ADVANCED
MOTION CONTROLS

Everything's possible.

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

for Electric Mobility and Vehicular Applications

Hardware Installation Manual

ORIGINAL INSTRUCTIONS

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:

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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

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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

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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.

⚠️ **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.

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⚠ **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.

⚠ **W a r n i n g**	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.

⚠ **C a u t i o n**	• 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.

⚠ **C a u t i o n**	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.

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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 µH.

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

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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.
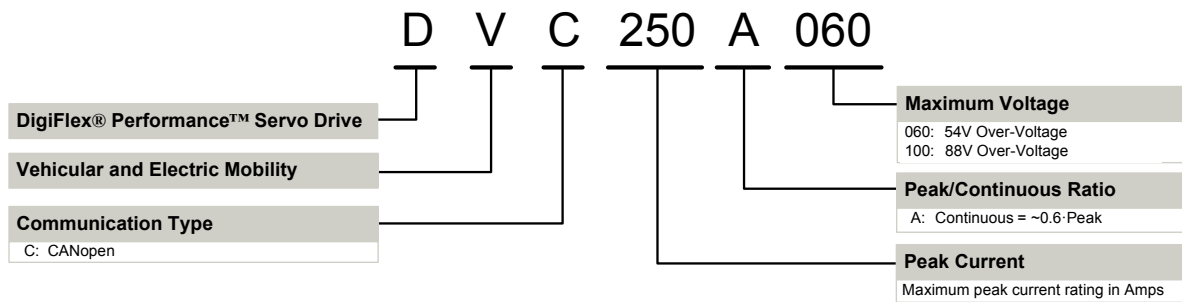
⚠ **Caution**

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.

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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

D V C 250 A 060

DigiFlex® Performance™ Servo Drive

Vehicular and Electric Mobility

Communication Type
C: CANopen

Maximum Voltage
060: 54V Over-Voltage
100: 88V Over-Voltage

Peak/Continuous Ratio
A: Continuous = ~0.6·Peak

Peak Current
Maximum peak current rating in Amps

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	µF	12600	6000
Minimum Load Inductance (Line-To-Line)	µH	200	250

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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
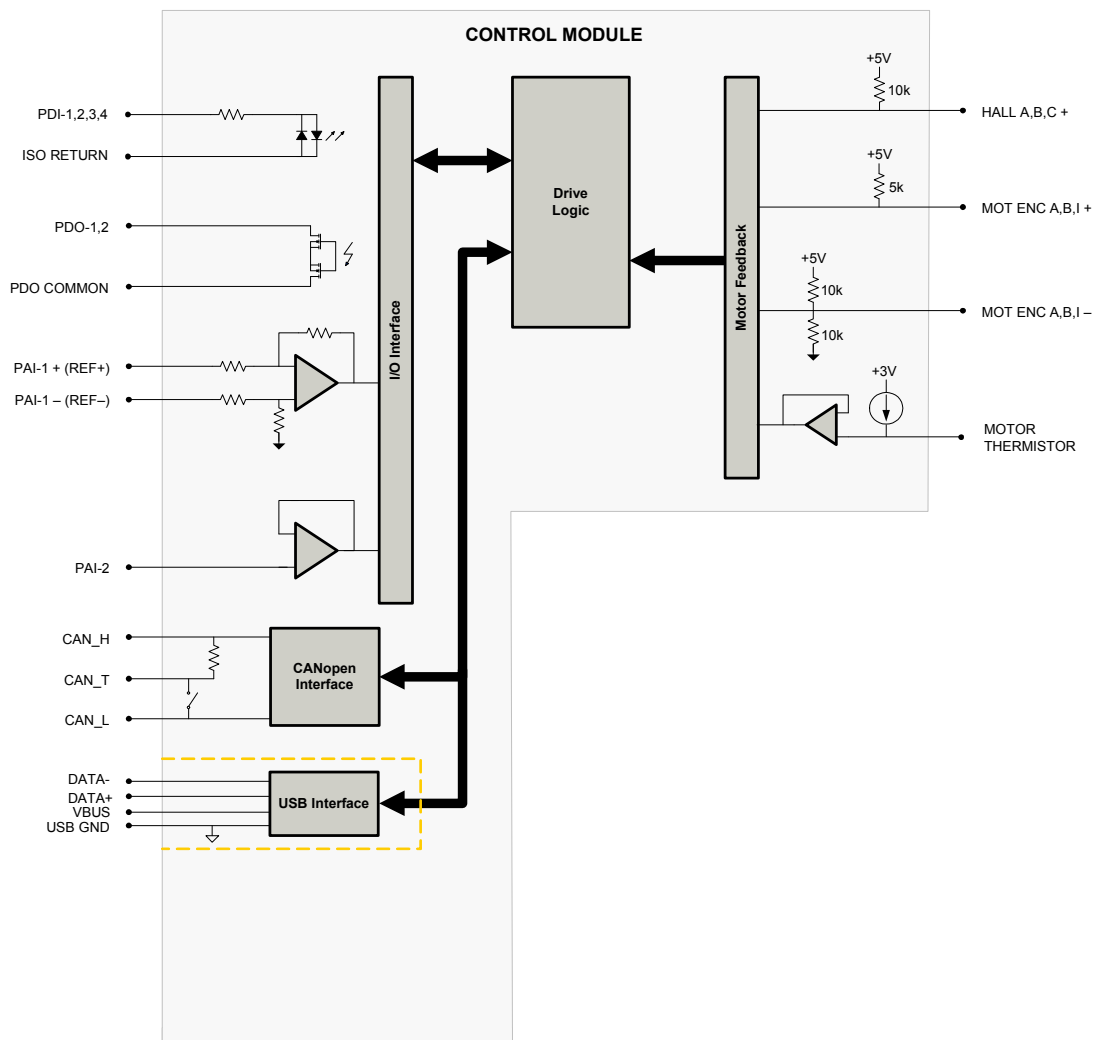
2.2.2 DC Power Modules

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
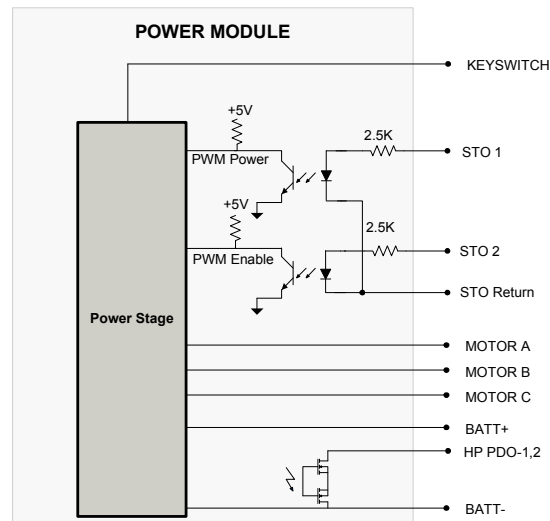
250A060

- 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)

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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 43 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.

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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.

> ℹ️ **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. 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.
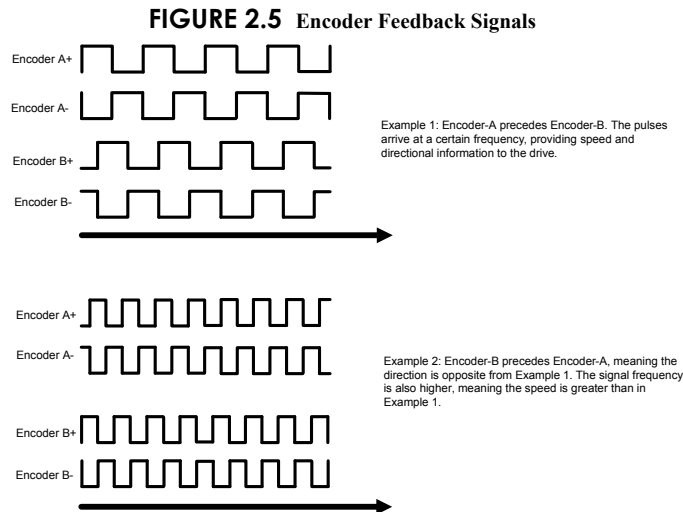
> **(i)** Hall velocity mode is not optimized for relatively high or relatively low Hall frequencies. To determine if Hall velocity mode is right for your application, contact Applications Engineering.
> *Note*

For more information on using Hall Sensors for trapezoidal commutation, see "Trapezoidal Commutation" on page 44.

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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

Example 1: Encoder-A precedes Encoder-B. The pulses arrive at a certain frequency, providing speed and directional information to the drive.

Example 2: Encoder-B precedes Encoder-A, meaning the direction is opposite from Example 1. The signal frequency is also higher, meaning the speed is greater than in Example 1.

> **i** 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 43.

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
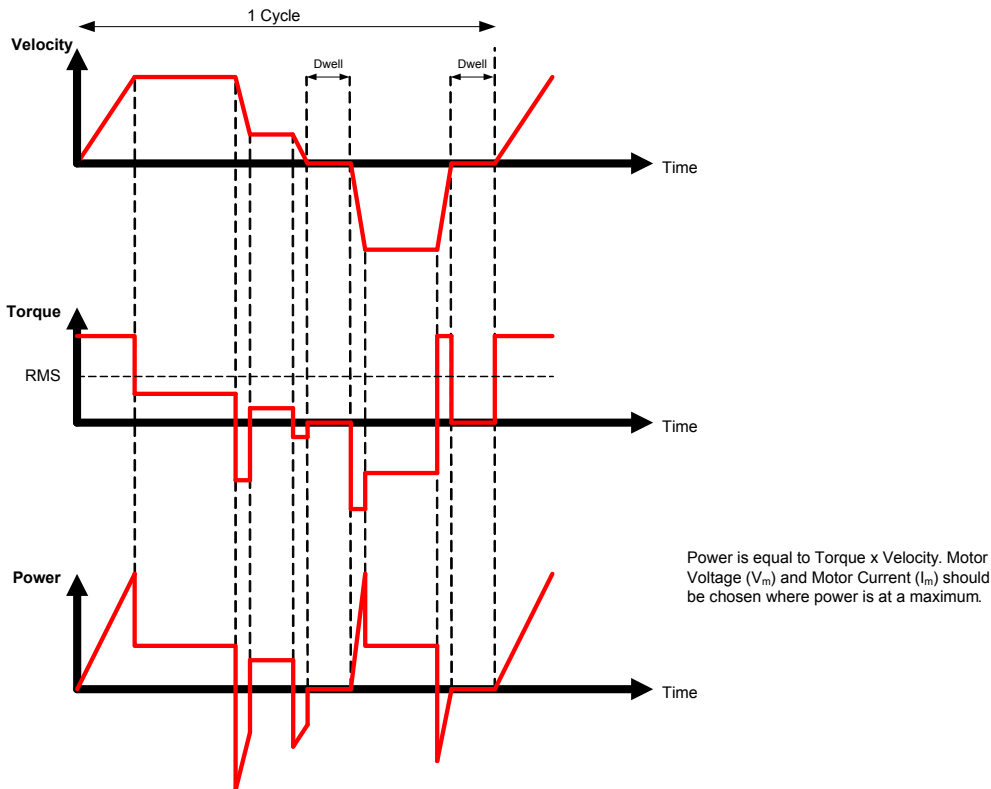
2.7.2 Motor Controller Selection and Sizing

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_i is the torque and t_i 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 $\qquad T = K_t I_m$

for linear motors $\qquad F = K_f I_m$

Where:

V_m	-motor voltage
I_m	-motor current (use the maximum current expected for the application)
R_m	-motor line-to-line resistance
E	-motor back-EMF voltage
T	-motor torque
F	-motor force
K_t	-motor torque constant
K_f	-motor force constant
K_e	-voltage constant
S_m	-motor speed (use the maximum speed expected for the application)

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The motor manufacturer's data sheet contain K_t (or K_f) and K_e 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_e = 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_t. For example, a motor with K_t = 0.5 Nm/A and maximum torque of 5 Nm would require 10 amps of current. Continuous current is RMS torque divided by K_t.

Motor Inductance

The motor inductance is vital to the operation of motor controllers, 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 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).

$$V_m \ = \ (R_m + j\omega L)I_m + E$$

Where:

L	-phase-to-phase motor inductance
ω	-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.

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

Where:

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

Use values of V_m and I_m 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.
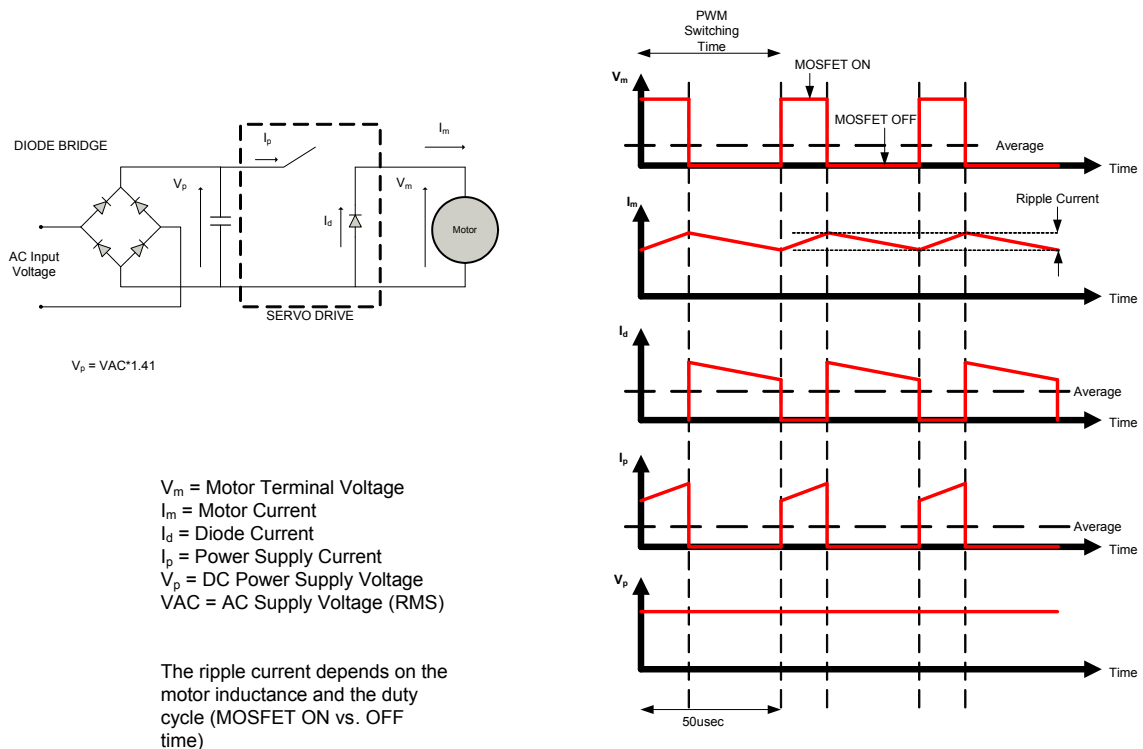
The power supply current is a pulsed DC current (Figure 2.7): when the MOSFET switch is on, it equals the motor current; when the MOSFET is off it is zero. Therefore, the power supply current is a function of the PWM duty cycle and the motor current (e.g. 30% duty cycle and 12 amps motor current will 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%.

> ⚠️
> **Caution**
>
> 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.

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FIGURE 2.7 Unregulated DC Power Supply Current

V_m = Motor Terminal Voltage
I_m = Motor Current
I_d = Diode Current
I_p = Power Supply Current
V_p = DC Power Supply Voltage
VAC = AC Supply Voltage (RMS)

The ripple current depends on the motor inductance and the duty cycle (MOSFET ON vs. OFF time)

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_t and K_e, and losses in the system external to the motor controller. The selected margin depends on the system parameter variations.


> ⚠ **Caution**
>
> 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.

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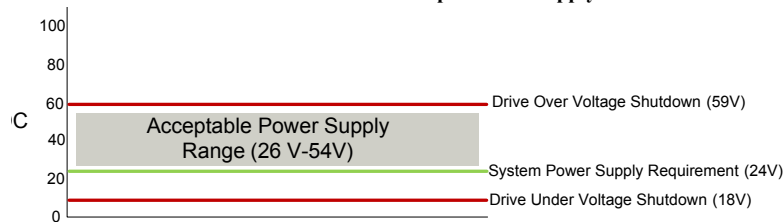
Isolation   In systems where an AC line is involved, isolation is required between the AC line and the signal pins on the motor drive. This applies to all systems except those that use a battery as a power supply. There are two options for isolation:

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

	Torque	Velocity	
I	Torque +	Velocity +	No Regen
II	Torque -	Velocity +	Regen
III	Torque -	Velocity -	No Regen
IV	Torque +	Velocity -	Regen
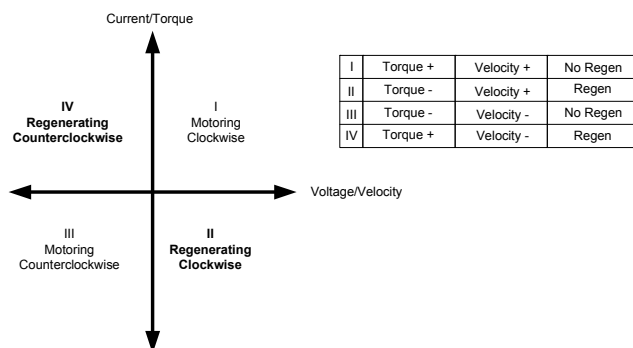
This regenerated energy can charge the power supply capacitors to levels above that of the motor controller over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must 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_i -initial energy
E_f -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:

$$E_c = \frac{1}{2}CV_{nom}^2$$

Where:

E_c -energy stored in a capacitor (joules)
C -capacitance
V_{nom} -nominal bus voltage of the system

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

Where:

E_r	-kinetic (mechanical) energy of the load (joules)
J	-inertia of the load (kg-m^2)
ω	-angular velocity of the load (rads/s)

$$E_p = mgh$$

Where:

E_p	-potential mechanical energy (joules)
m	-mass of the load (kg)
g	-gravitational acceleration (9.81 m/s^2)
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:

$$(E_c \cdot E_r \cdot E_p)_i = (E_c \cdot E_r \cdot E_p)_f$$

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

Which simplifies to:

$$V_f = \sqrt{V_{nom}^2 + \frac{J}{C}(\omega_i^2 - \omega_f^2) + \frac{2mg(h_i - h_f)}{C}}$$

The V_f 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

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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_R -voltage ripple
C_{PS} -power supply capacitance
I_{PS} -power supply output current
F_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:

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

Where:

I_M	-current through the motor
V_{PS}	-nominal power supply voltage
V_M	-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 75ºC. 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 75ºC. 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

Maximum Ambient °C
DVC250A060 Drive Models at 48VDC
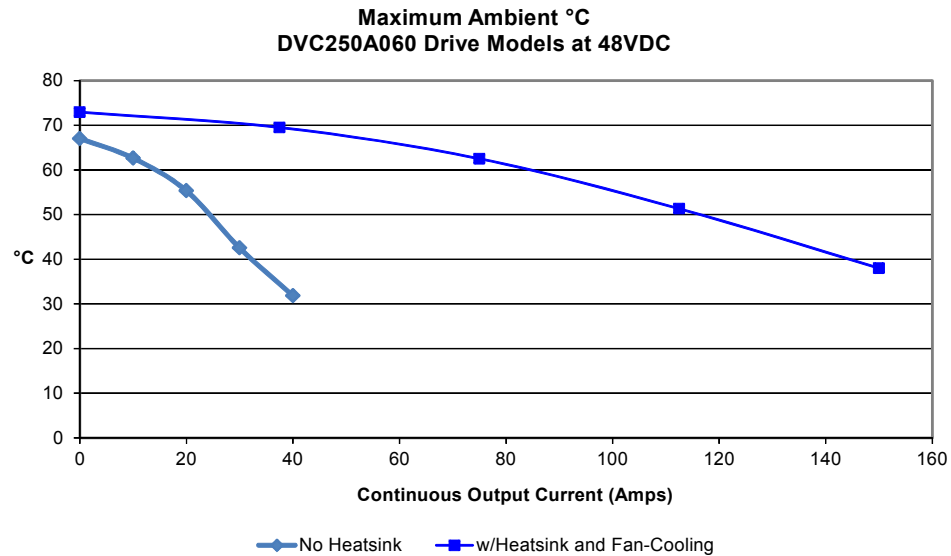
1. Heatsink used is a 15" x 22" x 0.65" aluminum plate.
2. Fan used is a 118 CFM NMB-MAT Model: 4715KL-05W-B40 - blowing directly up underneath the motor controller on the underside of the heat-sink.
3. Consult *ADVANCED* Motion Controls for DVC200A100 thermal data.

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 48 and the dimensional drawings and information on the datasheet.

> ⚠️ 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.
>
> C a u t i o n

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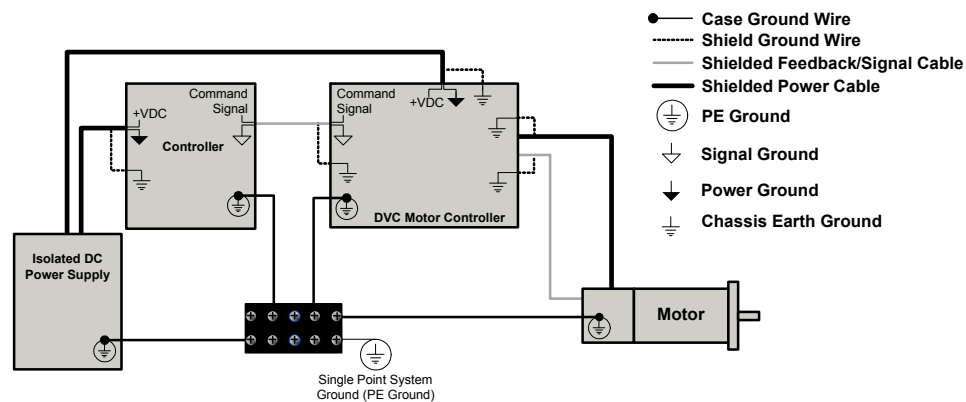
Ground cable shield wires at the drive side to a chassis earth ground point.

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.

⚠ **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.

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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	Current (A)	Minimum Wire Size (AWG)	mm^2
10	#20	0.518	60	#10	5.26
15	#18	0.823	80	#8	8.37
20	#16	1.31	120	#6	13.3
35	#14	2.08	150	#0	53.5
45	#12	3.31	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.

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

Caution

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.
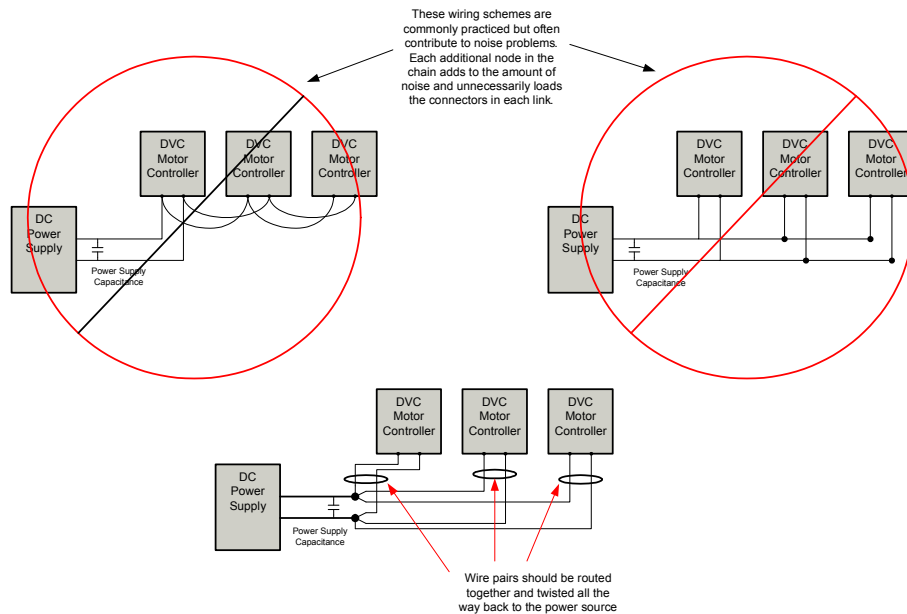
3.4.3 Power Supply Wires

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**

These wiring schemes are commonly practiced but often contribute to noise problems. Each additional node in the chain adds to the amount of noise and unnecessarily loads the connectors in each link.

Wire pairs should be routed together and twisted all the way back to the power source

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
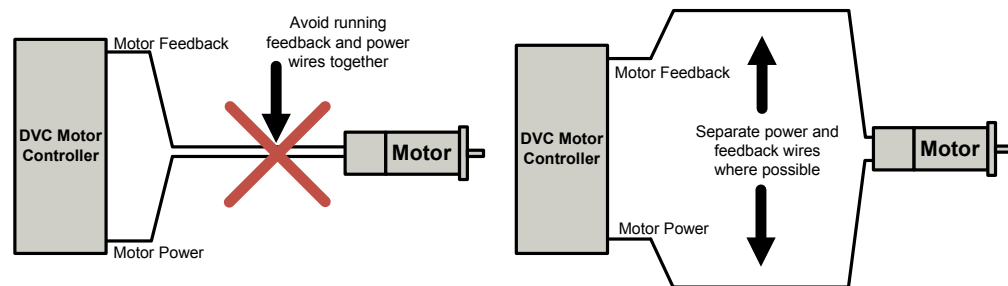
3.4.5 I/O and Signal Wires

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.

> ⚠ **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.

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
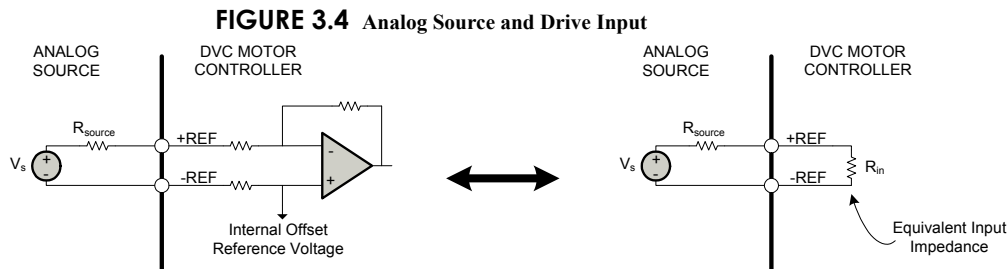
The DVC motor controller's analog input can be simplified to a single impedance, R_{in}, as shown in Figure 3.4. If the impedance of R_{source} is of the same magnitude or larger than R_{in}, there will be a significant voltage drop across R_{source}. Reduced values of R_{source} cause a lower voltage 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
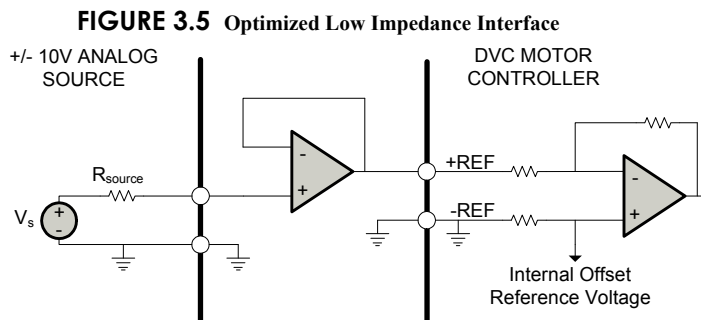
3.5 Connector Types

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

+5V OUT 12
MOT ENC I+ 11
MOT ENC B+ 10
MOT ENC A+ 9
CAN_T 8
PAI COMMON 7
PAI-2 6
STORET 5
PDO COMMON 4
PDI-1 3
PDI COMMON 2
HP PDO-1 1

13 HP PDO-2
14 PDI-2
15 PDO-1
16 STO-1
17 POT HIGH
18 PAI-1- (REF-)
19 CAN_L
20 MOT ENC A-
21 MOT ENC B-
22 MOT ENC I-
23 FEEDBACK COMMON

KEYSWITCH 24
PDI-3 25
PDI-4 26
PDO-2 27
STO-2 28
PAI-1+ (REF+) 29
CAN_GND 30
CAN_H 31
HALL 1 32
HALL 2 33
HALL 3 34
MOTOR THERMISTOR 35

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

USB GND 5
RESERVED 4
DATA + 3
DATA - 2
VBUS 1

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

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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.

⚠️

C a u t i o n

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 50.

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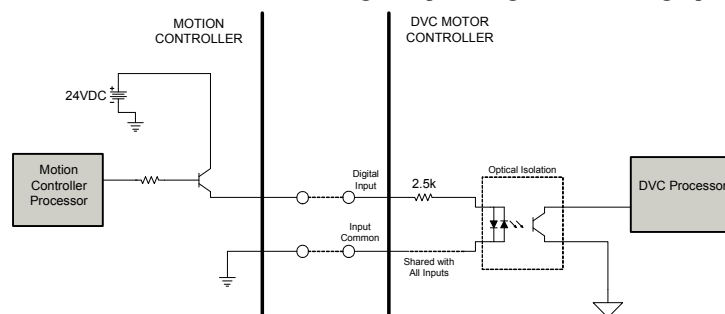
To configure the Isolated Digital Input as sourcing 24V is applied to the Input Common and the 24V ground is modulated at the digital input. Figure 4.2 shows the 24V supply rearranged so it feeds into the Input Common pin. As in the previous example, other switching devices can control the inputs besides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

FIGURE 4.2 **24VDC Isolated Digital Input configured as a sourcing input.**
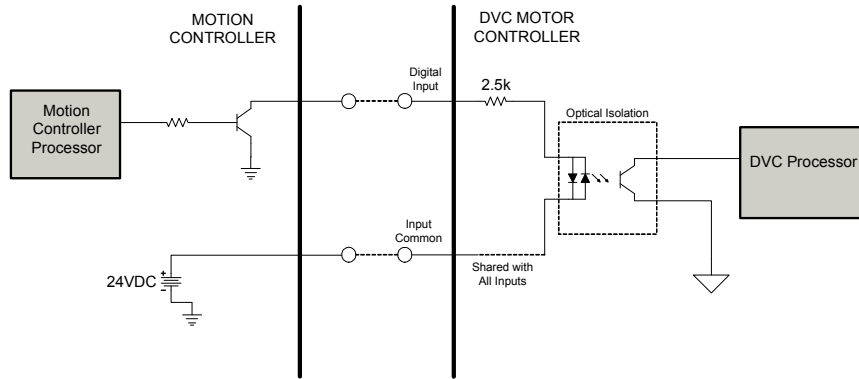
- **Outputs** - The Isolated Digital Outputs have a common grounding point labeled Output Common, and are +24VDC single-ended outputs.

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.**
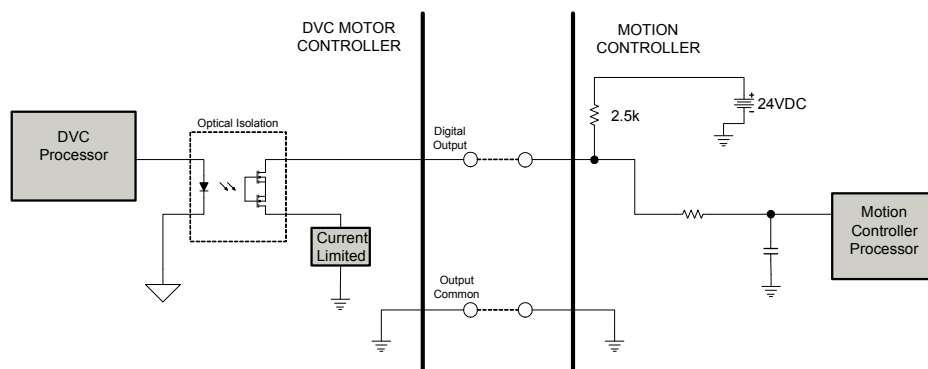
Programmable Analog Inputs   The Programmable Analog Inputs can be assigned to drive functions in DriveWare or used as analog input commands. PAI-1 is used for a ±10V analog input command, and PAI-2 is used for 0-5V or 0-5kohm command options. DVC motor controllers provide a +5V, 5mA supply output for 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**
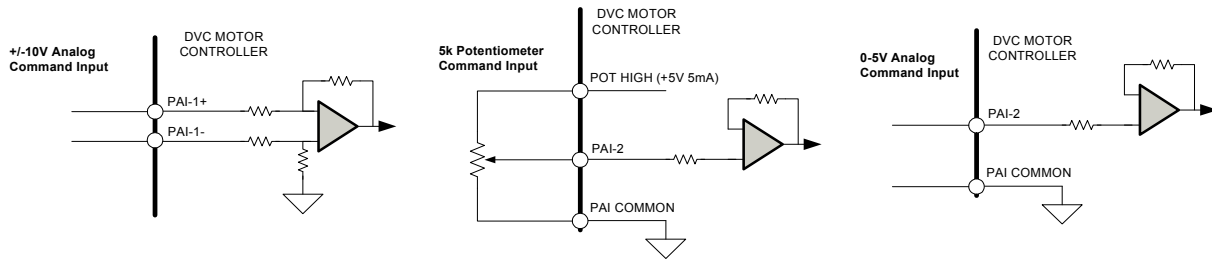
High Powered Programmable Digital Outputs   DVC motor controllers feature two High Powered Programmable Digital Outputs that are DIP Switch selectable for 24, 36, 48, or 72 V and can sink up to 3 A. A user-supplied load can be connected between the Keyswitch input and the HPDO.

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.

W a r n i n g

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 HDPO 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**
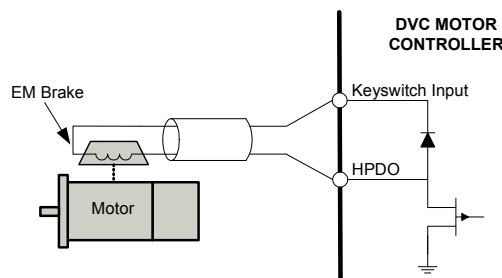
4.1.3 Feedback Operation

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**
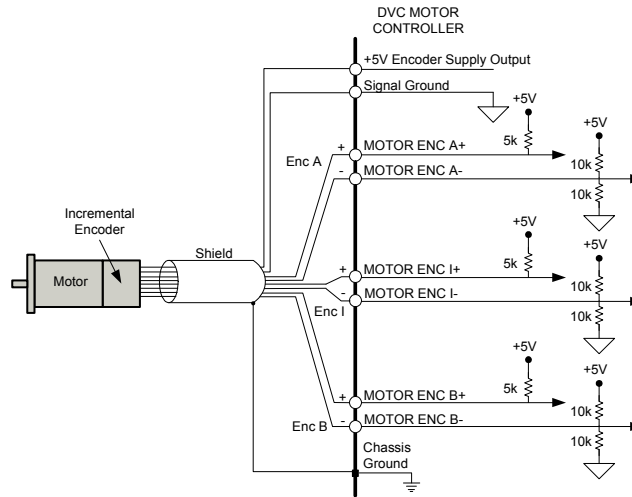
Hall Sensors DVC motor controllers accept Hall Sensor feedback primarily for commutation, although they can also be used for velocity control. The drive allows differential or single-ended Hall Sensor inputs. For single-ended Hall signals leave the negative terminals open. Verify on the motor datasheet 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**
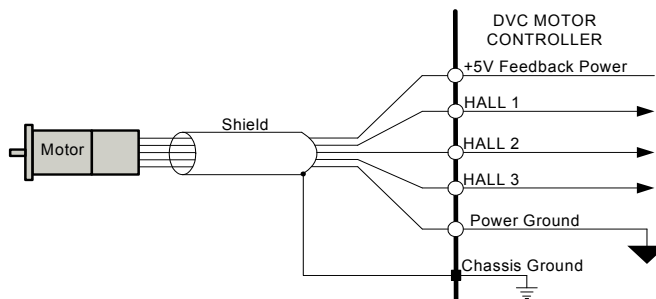
Tachometer (±10 VDC)   DVC motor controllers support the use of a tachometer for velocity feedback. The differential Programmable Analog Input is available for use with a tachometer. The tachometer signal is limited to ±10 VDC.

FIGURE 4.8 **Tachometer Input Connections**
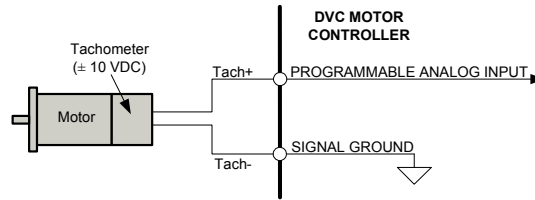
±10 VDC Position   DVC motor controllers support the use of ±10 VDC position feedback, typically through the use of a load-mounted potentiometer. The differential Programmable Analog Input is available for ±10 VDC position feedback.

FIGURE 4.9 **±10 VDC Position Feedback Connections**
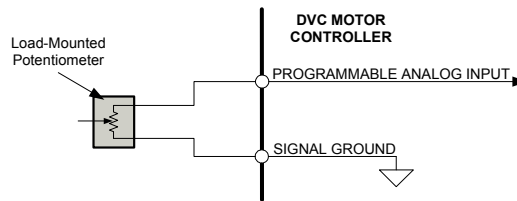
4.1.4 Motor Connections

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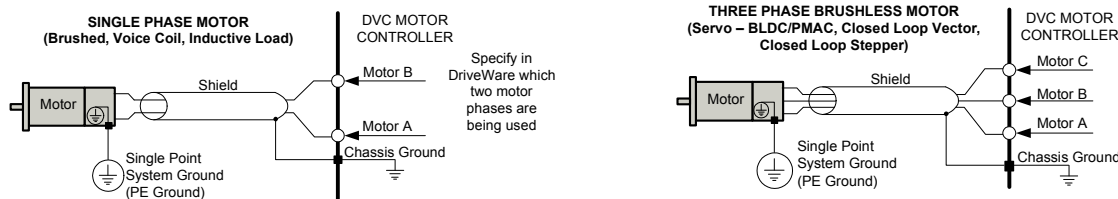
⚠ **Caution** If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

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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**
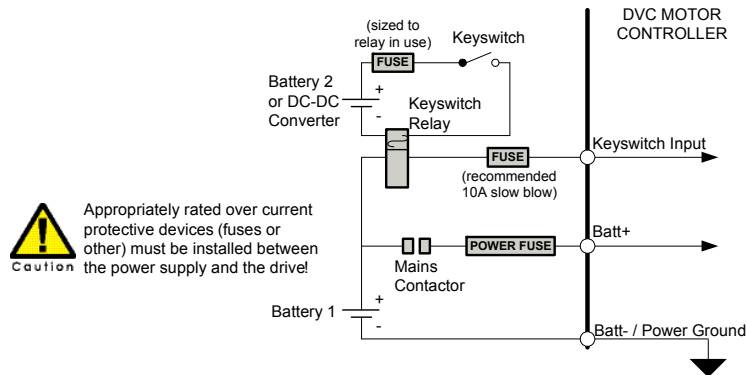
4.1.6 STO (Safe Torque Off)

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**
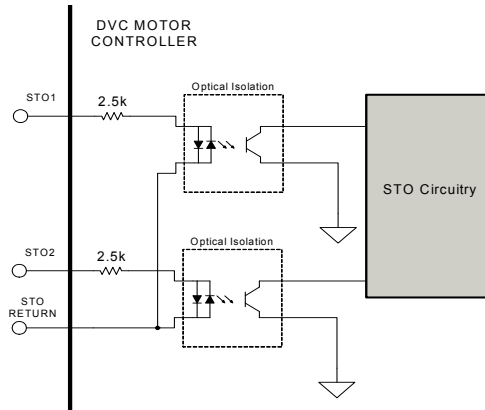
4.1.7 LED Functionality

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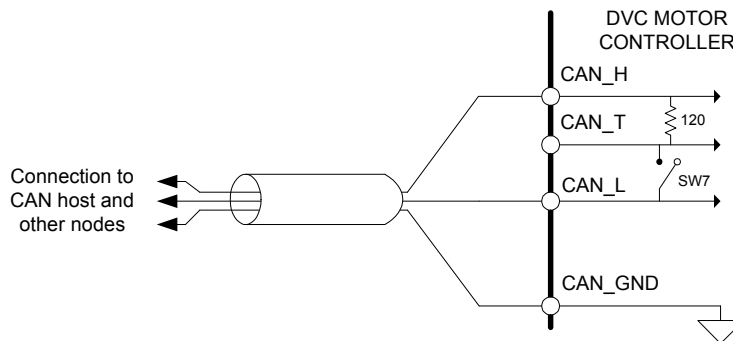
USB Interface   For drive commissioning, the DVC motor controller must be connected to a PC running *ADVANCED* Motion Controls' DriveWare software. The mini type-b USB port on the DVC motor controller should be used with a STD-A to MINI-B USB cable for connection to a USB port on a PC.

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**
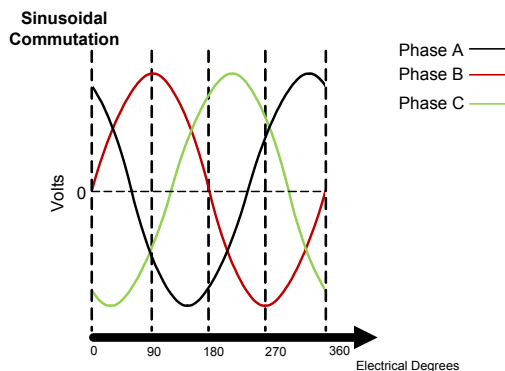
Trapezoidal Commutation   Trapezoidal commutation is accomplished with the use of Hall Sensors on three phase (brushless) motors. DVC motor controllers can commutate trapezoidally when used with properly spaced Hall Sensors. Unlike sinusoidal commutation, current flows through only two motor phases at 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
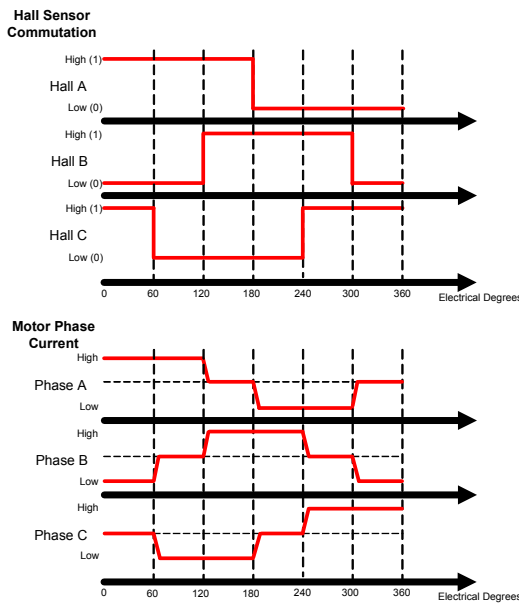
Note: Not all *ADVANCED* Motion Controls' servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

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	μF	12600	6000
Minimum Load Inductance (Line-To-Line)	μH	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 ℃ (32 - 167 ℉)
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

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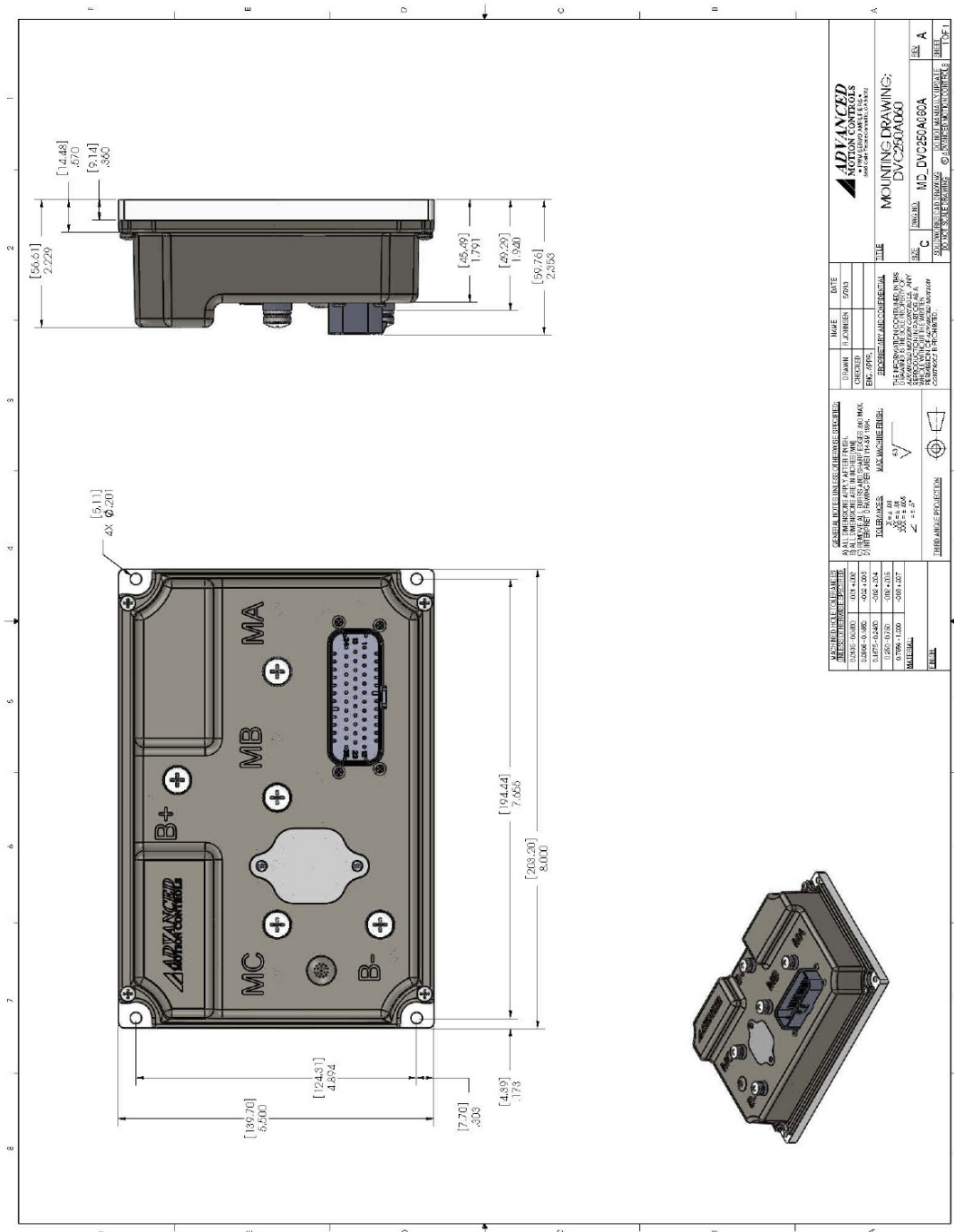
This section discusses how to ensure optimum performance and, if necessary, get assistance from the factory.

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.

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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 44 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^2t" 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^2t" 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
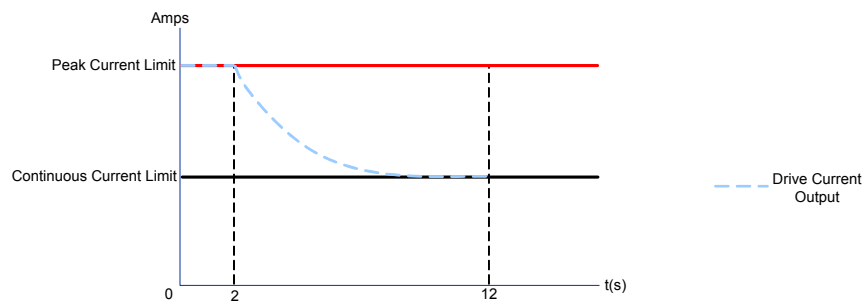
B.1.5 Motor Problems

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
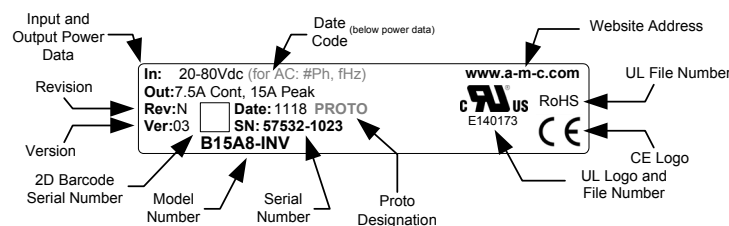
1. Model Number: This is the main product identifier. The model number can have a suffix designating a change from the base model.
2. Revision Letter: Product revision level letter ('A' is the earliest release from any model).
3. Version: The version number is used to track minor product upgrades with 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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MNDVDCIN-01

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