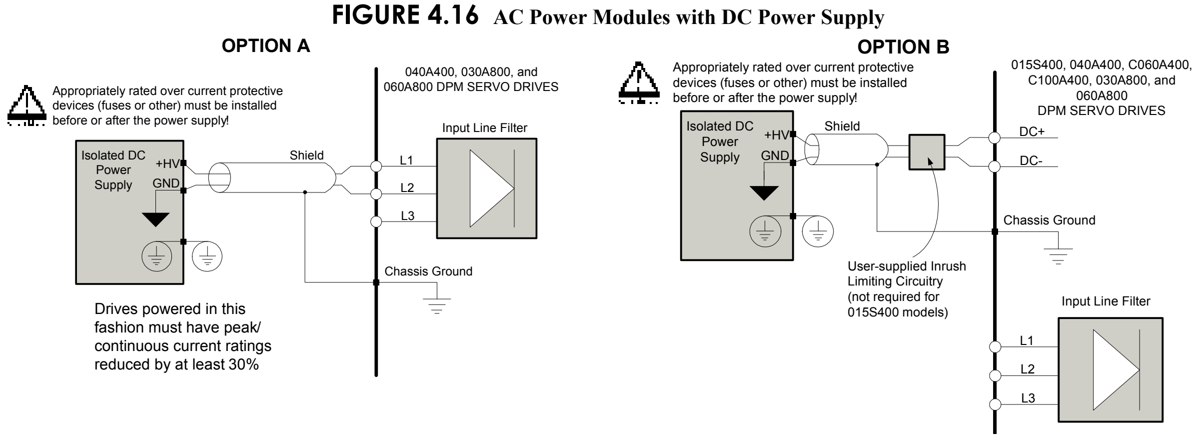
Model	Single-Phase AC De-rating Characteristics
040A400	Peak and continuous current ratings will be reduced by 30%
C060A400	Output power must not exceed 3KW. No current limit de-rating.
C100A400	Output power must not exceed 3kW. Current limits de-rated to 30A cont. / 60A peak.



If using a DC supply to power a drive with an AC power module, follow one of the methods below, depending on the connections available for the specific power module (Figure 4.16 below shows the recommended connections).

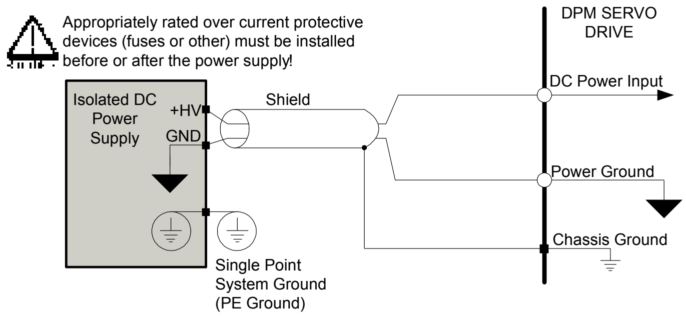
- **(Option A) Connect the isolated DC supply between any two of the three (L1, L2, L3) power terminals. Note that drives powered in this fashion must have peak and continuous current ratings reduced by at least 30% and should not be given current commands that exceed this derating.**
- **(Option B) Some drives feature DC+ and DC- terminals which can be used as DC inputs rather than using L1, L2, or L3. Except for 015S400 power modules, powering the drive in this fashion will require external inrush limiting circuitry that must be properly scaled to the application and drive power requirements.**

FIGURE 4.16 AC Power Modules with DC Power Supply



DC Only Power Modules **For drives using a DC power module, connect the isolated DC supply high voltage to the DC Power Input terminal, and the DC supply ground to the power ground terminal, as shown in Figure 4.17 below.**

FIGURE 4.17 DC Power Module Supply Wiring



4.1.6 Power LEDs Functionality

DPM drives feature LED status indicators for supply power and power bridge status.

Power LED **The Power LED indicates whether power is being supplied to the drive, as well as shunt regulator operation.**

Power LED	
State	**Description**
GREEN	Power is being supplied to the drive
OFF	No power is being supplied to the drive
RED	Drive is shunting excess energy through the shunt regulator (may appear as flashing RED/GREEN as the shunt regulator is turning off and on during regeneration)

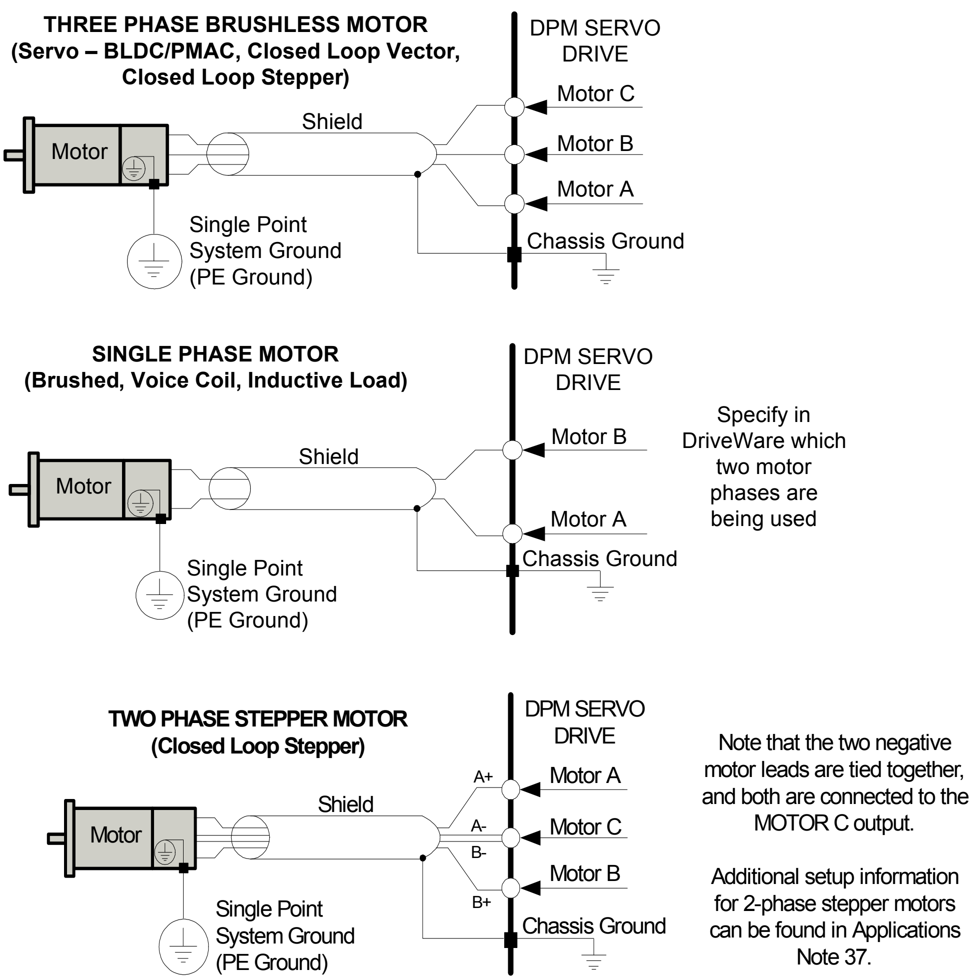
Status LED **The Status LED indicates whether the drive power bridge is enabled or disabled.**

Status LED	
State	**Description**
GREEN	Power output bridge is enabled
RED	Power output bridge is disabled (via inhibit or fault)

4.1.7 Motor Connections

The diagrams below show how a DPM drive connects to various motor types. Notice that the motor wires are shielded, and that the motor housing is grounded to the single point system ground (PE Ground). The cable shield should be grounded at the drive side to chassis ground.

FIGURE 4.18 Motor Power Output Wiring



Caution

If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

For applications using stepper motors, the maximum motor speed will be limited (typically ~600 RPM max).

4.1.8 External Shunt Resistor Connections

Most AC powered DPM drives allow the option of connecting an external shunt resistor to protect against damage that may occur due to over-voltage. Drives that do not include an internal shunt resistor require an external shunt resistor for the internal shunt regulator to operate. The figures below show how an external shunt resistor should be connected to the drive for the different AC Power Modules. The internal shunt regulator must be enabled and configured in DriveWare in order to operate.

FIGURE 4.19 C060A400 Power Module External Shunt Resistor Connection

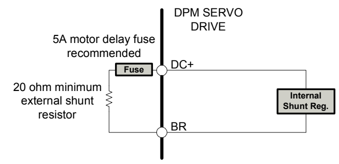


FIGURE 4.20 C100A400 Power Module External Shunt Resistor Connection

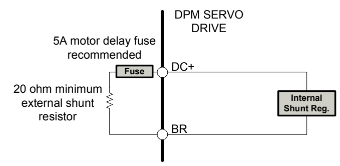


FIGURE 4.21 030A800 Power Module External Shunt Resistor Connection

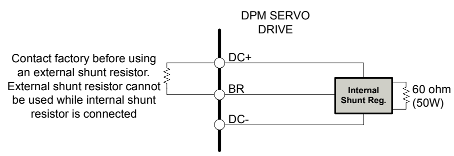


FIGURE 4.22 015S400, 040A400 and 060A800 Power Module External Shunt Resistor Connections

4.1.9 STO (Safe Torque Off)

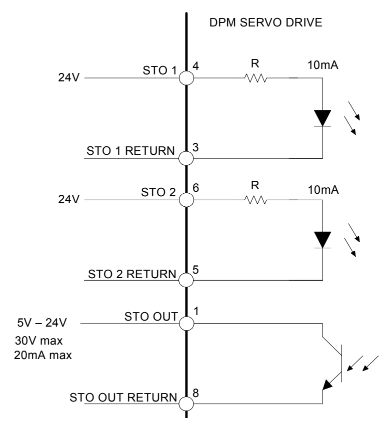
Some models of the DPM drive family feature an external dedicated +24VDC STO safety function designed to monitor an external 24V STO input from the user system and disable the motor output during an STO event. The STO circuit uses +24VDC sinking single-ended isolated inputs for STO functionality. Both STO1 and STO2 must be active (HIGH) to allow torque output at the drive motor outputs.

TABLE 4.7 STO Signal Behavior

STO 1	STO 2	Motor Outputs	STO OUT
Active (HIGH)	Active (HIGH)	Enabled	Open
Active (HIGH)	Not Active (LOW)	Disabled	Closed
Not Active (LOW)	Active (HIGH)	Disabled	Closed
Not Active (LOW)	Not Active (LOW)	Disabled	Closed

The STO circuitry also features an STO status output (STO OUT) that signifies when an STO condition has occurred. This status is also viewable in the setup software as an indicator only. The STO OUT output functions as a switch. When an STO event occurs, the STO OUT switch becomes CLOSED. When the drive is in normal functional operation (STO 1 and STO 2 = 24V), the STO OUT switch is OPEN.

FIGURE 4.23 STO Connections



See the drive datasheet for a drawing and description of the physical STO connector and mating hardware. Functional Safety is TÜV Rheinland certified and meets requirements of the following standards:

- EN ISO 13849-1 -- Category 4 / PL e
- EN IEC 61800-5-2 -- STO (SIL 3)
- EN 62061 -- SIL CL3
- IEC 61508 -- SIL 3

The user must verify proper operation of the monitoring circuit (STO 1 and STO 2) at least once per month to maintain SIL 3, Cat 4 / PL e certification. The monitoring circuit is required to be examined by an external logic element when STO is incorporated into a complete drive system in order for proper diagnostics to be fully implemented and utilized in the FMEA calculation (see "STO Operation Test" on page 44). The calculation of the safety relevant parameters are based on a proof test interval of one year and have shown that the requirements of up to SIL 3 are fulfilled. The safety relevant parameters are:

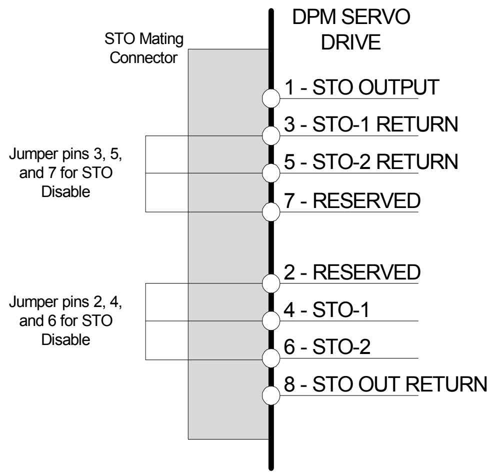
- Safe-Failure-Fraction: SFF = 97%
- Probability of a dangerous failure per hour: PFH = 1.3 x 10 1/h
- Average probability of a dangerous failure on demand (1 year): PFD = 1.7 x 10

Note

The above assessment and safety values defined were assessed with the STO function incorporated into the DigiFlex Performance DPM drive family. Product data for the DPM drive family can be found by visiting www.a-m-c.com.

STO Disable **For applications that do not require Safe Torque Off functionality, disabling of the STO feature is required for proper drive operation. A dedicated STO Disable Key connector is available for purchase and must be installed for applications where STO is not in use. Contact the factory for ordering information. Altenatively, STO may be disabled by installing the included mating connector for the STO connector, and wiring the designated pins together as given below in figure.**

FIGURE 4.24 STO Disable Connections



STO Operation Test **To maintain SIL 3, Cat 4 / PL e certification, the operation of the STO monitoring circuit (STO1 and STO2) must be verified at least once per month. The following procedure provides an example of a method to verify correct STO functionality. Note that it is the responsibily of the system operator to ensure all personal and machine safety requirements for the system are properly enforced during the proof test.**

1. **Power on the drive.**
2. **Verify the drive is in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
3. **Remove the voltage signal from the STO1 input pin via a digital controller signal, network command, or by physically removing the STO Connector if safe to do so.**
4. **Verify that the drive is in a Disabled state (by viewing the Status LED is RED, or by verifying the STO OUT switch has closed).**
5. **Re-apply the voltage signal to the STO1 pin. Verify that the drive is once again in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
6. **Repeat the above steps for the STO2 signal.**

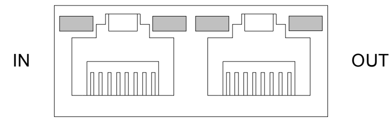
Note

End-product certification may require a different interval test schedule or test requirements. It is the responsibility of the end-user to determine the required test interval and requirements for certifications other than stated above.

4.1.10 Communication and Commissioning

DPM drives include an Ethernet interface for Modbus TCP or Ethernet networking and a USB interface for drive configuration and setup. A dual RJ-45 socket connector accepts standard CAT 5e or CAT 6 ethernetcables for the Ethernet network connections.

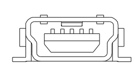
FIGURE 4.25 Ethernet Connectors



Dual RJ-45 Ethernet Communication Connector

For drive commissioning, the DPM drive must be connected to a PC running *ADVANCED* Motion Controls DriveWare software. The mini type-b USB port on the DPM drive should be used with a STD-A to MINI-B USB cable for connection to a USB port on a PC.

FIGURE 4.26 USB Connectors

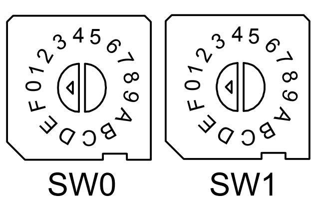


MINI TYPE-B USB Connector

Ethernet Node ID/Address

DPM drives include two hexadecimal switches to assign the last octet of the IP address of the drive within the Ethernet network. Figure 4.27 shows the hexadecimal switch settings and the corresponding node ID.

FIGURE 4.27 Ethernet Address Hexadecimal Switches



SW1	SW0	Node ID
0	0	Address stored in NVM
0	1	001
0	2	002
...	...	...
F	D	253
F	E	254
F	F	255

Network Communication LEDs Functionality

The LINK/ACT LEDs on the dual RJ-45 communication connector provide network status. Figure 4.28 shows the LED locations, and Table 4.8 below describes typical LED functionality.

FIGURE 4.28 Network LED Locations

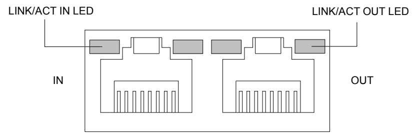


TABLE 4.8 Network Communication LEDs Function Protocol

LINK/ACT LED	
LED State	**Description**
Green - On	Valid Link - No Activity
Green - Flickering	Valid Link - Network Activity
Off	Invalid Link

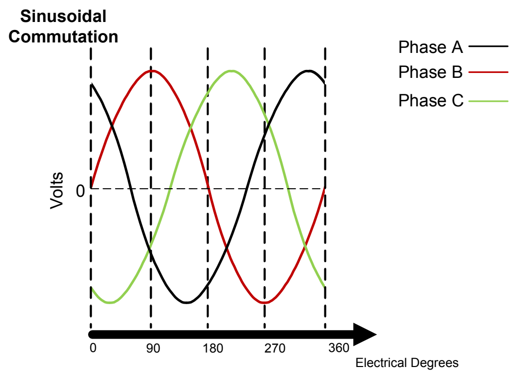
4.1.11 Commutation

Motor commutation is the process that maintains an optimal angle between the magnetic field created by the permanent magnets in the motor and the electromagnetic field created by the currents running through the motor windings. This process ensures optimal torque or force generation at any motor position. Single phase (brushed) motors accomplish this process with internal commutators built into the motor housing. Three phase (brushless) motors require a correctly configured drive to commutate properly, however.

See the DriveWare Software Guide for more information on AutoCommutation, Manual Commutation, and Phase Detect. DPM drives allow either sinusoidal or trapezoidal commutation.

Sinusoidal Commutation Sinusoidal commutation provides greater performance and efficiency than trapezoidal commutation. DPM drives can commutate sinusoidally when connected to a motor-mounted encoder. Sinusoidal Commutation works by supplying current to each of the three motor phases smoothly in a sinusoidal pattern. The flow of current through each phase is shifted by 120 degrees. The sum of the current flowing through all three phases adds up to zero. Figure 4.29 shows one electrical cycle of the motor phase currents.

FIGURE 4.29 Sinusoidal Commutation Motor Phase Currents

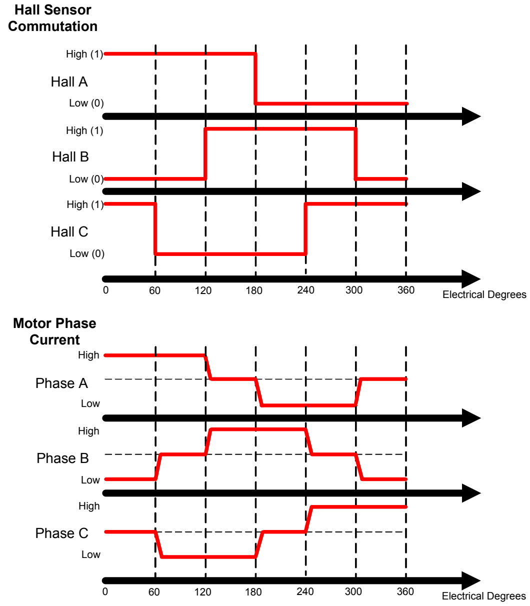


Trapezoidal Commutation Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DPM drives can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at a time with trapezoidal commutation. The Hall Sensors each generate a square wave with a certain phase difference (either 120- or 60-degrees) over one electrical cycle of the motor. This results in six distinct Hall states for each electrical cycle. Depending on the motor pole count, there may be more than one electrical cycle per motor revolution. The number of electrical cycles in one motor revolution is equal to the number of motor poles divided by 2. For example:

- a 6-pole motor contains 3 electrical cycles per motor revolution
- a 4-pole motor contains 2 electrical cycles per motor revolution
- a 2-pole motor contains 1 electrical cycle per motor revolution

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 4.30.

FIGURE 4.30 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing



Note: Not all *ADVANCED* Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

Table 4.9 shows the default commutation states for 120-degree and 60-degree phasing. Depending on the specific setup, the sequences may change after running Auto Commutation.

TABLE 4.9 Digital Drive Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

4.1.12 Homing

DPM drives can be configured in DriveWare to "home" to a certain reference signal. This reference signal can be any number of different signal types, such as limit switches, home switches, or encoder index pulses. See the DriveWare Software Guide for more information on Homing.

4.1.13 Firmware

DPM drives are shipped with the latest version of firmware already stored in the drive. Periodic firmware updates are posted on *ADVANCED* Motion Controls' website. See the DriveWare Software Guide for information on how to check the drive's firmware version, and how to download new firmware into the drive when necessary.

A Specifications

A.1 Specifications Tables

TABLE A.1 Power Specifications - AC Power Modules

Description	Units	Power Specifications 015S400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	528	528
AC Input Phases	-	1	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[1]	W	2415	6441	9662	16103	6830	13650
Max. Continuous Power Dissipation @ Rated Voltage	W	127	339	509	848	360	720
Internal Bus Capacitance	∝F	540	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	25	20	20	note 2	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	3000	3000

1. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
2. Contact factory before using an external shunt resistor with this power module

TABLE A.2 Power Specifications - DC Power Modules

Description	Units	Power Specifications 020B080	100B080
DC Supply Voltage Range	VDC	20-80	20-80
DC Bus Over Voltage Limit	VDC	88	88
DC Bus Under Voltage Limit	VDC	17	17
Maximum Peak Output Current	A (Arms)	20 (14.1)	100 (70.73)
Maximum Continuous Output Current	A (Arms)	10 (10)	60 (60)
Max. Continuous Output Power @ Rated Voltage[1]	W	760	4560
Max. Continuous Power Dissipation @ Rated Voltage	W	40	240
Internal Bus Capacitance	∝F	33	500
PWM Switching Frequency	kHz	20	20
Minimum Load Inductance (Line-To-Line)	∝H	600	250

TABLE A.3 Control Specifications

Description	DPMANIU
Network Communication	Modbus TCP / Ethernet (USB for Configuration)
Command Sources	Embedded Click&Move Program, ± 10V Analog, Over the Network, Encoder Following
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Current, Velocity, Position
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	11/7
Programmable Analog I/O	2/0
Primary I/O Logic Level	24 VDC

TABLE A.4 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Mechanical Shock	15g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m
Baseplate Maximum Allowable Temperature	0 - 75 ºC

TABLE A.5 Feedback Specifications

Feedback Specifications	
Parameter	**Value**
Maximum Incremental Encoder Input Frequency	20MHz (5 pre-quadrature)
Maximum Sin/Cos Encoder Input Frequency	200kHz
Maximum Hall Sensor Input Frequency	0.15 x PWM Switching Frequency
Maximum Tachometer Voltage	±10VDC

TABLE A.6 24 VDC Digital I/O Specifications

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

24VDC Isolated Digital Output	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA sinking, 8mA sourcing

B Troubleshooting

This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

B.1 Fault Conditions and Symptoms

A fault condition can either be caused by a system parameter in excess of software or hardware limits, or by an event that has been user-configured to disable the drive upon occurrence.

To determine whether the drive is in a fault state, use the Drive Status function in DriveWare to view active and history event items and drive fault conditions. See the DriveWare Software Guide for more information on reading the Drive Status window. Some common fault conditions caused by hardware issues are listed below.

Over-Temperature

Verify that the baseplate temperature is less than the drive Baseplate Temperature value. The drive remains disabled until the temperature at the drive baseplate falls below this threshold. See "Ambient Temperature Range and Thermal Data" on page 16 or consult the drive datasheet for the allowable temperature range.

Over-Voltage Shutdown

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Power Supply Specifications" on page 15 for more information.

Under-Voltage Shutdown

Verify power supply voltage for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply cannot provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing, power ground, and also phase-to-phase. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

Invalid Hall Sensor State

See the "Commutation Sequence" table in "Commutation" on page 47 for valid commutation states. If the drive is disabled check the following:

1. Check the voltage levels for all the Hall sensor inputs.
2. Make sure all Hall Sensor lines are connected properly.

B.1.1 Software Limits

Because DriveWare allows user configuration of many system parameters such as current, velocity, and position limits, as well as an associated "event action" for DriveWare to take when the system reaches this limit, it is possible for a drive to appear to be inoperative when in actuality it is simply in an assigned disable state.

For example, the motor velocity can be limited by giving a value to the Motor Over Speed selection in DriveWare. An "event action", such as "Disable the Power Bridge", can also be assigned for this particular limiting event for DriveWare to take if the motor reaches this speed. If the motor does happen to reach this velocity limit, DriveWare will automatically cut power to the drive's output in this particular case, and the drive will be disabled. In the Drive Status window, "Motor Over Speed" will be shown as a "history" event, and "Commanded Disable" will be shown as an "Action" event.

Depending on each specific system and application, there are many different options available for assigning system limits and associated actions. See the DriveWare Software Guide for more information.

B.1.2 Connection Problems

Connection problems are oftentimes caused by incorrect communication settings in DriveWare. Check all communications settings to be sure that the settings assigned in DriveWare are correct.

Faulty connection cables are also a possible cause of connection problems. Check all cables for any shorts or intermittent connections. Also check that all port hardware is properly installed and configured.

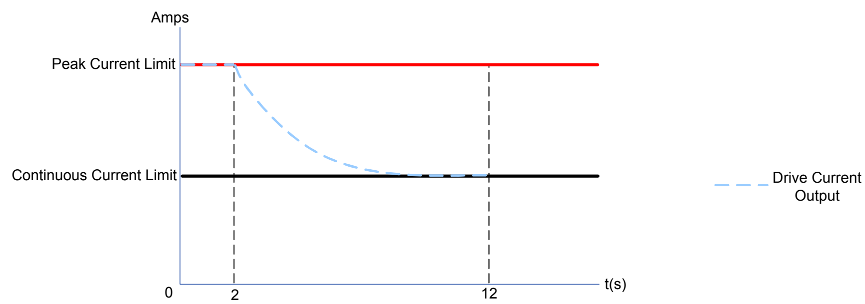
B.1.3 Overload

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip. Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive datasheets for minimum inductance requirements.

B.1.4 Current Limiting

All drives incorporate a “fold-back” circuit for protection against over-current. This “fold-back” circuit uses an approximate “I t” algorithm to protect the drive. All drives can run at peak current for a maximum of 2 seconds (each direction). Currents below this peak current but above the continuous current can be sustained for a longer time period, and the drive will automatically fold back at an approximate rate of "I t" to the continuous current limit within a time frame of less than 10 seconds. An over-current condition will not cause the drive to become disabled unless configured to do so in DriveWare.

FIGURE B.1 Peak Current Fold-Back



B.1.5 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, or by using DriveWare to reverse the internal velocity feedback polarity setting.

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper motor commutation or poor loop tuning. Follow the steps in the DriveWare Software Guide to properly commutate and tune the motor.

B.1.6 Causes of Erratic Operation

- Improper grounding (i.e., drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive voltage spikes on bus.

B.2 Technical Support

For help from the manufacturer regarding drive set-up or operating problems, please gather the following information:

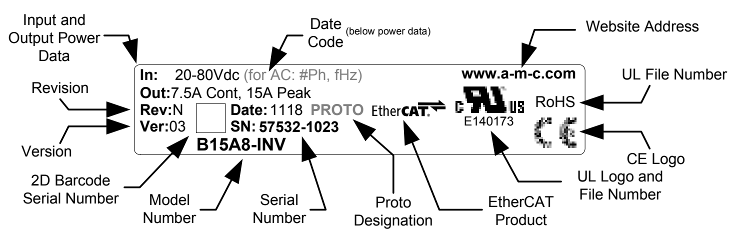
B.2.1 Drive Model Information

- DC bus voltage and range.
- Motor type, including inductance, torque constant, and winding resistance.
- Length and make-up of all wiring and cables.
- If brushless, include Hall sensor information.
- Type of controller, plus full description of feed back devices.
- Description of problem: instability, run-away, noise, over/under shoot, etc.
- Complete part number and serial number of the product. Original purchase order is helpful, but not necessary.

B.2.2 Product Label Description

The following is a typical example of a product label as it is found on the drive:

FIGURE B.2 Product Label



1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with the same model number and revision letter ('01' is the earliest release of any revision).
4. Proto Designation: When included, indicates that the model is a prototype unit and model number will also begin with an 'X' designator.
5. Serial Number: The serial number consists of a 5-digit lot number followed by a 4-digit sequence number. Each product is assigned a unique serial number to track product life cycle history.
6. Date Code: The date code is a 4-digit number signifying the year and week of manufacture. The first two digits designate the year and the second two digits designate the week (e.g. the drive label shown would have been built in the year 2011 during the 18th week).
7. Input and Output Power Data: Includes basic power parameters of the product.
8. General Information: Displays applicable agency approvals, UL file reference number, compliance approvals, and EtherCAT capability. More complete product information is availabe by following the listed website.

B.2.3 Warranty Returns and Factory Help

Seller warrants that all items will be delivered free from defects in material and workmanship and in conformance with contractual requirements. The Seller makes no other warranties, express or implied and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Seller's exclusive liability for breach of warranty shall be limited to repairing or replacing at the Seller's option items returned to Seller's plant at Buyer's expense within one year of the date of delivery. The Seller's liability on any claim of any kind, including negligence, for loss or damage arising out of, connected with or resulting from this order, or from the performance or breach thereof or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under this order shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim and in the event Seller fails to manufacture or deliver items other than standard products that appear in Seller's catalog. Seller's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. IN NO EVENT SHALL THE SELLER BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Buyer will take all appropriate measures to advise users and operators of the products delivered hereunder of all potential dangers to persons or property, which may be occasioned by such use. Buyer will indemnify and hold Seller harmless from all claims of any kind for injuries to persons and property arising from use of the products delivered hereunder. Buyer will, at its sole cost, carry liability insurance adequate to protect Buyer and Seller against such claims.

All returns (warranty or non-warranty) require that you first obtain a Return Material Authorization (RMA) number from the factory.

Request an RMA number by:

web	www.a-m-c.com/download/form/form_rma.html
telephone	(805) 389-1935
fax	(805) 389-1165

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DPM Digital Drives

Hardware Installation Manual

MNDGDMIN-04

ADVANCED MOTION CONTROLS

3805 Calle Tecate • Camarillo, CA 93012-5068
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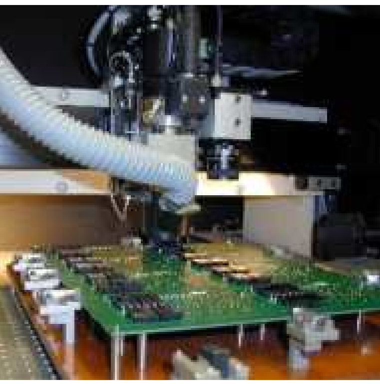


Everything's possible.

DigiFlex® Performance™ DPE Drives

EtherCAT® Communication

Hardware Installation Manual

www.a-m-c.com

ORIGINAL INSTRUCTIONS

MNDGDEIN-09

Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the most recent software, the latest revisions of this manual, and copies of compliance and declarations of conformity, visit the company's website at www.a-m-c.com. Otherwise, contact the company directly at:

ADVANCED Motion Controls • 3805 Calle Tecate Camarillo, CA • 93012-5068 USA

Agency Compliances

The company holds original documents for the following:

- UL 508c, file number E140173
- Electromagnetic Compatibility, EMC Directive - 2014/30/EU
  EN61000-6-2:2005
  EN61000-6-4:2007/A1:2011
  Electrical Safety, Low Voltage Directive - 2014/35/EU
  EN 60204-1:2006/A1:2009
- Reduction of Hazardous Substances (RoHS III), 2015/863/EU
- Functional Safety Type Approved, TUV Rheinland

Trademarks

ADVANCED Motion Controls®, the combined isosceles trapezoid/right triangle logo, **DIGIFLEX®, DIGIFLEX® Performance™** and DriveWare® are either registered trademarks or trademarks of *ADVANCED* Motion Controls in the United States and/or other countries. EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany. All other trademarks are the property of their respective owners.

Related Documentation

- Product datasheet specific for your drive, available for download at www.a-m-c.com
- DriveWare Software Guide, available for download at www.a-m-c.com
- EtherCAT Communication Manual, available for download at www.a-m-c.com

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.

Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.

Notice - Required instruction necessary to ensure successful completion of a task or procedure.

Caution - Instructs and directs you to avoid damaging equipment.

Warning - Instructs and directs you to avoid harming yourself.

Danger - Presents information you must heed to avoid serious injury or death.

Revision History

Document ID	Revision #	Date	Changes
MNDGDEIN-01	1	11/2011	DPE Install Manual First Release
MNDGDEIN-02	2	9/2012	- Updated for DriveWare 7 information - Updated for RMS Charge-Based Limiting capabilities
MNDGDEIN-03	3	10/2013	- Added C060A400 and C100A400 Power Module Information
MNDGDEIN-04	4	10/2014	- Added STO wiring recommendation
MNDGDEIN-05	5	02/2015	- Added 020B080 Power Module Information
MNDGDEIN-06	6	03/2016	- Added 040A400 Power Module Information
MNDGDEIN-07	7	09/2016	- Added 030A800 and 060A800 Power Module Information
MNDGDEIN-08	8	11/2017	- Added 100B080 Power Module Information
MNDGDEIN-09	9	05/2018	- Added 2-Phase Stepper Motor Information - Added PDO power-up delay information

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4 Operation and Features 31

1 Safety

This section discusses characteristics of your DPE Digital Drive to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

1.1 General Safety Overview

In order to install a DPE drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Caution

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Notice

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.

Warning

Keep clear of all exposed power terminals (motor, DC Bus, shunt, DC power, transformer) when power is applied to the equipment. Follow these safety guidelines:

- When using a separate logic supply, turn on the logic power supply first before turning on the main power supply.
- Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.
- Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative.
- Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.
- Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.
- Do not make any connections to the drive while power is applied.

Caution

- Do not reverse the power supply leads! Severe damage will result!
- If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

Use sufficient capacitance!

Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Caution

Make sure minimum inductance requirements are met!

Pulse Width Modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 ∝H.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2 Products and System Requirements

This document is intended as a guide and general overview in selecting, installing, and operating *ADVANCED* Motion Controls DigiFlex Performance™ digital servo drives that use EtherCAT® for networking. These specific drives are referred to herein and within the product literature as DPE drives. Other drives in the DigiFlex Performance product family that utilize other methods of network communication such as CANopen, POWERLINK, Modbus TCP/RTU, Ethernet, or RS-485 are discussed in separate manuals that are available at www.a-m-c.com. Contained within each DigiFlex Performance product family manual are instructions on system integration, wiring, drive-setup, and standard operating methods.

2.1 DPE Drive Family Overview

The DPE drive family can power tthree phase or single phase brushless or brushed servomotors, two phase or three phase closed loop stepper motors, and closed loop vector AC induction motors. The command source can be generated externally or can be supplied internally. A digital controller can be used to command and interact with DPE drives, and a number of dedicated and programmable digital and analog input/output pins are available for parameter observation and drive configuration. DPE drives are capable of operating in current (torque), velocity, or position modes, and utilize Space Vector Modulation, which results in higher bus voltage utilization and reduced heat dissipation compared to traditional PWM. DPE drives also offer a variety of firmware-dependent feedback options.

DPE drives offer EtherCAT communication for multiple drive networking, and feature a USB interface for drive configuration and setup. Drive commissioning is accomplished using DriveWare, the setup software from *ADVANCED* Motion Controls, available for download at www.a-m-c.com.

2.1.1 Drive Datasheet

Each DPE digital drive has a separate datasheet that contains important information on the options and product-specific features available with that particular drive. The datasheet is to be used in conjunction with this manual for system design and installation.

Caution

In order to avoid damage to equipment, only after a thorough reading and understanding of this manual and the specific datasheet of the DPE drive being used should you attempt to install and operate the drive.

2.2 Products Covered

The products covered in this manual adhere to the following part numbering structure. However, additional features and/or options are readily available for OEM's with sufficient ordering volume. Feel free to contact *ADVANCED* Motion Controls for further information.

FIGURE 2.1 DPE Part Numbering Structure

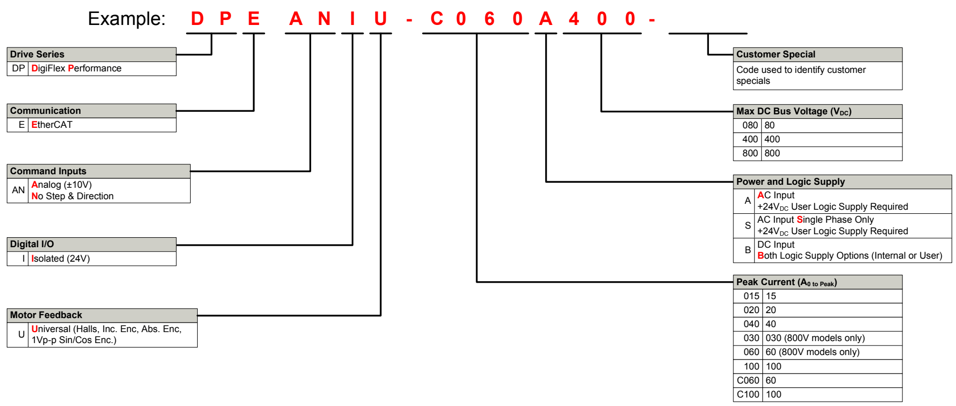


TABLE 2.1 Power Specifications - AC Power Modules

		Power Specifications					
Description	**Units**	**015S400**	**040A400**	**C060A400**	**C100A400**	**030A800**	**060A800**
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	528	528
AC Input Phases	-	1	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[1]	W	2415	6441	9662	16103	6830	13650
Max. Continuous Power Dissipation @ Rated Voltage	W	127	339	509	848	360	720
Internal Bus Capacitance	∝F	540	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	25	20	20	note 2	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	3000	3000

1. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
2. Contact factory before using an external shunt resistor with this power module

TABLE 2.2 Power Specifications - DC Power Modules

		Power Specifications	
Description	**Units**	**020B080**	**100B080**
DC Supply Voltage Range	VDC	20-80	20-80
DC Bus Over Voltage Limit	VDC	88	88
DC Bus Under Voltage Limit	VDC	17	17
Maximum Peak Output Current	A (Arms)	20 (14.1)	100 (70.73)
Maximum Continuous Output Current	A (Arms)	10 (10)	60 (60)
Max. Continuous Output Power @ Rated Voltage[1]	W	760	4560
Max. Continuous Power Dissipation @ Rated Voltage	W	40	240
Internal Bus Capacitance	∝F	33	500
PWM Switching Frequency	kHz	20	20
Minimum Load Inductance (Line-To-Line)	∝H	600	250

TABLE 2.3 Control Specifications

Description	DPEANIU
Network Communication	EtherCAT (USB for Configuration)
Command Sources	± 10V Analog, Over the Network, Encoder Following, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	11/7
Programmable Analog I/O	2/0
Primary I/O Logic Level	24 VDC

TABLE 2.4 Feedback Options

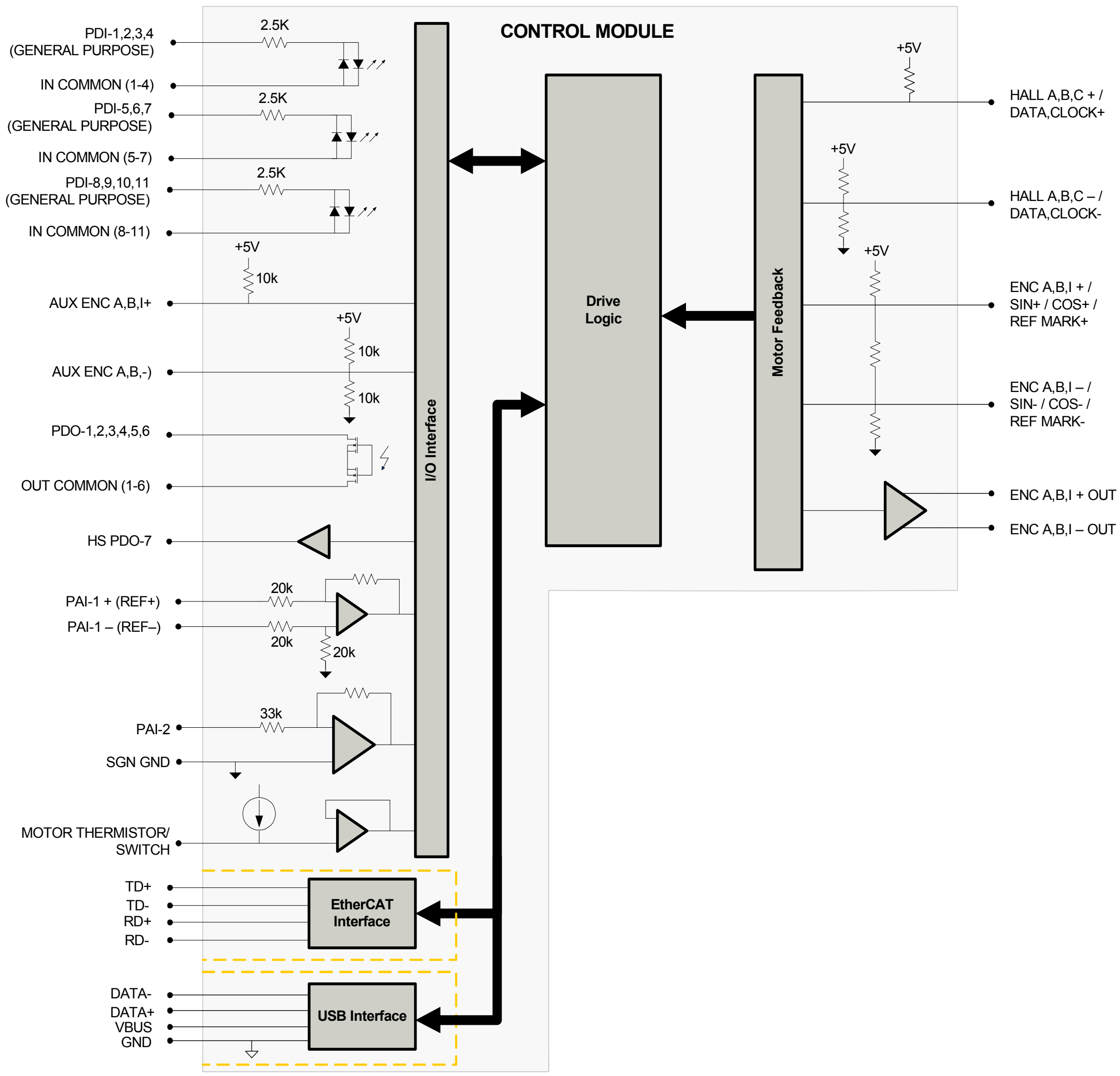
Description	DPEANIU
Hall Sensors	
Incremental Encoder	
Auxiliary Incremental Encoder	
Absolute Encoder (Hiperface®, EnDat® 2.1/2.2, BiSS C-Mode)	
1Vp-p Sine/Cosine Encoder	
Tachometer (10 ±VDC)	
±10 VDC Position	

Note: Drive will support either Incremental Encoder, Absolute Encoder, or 1Vp-p Sine/Cosine Encoder depending on drive firmware

2.2.1 Control Module

The diagram below shows the general block diagram for the DPEANIU control module. For complete pinouts, consult the drive's datasheet.

FIGURE 2.2 DPEANIU Control Module



2.3 Communication Protocol

DPE digital drives offer networking capability through EtherCAT® communication. An auxiliary USB port is featured for configuring the drive through DriveWare.

EtherCAT communication works by exchanging messages between a "host" and "nodes". The messages contain information on specific drive functions, each of which is defined by a group of objects. An object is roughly equivalent to a memory location that holds a certain value. The values stored in the drive's objects are used to perform the drive functions (current loop, velocity loop, position loop, I/O functions, etc.). For more detailed information on EtherCAT communication with DZEANTU drives and a complete list of objects, consult the *ADVANCED* Motion Controls EtherCAT Communication Manual available for download at www.a-m-c.com.

The EtherCAT interface for *ADVANCED* Motion Controls DZEANTU drives follows the ETG.1000.6 EtherCAT Application Layer protocol specification and the ETG.6010 Implementation guideline for CiA402 drive profile (device profile for drives and motion control). ETG (EtherCAT Technology Group) is the organization that governs the EtherCAT standard. More information can be found at www.ethercat.org.

2.4 Control Modes

DPE digital drives operate in a variety of operating modes. The setup and configuration parameters for these modes are commissioned through DriveWare. See the *ADVANCED* Motion Controls EtherCAT Communication Manual for mode configuration information.

2.4.1 Profile Modes

In Profile Modes, the trajectory is limited by the drive, using the Command Limiter values to limit the maximum command rate. If the host sends a large command step, the drive spreads the demand over some period of time to stay equal to or below the maximum defined rate.

Profile Current (Torque) In Current (Torque) Mode, the input command voltage controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored in DriveWare through the digital oscilloscope function. DriveWare also offers configuration of maximum and continuous current limit values.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

Profile Velocity In Velocity Mode, the input command voltage controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. DPE drives allow velocity control with either Hall Sensors, an encoder, or a tachometer as the feedback element. The motor velocity and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for velocity control must be specified in DriveWare, which also offers configuration of velocity limits. See “Feedback Supported” on page 11 for more information on feedback devices.

Profile Position In Position Mode, the input command voltage controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. DPE drives allow position control with either an encoder or ±10V Position feedback. The motor position and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for position control must be specified in DriveWare, which also offers configuration of position limits. See “Feedback Supported” on page 11 for more information on feedback devices.

2.4.2 Cyclic Synchronous Modes

Cyclic Synchronous Modes give responsibility of trajectory control to the host. The drive interpolates between command points, defining the rate by dividing the change in command by the interpolation time period. This allows the drive to respond smoothly to each step in command.

Cyclic Synchronous Current In Cyclic Synchronous Current Mode, the drive closes the current loop. The host is allowed more control by having the ability to instantly add current feedforward values. This allows for gain compensation in applications with varying loads.

Cyclic Synchronous Velocity In Cyclic Synchronous Velocity Mode, the drive closes two control loops: velocity and current. The host is allowed more control by having the ability to instantly add velocity and current feedforward values. This allows for gain compensation in applications with varying loads.

Cyclic Synchronous Position In Cyclic Synchronous Position Mode, the drive closes three control loops: position, velocity, and current. The host can send target position, velocity feedforward, and current feedforward values to the drive. This allows for gain compensation in applications with varying loads.

2.4.3 Current (Torque)

In Current (Torque) Mode, the input command controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored within the configuration software, or externally through network commands.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

2.4.4 Velocity

In Velocity Mode, the input command controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. The motor velocity and other parameters can be monitored within the configuration software, or externally through network commands. See “Feedback Supported” on page 11 for more information on velocity feedback devices.

2.4.5 Position

In Position Mode, the input command controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. The motor position and other parameters can be monitored within the configuration software, or externally through network commands. See “Feedback Supported” on page 11 for more information on position feedback devices.

2.5 Feedback Supported

DPE drives feature the ability to support a variety of primary feedback devices by downloading the appropriate firmware into the drive. Compatible firmware-dependent devices are Incremental Encoders, Absolute Sin/Cos Encoders (Hiperface®, EnDat®, and BiSS C-Mode), and 1Vp-p Sin/Cos Encoders. Consult the DriveWare Software Manual for instructions on how to download firmware into a digital servo drive.

Other supported feedback types that do not require a firmware change are Hall Sensors, Auxiliary Incremental Encoder, Tachometer, and ±10 VDC Position feedback.

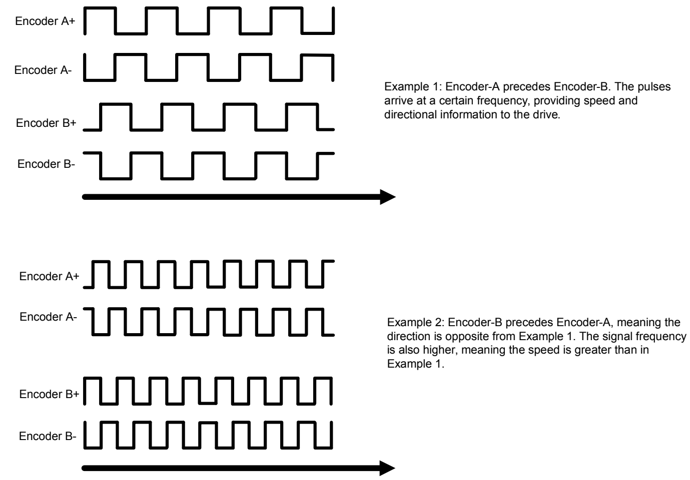
Feedback Polarity The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. The feedback element must be connected for *negative* feedback. Connecting the feedback element for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. The correct feedback polarity will be determined and configured during commissioning of the drive. Otherwise, to correct this, either change the order that the feedback lines are connected to the drive, or use DriveWare to reverse the internal velocity feedback polarity setting.

2.5.1 Incremental Encoder

DPE drive models can utilize incremental encoder feedback for velocity or position control, with the option of also using the encoder to commutate the motor. The encoder provides incremental position feedback that can be extrapolated into very precise velocity or position information. With an encoder being used as the feedback element, the input command controls the motor velocity or motor position, with the frequency of the encoder pulses closing the velocity and/or position loop. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor's speed, position and direction of rotation. Based on the speed and order in which these pulses are received from the encoder, the drive can interpret the motor velocity and physical location. The actual motor speed and physical location can be monitored within the configuration software, or externally through network commands.

Figure 2.3 below represents differential encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated. By keeping track of the number of encoder "pulses" with respect to a known motor "home" position, DPC drives are able to ascertain the actual motor location.

FIGURE 2.3 Encoder Feedback Signals



Note

The high resolution of motor mounted encoders allows for excellent velocity and position control and smooth motion at all speeds. Encoder feedback should be used for applications requiring precise and accurate velocity and position control, and is especially useful in applications where low-speed smoothness is the objective.

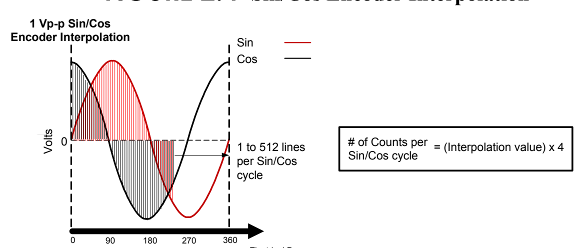
2.5.2 Absolute Encoder

DPE drives support Hiperface®, EnDat® (2.1/2.2 command set), or BiSS C-Mode absolute encoders for velocity and absolute position feedback. The encoder resolution and other options can be configured within the drive configuration software. The drive breaks down the signals from the encoder into individual reference points (counts). For feedback devices that accept 1Vp-p signals, the interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.4. This allows for very high interpolated encoder resolution (4-2048 counts).

Note

The absolute position feedback eliminates the need for a homing routine when the drive is powered on.

FIGURE 2.4 Sin/Cos Encoder Interpolation



2.5.3 1Vp-p Sin/Cos Encoder

DPE drives support 1Vp-p Sin/Cos encoders for position and velocity feedback. The drive breaks down the 1Vp-p sinusoidal signals from the encoder into individual reference points (counts). The interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.4. This allows for very high interpolated encoder resolution (4-2048 counts per Sin/Cos cycle).

2.5.4 Hall Sensors

DPE drives can use single-ended or differential Hall Sensors for commutation and/or velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. With Hall Sensors being used as the feedback element, the input command controls the motor velocity, with the Hall Sensor frequency closing the velocity loop.

Note

Hall velocity mode is not optimized for relatively high or relatively low Hall frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.

For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 48.

2.5.5 Auxiliary Incremental Encoder

The auxiliary encoder input pins can be used as a command source for encoder following mode, or as a secondary feedback device input for closing the position loop. The particular function is configured in the configuration software.

2.5.6 Tachometer (±10 VDC)

DPE drives support the use of a tachometer for velocity feedback. The tachometer measures the rotary speed of the motor shaft and returns an analog voltage signal to the drive for velocity control. DPE drives provide a Programmable Analog Input on the motor Feedback Connector that is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

2.5.7 ±10 VDC Position

DPE drives accept an analog ±10 VDC Position feedback, typically in the form of a load-mounted potentiometer. The feedback signal must be conditioned so that the voltage does not exceed ±10 V, and is connected to the drive through the Programmable Analog Input. In DriveWare, the connection method that is used must be selected under the Position Loop Feedback options. See the DriveWare Software Guide for more information.

2.6 Command Sources

The input command source for DPE drives can be configured for one of the following options.

2.6.1 ±10V Analog

DPE drives accept a single-ended or differential analog signal with a range of ±10 V from an external source. The input command signals should be connected to the programmable input on the I/O Signal Connector. See "Programmable Analog I/O" on page 36 for more information.

2.6.2 Encoder Following

DPE drives can utilize Encoder Following as a form of input command. In Encoder Following mode, an auxiliary encoder signal can be used to command the drive in a master/slave configuration. The gearing ratio (input counts to output counts ratio) can be configured in DriveWare by the user. Encoder Following is only a valid option when the DPE drive is operated in position mode.

2.6.3 Indexing and Sequencing

DPE drives allow configuration of up to 16 separately defined Index tasks in DriveWare. Indexes can be either Absolute (commands a pre-defined move to an absolute position) or Relative (commands a pre-defined move relative to the current position). Indexes can be combined with Homing routines and other control functions to form up to 16 different Sequences. Sequences can be configured to initiate on power-up, via a digital input, or by using an external network command.

2.6.4 Jogging

DPE drives allow configuration of two separate Jog velocities in DriveWare, commanding motion at a defined constant velocity with infinite distance.

2.6.5 Over the Network

DPE drives can utilize network communication as a form of input command through the EtherCAT interface. In order to send commands to the drive over the EtherCAT network, the command source in DriveWare must be set to Communication Channel. For more information on commanding the drive with EtherCAT, see "Communication and Commissioning" on page 46.

2.7 System Requirements

To successfully incorporate a DPE digital servo drive into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance.

2.7.1 Specifications Check

Before selecting a DPE digital servo drive, a user should consider the requirements of their system. This involves calculating the voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with. Before attempting to install or operate a DPE servo drive, be sure all the following items are available:

- DPE Digital Servo Drive
- DPE Drive Datasheet (specific to your model)
- DPE Series Digital Hardware Installation Manual
- DriveWare Software Guide

2.7.2 Motor Specifications

DPE digital servo drives have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a DPE drive may be selected that will best suit the motor capabilities. Some general guidelines that are useful when pairing a DPE servo drive with a motor:

- The motor current I_M is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T -motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile. The continuous torque is the average torque required by the system during the move profile, including dwell times.

- The system voltage requirement is based on the motor properties and how fast and hard the motor is driven. The system voltage requirement is equal to the motor voltage, V_M, required to achieve the move profile.

$$V_M = (K_E \cdot S_M) + (I_M \cdot R_M)$$

Where:

K -motor back EMF constant

S -motor speed (use the maximum speed expected for the application)

I -motor current (use the maximum current expected for the application)
R -motor line-to-line resistance

- The motor inductance is vital to the operation of DPE servo drives, as it ensures that the DC motor current is properly filtered.

Caution

A motor that does not meet the rated minimum inductance value of the DPE drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary.

A minimum motor inductance rating can be found in the drive datasheet. If the drive is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

2.7.3 Power Supply Specifications

DPE servo drives operate off a single-phase AC Power Supply. To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

- Drive over voltage
- External shunt regulator turn-on voltage

Use of a shunt regulator is necessary in systems where motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply. This regenerated energy can charge the power supply capacitors to levels above that of the DPE drive over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one drive, then the current requirements for each drive should be added together. Due to the nature of servo drives, the current into the drive does not always equal the current out of the drive. However, the *power* in is equal to the *power* out. Use the following equation to calculate the power supply output current, I_{PS}, based on the motor current requirements.

$$I_{PS} = \frac{V_M \cdot I_M}{V_{PS} \cdot (0.98)}$$

Where:

V_{PS} -nominal power supply voltage
I_M -motor current
V_M -motor voltage

Use values of V and I at the point of maximum power in the move profile (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.

2.7.4 Environment

To ensure proper operation of a DPE servo drive, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.5 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Baseplate Maximum Allowable Temperature	0 - 75 °C

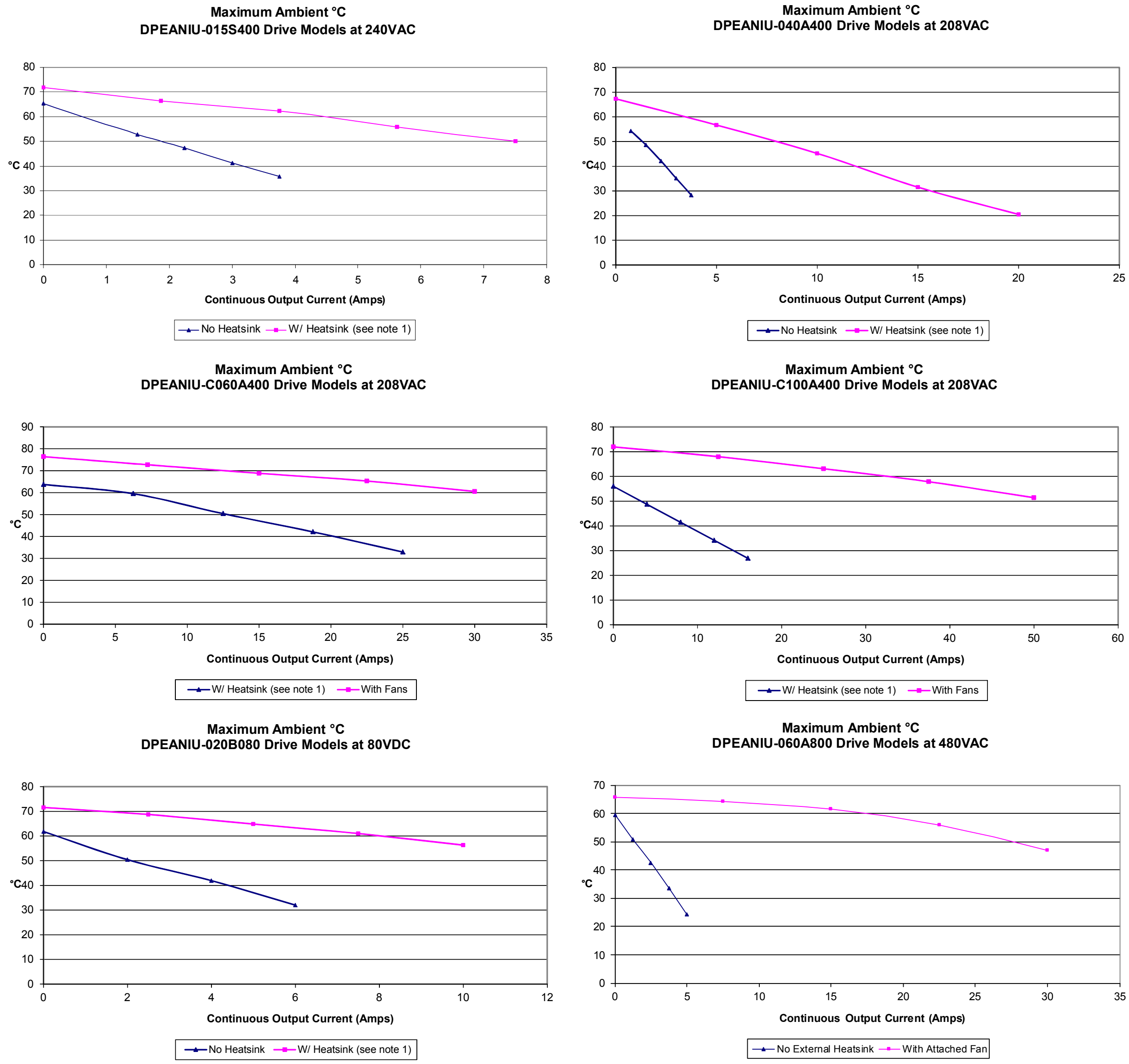
Shock/Vibrations **While DPE drives are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to. The best way to secure the drive against mechanical vibration is to use screws to mount the DPE drive against its baseplate. For information on mounting options and procedures, see "Mounting" on page 30.**

Caution

Care should be taken to ensure the drive is securely mounted in a location where no moving parts will come in contact with the drive.

Ambient Temperature Range and Thermal Data **DPE drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above 75 degrees Celsius. For a specific AC supply voltage and a specific output current, Figure 2.5 below specifies an upper limit to the ambient temperature range DPE drives can operate within while keeping the baseplate temperature below the maximum baseplate temperature. It is recommended to mount the baseplate of the DPE drive to a heatsink and/or use fan cooling for best thermal management results. For mounting instructions see "Mounting" on page 30.**

FIGURE 2.5 DPE Drives Maximum Ambient Temperature Range



1.The heatsink used in the above test is a 15" x 22" x 0.65" aluminum plate.
2.Contact the factory for DPEANIU-100B080 thermal data.

3 Integration in the Servo System

This chapter will give various details on incorporating a DPE servo drive into a system, such as how to properly ground the DPE drive along with the entire system, and how to properly connect motor wires, power supply wires, feedback wires, communication cables, and inputs into the DPE drive.

3.1 LVD Requirements

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the servo drives must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

Contact the factory for assistance in determining the type of drive in use.

General

1. Shielded cables must be used for all interconnect cables to the drive and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.
2. The drive's metal enclosure must be grounded to the closest ground point with the least amount of resistance.
3. The drive must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.

Analog Input Drives

4. A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.

PWM Input Drives

5. A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.

MOSFET Switching Drives

6. A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.
7. An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.

IGBT Switching Drives

8. An appropriately rated Cosel Tac series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.
9. A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.

Fitting of AC Power Filters

10. It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be

adversely affected by the noise. AC power filters can filter this noise and keep it from getting on the AC power signal.The above mentioned AC power filters should be mounted flat against the enclosure of the product using the mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power filter enters the enclosure as possible. Also, the AC power cable on the load end of the filter should be routed far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

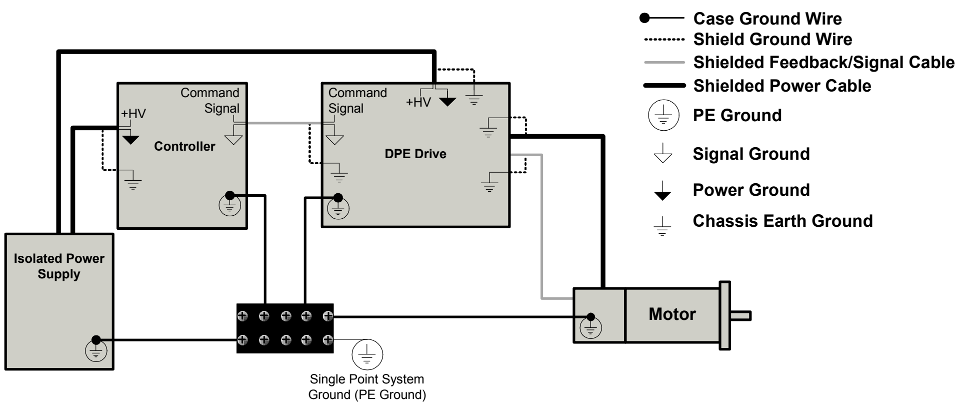
Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines.

3.3 Grounding

In most servo systems the case grounds of all the system components should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point through a single low resistance wire reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

- Motor chassis
- Controller chassis
- Power supply chassis
- DPE drive chassis

FIGURE 3.1 System Grounding



Ground cable shield wires at the drive side to a chassis earth ground point.

The power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the DPE drive to avoid picking up noise due to the "floating" differential servo drive input. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

Warning

Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed. As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

The main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card or a noise suppression device is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

ADVANCED Motion Controls recommends using the following hand crimp tools for the appropriate I/O and Feedback cable and wire preparation. Consult the drive datasheet to see which connectors are used on a specific drive.

Drive Connector	Hand Crimp Tool Manufacturer and Part Number
6-pin, 3.96 mm spaced, friction lock header	Tyco: P/N 770522-1
High Density D-sub headers	Tyco: P/N 90800-1

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of larger diameter wire rather than too thin. This becomes more critical as the cable length increases. The following table provides recommendations for selecting the appropriate wire size for a specific current. These values should be used as reference only. Consult any applicable national or local electrical codes for specific guidelines.

Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518
15	#18	0.823
20	#16	1.31
35	#14	2.08
45	#12	3.31

Current (A)	Minimum Wire Size (AWG)	mm^2
60	#10	5.26
80	#8	8.37
120	#6	13.3
150	#0	53.5
200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

- For a single phase motor or voice coil, twist the two motor wires together as a group.
- For a three phase motor, twist all three motor wires together as a group.

Caution

DO NOT use wire shield to carry motor current or power!

Ground the motor power cable shield at one end only to the drive chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the drive chassis ground.

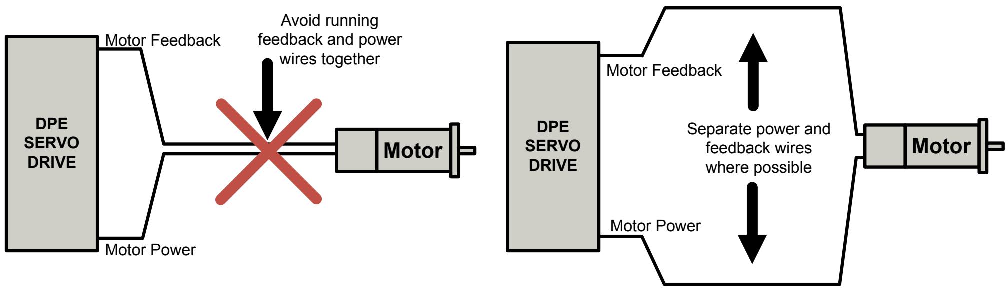
When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each drive directly from the power supply filter capacitor.
2. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the drive chassis ground. Also make sure that the feedback connector and D-sub shell preserve the shield continuity. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.2 Feedback Wiring



3.4.5 I/O and Signal Wires

Use of a twisted, shielded pair for the I/O and Signal wires is recommended. Connect the shield to the drive chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds.

In case of a single-ended reference signal when using ±10V as the input command source, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

3.5 Connector Types

Depending on the specific drive model, typically a DPE drive connection interface will consist of:

- Power Connectors **- used for Logic, Motor, and AC or DC Power, as well as optional external shunt regulator connections**
- Feedback Connectors **- used for primary and auxiliary feedback connections, programmable inputs and outputs, and other drive functions**
- EtherCAT Communication Connector **- used for EtherCAT networking connections**
- Auxiliary USB Communication Connector **- used for USB drive communication necessary for commissioning with DriveWare**
- I/O Signal Connector **- used for programmable inputs and outputs as well as some feedback connections.**
- STO Connector **- used for Safe Torque Off (STO) functionality.**

The different types of connectors used in the DPE drive series are shown in the sections below. Consult the specific drive datasheet for the actual connectors and pin labels used on the drive.

3.5.1 Power Connectors

TABLE 3.1 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 3.5 mm spaced insert connector
Mating Connector	Details	Phoenix Contact: P/N 1840366
	Included with Drive	Yes

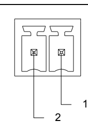


TABLE 3.2 POWER / MOTOR POWER / BRAKE - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		10-port, 5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1781069
	Included with Drive	Yes

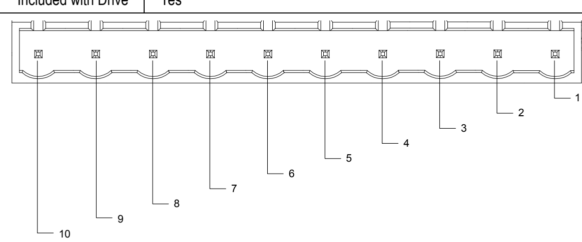


TABLE 3.3 POWER / MOTOR POWER / LOGIC - Power Connector

BRAKE/LOGIC - Logic Power Connector		
Connector Information		6-pin, 3.96 mm spaced, friction lock header
Mating Connector	Details	AMP: Plug P/N 770849-6; Terminals P/N 770522-1 (loose) or 770476-1 (strip)
	Included with Drive	Yes

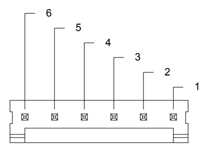


TABLE 3.4 AC POWER / MOTOR POWER / DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 10.16 mm spaced, enclosed, friction lock header
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

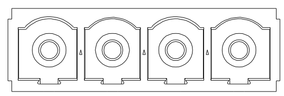


TABLE 3.5 AC POWER / MOTOR POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	No

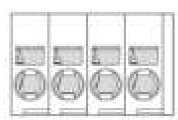


TABLE 3.6 DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		5-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	Not applicable

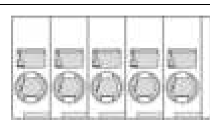


TABLE 3.7 DC POWER / MOTOR POWER - Power Connector

DC POWER / MOTOR POWER - Power Connector		
Connector Information		4-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804920
	Included with Drive	Yes

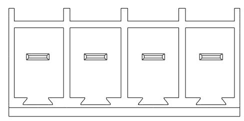
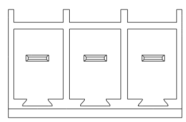


TABLE 3.8 AC POWER - Power Connector

ACPOWER - Power Connector		
Connector Information		3-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804917
	Included with Drive	Yes



3.5.2 Feedback Connectors

TABLE 3.9 FEEDBACK - Feedback Connector

FEEDBACK - Feedback Connector		
Connector Information		15-pin, high-density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 748364-1; Housing P/N 5748677-2; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No

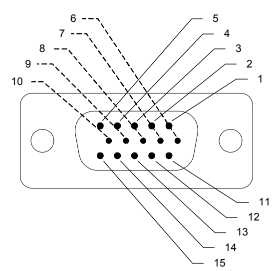
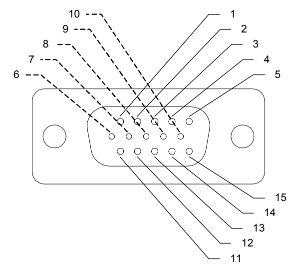


TABLE 3.10 AUX ENCODER - Auxiliary Feedback Connector

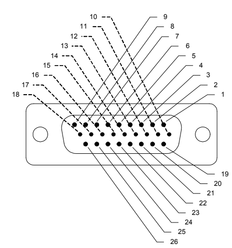
AUX ENCODER - Auxiliary Feedback Connector		
Connector Information		15-pin, high-density, male D-sub
Mating Connector	Details	TYCO: Plug P/N 1658681-1; Housing P/N 5748677-2; Terminals P/N 1658686-2 (loose) or 1658686-1 (strip)
	Included with Drive	No



3.5.3 I/O Connectors

TABLE 3.11 I/O - Signal Connector

I/O - Signal Connector		
Connector Information		26-pin, high density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 1658671-1; Housing P/N 5748677-3; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No



3.5.4 Communication Connectors

TABLE 3.12 COMM - EtherCAT Communication Connector

COMM - EtherCAT Communication Connector		
Connector Information		Shielded, dual RJ-45 socket with LEDs
Mating Connector	Details	Standard CAT 5e or CAT 6 ethernet cable
	Included with Drive	No

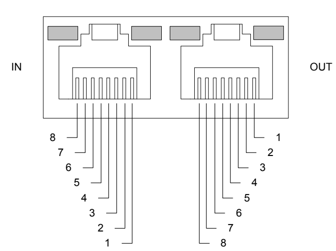
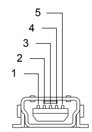


TABLE 3.13 AUX COMM - USB Communication Connector

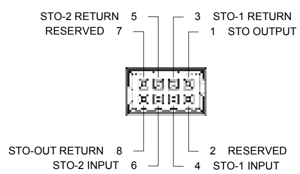
AUX COMM - USB Communication Connector		
Connector Information		5-pin, Mini USB B Type port
Mating Connector	Details	TYCO: 1496476-3 (2-meter STD-A to MINI-B ASSY)
	Included with Drive	No



3.5.5 STO Connector

TABLE 3.14 Safe Torque Off (STO) connector

STO Connector		
Connector Information		8-port, 2.00 mm spaced, enclosed, friction lock header
Mating Connector	Details	Molex: P/N 51110-0860 (housing); 50394-8051 (pins)
	Included with Drive	No



3.6 Mounting

DPE drives provide a number of mounting configuration options. The drive baseplate includes perimeter mounting screwholes allowing different mounting arrangements depending on the requirements or space limitations of the system. See the drive datasheet for specific mounting dimensions and screwhole locations.

4 Operation and Features

This chapter will present a brief introduction on how to test and operate a DPE servo drive. Read through this entire section before attempting to test the drive or make any connections.

4.1 Features and Getting Started

To begin operation with your DPE drive, be sure to read and understand the previous chapters in this manual as well as the drive datasheet and the DriveWare Software Guide. Ensure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the DPE drive. Also, be aware of the "Troubleshooting" section at the end of this manual for solutions to basic operation issues.

4.1.1 Initial Setup and Configuration

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up. For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- **DPE Servo Drive**
- **Motor**
- **AC Power Supply and Logic Power Supply for supplying power to system**
- **DriveWare Setup Software and Software Guide for detailed instructions on how to setup, tune and configure a DPE drive in DriveWare**

The following steps outline the general procedure to follow when commissioning a DPE drive for the first time. The DriveWare Software Guide contains more detailed information on each step.

1. **Check System Wiring:** Before beginning, check the wiring throughout the system to ensure proper connections and that all grounding and safety regulations have been followed appropriately for the system.

Caution

Do not apply power to the system until certain all wiring and grounding has been setup safely and properly!

For drives using a separate logic power supply, turn on the logic supply first before turning on the main power supply.

2. **Apply Power:** Power must be applied to the drive before any communication or configuration can take place. Turn on the Logic supply first for drives using a separate logic supply, then turn on the main Power supply. Use a multimeter or voltmeter to check that both power supply levels are within their specified ranges.
3. **Establish Connection:** Open DriveWare on the PC. The DPE drive should be connected to the PC with a USB cable. Choose the "Connect to a drive" option when DriveWare starts, and enter the appropriate communication settings in the options window that appears. See the DriveWare Software Guide for more information on connecting to a drive. For connection issues, see "Connection Problems" on page 53.
4. **Configure the drive in DriveWare:** DriveWare allows the user to manually configure user units, motor and feedback information, system parameters and limits, tune the Current, Velocity and Position Loops, commutate the motor, and assign drive and software "actions" to specific events. Consult the DriveWare Software Guide for detailed instructions.
5. **Connect to the Controller:** Once the drive has been properly commissioned, use an external controller to command an input signal to the drive. The controller wiring and setup should follow the safety and grounding guidelines and conventions as outlined in "Grounding" on page 22.

4.1.2 Input/Output Pin Functions

DPE drives provide a number of various input and output pins for parameter observation and drive configuration options. Consult the drive datasheet to see which input/output pin functions are available for each drive.

Programmable Digital I/O **The single-ended and differential Programmable Digital I/O can be assigned to over 40 different functions in DriveWare. The polarity of the signals can be set to active HIGH or active LOW depending on the preference of the user. The differential high speed inputs can also be used as command source inputs with an Auxiliary Encoder (see** **"Auxiliary Encoder Input" below)****. DPE drives offer both isolated and non-isolated Programmable Digital I/O.**

Note

When set to Active High, digital outputs will be pulled high for a period of time after a power cycle or drive reset. The delay period is given below.

FIGURE 4.1 Programmable Digital Output Power-up Delay

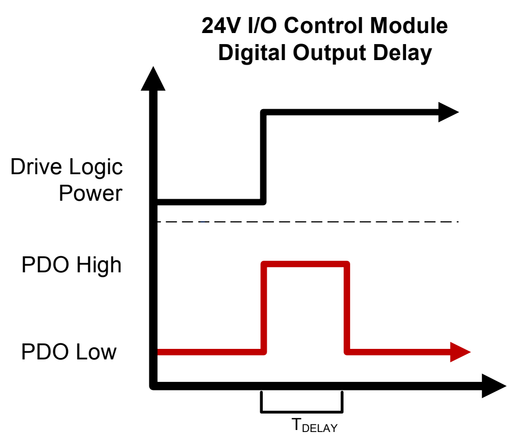


TABLE 4.1 Programmable Digital Output Power-up Delays

Active High		Active Low	
Power Cycle Delay (ms)	Reset Delay (ms)	Power Cycle Delay (ms)	Reset Delay (ms)
1900	1800	-	-

24VDC Digital I/O Specification

The 24VDC Digital I/O is designed to be compatible with controllers that interface with 24VDC signals, using optical isolation that separates the drive signal ground from the controller signal ground. Isolation increases a system's noise immunity by helping to eliminate current loops and ground currents.

- **Inputs - The Isolated Digital Inputs use bi-directional optical isolators to detect signals from the controller. Dual LED's in the optical isolator allow current to flow in either direction. Current flow through the LED activates the transistor, and the drive responds depending on whether the transistor is active or not. The presence or absence of current**

in the LED determines the logic level, not the direction of current. This flexibility allows the Isolated Digital Inputs to be compatible with a wide range of controllers.

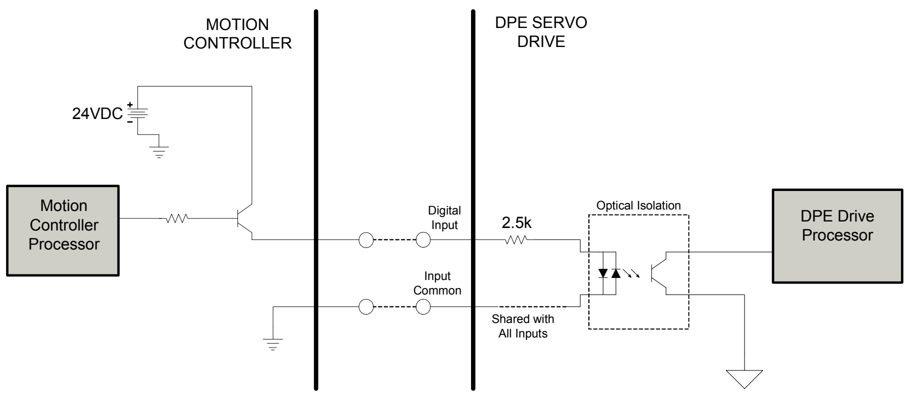
TABLE 4.2 24VDC Isolated Digital Input

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

When current flows into the digital input it is acting as a sinking input. When current flows out of the digital input it is acting as a sourcing input. Since current is allowed to flow in either direction, the inputs can either sink or source. The voltage at the Input Common pin determines whether the inputs sink or source. The Input Common pin is common to all of the inputs, but is isolated from the drive signal ground.

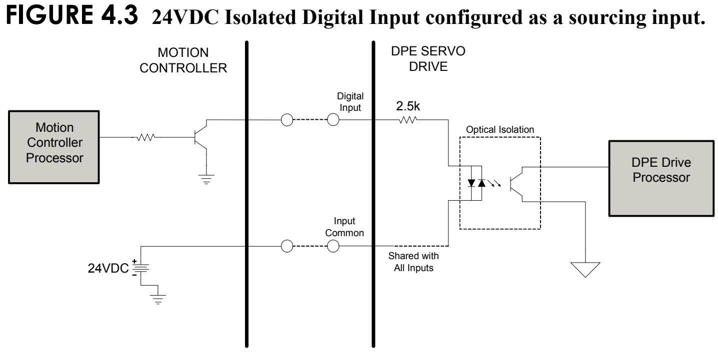
To configure the Isolated Digital Inputs as sinking, the 24V ground is applied to the Input Common and 24V is modulated at the digital input. Figure 4.2 shows a sourcing output from the motion controller feeding the sinking input at the drive. In this example the controller uses a transistor to control the 24V to the drive input. A mechanical switch, relay or other voltage-controlling device can be used in place of the transistor.

FIGURE 4.2 24VDC Isolated Digital Input configured as a sinking input



To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.3 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides a transistor.

FIGURE 4.3 24VDC Isolated Digital Input configured as a sourcing input.



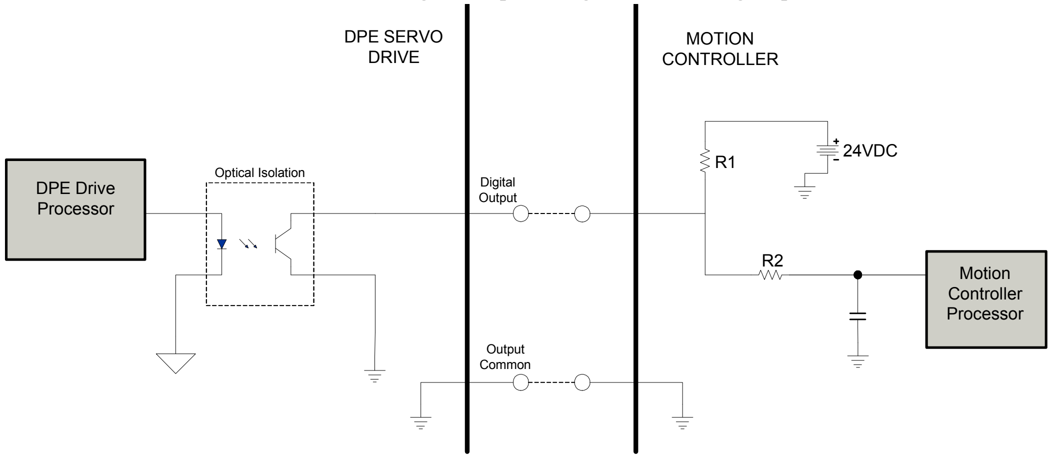
- **Outputs** - The Isolated Digital Outputs have a common grounding point labeled Output Common, and are +24VDC single-ended outputs.

TABLE 4.3 24VDC Isolated Digital Output

24VDC Isolated Digital Output (Sinking)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	120mA

A transistor controls the voltage at each digital output. The output pin is pulled to 24V and the 24V ground goes to the output common, as shown in Figure 4.4. A transistor controls the voltage at the digital output. When the transistor is open the voltage at the digital output is HIGH. When the transistor is closed the voltage is pulled to ground, which causes the output to go LOW.

FIGURE 4.4 24VDC Isolated Digital Output configured as a sinking output.



Programmable Limit Switch (PLS) Outputs

When a digital output is configured as a Programmable Limit Switch through the setup software, the maximum frequency of the output will correspond to the table below.

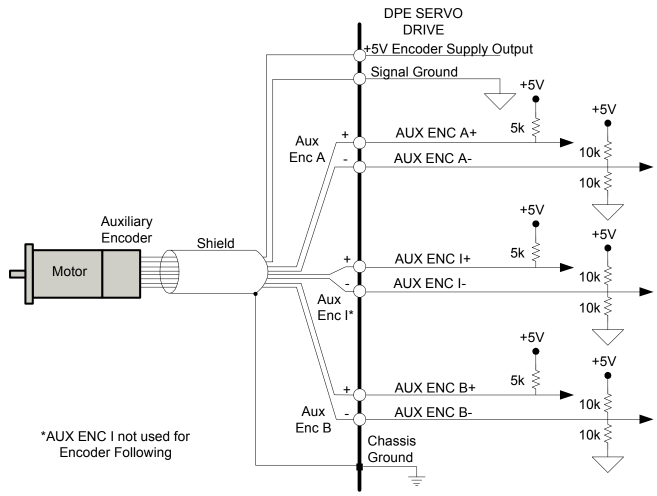
TABLE 4.4 Maximum Digital Output Frequency for PLS Outputs

	Maximum Frequency
24V I/O Control Modules	85 Hz (50% duty cycle)[1]

1. Higher duty cycles will result in higher maximum frequencies due to hardware filtering.

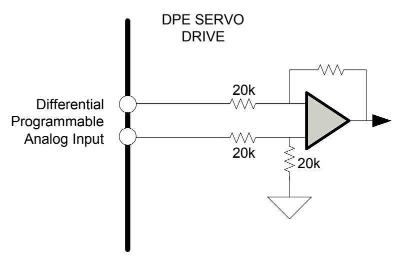
Auxiliary Encoder Input **DPE drives accept a differential auxiliary encoder input that can be used for auxiliary position feedback, or for a command source when configured for Encoder Following. Hardware settings and options can be entered and configured in DriveWare.**

FIGURE 4.5 **Auxiliary Encoder Input Connections**



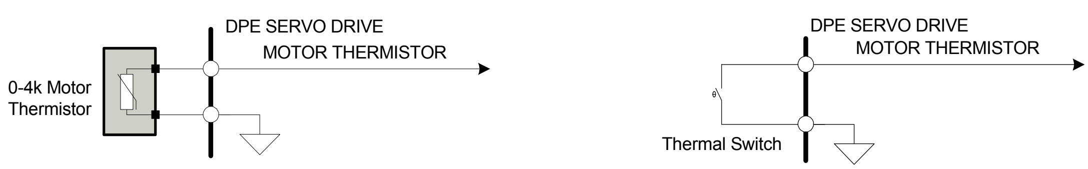
Programmable Analog I/O **The Programmable Analog I/O can be assigned to drive functions in DriveWare. These can be used to monitor drive signals, and are also useful for troubleshooting unexpected drive behavior. The drive I/O Signal Connector provides a differential programmable analog input that may be used for a ±10V analog input command.**

FIGURE 4.6 **Programmable Analog I/O**



Motor Thermistor **A 0-4 kohm thermistor or thermal switch can be connected between MOTOR THERMISTOR and GROUND. Thermistor/switch behavior can be configured in DriveWare.**

FIGURE 4.7 **Recommended Motor Thermistor Input**

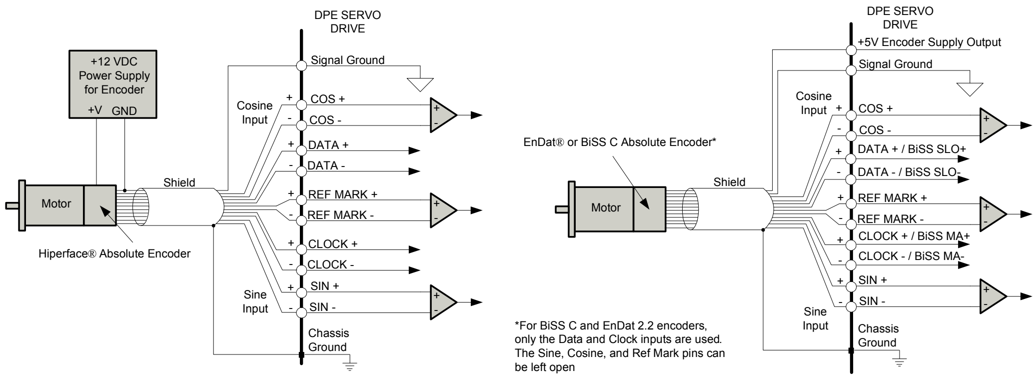


4.1.3 Feedback Operation

The functional operation of the feedback devices supported by DPE drives is described in this section. For more information on feedback selection, see "Feedback Supported" on page 11. See the drive datasheet specific pin locations.

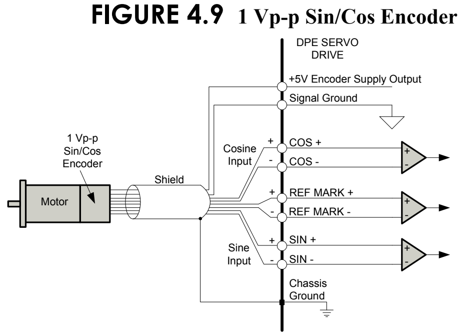
Absolute Encoder DPE drives support Hiperface®, EnDat® (2.1/2.2), or BiSS C-Mode absolute encoders. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs and differential RS-485 Data and Clock signals. Hiperface® encoders require an external +12 VDC supply for power, while EnDat® and BiSS C encoders can use the +5V Encoder Supply Output pin provided on the DPE drive. For BiSS C-Mode and EnDat 2.2 encoders, only the Data and Clock inputs are used. The Sine, Cosine, and Index pins can be left open.

FIGURE 4.8 Absolute Encoder Connections



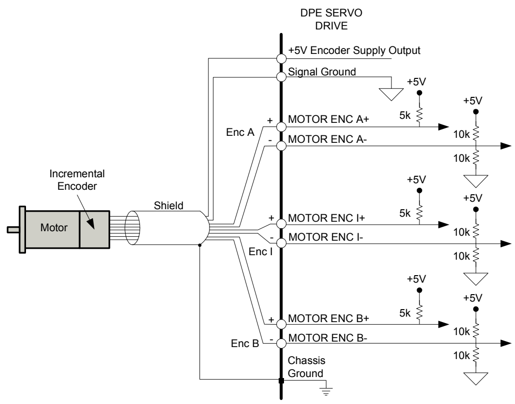
1 Vp-p Sin/Cos Encoder DPE drives support 1 Vp-p Sin/Cos Encoder feedback. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs. A +5V Encoder Supply Output pin is provided to supply power to the encoder.

FIGURE 4.9 1 Vp-p Sin/Cos Encoder



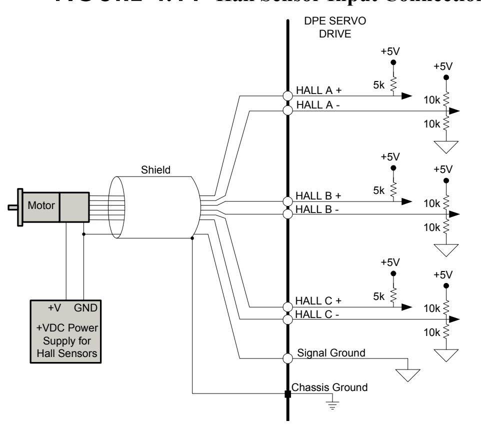
Incremental Encoder **DPE drives support incremental encoder feedback. The drive Feedback Connector allows inputs for differential inputs only. Both the "A" and "B" channels of the encoder are required for operation. DPE drives also accept an optional differential "index" channel that can be used for synchronization and homing. A +5V Encoder Supply Output pin is provided to supply power to the encoder.**

FIGURE 4.10 Incremental Encoder Connections



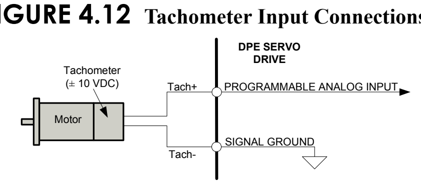
Hall Sensors **DPE drives accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive Feedback Connector allows differential or single-ended Hall Sensor inputs. For single-ended Halls leave the negative terminals open.**

FIGURE 4.11 Hall Sensor Input Connections



Tachometer (±10 VDC) **DPE drives support the use of a tachometer for velocity feedback. The Programmable Analog Input on the Auxiliary Feedback Connector is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.**

FIGURE 4.12 Tachometer Input Connections



4.1.4 Logic Power Supply

For DPE drives using an external +24 VDC nominal logic power supply (850mA), the logic supply ground should be referenced to the drive signal ground. The logic power inputs are made through a separate Logic Power connector on the drive.

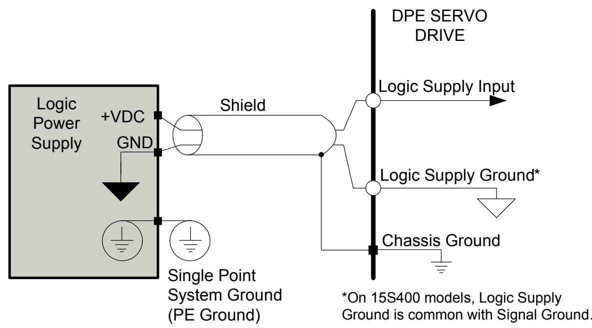
Caution

When using a separate logic power supply, the logic power must be turned on before the main power supply.

TABLE 4.5 AC Power Module Logic Supply Ratings

Logic Supply Range (VDC)	Input Current (mA)
20-30	850

FIGURE 4.13 Logic Power Supply Inputs

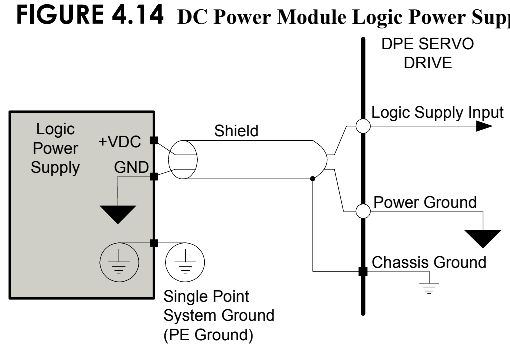


On drives using DC power modules, an external logic supply is optional. If no external logic supply is connected the drive will use the main DC power supply for logic power. If an external logic power supply is used, the voltage must be below the main DC Power Supply value. Table 4.6 shows the different DC power modules and their corresponding logic supply ranges.

TABLE 4.6 DC Power Module Logic Supply Ranges.

DC Power Module	Logic Supply Range (VDC)
020B080, 100B080	20-80

FIGURE 4.14 DC Power Module Logic Power Supply Inputs

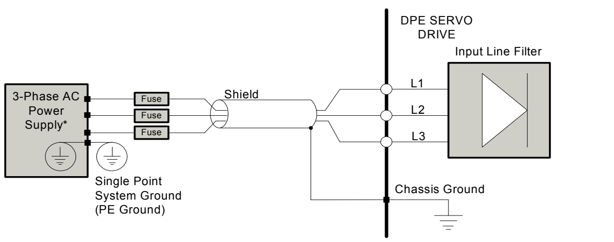


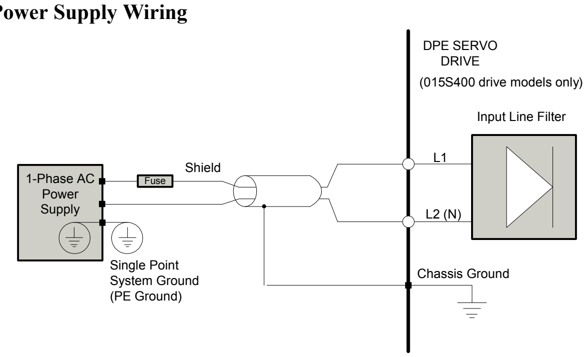
4.1.5 Power Supply Connections

The figures below show how an external power supply should be connected to the DPE drive.

AC or DC Power Modules **For drive models designed for a three-phase AC power supply, connect the AC supply to L1, L2, and L3. On certain drive models, a single-phase AC supply can be connected to any two of the three (L1, L2, L3) AC terminals with the result that some drive power de-rating may occur. See Figure 4.15 below or the drive datasheet for the specific model characteristics. For drives designed for a single phase AC supply, connect the AC supply to the L1 and L2 (N) AC terminals for. Figure 4.15 below shows the recommended connections.**

FIGURE 4.15 AC Power Supply Wiring





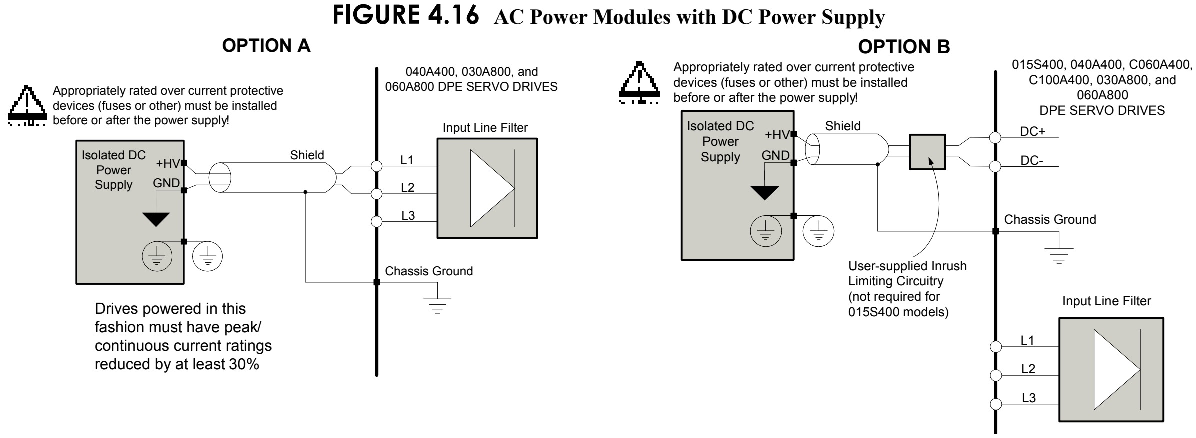
*To use a single-phase AC Supply with a drive designed for a three-phase AC supply, connect AC lines to any two of L1, L2, and L3. Do not connect AC line neutral to ground! See the chart below for specific drive model de-rating information for drives powered by single-phase AC.

Model	Single-Phase AC De-rating Characteristics
040A400	Peak and continuous current ratings will be reduced by 30%
C060A400	Output power must not exceed 3KW. No current limit de-rating.
C100A400	Output power must not exceed 3kW. Current limits de-rated to 30A cont. / 60A peak.

If using a DC supply to power a drive with an AC power module, follow one of the methods below, depending on the connections available for the specific power module (Figure 4.16 below shows the recommended connections).

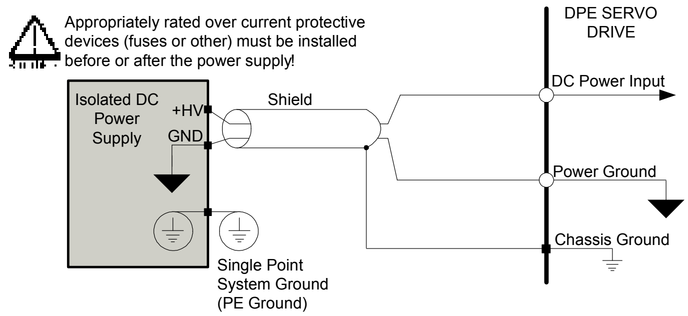
- **(Option A) Connect the isolated DC supply between any two of the three (L1, L2, L3) power terminals. Note that drives powered in this fashion must have peak and continuous current ratings reduced by at least 30% and should not be given current commands that exceed this derating.**
- **(Option B) Some drives feature DC+ and DC- terminals which can be used as DC inputs rather than using L1, L2, or L3. Except for 015S400 power modules, powering the drive in this fashion will require external inrush limiting circuitry that must be properly scaled to the application and drive power requirements.**

FIGURE 4.16 AC Power Modules with DC Power Supply



DC Only Power Modules **For drives using a DC power module, connect the isolated DC supply high voltage to the DC Power Input terminal, and the DC supply ground to the power ground terminal, as shown in Figure 4.17 below.**

FIGURE 4.17 DC Power Module Supply Wiring



4.1.6 Power LEDs Functionality

DPE drives feature LED status indicators for supply power and power bridge status.

Power LED **The Power LED indicates whether power is being supplied to the drive, as well as shunt regulator operation.**

Power LED	
State	**Description**
GREEN	Power is being supplied to the drive
OFF	No power is being supplied to the drive
RED	Drive is shunting excess energy through the shunt regulator (may appear as flashing RED/GREEN as the shunt regulator is turning off and on during regeneration)

Status LED **The Status LED indicates whether the drive power bridge is enabled or disabled.**

Status LED	
State	**Description**
GREEN	Power output bridge is enabled
RED	Power output bridge is disabled (via inhibit or fault)

4.1.7 STO (Safe Torque Off)

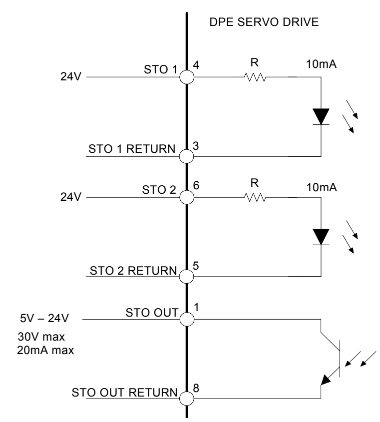
Some models of the DPE drive family feature an external dedicated +24VDC STO safety function designed to monitor an external 24V STO input from the user system and disable the motor output during an STO event. The STO circuit uses +24VDC sinking single-ended isolated inputs for STO functionality. Both STO1 and STO2 must be active (HIGH) to allow torque output at the drive motor outputs.

TABLE 4.7 STO Signal Behavior

STO 1	STO 2	Motor Outputs	STO OUT
Active (HIGH)	Active (HIGH)	Enabled	Open
Active (HIGH)	Not Active (LOW)	Disabled	Closed
Not Active (LOW)	Active (HIGH)	Disabled	Closed
Not Active (LOW)	Not Active (LOW)	Disabled	Closed

The STO circuitry also features an STO status output (STO OUT) that signifies when an STO condition has occurred. This status is also viewable in the setup software as an indicator only. The STO OUT output functions as a switch. When an STO event occurs, the STO OUT switch becomes CLOSED. When the drive is in normal functional operation (STO 1 and STO 2 = 24V), the STO OUT switch is OPEN.

FIGURE 4.18 STO Connections



See the drive datasheet for a drawing and description of the physical STO connector and mating hardware. Functional Safety is TÜV Rheinland certified and meets requirements of the following standards:

- **EN ISO 13849-1 -- Category 4 / PL e**
- **EN IEC 61800-5-2 -- STO (SIL 3)**
- **EN 62061 -- SIL CL3**
- **IEC 61508 -- SIL 3**

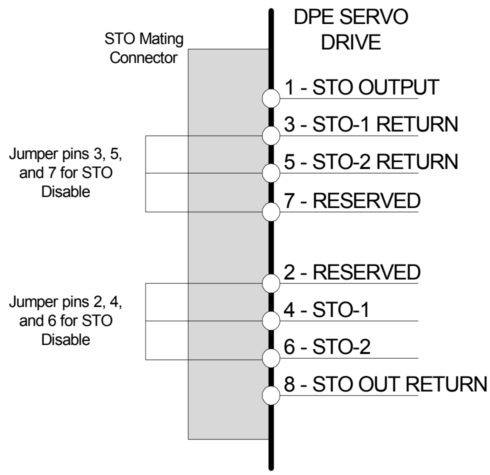
The user must verify proper operation of the monitoring circuit (STO 1 and STO 2) at least once per month to maintain SIL 3, Cat 4 / PL e certification. The monitoring circuit is required to be examined by an external logic element when STO is incorporated into a complete drive system in order for proper diagnostics to be fully implemented and utilized in the FMEA calculation (see "STO Operation Test" on page 43). The calculation of the safety relevant parameters are based on a proof test interval of one year and have shown that the requirements of up to SIL 3 are fulfilled. The safety relevant parameters are:

- **Safe-Failure-Fraction: SFF = 97%**
- **Probability of a dangerous failure per hour: PFH = 1.3 x 10 1/h**
- **Average probability of a dangerous failure on demand (1 year): PFD = 1.7 x 10**

Note: The above assessment and safety values defined were assessed with the STO function incorporated into the DigiFlex Performance DPE drive family. Product data for the DPE drive family can be found by visiting www.a-m-c.com.

STO Disable **For applications that do not require Safe Torque Off functionality, disabling of the STO feature is required for proper drive operation. A dedicated STO Disable Key connector is available for purchase and must be installed for applications where STO is not in use. Contact the factory for ordering information. Altenatively, STO may be disabled by installing the included mating connector for the STO connector, and wiring the designated pins together as given below in figure.**

FIGURE 4.19 STO Disable Connections



STO Operation Test **To maintain SIL 3, Cat 4 / PL e certification, the operation of the STO monitoring circuit (STO1 and STO2) must be verified at least once per month. The following procedure provides an example of a method to verify correct STO functionality. Note that it is the responsibily of the system operator to ensure all personal and machine safety requirements for the system are properly enforced during the proof test.**

1. **Power on the drive.**
2. **Verify the drive is in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
3. **Remove the voltage signal from the STO1 input pin via a digital controller signal, network command, or by physically removing the STO Connector if safe to do so.**
4. **Verify that the drive is in a Disabled state (by viewing the Status LED is RED, or by verifying the STO OUT switch has closed).**
5. **Re-apply the voltage signal to the STO1 pin. Verify that the drive is once again in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).**
6. **Repeat the above steps for the STO2 signal.**

Note

End-product certification may require a different interval test schedule or test requirements. It is the responsibility of the end-user to determine the required test interval and requirements for certifications other than stated above.

4.1.8 External Shunt Resistor Connections

Most AC powered DPE drives allow the option of connecting an external shunt resistor to protect against damage that may occur due to over-voltage. Drives that do not include an internal shunt resistor require an external shunt resistor for the internal shunt regulator to operate. The figures below show how an external shunt resistor should be connected to the drive for the different AC Power Modules. The internal shunt regulator must be enabled and configured in DriveWare in order to operate..

FIGURE 4.20 C060A400 Power Module External Shunt Resistor Connection

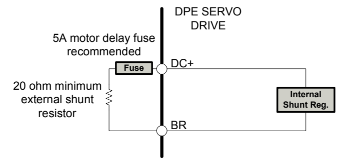


FIGURE 4.21 C100A400 Power Module External Shunt Resistor Connection

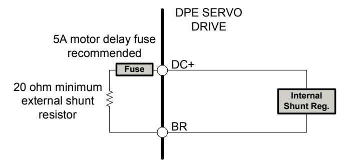


FIGURE 4.22 030A800 Power Module External Shunt Resistor Connection

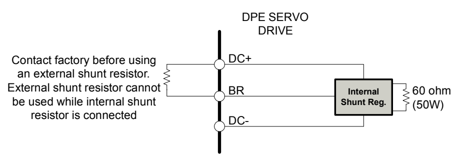
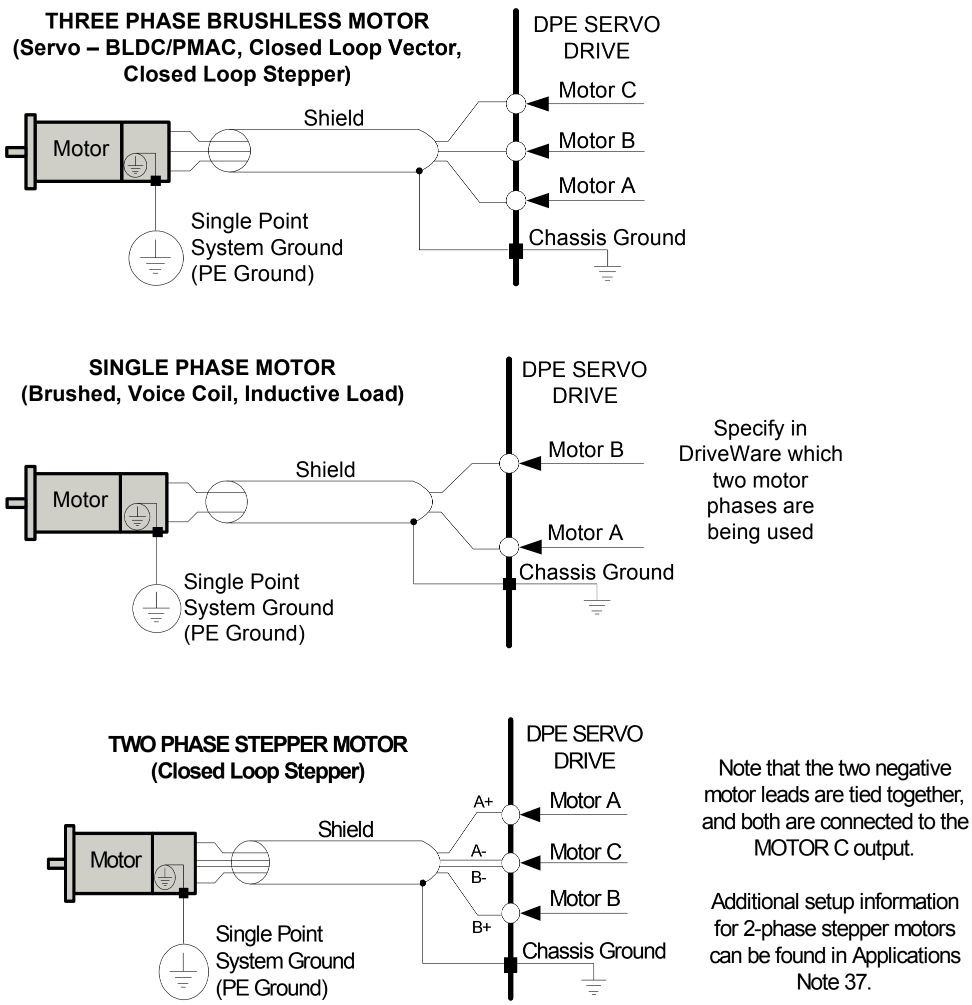


FIGURE 4.23 015S400, 040A400 and 060A800 Power Module External Shunt Resistor Connections

4.1.9 Motor Connections

The diagrams below show how a DPE drive connects to various motor types. Notice that the motor wires are shielded, and that the motor housing is grounded to the single point system ground (PE Ground). The cable shield should be grounded at the drive side to chassis ground.

FIGURE 4.24 Motor Power Output Wiring



Caution

If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

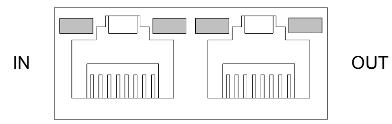
Caution

For applications using stepper motors, the maximum motor speed will be limited (typically ~600 RPM max).

4.1.10 Communication and Commissioning

DPE drives include an EtherCAT interface for networking and a USB interface for drive configuration and setup. A dual RJ-45 socket connector accepts standard CAT 5e or CAT 6 ethernetcables for the EtherCAT network connections.

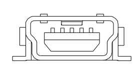
FIGURE 4.25 EtherCAT Connectors



Dual RJ-45 EtherCAT Communication Connector

For drive commissioning, the DPE drive must be connected to a PC running ADVANCED Motion Controls DriveWare software. The mini type-b USB port on the DPE drive should be used with a STD-A to MINI-B USB cable for connection to a USB port on a PC.

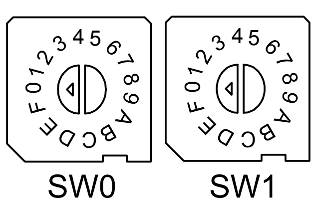
FIGURE 4.26 USB Connectors



MINI TYPE-B USB Connector

EtherCAT Station Alias DPE drives include two hexadecimal switches to assign the EtherCAT Station Alias. Note that drives on an EtherCAT network will be given an address automatically based on proximity to the host. Setting the switches manually is optional, and only necessary if a fixed address is required. Figure 4.27 shows the hexadecimal switch settings and the corresponding node ID.

FIGURE 4.27 EtherCAT Station Alias Hexadecimal Switches



SW1	SW0	Node ID
0	0	Address stored in NVM
0	1	001
0	2	002
...	...	...
F	D	253
F	E	254
F	F	255

EtherCAT Communication LEDs Functionality The LINK/ACT, STATUS, and ERROR LEDs on the dual RJ-45 communication connector provide EtherCAT network status. Figure 4.28 shows the EtherCAT LED Locations, and Table 4.8 below describes typical LED functionality.

FIGURE 4.28 EtherCAT LED Locations

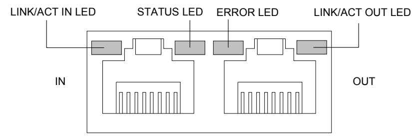


TABLE 4.8 EtherCAT Communication LEDs Function Protocol

LINK/ACT LED	
LED State	**Description**
Green - On	Valid Link - No Activity
Green - Flickering	Valid Link - Network Activity
Off	Invalid Link

STATUS LED	
LED State	**Description**
Green - On	The device is in the state OPERATIONAL
Green - Blinking (2.5Hz - 200ms on and 200ms off)	The device is in the state PRE-OPERATIONAL
Green - Single Flash (200ms flash followed by 1000ms off)	The device is in state SAFE-OPERATIONAL
Green - Flickering (10Hz - 50ms on and 50ms off)	The device is booting and has not yet entered the INIT state or The device is in state BOOTSTRAP or Firmware download operation in progress
Off	The device is in state INIT

ERROR LED		
LED State	**Description**	**Example**
Red - On	A PDI Watchdog Timeout has occurred.	Application controller is not responding anymore.
Red - Blinking (2.5Hz - 200ms on and 200ms off)	General Configuration Error.	State change commanded by master is impossible due to register or object settings.
Red - Flickering (10Hz - 50ms on and 50ms off)	Booting Error was detected. INIT state reached, but parameter "Change" in the AL status register is set to 0x01:change/error.	Checksum Error in Flash Memory.
Red - Single Flash (200ms flash followed by 1000ms off)	The slave device application has changed the EtherCAT state autonomously; Parameter "Change" in the AL status register is set to 0x01:change/error.	Synchronization error; device enters SAFE-OPERATIONAL automatically
Red - Double Flash (Two 200ms flashes separated by 200ms off, followed by 1000ms off)	An Application Watchdog Timeout has occurred.	Sync Manager Watchdog Timeout.

4.1.11 Commutation

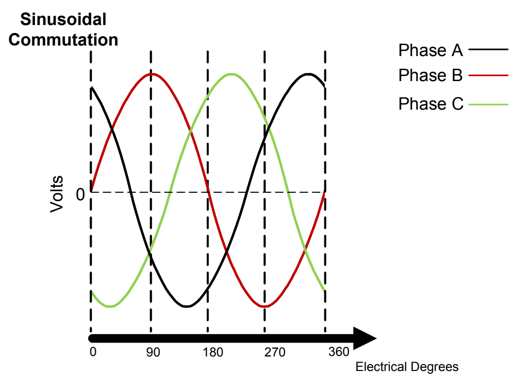
Motor commutation is the process that maintains an optimal angle between the magnetic field created by the permanent magnets in the motor and the electromagnetic field created by the currents running through the motor windings. This process ensures optimal torque or force generation at any motor position. Single phase (brushed) motors accomplish this process with internal commutators built into the motor housing. Three phase (brushless) motors require a correctly configured drive to commutate properly, however.

See the DriveWare Software Guide for more information on AutoCommutation, Manual Commutation, and Phase Detect. DPE drives allow either sinusoidal or trapezoidal commutation.

Sinusoidal Commutation

Sinusoidal commutation provides greater performance and efficiency than trapezoidal commutation. DPE drives can commutate sinusoidally when connected to a motor-mounted encoder. Sinusoidal Commutation works by supplying current to each of the three motor phases smoothly in a sinusoidal pattern. The flow of current through each phase is shifted by 120 degrees. The sum of the current flowing through all three phases adds up to zero. Figure 4.29 shows one electrical cycle of the motor phase currents.

FIGURE 4.29 Sinusoidal Commutation Motor Phase Currents



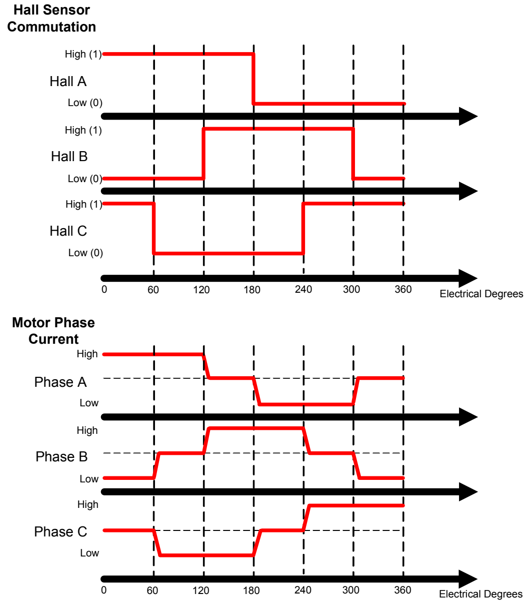
Trapezoidal Commutation

Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DPE drives can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at a time with trapezoidal commutation. The Hall Sensors each generate a square wave with a certain phase difference (either 120- or 60-degrees) over one electrical cycle of the motor. This results in six distinct Hall states for each electrical cycle. Depending on the motor pole count, there may be more than one electrical cycle per motor revolution. The number of electrical cycles in one motor revolution is equal to the number of motor poles divided by 2. For example:

- a 6-pole motor contains 3 electrical cycles per motor revolution
- a 4-pole motor contains 2 electrical cycles per motor revolution
- a 2-pole motor contains 1 electrical cycle per motor revolution

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 4.30.

FIGURE 4.30 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing



Note: Not all *ADVANCED* Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

Table 4.9 shows the default commutation states for 120-degree and 60-degree phasing. Depending on the specific setup, the sequences may change after running Auto Commutation.

TABLE 4.9 Digital Drive Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

4.1.12 Homing

DPE drives can be configured in DriveWare to "home" to a certain reference signal. This reference signal can be any number of different signal types, such as limit switches, home switches, or encoder index pulses. See the DriveWare Software Guide for more information on Homing.

4.1.13 Firmware

DPE drives are shipped with the latest version of firmware already stored in the drive. Periodic firmware updates are posted on *ADVANCED* Motion Controls' website, www.a-m-c.com. See the DriveWare Software Guide for information on how to check the drive's firmware version, and how to download new firmware into the drive when necessary.

A Specifications

A.1 Specifications Tables

TABLE A.1 Power Specifications - AC Power Modules

Description	Units	Power Specifications 015S400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	528	528
AC Input Phases	-	1	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	20 (20)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[1]	W	2415	6441	9662	16103	6830	13650
Max. Continuous Power Dissipation @ Rated Voltage	W	127	339	509	848	360	720
Internal Bus Capacitance	∝F	540	660	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance	Ω	25	25	20	20	note 2	40
Minimum Load Inductance (Line-To-Line)	∝H	600	600	600	600	3000	3000

1. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
2. Contact factory before using an external shunt resistor with this power module

TABLE A.2 Power Specifications - DC Power Modules

Description	Units	Power Specifications 020B080	100B080
DC Supply Voltage Range	VDC	20-80	20-80
DC Bus Over Voltage Limit	VDC	88	88
DC Bus Under Voltage Limit	VDC	17	17
Maximum Peak Output Current	A (Arms)	20 (14.1)	100 (70.73)
Maximum Continuous Output Current	A (Arms)	10 (10)	60 (60)
Max. Continuous Output Power @ Rated Voltage[1]	W	760	4560
Max. Continuous Power Dissipation @ Rated Voltage	W	40	240
Internal Bus Capacitance	∝F	33	500
PWM Switching Frequency	kHz	20	20
Minimum Load Inductance (Line-To-Line)	∝H	600	250

TABLE A.3 Control Specifications

Description	DPEANIU
Network Communication	EtherCAT (USB for Configuration)
Command Sources	± 10V Analog, Over the Network, Encoder Following, Sequencing, Indexing, Jogging
Commutation Methods	Sinusoidal, Trapezoidal
Control Modes	Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage
Programmable Digital I/O	11/7
Programmable Analog I/O	2/0
Primary I/O Logic Level	24 VDC

TABLE A.4 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Mechanical Shock	15g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m
Baseplate Maximum Allowable Temperature	0 - 75 °C

TABLE A.5 Feedback Specifications

Feedback Specifications	
Parameter	**Value**
Maximum Incremental Encoder Input Frequency	20MHz (5 pre-quadrature)
Maximum Sin/Cos Encoder Input Frequency	200kHz
Maximum Hall Sensor Input Frequency	0.15 x PWM Switching Frequency
Maximum Tachometer Voltage	±10VDC

TABLE A.6 24 VDC Digital I/O Specifications

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

24VDC Isolated Digital Output	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA sinking, 8mA sourcing

B Troubleshooting

This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

B.1 Fault Conditions and Symptoms

A fault condition can either be caused by a system parameter in excess of software or hardware limits, or by an event that has been user-configured to disable the drive upon occurrence.

To determine whether the drive is in a fault state, use the Drive Status function in DriveWare to view active and history event items and drive fault conditions. See the DriveWare Software Guide for more information on reading the Drive Status window. Some common fault conditions caused by hardware issues are listed below.

Over-Temperature Verify that the baseplate temperature is less than the drive Baseplate Temperature value. The drive remains disabled until the temperature at the drive baseplate falls below this threshold. See "Ambient Temperature Range and Thermal Data" on page 17 or consult the drive datasheet for the allowable temperature range.

Over-Voltage Shutdown

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Power Supply Specifications" on page 16 for more information.

Under-Voltage Shutdown Verify power supply voltage for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply cannot provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing, power ground, and also phase-to-phase. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

Invalid Hall Sensor State

See the “Commutation Sequence” table in “Commutation” on page 48 for valid commutation states. If the drive is disabled check the following:

1. Check the voltage levels for all the Hall sensor inputs.
2. Make sure all Hall Sensor lines are connected properly.

B.1.1 Software Limits

Because DriveWare allows user configuration of many system parameters such as current, velocity, and position limits, as well as an associated "event action" for DriveWare to take when the system reaches this limit, it is possible for a drive to appear to be inoperative when in actuality it is simply in an assigned disable state.

For example, the motor velocity can be limited by giving a value to the Motor Over Speed selection in DriveWare. An "event action", such as "Disable the Power Bridge", can also be assigned for this particular limiting event for DriveWare to take if the motor reaches this speed. If the motor does happen to reach this velocity limit, DriveWare will automatically cut power to the drive’s output in this particular case, and the drive will be disabled. In the Drive Status window, "Motor Over Speed" will be shown as a "history" event, and "Commanded Disable" will be shown as an "Action" event.

Depending on each specific system and application, there are many different options available for assigning system limits and associated actions. See the DriveWare Software Guide for more information.

B.1.2 Connection Problems

Connection problems are oftentimes caused by incorrect communication settings in DriveWare. Check all communications settings to be sure that the settings assigned in DriveWare are correct.

Faulty connection cables are also a possible cause of connection problems. Check all cables for any shorts or intermittent connections. Also check that all port hardware is properly installed and configured.

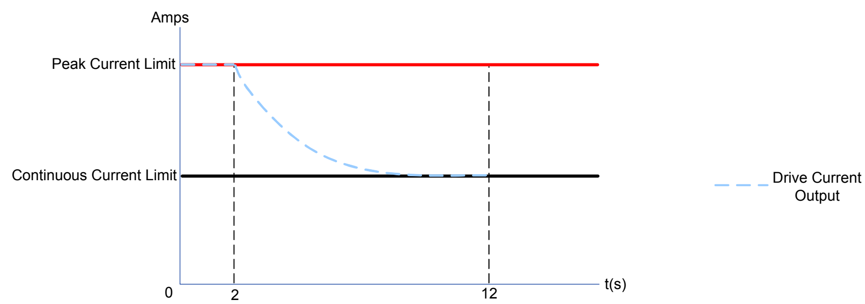
B.1.3 Overload

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip. Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive datasheets for minimum inductance requirements.

B.1.4 Current Limiting

All drives incorporate a “fold-back” circuit for protection against over-current. This “fold-back” circuit uses an approximate “I t” algorithm to protect the drive. All drives can run at peak current for a maximum of 2 seconds (each direction). Currents below this peak current but above the continuous current can be sustained for a longer time period, and the drive will automatically fold back at an approximate rate of "I t" to the continuous current limit within a time frame of less than 10 seconds. An over-current condition will not cause the drive to become disabled unless configured to do so in DriveWare.

FIGURE B.1 Peak Current Fold-Back



B.1.5 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, or by using DriveWare to reverse the internal velocity feedback polarity setting.

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper motor commutation or poor loop tuning. Follow the steps in the DriveWare Software Guide to properly commutate and tune the motor.

B.1.6 Causes of Erratic Operation

- Improper grounding (i.e., drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive voltage spikes on bus.

B.2 Technical Support

For help from the manufacturer regarding drive set-up or operating problems, please gather the following information:

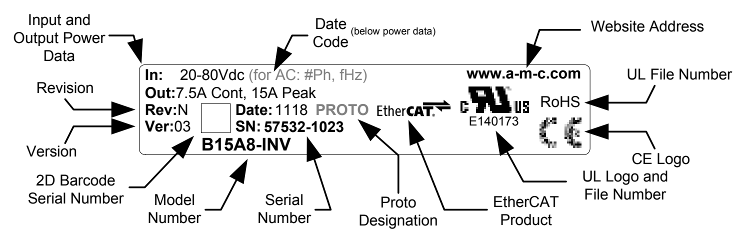
B.2.1 Drive Model Information

- DC bus voltage and range.
- Motor type, including inductance, torque constant, and winding resistance.
- Length and make-up of all wiring and cables.
- If brushless, include Hall sensor information.
- Type of controller, plus full description of feed back devices.
- Description of problem: instability, run-away, noise, over/under shoot, etc.
- Complete part number and serial number of the product. Original purchase order is helpful, but not necessary.

B.2.2 Product Label Description

The following is a typical example of a product label as it is found on the drive:

FIGURE B.2 Product Label



1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with the same model number and revision letter ('01' is the earliest release of any revision).
4. Proto Designation: When included, indicates that the model is a prototype unit and model number will also begin with an 'X' designator.
5. Serial Number: The serial number consists of a 5-digit lot number followed by a 4-digit sequence number. Each product is assigned a unique serial number to track product life cycle history.
6. Date Code: The date code is a 4-digit number signifying the year and week of manufacture. The first two digits designate the year and the second two digits designate the week (e.g. the drive label shown would have been built in the year 2011 during the 18th week).
7. Input and Output Power Data: Includes basic power parameters of the product.
8. General Information: Displays applicable agency approvals, UL file reference number, compliance approvals, and EtherCAT capability. More complete product information is availabe by following the listed website.

B.2.3 Warranty Returns and Factory Help

Seller warrants that all items will be delivered free from defects in material and workmanship and in conformance with contractual requirements. The Seller makes no other warranties, express or implied and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Seller's exclusive liability for breach of warranty shall be limited to repairing or replacing at the Seller's option items returned to Seller's plant at Buyer's expense within one year of the date of delivery. The Seller's liability on any claim of any kind, including negligence, for loss or damage arising out of, connected with or resulting from this order, or from the performance or breach thereof or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under this order shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim and in the event Seller fails to manufacture or deliver items other than standard products that appear in Seller's catalog. Seller's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. IN NO EVENT SHALL THE SELLER BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Buyer will take all appropriate measures to advise users and operators of the products delivered hereunder of all potential dangers to persons or property, which may be occasioned by such use. Buyer will indemnify and hold Seller harmless from all claims of any kind for injuries to persons and property arising from use of the products delivered hereunder. Buyer will, at its sole cost, carry liability insurance adequate to protect Buyer and Seller against such claims.

All returns (warranty or non-warranty) require that you first obtain a Return Material Authorization (RMA) number from the factory.

Request an RMA number by:

web	www.a-m-c.com/download/form/form_rma.html
telephone	(805) 389-1935
fax	(805) 389-1165

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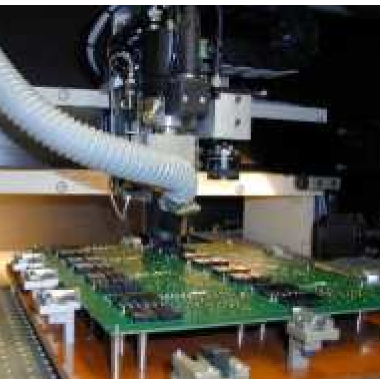
DPE Digital Drives

Hardware Installation Manual

MNDGDEIN-09

3805 Calle Tecate • Camarillo, CA 93012-5068

Tel: (805) 389-1935 Fax: (805) 389-1165 www.a-m-c.com




Everything's possible.

DigiFlex® Performance™ DPC Drives

CANopen Communication

Hardware Installation Manual

www.a-m-c.com

MNDGDCIN-11

Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the most recent software, the latest revisions of this manual, and copies of compliance and declarations of conformity, visit the company's website at ***www.a-m-c.com***. Otherwise, contact the company directly at:

ADVANCED Motion Controls 3805 Calle Tecate Camarillo, CA 93012-5068 USA

Agency Compliances

The company holds original documents for the following:

- UL 508c, file number E140173
- Electromagnetic Compatibility, EMC Directive - 2014/30/EU
  EN61000-6-2:2005
  EN61000-6-4:2007/A1:2011
  Electrical Safety, Low Voltage Directive - 2014/35/EU
  EN 60204-1:2006/A1:2009
- Reduction of Hazardous Substances (RoHS III), 2015/863/EU
- Functional Safety Type Approved, TUV Rheinland

Trademarks

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Related Documentation

- Product datasheet specific for your drive, available for download at www.a-m-c.com
- DriveWare Software Guide, available for download at www.a-m-c.com
- CANopen Communication Manual, available for download at www.a-m-c.com

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.

Note	**Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.**
Notice	**Notice - Required instruction necessary to ensure successful completion of a task or procedure.**
Caution	**Caution - Instructs and directs you to avoid damaging equipment.**
Warning	**Warning - Instructs and directs you to avoid harming yourself.**
DANGER	**Danger - Presents information you must heed to avoid serious injury or death.**

Revision History

Document ID	Revision #	Date	Changes
MNDGDCIN-01	1	6/2009	DPC Install Manual First Release
MNDGDCIN-02	2	3/2011	- Added DPCxxxx-015S400 Drive Model Information
MNDGDCIN-03	3	9/2012	- Updated for DriveWare 7 information - Updated for RMS Charge-Based Limiting capabilities
MNDGDCIN-04	4	10/2013	- Added DPCxxxx-C060A400 and DPCxxxx-C100A400 Drive Model Information
MNDGDCIN-05	5	10/2014	- Added STO wiring diagram
MNDGDCIN-06	6	1/2016	- Removed DPCxxxx-015A400 Drive Model Information (reserved)
MNDGDCIN-07	7	9/2016	- Added DPCxxxx-040A400 Drive Model Information
MNDGDCIN-08	8	5/2017	- Removed DPCANIR Drive Model Information
MNDGDCIN-09	9	11/2017	- Added DPCxxxx-100B080 Drive Model Information
MNDGDCIN-10	10	5/2018	- Added 2-Phase Stepper Motor Information - Added PDO power-up delay information
MNDGDCIN-11	11	03/2024	Removed DPCANTA Models

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3 Integration in the Servo System 25

4 Operation and Features 37

1 Safety

This section discusses characteristics of your DPC Digital Drive to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

1.1 General Safety Overview

In order to install a DPC drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Caution

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Notice

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.

Warning

Keep clear of all exposed power terminals (motor, DC Bus, shunt, DC power, transformer) when power is applied to the equipment. Follow these safety guidelines:

- **When using a separate logic supply, turn on the logic power supply first before turning on the main power supply.**
- **Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.**
- **Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative.**
- **Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.**
- **Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.**
- **Do not make any connections to the drive while power is applied.**

Caution

- **Do not reverse the power supply leads! Severe damage will result!**
- **If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.**

Caution

Use sufficient capacitance!

Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Caution

Make sure minimum inductance requirements are met!

Pulse Width Modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 H.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2 Products and System Requirements

This document is intended as a guide and general overview in selecting, installing, and operating ADVANCED Motion Controls DigiFlex Performance™ digital servo drives that use CANopen for networking. These specific drives are referred to herein and within the product literature as DPC drives. Other drives in the DigiFlex Performance product family that utilize other methods of network communication such as EtherCAT, POWERLINK, Modbus, Ethernet, or RS-485 are discussed in separate manuals that are available at www.a-m-c.com. Contained within each DigiFlex Performance product family manual are instructions on system integration, wiring, drive-setup, and standard operating methods.

2.1 DPC Drive Family Overview

The DPC drive family can power three phase or single phase brushless or brushed servomotors, two phase or three phase closed loop stepper motors, and closed loop vector AC induction motors. The command source can be generated externally or can be supplied internally. A digital controller can be used to command and interact with DPC drives, and a number of dedicated and programmable digital and analog input/output pins are available for parameter observation and drive configuration. DPC drives are capable of operating in current (torque), velocity, or position modes, and utilize Space Vector Modulation, which results in higher bus voltage utilization and reduced heat dissipation compared to traditional PWM. DPC drives also offer a variety of feedback options.

DPC drives offer CANopen communication for multiple drive networking, and feature an RS-232 serial communication interface for drive configuration and setup. Drive commissioning is accomplished using DriveWare 7, the setup software from ADVANCED Motion Controls, available for download at www.a-m-c.com.

2.1.1 Drive Datasheet

Each DPC digital drive has a separate datasheet that contains important information on the options and product-specific features available with that particular drive. The datasheet is to be used in conjunction with this manual for system design and installation.

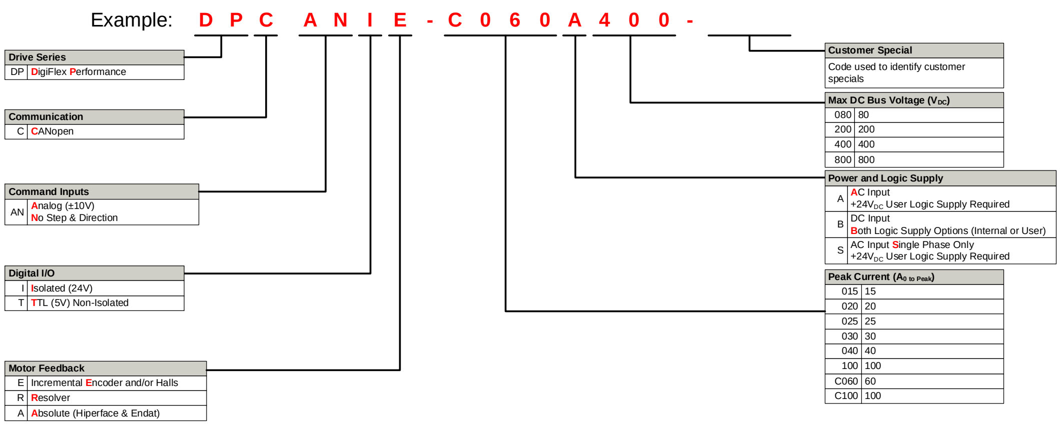
Caution

In order to avoid damage to equipment, only after a thorough reading and understanding of this manual and the specific datasheet of the DPC drive being used should you attempt to install and operate the drive.

2.2 Products Covered

The products covered in this manual adhere to the following part numbering structure. However, additional features and/or options are readily available for OEM's with sufficient ordering volume. Feel free to contact ADVANCED Motion Controls for further information.

FIGURE 2.1 DPC Part Numbering Structure*



* Note that not all possible part number combinations are offered as standard drives. For a list of standard drives, see Table 2.1 and Table 2.2.

When selecting a DPC drive, follow the part structure above to determine the Digital I/O, Motor Feedback, and Power Module choices that are applicable for the end application. The tables below outline the features and specifications that are available for standard DPC drive models.

TABLE 2.1 AC Drive Models

Drive Number	VAC (Nominal)	Peak Current (A) (Arms)	Cont. Current (A) (Arms)
DPCANIA-015S400	100-240	15 (10.6)	7.5 (7.5)
DPCANIA-030A400	100-240	30 (21.2)	15 (15)
DPCANIA-040A400	100-240	40 (28.3)	20 (20)
DPCANIA-C060A400	200-240	60 (42.4)	30 (30)
DPCANIA-C100A400	200-240	100 (70.7)	50 (100)
DPCANIA-030A800	200-480	30 (21.2)	15 (10.6)
DPCANIA-060A800	200-480	60 (42.4)	30 (21.2)
DPCANIE-015S400	100-240	15 (10.6)	7.5 (5.3)
DPCANIE-030A400	100-240	30 (21.2)	15 (10.6)
DPCANIE-040A400	100-240	40 (28.3)	20 (20)
DPCANIE-C060A400	200-240	60 (42.4)	30 (30)
DPCANIE-C100A400	200-240	100 (70.7)	50 (100)
DPCANIE-030A800	200-480	30 (21.2)	15 (10.6)
DPCANIE-060A800	200-480	60 (42.4)	30 (21.2)

TABLE 2.2 DC Drive Models

Drive Number	VDC (Nominal)	Peak Current (A) (Arms)	Cont. Current (A) (Arms)
DPCANIA-100B080	20-80	100 (70.7)	60 (60)
DPCANIE-100B080	20-80	100 (70.7)	60 (60)
DPCANTE-020B080	20-80	20 (14.1)	10 (10)
DPCANTE-040B080	20-80	40 (28.3)	20 (20)
DPCANTE-060B080	20-80	60 (42.4)	30 (30)
DPCANTE-015B200	40-190	15 (10.6)	7.5 (7.5)
DPCANTE-025B200	20-190	25 (17.7)	12.5 (12.5)
DPCANTR-020B080	20-80	20 (14.1)	10 (10)
DPCANTR-040B080	20-80	40 (28.3)	20 (20)
DPCANTR-060B080	20-80	60 (42.4)	30 (30)
DPCANTR-015B200	40-190	15 (10.6)	7.5 (7.5)
DPCANTR-025B200	20-190	25 (17.7)	12.5 (12.5)

TABLE 2.3 Control Specifications

Description	DPCANIx	DPCANTx
Network Communication	CANopen (RS-232 for Configuration)	
Command Sources	PWM & Direction, ± 10V Analog, Over the Network, Encoder Following, Sequencing, Indexing, Jogging	
Commutation Methods	Sinusoidal, Trapezoidal	
Control Modes	Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position, Interpolated Position Mode (PVT)	
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)	
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage	
Programmable Digital I/O	10 Inputs, 4 Outputs	8 Inputs, 4 Outputs
Programmable Analog I/O	4 Inputs, 1 Output	3 Inputs, 2 Output
Primary I/O Logic Level	24 VDC	5V TTL

TABLE 2.4 Feedback Options

Description	DPCANIA	DPCANxE	DPCANTR
Hall Sensors			
Incremental Encoder			
Auxiliary Incremental Encoder			
Resolver			
Absolute Encoder (Hiperface®, EnDat®)			
1Vp-p Sine/Cosine Encoder			
±10 VDC Position			
Tachometer (±10 VDC)			

TABLE 2.5 Power Specifications - AC Input DPC Drives

Description	Units	015S400	030A400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	264	528	528
AC Input Phases[1]	-	1	3	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	429	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	30 (21.2)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	15 (15)	20 (14.1)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[2]	W	2415	4831	6441	9662	16103	6840	13680
Internal Bus Capacitance	F	540	1410	339	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance		25	20	25	20	20	note 3	40
Minimum Load Inductance (Line-To-Line)	H	600	600	600	600	600	3000	3000

1. Certain 3-phase drive models can operate on single-phase VAC if peak/cont. current ratings are reduced by at least 30%.
2. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
3. Contact factory before using an external shunt resistor with this power module

TABLE 2.6 Power Specifications - DC Input DPC Drives

Description	Units	020B080	040B080	060B080	100B080	025B200	015B200
DC Supply Voltage Range	VDC	20-80	20-80	20-80	20-80	20-190	40-190
DC Bus Over Voltage Limit	VDC	86	86	86	88	198	198
DC Bus Under Voltage Limit	VDC	17	17	17	17	17	35
Maximum Peak Output Current	A (Arms)	20 (14.1)	40 (28.3)	60 (42.4)	100 (70.7)	25 (17.7)	15 (10.6)
Maximum Continuous Output Current	A (Arms)	10 (10)	20 (20)	30 (30)	60 (60)	12.5 (12.5)	7.5 (7.5)
Max. Continuous Output Power	W	760	1520	2280	4560	2256	1354
Max. Continuous Power Dissipation	W	40	80	120	240	118	71
PWM Switching Frequency	kHz	20	20	20	20	20	20
Internal Bus Capacitance	F	33	500	500	500	50	20
Minimum Load Inductance (Line-To-Line)	H	250	250	250	250	300	250

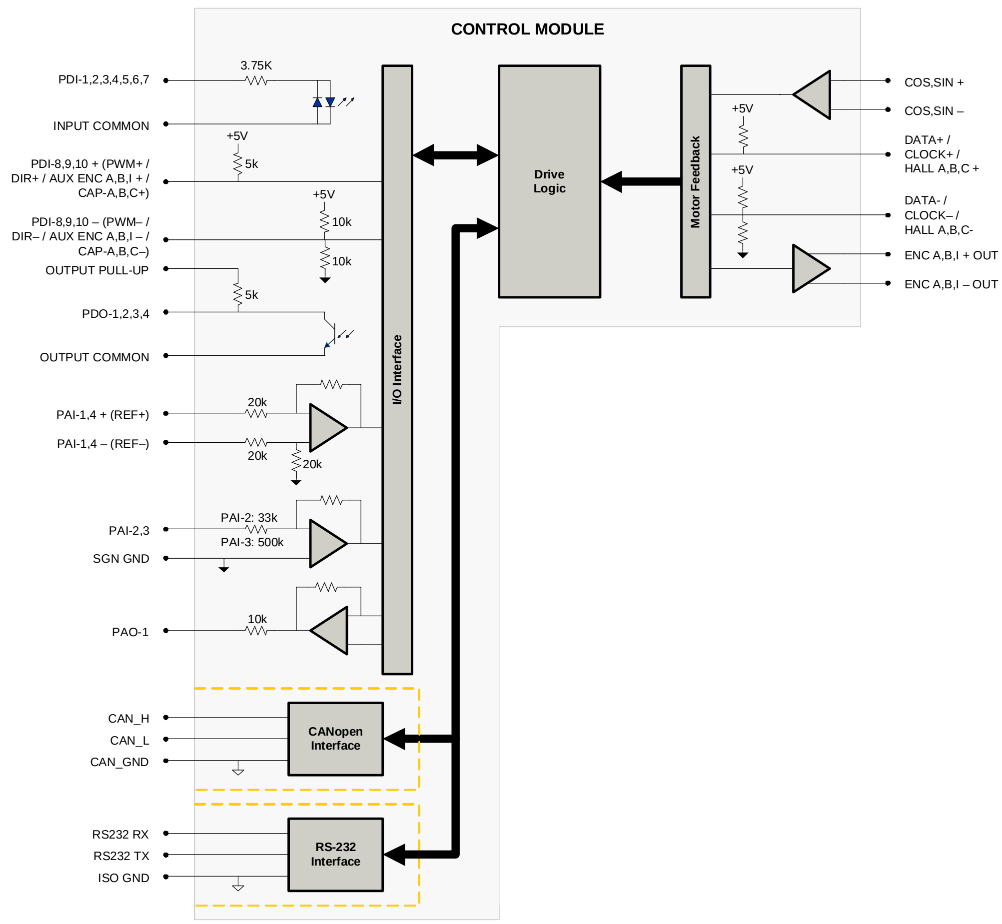
2.2.1 Control Modules

The DPC drive family consists of 6 different control modules. They are primarily differentiated by the type of feedback allowed, and the primary I/O logic level. The diagrams in this section show the general block diagrams for the different control modules. For complete pinouts, consult the specific drive's datasheet.

DPCANIA

- **CANopen Communication**
- **Absolute Encoder, 1Vp-p Sine/Cosine Encoder, Hall Sensor, Auxiliary Encoder, ±10 VDC Position, Tachometer (±10 VDC) Feedback**
- **24 VDC Primary I/O Logic Level**
- **±10 V Analog, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources**
- **10 Programmable Digital Inputs (PDIs)**
- **4 Programmable Digital Outputs (PDOs)**
- **4 Programmable Analog Inputs (PAIs)**
- **1 Programmable Analog Output (PAO)**

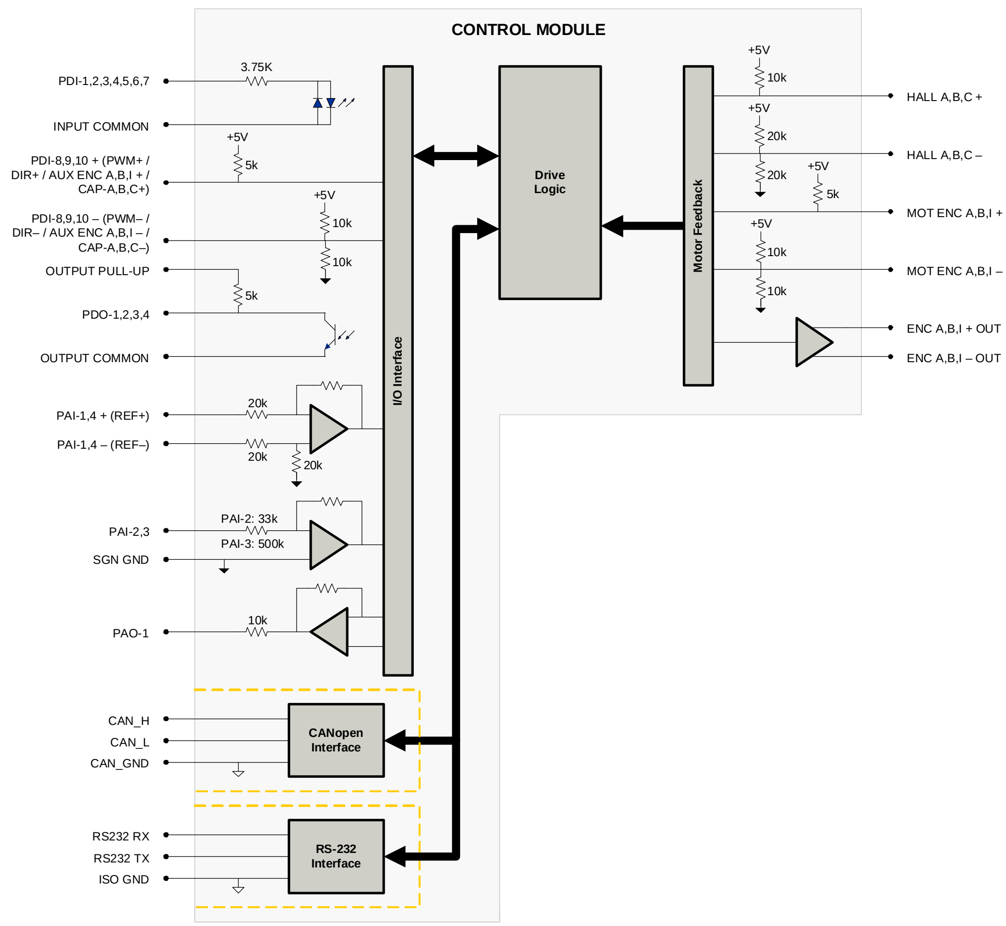
FIGURE 2.2 DPCANIA Control Module



DPCANIE

- **CANopen Communication**
- **Incremental Encoder, Hall Sensor, Auxiliary Encoder, ±10 VDC Position, Tachometer (±10 VDC) Feedback**
- **24 VDC Primary I/O Logic Level**
- **±10 V Analog, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources**
- **10 Programmable Digital Inputs (PDIs)**
- **4 Programmable Digital Outputs (PDOs)**
- **4 Programmable Analog Inputs (PAIs)**
- **1 Programmable Analog Output (PAO)**

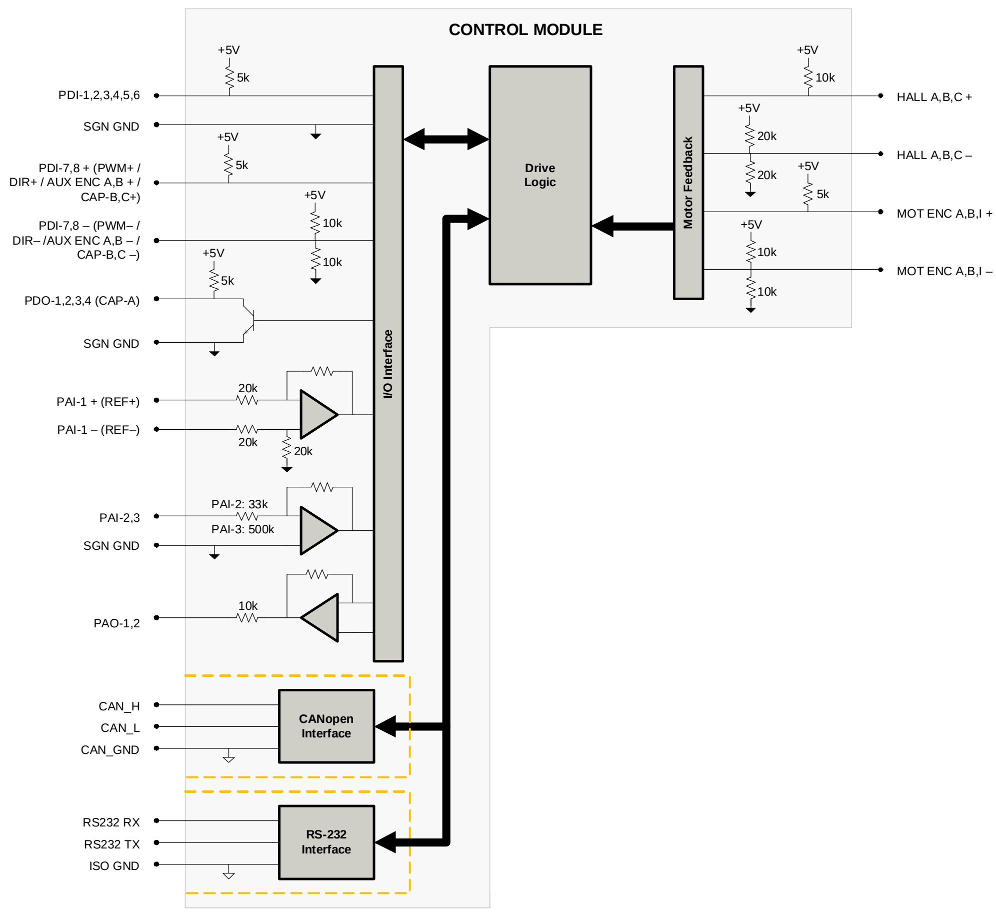
FIGURE 2.3 DPCANIE Control Module



DPCANTE

- CANopen Communication
- Incremental Encoder, Hall Sensor, Auxiliary Encoder, ±10 VDC Position, Tachometer (±10 VDC) Feedback
- 5V TTL Primary I/O Logic Level
- ±10 V Analog, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources
- 8 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 3 Programmable Analog Inputs (PAIs)
- 2 Programmable Analog Output (PAO)

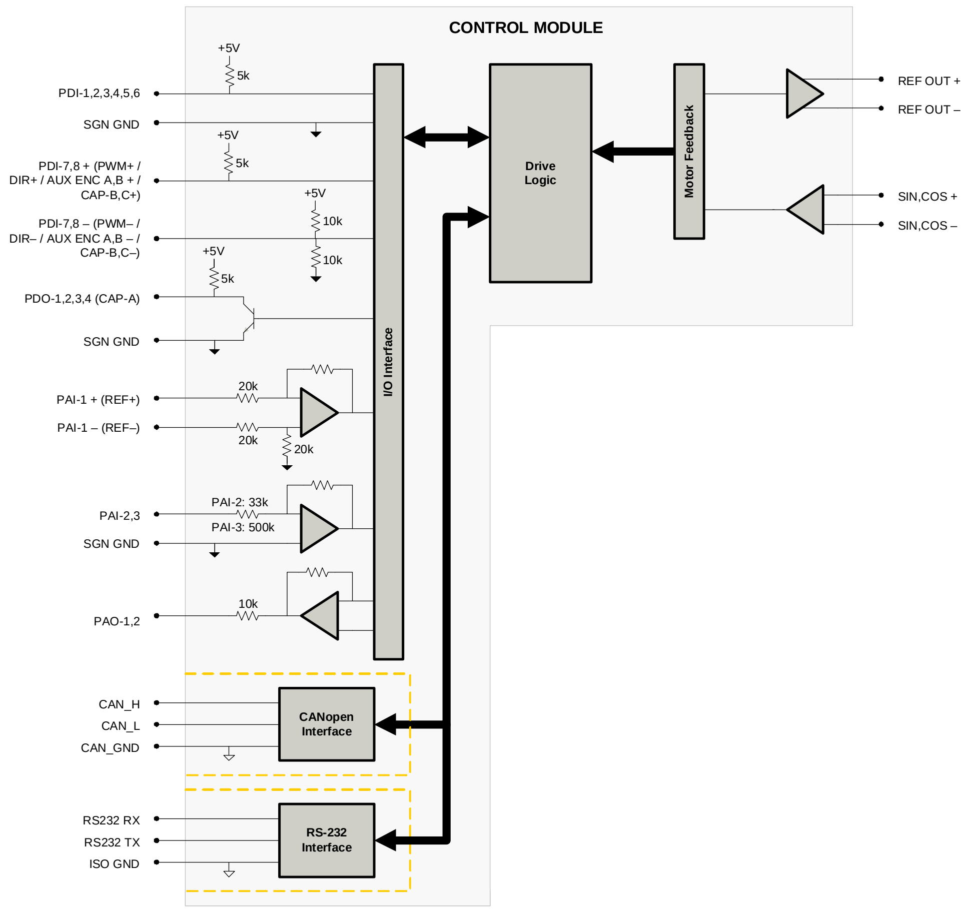
FIGURE 2.4 DPCANTE Control Module



DPCANTR

- CANopen Communication
- Resolver, Auxiliary Encoder, ±10 VDC Position, Tachometer (±10 VDC) Feedback
- 5V TTL Primary I/O Logic Level
- ±10 V Analog, Encoder Following, PWM and Direction, Sequencing, Indexing, Jogging, or Network Command Sources
- 8 Programmable Digital Inputs (PDIs)
- 4 Programmable Digital Outputs (PDOs)
- 3 Programmable Analog Inputs (PAIs)
- 2 Programmable Analog Output (PAO)

FIGURE 2.5 DPCANTR Control Module



2.2.2 AC Power Modules

There are 7 AC power modules in the DPC drive family, providing a wide variety of current output and supply voltage selections. For block diagrams and complete pinouts, consult the drive's datasheet.

015S400

- 15 Amps Peak Output Current
- 7.5 Amps Continuous Output Current
- Single-Phase 240 VAC (339 VDC) Rated Supply Voltage
- 100 - 240 VAC (127 - 373 VDC) Supply Voltage Range
- 2415 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

030A400

- 30 Amps Peak Output Current
- 15 Amps Continuous Output Current
- 240 VAC (339 VDC) Rated Supply Voltage
- 100 - 240 VAC (127 - 373 VDC) Supply Voltage Range
- 4831 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

040A400

- 40 Amps Peak Output Current
- 20 Amps Continuous Output Current
- 240 VAC (339 VDC) Rated Supply Voltage
- 100 - 240 VAC (127 - 373 VDC) Supply Voltage Range
- 6441 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

C060A400

- 60 Amps Peak Output Current
- 30 Amps Continuous Output Current
- 240 VAC (339 VDC) Rated Supply Voltage
- 200 - 240 VAC (255 - 373 VDC) Supply Voltage Range
- 9662 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

C100A400

- 100 Amps Peak Output Current
- 50 Amps Continuous Output Current
- 240 VAC (339 VDC) Rated Supply Voltage
- 200 - 240 VAC (255 - 373 VDC) Supply Voltage Range
- 16103 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

030A800

- 30 Amps Peak Output Current
- 15 Amps Continuous Output Current
- 480 VAC (678 VDC) Rated Supply Voltage
- 200 - 480 VAC (255 - 747 VDC) Supply Voltage Range
- 6840 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Resistor
- Internal Shunt Regulator
- External Shunt Resistor Connections

060A800

- 60 Amps Peak Output Current
- 30 Amps Continuous Output Current
- 480 VAC (678 VDC) Rated Supply Voltage
- 200 - 480 VAC (255 - 747 VDC) Supply Voltage Range
- 13680 W Maximum Continuous Output Power at Rated Voltage
- 20 - 30 VDC Logic Supply Voltage
- Internal Shunt Regulator
- External Shunt Resistor Connections

2.2.3 DC Power Modules

There are 5 DC power modules in the DPC drive family, each with a unique current output and supply voltage rating. For block diagams and complete pinouts, consult the drive's datasheet.

020B080

- 20 - 80 VDC Supply Voltage Range
- 20 Amps Peak Output Current
- 10 Amps Cont. Output Current
- 760 W Maximum Continuous Output Power
- 20 - 80 VDC Logic Supply Voltage (optional)

040B080

- 20 - 80 VDC Supply Voltage Range
- 40 Amps Peak Output Current
- 20 Amps Cont. Output Current
- 1520 W Maximum Continuous Output Power
- 20 - 80 VDC Logic Supply Voltage (optional)

060B080

- 20 - 80 VDC Supply Voltage Range
- 60 Amps Peak Output Current
- 30 Amps Cont. Output Current
- 2280 W Maximum Continuous Output Power
- 20 - 80 VDC Logic Supply Voltage (optional)

100B080

- 20 - 80 VDC Supply Voltage Range
- 100 Amps Peak Output Current
- 60 Amps Cont. Output Current
- 4560 W Maximum Continuous Output Power
- 20 - 80 VDC Logic Supply Voltage (optional)

025B200

- 20 - 190 VDC Supply Voltage Range
- 25 Amps Peak Output Current
- 12.5 Amps Cont. Output Current
- 2256 W Maximum Continuous Output Power
- 40 - 190 VDC Logic Supply Voltage (optional)

015B200

- 40 - 190 VDC Supply Voltage Range
- 15 Amps Peak Output Current
- 7.5 Amps Cont. Output Current
- 1354 W Maximum Continuous Output Power
- 40 - 190 VDC Logic Supply Voltage (optional)

2.3 Communication Protocol

DPC digital drives offer networking capability through the CANopen communication protocol. DPC drives include an auxiliary RS-232 serial port used for configuring the drive through DriveWare.

2.3.1 CANopen

CANopen is an open standard embedded machine control protocol that operates through the CAN communication interface on DPC digital drives. The CANopen protocol is developed for the CAN physical layer. The CAN interface for ADVANCED Motion Controls DPC drives follows the CiA (CAN in Automation) 301 communications profile and the 402 device profile. CiA is the non-profit organization that governs the CANopen standard. More information can be found at www.can-cia.org.

CAN communication works by exchanging messages between a CANopen "host" and CANopen "nodes". The messages contain information on specific drive functions, each of which is defined by a group of objects. An object is roughly equivalent to a memory location that holds a certain value. The values stored in the drive's objects are used to perform the drive functions (current loop, velocity loop, position loop, I/O functions, etc.). See "Communication and Commissioning" on page 55 for information on how to correctly setup and wire a CANopen network using DPC drives.

For more detailed information on CANopen communication and a complete list of CAN objects, consult the ADVANCED Motion Controls CANopen Communication Manual, available for download at www.a-m-c.com.

2.4 Control Modes

DPC digital drives operate in a variety of operating modes. The setup and configuration parameters for these modes are commissioned through DriveWare 7. See the ADVANCED Motion Controls CANopen Communication Manual for mode configuration information.

2.4.1 Profile Modes

In Profile Modes, the trajectory is limited by the drive, using the Command Limiter values to limit the maximum command rate. If the host sends a large command step, the drive spreads the demand over some period of time to stay equal to or below the maximum defined rate.

Profile Current (Torque) In Current (Torque) Mode, the input command voltage controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored in DriveWare through the digital oscilloscope function. DriveWare also offers configuration of maximum and continuous current limit values.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

Profile Velocity In Velocity Mode, the input command voltage controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. DPC drives allow velocity control with either Hall Sensors, an encoder, a resolver, or a tachometer as the feedback element. The motor velocity and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for velocity control must be specified in DriveWare, which also offers configuration of velocity limits. See “Feedback Supported” on page 17 for more information on feedback devices.

Profile Position In Position Mode, the input command voltage controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. DPC drives allow position control with either an encoder, a resolver, or ±10V Position feedback. The motor position and other parameters can be monitored in DriveWare through the digital oscilloscope function. The feedback element being used for position control must be specified in DriveWare, which also offers configuration of position limits. See “Feedback Supported” on page 17 for more information on feedback devices.

2.4.2 Cyclic Synchronous Modes

Cyclic Synchronous Modes give responsibility of trajectory control to the host. The drive interpolates between command points, defining the rate by dividing the change in command by the interpolation time period. This allows the drive to respond smoothly to each step in command.

Cyclic Synchronous Current In Cyclic Synchronous Current Mode, the drive closes the current loop. The host is allowed more control by having the ability to instantly add current feedforward values. This allows for gain compensation in applications with varying loads.

Cyclic Synchronous Velocity In Cyclic Synchronous Velocity Mode, the drive closes two control loops: velocity and current. The host is allowed more control by having the ability to instantly add velocity and current feedforward values. This allows for gain compensation in applications with varying loads.

Cyclic Synchronous Position In Cyclic Synchronous Position Mode, the drive closes three control loops: position, velocity, and current. The host can send target position, velocity feedforward, and current feedforward values to the drive. This allows for gain compensation in applications with varying loads.

2.4.3 Interpolated Position Mode (PVT)

Interpolated Position Mode (PVT) is typically used to stream motion data between multiple axes for coordinated motion. Arbitrary position and velocity profiles can be executed on each axis. A PVT command contains the position, velocity, and time information of the motion profile's segment end points. The drive performs a third order interpolation between segment end points, resulting in a partial trajectory generation where both host controller and drive generate a specific portion of the overall move profile trajectory. The host controller calculates position and velocity of intermittent points on the overall trajectory, while the drive interpolates between these intermittent points to ensure smooth motion. The actual position loop is closed within the drive. This reduces the amount of commands that need to be sent from host controller to drive, which is critical in distributed control systems. For more information on how to operate a DPC drive in PVT mode, consult the DriveWare Software Manual.

2.4.4 Current (Torque)

In Current (Torque) Mode, the input command controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current and other parameters can be monitored within the configuration software, or externally through network commands.

Note

While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to output a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

2.4.5 Velocity

In Velocity Mode, the input command controls the motor velocity. This mode requires the use of a feedback element to provide information to the drive about the motor velocity. The motor velocity and other parameters can be monitored within the configuration software, or externally through network commands. See "Feedback Supported" on page 17 for more information on velocity feedback devices.

2.4.6 Position

In Position Mode, the input command controls the actual motor position. This mode requires the use of a feedback element to provide information to the drive about the physical motor location. The motor position and other parameters can be monitored within the configuration software, or externally through network commands. See "Feedback Supported" on page 17 for more information on position feedback devices.

2.5 Feedback Supported

There are a number of different feedback options available in the DPC family of digital drives. The feedback element can be any device capable of generating a signal proportional to current, velocity, position, or any parameter of interest. Such signals can be provided directly by a potentiometer or indirectly by other feedback devices such as Hall Sensors or encoders. For information on the functional operation of the feedback devices, see "Feedback Operation" on page 45.

Feedback Polarity The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. The feedback element must be connected for negative feedback. Connecting the feedback element for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. The correct feedback polarity will be determined and configured during commissioning of the drive. Otherwise, to correct this, either change the order that the feedback lines are connected to the drive, or use DriveWare to reverse the internal velocity feedback polarity setting.

2.5.1 Hall Sensors

Drive models beginning with DPCANxE and DPCANxA can use single-ended Hall Sensors for commutation and/or velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. With Hall Sensors being used as the feedback element, the input command controls the motor velocity, with the Hall Sensor frequency closing the velocity loop.

Note

Hall velocity mode is not optimized for relatively high or relatively low Hall frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.

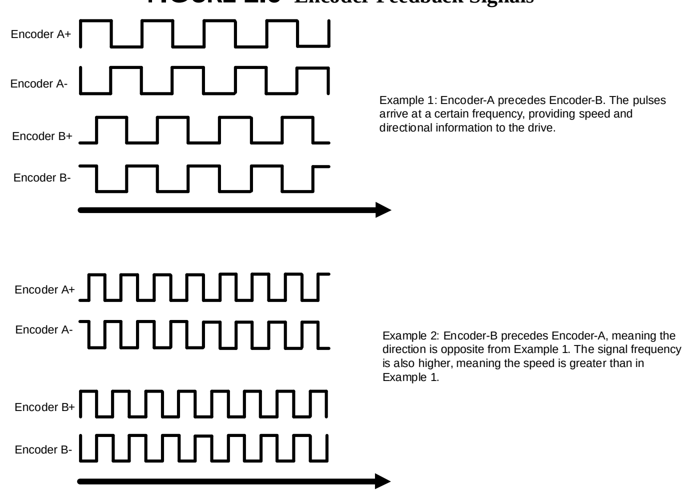
For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 57.

2.5.2 Incremental Encoder

DPCANxE drive models can utilize incremental encoder feedback for velocity or position control, with the option of also using the encoder to commutate the motor. The encoder provides incremental position feedback that can be extrapolated into very precise velocity or position information. With an encoder being used as the feedback element, the input command controls the motor velocity or motor position, with the frequency of the encoder pulses closing the velocity and/or position loop. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor's speed, position and direction of rotation. Based on the speed and order in which these pulses are received from the encoder, the drive can interpret the motor velocity and physical location. The actual motor speed and physical location can be monitored within the configuration software, or externally through network commands.

Figure 2.6 below represents differential encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated. By keeping track of the number of encoder "pulses" with respect to a known motor "home" position, DPC drives are able to ascertain the actual motor location.

FIGURE 2.6 Encoder Feedback Signals



Note

The high resolution of motor mounted encoders allows for excellent velocity and position control and smooth motion at all speeds. Encoder feedback should be used for applications requiring precise and accurate velocity and position control, and is especially useful in applications where low-speed smoothness is the objective.

2.5.3 Auxiliary Incremental Encoder

The auxiliary encoder input pins can be used as a command source for encoder following mode, or as a secondary feedback device input for closing the position loop. The particular function is configured in DriveWare.

2.5.4 Resolver

DPCANTR drives support resolver feedback for both velocity and position feedback. A resolver functions similar to a rotary transformer, in that when the resolver rotor winding is excited with an AC signal, the resolver stator windings then produce an AC voltage output that varies in amplitude according to the sine and cosine of the resolver shaft position. The AC voltage output is then read through a specialized converter as the velocity or position feedback signal. DPCANTR drives support resolvers with a carrier frequency of 5kHz, an excitation voltage of 4Vrms, and a 0.5 transformation ratio. The drive configuration software allows the user to determine the interpolation for 12-bit (high speeds) or 14-bit (high precision) resolution.

In general, resolvers are less common and more expensive than encoders, and are typically used in harsh physical environments.

Note

Resolvers using the inductive (brushless) method to couple the stator and rotor windings are very reliable in hostile industrial environments, as they are resilient to vibration and dirt and have a longer lifetime than brush type resolvers.

2.5.5 Tachometer (±10 VDC)

All DPC drives support the use of a tachometer for velocity feedback. The tachometer measures the rotary speed of the motor shaft and returns an analog voltage signal to the drive for velocity control. DPC drives provide a Programmable Analog Input on the motor Feedback Connector that is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

2.5.6 1Vp-p Sin/Cos Encoder

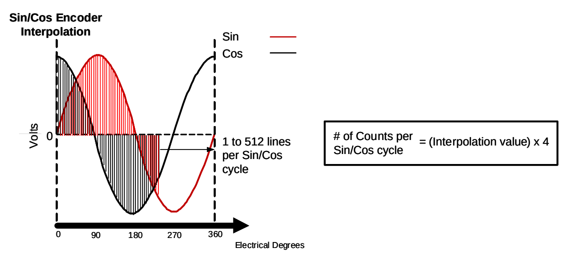
DPCANxA drives support 1Vp-p Sin/Cos encoders for position and velocity feedback. The drive breaks down the 1 Vp-p sinusoidal signals from the encoder into individual reference points (counts). The interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.7. This allows for very high interpolated encoder resolution (4-2048 counts per Sin/Cos cycle).

2.5.7 Absolute Encoder

DPCANIA drives support Hiperface® and EnDat® (2.1/2.2 command set) absolute encoders for velocity and absolute position feedback. The encoder resolution can be configured within the configuration software. The drive breaks down the signals from the encoder into individual reference points (counts). The interpolation is configurable in powers of 2 from 1 to 512 lines per Sin/Cos cycle. The quadrature number of counts per cycle is the interpolation value multiplied by 4, as shown in Figure 2.7. This allows for very high interpolated encoder resolution (4-2048 counts per Sin/Cos cycle).

Note: The absolute position feedback eliminates the need for a homing routine when the drive is powered on.

FIGURE 2.7 Sin/Cos Encoder Interpolation



2.5.8 ±10 VDC Position

DPC drives accept an analog ±10 VDC Position Feedback, typically in the form of a load-mounted potentiometer. The feedback signal must be conditioned so that the voltage does not exceed ±10 V, and is connected through the Programmable Analog Input. In DriveWare, the connection method that is used must be selected under the Position Loop Feedback options.

2.6 Command Sources

The input command source for DPC drives can be configured for one of the following options.

2.6.1 PWM and Direction

All DPCANIx drives support PWM and Direction as a command source for current, velocity, or position control. The drive can be configured for standard PWM and Direction, using two inputs, or for Single Input PWM control, using only a single input for bi-directional control. Additionally, scaling, offset and command inversion may be configured for customized control. The PWM and Direction command source supports broken wire detection for cases when the

PWM command reaches 0% or 100% duty cycle. The frequency range of the PWM and Direction command input is 1kHz - 125kHz.

2.6.2 ±10V Analog

DPC drives accept a single-ended or differential analog signal with a range of ±10 V from an external source. The input command signals should be connected to the programmable input on the I/O Signal Connector. See "Programmable Analog I/O" on page 44 for more information.

2.6.3 Encoder Following

DPC drives can utilize Encoder Following as a form of input command. In Encoder Following mode, an auxiliary encoder signal can be used to command the drive in a master/slave configuration. The gearing ratio (input counts to output counts ratio) can be configured in DriveWare by the user. Encoder Following is only a valid option when the DPC drive is operated in position mode.

2.6.4 Indexing and Sequencing

DPC drives allow configuration of up to 16 separately defined Index tasks in DriveWare. Indexes can be either Absolute (commands a pre-defined move to an absolute position) or Relative (commands a pre-defined move relative to the current position). Indexes can be combined with Homing routines and other control functions to form up to 16 different Sequences. Sequences can be configured to initiate on power-up, via a digital input, or by using an external network command.

2.6.5 Jogging

DPC drives allow configuration of two separate Jog velocities in DriveWare, commanding motion at a defined constant velocity with infinite distance.

2.6.6 Over the Network

DPC drives can utilize network communication as a form of input command through the CAN interface. In order to send commands to the drive over the CAN bus, the command source must be set to 'Communication Channel' in the Configuration window in DriveWare. For more information on commanding the drive with CANopen, see "Communication and Commissioning" on page 55.

2.7 System Requirements

To successfully incorporate a DPC digital servo drive into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance.

2.7.1 Specifications Check

Before selecting a DPC digital servo drive, a user should consider the requirements of their system. This involves calculating the voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with. Before attempting to install or operate a DPC servo drive, be sure all the following items are available:

- DPC Digital Servo Drive
- DPC Drive Datasheet (specific to your model)
- DPC Series Digital Hardware Installation Manual
- DriveWare Software Guide

2.7.2 Motor Specifications

DPC digital servo drives have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a DPC drive may be selected that will best suit the motor capabilities. Some general guidelines that are useful when pairing a DPC servo drive with a motor:

- The motor current I_M is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T -motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile. The continuous torque is the average torque required by the system during the move profile, including dwell times.

- The system voltage requirement is based on the motor properties and how fast and hard the motor is driven. The system voltage requirement is equal to the motor voltage, V_M, required to achieve the move profile.

$$V_M = K_E \; S_M + I_M \; R_M$$

Where:

K -motor back EMF constant

S -motor speed (use the maximum speed expected for the application)

- **I** -motor current (use the maximum current expected for the application)
- **R** -motor line-to-line resistance

- The motor inductance is vital to the operation of DPC servo drives, as it ensures that the DC motor current is properly filtered.

Caution

A motor that does not meet the rated minimum inductance value of the DPC drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary.

A minimum motor inductance rating for each specific DPC drive can be found in the drive datasheet. If the drive is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

2.7.3 Power Supply Specifications

Depending on the drive model, a DPC servo drive operates off either an AC Power Supply or an isolated DC Power Supply. To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

- Drive over voltage
- External shunt regulator turn-on voltage

Use of a shunt regulator is necessary in systems where motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply. This regenerated energy can charge the power supply capacitors to levels above that of the DPC drive over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one drive, then the current requirements for each drive should be added together. Due to the nature of servo drives, the current into the drive does not always equal the current out of the drive. However, the power in is equal to the power out. Use the following equation to calculate the power supply output current, I_{PS}, based on the motor current requirements.

$$I_{PS} = \frac{V_M \quad I_M}{V_{PS} \quad 0.98}$$

Where:

- V_{PS} -nominal power supply voltage
- I_M -motor current
- V_M -motor voltage

Use values of V and I at the point of maximum power in the move profile (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.

2.7.4 Environment

To ensure proper operation of a DPC servo drive, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.7 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m

Baseplate Temperature Range DPC drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above a certain value. Table 2.8 below shows the maximum allowable temperature range for standard drive power modules. It is recommended to mount the baseplate of the DPC drive to a heatsink for best thermal management results. For mounting instructions see "Mounting" on page 36.

TABLE 2.8 Baseplate Temperature Ranges

Baseplate Maximum Allowable Temperature	
Power Board	**Temperature Range**
015S400	0 - 75 °C
030A400	0 - 75 °C
040A400	0 - 75 °C
C060A400	0 - 75 °C
C100A400	0 - 75 °C
030A800	0 - 75 °C
060A800	0 - 75 °C
020B080	0 - 65 °C
040B080	0 - 75 °C
060B080	0 - 75 °C
100B080	0 - 75 °C
015B200	0 - 65 °C
025B200	0 - 75 °C

Shock/Vibrations While DPC drives are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to. The best way to secure the drive against mechanical vibration is to use screws to mount the DPC drive against its baseplate. For information on mounting options and procedures, see "Mounting" on page 36.

Caution

Care should be taken to ensure the drive is securely mounted in a location where no moving parts will come in contact with the drive.

3 Integration in the Servo System

This chapter will give various details on incorporating a DPC servo drive into a system, such as how to properly ground the DPC drive along with the entire system, and how to properly connect motor wires, power supply wires, feedback wires, communication cables, and inputs into the DPC drive.

3.1 LVD Requirements

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the servo drives must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

Contact the factory for assistance in determining the type of drive in use.

General

1. **Shielded cables must be used for all interconnect cables to the drive and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.**
2. **The drive's metal enclosure must be grounded to the closest ground point with the least amount of resistance.**
3. **The drive must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.**

Analog Input Drives

4. **A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.**

PWM Input Drives

5. **A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.**

MOSFET Switching Drives

6. **A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.**
7. **An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.**

IGBT Switching Drives

8. **An appropriately rated Cosel Tac series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.**
9. **A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.**

Fitting of AC Power Filters

10. **It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be**

adversely affected by the noise. AC power filters can filter this noise and keep it from getting on the AC power signal. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power filter enters the enclosure as possible. Also, the AC power cable on the load end of the filter should be routed far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

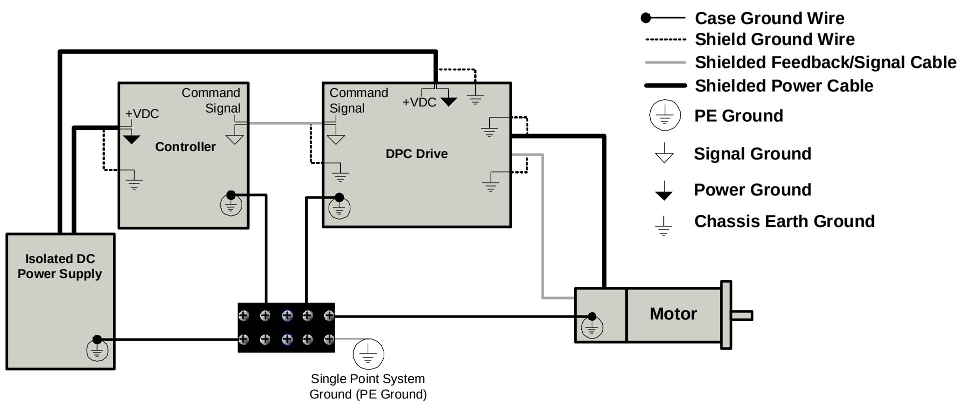
Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines.

3.3 Grounding

In most servo systems the case grounds of all the system components should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point through a single low resistance wire reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

- **Motor chassis**
- **Controller chassis**
- **Power supply chassis**
- **DPC drive chassis**

FIGURE 3.1 System Grounding



Ground cable shield wires at the drive side to a chassis earth ground point.

The DC power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the DPC drive to avoid picking up noise due to the "floating" differential servo drive input. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed. As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

The main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card or a noise suppression device is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

ADVANCED Motion Controls recommends using the following hand crimp tools for the appropriate I/O and Feedback cable and wire preparation. Consult the drive datasheet to see which connectors are used on a specific drive.

Drive Connector	Hand Crimp Tool Manufacturer and Part Number
6-pin, 3.96 mm spaced, friction lock header	Tyco: P/N 770522-1
High Density D-sub headers	Tyco: P/N 90800-1

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of larger diameter wire rather than too thin. This becomes more critical as the cable length increases. The following table provides recommendations for selecting the appropriate wire size for a specific current. These values should be used as reference only. Consult any applicable national or local electrical codes for specific guidelines.

Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518
15	#18	0.823
20	#16	1.31
35	#14	2.08
45	#12	3.31

Current (A)	Minimum Wire Size (AWG)	mm^2
60	#10	5.26
80	#8	8.37
120	#6	13.3
150	#0	53.5
200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

- For a single phase motor or voice coil, twist the two motor wires together as a group.
- For a three phase motor, twist all three motor wires together as a group.

Caution

DO NOT use wire shield to carry motor current or power!

Ground the motor power cable shield at one end only to the drive chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the drive chassis ground.

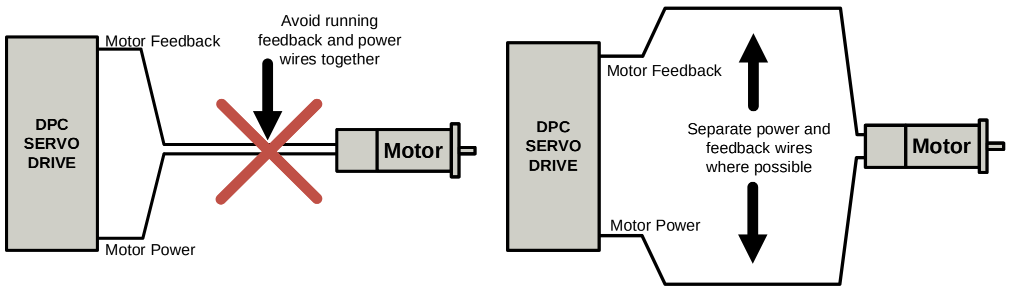
When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each drive directly from the power supply filter capacitor.
2. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the drive chassis ground. Also make sure that the feedback connector and D-sub shell preserve the shield continuity. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.2 Feedback Wiring



3.4.5 I/O and Signal Wires

Use of a twisted, shielded pair for the I/O and Signal wires is recommended. Connect the shield to the drive chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds.

Notice

In case of a single-ended reference signal when using ±10V as the input command source, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

3.5 Connector Types

Depending on the specific drive model, typically a DPC drive connection interface will consist of:

- **Power Connectors - used for Logic, Motor, and AC or DC Power, as well as optional external shunt regulator connections**
- **Feedback Connectors - used for primary and auxiliary feedback connections, programmable inputs and outputs, and other drive functions**
- **CANopen Communication Connector - used for CANopen networking connections**
- **Auxiliary RS232 Communication Connector - used for RS232 drive communication necessary for commissioning with DriveWare**
- **I/O Signal Connector - used for programmable inputs and outputs as well as some feedback connections.**

The different types of connectors used in the DPC drive series are shown in the sections below. Consult the specific drive datasheet for the actual connectors and pin labels used on the drive.

3.5.1 Power Connectors

TABLE 3.1 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 3.5 mm spaced insert connector
Mating Connector	Details	Phoenix Contact: P/N 1840366
	Included with Drive	Yes

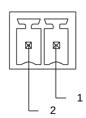


TABLE 3.2 +24V LOGIC - Logic Power Connector

+24V LOGIC - Logic Power Connector		
Connector Information		2-port, 5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1779987
	Included with Drive	Yes

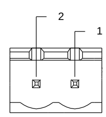


TABLE 3.3 POWER / MOTOR POWER / BRAKE - Power Connector

BRAKE/LOGIC - Logic Power Connector	
Connector Information	8-contact, 11.10 mm spaced, dual-barrier terminal block

BRAKE/LOGIC - Logic Power Connector		
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

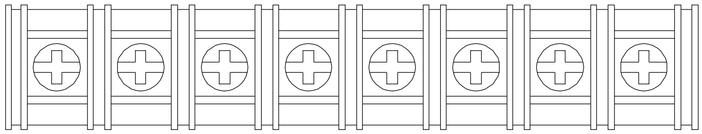


TABLE 3.4 AC POWER / MOTOR POWER / DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 10.16 mm spaced, enclosed, friction lock header
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

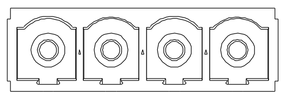


TABLE 3.5 POWER - DC Power Connector

POWER - DC Power Connector		
Connector Information		6-pin, 3.96 mm spaced, friction lock header
Mating Connector	Details	AMP: Plug P/N 770849-6; Terminals P/N 770522-1 (loose) or 770476-1 (strip)
	Included with Drive	Yes

TABLE 3.6 MOTOR POWER - Motor Power Connector

MOTOR POWER - Motor Power Connector		
Connector Information		3-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804917
	Included with Drive	Yes

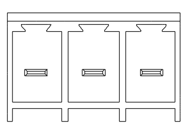


TABLE 3.7 POWER - Power Connector

POWER - Power Connector		
Connector Information		4-port, 7.62 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1804920
	Included with Drive	Yes

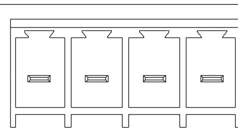


TABLE 3.8 POWER - Power Connector

POWER - Power Connector		
Connector Information		10-port,5.08 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: P/N 1781069
	Included with Drive	Yes

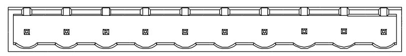


TABLE 3.9 AC POWER / MOTOR POWER / DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 10.16 mm spaced, enclosed, friction lock header
Mating Connector	Details	Not applicable
	Included with Drive	Not applicable

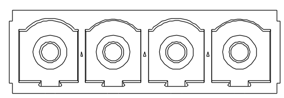


TABLE 3.10 AC POWER / MOTOR POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		4-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	No

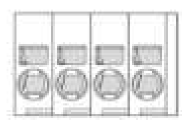
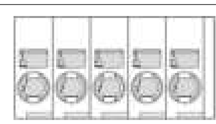


TABLE 3.11 DC POWER - Power Connector

AC POWER / MOTOR POWER / DC POWER - Power Connector		
Connector Information		5-port, 5.0 mm spaced, push-in front spring connection header
Mating Connector	Details	Push-in direct plug-in method for solid or stranded conductors with or without ferrules
	Included with Drive	Not applicable



3.5.2 Feedback Connectors

TABLE 3.12 FEEDBACK - Feedback Connector

FEEDBACK - Feedback Connector		
Connector Information		15-pin, high-density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 748364-1; Housing P/N 5748677-1; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No

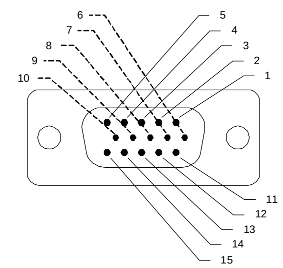
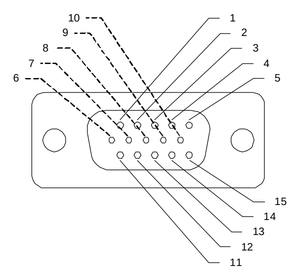


TABLE 3.13 AUX ENCODER - Auxiliary Feedback Connector

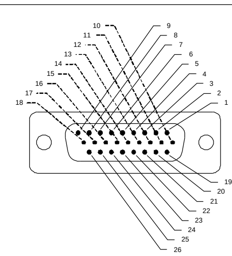
AUX ENCODER - Auxiliary Feedback Connector		
Connector Information		15-pin, high-density, male D-sub
Mating Connector	Details	TYCO: Plug P/N 1658681-1; Housing P/N 5748677-1; Terminals P/N 1658686-2 (loose) or 1658686-1 (strip)
	Included with Drive	No



3.5.3 I/O Connectors

TABLE 3.14 I/O - Signal Connector

I/O - Signal Connector		
Connector Information		26-pin, high density, female D-sub
Mating Connector	Details	TYCO: Plug P/N 1658671-1; Housing P/N 5748677-2; Terminals P/N 1658670-2 (loose) or 1658670-1 (strip)
	Included with Drive	No



3.5.4 Communication Connectors

TABLE 3.15 COMM - CAN Communication Connector

COMM - CAN Communication Connector		
Connector Information		Shielded, dual RJ-45 socket with LEDs
Mating Connector	Details	AMP: Plug P/N 5-569552-3
	Included with Drive	No

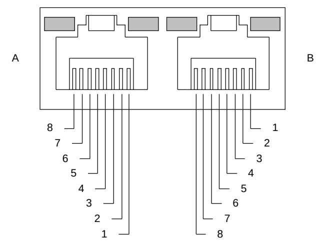
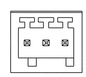


TABLE 3.16 AUX COMM - RS232 Communication Connector

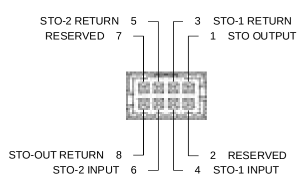
AUX COMM - RS232 Communication Connector		
Connector Information		3-pin, 2.5 mm spaced, enclosed, friction lock header
Mating Connector	Details	Phoenix Contact: Plug P/N 1881338
	Included with Drive	Yes



3.5.5 STO Connector

TABLE 3.17 Safe Torque Off (STO) connector

STO Connector		
Connector Information		8-port, 2.00 mm spaced, enclosed, friction lock header
Mating Connector	Details	Molex: P/N 51110-0860 (housing); 50394-8051 (pins)
	Included with Drive	No



3.6 Mounting

DPC drives provide a number of mounting configuration options. The drive baseplate includes perimeter mounting screwholes allowing different mounting arrangements depending on the requirements or space limitations of the system. See the drive datasheet for specific mounting dimensions and screwhole locations.

4 Operation and Features

This chapter will present a brief introduction on how to test and operate a DPC servo drive. Read through this entire section before attempting to test the drive or make any connections.

4.1 Features and Getting Started

To begin operation with your DPC drive, be sure to read and understand the previous chapters in this manual as well as the drive datasheet and the DriveWare Software Guide. Ensure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the DPC drive. Also, be aware of the "Troubleshooting" section at the end of this manual for solutions to basic operation issues.

4.1.1 Initial Setup and Configuration

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up. For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- DPC Servo Drive
- Motor
- AC or DC Power Supply and Logic Power Supply for supplying power to system
- DriveWare Setup Software and Software Guide for detailed instructions on how to setup, tune and configure a DPC drive in DriveWare

The following steps outline the general procedure to follow when commissioning a DPC drive for the first time. The DriveWare Software Guide contains more detailed information on each step.

1. **Check System Wiring: Before beginning, check the wiring throughout the system to ensure proper connections and that all grounding and safety regulations have been followed appropriately for the system.**

Caution

Do not apply power to the system until certain all wiring and grounding has been setup safely and properly!

For drives using a separate logic power supply, turn on the logic supply first before turning on the main power supply.

2. **Apply Power: Power must be applied to the drive before any communication or configuration can take place. Turn on the Logic supply first for drives using a separate logic supply, then turn on the main Power supply. Use a multimeter or voltmeter to check that both power supply levels are within their specified ranges.**
3. **Establish Connection: Open DriveWare 7 on the PC. The DPC drive should be connected to the PC with a serial cable. Choose the "Connect to a drive" option when DriveWare starts, and enter the appropriate communication settings in the options window that appears. See the DriveWare Software Guide for more information on connecting to a drive. For connection issues, see "Connection Problems" on page 62.**
4. **Configure the drive in DriveWare: DriveWare allows the user to manually configure user units, motor and feedback information, system parameters and limits, tune the Current, Velocity and Position Loops, commutate the motor, and assign drive and software "actions" to specific events. Consult the DriveWare Software Guide for detailed instructions.**
5. **Connect to the Controller: Once the drive has been properly commissioned, use an external controller to command an input signal to the drive. The controller wiring and setup should follow the safety and grounding guidelines and conventions as outlined in "Grounding" on page 28.**

4.1.2 Input/Output Pin Functions

DPC drives provide a number of various input and output pins for parameter observation and drive configuration options. Consult the drive datasheet to see which input/output pin functions are available for each drive.

Programmable Digital I/O

The single-ended and differential Programmable Digital I/O can be assigned to over 40 different functions in DriveWare. The polarity of the signals can be set to active HIGH or active LOW depending on the preference of the user. The differential high speed inputs can also be used as command source inputs with an Auxiliary Encoder (see "Auxiliary Encoder Input" below) or for PWM and Direction input (see PWM and Direction below). They also may be used as a High Speed Capture input (see "Capture Inputs" below). DPC drives offer both isolated and non-isolated Programmable Digital I/O.

Note: Depending on the configuration, digital outputs will be pulled either low or high for a period of time after a power cycle or drive reset. The delay period for each control module is given below.

FIGURE 4.1 Programmable Digital Output Power-up Delay

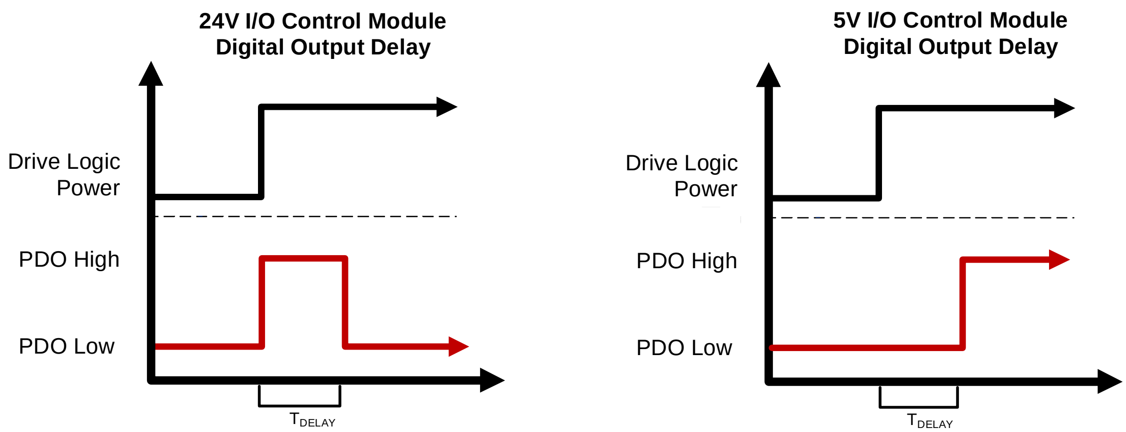


TABLE 4.1 Programmable Digital Output Power-up Delays

		Active High		Active Low	
		Power Cycle Delay (ms)	Reset Delay (ms)	Power Cycle Delay (ms)	Reset Delay (ms)
24V I/O Control Modules	DPCANIA	600	500	-	-
	DPCANIE	200	100	-	-
	DPCANIR	300	100	-	-
5V I/O Control Modules[1]	DPCANTE	-	60	250	100
	DPCANTR	-	60	200	100

1. 5V I/O control modules exhibit an ~100mV voltage spike when set to Active High when a drive reset is commanded.

24VDC Digital I/O Specification

The 24VDC Digital I/O is designed to be compatible with controllers that interface with 24VDC signals, using optical isolation that separates the drive signal ground from the controller signal ground. Isolation increases a system's noise immunity by helping to eliminate current loops and ground currents.

- **Inputs** - The Isolated Digital Inputs use bi-directional optical isolators to detect signals from the controller. Dual LED's in the optical isolator allow current to flow in either direction. Current flow through the LED activates the transistor, and the drive responds depending on whether the transistor is active or not. The presence or absence of current in the LED determines the logic level, not the direction of current. This flexibility allows the Isolated Digital Inputs to be compatible with a wide range of controllers.

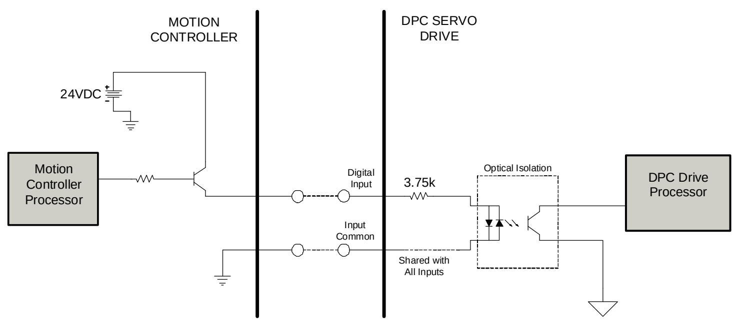
TABLE 4.2 24VDC Isolated Digital Input

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

When current flows into the digital input it is acting as a sinking input. When current flows out of the digital input it is acting as a sourcing input. Since current is allowed to flow in either direction, the inputs can either sink or source. The voltage at the Input Common pin determines whether the inputs sink or source. The Input Common pin is common to all of the inputs, but is isolated from the drive signal ground.

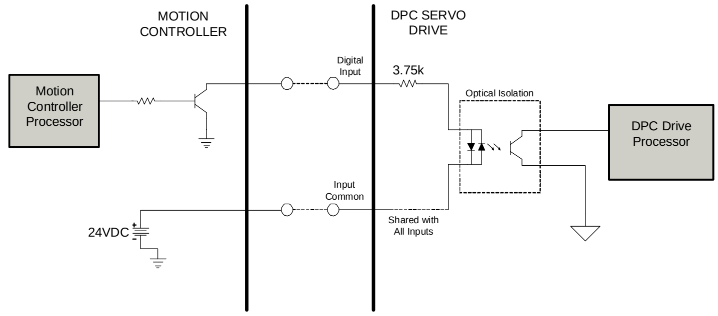
To configure the Isolated Digital Inputs as sinking, the 24V ground is applied to the Input Common and 24V is modulated at the digital input. Figure 4.2 shows a sourcing output from the motion controller feeding the sinking input at the drive. In this example the controller uses a transistor to control the 24V to the drive input. A mechanical switch, relay or other voltage-controlling device can be used in place of the transistor.

FIGURE 4.2 24VDC Isolated Digital Input configured as a sinking input



To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.3 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides a transistor.

FIGURE 4.3 24VDC Isolated Digital Input configured as a sourcing input.



- **Outputs - The Isolated Digital Outputs are pulled up with a 2.5k resistor via the pin labeled Output Pull-Up and have a common grounding point labeled Output Common.**

TABLE 4.3 24VDC Isolated Digital Output (Sinking)

24VDC Isolated Digital Output (Sinking)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA

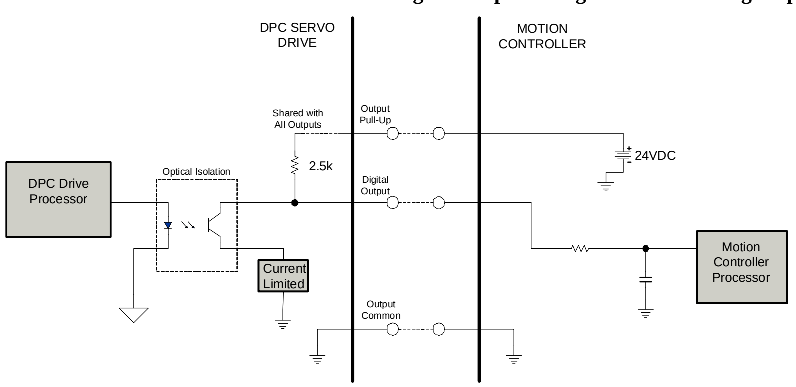
TABLE 4.4 24VDC Isolated Digital Output (Sourcing)

24VDC Isolated Digital Output (Sourcing)	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	9.6mA

A transistor controls the voltage at each digital output. The Isolated Digital Output can sink or source depending on how the wiring is configured.

For sourcing outputs the Output Pull-Up pin is pulled to 24V and the 24V ground goes to the output common, as shown in Figure 4.4. A transistor controls the voltage at the digital output. When the transistor is open the voltage at the digital output is HIGH. When the transistor is closed the voltage is pulled to ground, which causes the output to go LOW.

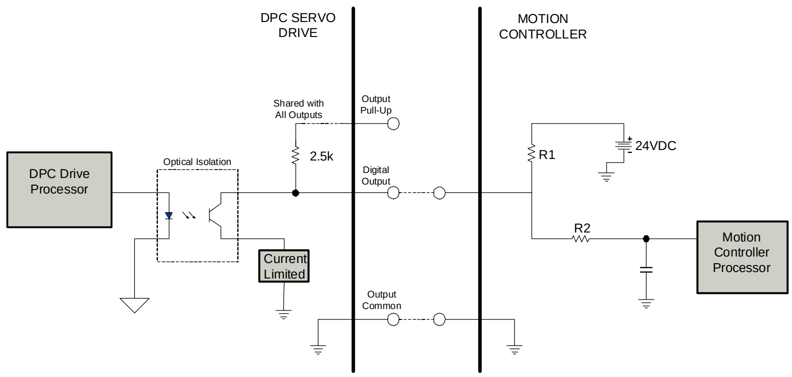
FIGURE 4.4 24VDC Isolated Digital Output configured as a sourcing output.



For sinking outputs the Output Pull-Up pin is not connected and the digital output pin is interfaced as an open collector, as shown in Figure 4.5. 24V is applied to the digital output

through a resistor R1 and the 24V ground goes to Output Common. As in the previous example a transistor controls the voltage of the digital output. R1 should be greater than 600 to limit the current into the digital output to less than 50mA.

FIGURE 4.5 24VDC Isolated Digital Output configured as a sinking output.



Programmable Limit Switch (PLS) Outputs

When a digital output is configured as a Programmable Limit Switch through the setup software, the maximum frequency of the output will correspond to the table below.

TABLE 4.5 Maximum Digital Output Frequency for PLS Outputs

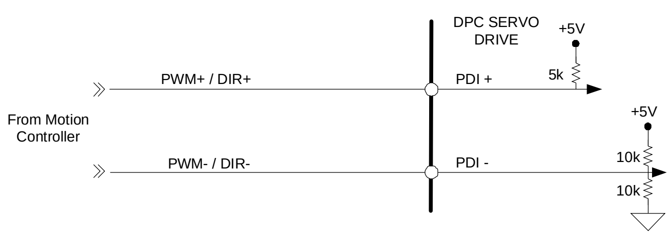
	Maximum Frequency
24V I/O Control Modules	85 Hz (50% duty cycle)[1]
5V I/O Control Modules	5 kHz (for 20 kHz switching frequency)[2]

1. Higher duty cycles will result in higher maximum frequencies due to hardware filtering.
2. Lower switching frequencies will result in lower output frequencies due to sampling on 5V I/O control modules.

PWM and Direction Inputs

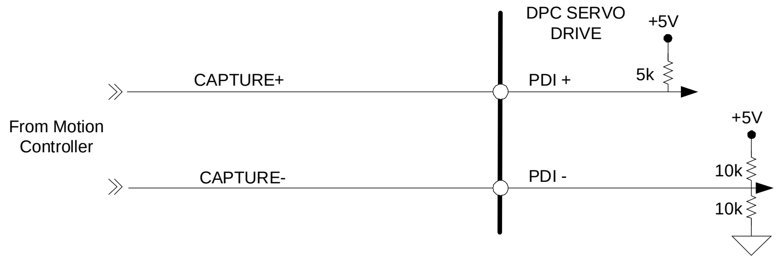
DPC drives allow configuration of PWM and Direction as a command source using High-Speed digital inputs. When configured for PWM and Direction control these inputs cannot be used for the Auxiliary Encoder or High-Speed Capture features. The command source must be set to PWM and Direction and configured in the Command Source window within DriveWare.

FIGURE 4.6 PWM and Direction Input Connections



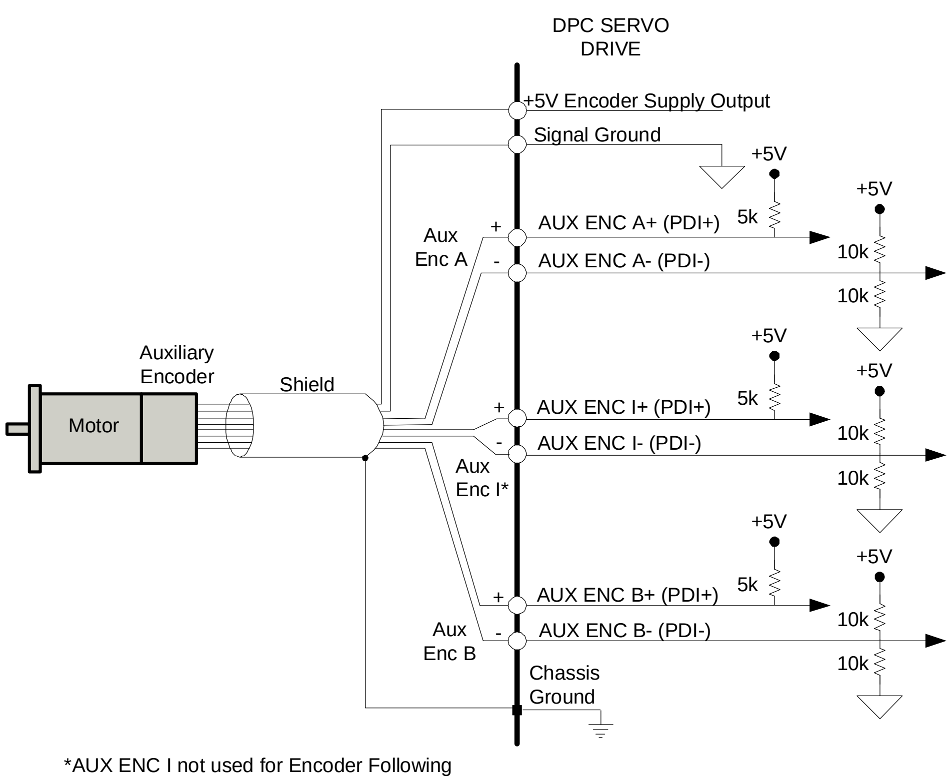
Capture Inputs DPC drives allow configuration of Capture inputs using High-Speed digital inputs. When configured for Capture signals these inputs cannot be used for the Auxiliary Encoder or PWM and Direction features. The Capture signals can be used to capture and view internal signals on a designated trigger (rising edge, falling edge, or both). Parameters and options for the Capture signals can be entered and configured in DriveWare.

FIGURE 4.7 High-Speed Capture Input Connections



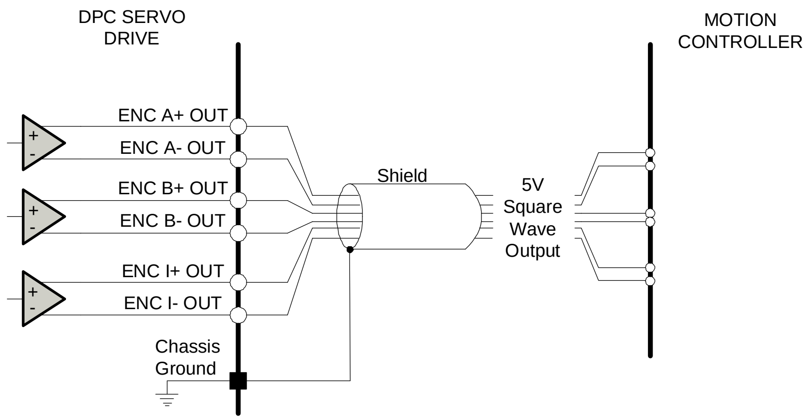
Auxiliary Encoder Input DPC drives accept a differential auxiliary encoder input that can be used for auxiliary position feedback, or for a command source when configured for Encoder Following. The auxiliary encoder signals are connected through High-Speed Programmable Digital Inputs. If using these pins for an auxiliary encoder input, the drive will not be able to utilize the High Speed Capture or PWM and Direction features. Hardware settings and options for the auxiliary encoder can be entered and configured in DriveWare.

FIGURE 4.8 Auxiliary Encoder Input Connections



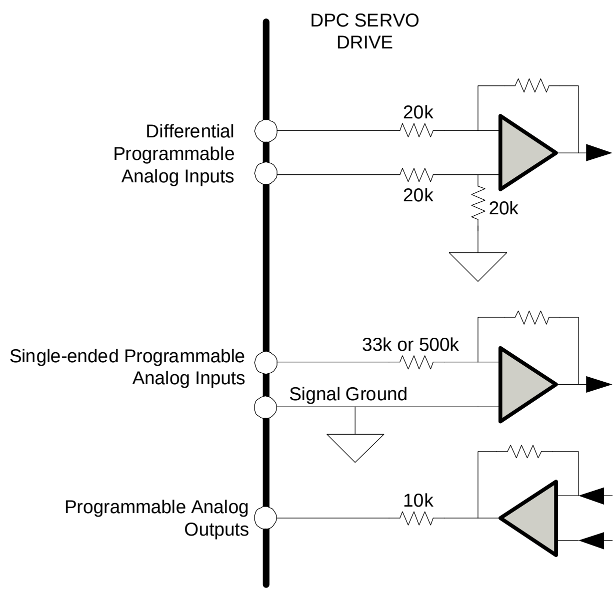
Encoder Output The Encoder Output pins provide a differential encoder output that can be used to synchronize the command to other axes, or to close the position loop. Depending on the type of feedback in use, the drive outputs either a 5V square wave buffered encoder signal (DPCxxxE/S/A drives) or a 5V square wave emulated encoder signal (DPCxxxR/S/A drives). The buffered encoder output has a 1:1 input-to-output ratio, while the emulated encoder input-to-output ratio is configurable within DriveWare (for resolver feedback the emulated output will match the resolver resolution setting). There is a small phase lag between the sinusoidal feedback to the drive and the emulated output due to the time required to process the emulated signal.

FIGURE 4.9 Encoder Output Connections



Programmable Analog I/O The Programmable Analog I/O can be assigned to drive functions in DriveWare. These can be used to monitor drive signals, and are also useful for troubleshooting unexpected drive behavior. The drive I/O Signal Connector provides a differential programmable analog input that may be used for a ±10V analog input command.

FIGURE 4.10 Programmable Analog I/O



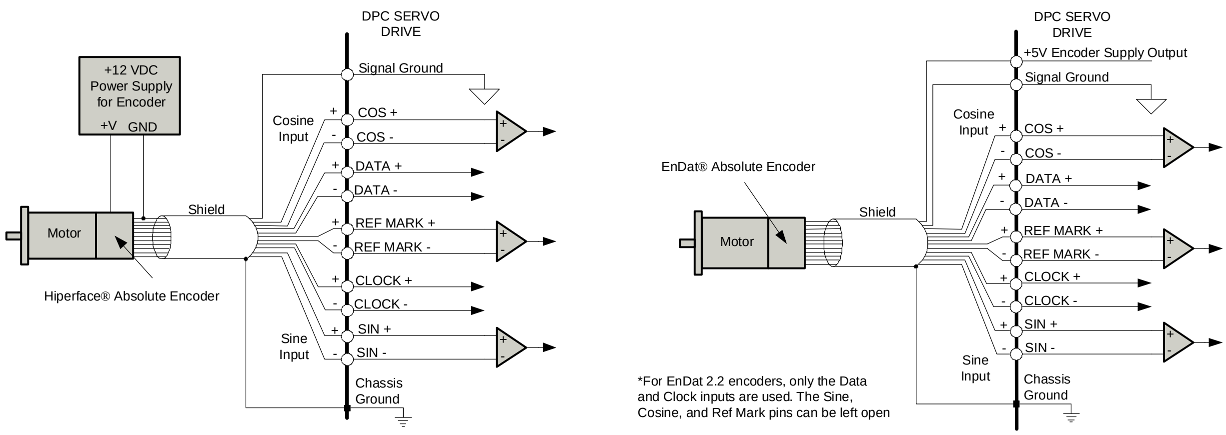
4.1.3 Feedback Operation

The functional operation of the feedback devices supported by DPC drives is described in this section. For more information on feedback selection, see "Feedback Supported" on page 17. See the datasheet of the drive in use for specific pin locations.

Absolute Encoder (Hiperface® & EnDat®)

DPCANIA drives support Hiperface® and EnDat® 2.1 (DPCANIA supports EnDat 2.2) absolute encoders. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs and differential Data and Clock signals. Hiperface encoders require an external +12 VDC supply for power, while EnDat encoders can use the +5V Encoder Supply Output pin provided on the DPC drive. For EnDat 2.2 encoders, only the Data and Clock inputs are used. The Sine, Cosine, and Index pins can be left open.

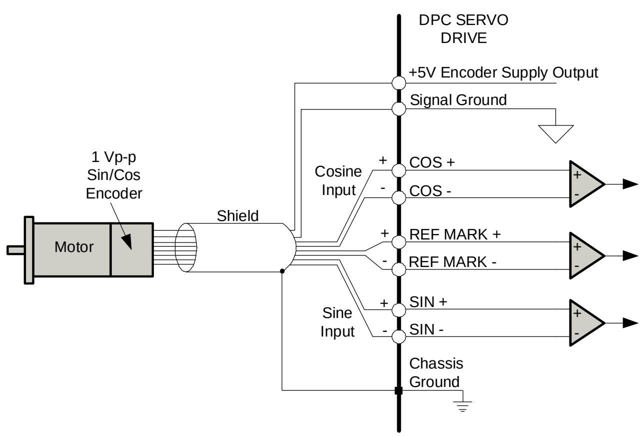
FIGURE 4.11 Absolute Encoder Connections



1 Vp-p Sin/Cos Encoder

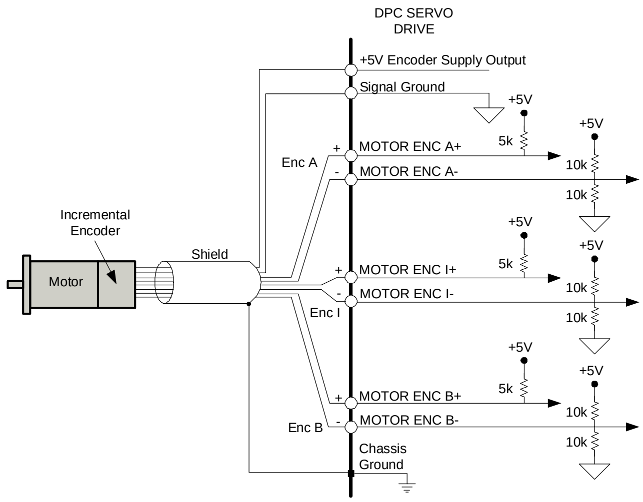
DPCANIA drives support 1 Vp-p Sin/Cos Encoder feedback. The drive Feedback Connector allows inputs for differential sine and cosine signals, as well as differential Reference Mark inputs. A +5V Encoder Supply Output pin is provided to supply power to the encoder.

FIGURE 4.12 1 Vp-p Sin/Cos Encoder



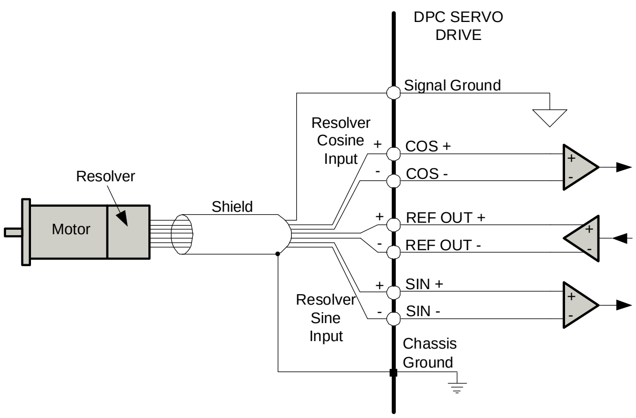
Incremental Encoder DPCANxE drives support incremental encoder feedback. The drive Feedback Connector allows inputs for differential and single-ended inputs. For single-ended encoder inputs, leave the negative terminal open. Both the "A" and "B" channels of the encoder are required for operation. DPCANxE drives also accept an optional differential "index" channel that can be used for synchronization and homing. A +5V Encoder Supply Output pin is provided to supply power to the encoder.

FIGURE 4.13 Incremental Encoder Connections



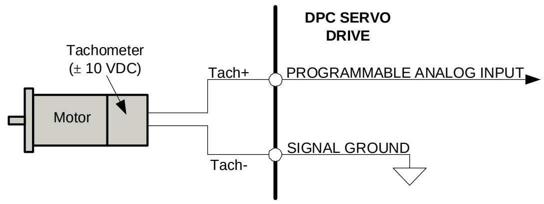
Resolver DPCANTR drives support resolver feedback with a carrier frequency of 5kHz, an excitation voltage of 4Vrms, and a 0.5 transformation ratio. The drive Feedback Connector provides a differential Resolver Reference/Excitation output, and allows differential sine and cosine resolver inputs.

FIGURE 4.14 Resolver Input Connections



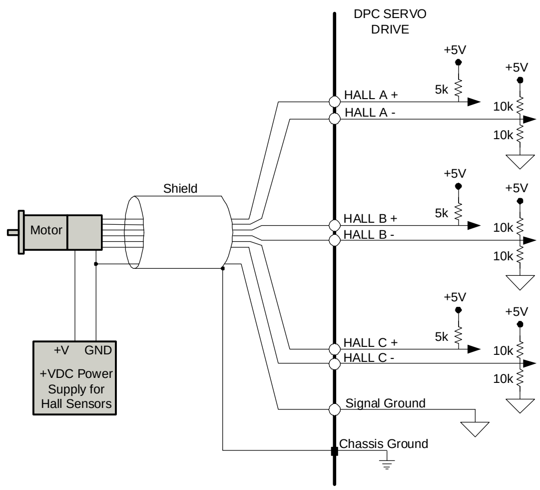
Tachometer (±10 VDC) All DPC drives support the use of a tachometer for velocity feedback. The Programmable Analog Input on the motor Feedback Connector is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

FIGURE 4.15 Tachometer Input Connections



Hall Sensors DPCANxE and DPCANIA drives accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive Feedback Connector allows differential or single-ended Hall Sensor inputs. For single-ended Hall signals leave the negative terminals open.

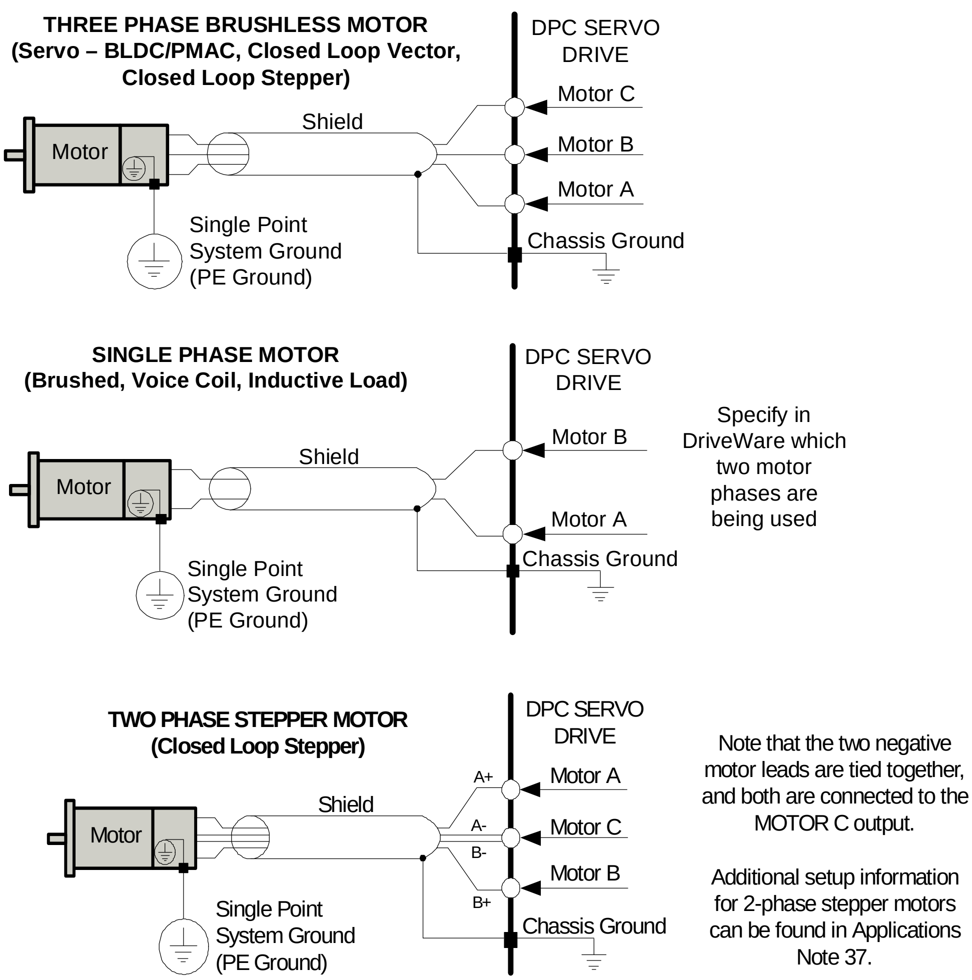
FIGURE 4.16 Hall Sensor Input Connections



4.1.4 Motor Connections

The diagrams below show how a DPC drive connects to various motor types. Notice that the motor wires are shielded, and that the motor housing is grounded to the single point system ground (PE Ground). The cable shield should be grounded at the drive side to chassis ground.

FIGURE 4.17 Motor Power Output Wiring.



If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

For applications using stepper motors, the maximum motor speed will be limited (typically ~600 RPM max).

4.1.5 Logic Power Supply

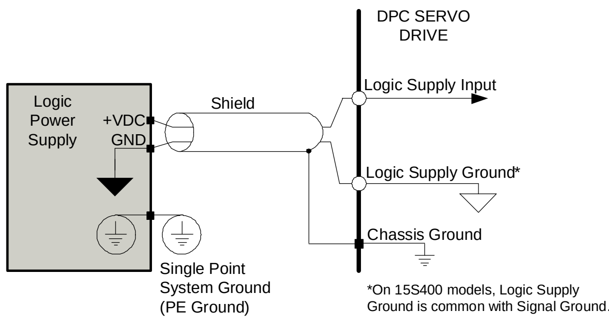
An external +24 VDC nominal logic power supply (850mA) is required on drives using AC power modules. The logic supply ground should be referenced to the drive signal ground. The logic power inputs are made through a separate Logic Power connector on the drive.

When using a separate logic power supply, the logic power must be turned on before the main power supply.

TABLE 4.6 AC Power Module Logic Supply Ratings

AC Power Module	Logic Supply Range (VDC)	Input Current (mA)
015S400, 030A400, 040A400, C060A400, C100A400, 030A800, 060A800	20-30	850

FIGURE 4.18 AC Power Module Logic Power Supply Inputs

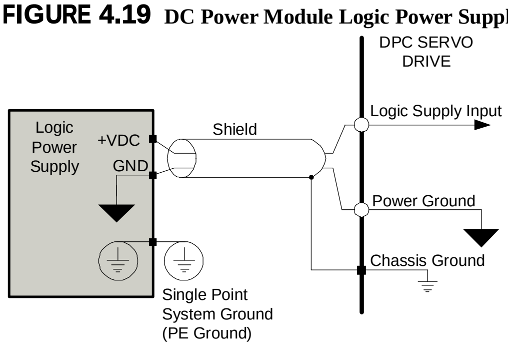


On drives using DC power modules, an external logic supply is optional. If no external logic supply is connected the drive will use the main DC power supply for logic power. If an external logic power supply is used, the voltage must be below the main DC Power Supply value. Table 4.7 shows the different DC power modules and their corresponding logic supply ranges.

TABLE 4.7 DC Power Module Logic Supply Ranges.

DC Power Module	Logic Supply Range (VDC)
020B080, 040B080, 060B080, 100B080	20-80
015B200	40-190
025B200	20-190

FIGURE 4.19 DC Power Module Logic Power Supply Inputs

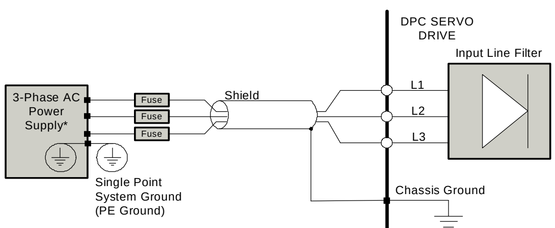


4.1.6 Power Supply Connections

The figures below show how an external power supply should be connected to the DPC drive.

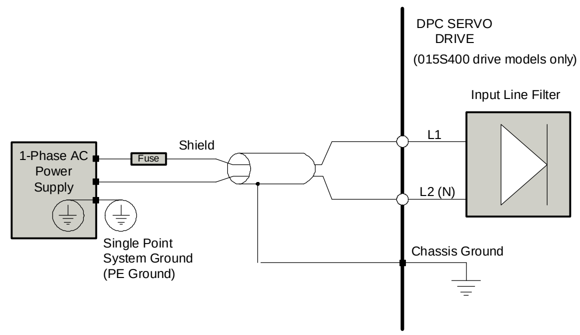
AC or DC Power Modules **For drive models designed for a three-phase AC power supply, connect the AC supply to L1, L2, and L3. On certain drive models, a single-phase AC supply can be connected to any two of the three (L1, L2, L3) AC terminals with the result that some drive power de-rating may occur. See Figure 4.20 below or the drive datasheet for the specific model characteristics. For drives designed for a single phase AC supply, connect the AC supply to L1 and L2 (N). Figure 4.20 below shows the recommended connections.**

FIGURE 4.20 AC Power Module Supply Wiring



*To use a single-phase AC Supply with a drive designed for a three-phase AC supply, connect AC lines to any two of L1, L2, and L3. Do not connect AC line neutral to ground! See the chart below for specific drive model de-rating information for drives powered by single-phase AC.

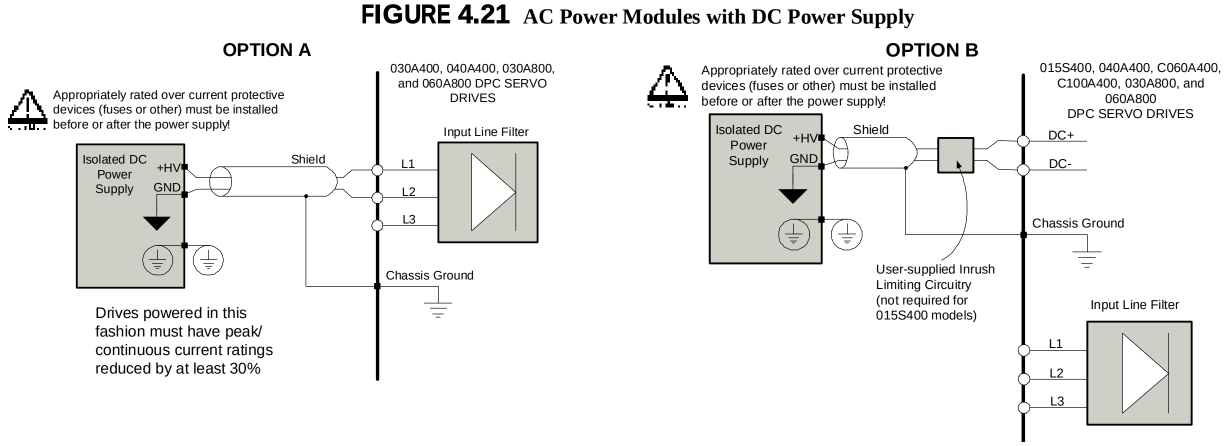
Model	Single-Phase AC De-rating Characteristics
030A400	Peak and continuous current ratings will be reduced by 30%
040A400	Peak and continuous current ratings will be reduced by 30%
C060A400	Output power must not exceed 3KW. No current limit de-rating.
C100A400	Output power must not exceed 3kW. Current limits de-rated to 30A cont. / 60A peak.



If using a DC supply to power a drive with an AC power module, follow one of the methods below, depending on the connections available for the specific power module (Figure 4.21 below shows the recommended connections).

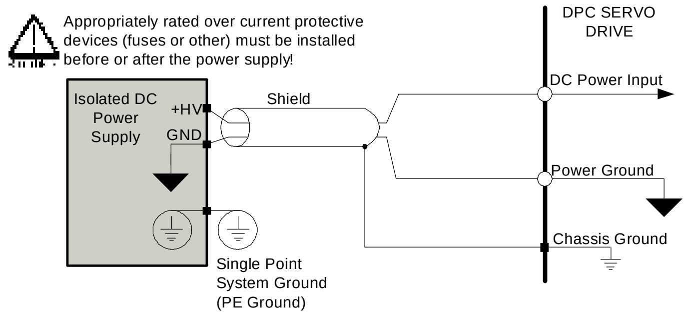
- **(Option A) Connect the isolated DC supply between any two of the three (L1, L2, L3) power terminals. Note that drives powered in this fashion must have peak and continuous current ratings reduced by at least 30% and should not be given current commands that exceed this derating.**
- **(Option B) Some drives feature DC+ and DC- terminals which can be used as DC inputs rather than using L1, L2, or L3. Except for 015S400 power modules, powering the drive in this fashion will require external inrush limiting circuitry that must be properly scaled to the application and drive power requirements.**

FIGURE 4.21 AC Power Modules with DC Power Supply



DC Only Power Modules For drives using a DC power module, connect the isolated DC supply high voltage to the DC Power Input terminal, and the DC supply ground to the power ground terminal, as shown in Figure 4.22 below.

FIGURE 4.22 DC Power Module Supply Wiring



4.1.7 STO (Safe Torque Off)

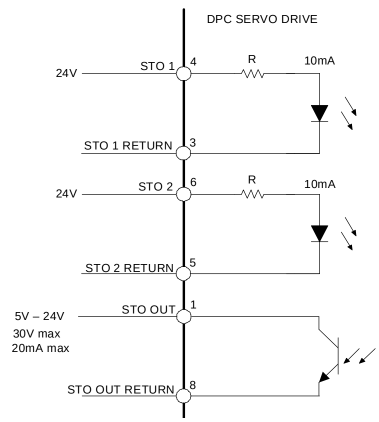
Some models of the DPC drive family feature an external dedicated +24VDC STO safety function designed to monitor an external 24V STO input from the user system and disable the motor output during an STO event. The STO circuit uses +24VDC sinking single-ended isolated inputs for STO functionality. Both STO1 and STO2 must be active (HIGH) to allow torque output at the drive motor outputs.

TABLE 4.8 STO Signal Behavior

STO 1	STO 2	Motor Outputs	STO OUT
Active (HIGH)	Active (HIGH)	Enabled	Open
Active (HIGH)	Not Active (LOW)	Disabled	Closed
Not Active (LOW)	Active (HIGH)	Disabled	Closed
Not Active (LOW)	Not Active (LOW)	Disabled	Closed

The STO circuitry also features an STO status output (STO OUT) that signifies when an STO condition has occurred. This status is also viewable in the setup software as an indicator only. The STO OUT output functions as a switch. When an STO event occurs, the STO OUT switch becomes CLOSED. When the drive is in normal functional operation (STO 1 and STO 2 = 24V), the STO OUT switch is OPEN.

FIGURE 4.23 STO Connections



See the drive datasheet for a drawing and description of the physical STO connector and mating hardware. Functional Safety is TUV Rheinland certified and meets requirements of the following standards:

- EN ISO 13849-1 -- Category 4 / PL e
- EN IEC 61800-5-2 -- STO (SIL 3)
- EN 62061 -- SIL CL3
- IEC 61508 -- SIL 3

The user must verify proper operation of the monitoring circuit (STO 1 and STO 2) at least once per month to maintain SIL 3, Cat 4 / PL e certification. The monitoring circuit is required to be examined by an external logic element when STO is incorporated into a complete drive system in order for proper diagnostics to be fully implemented and utilized in the FMEA calculation (see “STO Operation Test” on page 53). The calculation of the safety relevant parameters are based on a proof test interval of one year and have shown that the requirements of up to SIL 3 are fulfilled. The safety relevant parameters are:

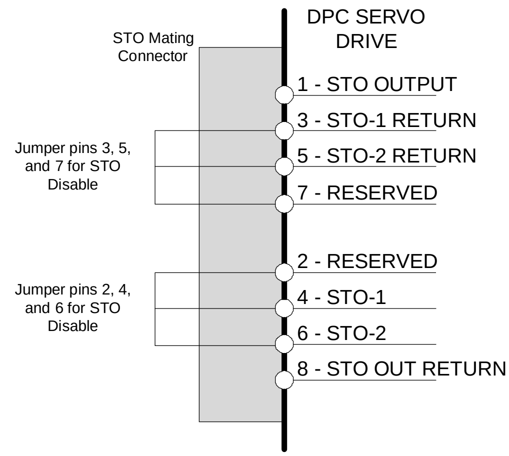
- Safe-Failure-Fraction: SFF = 97%
- Probability of a dangerous failure per hour: PFH = 1.3 x 10 1/h
- Average probability of a dangerous failure on demand (1 year): PFD = 1.7 x 10

Note

The above assessment and safety values defined were assessed with the STO function incorporated into the DigiFlex Performance DPC drive family. Product data for the DPC drive family can be found by visiting www.a-m-c.com.

STO Disable For applications that do not require Safe Torque Off functionality, disabling of the STO feature is required for proper drive operation. A dedicated STO Disable Key connector is available for purchase and must be installed for applications where STO is not in use. Contact the factory for ordering information. Altenatively, STO may be disabled by installing the included mating connector for the STO connector, and wiring the designated pins together as given below in figure.

FIGURE 4.24 STO Disable Connections



STO Operation Test To maintain SIL 3, Cat 4 / PL e certification, the operation of the STO monitoring circuit (STO1 and STO2) must be verified at least once per month. The following procedure provides an example of a method to verify correct STO functionality. Note that it is the responsibily of the system operator to ensure all personal and machine safety requirements for the system are properly enforced during the proof test.

1. Power on the drive.
2. Verify the drive is in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).
3. Remove the voltage signal from the STO1 input pin via a digital controller signal, network command, or by physically removing the STO Connector if safe to do so.
4. Verify that the drive is in a Disabled state (by viewing the Status LED is RED, or by verifying the STO OUT switch has closed).
5. Re-apply the voltage signal to the STO1 pin. Verify that the drive is once again in an Enabled state (by viewing the GREEN Status LED or by monitoring via a digital controller or network commands).
6. Repeat the above steps for the STO2 signal.

Note

End-product certification may require a different interval test schedule or test requirements. It is the responsibility of the end-user to determine the required test interval and requirements for certifications other than stated above.

4.1.8 External Shunt Resistor Connections

Most AC powered DPC drives allow the option of connecting an external shunt resistor to protect against damage that may occur due to over-voltage. Drives that do not include an internal shunt resistor require an external shunt resistor for the internal shunt regulator to operate. The figures below show how an external shunt resistor should be connected to the drive for the different AC Power Modules. The internal shunt regulator must be enabled and configured in DriveWare in order to operate.

FIGURE 4.25 030A400 Power Module External Shunt Resistor Connection

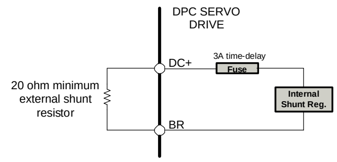


FIGURE 4.26 C060A400 Power Module External Shunt Resistor Connection

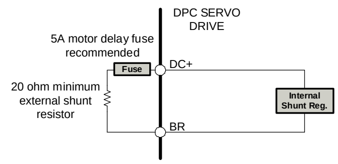


FIGURE 4.27 C100A400 Power Module External Shunt Resistor Connection

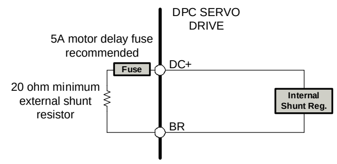


FIGURE 4.28 030A800 Power Module External Shunt Resistor Connection

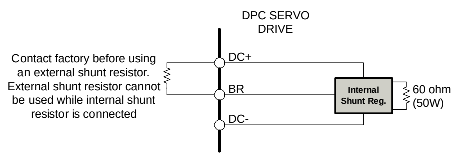


FIGURE 4.29 015S400, 040A400 and 060A800 Power Module External Shunt Resistor Connections

4.1.9 Communication and Commissioning

DPC drives include a CANopen interface for networking and a RS-232 interface for drive configuration and setup. The CANopen node ID and bit rate are set by dipswitches on the DPC drive. The dipswitch settings are different from and do not affect the RS-232 connection settings. Table 4.9 shows the CANopen node ID and bit rate dipswitch information.

TABLE 4.9 CANopen Node ID and Bit Rate Dipswitch Settings

Switch	Description	Setting	
		On	Off
1	Bit 0 of binary CANopen node ID.	1	0
2	Bit 1 of binary CANopen node ID.	1	0
3	Bit 2 of binary CANopen node ID.	1	0
4	Bit 3 of binary CANopen node ID.	1	0
5	Bit 4 of binary CANopen node ID.	1	0
6	Bit 5 of binary CANopen node ID.	1	0
7	Bit 0 of drive CANopen bit rate setting.	1	0
8	Bit 1 of drive CANopen bit rate setting.	1	0

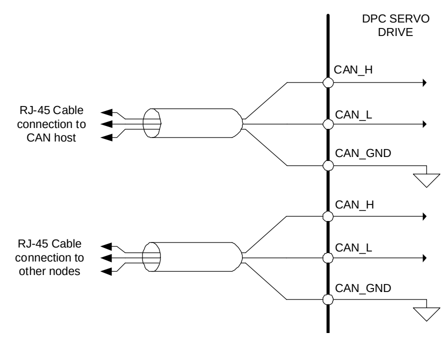
The drive can be configured to use the CANopen node ID and/or bit rate stored in non-volatile memory by setting the node ID and/or bit rate value to 0. The bit settings are given in Table 4.10 below. Note that additional bit rates are possible when using the value stored in NVM.

TABLE 4.10 CANopen Drive Bit Rate Settings

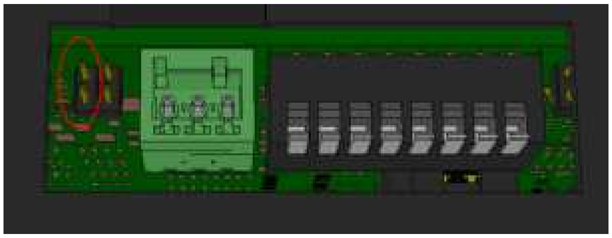
Bit Rate (kbits/sec)	Value For Bit Rate Setting
Load from non-volatile memory	0
500	1
250	2
125	3

CANopen Interface DPC drives feature a dual RJ-45 socket connector for CANopen communication and networking. Connect the CAN networking cables to the dual RJ-45 socket connector as required by the specific network coordination. The outer LEDs on the socket connector will light up when power is applied to the drive. Note that in order to send commands to the drive over the CAN bus, the command source must be set to Communication Channel in the Command Source tab in DriveWare. If the drive is the last node on the CANopen network, it must have a jumper (2.54mm) connected on the 4-pin header between the two pins farthest from the Auxiliary Communication RS-232 connector. Non-terminating drives on the CANopen network do not require a jumper on this header. Consult the drive datasheet for specific jumper details.

FIGURE 4.30 CANopen Interface and Termination Jumper

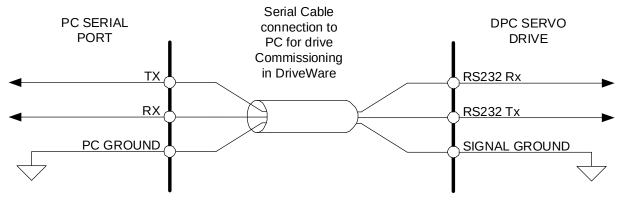


Install 2.54mm jumper between these two pins if the drive is the last node on the CANopen network.



RS-232 Interface The RS-232 interface allows DPC drive commissioning through DriveWare. To connect to the drive in DriveWare for the first time, the factory default RS-232 settings must be used for drive address and baud rate. The default drive address is 63, and the default baud rate setting is 115200 (115200 is the recommended baud rate setting. If necessary, a baud rate of 9600 can be used to connect to the drive, but the baud rate should be increased prior to commissioning the drive.) DPC drives include an Auxiliary Communication port for connection to a serial port on a PC. Connect the PC transmit pin (Tx) to the drive receive pin (Rx), the PC receive pin (Rx) to the drive transmit pin (Tx), and connect the PC RS-232 ground to the drive signal ground.

FIGURE 4.31 RS-232 Interface



4.1.10 LED Functionality

DPC drives feature LED status indicators for supply power and power bridge status. Certain models also include an LED to indicate regeneration mode status.

Power LED The Power LED indicates whether power is being supplied to the drive, as well as shunt regulator operation.

Power LED	
State	Description
GREEN	Power is being supplied to the drive
OFF	No power is being supplied to the drive
RED	Drive is shunting excess energy through the shunt regulator (may appear as flashing RED/GREEN as the shunt regulator is turning off and on during regeneration)

Status LED The Status LED indicates whether the drive power bridge is enabled or disabled.

Status LED	
State	Description
GREEN	Power output bridge is enabled
RED	Power output bridge is disabled (via inhibit or fault)

4.1.11 Commutation

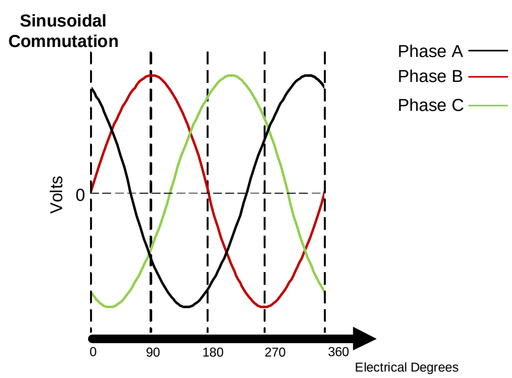
Motor commutation is the process that maintains an optimal angle between the magnetic field created by the permanent magnets in the motor and the electromagnetic field created by the currents running through the motor windings. This process ensures optimal torque or force generation at any motor position. Single phase (brushed) motors accomplish this process with internal commutators built into the motor housing. Three phase (brushless) motors require a correctly configured drive to commutate properly, however.

See the DriveWare Software Guide for more information on AutoCommutation, Manual Commutation, and Phase Detect. DPC drives allow either sinusoidal or trapezoidal commutation.

Sinusoidal Commutation

Sinusoidal commutation provides greater performance and efficiency than trapezoidal commutation. DPC drives can commutate sinusoidally when connected to a motor-mounted encoder. Sinusoidal Commutation works by supplying current to each of the three motor phases smoothly in a sinusoidal pattern. The flow of current through each phase is shifted by 120 degrees. The sum of the current flowing through all three phases adds up to zero. Figure 4.32 shows one electrical cycle of the motor phase currents.

FIGURE 4.32 Sinusoidal Commutation Motor Phase Currents



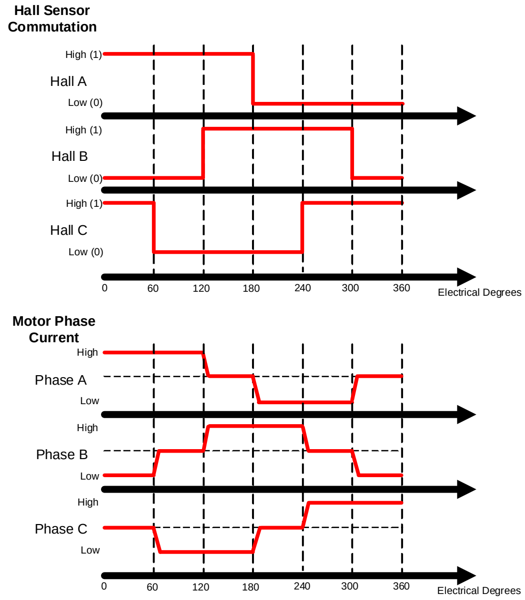
Trapezoidal Commutation

Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DPC drives can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at a time with trapezoidal commutation. The Hall Sensors each generate a square wave with a certain phase difference (either 120- or 60-degrees) over one electrical cycle of the motor. This results in six distinct Hall states for each electrical cycle. Depending on the motor pole count, there may be more than one electrical cycle per motor revolution. The number of electrical cycles in one motor revolution is equal to the number of motor poles divided by 2. For example:

- **a 6-pole motor contains 3 electrical cycles per motor revolution**
- **a 4-pole motor contains 2 electrical cycles per motor revolution**
- **a 2-pole motor contains 1 electrical cycle per motor revolution**

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 4.33.

FIGURE 4.33 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing



Note: Not all ADVANCED Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

Table 4.11 shows the default commutation states for 120-degree and 60-degree phasing. Depending on the specific setup, the sequences may change after running Auto Commutation.

TABLE 4.11 Digital Drive Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

4.1.12 Homing

DPC drives can be configured in DriveWare to "home" to a certain reference signal. This reference signal can be any number of different signal types, such as limit switches, home switches, or encoder index pulses. See the DriveWare Software Guide for more information on Homing.

4.1.13 Firmware

DPC drives are shipped with the latest version of firmware already stored in the drive. Periodic firmware updates are posted on www.a-m-c.com. See the DriveWare Software Guide for information on how to check the drive's firmware version, and how to download new firmware into the drive when necessary.

A Specifications

A.1 Specifications Tables

TABLE A.1 Power Specifications - AC Input DPC Drives

Description	Units	015S400	030A400	040A400	C060A400	C100A400	030A800	060A800
Rated Voltage	VAC(VDC)	240 (339)	240 (339)	240 (339)	240 (339)	240 (339)	480 (678)	480 (678)
AC Supply Voltage Range	VAC	100-240	100-240	100-240	200-240	200-240	200-480	200-480
AC Supply Minimum	VAC	90	90	90	180	180	180	180
AC Supply Maximum	VAC	264	264	264	264	264	528	528
AC Input Phases[1]	-	1	3	3	3	3	3	3
AC Supply Frequency	Hz	50-60	50-60	50-60	50-60	50-60	50-60	50-60
DC Supply Voltage Range	VDC	127-373	127-373	127-373	255-373	255-373	255-747	255-747
DC Bus Over Voltage Limit	VDC	394	429	394	420	420	850	850
DC Bus Under Voltage Limit	VDC	55	55	55	205	205	230	230
Maximum Peak Output Current	A (Arms)	15 (10.6)	30 (21.2)	40 (28.3)	60 (42.4)	100 (70.7)	30 (21.2)	60 (42.4)
Maximum Continuous Output Current	A (Arms)	7.5 (7.5)	15 (15)	20 (14.1)	30 (30)	50 (50)	15 (10.6)	30 (21.2)
Max. Continuous Output Power @ Rated Voltage[2]	W	2415	4831	6441	9662	16103	6840	13680
Internal Bus Capacitance	F	540	1410	339	1120	1120	330	330
PWM Switching Frequency	kHz	20	20	20	14	10	10	10
External Shunt Resistor Minimum Resistance		25	20	25	20	20	note 3	40
Minimum Load Inductance (Line-To-Line)	H	600	600	600	600	600	3000	3000

1. Certain 3-phase drive models can operate on single-phase VAC if peak/cont. current ratings are reduced by at least 30%.
2. P = (DC Rated Voltage) * (Cont. RMS Current) * 0.95
3. Contact factory before using an external shunt resistor with this power module

TABLE A.2 Power Specifications - DC Input DPC Drives

Description	Units	020B080	040B080	060B080	100B080	025B200	015B200
DC Supply Voltage Range	VDC	20-80	20-80	20-80	20-80	20-190	40-190
DC Bus Over Voltage Limit	VDC	86	86	86	88	198	198
DC Bus Under Voltage Limit	VDC	17	17	17	17	17	35
Maximum Peak Output Current	A (Arms)	20 (14.1)	40 (28.3)	60 (42.4)	100 (70.7)	25 (17.7)	15 (10.6)
Maximum Continuous Output Current	A (Arms)	10 (10)	20 (20)	30 (30)	60 (60)	12.5 (12.5)	7.5 (7.5)
Max. Continuous Output Power	W	760	1520	2280	4560	2256	1354
Max. Continuous Power Dissipation	W	40	80	120	240	118	71
PWM Switching Frequency	kHz	20	20	20	20	20	20
Internal Bus Capacitance	F	33	500	500	500	50	20
Minimum Load Inductance (Line-To-Line)	H	250	250	250	250	300	250

TABLE A.3 Control Specifications

Description	DPCANIx	DPCANTx
Network Communication	CANopen (RS-232 for Configuration)	
Command Sources	PWM & Direction, ± 10V Analog, Over the Network, Encoder Following, Sequencing, Indexing, Jogging	
Commutation Methods	Sinusoidal, Trapezoidal	
Control Modes	Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position, Interpolated Position Mode (PVT)	
Motors Supported	Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop), AC Induction (Closed Loop Vector)	
Hardware Protection	40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage	
Programmable Digital I/O	10 Inputs, 4 Outputs	8 Inputs, 4 Outputs
Programmable Analog I/O	4 Inputs, 1 Output	3 Inputs, 2 Output
Primary I/O Logic Level	24 VDC	5V TTL

TABLE A.4 Environmental Specifications

Environmental Specifications	
Parameter	**Description**
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m

TABLE A.5 Baseplate Temperature Ranges

Baseplate Maximum Allowable Temperature	
Power Board	**Temperature Range**
015S400	0 - 75 °C
030A400	0 - 75 °C
040A400	0 - 75 °C
C060A400	0 - 75 °C
C100A400	0 - 75 °C
030A800	0 - 75 °C
060A800	0 - 75 °C
020B080	0 - 65 °C
040B080	0 - 75 °C
060B080	0 - 75 °C
100B080	0 - 75 °C
015B200	0 - 65 °C
025B200	0 - 75 °C

TABLE A.6 Feedback Specifications

Feedback Specifications	
Parameter	**Value**
Maximum Incremental Encoder Input Frequency	20MHz (5 pre-quadrature)
Maximum Sin/Cos Encoder Input Frequency	200kHz
Maximum Hall Sensor Input Frequency	0.15 x PWM Switching Frequency
Resolver Specifications	5kHz, 4Vrms, 0.5 transformation ratio
Maximum Tachometer Voltage	±10VDC

TABLE A.7 24 VDC Digital I/O Specifications

24VDC Isolated Digital Input	
Logical LOW	0-1V
Logical HIGH	15-30V (24V Nominal)
Maximum Current	7mA @ 24V

24VDC Isolated Digital Output	
Output Pull-Up Voltage	15-30V (24V nominal, supplied by user)
Logical LOW	0-2V
Logical HIGH	Same as Output Pull-Up Voltage
Maximum Current	50mA sinking, 8mA sourcing

B Troubleshooting

This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

B.1 Fault Conditions and Symptoms

A fault condition can either be caused by a system parameter in excess of software or hardware limits, or by an event that has been user-configured to disable the drive upon occurrence.

To determine whether the drive is in a fault state, use the Drive Status function in DriveWare to view active and history event items and drive fault conditions. See the DriveWare Software Guide for more information on reading the Drive Status window. Some common fault conditions caused by hardware issues are listed below.

Over-Temperature Verify that the baseplate temperature is less than the drive Baseplate Temperature value. The drive remains disabled until the temperature at the drive baseplate falls below this threshold. See "Baseplate Temperature Range" on page 24 or consult the drive datasheet for the allowable temperature range.

Over-Voltage Shutdown

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Power Supply Specifications" on page 23 for more information.

Under-Voltage Shutdown Verify power supply voltage for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply cannot provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing, power ground, and also phase-to-phase. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

Invalid Hall Sensor State

See the “Commutation Sequence” table in “Commutation” on page 57 for valid commutation states. If the drive is disabled check the following:

1. Check the voltage levels for all the Hall sensor inputs.
2. Make sure all Hall Sensor lines are connected properly.

B.1.1 Software Limits

Because DriveWare allows user configuration of many system parameters such as current, velocity, and position limits, as well as an associated "event action" for DriveWare to take when the system reaches this limit, it is possible for a drive to appear to be inoperative when in actuality it is simply in an assigned disable state.

For example, the motor velocity can be limited by giving a value to the Motor Over Speed selection in DriveWare. An "event action", such as "Disable the Power Bridge", can also be assigned for this particular limiting event for DriveWare to take if the motor reaches this speed. If the motor does happen to reach this velocity limit, DriveWare will automatically cut power to the drive’s output in this particular case, and the drive will be disabled. In the Drive Status window, "Motor Over Speed" will be shown as a "history" event, and "Commanded Disable" will be shown as an "Action" event.

Depending on each specific system and application, there are many different options available for assigning system limits and associated actions. See the DriveWare Software Guide for more information.

B.1.2 Connection Problems

Connection problems are oftentimes caused by incorrect communication settings in DriveWare. The default factory setting for DPC drives are a Drive Address of 63 and 115200 Baud Rate (some older drives may have a default Baud Rate of 9600). When connecting to the drive with DriveWare for the first time, these default factory settings will have to be used along with the appropriate serial port being used with the PC. Once the connection has been established, the Drive Address and Baud Rate may be changed. Check all communications settings to be sure that the Drive Address, Baud Rate, and serial port are correct. If unable to determine the appropriate settings, the Auto Detect routine will automatically scan for serial port and Baud Rate settings.

Faulty connection cables are also a possible cause of connection problems. Check all cables for any shorts or intermittent connections. Also check that all port hardware (USB-to-serial, etc.) is properly installed and configured.

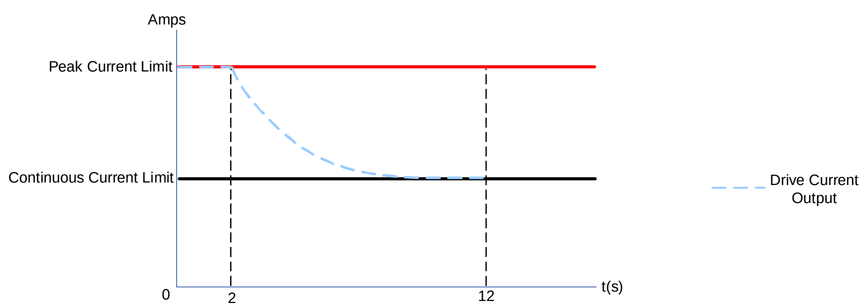
B.1.3 Overload

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip. Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive datasheets for minimum inductance requirements.

B.1.4 Current Limiting

All drives incorporate a “fold-back” circuit for protection against over-current. This “fold-back” circuit uses an approximate “I t” algorithm to protect the drive. All drives can run at peak current for a maximum of 2 seconds (each direction). Currents below this peak current but above the continuous current can be sustained for a longer time period, and the drive will automatically fold back at an approximate rate of "I t" to the continuous current limit within a time frame of less than 10 seconds. An over-current condition will not cause the drive to become disabled unless configured to do so in DriveWare.

FIGURE B.1 Peak Current Fold-Back



B.1.5 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, or by using DriveWare to reverse the internal velocity feedback polarity setting.

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper motor commutation or poor loop tuning. Follow the steps in the DriveWare Software Guide to properly commutate and tune the motor.

B.1.6 Causes of Erratic Operation

- Improper grounding (i.e., drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive voltage spikes on bus.

B.2 Technical Support

For help from the manufacturer regarding drive set-up or operating problems, please gather the following information:

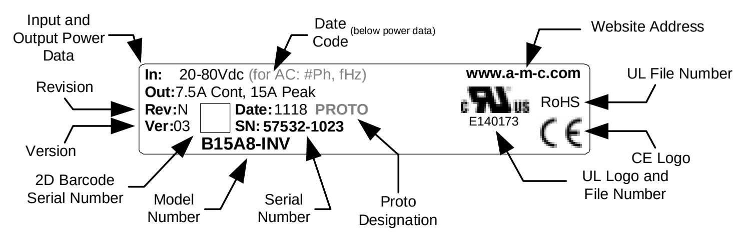
B.2.1 Drive Model Information

- DC bus voltage and range.
- Motor type, including inductance, torque constant, and winding resistance.
- Length and make-up of all wiring and cables.
- If brushless, include Hall sensor information.
- Type of controller, plus full description of feed back devices.
- Description of problem: instability, run-away, noise, over/under shoot, or other description.
- Complete part number and serial number of the product. Original purchase order is helpful, but not necessary.

B.2.2 Product Label Description

The following is a typical example of a product label as it is found on the drive:

FIGURE B.2 Product Label



1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with the same model number and revision letter ('01' is the earliest release of any revision).
4. Proto Designation: When included, indicates that the model is a prototype unit and model number will also begin with an 'X' designator.
5. Serial Number: The serial number consists of a 5-digit lot number followed by a 4-digit sequence number. Each product is assigned a unique serial number to track product life cycle history.
6. Date Code: The date code is a 4-digit number signifying the year and week of manufacture. The first two digits designate the year and the second two digits designate the week (e.g. the drive label shown would have been built in the year 2011 during the 18th week).
7. Input and Output Power Data: Includes basic power parameters of the product.
8. General Information: Displays applicable agency approvals, UL file reference number, and compliance approvals. More complete product information is availabe by following the listed website.

B.2.3 Warranty Returns and Factory Help

Seller warrants that all items will be delivered free from defects in material and workmanship and in conformance with contractual requirements. The Seller makes no other warranties, express or implied and specifically NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Seller's exclusive liability for breach of warranty shall be limited to repairing or replacing at the Seller's option items returned to Seller's plant at Buyer's expense within one year of the date of delivery. The Seller's liability on any claim of any kind, including negligence, for loss or damage arising out of, connected with or resulting from this order, or from the performance or breach thereof or from the manufacture, sale, delivery, resale, repair or use of any item or services covered by or furnished under this order shall in no case exceed the price allocable to the item or service or part thereof which gives rise to the claim and in the event Seller fails to manufacture or deliver items other than standard products that appear in Seller's catalog. Seller's exclusive liability and Buyer's exclusive remedy shall be release of the Buyer from the obligation to pay the purchase price. IN NO EVENT SHALL THE SELLER BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Buyer will take all appropriate measures to advise users and operators of the products delivered hereunder of all potential dangers to persons or property, which may be occasioned by such use. Buyer will indemnify and hold Seller harmless from all claims of any kind for injuries to persons and property arising from use of the products delivered hereunder. Buyer will, at its sole cost, carry liability insurance adequate to protect Buyer and Seller against such claims.

All returns (warranty or non-warranty) require that you first obtain a Return Material Authorization (RMA) number from the factory.

Request an RMA number by:

web	www.a-m-c.com/download/form/form_rma.html
telephone	(805) 389-1935
fax	(805) 389-1165

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