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RO(L)
Installation Manual

Old Number Manual M96103
Kollmorgen Motion
Technologies Group
July 1996

New Number MRO000H

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RO(L)
Installation Manual

Manual 96103
Kollmorgen Motion Technologies Group
201 Rock Road
Radford, VA 24141

July 1996

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WARNING

Dangerous voltages, currents, temperatures, and energy levels exist in this product and in the associated servo motor(s). Extreme caution should be exercised in the application of this equipment. Only qualified individuals should attempt to install, set-up, and operate this equipment. Ensure that the motor, amplifier, and the end-user assembly are all properly grounded and current limited per NEC requirements.

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European Community (EC) Declaration of Conformity

We, Kollmorgen Corporation Industrial Drives Division, 201 Rock Road, Radford, Virginia USA; declare under sole responsibility that this equipment is exclusively designed for incorporation in another machine. The operation of this equipment is submitted to the conformity of the machine in which it is incorporated, following the provisions of the EC Electro-Magnetic Compatibility (EMC) directive 89/392/EEC.

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TABLE OF CONTENTS

CHAPTER 1 SYSTEM DESCRIPTION 1

INTRODUCTION 1

PART NUMBER DESCRIPTION 1
RO(L) Model Number 2

SPECIFICATIONS AND RATINGS 2

CHAPTER 2 MOUNTING AND WIRING 7

INTRODUCTION 7

SAFETY INFORMATION 7

UNPACKING AND INSPECTION 8

INSTALLATION REQUIREMENTS 8
Environmental Considerations 8
Ventilation 8
Minimum Inductance Requirement 8
Noise and System Grounding 8

MOUNTING 9

MOUNTING THE FAN 9

WIRING OVERVIEW 9
Strain Relief 9
Motor Protection 10
Bus Capacitor (RO Only) 10
Regeneration 10
Motor Cable 11

WIRING THE ENCODER 11

WIRING THE AMPLIFIER 12
Wiring JL, Line Cord (ROL only) 12
Wiring J1, Bus Power and Motor Leads 12
Wiring J6, Amplifier Status and Control 15
Wiring J9, Encoder 15
Switch SW1 15

CHAPTER 3 CHECK OUT AND COMMISSIONING 23

START UP AND CHECK OUT 23
Mode Selection 23
Start up the Current/Open Loop Controller 25
Start up the Velocity Controller 28

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Velocity Loop Tuning 28
Troubleshooting 29

STABILITY AND PERFORMANCE 30
Critical Damping 30
Underdamping 30
Overdamping 31
Ringing 31

ADVANCED CURRENT LOOP TUNING 31
Theory of Operation 31
Measurement and Control 32

VELOCITY LOOP PROBLEMS 33
Compliance 33
Non-Linearities 33
Resonance 33

EMPIRICAL METHOD: PHASING NON-KOLLMORGEN MOTORS 34

CHAPTER 4 MAINTENANCE 35

INTRODUCTION 35

SPARE PARTS 35

PREVENTATIVE MAINTENANCE 35
Transient Voltages 36
Electrical Noise 36
Radio Frequency Energy 36

PERIODIC MAINTENANCE 36
Grounding Integrity 36

APPENDIX A WARRANTY INFORMATION 37

APPENDIX B OUTLINE DRAWINGS 39

APPENDIX C REGIONAL SALES OFFICES 45

SOUTHERN REGION 46

EASTERN REGION 46

MIDWEST REGION 46

WESTERN REGION 46

INTERNATIONAL 46

INDEX 47

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LIST OF TABLES

Table 1.1 Specifications **3**

Table 1.2 Velocity Loop **3**

Table 1.3 Integral Power Supply Specifications (ROL Only) **4**

Table 1.4 Environmental Specifications **4**

Table 1.5 Mechanical Specifications* **4**

Table 2.1 Silverline Encoder **11**

Table 2.2 Connector J1: Power **12**

Table 2.3 Connector J6 **13**

Table 2.4 Connector J9 **15**

Table 2.5 SW1 Settings **16**

Table 2.6 RO(L) Connector Function **16**

Table 3.1 SW1 Settings: Non-Velocity Control **25**

Table 3.2 SW1 Settings: Velocity Control **28**

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LIST OF FIGURES

Figure 1.1 RO(L) Model Number Scheme 2

Figure 1.2 Block Wiring Diagram for ROL and RO Amplifiers 5

Figure 1.3 ROL System Wiring Diagram, Velocity Loop Mode 6

Figure 2.1 Capacitive Coupling 9

Figure 2.2 Silverline Encoder 17

Figure 2.3 RO(L) Connector Layout--Main PCB 18

Figure 2.4 Connectors J1 and J6 for SILVERLINE/RBE Motors 19

Figure 2.5 Connector J6 Amplifier Enable, Command and Status 20

Figure 2.6 Connector J9 Feedback Encoder (Velocity Loop Mode Only) 21

Figure 3.1 Control Loop Function Diagram 24

Figure 3.2 Critical Damping 30

Figure 3.3 Underdamping 30

Figure 3.4 Overdamping 31

Figure 3.5 Ringing 31

Figure 3.6 -3dB Point: 70% Attenuation 32

Figure B.1 ROL Series Outline 40

Figure B.2 RO Series Outline 41

Figure B.3 Fan Bracket RO(L)-20012 Only 42

Figure B.4 Size 23 Outline 43

Figure B.5 Size 34 Outline 44

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CHAPTER 1
SYSTEM DESCRIPTION

INTRODUCTION

The Kollmorgen RO(L)-series amplifiers are six-step modules designed to bring high performance to cost-sensitive applications. RO(L) amplifiers have these important features:

- Small package
- Direct 115 VAC line operation (ROL only)
- Integral regen dissipation unit (ROL only)
- High linearity
- Differential ±10 volt input
- User selectable operation modes:
  - High performance current loop mode
  - Open loop mode
  - Velocity loop mode
- Switch selectable 60° or 120° commutation
- Over-current protection
- Over-voltage protection
- Continuous current limit
- Fully heat-sinked
- Up to 190 VDC input for RO
  Up to 130 VAC input for ROL
- Up to 12 amp continuous (25 amp peak) output

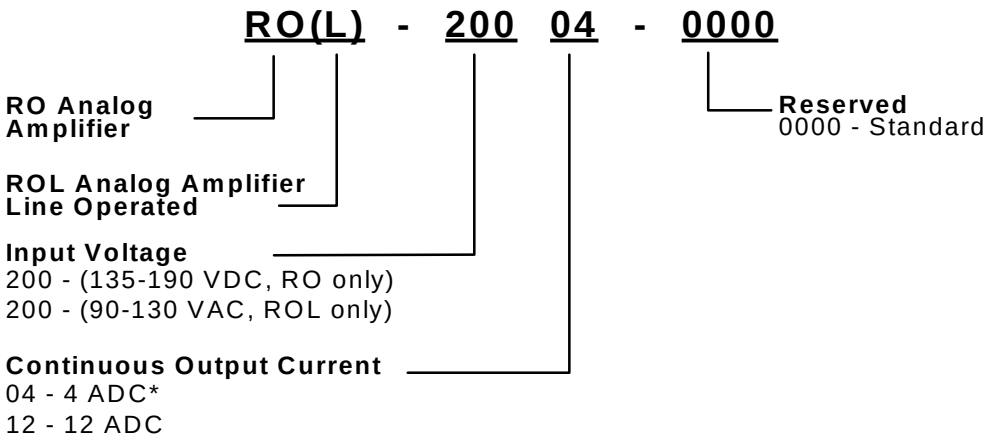
This manual provides information for installation and operation.

PART NUMBER DESCRIPTION

A model number is printed on a tag on the top of your RO(L). The model number identifies how the equipment is configured. Each component is described in Figure 1.1. Verify that the model numbers represent the equipment required for your application.

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RO(L) Model Number



*ADC refers to DC Amps. This unit is used on six-step systems to indicate the current in the two motor leads which are enabled (in six-step, one lead is always open circuit). 1 ADC = 1/1.22 amps RMS/Phase.

Figure 1.1 RO(L) Model Number Scheme

SPECIFICATIONS AND RATINGS

Specifications Control Outputs	AMP OK (TTL Level)
Current Overload	Monitor RMS Current
ANALOG INPUT Type	Full Differential, ±10 volts
Impedance, ANALOG INPUT	Approximately 50 kOhm
Maximum Current for AMP OK (sink only)	20 mA
Voltage Range for AMP OK	TTL (5 ±10%)

IMonitor	1V = 1.33 ADC RO(L) - 20004 1V = 4.00 ADC RO(L) - 20012
Control Inputs	ANALOG-CMD (Analog) ENABLE' (TTL Level)
Control Method	Switch selectable for Velocity Loop, Current Loop, Open Loop
AC Power Supply and Regen	Integral on ROL

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CAUTION

Do not short IMONITOR (J6-8) or IMONITOR RET (J6-15) to ground!

Do not connect to oscilloscope ground!

IMONITOR (J6-8) and IMONITOR RET (J6-15) are not isolated; they are referenced to bus-. There is normally 70 VDC between these signals and ground.



CAUTION

For ROL amplifier:

If load inertia is large or if rapid deceleration occurs frequently, regen unit will overheat. Permanent damage will occur.

Monitor case temperature behind regen resistor. If case temperature exceeds 60°C, regen is overloaded. Stop operation immediately!**

**Regen resistor is located on the cover {}

Table 1.1 Specifications

RO(L) - 200xx				
DESCRIPTION	**RO-20004**	**RO-20012**	**ROL-20004**	**ROL-20012**
Main Bus Minimum Maximum	 50 VDC 190 VDC	 50 VDC 190 VDC	 30 VAC 130 VAC	 30 VAC 130 VAC
Output Current (40°C Ambient) Continuous Peak (2 seconds)	 4 ADC 8 ADC	 12 ADC 25 ADC	 4 ADC 8 ADC	 12 ADC 25 ADC
PWM Switching Frequency	 22 kHz ± 15%	 22 kHz ± 15%	 22 kHz ± 15%	 22 kHz ± 15%
Minimum Inductance	 250 µH	 250 µH	 250 µH	 250 µH

Table 1.2 Velocity Loop

Velocity Loop Specification	
Linearity	0.2% Full Scale
Velocity Range	2000:1
Max Frequency	125 kHz
Encoder Level	TTL, single-ended

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Table 1.3 Integral Power Supply Specifications (ROL Only)

	ROL-20004	ROL-20012
DESCRIPTION	**RATING**	**RATING**
Phase	1	1
Frequency	47-63 Hz	47-63 Hz
Shunt Regulator Current (Peak)	20 ADC	20 ADC
Regen Power Dissipation (Cont.)	10 Watts	30 Watts
Regen Trip Voltage (Approximate)	195 VDC	195 VDC

Table 1.4 Environmental Specifications

Operating Temperature*	0°C to 40°C
Storage Temperature	-20°C to 70°C
Humidity (Non-Condensing)	10% to 90%

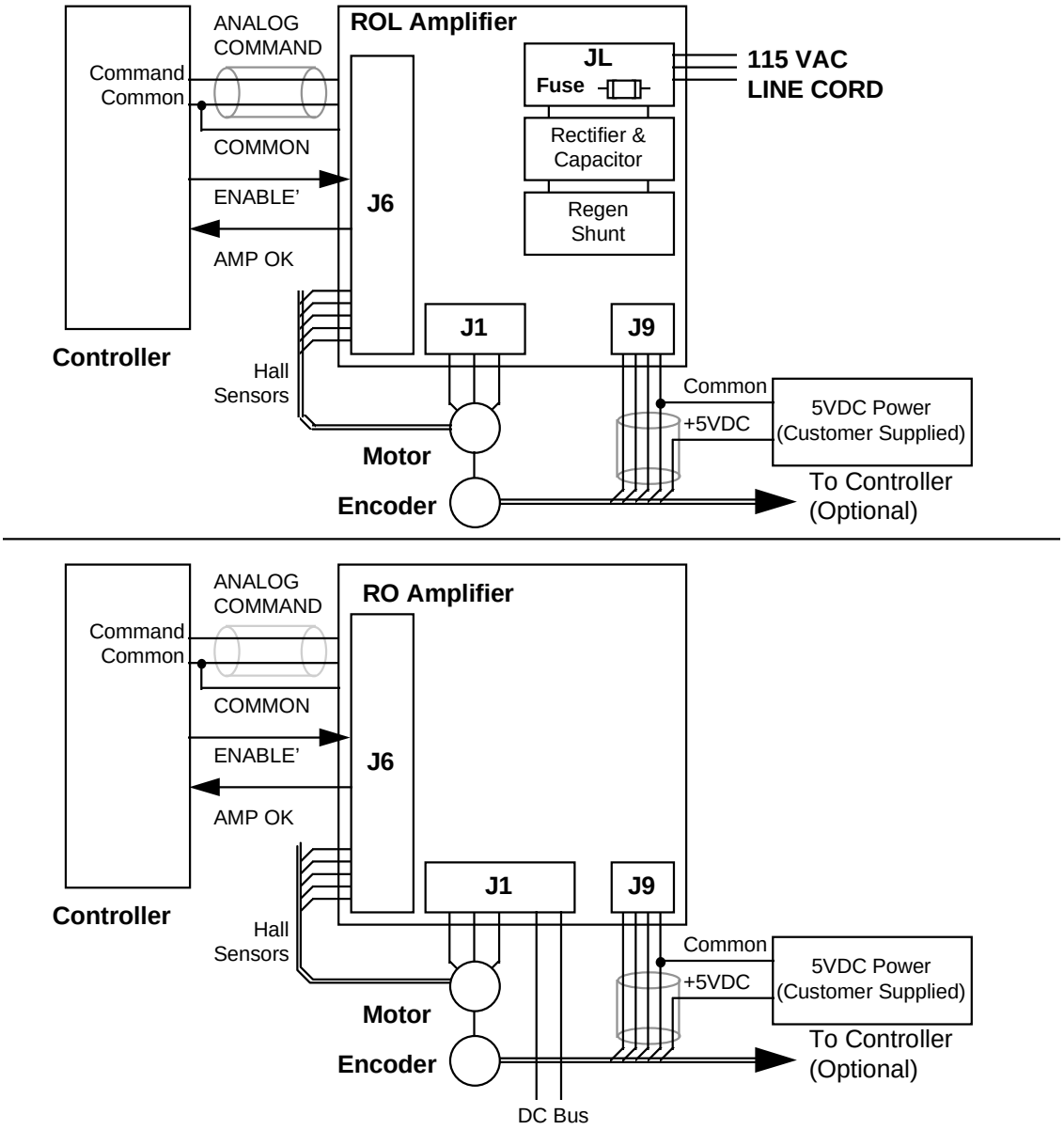
*For operation ambients above 40°C, consult the Applications Engineer at your ICP Regional Office

Table 1.5 Mechanical Specifications*

MODEL	WIDTH		HEIGHT		DEPTH	
NUMBER	**MM**	**IN.**	**MM**	**IN.**	**MM**	**IN.**
RO-200xx	57	2.25	187	7.35	108	4.25
ROL-200xx	94	3.70	187	7.35	108	4.25

*Please see Appendix B for outline drawings.
Please note that the RO(L)-20012 requires a separately mounted fan.

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(For RO Amplifier: Rectifier, reservoir capacitor, and regen shunt are supplied by customer)

Figure 1.2 Block Wiring Diagram for ROL and RO Amplifiers

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Error! No topic specified.

Figure 1.3 ROL System Wiring Diagram, Velocity Loop Mode

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CHAPTER 2
MOUNTING AND WIRING

INTRODUCTION

This chapter provides information concerning safety, unpacking, inspection, and installation for the RO and ROL amplifiers. Read the entire chapter carefully because most installation problems are caused by incorrect wiring or poor wiring practices.

SAFETY INFORMATION

This section will alert you to possible safety hazards associated with this equipment and the precautions you can take to reduce the risk of personal injury and damage to the equipment.

Safety notices in this manual provide important information. Read and be familiar with these instructions before attempting installation, operation, or maintenance. Failure to observe these precautions could result in serious bodily injury, damage to the equipment, or operational difficulty.



The safety-alert symbols are illustrated above. When you see these symbols in this manual, be alert to the potential for personal injury. Follow the recommended precautions and safe operating practices included with the alert symbols.

WARNING refers to personal safety and alerts you to potential danger or harm. Failure to follow warning notices could result in personal injury or death.

CAUTION directs attention to general precautions which, if not followed, could result in personal injury and/or equipment damage.

NOTE highlights information critical to your understanding or use of these products.

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UNPACKING AND INSPECTION



CAUTION

Electronic components in this amplifier are static sensitive. Use proper procedures when handling component boards.

Upon receipt of the equipment, closely inspect components to ensure that no damage has occurred in shipment. If damage is detected, notify the carrier immediately.

Carefully remove packing material and remove the equipment from the shipping container. Do not dispose of shipping materials until the packing list has been checked. Parts contained within the shipment but not physically attached to the equipment should be verified against the packing list. If any parts are missing notify Kollmorgen at once.

INSTALLATION REQUIREMENTS

Proper installation and field wiring are of prime importance in the application of servo amplifiers. Many problems will be avoided if installation is done properly. Users should familiarize themselves with and follow these instructions in addition to all applicable codes, laws, and standards. Pay special attention to the following topics when installing Kollmorgen equipment.

Environmental Considerations

The environment in which this equipment is placed can dramatically affect its operation. Kollmorgen recommends that the RO and ROL be operated and stored under the following conditions:

- Operating Temperature: 0°C to 40°C
- Storage Temperature: -20°C to 70°C
- Humidity: 10% to 90% (Non-Condensing)

Ventilation

Convection (non-fan) cooled units should be mounted vertically to allow maximum ventilation of the components. This configuration allows hot air to vent through the top and draft in cooler air through the bottom. Allow at least 25 mm (1") on all sides for ventilation. Ensure that ventilation paths are not constricted.

Minimum Inductance Requirement

The RO(L) requires a minimum motor line-to-line inductance of 250 µH to ensure that the motor current is properly filtered. If the motor inductance is too small, add external inductors. Contact your regional office for more information.

Noise and System Grounding

Electrical noise can degrade the performance of the entire system. Most electrical noise is caused by improper wiring. There are four ways noise is coupled into the amplifier:

1. Capacitive or electrostatic coupling from motor leads to signal wires. The path is shown below in Figure 2.1 as parasitic capacitance "C_{CAP}". This type of noise is usually the predominant one in motor controllers.
2. Magnetically coupling from motor leads to signal wires.
3. Voltage drops across ground connections.
4. Op-amp oscillation due to excessive capacitance in the ANALOG CMD line.

Figure 2.1 below shows a typical servo system using the RO(L) amplifier. The main source of noise is usually capacitive coupling. Voltage transients generated from power semiconductors couple to the ANALOG CMD lines through parasitic capacitance C_{CAP}. Reduce C_{CAP} by using a shielded, twisted-pair conductor for the ANALOG CMD. Also, separate signal and motor leads as much as is practical including routing them in separate conduits or wire ways; separation also reduces magnetic coupling. Finally, connect the motor frame to earth ground.

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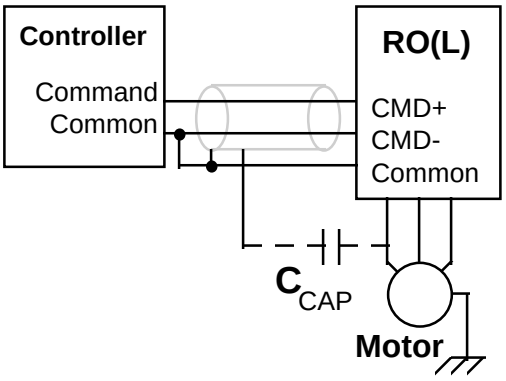


Figure 2.1 Capacitive Coupling

Voltage drops across ground leads become more significant as the distance between the controller and amplifier increase. Usually, the RO(L) differential input will correct this problem when connected as shown in Figure 2.1. Bear in mind that even though the commons of the controller and amplifier are electrically connected, there usually exists a small voltage difference between the units, especially if they are well separated. The differential input, with the controller common connected to ANALOG CMD-, compensates for this in most cases.

The commons of the controller and amplifier must be connected as shown in Figure 2.1. The differential input compensates only for sub-volt ground noise. The system will not operate properly if there is a substantial potential across the commons of the two units.

When wiring your RO(L) system, observe the following guidelines:

1. Use shielded, twisted-pair cable for ANALOG CMD.

2. Separate motor and signal leads. Run motor and signal leads in separate conduit or wire ways.

3. Minimize lead lengths.

4. Connect common of controller and amplifier.

5. Ground the motor case.

6. Provide adequate strain relief for all cables and wires.

MOUNTING

The RO(L) should be mounted in a cabinet or other suitable enclosure to protect it from physical and environmental damage. Convection (non-fan) cooled units must be mounted vertically. These units require 25 mm (1") clearance on both sides, as well as at least 25 mm (1") above and below. See the RO(L) outline drawing in Appendix B for more information.

MOUNTING THE FAN

A fan is required to cool the 12 ADC RO(L) (RO(L)-20012) and 4 ADC units (RO(L)-20004) that require more regenerative dissipation than can be obtained with convection cooling. The fan mounts in the fan bracket, both of which are standard with the RO(L)-20012. Mount the fan/bracket assembly 25 mm (1") below or 25 mm (1") above the RO(L) with the air stream pointed towards the amplifier and flowing through the heat sink fins. See the fan/bracket outline drawing in Appendix B for more information.

WIRING OVERVIEW

The customer is responsible for providing proper circuit breaker or fuse protection. The customer is responsible for providing proper wire gauge and insulation rating for all wiring, including motor, AC line, and DC bus. The customer is responsible for making sure that all system wiring and electrical protection comply with applicable national and local electric codes.

Strain Relief

All cables that connect to the RO(L) must be properly strain relieved. Excessive strain causes damage to the connectors, cables, or PCB and may result in failure or in unreliable operation. Ribbon cables must be properly strain relieved. Absent or inadequate strain relief of insulation displacement connector (IDC) systems causes unreliable interconnects.

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CAUTION

Strain relieve all cables leading to the RO(L).

Strain may cause damage which will result in failure or in unreliable operation.

Motor Protection

Be aware that fusing the power supply input lines does not necessarily limit current in the individual motor leads, especially when the motor is stalled or rotating slowly. The pulse-width modulation (PWM) topology used in this amplifier can produce large motor currents from small line currents. Do not rely on power-supply fusing to limit current in the motor leads. If motor leads must be current limited, then protect the motor leads with motor overload relays or fuses in addition to fusing the power supply input lines.

Bus Capacitor (RO Only)

The customer must provide bus capacitance for RO amplifiers (the ROL provide sufficient capacitance internally.) PWM amplifiers generate current surges from the reservoir capacitors. For single-phase AC input to a diode bridge, a bus capacitance of 2000 uF/amp (maximum output current) is recommended; this value reduces ripple to 4V, which will keep capacitor temperature low. Lower values of bus capacitance can be used for three-phase input. Also, lower values can be used with high-grade electrolytic capacitors. Contact capacitor manufacturers for guidelines. Twist leads from reservoir capacitor.



CAUTION

For RO amplifiers, customer must provide adequate bus capacitance. Inadequate capacitance will degrade system performance and generate excessive heat in bus capacitors.

The bus capacitors should be within three feet of the amplifier. If they are farther, an additional bypass capacitor (>1000 uF) must be placed within three feet of the servo amplifier.

When multiple RO amplifiers are installed in a single application, avoid ground loops by observing the following guidelines:

1. Run separate power supply leads from each amplifier to the bus capacitor(s).

2. Run separate twisted-pair, shielded cables to ANALOG CMD (+ and -) of each amplifier.

Regeneration

During braking, the amplifier returns the servo motor's kinetic energy to the power supply capacitor. This process raises the capacitor voltage. If the returned energy is sufficiently large, an over-voltage fault will be generated and the amplifier will disable. This problem can be corrected two ways: for the RO, increase the value of capacitance and, for the ROL, dissipate the energy through a shunt resistor.

Increasing Bus Capacitor (RO)

For the RO, over-voltage due to regen can sometimes be corrected by increasing the bus capacitance. This works best when the amount of energy to be returned is small. That is, load inertias are small and overall change in velocity is limited. The larger the amount of energy, the larger the bus capacitors. In some applications, the capacitors can become so large as to be impractical. This method works only on the RO as the connections to the bus are inaccessible on the ROL.

Dissipation of Regen Energy (ROL)

The ROL provides a "regen" unit, a circuit to dissipate regenerative energy into a shunt resistor. That resistor is mounted on the inside of the ROL cover. For 4 ADC units, which are convection cooled, the regen resistor can dissipate 10 watts (continuous). For 12 ADC units, which are fan cooled, that resistor can dissipate 30 watts. If you have an application for a 4 ADC unit and there is a large amount of regenerative energy, you can order a 12 ADC unit (which includes a fan kit) and set SW1-3 for 4 ADC operation.

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CAUTION

For ROL amplifier:

If load inertia is large or if rapid deceleration occurs frequently, regen unit will overheat. Permanent damage will occur.

Monitor case temperature behind regen resistor. If case temperature exceeds 60°C, regen is overloaded. Stop operation immediately!**

**Regen resistor is located on the cover {}

Motor Cable

For minimal generation of electrical noise, use of a twisted, shielded conductor for long motor power cables is recommended. Ground the shields at both ends: to the amplifier's chassis ground and to the motor's frame. The motor power input leads are connected to the amplifier's output.

WIRING THE ENCODER

The standard SILVERLINE encoder uses a 10-pin ribbon cable connector. It is wired according to the HEDL ® standard from Hewlett-Packard. Refer to Figure 2.2 (page 17). If you are using a standard SILVERLINE encoder or any encoder compatible with the HEDL standard, you may connect the encoder to a BJ-BKO-10 breakout terminal strip and from there, wire to the RO(L). Also, you can wire from the encoder directly to the RO(L) using discrete wires and appropriate connectors such as AMP 102387-1 shells.

Always strain relieve the encoder cable. If the encoder cable is disconnected or cable connections are broken, the motor will run away. Strain relieve at the connectors and along the length of the cable if necessary. Be particularly thorough when providing strain relief in environments with significant vibration.

Table 2.1
Silverline Encoder

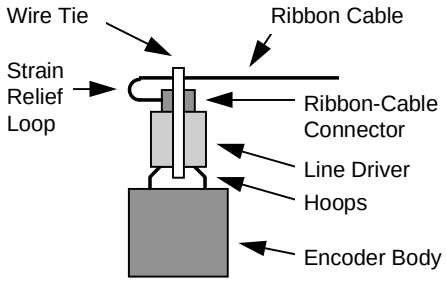
Pin	Signal Name
1	Not Used
2	+5 (Cust. Supplied)
3	Common
4	Not Used
5	Channel A-
6	Channel A+
7	Channel B-
8	Channel B+
9	Index-
10	Index+

The SILVERLINE line driver module is shipped loose in the same bag as the loose motor. When attaching the line driver, proper ESD precautions should be observed. The line driver attaches so that the body of the connector fully lies between the metal hoops on the encoder. It is possible to install the line driver module incorrectly.

On SILVERLINE motors, strain relief for the encoder cable is provided with a wire tie which secures the ribbon cable connector and line driver to the encoder body. Use a 0.1" wide, 4.5" long wire tie such as Richo WIT-18R. This wire tie fits securely in notches of the standard SILVERLINE encoder ribbon-cable connector (Amp 746285-1). Two steel hoops are attached to the encoder body through which the wire tie is threaded. Note that the connector does not have an integral strain relief, as the version with strain relief cannot be fastened reliably with a wire tie.

Since the connector does not provide strain relief for the cable, this function is also provided by the wire tie. Assemble as shown below: fold the ribbon cable across the back of the connector to form a small loop and install the wire tie securely, preferably with a wire-tie gun or similar device.

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Side View: Application of wire tie to secure and strain relieve ribbon cable

WARNING

If the encoder cable is disconnected, the motor will run away!

Vibration can loosen and disconnect this cable!

Strain relieve the encoder cable at both ends and along its length.

WIRING THE AMPLIFIER

Refer to Figure 2.3 (page 18) for an overview of all RO(L) connectors.

Wiring JL, Line Cord (ROL only)

Install standard three-prong IEC-style connector cord which provides 115 VAC line cord in connector JL. Note that integral to the JL connector is a line fuse. The fuse holder can be removed with a small screw driver. The fuse is a 5 mm x 20 mm series 16A fuse such as Wickman 19195-16.

If you are using the ROL with a DC bus, connect the bus leads to hot and neutral of JL. In this case, the ROL provides regen for DC input.

Wiring J1, Bus Power and Motor Leads

J1 is a 5-circuit screw-terminal with connections on 5 mm (0.2") centers. Note that in high-vibration environments, it is often preferable to crimp a ferrule onto each connection of J1. Refer to Figure 2.4 for wiring (page 19).

For the ROL, when using J1, you will need a long, narrow blade. Insert the blade carefully into the opening in the package above J1. Be careful not to inadvertently unscrew any leads in J1 and not to disturb wiring internal to the ROL. Be aware that J1 has two connections hidden by the frame and you must not loosen those connections. Doing so will allow internal wiring for the DC bus to come loose. These wire when loose present a shock hazard.

WARNING

For the ROL, J1 has two terminals hidden by the frame. Do not inadvertently loosen these screws or internal wiring may come loose.

This is a shock hazard.

Table 2.2
Connector J1: Power

Pin	Signal Name
1	Motor A
2	Motor B
3	Motor C
4 (RO only)	BUS (-) (Common)
5 (RO only)	BUS (+)

Wiring Bus Leads (RO only)

RO amplifiers operate from a single polarity, unregulated DC power supply. This supply does not need to be galvanically isolated from the line so that a suitable power supply may be constructed without a transformer. The customer must supply all components including diode bridge, reservoir capacitor, and regenerative energy shunt if required. (Note that these components are integral to the ROL.)

Connect bus+ to J1-5; connect bus- to J1-4. Bus must be 135 - 200 volts DC. Note: for ROL amplifiers, these connections are made internally.

WARNING

Do not reverse the power supply leads.

Severe damage will result.

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WARNING

Observe proper ESD protection procedures when handling encoder and hall sensor leads.

Wiring Motor Leads for Kollmorgen BLDC Motors

Connect the three motor leads according to the color code shown on Figure 2.4. This figure shows the color code for both Kollmorgen SILVERLINE and RBE motors. SW1-10 should be on to select 120° commutation. Note that hall sensors are connected to connector J6 which is detailed below.

Wiring Motor Leads for Other BLDC Motors

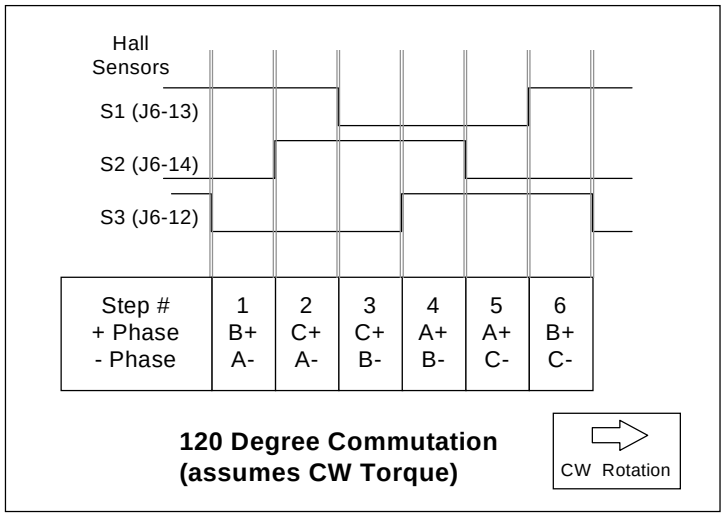
The graphs below show the commutation sequence for 120° commutation (SW1-10 on) and 60° commutation (SW1-10 off), respectively. Match the commutation of your motor as specified by the manufacturer to these graphs. If you do not have this information, refer to the empirical method on page 34. Note that hall sensors are connected to connector J6 which is detailed below.

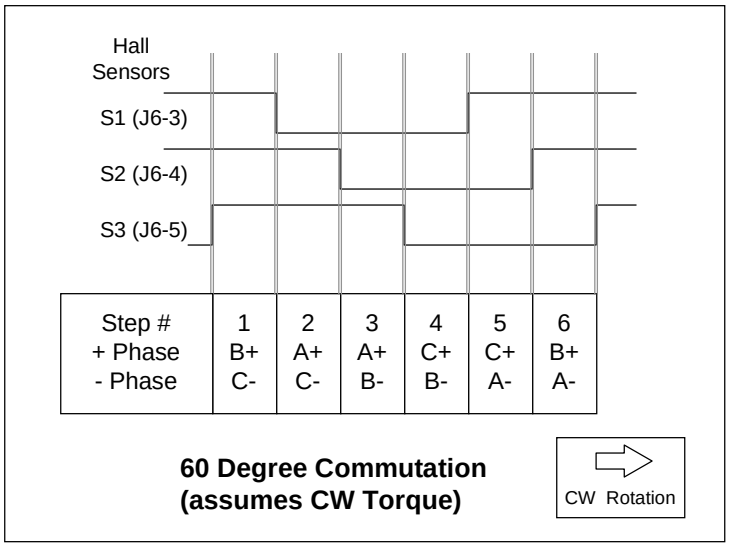
Be aware that phasing depends also on the encoder; if phasing of the encoder or the motor is reversed, the motor may run away.

Table 2.3 Connector J6

Pin	Name	Description
1	POT+	+10VDC (5 mA) supply for reference potentiometer.
2	COMMON	Signal common.
3	POT-	-10VDC (5 mA) supply for reference potentiometer.
4	ANALOG CMD+	Differential analog input.
5	ANALOG CMD-	
6	TACH IN	Not normally used.
7	TACH MONITOR	1V = 22 kHz encoder frequency.
8	IMONITOR	If SW1-3 is off, 1V = 1.333 ADC, if SW1-3 is on, 1V = 4 ADC. Note: IMONITOR is referenced to IMONITOR RET (pin 16), not control common. There is usually 70 VDC between this signal and the other control signals on this connector.
9	ENABLE'	Connect to ground to enable.
10	HALL POWER	+30 mA @ 6 VDC ±10%.
11	HALL COMMON	
12	S3	Hall sensor #3.
13	S1	Hall sensor #1.
14	S2	Hall sensor #2.
15	IMONITOR RET	Reference common for IMONITOR (Pin 8). This signal is connected to BUS- through a 10KOhm resistor. There is usually about 70 VDC between this signal and other control signals on this connector.
16	FAULT	TTL Signal. High if fault (short circuit, over-voltage, over temperature, illegal hall combination and power-up reset). When fault is asserted, the red LED on the front panel will light.

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WARNING

Motor may run away if motor or encoder leads are connected incorrectly.

Wiring J6, Amplifier Status and Control

J6 is a 16-pin Molex crimp connector with connections on 2.4 mm (0.1") centers. See Figure 2.5 (page 20).

The mating connector part for J6 is:

Molex plastic body: 22-01-3167
Insert terminals: 08-50-0114
Crimp tool: 11-26-0009

Wiring J9, Encoder

J9 is a 5-pin crimp style connector.

The mating connector part for J9 is:

Molex plastic body: 22-01-3057
Insert terminals: 08-50-0114
Crimp tool: 11-26-0009

Refer to Figure 2.6 (page 21). If you are using a standard SILVERLINE encoder you can use a BJ-BKO-10, a 10-pin ribbon-cable DIN-rail mounted breakout from Kollmorgen. The breakout provides screw-terminal connectors for wiring to J9. Connect the encoder via ribbon cable to the BJ-BKO-10, and then connect discrete wires from the BJ-BKO-10 screw terminals to J9. You can also use discrete wires directly from J9 to the encoder by using a connector such as AMP 102387-1 on the encoder.

If you are using a standard Silverline encoder or any other encoder that supplies differential signals, connect only the non-inverting signals as shown in Figure 2.6.
The customer is responsible for providing 5 VDC for the encoder. For Silverline encoders, this normally requires approximately 100 mA. If you are using a non-Silverline encoder, be aware that many encoders use much more than 100 mA when selecting the encoder power supply.

Table 2.4 Connector J9

Pin	Name	Description
1	N/C	
2	A	Channel A of quadrature encoder.
3	N/C	
4	B	Channel B of quadrature encoder.
5	COMMON	Reference common for customer supplied encoder power.

Switch SW1

SW1 is a 10-position, surface-mount switch block. These switches control operational modes such as loop type (velocity or current), test, gains, scaling, and commutation type. The settings are detailed below. Chapter 3 discusses how to set up the amplifier for various modes of operation.

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Table 2.5 SW1 Settings

Switch	Name	Description
SW1-1	Test/Offset	Normally off. If on, greatly increases sensitivity to offset pot to allow testing.
SW1-2	Current Loop Gain	Normally on. Off for high inductance (>2 mH) motors.
SW1-3	Current Scaling	On for 12 ADC units; Off for 4 ADC units. Caution: For 4 ADC units, turning SW1-3 on will cause unreliable amplifier operation and may damage the motor.
SW1-4	Vel. Loop Integrator	On for velocity loop and open loop; off for current loop. When on, shorts velocity loop integrator.
SW1-5	Duty Cycle	Normally off. On for open-loop mode.
SW1-6	Encoder Tach	On for encoder-based velocity loop. Off otherwise.
SW1-7	Velocity Direction	Normally off. On to reverse direction. Warning: Reversing SW1-7 may cause the motor to run away.
SW1-8	Current Reduction	Normally on. Off to reduce continuous current.
SW1-9	Velocity Loop Gain	Normally off. On to "detune" velocity loop.
SW1-10	120° Commutation	Normally on. Off for brush motors and some brushless DC motors.

Table 2.6 RO(L) Connector Function

	Name	Type	Description
J1 (RO Only)	Bus and Motor Power	5-Pin Screw Terminal	Connections for motor power leads and for bus power
J1 (ROL Only)	Motor Power	3-Pin Screw Terminal	Connections for motor power leads only
J6	Status, Control, and Hall Sensors	15-Pin Crimp Connector	ANALOG CMD, ENABLE, AMP OK, Hall Sensors
J9	Feedback Encoder	5-Pin Crimp Connector	Feedback Encoder connection for Velocity Loop Systems
JL (ROL Only)	Line Voltage with Integral Fuse	3-Pin Pluggable	Three-prong IEC-style connector; 115 VAC line cord

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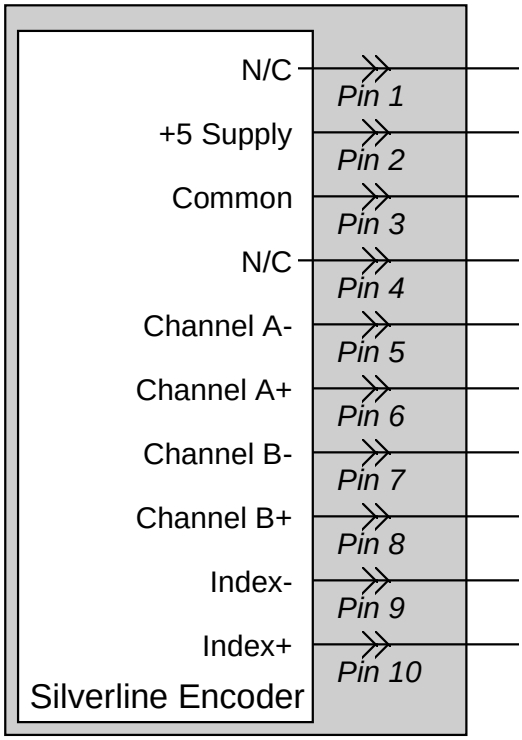


Figure 2.2 Silverline Encoder

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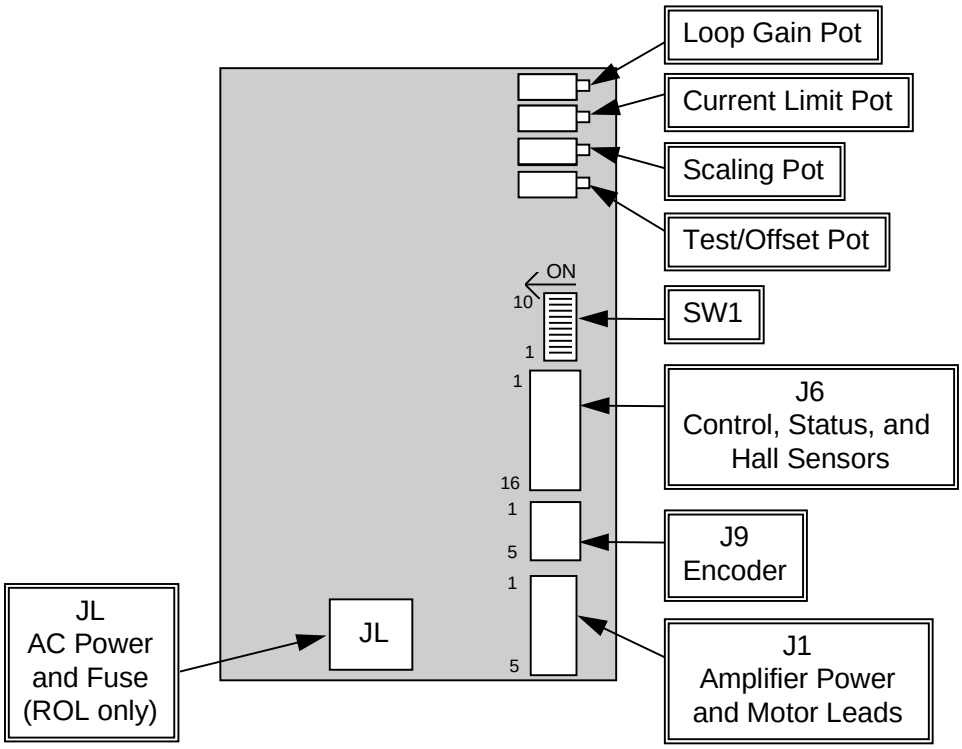


Figure 2.3 RO(L) Connector Layout--Main PCB

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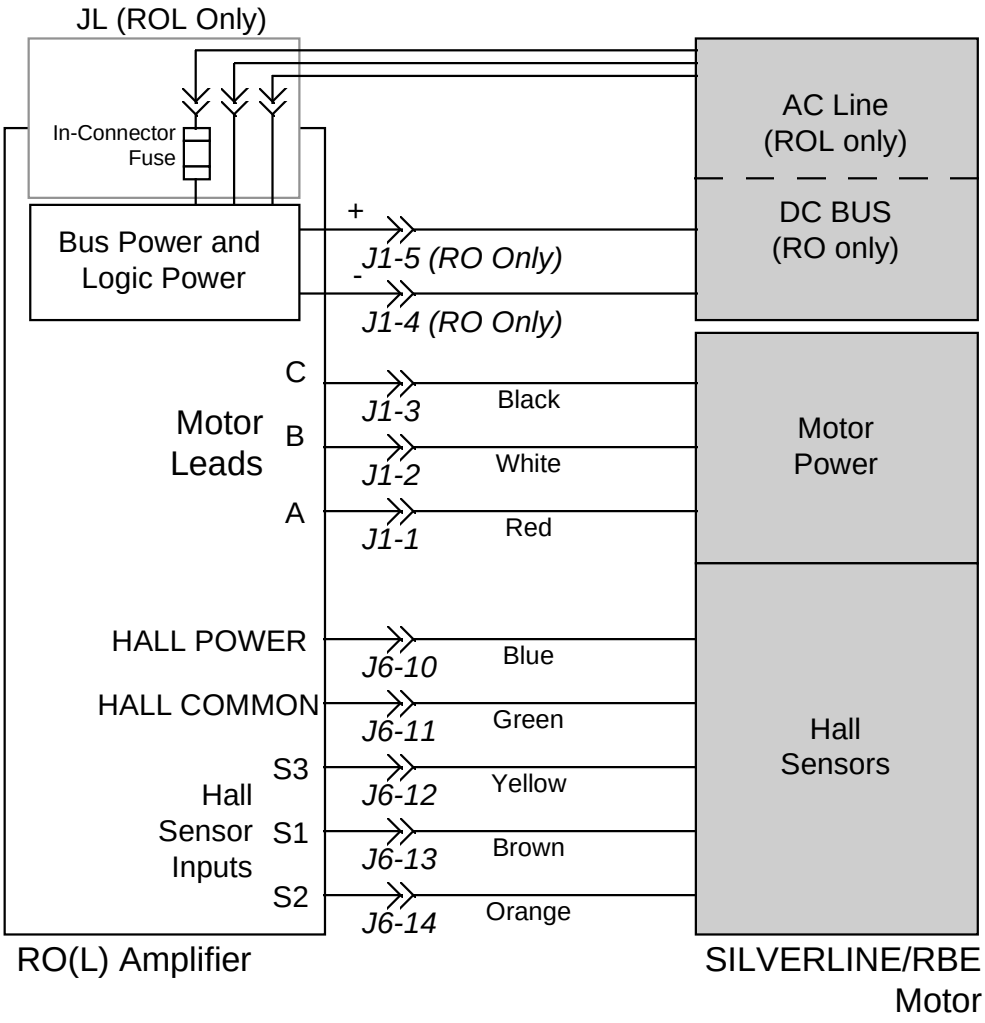


Figure 2.4 Connectors J1 and J6 for SILVERLINE/RBE Motors

(J6 Hall Sensors shown; remainder of J6 connections shown in Figure 2.5)

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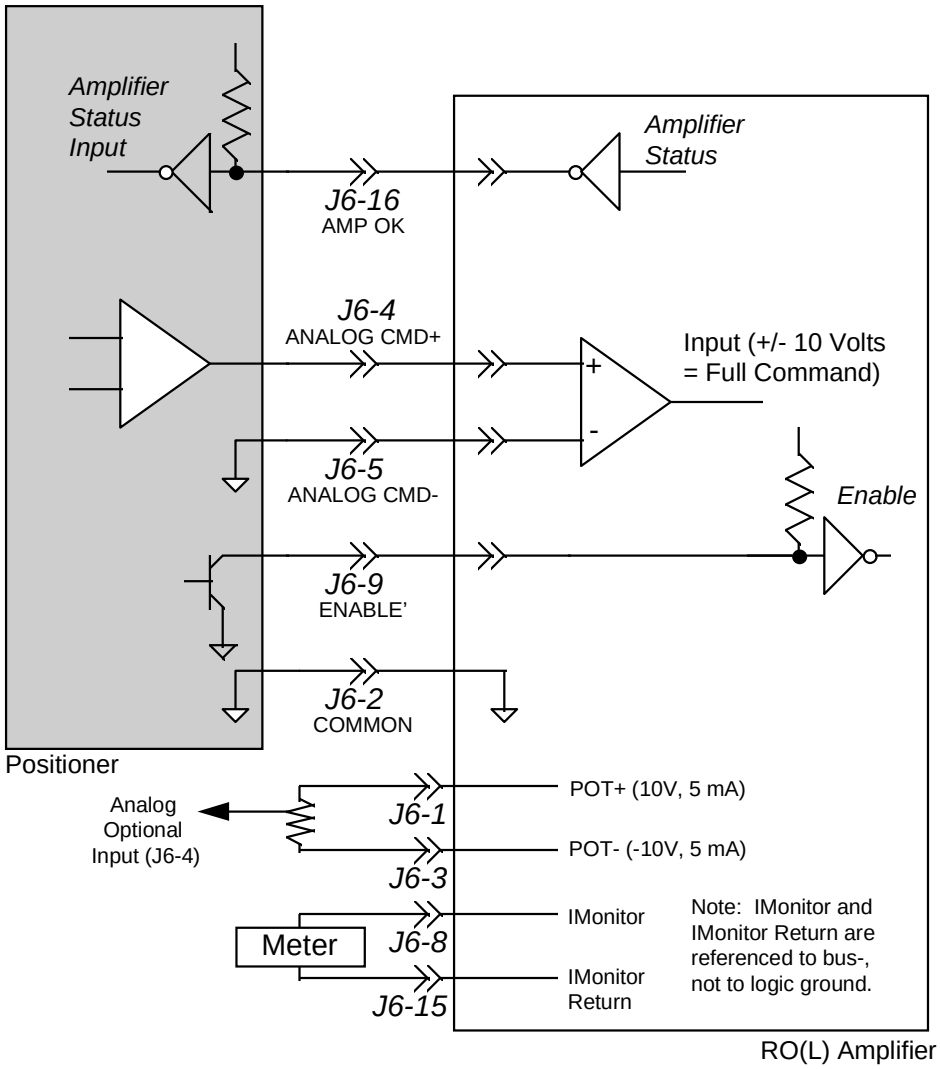


Figure 2.5 Connector J6 Amplifier Enable, Command and Status

(Hall Sensors shown in Figure 2.4)

CAUTION

Do not short IMONITOR (J6-8) or IMONITOR RET (J6-15) to ground!

Do not connect to oscilloscope ground!

IMONITOR (J6-8) and IMONITOR RET (J6-15) are not isolated; they are referenced to bus-. There is normally 70 VDC between these signals and ground.

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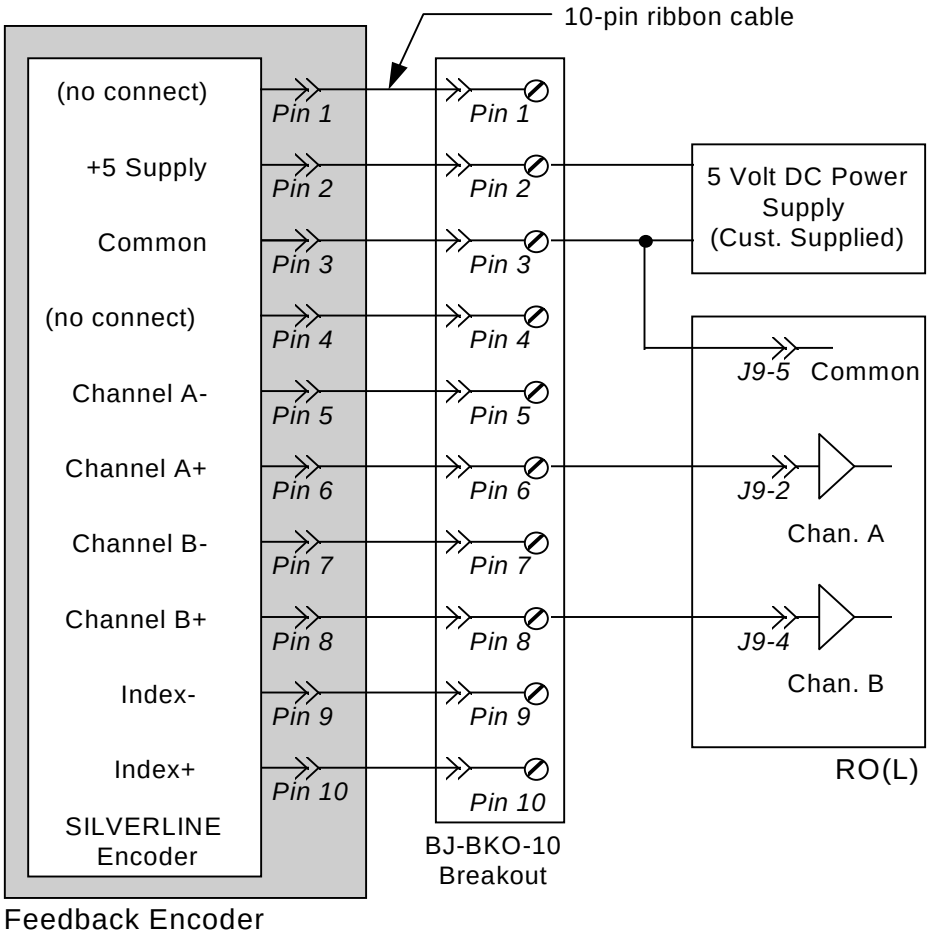


Figure 2.6 Connector J9
Feedback Encoder (Velocity Loop Mode Only)

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CHAPTER 3
CHECK OUT AND COMMISSIONING

START UP AND CHECK OUT

You should now be ready to test your system functions. Be prepared to remove power at any time. Limit switches and safety devices should be operational. In multi-axis systems, work with one axis at a time.

WARNING

Do not spin the motor without power!

Unexpected operation may occur. The amplifier may be damaged.

Do not spin a motor when the amplifier is disabled. The motor can act as a generator and charge the power supply. This will cause unreliable operation and may damage the amplifier. Also, the ROL may become operational unexpectedly because it has an internal power converter that operates from the high voltage supply.

WARNING

Do not short the motor at a high speed. This may damage the motor and the amplifier.

When the motor is shorted, its own generated voltage may produce very high current flow. The short and associated arcing may damage the motor and the amplifier.

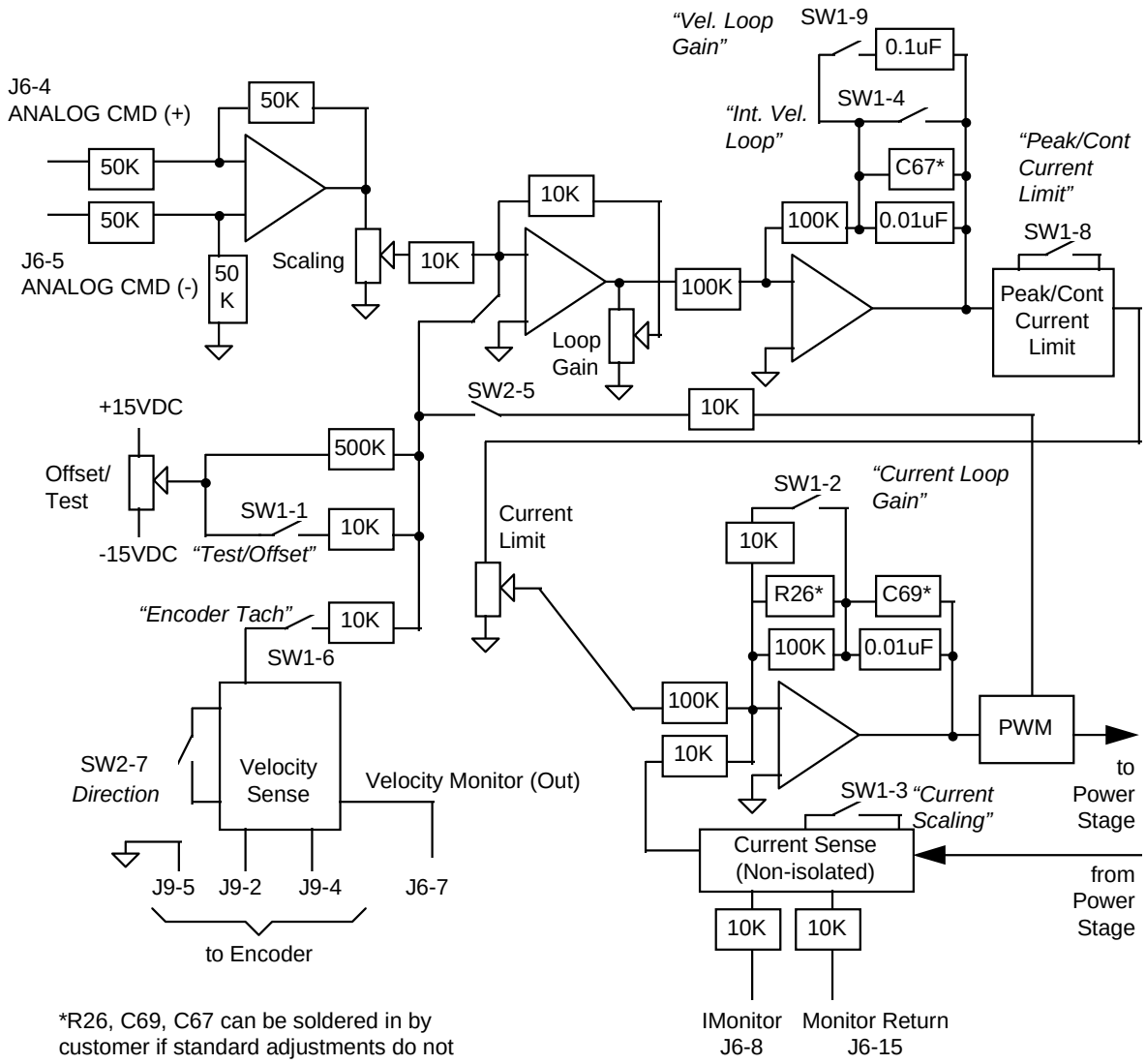
Mode Selection

The RO(L) amplifiers can operate in the following modes:

- Open-Loop Mode
- Velocity Mode
- Current Torque Mode

The RO(L) control section is shown in Figure 3.1. Note that switches SW1-4 and -6 control mode selection.

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*R26, C69, C67 can be soldered in by customer if standard adjustments do not provide acceptable performance. Always follow proper ESD protection procedures.

Note: IMonitor and Monitor Return are referenced to bus-, not control ground.

Figure 3.1 Control Loop Function Diagram

Open-Loop Mode

In open-loop mode, ANALOG CMD directly controls motor voltage through the PWM section. This is not a closed loop configuration; the output voltage varies in proportion to the bus voltage. In open-loop mode, do not connect the encoder to the amplifier.

Open loop provides low-performance speed control for set-up and for less demanding applications.

Current (Torque) Mode

In current-loop mode, ANALOG CMD controls the current into the motor. For servo motors such as KOLLMORGEN SILVERLINE Motors, current is approximately proportional to torque. Torque mode is used frequently where the machine controller closes the position and velocity loops and the amplifier closes the current loop. In current-loop mode, do not connect the encoder to the amplifier.

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Velocity Mode

In velocity-loop mode ANALOG CMD controls motor speed. A speed feedback signal ("tachometer") is synthesized from the encoder signal and used for loop feedback. Velocity-loop mode is the most complex mode because a current loop runs inside the velocity loop; both loops must be tuned. In velocity-loop mode, the encoder must be connected to J9. In most cases the encoder is connected to both the amplifier and the controller.

Be aware that the performance of the RO(L) velocity loop is not ideal for all applications. The RO(L) is designed for low cost and some features have been omitted. First, the encoder inputs are "single-ended" rather than differential. Differential inputs are less susceptible to electrical noise and are particularly well suited when the motor and amplifier are in a noisy environment or separated. Second, the range of adjustment is limited. Velocity loop operation may be unacceptable for some applications, particularly those with large inertial loads and those requiring high bandwidth. However, the RO(L) provides locations for various discrete components which you can solder directly into the PCB (see C67, C69, and R26 in Figure 3.1).

Start up the Current/Open Loop Controller

Configure and test current-loop or open-loop modes. If you plan to use velocity-loop mode, complete this section with your RO(L) amplifier in current-loop mode. See Table 3.1 below.

Table 3.1 SW1 Settings: Non-Velocity Control

Switch	Function	Position
SW1-1	Test Mode	OFF
SW1-2	Current Loop Gain	Normally ON
SW1-3	Current Scaling	OFF for 4 ADC Units RO-20004 and ROL-20004 ON for 12 ADC Units RO-200012 and ROL-200012
SW1-4	Velocity Loop Integrator	ON
SW1-5	Duty Cycle feedback	Velocity or Current Loop Modes: OFF Open-Loop Mode: ON
SW1-6	Velocity Feedback	OFF
SW1-7	Tach Direction	Normally OFF for Silverline Motors
SW1-8	Current (ON = 2:1 Peak/Continuous)	Normally ON
SW1-9	Velocity Loop Gain	OFF
SW1-10	120° Commutation	Normally ON



WARNING

The amplifier will be enabled and the motor will turn. Make sure the motor is secured.



WARNING

THE MOTOR MAY MOVE UNEXPECTEDLY! STAND CLEAR OF THE MOTOR!

BE PREPARED TO REMOVE POWER FROM THE RO(L)!

This procedure will enable the RO(L). The system may be unstable. The motor may begin oscillating or it may run away.

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WARNING

THE MOTOR WILL RUN AT FULL SPEED!

In current mode, an unloaded or lightly loaded motor will run at full speed. Load the motor or lock the shaft if high speed rotation is a safety hazard.

CAUTION

Use a non-conductive device to switch SW1.

A conductive device may slip and short connections which may damage the amplifier.

Apply Power and Enable

Apply bus power to your RO(L). Enable the RO(L) by shorting ENABLE' (J6-9) to COMMON (J6-2). Check that the LED is green, indicating normal operation.

Running the Motor

Adjust a separate power supply to about 1 VDC. Connect the negative side of that power supply to ANALOG CMD- (J6-5) and to common (J6-2); connect the positive side to ANALOG CMD+ (J6-4). If the RO(L) is in current mode, an unloaded motor should rotate at near full speed. If the RO(L) is in open-loop mode, the motor will rotate at about 10% of full speed. In either case, rotation should be smooth.

Slowly reduce the command power supply to zero and let the motor come to rest. Disable the amplifier and reverse the power supply and adjust back to 1 VDC. Enable the amplifier. The motor should rotate in the opposite direction at approximately the same speed.

If you do not have a power supply, you can put the RO(L) in test mode (close switch SW1-1) and adjust the offset to create a command voltage. However, using this method disturbs the offset potentiometer position so that after each use, you will need to adjust out offset error.

If the motor does not turn or does not turn smoothly, the hall sensors or motor leads may be connected improperly. Verify motor wiring according to Figure 2.4. Also, the commutation method may be selected incorrectly. Verify that SW1-10 is properly set: ON for SILVERLINE and RBE motors and for most other brushless motors, off for brush motors. If you are using a non-Kollmorgen motor, refer to the "Non-Kollmorgen Motor Phasing" section at the end of this chapter. Often when the hall sensors are miswired or when the selected commutation method does not match the commutation of the motor, the fault LED will flash red and green as the motor rotates.

CAUTION

Do not short IMONITOR (J6-8) or IMONITOR RET (J6-15) to ground!

Do not connect to oscilloscope ground!

IMONITOR (J6-8) and IMONITOR RET (J6-15) are not isolated; they are referenced to bus-. There is normally 70 VDC between these signals and ground.

Offset Adjustment

To adjust offset, short ANALOG CMD+ and ANALOG CMD- to COMMON (J6-4 and J6-5 to J6-2) and adjust trimpot 4 ("OFFSET") until motor torque is minimized. An unloaded motor should not turn. Optionally, you can monitor current with a volt meter across IMONITOR (J6-8) and IMONITOR RET (J6-15) and adjust until the meter reads near zero volts.

Command Scaling Adjustment

Command scaling is adjusted at the factory so that 10 volts generates peak current (or peak voltage if the RO(L) is in open-loop mode). You can reduce this scaling by adjusting the GAIN trimpot.

Peak Current Limit Adjustment

To change current limits, lock the motor shaft. Turn the Current Limit potentiometer counter-clockwise to zero, then turn clockwise to the appropriate value. For this adjustment, you can monitor current with a voltmeter from

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IMONITOR (J6-8) to IMONITOR RET (J6-15). The amplifier will produce peak current for about 2 seconds. Lower current commands are allowed for longer time periods.

You must set the current limit so that the instantaneous motor current does not exceed the specified motor peak current rating. This can permanently damage the motor. For RO(L) amplifiers, peak current is set at the factory at two times continuous current. The peak current of the RO(L)-20004 is normally 8 amps DC; the peak of the RO(L)-20012 is 25 amps DC. If your motor peak rating is below these levels you must adjust down the current limit.



CAUTION

Do not exceed the motor peak current rating. Adjust down the current limit to stay within motor ratings.

Improving Current-Loop Performance

For current-loop and velocity-loop systems, settings from Table 3.1 provide suitable performance for most systems. The current loop is stable and should have a bandwidth in excess of 1000 Hz. If you wish to modify the loop performance, please refer to discussions on tuning theory later in this chapter.

LEDs

The RO(L) provides one red/green, light-emitting diode (LED) on the front. Green indicates that bus power is applied and that the amplifier is OK. Red indicates a fault. Faults disable the amplifier and turn off the amplifier-OK LED. Removal of the fault condition enables the amplifier and turns the green LED on.

Faults

The RO(L) includes protection against excessive voltage, current, and temperature. Also, if you provide an invalid Hall sensor pattern (e.g. all sensors on in 120° commutation), a fault is generated. Any fault will turn on the red LED on the front panel and force AMP OK (J6-16) high.

If you exceed the RO(L) bus voltage (J1-4 and -5 on the RO), the amplifier will fault. The most common cause of this fault is bus voltage elevation due to regenerative energy. The ROL power supply provides a "regen" unit which can dissipate up to 10 Watts (convection) or 30 Watts (fan cooled) of regenerative energy. If you are using an ROL and you are still experiencing this fault, your system is probably overloading the regen unit. Contact your regional office for more information (see Appendix C).



CAUTION

For ROL amplifier:

If load inertia is large or if rapid deceleration occurs frequently, regen unit will overheat. Permanent damage will occur.

Monitor case temperature behind regen resistor. If case temperature exceeds 60°C, regen is overloaded. Stop operation immediately!**

**Regen resistor is located on the cover {}

If you exceed the RO(L) continuous current rating for an extended period of time, allow your unit to cool; it will re-enable automatically. If this happens regularly, your amplifier may be too small for the application or your cooling may be insufficient. Ensure that the ambient temperature does not exceed the specified maximum (40°C). For fan cooled units (RO(L)-20012), ensure that the fan is operational and that air paths are not blocked. For convection cooled units (RO(L)-20004), ensure that the unit is mounted vertically and that sufficient room is provided on all sides of the amplifier to allow air to draft up through the heat sink.



WARNING

Any fault will inhibit the amplifier. When the condition is corrected, the amplifier will automatically enable.

This may cause unexpected operation and motion!

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Table 3.2 SW1 Settings: Velocity Control

Switch	Function	Position
SW1-1	Test Mode	OFF
SW1-2	Current Loop Gain	Normally ON
SW1-3	Current Scaling	OFF for 4 ADC Cont. ON for 12 ADC Cont.
SW1-4	Velocity Loop Integrator	OFF
SW1-5	Duty Cycle Feedback	Current or Velocity Loop: OFF Open Loop: ON
SW1-6	Velocity Feedback	ON
SW1-7	Tach Direction	OFF
SW1-8	Current Limit (ON = 2:1 Peak/Continuous)	Normally ON
SW1-9	Velocity Loop Gain	OFF
SW1-10	120° Commutation	Normally ON

Start up the Velocity Controller

This section describes how to start up the velocity controller. Before proceeding in this section, you should complete the "Start up the Current Controller" section above.

Disable the RO(L).

Check-out the Encoder

Connect a meter or oscilloscope probe to TACH MONITOR (J6-7). Rotate the motor by hand. Verify that TACH MONITOR changes as you rotate the motor. The generated voltages will be small since TACH MONITOR is scaled for 1.0 volt ≈ 22 kHz of encoder line frequency (about 1300 RPM for 1000 Line encoder). Rotate the motor both directions and verify that the tach changes sign. Do not proceed until your system passes this test. Running a velocity loop system with the encoder disconnected or improperly connected may cause the motor to "run away"--a condition where the motor accelerates to full speed without control.



WARNING

Do not proceed until the encoder checks out properly.

Running a system with a disconnected or improperly connected encoder may cause the motor to run away.

Configure for Velocity Loop

Change your configuration according to Table 3.2.

Velocity Loop Tuning

Be prepared for the motor to run away when you enable the system. If the encoder or amplifier are wired incorrectly, the motor will run full speed. If this happens, it may be because the system is phased backwards. If so, inverting SW1-7 will correct this problem.



WARNING

If the encoder or amplifier are wired improperly, the motor may run away.

Be prepared for the motor to run full speed.

To reverse direction of rotation, invert SW1-7.



CAUTION

The velocity loop may be unstable.

If the velocity controller is unstable, reduce the velocity loop GAIN pot by turning it counterclockwise (CCW).

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Setting Velocity Loop Gain

Adjust the velocity command reference until the motor speed is approximately 300-400 RPM. If an adjustable command reference is not available, the OFFSET pot (Pot 4) can be used as a command. Turning SW1-1 on will raise the sensitivity to the OFFSET pot, allowing a much greater range than normal for offset adjustment. However, you must adjust offset error out after each use of the pot for this purpose.

To increase the response of the velocity loop, turn the velocity loop GAIN pot (Pot 1) CW until the motor is unstable or undesirably "noisy." Back off approximately one turn, or until the motor is stable again.

Detuning the Velocity Loop

Detuning reduces the velocity loop response. This can be accomplished two ways:
1) reduce GAIN pot, or 2) slowing the velocity loop integrator. The GAIN pot (Pot 1) can be manually adjusted by the user (CCW for less gain), while the velocity loop integrator value is increased by turning SW1-9 on. (Turning SW1-9 on detunes the velocity loop.)

Checking the Velocity Loop Response

The response can be monitored on the TACH MONITOR (J6-7). Attach an oscilloscope and monitor the motor velocity feedback. Velocity loop response should be tested by monitoring the TACH feedback on large velocity transitions. Quickly switch the velocity command from 0 to max. Observe the motor velocity feedback for overshoot and ringing. Adjust the GAIN pot or change the integrator value by turning on SW1-9.

Setting Velocity Offset

Short the velocity command (J6-4 and -5). Enable the RO(L) amplifier. The motor should not be moving but should have holding torque. If the motor is rotating slowly, adjust the offset pot until motion ceases.

Check Velocity Command Scaling

Attach velocity command reference to J6-4 and J6-5. Apply the maximum velocity command which is to be used. Adjust scaling pot until motor velocity is at the maximum velocity desired. This sets the ratio between RPM and velocity command voltage.

Troubleshooting

Fault

- Verify that the motor shaft rotates freely with no power applied when uncoupled from the load.
- Verify that the minimum inductance requirement is met.

Heat-Sink Temperature

Verify that the amplifier base-plate temperature does not exceed 60°C. A thermostat monitors the plate. Check for air blockage. For fan cooled units, ensure that the fan is operational.

Over-Voltage Shutdown

Check the power input voltage for a value in excess of those listed in the data sheet. If larger than listed value is observed, check the AC power line connected to the power supply for the proper value.

Under-Voltage Shutdown

Verify power supply voltages for minimum conditions per specifications.

Short Circuit Fault

Check each motor lead for shorts with respect to motor housing and power ground.

Measure motor armature resistance between motor leads with the amplifier disconnected. Ensure that it is at least 0.2 ohms.

Verify that motor inductance (lead-to-lead) is at least 250 μH.

Status

- Check ENABLE' for correct polarity (low to enable).
- Check for proper grounding. For example, ensure that either ANALOG CMD- (J6-5) or ANALOG CMD+ (J6-4) is connected to COMMON (J6-2).
- Mechanical backlash, dead-band, slippage, etc.

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- Check for excessive noise on encoder inputs. These inputs should be 0V/5V square waves. Noise spikes or high frequencies (> 100 kHz) should not appear on these lines.

- Check for noise on ENABLE'.

STABILITY AND PERFORMANCE

Feedback systems such as motor controllers require tuning to attain high performance. If you want to tune the current loop or velocity loop, you will need to determine loop gains according to a three-part criterion:

- Noise Susceptibility
- Response
- Stability

In a broad sense, the performance of a system is characterized by its noise susceptibility, response, and stability. These quantities tend to be mutually exclusive. The system designer must decide what noise susceptibility (in the form of a "busy" motor) is acceptable.

"Busyness" is random activity in the motor and can often be felt on the motor shaft. Busyness in a motor should not be confused with PWM noise. PWM noise is high pitched, relatively constant noise and is too high in frequency to be felt on the motor shaft.

Response is a measure of the system's quickness. Response can also be characterized by bandwidth and by rise time in response to a step command. Normally, designers want high bandwidth, though sometimes the response is purposely degraded to reduce stress on mechanical components. This is called *detuning*. Typical current loop bandwidths range from 1000 to 2500 Hz. Typical velocity loop bandwidths range from 20 to 60 Hz.

Stability measures how controlled the system is. Stability can be measured with damping ratio or with overshoot in response to a step command. A discussion of different levels of stability follows.

Critical Damping

Generally, the most desirable amount of damping is Critical Damping. Critically damped systems respond as fast as possible with little or no overshoot. The graph in Figure 3.2 shows the velocity response of a system to a square wave input when the system is critically damped.

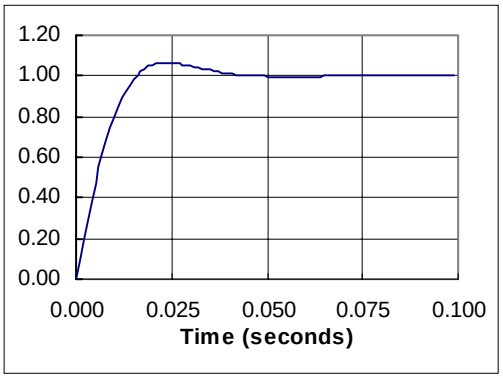


Figure 3.2 Critical Damping

Underdamping

Sometimes the system is tuned for critical damping and the system is still too slow. In these cases, you may be willing to accept less than critical damping. For applications that can work properly with a slightly underdamped system, you may reduce the stability to improve the response. The graph in Figure 3.3 shows a slightly underdamped system.

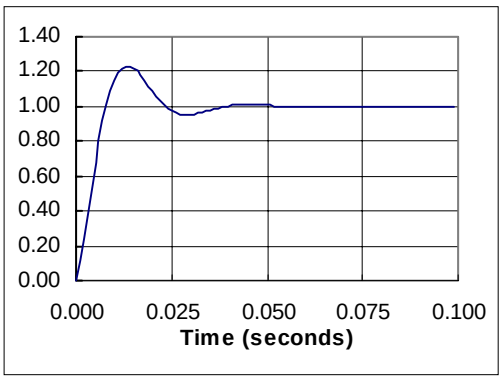


Figure 3.3 Underdamping

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Overdamping

An overdamped system is very stable but has a longer response time than critically damped or underdamped systems. Also, overdamped systems are noisier than less damped systems with the same response rate. The graph in Figure 3.4 shows an overdamped system.

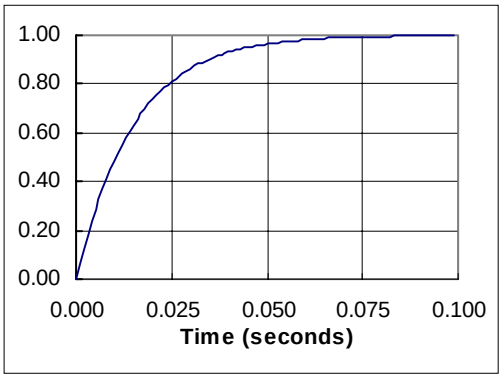


Figure 3.4 Overdamping

Ringing

When you are tuning the RO(L) you may tune it so that the response rings. Ringing is caused when you attempt to tune the RO(L) for too rapid response. Normally, the best solution is to reduce the bandwidth. The graph in Figure 3.5 shows a system that rings.

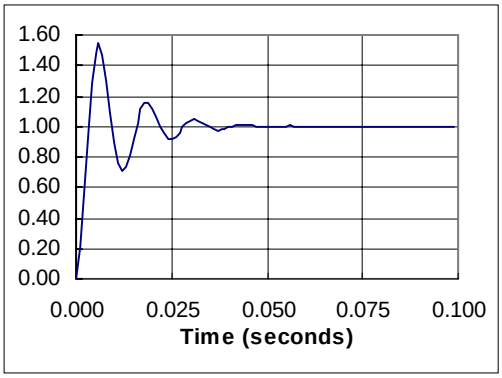


Figure 3.5 Ringing

ADVANCED CURRENT LOOP TUNING

Theory of Operation

Tuning is the process of optimizing several parameters of operation, including response, bandwidth, and noise. Tuning is based on control theory; the goal is to set loop gains with sufficient gain/phase margin while attaining the required response.

The Frequency Domain

A common way to specify response is measuring the response of the current loop to a sinusoidal command over a wide range of frequencies. That is, measuring the loop response in the frequency domain. The response of current loops gets poorer as the command frequency increases, which is to be expected. When the command is at very low frequencies, below 10 Hz for example, the loop is nearly perfect; that is, the actual current will look very much like the commanded current. At very high frequencies, above 10,000 Hz for example, the system will not be able to respond at all--the command may represent substantial current, but the actual current will be very small.

The basic measure of response is referred to as bandwidth. The bandwidth of a system is defined as the frequency at which the command is attenuated to 70% (-3dB) of its low frequency response. Figure 3.6 shows the response of a properly compensated current loop with a bandwidth of 1000 Hz. This graph illustrates a few key points to understanding response in the frequency domain. The frequency shown here is the -3dB point--the point at which the response is 70% of the command. We assume here that the command and response are scaled the same. However, in an actual system, you will need to adjust your scope so the magnitudes show the same. Do this at a low frequency so you can be sure the loop is responding without attenuation. After adjusting your oscilloscope, you can directly compare the two signals at higher frequencies. Notice also in Figure 3.6 that the feedback (current) lags the command. Here, the lag is about 1/8 of a revolution or 45°. This lag is typical for a well-behaved system. A large lag at the -3dB point, especially over 90°, indicates a somewhat unstable system.

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Measurement and Control

To observe current loop operation, lock the shaft. Apply a 10% on-time pulse to ANALOG CMD (J6-3, -4). Monitor current with a DC current probe on one of the two motor leads with current, or measure current with an oscilloscope on IMONITOR (J6-8) where 1.0 volt is scaled for either 4A (RO(L)-20012) or 1.33A (RO(L)-20004).

Do not short IMONITOR (J6-8) or IMONITOR RET (J6-15) to ground!

Do not connect to oscilloscope ground!

IMONITOR (J6-8) and IMONITOR RET (J6-15) are not isolated; they are referenced to bus-. There is normally 70 VDC between these signals and ground.

CAUTION

If locking the shaft is impractical, configure the drive for a zero-torque position: set for 60° commutation (turn SW1-10 off) and remove the HALL POWER (J6-10) to disable hall sensors. This allows current to be commanded without generating torque. In this procedure, always apply current in one direction or the shaft will turn. Use very low current rather than zero current.

Observe the response to the pulse; it should be rapid and not overshoot more than 10%. If the response is not as you desire, change the current loop gain switch (SW1-2). If response is still inadequate, turn SW1-2 off and install R26 and C69, with appropriate values. For tuning, install them temporarily, one at a time and in increments of about 20% until you achieve the desired response.

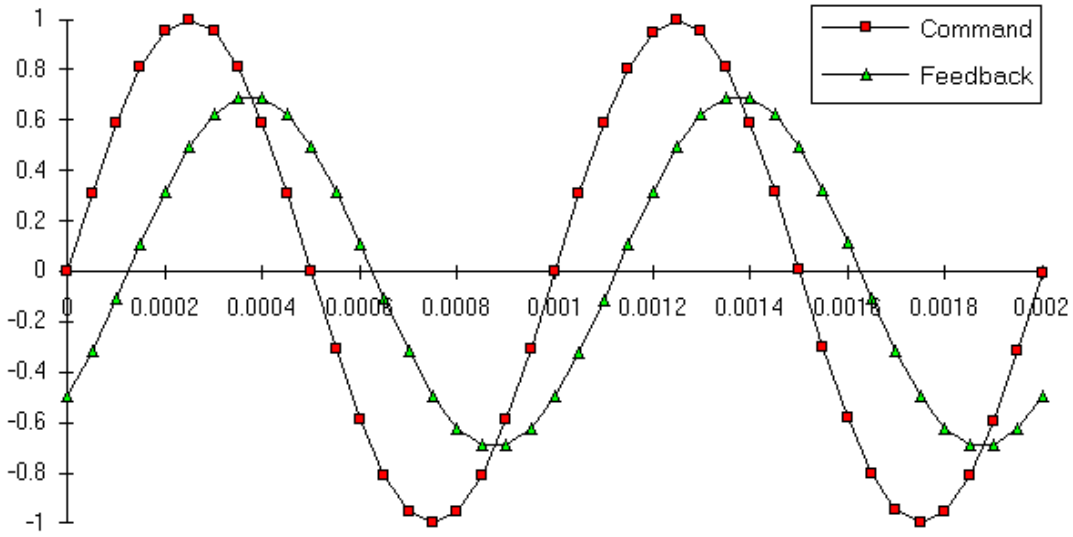


Figure 3.6 -3dB Point: 70% Attenuation

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VELOCITY LOOP PROBLEMS

The mechanical construction can limit the performance of your velocity loop. The problems caused by the mechanics fall into three categories:

1. Compliance
2. Non-Linearities
3. Resonance

Compliance

In compliant systems, the load is not tightly coupled to the motor shaft. If you move the load by hand, you can feel springiness. Compliant systems often are very stable when you tune with lower target bandwidths. However, they oscillate vigorously at low frequencies when you try to tune them for higher bandwidths.

A compliant system has the following characteristics:

- There is springiness between the motor and the load or at the motor mounting plate.
- The frequency of oscillation is less than 100 Hz.

Compliance can be corrected by the following actions:

- Reduce the bandwidth of the system.
- Stiffen the machine so the load is not springy.

Non-Linearities

Tuning is based on linear control theory. The most important requirement of a linear controller is that the total reflected inertia should not change substantially during operation. Load inertia includes all the inertia reflected to the motor, such as inertia through gearboxes and leadscrews. Inertia can change in ways that are easy to understand, such as the inertia of a spool of cable decreasing when the cable is unrolled. It can also change in less intuitive ways, such as chain drives (which have load in one direction but are unloaded in the other) and systems with excessive backlash (where there is no load when gear teeth are not touching).

When the inertia changes, the system has the following characteristics:

- System performance is excellent when the motor is in some positions and unacceptable when the motor is in other positions.
- Reducing the bandwidth eliminates the problem.

If the system performance is poor because of changing inertia, you can make the following corrections:

- Correct the system mechanics so that inertia is constant.
- Detune (that is, reduce the bandwidth of) the system.

Resonance

Resonance is a high frequency (> 500 Hz) where the system mechanics oscillate. Normally, systems with resonance will be very stable when you tune with lower target bandwidths. As you increase the target bandwidth, you will begin to hear a fairly pure, high pitch. If you want to decrease resonance, use shorter, larger diameter driving shafts.

When your system has a resonance, it will have the following characteristic:

- The system will emit a clear, high pitch (> 500 Hz). Do not confuse this problem with compliance, which has a low pitch.

If the system performance is poor because of resonance, you can make the following corrections:

- Reduce the bandwidth of the system.
- Shorten the length and increase the diameter of shafts and lead screws.

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EMPIRICAL METHOD: PHASING NON-KOLLMORGEN MOTORS

This section discusses how to determine empirical phasing for non-Kollmorgen motors.

Chapter 2 discussed how to connect non-Kollmorgen motors in "Wiring Motor Leads for Other BLDC Motors." That section is based on using sequences for either 60° or 120° commutation. However, if the corresponding information for the motor is not available, use the following trial-and-error procedure.

During this procedure, ensure that the motor does not overheat. Depending on the motor, the specified analog-command voltage may be too large. If the motor frame temperature exceeds 50°C, the command should probably be reduced. If the motor is below 50°C, you should be able to comfortably rest your hand on it.

If you are operating your RO(L) in velocity loop mode, temporarily configure for current loop mode as discussed at the start of Chapter 3.

Phasing by Trial and Error:

1. Turn SW1-10 on if your motor uses 120° commutation. Turn SW1-10 off for 60°. Contact the motor manufacturer to determine which is appropriate.
2. Put the amplifier in open-loop mode (see Table 3.1).
3. Set ANALOG-CMD for 1.0 volt.
4. Connect the three hall sensor S1, S2, and S3 leads arbitrarily. (Hall power and common must be connected correctly.)
5. Enable the amplifier.
6. Try all six combinations of motor lead connections until the motor rotates freely. Always remove power from the amplifier when changing motor lead connections.

Note some incorrect wiring combinations will cause the motor to rotate, but inefficiently and with zero-torque positions (or "dead spots"). Carefully stop the motor by hand and feel torque as you let the motor rotate slowly. If the wiring is correct, torque will be nearly continuous throughout the rotor rotation.

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CHAPTER 4
MAINTENANCE

INTRODUCTION

Information in this chapter will enable you to maintain the system components, ensuring reliable, efficient operation of the system. Preventative maintenance of the equipment is also specified along with periodic maintenance. Follow these practices when operating your servo system.

SPARE PARTS

BJ-BKO-10: Silverline Encoder Breakout Terminal

The BJ-BKO-10 can be used to simplify Silverline encoder connections. Mount the breakout near the amplifier and run a ribbon cable between the breakout and the motor. Connect J9 to screw terminals as shown in Figure 2.6. Use scissors to cut ribbon cable. A bench vise is necessary to make up ribbon cable connectors.

ROL Slow-Blow Glass Fuse Qty. 1
Wickman 19195-16
16 Amp Fuse

(The ROL Fuse is located in JL, the line connector.)

PREVENTATIVE MAINTENANCE

Preventative maintenance can prevent situations that will damage your equipment. Four types of preventative maintenance are presented below. Following each of these procedures can reduce problems with and add life to your equipment.



CAUTION

Electronic components in this amplifier are static sensitive. Use proper procedures when handling component boards.

Preventative maintenance should be performed with the RO(L) system out of operation and disconnected from all sources of power.

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CAUTION

Preventative maintenance to this equipment must be performed by qualified personnel familiar with the construction, operation, and hazards involved with the application.

Always take equipment out of operation and disconnect it from all power sources before performing maintenance.

Transient Voltages



NOTE

All transient-producing devices must be properly suppressed.

Solid state controls of the RO(L) may be affected by transient voltages. These voltages may exceed the specified voltage for any given circuit. When these peak voltages occur, even for less than a second, permanent damage can occur.

To help avoid transient voltages that may interfere with electronic circuit functions within the RO(L), all switched inductive devices or their wiring (solenoids, relay coils, starter coils, etc.) must be suppressed. A 220 ohm, 1/2 watt resistor in series with a 0.5 micro farad, 600 volt capacitor is suggested.

Electrical Noise

The low levels of energy in the RO(L) control circuits may cause them to be vulnerable to electrical noise. Sources of electrical noise include equipment having large, fast changing voltages and currents when they switch on and off. These devices have the capability of inducing current and voltage transients on their respective power lines. Accommodation must be made for these transients using noise immunity provisions.

Error! Bookmark not defined. Electrical noise is prevented with the same methods as surge current and transient voltages. However, there are other methods of preventing electrical noise, such as:

- Maintain physical separation between electrical noise sources and the RO(L) amplifier.
- Maintain physical separation between electrical noise sources and the RO(L) control wiring. This can be accomplished by using separate conduits or wiring trays for control wiring and power wiring.
- Follow good grounding practices when wiring the RO(L). Be careful not to create a grounding loop with multiple ground paths. Follow the NEC's provisions on grounding.

Radio Frequency Energy

This equipment is susceptible to, and can radiate, radio frequency energy. It must be installed and used in accordance with this installation manual to limit possible interference with radio communications or other electronic equipment.

PERIODIC MAINTENANCE

Periodically you will need to inspect your equipment for possible problems to ensure ongoing safe and efficient operation. Periodic maintenance should be performed at scheduled intervals to ensure proper equipment performance. It must be performed by qualified personnel familiar with the construction, operation, and hazards involved with the RO(L) and its application. Power should be disconnected during all maintenance procedures.

Periodic maintenance includes the following:

- Check that no screw terminals have vibrated loose.
- Check fan operation.
- Check integrity of wiring.
- Check PCBs for accumulation of contaminants such as fluids, dust, or shavings.
- Check all external circuit breakers to assure that they are within their original ratings as specified by the manufacturer.

Grounding Integrity

The method employed for grounding or insulating the equipment from ground should be checked to assure its integrity on a regular basis. This check should be performed with the power off and the testing equipment grounded.

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APPENDIX A
WARRANTY INFORMATION

Kollmorgen Corporation warrants that equipment delivered by it to the Purchaser will be of the kind and quality described in the sales agreement and/or catalog and that the equipment will be free of defects in design, workmanship, and material.

The terms and conditions of this Warranty are provided with the product at the time of shipping or in advance upon request.

The items described in this manual are offered for sale at prices to be established by Kollmorgen and its authorized dealers.

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APPENDIX B
OUTLINE DRAWINGS

This appendix contains outline drawings for H-Series motors and RO(L) electronics.

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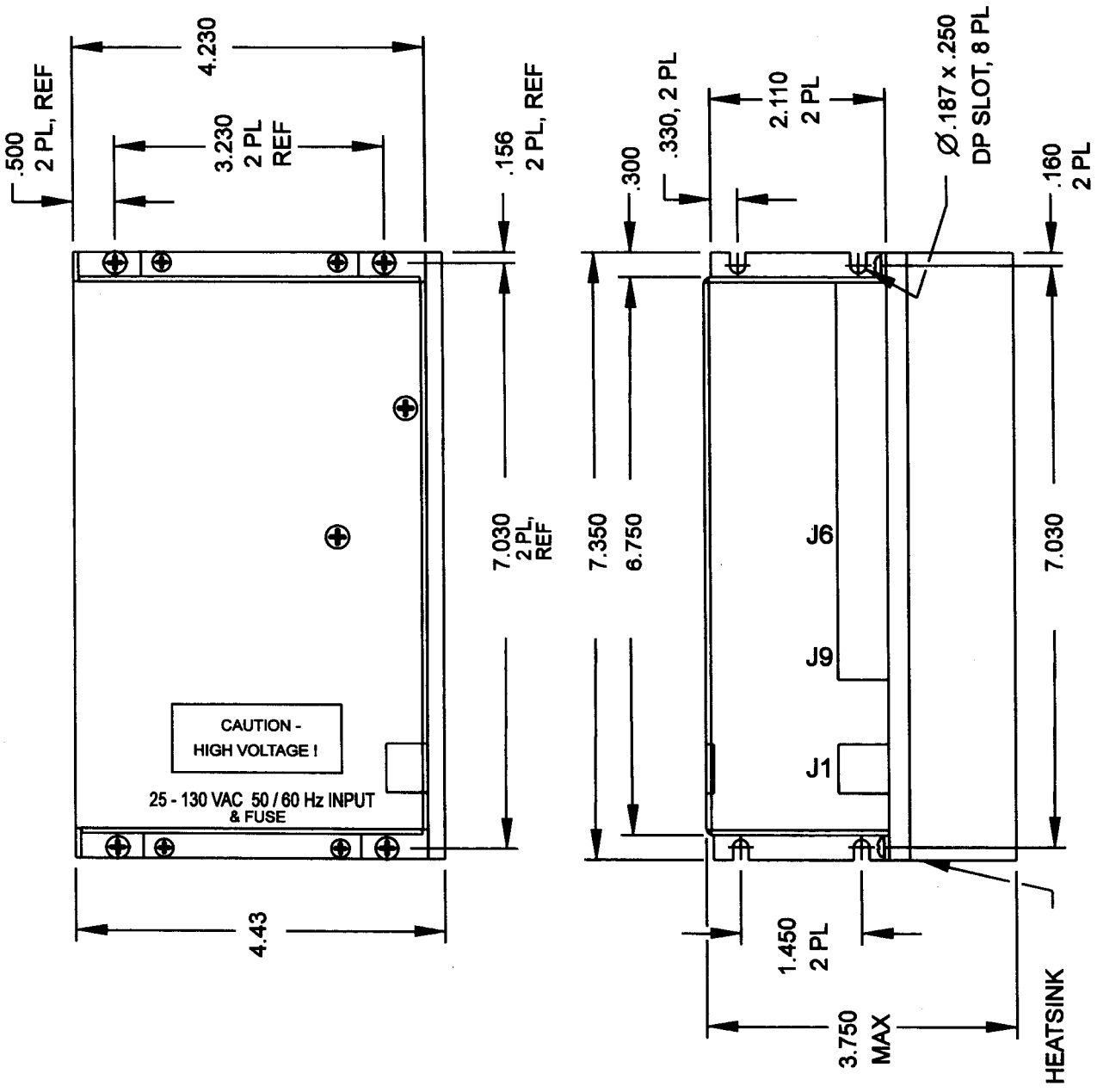


Figure B.1 ROL Series Outline

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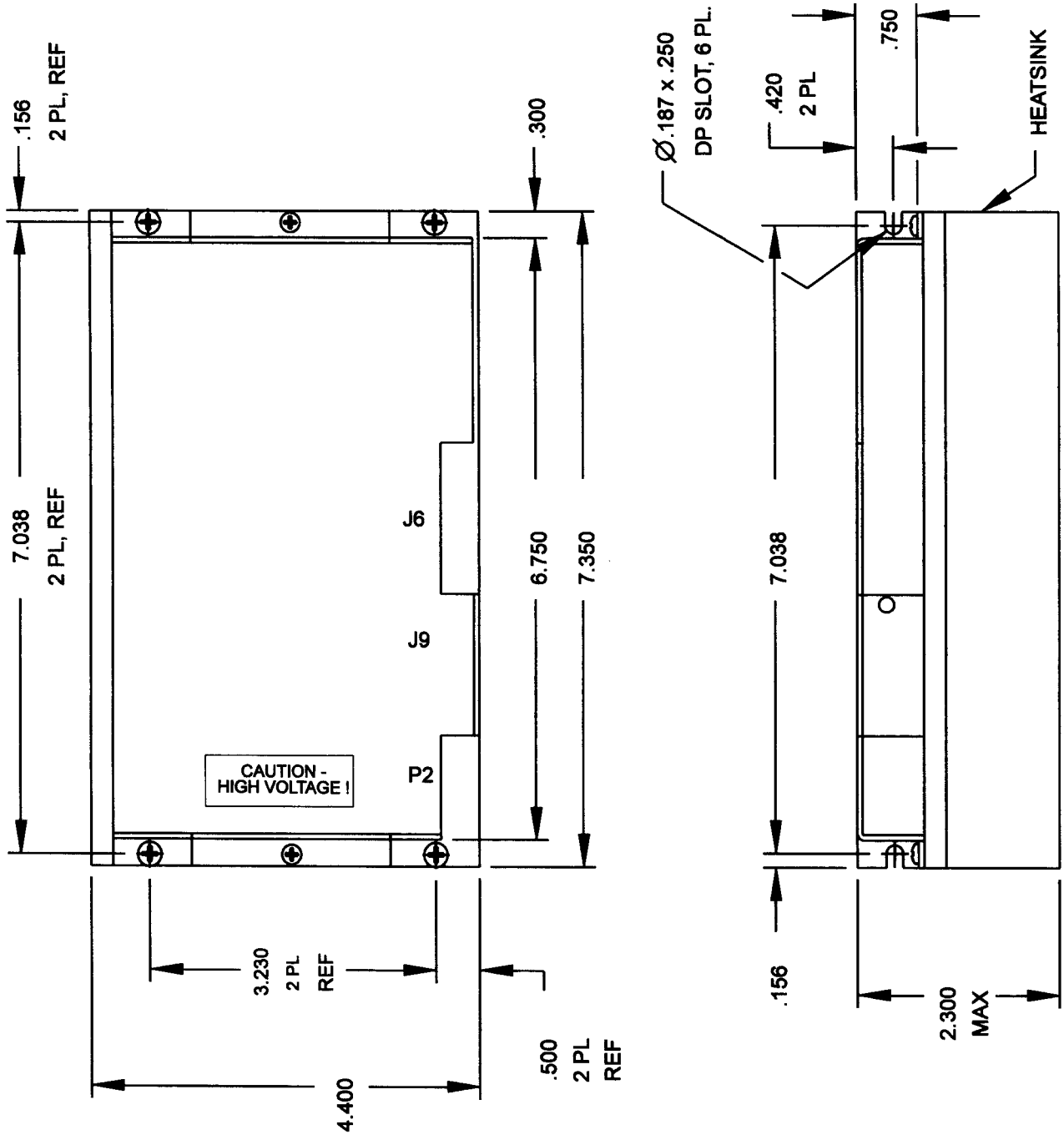


Figure B.2 RO Series Outline

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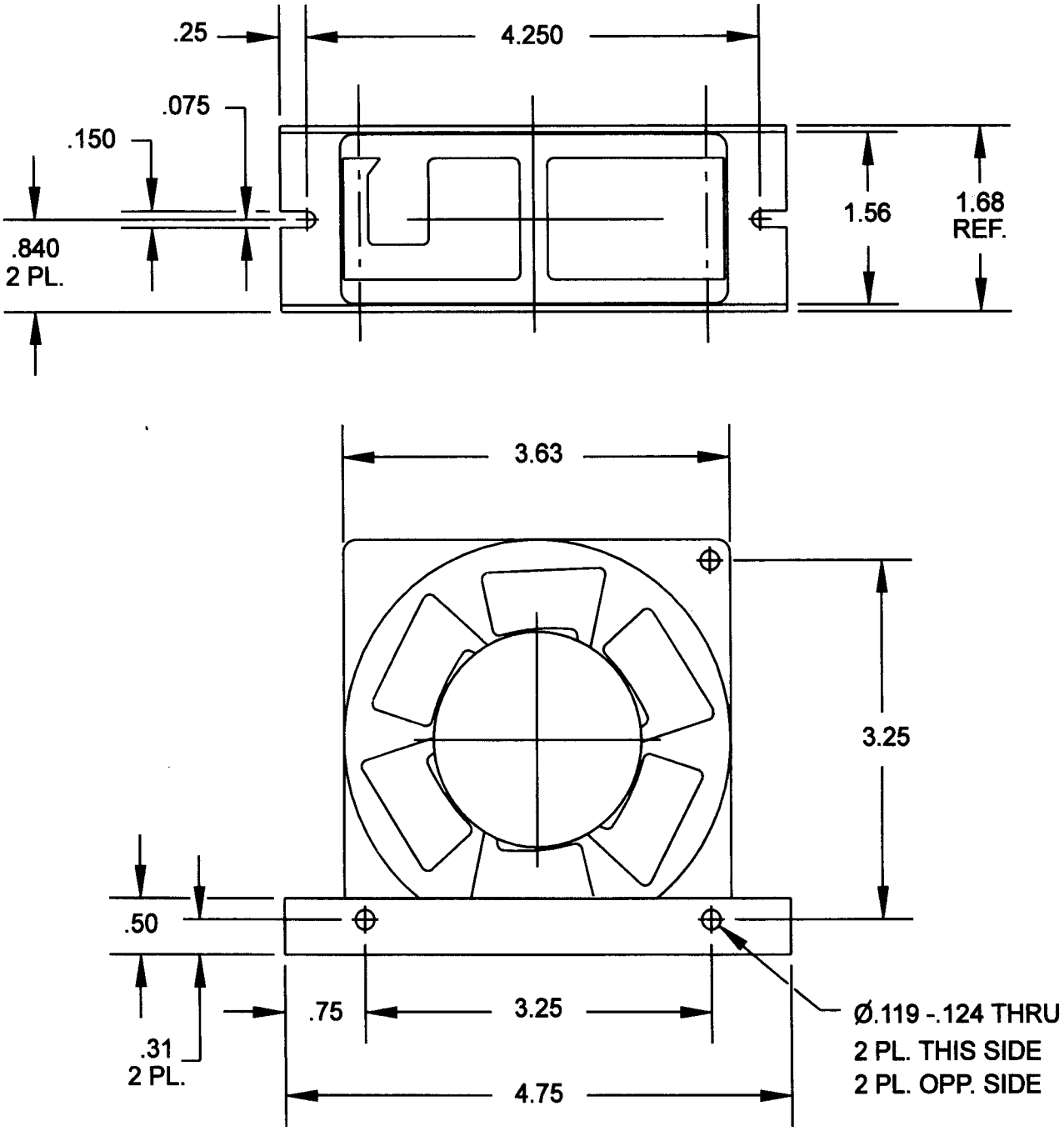


Figure B.3 Fan Bracket
RO(L)-20012 Only

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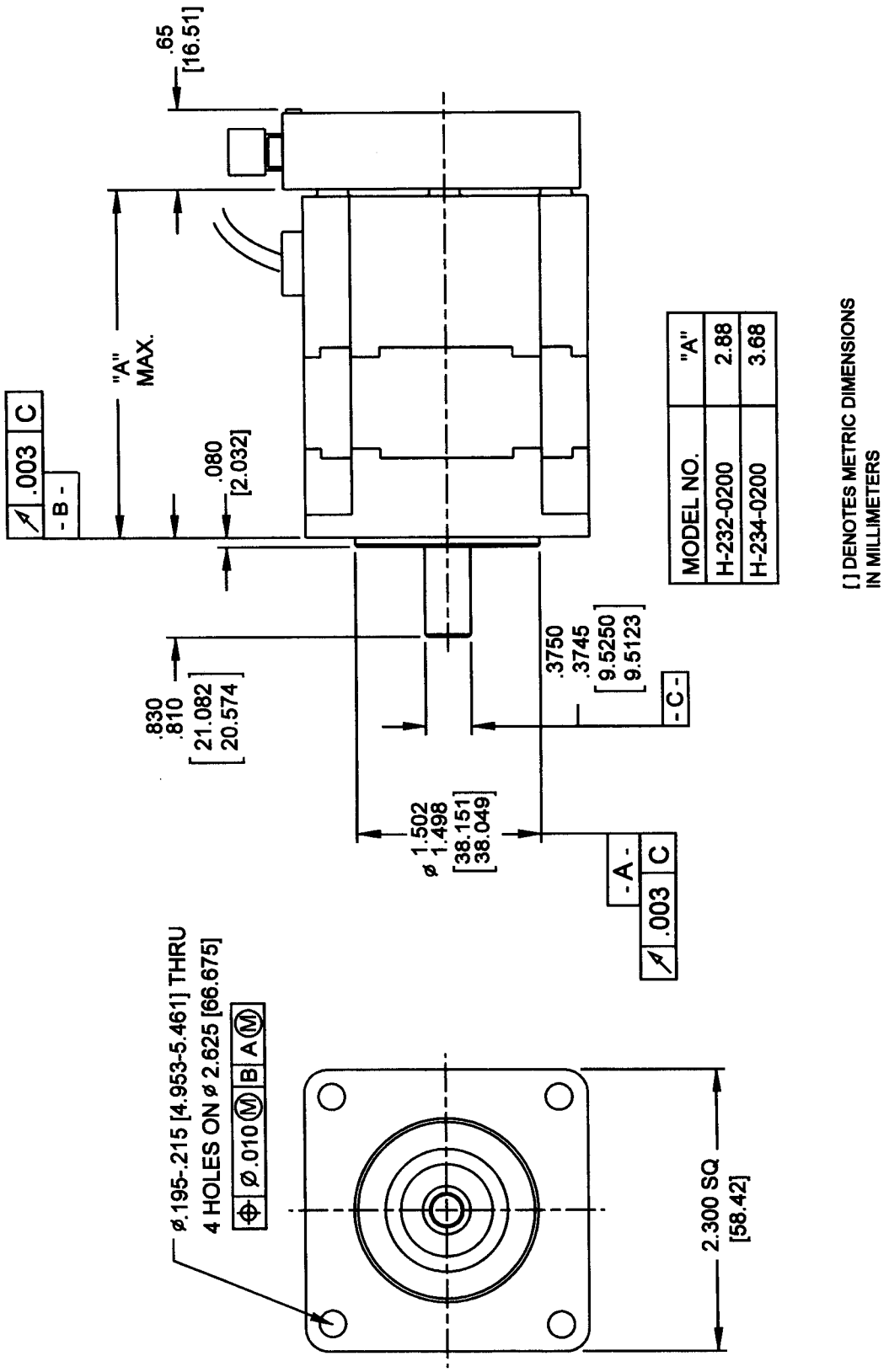


Figure B.4 Size 23 Outline

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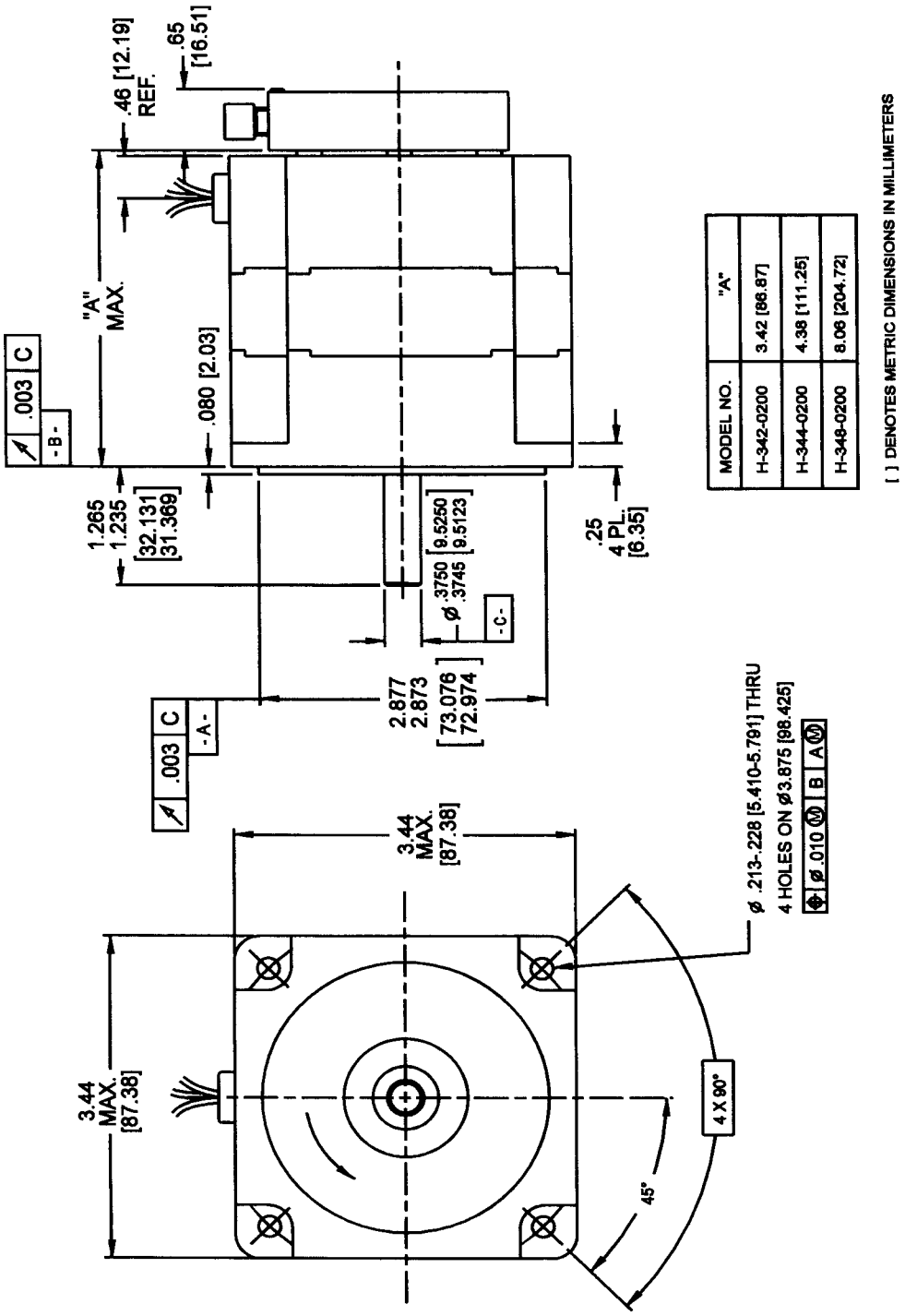


Figure B.5 Size 34 Outline

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APPENDIX C
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INDEX

BJ-BKO-10, 35
Block Wiring Diagram, 5
Bus Capacitor
  Reservoir, 10

Circuit Breakers, 9
Commutation, 26
Commutation Diagram
  120 Degree, 14
  60 Degree, 15
Compliance, 33
Connector, 36
Connector J1, 12, **19**
Connector J6, **15**, **19**, 20
Connector J9, 15, **21**
Connector Layout
  Main PCB, 18
Connector Overview, 16
Continuous Current, 3, 27
Convection, 8
Critical Damping, 30
Current
  Continuous, 3, 27
  Peak, 3
Current Loop Mode, 24
Current Monitor, 26

Detuning, 29, 30
Differential Encoder, 25
Direction
  Reversing, 28

Electrical Codes, 9
Electrical Noise, 9, 36
EMI, 9, 36
Encoder, 17
  Connection, 11
  Phasing, 13
Encoder output
  Single ended, 15
Environmental Considerations, 8

Fan, 8
Fault
  Hall Sensor, 27
  Over-current, 27
  Over-voltage, 27
  Troubleshooting, 29
Fuses, 9

Grounding Integrity, 36

Hall Sensor Fault, 27
Humidity, 8

IMONITOR, 13, 26, 32
Installation Requirements, 8
Isolation, 12

LEDs, 27
Limitations
  Velocity Loop, 25

Maintenance, 35
Mode
  Current Loop, 24
  Open Loop, 24
  Operational, 23
  Velocity Loop, 25
Model Number
  RO(L), 2
Motor, 13
  Encoder Connector, 11
  Noisy, 30
  Outline Drawings, 39
  Protection, 10

Noise Susceptibility, 30
Noisy, 30
Non-Linearities, 33

Open-Loop Mode, 24
Operating Temperature, 4, 8
Operation Mode, 23
Outline Drawings, 39
Over Current, 27
Over-current, 27
Overdamping, 31
Over-Temperature, 27
Over-voltage, 27

Part Number Description, 1
Peak Current, 3
Periodic Maintenance, 36
Phasing Motors, 34
Preventative Maintenance, 35
Pulse Width Modulation, 8
PWM, 8
PWM Noise, 30

Radio Frequency Energy, 36
Ratings, 2
RBE Motor, 13

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Regen, 4, 10, 12, 27
Regional Sales Offices, 45
Resonance, 33
Response, 30
Reversing Direction, 28
Ringing, 31
RO(L)
  Model Number, 2
  Outline Drawings, 39

Safety information, 7
safety-alert symbols, 7
Single-ended Encoder, 15, 25
Spare Parts, 35
Specifications, 2
Stability, 30
Start up, 23
Static Sensitive, 8
Storage Temperature, 8
Strain Relief, 9, 11
  Encoder Connector, 11
System Description, 1
System Wiring Diagram
  Velocity Loop Mode, 6

Temperature
  Operating, 4, 8
Transient Voltages, 36
Tuning, 30
  Criterion, 30
  velocity loop Problems, 33
Tuning Theory, 31

Underdamping, 30
Unpacking, 8

Velocity Loop, 3
  Detuning, 29
  Gain Adjust, 29
  Offset Adjust, 29
  Scale Adjust, 29
  Tuning, 28
Velocity Loop Limitations, 25
Velocity Loop Mode, 25
Ventilation, 8
Vibration, 11, 36

Warranty, 37
Wiring, 9
  Encoder, 13

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