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Hardware Manual:

Wiring and Installation

Document Part Number: 34-2100 R2

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1.0 Preface

This manual describes the installation and wiring of servo drives, controllers, and motor/drive combinations manufactured by Allied Motion Technologies, Inc.

Every effort has been made to ensure the accuracy of information in this manual. However, Allied Motion assumes no responsibility for any errors or omissions. The information contained within this document is regularly reviewed and we welcome your critical evaluation and suggestions for improvement. Allied Motion reserves the right to modify all documentation without prior notice. Be sure to download the most recent revision of this manual from the company website.

Table 1: Applicable Allied Motion Products

Product Family	Part Number	Description
EnduraMax iDrive	EMI-065xxxxx EMI-075xxxxx EMI-095xxxxx	65mm, 75mm, 95mm EnduraMax motors with integrated drive and encoder
EnduraMax sDrive	EMS-065xxxxx EMS-075xxxxx EMS-095xxxxx	65mm, 75mm, 95mm EnduraMax motors with integral sensorless drive
Housed Megaflux motor with drive	MFH-xxxxxx	110mm, 140mm, 170mm Megaflux motors with integrated drive and high resolution optical encoder
AC xDrive	XDA-xxxxxxxx	AC powered brushless servo drive
SX Drives	SXD-xxxxxxxx	DC powered brush-brushless servo drive
SX Controllers	SXC-xxxxxxxx	DC powered brush-brushless single axis servo controller
MX Controllers	MXC-xxxxxxxx	DC powered brush-brushless multiple axis servo controller

2.0 Safety

Read all provided documentation before assembly and commissioning. Failure or incorrect or improper use of this equipment can cause death, personal injury, and consequential damage. The final responsibility for the safe use of Allied Motion products is solely that of the user.

Do not wire the drive and apply full power to it without checking it first at low power levels for correct operation.

When drives or motors are powered, high voltages are present on the connector and elsewhere in the drive and can be dangerous. The drive cover should not be removed with the power on, and then only by a competent and trained engineer. It is important that all system components be properly grounded.

3.0 Tables

4.0 Figures

5.0 Wiring

This section summarizes the recommended practices for installation of servo equipment. These practices are based on and consistent with IEEE Standard 518-1982, “IEEE Guide for Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources”, particularly Section 6, “Installation, Recommendations and Wiring Practices”. This standard must be followed during assembly of our product in a machine.

It is highly recommended that Allied Motion products are used in end-products which comply with Machinery Directive 2006/42/EC and directive EMC Directive 2004/108/EC. All equipment grounding should also be in conformance with applicable national and local electrical codes. Failure to follow recommended procedures might result in incorrect system operation and void the product warranty.

5.1 Wire Size

The following table can be used for reference when selecting wire sizes for motors and drives. Consult applicable national or local electrical codes for specific guidelines.

Table 2: Wire Size Recommendations

Current (A)	Minimum Wire Size (AWG)	Minimum Wire Size (mm^2)
< 1	28	0.08
5	20	0.52
10	18	0.82
15	16	1.3
20	14	2.1
30	12	3.3
40	10	5.2
60	8	8.3
80	6	13.3

5.2 Motor Wiring

The following instructions apply to wiring the motor phase leads to the drive/controller. They do not apply to motor/drive combinations as this connection is made internal to the assembly.

It is recommended that twisted and shielded cable be used for motor wiring. For a brushed motor, twist the 2 motor leads. For a brushless motor, twist the 3 motor phase leads as a group.

5.3 Power Wiring

It is recommended that power wiring from the supply to the drive/controller or motor/drive combination be kept as short as possible. Power and return leads should be twisted and shielded to reduce inductance.

Power cables should not be daisy chained from drive to drive. Each power supply cable should be grounded at the drive chassis ground point. There should be a single ground point in the system, if at all possible. Ground connections for multiple drives should be wired in a “star” configuration.

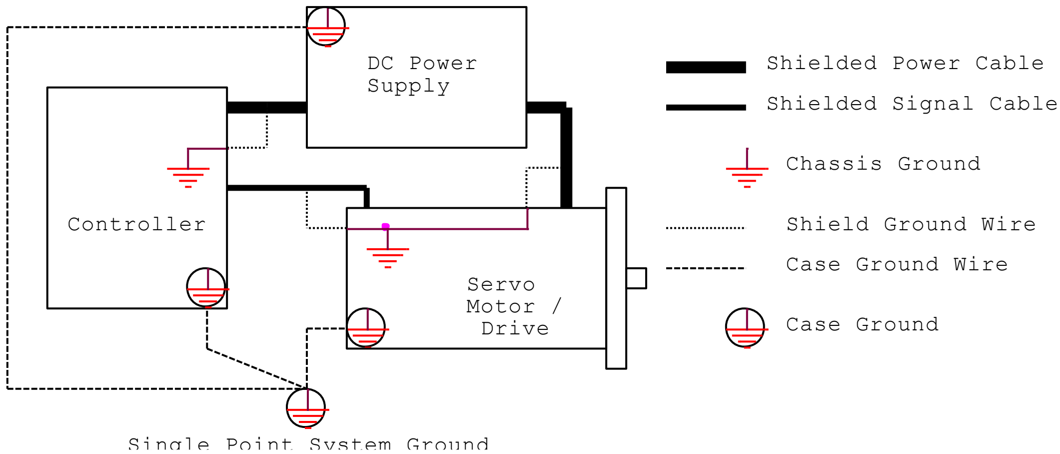

Figure 1: Example, Single-Point Ground for Integrated Motor/Drive and Controller

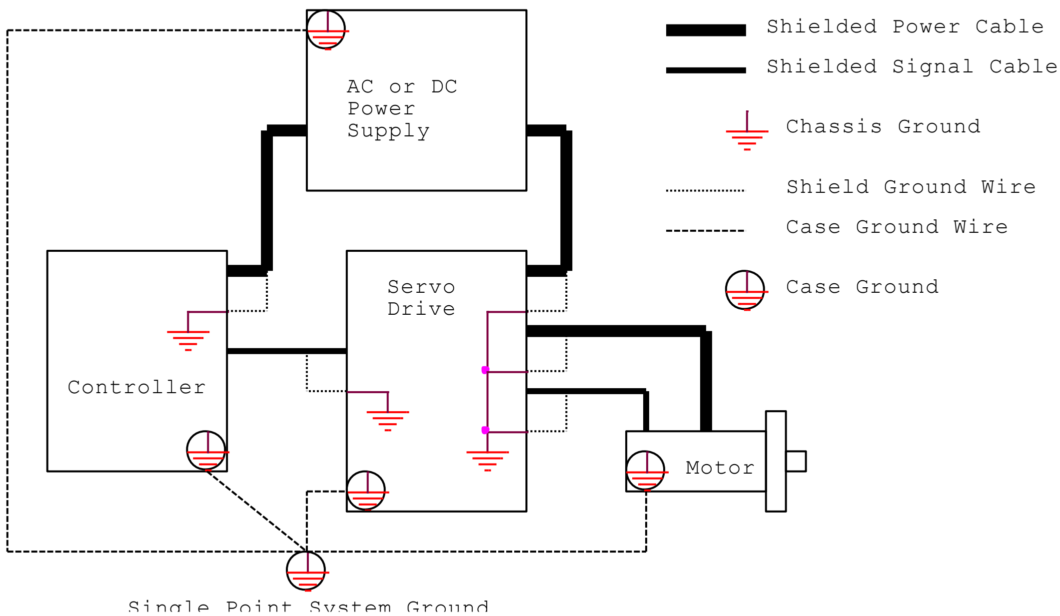

Figure 2: Example, Single-Point Ground for Stand-Alone Motor, Drive, and Controller

5.3.1 Line Filters

AC power lines brought into the panel can allow EMI to enter the panel. This is especially true in facilities that have silicone controlled rectifier (SCR) devices, such as variable speed drives and heating or welding devices. Line filters should be placed in the incoming power lines immediately after the safety circuits and before any critical control components.

Line filters can be necessary to achieve conducted noise levels that meet requirements for the CE Mark. Mount filters as close as possible to the incoming power feed as practical. The incoming power feed should be as short and direct as possible.

Do not bundle wiring from filtered sources together with unfiltered wiring.

5.4 Signal Wiring

Signal wiring (current less than 1 A) such as motor feedback wires or small signal analog wiring should be twisted shielded cables. The shield of the cable should be grounded at one end of the cable, usually the drive end. Signal wires should be separated physically from power and motor wires as much as possible to reduce noise in the signal wires.

Special care needs to be taken when wiring motor hall sensor feedback signals. Hall signals are typically open-collector in form, which means that they are most susceptible to noise pickup. Hall wiring should never be run with or near motor power wires, even if they are in a separate shielded cable.

It is recommended that signal wires are sized between 22 AWG and 28 AWG.

5.5 Grounding

Proper grounding is absolutely necessary for the motor and drive to work properly in a system. There are several important system grounds that must be made.

In addition, motion control servo systems contain circuitry that can be affected by electromagnetic interference (EMI). They also contain switching circuitry that can generate significant EMI at frequencies from 10 kHz to 300 MHz. The potential exists for this switching noise to interfere with the correct operation of both the servo system and any other electrical equipment in the vicinity. Immunity to and generation of EMI is greatly affected by installation techniques.

5.5.1 Drive and Controller Grounding

Drives or controllers which are mounted to a cabinet panel using mounting screws must have one mounting screw that connects the drive housing to earth ground. The screw will ground the drive housing provided the panel/cabinet containing the drive is metal and also properly grounded. A star lock washer should be used under the mounting screw head to ensure good electrical contact between the drive and the screw.

5.5.2 Motor Grounding

The motor housing should be attached to system ground whether or not the motor is separate from the drive or in a motor/drive combination.

6.0 Panel Layout

How parts are mounted and grounded will play an important role in reducing the effects of EMI. Proper control panel layout can be achieved by observing the following simple rules:

- To obtain rated output current from the drive, the ambient air temperature on the surface of the drive enclosure or drive heat sink, if equipped, must be maintained between -40 °C and +45 °C. No heat generating devices, such as transformers, power supplies, or power resistors, should be mounted near the drives in such a manner as to allow heat flow from these devices to the drive chassis.
- Allow a minimum clearance distance of 2 inches (52 mm) between the drive and any other drive or component above, below, or on either side of the drive.
- Do not mix power and control signal wiring in the same conduit, duct, or wire tray without a minimum of 1 inch (26 mm) separation.
- Provide separate wire ways for AC mains, low power AC, high power DC, and low power DC.
- Restrict all high voltage power wiring and power devices such as circuit breakers, contactors, fuses, etc., to an area separate from low-level control wiring.
- When mounting a unit, be sure to remove any paint from the mounting surfaces to obtain metal-to-metal contact. Use a star lock washer to improve the connection. If in doubt use a ground strap to ensure good connection between the unit and the enclosure.
- Use ground straps made of 1 inch (25 mm) silver tinned flat copper braid to connect cabinet doors to enclosures, the first sub-panel to the enclosure, and each sub-panel to the next.
- Where electrical codes call for green safety ground wires, use them in addition to any ground strap suggested in this guide.
- Follow the electrical codes for grounding of any mains power transformer.
- It is recommended that all heat-generating resistors be mounted outside the cabinet within a protective enclosure.
- The wiring must be properly strain relieved to ensure the interconnects, wiring, and terminal connections do not become damaged.

7.0 Digital I/O

Allied Motion provides several different kinds of discrete inputs and outputs for customer use in drives, controllers, and motor/drive combinations. Refer to product datasheet to determine your specifically installed hardware.

7.1 Optically Isolated Inputs

Isolated inputs can be wired in either a current sinking or a current sourcing configuration (see figures for wiring examples). Activation thresholds for optically isolated inputs are given in the following table:

Table 3: Isolated Input Threshold Voltages

	Min	Max
Turn on threshold	5 V	32 V
Turn off threshold	0 V	1.5 V

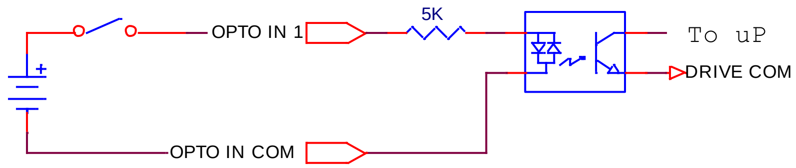

Figure 3: Example, Current Sinking Isolated Input

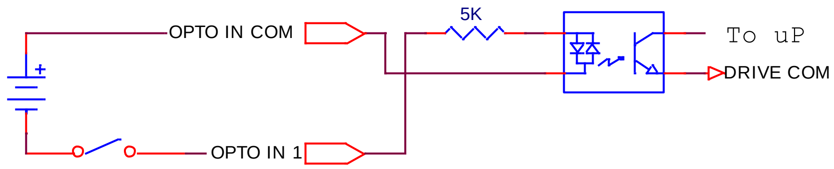

Figure 4: Example, Current Sourcing Isolated Input

7.2 Optically Isolated Outputs

Optically isolated outputs can be wired to sink or source up to 20 mA to a load and can tolerate voltages from 5 VDC to 32 VDC (see figures for wiring examples). These outputs are current limited to 20 mA maximum and are short-circuit protected.

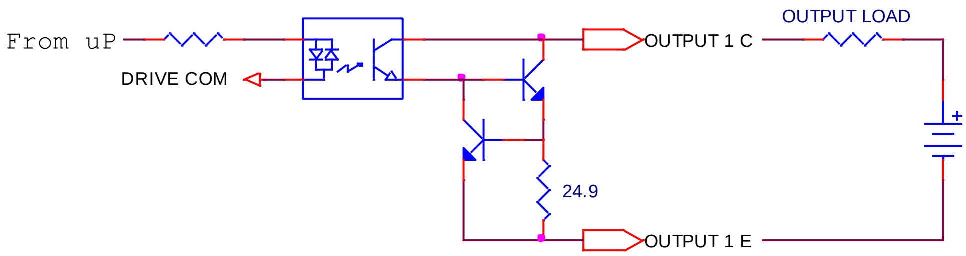

Figure 5: Example, Current Sinking Isolated Output

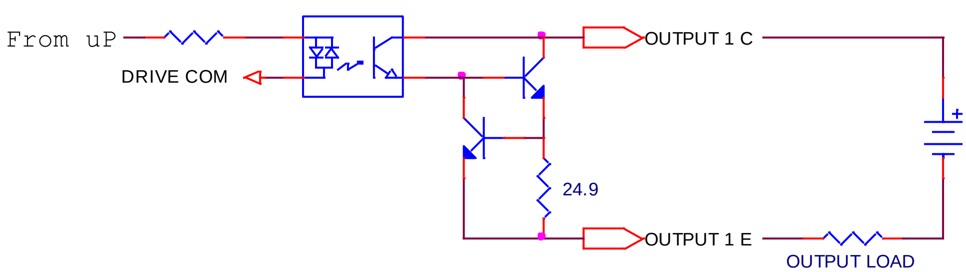

Figure 6: Example, Current Sourcing Isolated Output

7.3 Non-Isolated Inputs

Non-isolated inputs are fixed in function as either current sinking or current sourcing and must be wired accordingly (see figures for wiring examples). Activation thresholds for non-isolated inputs are given in the following tables:

Table 4: Current Sinking, Non-Isolated Input Threshold Voltages

	Min	Max
Turn on voltage	5 V	32 V
Turn off voltage	0 V	1.5 V

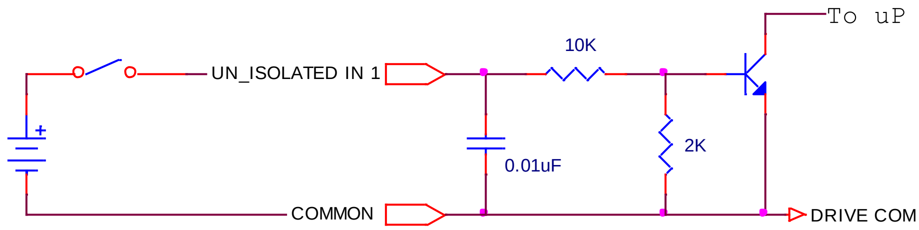

Figure 7: Example, Current Sinking Non-Isolated Input

Table 5: Current Sourcing, Non-Isolated Input Threshold Voltages

	Min	Max
Turn on voltage	0 V	1 V
Turn off voltage	3 V	60 V

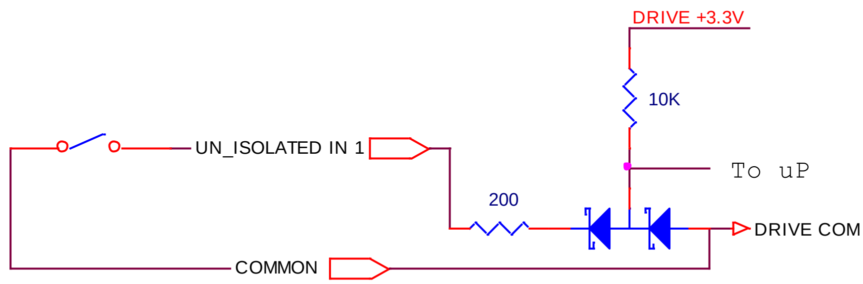

Figure 8: Example, Current Sourcing Non-Isolated Input

7.4 Non-Isolated Outputs

Non-isolated current sinking outputs can sink up to 100 mA from a load and tolerate a voltage of up to 60 VDC. An example of how to connect a load as a sinking output with un-isolated output circuitry is shown here:

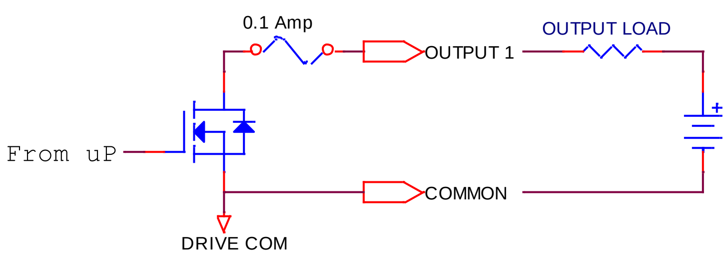

Figure 9: Example, Current Sinking Non-Isolated Output

Non-isolated sourcing outputs do not require a separate power supply to source current to a load. Power is supplied from the drive. The output voltage of the sourcing output is limited to approximately 24 VDC. The output is current limited to 20 mA maximum and is short circuit protected.

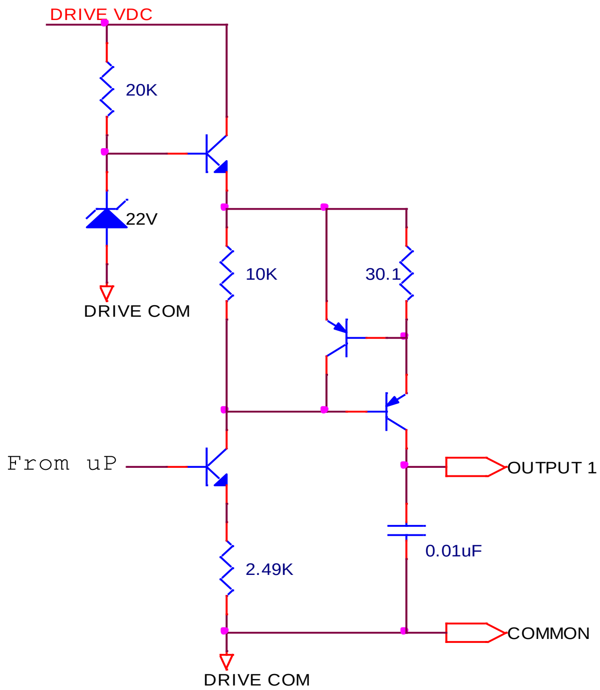

Figure 10: Example, Current Sourcing Non-Isolated Output

8.0 High Speed I/O

Some Allied Motion products are supplied with high speed discrete inputs/outputs. Refer to product datasheet to determine your specifically installed hardware. These high speed inputs and outputs are differential in nature. They are configured to either observe 0 to 5 V inputs or output a 0 to 5 V signal. The input circuits are biased to allow reading of single-ended signals if desired.

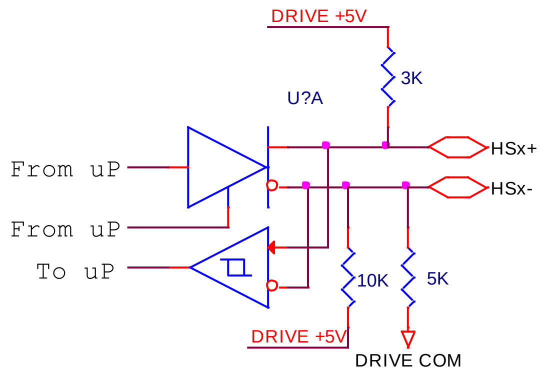

Figure 11: Schematic, High Speed I/O

9.0 Analog I/O

Allied Motion provides several different kinds of analog inputs and outputs for customer use in drives, controllers, and motor/drive combinations. Refer to product datasheet to determine your installed hardware.

9.1 Differential Analog Input

Differential analog inputs are configured to allow the device to observe a voltage of between -10 V and 10 V. A differential input removes common-mode voltages and allows the user to avoid the influence of voltage drop in the ground lead that always exists to some extent, especially when the motor is under heavy load.

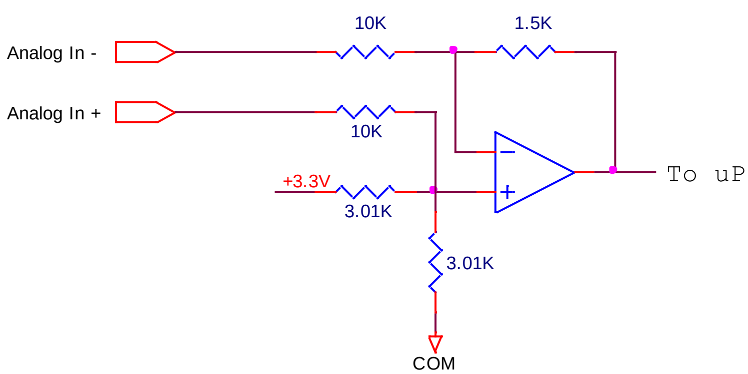

Figure 12: Schematic, Differential Analog Input

9.2 Single-Ended Analog Input

A single ended amplifier is sometimes used as a secondary analog input. It can have a 500 ohm input impedance, which allows a customer to directly read a transducer with a 4-20 mA output. This signal can be used as feedback for an available auxiliary PID loop if the user desires to control a process variable such as pressure, temperature, or air flow that is measured with a 4-20 mA transducer.

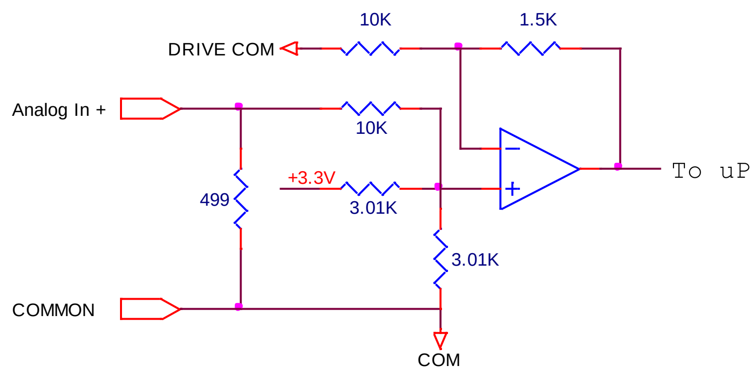

Figure 13: Schematic, Single-Ended Analog Input with 4-20 mA Conversion

9.3 Analog Output

Depending on your specific device, installed analog outputs provide voltages either in the range of 0 to 3.3 V or 0 to 5 V. Consult the device data sheet for your specific output.

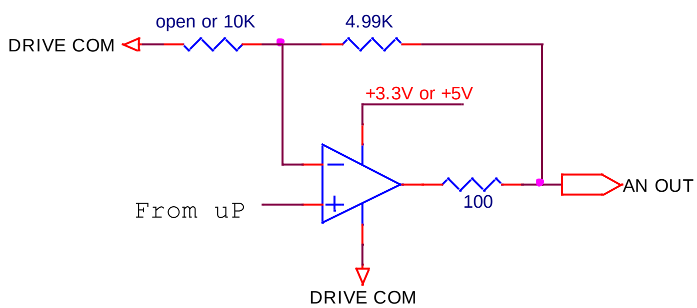

Figure 14: Schematic, Analog Output

10.0 Power Regeneration (Load Dump)

Regeneration occurs when the drive/controller or motor/drive combination is commanded to remove energy from the system. This typically occurs during a controlled deceleration of the mechanical load. If the power flowing back to the drive from the load exceeds the power dissipation available in the motor due to resistive losses, then the excess energy must be handled by the drive or power supply.

Some Allied Motion drives/controllers have the capability to dump this regenerative energy through regenerative circuitry. Consult the product datasheet for your specific device to determine its regeneration handling capability, regeneration threshold voltage, and any recommended external components (e.g. resistor, fuse, and fuse holder). For devices having regeneration control circuitry, consult the figure below for proper wiring of external components:

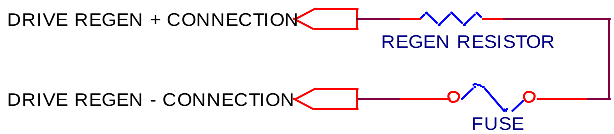

Figure 15: Regeneration, External Component Connection Diagram

10.1 Regeneration in AC Powered Drives and Controllers

Regenerative energy in an AC powered drive cannot be returned to the AC mains due to the diode rectifiers in the input power section of the drive. In this device, the regenerative energy is stored in the drive's DC bus filter capacitors. As more energy is stored, the DC bus voltage rises. If the DC bus voltage rises past the bus over-voltage threshold, the drive will fault. This scenario can be avoided by connecting a shunt resistor to the drive's regenerative circuit which will dissipate the excess energy stored in the bus capacitors. The regenerative circuit in the drive switches on the resistor across the DC bus when the bus voltage reaches the regenerative threshold voltage. Power dissipation in the shunt resistor is limited by the control circuitry (consult datasheet for continuous value).

10.2 Regeneration in DC Powered Drives and Controllers

Regenerative energy in a DC powered drive will be returned to the DC power source. If a battery is the DC power source, this regenerative energy can usually be absorbed by the battery with no harm to the battery. However, a DC power supply will typically not accept this returned energy. The user is advised to check the details of their power source to determine its ability to accept regenerated energy if produced by the user's system.

In the event that the DC power supply cannot accept the regenerative energy, a diode should be used to isolate the power supply from the drive; the user must take care to size the diode correctly for the anticipated current and voltage levels.

In this scenario, regenerative energy will be stored in the drive's DC bus filter capacitors. As more energy is stored, the DC bus voltage rises. The protection diode prevents the regenerated energy from going back to the DC power supply. Adequate heat sinking must be applied to keep the diode operating temperature within its rated limits.

If the DC bus voltage rises past the bus over-voltage threshold, the drive will fault. This scenario can be avoided by connecting a shunt resistor to the drive's regenerative circuit which will dissipate the excess energy stored in the bus capacitors. The regenerative circuit in the drive switches on the resistor across the DC bus when the bus voltage reaches the regenerative threshold voltage. Power dissipation in the shunt resistor is limited by the control circuitry (consult datasheet for continuous value).

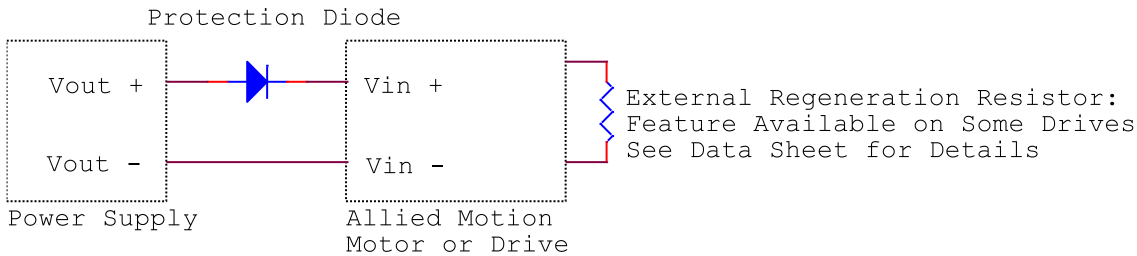

Figure 16: Example, User System with Installed Protection Diode

10.3 Calculating Regenerative Energy

10.3.1 Energy Stored in Rotating Inertia

Energy is stored in the rotating motor and load inertias. Let the sum of these inertias as reflected to the motor be J_{tot}. Then the energy stored is calculated as follows, where ω is the motor speed in rad/s:

$$E_s = \frac{1}{2} J_{tot}\, \omega^2$$

10.3.2 Energy Dissipated in the Motor

As the drive decelerates the motor and mechanical load, there is energy loss in the windings. This loss is calculated as follows, where R_m is the motor line to line resistance, T is the torque applied to decelerate the motor, and K_t is the motor torque constant:

$$P_m = \frac{3}{4} R_m (T/K_t)^2$$

So the equation for P_m simplifies to:

$$P_m = \frac{3}{4} R_m (I_{peak})^2 \qquad \text{(i)}$$

However, if the I^2t limit of the amplifier is exceeded, then current will be limited to the continuous current rating of the amplifier.

In this case equation (i) becomes:

$$P_m = \frac{3}{4} R_m (I_{const})^2 \qquad \text{(ii)}$$

The actual value of P_m is normally between these two values, and tends towards (i) for low inertia loads and (ii) for high inertia loads.

The total energy loss is then the product of power loss and time:

$$E_m = P_m \times \text{(deceleration time)}$$

10.3.3 Energy Stored in the Bus Capacitor

The regenerative energy storage capacity of the bus capacitors is a function of the difference between the voltage values squared of the capacitors when regeneration begins and the maximum value when the drive reaches its over-voltage threshold. Note that an external bus capacitor may be added to the drive or controller, which will increase the energy storage capacity of the system. The total regenerative energy stored is calculated as follows, where $V_{bus} = 1.414 \times$ RMS value of the input voltage for an AC powered drive or if DC voltage is supplied to the drive, then $V_{bus} = VDC_{in}$:

$E_c = ½ C [V_{regen}^2 – V_{bus}^2]$

10.3.4 Regenerative Energy to be Dissipated

The regenerated energy to be dissipated is calculated as:

$E_{regen} = E_s - E_m - E_c$

10.3.5 Pulse Power

The pulse power is the energy dissipated in a single deceleration divided by the duration of the dissipation

Pulse regenerative power (P_{pulse}) = E_{regen}/deceleration time

10.3.6 Continuous Power Dissipated

The continuous power dissipated is the sum of the regenerative energy dissipated divided by the period of time for that dissipation:

Average dissipated power = ($E_{regen1} + E_{regen2} + E_{regen3} + \ldots$) / time period

11.0 Revision History

Revision	Description of Change	Date
R1	Initial release.	May 7, 2014
R2	Renumbered document sections.	August 22, 2014