ISO 9001 CERTIFIED

#502-PD-RD-001-00

PosiDrive™ Series RD

DIGITAL SERVO MOTOR CONTROL & AMPLIFIER

INSTALLATION MANUAL

FORCE CONTROL®

Force Control Industries, Inc.

WARNING – Read this manual before attempting any installation of the *PosiDrive* Digital Servo Motor Control and Amplifier.

Record of Manual Revisions

ISSUE No.	Date	Description of Revision
00	05/20/02	Initial Release

Copyright Information

NOTICE:

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SAFETY INSTRUCTIONS

Only qualified personnel are permitted to transport, assembly, commission, and maintenance this equipment. Properly qualified personnel are persons who are familiar with the transport, assembly, installation, commissioning and operation of motors, and who have the appropriate qualifications for their jobs. The qualified personnel must know and observe the following standards and regulations:

IEC 364 resp. CENELEC HD 384 or DIN VDE 0100
IEC report 664 or DIN VDE 0110
National regulations for safety and accident prevention or VBG 4

- Read all available documentation before assembly and commissioning. Incorrect handling of products in this manual can result in injury and damage to persons and machinery. Strictly adhere to the technical information on the installation requirements.
- It is vital to ensure that all system components are connected to earth ground. Electrical safety is impossible without a low-resistance earth connection.
- The *PosiDrive*® product contains electro-statically sensitive components that can be damaged by incorrect handling. Discharge yourself before touching the product. Avoid contact with high insulating materials (artificial fabrics, plastic film, etc.). Place the product on a conductive surface.
- During operation keep all covers and cabinet doors shut. Otherwise, there are deadly hazards that could possibility cause severe damage to health or the product.
- In operation, depending on the degree of enclosure protection, the product can have bare components that are live or have hot surfaces. Control and power cables can carry a high voltage even when the motor is not rotating.
- Never pull out or plug in the product while the system is live. There is a danger of electric arcing and danger to persons and contacts.
- After powering down the product, wait at least ten minutes before touching live sections of the equipment or undoing connections (e.g., contacts, screwed connections). Capacitors can store dangerous voltages for long periods of time after power has been switched off. To be safe, measure the contact points with a meter before touching.

When these symbols are seen in this manual, be alert to the potential for personal injury. Follow the recommended precautions and safe operating practices included with the alert symbols. Safety notices in this manual provide important information. Read and be familiar with these instructions before attempting installation, operation, or maintenance. The purpose of this section is to alert users to possible safety hazards associated with this equipment and the precautions that need to be taken to reduce the risk of personal injury and damage to the equipment. Failure to observe these precautions could result in serious bodily injury, damage to the equipment, or operational difficulty.

- The safety-alert symbols are:

Warning Alerts users to potential physical 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 the product.

Directives and Standards

The *PosiDrive RD* product series have been successfully tested and evaluated to meet UL/cUL 508C for both U.S. and Canadian markets. This standard describes the fulfillment by design of minimum requirements for electrically operated power conversion equipment, such as frequency converters and servo amplifiers, which is intended to eliminate the risk of fire, electric shock, or injury to persons, being caused by such equipment.

CE Mark Conformance

Servo drives are components that are intended to be incorporated into electrical plant and machines for industrial use. When the servo drives are built into machines or plants, drives cannot be operated until the machine or plant fulfills the requirements of the EC Directive on Machines 89/392/EEC and the EC Directive on EMC (89/336/EEC). EN 60204 and EN 292 must also be observed.

In connection with the Low Voltage Directive 73/23/EEC, the harmonized standards of the EN 50178 series are applied to the amplifiers, together with EN 60439-1, EN 60146 and EN 60204.

The manufacturer of the machine or plant is responsible for ensuring that they meet the limits required by the EMC regulations. Advice on the correct installation for EMC - such as shielding, grounding, arrangement of filters, treatment of connectors and the laying out of cabling - can be found within this documentation.

Conformance with the EC Directive on EMC 89/336/EEC and the Low Voltage Directive 73/23/EEC is mandatory for the supply of servo drives within the European Community.

An authorized testing laboratory in a defined configuration with the system components has tested the servo drives. Any divergence from the configuration and installation described in this documentation means that you are responsible for the performance of new measurements to ensure that the regulatory requirements are met.

Force Control Industries, Inc.'s *PosiDrive RD Series* drives and systems have been successfully tested and evaluated to the limits and requirements of the EC Directive on EMC (89/336/EEC) and the EC Directive on Low Voltage (72/73/EEC). The product lines have been evaluated to EN50178 and EN60204 as a component of a machine and other relevant standards.

The EMC of a system can be identified by emissions and immunity. Emissions refer to the generation of EMI (electromagnetic interference) and immunity refers to the susceptibility levels of the equipment. Limits were derived from generic standards EN55081-2 and EN55082-2 for heavy industrial environments. The *PosiDrive RD* Series of drives and BUS Modules have been tested for radiated emissions, conducted emissions, EFT, ESD, surge, conducted immunity, and radiated immunity. These tests have been done in accordance with EN55011, EN61000-4-2, ENV50140, IEC 1000-4-4, EN61000-4-5, and ENV50141.

Installation of the equipment is critical in designing for system and machine electromagnetic compatibility (EMC). You must apply the installation recommendations and the CE filtering Practices when mounting and installing the drive system for CE conformance.

READ BEFORE INSTALLING

These installation steps are designed to lead you through the proper installation and setup of a *PosiDrive® RD* system. They were developed with the assumption that you have a fundamental understanding of basic electronics, computers, mechanics, and proper safety practices. However, you do not have to be an expert in motion control to install and operate the drive system. It is recommended that you read the entire manual completely before attempting installation or operation.

High voltage can present dangerous and hazardous conditions if not performed by a qualified electrician. Be certain to follow all national and local codes during installation. Follow all safety precautions outlined in the accompaning CD-ROM documentation.

1. Open the box(es) and remove all the contents. Check to ensure there is no visible damage to any of the equipment.
2. Mount the *PosiDrive RD* to the back panel. Refer to the appropriate Outline Dimensions in this manual. ***Metal-to-metal contact is important for electrical noise control!***
3. Wire the *PosiDrive RD* according to the appropriate System Wiring Diagram.
4. Connect solid earth ground to frames of all components.
5. Wire the main power (115/230 VAC).
   A. Wire the 24 volt supply to the connector at the top of the drive.
6. Wire user I/O at connector C3: At a minimum, 24 volts must be brought in to the enable circuit. Be certain that connector C3 is inserted correctly.
7. Wire the motor and feedback. Refer to the Feedback Wiring Diagram for additional information.
8. Wire Regen Resistor kit, if applicable.
9. Verify that all wiring is correct.
10. Verify that earth grounds are connected.
11. Verify all electrical and safety codes are met.
12. Connect the serial cable to connector C2 and PC.
    Refer to the appropriate System Wiring Diagram.
13. Install Software on the PC.

Startup processes can cause motor motion. Be certain that all applicable safety precautions are taken to ensure that no harm to personal or machine can occur.

14. Using the Startup Wizard for your Software:
    A. Configure the *PosiDrive RD* for your particular motor, if this was not done at the factory. Refer to the Software Startup Wizard.
    B. Enable the system.

UNPACKING AND INSPECTION

Open the box(es) and remove all the contents. Check to ensure there is no visible damage to any of the equipment.

Electronic components in this amplifier are design hardened to reduce static sensitivity. However, proper procedures should be used when handling.

Remove all packing material and equipment from the shipping container. Be aware that some connector kits and other equipment pieces may be quite small and can be accidentally discarded if care is not observed when unpacking the equipment. Do not dispose of shipping materials until the packing list has been checked.

Upon receipt of the equipment, inspect components to ensure that no damage has occurred in shipment. If damage is detected, notify the carrier immediately. Check all shipping material for connector kits, manuals, diskettes, and other small pieces of equipment.

Warranty Information

All products covered in this manual are warranted to be free of defects in material and workmanship and to conform to the specifications stated either in this document or a product catalog description. All Force Control Industries, Inc. brushless motors and electronics are warranty for a period of 12 months from the time of shipment.. There are no other warranties (expressed or implied, including the warranty of merchantability and fitness for a particular purpose) which extends beyond this warranty. Force Control Industries, Inc. warrants that the products covered in the manual are free from patent infringement when used for normal purposes.

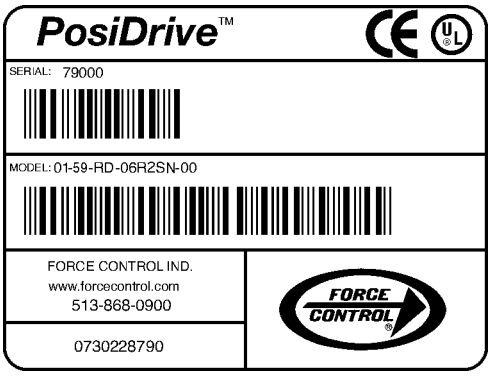
Use as directed

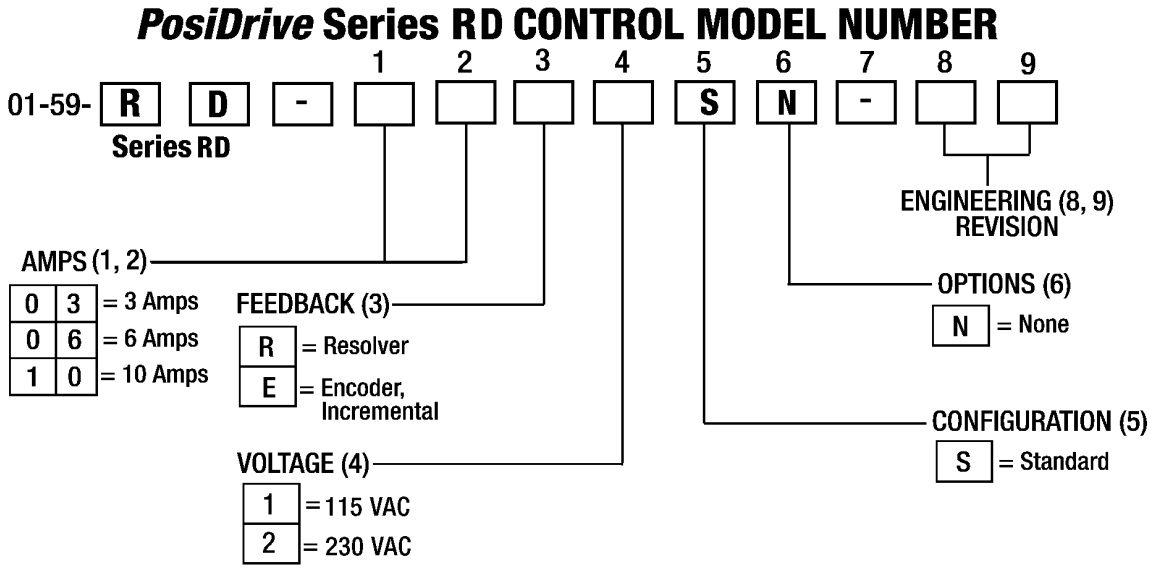
The restrictions for proper use of a *PosiDrive RD* system are:

- These amplifiers are components that are built into electrical equipment or machines and can only be commissioned as integral components of such equipment.
- The servo amplifiers are to be used only on earthed, three-phase industrial mains supply networks (TN-system, TT-system with earthed neutral point).
- The servo amplifiers must not be operated on power supply networks without an earth or with an asymmetrical earth.
- If the servo amplifiers are used in residential areas, or in business or commercial premises, you must implement additional filtering measures.
- The servo amplifiers are only intended to drive specific brushless synchronous servomotors from Force Control Industries, Inc., with closed-loop control of torque, speed, and position. The rated voltage of the motors must be at least as high as the DC-link voltage of the servo amplifier.

- The servo amplifiers may only be operated in a closed switch gear cabinet, taking into account the ambient conditions defined in the environmental specifications.
- Force Control Industries, Inc. guarantees the conformance of the servo amplifiers with the standards for industrial areas stated in the front of this manual only if Force Control Industries, Inc. delivers the components (motors, cables, amplifiers etc).

PosiDrive RD Name Plate and Model Numbers





MOUNTING

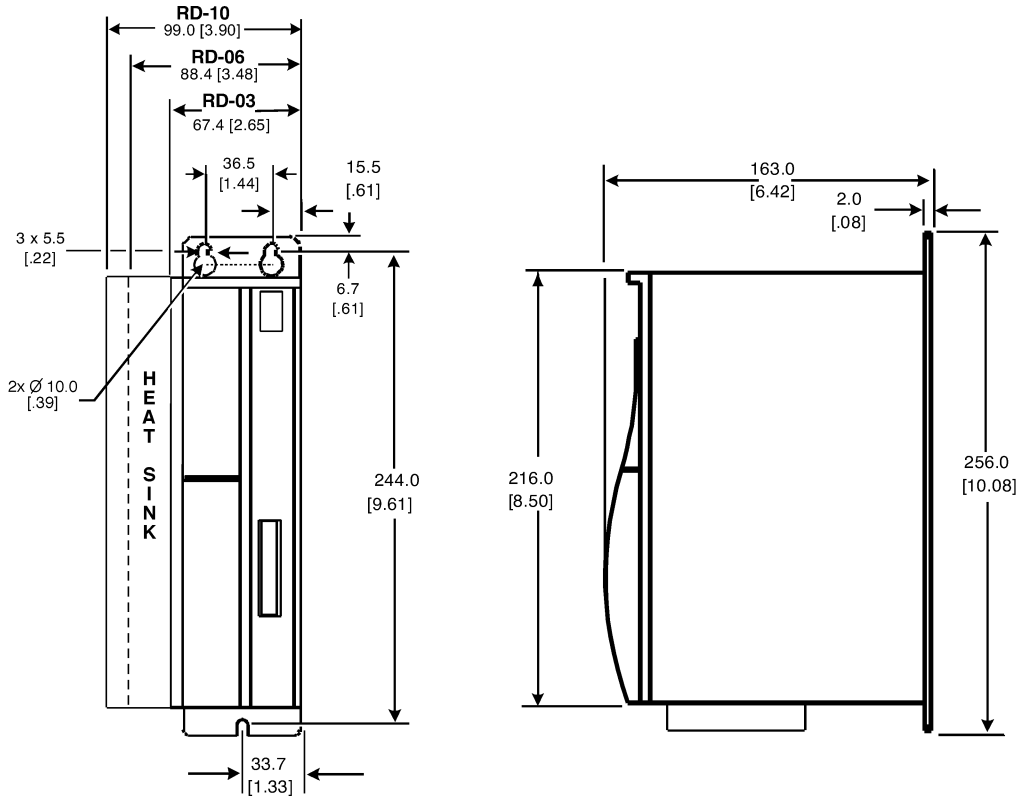
For proper ventilation, the *PosiDrive* should be mounted vertically. These products are designed for mounting in an electrical enclosure to protect them from physical and environmental damage.

Hardware Specifications

PosiDrive RD

Amplifier Model		RD-03	RD-06	RD-10
Unit Weight	Lbs./Kgs.	3.56/1.61	4.9/2.22	5.94/2.69
Mounting Hardware	English (Metric)	10-32 (M4)		
	Applied Torque	20 lb-in. (2.26 Nm.)		
Connection Hardware	Line Screw Size/Torque	M3.5/12 lb-in. (1.35 Nm.)		
	BUS Screw Size/Torque			
	Motor Screw Size/Torque			
	Ground Screw Size/Torque			
Wire Size (AWG#)	Control Logic (AWG/ mm^2)	16 / 1.5		
	Motor Line (AWG/ mm^2)	14 / 2.5		
	Main Input (AWG/ mm^2)	14 / 2.5	12 / 4	
	Configurable I/O wire gauge	22-18 AWG (0.3-0.75 mm^2) Ferrules recommended: 18 AWG Type H0 - 75/14 Weidmuller 4629.0 or equivalent 20 AWG Type H0 - 5/14 Weidmuller 6907.0 or equivalent 22 AWG Type H0 – 34/12 Weidmuller 902577 or equivalent		
	Spade Terminals	16/14 AWG (1.5 mm^2): Hollingsworth XSS0954S OR SS20947SF or equivalent 12/10 AWG (4-6 mm^2): Hollingsworth XSS20836 OR SS20832F or equivalent		
Clearance Distance	Side-to-Side	0.5in (12.7mm)		
	Top/Bottom	2.5in (63.5mm)		
Mating Connector Hardware	CK100 Kit	Includes: C1, C2, C4, C7 (plus 2 ft./0.69 m. of stranded bus ribbon), C8		
	C3	Vendor Info: Weidmuller BL3.5/13 Cat.No. 161574		
	C5	Vendor Info: PCD ELFP04110		
	Connector Screw Torque	2.25 lb-in. (0.25 m.)		
	24 V Logic	Vendor Info: PCD ELFP02210 (or equiv.)		

Outline Dimensions *RD Units*



Enclosure

The Force Control Industries, Inc. *PosiDrive* series of electronic system components are designed for panel assembly. This panel assembly should then be mounted in a metallic enclosure. Enclosures are supplied by the manufacturers of the final product and must meet the environmental IP rating of the end product. To ensure proper grounding (and to optimize EMC), the enclosure should have continuous ground continuity maintained between all metal panels. This ground continuity is intended to be both a safety ground and a high frequency ground. The units should be mounted on a back plane, which is installed into the enclosure. Ideally, the back plane should be an unpainted metallic surface to optimize electrical bonding of the frame and provide the lowest possible impedance path to earth ground. These enclosures also provide added safety.

WIRING

The environment that any electronic control system 'lives' in can effect its operation. Force Control Industries, Inc. recommends that the *PosiDrive* system be operated and stored under the environmental conditions stated in the product specification tables. The system may be operated in higher temperature ambient conditions with a derating applied. Please check with the factory for derating information.

Attention to proper installation and field wiring are of prime importance to ensure long-term and trouble-free operation. Users should familiarize themselves with and follow the installation and wiring instructions listed in this section. In addition to these practices, some localities and industries may require applicable electrical and safety codes, laws, and standards.

Particular care should be used when layout of an enclosure is designed. Efforts to separate power wires from small signal wires should be taken. The following guidelines highlight some important wiring practices to implement:

- Control and signal cables must be separated from power and motor cables. Distance of 20cm (8 in.) is sufficient in most cases.
- Control and signal cables must be shielded to reduce the effects of radiated interference.
- Where control cables must cross power or motor cables, they should cross at a 90º angle, if possible. This reduces the field coupling effect.

Grounding

System grounding is essential for proper performance of the drive system. A ground bus bar may be used as a single point ground for the system. Safety grounding should be provided to all pieces of the system from a "star point." In addition to the safety grounding, a high frequency ground must be provided that connects the back panel to the enclosure and, ultimately, to earth ground. The objective is to provide an extremely low impedance path between the filters, drives, power supplies, and earth ground. This high frequency ground is accomplished with the use of a flat braid or copper bus bar. It is important not to rely on a standard wire for the high frequency ground. In general, a wire has an inductance of 8nH-per-inch, regardless of diameter. At higher frequencies, this unwanted inductance between grounds equates to limited filter performance. When connecting high frequency grounds, use the shortest braid possible.

Bonding

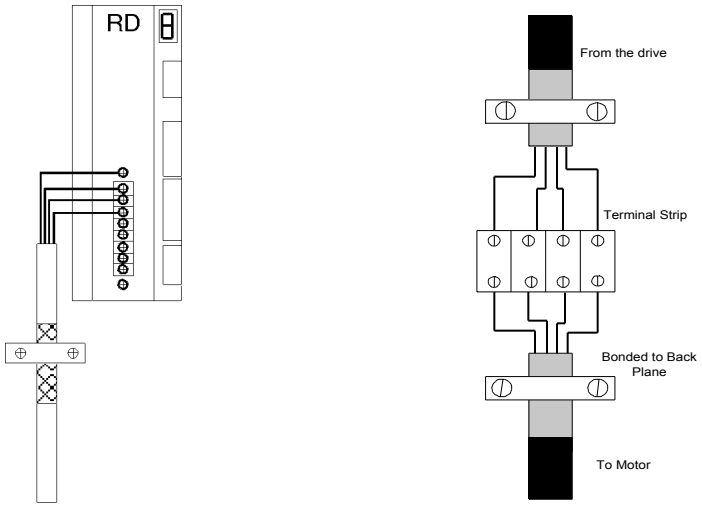
The proper bonding of shielded cables is imperative for minimizing noise emissions and increasing immunity levels of the drive system. Its effect is to reduce the impedance between the cable shield and the back panel. Force Control Industries, Inc. recommends that all shielded cables be bonded to the back panel.

Power input wiring does not require shielding (screening) if the power is fed to the cabinet (enclosure) via metallized conduit. If the metallized conduit is used with proper high frequency grounds, bonding technology, and recommended wire routing, then power input wire shielding has no affect. In the event that metallized conduit is not implemented into the system, shielded cable is required on the power input wires and proper bonding technologies should be implemented.

The motor and feedback cables should have the shield exposed as close to the drive as possible. This exposed shield is bonded to the back panel using one of the two suggested methods below.

Non-insulated Cable Clamp

The following figures shows how cable bonding is implemented using non-insulated metallic cable clamps.



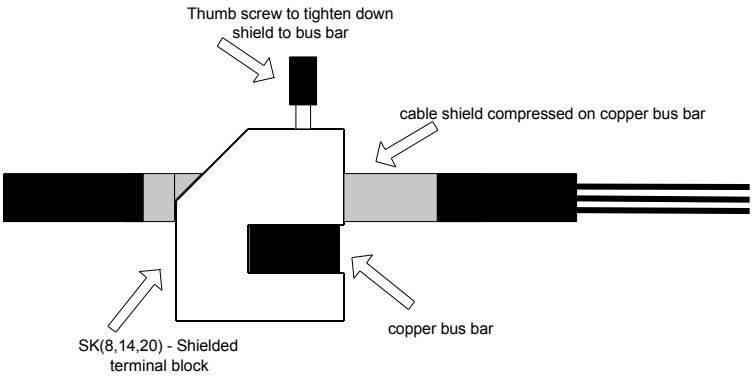
RD Drive Clamp and Terminal Clamp

Alternative Bonding Methods

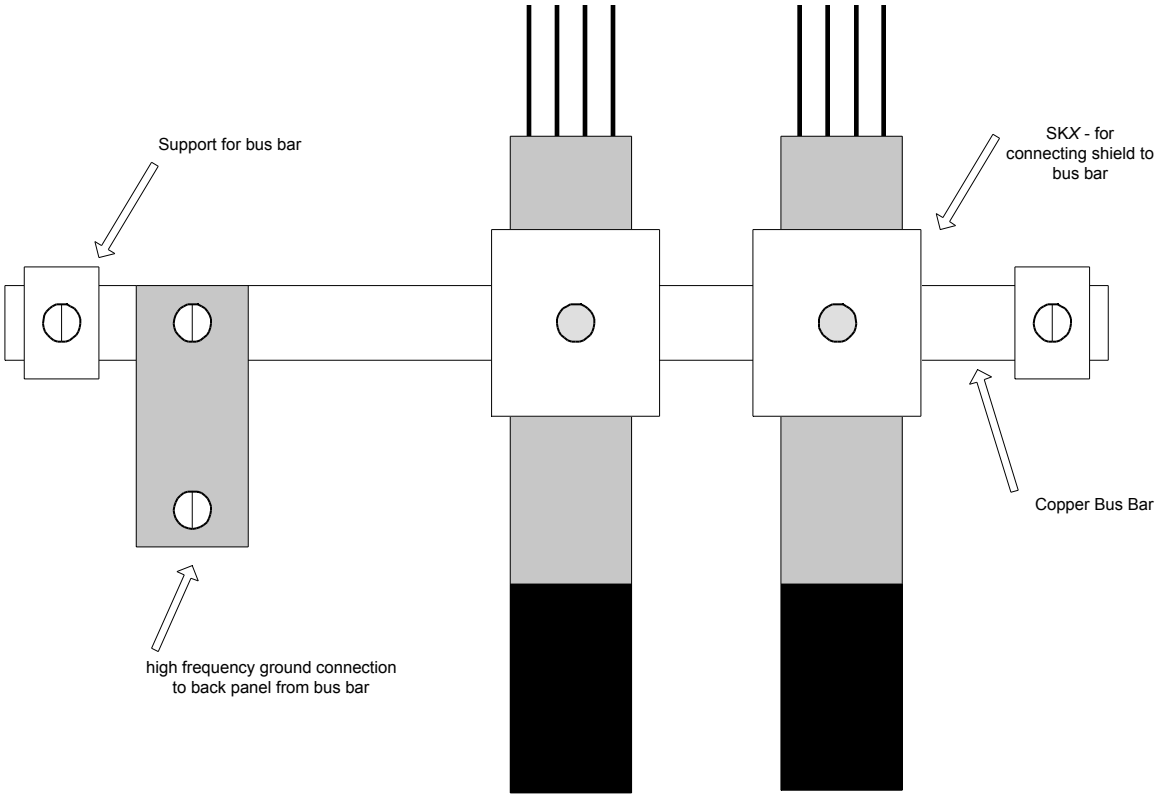
Another option is to use cable bonding clamps offered by Phoenix Contact (and others). When using the Phoenix Contact parts, make sure that a low impedance (high frequency) ground is connected from the ground bus bar to the back panel. This can be done with a flat braid or a copper bus bar. The SK parts from Phoenix (SK8, SK14, & SK20) slide onto the bus bar. The cable (with exposed shield) is inserted through the SK piece and the thumbscrew on top of the SK piece is used to tighten the connection between the cable shield and the bus bar.

Phoenix Contact Part #	Description	Cable Diameter Range
3025163 Type SK8	Shielded terminal block - for placing the shield on bus bars.	SK8 up to 8mm or 0.315 inches
3025176 TypeSK14	Shielded terminal block - for placing the shield on bus bars.	SK14 8mm to 14mm or 0.551 inches
3025189 Type SK20	Shielded terminal block - for placing the shield on bus bars.	SK20 14mm to 20mm or 0.787 inches
0404428 Type AB/SS	Support for bus bar. 2 needed to mount ground bus.	N/A
0402174 Type NLS-CU 3/10	Bus bar material - 10mm x 3mm copper at varying lengths.	N/A

The next two figures represent a side and top view of the SK device that clamps down on the shield of the cable. The Phoenix SK device is excellent for providing a low impedance path between cable shield and the back panel.



Phoenix Contact - Side View



Phoenix Contact -Top View

CE Filtering Techniques

The *PosiDrive* drive system (drive and motor) meets the CE Mark standards stated in the front of this manual. It is imperative for you to apply proper bonding and grounding techniques, described earlier in this section, when incorporating EMC noise filtering components for the purpose of meeting this standard.

Noise currents often occur in two types. The first is conducted emissions that are passed through ground loops. The quality of the system grounding scheme inversely determines the noise amplitudes in the lines. These conducted emissions are of a common-mode nature from line to neutral (or ground). The second is radiated high-frequency emissions usually capacitively coupled from line-to-line and are differential in nature.

To properly mount the filters, the enclosure should have an unpainted metallic surface. This allows for more surface area to be in contact with the filter housing and provides a lower impedance path between this housing and the back plane. The back panel, in turn, has a high frequency ground strap connection to the enclosure frame or earth ground.

Input Power Filtering

The Force Control Industries, Inc. *PosiDrive RD* electronic system components require EMI filtering in the input power leads to meet the conducted emission requirements for the industrial environment. This filtering blocks conducted-type emissions from exiting onto the power lines and provides a barrier for EMI on the power lines.

Care must be taken to adequately size the system. The type of filter is based on the voltage and current rating of the system and whether the incoming line is single or three-phase. One input line filter is used for multi-axis control applications. These filters are mounted as close to the incoming power as possible so noise is not capacitively coupled into other signal leads and cables. These lines may be noisy and should be separated from other sensitive cabling to avoid unwanted coupling of noise. Several manufacturers of these filters are listed below. They should be able to recommend the best filter design for most typical motor control applications. Force Control Industries, Inc. has also provided specific filters recommendations that adequately attenuate the conducted noise to levels well below the CE limits. The implementation of the EMI filter should be done in accordance with the following guidelines:

- Filter should be mounted on the same panel as the drive.
- Filter should be mounted as close as possible to incoming cabinet power.
- Filter should be mounted as close as possible to the drive. If separation exceeds 30cm. (1 ft.), flat cable (braid) is used for the high frequency connection between filter and drive.
- When mounting the filter to the panel, remove any paint or material covering. Use an unpainted metallic back panel, if possible.
- Filters are provided with an earth connection. All ground connections are tied to ground.
- Filters can produce high leakage currents. ***Filters must be earthed before connecting the supply!***
- Filters should not be touched for a period of 10 seconds after removing the supply.

BUS Module Model #	Recommended EMI Line Filter	Force Control Industries, Inc. Part #
RD03	Filter Concepts SF7 Schaffner FN258-7/07	
RD06	Filter Concepts SF15 Schaffner FN258-16/07	
RD10	Schaffner FN258-16/07	

Recommended Line Filters

The filters called out in the table on the previous page are used on a one-to-one corresponedence with the drive. If drives are paralled off one filter, it needs to be sized.

Drives can be ganged off one EMI filter as shown in the Filter and Bonding Diagrams.

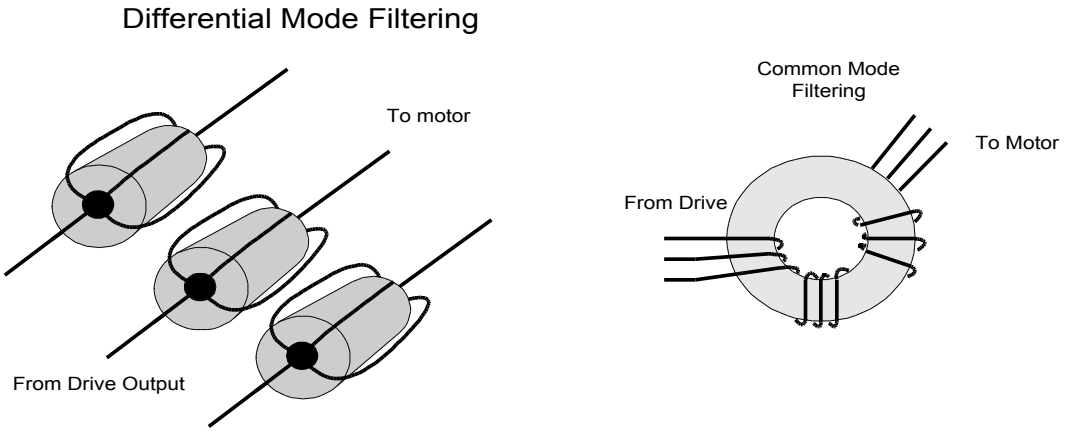
Motor Line Filtering

Motor filtering may not be necessary for CE compliance of *PosiDrive* systems. However, this additional filtering increases the reliability of the system. Poor non-metallic enclosure surfaces and lengthy, unbonded (or unshielded) motor cables that couple noise line-to-line (differential) are just some of the factors that lead to the necessity of motor lead filtering.

Motor lead noise may be either common-mode or differential. The common-mode conducted currents occur between each motor lead and ground (line-to-neutral). Differential radiated currents exist from one motor lead to another (line-to-line). The filtering of the lines feeding the motor provide additional attenuation of noise currents that enter surrounding cables and equipment I/O ports in close proximity.

Differential mode currents commonly occur with lengthy motor cables. As the cable length increases, so does its capacitance and its ability to couple noise from line-to-line. While every final system is different and every application of the product causes a slightly different emission profile, it may become necessary to use differential mode chokes to provide additional noise attenuation to minimize the radiated emissions. The use of a ferrite core (placed at the drive end) on each motor lead (shown in the diagram below), attenuates differential mode noise and lower frequency (30-60 MHz) broadband emissions to within specifications. Force Control Industries, Inc. recommends a Fair-Rite P/N 2643665702 (or equivalent) ferrite core. You should wrap each motor lead through the core several times, as shown in the next figure.

Never wrap a ground lead through a core.



Ferrite Core Wrapping

Common mode currents commonly occur from noise spikes created by the PWM switching frequency of the drive. The use of a ferrite or iron-powder core toroid places common mode impedance in the line between the motor and the drive. The use of a common mode choke on the motor leads increases signal integrity of encoder outputs and associated I/O signals. The following is a list of toroidal and ferrite cores that can be used to make common mode chokes:

Manufacturer	Manufacturer's Part #	Size		
Micrometals	T400-26D	OD 4in (102mm)	ID 2.25 in. (57.2 mm.)	HT 1.3in (33 mm.)
Micrometals	ST102-267	OD 1.025 in (26mm)	ID .6 in. (15.2 mm.)	HT .475 in (12.1 mm.)
Micrometals	ST150-275B	OD 1.52 in (38.6mm)	ID ..835 in. (21.2 mm.)	HT .825 in (21 mm.)
Micrometals	ST200-275B	OD 2.01 in (51.1mm)	ID 1.24 in. (31.5 mm.)	HT 1.025 in (26 mm.)
Magnetics	77930-A7	OD 1.09 in (27.7mm)	ID .555 in. (14.1 mm.)	HT .472in (11.99 mm.)
Fair-Rite	2643803802	OD 2.4in (61mm)	ID 1.4 in. (35.55 mm.)	HT .5in (12.7 mm.)

Toroidal Core Recommendations

Manufacturer	Manufacturer's Part #	Force Control Industries, Inc. Part #	Description
Schaffner	RD7137-36-0m5		500µH 3 phase common mode choke. 36 amps continuous.
Schaffner	RD8137-64-0m5		500µH 3 phase common mode choke. 64 amps continuous.

Pre-wound Common-Mode Chokes

I/O Filtering

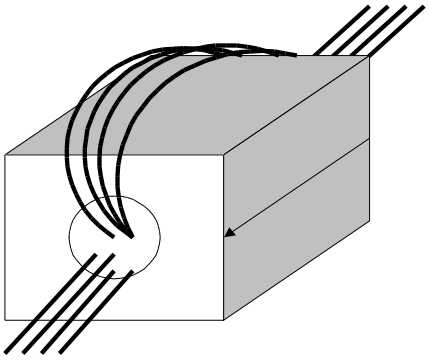
I/O filtering, while not a necessity for CE compliance, may be desired (depending on system installation, application, and integration with other equipment). It may be necessary to place ferrite cores on I/O lines to avoid unwanted signals entering and disturbing the drive system or other associated equipment. The following chart lists some ferrite parts that may be used for I/O filtering and noise attenuation. These parts are ideal for providing an in-line common mode impedance for I/O lines (Fair-Rite Products Corporation also has a varied selection for most any application).

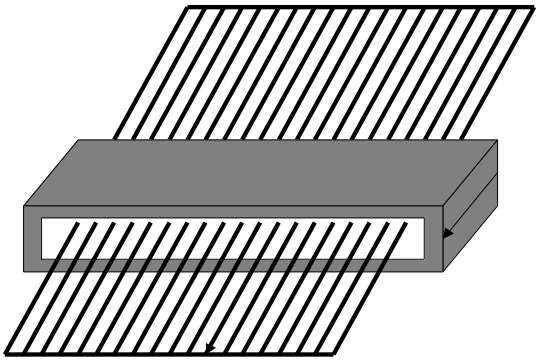
Manufacturer	Manufacturer's Part #	Force Control Industries, Inc. Part #	Description
Ferrishield	SS33B2032		Clamp on core
Ferrishield	SS33B2036		Clamp on core
Ferrishield	FA28B2480		Clamp on core - flat cable clamp
Ferrishield	SA28B4340		Clamp on core - flat cable clamp
* Fair-Rite	2643167251		

I/O Filter Recommendations

**** This core must be used for CE compliance. It should be applied to the 24 V input power lines and the Remote Enable lines (7 & 8 on C3 connector) with approximately three turns through the core.***

The following figure illustrates the use of multiple turns through a clamp-on core. The more turns created, the more impedance is added to the line. Avoid putting the shield in a clamp-on core. It is undesirable to place an impedance in-line with the shield. The use of ribbon cable may be common in many cabinets. Some ferrite clamps are designed just for ribbon cable use as shown below.

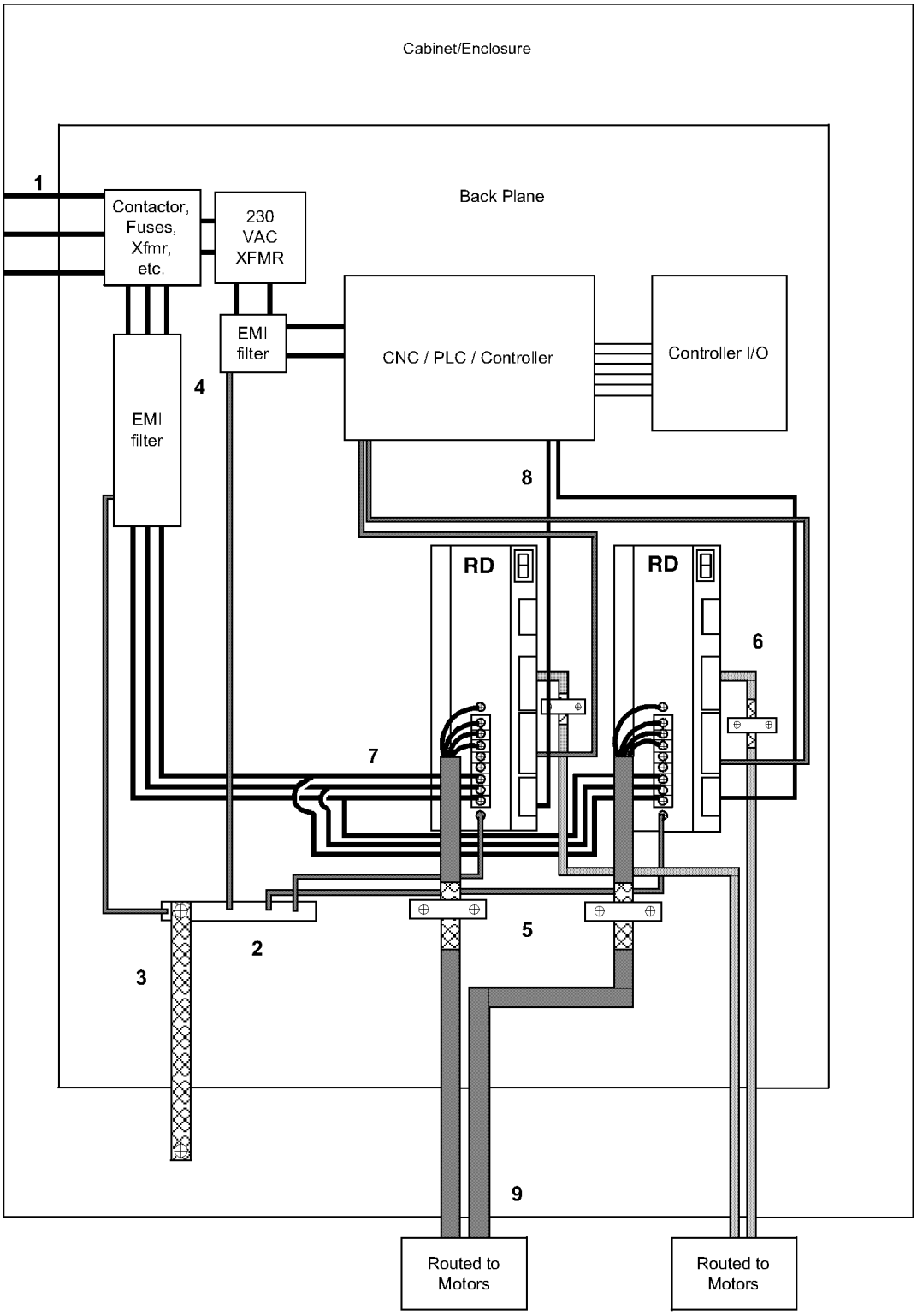




Flat cable clamp used with ribbon cable

I/O Filtering Techniques

RD Filter and Bonding Diagram



RD Filter and Bonding Diagram Notes

Note 1 Input power - Enters enclosure from metal conduit.

Note 2 Single point ground. A bus bar (ground bus) is an excellent way to achieve this.

Note 3 High frequency ground between conductive back panel and enclosure. Also, a high frequency ground is required between the enclosure and earth ground.

Note 4 EMI filter grounding. Safety grounds must be provided on the filters. Potentials can exist even when the power is off because of the capacitors internal to the filters.

Note 5 Bonding of motor cables. The use of armored (screened) motor cables that are bonded as close to the drive as possible are essential for CE compliance and strongly recommended to better the overall performance and reliability of the system.

Note 6 Feedback cable bonding is required for CE compliance. As with the motor cables, the feedback cables should be bonded to the back panel. This bonding will do two things. First it will cut down radiation from the drive. This radiation may be in the form of high frequency energy resulting from internal processor clocks. The second thing this bonding effort does is provide immunity for the drive. Since the feedback device is located internal to the motor it is going to pick up some noise currents and transmit them along the feedback cable. The bonding will direct the currents from the shield of the feedback cable to back panel ground. This will reduce the amount of noise entering the drive.

Note 7 AC power lines that must be routed past other lines (such as motor cables or I/O lines) should cross at a 90º angle. This will minimize the coupling effect. Additionally, the power lines should be routed as close to the back panel as possible. Any noise currents on the lines may then be capacitively coupled to the ground plane and not to other lines.

Note 8 Control (I/O) signals should be kept separate from all power and motor cables if possible. Keep control wiring as short as possible and use screened wire. Bonding is also recommended but not required for CE compliance. Separation distance of 20 cm. (8 in.) should be sufficient in most cases. Where control cables must cross power cables, they should cross at a of 90º angle.

Note 9 Motor cables and feedback cables exiting the cabinet going to the motor should be separated as much as possible. Ideally, the use of separate conduits will provide good isolation, which can limit coupling of noise from motor to feedback cables.

System Interconnect

The following sections provide connector information and the system connections up to the motor power and feedback connections. Cabling purchased from Force Control Industries, Inc. directly completes the system connections. Customers making their own cables can refer to Appendix A for drive/motor pinout connections.

RD Electrical Specifications

Product Model		RD-03	RD-06	RD-10
Main Input Power	Voltage (VAC_{L-L}) Nominal ±10%	110 to 230		230
	115VAC	1φ or 3φ		3φ only
	230VAC	1φ or 3φ		3φ only
	Line Frequency	47-63		
	KVA at 115	0.44 (1φ) 0.6 (3φ)	0.89 (1φ) 1.1 (3φ)	2.4 (3φ only)
	KVA at 230 VAC	0.88 (1φ) 1.4 (3φ)	1.8 (1φ) 2.8 (3φ)	4.6 (3φ only)
	Continuous Current (amps)	6.2 (1φ) 4 (3φ)	10 (1φ) 7.8 (3φ)	13 (3φ only)
	Peak Current (amps) for 500 mSec	18.6 (1φ) 12 (3φ)	30 (1φ) 23.4 (3φ)	26 (3φ only)
	Peak Current (amps) for 2Sec	12.4 (1φ) 8 (3φ)	20 (1φ) 15.6 (3φ)	26 (3φ only)
	Line Fuses (FRN-R, LPN, or equivalent)	10	20	25
Logic Input Power	+24 VDC Ext. Logic Voltage (volts)	22 to 27		
	+24 VDC Ext. Logic Current (amps sink)	1.5		
	+24 VCD Ext. Logic Current (amps max surge)	2.6		
SoftStart	Max. Surge Current (amps)	30		
	Max. Charge Time (sec)	0.25		
Protection Functions	Fault Contact Rating	1A		
	Fault Contact Closing Period (mSec)	Close = 3 mS, Open = 2 mS		
	OverTemperature trip	80°C (176°F)		
Rated Main Output (Ma, Mb, Mc)	Continuous Power (KVA) at 115 VAC Line Input (45°C (113°F) Ambient)	0.35 (1φ) 0.55 (3φ)	0.7 (1φ) 1.1 (3φ)	1.8 (3φ)
	Continuous Power (KVA) at 230 VAC Line Input (45°C (113°F) Ambient)	0.7 (1φ) 1.1 (3φ)	1.4 (1φ) 2.2 (3φ)	3.5 (3φ)
	Continuous Current (Arms)	3	6	10
	Peak Current (Arms) for 500 mSec	9	18	20
	Peak Current (Arms) for 2 Sec	6	12	20
	PWM Frequency (kHz)	16	8	8
	PWM Motor Current Ripple (kHz)	32	16	16
	Form Factor (rms/avg)	≤1.01		
Protective Functions	UnderVoltage Trip (nominal)	90 VDC		
	OverVoltage Trip	430 VDC		
	OverTemperature Trip	80°C (176°F)		
	Internal heat dissipation (watts)	60	80	132
Environment	Operation temperature	5°C (41°F)to 45°C (113°F)		
	Storage temperature	0°C (32°F) to 70°C (158°F)		
	Ambient humidity	10% to 90%		
	Atmosphere	without corrosive gasses or dust		
	Altitude	Derate 5% per 1000 ft. (300m) above 3300 ft. (1000m)		
	Vibration	0.5 g		

RD Regen Information

Product Model		RD-03	RD-06	RD-10
External Shunt Regulator	Peak current (amps)	20		
	Minimum resistance (ohms)	20		
	Watts	200		
Application Information	Capacitance (Farads)	.00082	.00164	
	BUS Voltage (nominal) (VDC)	325		
	V_{HYS} (Regen circuit turn-off) (VDC)	370		
	V_{MAX} (Regen circuit turn-on) (VDC)	390		
External Regen Kits Availability		Yes	Yes	Yes

**For guidance on application sizing of Regen Kits, please contact factory.*

Product Family Control Specifications

Product Model		Control Specifications
Current Loop	Update Rate	62.5 µS (16 kHz)
	Bandwidth	<2000 Hz
Commutation Loop	Update Rate	62.5 µS (16 kHz)
	Max. Commutation Frequency	400Hz
	Output Waveform	Sinusoidal
Velocity Loop	Update Rate	250 µS (4k Hz)
	Bandwidth	<400 Hz
	Speed Command Resolution	Serial: 1 RPM / Analog: (1/6554) * VMAX
	Long-term Speed Regulation	0.01% (µP clock tolerance)
Position Loop	Update Rate	500 µS (2 kHz)

Product Family Control Specifications (Concluded)

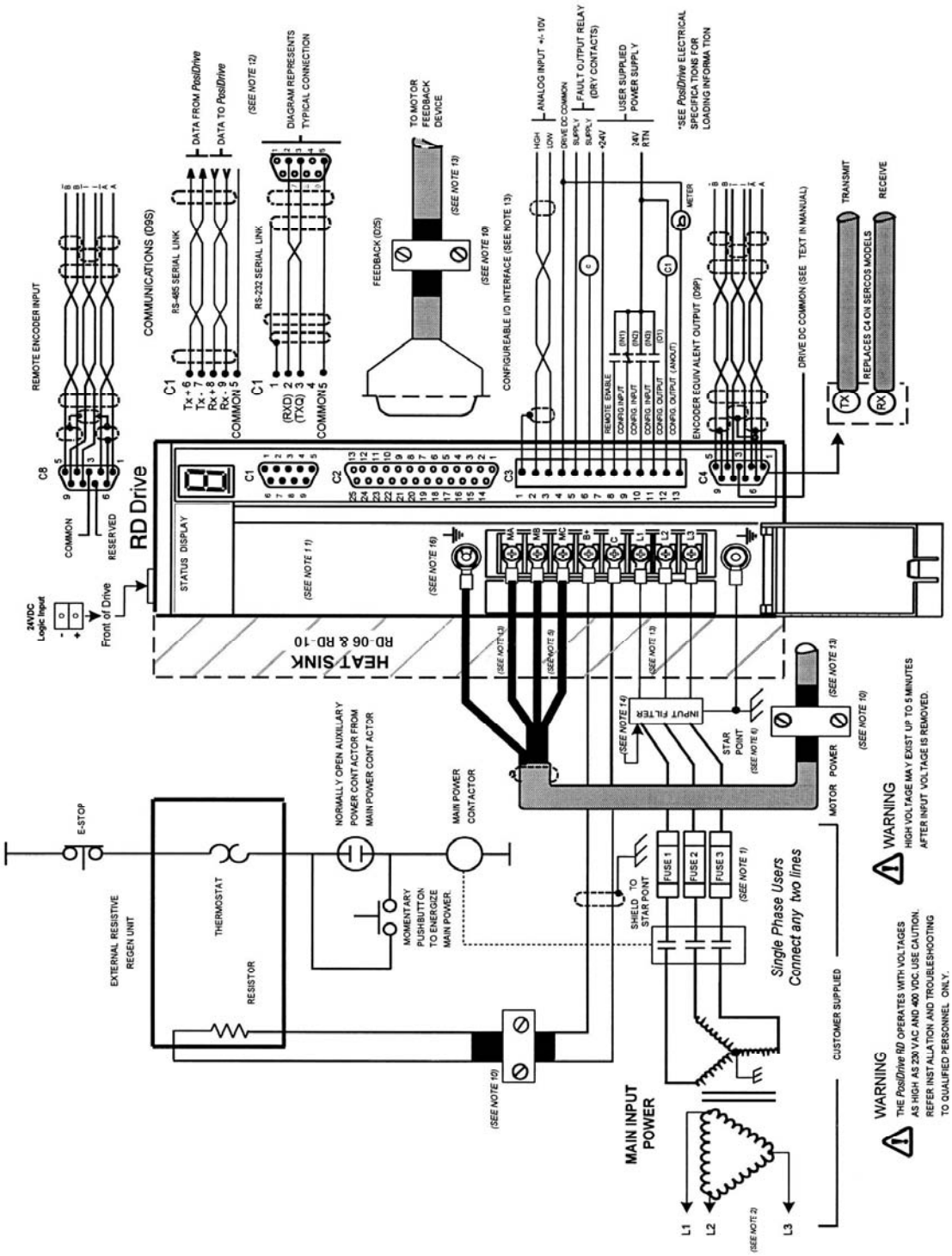
Product Model		Control Specifications
I/O Connector (C3 by pinout)		
Analog Input (2, 3)	Absolute Maximum Voltage	13 V differential
	Input Resolution	14 Bit/1.2
	Sensitivity	1.53 mV min
	Voltage Range	-10V to +10V = -120% Motor rated speed to +120% Motor rated speed (Adjustable Vscale parameter)
	Input Impedance/CMR	> 10 KΩ/50 dB
	Long-term Drift	100 ppm (0.075%/°C)
Fault Output Relay (5, 6)	Max Capacity	1 A at 24 VDC
Remote Enable (7, 8) **Configurable Inputs(7, 9, 10, 11)**	Bandwidth	2.5 kHz (Opto-isolated)
	Input Voltage Range	12 V to 24 V Nominal (bi-directional)
	Min. On/Max. Off	10 V/1 V
	Current Demand per Input	20 mA (max)
Configurable Digital Output (7, 12)	Output Voltage (max.)	0 V to 48 V Nominal – bi-directional (Open Collector)
	(Min. On)	1V
	Max. Output Current	60 mA
Configurable Analog Output (13, 4)	Max. Output Current	1 mA (1 KΩ internal series resistance)
	Sensitivity / Resolution	4.9 mV/12 Bit
	Voltage Range	-10 V to +10V
Encoder Equivalent Output (C4 by pinout)		
A/B/I & Complements (1, 2, 4, 5, 7, 8)	Output Voltage (high level) at 25°C	2.5 V min. at 20mA Differential
	RS 485 Line Drive Type	DS26C31TM
Remote Encoder Input (C8 by pinout)		
A/B/I & Complements (1, 2 ,4, 5, 7, 8)	Input Voltage at 25°C	±5 V Differential
	Input Sensitivity	±0.2V
	Input Impedance	100Ω
	RS 485 Line Receiver Type	SN75173

See the section on Position Loop in Section 6 for features using this input.

Note: A flyback diode is necessary for inductive loads connected across the 01 output.

Wiring Diagrams

RD Wiring Diagram



RD System Wiring Diagram Notes:

Note 1: FUSE 2 and contactor may not be required if input power line is neutral. Also see Note 9.

Note 2: Allow 30 seconds after turning power off before reapplying power.

Note 5: All AC Line wires should be twisted pair.

Note 6: The ground of the drive and motor best minimizes ground currents and noise when connected in a “star point” configuration.

Note 9: See the Electrical Specifications for recommended line input fusing.

Note 10: Cables should be properly bonded to the back panel and implemented as close to the drive side of the cable as possible for effective grounding. If bonding is installed, the shield on the cable end does not need to be connected to the “star point” configuration. Only connect the shield on one end of the cable; preferably on the drive side.

Note 11: Units must be installed in an enclosure that meet the environmental IP rating of the end product (ventilation or cooling may be necessary to prevent enclosure ambient from exceeding 45°C (113°F)).

Note 12: Do not connect unused pins on C1 connector. Some manufacturers’ cables connecting all pins may give unpredictable operation.

Note 13: See the Hardware Specifications for wire gauge and ferrule sizes.

Note 14: See CE Filtering Techniques for further information.

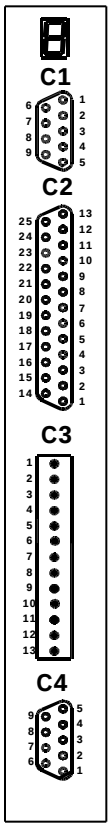
Note 16: See the Hardware Specifications for spade and ring terminal sizes.

Note 17: This system is suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amperes, 240V maximum.

Note 18: A flyback diode is necessary for inductive loads connected across the 01 output.

Pin-out Connections

Front View



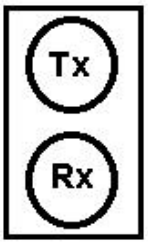
C1: Communications Connector	
Pin	**Function**
1	Shield
2	REC (RXD) (RS232)
3	XMIT (TXD) (RS232)
4	Reserved DO NOT CONNECT
5	Common
6	TxD+ (RS485)
7	TxD- (RS485)
8	RxD+ (RS485)
9	RxD- (RS485)

C2: Feedback Connector			
Pin	**Resolver**	**Encoder**	**Sine Encoder**
1	Sine High	A	A
2	Sine Low	/A	/A
3	Shield	Shield	Shield
4	Cosine High	B	B
5	Cosine Low	/B	/B
6	Shield	Shield	Shield
7		E5V Return	E5V Return
8		E5V Return	E5V Return
9		H1B	H1B (/C) (/Data)
10		H2B	H2B (/D) (/Clock)
11		H3B	H3B
12	Shield	Shield	Shield
13	Thermostat High	Thermostat High	Thermostat High
14	Shield	Shield	Shield
15	Ref. High Out	Index	Index
16	Ref. Low Out	/Index	/Index
17	Shield	Shield	Shield
18		E5V Supply	E5V Supply
19		E5V Supply	E5V Supply
20		E5V Supply	E5V Supply
21	Shield	Shield	Shield
22		H1A	H1A (C) (Data)
23		H2A	H2A (D) (Clock)
24		H3A	H3A
25	Thermostat Low	Thermostat Low	Thermostat Low

C3: User I/O Connector	
Pin	**Function**
1	Analog Signal Shield
2	Analog Differential Input + (High)
3	Analog Differential Input - (Low)
4	DC Common
5	Fault Output Relay Contact
6	Fault Output Relay Contact
7	+24V Input (Common Rail for return pins 8,9,10,11)
8	Remote Enable Input
9	Configurable Input(See IN1 variable)
10	Configurable Input (See IN2 variable)
11	Configurable Input (See IN3 variable)
12	Configurable Output (See O1 variable)
13	*Configurable Output (See ANOUT variable)
* Reference to Pin 4: DC Common	

C4: Encoder Equivalent Output	
Pin	**Function**
1	Channel A Output + (High)
2	Channel A Output - (Low)
3	DC Common
4	Channel B Output + (High)
5	Channel B Output - (Low)
6	Shield
7	Index Output + (High)
8	Index Output - (Low)
9	Shield

SERCOS Ports
(Replaces C4)



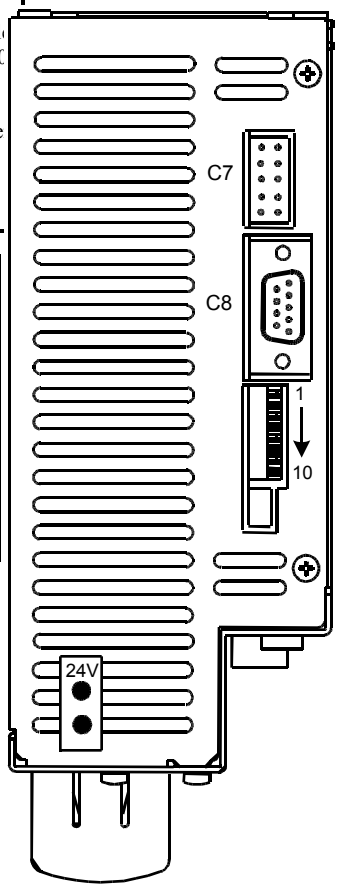
Top View

C7: MultiDrop Communications
Type: 10 Pin (0.1"x 0.1") Female Ribbon Cable. Connector and cabl are included in the optional CK10(kit.

This connector functions only whe using the R-S232 interface. It will NOT function using RS-485.

C8: Remote Encoder Input	
Pin	**Function**
1	A Input + (High)
2	A Input - (Low)
3	DC Common
4	B Input + (High)
5	B Input - (Low)
6	Shield Connection
7	Reserved
8	Index +
9	Index -

See section **Position Loop** on page 50 for features using this input



Notes for DIP switch:
The 10 position DIP switch is provided for drive configuration. The first 6 switches control communications parameters and are read only at power up. Any changes in these settings will require cycling the power. The other two switch functions (7, 8) control the motor operation and are monitored in realtime. This switch provides the following functions:

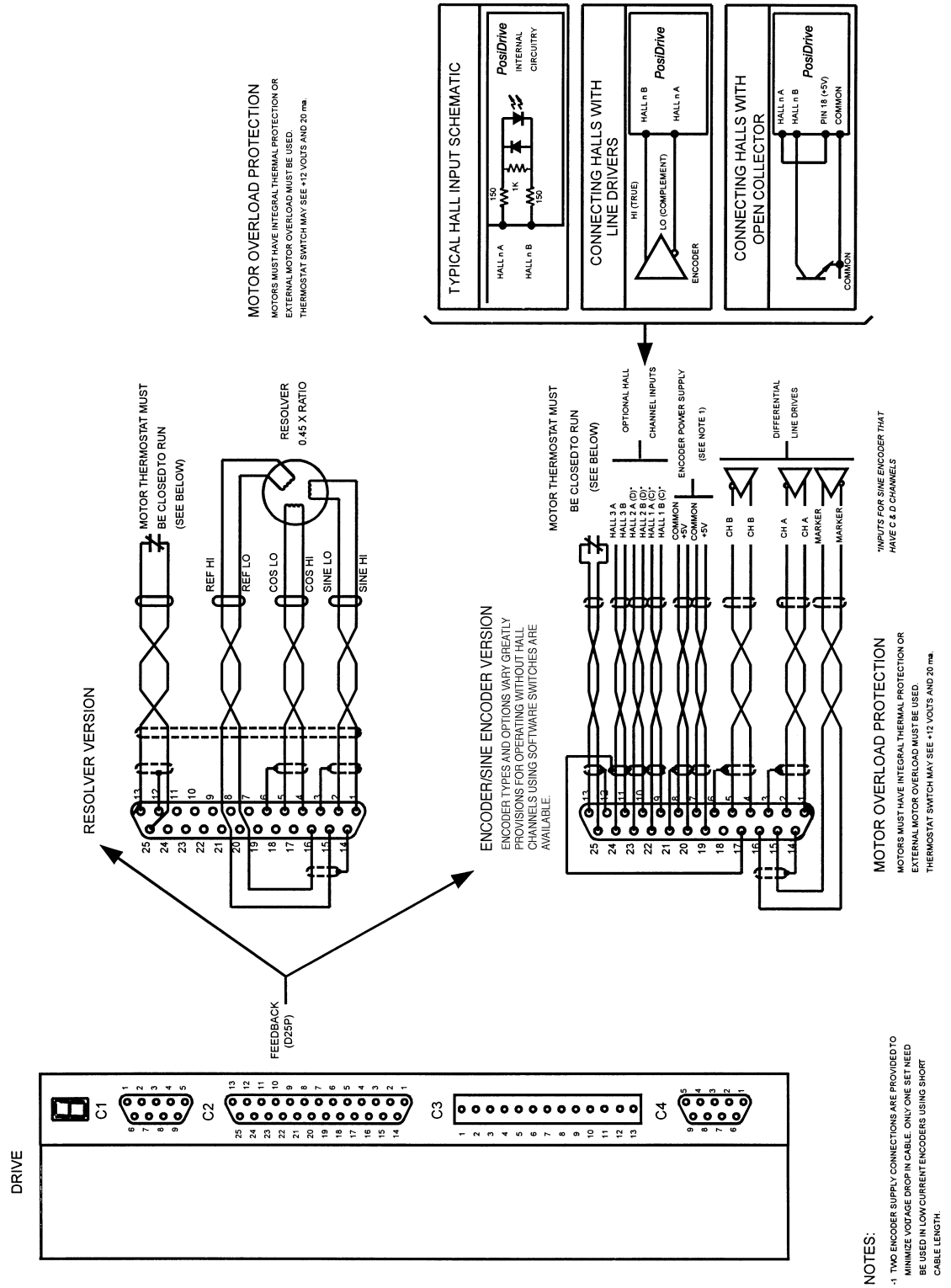
- MultiDrop Address Select: Switches 1 through 5 set the drive's address. A drive having address 0 powers up in the addressed state. If these five switches are set to anything but 0, the drive will assume an address code indicated by the switch settings.
- Baud Rate: Switch 6 sets the Serial/SERCOS baud rate to either 9600/2M (switch off) or 19200/4M (switch on).
- Position Hold: Activating switch 7 causes the drive to enter a position hold mode. The condition is denoted by a flashing status display. The display maintains its current OPMODE code. If the drive is running during a HOLD command detection, the motor will ramp to a stop at the DECSTOP rate.
- Enable: Switch 8 is an input to the drive enable circuitry and can be used to force the drive to a disabled state.
- SERCOS Power Level: Functions only on SERCOS interface products. If switch 9 is set to 0, the SERCOS transmitter uses a low power setting so the receiver is not overdriven when using short cables. Long cables require more power.
- Factory Reserved: Must be set to 0.

Note: Setting the switch to "1" means "Closed" or "On".

Configuration Switch		
Switch #	**Function**	**Settings**
1	MultiDrop Addressing	Bit 0 of MultiDrop Address (LSB)
2		Bit 1 of MultiDrop Address
3		Bit 2 of MultiDrop Address
4		Bit 3 of MultiDrop Address
5		Bit 4 of MultiDrop Address (MSB)
6	Serial/SERCOS Baud Rate	0 = 9600 (2M) 1 = 19200 (4M)
7	HOLD Mode Switch	0 = Hold Mode Inactive 1 = Hold Mode Active
8	Drive Enable / Disable	0 = Drive Enable 1 = Drive Disable
9	SERCOS Transmit Power	0 = Low Power 1 = High Power
10	Factory Reserved	Must Be set to 0

24 VDC Input
Logic Supply Input

System Feedback Diagram



Feedback Devices

The *PosiDrive* can receive resolver, encoder (with or without halls), or sine encoder feedback. Force Control Industries, Inc. offers a variety of motors with options for these various feedback devices. The device preference and the associated model number must be determined when the order is placed.

Resolver

The *PosiDrive* uses either single (two poles) or multi-speed (multiple poles) resolver feedback to monitor the motor shaft position. A resolver can be thought of as a transformer whose output is unique for any given shaft position (an absolute position feedback). The transformer is driven with a sinewave reference signal. Two AC signals are returned from the resolver into the Sine and Cosine inputs. All three of these sinewave signals are low-level and susceptible to noise.

SPECIFICATIONS

Resolver Requirements	
Type	Control Transmitter
Transformation Ratio	0.47
Modulation Frequency	7-8 kHz
Input Voltage (From Drive)	4.25 VAC
Max DC Resistance	120 Ohms (stator)
Max Drive Current	55mA AC-RMS
Output Voltage (To Drive)	2 VAC

CABLE LENGTHS

It is important to use properly- shielded cable and to keep it away from other noise-radiating devices and cables. It is not recommended to run the feedback and motor cables in the same conduit. Force Control Industries, Inc. has tested cable lengths up to 75 ft. (22 9 m.). without degradation of performance. However, performance may vary, depending on motor and resolver type. Tests were performed with standard Force Control Industries, Inc. cable and its low-impedance and Force Control Industries, Inc. *PosiDrive* motor resolver. Please consult the factory for cable and resolver impedance specifications when long cable runs above 250 ft. (76 m.) are desired. Force Control Industries, Inc. recommends twisted-shielded pair for feedback cables.

RESOLUTION AND ACCURACY

The *PosiDrive* calculates motor velocity as the derivative of position (change in position over time). With its patented technique, all readings are extended to a resolution of 16-bit. For velocity feedback calculations, the drive converts the resolver input to 18-bits of resolution, giving smooth motor velocity control. The digital resolution (RDRES) of the Resolver-to-Digital Converter system is determined automatically according to the application velocity limit (VLIM). The following is a summary of the *PosiDrive's* resolution capabilities:

VLIM (RPM)	RDRES	Counts/Rev	Encoder Eqv. Output (C4)
> 6100	12	4096	4096 quad counts
1500 to 6100	14	16384	16384 quad counts
< 1500	16	65536	65536 quad counts

R/D Converter Specifications

System accuracy using resolver feedback is effected by several components. The following table gives information on the inaccuracy that each of these components contribute to the total accuracy of a standard *PosiDrive* system:

Components	**ArcMinutes**
R/D Converter	4
Resolver mechanics (rotational)	8
Resolver mounting on motor shaft	2
Inter-LSB (digital dither over the least significant bit)	5
Total (Worse-case)	**19**

Resolver Accuracy Specifications

Encoder

The *PosiDrive* can use encoder feedback to monitor the motor shaft position. As opposed to a resolver, which is an absolute position feedback device, the encoder is an incremental device that indicates changes in position. The encoder resolution of the *PosiDrive* (and therefore the drive's encoder equivalent output) is fixed because it is a hardware characteristic of the encoder device. The encoder interface includes three groups of wires:

1. A/B (and complements) lines make up the encoder quadrature signals. The signals are received differentially through line receivers before being passed through a wire-break detection circuit.
2. The narrow Index pulse normally appears once per revolution and indicates a known physical position of the shaft. This pulse is received differentially through a line receiver before being passed through a wire-break detection circuit. This signal is hardware-capturable.
3. Hall signals provide information representing the approximate absolute location of the motor shaft. From this information, the motor can sinusoidally commutate forward until the index signal is detected - at which time, true position is known. These signals are isolated by an opto-coupler and can be differential or open-collector type signals.

SPECIFICATIONS

Encoder Requirements	
Required Signals	Types: A, B with or without Index pulse A, B, Index with or without Hall Channels * Halls may be integral or discrete
Signal Type: A-quad-B and Marker Halls	Differential: do not connect single-ended Differential or Open Collector
System Voltage	5 VDC
Maximum Input Frequency	3 MHz
Maximum Cable Length	System Dependent: 50 ft. (15m.) Recommended
Maximum Line Count	10,000,000 Lines per Motor Electrical Cycle
Maximum Supply Current from *PosiDrive*	250 mA
Protection	Separate Voltage Regulator, Broken wire detector for A, B, Index, and Hall channels, Illegal Hall Code Detection

CABLE LENGTHS

The recommended cable length when using the *PosiDrive* to source the encoder is no longer than 50 ft. (15 m.). Long encoder cables tend to have high DC resistance that may create significant loading effects in the supply lines to the encoder. Please consider this carefully when designing the system. An option that would allow the use of longer lengths, implements a separate supply located at the motor to source the encoder. Quadrature signals returned to the drive are differentially connected which normally do not constitute a problem with longer cable lengths.

RESOLUTION AND ACCURACY

A *PosiDrive* encoder-based system typically exhibits minimal inaccuracies outside of the encoder itself. To get an approximate total value the customer need only look to the specifications listed for the encoder being used.

Sine Encoder

The *PosiDrive* can receive an analog (or sine) encoder feedback device to monitor the motor shaft position. As opposed to a digital encoder, which generates incremental square-wave signals, a sine encoder outputs analog differential sinusoidal signals. These sine signals are quadrature-decoded and passed to an interpolation circuit that breaks each 360° cycle into 256 parts before passing it to the drive's control board. Thus, the resolution seen by the drive is 256 times the fundamental sinusoidal track on the motor's encoder. The advantage of this approach is the ability to obtain much high encoder resolution while maintaining a relatively low input frequency through the cable and into the *PosiDrive.* The encoder interface includes three groups of wires:

1. A/B (and complements) lines make up the encoder quadrature signals. The signals are received differentially at 1V peak-to-peak amplitudes before being processed by the interpolation circuitry.

2. The narrow Index pulse normally appears once per mechanical revolution and indicates a known physical position of the shaft. This pulse is received differentially through an op amp before being squared up and sent to the control board.

3. Upon power up, commutation signals are used to communicate coarse position information. The first three signal types give approximate position information so the drive can commutate the motor forward until the Index pulse is found (There are situations where the index signal is not available. Course position information is used to commutate the motor indefinitely). The fourth gives absolute information bypassing the need for the Index signal. They are:

   · No Hall signals exist if no power-up commutation signals are available. The *PosiDrive* can excite two phases and lock the shaft in place. It then approximates position of the locked shaft and uses only the incremental signals to commutate forward until the index is found.

   · Hall signals provide information representing the approximate location of the motor shaft (6 transitions per electrical cycle of the motor). From this information, the motor can six-step commutate forward until the index signal is detected - at which time true position is known and sinusoidal commutation begins. These signals are isolated by an opto-coupler and can be differential or open-collector type signals.

   · C/D lines are an alternative to Hall signals. These lines provide a SIN/COS sinusoidal signal where one electrical cycle equals one mechanical revolution (identical to single-speed resolver feedback). Interpolation is performed on these signals: thus, absolute position is known within 256 parts of a mechanical revolution. The motor can commutate forward until the Index signal is detected.

   · Sine encoders with Endat capability add another approach to communicating commutation position. Here, absolute position information is stored in the encoder and is serially communicated to the drive upon power up. The data is received synchronously by a clock signal provided by the drive. Absolute position is known immediately; therefore, an index signal is not needed.

SPECIFICATIONS

Sine Encoder Requirements	
Required Signals	Types: A, B with or without Index A, B, Index with discrete Hall Channels A, B, Index with C, D once per revolution A, B, Endat
Signal Level:	1V peak-to-peak
Signal Type: A, B, Index C, D Endat (Data/Clock) Halls	Differential Differential Differential Differential or Open Collector
System Voltage	5 VDC
Maximum Input Frequency	From encoder: 125 kHz line, 500 kHz quad After Interpolation: 31.25 MHz line, 125 MHz quad
Maximum Cable Length	System Dependent: 50 ft. (15 m.)Recommended
Maximum Line Count per Motor Electrical Cycle	39,000 Line counts 10,000,000 Line counts after interpolation
Maximum Supply Current from the PosiDrive for encoders	250 mA
Protection	Separate Voltage Regulator, Broken wire detector for A, B, Index, and Hall channels, Illegal Hall Code Detection, A/B signals out of range, ”burst” pulse overflow
Maximum Interpolation (input)	x256 (after quad)

CABLE LENGTHS

The recommended cable length when using the *PosiDrive* to source the encoder is no longer than 50 ft. (15 m.) Long encoder cables tend to have high DC resistance that may create significant loading affects in the supply lines to the encoder. Consider this carefully when designing the system. An option that would allow the use of longer lengths would be to put a separate supply at the motor to source the encoder. Except for noise susceptibility, signals returned to the drive are differentially connected which normally do not constitute a problem with longer cable lengths.

RESOLUTION AND ACCURACY

Internal resolution of the system can be derived through the following calculation:

Encoder line resolution x 256 x 4 (quadrature).

System accuracy is largely dependent upon the accuracy of the encoder itself. To get an approximate total value, the customer need only look to the specifications listed for the encoder being used.

Encoder Equivalent Output

The *PosiDrive* provides a motor position output to you in the form of quadrature encoder signals eliminating the need for an additional position feedback device. The outputs are differential line drivers. There is an associated DC common output (C4: pin 3) which can connect to your port to keep common mode noise and voltage spikes minimized for device protection. Because there are normally differences of potential between your controller and the drive, connection is recommended (if ground loops occur, disconnect and retest).

The source of the Encoder Equivalent Output (EEO) signals depends on the type of motor feedback device:

Resolver Systems

The output signal is developed through the R/D hardware circuitry for minimal phase lag and has a maximum frequency determined by the motor speed and R/D limits. It provides a configurable (ENCOUT) resolution of up to 16384 lines (65536 quad counts) per revolution of the motor shaft. The placement of the index pulse (INDEXPOS) can be varied on resolver systems within 360 electrical degrees of the feedback signal. For single-speed resolvers, this means you can vary the position of this signal over one mechanical revolution. For multi-speed resolvers, the mechanical position variation is determined by the pole-pair count of the resolver (e.g. three-speed resolver gives mechanical variation of the pulse within 1/3 of a revolution).

Encoder Systems

The output signal is the actual encoder feedback signal that is pre-configured (MENCRES) in the drive's motor parameters. It can be scaled down by multiples of two (ENCOUTO: 1, 2, 4, 8, 16) and has a maximum frequency limit of 3 MHz.

Sine-encoder Systems

This output signal is developed for a resolution that is determined by a divisor (SININTOUT: 128, 64, 32, 16, 8, 4, 2, 1) of the actual sine-encoder line resolution (MENCRES). It is then encoded to a quadrature signal before being exported out of the drive. The maximum frequency limit is 1.2 MHz. A frequency limiter (MSINFRQ) is provided with burst frequency fault protection.

EEO Phasing

The EEO signals are not phased the same for resolver and encoder systems. The following demonstrates these phasing relationships:

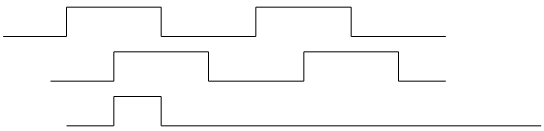
RESOLVER SYSTEMS

A-Leads-B convention for clockwise rotation:

Channel A

Channel B

Index (AB high)



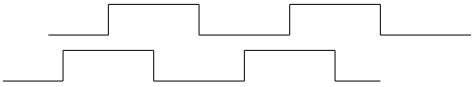
ENCODER AND SINE-ENCODER SYSTEMS

B-Leads-A convention for clockwise rotation

Channel A

Channel B

Index (determined by encoder)



Recommended Manufacturers' List

Schaffner Electronik AG
Nordstrasse 11
CH-4708 Luterbach
Switzerland
Phone: 065 802 626
Fax: 065 802 641

North America
Schaffner EMC Inc.
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SERCOS SETUP

The *PosiDrive RD*-Series drives comes with SERCOS communication capability. It must be ordered from the factory with this option. The Encoder Equivalent Output D9 connector (C4) is replaced with two fiber-optic ports, transmitter (Tx) and receiver (Rx).

This section provides the SERCOS-specific information needed to complete the installation and setup of a SERCOS *PosiDrive* drive to the fiber-optic ring.

DIP Switch Configuration

DIP switch configuration is similar to that of the standard *PosiDrive* drive. Through these switches, the drive's address and communication power levels are set.

Setting Drive Address

Up to 31 *PosiDrive* drives can be configured on the SERCOS ring. The first five switches of the DIP set the drive address. When the address is zero (00000), the drive operates as a SERCOS repeater and as a single-axis unit with serial communication. You can monitor and configure the drive through the serial port. Any other address setting, 1-31 (00001 – 11111), establishes the drive as an active SERCOS ring participant with communications through the Tx/Rx ports. When the drive has a non-zero address, you can communicate through the serial port only for monitoring purposes.

Setting Transmission Power Levels

The SERCOS transmitter power level (DIP switch 9) should be set according to the expected signal attenuation between a SERCOS transmitter and the next receiver. Signal attenuation is based upon cable length, cable type, and intermediate connection losses (e.g. bulk head connectors). The following table may be used to calculate the maximum allowable and minimum required signal attenuation for a given power level and cable attenuation:

Power Level Attenuation Specifications		
Attenuation	**Low Power**	**High Power**
Maximum	9.5 dBm. + 2 m. *Ac	12.5 dBm. + 2 m. *Ac
Minimum	-	1.5 dBm. + 2 m. *Ac
Note: Ac = Fiber optic cable attenuation in dBm./m.		

The maximum and minimum cable lengths may be calculated by dividing the maximum and minimum signal attenuations by the cable attenuation. The following table shows the cable lengths for 1 mm plastic fiber with an attenuation of 0.18 dBm/m:

Cable Length Specifications		
Length	**Low Power**	**High Power**
Maximum	54.7 m	71.4 m
Minimum	-	10.3 m
Note: *1) Fiber optic cable attenuation is 0.18 dBm/m.* *2) Cable length calculations assume that the fiber is not attenuated by intermediate connections.*		

For most applications, the low power setting is sufficient. Longer cable runs or the use of intermediate connectors may require the high power setting. Communication problems may occur if the power level at the receiver is too large or too small. Receiver power problems may cause erroneous data transfer resulting in the drive returning to CP0, or failure to advance out of CP0.

For more information on SERCOS signal attenuation, refer to the following sections of the IEC 61491 SERCOS specification:

- 5.3 - Optical Signals on the Transmission Line
- Annex G: Attenuation on the Transmission Line

Status Display

After the CP run-up sequence has completed, the drive will be in OPMODE 5 when communicating on a SERCOS ring. This is indicated by the number “5” on the Status Display. The SERCOS version of the *PosiDrive* differs from the standard unit in that errors and faults are not communicated through this display (only through the SERCOS ring to the controller). Therefore, if an error occurs, the “5” remains on the display. The Status Display decimal point operates identically to that of the standard unit in that it turns ON and OFF when the drive is enabled or disabled.

The SERCOS version of the PosiDrive is not automatically enabled on power-up, no matter what the address.

Connection

The mating connector selected for the Tx and Rx ports follow the IEC 874-2 specification, which recommends an F-SMA type connector. A hand-tight connection is adequate.

Force Control Industries, Inc. offers 30, 60, and 100cm plastic fiber optic cables with SERCOS compatible F-SMA connectors. The following specifications provide general cable information:

Cable Characteristics	Specifications
Cable Type	1mm plastic
Attenuation	≤0.18dBm/m
Fiber NA	.47
Temperature	-55ºC to 85ºC
Jacket material	PVC
Jacket OD	2.2 ± 0.07mm
Tensile Strength	7kg

Also refer to the following IEC 61491 specification for more connector and cabling information:

- 5.2.2 Structure of the Transmission Lines
- 5.3.3 Fiber Optic Cable
- 5.3.4 Connectors

Communications

The *PosiDrive* SERCOS drive offers two communication approaches for drive configuration. The first approach is to communicate, via a multi-axis SERCOS controller, all the drive parameters through the fiber-optic ring during the CP2 and CP3 run-up stages. This requires a broad understanding of the controller functionally and knowledge of the SERCOS standard and manufacturer's IDN set. The standard and manufacturer IDNs supported by Force Control Industries, Inc. are functionally categorized to make this method of configuring easier.

The second approach gives you the ability to configure each axis separately through the serial port using the Software. The Software is very intuitive and guides you through the setup stages of the configuration process. It provides interactive setup screens for easy manipulation of the drive's parameters while giving you realtime monitoring and recording tools that help in optimizing axis performance. Once performance is optimized, the parameters can be stored in the drive's EEPROM memory before establishing communication through the SERCOS interface.

Drive Configuration

Before you can begin the CPx (where x = 0,1,2,3,4) run-up process, the drive should be configured and tuned for the axis of operation. To accomplish this, follow the guidelines below:

1) Power down the drive.
2) Set the drive address to zero for single-axis operation.
3) Select a serial baud rate.
4) Connect a serial cable from the drive to a host.
5) Power up the drive

6) Install the Software and communicate with the drive.
7) Follow the user screens to configure the drive and motor combination.
8) Enable the drive.
9) Tune the system as desired.
10) Save the drive parameters to EEPROM.
11) Power down and reset that actual DIP address. Any non-zero address will set the drive up for communication on the SERCOS ring. Each drive on the ring must have a unique non-zero address.
12) Set the SERCOS baud rate (DIP switch 6 off/on for 2/4Mbits/s)
13) Depending on the ring configuration, link the fiber optic cables from drive-to-drive or drive-to-master as follows: Tx_1 to Rx_2, Tx_2 to Rx_3, etc.
14) Power up the drive. It is now prepared to ascend through the SERCOS communication phases under the master's control.

CP Run-up

Upon power-up, the Status Display should alternately flash a "P" and a "0" to indicate SERCOS communication phase 0. As the drive ascends through each communication phase, the display will alternately flash a "P" and a number indicating the next sequential communication phase (phase 0-4). Upon reaching communication phase 4 (CP4), the display will briefly flash "P" and "4" before displaying a steady state "5". This indicates that SERCOS has been initialized and the drive and motor system is ready for commanding motion.

CP2 INITIALIZATION

IDN 18 contains a list of IDNs that must be written to the drive in CP2. The CP2 transition procedure (IDN 127) verifies the drive's readiness to transition from CP2 to CP3 and checks whether each IDN listed within IDN 18 has been written by the master. If any IDN has been written with illegal values, then the drive will not allow a transition to CP3. If the drive fails to transition, then IDN 21 will contain a list of IDNs that are not configured properly. The following IDNs should be configured during CP2:

IDN	Description	Notes
2	Communication cycle time (tncyc).	
6	AT transmission starting time (t1).	
9	Position of data record in MDT.	
10	MDT length.	
89	MDT transmission starting time (t2).	

Some masters do not support toggling the control unit synchronization bit (MDT control word, bit 10) during CP3 and CP4. In this case, initialize the control unit synchronization bit monitoring IDN (P152) to 0 during CP2. Refer to the IDN descriptions for more information.

CP3 INITIALIZATION

IDN 19 contains a list of IDNs that must be written to the drive during CP3. If the drive was properly configured using the Software, IDN 19 should be empty and the master requires no IDN initialization during this phase.

OPERATIONAL NOTES

- Remember that the hardware enables, DIP switch 8 and the Remote Enable line must be enabled before the drive can be system enabled through the MDT control word during CP4. If system enabling fails, refer to IDN P15 for a list of conditions that prevent this action.
- If a fault occurs, the drive will not allow the master to clear faults while any of the MDT control bits (13-15) are set.
- SERCOS Torque Units:

Standard SERCOS torque units are based on 0.1% of motor continuous current. However, when using the Software, the torque units are based on 0.1% of drive peak current.

- SERCOS Velocity Units: counts/CUCT * 256

The following formulas may be used to convert to and from the SERCOS units and RPM.

Vel {RPM} = Vel {cnts/CUCT * 256} * 1875 / (8 * Cnts * CUCT)

Vel {cnts/CUCT * 256} = Vel {RPM} * 8 * Cnts * CUCT / 1875

EQUATION NOTES

1) Cnts = the number of encoder (or resolver equivalent) counts per revolution.
   Where: Encoder counts = Encoder lines * 4.
   Resolver counts = 2^16 * MResPoles/2
2) CUCT = The control unit cycle time (IDN 1) in mS.
3) The units "CUCT/ms" is the number of CUCT periods per mS. For example, a 2 mS CUCT has 1/2 a CUCT per 1 mS.

- Remember the following when monitoring a SERCOS drive through the serial port,:
  1) the SERCOS address is also the serial MultiDrop address
  2) SERCOS operation changes the UNITS variable to internal units
- The SERCOS version of the *PosiDrive* is not automatically enabled on power-up, even with the drive address set to 0.

SYSTEM OPERATION

The *PosiDrive* has a seven-segment indicator, called a Status Display that indicates four types of states: Power-up, Steady State, Flashing State, and Momentary State. The decimal point directly relates to the global drive enable.

Status Display	
DRIVE STATE	**DISPLAY APPEARANCE**
Power-up	Momentarily illuminates all display segments (forming an 8) and the decimal point.
Steady State (No Faults)	Displays the operational mode (OPMODE) of the drive (0-8).
Flashing State	Used to indicate an abnormal operating state: If the position hold feature is active, the OPMODE number will flash at a 1 Hz rate. If a fault was detected, a flashing code will be displayed to identify the fault. Some codes consist of a sequence of two or more digits (see Troubleshooting section). In general, these faults will cause a latched disable (sometimes controllable through software switches). To clear fault, toggle remote enable (except for OverCurrent). If the encoder initialization function (ENCSTART) is active, the OPMODE number will flash at a 3 Hz rate.
Momentary Fault	Displays a character momentarily for 500 ms before returning to the steady state. The timer is resetable. C = Communications Error F = Drive is in FoldBack mode

Status Display States

Status Display Decimal Point	
DECIMAL POINT STATE	**DRIVE STATUS**
Steady OFF	No power to the motor
Steady ON	Drive enabled, power to the motor
Flashing	Drive enabled, power to the motor, but a motor safety feature has been disabled (for example, LIMDIS = 1).

Status Display Decimal Point

Operational Modes

The *PosiDrive* has the ability to assume different modes of operation. It is factory configured in OPMODE 1 (Analog Velocity Controller) but may be reconfigured. Not all commands and variables are active or meaningful in every OPMODE.

1. Serial Velocity Controller (OPMODE = 0): the *PosiDrive* is configured as a velocity-loop controller and is controlled by issuing a velocity command (J: jog command, or STEP: step command) to the drive via the serial port.
2. Analog Velocity Controller (OPMODE = 1): the *PosiDrive* is configured as a velocity-loop controller and is controlled through either a ± 10 V analog input signal or jog (J) commands stored in the Configurable I/O. The commanded velocity is proportional to the input voltage.
3. Serial Torque (Current) Controller (OPMODE = 2): the *PosiDrive* is configured as a torque-loop controller and is controlled by issuing a current command (using the T command) to the drive via the serial port.
4. Analog Torque (Current) Controller (OPMODE = 3): the *PosiDrive* is configured as a torque-loop controller and is controlled via a ± 10 V analog input signal. The commanded current is proportional to the input voltage.
5. Gearing Position Controller (OPMODE = 4): the *PosiDrive* is configured as a positioning controller that can operate in one of three settings (Encoder Follower, Pulse/Direction, Up/Down Counter). The setting used is determined by the GEARMODE variable.
6. Position Controller (OPMODE = 8): the *PosiDrive* is configured as a serial or an analog positioning controller, depending on the value of PCMDMODE, that can receive simple absolute, incremental, indexing, homing, and analog commands.
7. SERCOS Controller (OPMODE = 5): the *PosiDrive* must be ordered from the factory as a SERCOS unit to establish communications in this OPMODE. The drive is shipped with Connector C4 as the Transmit/Receive port (no longer the Encoder Equivalent Output).

System I/O

This section discusses the I/O features of the C3 connector (except for the Thermostat input on C2). For further explanation on how to use these features, refer to the *VarCom Reference Guide*.

Analog Input (ANIN)

The position, velocity, or torque loop can receive its command from an analog voltage source and is selectable through the OPMODE variable. The analog input to the *PosiDrive* is differential. This means that the signals received at the two inputs are subtracted from each other to create a 'difference', which is then used to command the rest of the system. This type of input has a high degree of noise immunity and, in many cases, will allow for ground isolation between systems. This analog input also has a low pass filter (ANLPFHZ) to prevent high frequency noise from entering the system.

The input voltage from the differential receiver is applied to a precise 14-bit Analog-to-Digital (A/D) conversion system. The A/D conversion system is read by the microprocessor every 500µS for the position loop modes, every 250 µS for the velocity loop mode, and every 62.5 µS for the torque (current) loop mode of operation. Encoder-based units come with the additional benefit of a Dual Gain (ANDG) input. When enabled, the system uses two 14-bit A/D inputs to read the user-supplied analog signal. One input is a direct reading of the ± 10V signal, while the other incorporates a 2x gain term. When the input voltage is less than 4 V, the 2x channel is used to determine the input voltage, which extends the resolution to a 15-bit equivalent. Above 4 V, the system uses the straight 14-bit conversion. Special software algorithms are used to minimize cross-over distortion and add 0.25 V of hysterisis.

Analog systems often require scaling and offset bias. The *PosiDrive* adds an analog offset (ANOFF) variable to this reading, performs an analog deadband (ANDB) adjustment, and scales it through the either the position loop input scaling (GEARI, GEARO), velocity loop input scaling (VSCALE), or torque loop input scaling (ISCALE) before passing the data to the selected control loop. The analog input (ANIN) variable indicates the analog reading after the offset (ANOFF) and the deadband (ANDB) adjustments but before the loop scaling. The ANIN variable range is ± 22500 counts (or mV).

The *PosiDrive* also offers an automatic analog input zeroing function. Invoking the ANZERO command while the drive is enabled or disabled samples motor velocity over a 32 mSec period and updates ANOFF accordingly to the analog input offset. This command also incorporates an internal offset mechanism that has finer resolution than ANOFF is capable of providing.

Remote Enable Input (REMOTE)

The opto-isolated Remote Enable input (REMOTE) provides a hardware drive enable switch. This 12 VDC to 24 VDC input will disable or enable the power stage output to the motor. The signal must be customer supplied in order to get the drive to enable (in combination with other parameters; ACTIVE) and operate. Tapping the signal off the logic supply (C5) is not recommended. The toggling of this switch will also initiate an attempt to recover from a fault condition. It can also be used to trigger various position homing features (HOMETYPE).

Configurable Inputs (IN1, IN2, IN3)

These 12 VDC to 24 VDC inputs are defined by the INxMODE variable. Placing the appropriate value in INxMODE sets up the inputs to be used for such features as CC/CCW hardware position limits, Electronic Gearing, serial and analog position triggering (for incremental moves and homing), fault output relay configuration, Software scope triggering, and more. When set for the CC/CCW hardware position limits, the inputs prevent any further motor travel in their respective direction but do not disable the drive or prevent motion in the opposite direction. Note that if acceleration control is in place (PROFMODE = 1), the motor will ramp to a stop after the opening of the End Travel Limit. These inputs are opto-isolated and considered "active enable", meaning current must flow through these signals to allow the system to operate. This provides a 'dead-man' safety feature. Energizing both the CW and CCW hardware position limits causes the *PosiDrive* to enter the HOLD mode. These inputs can also be inverted (ININVx, where x = 1, 2, 3).

The default settings of these inputs are for the hardware position limits. The Status Display may flash an 'L' upon power-up indicating that a travel limit has been tripped. If these position limits are not in use, set LIMDIS=1.

Configurable Outputs (ANOUT, O1)

The ±10 V, 12-bit analog output (ANOUT) is normally off (used for monitoring). The setting of this variable will allow you to meter various feedback quantities such as velocity, current, horse power, position feedback and following error, and more. This pin must be referenced to DC Common (pin 4).

The digital output (O1, O1MODE) can be toggled in an On/Off state to indicate various drive, motor, and variable conditions. These include: absolute speed and current levels, FoldBack conditions, motor braking, motion complete and zero speed conditions, position overshoot flagging, programmable limit switch detection, and an enable (ACTIVE) flag. Condition, reset, and triggering levels are established through O1MODE, O1RST, O1TRIG.

Fault Output Relay (RELAY, RELAYMODE)

The *PosiDrive* provides a drive ready/drive up output in the form of a relay (RELAY) output. The relay (RELAY) output is controlled by the *PosiDrive's* microprocessor. There is a software switch (RELAYMODE) that configures the relay (RELAY) output to act as a 'Drive Ready' or 'Drive Up' indicator:

1. If RELAYMODE = 0, the relay is closed when the drive is error free and ready to run. This is a 'Drive Ready' configuration.
2. If RELAYMODE = 1, the relay is closed only when the drive is enabled. This is a 'Drive Up' configuration.
3. If RELAYMODE = 2, the relay opens during a fault when the drive is disabled.

You can program this fault output to open on any system fault by triggering the Configurable Inputs (IN1MODE, IN2MODE, IN3MODE, IN1, IN2, or IN3)

Motor Thermostat Input (THERM, THERMODE)

The *PosiDrive* provides a motor thermostat input on the C2 connector that is configured for different types of thermal protections (THERMTYPE), as well as manipulation of how the drive responds to a motor thermal condition (THERM, THERMODE, THERMTIME). Force Control Industries, Inc. *PosiDrive* motors and cables connect the thermostat through the feedback cable. The input to the *PosiDrive* is electrically closed through the thermostat for proper operation. The drive normally flashes an 'H' in the Status Display when this input is electrically opened.

If a motor thermal device is not used, set THERMODE to 3 to disable the feature (turns the 'H' status display indicator off).

Control loops

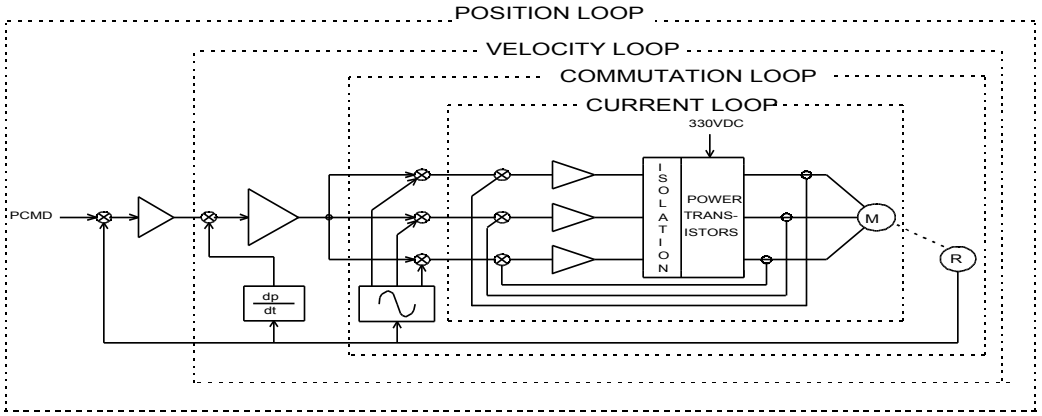
This section describes the servo control loops, their characteristics, and how to configure them.

Core Processors

A 40 MHz embedded Controller and a 40 MHz DSP controller are the heart of the *PosiDrive*. They use its internal operating system to monitor inputs, adjust outputs, communicate serially, maintain servo control, and monitor faults. The flash memory firmware that controls the core processor and gives the *PosiDrive* its operating characteristics is saved in EPROM. The version number of the firmware can be read using the VER command. When calling Force Control Industries, Inc. for technical support, be sure to have the firmware version number readily available. The most recent version of firmware is available for purchase and is easily field upgradable through a PC. It can be obtained by contacting a Force Control Industries, Inc. sales representative or by contacting Force Control Industries, Inc. Customer Support.

Servo Loop Description

The *PosiDrive* provides high performance motor control by controlling up to four distinct closed loop systems within the DSP: the current, commutation, velocity, and position loops. The next figure depicts the control loops graphically.



Control Loop Structure

CURRENT LOOP

Since current and torque are proportional in a Permanent Magnet (PM) motor, the current loop is often referred to as the torque loop. The function of the current loop is to regulate motor current as directed by a current command signal. The current command signal from the microprocessor can either come from a direct user input (OPMODE 2 & 3) or from the output of the velocity loop. There are actually three current loops, one for each motor phase. Each current loop receives its own command input from the commutation loop.

The *PosiDrive* uses a fully digital, pole placement current loop with high bandwidth and a current loop sampling rate of 16 kHz (62.5 µS.). All coefficients of the current loop are digitally calculated inside the drive for a given set of motor and drive characteristics. The current loop also includes adaptive gain terms to compensate for some non-linear effects.

The current loop incorporates electrical isolation for protection from the high-voltage BUS. These current loops also convert the output voltage to a Pulse Width Modulated (PWM) signal providing the highest efficiency possible. The PWM center frequency can be 8 or 16 kHz according to the drive size.

COMMUTATION LOOP

This loop converts a single-phase current command signal into a three-phase, position-modulated sine wave input to the current loops. The *PosiDrive* has a patented sinusoidal wave form generator, which uses a technique called Torque Angle Advance to get top performance out of its motors. The waveform generator is part of the microprocessor and is updated at a 16 kHz rate. This provides hi-fidelity sinewave commutation at both low and high velocities. The sinewave output must be aligned to the back EMF (MOTORBEMF) characteristics of the motor. This is why resolver or encoder alignment to the motor is critical.

VELOCITY LOOP

The purpose of the velocity loop is to regulate motor speed. Like the current and the commutation loops, the velocity loop is fully digital and uses the resolver or the encoder feedback signals to calculate actual motor velocity. The command for the velocity loop can come from a direct user input (OPMODE'S 0&1) or can be the output of the position loop. The velocity loop is a digital sampling system operating at 4 kHz.

The difference between actual and desired velocity is filtered through a compensator algorithm and fed to the commutation loop. The *PosiDrive* offers four velocity compensators (methods of regulating velocity) and are selectable through the COMPMODE variable. The four are: Proportional-Integral (PI), Pseudo-Derivative-Feedback with Feed-Forward (PDFF), Standard Pole Placement, and Extended Standard Pole Placement.

POSITION LOOP

The final control configuration is the position loop. The purpose of this loop is to maintain motor shaft position. Like the previous loops, the position loop is fully digital and uses resolver, encoder, and sine encoder feedback signals to determine actual motor position. The drive can also accept a position signal from an external feedback device (e.g., load encoder). It samples at a rate of 2 kHz and can be configured for three different modes of operation:

OPMODE 4: This mode of operation sets the *PosiDrive* up to run as a pulse (or master encoder) follower by using the Electronic Gearing feature. The pulse input can either be applied through the Configurable Inputs on the C3 connector (up to 2.5 KHz max. - opto-isolated) or through the Remote Encoder Input on the C8 connector (up to 3 MHz) on top of the drive.

OPMODE 8: This mode of operation configures the *PosiDrive* as a simple positioning controller. Once in this mode, position commands can be given through the serial port, through the Configurable I/O, or through the analog input (determined by the PCMDMODE variable). The position loop has been enhanced to a full PID controller with acceleration and velocity feed-forward gains. Two integral gain variables have been added to limit the action of the integral term during selected parts of the profile. This helps to minimize overshoot and settling problems.

Using a serial command (PCMDMODE=0), the *PosiDrive* executes simple absolute, incremental (or indexing), and homing motion profiles. This is done either by direct commands through the serial port (MI, MA, MH) or by pre-configuring a profile in memory to be used in conjunction with the Configurable I/O (MASPEED, MISPEED0-3, MAPOS, O1, O1MODE, INx, INxMODE).

Using an analog command (PCMDMODE=1), the *PosiDrive* scales the analog input (GEARI, GEARO) to establish a wide range of relationships between an analog input adjustment and a corresponding shaft movement. Homing types (HOMETYPE) are available that home to a particular analog input level (and position count), triggering either through the Configurable Inputs or the Remote Enable.

In this mode of operation, the drive can also accept an external load feedback signal through the C8 connector (DUALFB=1). This helps eliminate the positional inaccuracies, due to gear backlash and poor coupling, by positioning according to the load's position (not the motor shaft's position).

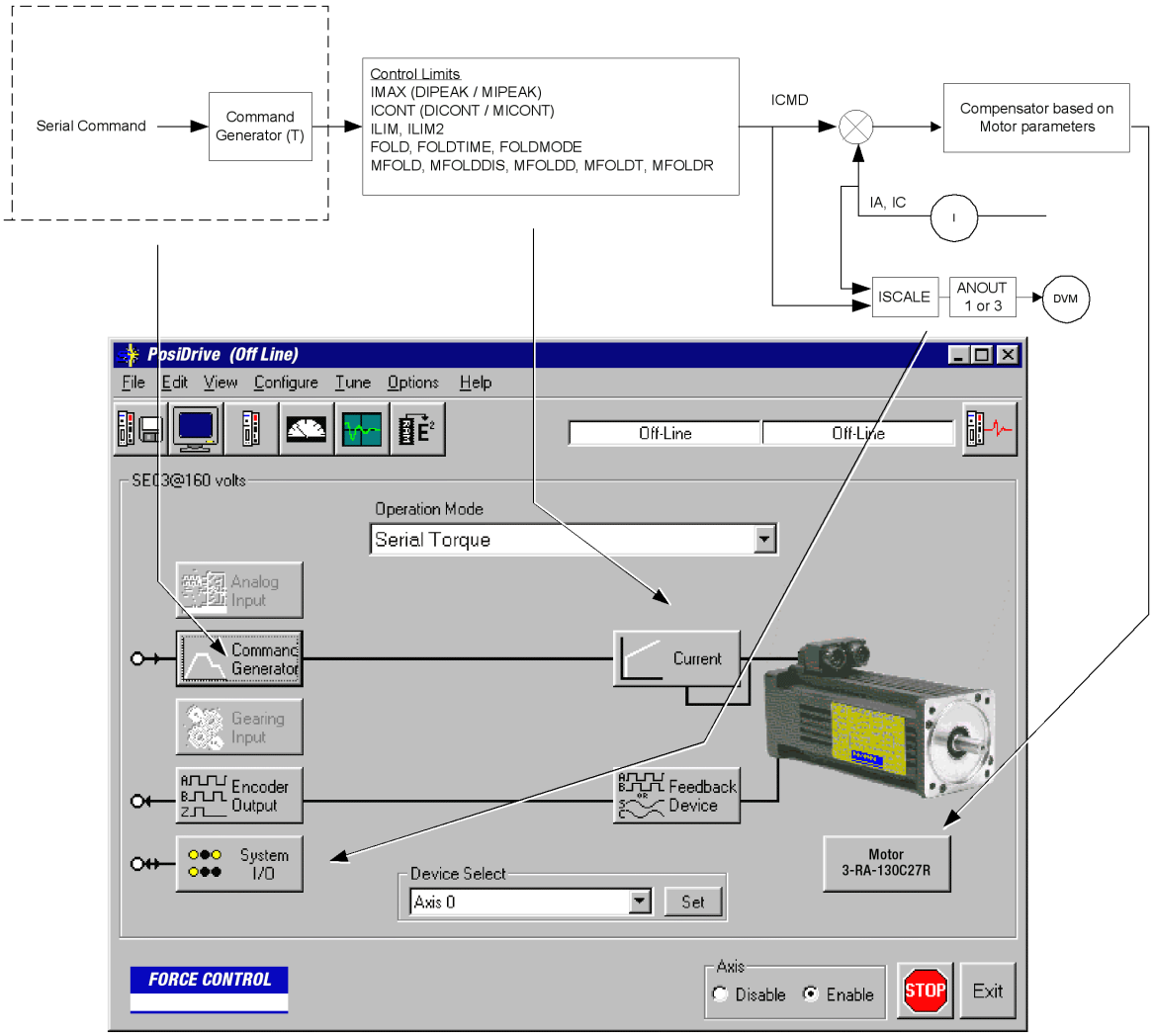
The *PosiDrive* also operates in the position mode when the drive is in the hold position state (HOLD = 1).

Torque Loop Operation

The design of the control loops was discussed in the previous section. Now, the operation as a system is presented. The *PosiDrive* has many internal variables that are used to examine and dictate system operation. Many of these variables and their locations in the Software are presented graphically in the following discussions to help disclose meanings and relationships.

SERIAL TORQUE

The *PosiDrive* can be operated as a serial torque-controlled amplifier (OPMODE 2). It receives a serial command (T) via a host to a command generator, which in turn creates a current command (ICMD). The current (or torque) command is checked against peak (IMAX, ILIM) and continuous (FoldBack features, ICONT) current clamp limits. Sinusoidal commutation modulation is added to the command and then fed to the three-phase current loop regulator, which calculates a current error. This error is then fed through a digital pole-placement compensation algorithm. The output of the compensator is converted to a PWM signal and fed to the power transistor bridge. The power bridge uses the high voltage DC BUS Module (typical 325 VDC bus) to supply the required current to the motor windings. The actual motor current is updated and the process begins again. The following is a graphical representation of the serial torque loop operation

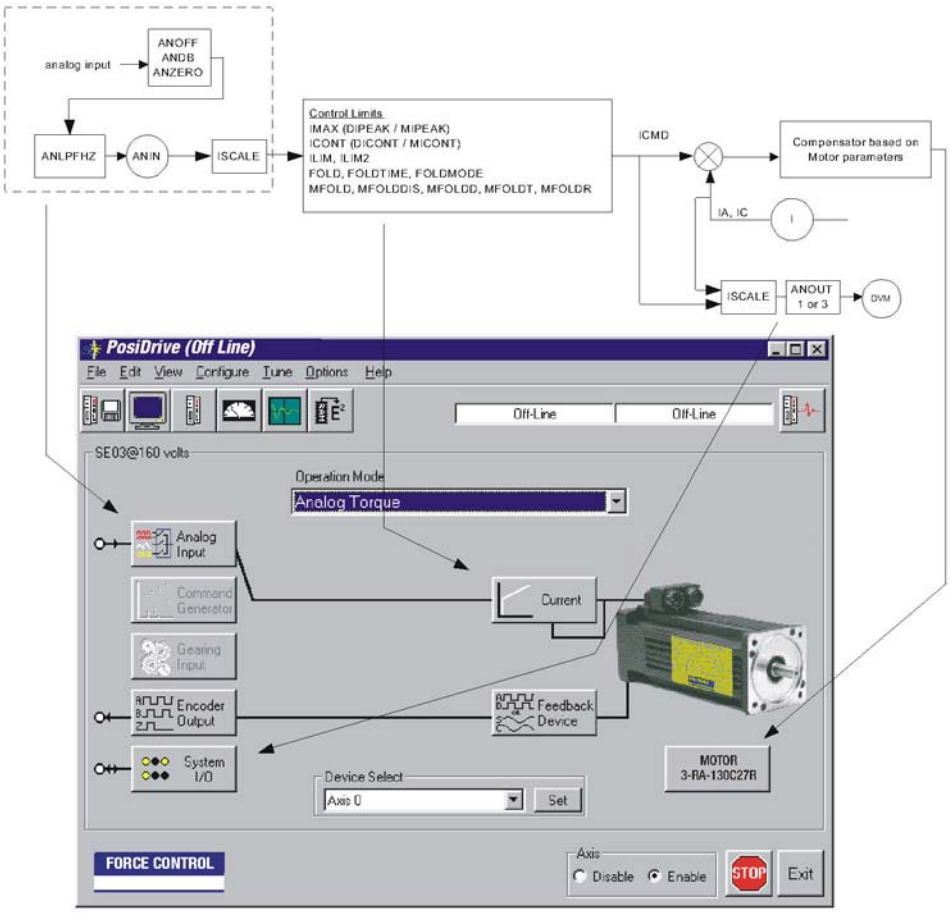


Serial Torque Mode with PC Software

ANALOG TORQUE

The *PosiDriv*e can be often configured to operate as an analog torque loop controller (OPMODE 3). In this case, the current loop receives its input from the analog-to-digital (A/D) conversion system. After conversion, the input command signal is processed through an algorithm which adjust the signal (ANOFF, ANDB, ANZERO), filters it (ANLPFHZ) and then scales it (ISCALE), before developing the current command (ICMD). The current (or torque) command is then checked against peak (IMAX, ILIM) and continuous (FoldBack features, ICONT) current clamp limits.

Sinusoidal commutation modulation is added to the command and then fed to the three-phase current loop regulator, which calculates a current error. This error is then fed through a digital pole-placement compensation algorithm. The output of the compensator is converted to a PWM signal and fed to the power transistor bridge. The power bridge uses the high voltage DC BUS Module (typical 325 VDC bus) to supply the required current to the motor windings. The actual motor current is updated and the process begins again.



Analog Torque Mode with PC Software

Current Sampling

The current loop receives corrective feedback from the current sampling circuitry. The current sensors use closed-loop hall sampling techniques in all units.

The current sample is used by the current loops to regulate the current in each of the three motor phases. Two phases (A and C) of the current signal are sampled by the microprocessor at a 16kHz rate. The momentary A phase current and C phase current can be monitored by examining the IA and IC variables, respectively. The microprocessor calculates the equivalent absolute current, which can be monitored as I. This value can be averaged for 2, 4, 8, 16, 32, or 64 samples.

Foldback

The *PosiDrive* offers two types of FoldBack protection for both the motor and the drive. The drive's microprocessor monitors the current feedback signal and develops a RMS value of this signal for the purpose of providing a value that represents the current in the motor. The system is similar to an "I-squared-T accumulator.

Drive FoldBack

This FoldBack algorithm monitors current feedback and, if the feedback exceeds the continuous current rating of the drive/motor combination (ICONT), will decrease the system's current to the ICONT level. For example, under a step command input condition, the FoldBack algorithm will allow maximum peak current (IMAX) output from the drive for 2 seconds (or _ second for RD units). After two seconds, the drive enters "FoldBack mode" (FOLD = 1) and begins an exponentially FoldBack to the system's continuous current. It will take approximately six seconds for the exponential decay to drop from the system's peak current to its continuous level.

For drive currents that exceed ICONT, but are below IMAX, the system period before FoldBack occurs is extended beyond two seconds. Two seconds is the shortest time period that will elapse before the drive enters FoldBack and only occurs when maximum peak current (IMAX) is drawn.

This FoldBack feature is designed to protect the drive electronics, not the motor. The Configurable Output, O1, (pin 12) can be configured to indicate a drive FoldBack condition.

Motor FoldBack

This FoldBack algorithm is designed to provide motor protection in cases where the drive's continuous current rating is above the motor's continuous rating. This combination is often desired in applications where maximum peak motor torques are required. However, the possibility exists that the drive could source current on a continuous basis indefinitely to the motor and would force it beyond its thermal capability. Unlike the drive FoldBack, you have complete configurability over this feature (MFOLD, MFOLDD, MFOLDDIS, MFOLDR, MFOLDT).

SYSTEM DESCRIPTION

The *PosiDrive RD* is a digital servo motor amplifier that meets the needs of many servo applications such as machine tooling, packaging, electronic assembly, and document handling. It has been designed to be a multifaceted amplifier, capable of driving Force Control Industries, Inc.'s vast product basket of motors and their assorted feedback devices. The RD-Series is available in 3 and 6 amp sizes. All are packaged in a small frame size for minimizing cabinet space. This product can be commanded through analog, serial, and SERCOS user interfaces and has its own tailored, Windows based, software.

Product Features

The *PosiDrive RD* includes a vast array of features. Its various control techniques, interfaces, and user tools give the customer a compatible drive to meet most motion control applications. User features include:

Bulleted words that begin in capital letters indicate formal feature names. Words that are capitalized indicate the software variables and commands associated with the feature. This section is designed to direct you to the PosiDrive Variable Reference Manual for details on these features.

Current/Torque Control

- Digital current loop control (Torque Mode - OPMODE 2 or 3) receiving serial (T) or analog commands.
- Pulse Width Modulated (PWM) sine wave commutation (PWMFRQ) providing smooth and precise low-speed control and high-speed performance.
- Current loop adaptive gain (MLGAINC, MLGAINP, MLGAINZ).
- System current-limiting capability (ILIM, ILIM2, IMAX, MICONT, MIPEAK).
- Exponential current vs. Time limiter (FOLD, FOLDMODE).
- Back EMF compensator (MBEMFCOMP).

Velocity Control

- Digital velocity loop control (Velocity Mode - OPMODE 0 or 1) receiving serial (J), analog (ANIN), or I/O triggered commands (MISPEED1, MISPEED2, MISPEED3, IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Velocity stepping and jogging capability (STEP, J).
- Serial control through stored commands triggered through the Configurable I/O (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).

- Automatic control loop tuning through the auto-tune feature (TUNE).
- Configurable application and system speed limits (VLIM, VOSPD, VMAX).
- Advanced control algorithms (COMPMODE):
  1. Proportional-Integral (GV, GVI).
  2. Pseudo-Derivative with feed forward (KV, KVI, KVFR).
  3. Standard Pole Placement (BW, MJ, LMJR, TF).
  4. Extended Standard Pole Placement (BW, MJ, LMJR, TF).
- First- and second-order low pass filtering capability (FILTMODE, LPFHZ1, LPFHZ2, COMPFILT).
- Notch filtering capability (FILTMODE, NOTCHHZ, NOTCHBW).
- Bandwidths up to 400Hz.
- "On-the-fly" homing capability (HOMETYPE) in analog velocity mode (OPMODE 1) through either the Configurable Inputs or terminal.
- "On-the-fly" switching between velocity and current/torque control (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).

Position Control

- Serial positioning loop control (Position Mode - OPMODE 8 & PCMDMODE) receiving serial or I/O-controlled command (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Analog positioning loop control (Position Mode - OPMODE 8 & PCMDMODE) over a ±10 V range with scaling capability (PSCALE, GEAR, GEARI, GEARO) and I/O triggering.
- Incremental and absolute positioning with an "in position" indicator (MI, MA, INPOS, PEINPOS).
- Simple absolute and incremental indexing with I/O triggering capability (MAPOS, MASPEED, MIDIST0, MIDIST1, MIDIST2, MIDIST3, MISPEED0, MISPEED1, MISPEED2, and MISPEED3) through either the serial port or the hardware configurable inputs (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Position homing with I/O triggering capability (MH, HOMESPD, HOMESTATE, HOMETYPE) through either the serial port or the configurable inputs (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Electronic Gearing (Position Mode - OPMODE 4) featuring pulse following or master encoder capability with resolution up to 3mhz through C8 connector (2.5khz through opto-isolators in C3) (GEAR, GEARMODE, GEARI, GEARO, PEXT, PEXTOFF, VEXT, XENCRES, XENCDIR). Homing capability is provided.
- Dual-loop mode (DUALFB) capable of positioning from a load feedback (C8 input, PEXTOFF, PEXT, VEXT, XENDIR) device while controlling velocity and torque from the motor feedback (C2 input).

- PID position loop tuning (GP, GPD, GPI,) with feed-forward acceleration gain input to both the velocity and current loops (GPAFR, GPAFR2), and feed-forward velocity gain input to the velocity loop (GPVFR).
- Software position limits (PLIM, PMAX, PMIN, PEMAX).
- Configurable integrator dynamics through travel range (GPISATOUT, GPISATIN).
- Cumulative, revolution, and error position counters (PFB, HWPOS, PRD, PE).
- Position indicators (INPOS, PEINPOS, PE, PEMAX, PFB, PFBOFF).

Profile Ramping Control

- Electronic Braking (STOPMODE, ISTOP).
- Separate ACCEL and DECEL linear ramping control in velocity and position mode (ACC, DEC, PROFMODE).
- S-curve ACCEL and DECEL ramping control (PROFSCRV, PROFMODE) in the position mode (OPMODE=8).
- Controlled decelerating (DECSTOP, DISSPEED, DISTIME) with acceleration feed-forward when the drive is left enabled (STOP, HOLD, CWLIM, CCWLIM, LIMDIS) or becomes disabled (K, S, ACKFAULT, DIS). This feature can be used in conjunction with the Electronic Braking feature.
- Torque compensator for coulomb friction and weight counter-balancing (IFRIC, IGRAV).

Motor Controllability

- Provides linear and rotary motor control (MOTORTYPE, MPITCH, MENCRES) with automatic unit conversion.
- Configurable back EMF characteristics for effective current loop controller design and command (MBEMF, MBEMFCOMP).
- Torque Angle control to maximize motor output power (MTANGLC, MTANGLP, MVANGLF, MVANGLH).
- Motor speed and current limits (MSPEED, MICONT, MIPEAK).
- Thermal protection control (MFOLD, MFOLDD, MFOLDDIS, MFOLDR, MFOLDT) adaptable to any motor.
- Auto-configuration feature (ACONFIG, ACONFIGST, MFBDIR) automatically configures the motor's power and feedback cables. It checks, warns, and corrects for incorrect wiring of these cables.
- Configurable positive motion direction (DIR).

Feedback Devices

- Device zeroing mode that rotates the motor to an electrical null point (ZERO, IZERO).

RESOLVERS

- Variety of motor and resolver pole combinations (MPOLES, MRESPOLES).
- Resolver-zero offsetting (MPHASE).
- System accuracy's better than 20 arc minutes (reduced when resolver pole count is increased).
- Inter-LSB interpolation between least significant bits (ILSBMODE) allows 18-bit velocity control and 16-bit positioning capability.
- Automatic resolution configuring, based on application speed requirements (RDRES, VMAX).

ENCODERS

- Maximum frequencies to 3 MHz before quad.
- Up to 10 million counts per motor electrical cycle (MENCRES).
- Configures automatically (ENCINIT, ENCINITST, ENCSTART, IENCSTART).
- Index pulse offsetting capability (MENCOFF).
- Variety of encoder types (MENCTYPE):
  1. Encoder with or without index.
  2. Encoder-hall effects with or without index (MHINVA, MHINVB, MHINVC, HALLS).

SINE ENCODERS

- 256x internal interpolation.
- Up to 128x encoder equivalent output (SININTOUT).
- Most standard encoder features mentioned above.

System Communications

- Serial communications port (address setting through DIP switch on top of drive).
  1. RS-232 single and up to 31-axis multi-drop addressing (ADDR).
  2. RS-485 single and up to 31-axis multi-drop addressing (ADDR).
  3. Data transmission (DUMP, GET, LIST, MLIST, GETMODE) baud rates of 9600 or 19200.
  4. Configurable protocol (ECHO, PROMPT, ACKMODE, GETMODE, MSG).
  5. Interface through Force Control Industries, Inc.'s software or a dumb terminal.

- Differential analog input command (ANIN).
  1. ±10V at 14 bit resolution.
  2. ±10V at 15 bit resolution below 4V of input for slow speed operation using the Dual Gain feature (ANDG - SE units only).
  3. Input signal filtering (ANLPFHZ).
  4. Flexible analog input scaling (VSCALE, ISCALE, ANOFF, ANZERO, ANDB).
- SERCOS communications port (SERCOS versions only).
  1. 2-msec update rate.
  2. Complete set of manufacturer's IDNs.
  3. Software communication through the serial port.
- Encoder Equivalent Output signal (C4 connector) eliminates the need for an additional position feedback device. The maximum frequency of this output is 3 MHz for standard encoders and
  1.2 MHz for sine encoders.
  1. **Resolver-based systems**: developed through R/D hardware circuitry for minimal phase lag, it provides a before quad resolution of up to 16384 lines (65536 quad counts) per revolution of the motor shaft (dependant on motor speed). This signal resolution is configurable (ENCOUT). Index pulse can be varied as much as one complete revolution (INDEXPOS).
  2. **Encoder-based systems**: actual encoder signals are exported through this output (MENCRES) and can be scaled down by multiples of two (ENCOUTO).
  3. **Sine-encoder systems**: developed through the interpolator circuit (SININTOUT) and encoded to a quadrature signal. A frequency limiter (MSINFRQ) is provided with fault protection.

Software Environment

- Easy setup, commanding, and monitoring techniques.
- Contains an extensive database for many of Force Control Industries, Inc.'s motor series.
- A backup screen that provides automatic loading of system parameters.
- Realtime metering of many system parameters.
- PC scope feature for profile recording and realtime motion performance measuring.
- Optional terminal mode feature for keystroke commanding and monitoring.
- Status screen indicating system operation and fault/error checking.
- Extensive on-line help file (F1) designed to assist you in the Software's intuitive nature.
- A set of limits folders allowing you to manipulate the position, velocity, current, and filtering limits from one screen.
- An I/O screen for easy manipulation of the drive's I/O, thermostat options, encoder output, and hardware position limits capabilities.

- A feedback device screen that provides realtime pictorial positioning information. It also includes a resolver zeroing routine and an encoder initialization folder.
- A tuning screen designed to allow you to adjust control loop gains quickly while visibly watching the affects on performance.
- A control loops screen that provides direct manipulation of velocity and position loop gain parameters.

Monitoring and Troubleshooting Tools

- Performance recording (RECDONE, RECING, RECOFF, RECORD, RECRDY, RECTRIG).
- System status checking (STAT, STATUS, STATUS2).
- Control loop monitoring:
    1. Current/torque (I, IA, IC, ICMD, IMAX, ICONT, DICONT, DIPEAK).
    2. Speed (V, VCMD, VE).
    3. Position (PCMD, PFB, PE, HALLS, HWPOS, INPOS, PRD, PEXT, PEINPOS).
- Analog output (ANOUT) with 12-bit resolution and scaling flexibility (PSCALE) that can be configured to monitor speed, torque, current, power, velocity error, following error, and position feedback (PFB). Should be used as a monitoring tool only.
- Dual-state digital output (O1, O1MODE, O1RST, O1TRIG) that toggles according to various absolute current, speed, and position parameter settings. Also can be used to communicate occurrences of fold-back, motor braking, and the status of the Remote Enable hardware switch.
- Status Display (TESTLED) indicator that communicates operational and fault characteristics.
- Realtime reading of the 10-position DIP switch (DIP, DIPEN).
- Software status switch indicator provided for configurable inputs (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).

Fault and Safety Detection

- Watchdog faults.
- General faults (ACKFAULT, STAT, STATUS).
- Configurable under-volt protection (UVMODE, UVTIME, UVRECOVER).
- Speed and current protection (VOSPD, VLIM, ACC, DEC, ILIM, ILIM2).
- Fatal and non-fatal error coding with text explanation to the host (ERR, FLTHIST, FLTCLR). A run-time counter (TRUN) that records the time the error occurred is also provided.
- Configurable motor thermal protection that accepts various thermostat types (THERM, THERMODE, THERMTYPE, THERMTIME).

- Configurable drive thermal protection through the fold-back feature (FOLD, FOLDMODE). It sets the maximum time limit the drive can provide peak current to the motor.
- Configurable motor thermal protection through the motor fold-back feature (MFOLD, MFOLDD, MFOLDDIS, MFOLDR, MFOLDT). It sets the maximum time limit the drive can provide continuous current to the motor.
- Hardware position limit switch detection (CCWLIM, CWLIM, LIMDIS, IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Configurable software position limits (PLIM, PMAX, PMIN, PEMAX).
- Configurable fault relay output (RELAY, RELAYMODE, DISTIME, IN1MODE, IN2MODE, IN3MODE).
- Active disable feature (ACKFAULT) that allows you to determine how the system should react at the occurrence of a fault. The system can immediately disable, where the motor will coast to a stop, or it can be programmed to a controlled decelerated stop (DECSTOP, DISSPEED, DISTIME, STOPMODE, ISTOP).
- Active enable indicator through the Status Display decimal (ACTIVE, DRIVEOK, SWEN, READY, REMOTE, DIPEN).

General

- Many enabling and disabling features (K, S, STOP, REMOTE, EN, DIS).
- Flash firmware memory for easy field upgrade installation.
- "Torque Angle Control" (MTANGLC, MTANGLP, MTANGLF, MTANGLH)- defined as speed and torque optimization through commutation angle advancing of the drive's output current waveform with respect to the motor's back EMF waveform.
- Firmware and serial number information (VER, SERIALNO, MOTOR) via terminal.

TROUBLESHOOTING

Troubleshooting Tools

The *PosiDrive's* software package comes with a comprehensive monitoring and troubleshooting help set. For troubleshooting the drive, it provides a Status screen (click on "Status" button in the upper right-hand corner of Main Software screen). The Status screen allows you to check the drive enable switches, the Status Display LED, fault status with complete error history, and mode settings for several of the drive's protection features. If using the terminal mode, you can simply check the contents stored in the STATUS, FLTHIST, and ERR variables.

An additional help provided by the software is the I/O screen (click on "I/O" button on the side of the Main Software screen). The I/O screen gives you the ability to check the status of the hardware position limit switches, the motor thermostat, and the encoder equivalent output. It also allows you to set up the I/O on the C3 connector for a variety of troubleshooting and monitoring approaches.

For monitoring system performance, the Software comes with a variety of monitoring tools. The customer can monitor a variety of variables from the Monitor screen (click "Monitor" button at the top of the Main Software screen) to compare up to three variables against themselves at one time. The Tune and Record screen allows you to evaluate the system's actual performance against a predefined command profile. Also from this screen, adjusting the gains until optimum following is achieved can vary the performance.

Error codes

In most cases, the *PosiDrive* communicates error codes with a text message via the serial port to the host. Some error codes are also transmitted to the Status Display. The same message is saved in the EEPROM under an error history log (FLTHIST, ERR) so that nothing is lost when power is removed. Not all errors reflect a message back to the host. In these cases, the no-message errors communicate to the Status Display only.

The response of the *PosiDrive* to an error depends on the error's severity. There are three levels of severity:

1) Warnings, simply called errors, are not considered faults and do not disable operation

2) Non-fatal errors, or simply faults, that disable the drive and indicate a fault status

3) Fatal errors, or fatal faults, that disable almost all drive functions (including communications)

The drive is automatically disabled at the occurrence of a fault. Executing a drive disable command (DIS or K) followed by the EN command, or toggling the Remote Enable line (REMOTE) resets the fault latch, and if the fault condition is no longer present, re-enables the system.

FATAL FAULT ERROR CODES

Status Display	Fault Message	Possible Cause	Err #
t	Power stage OverTemp	overload, fan malfunction, power stage failure	1
o	OverVoltage	excessive decel rate*	2
P	OverCurrent	power stage surge current*	3
r0	External feedback fault	Feedback signal through C8 not correctly detected	4.0
r1	Resolver line break	break in resolver feedback detected	4.1
r2	RDC error	fault in resolver-to-digital converted detected	4.2
r3	Sine Encoder init fail	sine encoder card has not initialized properly	4.3
r4	A/B line break	break in encoder A/B input lines detected	4.4
r5	Index line break	break in encoder index line	4.5
r6	Illegal halls	illegal hall combination detected	4.6
r7	C/D line break	break in sine encoder C/D line detected	4.7
r8	A/B out of range	sine encoder A/B level out of range	4.8
r9	Burst pulse overflow	sine encoder fault	4.9
r10	Endat Communication Fault	Serial communication to the Endat Encoder failed	
u	Under voltage	bus voltage is too low	5
H	Motor over temperature	motor overload caused overheating	6
A1	Positive analog supply fail	Failure in +12V supply (regulated)	7.1
A2	Negative analog supply fail	Failure in -12V supply (regulated)	7.2
J	OverSpeed	velocity ≥ VOSPD	8
J1	OverSpeed	Velocity ≥ 1.8 x VLIM	8.1
E	EEPROM failure	Faulty EEPROM	9
e	EEPROM checksum fail	EEPROM checksum invalid on power up*	10
F	Foldback	System in FoldBack mode	12
d5	Positive over travel fault	PFB exceeded PMAX with PLIM=1	14.1
d6	Negative over travel fault	PFB exceeded PMIN with PLIM=1	14.2
d1	Numeric position deviation	Internal fault	15.1
d2	Excessive position deviation	PE > PEMAX	15.2
c	Communication interface	A communications fault has occurred	16

*These faults can only be cleared by cycling power

NON-FATAL ERROR CODES

Error Message	Possible Cause	Err #
No Error	no error was recorded	0
Unknown Command	Undefined command	20
Unknown Variable	undefined variable name	21
Checksum error	error on comm. message checksum (ACKMODE 2)	22
Drive Active	drive needs to be inactive for the requested command or variable	23
Drive Inactive	drive needs to be active for the requested command or variable	24
Value out of range	variable value out of range	25
Negative Number	variable must be ≥ 0	26
Not in proper Opmode	not in correct Opmode for specified command	27
Syntax Error	communication message syntax error	28
Tune Failed	auto tuning failed	33
Bad Bandwidth	AutoTuning BW is out of range	34
Bad Stability	bad stability	35
Not programmable	variable is read-only	36
Current loop design failed	CONFIG failed due to current loop design failure	37.01
MENCRES out of range	CONFIG failed due to MENCRES	37.02
MENCOFF out of range	CONFIG failed due to MENCOFF	37.03
MSPEED out of range	CONFIG failed due to MSPEED	37.04
MBEMF out of range	CONFIG failed due to MBEMF	37.05
MJ out of range	CONFIG failed due to MJ	37.06
ACC out of range	CONFIG failed due to ACC	37.07
DEC out of range	CONFIG failed due to DEC	37.08
DECSTOP out of range	CONFIG failed due to DECSTOP	37.09
VLIM out of range	CONFIG failed due to VLIM	37.10
VOSPD out of range	CONFIG failed due to VOSPD	37.11
VSCALE out of range	CONFIG failed due to VSCALE	37.12
O1TRIG out of range	CONFIG failed due to O1TRIG	37.13
O1RST out of range	CONFIG failed due to O1RST	37.14
DISSPEED out of range	CONFIG failed due to DISSPEED	37.15
MENCTYPE out of range	CONFIG failed due to MENCTYPE	37.16
Communication error	Error at physical comm. layer	38
Not in proper COMPMODE	The REFRESH command was given with COMPMODE ≠ 3	39
EXT velocity param warning	D, H, R parameters for COMP-MODE 3 do not have the proper relationship to each other.	40
Vel loop design failed	The velocity loop can't be con-figured with given parameters	41
Invalid EEPROM	The EEPROM test failed	42
Recording active	The requested command cannot be executed because it conflicts with a recording in progress	43
Rec data not available	No data are available for the GET command	44
EEPROM is empty	Data cannot be loaded because the EEPROM is empty	45
Argument must be binary	Variable argument must be a power of 2	46
Burnin is active	The requested function cannot be executed during Burnin (a factory function)	47
Burnin is not active	Burnin (factory function) cannot be stopped if it is not active	48
Conflicts with ENCOUT	The requested value for VLIM conflicts with ENCOUT.	49
Conflicts with VLIM	The requested value for ENCOUT conflicts with VLIM.	50
Not available	The requested variable value is not available; refer to the description of the variable in section 1 to determine why.	51
Drive is in Hold mode	Motion was requested with the drive in Hold mode	52

Error Message	Possible Cause	Err #
Limit Switch Hold	Drive is in Hold mode due to limit switch being tripped	53
Command Into Limit	Requested motion is in direction of tripped limit switch	54
Drive is in Zero Mode	Motion requested while in Zero mode	55
Motor is Jogging	Tune cmd cannot be executed because motor is jogging	56
Argument not divisible by 20	Argument must be a multiple of 20 to be accepted	57
Encoder Initialization Process Active	A command cannot be executed because it has been requested while the encoder initialization process is active	58
Tune failed-no rotation	Tune cmd failed because motor could not rotate	60
Tune failed-current sat	Tune cmd failed because the current loop saturated	62,66 70,74
Tune failed-no vel design	Tune cmd failed because the vel loop could not be designed	63,67 71,75
Disable During Tune	Tune cmd failed because drive was disabled while tuning	76
Hold During Tune	Tune cmd failed because drive entered Hold mode while tuning	77
Low Velocity Limits	Tune cmd failed because VLIM is too low	78
Use Lower Bandwidth	Tune cmd requires a lower bandwidth in order to execute	79
Drive in Dual Feedback mode	Command cannot be accepted because dual feedback is active	80
Drive is in Gear mode	Command cannot be accepted because drive is in gear mode	81
Functionality is occupied	Selected INxMODE function is already assigned to another INxMODE	82
Warning: A/B Line not routed	Selected GEARMODE requires A/B inputs to be routed using INxMODE 5 and 6.	83
Warning: Limit sw not routed	Limit switches must be routed using INxMODE 1 and 2.	84
Move is pending	The last ordered move command has not been completed yet.	85
Incorrect password	The password entered was incorrect	90
Password protected	The command or variable requested is password protected and intended for factory use only	91
Capture during homing	A position capture occurred during homing	92
Homing during capture	A homing request was made during position capture	93
Capture process not done	The requested command can’t be processed due to pos capture not being complete	94
Capture process not active	The requested command can’t be processed due to pos capture not being active	95
Capture process not enabled	Position capture cannot be executed	96
ENCSTART while ACONFIG		97
SERCOS test failure		999

NO MESSAGE FAULTS

Display	Fault Description	Fatal	Non-Fatal	Flashing Display	Steady Display
≡	Watchdog (DSP)	✿		✿	
≡	Watchdog (HPC)	✿			✿
-1	No Compensation	✿		✿	
-2	Invalid Velocity Control	✿		✿	
-3	Encoder not Initialized on attempt to enable	✿		-✿	
-4	Encoder Initialization failure	✿		✿	
-5	AutoConfig failure	✿		✿	
L 1	Hardware CW limit switch open		✿	✿	
L 2	Hardware CCW limit switch open		✿	✿	
L 3	Hardware CW and CCW limit switches open		✿	✿	
L 4	Software CW limit switch is tripped (PFB>PMAX & PLIM=2)		✿	✿	
L 5	Software CCW limit switch is tripped (PFB<PMIN & PLIM=2)		✿	✿	
A 3	Positive and negative analog supply fail	✿		✿	
I	RAM failure (during init)	✿			✿
c	EPROM checksum (during init)	✿			✿
E101	Altera load failure (during init)			✿	
E102	Altera DPRAM failure (during init)			✿	
E103	DSP load fail (during init)			✿	
E104	DSP alive failure (during init)			✿	
8	Test LED			✿	
B	Indexed position with zero velocity			✿	

Fault Monitoring System

The *PosiDrive's* microprocessor is constantly monitoring the status of many different components. In general, the philosophy of the *PosiDrive* is to latch all fault conditions so you can readily determine the source of the problem. When a fault is detected, it is logged in the internal error log, indicated in the Status Display, enunciated over the serial port, and in most conditions causes a drive disable. Many faults can be reset by toggling the hardware remote enable (REMOTE input).

The following provides a list of some of the more frequent faults the drive may detect in the unit hardware and operating system.

- **Motor OverTemperature:** The Motor's External Thermostat input is monitored for an open circuit condition. You can define (using THERMODE) what happens under this fault condition. The worst case event is a power stage disable when an 'H' appears in the status display, and the fault relay contacts (RELAY) are open.

- **Hardware Position Limit Inputs:** The IN1, IN2, IN3 Inputs are constantly monitored. If INxMODE set these inputs for CW/CCW hardware position limits, they are monitored for an open-circuit condition. Although not necessarily an error condition, motor operation can be affected by these inputs. The *PosiDrive* can ignore the hardware position limits if you set LIMDIS = 1. The worst case event is that further motion in the given direction is not allowed with an 'L' illuminated in the status display. If both CW and CCW position limit inputs have detected an open-circuit condition, the *PosiDrive* enters into Hold position state
(HOLD = 1).
- **Drive OverTemperature:** The internal heatsink temperature is monitored for an unsafe condition. This condition causes a 't' to be displayed and disables the drive. The drive will eventually cool enough to allow reset of this condition.
- **RMS OverCurrent (FoldBack):** The FoldBack detection system can 'clamp' the available output current. This is not a true fault condition, but may cause undesired performance, due to the command current being limited below what is required to achieve the desired performance. This condition is indicated with a flashing 'F' in the status display and can be detected by monitoring the FOLD switch variable.
- **Bus OverVoltage:** An over-voltage condition shuts down the drive and displays a lower-case 'o' in the status display. This fault will occur mostly during regen operation where the BUS is raised to higher values than that produced by the power supply.
- **Bus UnderVoltage:** An under-voltage condition shuts down the drive and displays an 'u' in the status display. This fault normally occurs when the incoming line voltage drops out or a fault occurs in the power supply.
- **PowerStage Fault (OverCurrent):** Hardware circuitry monitors load short-circuit, transistor failure, and instantaneous OverCurrent. In general, toggling the Remote Enable cannot reset a power stage fault. Power must be cycled. A flashing 'P' in the status display indicates this condition.
- **Feedback Loss:** Hardware is used to detect a wire-break condition in encoder based systems or the presence of the Sine and Cosine resolver feedback signals in resolver based systems. Either of these signals not being present will cause the *PosiDrive* to disable and display an 'r' in the status display.
- **Low-voltage power supply faults:** Out of tolerance values on the ± 12 VDC analog supplies will cause an 'A' to be displayed and cause the drive disable.
- **OverSpeed fault:** Software continuously monitors the actual (feedback) speed. If the motor speed exceeds the VOSPD limit, a 'J' will be displayed and the drive will be disabled. This normally occurs when there is an improperly tuned system and the load overshoots its commanded speed.

- **No compensator:** In case the *PosiDrive* cannot design a compensator, such as after a RSTVAR command, CLREEPROM, or any change in the motor or drive parameters, a flashing minus sign (-) will be displayed and will cause the drive to disable. This display normally indicates that the drive does not have a compensation file loaded.
- **Memory reliability:** During the initialization process upon power up, the run time, variables memory (RAM - Random Access Memory), and the program memory (EPROM - Electrically Programmable Read Only Memory) are tested.

  If a RAM fault is detected, an 'I' is displayed and the drive is halted. If an EPROM fault is detected, a 'c' is displayed and the drive is halted.

  The non-volatile memory (EEPROM) is also checked for integrity upon power-up. Any discrepancy in this data is noted with an 'e' in the status display. After power-up is successfully completed, any subsequent fault in the operation of the EEPROM is noted with an 'E' in the status display.
- **WatchDogs:** In addition, the *PosiDrive* incorporates a watchdog system to maintain software operation integrity. Failure of the watchdog mechanism will display three bars on the status display and cause the drive to halt. This normally indicates serious problems. Please contact the factory for support.

Firmware Upgrades

From time to time, Force Control Industries, Inc. adds features to its products that expand their overall capabilities. Features added to the *PosiDrive* can be easily implemented at the customer's site. This is accomplished by downloading new firmware via the drive's serial port directly from a host computer.

The customer ordering a firmware upgrade receives a file labeled "UPGRADE.EXE". Click on this file and a Windows program will prompt you to choose an unzipping method, baud rate, and communications port. If the baud rate and communications port selection is incorrect or the drive is set up for MultiDrop communications, then a DOS screen will pop up indicating an error has occurred. Simply close the window and select another baud rate and/or communications port.

NOTICE:
Be sure to check the "Type" specifier on your unit. If your unit has the following label:

It requires firmware version 4.0.0 or higher. Other types will work with all firmware versions.

NOTE:
Firmware version 4.0.0 and higher is not compatible with the older versions of IGNITE (firmware loading software). Attempting to load incompatible firmware will result in the IGNITE program generating an error.

To obtain the latest firmware version or receive additional help, contact Force Control Industries, Inc. Customer Support.

Customer Support

Force Control Industries, Inc. is committed to quality customer service. Our goal is to provide the customer with information and resources as soon as they are needed. In order to serve in the most effective way, Force Control Industries, Inc. offers a one-stop service center to answer all your product needs. This one number provides order status and delivery information, product information and literature, and application and field technical assistance:

Force Control Industries, Inc.
3660 Dixie Highway
Fairfield, Ohio 45014
Phone: (513) 868-0900
Fax: (513) 868-2105
Email: info@forcecontrol.com
Web: http://www.forcecontrol.com

If you are unaware of your local sales representative, please contact us at the number above. Visit our web site for software upgrades, application notes, technical publications, and the most recent version of our product manuals.

APPENDIX A

Motor Pinouts

The ***PosiDrive RD*** product family can be mated with a variety of motors. Cable sets (motor and feedback) can be purchased directly from Force Control Industries, Inc.; which gives you a complete plug-n-play system. However, you may find it necessary to manufacture your own cable sets. This Appendix provides pinout information between the drive's power and feedback connections and the motor receptacles for most of Force Control Industries, Inc.'s motor products.

Motor Power Connections

Control **DRIVE CONNECTIONS**	***Motor***		
	MS Style Receptacle	**Rotateable Recepticle**	**WIRE Color** (Winding to Receptacle)
MA	Pin A	3	Brown
MB	Pin B	4	Red
MC	Pin C	1	White
GND	Pin D	2	Green/Yellow

RESOLVER Connections

Control **C2**	***Motor***			
	Frame Sizes: 070, 095, 115 145 & 190	**Frame Sizes: 130 & 175**	**Frame Size: 090**	**Wire Color** (From resolver to motor receptacle)
Pin 1	Pin A	Pin A	Pin 3	Black
Pin 2	Pin B	Pin B	Pin 7	Red
Pin 3 (shield)				
Pin 4	Pin D	Pin D	Pin 8	Yellow
Pin 5	Pin C	Pin C	Pin 4	Blue
Pin 6 (Shield)				
Pin 14 (Shield)				
Pin 15	Pin F	Pin F	Pin 5	Yellow/White
Pin 16	Pin E	Pin E	Pin 9	Red/White
Pin 13	Pin T	Pin R	Pin 2	Yellow
Pin 25	Pin U	Pin S	Pin 6	Yellow
Pin 12 (Shield)				

Incremental Encoder Connection

Control C2	Motor		
	Encoder Receptacle		Wire Color (At Motor Receptacle)
	MS Style Receptacle	Rotateable Recepticle	
Pin 1	Pin A	Pin 1	Blue
Pin 2	Pin M	Pin 2	Blue / Black
Pin 3 (shield)			
Pin 4	Pin B	Pin 3	Green
Pin 5	Pin C	Pin 4	Green / Black
Pin 6 (Shield)			
Pin 7 & 8	Pin S	Pin 7	Red
Pin 9	Pin F	Pin 17	Brown
Pin 10	Pin H	Pin 16	Gray
Pin 11	Pin K	Pin 15	White
Pin 12 (Shield)			
Pin 13	Pin T	Pin 8	Yellow
Pin 14 (Shield)			
Pin 15	Pin D	Pin 5	Violet
Pin 16	Pin E	Pin 6	Violet / Black
Pin 18,19 & 20	Pin R	Pin 10	Black
Pin 22	Pin G	(see note 1)	(see note 1)
Pin 23	Pin J	(see note 1)	(see note 1)
Pin 24	Pin L	(see note 1)	(see note 1)
Pin 25	Pin U	Pin 9	Yellow

NOTE 1. Must be shorted to C 2 pin 18 for proper operation

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