PACIFIC SCIENTIFIC

HIGH PERFORMANCE MOTORS & DRIVES

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6 4 1 5 Oscillator/Drive

Installation & Hardware Reference Manual

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Table of Contents

1 Overview of the 6415

In this chapter

This chapter introduces the 6415 stepper drive. Topics covered are:

- 6415 definition
- Other system components
- System diagram
- How to use this manual
- Warranty information

1.1 6415 Definition

Overview

The Pacific Scientific 6415 Oscillator/Microstepping Drive Module is an economical microstepping drive with an integral ramped oscillator card. The ramped card contains a stable wide range voltage controlled oscillator (VCO) and associated control circuitry which provides step pulses and direction command signals to the drive card. The drive card converts step and direction command signals into motor winding currents to control a two-phase stepper motor.

Principal features include independent acceleration and deceleration profiles which enable the motor to be operated at high speed in a reasonable time. In addition, microstepping and digital electronic damping provide for high resolution and smooth operation through both the low speed and mid-speed resonance regions.

Run speed pulse frequency is controlled by an on-board potentiometer, an external user's potentiometer or a bipolar external analog input voltage. Acceleration and deceleration ramps are also potentiometer controlled. When a bipolar analog voltage is used as the input, the direction command is derived from a polarity detector on the ramped oscillator card. Deceleration can include a slow speed adjustable potentiometer before stopping, to enhance accuracy of stopping position. Control signals are optically isolated.

The output current of the 6415 is dip switch selectable from 5A rms (7.1A peak in microstep mode) to 0.625A rms (0.88A peak in microstep mode)

The drive supplies regulated phase currents for supply voltages between 24 Vdc and 75 Vdc. It is designed for use with Pacific Scientific's line of hybrid stepping motors and will work with either the standard line or the enhanced performance line.

Note: *The motor winding must be compatible with the output current of the driver.*

Drive features

Bipolar chopper drive - patented 4-phase PWM (pulse width modulation) chopping electronically controls the motor winding currents at 20 kHz frequency. This combines the best of recirculating and non-recirculating current regulation producing high back EMF rejection with low chopping ripple current. Benefits include: reduced heat dissipation, low electric noise and improved current control during motor breaking.

Microstepping - switch selectable: full, 1/2, 1/5, 1/10, 1/25, 1/50, 1/125, and 1/250 step capability with decimal jumper installed and 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256 with decimal jumper removed.

Digital Electonic Damping - patented circuit eliminates torque loss and/or motor stalling through the mid-speed region, that is inherent in all open loop stepper applications.

Short circuit protection circuitry - disables the drive if a short circuit occurs on the motor outputs. The drive must be power cycled to clear fault.

Bus overvoltage - disables the drive if the voltage exceeds 83 Vdc. The drive must be power cycled to clear fault.

MOSFET power devices - allows chopper frequency of approximately 20 KHz, eliminating acoustical noise often associated with choppers.

Acceleration and deceleration circuitry - Acceleration rate is non-linear which produces an exponential velocity ramp profile. This method improves the acceleration profile since at low motor speed a higher acceleration rate is produced and a lower acceleration rate at high speeds. Constant deceleration rate resulting in a linear velocity ramp allowing a more precise and repeatable stopping position. The acceleration and deceleration rates are adjustable with the on-board potentiometers to optimize system performance.

Two independent run speeds - selected by using the Low_Spd input. The motor high speed range is controlled by the Run Speed potentiometer, low speed range is controlled by the Low Speed potentiometer. Low speed setting is typically selected prior to stopping the motor to improve stopping position repeatability. It can also be used as an independent secondary speed.

Internal and/or external speed command - allows for stand alone and/or speed following operation.

Separate (latched) and/or single RUN/STOP inputs - allows for direct clutch brake replacement application.

Enabled LED indicator - LED lit when drive is enabled and not lit when the drive is disabled or faulted.

Optically isolated signal interface connection - optical isolation is provided on the RUN/STOP, low speed, direction, and enable inputs. The use of optical isolation increases the options available for system grounding. The source commanding these control signals is not tied directly to the motor power supply ground, allowing the system ground point for these control signals to be made external to the unit.

UL Recognized - 508C (Type R) - File E137798. This also complies with CSA Standard for Process Control Equipment, C22.2 No. 142-M1987.

Vibration - IEC Standard 68-2-6.

User adjustments

Using DIP switch S1

Motor current - sets the motor phase current to 5.0, 4.375, 3.75, 3.125, 2.5, 1.875, 1.25, or 0.625 A rms.

Step size - sets the amount of shaft rotation per pulse (with the decimal jumper installed). The settings are full, half, 1/5, 1/10, 1/25, 1/50, 1/125, and 1/250 steps per (micro)step. This corresponds to 200, 400, 1000, 2000, 5000, 10,000, 25,000, and 50,000 (micro)steps per revolution with a standard 1.8° motor. With the decimal jumper removed, the settings are 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256 steps per (micro) step. This corresponds to 400, 800, 1600, 3200, 6400, 12,800, 25,600, and 51,200 (micro) steps per revolution.

Digital Electronic Damping - enables this patented feature which eliminates loss of torque and possible motor stalling conditions when operating at mid-range speeds. This instability is a phenomenon of the electronic, magnetic and mechanical characteristics of a stepping motor system. The compensation circuit damps mid-range oscillations by advancing or delaying switching of the output current relative to the incoming pulse train.

Idle current reduction (ICR) - enables or disables idle current reduction which reduces motor winding current by 50% of its rated value during motor dwell periods. ICR begins 0.1 second after the last input step pulse occurs. This delay can also be set to 0.05 seconds or 1 second using a plug-on jumper.

Note: *The current will return to 100% at the next step pulse.*

Using plug-on jumpers

Step filter - when enabled (jumper installed) rejects noise pulses on step input less than 500ns wide. Useful if maximum step rate is 500 KHz.

Enable sense - allows the polarity of the enable input to be reversed. With the jumper installed, the enable input opto-isolator must be driven to enable the drive. With the jumper removed, enable input opto-isolator must be driven to disable.

Run and/or Stop controls - allows for independent inputs or a single input for Run/Stop. With separate input control mode (E4 jumper installed) the 6415 is controlled by two separate optically isolated inputs. This separate input control mode is useful for functioning in a clutch brake application. In the single input mode (E4 jumper removed) , the drive run or stop is controlled directly from the run input only.

Internal or External speed source - the analog speed command is derived from the internal run speed potentiometer, external user's potentiometer, external analog input, and external analog input scaled by internal run speed potentiometer sources depending upon the on-board E1 and E3 jumpers setting configurations.

Oscillator frequency range - sets the voltage controlled oscillator (VCO) output full scale frequency range. With E2 jumper installed, the maximum full scale VCO output frequency is set to 250 KHz for Run Speed and 180 KHz for Low Speed controls. When removed E2 jumper, the maximum full scale output frequency is set to 500 KHz for run speed and 370 KHz for low speed controls. This feature offers user's selectable speed resolution for the best system performance.

Min speed control - sets the minimum speed which is the initial motor speed. The minimum speed is set to 4 KHz and 2 KHz maximum (E5 jumper removed) for high and low frequency range respectively. Steps below this frequency are inhibited to insure no movement at end of deceleration ramp. This functionality can be disabled by installing the on-board E5 jumper.

Note: *Motor stalling may occur if this feature is used with step sizes less than 1/4 step.*

Direction controls - This optically isolated input controls the direction of motor rotation when all on-board direction controls jumpers are removed. Motor rotation is CCW if the opto is driven and CW otherwise. The direction of the motor can also be controlled by the analog input or on-board plug on jumpers (E6, E7, and E8).

Using on-board potentiometer

Acceleration and deceleration controls -Acceleration rate is non-linear resulting in an exponential velocity ramp. Constant deceleration rate resulting in a linear velocity ramp. Accel Ramp Pot (R14) and Decel Ramp Pot (R17) adjust the initial acceleration and deceleration rate of the motor from 0.4 msec to 0.4 sec (accel. single time constant) and 6.0 msec to 1.4 sec (decel. time).

Run speed and low speed controls - Run Speed Potentiometer (R7) and Low Speed Potentiometer (R43), both independent speed potentiometers, set the steady state run speed of the motor when the optically isolated input RUN/STOP or LOW_SPD opto is driven. The motor speed ramps up from the selectable MIN_SPD threshold (enable or disable with E5 jumper) until it reaches the final speed. Run Speed Potentiometer adjusts the final motor speed from 8 KHz to 500 KHz and 4 KHz to 250 KHz for high and low frequency range operation. Unlike the Low Speed Potentiometer which is adjustable from 8 KHz to 370 KHz and 4 KHz to 180 KHz for high and low frequency ranges.

Typical applications

Typical applications for 6415 include:

- X-Y tables and slides
- Packaging machinery
- Robotics
- Specialty machinery
- Index feed of material
- Labeling machines
- Clutch brake replacement
- Smart conveyor systems
- Semiconductor wafer polishing
- Constant speed applications

1.2 Other System Components

Overview

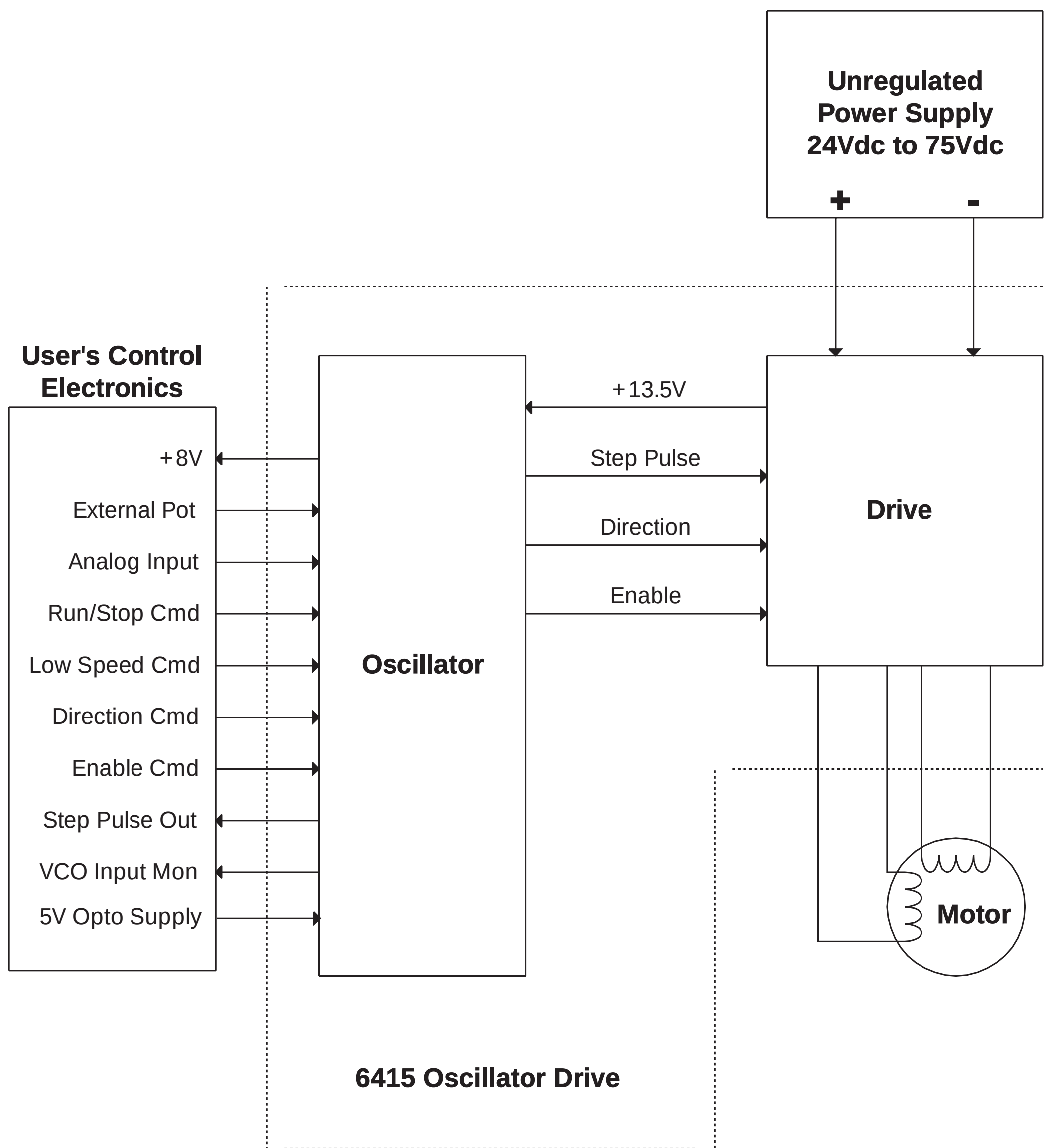
The other components that, along with the drive, comprise a complete motor control system are:

- Single logic power supply (4.75 - 5.25 Vdc)
- Single bus power supply (24 - 75 Vdc)
- Motor

Installation guidelines for these components are described in Chapter 2, "Installing the 6415 Stepper Motor Drive."

System Block Diagram

The following diagram shows the drive in a typical system.



Overview

1.3 How to Use this Manual

This manual contains information and procedures to install, setup, and troubleshoot the 6415 stepper motor drive.

The most effective way to use this manual is to follow the installation and power up instructions contained in Chapter 2 and Chapter 3.

1.4 Warranty

The Pacific Scientific 6415 drive has a **two year warranty** against defects in material and assembly. Products that have been modified by the customer, physically mishandled, or otherwise abused through miswiring, incorrect switch settings, and so on, are exempt from the warranty plan.

2 Installing the 6415

In this chapter

This chapter explains how to install the 6415 stepper motor drive. Topics covered are:

- Unpacking and inspecting the 6415
- Installing and using the 6415 unit safely
- Selecting other system components
- Mounting the 6415 in your installation
- Connecting input/output cables

Installation

2.1 Unpacking and Inspecting

Unpacking procedure

1. Remove the 6415 from the shipping carton. Make sure all packing materials are removed from the unit.
2. Check the items against the packing list. A label located inside the chassis of the unit identifies the unit by model number, serial number, and date code.

Inspection procedure

Inspect the unit for any physical damage that may have been sustained during shipment.

If you find damage, either concealed or obvious, contact your buyer to make a claim with the shipper. Do this within 10 days of receipt of the unit.

Storing the unit

After inspection, store the drive in a clean, dry, place. The storage temperature must be between -55 degrees C and 70 degrees C. To prevent damage during storage, replace the unit in the original shipping carton.

2.2 Installing and Using the 6415 Unit Safely

Your responsibility

As the user or person applying this unit, you are responsible for determining the suitability of this product for any application you intend. In no event will Pacific Scientific Company be responsible or liable for indirect or consequential damage resulting from the misuse of this product.

Note: *Read this manual completely to effectively and safely operate the 6415 unit.*

Warning

The circuits in the 6415 drive are a potential source of severe electrical shock. Follow the safety guidelines to avoid shock.

Safety guidelines

To avoid possible personal injury whenever you are working with the 6415 unit:

- Do not operate the drive without the motor case tied to earth ground.

  Note: *This is normally done by connecting the motor's case to J3-5 of the 6415 and connecting J2-3 of the 6415 to earth ground.*

- Do not make any connections to the internal circuitry. The input and output signals are the only safe connection points.
- Always remove power before making or removing connections from the unit.
- Be careful of the J3 motor terminals when disconnected from the motor. With the motor disconnected and power applied to the drive, these terminals have high voltage present, even with the motor disconnected.
- Do not use the ENABLE input as a safety shutdown. Always remove power to the drive for a safety shutdown.

2.3 Selecting Other System Components

Selecting external analog input and logic input power supplies

The 6415 drive requires an external +5Vdc (±0.25) logic power supply for all user's control inputs and 0 to +10Vdc (±0.10) analog input power supply if the analog speed command is derived from external input source configuration.

Selecting a motor

The 6415 is designed for use with Pacific Scientific's line of hybrid stepper motors or most other 2 phase stepper motors. The drive works with either the standard line or the enhanced high performance line of stepper motors. The motor winding current rating must be compatible with the output current of the drive package.

Refer to the Torque/Speed Curves in the Pacific Scientific *Motion Control Solutions Catalog* or contact your local Pacific Scientific distributor for sizing and motor compatibility assistance.

Selecting bus power supply

A single power supply is required to operate the 6415 unit.

Note: *In multi-axis applications, it is preferable to run each power connection from supply to drive and not daisy-chain the power connections.*

The power supply can vary from +24 to 75 Volts maximum at a maximum current of 5 amps. It does not have to be a regulated supply.

Note: *The supply voltage cannot exceed 75 volts. The bus overvoltage circuit is designed to protect the drive from minor transients. Voltages in excess of 100 Vdc will damage the drive and void the warranty.*

IMPORTANT NOTE

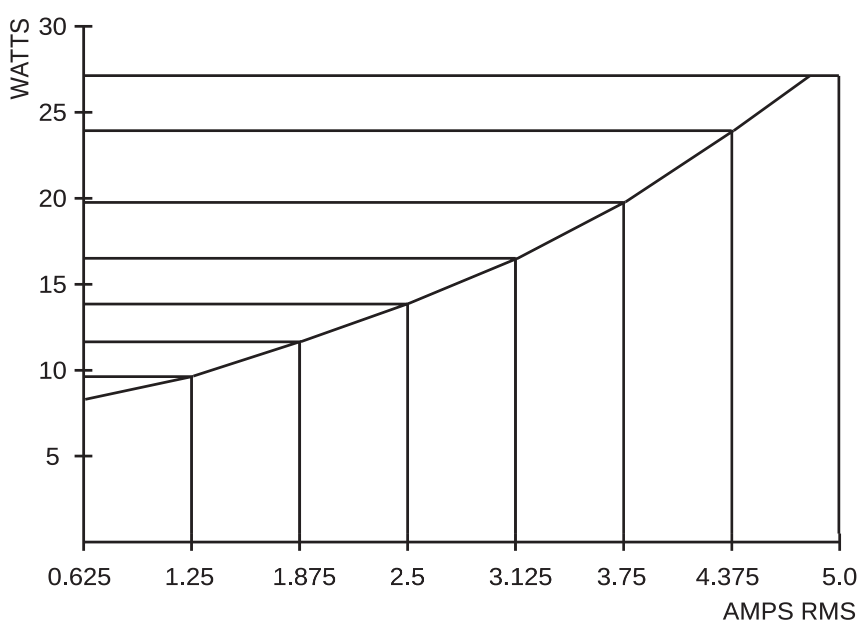
Important information about the power supply is outlined in Section 2.5.2 and Appendix C. Read these sections carefully before applying power to the drive.

2.4 Mounting the 6415 Unit

Cooling plate mounting

For optimal thermal performance and minimum panel usage, mount the 6415 bookcase style to a cooling plate (typically an Aluminum plate or heatsink with enough thickness and surface area to maintain the 6415's chassis below 60°C) using two M4 or 6-32 screws inserted through the mounting slots on the back of the unit. Use a thermal pad or grease if surface is irregular. The maximum temperature of the 6415's back plate must be held below 60°C. The graph of 6415 power dissipation vs. current setting shown below may be used to design the cooling plate or direct measurements can be taken during normal operations and adjustments made to plate area or airflow over the plate if necessary. Make sure that any difference between the ambient temperature during the measurement and worst case ambient temperature is accounted for. The 6415 can also be mounted with its side against the cooling plate using 4 M4 or 6-32 screws if mounting depth is of greater concern than panel area. The same thermal considerations apply as for back mounting.

Power dissipation vs. current



Heatsink mounting

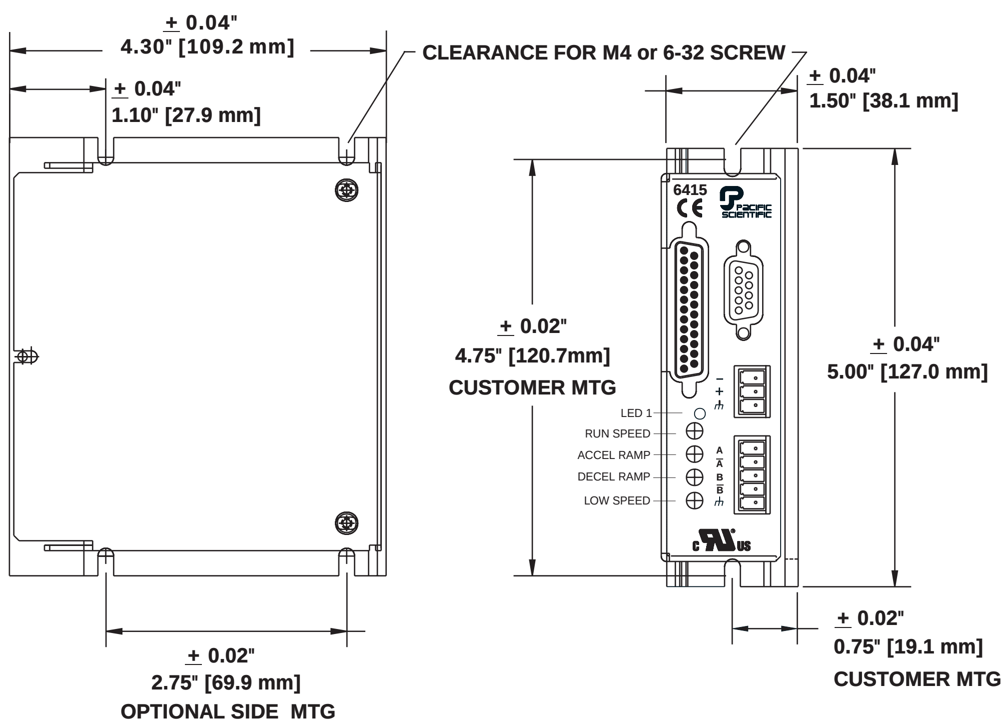
If a cooling plate is not provided, the optional heatsink available from Pacific Scientific can be mounted to the side of the 6415 and the combined unit mounted to a panel using the slots on the back of the 6415 as described above (bookcase mounting). With a minimum unobstructed space of four inches above and below the unit, and cooling accomplished solely through convection (no fan), the 6415 can be run at 5 Amps RMS maximum for ambient temperatures of 25°C or less and 2.5 Amps RMS maximum for ambient temperatures of 45°C or less. Using a fan to blow air past the heatsink will increase the allowable current significantly. It is always required that the 6415's chassis temperature not exceed 60°C. It is best to confirm this by direct measurement with a temperature probe during system operation. Any difference between the ambient temperature during the measurement and the worst case should be added to the measured chassis temperature. The resulting sum must be under 60°C.

Panel mounting

If the 6415 is mounted to a panel with no cooling plate and no heat sink, a minimum unobstructed space of four inches above and below and one inch between the side plate and any other object must be provided. If cooling is accomplished solely through convection air flow (no fan), the unit can be run at 2.5 Amps RMS maximum if the ambient temperature is 25°C or less and 1.25 Amps RMS maximum if the ambient temperature is 45°C or less. Again, use of a fan to blow air past the side plate of the 6415 will increase the allowable current. The same considerations given above for the optional heatsink apply.

Mounting dimensions

When mounting the 6415, please refer to the dimensions below:



Mounting guidelines

Your installation should meet the following guidelines:

- Vertical orientation for the unit.
- Flat, solid surface capable of supporting the approximate 1.0 lb. weight (0.5 kg. mass) of the unit.
- Free of excessive vibration or shock.
- Minimum unobstructed space of 4 inches (10 cm) above and below the unit.
- Maximum ambient temperature of 50° C and maximum 6415 chassis temperature of 60° C.

2.5 Connecting to the 6415

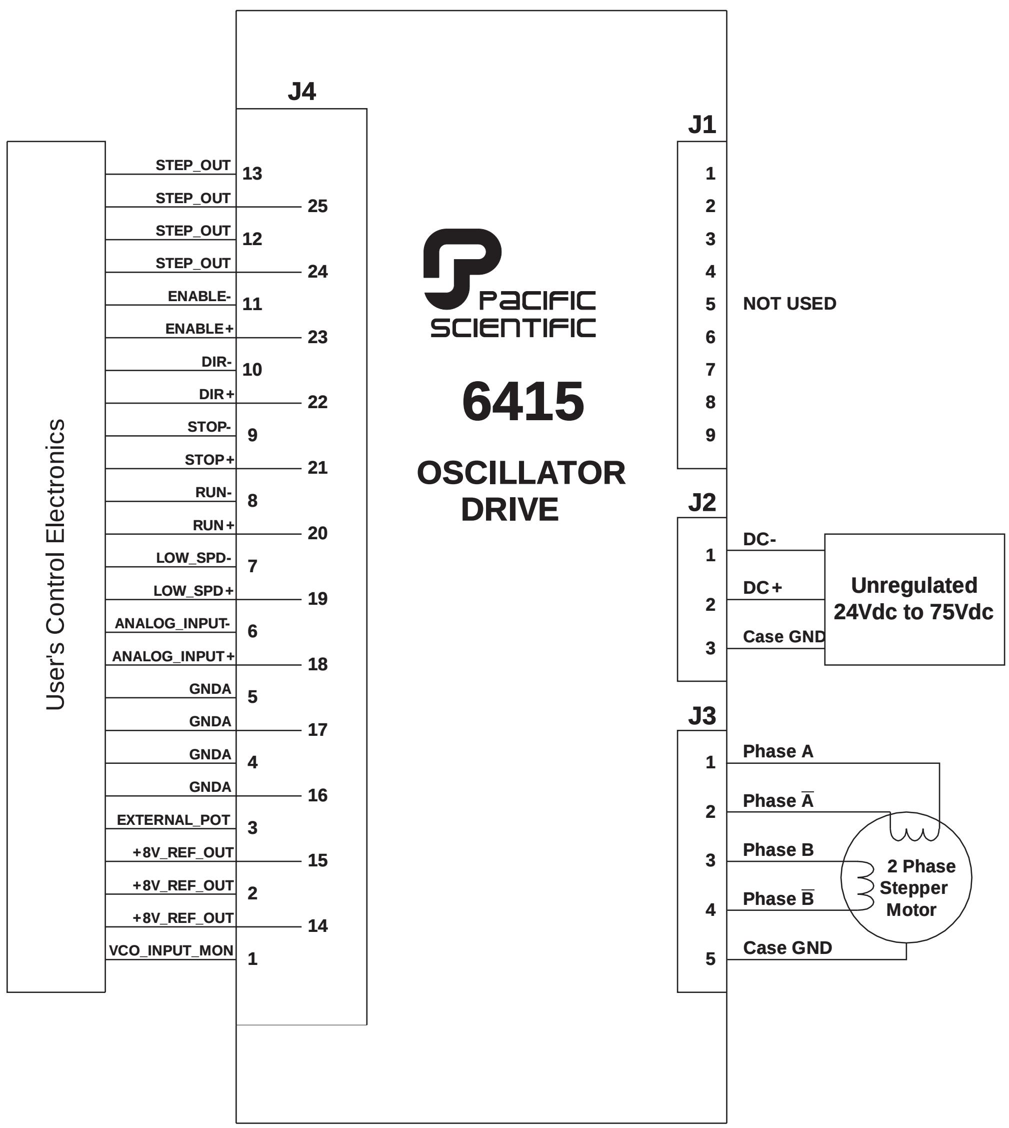
Introduction

The four input/output (I/O) connectors are:

- J1 - Not used
- J2 - Power connector
- J3 - Motor connector
- J4 - Signal connector

These inputs and outputs are shown on the following page.

Connection diagram



Wiring is application specific

Wiring sizes, wiring practices and grounding/shielding techniques described in the following section represent common wiring practices and should prove satisfactory in the majority of applications.

Caution

Non-standard applications, local electrical codes, special operating conditions, and system configuration wiring needs take precedence over the information included here. Therefore, you may need to wire the drive differently then described here.

Noise pickup reduction

Use shielded and twisted cabling for the signal and power cables as described below. This precaution reduces electrical noise.

Shock hazard reduction

Refer to section 2.2 for safety information that must be followed to reduce shock hazard.

2.5.1 J3 Motor Connections

Introduction

The J3 motor cable connects the drive to the motor windings and motor case. J3 utilizes a plug-in screw terminal/type connector to simplify assembly and allow quick connect and disconnect.

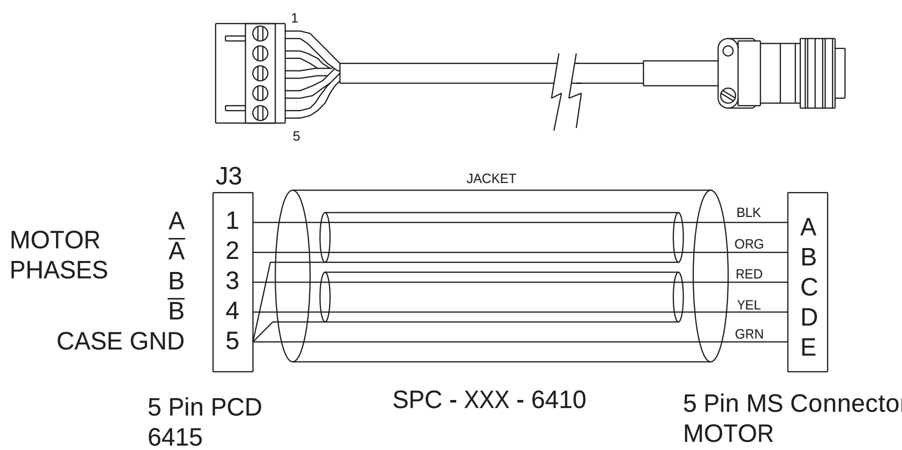
Note: *Never disconnect the motor connection while the drive is enabled. This may damage the drive and void the warranty.*

Pacific Scientific cable

Pacific Scientific makes cables that connect directly from J3 to our system motors. To order the cable from Pacific Scientific, use the order number SPC-xxx-6410, where “xxx” is the length, in feet (one-foot increments) up to 50 feet. For example, SPC-050-6410 is a cable 50 feet long.

Pacific Scientific cabling diagram

If you are using Pacific Scientific motor cable, with the mating connectors already attached, install as follows:



Note: *All wires are #16 AWG.*

Making your own cable

To make your own motor cable, follow the guidelines given below for wiring to the J3 mating connector. Depending on your motor configuration, refer to the appropriate diagram at the end of this section to determine the motor connections required.

J3 connection table

Output	Pin	Explanation
Motor Phase A	J3-1	Motor Phase A excitation. Twisted Pair.
Motor Phase $\overline{A}$	J3-2	
Motor Phase B	J3-3	Motor Phase B excitation. Twisted Pair.
Motor Phase $\overline{B}$	J3-4	
Drive Case (Earth) Ground	J3-5	Connected to the motor case ground.

Mating connector

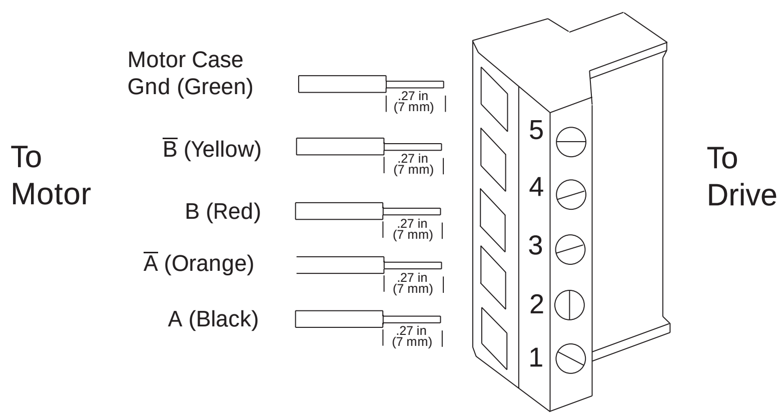
The J3 motor connector on the 6415 mates to a PCD 5-pin screw cable connector. The mating cable connector is type ELVP05100.

Cable requirements

The mating connector terminals will accept #16 to #28 AWG wire. However, use #16 AWG or heavier for motor phase excitations.

For the motor cable, use cable with two twisted pairs twisted at about 3 to 4 turns per inch (1 to 1.5 turns per centimeter) for the motor phase excitations and a fifth wire for the case ground. As an option, the cable may be shielded to reduce radiated noise. A single shield can be used around both phase excitations and the ground wire or each phase excitation (twisted pair) can be individually shielded as in the Pacific Scientific cables. Connect shields to pin 5 of the mating connector.

Cabling diagram - J3 motor

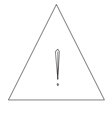


Note: *The colors in the diagram follow the Pacific Scientific stepper motor cable color code.*

Procedure

1. Strip the wires to 0.27 in (7mm).
2. Attach wires to connector as indicated in the diagram.

Note: *Make sure the screws on the PCD connector are tightened down firmly on the wiring.*

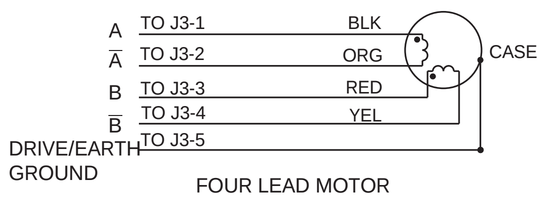


Caution

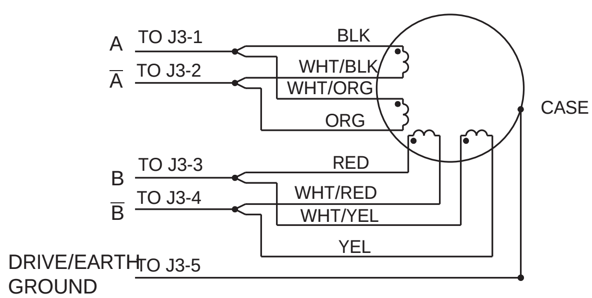
Do not solder the tips of the cables before insertion into the connector. Solder can contract and cause a loose connection over time.

Flying Lead Connection

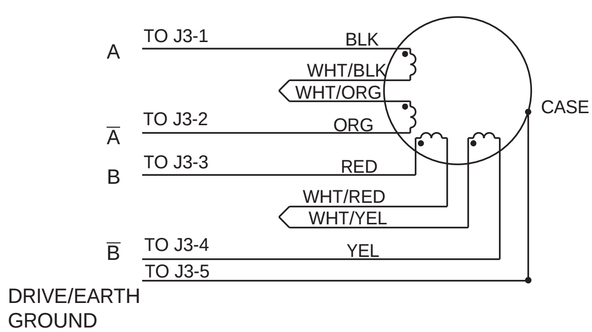
The figure below shows the connections required between the 6415 connector J3 and Pacific Scientific motors having flying leads. Connections are shown for 4 lead motors, 8 lead motors with paralleled windings, and 8 lead motors with series windings. Wire nuts may be used for the winding connections at the motor end.



FOUR LEAD MOTOR



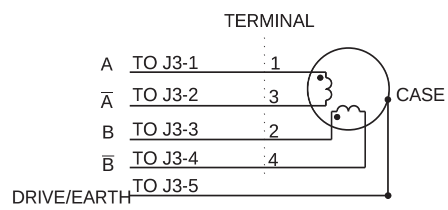
EIGHT LEAD MOTOR CONNECTED IN PARALLEL



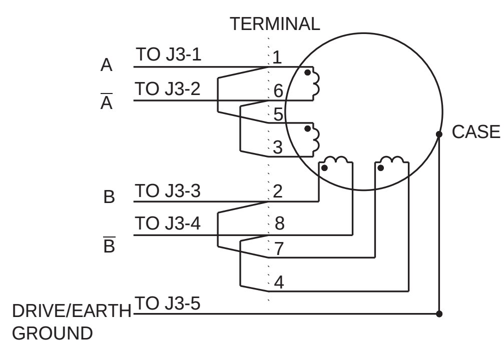
EIGHT LEAD MOTOR CONNECTED IN SERIES

Terminal board connections

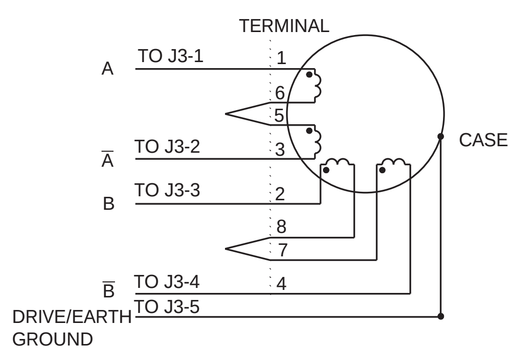
The figure below shows the connections required between the 6415 connector J3 and Pacific Scientific stepper motors having a terminal board in the rear end bell. Connections are shown for 4 lead motors, 8 lead motors with paralleled windings, and 8 lead motors with series windings.



FOUR LEAD MOTOR



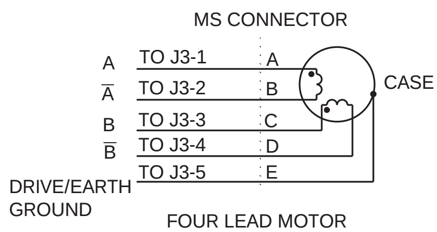
EIGHT LEAD MOTOR CONNECTED IN PARALLEL



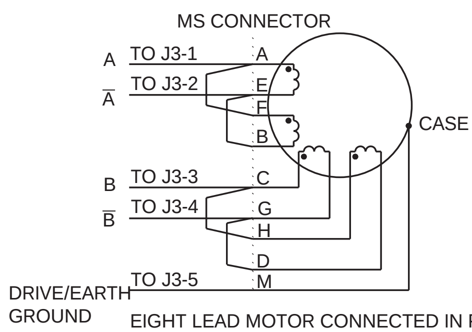
EIGHT LEAD MOTOR CONNECTED IN SERIES

MS connectors connection

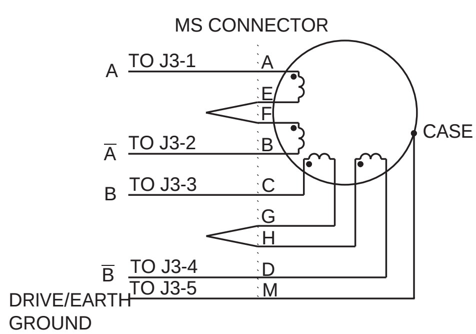
The figure below shows the connections required between the 6415 J3 connector and Pacific Scientific stepper motors having MS connectors. Connections are shown for 4 lead motors, 8 lead motors with paralleled windings, and 8 lead motors with series windings.



FOUR LEAD MOTOR



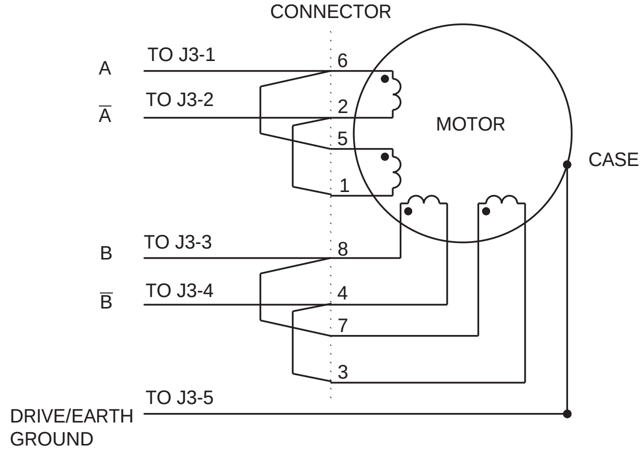
EIGHT LEAD MOTOR CONNECTED IN PARALLEL



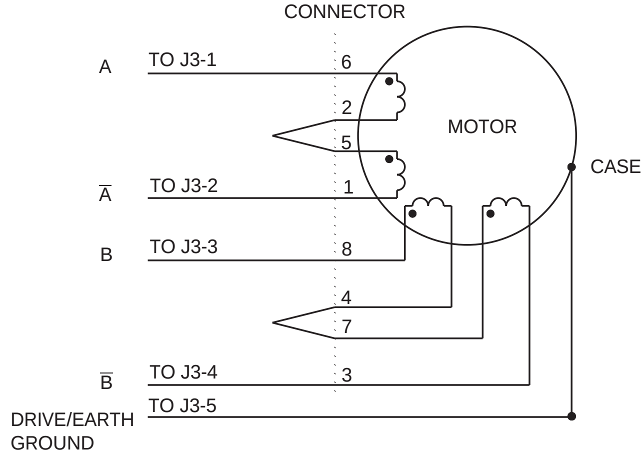
EIGHT LEAD MOTOR CONNECTED IN SERIES

Power Max motor connections

The figure below shows the connections required between the 6415 and Pacific Scientific Power Max Motors. Power Max motors have an eight pin connector and can be configured with either parallel or series windings.



PARALLELED WINDINGS



SERIES WINDINGS

2.5.2 J2 Power Connector

Introduction

The J2 power cable connects the 6415 to the power supply. Please refer to Appendix C for additional information on power supply considerations.

J2 power table

Input	Pin	Explanation
DC -	J2-1	+24 to +75 Vdc max at 5 amps The negative side of the power supply (connected to DC-) should be connected to Earth ground. No connection is made within the 6415 between J2-1 and J2-3.
DC +	J2-2	
Earth Ground	J2-3	Connected to 6415 Case and J3-5 (Motor Ground)

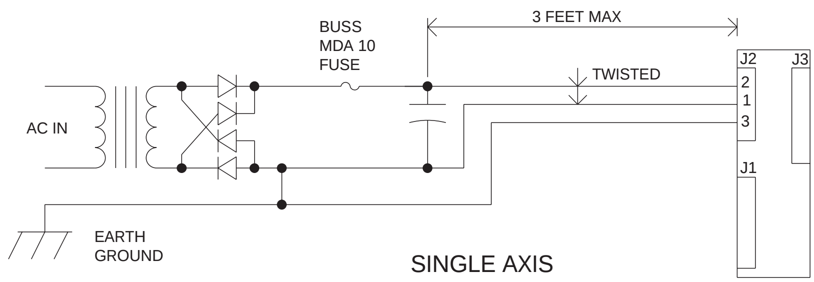
Power connection

Connections between the 6415 and power supply are shown in the diagram on the following page. A simple non-regulated supply is used for this example. DC+ and DC- should be run from the power supply's capacitor to the 6415 as a twisted pair no longer than 3 feet in length (shielding, with the shield connected to earth ground, can reduce noise emissions). A Buss MDA 10 A, slow-blow fuse (or equivalent) should be included in the power supply between the rectifier and capacitor as shown.

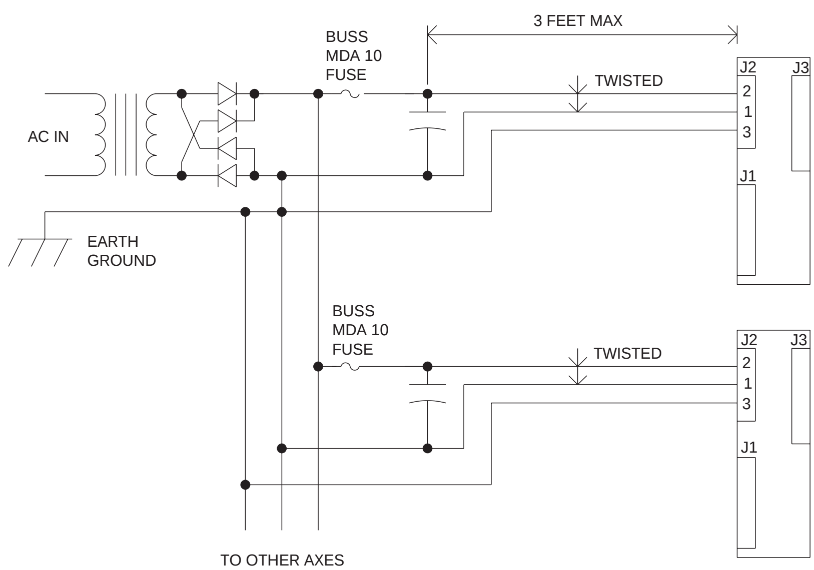
IMPORTANT NOTE

It is extremely important that the supply voltage never exceed 75 volts even on a transient basis. This is one of the most common causes of drive failures. Wiring inductance between the 6415 power input and the external capacitor is significant because a PWM chopper drive requires pulse currents. Therefore, it is extremely important that the two be connected by a twisted pair no longer than three feet in length.

Connection diagram



SINGLE AXIS

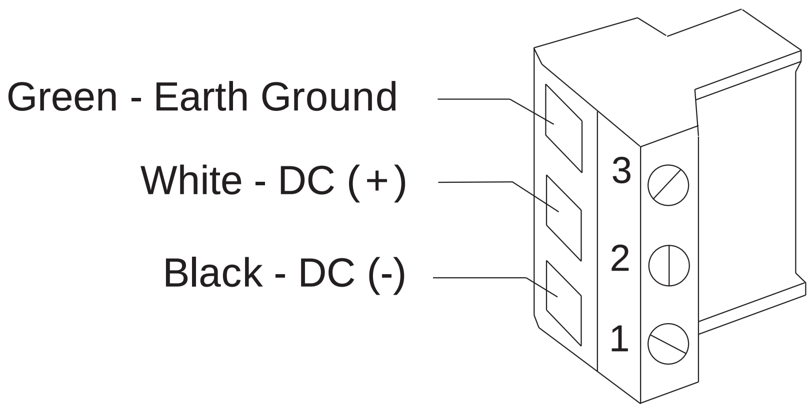


MULTIPLE AXES

Cable requirements

Use #16 AWG for the power supply cable. Use cable twisted at about 3 to 4 turns per inch (1 to 1.5 turns per centimeter).

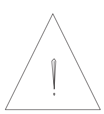
Cable diagram - J2 power cable



Procedure

1. Strip the wires 0.27 inch (7mm).
2. Attach the wires to the connector as indicated in the diagram.

Note: *Make sure the screws on the PCD connector are tightened down firmly on the wiring.*



Caution

Do not solder the tips of the cables going into the PCD connector. This can result in a loose connection.

2.5.3 J4 Signal Interface Connection

Introduction

The J4 control I/O signal interface accepts external speed potentiometer, analog input, direction, and enable signals from a user's control input or other sources and outputs pulse signals (STEP_OUTPUT) which indicates the 6415 is applying current to the motor windings. The control I/O interface also provides +8.0 volts for external reference voltage (+8V_REF_OUT) to power an external user's speed potentiometer and a monitor test point (VCO_INPUT_MON) to monitor the accel/decel motion profile.

J4 signal table

Input/Output	Pin(s)	Explanation
VCO_INPUT_MON	(J4-1)	Accel/Decel profile and final run speed command monitor point.
+8V_REF_OUT	(J4-2, 14, 15)	+8V user supply output. This supply is for the external customer potentiometer and step output interface and is referenced directly to the internal drive module GNDA.
EXTERNAL_POT	(J4-3)	Connection to the wiper which is the center tap of the external customer potentiometer. The voltage at this point controls the VCO oscillator frequency.
GNDA	(J4-4, 5, 16, 17)	Drive module return. This return is used in conjunction with the external customer potentiometer and step output interface and is not referenced directly to the user supply return.
ANALOG_IN+	(J4-18)	Differential amplify analog input with customer supplied -10Vdc to +10Vdc analog input voltage for external analog input control. Analog input has an input impedance of 20KΩ.
ANALOG_IN-	(J4-6)	

Table cont'd

Input/Output	Pin(s)	Explanation
LOW_SPD+	(J4-19)	Optically isolated input that selects the source of the analog speed command. The analog command is derived from the low speed potentiometer with low speed opto on.
LOW_SPD-	(J4-7)	
RUN_SPD+	(J4-20)	Optically isolated input that initiates the move of the motor rotation. In separate latched input mode, the RUN opto is placed in the RUN state when the RUN opto is driven momentarily. In single run mode, the run opto is controlled directly from the RUN input.
RUN_SPD-	(J4-8)	
STOP+	(J4-21)	Optically isolated input that terminates motor rotation. In separate latched input mode, the STOP opto is placed in the STOP state when the STOP opto is driven momentarily. In single STOP mode, the STOP opto is controlled directly from the STOP input. The 6415 is designed to be in the STOP state after applying power to insure that motion does not occur unintentionally.
STOP-	(J4-9)	

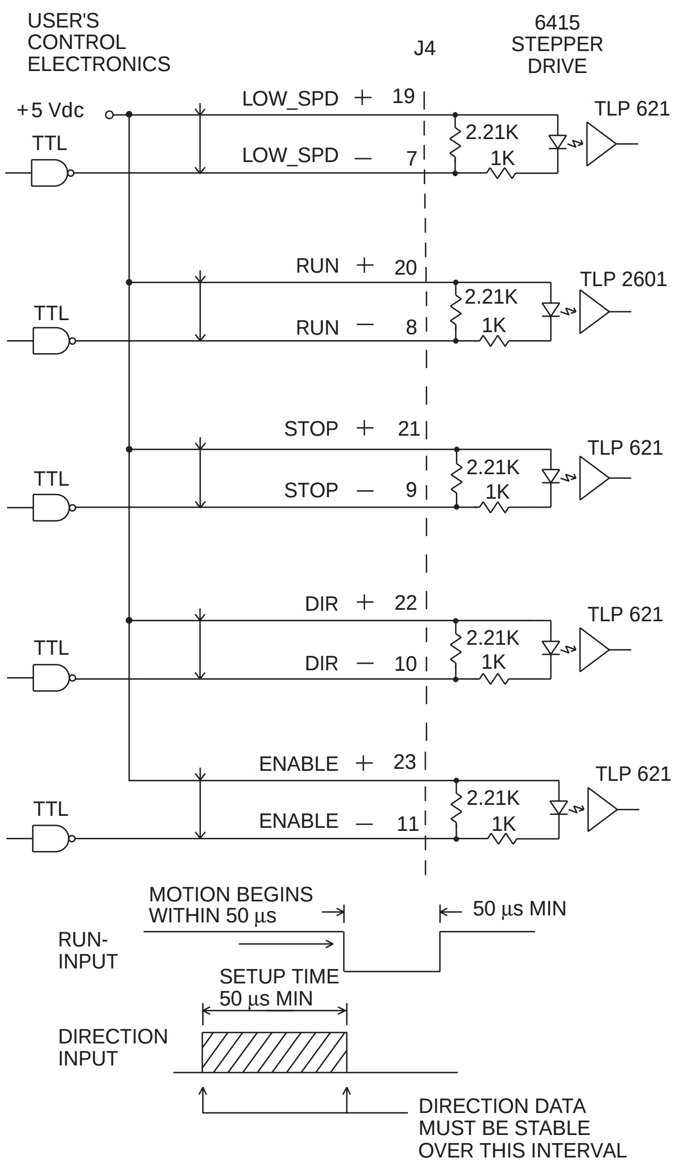
Installation

Table (cont'd)

Input/Output	Pin(s)	Explanation
DIR+	(J4-22)	Optically isolated input that determines the direction of motor rotation. If standard motor wiring is followed, the motor will turn clockwise if the opto current is zero. The sense of the DIR+ input can be reversed by reversing the connection of either (but not both) motor phase connectors (i.e. switching A and $\overline{A}$ OR B and $\overline{B}$). Refer to the figure at the end of the table for timing and circuit information.
DIR-	(J4-10)	
ENABLE+	(J4-23)	Optically isolated input used to enable or disable the 6415's power stage. With the enable sense (J6 5-6) jumper out (factory default) the power stage is enabled if the opto current is zero and disabled if the opto is driven. Inserting the jumper reverses this functionality. See figure at the end of the table for circuit information. There is a delay of approximately 500ms after enabling the drive and power stage becoming active.
ENABLE-	(J4-11)	
STEP_OUT	(J4-12, 13, 24, 25)	The VCO output step pulses rate is proportional to the analog speed command and available to connected up to four additional 6410 drives.

Typical interface

The figure below shows a typical interface between the user's electronics and the 6415. The TTL gates should have totem pole outputs and be capable of sinking at least 10.0 mA at 0.4 volts.



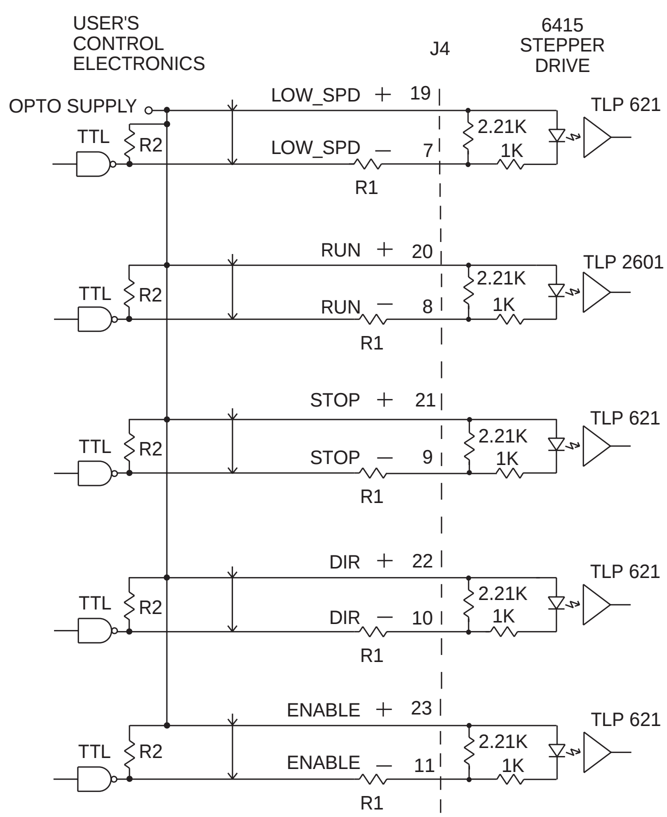
Installation

Higher voltage interface

Voltages up to 30 volts can be used for the opto power input to the 6415 drive. However, a resistor must be put in series with the command inputs as shown below. Values for several common supply voltages are given in the following table.

If the drives have open collector outputs, pull up resistors (R2) should be added as shown. A typical value of R2 is 2.7K.

Opto Supply to 6415	**R1**
+12 Vdc	1.5 K
+15 Vdc	2.2 K
+30 Vdc	6.8 K



Mating connector

The J4 signal interface connector is 25 contact female D connector. The mating cable connector is an ITT Cannon DB-255 with ITT Cannon DB110963-3 Hood.

3 Powering Up the 6415 Drive

In this chapter

This chapter explains how to power up the 6415 drive after installation. Topics covered are:

- Oscillator Board potentiometers and Jumpers E1 - E8
- Setting up functions using switch S1 and Jumper J6

This section is intended to familiarize the 6415 user with the hardware adjustments and settings required to power up and operate the 6415 drive.

Introduction

The 6415 drive is a two board assembly incorporating a Drive and an Oscillator card set. The topmost visible board is the Oscillator. The Oscillator board mounts on the Drive board and is separated by standoffs.

Drive

The drive has an eight position DIP switch (S1) and a group of four jumpers (J6) controlling drive current, digital electronic damping, idle current reduction and binary or decimal step size. The DIP switch (S1) is easily accessible without removing the Oscillator card. The default factory set jumpers are usually suitable for most applications but can be modified if necessary. The jumpers (J6) may be removed using needle-nose pliers. To reinstall the jumper, loosen the screws on the oscillator board. If the oscillator board must be removed, it must be re-aligned properly before tightening the screws.

Warning

When installing the oscillator board, make sure the 20 pin connector is aligned properly. Misalignment will seriously damge the drive.

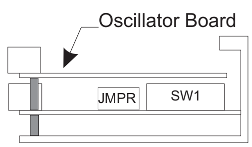
Oscillator

The Oscillator has four multi-turn potentiometers (R7, R14, R17, and R43) and eight plug on jumpers (E1 through E8) controlling motor run speed, low speed, accel/decel, high/low frequency range, min speed threshold (enable or disable), run/stop command (separate latched input or single input mode), and direction control.

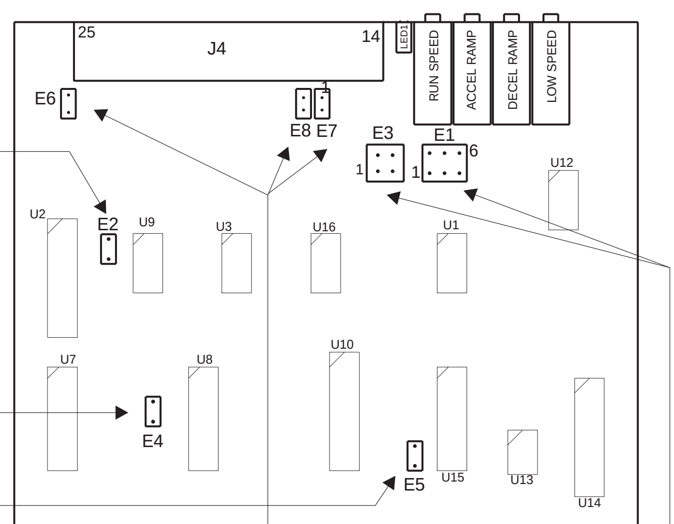
3.1 Oscillator Board Settings

Location of jumpers and pots

Note: *Default settings are in **bold**.*



Side View 6415



E2 - Frequency Range	
IN	**LOW FREQUENCY**
OUT	HIGH FREQUENCY

E4 - RUN/STOP Control	
IN	**SEPARATE INPUTS**
OUT	SINGLE INPUT

E5 - MIN SPEED Frequency	
IN	DISABLED
OUT	**ENABLED**

Control Source	E6	E7	E8	DIR Opto	Analog In	Rotation
DIR+/DIR-	OUT	OUT	OUT	Driven	--------	CCW
	OUT	OUT	OUT	Not Driven	-------	CW
Jumpers	IN	IN	OUT	Driven	-------	CCW
	OUT	**OUT**	**OUT**	Not Driven	-------	CW
Analog In	IN	OUT	IN	Driven	Negative	CCW
	IN	OUT	IN	Not Driven	Positive	CW

E1	E3 -	Velocity Control Mode
1-2 IN	**1-2 IN**	Internal RUN SPEED Potentiometer
3-4 IN	N/A	External Potentiometer
5-6 IN	1-2 IN	External Analog Input
1-2 IN	3-4 IN	External Analog Input scaled by internal RUN SPEED potentiometer

3.1.1 Potentiometer Settings

Potentiometer Settings

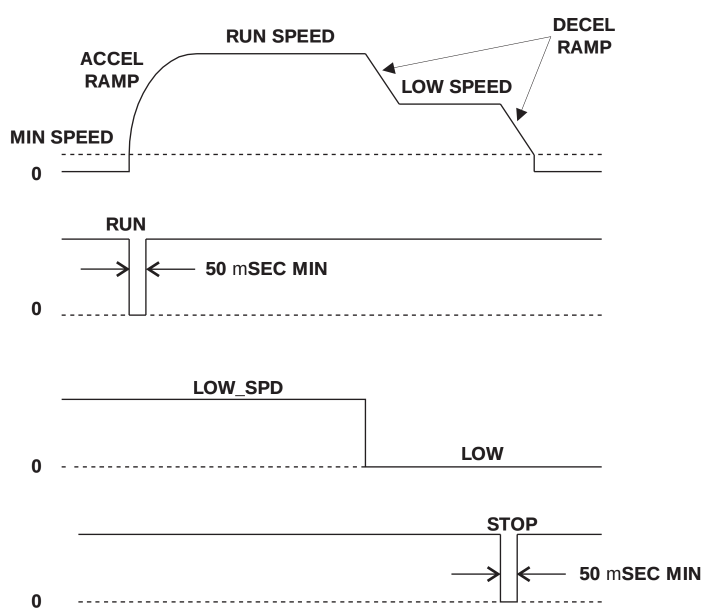
The 6415 has four potentiometers which adjust the output move profile of the motor. The acceleration rate and deceleration rate are usually adjusted and not changed for a particular motor/load combination. The run speed and low speed potentiometers are adjustable during operation with the velocity ramping up or down to the new velocity.

Adjustments for RUN SPEED, LOW SPEED, ACCEL RAMP, and DECEL RAMP are made with 4 multi-turn potentiometers.

LOW SPEED is typically set lower than RUN SPEED to allow for accurate stopping. It can also be used as a second RUN SPEED. ACCEL RAMP is typically set to minimize time to reach RUN SPEED without allowing the motor to stall. The DECEL RAMP is linear and stable, allowing a more precise, repeatable stopping position.

The figure below shows the typical velocity (pulse frequency) profile in response to separate RUN/STOP and RUN/LOW commands.

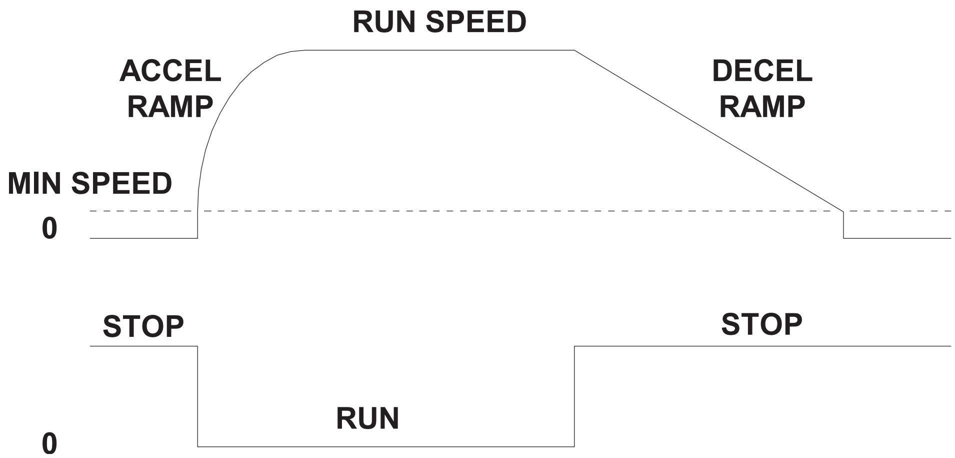
Separate command signals



Powering Up

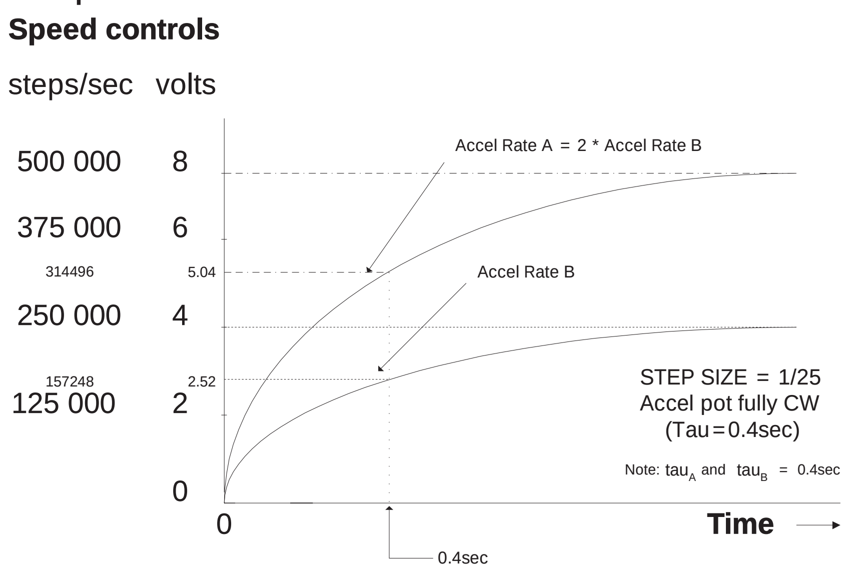
Single Command Signal

The figure below shows the typical velocity (pulse frequency) profile in response to a single RUN/STOP command.

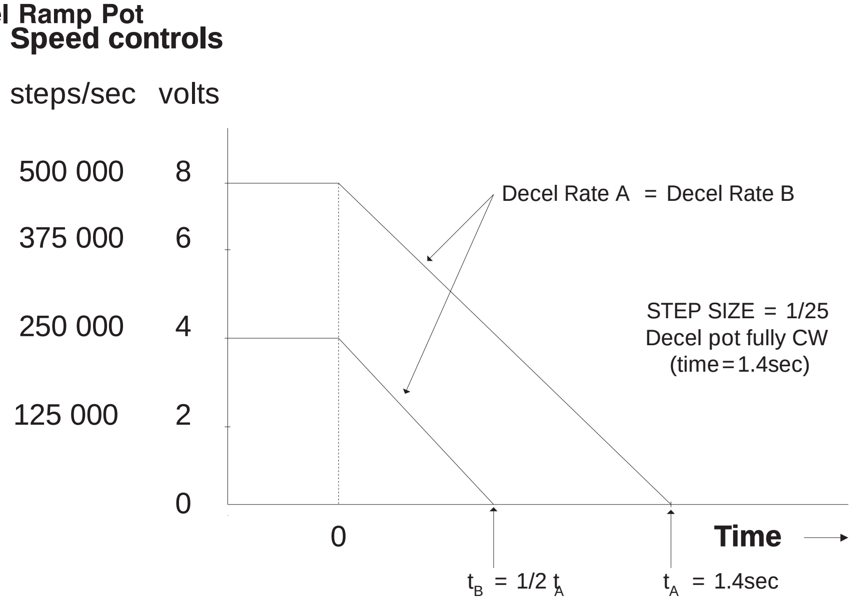


Acceleration rate is non-linear resulting in an exponential velocity ramp. Deceleration rate is constant, resulting in a linear velocity ramp. Accel Ramp Potentiometer (R14) and Decel Ramp Potentiometer (R17) adjust the time for acceleration and deceleration. With fixed accel potentiometer and step size settings, the acceleration rate is a function of speed control inputs. For example, increasing the run speed command by a factor of two will result in twice the acceleration rate.

Accel Ramp Pot



Decel Ramp Pot



Powering Up

3.1.2 Jumper Settings

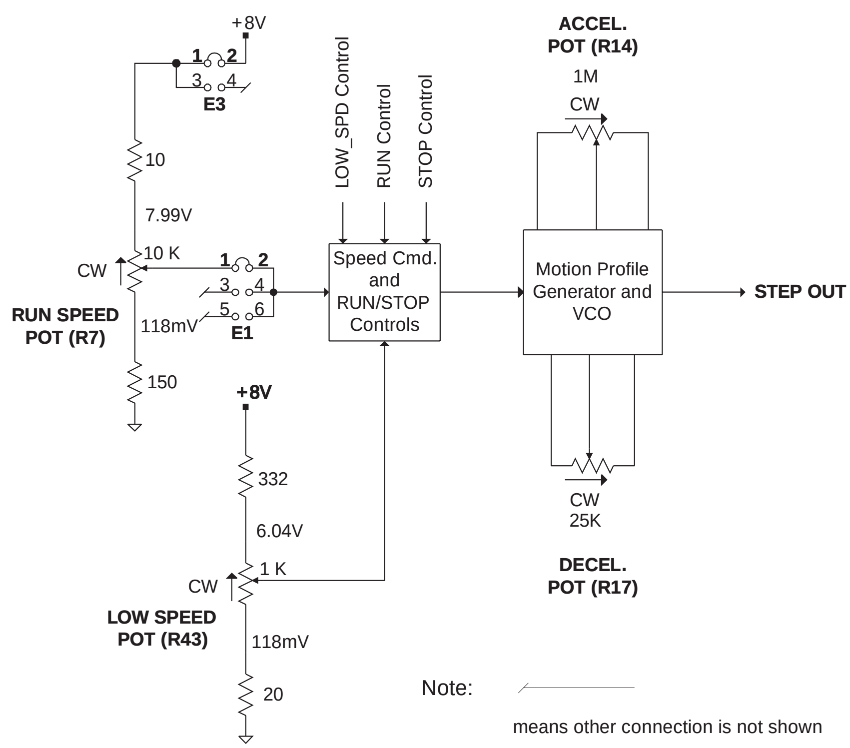
The Oscillator is configured with several jumpers as follows:

Speed Command Settings

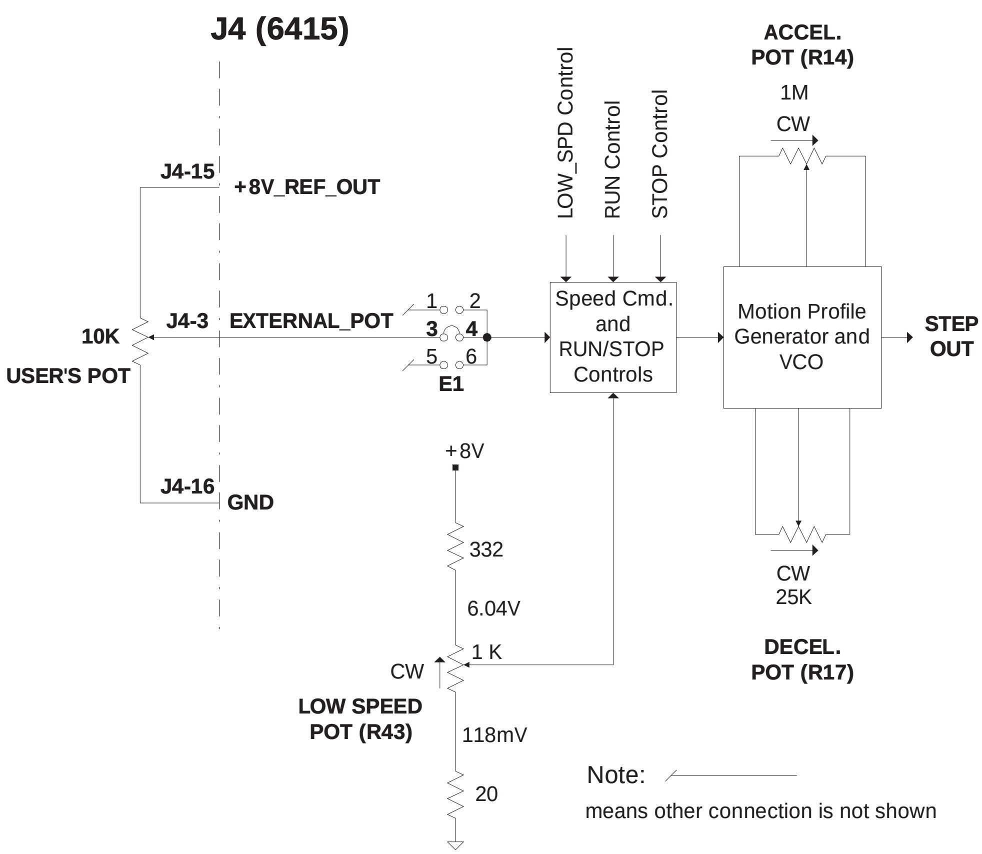
The analog speed command is derived from one of the following sources depending upon the E1 and E3 jumper configuration:

E1	E3	Velocity Control Mode
1-2 IN	1-2 IN	Internal RUN SPEED Potentiometer
3-4 IN	N/A	External Potentiometer
5-6 IN	1-2 IN	External Analog Input
1-2 IN	3-4 IN	External Analog Input scaled by internal RUN SPEED potentiometer

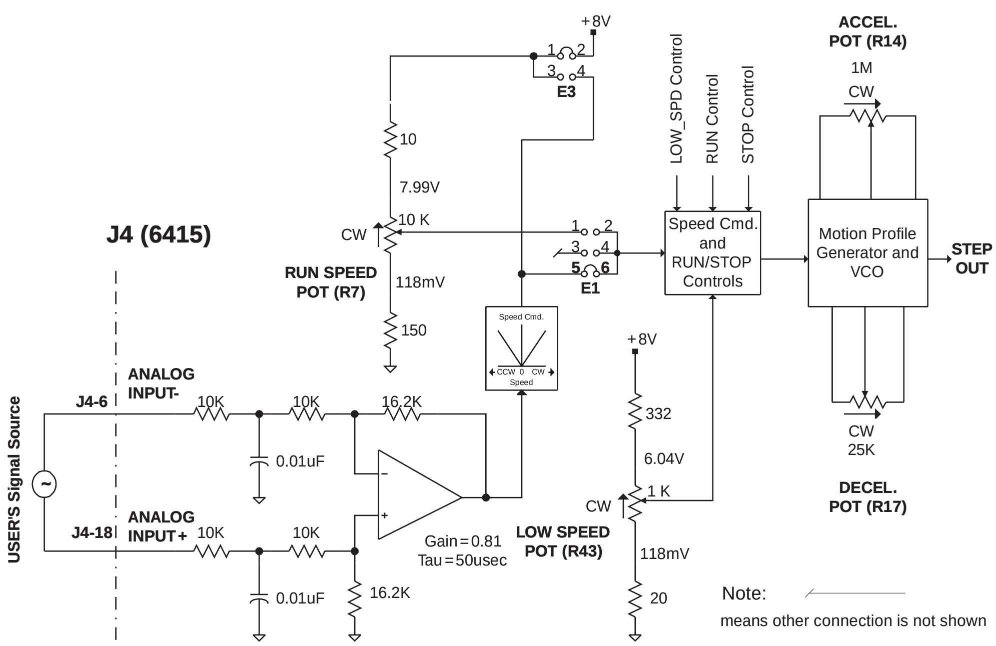
Internal RUN SPEED Pot



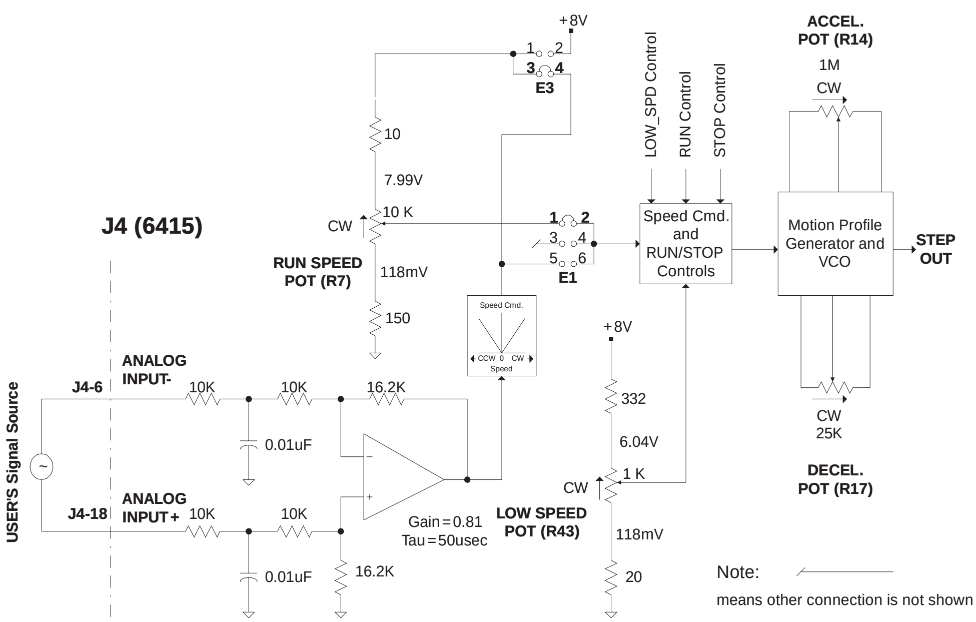
External Potentiometer



External Analog Input



External analog input with internal RUN SPEED pot



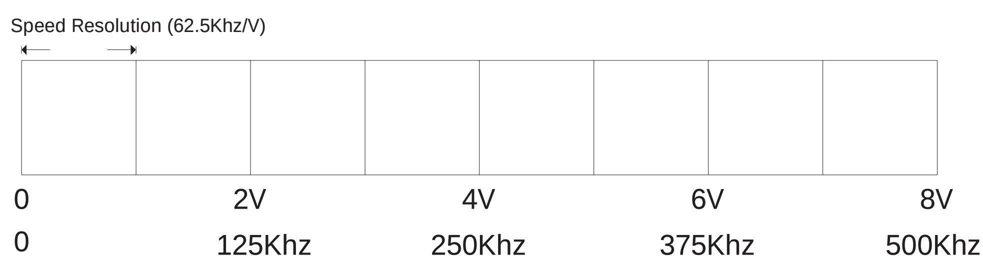
Powering Up

Frequency Range Settings

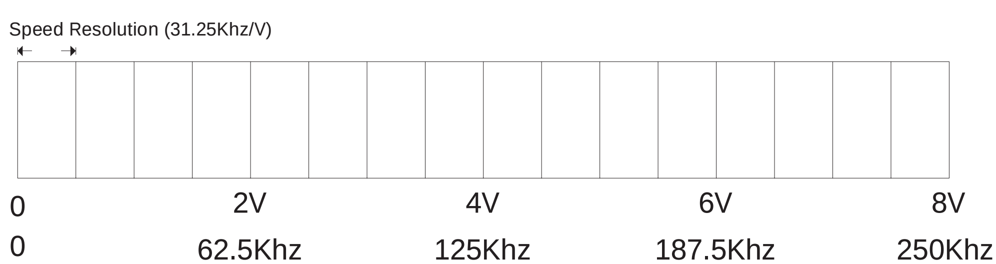
E2 jumper sets the VCO maximum output pulses frequency range. There are two frequency ranges selectable by a jumper to enhance output speed resolution.

E2	Frequency Range
IN	Low Frequency 250 Khz maximum VCO output pulses
OUT	High Frequency 500 Khz maximum VCO output pulses

Coarse Resolution (E2 Removed)



Fine Resolution (E2 Installed)



Run/Stop Command

E4	RUN/STOP Control
IN	Separate Inputs
OUT	Single Input

With the E4 jumper installed, the RUN/STOP (Clutch brake) mode of the 6415 is controlled by two separate optically isolated inputs. When the RUN opto is driven momentarily, the RUN/STOP latch is placed in the RUN state and the oscillator frequency ramps to the selected speed at a rate controlled by the ACCEL potentiometer. When the STOP opto is driven momentarily, the RUN/STOP latch is placed in the STOP state and the oscillator frequency ramps to zero frequency at a rate controlled by the DECEL potentiometer.

The RUN/STOP latch is designed to be in the STOP state after applying power to the 6415 to insure that motion does not occur unintentionally.

Single Input (E4 jumper removed)

If the E4 jumper is removed, the RUN/STOP mode of the drive is controlled directly from the RUN input. When the RUN opto is driven, the oscillator frequency ramps to the selected speed at a rate controlled by the ACCEL potentiometer. When the RUN opto is off, the oscillator frequency ramps to zero frequency at a rate controlled by the DECEL potentiometer.

Minimum Speed Threshold Setting

E5 jumper sets the VCO minimum output pulses frequency threshold depending on the E2 jumper configuration. Steps below this frequency are inhibited to insure no movement at end of decel ramp.

This functionality can be disabled by inserting jumper E5.

E5	**MIN SPEED Frequency**
IN	Disable minimum speed
OUT	Enable minimum speed

Min Speed Threshold: 4 Khz Max for high frequency range
2 Khz Max for low frequency range

Direction Command Setting

DIR+/DIR-

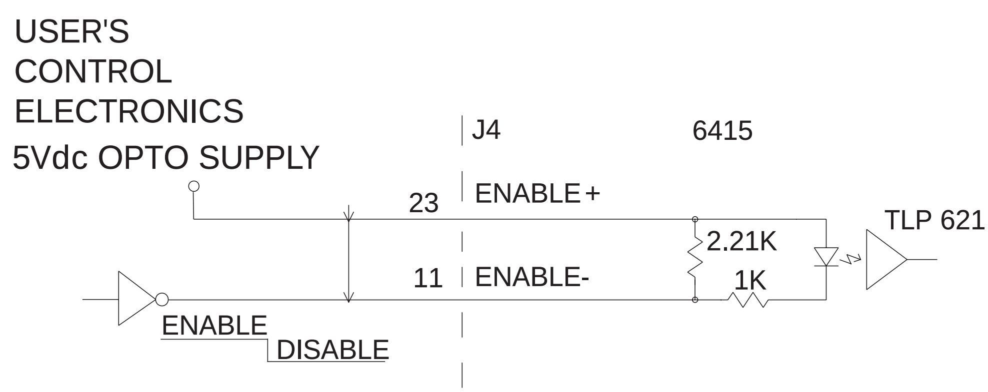
This optically isolated input controls the direction of motor rotation when the E6, E7 and E8 jumpers are removed. Motor rotation is CCW if the opto is driven and CW otherwise. The direction of motor rotation can also be controlled by the analog input or plug on jumpers as shown.

Control Source	**Jumper E6**	**Jumper E7**	**Jumper E8**	**DIR Opto**	**Analog In**	**Rotation**
DIR+/DIR-	Out	Out	Out	Driven	——-	CCW
	Out	Out	Out	Not Driven	——-	CW
Jumpers	In	In	Out	Driven	——-	CCW
	Out	Out	Out	Not Driven	——-	CW
Analog In	In	Out	In	Driven	Negative	CCW
	In	Out	In	Not Driven	Positive	CW

Oscillator
- Enable

The 6415 Enable input factory default is the drive is enabled unless the Enable opto is driven. However, this functionality can be reversed, by inserting jumper J6 5-6, so that the opto must be driven to enable the drive.

Minimum opto current (opto on) 3 ma
Maximum opto current (opto on) 4.5 ma



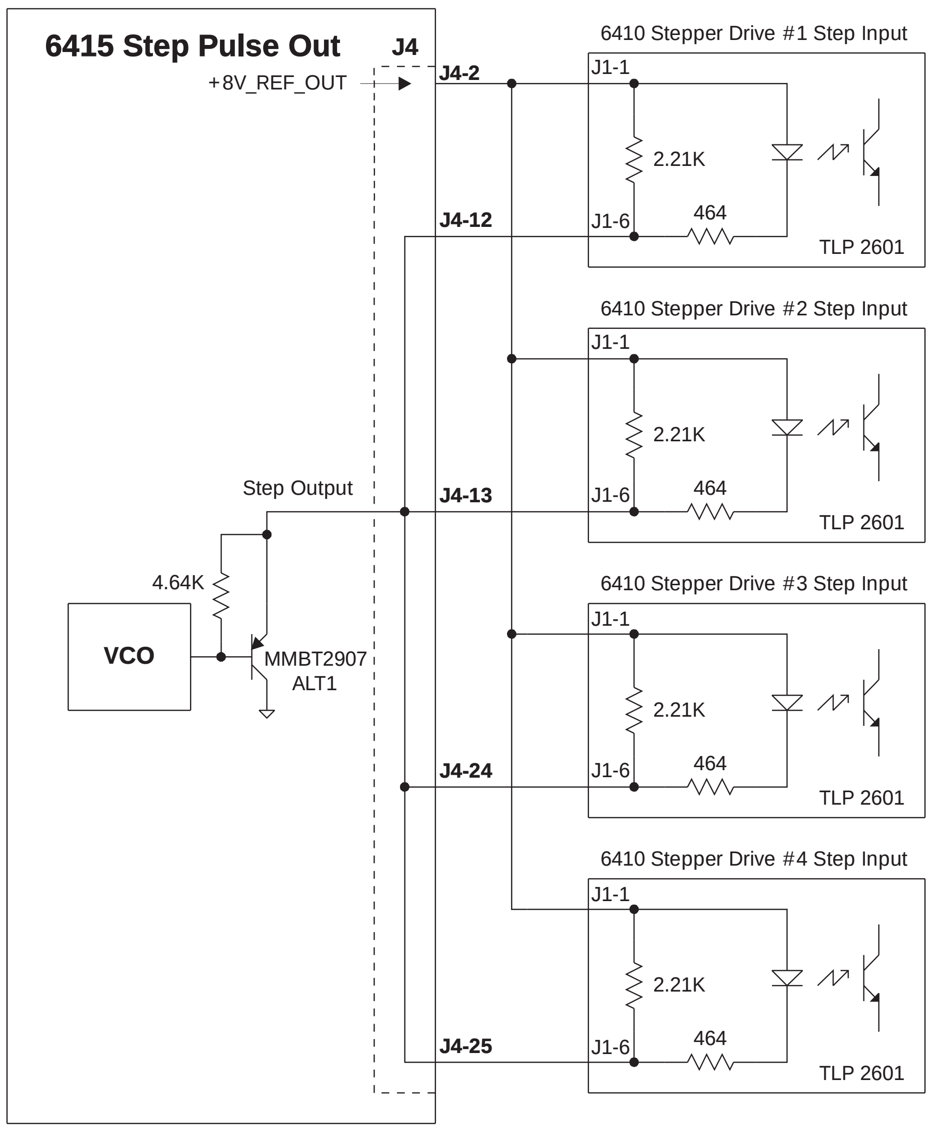
Powering Up

Oscillator
- Enabled LED

LED is lit when drive is enabled. A fault is indicated if the drive is commanded enabled but the LED is not lit.

Oscillator - External Step Pulse

The step pulse output from the VCO is available on J4-12, J4-13, J4-24, and J4-25. This can be connected to up to four additional 6410 drives.



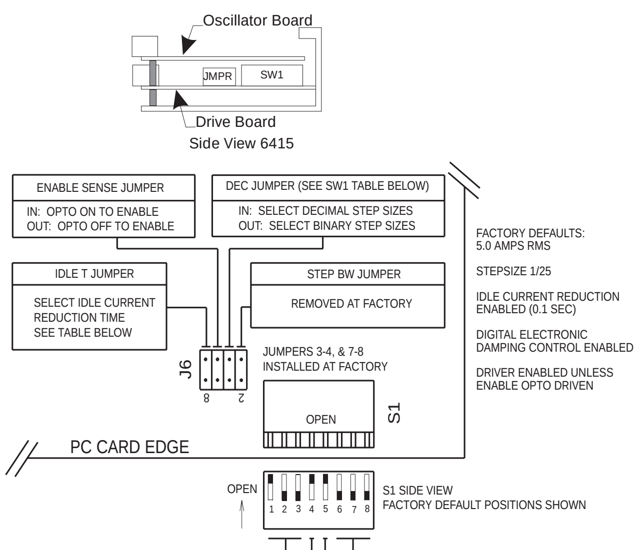
3.2 Drive Board Settings - Switch S1 & Jumper J6

Introduction

DIP switch S1 and Jumper J6 on the drive board set the following:

- Step size
- Motor current level
- Digital electronic damping ON/OFF
- Idle current reduction
- Enable sense
- Step filter response time

Location of S1



SW1 POSITION 1	SW1 POSITION 2	SW1 POSITION 3	STEP SIZE DEC JMPR IN	STEP SIZE DEC JMPR OUT
CLOSED	CLOSED	CLOSED	FULL	HALF
CLOSED	CLOSED	OPEN	HALF	1/4
CLOSED	OPEN	CLOSED	1/5	1/8
CLOSED	OPEN	OPEN	1/10	1/16
OPEN	CLOSED	CLOSED	1/25	1/32
OPEN	CLOSED	OPEN	1/50	1/64
OPEN	OPEN	CLOSED	1/125	1/128
OPEN	OPEN	OPEN	1/250	1/256

SW1 POSITION 6	SW1 POSITION 7	SW1 POSITION 8	MOTOR CURRENT AMPS RMS
CLOSED	CLOSED	CLOSED	5.0
CLOSED	CLOSED	OPEN	4.375
CLOSED	OPEN	CLOSED	3.750
CLOSED	OPEN	OPEN	3.125
OPEN	CLOSED	CLOSED	2.5
OPEN	CLOSED	OPEN	1.875
OPEN	OPEN	CLOSED	1.25
OPEN	OPEN	OPEN	0.625

SWI POSITION 4	DIGITAL ELECTRONIC DAMPING
CLOSED	DISABLED
OPEN	ENABLED

IDLE-T JUMPER	SW1 POSITION 5	IDLE CURRENT REDUCTION
IN	CLOSED	DISABLED
IN	OPEN	0.1 SEC DELAY
OUT	CLOSED	0.05 SEC DELAY
OUT	OPEN	1.0 SEC DELAY

3.2.1 Step Size

Definition

The step size sets the amount of rotation per input step. Fifteen step sizes are available using Jumper J6 position 3-4 and DIP switch S1 positions 1-3 as shown. For all Pacific Scientific stepper motors and all 1.8° step motors, step size can be converted to steps per rotation using the following table:

Decimal		**Binary**	
Full	200	Half	400
Half	400	1/4	800
1/5	1,000	1/8	1,600
1/10	2,000	1/16	3,200
1/25	5,000	1/32	6,400
1/50	10,000	1/64	12,800
1/125	25,000	1/128	25,600
1/250	50,000	1/256	51,200

Benefits

Selecting a microstep size of 1/4 or smaller results in:

- higher resolution
- smoother low speed operation
- ability to operate in low-speed resonance regions

3.2.2 Digital Electronic Damping Control

Definition

Mid-speed instability and the resulting loss of torque occurs in any step motor/drive system due to the motor back EMF modulating the motor winding currents at certain speeds. Mid-speed instability can be explained as a region of potential instability that occurs as a result of the electronic, magnetic, and mechanical characteristics of any stepping motor system. The circuitry used to control this phenomenon does so by advancing or delaying the switching of the output current with respect to the incoming pulse train. This should be taken into account if the user is attempting to employ pulse placement techniques.

Enable the digital electronic damping function by placing DIP switch S1 position 4 in the open position as shown. This is the default position and should be used for most applications if your application is affected by loss of torque at mid-range speeds. If pulse placement techniques are being used, disable the digital electronic damping function by placing DIP switch S1 position 4 in the open position.

Benefit

This feature controls torque loss at mid-range speeds. When enabled, the motor maintains torque at mid-range operation, provided the torque load does not exceed motor torque ratings.

3.2.3 Idle Current Reduction

Definition

The Idle Current Reduction (ICR) function reduces the phase current at times when no motion is commanded. Motor current is reduced when no step commands are received for a given time. This time can be set to 0.05 seconds, 0.1 seconds or 1.0 second. Current to both motor windings is reduced by one-half.

The ICR function can be enabled/disabled and the time delay between the last step command and current reduction can be set to 50 ms, 0.1 seconds, or 1.0 second using DIP switch S1 position 5 and Jumper J6 position 7-8. With the jumper installed (factory default), ICR is disabled when DIP Switch S1 position 5 is in the closed position and enabled with a delay of 0.1 second (current is reduced by 50% when no step command is received for 0.1 second when the switch is open. With the jumper removed, ICR is enabled and the delay can be set to 0.05 second or 1.0 second by placing DIP Switch S1 position 5 in the closed or open position respectively.

Note: *When ICR is active, both the holding torque generated by the motor and the motor stiffness around the holding position are reduced by approximately 50%.*

Benefits

The ICR function:

- Reduces motor and drive heating during stand-by operation

3.2.4 Setting Motor Current

Motor current can be set using DIP Switch S1 positions 6, 7, and 8 as shown. Current should be compatible with motor current ratings.

Note: *Power dissipation in the 6415 drive increases as the output current is increased, so that more cooling is required at high motor currents.*

3.2.5 Enable Sense Control

The polarity of the enable input can be changed using Jumper J6 position 5-6. With the jumper removed (factory default), the drive is enabled when the enable input is not driven and disabled when driven (current flows in enable opto). This allows the 6415 to be used with no connection to the enable input. With the J6 5-6 jumper installed, the enable input must be driven (current in opto) for the 6415 power stage to be enabled.

3.2.6 Step Bandwidth Adjustment

A digital filter can be enabled which reduces susceptibility to noise on the step input at the expense of a lower limit on maximum step frequency. With Jumper J6 positions 1-2 installed the filter is enabled and step pulses must have a minimum width of one microsecond. Pulses less than 0.5 microseconds in width will be rejected. With the filter disabled, Jumper J6 position 1-2 removed, step pulses must be a minimum of 0.25 microseconds wide.

3.3 Testing the Installation

Background

The following procedure verifies that the 6415 is installed properly and that it was not damaged during shipment.

Procedure

After installing the 6415 as described in Chapter 2, test your installation as follows.

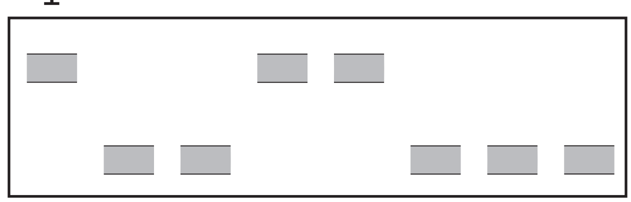
Warning

Perform this initial power up with the motor shaft disconnected from the load. Improper wiring or undiscovered shipping damage could result in undesired motor motion. Be prepared to remove power if excessive motion occurs.

Connections test

1. Check all wiring and mounting to verify correct installation.
2. With the power Off, check that S1 is set as follows (factory default settings):

1



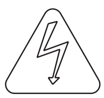
These settings reflect the following:

- Step size of 1/25
- Digital electronic damping enabled
- Idle current reduction enabled
- 5 A rms motor current

Warning

If the motor is rated at less than 5 A rms winding current, set positions 6, 7, & 8 accordingly.

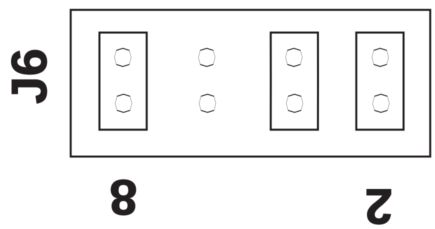
Procedure cont'd



Warning

Make sure power is removed before proceeding.

3. Check that Jumper J6 is set as follows:



These settings reflect the following:

- Idle Current Reduction Enabled (0.1 second delay)
- 6415 enabled without enable input driven
- Decimal step size selected
- Step input filter enabled

4. Switch On power.

Signals test

1. Connect the motor leads and power supply wires to the 6415 Oscillator Board connectors as shown in Section 3.1.

Note: *J1 on the lower board is not used.*

2. Wire the control signals for the independent RUN, STOP and DIRECTION control into connector J4.

3. Pull the RUN signal Low (J4-8) and the motor will ramp up to speed. Pull the STOP signal low (J4-9) and the motor decelerates to a stop. When the DIRECTION signal is pulled low (J4-10) the motor will run in the CCW direction, looking at the motor shaft. If the desired rotation for a low signal is CW, swap the connections of the motor leads on pins J3-1 and J3-2.

Note: *Remove power from the drive before swapping the leads.*

Procedure (cont'd)

4. If the motor emits a high frequency noise but the shaft is not rotating, stop the motor. Lower the RUN SPEED by turning the RUN SPEED potentiometer CCW. Increase the ACCEL RAMP by turning the ACCEL RAMP potentiometer CW.
5. After successfully establishing motion, the system can be powered down and connected to a load.

Note: *A bus capacitor should be connected to the 6415 power input. The bus capacitor should be connected using a twisted pair cable no longer than three feet in length. For maximum voltage and current, a 100 volt, 5 A rms (120 Hz ripple current rating), 6000 uf capacitor is recommended.*

Getting help

If you need further assistance with your installation, please contact your local distributor.

4 Maintaining/Troubleshooting

In this chapter

This chapter covers maintenance and troubleshooting of the 6415 unit.

4.1 Maintaining the 6415 Drive

Introduction

The 6415 drives are designed for minimum maintenance. The following cleaning procedure, performed as needed will minimize problems due to dust and dirt build-up.

Procedure

Remove superficial dust and dirt from the unit using clean, dry, low-pressure air.

4.2 Troubleshooting the 6415 Drive

Introduction

The 6415 has an "enabled LED" output which is on when the drive is enabled and off when the drive is disabled or faulted due to any of the following:

- Output overcurrent (line-to-line or line-to-neutral short)
- Bus overvoltage
- Low voltage supply out of tolerance

Use the troubleshooting table to diagnose and correct most problems. If you are unable to achieve satisfactory operation, contact your local Pacific Scientific Distributor or the Applications Engineering Department.

IMPORTANT NOTE!

If you suspect that the 6415 drive has been damaged, DO NOT simply replace it with another and apply power. Re-check the power supply design and verify that it meets all requirements. Improper supply design is the most common cause for damaged drives.

Corrective action table

SYMPTOM	CORRECTIVE ACTION
Motor produces no torque, enabled LED not lit.	Ensure that the J6 5-6 jumper is out, or if in, that the enable input opto is driven with at least 3 mA. Disconnect the motor cable and cycle the J2 power supply Off and On. If the enabled LED lit, check the step output and VCO input monitor point. Also, check motor cable and motor for shorts across the windings or between the windings and the motor case. Check that the J2 power supply voltage is ≥ 24 Volts and ≤ 75 Vdc. If possible, check with an oscilloscope to verify that this is true on a transient basis.
Motor produces no torque, enabled LED lit.	Verify that DIP Switch S1 position 6, 7, and 8 (current select) are set correctly. Re-check that the motor cable is wired correctly and properly plugged into the drive.
Motor produces torque but does not turn.	Make sure that the STEP output is switching.

Table (cont'd)

SYMPTOM	CORRECTIVE ACTION
Motor rotates in the wrong direction.	Check polarity of the DIRECTION input. Also, verify that the direction selection jumpers (E6, E7, E8) are set correctly. Reverse the A and $\overline{A}$ motor phases.
Motor does not reach expected position.	Check that the step size setting of the drive and speed potentiometer are set correctly. Verify that the motor does not stall. If it does: 1. Re-check sizing calculations. Be sure that the power supply voltage is high enough for the required torque vs. speed curve. 2. Use a finer step size to avoid low-speed resonance problems. 3. Enable Digital Electronic Damping (S1 position 4 OFF).
Enabled LED not lit - drive is disabled.	1. Turn the bus power off. 2. Disconnect the motor winding from the drive. 3. Turn the bus power back to on. If the Enabled LED is still not lit, check that the +8V reference output (+8V_REF_OUT) is within specifications. 4. Remove any external connections to the enable input opto (ENABLE) and check to see that the enable sense jumper (J6 5-6) is removed (factory default). 5. Reapply the power. If ENABLED LED is still not lit, drive has an internal short.

Table (cont'd)

SYMPTOM	CORRECTIVE ACTION
Motor produces torque, but does not run.	1. No Step pulses out - Check that there is a final speed command voltage at the VCO monitor test point (VCO_INPUT_MON) and the step pulses output (STEP_OUT) is switching. Also verify that E1 and E3 jumpers are set correctly. 2. Loss of phase current in one winding. Check phase current in both phases by placing an ammeter in series with each winding. If not present, check for open circuit in motor phase winding by measuring resistance. 3. One motor phase not wired correctly at stepping motor. Check stepping motor wiring. 4. Step pulses output (STEP_OUT) is too high. Lower step pulses output by adjusting Run Speed and Accel/Decel Potentiometers. Also check to make sure that the step size and frequency range jumper (E2) are set correctly.
Motor misses steps.	Incorrect run speed or low speed. Adjust run speed potentiometer or low speed potentiometer. Incorrect accel ramp time or decel time. Adjust accel potentiometer or decel potentiometer.

If the drive is defective

Return procedure

If you cannot correct the drive problem, or if it is defective, return it to Pacific Scientific for repair or replacement.

1. Call Pacific Scientific at (815) 226-3100 from 8am to 6pm Eastern Standard Time to get a Returned Materials Authorization Number (RMA#).

Note: *Do not attempt to return the 6415 or any other equipment without a valid RMA#. Returns received without a valid RMA# will not be accepted and will be returned to the sender.*

2. Pack the drive in its original shipping carton. Pacific Scientific is not responsible or liable for damage resulting from improper packaging or shipment.

3. Ship the drive to:

   Pacific Scientific

   110 Fordham Road

   Wilmington, MA 01887

   Attn: Repair Department, RMA# _________

Note: *Do not ship Pacific Scientific motors to the above address. The correct address for motors is:*

   Pacific Scientific

   4301 Kishwaukee Street

   Rockford, IL 61105

   Attn: Stepper Repair Department, RMA# ________

Shipment of your drive or motor to Pacific Scientific constitutes authorization to repair the unit. Refer to Pacific Scientific's repair policy for standard repair charges. Your repaired unit will be shipped via UPS Ground delivery. If another means of shipping is desired, please specify this at the time of receiving an RMA#.

Appendix A Specifications

Electrical

Input power supply 24 - 75 Vdc @ 5.0 Amps

Rated drive current (motor phase current) Setting

5 A	5A ± 0.25A
4.375	4.375 ± 0.2A
3.75	3.75 ± 0.2 A
3.125	3.125 ± 0.15 A
2.5	2.5 ± 0.15 A
1.875	1.875 ± 0.125
1.25	1.25 ± 0.125
0.625	0.625 ± 0.1 A

Drive circuit Two-phase bipolar, chopper current regulated

Chopper frequency 20 KHz, nominal

Step size

Switch settable	Steps/motor revolution (1.8^o stepper motor)
Full **(1/2)**	200 **(400)**
1/2 **(1/4)**	400 **(800)**
1/5 **(1/8)**	1000 **(1600)**
1/10 **(1/16)**	2000 **(3200)**
1/25 **(1/32)**	5000 **(6400)**
1/50 **(1/64)**	10000 **(12800)**
1/125 **(1/128)**	25000 **(25600)**
1/250 **(1/256)**	50000 **(51200)**

Signal input requirements

(See circuit diagram, Section 2.5.3)

Optically Isolated Inputs:

Input	Min Input Current - Opto ON	Max Input Current	Max Reverse Voltage
J4-19, J4-7 Low Speed	3.0 mA	4.5 mA	5 volts
J4-22, J4-10 Direction	3.0 mA	4.5 mA	5 volts
J4-23, J4-11 Enable	3.0 mA	4.5 mA	5 volts
J4-20, J4-8 Run	3.0 mA	4.5 mA	5 volts
J4-21, J4-9 Stop	3.0 mA	4.5 mA	5 volts

Signal output characteristics

(See circuit diagram, Section 2.5.3)

J4-1
VCO Input
Monitor

≅ 100KΩ Input Impedance

J4-2, J4-14,
J4-15
+8 V Ref Out

50 mA max @ 25°C Ambient
25 mA max @ 50°C Ambient

J4-3
External Pot

≅ 1MΩ Input Impedance

J4-12, J4-13,
J4-24, J4-25
Step Out

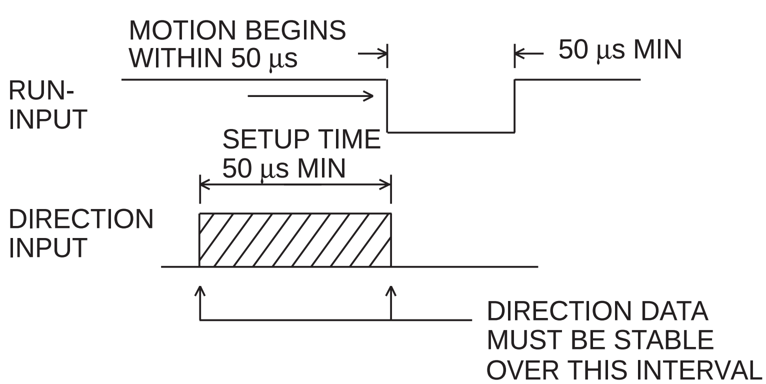
100 ma Max (Max Reverse voltage = -50 Vdc)@ 25°C Ambient
50 ma Max (Max Reverse voltage = -50 Vdc)@ 50°C Ambient

Maximum step rate

500 KHz

Run/Direction timing requirements

The figure below show the required timing relationship between the RUN and DIRECTION inputs:



Specifications

Minimum ramp time for step rate (Accel/Decel)	50 milliseconds (This restriction only applies with digital electronic damping circuit enabled.
Driver state generator transition delay relative to input step	1. With digital electronic damping circuit enabled, at pulse frequencies less than 500 full steps/sec, delay is less than 500 µsec. At frequencies greater than 500 full steps/sec, delay is less than 270° of the input pulse period. 2. With digital electronic damping circuit disabled, delay is less than 10 µsec at all step frequencies.

RUN SPEED Control (Analog Input)

Analog Input Range	± 10 Vdc Also controllable with internal or external potentiometers
Analog Input Impedance	20 KΩ (differential amp)

High Frequency Range

RUN SPEED Control	8 KHz to 500 KHz
LOW SPEED Control	8 KHz to 370 KHz

Low Frequency Range

RUN SPEED Control	4 KHz to 250 KHz
LOW SPEED Control	4 KHz to 180 KHz

RUN SPEED /LOW SPEED

Stability Over Temp. /Range	±1% of full scale (typical)

ACCEL RAMP (exponential)

accel pot fully CW	0.4 sec (single time constant)
accel pot fully CCW	0.4 msec (single time constant)

DECEL RAMP (linear)

decel pot fully CW	1.4 sec
decel pot fully CCW	6.0 msec

MIN SPEED

4 Khz Maximum (high frequency range)
2 KHz Maximum (low frequency range)

Steps below this frequency are inhibited to insure no movement at end of decel ramp. This functionality can be disabled by inserting jumper E5.

Note: *Motor rpm = 0.3 * Freq. (Hz)/step size. For example: If frequency = 500,000 Hz and step size = 125, rpm = 1200.*

Environmental

Operating Temperature

Full rated current 0 to 50°C ambient air with or without cover provided chassis properly mounted so as not to exceed 60°C.

Storage Temperature

-55°C to +70°C

Maximum chassis temperature

60°C

Note: *For optimal thermal performance, mount the 6415 chassis (back or side) to a cooling plate or heatsink. Use a thermal pad or grease if surface is irregular. A fan or idle current reduction may be employed to keep chassis below 60°C.*

Humidity Range

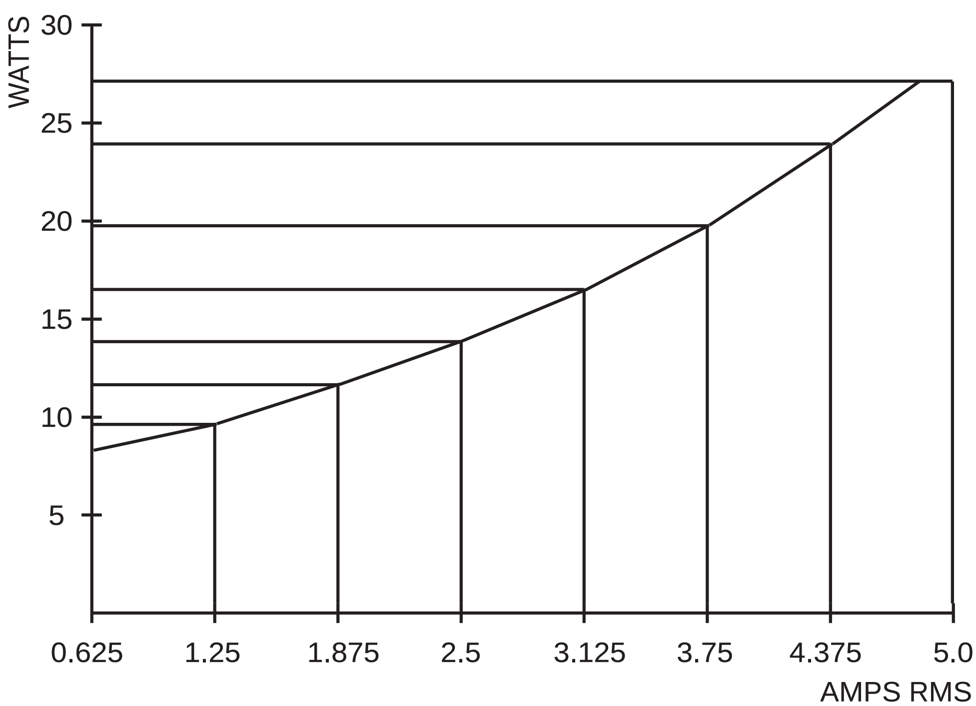
10 to 90%, non-condensing

Convection Cooling (6415 not mounted on cooling plate)

With optional heat sink	Full rating (5 A) at 25°C Ambient 2.5 A max at 45°C Ambient
Without heat sink	2.5 A max at 25°C Ambient 1.25 A max at 45°C Ambient

See Figure 1 for plot of driver power dissipation vs. output current.

Figure 1



Specifications

Mechanical

Dimensions	Refer to Section 2.4
Weight	1.0 lb nominal
Connectors	
Power Supply	PCD ELVH0310 connector. Mating connector: PCD ELVP03100.
Signal	25 contact female D connector, Mating connector: ITT Cannon DB-255 with ITT Cannon DB110963-3 Hood.
Motor	PCD ELVH0510 connector. Mating connector: PCD ELVP05100.

Appendix B Ordering Information

Background

This appendix lists 6415 part numbers and gives information on ordering.

6415 part number table

Part	Pacific Scientific Order #	Comment
Stepper Drive	6415	
Connector Kit	CK6415	25-pin D connector
		5-pin PCD
		3-pin PCD
Installation and Hardware Manual	MA6415	
Motor Cable	SPC-xxx-6410	xxx represents length in feet; for example, SPC-005-6410 is a cable 5 feet long. For lengths over 50 feet contact Pacific Scientific. The connectors are MS on the motor end and PCD on the drive end to connect to Pacific Scientific motors.
Heatsink	HS6410	Heatsink with mounting hardware.
Cover	CV6415	Cover with mounting hardware.

How to order	Contact Pacific Scientific to order these parts.
Call	815-226-3100 from 8am to 6pm Eastern Standard Time.
Write	Pacific Scientific 4301 Kishwaukee Street Rockford, IL 61105
Fax	(815) 226-3048

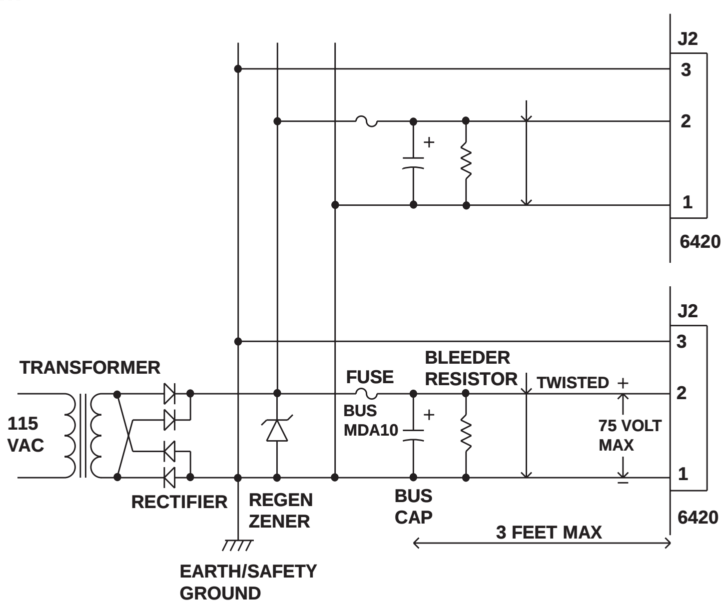
Appendix C Power Supply Considerations

C.1 Bridge, Capacitor Power Supply

The figure below shows the full-wave-bridge, capacitor-input configuration most commonly used to power one or more 6415 drive modules. A single transformer provides isolation and transforms the AC input voltage to a level that, when rectified, provides the desired DC bus voltage. Fusing should be between the rectifier and individual bus capacitors. This allows fuse size to be based upon the current requirements of a single module to provides the greatest protection. The capacitors must be connected to the 6415 DC+ and DC- inputs using twisted pairs no longer than three feet in length as shown to control winding inductive effects. A regen clamp to absorb power transferred from the motor to the 6415(s) is sometimes required. This section provides selection guidelines for the power supply components.

Power Supply Considerations

Block diagram



Warning

Power supply design must insure that the voltage between J2-2 and J2-1 never exceeds 75 volts under any operating conditions ***. These conditions include high line voltage, transformer regulation effects, voltage spiking due to current switching within the module and regeneration. Failure to do this can result in permanent damage to the 6415.***

C.1.1 Line Transformer Selection

Primary voltage and frequency rating

Make sure that the transformer is guaranteed to operate at the highest line voltage combined with the lowest line frequency that will ever be used to power your system. Failure to do so can result in saturation, large current increases and winding failure.

Secondary voltage rating

Maximum motor speed performance will be achieved by using as high a motor supply voltage as possible without ever exceeding 75 volts. Of course lower voltages can also be used (so long as the voltage is greater than the minimum specified value of 24 volts) but motor torque will drop more rapidly as speed increases.

The peak bus voltage (excluding any spiking due to current switching in the drive module or any regeneration effects) is approximately equal to:

(1.414 * **Actual** Secondary rms voltage) - 1.5

Note: *This assumes a 0.75 volt drop across each rectifier diode. To insure this, as well as to discharge the bus capacitor when AC power is removed, it is recommended that a bleed resistor be placed across each bus capacitor as shown.*

Example

If, for example, the secondary rms voltage is 40 Vac, the peak bus voltage will be 1.414 * 40 - 1.5 = 55 volts. A transformer with 115 Vac primary and 40 Vac secondary would produce 55 volts peak bus voltage under nominal line conditions and at rated loading.

However, if the line voltage increases 10% the peak bus voltage increases to:

$$(1.414 * 1.1 * 40) - 1.5 = 60.7 \text{ volts}$$

at rated transformer loading.

Load regulation must also be accounted for when selecting the transformer. Transformers are designed to produce their specified secondary voltage when loaded by their rated current. **For currents less than rated, the secondary voltage will increase**. Signal Transformer gives the following load regulation data for its line of rectifier transformers:[1]

VA Rating	Load Regulation
1 - 100	10%
100 - 350	8%
> 500	5% or less

This means that the secondary voltage of a 100 VA transformer will increase 10% over the specified voltage if the load current is reduced from rated current to zero. Since the stepper drive(s) might sometimes be disabled, the full regulation effect as well as maximum line voltage should be considered when selecting the transformer.

1 The VA product is obtained by multiplying the specified secondary voltage (Volts rms) by the rated secondary current (Amps rms). For example, a 24 Vac transformer with a rated secondary current of 1 Amp has a VA of 24.

Based upon these considerations, the table below gives the highest allowable rated secondary voltage when using a line with +10% voltage tolerance:

Transformer VA Rating	**Maximum Rated Secondary Voltage**
1 - 100	44.7 Vac
100 - 350	45.5 Vac
> 500	46.8 Vac

Current Rating

The average current load of the 6415 is a function of the motor used as well as motor speed and torque. To optimize the power supply design, the supply current can be measured using a DC current meter when the motor is producing the highest shaft power. If it is difficult to make this measurement, assume the maximum average load current equals the selected phase current. Thus, if the DIP switch is set for 5 Amps RMS, assume the maximum average power supply current is 5 amps.

The average transformer secondary current equals the sum of the average currents for all 6415s powered by the supply. Because the transformer supplies pulses of current to charge the "bus" capacitor(s) on the other side of the diode bridge, the rms current is higher than the average current. The transformer should have a rated secondary rms current of at least 1.8 times the average current.

Example

The transformer used to supply three 6415 drive modules, each set for 5 Amps rms should have a rated secondary rms current of 1.8 * (5 + 5 + 5) = 27 amps or greater.

Note: *It is generally* <u>*not*</u> *advisable to significantly oversize the transformer because this will increase rectifier surge current during turn on, as well as capacitor ripple current.*

C.1.2 Rectifier Diode Selection

Voltage rating

For the bridge rectifier configuration shown, the peak inverse voltage (PIV) equals 1.414 times the secondary rms voltage. For example, a 40 Vrms secondary will develop 1.414 * 40 = 56.6 PIV across the rectifier diodes. To allow for line variation and spiking, allow at least a 50% safety factor in the diode rating. Therefore, **the PIV rating of the rectifier diodes should be at least twice the rated secondary rms voltage.**

Current Rating

Since each diode conducts only on alternate cycles, the average diode current will be half the supply's average DC current load on the supply. When power is first applied, there is a surge of current to charge the capacitor(s) which must be less than the diode's peak one cycle surge current (I_{FSM}) rating. Typically, diodes are chosen with an average current rating of at least twice the average current load of the supply. It is often advisable to select diodes with an even greater average current rating because they have lower thermal resistance between junction and case and hence ease heat sinking requirements. It is good design practice to limit the maximum junction temperature to 125°C. Testing should be done to insure the power-on surge current is within the diode's I_{FSM} rating.

C.1.3 Capacitor Selection

The table below gives the minimum bus capacitance value for a single 6415 as a function of the current setting and bus voltage. These values give approximately 10% peak-to-peak ripple voltage with a 60 Hz line (increase capacitor values by 20% for use with a 50 Hz line).

Current Setting	30 Volt Bus	50 Volt Bus	70 Volt Bus
5.0	14,000	8300	6000
4.375	12,000	7300	5200
3.75	10,000	6300	4500
3.125	8700	5200	3700
2.5	6900	4200	3000
1.875	5200	3100	2200
1.25	3500	2100	1500
0.625	1700	1000	740

Bus Capacitance in Micro farads

Ripple current rating

The bus capacitor's 120 Hz ripple current rating should equal or exceed the 6415's current setting. The capacitor's working voltage rating must exceed the maximum bus voltage under all line, load, and regen conditions. Select a capacitor rated for at least 1.3 times the nominal bus voltage.

Example

Suppose a 6415 is operating at 70 volts and is set for 5 A rms motor current. Assuming a 60 Hz line, a bus capacitor of 6000 micro farads should be used. The capacitor should have a 120 Hz ripple current rating of at least 5 amps rms and a working voltage of at least 1.3 * 70 = 91 volts.

The bus capacitor should be connected to the 6415 using a twisted pair, no longer than 3 feet in length.

C.1.4 Fuse Selection

The BUS MDA10 slow blow fuse or equivalent is recommended when the 6415 is set for 5 Amps. Fuses from the same family but with proportionally lower current rating can be used with lower current settings.

C.1.5 Regeneration Considerations

The motor power supply voltage can be "pumped up" when the motor and load are decelerated by the drive. In effect, the motor becomes a generator converting mechanical energy stored in the spinning motor and load inertia into electrical energy. If the mechanical energy is less than the losses in the drive and motor, the supply voltage does not increase. If the mechanical energy is greater than these losses, the supply voltage will increase (be pumped up).

The mechanical energy of a spinning inertia is given by:

$$E = 3.87 * 10^{-5} * J * S^2$$

where: E = kinetic energy (joules)

J = inertia in oz-in-sec^2

S = speed in rpm

Final voltage

If this energy is converted to electrical energy in the form of charge on the bus capacitor(s), the voltage will be:

$$V = \sqrt{V_O^{\,2} + \frac{2E}{C}}$$

where: V is the final voltage (after energy transferred to capacitor(s)

V_o is the initial voltage

C is the total capacitance in farads

E is the initial kinetic energy in joules

Power Supply Considerations

Example

If an unloaded E34 motor (rotor inertia = .035 oz-in-sec^2) is rotating at 1500 rpm, the stored energy is:

$3.87 * 10^{-5} * .035 * 15002 = 3.0$ joules

If all this energy is transferred to a 6800 mf capacitor, initially charged to 70 volts, the voltage on the capacitor after the transfer is equal to 76 volts.

Note: *This exceeds the volt maximum specification of the 6415 drive.*

In practice, most or all the kinetic energy is dissipated in the motor windings or in the drive power circuitry so that voltage pump-up is often not a problem. However, in systems running at high speeds and having large load inertia, the voltage might be pumped up significantly and circuitry must be added to insure that the 75 volt limit is never exceeded.

Note: *Regeneration effects should be considered in the presence of high line conditions.*

To find out if regenerative energy is a problem, run the system while monitoring the supply voltage with a storage oscilloscope. Alternatively, a simple peak detector made form a diode and a capacitor can be attached to the bus and the peak voltage measured using a digital voltmeter. Start the system with slow deceleration rates and monitor the motor power supply to see if the voltage rises during deceleration. Slowly increase the deceleration rate (shorten the deceleration time) while monitoring the voltage. If regeneration causes the supply voltage to exceed 75 Vdc peak, a clamping circuit is required.

Note: *Be sure to consider the effect of high line voltage when evaluating this test.*

Clamping Circuit

If a clamp is required, a power zener diode can be used as shown in the figure. The maximum zener clamp voltage must not exceed 75 volts.

Caution

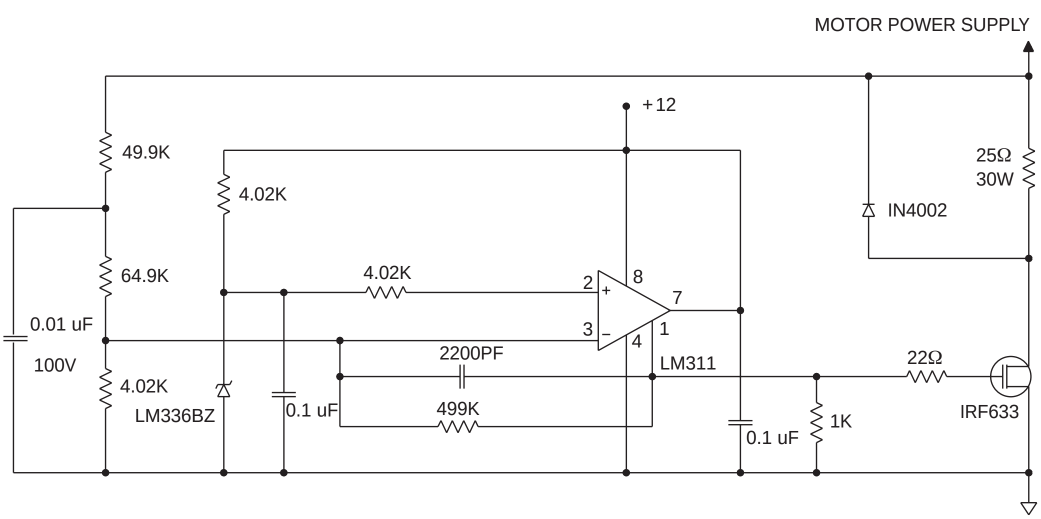
If a clamp is required, the transformer secondary voltage must be re-checked to insure that the minimum clamp voltage is not exceeded under high line and low load conditions when there is no regeneration. Otherwise, the zener might overheat and fail.

To determine the required diode power rating, start with a 5W device and monitor the zener current with a current probe. Power (in watts) is the average current (in amps) times the zener voltage. Estimate the average current from the oscilloscope trace and compute the power. Select a zener rated slightly higher than the measured power.

If the average power is too high to be conveniently dissipated in a zener diode, the active voltage clamp circuit shown below can be used instead. Power is dissipated in the 25Ω, 30W resistor if the Motor Power Supply voltage exceeds 75 volts.

Power Supply Considerations

Active clamp circuit



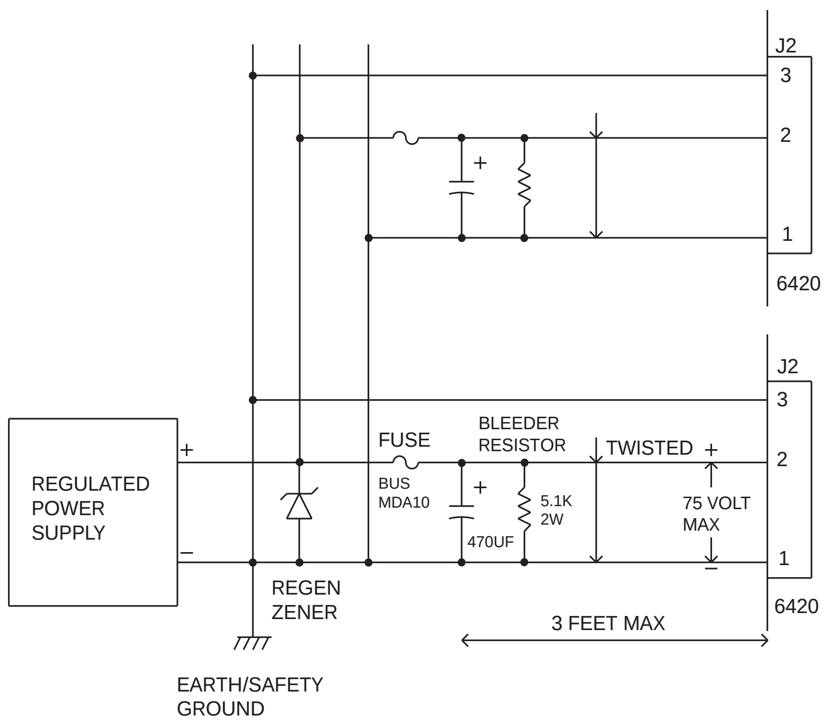
C.2 Powering the 6415 from a Regulated Supply

Certain precautions should be taken when powering the 6415 drive from a regulated power supply. The 6415's bipolar chopper output stage draws current from the DC supply in the form of pulses with fast rise and fall times. This may be a problem for some regulated supplies designed to drive loads having relatively constant or slowly varying current drain. If a regulated supply is used and problems are encountered, a 470uf capacitor should be placed across the DC+ and DC-lines between the power supply and 6415. Ideally this capacitor is located close to the 6415 drive but it can be located near the power supply and connected to the 6415 with a twisted pair no longer than 3 feet in length. The capacitor should have a 20KHz ripple current rating of at least the 6415's current setting and a voltage rating of 1.3 times the nominal bus voltage.

A second precaution involves regenerated power (see section C.1.5). Regulated supplies are usually not designed to absorb power. This might cause their output voltage to rise during regeneration and lead to power supply and/or 6415 damage. The same considerations and solutions described in section C.1.5 apply.

6415(s) powered by regulated supply

The figure below illustrates powering the 6415 from a regulated supply where both an external capacitor and regenerated power dump circuit are required. The recommended fusing is also shown.

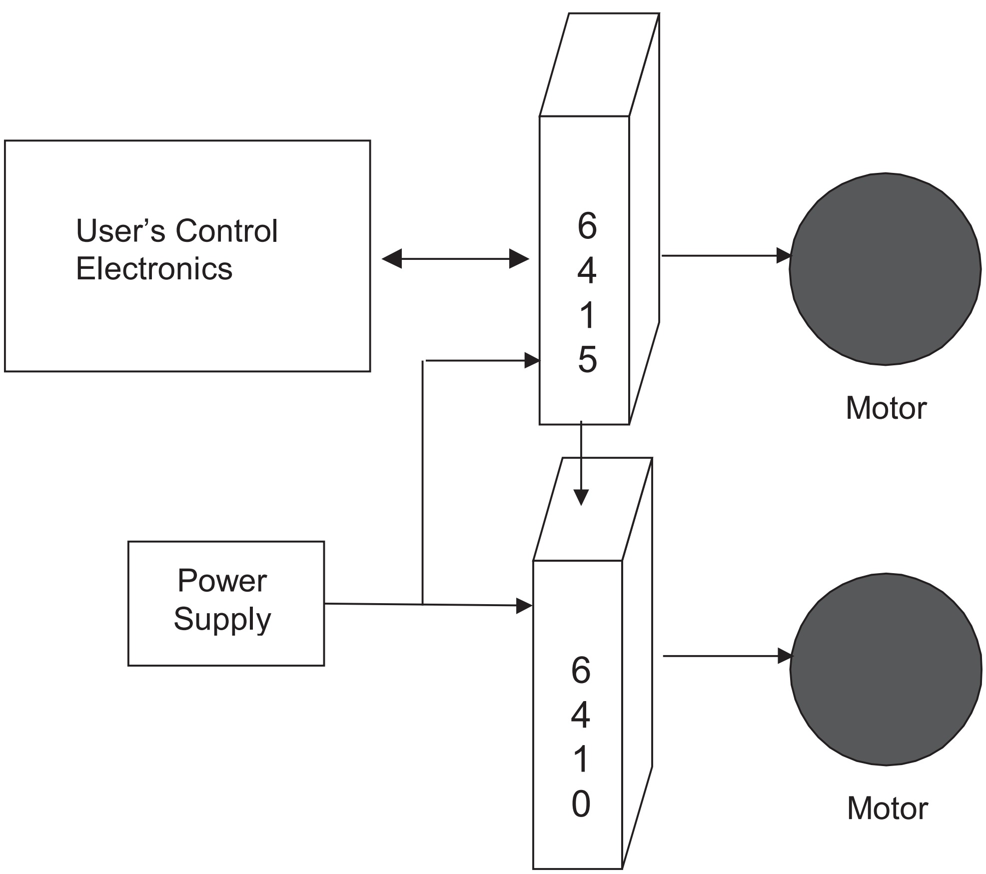


Power Supply Considerations

Appendix D Application Examples

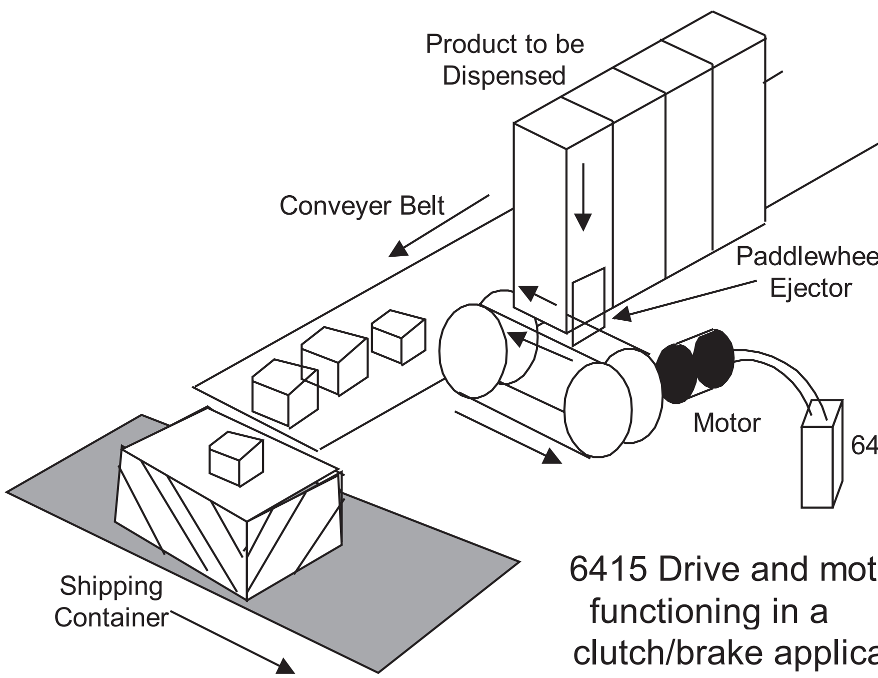
Introduction The following examples give a flavor of just a few of the myriad applications for the 6415.

D.1 Standalone Operation



D.2 6415 Dispensing Product onto Conveyer Belt

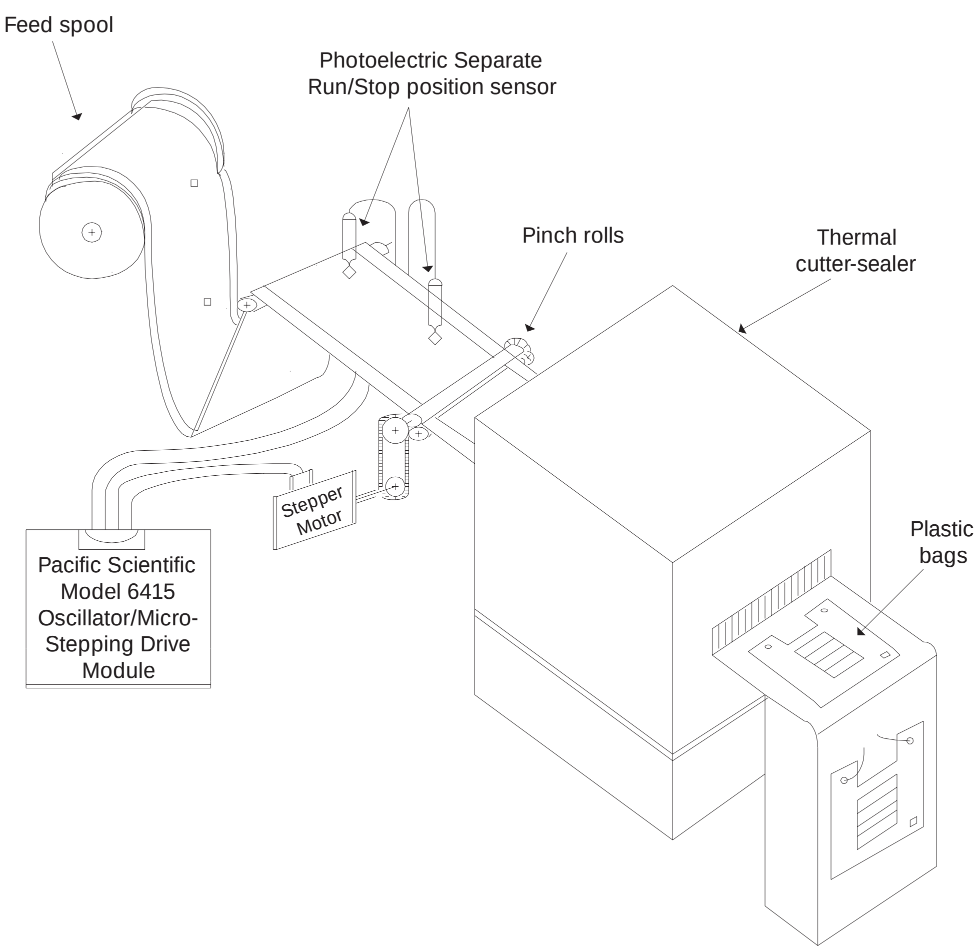
This example shows the 6415 Oscillator/Microstepping Drive Module and motor dispensing products onto a conveyor belt and into a shipping container. The stepper motor supplies start-stop motion to a paddlewheel ejector to dispense the product. An optic sensor is used to advance the paddlewheel to the starting point. An external Start signal initiates motion to eject the product, the motion continues for one revolution until the paddlewheel is aligned for the next cycle.



6415 Drive and motor functioning in a clutch/brake application

D.3 6415 Clutch Brake

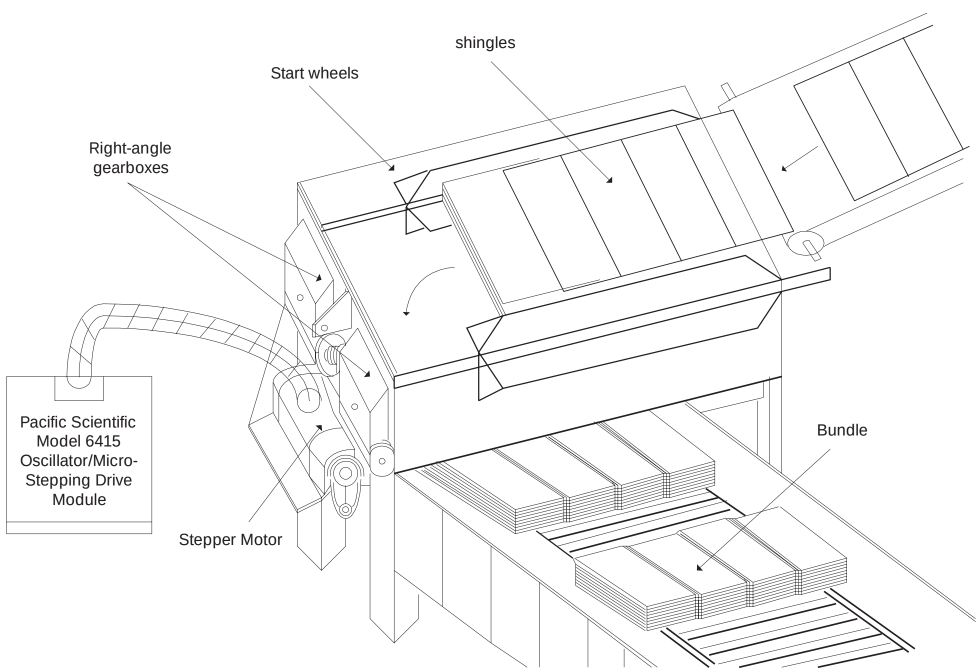
Cut-and-Seal Machine uses 6415 Oscillator/Microstepping Drive Module to accurately index pinch rolls so plastic web is in position for cutting and sealing into bags.



Application Examples

D.4 6415 Shingle Catcher

Roofing shingle machine uses 6415 Oscillator/Microstepping Drive Module to catch and stack fast moving shingles and then place them in a bundle forming chamber.



Appendix E CE Installation Guide

Introduction

The information contained in this appendix applies to the 6415 ONLY. The 6415 is designed for use within machines that require compliance with European Safety and EMC Directives. The standards that the 6415 complies with are described in the Declaration of Conformity on the following page.

Note: *The information contained in this appendix supplements the material in the MA6415.*

Customer Responsibility

This appendix, supplied with all 6415 series drives, provides detailed information on installation. This appendix must be closely followed if EMC compliance is to be maintained. It covers details such as mechanical mounting, safety earth connections and motor wiring.

The 6415's input voltage is provided by a user supplied dc power supply. System harmonics and conducted emissions are dependent on the system chosen. Therefore, the machine builder is responsible to properly filter the installation thereby preventing unwanted conducted line noise.

EN 61800-3 also puts the responsibility of filtering on the machine builder. For additional information please see the "Assessment of Compatability" section in EN 61800-3.

CE Declaration of Conformity

This is to certify that:

Pacific Scientific
Motion Technology Division
110 Fordham Road
Wilmington, MA 01887 USA

Declares that the product(s):	
Designation	*STEPPER DRIVE*
Type	*6410, 6415, 6420*

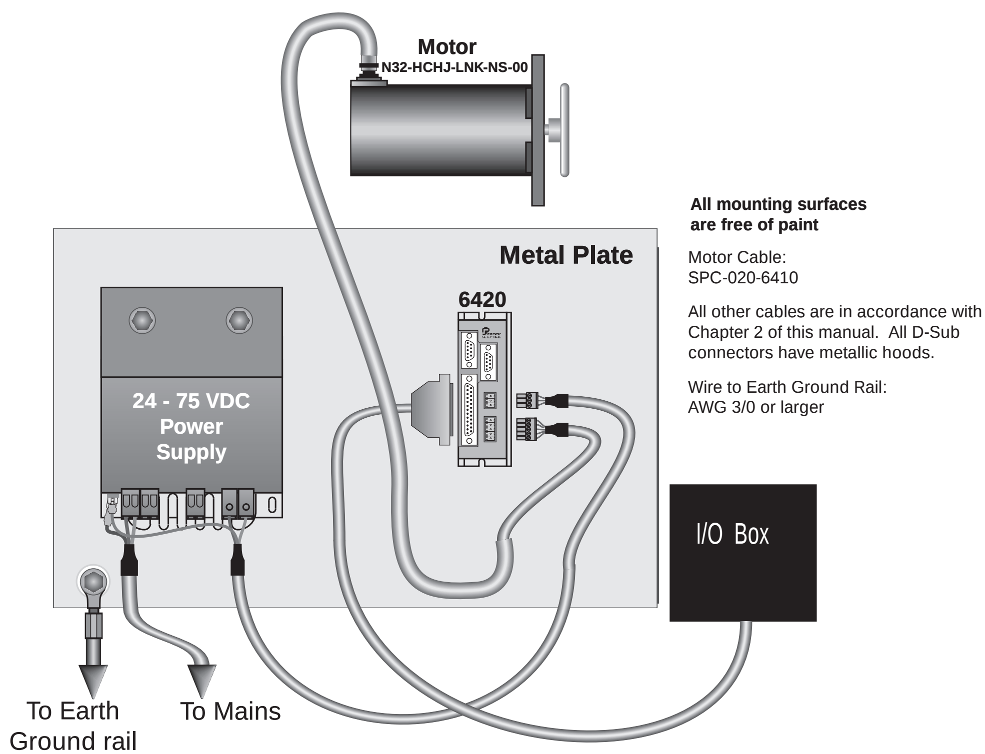
comply with the following relevant regulations:		
CE Guideline	*89/336/EEC*	*EMC Directive*
Applied harmonized standards:		EN 61800-3: 1996

Manufacturer's Contact:	Peter Deneault Compliance Engineer

Issued By:	Pacific Scientific, Motion Technology Division President, William T. Fejes
Place, Date:	Wilmington, MA, USA, 10-29-98

Legally binding
Signature

CE Test Set Up The 6420 was determined to be the noisiest configuration for the 64xx family. Therefore it was used for all EMC testing.



Safety

In addition to the safety guidelines given in Section 2.2, observe the following:

- Electronic drives contain electrostatic sensitive devices which can be damaged when handled improperly. Qualified personnel must follow ESD protection measures. For example: wear grounded heel and wrist straps when contacting drive.
- Follow IEC 536-2 and IEC 1140 for installation protection against electric shock.
- Installation shall be performed in accordance with local electric codes, local accident prevention rules, and EN 61800-3.
- All covers shall be closed during operation.
- Braided cable shields should be connected to protective earth ground.

Drive mounting

Mount the drive to a conductive surface of the machine chassis, to ensure a good high frequency ground. If the chassis is painted or coated with another nonconductive coating, remove the coating from the mounting location prior to mounting the drive.

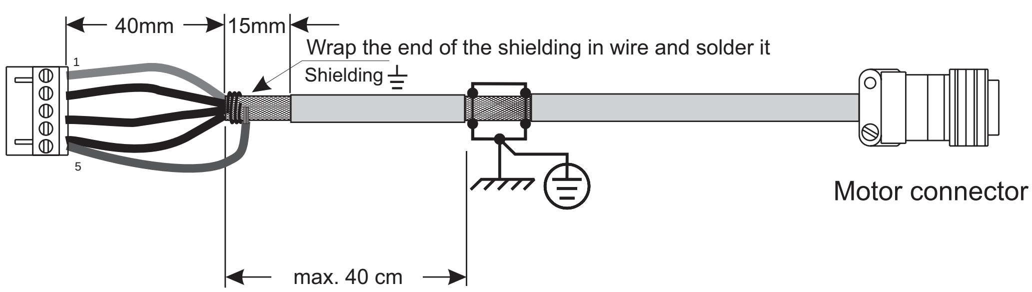
Cable Routing

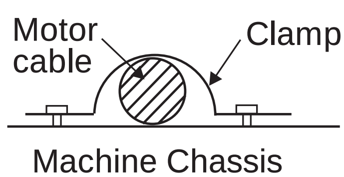
To avoid the risk of crosstalk, motor and command I/O cables should be kept away from sensitive signal cables such as telephone and intercommunication lines.

Cable shielding and grounding

The following information is not required for CE compliance of a single axis installation. When planning a multi-axis installation, or if extra high frequency noise reduction is required, Pacific Scientific suggests:

- In addition to the cable requirements given in this manual the motor and signal interface cables should have a braided shield which can be grounded to reduce high frequency disturbances.
- The motor cable shield must be grounded near the drive with a suitable high frequency ground. Such a ground connection is made by removing the cable's outer insulation, to expose the braided shield, then clamping the exposed braid to a conductive surface of the machine chassis. If the chassis is painted or coated with another nonconductive coating, remove the coating from the clamping location prior to clamping the shield. It is important that the clamp chosen be conductive and provide a full 360 degree connection.





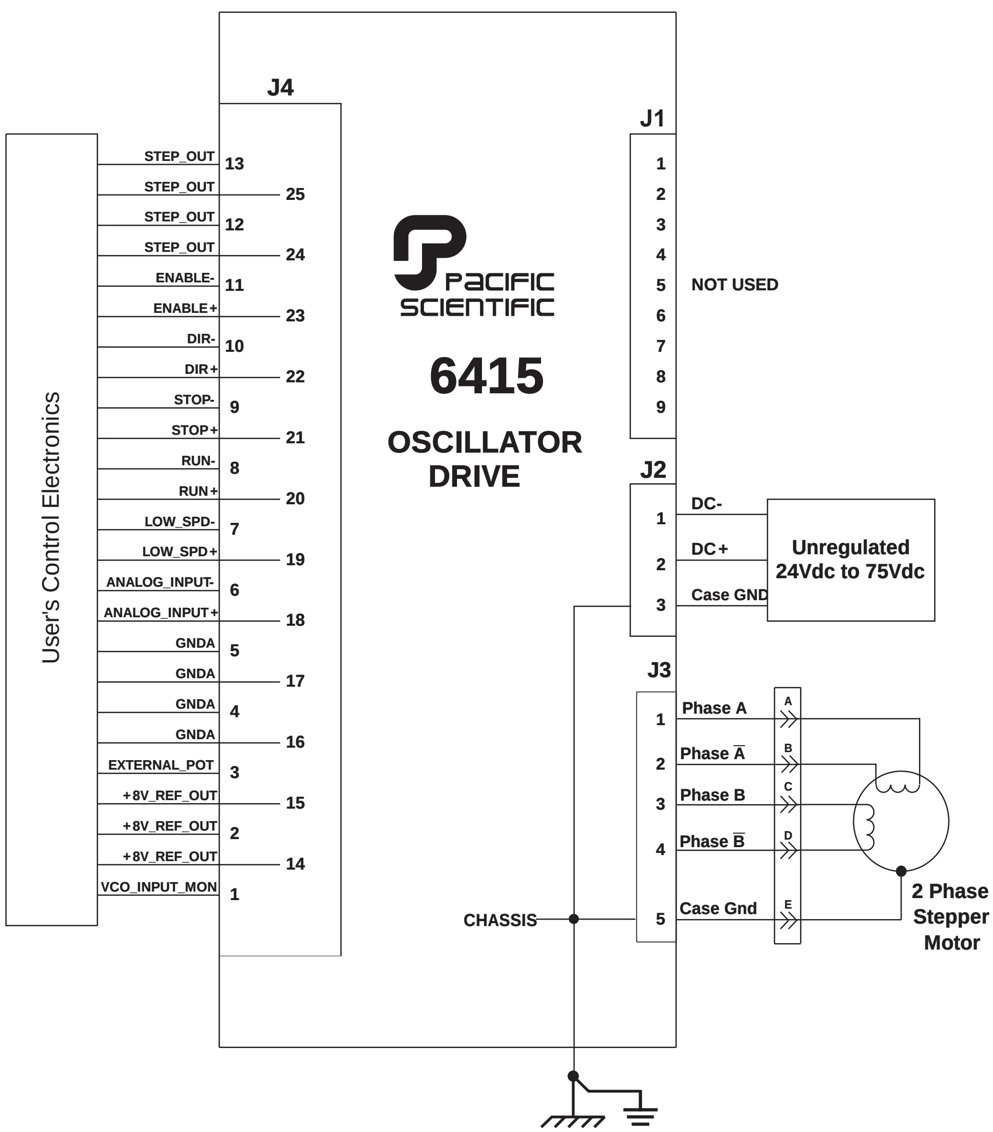
Note: *Ground shield to machine chassis with a metal clamp providing a 360 degree termination cable.*

The signal interface cable shield should be grounded to the drive through the 9 pin D-sub connector's conductive hood. If the cable connector does not provide a 360 degree ground connection to the shield, the signal interface cable should be grounded in accordance with the instructions given in the previous paragraph for the motor cable.

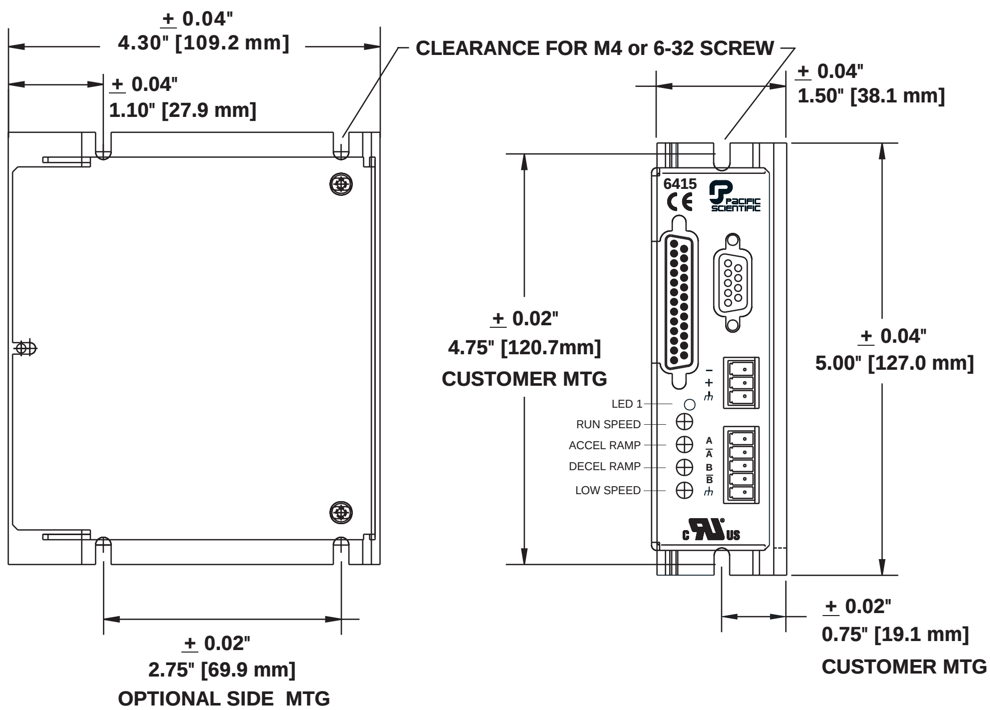
For additional information please contact the factory to request:

- Application Note 106 - Reducing Motor Drive Line Noise
- Application Note 107 - Reducing Motor Drive Radiated Emissions.

Connection Diagram



Mechanical Outline



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