

*SMART DRIVE*

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*INSTALLATION AND SETUP MANUAL*

Old Number M93103 - ISSUE 6

**New Number MSM000H**



# TECHNICAL MANUAL CONFIGURATION

( INSTALLATION AND SETUP MANUAL M93103 )

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ISSUE NO. (Revision)	DATE	CHANGED PAGES/BRIEF DESCRIPTION OF CHANGE	CHANGE NO.
3	15 May 95	All / Revise Technical Manual	Original Release
4	--	Advance Release of Issue 5	
5	29 Sept 95	Kollmorgen Industrial Drives Update	
6 (Review)	20 Nov 95	Incorporate Review Comments / Add Windows Information	
6	15 Jan 96	Incorporate Review Comments / Release Issue 6	

# THANK YOU!



Thank you and congratulations for choosing Industrial Drives' servo products for your motion control requirements. We seek to provide our customers with quality products, excellent support and outstanding value. In an effort to provide you with dependable and useful documentation, we offer you an opportunity to critique this manual with your comments and suggestions. Your feedback on this reader comments form is very important to us. Please answer the questions below and return the form to:

## INDUSTRIAL DRIVES - Technical Manual Department

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# FOREWORD

The commitment to quality at Industrial Drives is our first priority. In all aspects of our business: research, development, product design and customer service, we strive to guarantee total quality. This pledge is founded on a solid history of innovative technological achievements dating back to 1948. One of the finest tributes to that achievement can now be seen at the Smithsonian which has on display the first stellar inertial navigation system developed by Dr. Charles Stark Draper. This system contains the first models of torque motors built by the founding organization of Industrial Drives. During the period of 1948 to 1960, our "firsts" in the industry numbered more than a dozen; they ranged from the simple but invaluable (such as the direct-drive DC torque motor and movie theater projection motors) to the exotic: submarine periscope drive motors for the U.S. Navy, electric drives, Curtis Wright electric brake coils, and numerous other innovations.

For more than a decade, Industrial Drives (known in the early days as part of Inland Motor Division of Kollmorgen) has continued to enhance its sophisticated engineering solutions to pioneer new product development.

The results of these and other efforts has encouraged some of the most significant innovations in the servo industry. We developed the application of servo motors and drives in the Machine Tool market. We were the first with water-cooled servos, the integral brake, the flux forcing concept and the brushless motor. We developed the electronically commutated electric car motor. Industrial Drives pioneered rare

earth magnet development for the servo motor industry.

Between 1974 and 1980, Industrial Drives continued to lead the industry in servo application innovations. Our commitment to engineering excellence never wavered. In fact, that commitment grew stronger with the development of brushless submarine and submersible motors (visiting the Titanic graveyard), multi-axis electronic drives and antenna pedestal drives (delivering unprecedented accuracy and revolutionizing the entire industrial automation process).

The decade of the 1980's brought continued advancements in technology and penetration of new markets requiring precise motion control. Already in the fifth generation of brushless products, Industrial Drives continues to lead the way with digital servo positioning capability and our newest motor offering, the GOLDLINE Series, incorporating the very latest high-energy, rare earth magnets (neodymium iron boron). Once again, we are setting the standards that others only hope to duplicate. Recently acknowledged by the Frost and Sullivan Foundation, a leading market specialist in the motion control industry, Industrial Drives and its parent, Kollmorgen Corporation, continue to rank first in servo technology.

Other achievements? Yes, too many in fact to mention. Each achievement stands as a testimony to the committed quality and excellence in design technology. This constancy of purpose is unyielding in an era of rapidly changing technology.





## **European Community (EC) Declaration of Conformity**

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



# HOW TO USE THIS MANUAL

## INTRODUCTION

This Installation and Setup Manual is designed to help you properly install a Smart Drive Servo System. You do not have to be an expert in motion control to operate the system, however, this manual does assume you have the fundamental understanding of basic electronics and motion control concepts and safety. Many of these are explained in the glossary of this manual.

The Smart Drive is a computer configurable servo loop controller. An understanding of computer operation techniques will be beneficial to most users, however, this product is designed to be used without prior computer knowledge.

## RECOMMENDATIONS

It is recommended that you read this entire manual before you attempt to install the Smart Drive. This will familiarize you with system components, and their relationship to one another.

After installation check all system parameters to insure you have configured your Smart Drive properly.

Be sure to follow all instructions carefully and pay special attention to safety.

## ABBREVIATIONS

A/D	Analog-to-Digital Converter
CCW	Counter Clockwise*
CMR	Common Mode Rejection
CNC	Computer Numerical Control
Cont.	Continued
CW	Clockwise*
CR-LF	ASCII Carriage Return, Line Feed
D/A	Digital-to-Analog Converter
D/L	Direction Limit
EMF	Electro-Motive Force
EMI	Electro-Magnetic Interference
ESD	Electrostatic Discharge
GC	Goldline Cable
GCS	Goldline Cable Set
Hz	Hertz
I	Current
I/O	Input / Output
kHz	KiloHertz
KW	KiloWatts
LED	Light Emitting Diode
NEC	National Electrical Code
PC	Personal Computer
P/N	Part Number
PK	Peak
PLC	Programmable Logic Control
PWM	Pulse Width Modulation
R/D	Resolver-to-Digital
Regen	Regeneration
RMS	Root Mean Square
Tach	Tachometer
TL	Test Limits
UL	Underwriters Laboratories

\* Clockwise and counterclockwise reference as viewing the motor output shaft.



**NOTE**

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**There is a software switch that can change the direction of the motor. All references to direction (CW and CCW) in this manual are made with the assumption that DIR=1.**

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# CHAPTER 1

## PRODUCT DESCRIPTION

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### 1.1 INTRODUCTION

The Smart Drive product line is described. Product features are explored and the part numbering system is explained. This basic information will enable you to understand the Smart Drive's basic functionality. These concepts will develop a fundamental understanding required for the rest of the manual.

### 1.2 PRODUCT LINE DESCRIPTION

The Smart Drive is a full-featured, high-performance, brushless sinusoidal velocity loop servo controller. It is configurable to operate in one of many user selectable modes of operation. Examples of operational modes include; Velocity loop controller, Current (or torque) loop controller, and Pulse follower, or Electronic gearbox modes. All control modes use closed-loop servo feedback, are digitally compensated, and offer a wide degree of flexibility.

The Smart Drive Product line consists of the following components:

**3 Amp Drive Amplifier**

**10 Amp Drive Amplifier**

**20 Amp Drive Amplifier**

**30 Amp Drive Amplifier**

**55 Amp Drive Amplifier**

**50 Amp Power Supply**

**75 Amp Power Supply**

The Smart Drives rated 3, 10 and 20 Amp have integral power supplies (Self contained). The 30 and 55 Amp Drives require an external power supply and can use either the 50 or the 75 Amp units.

## 1.3 FEATURES

The Smart Drive offers a wide feature set to accommodate real-world requirements:

**EASY TO INSTALL:** The Smart Drive is easy to install because the servo amplifier and the power supply in lower amperage models are integrated into one package. Many interconnects are eliminated.

**PLUG-IN SCREW CONNECTORS:** Greatly simplifies installation and increases reliability. Special tools are not required. Electrical connections are made with a simple screw driver. All connections use plugs allowing cables to be pre-made.

**RUGGEDIZED RESOLVER BASED SYSTEM:** Resolvers provide inherent reliability in the harsh shock, vibration, and temperature environments found in servo motor applications.

**ESD and EMI PROTECTION :** The Smart Drive is designed with special isolated power supplies and custom circuitry to be hardened from ESD and EMI damage. EMI filters are built into the power supply sections of all units. Most connections to the drive are electrically isolated.

**USER CONFIGURABLE :** The Smart Drive uses simple variables and software switches to allow configuration and fine tuning to the end application.

**VELOCITY, TORQUE, and POSITION MODES:** User configurable modes of operation offer a wide variety of primary control.

**MASTER/SLAVE - ELECTRONIC GEARBOX MODE:** The electronic gearbox can be used to link two motors (or an external encoder and motor) together so that the velocity of the slave is proportional to the velocity of the master. The ratio can be from 32767:1 to 1:32767 and can be negative to allow the slave to move in the opposite direction.

**PULSE FOLLOWER MODES:** Pulse Follower modes give the Smart Drive the ability to emulate a stepper motor drive. Several different pulse modes are available; Pulse and Direction, Pulse Only, and Up/Down Pulse Trains.

**DIGITAL SERVO LOOPS:** Both the position and velocity loops are totally digital. The digital loops give the Smart Drive features not available in standard velocity drives, such as self-tuning, very low velocity offset, and digitally-adjustable servo tuning parameters. No potentiometers or compensation cards are used in the Smart Drive. This feature provides the user with a repeatability of setup. The user can download a file from one drive to another and have identical performance on each drive.

**SUPERIOR SERVO LOOP CONTROL:** The Smart Drive offers smooth, high-resolution control. The Smart Drive, through patented techniques, completely eliminates the digital dither normally associated with digital servo systems. Velocity feedback resolution is 1 part in 1,000,000 standard. Long-term speed stability is 0.01%.

**SELF-TUNING:** The Smart Drive can tune itself. Specify the desired bandwidth, damping type and the Smart Drive will do the rest. If the bandwidth is not known it can easily be determined experimentally.

**CHOICE OF TUNING COMPENSATORS:** The Smart Drive offers the user a choice between Pseudo - Derivative - Feedback (PDF) or Proportional-Integral (PI) compensation algorithms.

**HIGH FIDELITY COMMUTATION:** The Smart Drive has been designed with an effective 20-bit sinusoidal current commutation control. Combined with an 8 kHz update rate this allows both precise low speed smoothness and high speed torque. Speeds in excess of 12,000 RPM are possible with a six pole motor.

**EXTENSIVE DIAGNOSTICS:** The Smart Drive offers a comprehensive set of error diagnostics. Should an error occur, the Smart Drive displays an error message on a seven-segment display. The error is also logged in non-volatile memory and enunciated over the serial port. The Smart Drive maintains an error log which stores the last 20 errors. The Smart Drive has complete fault monitoring, including end-travel limit switches, feedback loss detection, and power stage status, hardware safety circuits (WatchDogs) and memory checksums.

**PC SCOPE:** The Motion Link programming environment also provides performance evaluation software, called PC-Scope, which allows the user to

plot out to the computer screen velocity feedback, velocity command, and motor current to a graphics mode IBM-PC compatible computer. This gives the user the ability to view drive characteristics without the use of an oscilloscope.

**HIGH RESOLUTION ANALOG INPUT:** The Smart Drive analog input command signal is converted to a digital signal using a dual gain converter system providing signal recognition as low as 610 microvolts.

**USER INPUTS AND OUTPUTS:** User inputs are current limited for a wide voltage range and EMI/ESD resistance. They include: Clockwise End Limit Travel, Counterclockwise End Limit Travel and Remote Enable. Discrete outputs include two Status Relays. One relay is a watchdog and the other is configurable as a drive-up or drive-fault relay.

**OPEN ARCHITECTURE OPTION PORT:** This port allows for future growth and option expansion. The port also makes possible Industrial Drives' ability to modify the product easily for large volume OEM applications.

**INTERNAL RAMP LIMITS:** The Smart Drive includes built-in acceleration and deceleration control.

**LINE REGEN OPTION CONNECTIONS:** Allows for efficient power and thermal management options.

**SERIAL COMMUNICATIONS:** The Smart Drive's serial communications can provide a powerful link to other popular factory automation devices such as PLC's, process control computers, and smart terminals. The Smart Drive offers RS-232 for most terminals and RS-422/RS-485 for multidrop communications. With multidrop the user can put up to 15 axes on one serial line. The Smart Drive can autobaud from 300 baud to 19.2k baud, eliminating the need to configure to start communicating.

**MOTION LINK Host Environment:** The Smart Drive also includes Motion Link, a powerful, menu-driven communications package for use with an IBM-PC<sup>®</sup> compatible computer. Motion Link provides a simple method of configuring the Smart Drive. Facilities are provided to archive users configuration to computer disk. On-line help and a full screen editor are built into Motion Link. The Smart Drive can also be reconfigured for use with a different motor by downloading the disk data with help from Motion Link.

Motion Link also provides functions similar to a digital storage oscilloscope for performance evaluations. Motion Link is available in versions for MSDOS or MS Windows.

**PRECONFIGURED:** Each Smart Drive is shipped from the factory configured for the appropriate motor. Standard factory settings include velocity mode of operation, all safety features enabled, and tuned for about 0 to 4 times rotor inertia mismatch.

## 1.4 PART NUMBER DESCRIPTION

A model number label is located on the right side of the Smart Drive, Power Supply Units, and External Regen Resistor Kits. The model number identifies how the equipment is configured.

The Smart Drive is factory loaded with a data file to match the motor's characteristics to the drive. This configuration is known as compensation. The part number indicates what configuration is present in the drive's memory.

An occasional request to ship a Smart Drive without a compensation file installed is received. The part number for this product is DXXXXX-00000000.

The Smart Drive will indicate that no compensation file is installed with an error log ("17: No Compensation File") message. The status LED display will flash a minus sign (-) to indicate the need for configuration.

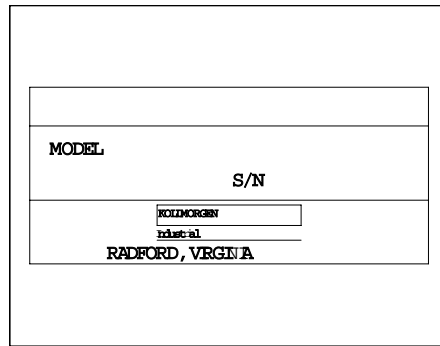


Figure 1-1. Smart Drive Part Number Label

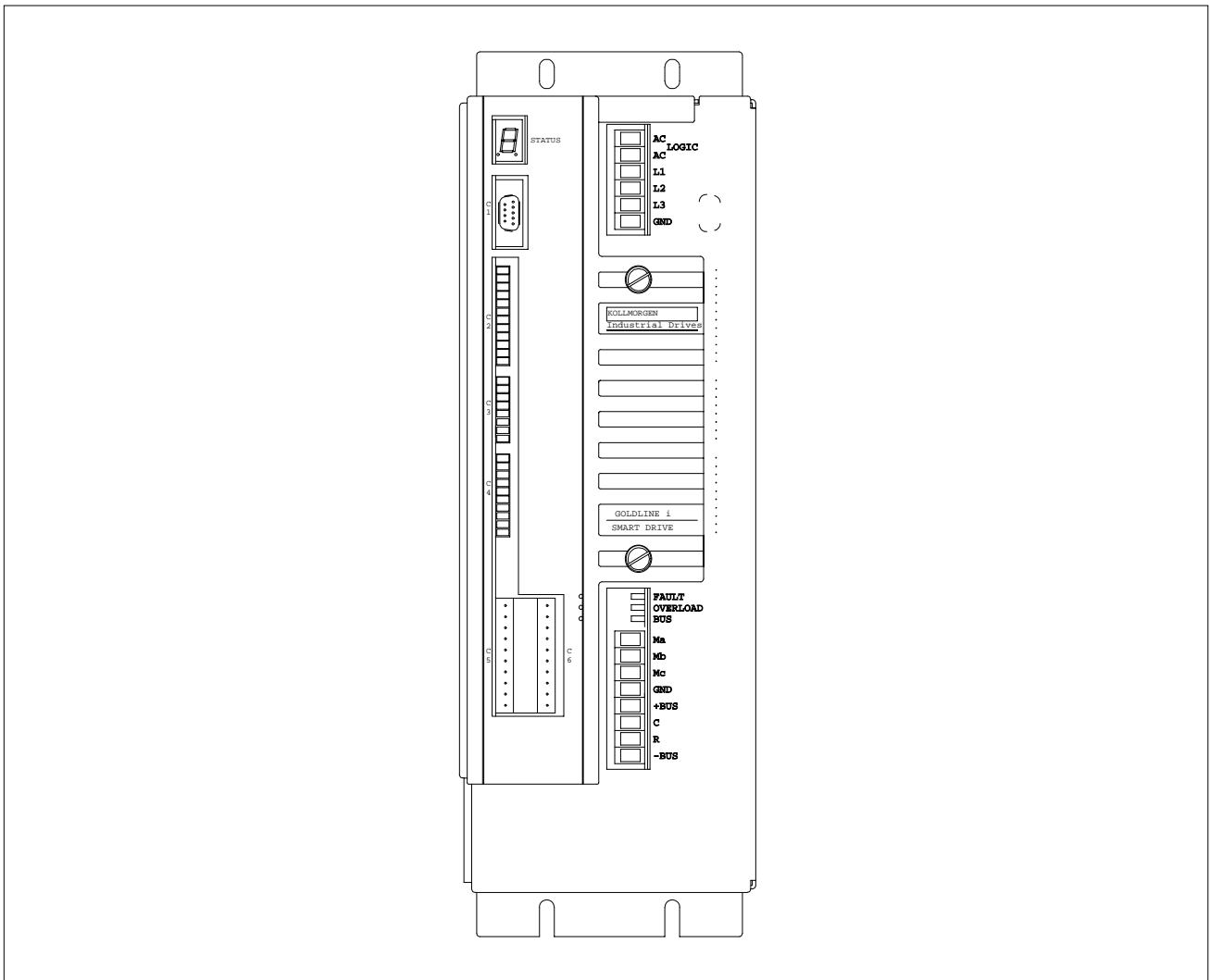
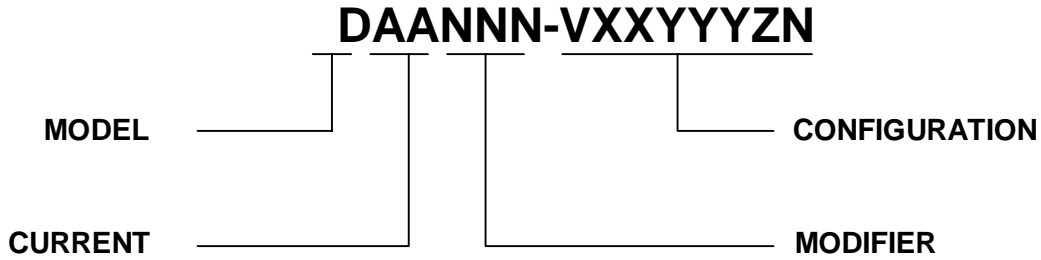


Figure 1-2. Smart Drive Front Panel (10 Amp Version)



**1.4.1 Smart Drive Model Number**

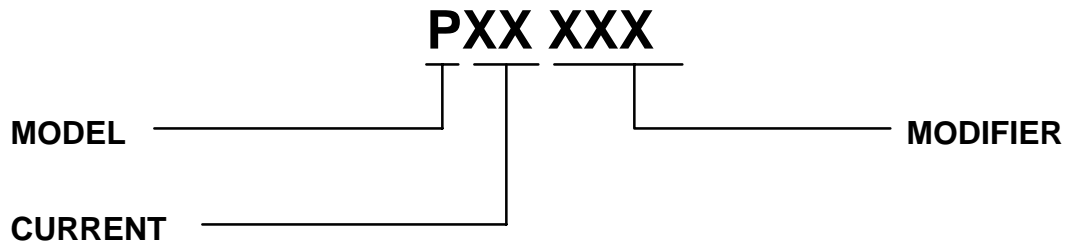


LEGEND	DEFINITION
Model D	D = Smart Drive
Current AA	03 = 3 Amps Cont. / Phase 10 = 10 Amps Cont. / Phase 20 = 20 Amps Cont. / Phase 30 = 30 Amps Cont. / Phase 55 = 55 Amps Cont. / Phase
Modifier NNN	-001 = Standard Hardware Identifier -00X = Factory Defined
Configuration V XX YYY Z N	Note: 00000000 = No Configuration - Standard Hardware Components  Compensation Voltage Rating: 1 = 115 VAC 2 = 230 VAC  Drive Current Rating: 03 = 3 Amp 10 = 10 Amp 20 = 20 Amp 30 = 30 Amp 55 = 55 Amp  Motor Type: 102 = B-102 205 = M-205, etc.  Winding: A = Motor Name Plate B = C =  Compensator Variation: 2 = Standard Configuration

**PART NUMBER EXAMPLE: D10001-210104B2**

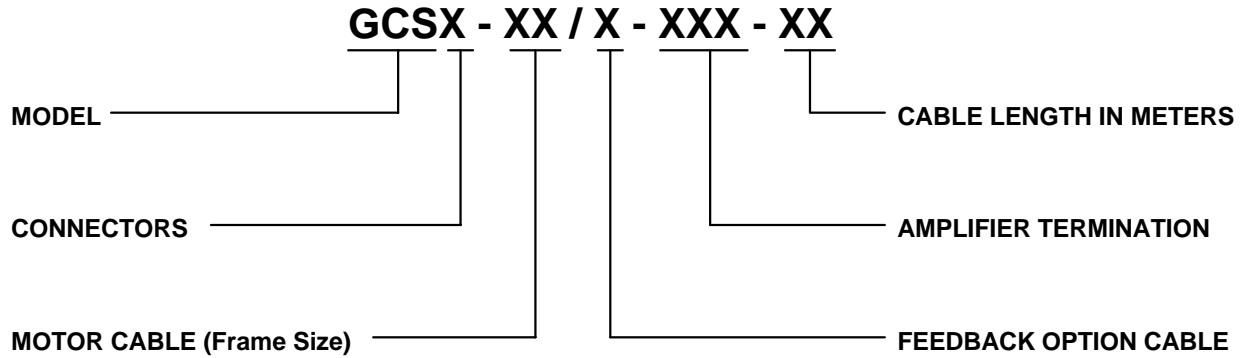
Represents a standard 10 Amp Smart Drive factory configured for a Goldline B-104-B motor operating on 220 VAC.

1.4.2 Power Supply Model Number



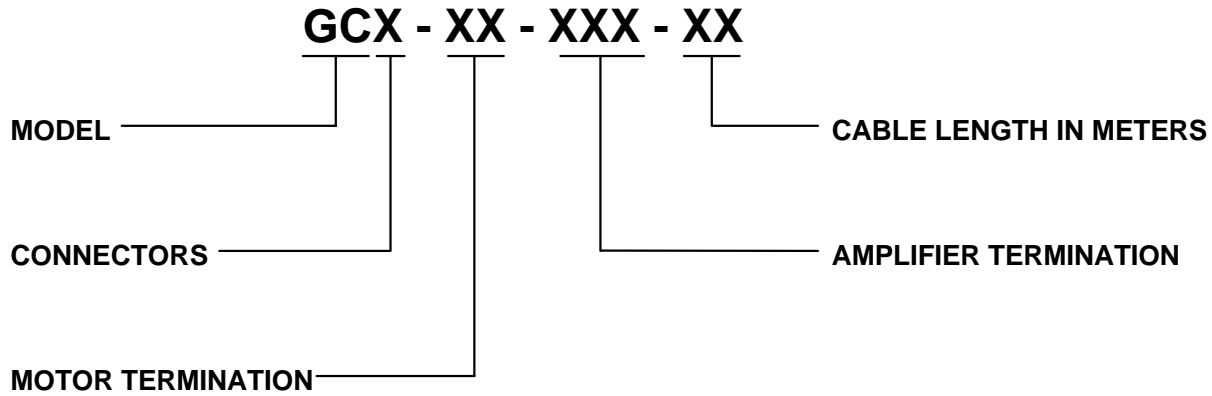
LEGEND	DEFINITION
Model P	Smart Drive Power Supply
Current 50 75	50 Amps/Phase 75 Amps/Phase
Modifier 001 00X	001 Standard 00X Factory Defined

1.4.3 Cable Set Model Number



LEGEND	DEFINITION
Model GCS	(Consists of separate motor and system feedback cables) Goldline Cable Set
Connectors A	Screw style (40X to 80X series only) Omit for bayonet style
Motor Cable (Frame Size) M1 M2A M2B M4A M4B M6A M6B M8A	B-10X, M-10X B-20X, M-20X (Smart Drive 3 to 10 amp continuous models) B-20X, M-20X (Smart Drive 20 amp continuous models) B-40X, M-40X (Smart Drive 3 to 20 amp continuous models) B-40X, M-40X (Smart Drive 30 amp continuous models) B-60X, M-60X (Smart Drive 3 to 20 amp continuous models) B-60X, M-60X (Smart Drive 30 to 55 amp continuous models) B-80X, M-80X (Smart Drive 30 to 55 amp continuous models)
Cable Length in Meters	3-75 meters in three meter increments
Amplifier Termination S/D N	Smart Drive Not Terminated
Feedback Option Cable R RB	System Resolver only System Resolver, Brake

1.4.4 Individual Cable Model Number



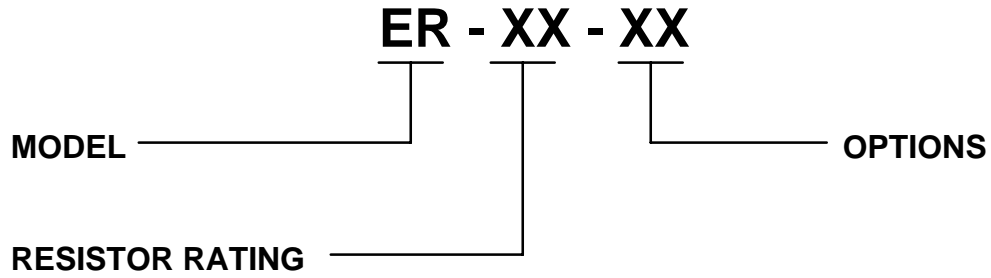
LEGEND	DEFINITION
Model GC	(Consists of separate motor and system feedback cables) Goldline Cable
Connectors A	Screw style (40X to 80X series only) Omit for bayonet style
Motor Termination  M1 M2A M2B M4A M4B M6A M6B M8A R RB AR	Motor or Feedback Option Cable  B-10X, M-10X B-20X, M-20X (Smart Drive 3 to 10 amp continuous models) B-20X, M-20X (Smart Drive 20 amp continuous models) B-40X, M-40X (Smart Drive 3 to 20 amp continuous models) B-40X, M-40X (Smart Drive 30 amp continuous models) B-60X, M-60X (Smart Drive 3 to 20 amp continuous models) B-60X, M-60X (Smart Drive 30 to 55 amp continuous models) B-80X, M-80X (Smart Drive 30 to 55 amp continuous models) System Resolver System Resolver, Brake Application Resolver
Cable Length in Meters	3-75 meters in three meter increments
Amplifier Termination S/D N	Smart Drive Not Terminated

1.4.5 ER-External Resistor Kit Model Number



**NOTE**

Contact Kollmorgen Regional Office Application Engineering to size regeneration capability.



LEGEND	DEFINITION
Model ER	External Resistor Kit
Resistor Rating 10 11 12 13 20 21 22 23 30	To Be Assigned 40 Ohms, 400 W., 230V, 3 Amp Model Only 20 Ohms, 400 W., 230V, 10 Amp Model Only 8.8 Ohms, 700 W., 230V, 20 Amp Model Only 4.5 Ohms, 500 W., 230V, 50 & 75 Amp Models Only 4.4 Ohms, 1000 W., 230V, 50 & 75 Amp Models Only 2.2 Ohms, 1000 W., 230V, 75 Amp Model Only 4.5 Ohms, 500 W., 230V, 50 & 75 Amp Models Only 8.8 Ohms, 400 W., 230V, 20 Amp Model Only
Options XX	Factory Defined

## 1.5 Specifications and Ratings

**Table 1-1. Smart Drive Specifications**

<b>Table 1-1. Smart Drive Specifications</b>							
	<b>Amplifier Model</b>	<b>03</b>	<b>10</b>	<b>20</b>	<b>30</b>	<b>55</b>	
	Power Supply type	internal	internal	internal	external	external	
<b>Main Input Power</b>	Voltage (Vac)	95 to 254	95 to 254	95 to 254	n/a	n/a	
	Voltage (Vdc)	125 to 360	125 to 360	125 to 360	295 to 360	295 to 360	
	1 Phase / 3 Phase / DC	1/3 ph	1/3 ph	1/3 ph	3 ph	3 ph	
	Frequency $\pm 5\%$	50/60	50/60	50/60	50/60	50/60	
	Input power @ dc (kva)	n/a	n/a	n/a	13.33	24.18	
	Input power (kva) @ 115 Vac 1 ph	0.85 kva	2.3 kva	2.3 kva	n/a	n/a	
	Input power (kva) @ 230 Vac 3 ph	1.7 kva	5.7 kva	7.9 kva	n/a	n/a	
	Under volt trip (on power-up)	90Vdc	90Vdc	90Vdc	255Vdc	255Vdc	
	Under volt trip (normal)	90Vdc	90Vdc	90Vdc	125Vdc	125Vdc	
	Over volt trip	430 Vdc	430 Vdc	430 Vdc	430 Vdc	430 Vdc	
<b>Control Input Power</b>	Input voltage (Vac, 1 phase)	95 to 254	95 to 254	95 to 254	95 to 254	95 to 254	
	Input current	1 to .5 A	1 to .5 A	1 to .5 A	1 to .5 A	1 to .5	
	Frequency $\pm 5\%$	50/60	50/60	50/60	50/60	50/60	
	Logic dc voltage			n/a			
	Logic dc current			n/a			
	Fan current (115 Vac)			n/a			
<b>Output Power</b>	Continuous Power (kw) (45°C ambient) @ 115 Vac 1 ph	0.55 kw	1.7 kw	1.7 kw	n/a	n/a	
	Continuous Power (kw) (45°C ambient) @ 230 Vac 3 ph	1 kw	3.3 kw	6.7 kw	11 kw	20 kw	
	Control method	Sinusoidal PWM current control					
	Rated output current (amps)	3	10	20	30	55	
	Max. current for 2 sec. (amps)	6	20	40	60	110	
	Tolerable load inertia range (B series)	0 to 5 times (Standard)					
	Tolerable load inertia range (M series)	0 to 3 times (Standard)					
	PWM switching frequency	15 kHz	15 kHz	15 kHz	10 kHz	10 kHz	
	Motor current ripple	30 kHz	30 kHz	30 kHz	20 kHz	20 kHz	
	Form factor (rms/avg.)	$\leq 1.01$	$\leq 1.01$	$\leq 1.01$	$\leq 1.01$	$\leq 1.01$	
<b>Protective Functions</b>	Over Current, Over Volts, Under Volts, Control Volt Loss, Feedback Loss, Over Speed, Resolver loss, Over Temp						
	Over temperature trip (°C)	3 to 20 amp drives 118 °c and 90 °c for 30 and 55 amp drives					
<b>Diagnostics</b>	ROM/RAM check on power-up, Checksum EEPROM storage, Software and Hardware watchdog timers.						
	Display	Seven segment display for operation mode, drive status, and fault display					
<b>Commutation</b>	Update rate	125 us (8 kHz)					
	Resolver excitation frequency	8.0 kHz	8.0 kHz	8.0 kHz	8.0 kHz	8.0 kHz	

<b>Table 1-1. Smart Drive Specifications Continued</b>							
	<b>Amplifier Model</b>	<b>03</b>	<b>10</b>	<b>20</b>	<b>30</b>	<b>55</b>	
<b>Current Loop Specifications</b>	Current loop update rate	Analog (Continuous)					
	Current loop BW	1000 Hz @ 0 speed					
	Torque limit input (serial/analog)	0 to ±4095					
<b>Velocity Loop Specifications</b>	Control Algorithm	PID/PDF					
	Velocity loop update rate	500 us (2 KHz)					
	Velocity loop BW	up to 125 Hz					
	Speed control range	0 to 14000 rpm in serial mode and 0 to 16393 in analog mode					
	Speed command Input	Serial/Analog					
	Maximum speed	14,000 RPM @ 12 bits					
	Minimum speed	1 RPM serial or 1/16393 in analog mode					
	Long term speed regulation	.01%					
<b>Position Control Specifications</b>	Control Algorithm	PID/PDF					
	Position loop update rate	500 us (2 KHz)					
	Position loop BW	up to 25 Hz					
	Position range	32 bit signed					
	Position feedback resolution	12-16 bit/rev (4096-65536 cts/rev) 5.27 Minutes @ 12 bits					
	Position feedback accuracy	18 Minutes @ 12 bits					
	Position feedback repeatability	1 Minute					
	Max. input pulse frequency	1.2 MHz					
<b>Remote Enable, CW limit, CCW limit,</b>	Input voltage (max.) Min. on Max. off	32 V differential 10 V 1 V					
	Input current @ 12 volts @ 24 volts	10 mA 20 mA					
<b>Analog Input</b>	Maximum voltage	13 V differential					
	Minimum voltage	610 uV (0 to ± 1.25 V) and 4.9 mV (±1.25 to ±10)					
	Voltage range	-10 to +10 V					
	Input impedance	> 10K ohms					
	CMR	50dB					
	Long term drift	100 ppm (0.075%/°C)					
<b>Encoder Input</b>	Absolute maximum voltage	±10 V differential					
	Common-mode range	n/a					
	Input Current	7.5mA @ ±3V to 15mA @ ±5 V					
	Input Impedance	n/a					
	Differential-Input voltage on	2.5 V min.					
	Differential-Input voltage off	.5 V max.					
	Line receiver type	Discrete Opto-Isolator					

**Table 1-1. Smart Drive Specifications Continued**

	<b>Amplifier Model</b>	<b>03</b>	<b>10</b>	<b>20</b>	<b>30</b>	<b>55</b>
<b>Encoder Output (RS485 standard)</b>	Output voltage (high-level)	3.75 V @ 20 milliamps @ 25° C				
	Output voltage (low-level)	1.10V @ 20 milliamps @ 25°C				
	Line driver type	LTC487 driver				
<b>Status Relays</b>	Capacity	2 A @ 28 Vdc or 300 Vac resistive				
<b>Tach monitor</b>	Output voltage range	0 to ± 8 V				
	Output impedance	1K ohms				
<b>Current Monitor (IMON)</b>	Output voltage range	0 to 5 volts				
	Output impedance	1K ohms				
<b>Environment</b>	Internal heat dissipation (watts) (not including regen)	37 w	120 w	240 w	254 w	465 w
	Operation temperature (°C)	0 to 45				
	Storage temperature (°C)	-20 to 70				
	Humidity (non-condensing)	10% to 90%				
	Atmosphere	With no Corrosive gasses or dust				
	Altitude	3300 feet max. without derate				
	Vibration	0.5g				
<b>Package</b>	Weight lb (kg)	14 (6.36)	20 (9.08)	20 (9.08)	24.0 (10.9)	24.0 (10.9)
	Height in (mm)	14 (355.6)	16 (406.4)	16 (406.4)	16 (406.4)	16 (406.4)
	Width in (mm)	4.65 (118)	5.6 (142)	5.6 (142)	6.57 (167)	6.57 (167)
	Length in (mm)	11 (280)	11 (280)	11 (280)	11 (280)	11 (280)



<b>Table 1-2. Smart Drive Power Supply Specifications</b>							
	<b>Amplifier Model</b>	<b>03</b>	<b>10</b>	<b>20</b>			
	<b>Power Supply Model</b>				<b>50</b>	<b>75</b>	
<b>Input Power</b>	Voltage (Vac)			207 to 253		207 to 253	
	1 Phase / 3 Phase / DC			3 Phase		3 Phase	
	Frequency ±5%			50/60		50/60	
	Output voltage (Vdc)			255 to 360		255 to 360	
	Power facility capacity (kva)			15 kva		22.5 kva	
<b>Input Current</b>	Rated current (amps)	7	20	20	50	75	
	Max. current, 2 sec. (amps)			75		112	
	Max. current, 50 msec (amps)			100		150	
<b>Output Power</b>	Output volts			310		310	
	Output current			50		75	
<b>Control Power</b>	Voltage (Vac, 1 phase)			n/a			
	Frequency ±5%			n/a			
	Logic voltage (volts)			n/a			
	Logic current (amps)			n/a			
	Fan current (115 Vac)			n/a			
<b>Protective Functions</b>	Over temperature trip						
	Other			Under volts, Over Temp, shorted regen transistor			
<b>Regen</b>	Regen trip voltage (on)	390 Vdc	390 Vdc	390 Vdc	390 Vdc	390 Vdc	
	Regen off voltage						
<b>Internal Shunt Regulator</b>	Peak current (amps)	10	13	19.5	25	50	
	Resistance (ohms)	40	30	20	16	8	
	Watts	40	40	40	100	150	
<b>External Shunt Regulator</b>	Peak current (amps)	10	20	45	100	200	
	Minimum resistance (ohms)	40	20	8.8	4.3	2.15	
	Watts						
<b>Soft Start</b>	Surge current (max. amps)	17	17	17	40	40	
	Charge time (max. sec)	1.5	1.5	1.5	1.5	1.5	
	Under volt trip (on power-up)			255 Vdc		255 Vdc	
	Under volt trip (normal)			125 Vdc		125 Vdc	
<b>Environment</b>	Internal heat dissipation (watts) (not including regen)			175		250	
	Operation temperature (°C)	0 to 45					
	Storage temperature (°C)			-20 to 70			
	Ambient humidity			10% to 90%			
	Atmosphere			With no Corrosive gasses or dust			
	Altitude			3300 feet max. without derate			
	Vibration			0.5g			
	<b>Power Supply Model</b>				<b>50</b>	<b>75</b>	
<b>Package</b>	Weight lb (kg)			23 (10.44)		24 (10.9)	
	Height in (mm)			16 (406.4)		16 (406.4)	
	Width in (mm)			5.7(144.6)		5.7 (144.6)	
	Depth in (mm)			11.2 (284)		11.2 (284)	



# CHAPTER 2

## THEORY OF OPERATION

---

### 2.1 INTRODUCTION

The material presented in this chapter is designed to build a basic understanding of the operation of the Smart Drive System. This foundation of knowledge will allow a user to continue on with this manual and become proficient at integrating the Smart Drive into a machine control system.

As with any microprocessor based product, the operational characteristics are often governed by three characteristics; the hardware platform, the operating firmware, and the user's configuration. It is therefore necessary to make some references to system variables which have not yet been introduced by this manual.

### 2.2 CORE PROCESSOR

A 16MHz embedded micro-controller is the heart of the Smart Drive. It uses its internal operating system to monitor inputs, adjust outputs, communicate serially, maintain servo control, and monitor faults.

The Smart Drive uses electrically-erasable-programmable-read-only-memory (EEPROM) to maintain user configuration data. The microprocessor has direct connections to an Option Port for interface to factory-made peripheral devices.

The firmware that controls the core processor and gives the Smart Drive its operating characteristics is saved in EPROM. The identification number for this firmware is available using the "VER" command. The "HVER" command can be used to determine the hardware revision identifier.

### 2.3 STATUS DISPLAY AND LEDES

A seven segment status display is available to the microprocessor to indicate important system information. The Status Display normally indicates the set mode of operation (OPMODE) but in the event of a fault it will flash a distinct error code.

The decimal point in the display is also used for status indication. It indicates the state of the 'global' drive enable. If the Remote Enable input is active, the software enable (EN) is active, and no serious faults are present the microprocessor will enable the power stage. This condition is indicated by an illuminated decimal point. If any of the above conditions prevent the drive from enabling the decimal point will remain off. A flashing decimal point is used to indicate that the drive is enabled but some safety feature has been disabled.

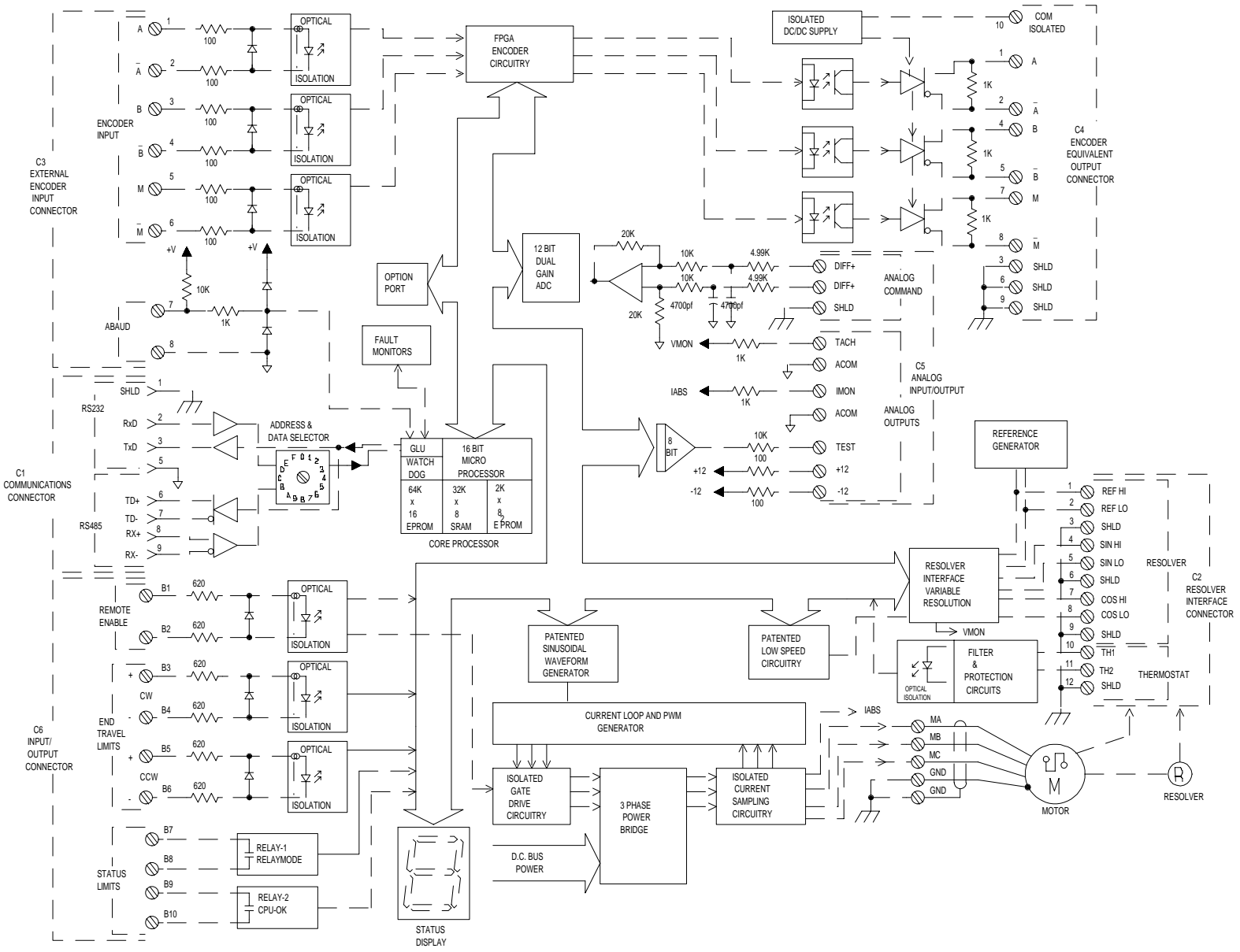
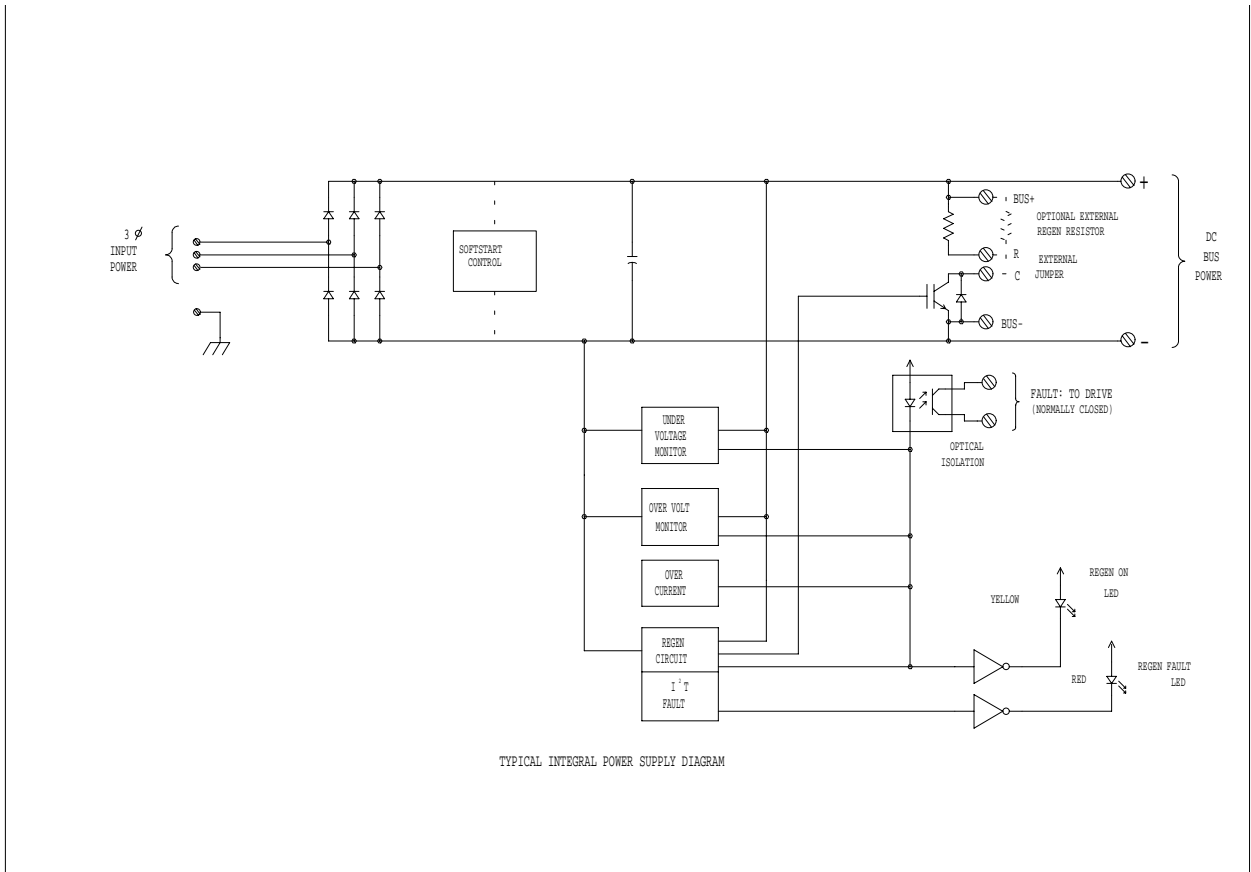


Figure 2-1. The Smart Drive Amplifier Simplified Schematic ic Diagram



**Figure 2-2. The Smart Drive Power Supply Simplified Schematic Diagram**

The Smart Drive also has three Status LED's associated with the power section of the drive:

- GREEN: DC BUS POWER ON
- YELLOW: REGEN CIRCUIT ACTIVE
- RED: REGEN OVERLOAD FAULT

In addition, the 50 Amp and 75 Amp power supply units provide an extra LED.

- RED: OVER TEMPERATURE

Under normal static conditions the green BUS LED is the only LED that will be illuminated. The yellow REGEN ACTIVE LED may flash during aggressive decelerations. The red REGEN OVERLOAD LED coming on will also log an over-voltage fault and indicates that too much power is being pumped back into the drive.

## 2.4 ANALOG INPUT

The velocity loop (or torque loop) described later in this chapter can receive its input from an analog voltage source. The analog input to the Smart Drive is differential meaning that the signals received at the two inputs are subtracted from each other to create a 'difference' which is then used by 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 front-end also has a low pass filter to prevent high frequency noise from entering the system.

The input voltage from the differential receiver is applied to precision dual gain Analog-to-Digital (A/D) conversion system. The purpose of the dual gain front end is to provide a low signal input

resolution of 610uV. The microprocessor has direct control over the gain stage which is selectable as 1:1 or 8:1. The processor is responsible for offsets, monotonicity, and hysteresis.

On an increasing ramp (Absolute value) the high gain stage is in place until the input voltage exceeds 1.2 Volts at which time the micro switches to low gain. On a decreasing ramp the micro keeps the low gain until the input goes below 1.0 volts.

The A/D conversion system is read by the microprocessor every 500uS. The raw input reading is available as the "ANIN" variable and is scaled +/- 16,383 for an input voltage of +/- 10 Volts. Since analog systems often require scaling and offset bias, the Smart Drive adds the ANOFF ( Analog Offset) variable to this reading, performs a 'logical AND' with ANDB ( Analog Dead Band) and scales it with VREF (or TREF) before passing the data to the velocity or torque loops. The 'ANIN' variable indicates the analog reading after being offset.

The Smart Drive also offers an automatic velocity zeroing function. Invoking the ANZERO command while the drive is enabled will sample motor velocity over a 100 millisecond period and update ANOFF accordingly. This command also incorporates an internal offset mechanism which has finer resolution than ANOFF is capable of providing.

## 2.5 DISCRETE INPUTS

The microprocessor has an I/O processor which constantly monitors the external inputs. The remote enable input will disable or enable the power stage output to the motor. The assertion of this signal will also initiate an attempt to recover from a fault condition. The Clockwise End Limit Travel, and the Counterclockwise End Limit Travel inputs are used to limit current or velocity commands to the motor. These two 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 three inputs are "active enable," meaning current must flow through these signals to allow the system to operate. This provides a 'dead-man' safety feature.

All inputs are current limited and will operate with 10 to 30 Vdc applied. Current is a non-linear function of voltage and can be expected to be between 10 and 30 milliamps.

## 2.6 ENABLING THE DRIVE

The enable circuit, which can be controlled by both hardware and software, has two states - enabled and disabled. In order for the drive to become enabled there must be no severe faults, the software enable must be active and the hardware enable must be active. See READY and ACTIVE switch variables.

The software enable logic can be enabled by the serial port using the 'EN' command (READY 1) and can be disabled using the "DIS" (or "K") command. The software enable (EN) initializes on power-up to enabled allowing a hardware enable without a software enable. Fault resetting and re-enabling action is initiated by "EN" command or rising edge of the hardware enable line. The software enable and disable are generally used for debug purposes.

The Remote Enable Input also has a direct connection to the Power Stage and must be active to allow power to the motor. A rising edge on the Remote Enable input will automatically perform an 'EN' command.

Enable status is displayed in the 7 segment display's decimal point.

Remote Enable	EN / DIS	FAULT Switch	READY Switch	ACTIVE	DRIVE STATE
OFF	DIS	OK	0	0	OFF
OFF	EN	OK	1	0	OFF
ON	EN	OK	1	1	ON
OFF→ ON	X	X	1	1	ON
X	X	FAULT	0	0	OFF

**Table 2-1. Drive Enable and Switch Status**

## 2.7 RELAY OUTPUTS

The Smart Drive has two Relay outputs for customer interface. One of these relays is controlled by the Smart Drive hardware and is a CPU Active watchdog relay. If the CPU fails to operate properly the relay opens its contacts. This relay is wired in the user's power control circuit for added safety. The CPU Active relay requires about 500 mS to become active and is typically shunted by a momentary contact during power up.

The other relay is controlled by the Smart Drive's microprocessor. It is user configurable for use as a 'Drive Up' or 'Drive Fault' indicator. These relay contacts are normally closed when the condition is true and will open to signal the user as follows:

1. The Drive is disabled and/or there is a fault (RELAYMODE = 1). This is a drive-up configuration.
2. The drive is disabled only when there is a fault (RELAYMODE = 0). This is a fault relay configuration.
3. The drive is disabled for undervoltage and/or motor overheat faults (RELAYMODE = 2). The fault automatically resets after the fault condition is corrected.

## 2.8 MOTOR THERMOSTAT INPUT

The Smart Drive provides an input designed to accept the motor thermostat connection. Industrial Drives Gold Line motors and cables connect the thermostat using the resolver cable. The input to the Smart Drive should be electrically closed through the thermostat for proper operation. The Smart Drive would normally flash an 'H' in the status display when this input is neither disabled or closed. The thermostat may alternatively be used as an input to a PLC or in the AC safety circuit if desired by simply shorting the thermostat input. There is a software switch that can disable the Smart Drives scan of the thermostat input (THERMODE).

## 2.9 SERVO LOOP DESCRIPTION

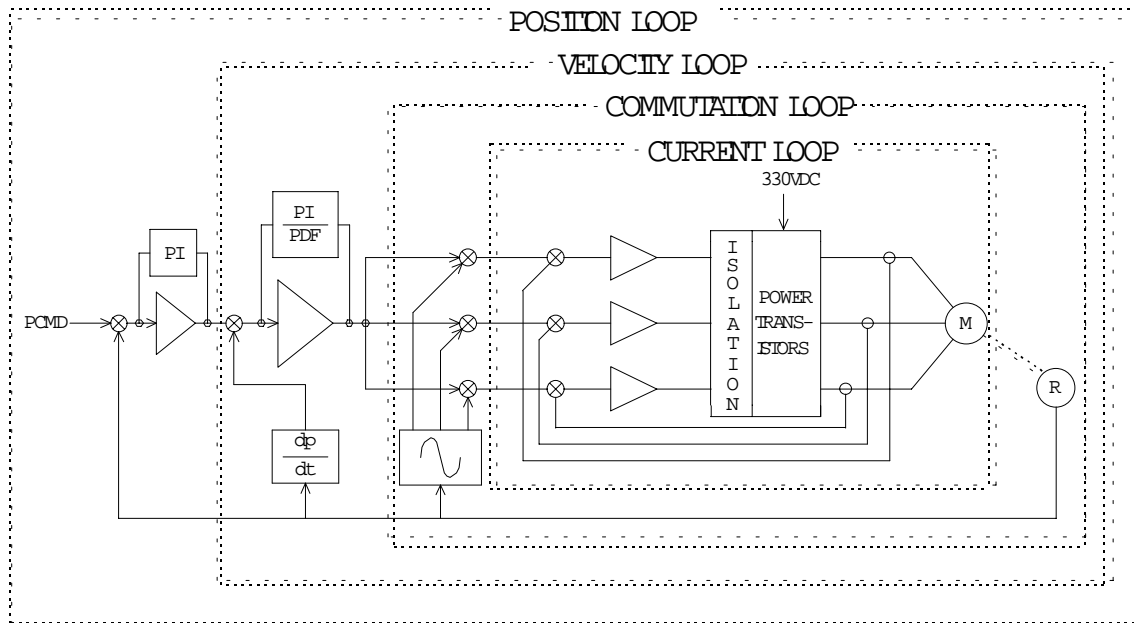
The Smart Drive provides high performance motor control by closing up to four distinct closed loop systems; the commutation, current, velocity, and position loops.

The inner most control loop is the current loop. The function of the current loop is to regulate motor current as directed by an input command signal. Since current and torque are proportional in a Permanent Magnet (PM) motor, the current loop is often referred to as the Torque Loop. The Smart Drive uses a digitally programmable analog current loop for high bandwidths. The gain of the current loops is digitally set able for a given motor's load characteristics. There are actually three current loops; one for each motor phase. 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 for highest efficiency. The PWM center frequency is 15 kHz for the 3, 10, and 20 Amp units. The 30 and 55 Amp units switch at 10kHz. The input to the current loop comes from the microprocessor and may be the output of the velocity loop or, if operating as a torque controller (OPMODES 2 & 3) directly from the user commanded torque.

The next basic loop is the commutation loop which converts a single phase current command signal into a three phase, motor-position-modulated sine wave

input to the current loops. The Smart Drive has a patented sinusoidal wave form generator which uses a technique called Torque Angle Advance to get top performance out of the Industrial Drives GoldLine motors. The waveform generator is part of the microprocessor and is updated at an 8 kHz rate. This provides hi-fidelity sinewave commutation at both low and high velocities. The sinewave output must be aligned to the back-emf (BEMF) characteristics of the motor. This is why resolver alignment to the motor is critical.

The next loop in the system is the velocity loop. The purpose of the velocity loop is to regulate motor speed. Like the commutation loop, the velocity loop is fully digital and uses the resolver feedback to calculate actual motor velocity. The difference between actual and desired velocity is filtered through a compensator algorithm and fed to the commutation circuit. The compensator may be chosen by the user to be either Pseudo-Derivative-Feed Forward (PDF) KV, KVI or Proportional-Integral (PI) GV, GVI. The command for the velocity loop can come from a direct user input or can be the output of the position loop. The velocity loop is a digital sampling system operating at 2 kHz.



**Figure 2-3. Smart Drive Servo Loop Concepts**

The final control loop is the position loop. The purpose of the position loop is to maintain motor



position and is present only when using operational modes incorporating the encoder input channel or the position loop mode (OPMODES 4-8). Like the commutation and velocity loops, the position loop is fully digital and uses the resolver to determine actual motor position. The position error is fed through a PI compensator (GP, GPI) algorithm to the velocity loop regulator. The position loop is a digital sampling system operating at 2 kHz.

## 2.10 POWER UP SEQUENCE

Upon power-up the Smart Drive performs a series of self-tests as indicated by the rotating status display. After finding no errors working RAM is loaded with saved variables from the EEPROM non-volatile memory. Failure to find a valid compensation file would result in a '-' in the status display. If the bus voltage comes on after power-up a 'U' - under voltage fault may appear in the display. The Remote Enable input may now be energized, enabling the servo loops.

## 2.11 SERVO LOOP OPERATION

The design of the control loops has been discussed individually. Now the operation as a system is presented. The Smart Drive has many internal variables that can be used to examine and dictate system operation. Many of these variables are presented parenthetically in the below discussion to help disclose meanings and relationships.

The Smart Drive is most often configured to operate as an analog velocity loop controller (OPMODE 1). The velocity loop (described above) receives its input from the analog-to-digital (A/D) conversion system. This input command signal ("ANIN") is then processed through an algorithm which scales the signal (VREF, ANOFF, ANDB) and turns it into a velocity command ('VCMD'). The actual present velocity ('VFB') is subtracted from the commanded velocity creating a velocity error ('VE'). The velocity error is then fed through a digital compensation algorithm ('PDF', 'KP', 'KPI', 'GP', 'GPI'). The output of the compensator is the desired torque ('TCMD'). This torque command is checked against peak ('IMAX'), continuous ('ICONT'), and Foldback current clamp (FOLD) limits. Sinusoidal commutation modulation is added to the command before it is outputted to the three phase current loop regulator which calculates a current error. The error is

converted to a pulse width modulated (PWM) signal and fed to the power transistor bridge. The power bridge uses the high voltage DC power supply (325 Vdc bus) to supply a required current to the motor windings. Actual motor current ('IFB'), velocity ('VFB'), and position ('PRD') are updated and the process begins again.

## 2.12 CURRENT SAMPLING

The current loop receives corrective feedback from the current sampling circuitry. The current sensors use resistive sampling techniques in the 3, 10, and 20 Amp units while the 30 and 55 Amp units use Hall Effect samplers.

The current sample is used by the current loops to regulate the current in each of the three motor phases. The three phase current signals are rectified and monitored by the microprocessor ('IFB') to limit motor currents to safe values as set by compensation file parameters. The rectified composite current feedback signal is available for user use and is called the 'I Monitor'. It should be noted that the composite current feedback signal suffers from signal loss in the rectifier circuitry and is not a good representation of motor current at low current values.

## 2.13 CURRENT FOLDBACK

The Smart Drive microprocessor monitors the current feedback signal and accumulates an 'RMS' value designed to indicate safe drive operating conditions. The system is similar to an I-squared-T accumulator. Under a step command input condition, this system will allow peak current (AMPS or 'IMAX') output from the drive for two seconds. After two seconds the drive begins an exponential 'Foldback' of the output current which over a period of six seconds will reduce the output current to the continuous drive rating. The system requires 16 seconds to fully recover. This feature is designed to protect the drive electronics, not the motor.

## 2.14 ANALOG OUTPUTS

Equivalent tachometer output and an Absolute Current monitor output are provided for customer

convenience. Each signal has a 1 kOhm resistor in series with it and may be referenced to the analog common (ACOM). The Tachometer equivalent signal comes directly from the resolver converter circuitry and is effected with the RDRES setting. The absolute current monitor comes from a three phase rectifier circuit receiving the current sample signals. Again, the current monitor output is not accurately scaled at low levels.

## 2.15 RESOLVER INTERFACE

The Smart Drive uses 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. The transformer is driven with an 8 kHz 4.2 Vac(rms) 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. It is important to use properly shielded cable and keep the cable away from noise radiating devices and cables.

The Smart Drive calculates motor velocity as the derivative of position (change in position). The digital resolution of the Resolver to Digital (R/D) converter system is variable and normally shipped from the factory as 12 bits ('RDRES' = 12) providing resolution of 1 part in 4096 per revolution. The Smart Drive additionally converts the resolver input to an extended 8 bit resolution using patented techniques. The total resolution is now 20-bit providing 1 part in 1,000,000 per revolution velocity data for extremely smooth motor velocity control. The user can change the conversion resolution to 14 or 16 bits at the expense of top speed. This allows the system designer to match pulses for master / slave applications or pulse follower applications, or to change the encoder equivalent output resolution.

## 2.16 ENCODER EQUIVALENT OUTPUT

The Smart Drive provides motor position data to the user in the form of quadrature encoder signals. These signals are created from the resolver signal using hardware for minimum phase lag. The outputs are driven using RS-485 line drivers and are isolated electrically from the Smart Drive system. Internally there is an isolated DC-to-DC power supply to drive

those outputs. There is a common pin associated with this power supply which can connect to the user's port to keep common mode noise and voltage spikes down to protect the devices. The Smart Drive provides a maximum line count governed by the R/D resolution ('RDRES') setting. This maximum setting is one-fourth of the R/Ds resolution. For example, 'RDRES' = 12 sets the converter to a 12 bit data width - or 4096 parts per revolution. This provides an equivalent 1024 line count encoder output which is quadrature encoded. The user can lower the line count ('ENCLINES') as required.

## 2.17 REGENERATION CIRCUIT

The regeneration circuit includes circuitry which monitors the main DC bus. During quick decelerations, the motor basically operates as a DC generator and pumps energy back into the bus causing the bus voltage to rise. The regeneration circuit limits excessive voltage rise during the deceleration periods by dumping the excess energy into a resistor load. An internal regeneration resistor is provided. Provisions for extra regen capacity are made through connections designed for a larger external regeneration resistor. The regeneration circuit turns on when the bus is above 390 VDC. This circuit is also used to quickly discharge the DC bus when power to the drive is removed. This feature is referred to as Dynamic Bus Discharge. An amber LED is provided to indicate that the regen circuit is active.

An electronic RMS power limiter circuit monitors the use of the regen circuit only when the internal regen resistor is used. A red Overload LED illuminates if this circuit detects excessive use of the regen circuitry.

The bus monitors also provide protection. A low input voltage is dangerous to the power stage, if left running. An under-voltage fault is signaled to the microprocessor and prevents drive operation with a latched fault. Likewise an excessive voltage condition can be dangerous to the entire power stage and is detected and latched with an over-voltage condition.

## 2.18 FAULT MONITOR

The Smart Drive's microprocessor is constantly monitoring the status of many different components. In general, the philosophy of the Smart Drive is to latch all fault conditions so the user 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. Here is a list of faults belonging to the drive hardware and operating system:

**Motor Over-Temperature:** The Motor's External Thermostat input is monitored for an open circuit condition. The user can define (THERMODE) what happens under this fault condition. The worst case event is a power stage disable with an 'H' placed in the status display.

**End Travel Limit Inputs:** The CW and CCW End Travel Limit Inputs are constantly monitored for an open-circuit condition. Although not necessarily an error condition, motor operation can be effected by these inputs. The user can define ('LIMDIS') what happens under this fault condition. The worst case event is that further motion in the given direction is not allowed with an 'L' placed in the status display.

**Drive Over-Temperature:** 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 Over-Current:** As described above, the Foldback detection system can 'clamp' the available output current. This is not a true fault condition but may cause undesired performance. This condition is indicated with a flashing 'F' in the status display and can be detected by monitoring the 'SAT' (saturated) switch variable.

**Bus Over-voltage:** As described in the Regeneration section an over-voltage condition shuts down the drive and displays a lower-case 'o' in the status display.

**Bus Under-Voltage:** As described in the Regeneration section, an under-voltage condition shuts down the drive and displays an 'u' in the status display.

**Power Stage Fault:** Hardware circuitry monitors load short-circuit, transistor failure, and instantaneous over-current. In general, a power stage fault can not be reset by toggling the Remote Enable.

**Resolver Loss:** Hardware is used to detect the presence of the Sine and Cosine resolver feedback signals. Either of these signals not being present will cause the Smart Drive to disable and display an 'r' in the status display.

**Low-voltage power supply faults:** Out of tolerance values on the internal +5Vdc logic supply will cause an 'n' to be displayed while out of tolerance +/- 12Vdc analog supplies will cause an 'A' to be displayed. Both conditions cause a drive shut-down.

**Memory reliability:** The user configuration non-volatile memory is checked for integrity upon power-up. Any discrepancy in this data is noted with an 'E' in the status display. The Smart Drive also checks its operating system memory and displays an 'e' in the status display if it finds something wrong.

**WatchDogs:** In addition, the Smart Drive incorporates two different watchdog systems. One system is hardware and is described in the Relay Outputs section. The other watchdog is maintaining software operation integrity. Failure of either watchdog circuit will open the CPU Active relay momentarily.

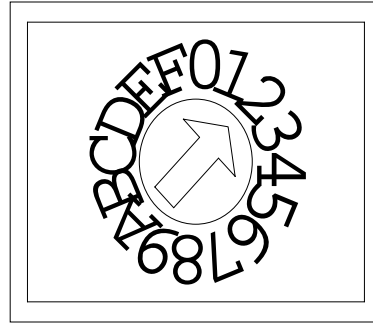
## 2.19 OPTION PORTS

There are two options ports on the Smart Drive. An OEM Option port and an Industrial Drives Option port. The OEM option port provides all user connections to an internal PCB connector. This allows an OEM user to design a custom interface that can reside within the Smart Drive enclosure. The Industrial Drives Option Port allows the factory to provide custom electronics for adapting the Smart Drive to specific applications such as emerging real-time network adapters.

## 2.20 SERIAL COMMUNICATIONS

The Smart Drive has a serial communications port for communicating with the MotionLink program or to a

machine controller computer. This port allows the user (or host computer) to monitor operations, issue commands, modify configuration, and troubleshoot the system. Both RS-232 or RS-485 physical layers are available. The user can select between RS-232 or RS-485 (and multi-drop address) by positioning a 16-position rotary switch accessible through the front panel.



**Figure 2-4. Smart Drive Address Switch**

The Smart Drive has the ability to automatically determine the hosts baud rate. This is called Autobauding. Upon power-up, if the autobaud enable input is jumpered, the Smart Drive will assume the autobaud sequence. While autobauding the Smart Drive waits for a series of carriage return characters (0Dh) to determine what rate the host is using. Once the rate is determined the BAUD variable gets set to that value. If the autobaud input is open the Smart Drive will use the preset baud rate (BAUD) on power-up. The baud rate can be set up to 19.2 Kb/s.

Further explanation of the serial port is available in Chapter 5: Serial Communications.

**2.21 DIGITAL FILTERS**

Two types of digital filters are available on the Smart Drive to provide greater latitude for load compliance and resonances. The filter switch variable, FILTMODE, has three modes - off (no filtering), low-pass filtering, and notch filtering.

Setting the switch to 1 ( FILTMODE = 1) inserts a low-pass filter in the torque command signal. The switch may be turned on and off while the drive is operating. The frequency of the low-pass filter is stored in LPFHZ in Hz and can also be changed while the drive is operating. The filter can be modeled as two cascaded, low-pass, single-pole filters, both with a 3 dB frequency of 200 Hz. LPFHZ should be set as high as possible since it limits the system performance.

FILTMODE 2 provides a notch filter that may be used to reduce the effect of resonance. When the notch filter is selected, the center frequency of the rejection band is determined by NCHHZ while its

bandwidth is controlled by NCHBW (both measured in Hertz).

Filters are temporarily disabled during the TUNE command.

**2.22 COMPENSATION FILES**

The Smart Drive is configured to operate with a given motor's characteristics by down-loading a compensation file to the drive. The compensation file (also called a TL file) contains factory settings to protect the motor and drive. Chapter 1 describes the Smart Drive Part Numbering System which includes the DOS file naming conventions. Each Smart Drive is factory configured with this compensation file already loaded. The name of the file can be found on the part number sticker on the right-hand side of the drive. It can also be determined using the 'MOTOR' command which causes the filename to be printed.

**Table 2-2. DOS Compensation Filename: VXXYYYYZN.DTL**

LEGEND	DEFINITION
Configuration	Note: 00000000 = No Configuration
V	Compensation Voltage Rating: 1 = 115 VAC 2 = 230 VAC
XX	Drive Current Rating: 03 = 3 Amp 10 = 10 Amp 20 = 20 Amp 30 = 30 Amp 55 = 55 Amp
YYY	Motor Type: 102 = B-102 205 = M-205, etc.
Z	Winding: A = Motor Name Plate B = C =
N	Compensator Variation: 2 = Standard Configuration

## 2.23 MEMORY MANAGEMENT

The Smart Drive's configuration data is stored in non-volatile memory (EEPROM). Upon completion of the power-up tests the stored variables are copied from the EEPROM to working RAM. This load procedure can be forced at any time by the user with the 'LOAD' command. As the user changes the Smart Drive configuration through the serial port, only the variables in working RAM are changed. The user may write the new configuration to EEPROM using the 'SAVE' command.

Once a Smart Drive is configured by the user for exact performance, the settings can be archived to diskette. Motion Link has the menu: Variables: Receive for this purpose. The user may alternately choose to use the 'DUMP' facility instead. The archive file does not include some of the factory-determined compensation file parameters. To create an identical performance Smart Drive:

First, issues the "RSTVAR" command. This puts all user set-able variables and switch variables to factory-known settings.

Second, download the factory compensation file using the Setup:Open TL menu in Motion Link. This sets all motor-dependent variables. The Smart Drive is now configured as the factory would ship it.

Third, use the Motion Link: Variables:Open facility to download the archived data file.

# CHAPTER 3

## INSTALLATION

### 3.1 INTRODUCTION

The information in this chapter discusses the installation of the Smart Drive System. This chapter first discloses information common to all Smart Drive Systems then diverges into separate sections for mounting and wiring of Smart Drives with integral power supplies, Smart Drives with separate power supplies, and regen resistor options.

### 3.2 SAFETY INFORMATION

The safety-alert symbols are illustrated as follows:



**Figure 3-1. Safety-Alert Symbols**

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.

"**Warning**" alerts users to potential danger or harm. Failure to follow warning notices could result in personal injury or death.

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

"**Note**" highlights information critical to the users understanding or use of these products.

### 3.3 UNPACKING AND INSPECTION



**CAUTION**

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

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



**NOTE**

**Check all shipping material for connector kits, manuals, diskettes, and other small pieces of equipment.**

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.

### 3.4 INSTALLATION REQUIREMENTS

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

The environment that any electronic control system 'lives' in can effect its operation. Industrial Drives recommends that the Smart Drive and Power Supply be operated and stored under the following conditions. The components may be operated in higher temperature ambient conditions with derating. Please check with the factory for derating information.

Operating Temperature: 0° C to 45° C  
 Storage Temperature: -20° C to 80° C  
 Humidity: 10% to 90% (Non-Condensing)  
 Shock: 0.5 g

It is suggested that the Smart Drive (and associated components) be mounted in an electrical enclosure cabinet (or other suitable enclosure) to protect them from physical and environmental damage and provide added safety.

### 3.5 MOUNTING SMART DRIVES WITH INTEGRAL POWER SUPPLIES: 3-20 AMP MODELS

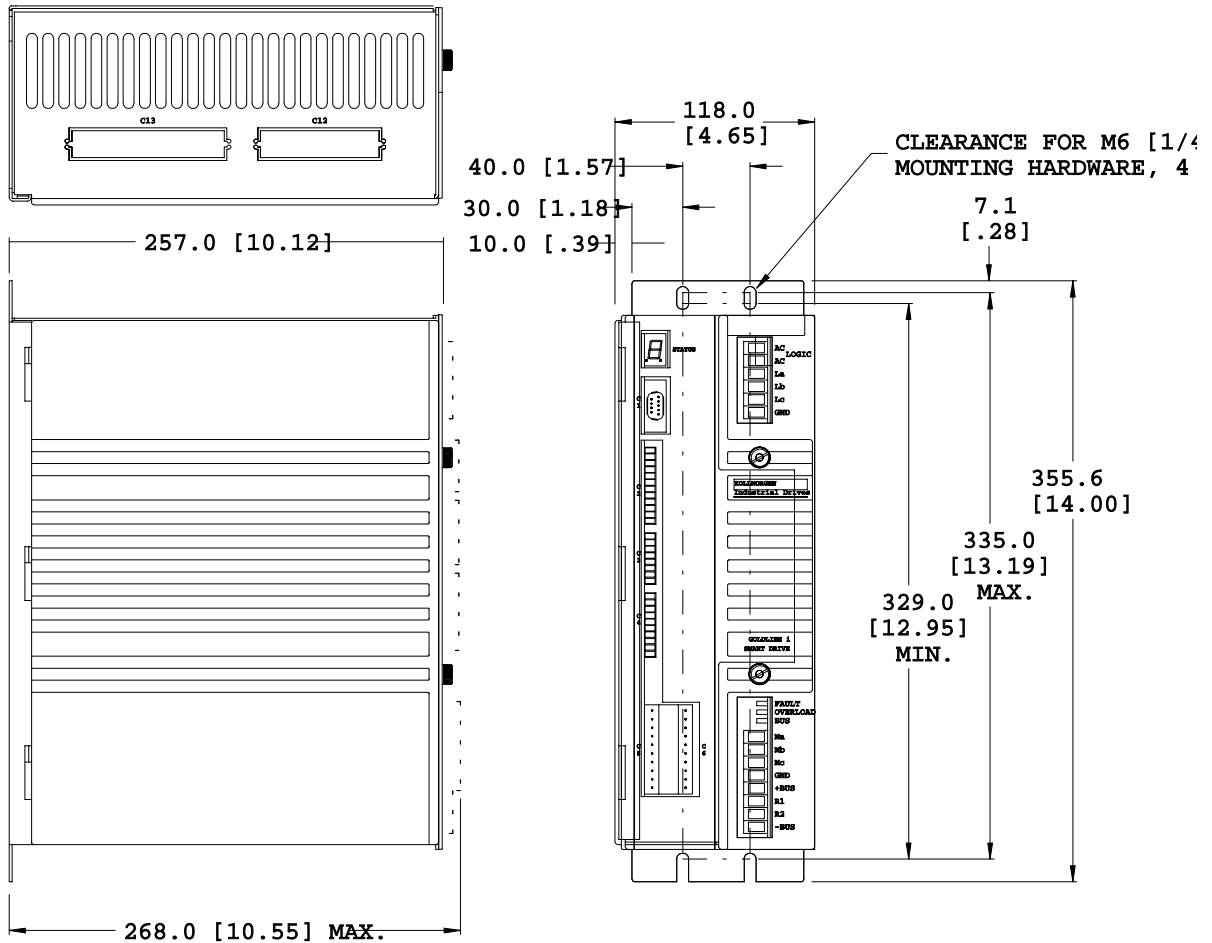
The Smart Drive should be mounted in the vertical position for maximum air flow. There should be a minimum of 25 millimeters (1 inch) of unobstructed space above and below the units. In addition, there should be a minimum of 20 millimeters (0.8 inch) between units to ensure proper airflow for these convection-cooled units.

The drawings on the following pages provide outline and dimensions and hole patterns for mounting these units. The Smart Drive is mounted to the grounded electrical panel using four M6 or 1/4-20 (or similar) screws. The use of lock washers is highly recommended.

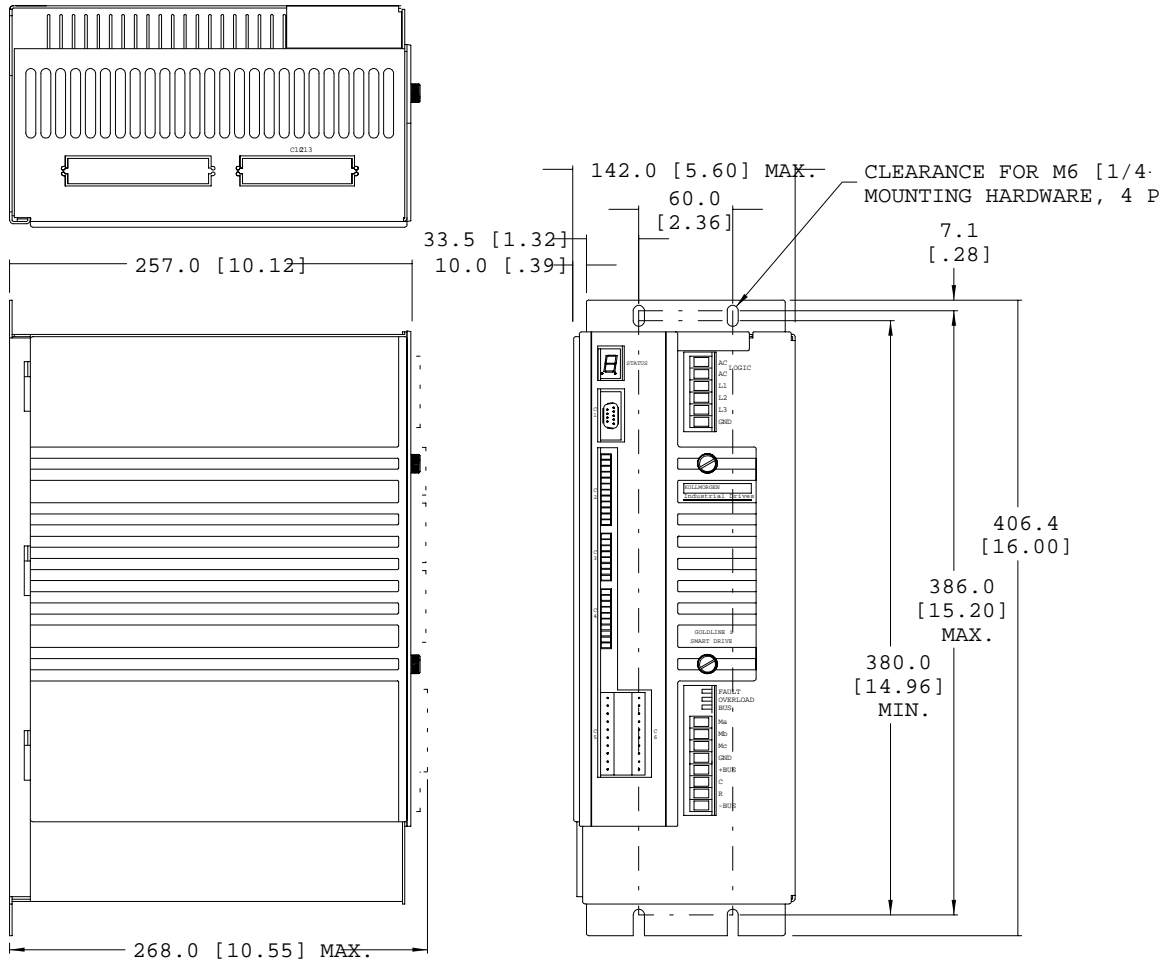
### 3.6 MOUNTING SYSTEMS WITH MODULAR POWER SUPPLY: 30 AND 55 AMP MODELS

The Smart Drive(s) and Power Supply units should be mounted vertically. The Power Supply unit may be mounted on either side of the Smart Drive(s). A 20 millimeter (0.8 inch) space should be left between units. No more than two Smart Drives should be mounted to a side of the Power Supply. In systems using more than two Smart Drives per Power Supply, divide the drives to the left and the right of the Power Supply. Drawings in the following pages give the mounting dimensions and hole patterns for mounting these devices. The Smart Drive and Power Supply units are mounted to the grounded electrical panel using four M6 or 1/4-20 (or similar) screws each. The use of lock washers is highly recommended.





**Figure 3-2. Smart Drive 3 Amp Amplifier Outline and Dimension Drawing**



**Figure 3-3. Smart Drive 10 and 20 Amp Amplifier Outline and Dimension Drawing**

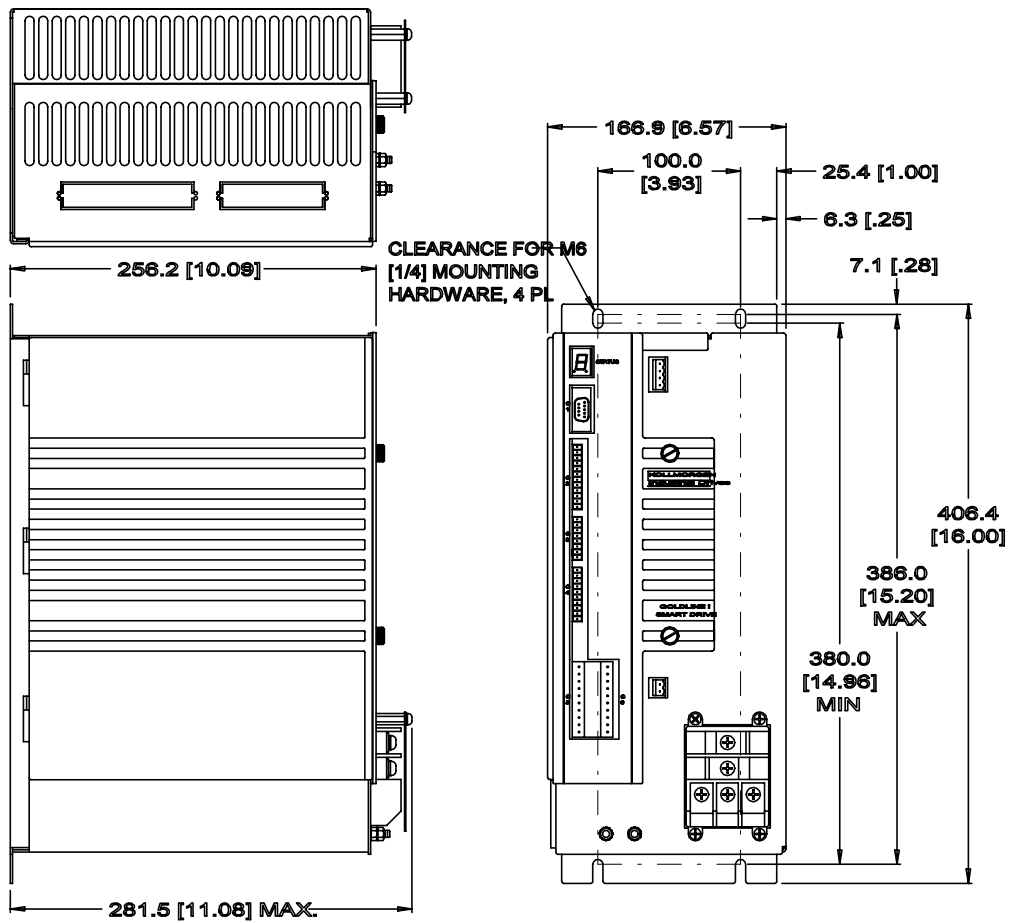
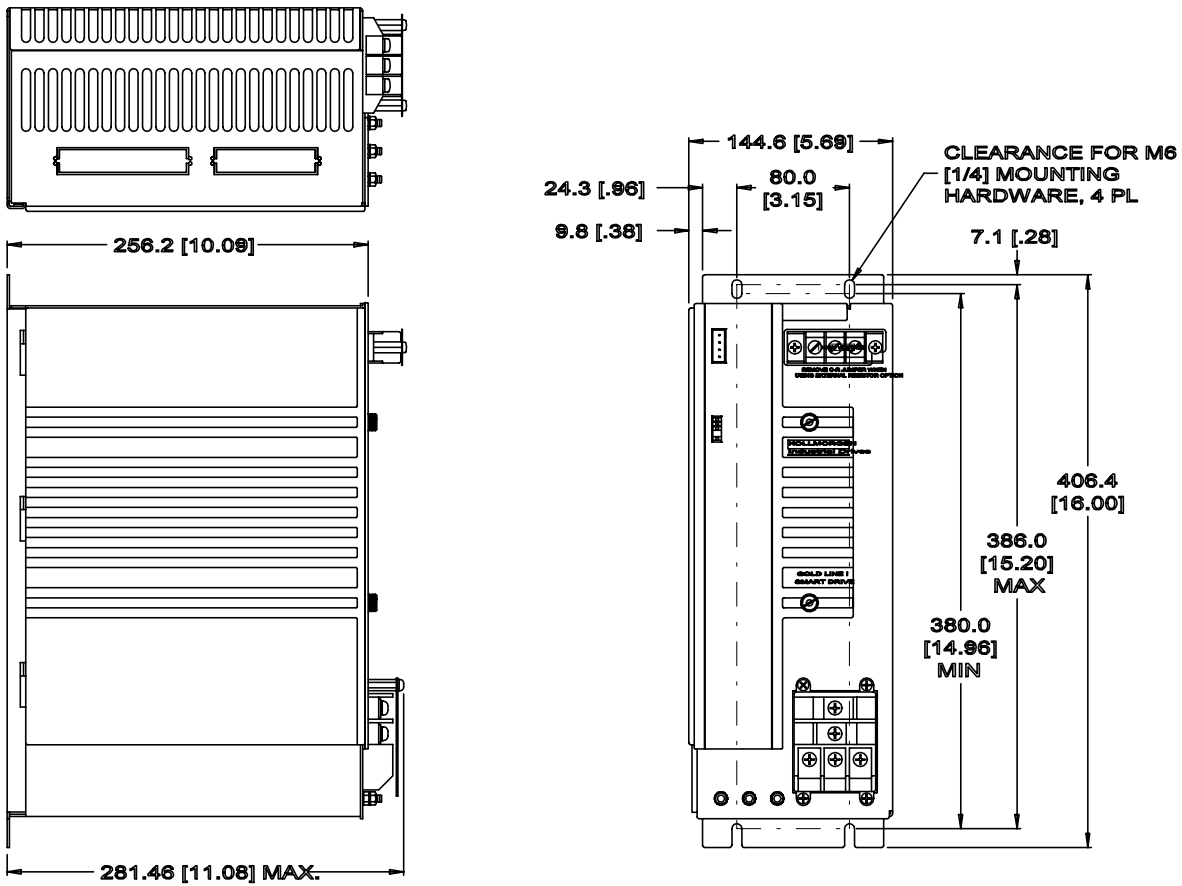


Figure 3-4. Smart Drive 30 and 55 Amp Amplifier Outline and Dimension Drawing



**Figure 3-5. Smart Drive 50 and 75 Amp Power Supply Outline and Dimension Drawing**

**SMART DRIVE AMPLIFIER PIN ASSIGNMENTS**

**C1**  
**RS232 SERIAL CONNECTOR**

- 1 SHIELD
- 2 RECEIVE (RXD)
- 3 TRANSMIT (TXD)
- 4 N/C
- 5 COMMON
- 6 TD+
- 7 TD-
- 8 RD+
- 9 RD-

**C2**  
**RESOLVER CONNECTOR**

- 1 REF HI
- 2 REF LO
- 3 SHIELD
- 4 SIN HI
- 5 SIN LO
- 6 SHIELD
- 7 COS HI
- 8 COS LO
- 9 SHIELD
- 10 THERMOSTAT
- 11 THERMOSTAT
- 12 SHIELD

**C3**  
**ENCODER/PULSE INPUT CONNECTOR**

- 1 CHANNEL A IN +
- 2 CHANNEL A IN -
- 3 CHANNEL B IN +
- 4 CHANNEL B IN -
- 5 MARKER IN +
- 6 MARKER IN -
- 7 ABAUD EN
- 8 COMMON

**C4**  
**ENCODER EQUIVALENT OUTPUT CONNECTOR**

- 1 CHANNEL A OUT +
- 2 CHANNEL A OUT -
- 3 SHIELD
- 4 CHANNEL B OUT +
- 5 CHANNEL B OUT -
- 6 SHIELD
- 7 MARKER OUT +
- 8 MARKER OUT -
- 9 SHIELD
- 10 COMMON

**C5**  
**ANALOG I/O CONNECTOR**

- 1 ANALOG INPUT +
- 2 ANALOG INPUT -
- 3 SHIELD
- 4 ANALOG TACHOMETER (CW 1000 RPM= +1 VDC)
- 5 COMMON
- 6 CURRENT MONITOR FULL CURRENT = +5 VDC
- 7 COMMON
- 8 TEST OUT
- 9 +12 VOLTS DC
- 10 -12 VOLTS DC

**C6**  
**DISCRETE I/O CONNECTOR**

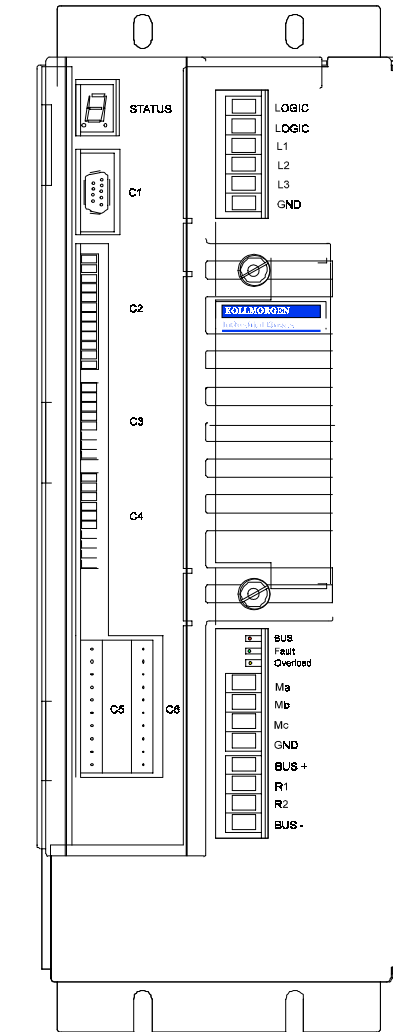
- 1 ENABLE +
- 2 ENABLE -
- 3 CW LIMIT +
- 4 CW LIMIT -
- 5 CCW LIMIT +
- 6 CCW LIMIT -
- 7 RELAY 1A
- 8 RELAY 1B
- 9 RELAY 2A
- 10 RELAY 2B

**POWER CONNECTOR**

- AC 95-260 VAC INPUT 50-60 HZ
- AC 95-260 VAC INPUT 50 -60 HZ
- L1 LINE 1 MAIN POWER
- L2 LINE 2 MAIN POWER
- L3 LINE 3 MAIN POWER
- GND EARTH/MACHINE GROUND

**MOTOR CONNECTOR**

- Ma MOTOR φ A
- Mb MOTOR φ B
- Mc MOTOR φ C
- GND
- BUS DC BUS +
- +
- R Regen Transistor
- C Regen Resistor
- BUS - DC BUS -



### 3.7 WIRING COMMON TO ALL MODELS

All Smart Drive amplifier models use the same main control board and therefore have common connections as indicated in the wiring diagrams. This section is designed to explain the details of this wiring. The Smart Drive offers many features for a variety of applications. Not all installations require every connection to be wired, however each connection is discussed.

Refer to the System Wiring Diagrams provided in Appendix E - Drawings Drawing Number A-93967. Carefully study the Wiring Diagrams before wiring the Smart Drive system. Please read and understand all notes.



**Carefully read all of the Wiring Diagrams before wiring the Smart Drive system, including ALL of the notes.**

When wiring the Smart Drive system, it is important to observe the following guidelines:

- Twist all AC leads to minimize electromagnetic emissions (noise).
- Avoid running signal leads in close proximity to power leads, motor stator leads, or other sources of electromagnetic noise. Run signal leads in separate conduit from power leads. The use of shielded cable is required for signal leads.
- Minimize lead lengths.
- Connect the Smart Drive system according to the System Wiring Diagram, pay close attention to the grounding scheme and notes.

- The use of wire ferrules in all Smart Drive wiring is highly recommended. Wire ferrules; prevent shorting of wires, provide strain relief, and prevent migration of wire strands that can cause loosening of connections.



**NOTE**

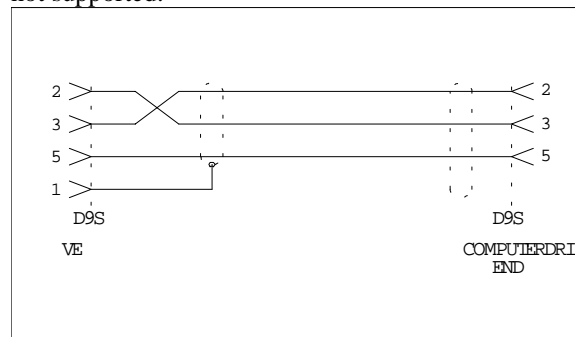
**Use wire ferrules in all Smart Drive wiring.**

Industrial Drives offers factory made resolver cables to ease installation. Cable data is provided in the following pages for those customers wishing to manufacture their own cables.

#### 3.7.1 Serial Communications (C1)

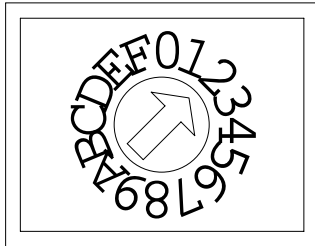
Connector C1 provides user access to the Smart Drives serial communications port. Both RS-232 and RS-485 connections are made at this connector. It is a 9-pin, D-type, sub-miniature plug connector (DE-9P).

The communications cable will use a D9S mating connector. This connector may be wired for use with RS-232 or RS-485. In either case it is important to tie system commons together to reduce single-ended noise which can have voltage spikes high enough to damage the electronics associated with these devices. Note that handshaking signals (CTS, DTR, etc.) are not supported.



**Typical RS-232 Cable Drawing**

A rotary switch located near C1 will determine which serial communications mode the Smart Drive will use. Turning the rotary switch so that the arrow points to '0' will cause the Smart Drive to assume RS-232. Turning the rotary switch to point at any other position than '0' will cause the Smart Drive to assume RS-485 at that address.



**Serial Communications Switch**

RS-232 generally works well up to 20 feet using standard cable. Special low capacitance cable can extend this range up to 500 feet, although the baud rate may need to be reduced and the industrial environment is hostile to these lengths. These cables are available from many companies, including Black Box (Pittsburgh, PA).

RS-485 can be used up to 4000 feet. Be forewarned, however, that using very long cables may be more difficult than just making the connections. Special attention must be paid to AC loading, transmission line effects, noise pickup, and common-mode voltages. Again, baud rates may need to be reduced as the length increases, and low capacitance cables may be required. The Smart Drive does not provide line termination for RS-485. The customer is responsible for any line termination that may be required. Typically a 120 Ohm resistor is placed at each end of the cable.

You can obtain a copy of the specification for RS-232 or RS-485 by contacting:

Electronic Industries Association  
Engineering Department  
2001 Eye Street, N.W.  
Washington, D.C. 20006

Computers and data terminals typically have the transmit and receive pins swapped so that a one-to-one cable can be used to interconnect the two. This often presents confusion. If problems occur try interchange Pins 2 and 3 at one end of the cable.



**CAUTION**

**Make sure that the Computer and Smart Drive share the same power supply common. Either your computer or the Smart Drive or both can be damaged if the commons are not at the same potential.**

### 3.7.2 Resolver Connections (C2)



**WARNING**

**Connect the resolver leads correctly. Incorrect motor resolver phasing can cause erratic operation, runaway, or damage to the system. The use of Industrial Drives resolver cable sets is highly recommended.**

The resolver cable is a separate cable assembly either made or purchased. Install the resolver cable between the motor and the Smart Drive. Make the connection at the motor resolver connector and Connector C2 on the Smart Drive. Detailed pin information is provided here but is not normally required:

**Reference:** Pins 1 & 2

The reference terminals outputs a sinewave signal to drive the resolver. This signal is nominally rated for 7.6 kHz at 4.25 Vac.

**Sine:** Pins 4 & 5

The Sine signal is a feedback input from the resolver. The Sine input voltage signal is transformer coupled from the Reference signal via the resolver. Input voltage is 2 Vac, RMS nominal.

**Cosine:** Pins 7 & 8

The Cosine signal is a feedback input from the resolver. The Cosine input voltage signal is transformer coupled from the Reference signal via the resolver. Input voltage is 2 Vac, RMS nominal.

**Thermostat:** Pins 10 & 11

A normally-close thermostat contact buried in the motor windings is wired to these terminals through the resolver cable. See THERMODE switch variable and thermostat description below.

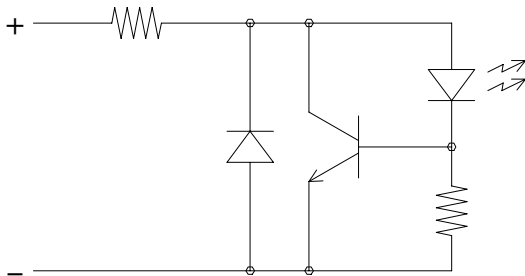
**Shields:** Pins 3, 6, 9, & 12

These terminals provide a connection to earth ground for terminating shields used in the resolver cable.

### 3.7.3 Encoder Equivalent Input (C3)

The Smart Drive provides inputs intended to receive input pulse signals, typically from a master encoder (i.e.: an encoder on line shaft, or the encoder output of another Smart Drive) or pulse source for operation in OPMODES 4-7.

The Smart Drive uses standard encoder format (A-B quadrature). As an option, pulse inputs in different formats are also supported in pulse follower modes. The encoder input circuitry consists of a current regulator and an opto coupler. Although not a true differential input it is compatible to differential line drives. Current to the input is a function of voltage. The input requires about 12 mA to operate. The Smart Drive Encoder Equivalent Output has enough drive capacity for two sets of these encoder input channels.



#### Equivalent Encoder Input Circuit

**Channel A Input:** Pins 1 & 2  
Encoder input channel A in OPMODE 4, Pulse input channel in OPMODES 5 & 6, or CW Pulse input channel in OPMODE 7. Differential input pin 1 with respect to Pin 2.

**Channel B Input:** Pins 3 & 4  
Encoder input channel B in OPMODE 4, Direction input channel in OPMODES 5 & 6, or CCW Pulse input channel in OPMODE 7. Differential pin 3 with respect to Pin 4.

**Channel Z Input:** Pins 5 & 6

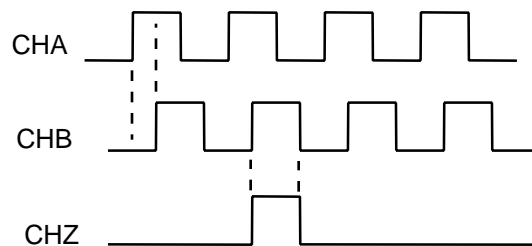
Encoder input marker Channel. Function is to be defined in future growth. Differential pin 5 with respect to Pin 6.

**Abaud Input:** Pins 7 & 8  
A jumper across these pins will be read on power-up as a command to auto-baud the serial port. Leaving these pins unconnected causes the Smart Drive to open its communications port at the baud rate specified by the BAUD variable. It is suggested that the user leave these pins open for normal product use.

### 3.7.4 Encoder Equivalent Output (C4)

The Encoder Equivalent Output provides position information to another device in the system. The output is in standard A-Quad-B encoder format. These outputs conform to RS485 Line Driver specifications and are internally isolated using a DC-to-DC converter. It is important to connect pin 10:Common back to the system receiving these signals. If the Smart Drive is being used as a velocity drive, and another controller is closing a position loop, reversing the Encoder Equivalent Output can cause the Smart Drive to run away or oscillate. The encoder output has enough drive capacity to drive two Smart Drive Encoder Input connections.

The Smart Drive uses the same phasing for the encoder inputs and outputs; for clockwise rotation, Channel A leads Channel B. For standard systems, the inputs are Channel A and Channel B. The outputs are Channel A, Channel B, and the marker channel, Channel Z. The Channel Z pulse occurs once per shaft rotation and is aligned with the Channel B pulse as shown.



**Encoder Phasing For Clockwise Rotation**



**WARNING**

**Phase the Encoder Equivalent Output correctly. Incorrect phasing of the Encoder Equivalent Output can cause excursions, oscillations, or runaways.**

**Channel A Output:** Pins 1 & 2  
Encoder output signal A. Differential, pin 1 with respect to pin 2.

**Channel B Output:** Pins 4 & 5  
Encoder output signal B. Differential pin 4 with respect to pin 5.

**Z Output:** Pins 7 & 8  
Encoder marker channel output signal. Differential pin 7 with respect to pin 8.

**Shields:** Pins 3,6, & 9  
The shield pin is connected to the Smart Drive frame. Cable Shields can be connected to the shield pins.

**Common:** Pin 10  
The internal isolated DC-to-DC converter common. This pin should be connected to the common of the device receiving the encoder equivalent output signals. The purpose is to keep electrical noise spikes from damaging the output drivers internal to the Smart Drive.

### 3.7.5 Analog Input / Output (C5)

**Analog Input:** Pins 1, 2  
The Smart Drive accepts an analog voltage command input. The analog input command range is  $\pm 10$  volts. Input impedance is  $\geq 10$  k ohm. The analog input is differential; that is, the input voltage is taken to be the voltage at Pin 1 minus the voltage at Pin 2. Differential (two-wire) signals have higher noise immunity than single-ended signals, since noise picked up by the wires is eliminated when the two voltages are subtracted. The common mode rejection is 50 dB minimum. Typically, one of the two wires will be at a voltage nominally the same as Common. Connecting this wire to pin 2 will provide the best performance.

Take care to properly shield this input from electrical noise. Use shielded, twisted-pair cable. The shield may be connected to Pin 3 on Connector C5 on the Smart Drive, but better performance may be realized when the shield is terminated at the source side of the

cable. Determining the best shield connection is often a matter of trial-and-error. Begin by wiring the shield only at the source side.

The voltage polarity at this input determines the direction of rotation of the motor. If the Smart Drive is being used as a velocity drive, and a different controller is closing a position loop, reversing the polarity of the analog input can cause the Smart Drive to run away or oscillate. The Smart Drive is normally factory configured to run in the clockwise direction for a positive input voltage (Pin 1 with respect to Pin 2).

**Shield:** Pin 3  
The shield pin is connected to the Smart Drive frame. Cable Shields can be connected to the shield pins.

**Tach Monitor:** Pin 4  
Tach monitor provides an analog voltage signal proportional to velocity. It is referenced to Common and scaled for 15,455 RPM clockwise = +8 volt but can be effected by the RDRES setting (see Chapter 5). This output has a 1k ohm resistor in series and a 4700 pF filter capacitor connected to Common.

**I Monitor:** Pin 6  
Motor current can be viewed using the I monitor connection. This signal is common-referenced, and scaled for peak rated drive current ( 2 times continuous current rating) = 5 volts. This output has a 1k ohm resistor in series. I Monitor is absolute (always positive) and does not represent true motor current when the signal is low due to rectification diode losses.

**Common:** Pins 5, 7  
The internal analog power supply common is provided on several pins for use with IMON and TACH. Do not connect shields to Common and do not inject noise into these connections.

**Reserved:** Pin 8  
A factory programmable analog output is available at this connection. Do not connect to this pin unless otherwise instructed by the factory.

**Analog Supply:** Pins 9, 10  
Pin 9 is attached to the internal +12 Vdc rail through a 100 Ohm resistor. Pin 10 is attached to the internal -12 Vdc rail through a 100 Ohm resistor. These connections are provided for convenience but should not be used as noise can easily be injected into the Smart Drive waging its reliability.

### 3.7.6 Discrete Input / Output (C6)

Connector C6 provides control interface to the user. All connection to these terminals are electrically isolated from the Smart Drives internal electronics.

There are three discrete input connections. Each requires external power to operate. Electrically, they consist of a current regulator and an opto coupler. They require a DC voltage between 10 and 30 volts (24 VDC nominal) to activate the signal.

Exceeding 30 volts could damage this input. Observe polarity when connecting source.

**Remote Enable:** Pins 1, 2

The Remote Enable input must be activated for the Smart Drive to be enabled. It is provided to give the user direct control over the motor power. The Remote Enable input can also be used to reset fault conditions by toggling this input.

Note that the decimal point in the seven segment display indicates the state of the drive enable, and in most cases (exempting fault and DIS) directly represents the state of the Remote Enable Input.

**Clockwise Limit:** Pins 3, 4

The Clockwise End Travel Limit input is used to prevent motor travel in the clockwise direction when this input is open. If motion in this direction is commanded, the motor will decelerate at the programmed deceleration rate to a stop when this limit is opened. This input must be active for the motor to run in the given direction. This limit is defeatable using the LIMDIS variable.

**Counter Clockwise Limit:** Pins 5, 6

The Counter Clockwise End Travel Limit input is used to prevent motor travel in the counter clockwise direction when this input is open. If motion in this direction is encountered the motor will decelerate at the software programmed deceleration rate to a stop when this limit is opened. This input must be closed for the motor to run in the given direction. This limit is defeatable using the LIMDIS variable.

There are two discrete output connections. These two sets of relay contacts are non-polarized and may be used with AC or DC connections. These contacts are rated for a maximum current of 2 Amps and a maximum voltage of 115 volts AC. The maximum switched power is 60 volt-amps AC.

**Drive Ready:** Pins 7 & 8

This set of relay contacts is configurable as either a drive-fault relay or a drive-ready relay (see RELAYMODE). With the drive-fault relay configuration, the contacts will be closed when power is on the drive and there is no fault condition. In the drive-ready relay configuration contacts are closed when there is no fault and the drive is enabled.

**CPU Active:** Pins 9 & 10

The CPU Active Relay is a hardware watchdog for the Smart Drive. These contacts are open until about 500 mS after power is applied to the drive. Always wire the CPU Active relay to disconnect drive power in the event of this extreme failure mode.

**3.8 WIRING SPECIFIC TO UNITS WITH INTEGRAL POWER SUPPLIES: 3, 10, AND 20 AMP MODELS**

The user is responsible for providing proper circuit breaker or fuse protection of the incoming power. The user is also responsible for providing proper wire gauge and insulation rating for all wiring, including motor and AC line connections. It is also the responsibility of the user to make certain that all system wiring and electrical protection comply with all applicable National and Local Electric Codes.

Industrial Drives offers factory made motor cables to ease installation.

**3.8.1 Wiring Earth Ground**

To prevent shock hazard and to ensure proper operation of the system, the Smart Drive and motor must be properly grounded. Most difficult-to-solve problems with system operation are caused by poor grounding techniques. An extremely low impedance (low inductance) earth ground is extremely important to proper system operation. Be sure to use a heavy gauge grounding wire as shown in Table 3-1 to provide the proper low inductance path. The larger the conductor the lower the inductance.



**GROUND the Smart Drive, Power Supply, and motor PROPERLY! Failure to provide proper grounding can result in a shock hazard.**

Each drive, in multi-axis systems with integral power supply, should have its own wire from the GND terminal at the power connector brought back to the central earth ground connection. Do not daisy-chain the ground connections. A solid earth ground is mandatory!

**Table 3-1. Minimum Ground Wire Gauge**

Drive Model	Wire Gauge
3 Amp	10 AWG
10 Amp	10 AWG
20 Amp	8 AWG
30 Amp w/ PS	see NEC or Local Codes
50 Amp w/ PS	see NEC or Local Codes

**3.8.2 Wiring the Input Power Connections**

The Smart Drive 3, 10 and 20 Amp units can be used with either 115V single phase or a 230V 1 or 3 phase AC line. Derating for 115V and single phase operation must be adhered to for proper drive performance. The output power and motor speed will be limited due to lower DC Bus voltage.

The Smart Drive has no internal protection for incoming power lines so an external fuse block or circuit breaker is required. FUSES FOR MAIN POWER SHOULD BE A U.L. RATED TIME DELAY TYPE, SUCH AS, BUSS FRN-R SERIES. In most applications, a line contactor is also used to control power to the main DC Bus.

The Smart Drive provides separate power input terminals for logic and bus supplies for maximum flexibility.

Wire the main bus input power to terminal La, Lb, and Lc for three phase hook up. Use any two-of-three for single phase connection.

Wire logic power to the Logic terminals. This input voltage may be 115 Vac to 230 Vac without having to program the voltage. All incoming wires that are considered 'Hot' must be fused as there is no internal protection within the Smart Drive.



**To prevent equipment damage, the AC Line and the DC Bus must be connected as indicated by the System Wiring Diagram.**

### 3.8.3 Wiring the Motor

Pins A, B, and C of the motor connector are wired through a motor cable to Ma, Mb, and Mc, respectively, on the motor terminal block located on the front of the Smart Drive. Connect Pin D of the motor connector through the same motor cable to the GND terminal. The use of shielded motor cable is recommended. Terminate the shield at the Smart Drive's GND terminal.



**CAUTION**

**IT IS VERY IMPORTANT THAT THE MOTOR BE WIRED PROPERLY. Brushless permanent magnet motors are not like induction motors. Two phases cannot simply be interchanged to reverse the direction of rotation.**

*Table 3-2. Motor Cable Code*

Motor Connector	Wire Marker	Smart Drive Power Terminal
Pin A	Ma	Terminal Ma
Pin B	Mb	Terminal Mb
Pin C	Mc	Terminal Mc
Pin D	GND	GND
Cable Shield	GND	No Connection

The Smart Drive is designed to protect the motor; however, external motor protection is required to meet UL ratings with the Smart Drive. A thermal relay should be wired in series with the motor wire. The relay should be sized at 125% of the motors continuous rated current. The contacts on the relay should be wired to disable power to the drive should the relay open.

### 3.8.4 Motor Thermostat

The Smart Drive can accept a motor thermostat input as stated above in the Resolver Wiring Section. If the system designer decides not to use this function of the Smart Drive, the thermostat must be connected to some other safety circuit.



**CAUTION**

**Do not ignore the purposes of thermostat protection.**

Industrial Drives thermostats are rated as follows:

Rated Voltage:

277 VAC at 60 Hz

250 VAC at 50 Hz

Rated Current:

2.5 Amps at a Power Factor of 1.0

1.6 Amps at a Power Factor of 0.6

Resistance:

50 m Ohms

The thermostat automatically resets (closes) when the motor cools. If the thermostat is not wired into the Smart Drive, the system designer is responsible for making sure that the motor does not begin moving unexpectedly when the thermostat closes.

**EXTERNAL USE OF THE THERMOSTAT REQUIRES THE USER TO LATCH THE MOTOR THERMOSTAT!**



**DO NOT CONNECT THE THERMOSTAT DIRECTLY TO THE DIGITAL DRIVE REMOTE ENABLE OR LIMIT INPUTS.**

The motor thermostat resets (closes) when the motor cools. This can allow the motor to restart operation unexpectedly after a motor thermostat fault unless the thermostat is latched. Always latch the thermostat.

**3.9 WIRING SPECIFIC TO UNITS WITH MODULAR POWER SUPPLIES: 30 AND 55 AMP MODELS**

The user is responsible for providing proper circuit breaker or fuse protection of the incoming power. The user is also responsible for providing proper wire gauge and insulation rating for all wiring, including motor and AC line connections. It is also the responsibility of the user to make certain that all system wiring and electrical protection comply with all applicable National and Local Electric Codes.

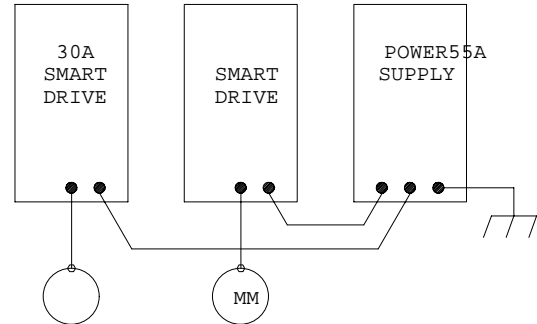
Industrial Drives offers factory made motor cables to ease installation.

**3.9.1 Wiring Earth Ground**

To prevent shock hazard and to ensure proper operation of the system, the Smart Drive, Power Supply, and motor must be properly grounded.

Most difficult-to-solve problems with system operation are caused by poor grounding techniques. An extremely low impedance (low inductance) earth ground is extremely important to proper system operation. Be sure to use a heavy gauge grounding wire as shown in Table 3.1 to provide the proper low inductance path. The larger the conductor the lower the inductance.

To reduce EMI, each drive frame connects to the Power Supply unit and then the power Supply is returned to the central earth ground connection. This is clearly shown in the wiring diagram.



**Proper Grounding Of High Power Smart Drives**



**GROUND the Smart Drive, Power Supply, and motor PROPERLY! Failure to provide proper grounding can result in a shock hazard.**

**3.9.2 Wiring the Input Power Connections**

The input power is wired to the Power Supply Units. These Power Supplies use 230 Vac 3-Phase input power. The Power Supply has no internal protection for incoming power lines so an external fuse block or circuit breaker is required. FUSES FOR MAIN POWER SHOULD BE A U.L. RATED TIME DELAY TYPE, SUCH AS, BUSS FRN-R SERIES. In most applications, a line contactor is used to control power to the main DC Bus.

The Smart Drive provides separate power input terminals for logic and bus supplies for maximum flexibility.



**To prevent equipment damage, the AC Line and the DC Bus must be connected as indicated by the System Wiring Diagram.**

Connect the three-phase AC Line through properly rated fuses to L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub> on the Power Terminal Block located on the front of the Smart Drive or Power Supply unit .

Power for the low voltage electronics is wired to the Smart Drives AC Logic connector and may be 115 Vac or 220 Vac. Control power for the power supplies is created from the main 230 Vac power and does not require further wiring.

### 3.9.3 Wiring the Motor

Pins A, B, and C of the motor connector are wired through a motor cable to Ma, Mb, and Mc, respectively, on the motor terminal block located on the front of the Smart Drive. Connect Pin D of the motor connector through the same motor cable to the Smart Drive motor ground screw located at the bottom of the Smart Drive chassis. The use of electrically shielded motor cable is recommended to reduce EMI emissions. The cable shield also connects to the ground screw on the Smart Drive.



**IT IS VERY IMPORTANT THAT THE MOTOR BE WIRED PROPERLY. Brushless permanent magnet motors are not like induction motors. Two phases cannot simply be interchanged to reverse the direction of rotation.**

The Smart Drive is designed to protect the motor; however, external motor protection is required to meet UL ratings with the Smart Drive. A thermal overload relay should be wired in series with the motor wire. The relay should be sized at 125% of the motors continuous rated current. The contacts on the relay should be wired to disable power to the drive should the relay open.

### 3.9.4 Motor Thermostat

The Smart Drive can accept a motor thermostat input as stated above in the Resolver Wiring Section. If the system designer decides not to use this function of the Smart Drive, the thermostat must be connected to some other safety circuit.



**CAUTION**

**Do not ignore the purposes of thermostat protection.**

Industrial Drives thermostats are rated as follows:

Rated Voltage:

277 VAC at 60 Hz

250 VAC at 50 Hz

Rated Current:

2.5 Amps at Power Factor of 1.0

1.6 Amps at power factor of 0.6

Resistance:

50 m Ohms

The thermostat automatically resets (closes) when the motor cools. If the thermostat is not wired into the Smart Drive, the system designer is responsible for making sure that the motor does not begin moving unexpectedly when the thermostat closes.

**EXTERNAL USE OF THE THERMOSTAT REQUIRES THE USER TO LATCH THE MOTOR THERMOSTAT!**



**WARNING**

**DO NOT CONNECT THE THERMOSTAT DIRECTLY TO THE DIGITAL DRIVE REMOTE ENABLE OR LIMIT INPUTS.**

**The motor thermostat resets (closes) when the motor cools. This can allow the motor to restart operation unexpectedly after a motor thermostat fault unless the thermostat is latched. Always latch the thermostat.**

### 3.9.5 Wiring the DC Bus

Connect the DC Bus from the Power Supply Power Terminal Block (BUS+, BUS-) to the Smart Drive Power Terminal Block (BUS+, BUS-). Observe the polarity of DC Bus connections; always connect BUS+ to BUS+ and connect BUS- to BUS-. The Power Supply units can be connected to multiple Smart Drives. No more than three units should be connected on each side of the Power Supply.



**WARNING**

**Failure to observe polarity of the DC Bus can result in personal injury.**



**CAUTION**

**Failure to observe the polarity of the DC Bus will result in damage to the Power Supply and Smart Drive.**

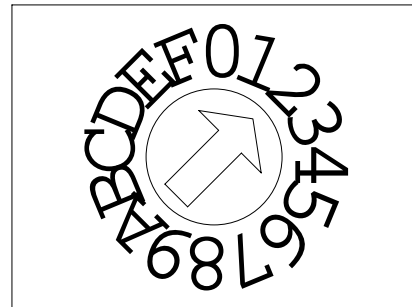
### 3.9.6 Power Supply Fault

The Power Supply units provide a 'Supply OK' signal which is to be wired to the Smart Drives connected to that Power Supply. This contact actually supplies current to the Smart Drive input when the Power Supply is operable. There are four connections on the Fault connector providing dual connections for daisy-chaining multiple Smart Drives. When the Smart Drive receives the power from this signal it means that the Power Supply is up and the Smart Drive can use Bus voltage from the Power Supply. All drives need to see this signal to verify that power can be supplied to the motor.

Connect the A terminal from the Power Supply Fault Connector to the A terminal on the Smart Drive Fault Connector. Connect the B terminal from the Power Supply Fault Connector to the B terminal on the Smart Drive Fault Connector. For daisy-chaining this signal in multi-axis systems, use the Smart Drive's A1 (B1) terminal to connect to the next Smart Drive's A1 (B1) terminal.

### 3.10 SELECTING COMMUNICATIONS MODE AND RS-485 ADDRESS

A rotary dip switch is accessible through the front panel. Zero on the dip switch implies RS-232. Selecting switch positions '1' through 'F' on the dip switch provides RS-485 at address "1-F" providing 15 multi-drop addresses. Power must be cycled for a change in switch position to be recognized. Set the address switch as desired.



### 3.11 INSTALLING SMART DRIVE OPTIONS

#### 3.11.1 Motor Brake

Fail safe brakes are an option with Industrial Drives motors. With GoldLine motors, the brake connections are available as blue flying leads on the resolver cable. They are available in more than one voltage rating, so check the model number of the motor carefully to determine the voltage and current required by the brake on the motor. Brakes are fail-safe and must be energized prior to commanding motion.

Exact wiring of the brake system is up to the system designer.

### 3.11.2 External Regen Resistor Option

#### Mounting:

All Smart Drive power supply section's have internal shunt resistors which dissipate the energy returned to the power supply during regenerative braking. These are referred to as regen resistors. Some applications require added capacity in the form of externally mounted regen resistors.

The mounting data of optional external regen resistors is supplied with the kit. These resistors can expose high voltages and must be enclosed to reduce shock hazard. Regen resistors get hot! They are a potential burn and fire hazard. They can produce enough heat to melt insulation and plastic wiring duct. The enclosure must provide ventilation and be able to withstand high temperatures. Do not mount the resistors underneath the Smart Drive, Power Supply, or other electronic equipment. External Regen Resistors require an overload relay connection that should be wired to drop power to the servo system should the relay open.



**WARNING**

---

**EXTERNAL REGEN RESISTORS ARE A SHOCK HAZARD!**

**Mount these resistors properly! Enclose these resistors to protect personnel and equipment!**

---



**CAUTION**

---

**EXTERNAL REGEN RESISTORS GET HOT!**

**If External Regen Resistors are used, allow sufficient clearance around the resistors. Enclosures must dissipate created heat mounting thermal protection.**

---

#### Wiring to a 3, 10 or 20 Amp Smart Drive:

Remove the jumper from C to R on the Motor Connector. Wire one lead of the External Regen Resistor to the terminal labeled Bus+. Wire the other resistor lead through the thermal overload relay to the C terminal. The thermal overload normally closed contacts must be wired into the system power circuit to provide the means for the relay to safely cease power to the drive in the event of an overload condition.

#### Wiring to a 50 or 75 Amp Power Supply:

Remove the jumper from C to R on the REGEN Connector. Wire one lead of the External Regen Resistor to the terminal labeled +. Wire the other resistor lead through the thermal overload relay to the C terminal. The thermal overload normally closed contacts must be wired into the system power circuit to provide the means for the relay to safely cease power to the drive in the event of an overload condition.

### 3.12 COMPLETING THE INSTALLATION

The system should now be installed and wired. Check to be certain that all connections are tight and free from short circuits. Dress all wires and remove any metal chips or wire fragments.



# CHAPTER 4

## MOTION LINK SERIAL COMMUNICATIONS

### 4.1 INTRODUCTION

The information in this chapter will enable you to use the Motion Link for Smart Drives communication program. Motion Link is available in both DOS and Windows based versions. The Windows version is highly intuitive and has its own help files.

The Smart Drive communicates over an RS-232 or RS-485 communications port and most users of this product will want to use the software package that comes with this product called Motion Link. However, this is not required to be able to communicate with the Smart Drive. Computer requirements, software installation, commands, variables, and disk operations are discussed as well in this chapter.

### 4.2 COMPUTER REQUIREMENTS

Motion Link requires an IBM-PC or compatible computer with the following features:

- IBM-PC, XT, AT, 386, 486, PS/2, or compatible computer.
- 512 K RAM.
- PC-DOS or MS-DOS Version 2.5 or later.
- 3-1/2" Floppy Drive.
- Standard Video Adapter (CGA, MDA, EGA, MCGA, and VGA).
- Serial Port (for communication link with Smart Drive). The serial communications port may be COM1, COM2, COM3 or COM4. COM1 is the normal configuration:

COM1: Address 3F8h, Interrupt Request #4

COM2: Address 2F8h, Interrupt Request #3

COM3: Address 3E8h, Interrupt Request #4

COM4: Address 2E8h, Interrupt Request #3

When using an IBM compatible, make sure it has been booted with the optional serial/parallel adapter plugged in. Also make sure it has been configured to allow the operation of the serial/parallel adapter on batteries.

### 4.3 SOFTWARE INSTALLATION

Before installing or using Motion Link, back up the Motion Link disk that came with the Smart Drive. This way if something happens to the master disk, you'll always have a copy. Remember, disks can be damaged by heat, magnets, pressure, and dirt — all extensively found in a manufacturing environment.

Follow the procedure below to back up your disk.

To install Motion Link on a hard disk.

1. Type:

**C:**

2. Make a subdirectory named MLSD on the hard disk. Type:

**MD MLSD**

3. Change to subdirectory MLSD. Type:

**CD MLSD**

4. Insert the Motion Link disk into the A-drive. This disk should be in the disk holder in the front of this manual.
5. Copy all the files from the Motion Link disk onto the hard disk by typing:  
**Copy A:\*.\***
6. Store the original Motion Link disk in a safe place. Do not use this disk, except to make other copies.

## 4.4 MOTION LINK OVERVIEW

Motion Link is a full-featured communications program written by Industrial Drives and designed especially for the Smart Drive. Motion Link makes the IBM-PC compatible into a smart terminal. Smart Drive commands are entered from the computer as if a terminal were being used. Motion Link also provides "smart" features such as a full-screen menus, disk storage and retrieval, and the communications "capture" for debugging.

Motion Link's special features are accessed through a menu bar printed at the top of the PC screen. When selecting an entry from the menu bar, a pull-down window appears, allowing selection of an item. Press the F10 key, the right arrow key, or the left arrow key, to display the menu bar. Leave a window or the menu bar by pressing the escape key. There are six choices on the menu bar:

- VARIABLE - edit new or old Smart Drive variable files; open variable files from disk or from the Smart Drive; save variables; print variables; shell to DOS. Variable files contain Smart Drive dedicated variables that configure the operation of the Smart Drive.
- CAPTURE - Start or stop capturing communications from the Smart Drive; retrieve previous capture files from disk; examine (edit) capture files; print capture files; shell to DOS.
- SCOPE - Retrieve, plot, print, and store PC-Scope files; print PC-Scope files.
- SETUP - zero resolver; tune drive; test drive; test drive feedback; review drive information and configuration; view, open, receive, and print the TL (Compensation File).
- OPTIONS - Set up communications, screen colors, computer configuration.
- HELP - Provide on-screen help for Motion Link and for the Smart Drive; provide Last Command function and Error History.

### 4.4.1 Variables Menu

The VARIABLES pull-down window allows you to receive, edit, transmit, and save the Smart Drive variable files. A Smart Drive variable file contains a list of all of the Smart Drive User variables. Together, these variables configure a Smart Drive for an application.

- EDIT - This selection calls the Motion Link Editor and assumes that you want to "re-edit" the last variable file that you edited. It is a short-cut, allowing you to edit without first loading a variable file from the Smart Drive or from the disk. If you exit the Motion Link Editor, Motion Link remembers the variables you were last editing. Note that if you have selected an item from either the SCOPE or CAPTURE menu since you last edited a variable file, this selection is invalid.
- NEW - This selection calls the Motion Link Editor, allowing you to enter a new set of variables.
- RECEIVE - This selection will receive all of the User variables currently stored in the Smart Drive. After the variables are retrieved, the Motion Link Editor is called, allowing you to examine and change the variable file.
- PRINT - Prints the variables on a line printer.
- DOS SHELL - This selection allows you to temporarily exit (or "shell") to DOS so that you can execute a DOS command. Type "EXIT" to return to Motion Link.
- EXIT - This selection terminates Motion Link and returns to DOS. You can also press Alt-X (hold the alternate key down and press X) for this function. Upon exiting Motion Link, if you have not saved to disk the contents of the editor, Motion Link will prompt you to do so.

### 4.4.2 Capture Menu

- EDIT - This selection allows you to examine the communications that have been captured. Upon exiting the Motion Link Editor, you can store the

captured data on your computer disk. Note that if you selected an item from either the PROGRAM or VARIABLES menu since you last captured communications or loaded a communications capture file, this selection is invalid.

- **START** - This selection starts capturing communications from the Smart Drive. This selection always clears the capture storage area before beginning to capture new communications.
- **STOP** - This selection terminates the communications capture. You will be automatically placed into the Motion Link editor.
- **OPEN** - This selection allows you to retrieve a capture file from disk and examine it with the Motion Link Editor.
- **PRINT** - Print the variables on a line printer.
- **DOS SHELL** - This selection allows you to temporarily exit (or "shell") to DOS so that you can execute a DOS command. Type "EXIT" to return to Motion Link.
- **EXIT** - This selection terminates Motion Link and returns to DOS. You can also press Alt-X (hold the alternate key down and press X) for this function.

#### 4.4.3 Scope Menu

- **PLOT** - This selection lets you view playback data that was previously received from the Smart Drive.
- **OPEN** - This selection retrieves recorded data from your computer disk. Motion Link will display all of the playback files currently on your disk and allow you to choose the file you want. Playback files have the file type .CSV for "comma separated variables." This format is compatible with most spreadsheets.

- **RECEIVE** - This selection will receive any Scope data that the Smart Drive has received. After the data is received, Motion Link will plot the data to the PC's display. Press <Esc> to exit the Plot screen. After this you will be prompted to save the data to disk.

Note: You need to capture some plot data on the Smart Drive before you can receive and valid data.

To capture data you can use one of two commands:

**STEP** - Generates a step input and records the response of the drive. This is useful for analyzing the time response of the drive.  
 Syntax: STEP <period> <magnitude>  
 <period> of step pulse in mSec (10-1000)  
 <magnitude> Amount of step in RPM or Counts (10-1000)

**RECORD** - This will capture real-time data to memory for later playback by the PLAY command.  
 Syntax: RECORD <n> <trigmode> [<triglevel>]  
 <n> Sample data every <n> \* 0.5 mSec  
 <trigmode>  
 1: Upon start of move (Vcmd > triglevel)  
 2: Upon any next command  
 3: Upon ABAUD input jumper transition  
 [<triglevel>] Defines the threshold value of Vcmd (only used with trigmode=1)

You can also check the recording status with the three record status flags:

**RECDONE** Record command done, data is available.

**RECING** Record command in progress.

**RECRDY** Record command waiting for trigger.

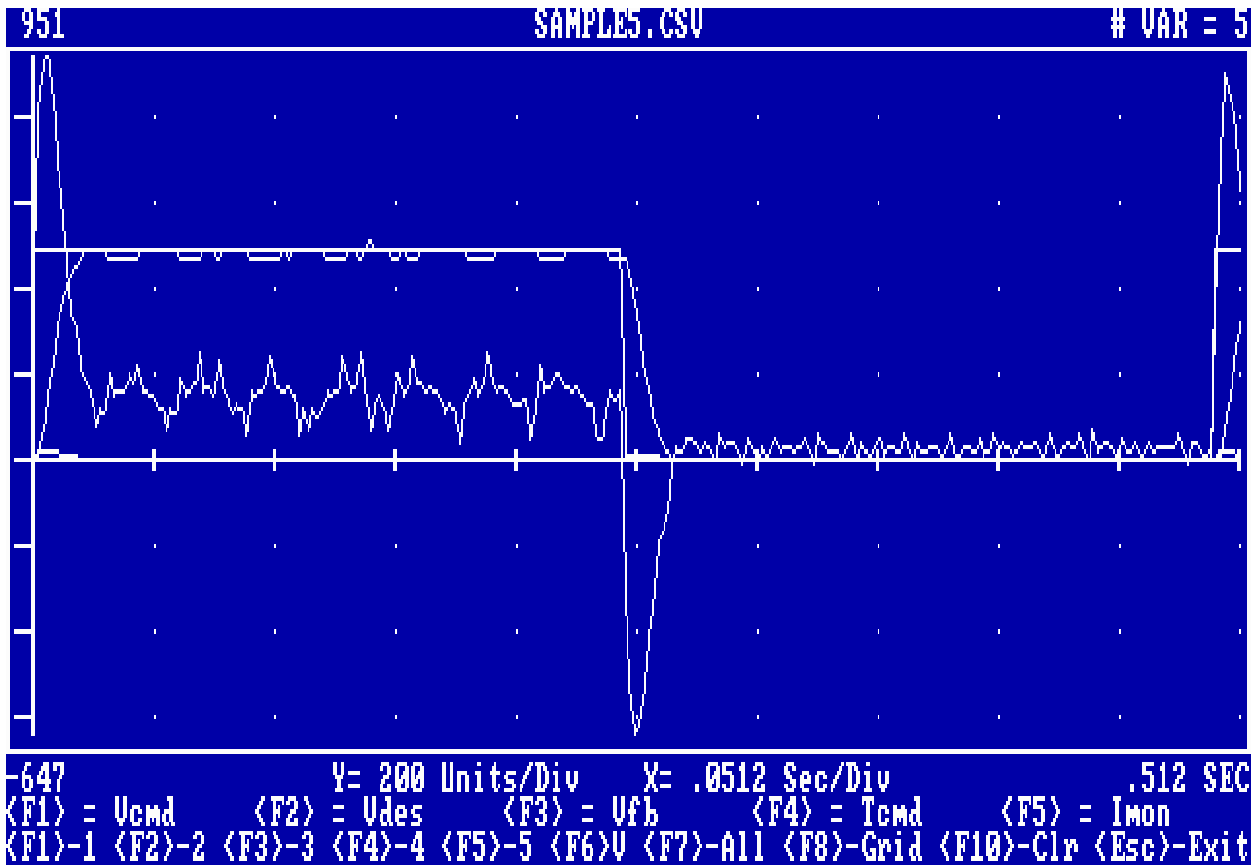


Figure 4-1. Sample PC Scope Plot

- VIEW DATA - View the data in numerical (rather than graphical) format.
- SAVE - This selection saves a scope file to your computer disk. Motion Link will request a file name for the scope data. After you choose a variable file name, the Motion Link Editor creates the scope file.
- EXPORT - The file format that the Scope data is saved in is a universal spreadsheet standard: To read a SD Scope file into a spreadsheet:
  1. The SD Scope file is a Comma Separated Variable (.CSV) file.
  2. Most spreadsheets have a .CSV Import selection.
    - i.e. , QUATTRO COMMAND -> /FIC (File-Import-Comma)
    - i.e. , QUATTRO PRO COMMAND -> /TIC (Tools-Import-Comma)
    - i.e. , SUPERCALC -> //IC (Import-CSV)
    - i.e. , LOTUS -> /FIN (File-Import-Numbers)
    - i.e. , EXCEL -> Alt-FO (File-Open) or use LOTUS HELP
  3. After the above command string enter the Drive, Path, Filename, and Extension (.CSV) of the SD Scope file.
    - i.e., C:\MLSD\SAMPLE.CSV
- PRINT - The Scope picture can be printed by the following method:
  - To print a plot make sure you:
    - 1.) Have run the DOS "GRAPHICS" program before running MotionLink.
    - 2.) Have a printer that is compatible with the graphics program.
    - 3.) Then while viewing the plot on the computers display.
- DOS SHELL - This selection allows you to temporarily exit (or "shell") to DOS so that you can execute a DOS command. Type "EXIT" to return to Motion Link.
- EXIT - This selection terminates Motion Link and returns to DOS. You can also press Alt-X (hold the alternate key down and press X) for this function.

#### 4.4.4 Setup Menu

- OPMODE - This selection allows you to easily view and set the Smart Drive mode of operation.
- RESOLVER ZERO - This selection zeros the resolver.
- DRIVE TUNE - This selection tunes the drive to the specified variables.
- DRIVE TEST - This selection tests the drive by jogging at 100 RPM for 1 second.
- DRIVE FEEDBACK - This selection allows you to command a jog and view the position, velocity, and current feedback.

Note: TL is used interchangeably with Compensation.

- VIEW TL - This selection allows the user to view the TL. No editing can be done from this selection.
- OPEN TL - This selection allows the user to open a TL from computer disk.
- RECEIVE TL - This selection receives a TL from the Smart Drive.
- PRINT TL - This selection allows the user to print a TL to a printer.

#### 4.4.5 Options Menu

- COMMUNICATIONS - This selection allows you to set up your communications port. After you have set up this port, Motion Link will initiate an autobaud sequence to re-establish communications. If you want Motion Link to use the new communications setup in the future, you must use the SAVE CONFIGURATION function below to write a new configuration file on your computer disk.
- SCREEN COLORS - This selection allows you to change the colors displayed on your computer monitor. If you want Motion Link to use the new colors in the future, you must use the SAVE CONFIGURATION function below to write a new configuration file.

- **SAVE CONFIGURATION** - This selection allows you to save the Motion Link configuration file to disk. This file contains information about your computer, such as what communications port you are using, the baud rate at which your computer is transmitting, and what your screen colors are. All of the settings displayed in this selection can be changed by the **OPTIONS-COMMUNICATIONS**, and **OPTIONS-SCREEN COLORS** selections. This file is read by Motion Link on power-up when you type "MLSD" from DOS.

#### 4.4.6 Help Menu

- **SD HELP <F1>** - This selection displays several pages of help for the Smart Drive. It lists Smart Drive commands and variables with brief descriptions. You can also press F1 for this help.
- **INTRO HELP** - This selection displays introductory information about Motion Link.
- **RECALL COMMANDS <F3>** - This selection recalls your previous commands. You can also use the function key F3 to recall a previous command.
- **ERROR HISTORY** - This command provides the user with the Error History of the Smart Drive.

#### 4.5 DOS DATA FILES

Motion Link stores, retrieves, displays, and edits three types of data files. Each type has a different *file extension* or *file type*. *File extension* refers to the characters in the file name that follow the period. For example, the file TEST.DVA has the file extension ".DVA" The three types of files are:

- **.DVA** User Variable sets for the Smart Drive. Variable sets are Smart Drive variables that define an application. For example, you may have different variable sets to change the tuning when the application requires it. Variable files may include some or all of the Smart Drive User Settable variables. For example, your Motion Link disk has the file "STANDARD.VAR." This variable file includes all of the "standard" or "default" variable settings. Variable files are transmitted to the Smart Drive to initialize variables. Read-only variables and comment lines must be preceded with a semi-colon (;). The Semi-colon will comment-out any text it is in front of.

Commented-out text is not transmitted to the Smart Drive.

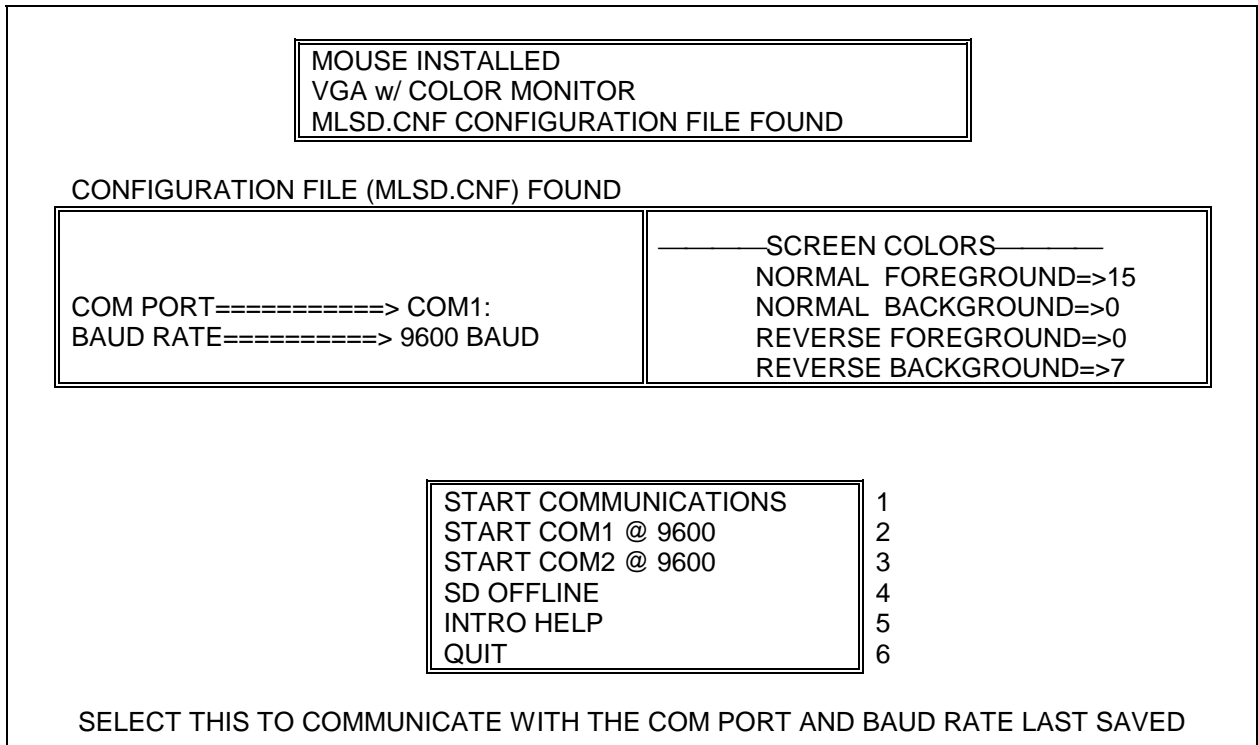
- **.CAP** Capture files contain captured communications from the Smart Drive. The capture features of the Smart Drive allow you to collect and store up to 16,000 bytes of transmissions from the Smart Drive. Capture is provided to help you capture all communications between yourself and the Smart Drive.
- **.CSV** The Comma Separated Variable file is a universally accepted file format. Most all spreadsheets will import the file type. By using your spreadsheet you can get much higher resolution plots and can manipulate the data to your specific needs.
- **.TL** The TL file is the compensation file. The .TL file contains a set of Factory settable variables that are used to configure critical limits and ranges for the exact motor and amplifier size. These files should not be edited by the user.

Any time you store variable sets or captured communication onto your computer disk, Motion Link will automatically determine the proper file extension.

#### 4.6 ESTABLISHING COMMUNICATIONS

This procedure will get users started using Motion Link after installation.

1. Connect and turn on the Smart Drive as described in this manual.
2. If Motion Link is installed on a hard disk, type:  
**CD WLS D**  
**MLSD**  
Skip to Step 4.
3. If Motion Link is installed on a floppy disk, insert the copy of Motion Link in the A-drive, type:  
**A:**  
**MLSD**
4. When Motion Link responds, the Smart Drive should respond on the PC monitor with the message in Figure 4-2 (or a similar one).



**Figure 4-2. Motion Link Introduction Screen**

This screen displays the current Smart Drive configuration. The small box at the lower half of the screen provides five choices for the operator — Start Communications, Start COM1 @ 9600, Start COM2 @ 9600, SD Offline, Intro. Help, and Quit. First time users may wish to refer to the online Intro Help by pressing "5." Choosing to Start Communications with the Smart Drive allows direct interactive communication with the Smart Drive. The Smart Drive interactive prompt is "-->." This means the Smart Drive is waiting and ready for a command. When the user types, that information is talking to the Smart Drive just as if it were a terminal. For example, type:

**OPMODE**

and the Smart Drive should respond by printing which OPMODE it is in (0-8):

**0**

Any Smart Drive command can be entered from Motion Link just as if the IBM-PC compatible computer were a terminal.

## 4.7 SERIAL COMMUNICATION FORMAT

The Smart Drive and the terminal must use the same format for serial data. Motion Link takes care of these issues for the user. In the event that some other device is desired to communicate with the Smart Drive the communications format is presented.

RS-232-C and RS-485 describe hardware only. There are other specifications left to up to the user: full- or half-duplex, the number of bits per character, whether or not parity is used, the number of stop bits, and the baud rate. Full-duplex means both the terminal and the Smart Drive can send and receive at the same time. Half-duplex means only one system can talk at a time. Bits per character refers to the number of actual data bits sent at one time. The number of start and stop bits sets a minimum delay between characters. The baud rate is the rate at which bits are transmitted and received.

The Smart Drive requirements are:

- Full-duplex
- 8 bits per character
- No parity
- 1 Start bit
- 1 Stop bit
- Baud rates equal 300, 600, 1200, 2400, 4800, 9600, or 19200.

Most terminals and computers will allow setting these options with little difficulty.

## 4.8 FIRST TRANSMISSION

Before attempting to establish communications:

1. Mount the Smart Drive and Power Supply system as described earlier in this manual.
2. Make all connections as described in previous chapters, especially connecting the Smart Drive serial connector to the terminal or computer.
3. Turn on control power.
4. The Smart Drive will either power-up and sense the connection at C3 pin 7: ABAUD input. If the input is open, the Smart Drive will initialize its serial port with the baud rate in the BAUD variable. If the ABAUD input is shorted, the Smart Drive will assume an AUTO-BAUD sequence indicated by the seven-segment display LED on the front of the Smart Drive flashing, about twice per second.

5a. If the seven-segment display is blinking...

1. Auto Baud sequence is happening. The Smart Drive will continue the Autobaud sequence for 20 seconds during which the drive can not be enabled.

If using Motion Link with an IBM-PC, type "MLSD" from DOS to start the program. Motion Link will attempt to establish communications.

If unable to establish a baud rate within 20 seconds, the Smart Drive will default to 9600 and assume normal operation.

2. Whether using a terminal or a PC that is running a "dumb terminal program", press the return key 5 to 10 times, pressing the key about twice per second.

Either of these steps cause carriage return characters to be sent to the Smart Drive. When Autobauding, the Smart Drive looks for carriage returns and uses

them to determine the *baud rate* or speed at which the terminal is transmitting. Once the baud rate is determined, the Smart Drive can establish communications with the terminal or computer.

5b. If the seven-segment display is not blinking...

1. If using Motion Link with an IBM-PC, type "MLSD" from DOS to start the program. Motion Link will establish communications. Make sure that Motion Link is set to the same baud rate that the Smart Drive is set to.
2. Whether using a terminal or a PC that is running a "dumb terminal program", make sure the terminal's or the PC terminal emulation program's baud rate is set to the same baud rate that the Smart Drive is using.

Then the Smart Drive should print this message (or one similar to it) on the terminal:

**(c) 1994 Kollmorgen Smart Drive**  
**Voltage Rating: 115 / 230**  
**Current Rating: 10**  
**Firmware Version: 2.0.0**  
 -->

The seven-segment display on the front of the Smart Drive should turn on and remain on at all times after power-up (and Autobauding). The "-->" means that the Smart Drive is ready to accept commands.

If the Smart Drive should fail to respond first make sure the communications control flags ECHO and PROMPT are set to a "1":

Carefully type the following two lines. You may not see any characters appear as you type if these flags are set to "0".

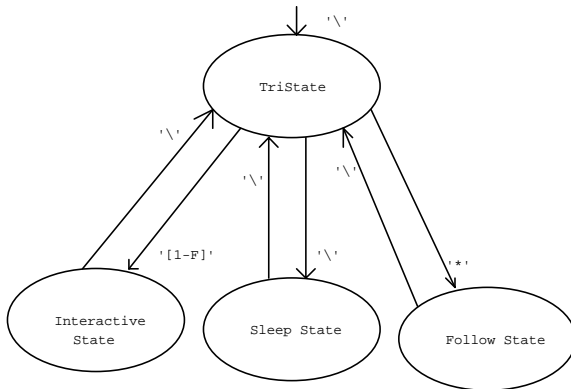
```
ECHO = 1
PROMPT = 1
```

## 4.9 RS485 MULTIDROP

The Smart Drive offers multi-drop communications facility which allows the drive to sit on an RS485 communications network. Multi-drop facilities



require a unique address to each of the units connected to the network. The Smart Drive's address can be selected using the rotary switch accessible from the front of the drive amplifier unit located just below the Status Display. Address switch settings 1-F selects the RS485 multi-drop communications. (Address 0 is reserved for RS-232). Set each Smart Drive to different address if they are connected to the same network. Upon power-up, the Smart Drive checks the address selector switch. If the address range is between 1-F it automatically switches to multidrop mode with that address. No messages will be sent onto the network on power-up. The state diagram of SmartDrive multidrop communications is given in the following figure.



**Multi Drop Communications State Transition Diagram**

**TriState:** This is the power-up state of the Smart Drive and can be entered at anytime by sending a backslash (\) character. The Smart Drive will not send any communication messages while in this state.

**Interactive State:** This state can entered from the TriState if the valid address is sent to the drive preceded by the backslash command (i.e. \A). In this mode, the Smart Drive's transmitter is active and the drive obeys all serial commands and acts as it would in RS232 mode: Prints all the messages (if msg=1), echoed characters (if echo=1) and prompt ([1-F]-> if PROMPT=1) to the network.

**Follow State:** This state can be entered from the TriState if a '\*' is typed after a '\' command (i.e. \\*). In this state, Smart Drive follows all serial commands from the serial port but never turns on its transmitter or prints to the Serial Port.

**Sleep State:** This state can be entered from the TriState if any character other than the valid address

of this drive ( including \*). In this state the Smart Drive does not follow commands from the Serial port (except a '\' command) and does not print anything to Serial port.

**Examples:**

Note: No prompt will appear if no specific Smart Drive is addressed. If a specific Drive is addressed, the address of the drive appears within the prompt.

The prompt length is always 3 characters in both RS 232 and RS 485.

\3EN<return>  
Smart Drive with address 3 is enabled

3->\\*DIS<return>  
All Smart Drives connected to the network all disabled

EJ=100  
Smart Drive with address E is jogged at 100 rpm

E->||  
Smart Drive with address E is kept in Sleep mode

## 4.10 MOTIONLINK FOR WINDOWS OPERATION

1. Install **SD Motion Link for Windows** on computer hard drive.
2. Open file **MLSDW**.
3. At the opening screen, click on **OK** button.
4. Power up the Smart Drive unit and the monitor response should be similar to either one of the following:

### KOLLMORGEN Smart Drive

Voltage Rating: 115 / 230

Current Rating: 3

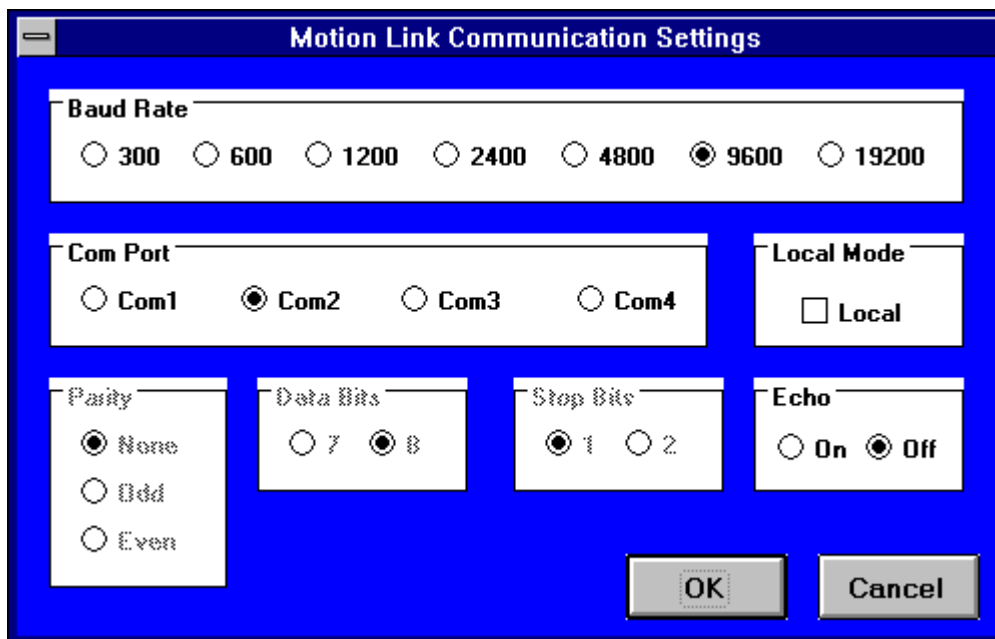
Firmware Version: 2.2.4

-->

OR

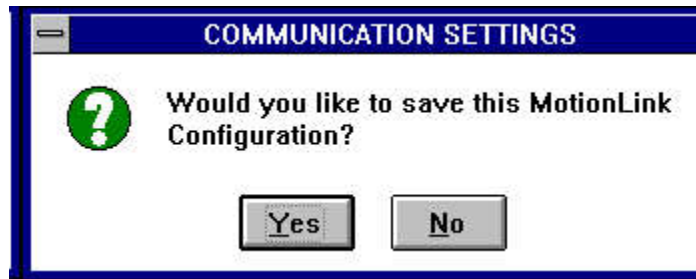
-->

5. At the menu bar select Options then Communications.
6. The monitor will display:



7. At this time, setup the desired Communication Settings parameters. At the Local Mode selection, ensure that the Local mode is not selected (an X should not appear in the box). Then, chose the OK button.

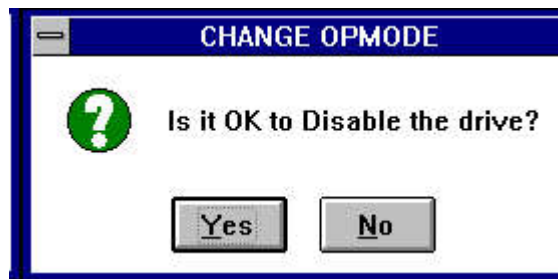
8. The monitor will display:



9. Choose the Yes button.

At this point, OPMODE 0 - 9 parameters may be programmed.

If at any time an OPMODE change is requested and the drive is Enabled, the monitor will display:



The Yes button MUST be chosen to implement the OPMODE change.

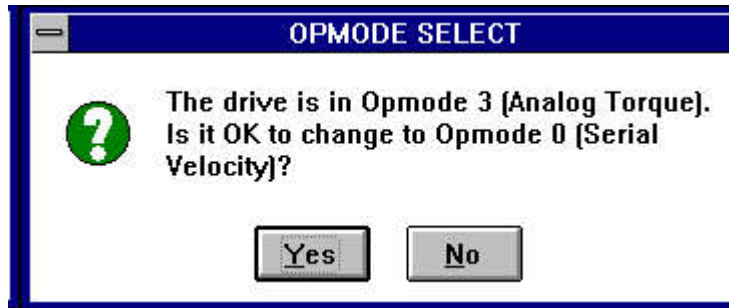
The following paragraphs introduce the OPMODE 0 - 9 windows. The Accel/Decel, Monitor, and Other button window selections are common to all OPMODES and are shown at the end of the OPMODE discussions.

The following chart defines the active window pullup buttons for each OPMODE.

OPMODE	ACTIVE WINDOW PULLUP BUTTONS		
	Accel/Decel	Monitor	Other
0 SERIAL VELOCITY	X	X	X
1 ANALOG VELOCITY	X	X	X
2 SERIAL TORQUE	N/A	X	X
3 ANALOG TORQUE	N/A	X	X
4 A/B QUADRATURE	X	SAME AS OTHER	X
5 CNT/DIR PULSE	X	SAME AS OTHER	X
6 CNT/DIR EDGE	X	SAME AS OTHER	X
7 UP/DOWN	X	SAME AS OTHER	X
8 SERIAL POSITION	X	X	X
9 ANALOG POSITION	N/A	X	X

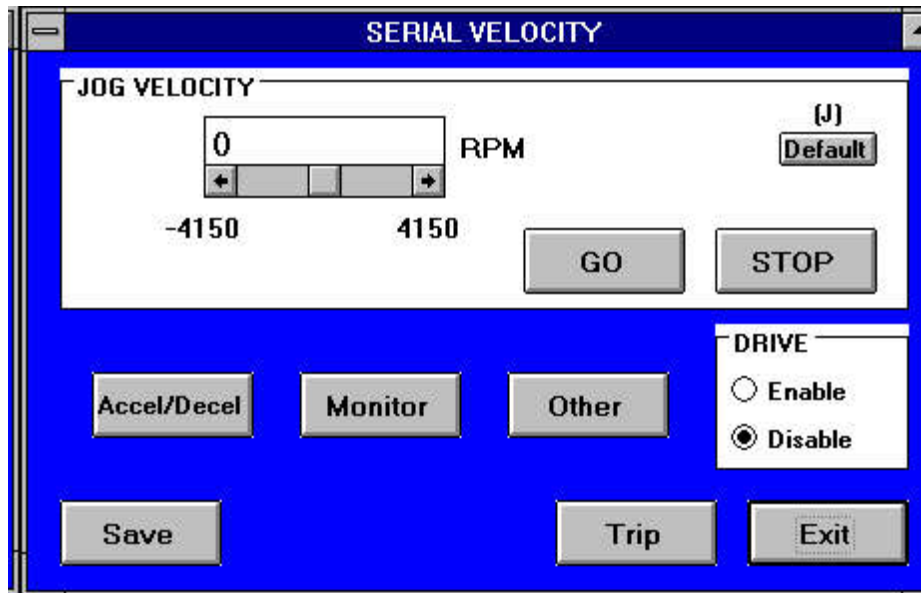
### 4.10.1 OPMODE 0 - Serial Velocity

1. At the menu bar select OpMode then, select 0 - Serial Velocity.
2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

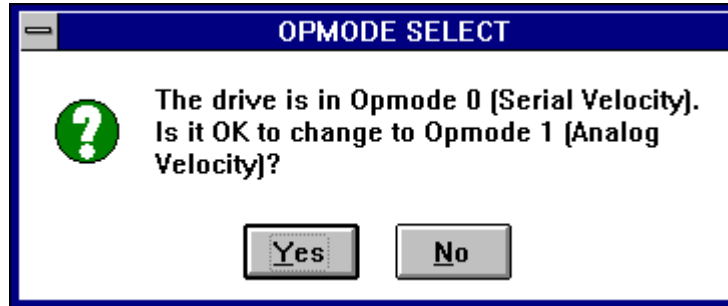
3. Click on the Yes button.
4. The monitor will display the following window:  
(Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive. Yes must be selected to implement the change).



5. At this time, OPMODE 0 SERIAL VELOCITY parameters may be set and saved. Related Accel/Decel, Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.
  - a. Serial Jog (J) - sets the Serial Jog variable
6. Select the Save button to save the entered SERIAL VELOCITY parameters.
7. Select the Exit button to close the active window displayed.

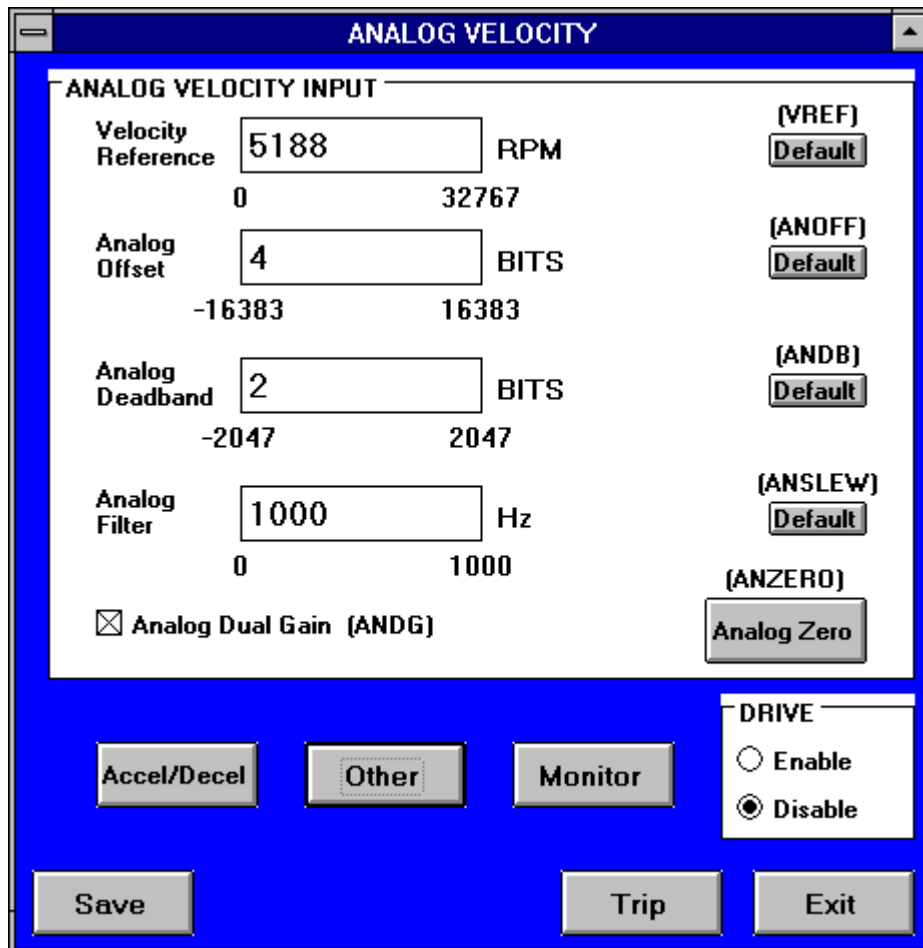
### 4.10.2 OPMODE 1- Analog Velocity

1. At the menu bar select OpMode then, select 1 - Analog Velocity.
2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.
4. The monitor will display the following window:  
 (Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive.  
Yes must be selected to implement the change).



5. At this time, OPMODE 1 ANALOG VELOCITY parameters may be set and saved. Related Accel/Decel, Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

- a. Velocity Reference (VREF) - scales the analog input. The reference velocity represents the rated motor speed at +10 V analog input. The value entered is the desired motor velocity if 10 volts were applied to the analog input.
- b. Analog Offset (ANOFF) - sets the analog offset bias velocity. This is useful to compensate for the analog command signal offset or drift.
- c. Analog Deadband (ANDB) - sets the deadband of the velocity input signal. If the velocity input voltage is less than this value then no velocity command signal is generated. This is useful in suppressing noise.
- d. Analog Filter (ANSLEW) - sets the bandwidth (corner frequency) of the low pass filter.
- e. Analog Dual Gain (ANDG) - enables the analog input dual gain (or high resolution) feature of the Smart Drive.
- f. Analog Zero (ANZERO) - automatically zeroes the analog input.

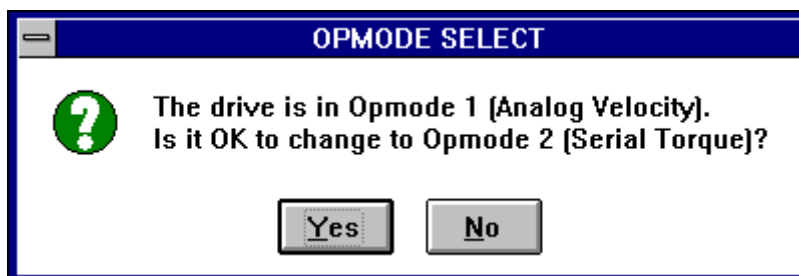
6. Select the Save button to save the entered ANALOG VELOCITY parameters.

7. Select the Exit button to close the active window displayed.

### 4.10.3 OPMODE 2- Serial Torque

1. At the menu bar select OpMode then, select 2 - Serial Torque.

2. The monitor will display a window similar to:

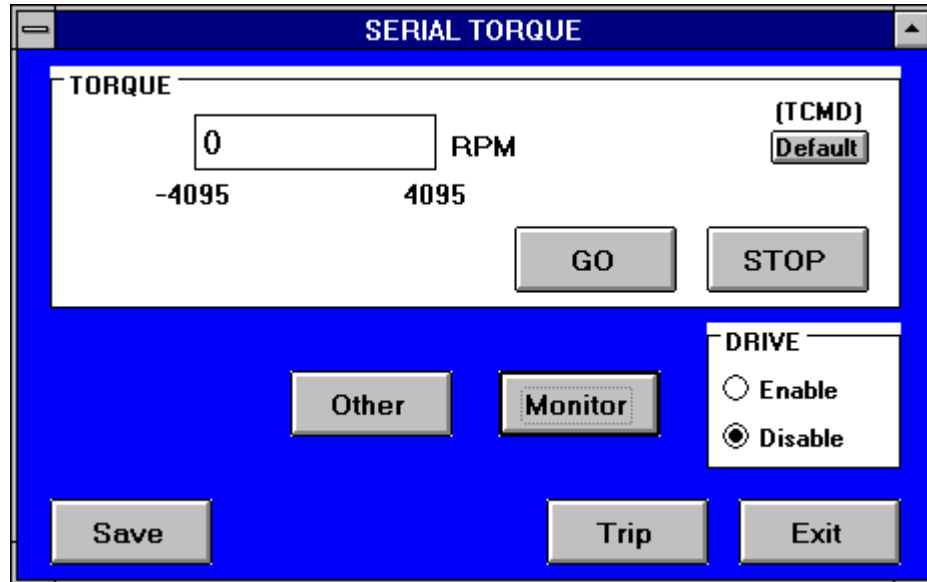


Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.

4. The monitor will display the following window:

(Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive. Yes must be selected to implement the change).



5. At this time, OPMODE 2 SERIAL TORQUE parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

- a. Torque Command (TCMD) - displays the commanded torque (motor current is generally proportional to the torque command).

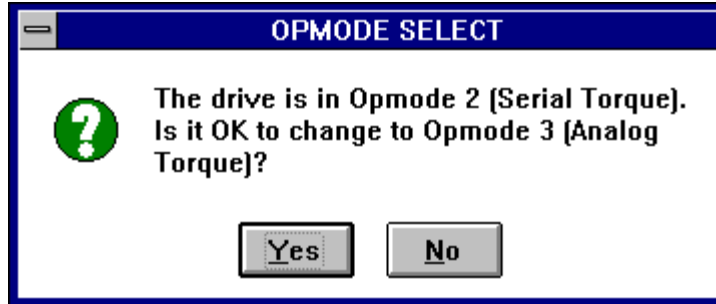
6. Select the Save button to save the entered SERIAL TORQUE parameters.

7. Select the Exit button to close the active window displayed.

#### 4.10.4 OPMODE 3- Analog Torque

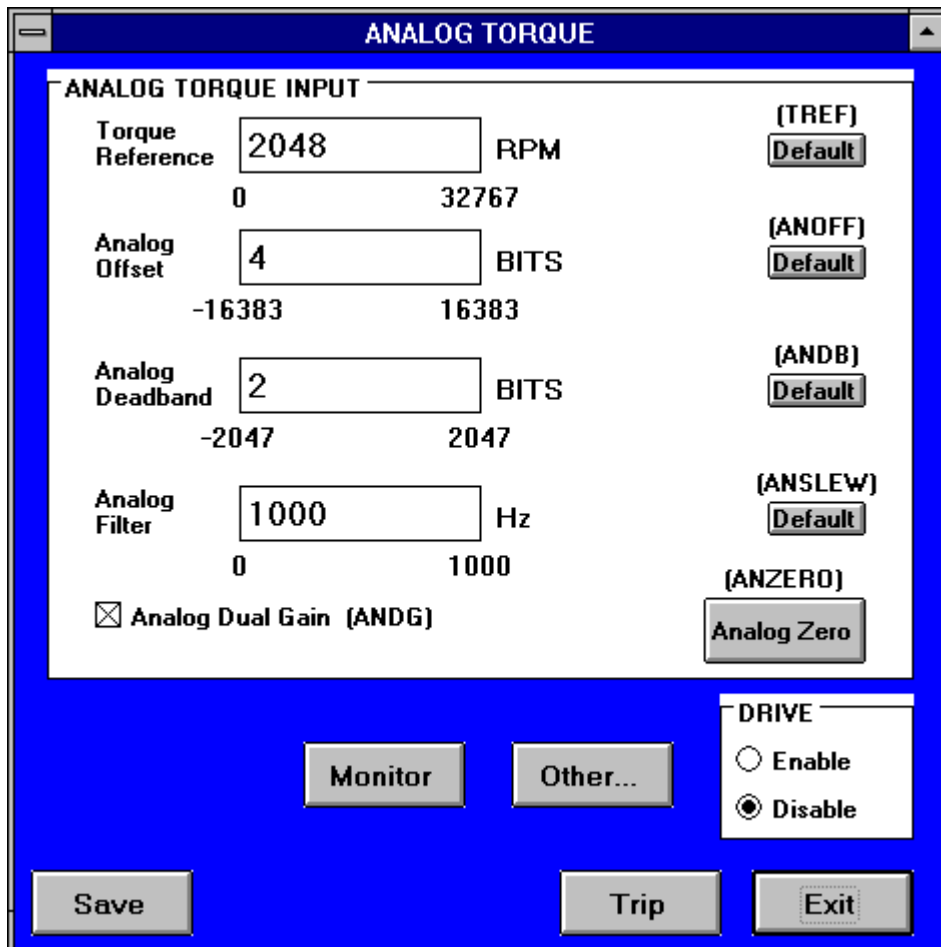
1. At the menu bar select OpMode then, select 3 - Analog Torque.

2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.
4. The monitor will display the following window:  
 (Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive.  
Yes must be selected to implement the change).



5. At this time, OPMODE 3 ANALOG TORQUE



parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

- a. Torque Reference (TREF) - scales the analog input. The reference torque (current) represents the output torque for an analog input voltage signal of 10 V. The value entered is the desired motor torque if 10 volts were applied to the analog input.
- b. Analog Offset (ANOFF) - sets the analog offset bias velocity. This is useful to compensate for the analog command signal offset or drift.
- c. Analog Deadband (ANDB) - sets the deadband of the velocity input signal. If the velocity input voltage is less than this value then no velocity command signal is generated. This is useful in suppressing noise.
- d. Analog Filter (ANSLEW) - sets the bandwidth (corner frequency) of the low pass filter.
- e. Analog Dual Gain (ANDG) - enables the analog input dual gain (or high resolution) feature of the Smart Drive.
- f. Analog Zero (ANZERO) - automatically zeroes the analog input.

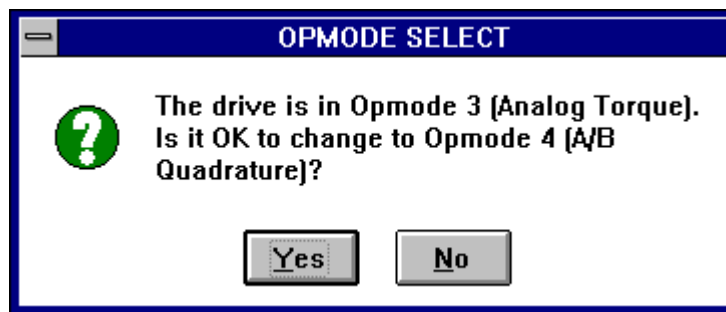
6. Select the Save button to save the entered ANALOG TORQUE parameters.

7. Select the Exit button to close the active window displayed.

#### 4.10.5 OPMODE 4- A/B QUADRATURE

1. At the menu bar select OpMode then, select 4 - A/B Quadrature.

2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.

4. The monitor will display the following window:  
 (Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive.  
Yes must be selected to implement the change).

**PULSE FOLLOWING**

**INPUT MODE (OPMODE4-7)**

A/B Quadrature    Cnt/Dir Pulse    Cnt/Dir Edge    Up/Down

**GEAR**

Gear Enable (GEAR)

Input  Ratio

Output  Ratio

**DRIVE**

Enable  
 Disable

Accel/Decel   Monitor   Other

Save   Trip   Exit

5. At this time, OPMODE 4 A/B QUADRATURE parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.
- INPUT MODE - indicates active OPMODE
  - Gear Enable (GEAR) - enables/disables the electronic gearing acting as an electronic clutch.
  - Gearing Ratio Numerator - Input (GEARI) - sets the number of teeth on the input "gear" for the electronic gearbox or ratios the scaling.
  - Gearing Ratio Denominator - Output (GEARO) - sets the number of teeth on the output "gear" for the electronic gearbox or ratios the scaling.

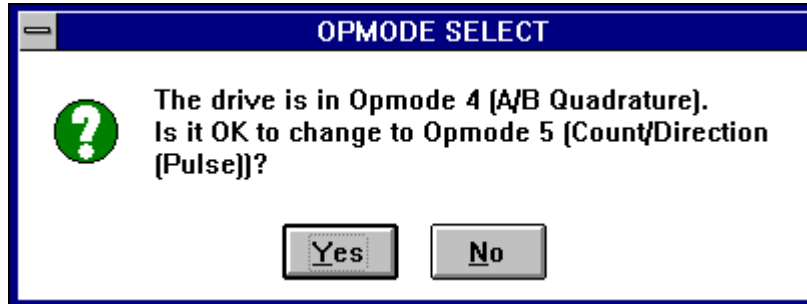
6. Select the Save button to save the entered A/B QUADRATURE parameters.

7. Select the Exit button to close the active window displayed.

### 4.10.6 OPMODE 5- Count/Direction PULSE

1. At the menu bar select OpMode then, select 5 - Count/Direction Pulse.

2. The monitor will display a window similar to:

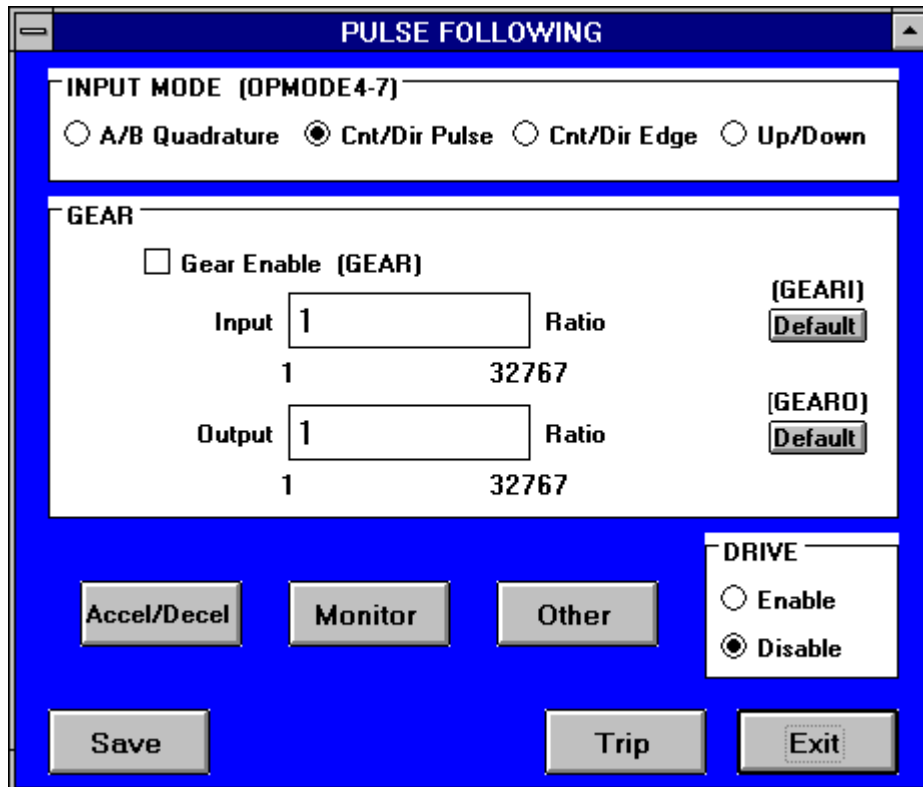


Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.

4. The monitor will display the following window:

(Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive. Yes must be selected to implement the change).



5. At this time, OPMODE 5 COUNT/DIRECTION PULSE parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

- a. INPUT MODE - indicates active OPMODE
- b. Gear Enable (GEAR) - enables/disables the electronic gearing acting as an electronic clutch.
- c. Gearing Ratio Numerator - Input (GEAR1) - sets the number of teeth on the input "gear" for the electronic gearbox or ratios the scaling.
- d. Gearing Ratio Denominator - Output (GEAR0) - sets the number of teeth on the output "gear" for the electronic gearbox or ratios the scaling.

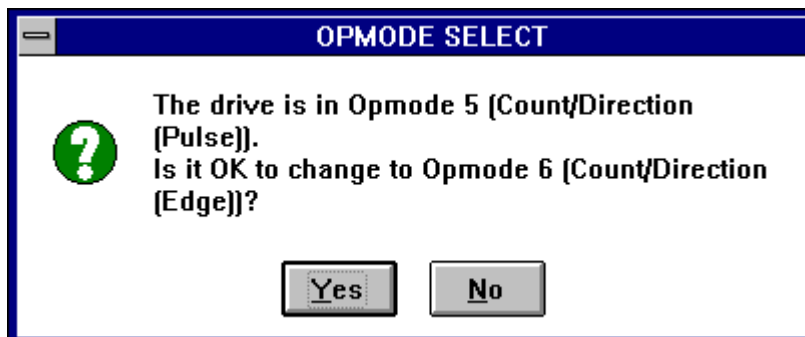
6. Select the Save button to save the entered SERIAL TORQUE parameters.

7. Select the Exit button to close the active window displayed.

#### 4.10.7 OPMODE 6- Count/Direction Edge

1. At the menu bar select OpMode then, select 6 - Count/Direction Edge.

2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.

4. The monitor will display the following window:

(Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive. Yes must be selected to implement the change).

**PULSE FOLLOWING**

**INPUT MODE (OPMODE4-7)**

A/B Quadrature  
 Cnt/Dir Pulse  
 Cnt/Dir Edge  
 Up/Down

**GEAR**

Gear Enable (GEAR)

Input	<input type="text" value="1"/>	Ratio	<input type="text" value="32767"/>	(GEARI)
	1			<input type="button" value="Default"/>
Output	<input type="text" value="1"/>	Ratio	<input type="text" value="32767"/>	(GEARO)
	1			<input type="button" value="Default"/>

**DRIVE**

Enable  
 Disable

5. At this time, OPMODE 6 COUNT/DIRECTION EDGE parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

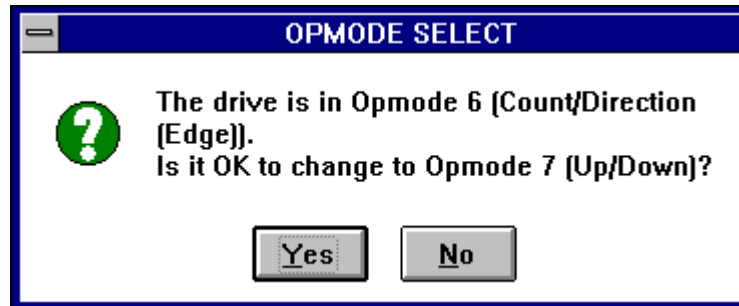
- a. INPUT MODE - indicates active OPMODE
- b. Gear Enable (GEAR) - enables/disables the electronic gearing acting as an electronic clutch.
- c. Gearing Ratio Numerator - Input (GEARI) - sets the number of teeth on the input "gear" for the electronic gearbox or ratios the scaling.
- d. Gearing Ratio Denominator - Output (GEARO) - sets the number of teeth on the output "gear" for the electronic gearbox or ratios the scaling.

6. Select the Save button to save the entered COUNT/DIRECTION EDGE parameters.

7. Select the Exit button to close the active window displayed

### 4.10.8 OPMODE 7- Up/Down

1. At the menu bar select OpMode then, select 7 - Up/Down.
2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.
4. The monitor will display the following window:  
(Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive.  
Yes must be selected to implement the change).

**PULSE FOLLOWING**

**INPUT MODE (OPMODE4-7)**

A/B Quadrature
  Cnt/Dir Pulse
  Cnt/Dir Edge
  Up/Down

**GEAR**

Gear Enable (GEAR)

Input  Ratio  (GEARI)

Output  Ratio  (GEARO)

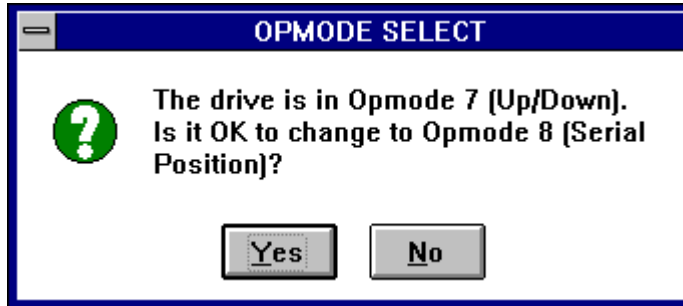
**DRIVE**

Enable
  Disable

5. At this time, OPMODE 7 UP/DOWN parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.
  - a. INPUT MODE - indicates active OPMODE
  - b. Gear Enable (GEAR) - enables/disables the electronic gearing acting as an electronic clutch.
  - c. Gearing Ratio Numerator - Input (GEARI) - sets the number of teeth on the input “gear” for the electronic gearbox or ratios the scaling.
  - d. Gearing Ratio Denominator - Output (GEARO) - sets the number of teeth on the output “gear” for the electronic gearbox or ratios the scaling.
6. Select the Save button to save the entered UP/DOWN parameters.
7. Select the Exit button to close the active window displayed.

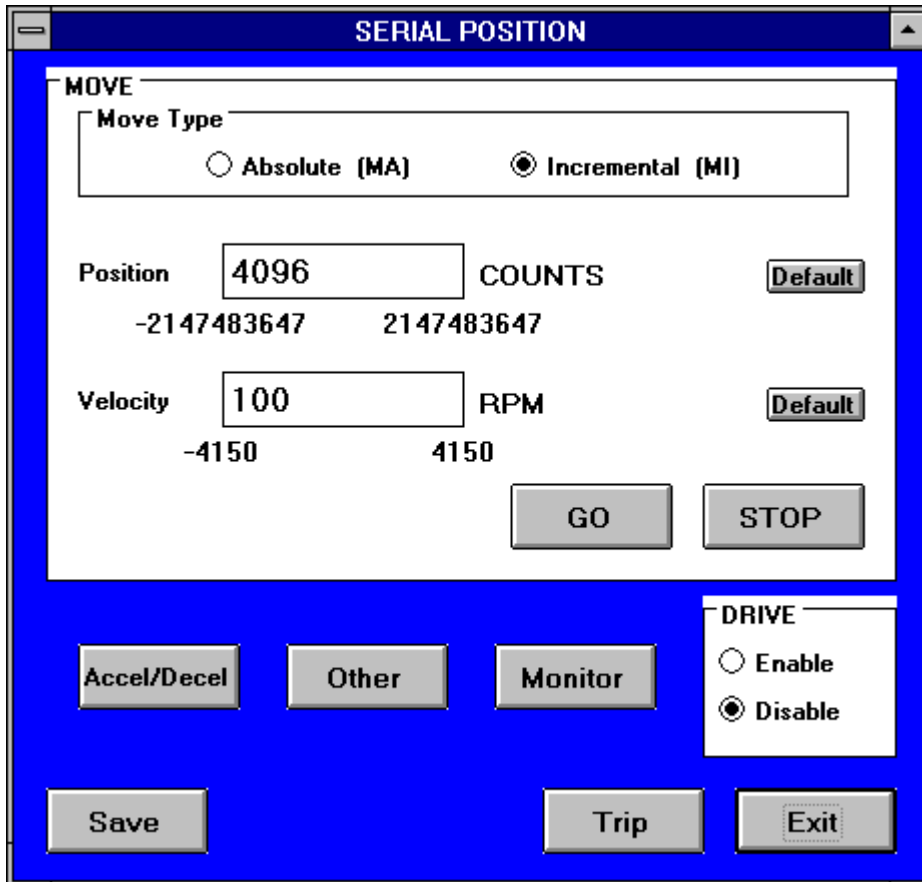
### 4.10.9 OPMODE 8- Serial Position

1. At the menu bar select OpMode then, select 8 - Serial Position.
2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.
4. The monitor will display the following window :  
 (Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive.  
Yes must be selected to implement the change).





5. At this time, OPMODE 8 SERIAL POSITION parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

- a. MOVE - indicates the type of move to be implemented.
- b. Position -
- c. Velocity -

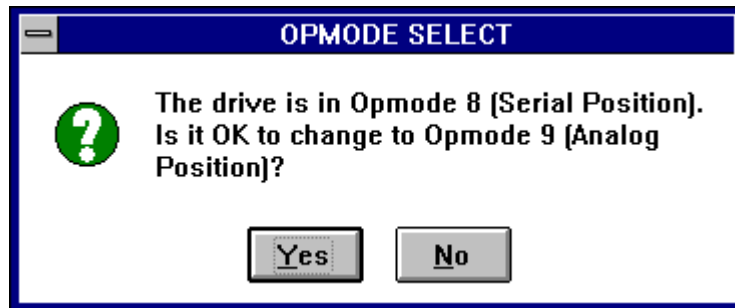
6. Select the Save button to save the entered SERIAL POSITION parameters.

7. Select the Exit button to close the active window displayed.

#### 4.10.10 OPMODE 9- Analog Position

1. At the menu bar select OpMode then, select 9 - Analog Position.

2. The monitor will display a window similar to:



Opmode numbers (Description) will vary depending upon current and selected change to mode.

3. Click on the Yes button.

4. The monitor will display the following window:

(Note that if the drive is Enabled the CHANGE OPMODE window will be displayed to ask if it is OK to Disable the drive. Yes must be selected to implement the change).

**ANALOG POSITION**

**SPAN CONTROL**

Gear Enable (GEAR)

Input  Ratio  (GEARI)

Output  Ratio  (GEARO)

**ANALOG POSITION INPUT**

Analog Offset  BITS (ANOFF)   
-16383 16383

Analog Deadband  BITS (ANADB)   
-2047 2047

Analog Filter  Hz (ANSLEW)   
0 1000

**DRIVE**

Enable

Disable

5. At this time, OPMODE 9 ANALOG POSITION parameters may be set and saved. Related Monitor, and Other windows are displayed when the respective button is selected. The windows are shown in paragraphs 4.10.11 through 4.10.13.

a. SPAN CONTROL

1. Gear Enable (GEAR) - enables/disables the electronic gearing acting as an electronic clutch.
2. Gearing Ratio Numerator - Input (GEARI) - sets the number of teeth on the input "gear" for the electronic gearbox or ratios the scaling.
3. Gearing Ratio Denominator - Output (GEARO) - sets the number of teeth on the output "gear" for the electronic gearbox or ratios the scaling.

b. ANALOG POSITION INPUT

1. Analog Offset (ANOFF) - sets the analog offset bias velocity. This is useful to compensate for the analog command signal offset or drift.
2. Analog Deadband (ANDB) - sets the

deadband of the velocity input signal.

If the velocity input voltage is less than this value then no velocity command signal is generated. This is useful in suppressing noise.

3. Analog Filter (ANSLEW) - sets the bandwidth (corner frequency) of the low pass filter.
6. Select the Save button to save the entered ANALOG POSITION parameters.
7. Select the Exit button to close the active window displayed.

#### 4.10.11 Accel/Decel Window

1. When the Accel/Decel button is selected at any OPMODE window, the monitor will display the following Accel/Decel window: Note that the Accel/Decel button is not available for OPMODES 2, 3, and 9.

The screenshot shows a window titled "ACCELERATIONS" with a blue background. At the top, there is a "Profile (PROFMODE)" section with four radio button options: "None" (selected), "Linear", "Partial S-Curve", and "Full S-Curv". Below this are three input fields, each with a "Default" button and a "[ ]" label:

- Acceleration:** Input field contains "100000", units "RPM/Sec", label "[ACCEL] Default". Range "1" to "100000" is shown below.
- Deceleration:** Input field contains "100000", units "RPM/SEC", label "[DECEL] Default". Range "1" to "100000" is shown below.
- Limit Switch Deceleration:** Input field contains "100000", units "RPM/SEC", label "[DECSTOP] Default". Range "1" to "100000" is shown below.

At the bottom of the window are three buttons: "Save", "Trip", and "Exit".

2. At this time, the operating variables may be set for:
  - a. Profile Mode (PROFMODE) - the type of acceleration/deceleration profile.
  - b. Acceleration Rate (ACCEL) - sets the drive acceleration rate if PROFMODE is set to Linear.
  - c. Deceleration Rate (DECEL) - sets the drive deceleration rate if PROFMODE is set to Linear.

d. Deceleration Stop (DECSTOP) - sets the deceleration that is used when a LIMIT Switch is tripped.

Note that the lower limit and upper limit for each variable is indicated.

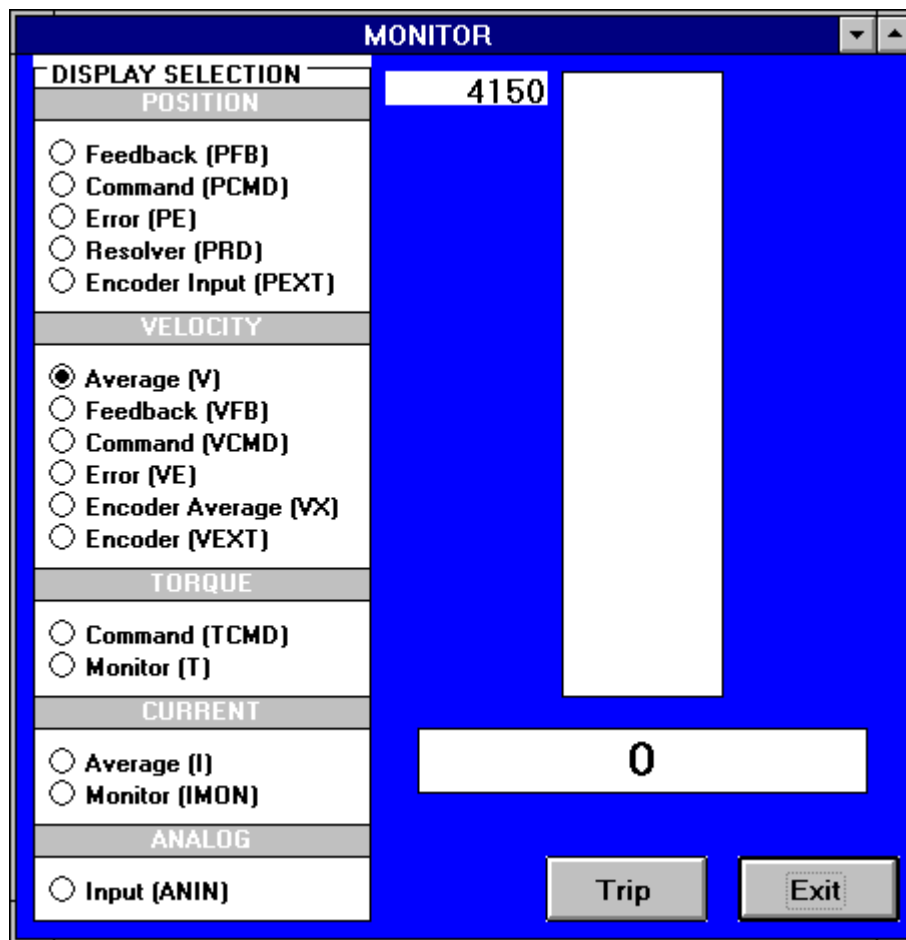
Selecting the Default button for any variable will set that variable to its default value.

3. Select the Save button to save the entered variables.

4. Select the Exit button to close the active window displayed.

#### 4.10.12 Monitor Window

1. When the Monitor button is selected at any OPMODE window, the monitor will display the following Monitor window: Note that when the Monitor button is selected in OPMODES 4 through 6, the Monitor window is displayed.



2. At this time, the operating variables may be set for:

a. POSITION:

- Position Feedback (PFB) - indicates the position feedback.
- Position Command Register (PCMD) - the current commanded position.
- Position Error (PE) - the current following error. If this value is greater than the value of variable

PEMAX, the drive will be disabled.

- Resolver-to-Digital Converter Position (PRD) - monitors the current position of the resolver-to-digital converter .
- External Input Position (PEXT) - indicates the external encoder position. The position is updated only when the drive is enabled.

b. VELOCITY:

- Average Velocity (V) - command which prints the average velocity from the previous 8 milliseconds.
- Velocity Feedback (VFB) - indicates the instantaneous velocity feedback of the motor.
- Velocity Command (VCMD) - indicates the velocity commanded to the drive.
- Velocity Error (VE) - indicates the velocity error. This is the difference between the actual motor velocity (VFB) and the commanded motor velocity (VCMD).
- Average Encoder Velocity (VX) - indicates the average external velocity.
- External Velocity (VEXT) - holds the average velocity seen on the external encoder input channel. This measurement is the average velocity over 8 milliseconds and assumes a 1024 line count encoder or a 4096 pulse-per-revolution master.

c. TORQUE:

- Torque Command (TCMD) - displays the commanded torque (motor current is generally proportional to the torque command). This variable can only be set in OPMODES 2 and 3.
- Average Torque (T) - holds the absolute average torque command output (TCMD) averaged over 8 milliseconds.

d. CURRENT:

- Average Current (I) - command which prints the average current. This is a percent of IMAX.
- Current Monitor (IMON) - prints the instantaneous current.

e. ANALOG:

- Analog Input (ANIN) - indicates (read only) the value of the analog input used for analog velocity input mode of operation. This variable has a range of -16,384 to +16,383 corresponding to -10 to +10 VDC input.

Note that the lower limit and upper limit for each variable is indicated.

Selecting the Default button for any variable will set that variable to its default value.

3. Select the Save button to save the entered variables.
4. Select the Exit button to close the active window displayed.

### 4.10.13 Other Window

1. When the Other button is selected at any OPMODE window, the monitor will display the following Other window:

The screenshot shows a software window titled "OTHER...". It contains several sections for configuring drive parameters:

- SYSTEM LIMITS:**
  - Current Limit (ILIM):** A text box containing "100" with a percentage sign to its right. Below it is a horizontal scale from 0 to 100. A "Default" button is to the right.
  - Overspeed (VOSPD):** A text box containing "4980" with "RPM" to its right. Below it is a horizontal scale from 0 to 4980. A "Default" button is to the right.
  - Thermostat (THERMODE):** Three radio buttons: "Disables Drive" (selected), "Disables Drive after 2 minutes", and "No Disable, drop Fault relay".
  - Direction Sense (DIR):** Two radio buttons: "+ Motion is CW" (selected) and "+ Motion is CCW".
  - Travel Limit (LIMDIS):** Two radio buttons: "Enable" and "Disable" (selected).
  - Travel Limit Deceleration Rate:** A button labeled "Goto ACCELERATIONS Menu".
  - Maximum Following Error (PEMAX):** A text box containing "0" with "COUNTS" to its right. Below it is a horizontal scale from 0 to 32767. A "Default" button is to the right.
- Resolver (RDRES):** Four radio buttons: "10 bit", "12 bit" (selected), "14 bit", and "16 bit".
- Encoder Output Lines (ENCLINES):** Ten radio buttons: "32", "64", "1024" (selected), "2048", "4096", "8192", "16384", "256", and "512".

At the bottom of the window are three buttons: "Save", "Trip", and "Exit".

2. At this time, the operating variables may be set for:

a. SYSTEM LIMITS:

- Current Limit (ILIM) - set to limit the drives peak output current. May be set to any value 0 - 100% of IMAX. This variable is useful while using the TUNE command, on machine setup, or to protect delicate load equipment.
- Overspeed Velocity Set-point (VOSPD) - sets the overspeed trip limit for the motor. The drive is disabled with an error condition when the drive velocity crosses this limit. This value is initially set to 20% above the rated speed but can be reduced by the user during regular motor operation for protection.

b. Thermostat Input Mode (THERMODE):

- Switch mode variable which determines the operation of the drive when the Motor Thermostat Input opens. .

c. Direction Sense (DIR):

- Sets the drive direction of motion. (As seen from the shaft end).

d. Travel Limit (LIMDIS):

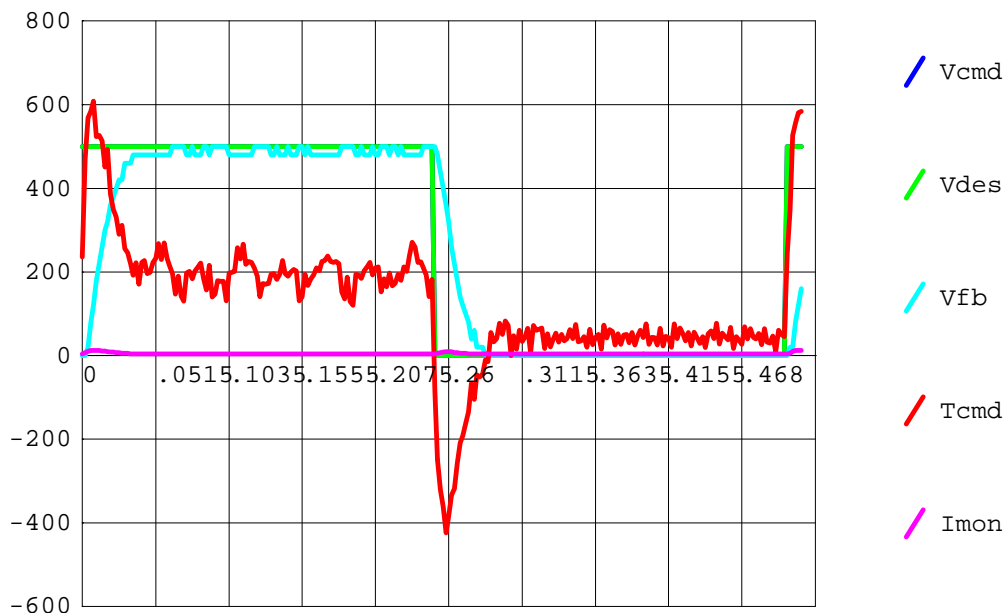
- Enables or Disables the Travel Limit function.
- e. Maximum Following Error (PEMAX):
- Sets the maximum allowable positioning error. If the PE exceeds this value, an error occurs and the drive is disabled. Setting PEMAX to 0 disables this function.
- f. Resolver-to-Digital Resolution (RDRES) - sets the resolver resolution. Active selections include 12 bit, 14 bit, and 16 bit.
- g. Encoder Output Lines (ENCLINES) - selects the resolution of the user output channel. Allowable line counts are dependent upon the RDRES selected.

Refer to the Drive Commands/Variables listing (Paragraph 5.6.9) for particular variable characteristics.

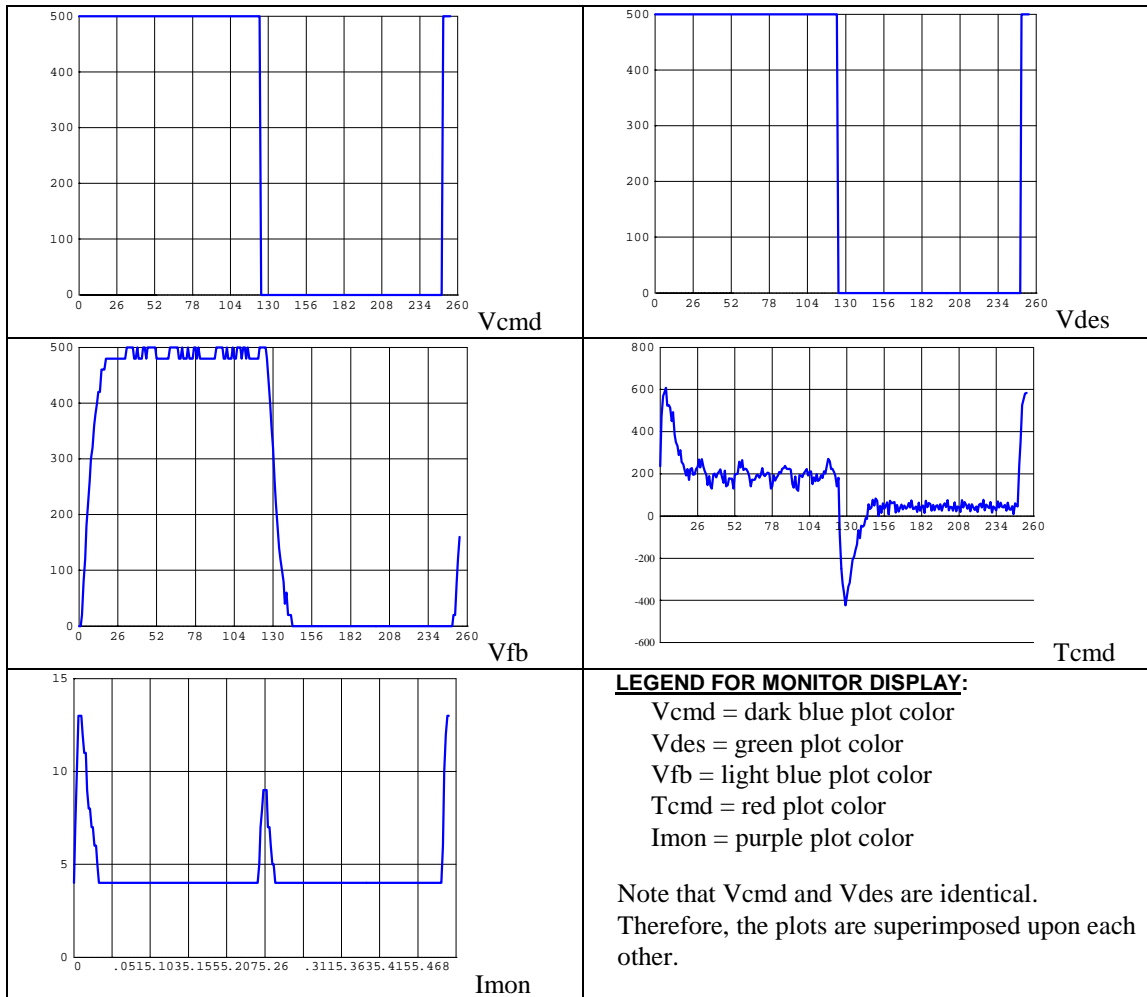
3. Select the Exit button to close the active window displayed.

#### 4.10.14 Sample PC Scope Plot for MotionLink for Windows

1. At the menu bar select Scope then, select Open.
2. At Files, select sample8.csv then OK.
3. A sample plot will be generated as shown in Figure 4-3. The composite plot is generated. The individual plot waveforms are shown in Figure 4-4 for clarity and identification



**Figure 4-3. Sample PC Scope Plot for MotionLink For Windows**



**Figure 4-4. Sample PC Scope Plot for MotionLink For Windows (Individual Plot Components)**



# CHAPTER 5

## SERIAL COMMANDS

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### 5.1 INTRODUCTION

The Smart Drive is a user configurable device with extensive serial communications capability. The information in this chapter explains how to use the serial communications capability and the commands available. A communications program is supplied with the Smart Drive and is called Motion Link. An extensive discussion on Motion Link can be found in Chapter 4. The use of Motion Link is a convenience, not a requirement to be able to communicate with the Smart Drive as any device capable of meeting the ASCII protocol can be used. This chapter uses the word HOST to indicate the device communicating to the Smart Drive be it a computer, terminal, or PLC.

### 5.2 SERIAL PROTOCOL

The Smart Drive and the terminal must use the same format for serial data. RS-232-C and RS-485 describe hardware only. There are other specifications left up to the user: full- or half-duplex, the number of bits per character, whether or not parity is used, the number of stop bits, and the baud rate. Full-duplex means both the terminal and the Smart Drive can send and receive at the same time. Half-duplex means only one system can talk at a time. Bits per character refers to the number of actual data bits sent at one time. The parity is a bit sent for error detection. The number of start and stop bits sets a minimum delay between characters. The baud rate is the rate at which bits are transmitted and received.

The Smart Drive requirements are:

- Full-duplex
- 8 bits per character
- No parity
- 1 Start bit
- 1 Stop bit
- Supported Baud rates:
  - 300, 600, 1200, 2400,
  - 4800, 9600, or 19200.

Most terminals and computers will allow setting these options with little difficulty.

### 5.3 MODES OF OPERATION

The Smart Drive has the ability to assume many different modes of operation. It is factory configured in OPMODE 1: Analog Velocity Loop Controller but may be reconfigured by the user. Not all commands and variables are active, or even meaningful in every OPMODE. Table 5.1 lists and defines the available operational modes.

**Table 5.1 OPMODE DEFINITION**

OPMODE	Name	Function
0	Serial Velocity Mode	The Smart Drive is configured as a velocity loop controller. Velocity is controlled by the serial jog (J) command.
1	Analog Velocity Mode	The Smart Drive is configured as a velocity loop controller. Velocity is controlled by the analog input channel.
2	Serial Torque Mode	The Smart Drive is configured as a torque loop controller. Torque is controlled by the serial torque (TCMD) command.
3	Analog Torque Mode	The Smart Drive is configured as a torque loop controller. Torque is controlled by the analog input channel.
4	Electronic Gear Mode	The Smart Drive is configured as a slave axis in a position loop configuration. The position command comes from the external encoder input channel configured to receive quadrature encoder counts.
5	Edge and Direction Mode	The Smart Drive is configured as a slave axis in a position loop configuration. The position command comes from the external encoder input channel configured to receive positive edges on the A encoder channel for motor motion and a level on the B encoder channel to determine direction.
6	Pulse and Direction Mode	The Smart Drive is configured as a slave axis in a position loop configuration. The position command comes from the external encoder input channel configured to receive pulse edges on the A encoder channel for motor motion and a level on the B encoder channel to determine direction. This mode of operation varies from OPMODE 5 in that both the positive and negative edges of the pulse increment the commanded position
7	Up / Down Mode	The Smart Drive is configured as a slave axis in a position loop configuration. The position command comes from the external encoder input channel configured to receive positive edges on the A encoder channel for clockwise motor motion while positive edges on the B encoder channel will cause counter clockwise motor motion.
8	Position Mode	The Smart Drive is configured as a position loop controller able to execute a limited set of point-to-point serial position commands.
9	Analog Position Input	With unity gear ratio a 10 V change in input voltage will rotate the motor 2048 counts. ( 1 rev for 12 bit; $1/4$ rev for 14 bit; $1/16$ rev for 16 bit resolution)

## 5.4 SMART DRIVE COMMAND SET

A command is a transmission to the Smart Drive which causes it to do something. In General, all communications to the Smart Drive are commands. The print and variable assignment commands are the most common commands and yet ones that are not obvious as being commands.

The Smart Drive allows a great amount of flexibility using a very simple command set. The following command set is executed as indicated by sending the indicated ASCII string to the serial port followed by the CR-LF terminator.

Serial commands are received by the Smart Drive at anytime after self-tests are completed. The Smart Drive does not process a command until the end-of-line-terminator (CR-LF). The commands are sent to the serial port in a 'dumb-terminal' fashion meaning that each message is sent in ASCII code as though one were typing it on a keyboard.

The Smart Drive responds to all commands, unless otherwise suppressed by the PROMPT switch variable, with a minimum of a prompt. The Smart Drive prompt is two minus signs followed by a greater than sign: -->. The Smart Drive also responds to power-up and fault conditions with a message, unless otherwise suppressed using the MSG switch variable.

The Smart Drive 'echoes' (retransmits) all received messages character-by-character unless suppressed by the ECHO switch variable. This feature can be used by the host to check for valid data reception.

## 5.5 SMART DRIVE VARIABLE SET

The Smart Drive compliments a simple set of commands with an extensive set of variables accessible by the user. Some of the variables are used to provide status information for installation and debugging. Other variables are provided to allow the user to customize the system for the particular application. The Smart Drive recognizes four different types of variables:

### String Variables

A string variable is a variable which does not have to be a number as it may include letters or punctuation.

The Smart Drive does not require entry of string variables but may transmit them as in the case of ERR and MOTOR commands. Most string variables transmitted by the Smart Drive are properly formatted to fit on a 2-line by 40-character LCD display terminal.

### Variables

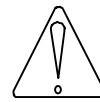
A variable is a number within the Smart Drive that has a very specific meaning. Some variables are user settable to configure the drive, such as maximum position error: PEMAX. Some variables are calculated by the Smart Drive and not settable, such as velocity feedback: VFB. Others are determined by hardware readings, such as resolver position: PRD. All are readable.

### Switch Variables

A sub-class of variables, switch variables can only assume two states; 1 (on) or 0 (off). Some of these can be set by the user, such as the direction switch variable: DIR. All are readable (or testable).

### Switch Mode Variables

Also a sub-class of variables, switch mode variables are like a multiple-pole rotary switch. They can assume only one-of-n values where 'n' is defined as a function. An example of the switch mode variable is the filter switch: FILTMODE. Setting FILTMODE = 0 means no filter is used. FILTMODE = 1 means a low-pass filter is used. FILTMODE = 2 means that a notch filter is used. In general, switch mode variable names end with the letters 'MODE'.



**NOTE**

**Modifying any component in the Smart Drive's memory will only be in effect until power is cycled if a SAVE command is not executed.**

### TL Reference

The value to which some variables are set depend highly upon motor and load characteristics. The following variable definition section contains references to default values. Those indicating TL mean they are factory set to Test Limits to provide initial values. TL variables are part of the compensation files (see sections 2.22 and 2.23) that are loaded to configure the drive.

## 5.6 CONVENTIONS

The following description of commands and variables use common definitions to technically describe the characteristics of the Motion Link For Windows, Smart Drive variables.

### 5.6.1 Variable Type

Classifies commands and variables. Variables are further classified as read and write (R/W) programmable, or read only (RO) variables.

### 5.6.2 Syntax

Syntax is the definition of how a command or variable must be used. It is exacting to each letter. The drive processor is not case sensitive, does not discriminate between upper and lower case. If the command/variable requires any arguments, the argument RANGE is enclosed in brackets [ ]. If the command, variable, or switch is not programmable, read only (R/O), the output range is specified in brackets { }.

### 5.6.3 Data Range

Each variable in the Smart Drive may assume a value within a given range, a minimum to maximum limit. The ranges are defined in table 5-2.

### 5.6.4 Data Units

Specifies the units of the variable. Some variables have a direct measurement quantity, such as Speed in revolutions per minute which would be specified as RPM.

### 5.6.5 Variable Default

Specifies the default (preset) value of the variable.

### 5.6.6 EEPROM

Specifies if the variable is stored in the non-volatile memory.

### 5.6.7 OPMODES

Specifies the applicability of the particular command or variable for the operational modes of the Smart Drive.

### 5.6.8 Drive Status

Specifies the drive status when it is allowed to issue the command or change the value of the variable.



**NOTE**

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**Not all variables can be modified with the drive enabled**

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**Table 5-2. Data Ranges**

Type	Range
Long Limit	-2147483648 < x < 2147483648
Long > 0 Limit	0 < x < 2147483648
Short Limit	-32768 < x < 32767
Short > 0 Limit	0 < x < 32767

### 5.6.9 Drive Commands/Variables

#### ABAUD

Auto Baud Input State: This is a switch variable that represents the state of the external ABAUD enable input. When the ABAUD enable input is jumpered low, or set to 0, it initiates the communication between the terminal and Smart Drive with the automatic baud rate sequence of 9600, 1200, 2400, 4800, 19200. The baud rate (variable BAUD) will be set to the first successful value of the sequence.

*Type:* ..... Switch Variable (Read Only)

*Syntax/Range:* ... ABAUD [0, 1]

where: 0 = Jumper Out, Use baud rate stored in BAUD.  
1 = Jumper In, Autobaud active

*Units:* ..... n/a

*Default:* ..... n/a

*EEPROM:* ..... no

*OPMODES:* ..... All

*Drive Status:* ..... EN/DIS

#### ACC

Acceleration Rate: This is a variable used to set the drive acceleration rate. ACC will only work if PROFMODE = 1.

*Type:* ..... Variable (Read/Write)

*Syntax/Range:* ... ACC [1 to 100,000]

*Units:* ..... RPM/Second

*Default:* ..... 100000 (RPM/sec)

*EEPROM:* ..... Yes

*OPMODES:* ..... 0, 1, 4, to 8

*Drive Status:* ..... EN/DIS

#### ACTIVE

Drive Active: This is a command switch variable used to indicate the drive status. ACTIVE is a logical AND of the drive READY with the REMOTE input.

*Type:* ..... Switch Variable (Read Only)

*Syntax/Range:* ... ACTIVE {0, 1}

where: 0 = READY or REMOTE is OFF  
1 = READY & REMOTE are ON

*Units:* ..... n/a

*Default:* ..... n/a

*EEPROM:* ..... no

*OPMODES:* ..... All

*Drive Status:* ..... EN/DIS

- ADDR**                    Multidrop Address: This variable allows setting of the ADDRESS select switch, located on the front of the Smart Drive, to be read..
- Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* .... ADDR {0-15}  
                   where: 0 = RS-232  
                        1-9 and A-F = RS-485
- Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- AMPS**                    Drive Amperage Rating: This variable indicates the continuous rated current on the Smart Drive. The Peak Rated current is twice the Continuous rated. Both ratings are sinusoidal RMS. The drive may be configured to output less than rated by the user (ILIM) or by the factory (IMAX, ICONT).
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* .... AMPS (3, 10, 20, 30, 55)  
*Units:* .....Amps  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- ANDB**                    Analog Deadband: This variable sets the deadband of the velocity input signal. If the velocity input voltage is less than this value then no velocity command signal is generated. This is useful in suppressing noise.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* .... ANDB (0 to 2047)  
*Units:* .....10 / 2047 volts     (4.88 mV)  
*Default:* .....0  
*EEPROM:* .....Yes  
*OPMODES:* .....1, 3, 9  
*Drive Status:* .....EN/DIS
- ANDG**                    Analog Dual Gain Control: This switch variable enables the analog input dual-gain (or high resolution) feature of the Smart Drive.
- Type:* .....Switch Variable (Read/Write)  
*Syntax/Range:* .... ANDG [0, 1]  
                   where: 0 = disable dual gain feature (gain stage 1:1)  
                        1 = enable dual gain feature (gain stage 8:1)
- Units:* .....n/a  
*Default:* .....1  
*EEPROM:* .....Yes  
*OPMODES:* .....1, 3, 9  
*Drive Status:* .....DIS

- ANIN** Analog Input: This is a read only variable which indicates the value of the analog input used for analog velocity input mode of operation. This variable has a range of -16,384 to +16,383 corresponding to -10 to +10 VDC input.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ... ANIN {-16,384 to 16,383}  
*Units:* ..... 10 / 16,384 volts (0.610mV)  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... 1, 3, 9  
*Drive Status:* ..... EN/DIS
- ANOFF** Analog Offset: This variable sets the analog offset bias velocity of the drive in the analog velocity input mode. This is useful to compensate for the analog command signal (see ANIN) offset or drift.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... ANOFF (-16383 to 16383)  
*Units:* ..... 10 / 16,383 volts (0.610mV)  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 1, 3, 9  
*Drive Status:* ..... EN/DIS
- ANSLEW** This variable sets the bandwidth (corner frequency) of the low pass filter of the analog input.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... ANSLEW (1 to 1000)  
*Units:* ..... n/a  
*Default:* ..... 1000  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 1, 3, 9  
*Drive Status:* ..... EN/DIS
- ANZERO** This variable is used to automatically zero the analog input.
- Type:* ..... Command  
*Syntax/Range:* ... ANZERO  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... 1, 3, 9  
*Drive Status:* ..... DIS

**BAUD**

Baud Rate: This variable is used to set the communication baud rate between the terminal and Smart Drive when ABAUD = 0. This variable is automatically set after the autobaud sequence.

*Type:* .....Variable (Read/Write)  
*Syntax/Range:*.....BAUD [<baud rate>]  
                                   <baud rate> = [19200, 9600, 4800, 2400, 1200, 600, 300]  
*Units:* .....baud  
*Default:* .....9600  
*EEPROM:* .....No  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS

**CWLIM**

CW Limit: This switch variable indicates the travel limit in the clockwise direction (as seen from the shaft end). When the travel limit is reached, the drive is inhibited from further travel in the clockwise direction.

*Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....CWLIM [0,1]  
                                   where: 0 = Clockwise travel limit not reached  
   1 = Clockwise travel limit reached  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS

**CCWLIM**

CCW Limit: This switch variable indicates the travel limit in the counter-clockwise direction (as seen from the shaft end). When the travel limit is reached, the drive is inhibited from further travel in the counter-clockwise direction.

*Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....CCWLIM [0,1]  
                                   where: 0 = Counter-Clockwise travel limit not reached  
   1 = Counter-Clockwise travel limit reached  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS

**DEC**

Deceleration Rate: This variable sets the deceleration rate of the drive. This variable is only works if PROFMODE = 1.

*Type:* .....Variable (Read/Write)  
*Syntax/Range:* ....DEC [1 to 100,000]  
*Units:* .....RPM / Second  
*Default:* .....100000 (RPM/sec)  
*EEPROM:* .....Yes  
*OPMODES:* .....0, 1, 4 to 8  
*Drive Status:* .....EN/DIS



- DECSTOP** Deceleration Stop: This variable sets the deceleration that is used when a LIMIT switch is tripped.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... DECSTOP [1 to 100,000]  
*Units:* ..... RPM / Second  
*Default:* ..... 100000 (RPM/sec)  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 0, 1, 4, 5, 6, 7  
*Drive Status:* ..... DIS
- DEP** DEP Message Mode: This switch variable sets the length of the error messages (sent by the Smart Drive) for 40 column displays like that of the DEP01.
- Type:* ..... Switch Variable (Read/Write)  
*Syntax/Range:* ... DEP [0, 1]  
                   where: 0 = long messages  
                           1 = short messages (40 columns)  
*Units:* ..... n/a  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- DIR** Direction: This switch variable sets the drive direction of motion.  
 (As seen from the output shaft end)
- Type:* ..... Switch Variable (Read/Write)  
*Syntax/Range:* ... DIR [0, 1]  
                   where: 0 = Positive motion Counter-Clockwise  
                           1 = Positive motion Clockwise  
*Units:* ..... n/a  
*Default:* ..... 1  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... DIS
- DIS** Disable: This command disables the drive. Software servo loops are halted and a direct connection to the power stage removes power from the motor. The function is immediate and the motor may coast.
- Type:* ..... Command  
*Syntax/Range:* ... DIS  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN

- DUMP** DUMP: This command dumps all the variable settings to the serial port.
- Type:* .....Command  
*Syntax/Range:* ....DUMP  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....No  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- DUMP TL** Dump Test Limit Variables: This command is used to display all the test limits from RAM to the monitor.
- Type:* .....Command  
*Syntax/Range:* ....DUMP TL  
*Units:* .....n/a  
*Default:* .....n/a  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- =** Equals: This command is the assignment operator. A writeable variable name followed by the '=' sign is an attempt to modify the variable to the value following the '='. Note that if no '=' separates a variable name from a value that the Smart Drive still interpretes this as an attempt to modify the variable. The '=' is therefore optional. Note that if neither a value or an '=' sign follows a variable name, the Smart Drive intuitively understands that as a request to print the current value of the variable (See P). Modification of variables occur in working RAM and will be lost on power cycle unless the SAVE command is executed. Variables may be any of the three variable classes.
- Type:* .....Command  
*Syntax/Range:* ....[variable] = [value]  
*Alternate Syntax:* [variable] [value]
- Example: ILIM = 20*  
*ILIM 20*
- ECHO** Echo Enable: This switch variable suppresses the serial port echo when set to 0.
- Type:* .....Switch Variable (Read/Write)  
*Syntax/Range:* ....ECHO [0, 1]  
                   where: 0 = Disable serial port character echo  
                        1 = Enable serial port character echo
- Units:* .....n/a  
*Default:* .....1  
*EEPROM:* .....Yes  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS

**EN** Enable: This command initiates a software enable of the Smart Drive. The drive attempts to reset any existing fault condition, zero all internal integrators, zero the position and velocity errors and set the READY switch variable. If the external Remote Enable is active then the drive becomes active and applies power to the motor.

Type: ..... Command  
 Syntax/Range: ... EN  
 Units: ..... n/a  
 Default: ..... n/a  
 EEPROM: ..... No  
 OPMODES: ..... All  
 Drive Status: ..... DIS

**ENCLINES** Encoder Lines: This variable allows the user to select the resolution of the encoder equivalent output channel. Allowable line counts are shown in the table below.

Type: ..... Variable (Read/Write)  
 Syntax/Range: ... ENCLINES [ 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384 ]  
 Units: ..... lines  
 Default: ..... 1024  
 EEPROM: ..... No  
 OPMODES: ..... All  
 Drive Status: ..... EN/DIS

AVAILABLE ENCLINES	RDRES =12 (14000 RPM)	RDRES =14 (3500 RPM)	RDRES =16 (850 RPM)
16,384			√
8192			√
4096		√	√
2048		√	√
1024	√	√	√
512	√	√	√
256	√	√	√
128	√	√	√
64	√	√	√
32	√	√	√
16	√	√	√
8	√	√	√

- ENCODERIN** Encoder Input: This variable displays the value of the current position signal of the external encoder.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* .... ENCODERIN {0 to 4095}  
*Units:* ..... encoder counts  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- ERR** Error: This command displays the last fault in the drive. The faults are displayed in the order of their occurrence with the first fault listed first and the last fault listed last. 1 to 100 is used to display the error error message associated.
- Type:* ..... Command  
*Syntax/Range:* .... ERR [CLR | HIST | 1 to 100]  
                   where: CLR - Clears the error history buffer  
                           HIST - Lists the last 20 errors/faults of the drive
- Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- ERR CLR** Error Buffer Clear:  
 This command will clear the error history buffer which is 20 messages long.
- Type:* ..... Command  
*Syntax/Range:* .... ERR CLR  
*Units:* ..... n/a  
*Default:* ..... n/a  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- ERR HIST** Recall Error Buffer:  
 This command will display the error history buffer. The most recent error is sent first. Up to 20 string messages may be transmitted to the serial port. Each message is terminated with a CR-LF. A relative time-tag is printed with the error message. The time-tag is very coarse and intended for the factory QA program.
- Type:* ..... Command  
*Syntax/Range:* .... ERR HIST  
*Example:* --> ERR HIST  
                   Resolver Loss 3:8:6  
                   Resolver Loss 4:1:3  
                   -->
- Units:* ..... n/a  
*Default:* ..... n/a  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS

- ERR xx**                    Error Explanation:  
This command will display the error message associated with a particular error number.  
It is a dictionary for error code numbers.
- Type:* ..... Command  
*Syntax/Range:* ....ERR [1 to n]  
*Example:* --> ERR 1  
          Over Temperature  
          -->
- Units:* ..... n/a  
*Default:* ..... n/a  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- FILTMODE**                Filter Mode: This command variable selects a filter to be inserted in the velocity loop compensator. The Smart Drive has two built-in filters - low pass and notch.
- Type:* ..... Command variable  
*Syntax/Range:* ...FILTMODE [ <filter> ]  
          <filter>    0 = No filter selected  
                      1 = Low pass filter selected  
                      2 = Notch filter selected
- Units:* ..... n/a  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- FOLD**                     Foldback State: This is a switch variable which indicates the status of the foldback circuit. Value 0 represents foldback off (inactive) condition and value 1 represents foldback on (active). When the foldback is on, the continuous current is limited to Icont.
- Type:* ..... Read Switch (Read Only)  
*Syntax/Range:* ...FOLD {0, 1}  
                      where: 0 = Not in Foldback  
                              1 = In Foldback
- Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS

- GAINSHIFT** This switch variable enables the Smart Drive to drive very high loads (up to 40:1 inertia mismatch).
- Type:* .....Switch variable (Read/Write)  
*Syntax/Range:* ....GAINSHIFT [0, 1]  
                   where: 0 = High gain mode not enabled  
                        1 = High gain mode enabled
- Units:* .....n/a  
*Default:* .....0  
*EEPROM:* ..... Yes  
*OPMODES:* .....All  
*Drive Status:* .....DIS
- GEAR** Gear Enable: This switch variable enables/disables the electronic gearing acting as an electronic clutch.
- Type:* .....Switch Variable (Read/Write)  
*Syntax/Range:* ....GEAR [0, 1]  
                   where: 0 = Gear mode not enabled  
                        1 = Gear mode enabled
- Units:* .....n/a  
*Default:* .....0  
*EEPROM:* ..... Yes  
*OPMODES:* .....4 to 7, 9  
*Drive Status:* .....EN/DIS
- GEARI** Gearing Ratio Numerator: This variable sets the number of teeth on the input "gear" for the electronic gearbox or ratios the scaling.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ....GEARI [SHORT]  
*Units:* .....n/a  
*Default:* .....1  
*EEPROM:* ..... Yes  
*OPMODES:* .....4 to 7, 9  
*Drive Status:* .....EN/DIS
- GEARO** Gear Ratio Denominator: This variable sets the number of teeth on the output "gear" for the electronic gearbox or ratios the scaling.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ....GEARO [1 to 32767]  
*Units:* .....n/a  
*Default:* .....0  
*EEPROM:* ..... Yes  
*OPMODES:* .....4 to 7, 9  
*Drive Status:* .....EN/DIS

- GICAP** This variable sets the Integrator Band in PI position loop. This is used to reduce the overshoot although it tends to increase the following error during a move.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... GICAP [1 to 100]  
*Units:* ..... n/a  
*Default:* ..... 10  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- GP** Proportion Gain, Position Loop, PI: Tuning variable which sets the Proportional Gain for Proportional Integral Position Control Loop (PI Position Loop). This variable may be changed using the TUNE command or can be set manually.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... GP ( 0 to 32767 )  
*Units:* ..... n/a  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- GPI** Integral Gain, Position Loop, PI: Tuning variable which sets the velocity integral gain for Proportional Integral Position Control Loop (PI Position Loop). This variable can be changed using the tune command (see TUNE) or can be set manually.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... GPI ( 0 to 32767 )  
*Units:* ..... n/a  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- GV** Proportional Gain, Velocity Loop, PI: Tuning variable which sets the proportional gain for Proportional Integral Velocity Control Loop (PI loop). This variable may be changed using the TUNE command or can be set manually.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... GV [50 to 32767]  
*Units:* ..... n/a  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 0, 1, 4 to 9  
*Drive Status:* ..... EN/DIS

- GVD** Derivative Gain, Velocity Loop, PID: Tuning variable which sets the velocity derivative gain for the Proportional Integral Derivative velocity control loop (PID loop). This variable is not modified by the TUNE command.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ....GVD ( 0 to 32767 )  
*Units:* .....n/a  
*Default:* .....0  
*EEPROM:* ..... Yes  
*OPMODES:* .....0, 1  
*Drive Status:* .....EN/DIS
- GVI** Integral Gain, Velocity Loop, PI: Tuning variable which sets the velocity integral gain for the Proportional integral velocity control loop (PI loop). This variable can be changed using the TUNE command or can be set manually. GVI = 0 makes the PI controller to act as proportional controller.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ....GVI (0 to 32767)  
*Units:* .....n/a  
*Default:* .....TL  
*EEPROM:* ..... Yes  
*OPMODES:* .....1, 2, 4 to 9  
*Drive Status:* .....EN/DIS
- HVER** Hardware Version: This variable indicates the version of the Hardware circuitry. It is used by the factory to help identify component compatibility.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ....HVER  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* ..... Yes  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- I** This variable prints the Average Current. This is a percent of IMAX.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ....I {0 to 100}  
*Units:* .....Amps (Percent of Drive Peak Current Rating)  
*Default:* .....n/a  
*EEPROM:* .....n/a  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS



- ILIM** Current Limit: This variable allows the user to limit the drives peak output current. The user may set ILIM to any value 0 to IMAX. This is useful while using the TUNE command, on machine startup, or to protect delicate load equipment.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... ILIM [0 to 100] limited by IMAX  
*Units:* ..... Drive Peak Current Rating (2 x AMPS)  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- IMAX** Maximum Current: This variable indicates the maximum allowed peak current from the Smart Drive. The drive's peak rated current sometimes exceeds the motors capability. This setting is used to protect the motor. Note that a reading of 100% indicates drive rated peak current which is twice its continuous rated current.
- Type:* ..... Factory Variable (Read Only)  
*Syntax/Range:* ... IMAX [0 to 100]  
*Units:* ..... Percent of Drive Peak Current Rating (2x AMPS)  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- IMON** Current Monitor: This variable prints the instantaneous current.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ... IMON {0 to 100}  
*Units:* ..... Percent of IMAX  
*Default:* ..... 0%  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- INPOS** In Position Status: This switch variable indicates that the actual motor position has reached its commanded position within the following window set by PEINPOS.
- Type:* ..... Switch Variable (Read Only)  
*Syntax/Range:* ... INPOS {0,1}  
                   where: 0 = Motor not in Position  
                           1 = Motor in Position
- Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... n/a  
*OPMODES:* ..... 8  
*Drive Status:* ..... EN/DIS

- J** This is the Serial Jog command.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* .... J [-15,000 to 15,000]  
*Units:* ..... RPM  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... 0  
*Drive Status:* ..... EN
- K** Kill: This is the same as the disable (DIS) command.
- Type:* ..... Command  
*Syntax/Range:* .... K  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN
- KP** Tuning variable which sets the proportional gain for position loop (PDF loop). This variable can be changed using the TUNE command or can be set manually.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* .... KP [0 to 32767]  
*Units:* ..... n/a  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- KV** Proportional Gain, Velocity Loop, PDF: Tuning variable which sets the proportional gain for velocity control loop (PDF loop). This variable can be changed using the TUNE command or can be set manually.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* .... KV [50 to 32767]  
*Units:* ..... n/a  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 0, 1, 4 to 9  
*Drive Status:* ..... EN/DIS
- KVI** Integral Gain, Velocity Loop, PDF: Tuning variable which sets the integral gain for the PDF velocity control loop (PDF loop). This variable can be changed using the TUNE command or can be set manually.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* .... KVI [50 to 32767]  
*Units:* ..... n/a  
*Default:* ..... TL  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 0, 1, 4 to 9  
*Drive Status:* ..... EN/DIS

- LIMDIS**            Limit Switch Disable: This switch variable allows the Travel Limit function to be disabled.
- Type:* ..... Switch Variable (Read/Write)  
*Syntax/Range:* ... LIMDIS [0, 1]  
                   where: 0 = Travel Limits active  
                        1 = Travel Limits disabled
- Units:* ..... n/a  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- LOAD**            This command loads all the variables from the EEPROM to system RAM. This command is automatically executed on power-up.
- Type:* ..... Command Variable  
*Syntax/Range:* ... LOAD  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... DIS
- LPFHZ**            Low Pass Cutoff Frequency: This variable defines the low pass frequency cutoff value for the Low Pass Filter.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... LPFHZ [ <bw> ]  
                   where: <bw> = 1 to 1000
- Units:* ..... Hz  
*Default:* ..... 500 Hz  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- MA**                Move Absolute
- Type:* ..... Command  
*Syntax/Range:* ... MA <pos> <vel>  
                   where: <pos> = LONG  
                        <vel> = 0 to Vmax
- Units:* ..... Counts & RPM  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... 8  
*Drive Status:* ..... EN

<b>MI</b>	<p>Move Incremental</p> <p><i>Type:</i> .....Command  <i>Syntax/Range:</i> ....MI &lt;pos&gt; &lt;vel&gt;                            where: &lt;pos&gt; = LONG                                    &lt;vel&gt; = 0 to Vmax</p> <p><i>Units:</i> .....Counts &amp; RPM  <i>Default:</i> .....n/a  <i>EEPROM:</i> .....No  <i>OPMODES:</i> .....8  <i>Drive Status:</i> .....EN</p>
<b>MOTOR</b>	<p>This command displays the TL (Compensation) File in use.</p> <p><i>Type:</i> .....String Variable (Read Only)  <i>Syntax/Range:</i> ....MOTOR  <i>Units:</i> .....n/a  <i>Default:</i> .....TL  <i>EEPROM:</i> .....Yes  <i>OPMODES:</i> .....All  <i>Drive Status:</i> .....EN/DIS</p>
<b>MSG</b>	<p>Message Enable: This switch variable suppresses the drive power-up message.</p> <p><i>Type:</i> .....Switch Variable  <i>Syntax/Range:</i> ....MSG [0, 1]                            where: 0 = Messages Suppressed                                    1 = Messages Active</p> <p><i>Units:</i> .....n/a  <i>Default:</i> .....1  <i>EEPROM:</i> .....Yes  <i>OPMODES:</i> .....All  <i>Drive Status:</i> .....EN/DIS</p>
<b>NCHBW</b>	<p>Notch Filter Bandwidth: This variable defines the Notch Filter Bandwidth.</p> <p><i>Type:</i> .....Variable (Read/Write)  <i>Syntax/Range:</i> ....NCHBW [ &lt;bw&gt; ]                            where: &lt;bw&gt; = 1 to 200</p> <p><i>Units:</i> .....Hz  <i>Default:</i> .....10  <i>EEPROM:</i> .....Yes  <i>OPMODES:</i> .....All  <i>Drive Status:</i> .....EN/DIS</p>

**NCHHZ** Notch Filter Center Frequency: This variable defines the Notch Filter center frequency.

*Type:* ..... Variable (Read/Write)

*Syntax/Range:* ... NCHHZ [1 to 500]

*Units:* ..... Hz

*Default:* ..... 500 Hz

*EEPROM:* ..... Yes

*OPMODES:* ..... All

*Drive Status:* ..... EN/DIS

**OPMODE** Operational Mode: This command variable sets the operation mode for the drive.

*Type:* ..... Command Variable

*Syntax/Range:* ... OPMODE [0 to 9]

where: 0 = Serial velocity mode

1 = Analog velocity mode

2 = Serial torque mode

3 = Analog torque mode

4 = A/B Quad input mode

5 = CNT/DIR 1X (PULSE) mode

6 = CNT/DIR 2X (EDGE) mode

7 = UP/DN counter input mode

8 = Serial Position

9 = Analog Position

*Units:* ..... n/a

*Default:* ..... 1

*EEPROM:* ..... Yes

*OPMODES:* ..... All

*Drive Status:* ..... DIS

**P** This command causes the value of the Variable/switch to be printed to the serial port. All numbers are printed right hand justified, leading zero suppression, with 12 digits. Up to 20 variables/switches can be specified for printing.

*Type:* ..... Command

*Syntax/Range:* ... P [ <variable> ]

*Units:* ..... n/a

*Default:* ..... n/a

*EEPROM:* ..... No

*OPMODES:* ..... All

*Drive Status:* ..... EN/DIS

EXAMPLE:

P MOTOR VMAX IMAX

will print MOTOR, VMAX, and IMAX in 12 column format for each.

- PCMD**                    Position Command Register: This variable is the current commanded position.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* .... PCMD {LONG}  
*Units:* ..... Counts  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- PDF**                    This is a switch variable which is used to select PDF or PI(D) control loop
- Type:* ..... Switch Variable (Read/Write)  
*Syntax/Range:* .... PDF [0, 1]  
                               where: 0 = selects the PI(D) loop  
                                       1 = selects the PDF loop
- Units:* ..... n/a  
*Default:* ..... 1  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 0, 1, 4, to 9  
*Drive Status:* ..... DIS
- PE**                    This variable displays the current following error. If this value is greater than PEMAX, the drive will be disabled.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* .... PE {LONG>0}  
*Units:* ..... Counts  
*Default:* ..... n/a  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- PEINPOS**                This variable stores the threshold position error so that if PE is less than PEINPOS after a move, INPOS switch is set.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* .... PEINPOS {Short >0}  
*Units:* ..... Counts  
*Default:* ..... 100  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 8  
*Drive Status:* ..... EN/DIS

- PEMAX** Maximum Position Error: This variable sets the maximum allowable positioning error. If the PE exceeds this value, an error occurs and the drive is disabled. Setting PEMAX to 0 disables this function.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... PEMAX [0 to 10,000,000]  
*Units:* ..... Counts  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... 4 to 9  
*Drive Status:* ..... EN/DIS
- PEXT** External Input Position: This variable displays the accumulated position feedback from the encoder. The position is updated only when the drive is enabled.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ... PEXT {LONG}  
*Units:* ..... Counts  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- PFB** Position Feedback: This variable indicates the accumulated position feedback from the resolver.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... PFB {LONG}  
*Units:* ..... Counts  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- PLAY** This command dumps the recorded variables to the serial port.
- Type:* ..... Command  
*Syntax/Range:* ... PLAY  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS

- PRD** Resolver-to-Digital Converter Position: This variable is used to monitor the current position output of the resolver-to-digital Converter. The values are:  
 For 12-bit resolution: 0 to 4,095  
 For 14-bit resolution: 0 to 16,383  
 For 16-bit resolution: 0 to 65,535
- Type:* .....Variable (Read Only)  
*Syntax/Range:* ....PRD { SHORT > 0}  
*Units:* .....Counts  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- PROFMODE** Profile Mode: This variable selects the type of acceleration/deceleration profile
- Type:* .....Switch Variable (Read/Write)  
*Syntax/Range:* ....PROFMODE [ <curve> ]  
                   <curve> 0 = No profile generation  
                           1 = Linear profile  
                           2 = Partial S-curve profile (Opmode 0, 8)  
                           3 = Full S-curve profile (Opmode 0, 8)
- Units:* .....n/a  
*Default:* .....1  
*EEPROM:* .....Yes  
*OPMODES:* .....0, 1 (OPMODE 1 is Linear Profile Only), 4 to 8  
*Drive Status:* .....EN/DIS
- PROMPT** Prompt Enable: This switch variable enables/disables the serial port prompt (-->).
- Type:* .....Switch Variable (Read/Write)  
*Syntax/Range:* ....PROMPT [0, 1]  
                   where: 0 = System prompt disabled  
                           1 = System prompt enabled
- Units:* .....n/a  
*Default:* .....1  
*EEPROM:* .....Yes  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS



**RDRES** Resolver-to-Digital Resolution: This variable sets the resolver resolution.

Type: ..... Variable (Read/Write)  
 Syntax/Range: ... RDRES [ 12, 14, 16 ]  
 Units: ..... bits  
 Default: ..... 12  
 EEPROM: ..... Yes  
 OPMODES: ..... All  
 Drive Status: ..... DIS

RESOLUTION	Counts / Rev	Speed limit	Tach Scaling
12 bit	4096	14000 rpm	8V = 15,455 RPM
14 bit	16384	3500 rpm	8V = 3,864 RPM
16 bit	65536	850 rpm	8V = 966 RPM

**READY** Software Ready State: This is a read only flag that indicates the status of the drive's software enable (EN) command. READY will not take into account the state of the REMOTE input. (also see ACTIVE)

Type: ..... Switch Variable (Read Only)  
 Syntax/Range: ... READY {0,1}  
 where: 0 = Drive Not Ready  
 1 = Drive Ready  
 Units: ..... n/a  
 Default: ..... n/a  
 EEPROM: ..... no  
 OPMODES: ..... All  
 Drive Status: ..... EN/DIS

**RECORD** This command captures real-time data to memory for later playback by the PLAY command. 256 data points of 5 variables are recorded, (VCMD, VDES, VFB, TCMD, and IMON)

Type: ..... Command  
 Syntax/Range: ... RECORD <period> <trigmode> <triglevel>  
 <period> 1 = 1/2 every millisecond  
 2 = every millisecond  
 etc.  
 <trigmode> 1 = Upon start of move (Vcmd > triglevel)  
 2 = Upon any next command  
 3 = Upon ABAUD input jumper  
 <triglevel> Defines the threshold value of Vcmd, in RPM, at which recording will start.  
 Units: ..... n/a  
 Default: ..... n/a  
 EEPROM: ..... no  
 OPMODES: ..... All  
 Drive Status: ..... EN

- RECDONE** Record Done: This is a read only switch variable that indicates whether or not the Record command is done and data is available.
- Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....RECDONE {0, 1}  
 where: 0 = Recording Not Done  
 1 = Recording Done; Data is available for playback
- Units:* .....n/a  
*Default:* .....0  
*EEPROM:* .....n/a  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- RECING** Recording: This is a read only switch variable that indicates the status of the RECORD command.
- Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....RECING {0, 1}  
 where: 0 = Done  
 1 = Recording in Process
- Units:* .....n/a  
*Default:* .....0  
*EEPROM:* .....n/a  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- RECRDY** Record Ready State: This is a read only switch variable that indicates the status of the RECORD command.
- Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....RECRDY {0, 1}  
 where: 0 = Done  
 1 = Ready to Record
- Units:* .....n/a  
*Default:* .....0  
*EEPROM:* .....n/a  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- RELAY** Relay State: This is a read only switch variable that indicates the status of the Fault/Drive up Relay.
- Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....RELAY {0, 1}  
 where: 0 = Fault relay open (Fault present)  
 1 = Fault relay closed (Normal -- No fault present)
- Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....No  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS

- RELAYMODE**      Status Relay Mode: This switch variable sets the trigger condition of the Fault relay.
- Type:* ..... Switch Variable (Read/Write)  
*Syntax/Range:* ... RELAYMODE [0, 1, 2]  
                   where: 0 = Fault relay drops when any fault condition exists  
                        1 = For undervolts and motor overtemperature.  
                        Automatically resets when the fault condition is cleared. All other faults are the same as Relaymode 0.
- Units:* ..... n/a  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- REMOTE**      Remote Enable State: This is a read only switch variable that indicates the state of the REMOTE ENABLE INPUT.
- Type:* ..... Switch Variable (Read Only)  
*Syntax/Range:* ... REMOTE {0, 1}  
                   where: 0 = Remote input open  
                        1 = Remote input closed
- Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- RSTVAR**      Reset Variables: This command sets all variables, switch variables, and switch mode variables to a factory known state as shipped from the factory. Variables included in the compensation file are not effected by this command. A complete system reset requires the RSTVAR and then a reload of the compensation file.
- Type:* ..... Command  
*Syntax/Range:* ... RSTVAR  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS

- S** Stop: This command will stop a J, MA, or MI command. Deceleration ramp control is used if PROFMODE is active. If invoked in OPMODES 2 or 3, the drive is simply disabled.
- Type:* .....Command  
*Syntax/Range:* ....S  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN
- SAT** Saturation State: This is a read only switch variable used to indicate if the current command exceeds the ILIM Variable..
- Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....SAT {0, 1}  
                   where: 0 = Current loop is not saturated  
                        1 = Current loop is saturated
- Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- SAVE** Save: This command saves all designated variables from system ram to the EEPROM. System RAM is cleared on power loss.
- Type:* .....Command  
*Syntax/Range:* ....SAVE  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS
- SCRVTM** S-Curve Time: This variable is used to set the time duration of S-Curve acceleration.
- Type:* .....Variable (Read/Write)  
*Syntax/Range:* ....SCRVTM [1 to 100000]  
*Units:* .....milliseconds  
*Default:* .....0  
*EEPROM:* ..... Yes  
*OPMODES:* .....0, 8  
*Drive Status:* .....EN/DIS

**STATUS**

Drive Status: This variable is used to print six status bytes to the serial port. The bytes are displayed in hex format as six hex numbers (XX XX XX XX XX XX).

Type: ..... Variable (Read Only)  
 Syntax/Range: ... STATUS  
 Units: ..... n/a  
 Default: ..... n/a  
 EEPROM: ..... n/a  
 OPMODES: ..... All  
 Drive Status: ..... EN/DIS

Byte 0	Hardware & Fault Status
Bit 0	Remote (External) Enable
Bit 1	Power Stage Enable
Bit 2	+/-12 V Analog Supply Fault (A)
Bit 3	Resolver Loss (r)
Bit 4	Power Stage Fault (P)
Bit 5	Over-Temperature Fault (t)
Bit 6	Over-Voltage Fault (O)
Bit 7	Under-Voltage Fault (u)
Byte 1	Software Fault Status
Bit 0	Overspeed
Bit 1	Gear Overflow
Bit 2	Foldback Bad
Bit 3	Scale Overflow
Bit 4	Excessive Position Error
Bit 5	RAM Failed
Bit 6	Not Used
Bit 7	Not Used
Byte 2	Mode_Flag2 (OPmode)
Bit 0	Serial Position mode
Bit 1	Analog Position mode
Bit 2	Not Used
Bit 3	Not Used
Bit 4	Not Used
Bit 5	Not Used
Bit 6	Not Used
Bit 7	Not Used

Byte 3	Mode_Flag1 (OPmode)
Bit 0	Serial Velocity mode
Bit 1	Analog Velocity mode
Bit 2	Serial Torque mode
Bit 3	Analog Torque mode
Bit 4	A/B Quadrature Input mode
Bit 5	Pulse Counting Pulse/Direction mode
Bit 6	Edge Counting Pulse/Direction mode
Bit 7	Up/Down count Input mode
Byte 4	Running Status
Bit 0	READY
Bit 1	ACTIVE
Bit 2	FOLD
Bit 3	SAT
Bit 4	IN-POS
Bit 5	Stopped
Bit 6	DIR
Bit 7	Not Used
Byte 5	MISC Status
Bit 0	CWLIM
Bit 1	CCWLIM
Bit 2	LIMDIS
Bit 3	GEAR
Bit 4	ZERO
Bit 5	PDF
Bit 6	RELAY
Bit 7	Not Used

**STEP** Step: This command generates a step input and records the response of the drive to the PC Scope memory. The PC Scope memory can be printed to the serial port with the PLAY command. This is useful for analyzing the time response of the drive.

*Type:* .....Command  
*Syntax/Range:* ....STEP [<period>] [<magnitude>]  
                   <period> 10 to 1000 milliseC  
                   <magnitude> 10 to 1000 RPM  
*Units:* .....msec & RPM  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....0, 1  
*Drive Status:* .....EN

**STOPPED** Stopped: This switch variable indicates whether or not the drive has completed a commanded move.

*Type:* .....Switch Variable (Read Only)  
*Syntax/Range:* ....STOPPED {0, 1}  
                   where: 0 = Move is in progress  
                        1 = Move is complete  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....8  
*Drive Status:* .....EN/DIS

**T** Average Torque: This variable holds the absolute average torque command output (TCMD), averaged over 8 Milliseconds.

*Type:* .....Variable (Read Only)  
*Syntax/Range:* ....T {0 to 4095}  
*Units:* .....n/a  
*Default:* .....n/a  
*EEPROM:* .....no  
*OPMODES:* .....All  
*Drive Status:* .....EN/DIS

**TCMD** Torque Command: This variable is used to display the commanded torque (motor current is generally proportional to the torque command). This variable can be set only in the OPMODES 2 and 3. This variable can be viewed in any OPMODE.

*Type:* .....Variable (Read/Write)  
*Syntax/Range:* ....TCMD [-4096 to +4095]  
*Units:* .....n/a  
*Default:* .....0  
*EEPROM:* .....No  
*OPMODES:* .....2, 3  
*Drive Status:* .....EN/DIS

- THERM** Thermostat Input State: This switch variable indicates the state of the motor thermostat input.
- Type:* ..... Switch Variable (Read Only)  
*Syntax/Range:* ... THERM {0, 1}  
 where: 0 = Closed, motor not overtemp  
 1 = Open, motor overtemp
- Units:* ..... n/a  
*Default:* ..... 0  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- THERMODE** Thermostat Input Mode: This switch mode variable determines the operation of the drive when the Motor Thermostat Input opens.
- Type:* ..... Switch Mode Variable (Read/Write)  
*Syntax/Range:* ... THERMODE [0, 1, 2]  
 where: 0 = Disables the drive instantly and drops the fault relay.  
 1 = Disables the drive after two minutes but the fault relay is dropped immediately.  
 2 = Drops the fault relay but does not disable the drive.
- Units:* ..... n/a  
*Default:* ..... 0  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- TREF** Torque Input Scale Factor: This variable scales the analog input. The reference torque (current) represents the output torque (4096 maximum) for an analog input voltage signal of 10 V. The value entered is the desired motor current (4096 = Peak Drive Rated) if 10 volts were applied to the analog input.
- Type:* ..... Variable (Read/Write)  
*Syntax/Range:* ... TREF [1 to 32767]  
*Units:* ..... 1 / 4096 Tmax  
*Default:* ..... 4096  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- TRUN** Run Time: This command displays the accumulated run time of the drive. The error history includes the accumulated run time at the time of the error.
- Type:* ..... Command  
*Syntax/Range:* ... TRUN  
*Units:* ..... Days:Hours:Minutes  
*Default:* ..... n/a  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS

**TUNE**

Tune: This command tunes the system for the given drive and load conditions. The command sets the variables KV, KVI, GV, GVI, GP, and GPI. Often, when the motor load is changed, tuning parameters need to be reset. The "TUNE" command specifies Bandwidth and Damping Factor. Higher bandwidth will produce faster response time. Lower damping factor will produce less overshoot, but also noisier performance.

Type: .....Command  
Syntax/Range: ...TUNE <bw> <damping factor>  
                  <bw> 5 to 100 Hz  
                  <damping factor> 0 = Overdamped  
  1 = Critically damped  
  2 = Underdamped

Units: .....n/a  
Default: .....n/a  
EEPROM: .....No  
OPMODES: .....0, 1, 4 to 9  
Drive Status: .....EN/DIS

**V**

Average Velocity: This variable prints the average velocity from the previous 8 milliseconds.

Type: .....Variable (Read Only)  
Syntax/Range: ...V {-VMAX to +VMAX}  
Units: .....RPM  
Default: .....n/a  
EEPROM: .....No  
OPMODES: .....All  
Drive Status: .....EN/DIS

**VCMD**

Velocity Command: This variable displays the commanded velocity to the drive.

Type: .....Variable (Read Only)  
Syntax/Range: ...VCMD {-VMAX to +VMAX}  
Units: .....RPM  
Default: .....0  
EEPROM: .....No  
MODES: .....ALL  
Drive Status: .....EN/DIS

**VDES**

Velocity Desired: This variable displays the desired velocity commanded to the drive.

Type: .....Variable (Read Only)  
Syntax/Range: ...VDES {-VMAX to +VMAX}  
Units: .....RPM  
Default: .....0  
EEPROM: .....No  
MODES: .....ALL  
Drive Status: .....EN/DIS



- VE** Velocity Error: This variable displays the velocity error. It indicates the difference between the actual motor velocity (VFB) and the commanded motor velocity (VCMD).
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ... VE {LONG}  
*Units:* ..... RPM  
*Default:* ..... n/a  
*EEPROM:* ..... Yes  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- VER** Firmware Version: This command displays the version of the firmware in use. Use this command to determine the version of firmware installed in the Smart Drive Unit.
- Type:* ..... Command  
*Syntax/Range:* ... VER  
*Units:* ..... n/a  
*Default:* ..... n/a  
*EEPROM:* ..... no  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- VEXT** External Velocity: This variable holds the average velocity seen on the external encoder input channel. Measurement is the average velocity over 8 milliseconds and assumes a 1024 line count encoder or a 4096 pulse-per-revolution master.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ... VEXT {-VMAX to +VMAX}  
*Units:* ..... RPM  
*Default:* ..... 0  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS
- VFB** Velocity Feedback: This variable displays the instantaneous velocity feedback of the motor.
- Type:* ..... Variable (Read Only)  
*Syntax/Range:* ... VFB {-VMAX to +VMAX}  
*Units:* ..... RPM  
*Default:* ..... 0  
*EEPROM:* ..... No  
*OPMODES:* ..... All  
*Drive Status:* ..... EN/DIS

<b>VMAX</b>	<p>Maximum Velocity: This variable is the maximum allowable velocity of the drive.</p> <p><i>Type:</i> ..... Factory Variable (Read Only)  <i>Syntax/Range:</i> .... VMAX {0 to 20,000}  <i>Units:</i> ..... RPM  <i>Default:</i> ..... TL  <i>EEPROM:</i> ..... Yes  <i>OPMODES:</i> ..... All  <i>Drive Status:</i> ..... DIS</p>
<b>VOLTS</b>	<p>Drive Voltage Rating: This variable indicates the rated voltage drive.</p> <p><i>Type:</i> ..... Variable (Read Only)  <i>Syntax/Range:</i> .... VOLTS {0 to 480}  <i>Units:</i> ..... volts  <i>Default:</i> ..... n/a  <i>EEPROM:</i> ..... No  <i>OPMODES:</i> ..... All  <i>Drive Status:</i> ..... EN/DIS</p>
<b>VOSPD</b>	<p>Overspeed Velocity Set-point: This variable sets the over-speed trip limit for the motor. The drive is disabled with an error condition when the drive velocity crosses this limit. This value is initially set to 20% above the rated speed (VMAX) but can be reduced by the user during regular motor operation for protection.</p> <p><i>Type:</i> ..... Variable (Read/Write)  <i>Syntax/Range:</i> .... VOSPD [0 to 1.2 x VMAX]  <i>Units:</i> ..... RPM  <i>Default:</i> ..... 1.2 x VMAX  <i>EEPROM:</i> ..... Yes  <i>OPMODES:</i> ..... All  <i>Drive Status:</i> ..... DIS</p>
<b>VREF</b>	<p>Velocity Input Scale Factor: This variable scales the analog input for OPMODE 1. The reference velocity represents the rated motor speed at +10 V analog input. The value entered is the desired motor velocity if 10 volts were applied to the analog input.</p> <p><i>Type:</i> ..... Variable (Read/Write)  <i>Syntax/Range:</i> .... VREF (1 to 100,000)  <i>Units:</i> ..... RPM  <i>Default:</i> ..... TL  <i>EEPROM:</i> ..... Yes  <i>OPMODES:</i> ..... 1  <i>Drive Status:</i> ..... DIS</p>
<b>VX</b>	<p>This variable displays the Average external velocity.</p> <p><i>Type:</i> ..... Variable (Read Only)  <i>Syntax/Range:</i> .... VX (1 to 100,000)  <i>Units:</i> ..... RPM/Sec  <i>Default:</i> ..... n/a  <i>EEPROM:</i> ..... Yes  <i>OPMODES:</i> ..... 4 to 8  <i>Drive Status:</i> ..... EN/DIS</p>

**ZERO**

Resolver Zero Mode: This switch variable enables/disables the Smart Drive Resolver Zeroing Mode.

*Type:* ..... Variable (Read/Write)

*Syntax/Range:* ...ZERO [0, 1]

where 0 = Zero mode not active

1 = Zero mode active

*Units:* ..... n/a

*Default:* ..... 0

*EEPROM:* ..... No

*OPMODES:* ..... All

*Drive Status:* ..... EN/DIS



# CHAPTER 6

## TROUBLESHOOTING

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### 6.1 INTRODUCTION

The information in this chapter will enable you to isolate and resolve common system problems. The Smart Drive aids in diagnostic evaluation through its Seven-Segment Display Indicator and the Smart Drive Error Log. Both of these features are explained to assist you in finding solutions. As another part of Industrial Drives' obligation to its customers, Factory Support and Repair is also defined.

The Smart Drive control system uses high voltage and performs mechanical motion. Potential danger exists. Electrocutation and personal injury are possible. Refer all troubleshooting to qualified personnel!

### 6.2 POWER UP TESTS

The Smart Drive performs a series of power up tests when power is first applied. Upon completion of the tests, the status display will assume a numerical display indicating the OPMODE for which it is configured. In the event of the power up test failure the status display will indicate an error. Many error conditions can be easily diagnosed using the indication.

### 6.3 LED DISPLAYS

#### 6.3.1 Status Display

The Smart Drive has a Seven-Segment Display Indicator that indicates errors. The Display has three types of states; Steady State, Flashing State, and Momentary State.

1. Steady State - A number is displayed on the display which indicates the mode of operation (set by the OPMODE command). The steady state display indicates that no errors are detected. The number displayed indicates the OPMODES as follows:

- 0 - Serial Velocity Mode
- 1 - Analog Velocity Mode
- 2 - Serial Torque Mode
- 3 - Analog Torque Mode
- 4 - GEAR: A/B Quad Input Mode
- 5 - CNT/DIR (PULSE) Mode
- 6 - CNT/DIR (EDGE) Mode
- 7 - UP/DN Counter Input Mode
- 8 - Serial Position Mode
- 9 - Analog Position Mode

2. Flashing State - A letter is displayed on the display which indicates a fatal fault condition. In general, these faults will cause a latched disable. An attempt to reset the fault can be made by removing the remote enable for 2 seconds and then re-asserting it. The letter displayed indicates the faults as follows:

- u - Under Voltage Fault
- o - Over Voltage Fault
- P - Power Stage Fault
- t - Drive Overtemperature Fault
- r - Resolver Loss Fault
- A - Analog Supply Fault
- i - Initialization Error (Ram Test)
- J - Overspeed Fault
- L - Travel Limit Fault (Exception to the Latched Disable)
- S - Checksum Failure (Resetable only by Serial Command)
- E - EEPROM Checksum Failure
- H - Motor Overtemperature
- n - Loss of Logic Supply
- y - Excessive Position Error
- e - EPROM Checksum Failure

**Decimal Point:**

The decimal point directly relates to the global drive enable. The states are defined as follows:

- Steady Off - No power to the motor.
- Steady On - Drive is enabled and power is on the motor.
- Flashing - Drive is enabled, power is on the motor, but some safety feature has been disabled (ie: CW and CCW Limits being disabled with LIMDIS=1).



**WARNING**

**A flashing decimal point in the seven segment display indicates the drive is enabled with a safety feature disabled.**

**6.3.2 MOMENTARY STATE ERRORS**

Display	Description
[	Communications Error
F	Foldback Condition

**Momentary State Errors**

Momentary State - A letter is displayed on the display which indicates a momentary fault condition. These faults will reset automatically. The letter displayed indicates the faults as follows:

- C - Communications Error
- F - Foldback Condition

**Communications Error:** This fault indicates that there is a problem with the serial communications. Typically this is a baud rate or parity error. This is not a latched error. Lowering the baud rate often fixes this problem.

**Foldback:** This fault indicates that the current commanded to the motor is higher than what the drive can deliver for an extended period of time. The drive is self-protecting for its rated current level. Peak current to the motor is allowed for two seconds. After the two seconds the drive "folds-back" or limits the current that is allowed out to the motor to protect the drive. This condition is a self-resetting error.

### 6.3.3 FLASHING STATE ERRORS

Display	Description
U	Under-voltage (u)
O	Over-voltage (o)
P	Power Stage Fault (P)
T	Drive Over-temperature (t)
H	Motor Over-temperature (H)
R	Resolver Loss (r)
A	Analog Supply Fault (A)
N	Logic Supply Fault (n)
I	Initialization Failure (i)
L	Travel Limit Fault (L)
E	EEPROM Checksum Failure (E)
E	EPROM Checksum Failure (e)

#### Flashing State Errors

**Under-Voltage:** Indicates that the Bus voltage is less than 90 Vdc. The Bus voltage should be 325 Vdc from 230 Vac (nominal) line or 160 Vdc from 115 Vac line.

**Over-Voltage:** Indicates that the voltage has exceeded approximately 390 Vdc on the Bus. This is a latched error that will shut the power stage down. There are two common reasons for and Over-Voltage faults: the input line voltage exceeds 230 Vac or there is excessive regeneration occurring during deceleration.

If the latter is true, easing up on the deceleration rate or adding an external Regen Resistor will cure a persistent problem.

**Power Stage Fault:** Indicates that there is something wrong with the Power Stage of the Smart Drive. This is a latched fault that, if persists, requires the Smart Drive to be sent back to the factory for service. This condition may also be caused by a short in the motor wiring or a faulty motor.

**Drive Over-temperature Fault:** Indicates that the internal heat sink in the Smart Drive has been overheated. The fault is usually due to improper ventilation or excessive ambient operating temperatures. The Smart Drive system may also be exceeding the RMS current rating output to the motor.

**Motor Over-temperature Error:** The function of the motor thermostat input to the Smart Drive can be configured in one of three ways determining the effect of this error message:

1. If the motor thermostat is internally configured to disable the drive (THERMODE = 0, disables the drive instantly and drops the fault relay), the motor will coast to a stop and display the "H" when a fault occurs.
2. If the motor thermostat is configured to drop the drive-up relay contact at Over-temperature (THERMODE = 1, disables the drive after two minutes but drops the fault relay immediately), the "H" will be displayed without stopping the motor.
3. If the thermostat is configured to ignore the thermostat altogether (THERMODE = 3, drops the fault relay but does not disable the drive), the "H" will not be displayed but the decimal point will flash.

**Resolver Loss:** Hardware detection of the resolver signal has detected an absence of the resolver feedback signal. This is not a latched fault.

**Analog Supply Fault:** Indicates that the Smart Drive's internal  $\pm 12$  V supplies have gone out of tolerance. This is a latched fault and may require the drive be returned to the factory for repair.

**Logic Supply Fault:** Indicates that the Smart Drive's internal logic supply has gone out of tolerance. This is a latched fault and may require that the drive be returned to the factory for repair.

**Initialization Failure:** Indicates that the internal microprocessor power-up initialization check has failed. A persistent initialization failure requires factory servicing.

**Travel Limit Fault:** This indicates that either the Clockwise or Counterclockwise End Travel Limit input is inactive. This is not a latched condition and is not necessarily to be considered a fault. It indicates that the motor will not be allowed to travel any further in the said direction.

**EEPROM Checksum Failure:** This fault indicates that the memory within the internal EEPROM is corrupt. This error can occur when power to the microprocessor is lost during a SAVE command. This error can be fixed by executing an RSTVAR command and reloading the compensation, or TL, file data to the drive.

**EPROM Checksum Error:** This fault indicates that the internal ROM is corrupt. This error requires factory service if it persists.

**6.3.4 Discrete LED's**

All Smart Drive's power supply sections have three discrete LEDs. The Power Supply 50 and 75 Amp models have 4 indication LEDs. The purpose of the LEDs are defined as:

**OVERLOAD** - This yellow LED turns on when the Power Supply Regen circuit is actively dumping power.

**REGEN FAULT (OVERLOAD)** - This LED is only on the 50 and 75 Amp Power Supply Units. This red LED indicates a hardware fault. It turns on when the fuse that protects the Regen resistor has absorbed too much energy. Remove power and replace the fuse. If the replaced fuse blows within a few seconds of applying power the unit must be returned to the factory for repair.

**FAULT** - This red LED indicates an Regen overload fault. It turns on when the Power Supply circuitry detects that the Regen resistor has absorbed too much energy. It is turned off when power is removed and then reapplied. The circuitry that turns on this LED is not used when external Regen resistors are used. If this fault occurs persistently, the power rating of the Regen resistor may need to be increased. Contact the factory.

**BUS** - This green LED indicates that the high-voltage DC bus power is present to the drive.

**6.4 ERROR CODES**

In addition to the Status Display and LEDs the Smart Drive also sends error codes with a text message to the serial port. The same message is saved in non-volatile memory in an error history log. (See ERR.)

**6.4.1 Error Levels**

The Smart Drive's response to an error depends on the error's severity. There are three levels of severity as listed below:

1.	Errors which cause warnings. These are called Errors.
2.	Errors which disable the system and indicate fault status. These are called Faults.
3.	Errors which disable almost all Smart Drive functions (including communications). These are called Fatal Errors.

**Error Severity Levels and Actions**



## 6.4.2 Error Log

In addition to the Status Display, LEDs, and the serial notification of errors, the Smart Drive also records the error message in non-volatile memory for later interrogation. Each entry into the error log has an associated error code number as defined in the tables below. The Smart Drive stores the twenty most recent errors in the Error History Buffer. To display the entire Error History, type:

### ***ERR HIST***

This causes the Error History to be sent out the serial port to the terminal, with the most recent error sent first.

To clear the Error History, type:


















### ***ERR CLR***

The Error History Buffer remains intact even through power-down.

To display the last error generated type:

### ***ERR***

The Smart Drive responds with the last (most recent) error that is in the Error History.

Error Code Number	Status LED	Associated Text Message and Meaning
1		Drive Over-Temperature
2		Bus Over-Voltage
3		Power Stage Fault
4		Resolver Loss
5		Bus Under-Voltage
6		Motor Over-Temperature
7		Analog (+/-12V) Supply
8		
9		RAM Test Failed (Initialization Fault)
10		Motor Over-Speed Fault
11		Gear Mode Overflow
12		Foldback Values Bad
13		Unit Scale Overflow
14		Position Following Error
15		EEPROM Checksum Error
16		EPROM Checksum Error
17	-	No Compensation Loaded
18		Resolver Over-speed
19		Profile Failed

### **Fatal Errors Codes**

Error Code Number	Fault Message
20	Unknown Command
21	
22	Access Denied
23	Wrong State: Drive Active
24	Wrong State: Drive Inactive
25	Value Out of Bound
26	Must Not Be A Negative Number
27	Drive Not in Proper Mode
28	Profile Generation Fault
29	Wrong Mode: Drive in Motion
33	Auto-Tune Failed
34	Auto Tune Bad Bandwidth
35	Auto Tune Bad Stability
36	Not A Programmable Function
37	Bad Compensation File
38	Communication Error
39	

### Smart Drive Errors and Codes

#### 6.4.3 Error Code Definitions

The Smart Drive's response to an error depends on the error's severity. The following is a complete list of errors generated by the Smart Drive.

##### **ERROR 1** **DRIVE OVER-TEMPERATURE** **Error Level: 2**

The thermostat on the Smart Drive heatsink opened, indicating power stage overheating. Overheating may be caused by excessive ambient temperature, obstructed airflow, poor tuning, excessive motor loading, broken fan, etc. Correct any such condition before resuming operation. **REMOVE ALL POWER BEFORE CHECKING THIS.** If everything is functioning properly, a drive with a higher current rating may be required. This error displays a "t" on the Smart Drive display.

##### **ERROR 2** **BUS OVER-VOLTAGE** **Error Level: 2**

The power supply bus voltage has exceeded 390 Vdc (Bus+, Bus-). This error can be caused by applying

input power in excess of 250 Vac. The problem may also be caused by an inoperative or inadequate Regen

Circuit. Check external Regen connections (R-C jumper or resistor connections).

##### **ERROR 3** **POWER STAGE FAULT**

**Error Level: 2**  
The Smart Drive power stage has excessive surge current or has detected a failed component. Check motor leads Ma, Mb, and Mc for shorts together and to earth ground. Perform motor tests.

##### **ERROR 4** **RESOLVER LOSS**

**Error Level: 2**  
This error indicates that the Smart Drive has failed to detect the presence of the resolver Sine or Cosine signals. Check resolver connections and wiring. Perform resolver checks.

##### **ERROR 5** **BUS UNDER-VOLTAGE**

**Error Level: 2**  
The Smart Drive has too little bus voltage at its power supply section (Buss +, Bus -). Check input voltages at La (L1), Lb (L2), and Lc (L3). The minimum Bus voltage is 120 Vdc. If this fault happens only during operation, one of the three phase inputs may be missing or the input line is sagging.

##### **ERROR 6** **MOTOR OVER-TEMPERATURE**

**Error Level: 2 or 1**  
The error level can vary upon the THERMODE switch setting. The Smart Drive has detected an open between its two motor thermostat inputs. The problem is meant to indicate an overheated motor.

##### **ERROR 7** **ANALOG ( $\pm 12$ V) SUPPLY**

**Error Level: 3**  
The Smart Drive detected an out-of-tolerance condition on its internal  $\pm 12$  V power supplies. Check logic input voltage. Pull connector C5 and cycle power. If problem remains the unit is in need of repair.

##### **ERROR 8** **To Be Defined**

**ERROR 9  
RAM TEST FAILED****Error Level: 3**

The Smart Drive has detected an internal problem with RAM and must be repaired if this problem persists.

**ERROR 10  
MOTOR OVER-SPEED****Error Level: 2**

The Smart Drive determined that the speed of the motor was greater than the variable VOSPD. The VOSPD variable is user settable. Electrical noise on the resolver wires can cause false trips of this error.

**ERROR 11  
GEAR OVERFLOW****Error Level: 2**

The Smart Drive has detected an invalid gear ratio. Review and modify GEARI and/or GEARO.

**ERROR 12  
FOLDBACK BAD****Error Level: 2**

This is a factory level problem dealing with data loaded from the compensation file. The user should not see this error. Consult the factory.

**ERROR 13  
UNIT SCALE OVERFLOW****Error Level: 2**

This is a factory level problem dealing with data loaded from the compensation file. The user should not see this error. Consult the factory.

**ERROR 14  
POSITION FOLLOWING ERROR****Error Level: 2**

The Smart Drive has detected excessive position error. The allowable error is set by the PEMAX variable. System settings which can affect the position following error include motor load, current limits (ILIM), and tuning gains (GP). Inserting an integrator in either the position or velocity loops can help resolve persistent problems. See Chapter 7.

**ERROR 15  
EEPROM CHECKSUM ERROR****Error Level: 2**

The Smart Drive detected a corrupt data in its EEPROM -or- user data area. The compensation file and user configuration must be reloaded. This error should not occur unless power was interrupted during a SAVE command. Appearance of this error would

indicate that EMI / RFI noise environment is excessive.

**ERROR 16  
EPROM CHECKSUM****Error Level: 3**

The Smart Drive detected corrupt memory in its internal operating system EPROM. The unit is in need of repair or received an electrical noise spike during power up.

**ERROR 17  
NO COMPENSATION FILE****Error Level: 2**

The Smart Drive detected an empty memory for motor configuration. A valid compensation file must be loaded.

**ERROR 18  
RESOLVER OVER-SPEED****Error Level: 2**

The Smart Drive detected a bad signal from its resolver to digital converter system caused by the actual speed exceeding the converter's tracking limit. See RDRES switch variable for limits. If this problem occurs during the TUNE function lower the current limit (ILIM) and repeat. Electrical noise on the resolver wires can cause nuisance trips.

**ERROR 19  
PROFILE FAILED****Error Level: 3**

The Smart Drive was unable to execute the requested motion profile in OPMODE 8. This error should not occur.

**ERROR 20  
UNKNOWN COMMAND****Error Level: 1**

The Smart Drive received an unknown command from the serial port.

**ERROR 21  
To Be Defined****ERROR 22  
ACCESS DENIED****Error Level: 1**

The Smart Drive has detected an attempt to operate a non-user function.

**ERROR 23****DRIVE SHOULD BE INACTIVE****Error Level: 1**

The request for operation is denied because the Smart Drive is active (enabled). Disable the drive first.

**ERROR 24****DRIVE SHOULD BE ACTIVE****Error Level: 1**

The request for operation is denied because the Smart Drive is inactive (disabled). Enable the drive first.

**ERROR 25****VALUE OUT OF BOUND****Error Level: 1**

The Smart Drive has detected that a value is out of the range of the given variable.

**ERROR 26****NEGATIVE NUMBER NOT ALLOWED****Error Level: 1**

The Smart Drive has detected a negative number value entered where only a positive number should be.

**ERROR 27****NOT IN PROPER OP MODE****Error Level: 1**

The Smart Drive is not in the proper operational mode to perform the current task. Change to the proper OPMODE first.

**ERROR 28****BAD PROFILE GENERATION****Error Level: 1**

The Smart Drive has an internal calculation error for the given distance, speed, acceleration rate, and deceleration rate. This error should not occur.

**ERROR 29****DRIVE IN MOTION****Error Level: 1**

The Smart Drive has rejected a command due to a conflict between the command and the present motor state. The motor must be stopped.

**ERROR 30****NUMBER OF PARAMETERS INCORRECT****Error Level: 1**

The number of parameters entered for the command is either too few or too many. Check the syntax of the command and try again to enter.

**ERROR 31****To Be Defined****ERROR 32****To Be Defined****ERROR 33****TUNE FAILED****Error Level: 1**

The Smart Drive's Auto-Tune function has failed. Try lowering ILIM, turning off the filters, or tuning the system manually.

**ERROR 34****BANDWIDTH OUT OF RANGE****Error Level: 1**

The Smart Drive's TUNE command bandwidth is out of range. See TUNE.

**ERROR 35****STABILITY OUT OF RANGE****Error Level: 1**

The Smart Drive's TUNE command stability is out of range. See TUNE.

**ERROR 36****NOT PROGRAMMABLE****Error Level: 1**

The Smart Drive has detected that an attempt has been made to modify a variable that is not programmable (Read Only).

**ERROR 37****ANALOG READING FAILED****Error Level: 1**

An attempt to zero the analog input, using the ANZERO command, has failed. Attempt the command again. If the problem persists, consult the factory.

**ERROR 38****BAD PROFILE; VEL-TO ACC RATIO TOO HIGH****Error Level: 1**

The Smart Drive was unable to execute a requested move, in OPMODE 8, due to an excessive Velocity/Acceleration ratio. This fault rarely occurs. However, if this fault is present, decrease the Velocity or increase the Acceleration to correct the fault condition.

### 6.4.4 Displaying Error Messages

The Smart Drive has a built-in error code dictionary for user convenience. The ERR command can be used to display an abbreviated description of the error. For example, type:

#### **ERR 2**

The Smart Drive responds with:

#### **OVER VOLTAGE**

Messages may be displayed for all valid error codes. If typing in an error number that the Smart Drive does not recognize, it will respond with:

#### **UNKNOWN ERROR**

## 6.5 COMMUNICATION PROBLEMS

The Smart Drive typically echoes back all ASCII characters and proceeds to act upon a message after receiving a CRLF sequence. The MSG and ECHO software switches can modify the operation of the serial port. Begin troubleshooting with these both set to a '1'. Further, the rotary switch located on the Smart Drive near C1 must be set to point to the '0' for RS 232 communications. The following procedures assume an RS 232 system. If communications appears to be non functional, type 'RSTVAR' blindly on the keyboard. This will set all parameters to the normal factory-set condition. Recycle power and the baud rate will be at 9600.

Communications problems can be challenging due to the large number of variables. The terminal or computer may not be configured for the data format listed. Check the Serial Communications section for proper communications protocol. If using a terminal or MODEM program, be sure the protocol is set properly.

A simple method of narrowing communication problems is to try to determine if the receiver or transmit circuits function. See if the power-up message reaches the terminal from the drive. This tests the drive's transmit and computer's receiver. Then type DIS followed by OPMODE 'n'; where n is any OPMODE other than the mode currently displayed in the Status Display.

If the drive does not appear to transmit, then check to be sure that connector C1 is wired properly. A common mistake is that of having the transmit and receive lines swapped. Also, make sure that none of the wires in the cable are broken. Determine if the serial cable has open circuits by connecting the terminal on one end and disconnecting the cable on the Smart Drive end.

The computer can be checked by shorting the transmit and receive pins at the far end of the cable causing a direct echo. Pull the communications cable from the Smart Drive and temporarily connect the transmit and receive pins (pins 2 & 3) then type on the keyboard. The characters that are typed should appear on the terminal screen. If they do not, the cable is not functioning properly.

If the cable is functioning properly be certain the ground wire is connecting both units (Pin 5 of the Smart Drive).

## 6.6 TUNING PROBLEMS

The Auto-Tuning feature of the Smart Drive will provide the user with a tuning that is either acceptable or close to acceptable. In some installations the TUNE command may fail to give optimum results. There are several physical factors that prevent users from attaining the performance they need. These problems fall into five categories:

1. **Overloading the Motor:** Overloading the motor is the most common problem for positioning systems. If the system becomes overloaded, the position error can grow to very large values. When the command stops, the motor "reels in" the following error and can overshoot excessively. It looks like a tuning problem, but it is actually caused by the motor being undersized, ACC or DEC being set too high, or ILIM being set too low.

When a motor is overloaded, it has the following characteristics:

- The system overshoots, sometimes excessively, but does not ring or oscillate.
- Decreasing ACC and DEC eliminates the problem.
- The motor current is near or at saturation during a large part of the move. (See SAT.)

Overloading the motor can often be corrected by performing the following actions:

- Increase ACC and DEC.
- Reduce the load on the motor.
- Increase ILIM (if it is less than IMAX).
- Use a Smart Drive ( and / or Motor) with a higher current (Torque) rating.

2. Compliance: In compliant systems, the load is not tightly coupled to the motor shaft. This can occur most often when using belts, soft couplings, or small diameter shafts. Compliant systems often are very stable when tuned with lower target bandwidths. However, they tend to oscillate vigorously at low frequencies when tuned for higher bandwidths.

When a system is compliant, it has the following characteristics:

- There is springiness between the motor and the load or at the motor mounting plate.
- The TUNE command calculates tuning variables that cause the system to oscillate.
- The frequency of oscillation is less than 100 Hz.

Compliance problems are system design problems. The problems that they create can sometimes be compensated for by performing the following actions:

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

3. Resonance: Resonance typically occurs at a high frequency (> 300 Hz) where the system mechanics oscillate. Normally, systems with resonance will be very stable when tuned with lower target bandwidths. Increase the target bandwidth and users will begin to hear a fairly pure, high pitch. To decrease resonance, use shorter, larger diameter driving shafts. Often, the low-pass filter can help eliminate resonance while keeping a high gain, but this can be a difficult trial-and-error process. The Smart Drive has a user programmable filter. Start by setting LPFHZ to 500 and turning the filter on (FILTMODE = 1). Slowly lower the low-pass filter frequency (LPFHZ) and attempt to raise the target bandwidth for tuning. (This will increase gain instead of bandwidth.) If the system

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

- Enable the low-pass filter (FILTMODE) and reduce LPFHZ, if necessary.
- Reduce the bandwidth of the system.
- Shorten the length and increase the diameter of shafts and lead screws.

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

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

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

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

- Correct the system mechanics so that inertia is constant.
- De-tune (that is, reduce the bandwidth of) the system. If the times when the system will have excessively changing inertia are predictable, de-tune the system in these regions via serial control.

5. Excessive load-to-rotor inertia mismatch: A good design will have no more than a five-to-one mismatch between the motor's rotor inertia rating and the inertia reflected to the motor shaft by the load. Mismatches higher than this tend to be more difficult to tune for. The Smart Drive has a robust tuning algorithm to handle large mismatches but generally must be de-tune by:

- Removing integrators.
- Lowering gains.
- Using ramp control.

If satisfactory performance can not be gained, the load can be geared or a larger motor can be applied to the application.

Chapter 7 contains some very detailed explanations of the tuning algorithms, compensator types, and tuning problems.

## 6.7 PC Scope

The Smart Drive has built-in functions designed to emulate a digital Storage Oscilloscope. Using these features with Motion Link provides a simple means of checking motor performance. Refer to Chapter 4 on Motion Link for more details.

## 6.8 ENABLE AND FAULT LOGIC

Problems getting the drive to enable when no faults are indicated are usually caused by the EN/DIS software commands. Refer to Chapter 2: Theory of Operation for further help. Some faults that cause the drive to disable do not latch the status display indicator for very long. Check the Error History Buffer (ERR HIST).

## 6.9 RESOLVER ZEROING

In order to have accurate position feed back measurement, the resolver zero has to be aligned to the electro-magnetic position of the motor. When there is no commutation, and when a constant current is applied, the rotor and the stator of the motor locks to an equilibrium state. At this position, the resolver reading must show (assuming RDRES = 12) 2048 or 4096 for a 4 pole motor and 1365 or its multiples up to 4096 for a 6 pole motor.

The resolver zeroing is done at the factory and should not require readjusting. The zero position of the resolver can be checked using the switch variable ZERO. When ZERO = 1 and when the motor is enabled, then the position of the resolver (PRD variable) must show one of the values described

above. If the position reading is not within 3 counts, then the resolver adjustment is required. Remove the back plate of the motor and slightly loosen the resolver mounting clips.



**WARNING**

**Placing hands near powerful rotating components and machinery can be hazardous. Always exercise extreme caution and refer service to qualified personnel.**

Rotate the position of the resolver (located at the rear end of the shaft) while continuously reading the PRD variable till desired position readout is achieved.

Note: F3 is a recall buffer command in Motion Link.

## 6.10 RETURNING TO FACTORY SET STATE

Modifying variables and operation characteristics can provide problems in terms of too many changes to back-track and trouble-shooting communications impairment. The Smart Drive can easily be returned to the state as it was shipped from the factory. Start by using the RSTVAR command to place all user settings to factory defaults. Next, reload the compensation, or TL, file using the Motion Link Setup:Open TL facility.

## 6.11 MOTOR TESTS

All permanent magnet motors act as a generator when the motor shaft rotates. This characteristic makes it relatively easy to do a quick motor test. These tests can not detect all faults but will show the more serious ones. Disconnect the motor leads from the drive for these tests and reconnect them when done.

1. Check each of the three motor phase leads (Ma, Mb, and Mc) at the drive end of the cable for continuity to ground. The Ohm-meter should show an impedance greater than 10 kOhms.
2. Check each motor lead (Ma, Mb, and Mc) at the drive end of the cable to each other motor wire with a DC Volt-meter. While attempting to turn the motor at a consistent speed, the voltage reading should be about the same for each of the 3 possible readings.

Failure to achieve the results described indicates a problem with the motor or motor cabling.

## 6.12 RESOLVER TESTS

The resolver consists of three transformer windings which typically have somewhere between 10 and 200 ohms of resistance. This makes for an easy static test using an Ohm-meter. Disconnect the resolver cable at the drive end to perform these tests and reconnect when finished.

1. Measure the resistance between cable leads attached to pins 1 & 2.
2. Measure the resistance between cable leads attached to pins 4 & 5.
3. Measure the resistance between cable leads attached to pins 7 & 8.
4. Measure the resistance from each of these pins to earth ground. The impedance should be greater than 10 kOhms.

Failure to achieve the results mentioned indicates a problem with either the resolver or the resolver cabling.

## 6.13 FACTORY SUPPORT AND REPAIR POLICIES

Industrial Drives is committed to helping you install, operate, maintain and troubleshoot your Smart Drive servo system. If your Smart Drive did not pass the "Initial Check Out" tests or is not operating properly, then contact the Field Service Department of Industrial Drives. Be prepared to provide the full Smart Drive Amplifier, Power Supply, and Motor model numbers listed on the front of your Smart Drive and Power Supply.

The Smart Drive is a programmable product and is shipped from Industrial Drives at all times with internal settings that are factory default. Any user modified variables will be no longer be present in the drive when it is returned to user from Industrial Drives repair department. For this reason it is imperative that all users download a working copy of the Smart Drives internal variables data to disk with the Receive Variables command. Do not wait until

there is a fatal error to save system variables as, depending on the nature of the problem, it may not be possible to download the variables at that time.

Contact us at:

INDUSTRIAL DRIVES  
ATTN: Field Service Dept.  
201 Rock Road  
Radford, VA 24141

Telephone: (703) 639-2495  
FAX: (703) 731-0847



# CHAPTER 7

## ADVANCED TECHNICAL NOTES

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### 7.1 INTRODUCTION

The interactive nature of microprocessor controlled user-configurable devices often makes it difficult to explain all the details in text-book fashion. This chapter discusses miscellaneous topics to help explain the details of some advanced features.

### 7.2 NOTCH AND LOW PASS FILTERS

For aid in applications with difficult vibration and/or torsional resonance problems, two types of filters are provided in the Smart Drive. One is a low pass filter which attenuates all the frequency components above certain value (LPFHZ) and the other is a notch filter (also called as band-stop filter) which filters a band of frequencies (NCHHZ, NCHBW). Only one filter type may be selected (FILTMODE).

A number of vibrations can occur in servo motor applications. Some of these are: torsional resonance, lateral resonance, power ripple (60/120... Hz), and other structural vibrations. The effects of these undesirables are: audible noise, weakening of structures/mounting failures, reduction in the bandwidth, excessive motor current, and control loop oscillations. Many of these can be effectively filtered out using a low pass or notch filter. These filters can

not compensate for a poorly designed mechanical system.

Both the low pass and notch filters are implemented digitally in the microprocessor. Software filters are easy to tune and are as effective as hardware filters. The Low Pass Filter (LPF) is implemented as a second order (two first orders cascaded for reduced quantization effects) filter. The filter is placed in the velocity error signal before the torque command is clamped by current limiters.

The LPF has an effective cutoff frequency range of 1 to 1000 Hz. However, if the filter cutoff is specified at low frequencies, then the bandwidth of the system will be low. So low that total instability may be exhibited. If the system is tuned to have high bandwidth and the filter cutoff is low, then the motor may oscillate. In such a case either the filter cutoff should be increased or the bandwidth of the compensator needs to be decreased.

The LPF can be used to suppress torsional resonances. However, if the torsional resonance is very low (within 2 or 3 times the bandwidth) the use of the Notch Filter is recommended. In the field, when the Smart Drive is used for controlling similar kind of machines with similar loads, the torsional resonances observed may be close but not exactly same. In such cases an LPF may be a better choice to

avoid having to tune the Notch Filter to individual machines.

The Notch Filter (NF) is useful for torsional resonance and power supply ripple suppression. These resonances stem from compliance, or spring wind-up, in the load. When the torsional resonance is 'in-band', meaning it is very close to or within the bandwidth of the system, the low pass filter cannot be used. The generic transfer function is-

$$H(s) = \frac{(s^2+k^2)}{(s^2+Bs+k^2)}$$

The Notch Filter in the Smart Drive is designed as a second order filter implemented in software. It can be used in the frequency range of 1 to 500Hz (NCHHZ). The notch band can also be specified easily with a variable (NCHBW). The Notch Filter bandwidth value may range from 1 to 20Hz. The attenuation of the notch filter is related to this notch band. The higher the band, the lesser the attenuation and vice-versa.

Adding filters to control systems can have some undesirable side effects:

- The motor may oscillate if the filter is tuned to too low a frequency.
- Auto-Tuning may provide satisfactory results when the NF/LPF is tuned to low frequencies. The tuning parameters may have to be manually adjusted.
- Even after applying the Notch Filter a resonance may appear at some other frequency. This is likely if the load is changing with motion, which changes the resonant frequencies. An alternative may be to use the LPF filter.
- All filters add phase-lag delays. In applications where the Smart Drive is being controlled by another position loop controller this will lessen the system's phase margins.

### 7.3 TORSIONAL RESONANCE

Torsional resonance occurs because of flexible nature of the rotor shaft and load shaft(s) and belts. All mechanical structures exhibit resonant frequencies. These resonant frequencies are usually high enough that they are of no concern. When components carrying the movement have flexible components, the resonant frequency can become low enough that energy from the motor can excite them enough to cause resonance. If this resonance occurs at very low frequency then the bandwidth of the system must be

reduced to avoid oscillations. If the bandwidth cannot be compromised, the resonant frequency should be raised by using stiffer mechanical components:

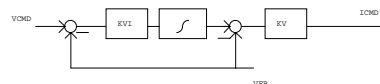
- Reducing load inertia tends to help push the torsional resonance frequency higher.
- Adding mechanical dampers would reduce the torsional excitations. For example, a resilient coupling can add torsional damping to the system.
- Reduce system bandwidth so that the torsional frequencies are not excited with sufficient amplitude. This will lower the possibility of oscillations. The bandwidth can be reduced either by using Auto-Tune command or by lowering the proportional gain.
- The PDF control algorithm may give better results than PI control algorithm.
- If the resonant frequency is very low, use notch filter. If it is substantially higher than the system bandwidth, use low pass filter.
- The input command profile may be made 'smoother' so that it will not excite torsional frequencies. This can be done using ramp type inputs.

## 7.4 CONTROL ALGORITHMS

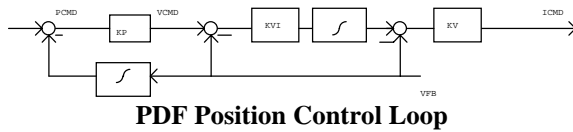
The Smart Drive offers the user a choice of two classical compensator algorithms. One is Pseudo Derivative Feedback (PDF), the other is the Proportional & Integral (PI) algorithm. Either compensator may be selected for use in the velocity loop using the PDF switch variable. The position loop (OPMODES 4-8) has an additional PI compensator.

### 7.4.1 THE PDF COMPENSATOR

The velocity control structure of the PDF compensator and the position control structure are illustrated below. The difference between the PDF structure and PI is the feedback between the integral and proportional gain blocks. The PDF's feedback is superior from load-noise rejection point of view.



PDF Velocity Control Loop



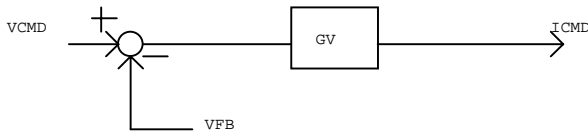
**PDF Position Control Loop**

The PDF control algorithm tends to be excellent for process control applications or other applications where:

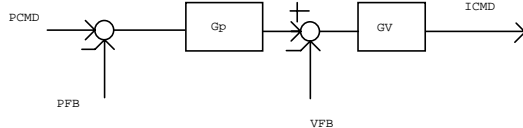
- The velocity target is generally constant or changing slowly.
- Load variation is expected.
- Load noise rejection is required.

**7.4.2 PROPORTIONAL CONTROL ALGORITHM**

A Proportional Only control algorithm is possible in both position and velocity control modes. Use the PI compensator (PDF =0) and set the integral term to 0. The structures are shown below.



**Proportional Velocity Control Mode**

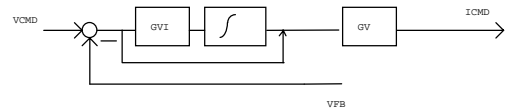


**Proportional only Position control structure**

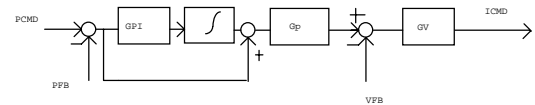
Proportional Only control exhibits excellent stability properties providing type-1 servo control. This implies that this control algorithm can be used for very high bandwidth applications. However, the lack of an integral term may pose steady-state following error problems which means that this algorithm may not be very suitable for constant set point applications. For applications where this is not a problem or where the external reference signal has an integrator, proportional only control is a good choice especially if high bandwidth is required.

**7.4.3 THE PROPORTIONAL AND INTEGRAL CONTROL ALGORITHM**

The velocity control structure for the PI algorithm is shown below as well as the position control structure.



**PI Velocity Control Mode**



**PI Position Control Mode**

The PI control scheme is excellent for CNC applications or other applications where:

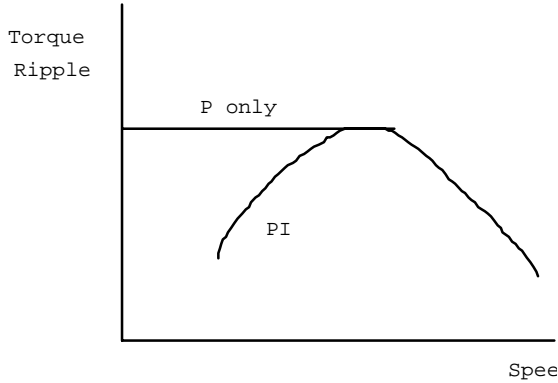
- The target set point varies frequently.
- The system requires good input tracking capability to meet multi-axis control requirements.

The PI compensator offers good set point tracking capability as the algorithm is entirely error driven. It also tends to provide relatively higher bandwidth which again permits good set point tracking capability.

**7.4.4 COMPENSATOR PERSONALITIES**

The integral term in PI compensates for the steady-state offset errors which may otherwise be there. However, an integral term may pose stability problems. For applications where some offset error is not a problem and where it is difficult to stabilize the system, proportional only control can be used. Also, for systems with very high bandwidth requirements, proportional only controller may yield a higher bandwidth than a PI controller.

For systems sensitive to velocity ripple, the PI compensator may be a better choice at lower speeds as the integrator acts to attenuate low speed fluctuations. High speed ripples in any compensator are generally taken care by the system inertia. The Proportional Only controller has constant ripple attenuation for much of the speed range until the rotor inertia comes into play in quenching the high speed ripple.



The Proportional controller has relatively poor DC (low frequency) disturbance rejection due to the absence of an integrator. High frequency disturbance is taken care of, as in the case of torque ripple, by the rotor inertia which acts as an integrator.

The major difference between the PDF and the PI compensators is the load disturbance rejection capability vs. input following capability. OPMODES 4 to 8 utilize a position control algorithm as all these modes deal with some kind of input pulse following. When the PDF compensator is used, there may be a following error proportional to the speed of the motor. The outer loop (position loop) of Fig. 2 contains the proportional term which multiplies the position error (PE).

A summary of positives and negatives of each compensator type is presented in the following table.

	P	PI	PDF
Bandwidth	1	2	3
Stability	1	2	2
Load Disturbance Rejection	3	2	1
Steady State Input Following	3	1	2*
Torque Ripple	2	1	1
Step Response	1	3	2
Industry Familiarity, Ease of Tuning.	1	1	2

\*In steady state, the position error is proportional to the velocity and the compensation values (KV etc.)  
 # PI loop tends to overshoot as it tries to follow the input very closely. Proportional only control may give offset error to a step input.

The PDF compensator is usually a better choice for positioning applications as the PI loop tends to overshoot because of the integrator.

The PDF algorithm is enabled when PDF switch mode variable is set to 1. The PI compensator is selected when the PDF switch mode variable is 0.

## 7.5 SERVO AND REGULATION

In the above sections it was mentioned that the PDF compensator has good load rejection capabilities (regulation) and the PI compensator has good following capabilities (servo). In some applications, it

may not be very obvious whether the control problem in hand is a servo problem or the regulation problem. The following procedure will help in classifying the application into servo and regulation categories.

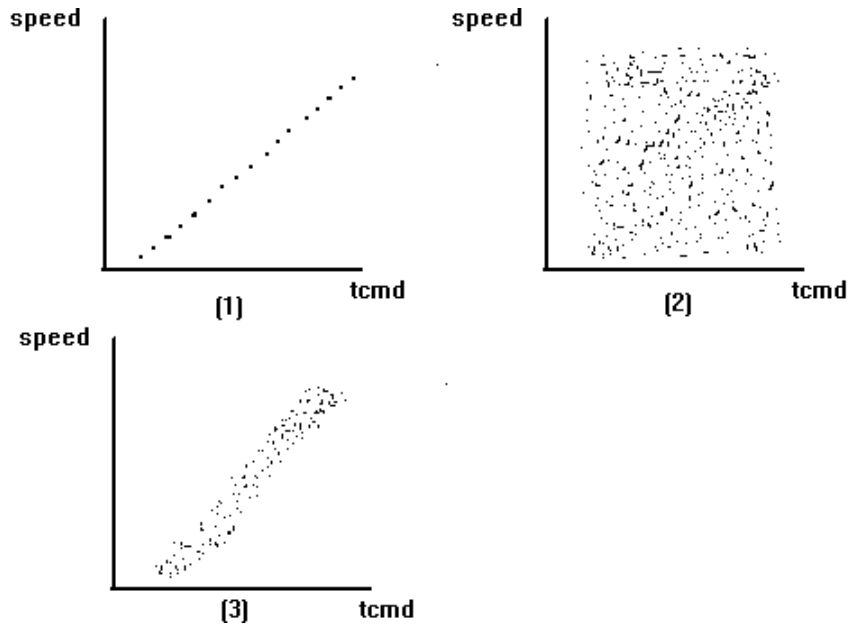


Fig. 1, above, shows that the relationship between velocity and torque commands is more or less linear which means we can classify as a servo problem. The PI compensator would probably perform better in this application..

Fig. 2, above, on the other hand, shows a highly irregular relationship between velocity and torque which means lot of load changes are present in the system. For this application the PDF compensator may be better suited.

Fig. 3, above, shows a relationship somewhere in-between and the initial choice between PDF and PI is a matter of judgment. Some experimentation may be required to obtain best results.

## 7.6 AUTO-TUNING

The Smart Drive has an Auto-Tuning facility which adjusts all tuning parameters in any mode automatically by applying some disturbance to the motor and measuring its response. Smart Drive can derive its tuning parameters optimally for the particular motor and load conditions. The parameters calculated by the Auto-Tune facility are also dependent on the user specified requirements for bandwidth and damping (stability) levels.

The Smart Drive is tuned using the following command syntax:

**TUNE <bandwidth> <stability>**

The bandwidth can vary between 5 and 100 Hz. The actual tuning parameters change only in increments of 5 Hz. If we specify 44 Hz then it is interpreted as 40 Hz bandwidth. Stability takes one of 1,2, or 3 numbers which specify the under damped, critically damped and over-damped response respectively. The advantage of specifying a bandwidth response level is that different applications are limited in their ability to handle higher bandwidths. As the bandwidth is increased the system tries to follow the input closely and the energy consumed is increased. The jerk on the load is also increased with the increased bandwidth. Alternately, too little system bandwidth may make the system sluggish in responding to the input.

The user, depending upon the application, needs to determine an acceptable bandwidth. An optimum bandwidth is generally the minimum bandwidth at which an acceptable performance is attained. The best method to determine optimal bandwidth is to start with a low bandwidth and gradually increase it while testing the system response to the input command / load change. If the command input / load is changing slowly then a low bandwidth is generally sufficient.

The user is also given the facility to specify the stability level. The options are -

- Stability level -1 : Over damped
- Stability level-2 : Critically damped
- Stability level-3 : Under damped

Each stability level is differentiated by a phase margin difference of about 5 degrees. That is, the over-damped case has 5 degrees more phase margin than critically damped case and 10 degrees more phase margin than the under damped case. The critically damped case has a 90 degree phase margin at the -3dB point.

Tuning can be done when the drive is enabled or disabled. The Smart Drive will enable the drive momentarily if it is not already enabled. After tuning, the drive is returned to its previous state before tuning. If the tuning fails the old tuning values are retained.

Auto-Tuning shakes the motor at about 30 Hz for approx. 2sec. The level of energy applied for shaking the motor can be limited by the variable ILIM. Generally 25% of the maximum torque (TCMD = 512 out of 2048) is applied while tuning, provided

ILIM is set above 25%. For applications with sensitive mechanical loads the amount of jerk applied with this torque command may be high and may over-speed the motor or damage the load. Therefore, before issuing Auto-Tuning command, the ILIM may be set at a low value (say 5%) and gradually raised until satisfactory tuning is obtained. The Auto-Tune facility may fail at low ILIM values because the amount of torque issued may not be sufficient to excite the load properly. Once the tuning is completed ILIM should be restored to its original value.

Some tuning parameters as outputted from the Tune facility are OPMODE dependent. If the system is tuned in one mode of operation, and operation is changed to a different mode, the drive should be re-tuned.

The Low Pass and Notch Filters effect the servo loop performance. The reason is that filters increase the lag times in the system. The lag time increases as the frequency of filter operation is lowered. Normally, Auto-Tuning is done with filters turned off. If the filters are on while a tune command is issued, the tune algorithm turns off the filters, tunes the system and turns the filters back on. If the filters are on in the normal operation, the tuning parameters may require a little adjustment. Generally, one may think that the gains (KV, GV etc.) need to be increased to take care of the filter lag time. However, increasing gain may reduce the phase margin affecting the stability. Therefore depending on the frequency of filter operation, the gains may have to be increased or decreased to achieve required performance and stability margin. Generally, turning on the filters may not affect the system much if the filter corner frequencies are at much higher values than the corner frequency (bandwidth) of the system.

## 7.7 MANUAL TUNING

The Auto-Tune facility may fail for certain applications such as those involving large inertia loads. In such cases the loops must be tuned manually before enabling the drive.

In general, the following guidelines may be followed for manual tuning:

Desires	PDF LOOP			PI LOOP		
	KP	KV	KVI	GP	GV	GVI/GPI#
To increase bandwidth	↑ 2	↑ 1		↑ 1	↑ 2	
To reduce overshoot	↑ 2	↑ 1	↓ 3	↑ 3	↑ 1	↓ 2
To reduce settling time			↑			↑
To reduce sustained oscillations	↓ 1	↓ 2		↓ 2	↓ 1	
To reduce oscillations while settling*			↓			↓
To reduce following error	↑			↑		

Notes:

1 2 3 numbers indicate that the changes are recommend in this order.

# GVI is used for PI velocity loop and GPI is used for PI position loop

\* This basically increases the settling time while reducing the amplitude of oscillations during settling

### 7.8 TUNING PROBLEMS

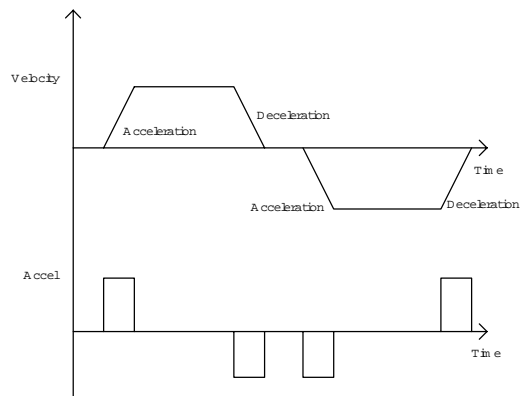
There can be many reasons why systems are difficult to stabilize:

- If the loop is tuned for one particular load condition and if the load changes substantially then oscillations may occur. One way to tackle this is to tune the loop for some load which is in between the minimum and maximum
- If the bandwidth of the system is too high then oscillations can occur. Reduce bandwidth using Auto-Tuning or reduce proportional gain.
- If the low pass filter cutoff is too low then oscillations can occur. Increase the cutoff or reduce the bandwidth. Similarly if the notch filter is tuned in-band then reducing the notch width may improve the situation.
- If the resolver is not zeroed properly then oscillations or runaway conditions may result. Zero the resolver by setting ZERO = 1. The PRD (position read) variable must show; for a 4 pole motor: 2048 or 4096; for a 6 pole motor: 1365 or its multiples up to 4096)
- Setting ILIM to lower values may also induce oscillations. The current loop may saturate causing an out-of-control condition.
- Torsional resonance may cause oscillations. Reducing bandwidth, use of filters, changing coupling etc. are potential solutions.
- Low speed operation and high bandwidth may also induce oscillations if the 1st or other lower harmonics of motor vibrations excite 60Hz ripple or other low resonant frequencies. Changing speed, reducing bandwidth, use of filters, changing coupling etc. are possible solutions.

- If the ground connection between the motor and the amplifier is not proper then the resolver signal may jump causing oscillations.

### 7.9 RAMP CONTROL

Command profiling means to generate smooth (generally first or second order) command curves instead of step inputs. This can be desirable from many aspects such as reducing over shoots, reducing wear, reducing oscillations, and reducing following error. The Smart Drive can provide ramp (or profile) control in all OPMODES except OPMODES 2 and 3. Two basic types of ramps are available; Linear and S-Curve. The shape of linear profile ramp curve is shown below.

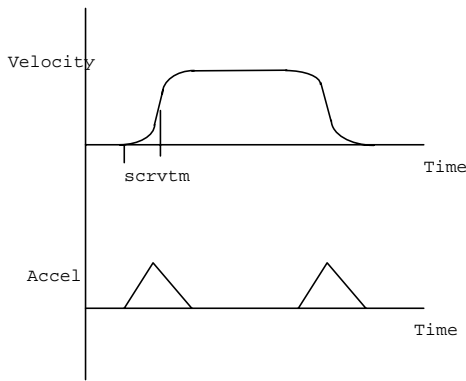


Linear Ramp Profile

This figure shows the trapezoidal profile in which linear acceleration (deceleration) is applied to the load till it reaches the set velocity. This type of profiling ramps to speed time-efficiently and requires minimum peak horse-power. The slope of the acceleration and deceleration are set by separate variables in the Smart Drive, ACC and DEC. These variables are in Revolution-per-minute-per-second.

When a linear acceleration is applied, the jerk on the load (jerk = derivative of acceleration) is abrupt. This may be of concern in some applications where there is a free sitting loads (such as loads on conveyor belts) in which the load may move upon application of high jerk.

The S-Curve ramp profile is shown below.



**S-Curve Profile Ramp**

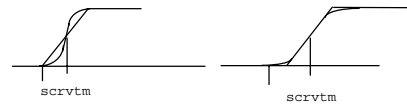
The S-Curve is useful in reducing the jerk on the system as the acceleration/deceleration on the motor is gradually changed as against an abrupt change as in the case of linear ramp. The price paid for this is the increase in time to reach the same velocity with the same peak acceleration and an increase in peak horse-power. Unlike the linear ramp mode, the S-Curve deceleration time is always equal to acceleration. The S-Curve time is controlled using the SCRVTM (time in msec) variable. There is a maximum limit on the S-Curve time which is given below:

$$\text{scrvtm} \leq \text{move time,}$$

where, move time = velocity/acceleration.

In OPMODE 0, if SCRVTM is more than the move time, then full S-Curve time is automatically used. IN OPMODE 8, specifying SCRVTM more than the move time will generate error.

There are two considerations when specifying time for S-Curves. We can think of S-Curves in the following two ways:



Type-1

Type-2

From these figures, for the same given acceleration, two types of S-curve can be constructed. The first one, in which the time taken to accelerate to the required velocity is same for the S-Curve profile as with linear acceleration profile. However, the acceleration in the mid-region of the S-Curve is more (double for the full S-Curve) as compared to the linear acceleration. In the second case, the maximum acceleration of the S-Curve profile is matched with the linear acceleration. However, in this case the total time taken for the S-Curve to reach the required velocity is increased. By adjusting the ACC variable suitably, we can get identical S-Curves in both of the above cases. In the Smart Drive type-2 S-curve is implemented. Therefore, if we need to reduce the total time taken by the S-Curve, then the acceleration needs to be increased.

The type of profiling used by the Smart Drive is controlled using PROFMODE switch mode variable.

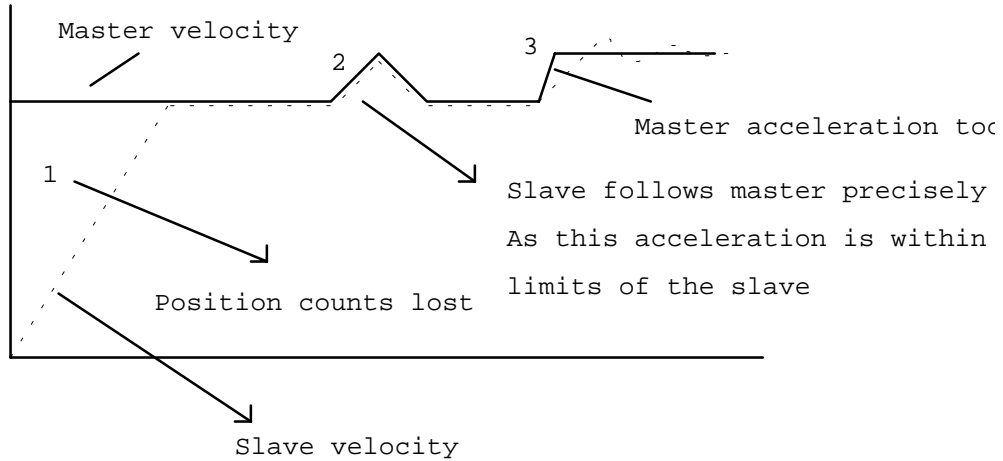
- PROFMODE = 0: No profiling. In this mode the commanded velocity/position is directly transferred to the control loops. In this case the motor accelerates with maximum possible acceleration and deceleration, limited only by system horse power.
- PROFMODE = 1: Linear profile. This turns on the linear ramp profile using the ACC and DEC variables which specify acceleration and deceleration of the motor respectively in RPM / S. OPMODES 4 to 7 will lose the position lost when accelerating to a moving master.
- PROFMODE = 2: Partial S-Curve. This mode enables the S-Curve generators using ACC and SCRVTM variables. By properly adjusting the SCRVTM it is possible to get full S-Curve in this mode. However PROFMODE 3 automatically generates full S-curve.
- PROFMODE = 3: Full S-curve. This mode generates full S-Curve ramps using the ACC variable. SCRVTM is unchanged.

OPMODES 0 and 1 provide serial and analog input velocity loop control. In both these modes,



trapezoidal profiles are supported. S Curves are supported only in OPMODE 0 (and in OPMODE 8). Using ramp control in OPMODE 1 while using an external position loop controller can cause system instability as ramp control is simply another form of filter with added phase-lag. S-Curve motion is available only in OPMODE 0. The S-Curve time is specified using SCRVTM variable.

OPMODES 4 to 7 are used to follow external position commands which can come from an external source. Ramp control is very useful when attempting to lock on to a moving input signal. PROFMODE = 1 provides the slave acceleration limiting capability as explained in the following figure.

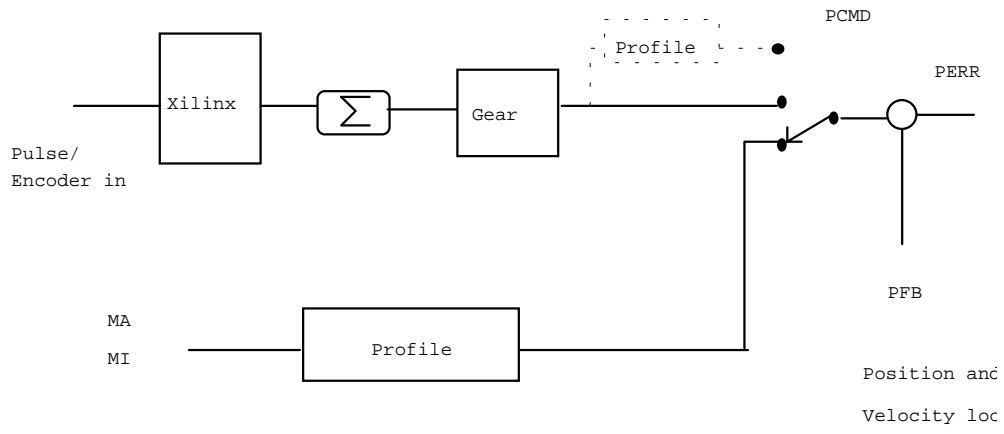


In the above figure, at time = 0, the slave motor is enabled with PROFMODE = 1. The slave ramps up to the master velocity and tries to follow master count by count. When the slave reaches the target velocity, the position represented by area #1 is lost. At area #2, the master acceleration is changed. As this acceleration is within the limit set by the ACC and DEC variables of the Smart Drive, the slave follows master perfectly.

position counts. This is because the position count integrator in the PROFMODE 1 of the Smart Drive is limited. If the master acceleration is greater than the slave's persistently, then this integrator will overflow resulting in lost position. Since it is possible to switch PROFMODE from mode 1 to 0 and vice-versa at any time during the move, one could ramp up to the master speed and switch PROFMODE from 1 to 0 to ensure that no position counts are lost.

At area 3, the master input acceleration is above the Smart Drive's set ACC / DEC limits. The slave response is shown in the figure. If this acceleration is substantially high and persists for more than a few milliseconds then there is a possibility of losing

Profiling can be used in OPMODES 4-7 with any gear ratio. However, if the gear ratio is high, the position count integrator may overflow quicker resulting in lost position.

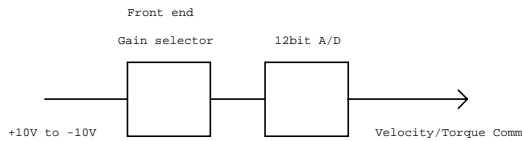


***Profiling in OPMODES 4 thru 8***

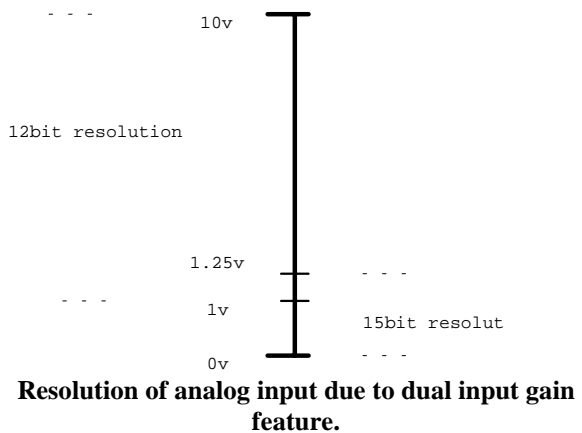
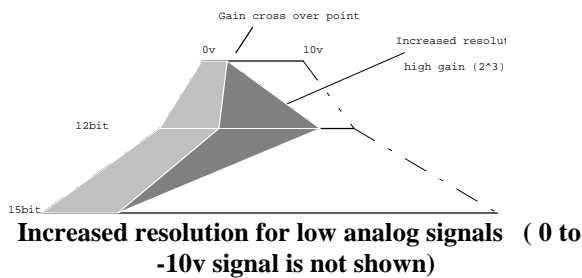
OPMODE	PROFMODE = 0 (No profile)	PROFMODE = 1 (Trapezoidal)	PROFMODE = 2 (Partial - S)	PROFMODE = 3 (Full - S)	Remarks
0	Yes	Yes	Yes	Yes	
1	Yes	Yes	No	No	PROFMODE 2,3 same as PROFMODE 1
2	Yes	No	No	No	PROFMODE 2,3 same as PROFMODE 1
3	Yes	No	No	No	PROFMODE 2,3 same as PROFMODE 1
4	Yes	Yes	No	No	PROFMODE 2,3 same as PROFMODE 1
5	Yes	Yes	No	No	PROFMODE 2,3 same as PROFMODE 1
6	Yes	Yes	No	No	PROFMODE 2,3 same as PROFMODE 1
7	Yes	Yes	No	No	PROFMODE 2,3 same as PROFMODE 1
8	No	Yes	Yes	Yes	PROFMODE 0 same as PROFMODE 1
9	Yes	No	No	No	

### 7.10 ANALOG INPUT MODES (OPMODES 1 AND 3)

The analog input facilitates driving the motor using analog voltage. The analog input can be considered either as a velocity command or as a torque command. The analog input accepts a +10V to -10V DC voltage signal. The analog voltage input is processed in the smart drive as shown below.



The front end gain selector is used to select the gain according to the input voltage level. A high gain is selected to amplify low level voltage input signals so as to increase the resolution. This gain selector switches its gain from high to low at 1.25V+ and from low to high at 1V-. With this mechanism, although a 12bit A/D converter is used, the effective resolution is increased to 15 bit for signal in the range 0 to 1/1.25v.



Over the range of -10 to +10 Volts, the signal maps to a 12 bit ADC signal which provides a resolution of 20v/4096. This implies that the digital conversion increases by 1 count for every 4.88 mv. At low voltage signals (up to 1 to 1.25 V depending on whether the voltage is raising or falling) the gain is increased by a factor of 8. This implies that for low voltages the digital conversion increases by 1 count for every 0.61 mv.

With the above scheme the resolution of analog input can be computed as follow:

- For 10 to 100% speed (voltage) range, the 12-bit A/D converter provides a resolution of :  $V_{REF}/2048$  rpm.
  - For 0 to 10% speed (voltage) range, a gain of 8 provides resolution of :  $V_{REF}/8*2048$
- For example: If  $V_{REF} = 3000$ , then between 300 to 3000 rpm, the speed can be changed with a resolution of  $4000/2048$  or 1.95 rpm. Between 0 to 300 rpm, the resolution is:  $4000/(8*2048) = 1.95/8$  or 0.24rpm

The Smart Drive automatically selects the gain of the analog input based on its signal level. The gain select thus is transparent to the user. The ANDG switch variable is normally set to 1 but may be made 0 by the user to disable the dual gain function. In this case the input is scaled 12 bits for +/- 10 Volts.

The analog input is scaled using a variable called VREF. VREF is defined as RPM-per-10V input signal. This is equivalent to a scale pot on analog drive systems. The factor setting of VREF is  $1.25 * V_{MAX}$  resulting in full motor velocity for 8 volts input. All other voltages and speeds are scaled linearly according to the following equations.

- velocity command = (Analog input voltage at high gain/16384)\*VREF
- velocity command = (Analog input voltage at low gain\*8/16384)\*VREF

The industrial environment tends to be full of electrical noise. Even with the use of shielded cables it may not be possible to suppress noise entirely. Therefore, a deadband facility is provided on the analog input. All signals below this deadband are ignored. The deadband is specified using variable ANDB (units in mv).

Analog systems also require the ability to compensate for offsets. The Smart Drive provides the ANOFF variable for compensating for these offsets. The ANOFF variable may be modified for 0 RPM by trial and error. Or with 0 Volts into the Smart Drive's

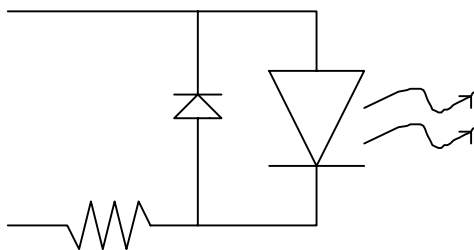
analog input, read the analog signal using the ANIN variable. Negate the value and enter it as ANOFF.

An other method of zeroing the analog input uses velocity feedback. The ANZERO command averages the motor velocity over time and sets ANDB and another internal variable to null the speed offset. ANDB should be 0 before executing the ANZERO command and the drive should be enabled. A SAVE command is required to save the zeroing values in EEPROM.

## 7.11 SMART DRIVE ELECTRONIC GEARING AND PULSE FOLLOWER MODES

The Smart Drive provides four operating modes: 4,5,6, & 7 as pulse follower input modes of operations. Each one performs a slightly different function.

Each mode requires external connections from an encoder or some sort of pulse generator circuitry. All external connections are made at connector C3 and are detailed in the wiring diagrams in Chapter 3. The Smart Drive is designed to receive differential drive signals. This type of signal interface is most immune to electrical noise in the industrial environment. It is also easy to sequence in the sense that swapping Hi and Low inputs of one channel changes electrical direction. There are many ways to connect to these inputs, even when using drives which are not differential.



**Equivalent Encoder Input Circuit**

The Smart Drive typically runs with 12 bit resolver resolution which provides 4096 bits per revolution. All pulse follower inputs are referenced to this resolution. For example, a 1024 line count encoder is seen by the Smart Drive to have 4096 bits per revolution. Set to track 1:1 in OPMODE 4, the motor shaft tracks the encoder shaft exactly 1-to-1. A 512 line encoder would require two encoder shaft

revolutions to make the motor shaft rotate one revolution. A 2048 line encoder would only require 1/2 revolution.

### 7.11.1 Closely Associated Variables

#### **GEAR <0,1> :**

This switch variable is used to connect or disconnect the incoming pulses to the motor position command word. Effectively an electronic clutch, GEAR, can be used to theoretically disconnect or stop the encoder's electrical input to the gearbox. With PROFMODE = 0 (no acceleration control) the GEAR = 1 command would cause the motor to immediately lock on the pulse input signal. This is good for starting a system at rest to lock the shafts in a position-to-position relationship. This is not practical for locking on to a moving pulse train because the motor would attempt a step function to the target velocity. PROFMODE = 1 installs linear ramp control in place with the ACC and DEC variables. Implementing this ramp control allows locking onto a moving master under controlled conditions. This is a velocity-to-velocity lock which means that the difference in position between the distance the master traveled during the motors acceleration and the distance the motor traveled during its acceleration is lost.

#### **GEARI < -32,767 to +32,767 >**

#### **GEARO < 1 to 32767 >**

The exact tracking ratio of a pulse follower input to motor shaft can be set by the user using the GEARI and GEARO variables. These variable can be set from 1 to 32,767 and allow a very wide range of following ratios. Note that GEARI can be a negative value which can be used to reverse the CW / CCW operation of the system. GEARI = GEARO represents a 1:1 tracking ratio. GEARI = 10, GEARO = 1 means that the motor will turn ten turns for each 4096 counts into the pulse follower channel.

#### **PEMAX < 0 to 32,767 >**

This variable is used to set a maximum following error between the motor's desired position and the motor's actual position, in bits. It is important to note that the motor's desired position is directly related to the pulse input frequency in these modes of operation. With PROFMODE = 0, locking onto a moving master can quickly cause this position error to exceed PEMAX and cause a fault. When PROFMODE ≠ 0, the motor's desired position slews under ramp control and provides a means to manage position error overflow conditions.

### 7.11.2 Design Considerations

Thoughtful design is required for master input signals to a digital system. The master must supply enough data (quantity over time) for the digital system to resolve it without jitter on the motor shaft. It would not be a good design to ask a 100 line count encoder to move the motor 1 RPM with GEARI = 10 and GEARO = 1. The motor would stop-start-stop with 1/40th of a revolution jumps.

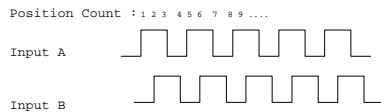
It is important to note that discussing motor shaft directions can get confusing because there are so many ways to change the direction of rotation (ie: DIR, GEARI, Swapping differential inputs, etc.). This document assumes that all variables are in the factory default state and only one variable deviates at a time. This notation is referred to as the 'Standardized' direction. Also recall that all factory documentation referring to motor shaft direction is referenced as though one was directly facing and looking at the motor's load shaft.

### 7.11.3 OPMODE 4: Electronic Gearing

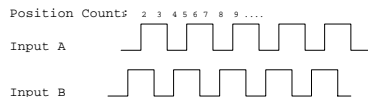
The most straight forward of all pulse follower modes, OPMODE 4 is the electronic gearbox mode. In its most basic application it causes the motor shaft to track movement on an external encoder shaft. This is often referred to as an electronic line shaft or master-slave application.

The encoder input is from a differential line driver type encoder which encodes pulses in quadrature mode or A-quad-B. This means that the encoder outputs two square wave channels that are identical in frequency but are phase shifted by 90 electrical degrees.

Dir A leads B



Dir B leads A

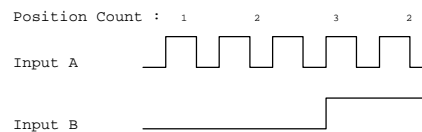


The Smart drive receives these signals and performs a quadrature decode on them. This provides 4 digital bits of incremental position change for each line of change on the encoder. Simply stated, the Smart drive sees 4 times the encoder line count per revolution. The Smart Drive uses a 'A leads B' convention for

forward counting. Note that A-leads-B can be made B-leads-A by swapping the channels or swapping one channels HI / Lo inputs.

### 7.11.4 OPMODE 5: Pulse and Direction Follower

This operational mode is widely used in stepper motor technology and allows for an retrofit. A pulse train (frequency) is supplied in one channel and a direction signal is applied to another. The Smart Drive receives the pulse input on the A encoder channel and counts on the positive edge of this signal. Direction is controlled by the B channel input where an inactive (or off) state indicates a standardized CW direction and an active B channel indicates a standardized CCW direction. With GEARI = GEARO it would take 4096 pulses to rotate the motor one complete revolution. Note that the Direction can be reversed by inverting the B channel input by swapping the HI / Lo connections.



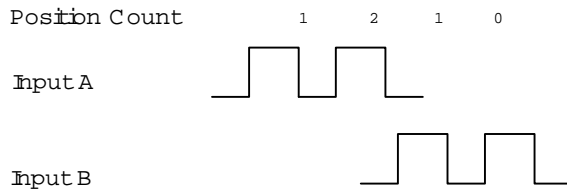
### 7.11.5 OPMODE 6: Edge and Direction Follower

This operational mode is identical to OPMODE 5 except that the pulse input increments the motor position twice per pulse; once on the rising edge, once of the falling edge. With GEARI = GEARO it would take 2048 pulses to rotate the motor one complete revolution.

### 7.11.6 OPMODE 7: Up / Down Count Follower

This operational mode is conceptualized as an up / down counter logic IC whose net output is the motor's commanded position. Pulses applied to the A channel causes the counter to count up on both rising and falling edges of the pulse. This results in a change of motor position in the standardized CW direction. Pulses applied to the B channel causes the counter to count down on both rising and falling edges of the pulse. This results in a change of motor position in the standardized CCW direction. The counter is not

effected by pulses occurring simultaneously on both channels.



### 7.12 SMART DRIVE CURRENT LIMITING

The Smart Drive incorporates some current limiting functions to protect both the motor and the drive from potential damage due to excessive power. Factory set protection variables include:

- **IMAX:** Limits the peak rms current allowed to the motor. While the drives are built to a 2:1 ratio peak-to-continuous current rating the Goldline series of motors are designed to handle a 3:1. This variable allows limiting peak output current from 0 to  $I_{pk}$  of the drive. Data Range is 0 - 100%  $I_{pk}$  Drive.
- **ICONT:** Limits continuous rms drive current to protect the drive or motor. This variable allows limiting rms output current from 0 to 50% of peak drive current. Data range is 0 - 100% of  $I_{pk}$  Drive: Limited by IMAX.

In addition, the Smart Drive includes a current foldback scheme where peak drive current is allowed for only two seconds before being exponentially decreased over six seconds to the drives continuous rated current.

The Smart Drive also allows the user to lower the potential current output from the drive using the ILIM variable. ILIM allows user to lower IMAX under the following guidelines:

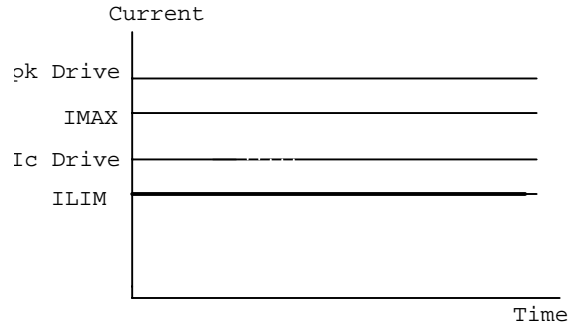
- Peak (RMS) output current is limited to ILIM.
- Continuous motor current cannot exceed ILIM. This is to say that foldback will not increase current to  $I_{cont}$ .

Data Range is 0 - 100% of  $I_{pk}$  Drive: Limited by IMAX

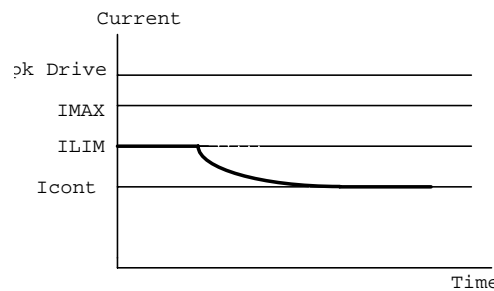
There are also some user variables to help understand what is happening in the system:

- **IMON:** A variable which holds the actual motor current in percent of peak rated drive current. This variable may be inaccurate at low levels due to conversion losses.

- **I:** A variable which holds the average motor current as sampled over 8mS. Also in percent of peak rated current.
- **SAT:** A switch variable which is set to 1 whenever and internal current limit clamp is instilled on the current command signal.
- **FOLD:** A switch variable which is set to 1 whenever the drive's output current is limited by the foldback system. The display will also flash an 'F' when the foldback limit is active.



**Motor Current Limited by ILIM will never exceed set value.**



**Motor Current Limited by ILIM will FOLDBACK to ICONT.**

### 7.13 TORQUE CONTROL COMMANDS

The Smart Drive provides several commands designed to allow maximum flexibility in the torque (current) control mode of operation:

- TREF: This variable scales the analog input for OPMODE 3. The reference torque (current) represents the output torque (2048 maximum) for an analog input voltage signal of 10 V. The value entered is the desired motor current (2048 = Peak Drive Rated) if 10 volts were applied to the analog input.
- TCMD: A variable representing the actual torque (current) command. This input variable is subject to the current limiting described above. This variable is used in OPMODE 3 to command motor torque through the serial port. The units are calculated as follows:

$$AMPS = (I_{pk} (Drive) / 4096) * TCMD$$

- TDAC: This variable holds the actual output torque command after filtered (or limited) by the Smart Drives current limiters.
- T: Actual motor current. It is the Imonitor scaled 0 - 4095 to match TCMD. The actual resolution of this data is 4 LSB as it is sampled with a 10 bit converter.



# APPENDIX A

## WARRANTY INFORMATION

---

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

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

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



# A

## PPENDIX B

### ASCII TABLE

The Smart Drive does not support extended ASCII (128 - 255).

DEC	HEX	CHR	CONTROL CODE
000	00		NUL
001	01	^A	SOH
002	02	^B	STX
003	03	^C	ETX
004	04	^D	EOT
005	05	^E	ENQ
006	06	^F	ACK
007	07	^G	BEL
008	08	^H	BS
009	09	^I	HT
010	0A	^J	LF
011	0B	^K	VT
012	0C	^L	FF
013	0D	^M	CR
014	0E	^N	SO
015	0F	^O	SI
016	10	^P	DLE
017	11	^Q	DC1
018	12	^R	DC2
019	13	^S	DC3
020	14	^T	DC4
021	15	^U	NAK
022	16	^V	SYN
023	17	^W	ETB
024	18	^X	CAN
025	19	^Y	EM
026	1A	^Z	SUB
027	1B	^[	ESC
028	1C	^\	FS
029	1D	^]	GS
030	1E	^^	RS
031	1F	^_	US

DEC	HEX	CHR	CONTROL CODE
032	20	SP	
033	21	!	
034	22	"	
035	23	#	
036	24	\$	
037	25	%	
038	26	&	
039	27	'	
040	28	(	
041	29	)	
042	2A	*	
043	2B	+	
044	2C	,	
045	2D	-	
046	2E	.	
047	2F	/	
048	30	0	
049	31	1	
050	32	2	
051	33	3	
052	34	4	
053	35	5	
054	36	6	
055	37	7	
056	38	8	
057	39	9	
058	3A	:	
059	3B	;	
060	3C	<	
061	3D	=	
062	3E	>	
063	3F	?	

DEC	HEX	CHR	CONTROL CODE
064	40	@	
065	41	A	
066	42	B	
067	43	C	
068	44	D	
069	45	E	
070	46	F	
071	47	G	
072	48	H	
073	49	I	
074	4A	J	
075	4B	K	
076	4C	L	
077	4D	M	
078	4E	N	
079	4F	O	
080	50	P	
081	51	Q	
082	52	R	
083	53	S	
084	54	T	
085	55	U	
086	56	V	
087	57	W	
088	58	X	
089	59	Y	
090	5A	Z	
091	5B	[	
092	5C	\	
093	5D	]	
094	5E	^	
095	5F	_	

DEC	HEX	CHR	CONTROL CODE
096	60	`	
097	61	a	
098	62	b	
099	63	c	
100	64	d	
101	65	e	
102	66	f	
103	67	g	
104	68	h	
105	69	i	
106	6A	j	
107	6B	k	
108	6C	l	
109	6D	m	
110	6E	n	
111	6F	o	
112	70	p	
113	71	q	
114	72	r	
115	73	s	
116	74	t	
117	75	u	
118	76	v	
119	77	w	
120	78	x	
121	79	y	
122	7A	z	
123	7B	{	
124	7C		
125	7D	}	
126	7E	~	
127	7F	DEL	

# APPENDIX C

## Customer Support

---



Kollmorgen 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, Kollmorgen offers a one-stop service center to answer all our customer's product needs. This one number provides order status and delivery information, product information and literature, and application and field technical assistance:

**Kollmorgen Customer Support Network**  
203 Rock Road Suite A  
Radford, VA 24141  
Phone: (888) 774-KCSN (5276)  
Fax: (540) 639-1640 Inside Sales  
Fax: (540) 639-1574 Technical Support  
Email: [servo@Kollmorgen.com](mailto:servo@Kollmorgen.com)  
[Http://www.Kollmorgen.com](http://www.Kollmorgen.com)

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



# APPENDIX D

## SERIAL FUNCTION GROUPING

---

### D.1.0 SMART DRIVE COMMANDS

=  
DIS  
DUMP  
DUMP TL  
EN  
ERR  
ERR CLR  
ERR HIST  
ERR xx  
I  
J  
K  
LOAD  
MA  
MI  
P  
PLAY  
RECORD  
RSTVAR  
S  
SAVE  
STEP  
TUNE  
V

### D.2.0 MODE CONTROL VARIABLES

DEP  
ECHO  
FILTMODE  
GEAR  
LIMDIS  
MSG  
OPMODE  
PDF  
PROFMODE  
PROMPT  
RDRES  
RELAYMODE  
THERMODE  
ZERO

### D.3.0 SERIAL PORT VARIABLES

ABAUD  
ADDR  
BAUD  
DEP  
ECHO  
MSG

**D.4.0 MOTION CONTROL VARIABLES**

ACC  
 CWLIM  
 CCWLMIM  
 DEC  
 DIR  
 GEAR  
 GEARI  
 GEARO  
 LIMDIS  
 OPMODE  
 PCMD  
 PFB  
 PRD  
 PROFMODE  
 SCRVTM  
 TCMD

**D.5.0 DRIVE STATUS VARIABLES**

ACTIVE  
 AMPS  
 CWLIM  
 CCWLMIM  
 FOLD  
 HVER  
 MOTOR  
 PCMD  
 PEXT  
 PFB  
 PRD  
 READY  
 RECDONE  
 RECING  
 RECRDY  
 RELAY  
 OPMODE  
 SAT  
 STATUS  
 TDAC  
 TRUN

THERM

VCMD  
 VE  
 VER  
 VFB  
 VOLTS

**D.6.0 ANALOG INPUT VARIABLES**

ANDB  
 ANDG  
 ANIN  
 ANOFF  
 ANZERO  
 VREF  
 TREF

**D.7.0 TUNING VARIABLES****D.7.1 Position Loop**

GP  
 GPI  
 GPICAP

**D.7.2 Velocity Loop: PDF=1**

KV  
 KVI  
 VREF

**D.7.3 Velocity Loop: PDF=0**

GV  
 GVI  
 VREF



**D.7.4 Filters**

FILTMODE  
LPFHZ  
NCHBW  
NCHHZ  
PROFMODE

**D.7.5 USER INTERFACE  
VARIABLES**

BAUD  
CWLIM  
CCWLIM  
ECHO  
ENCLINES  
INPOS  
LIMDIS  
MSG  
OPMODE  
PROMPT  
PEINPOS  
RELAY  
RELAYMODE  
REMOTE  
THERM  
THERMODE  
TRUN  
ZERO

**D.7.6 SYSTEM LIMITS**

AMPS  
ENCLINES  
ICONT  
ILIM  
IMAX  
IMON  
MOTOR  
OPMODE  
PEMAX  
PROFMODE  
RDRES  
VMAX  
VOLTS  
VOSPD

**D.7.7 MEMORY COMMANDS**

LOAD  
RSTVAR  
SAVE  
DUMP  
DUMP TL



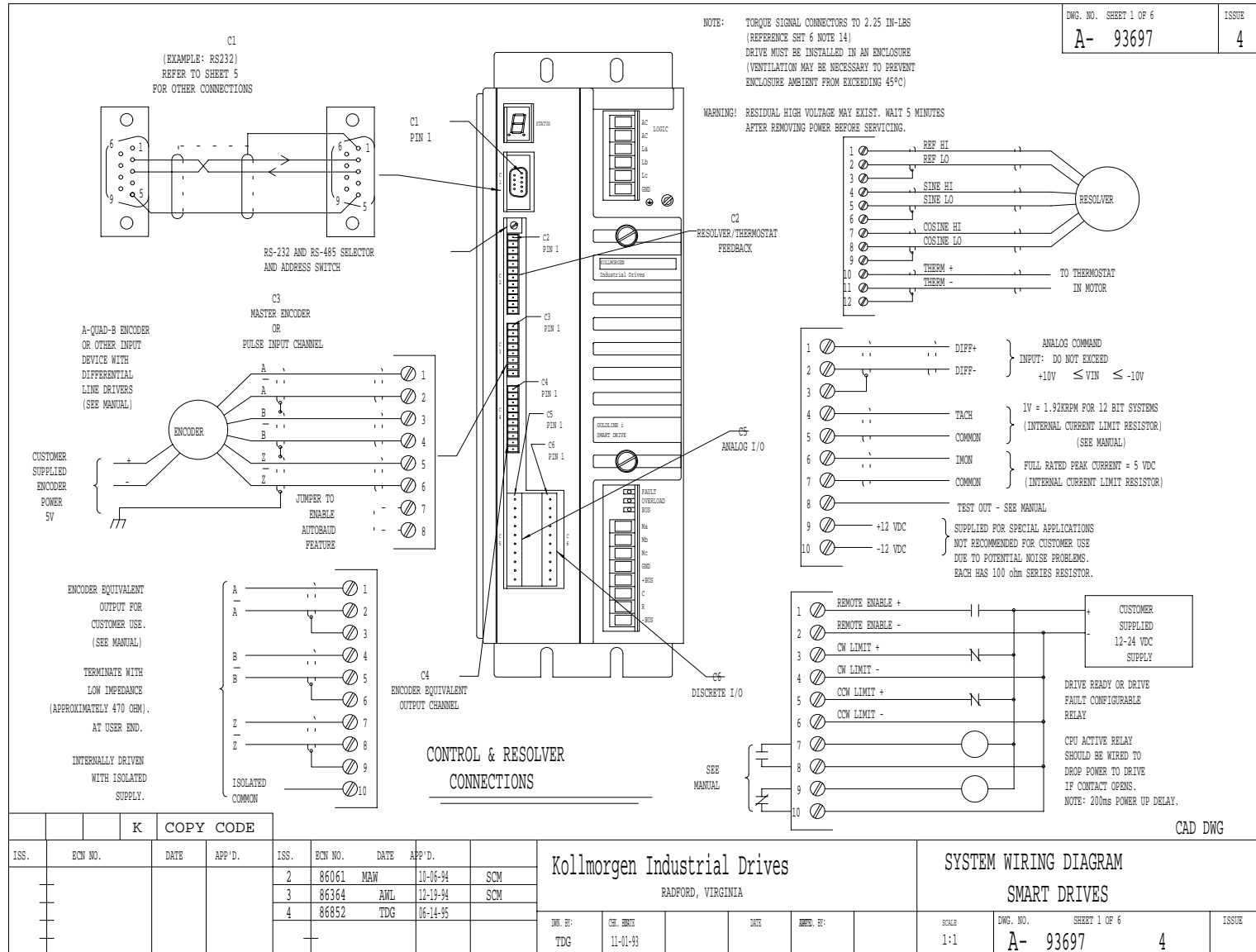
# APPENDIX E

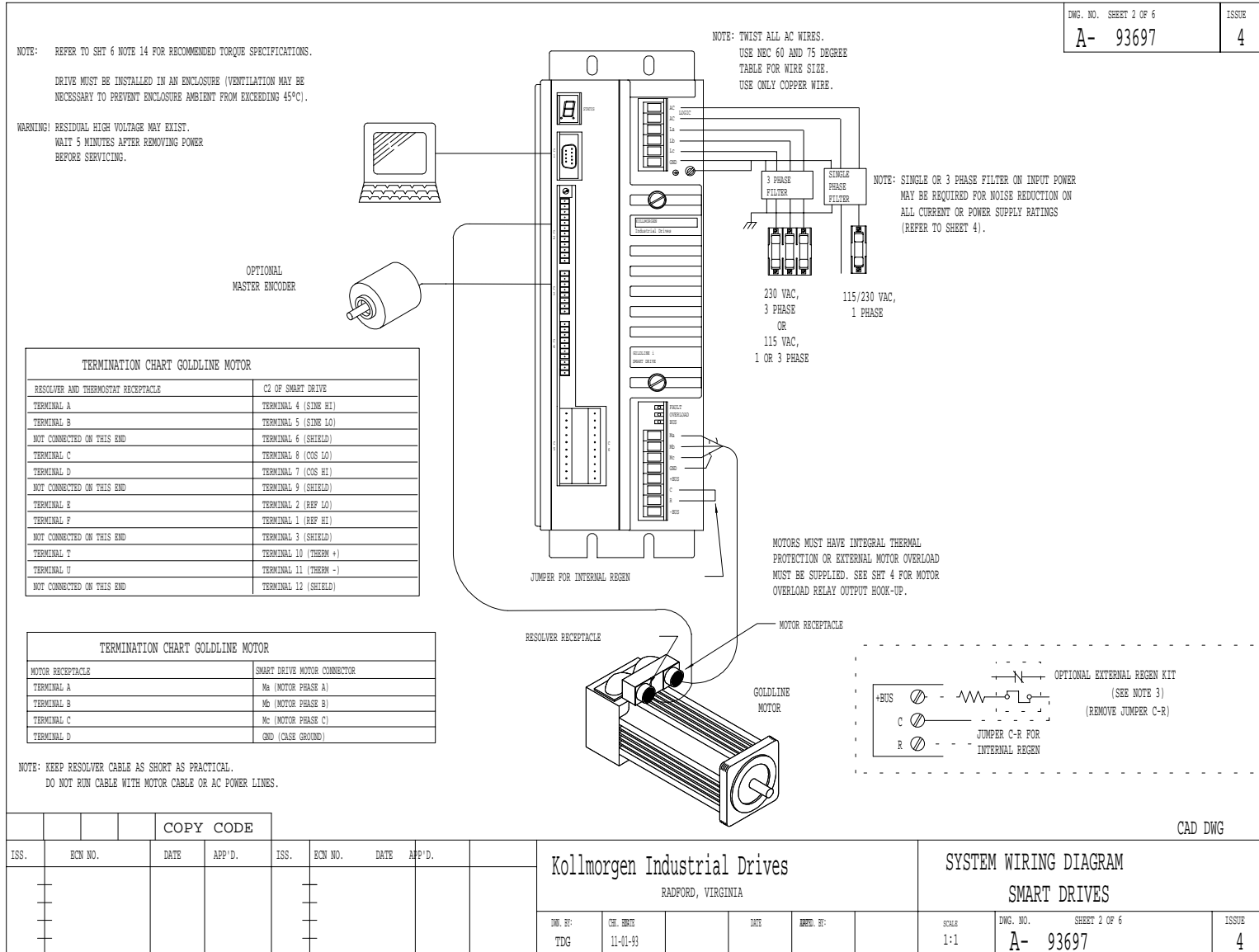
## DRAWINGS

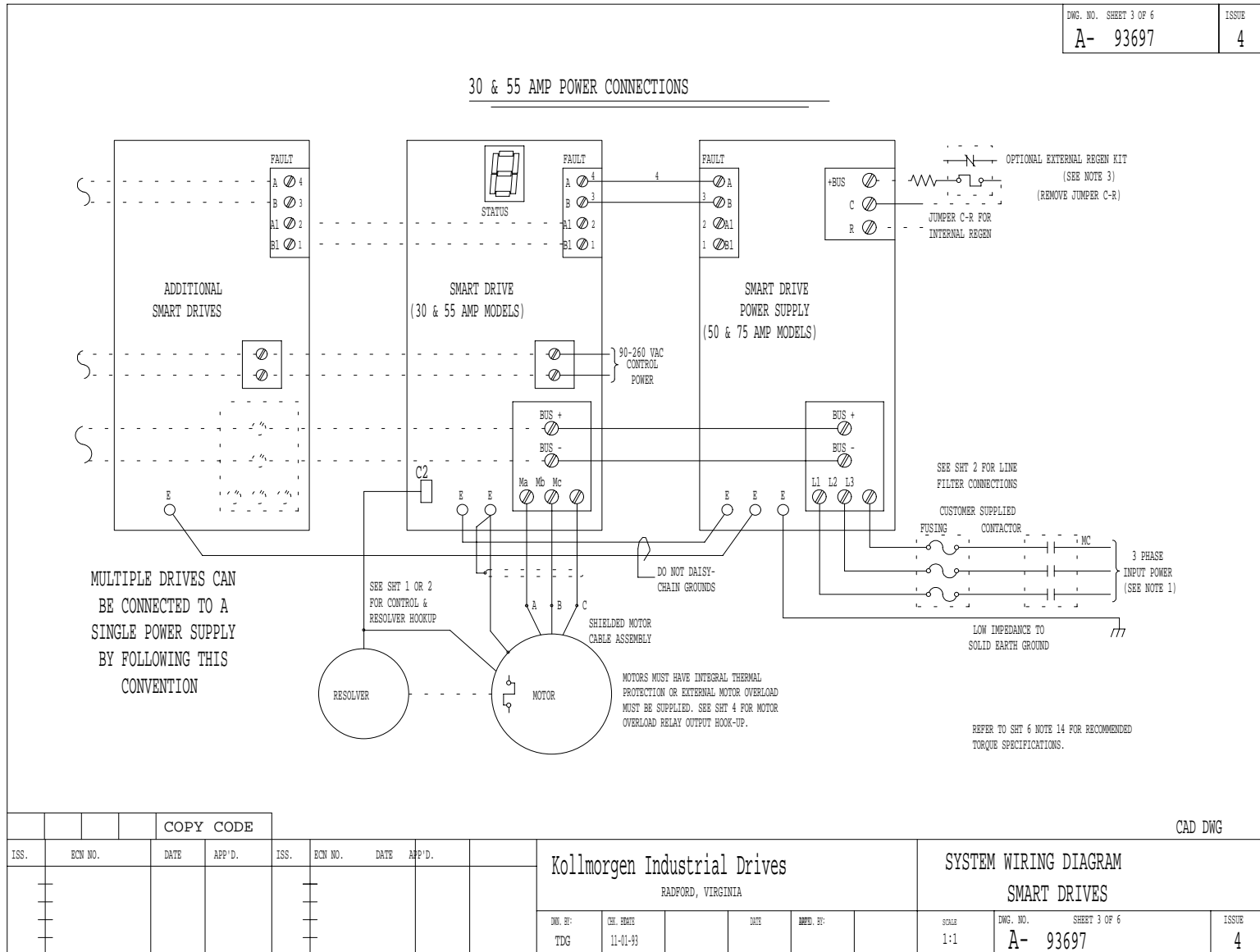
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<b>PAGE NUMBER</b>	<b>TITLE</b>	<b>DRAWING NUMBER</b>
E-3	System Wiring Diagram Smart Drives	A-93697
E-9	Assembly Guide for Motor Cables	A-93981
E-17	Assembly Guide For Resolver Cables	A-93982
E-27	Assembly Guide for Resolver Cables	A-96068
E-37	Assembly Guide for Motor Cables (S/D - 3 THRU 20 AMP)	A-96069

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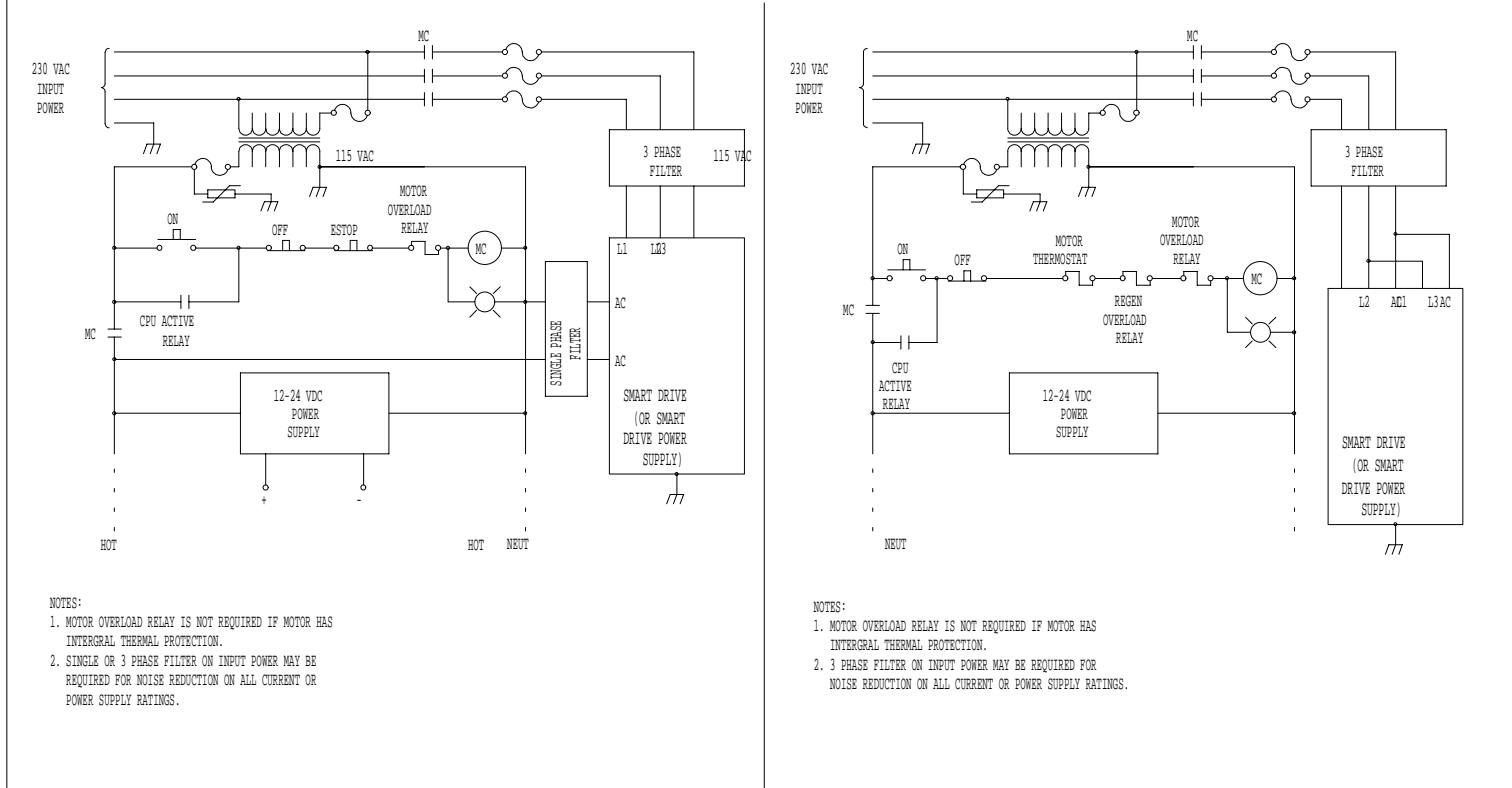






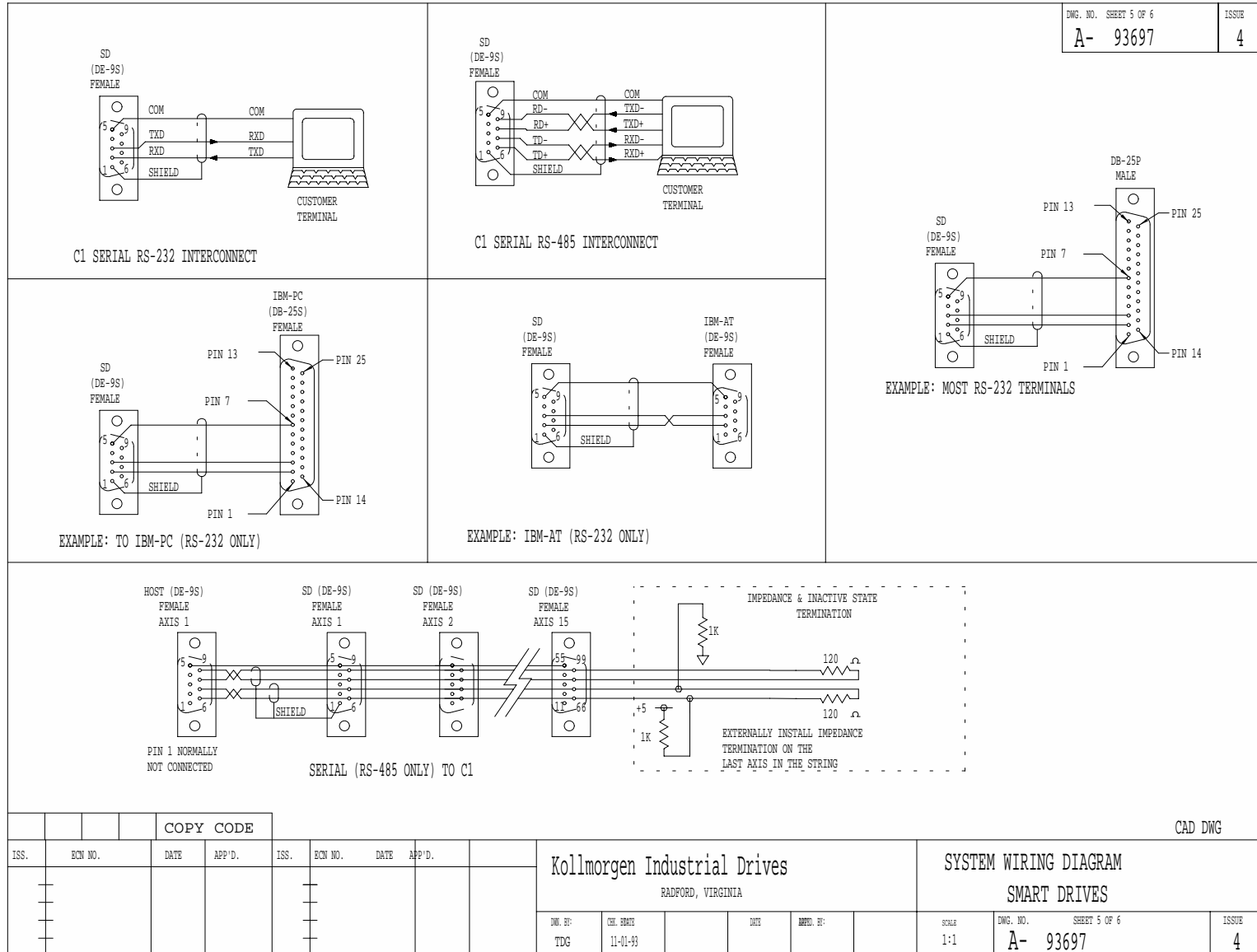
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 ISSUE  
**4**

TYPICAL CONTROL POWER WIRING DIAGRAMS



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ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives RADFORD, VIRGINIA			
								SYSTEM WIRING DIAGRAM SMART DRIVES			
								SCALE	DWG. NO.	SHEET 4 OF 6	ISSUE
								1:1	<b>A- 93697</b>		<b>4</b>





NOTES:										DWG. NO. SHEET 6 OF 6 <b>A - 93697</b>	ISSUE <b>4</b>																																							
1. DRIVE MUST BE INSTALLED IN AN ENCLOSURE (VENTILATION OR COOLING MAY BE NECESSARY TO PREVENT ENCLOSURE AMBIENT FROM EXCEEDING 45° C).										6. ALL AC LINES SHOULD BE TWISTED CABLES.  7. THE TOTAL NUMBER OF AXES ALLOWED, PER P50 OR P75, DEPENDS ON THE APPLICATION AND THE COMBINATION OF D30 AND D55: P50: A MAXIMUM OF 6 D30 AND D55 P75: A MAXIMUM OF 6 D30 AND D55.  8. THE SMART DRIVE IS CONFIGURED AT THE FACTORY FOR RS-232. USE RS-232 AND RS485 SELECTOR AND ADDRESS SWITCH FOR RS-485.  9. FOR MOTOR & RESOLVER CABLE ASSEMBLIES, REFER TO MANUAL #93103 OR CONSULT FACTORY.  10. A THERMAL OVERLOAD RELAY IS SUPPLIED IN THE REGEN RESISTOR KIT FOR EXTERNAL REGEN. THE THERMAL OVERLOAD RELAY, INCLUDED IN THE KIT, WAS SIZED FOR YOUR RESISTANCE AND POWER RATING. THE OUTPUT CONTACTS OF THE RELAY MUST BE WIRED TO DROP POWER TO THE MAIN POWER CONTACTOR IN A FAULT CONDITION, AS SHOWN ON SHEET 4.  11. RECOMMENDED TORQUES ARE: A. 2.25 IN-LB: CONTROL SIGNALS ( C2, C3, C4, C5, C6, ETC )  B. D03 TO D20 AMP MAX TORQUE 12 IN-LB: EXTERNAL REGEN, MAIN POWER AND BUS CONNECTION, GROUND SCREW.  C. D30 TO D55 AMP MAX TORQUE 20 IN-LB: MOTOR, BUS CONNECTION AND GROUND STUD  D. P50 TO P75 AMP MAX TORQUE 20 IN-LB: MAIN POWER, BUS CONNECTION AND GROUND STUD MAX TORQUE 12 IN-LB: EXTERNAL REGEN CONNECTION  E. FOR GROUNDING TO MACHINE OR EARTH GROUND, A SCREW LUG SHOULD BE ATTACHED TO GROUND SCREW OR STUD. RECOMMENDED TORQUE OF 12 IN-LB FOR GROUND SCREWS AND 20 IN-LB FOR GROUND STUDS. MAY ALSO REFER TO NATIONAL ELECTRICAL CODE (NEC) OR UL STANDARD 486B FOR RECOMMENDED TORQUES.																																								
2. CAUTION: THE CPU ACTIVE RELAY CONTACTS (RATED 115VAC 1 AMP) MUST BE WIRED IN SERIES WITH THE OVERLOAD RELAY AS SHOWN ON SHEET 4. THIS CONTACT IS NORMALLY OPEN AND WILL CLOSE WITHIN 200 MSEC. AFTER APPLICATION OF CONTROL AND MAIN POWER. THIS CONTACT OPENS IN FAULT CONDITIONS.																																																		
3. CAUTION: RESISTOR IS CONNECTED TO HIGH VOLTAGE; ENSURE SUFFICIENT ELECTRICAL CLEARANCE WHEN MOUNTING. RESISTOR MAY BECOME VERY HOT DURING OPERATION. DO NOT MOUNT NEAR MATERIALS THAT ARE FLAMMABLE OR DAMAGED BY HEAT. VENTILATION MAY BE REQUIRED. SEE WIRING DRAWING FOR SPECIFIC REGEN RESISTOR KIT. EACH KIT HAS DIFFERENT SERIES/PARALLEL RESISTOR CONNECTIONS TO OBTAIN SPECIFIC RESISTANCE AND POWER RATING.																																																		
4. WIRE SIZES, BREAKERS AND FUSES FOR SMART DRIVE: D03-XXX HAS A MAXIMUM MAIN POWER INPUT CURRENT OF 7 AMPS RMS, FUSE FOR 10 AMPS D10-XXX HAS A MAXIMUM MAIN POWER INPUT CURRENT OF 20 AMPS RMS, FUSE FOR 25 AMPS D20-XXX HAS A MAXIMUM MAIN POWER INPUT CURRENT OF 20 AMPS RMS, FUSE FOR 25 AMPS P50-XXX HAS A MAXIMUM MAIN POWER INPUT CURRENT OF 50 AMPS RMS, FUSE FOR 60 AMPS P75-XXX HAS A MAXIMUM MAIN POWER INPUT CURRENT OF 75 AMPS RMS, FUSE FOR 80 AMPS.  THE ACTUAL APPLICATION MAY REQUIRE LESS CURRENT, USE 600 VAC INSULATED WIRE AND REFER TO LOCAL ELECTRICAL CODES FOR PROPER WIRE SIZE FOR THE CURRENTS LISTED ABOVE. FUSES FOR MAIN POWER SHOULD BE A U.L. RATED TIME DELAY TYPE, SUCH AS, BUSS FRN-R SERIES. CONTROLS CIRCUITS SHALL BE PROVIDED WITH APPROPRIATE OVER-CURRENT PROTECTION.  THE POWER BUS BETWEEN A P50 OR P75 AND D30 AND D55 SHOULD USE THE FOLLOWING WIRE GAUGE WITH 600 VAC INSULATION P50-XXX, 8 AWG (OR LARGER) WIRE, P75-XXX, 4 AWG (OR LARGER) WIRE. IT IS RECOMMENDED FERRULES BE USED FOR POWER AND MOTOR LEADS ON THE D03, D10, AND D20. 14 AWG TYPE H2, 5/19 NO. 6352.0, 12 AWG TYPE H4, 0/19 NO. 6354.0, AND 10 AWG TYPE H6, 0/20 NO. 5335.0 FROM WEIDMULLER.  RECOMMENDED RING TERMINALS FOR D30, D55, P50, AND P75. 8 AWG HOLLINGSWORTH R3027BF 6 AWG HOLLINGSWORTH R4001BF 4 AWG HOLLINGSWORTH R5100BF																																																		
5. ALL SIGNAL AND CONTROL WIRES TO BE 22-18 AWG WIRE. FERRULES ARE RECOMMENDED TO IMPROVE CONNECTIONS. FOR 20 AWG TYPE H0, 75/14 NO. 4629.0 FROM WEIDMULLER IS RECOMMENDED.																																																		
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<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="4">COPY CODE</th> <th colspan="4"></th> <th colspan="4" rowspan="2" style="text-align: center;">                     Kollmorgen Industrial Drives                      RADFORD, VIRGINIA                 </th> <th colspan="4" rowspan="2" style="text-align: center;">                     SYSTEM WIRING DIAGRAM                      SMART DRIVES                 </th> </tr> <tr> <th>ISS.</th> <th>ECN NO.</th> <th>DATE</th> <th>APP'D.</th> <th>ISS.</th> <th>ECN NO.</th> <th>DATE</th> <th>APP'D.</th> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </table>												COPY CODE								Kollmorgen Industrial Drives RADFORD, VIRGINIA				SYSTEM WIRING DIAGRAM SMART DRIVES				ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.															
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A- 93981

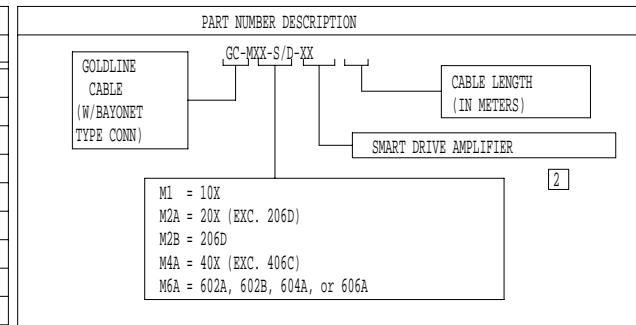
ISSUE  
3

THIS DRAWING CONTAINS THE INFORMATION NECESSARY TO FABRICATE MOTOR CABLES TO BE USED WITH SD-3, 10 & 20 AMP UNITS WHEN USED ON THE FOLLOWING MOTORS, IF THEY HAVE BAYONET TYPE CONNECTORS.

2

FOR 10X & 20X (EXC. 206D) MOTORS: SEE SHEET 3 or 4  
206D & 40X (EXC. 406C) MOTORS: SEE SHEET 5 or 6  
60X MOTORS: SEE SHEET 7 or 8

DASH NO.	CABLE LENGTH		DASH NO.	CABLE LENGTH		DASH NO.	CABLE LENGTH	
		FEET METERS		METERS	FEET		METERS	FEET
		10 303			1003930	-57	57	190
		20 606			1103333	-60	60	200
		30 909			1203636	-63	63	210
		401212			1303939	-66	66	220
		501515			1404242	-69	69	230
		601818			1504545	-72	72	240
		702121	-48	48	160	-75	75	250
		802424	-51	51	170			
		902727	-54	54	180			



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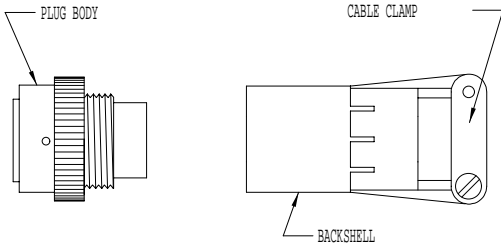
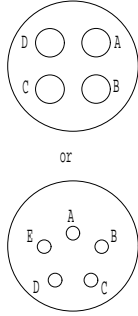
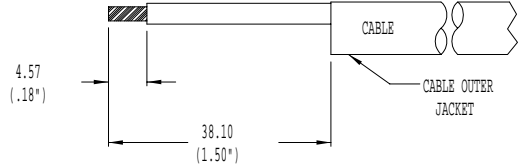
Kollmorgen Industrial Drives  
RADFORD, VIRGINIA

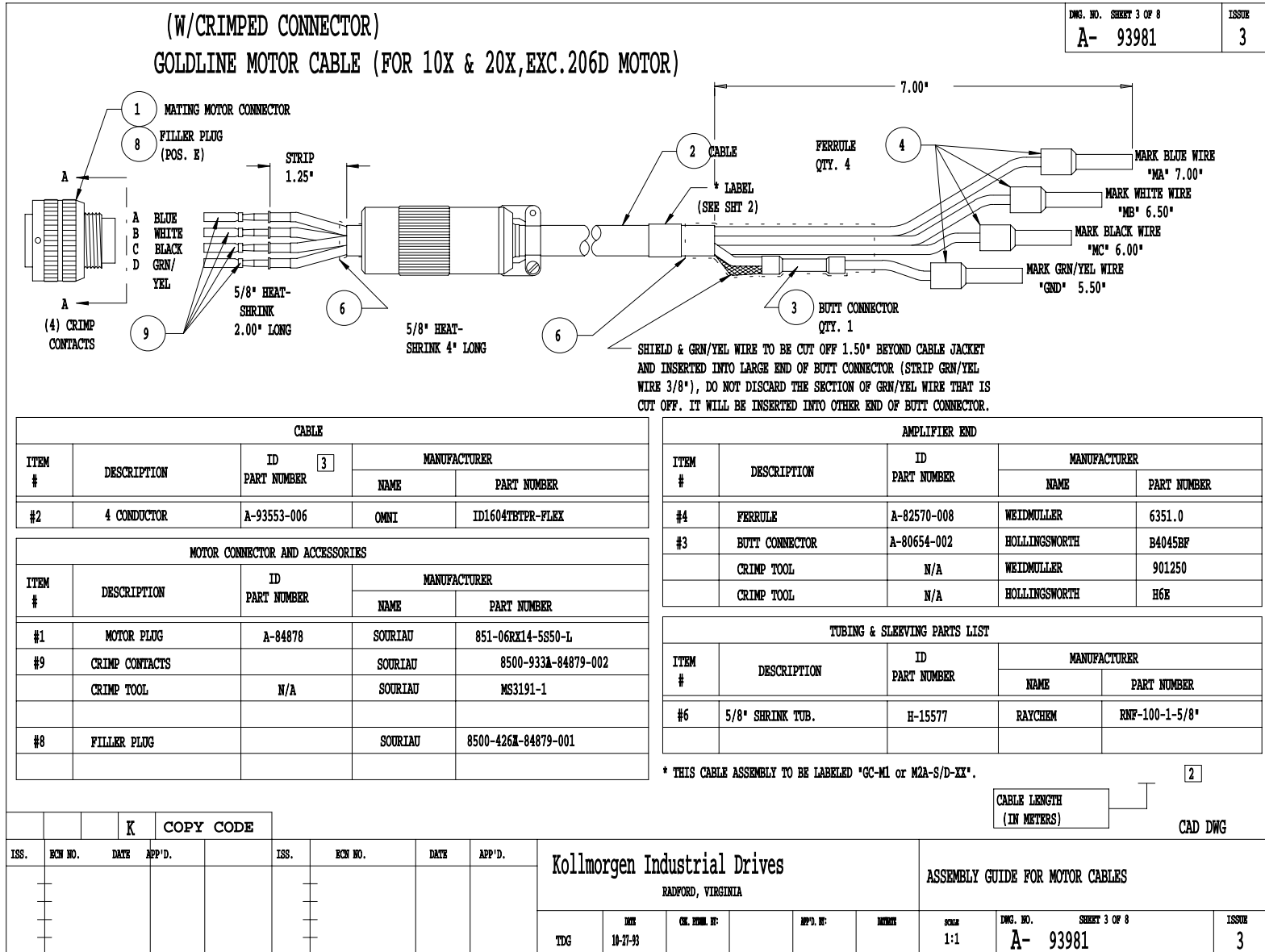
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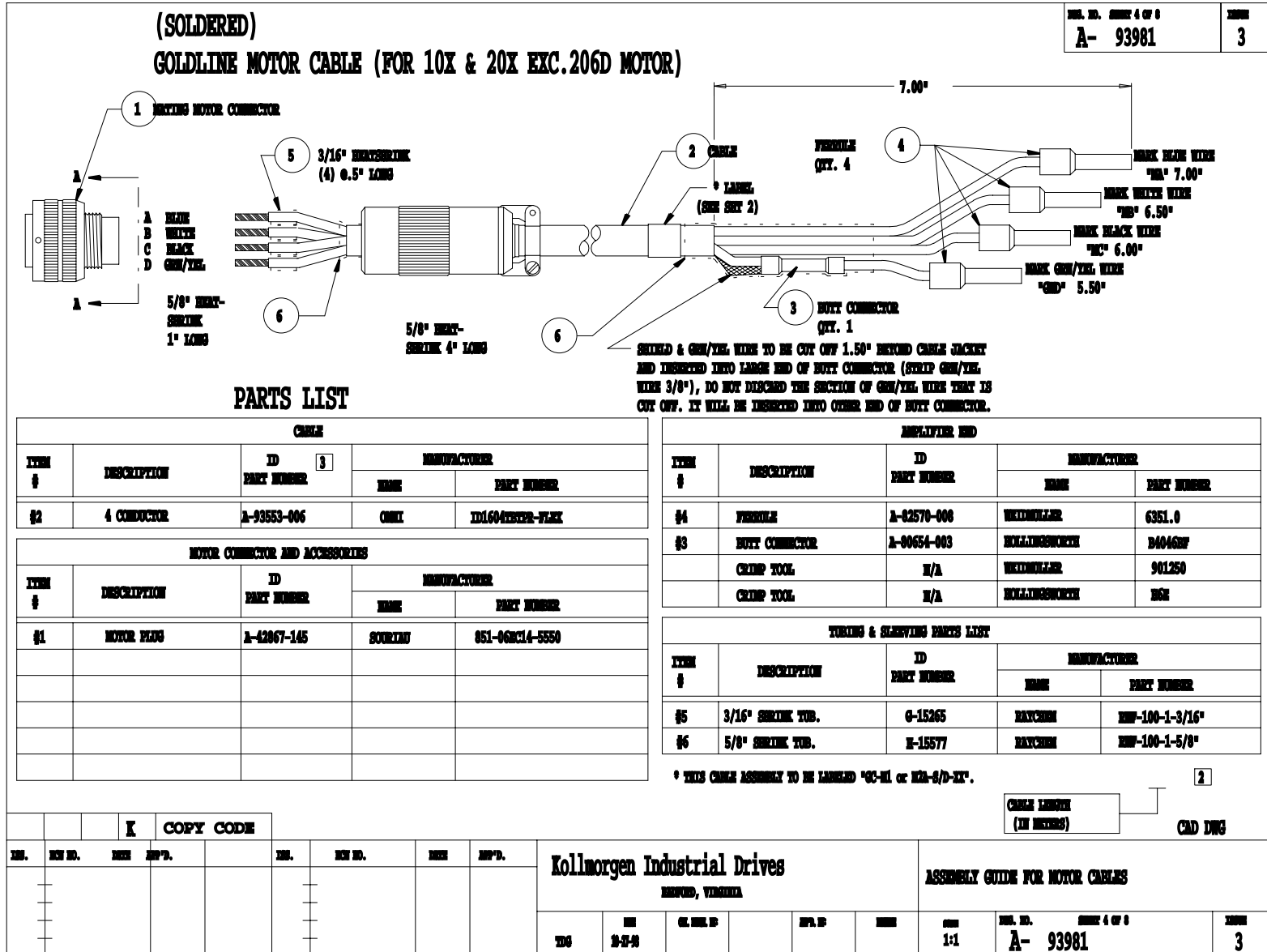
ASSEMBLY GUIDE FOR MOTOR CABLES

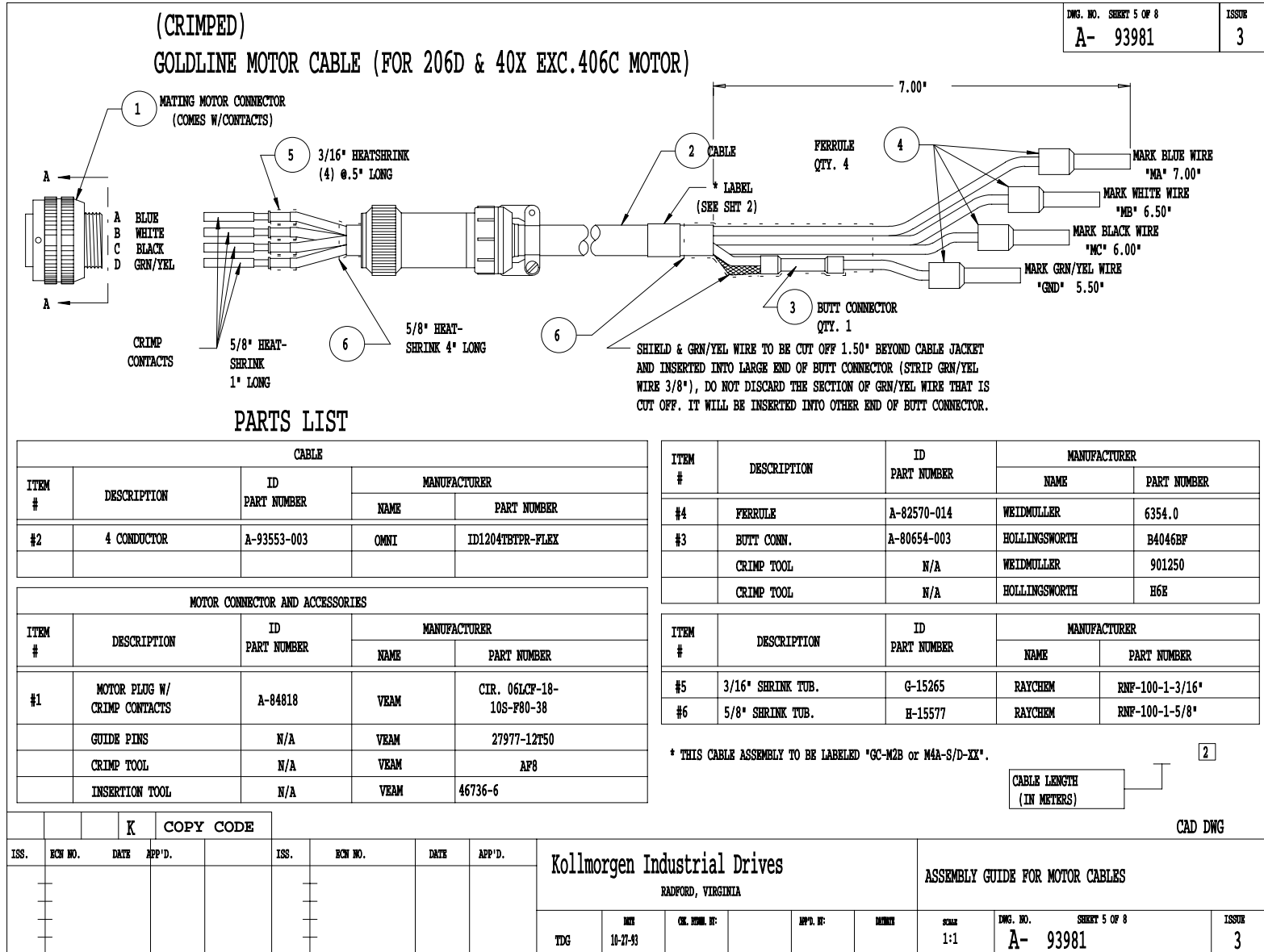
SCALE 1:1	DWG. NO. A- 93981	SHEET 1 OF 8	ISSUE 3
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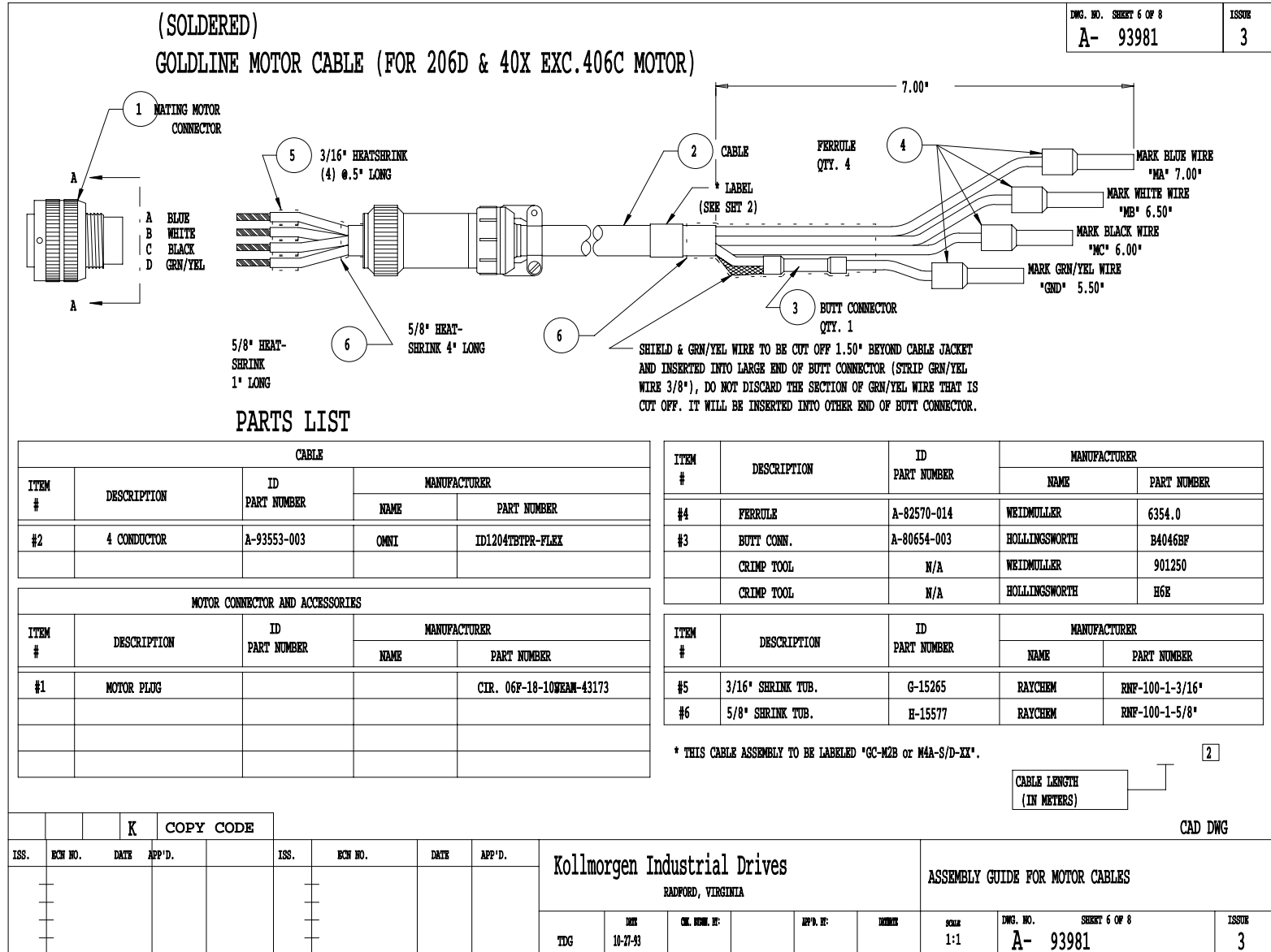
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		 <p style="text-align: center;">DETAIL A - A</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="font-size: small;">DWG. NO. SHEET 2 OF 8</td> <td style="font-size: small;">ISSUE</td> </tr> <tr> <td style="font-size: large;">A- 93981</td> <td style="font-size: large;">3</td> </tr> </table>	DWG. NO. SHEET 2 OF 8	ISSUE	A- 93981	3																																																																																
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<h3>CONNECTOR ASSEMBLY PROCEDURE</h3>																																																																																							
<p><b>STEP 1</b> BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE THE FOLLOWING ITEMS ONTO THE CABLE: 12.7MM (1/2") SHRINK TUBING, BACKSHELL AND 15.88MM (5/8") SHRINK TUBING.</p> <p><b>STEP 2</b> STRIP THE OUTER CABLE JACKET BACK 38.1MM (1.5"). THIS WILL EXPOSE THE SHIELD AROUND THE INDIVIDUAL WIRES. (THE DIAGRAM ONLY SHOWS ONE WIRE FOR CLARITY)</p> <p><b>STEP 3 A</b> CUT &amp; DISCARD THE SHIELD FROM THIS END OF CABLE.  <b>B</b> USE STRIPPING PLIERS TO STRIP INSULATION 4.57MM (.18") FROM INDIVIDUAL WIRES.</p> <p><b>STEP 4 A</b> FOR CRIMP CONNECTORS:  <b>B</b> INSERT WIRES INTO THE CRIMP CONTACTS AND CRIMP.  <b>C</b> INSERT THE CRIMP CONTACTS INTO THE PLUG BODY, WITH USE OF GUIDE PINS, ACCORDING TO THE CONNECTION CHART.</p> <p><b>STEP 4 A</b> FOR SOLDER CONNECTORS:          INSERT WIRES INTO THE SOLDER CUPS AND SOLDER.</p>	<p><b>STEP 5</b> A POSITION THE 5/8" HEAT SHRINK TUBING AND APPLY HEAT TO SHRINK TUBING, AS SHOWN ON FOLLOWING SHEETS.          B SLIDE THE BACKSHELL ALONG THE CABLE TO PLUG BODY.          C HOLD PLUG BODY SECURELY AND SCREW BACKSHELL ONTO PLUG BODY,          D TIGHTEN CABLE CLAMP.          E POSITION THE 1/2" SHRINK TUBING AND APPLY HEAT TO SHRINK TUBING, AS SHOWN ON FOLLOWING SHEETS.</p> <p><b>STEP 6</b> PLACE LABEL IN APPROXIMATE LOCATION AS SHOWN ON FOLLOWING SHEETS.</p>	<p><b>NOTE:</b></p> <p>1. FOR CABLE ASSEMBLY GC-M1 or M2A-S/D-XX...SEE SHEET #3 OR 4          FOR CABLE ASSEMBLY GC-M2B or M4A-S/D-XX...SEE SHEET #5 OR 6          FOR CABLE ASSEMBLY GC-M6A-S/D-XX.....SEE SHEET #7 OR 8</p> <p style="text-align: center; border: 1px solid black; width: 20px; margin: 0 auto;">2</p>																																																																																					
CAD DWG																																																																																							
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2"></th> <th colspan="2">K</th> <th colspan="2">COPY CODE</th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> </tr> <tr> <th>ISS.</th> <th>ECN NO.</th> <th>DATE</th> <th>APP'D.</th> <th></th> <th></th> <th>ISS.</th> <th>ECN NO.</th> <th>DATE</th> <th>APP'D.</th> <th colspan="4" style="text-align: center;">Kollmorgen Industrial Drives</th> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <th colspan="4" style="text-align: center;">RADFORD, VIRGINIA</th> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <th colspan="4" style="text-align: center;">ASSEMBLY GUIDE FOR MOTOR CABLES</th> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <th>SCALE</th> <th>DWG. NO.</th> <th>SHEET 2 OF 8</th> <th>ISSUE</th> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>1:1</td> <td>A- 93981</td> <td></td> <td>3</td> </tr> </thead> </table>						K		COPY CODE										ISS.	ECN NO.	DATE	APP'D.			ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives														RADFORD, VIRGINIA														ASSEMBLY GUIDE FOR MOTOR CABLES														SCALE	DWG. NO.	SHEET 2 OF 8	ISSUE											1:1	A- 93981		3
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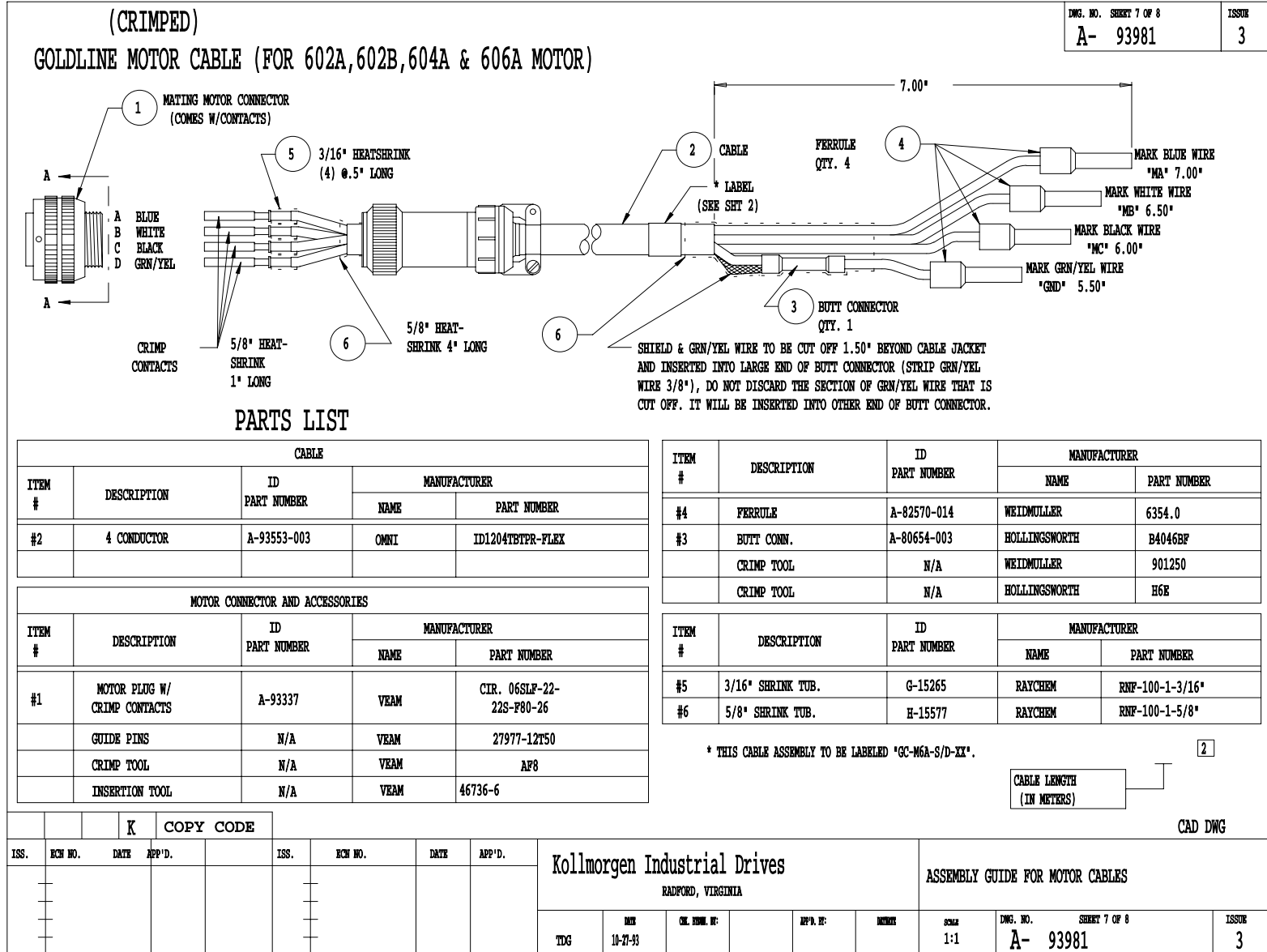


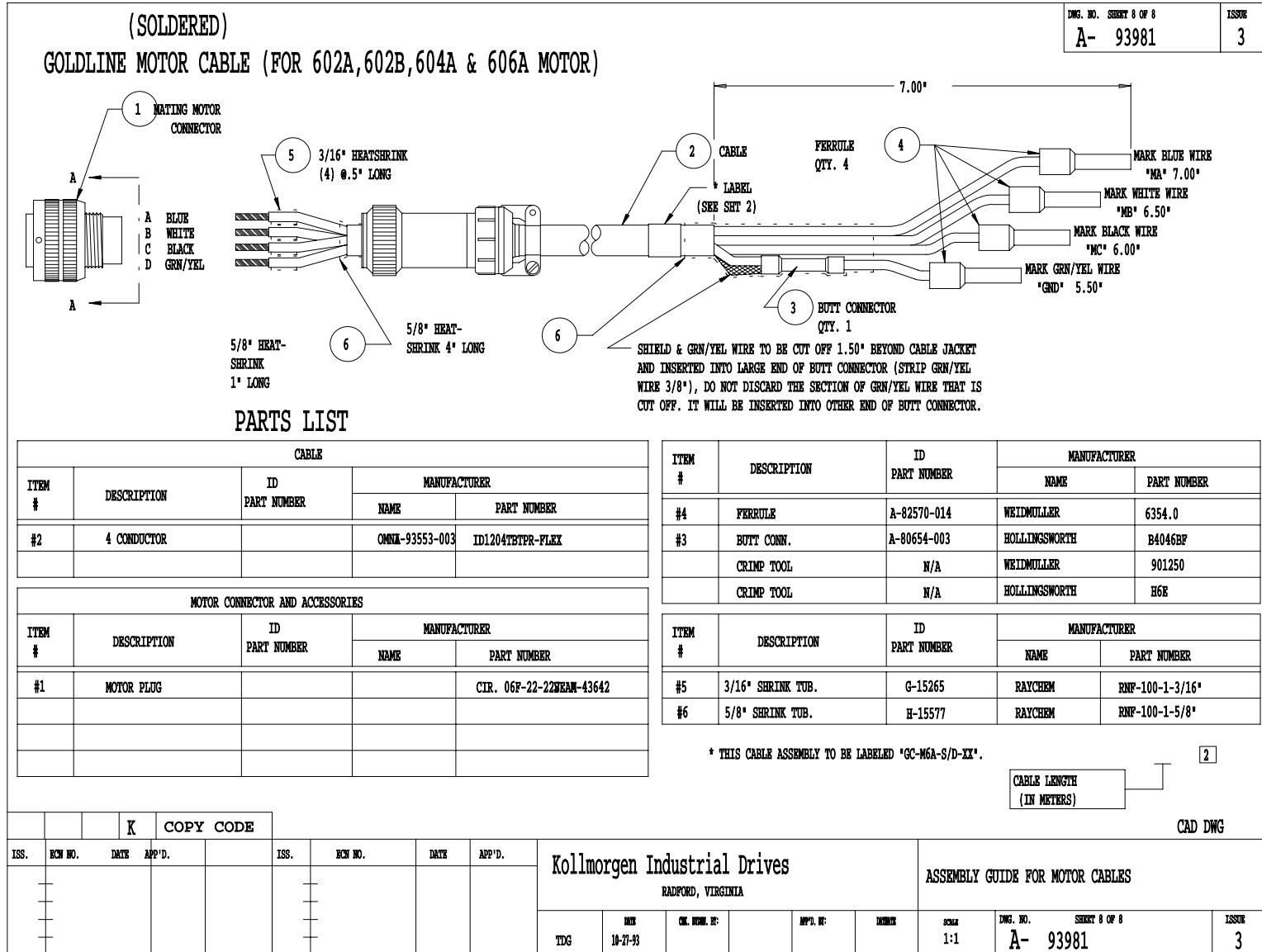


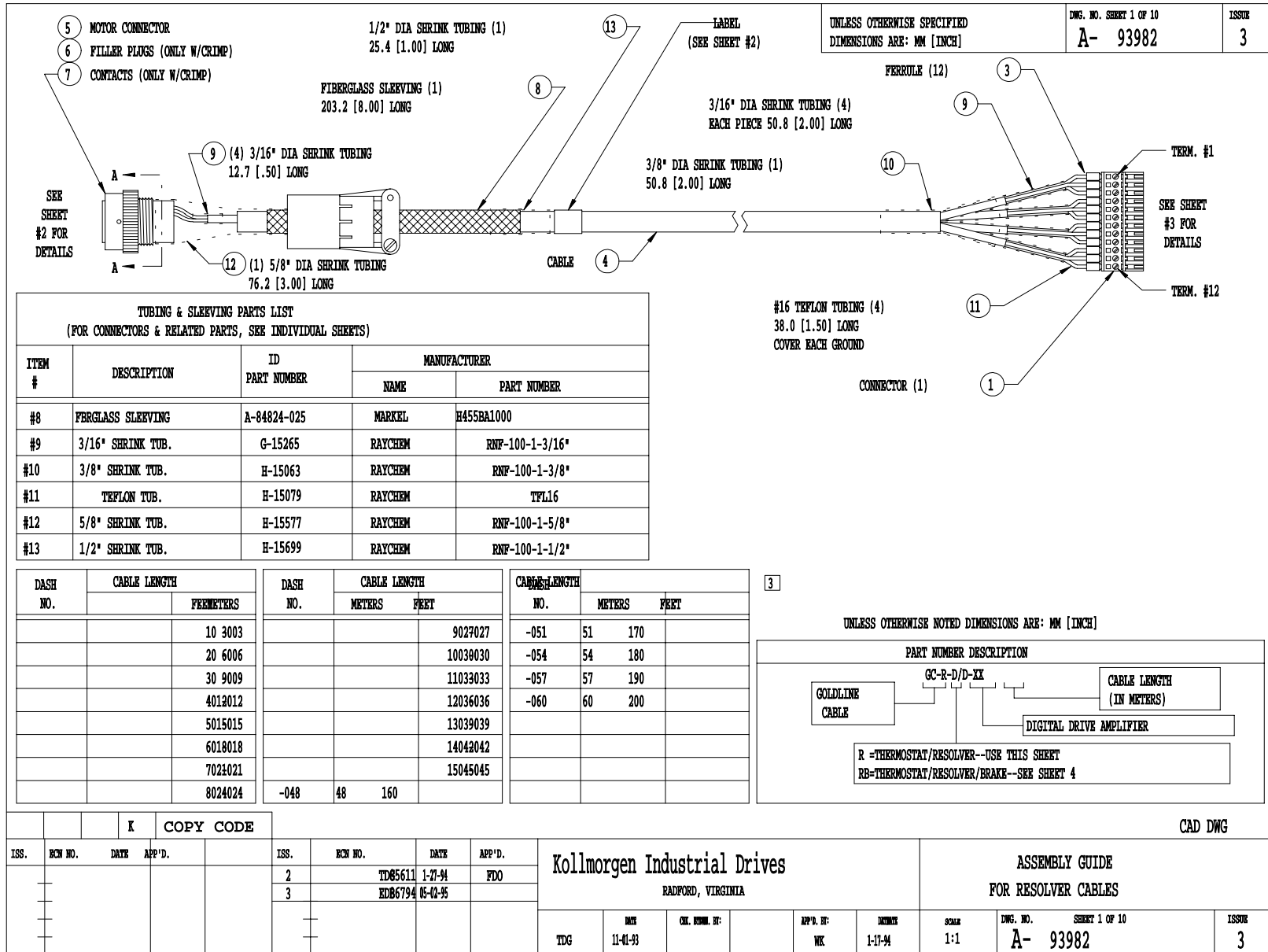


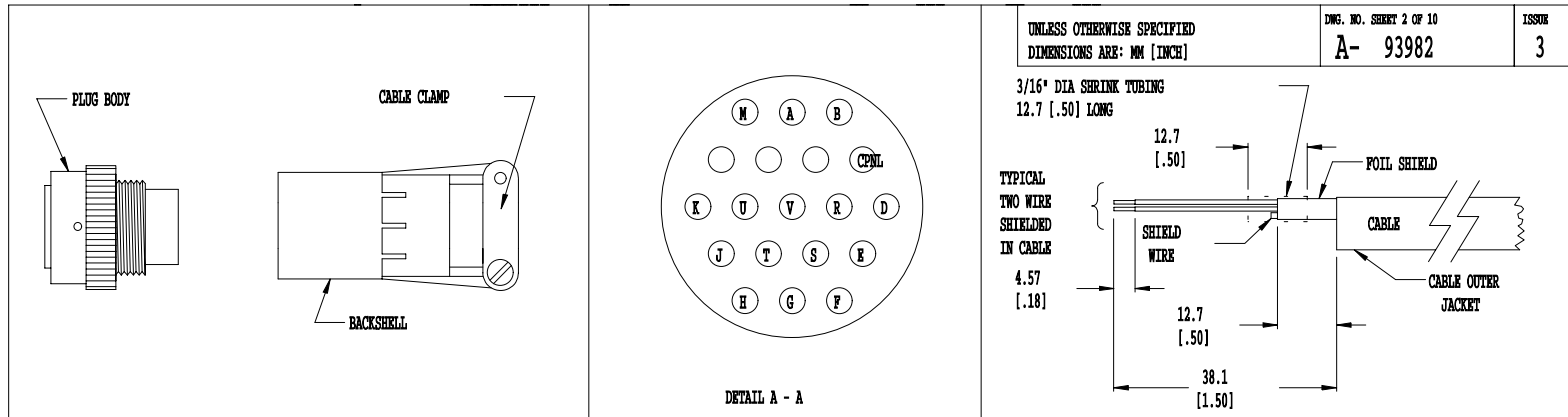












CONNECTOR ASSEMBLY PROCEDURE

STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE THE FOLLOWING ITEMS ONTO THE CABLE: 1/2" DIA SHRINK TUBING, FIBERGLASS SLEEVING, BACKSHELL AND 5/8" DIA SHRINK TUBING.

STEP 2 STRIP THE OUTER CABLE JACKET BACK 38.1 [1.50]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDED WIRES. (THE DIAGRAM ONLY SHOWS ONE SHIELDED PAIR FOR CLARITY)

STEP 3 A REMOVE THE FOIL SHIELD FROM THE WIRE.  
 B CUT THE SHIELD WIRE FUSH WITH THE FOIL SHIELD.  
 C PLACE HEATSHRINK OVER THE END OF THE FOIL SHIELD AND SHIELD WIRE TO KEEP THE SHIELDS FROM TOUCHING.  
 D USE STRIPPING PLIERS TO STRIP INSULATION 4.6 [.18] FROM INDIVIDUAL WIRES.

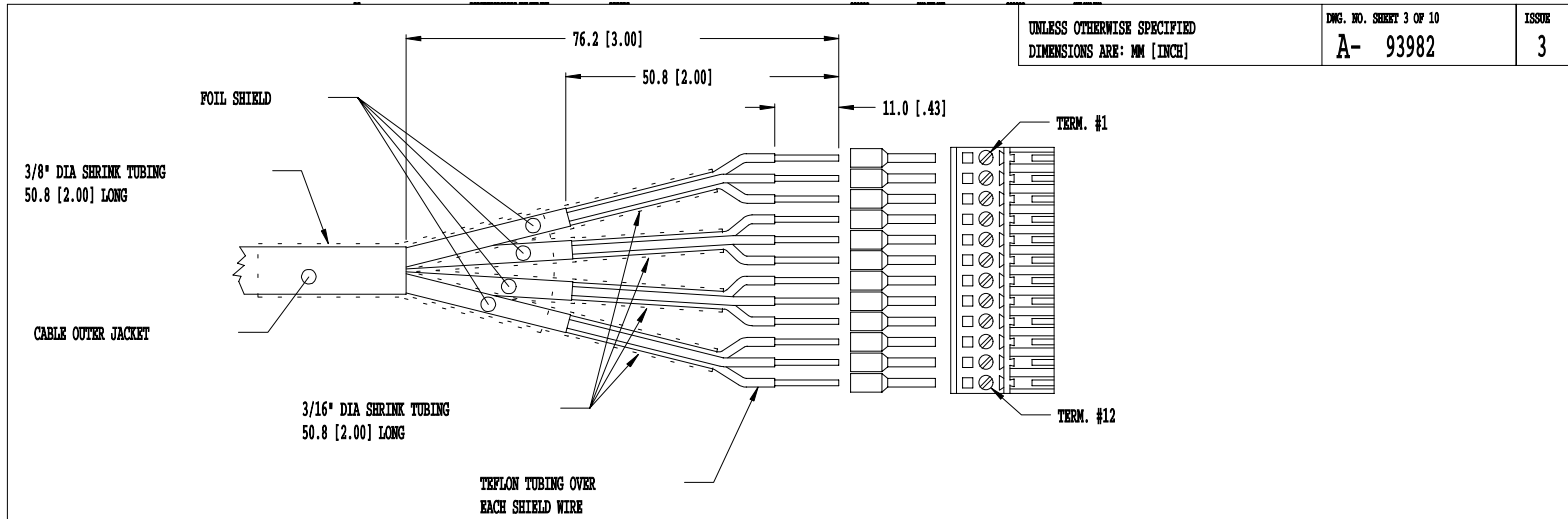
STEP 4 A FOR CRIMP CONNECTORS:  
 B INSERT FILLER PLOGS IN:M,L,K,J,H,G & V UNTIL THEY ARE FUSH WITH THE PLOG.  
 C INSERT WIRES INTO THE CRIMP CONTACTS AND CRIMP. INSERT THE CRIMP CONTACTS INTO THE PLOG BODY, WITH USE OF GUIDE PINS, ACCORDING TO THE CONNECTION CHART.

STEP 4 A FOR SOLDER CONTACTS:  
 INSERT THE WIRES INTO THE SOLDER CUPS AND SOLDER.  
 STEP 5 A POSITION THE 5/8" DIA HEAT SHRINK TUBING AND FIBERGLASS SLEEVING AS PICTURED ON SHEET #1. APPLY HEAT TO SHRINK TUBING.  
 B SLIDE THE BACKSHELL ALONG THE CABLE TO PLOG BODY.  
 C HOLD PLOG BODY SECURE AND SCREW BACKSHELL ONTO PLOG BODY.  
 D TIGHTEN CABLE CLAMP.  
 E POSITION THE 1/2" DIA SHRINK TUBING AS PICTURED ON SHEET #1. APPLY HEAT TO SHRINK TUBING.

STEP 6 PLACE LABEL IN APPROXIMATE LOCATION AS SHOWN ON SHEET #1. REFER TO NOTE BELOW CONNECTION CHART, SAME AS USED IN STEP 4 A, FOR CORRECT LABEL MARKING.

NOTE:  
 1. FOR CABLE ASSEMBLY GC-R-D/D-XX ....SEE SHEET #7 OR 8

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												DRG. NO. TDG CK. DATE 11-01-93 REV. NO. REV. DATE	SCALE 1:1	DWG. NO. A- 93982	SHEET 2 OF 10 3



UNLESS OTHERWISE SPECIFIED  
DIMENSIONS ARE: MM [INCH]

DWG. NO. SHEET 3 OF 10  
**A- 93982**

ISSUE  
**3**

**CONNECTOR ASSEMBLY PROCEDURE**

STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE A SECTION OF 3/8" DIA HEAT SHRINK TUBING ONTO THE CABLE.

STEP 2 STRIP THE CABLE OUTER JACKET BACK, 381 [15.0]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDS.

STEP 3 ACCORDING TO THE CONNECTION CHART, SELECT ONE OF THE WIRE PAIRS AND COMPLETE THE FOLLOWING OPERATIONS. SEE NOTE #1.

- A REMOVE THE FOIL SHIELD FROM THE WIRE.
- B COVER SHIELD WIRE WITH TEFLON TUBING.
- C COVER THE THREE LEADS WITH HEAT SHRINK.
- D USE STRIPPING PLIERS TO STRIP INSULATION FROM INDIVIDUAL WIRES, 11.0 [.43].
- E CRIMP FERRULES ONTO EACH OF THE THREE WIRES.
- F INSERT WIRES INTO 12 POSITION CONNECTOR.

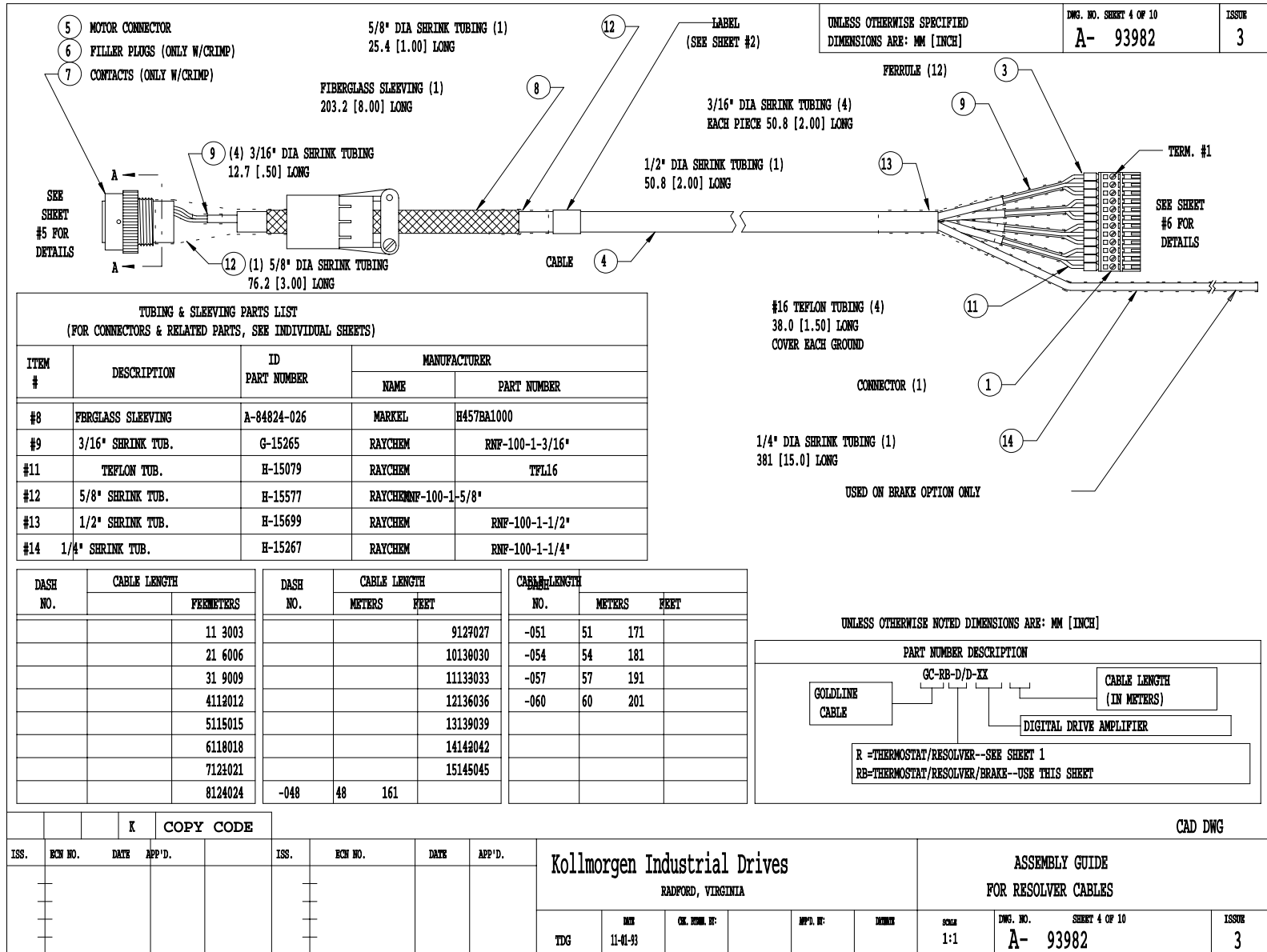
STEP 4 PERFORM STEP 3 FOR EACH REMAINING PAIRS.

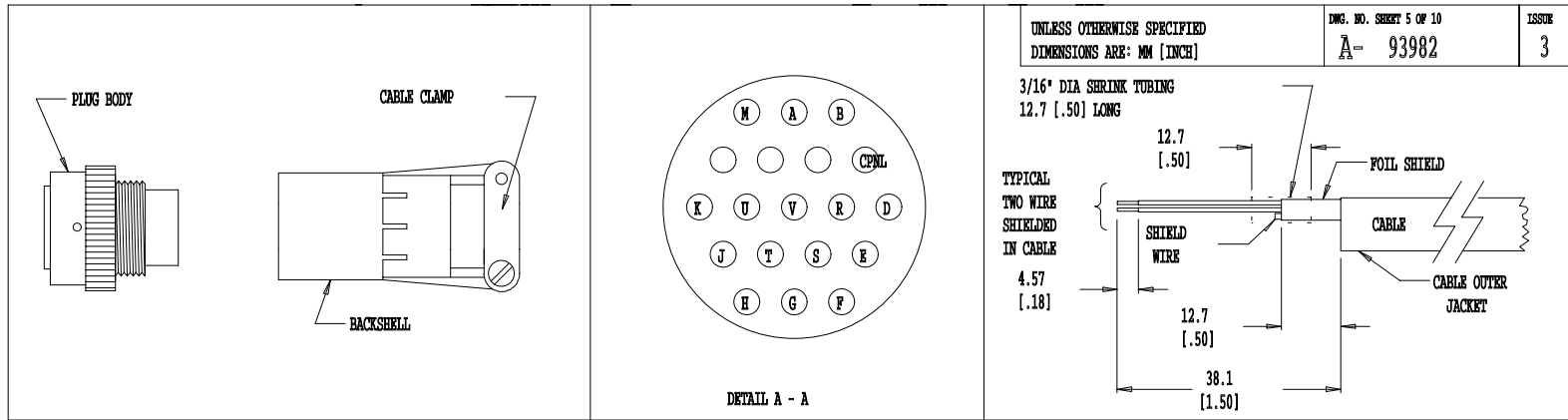
STEP 5 SLIDE THE HEATSHRINK TUBING, FROM STEP #1, ONTO THE END OF THE CABLE AND SHRINK, AS SHOWN ABOVE.

**NOTE:**

- 1. FOR CABLE ASSEMBLY GC-R-D/D-XX .....SEE SHEET #7 OR 8

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TDG		11-01-93						1:1		A- 93982		3			





CONNECTOR ASSEMBLY PROCEDURE

STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE THE FOLLOWING ITEMS ONTO THE CABLE: 5/8" DIA X 76.2 [3.00] LONG SHRINK TUBING, FIBERGLASS SLEEVING, BACKSHELL AND 5/8" DIA X 25.4 [1.00] LONG SHRINK TUBING.

STEP 2 STRIP THE OUTER CABLE JACKET BACK 38.1 [1.50]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDED WIRES. (THE DIAGRAM ONLY SHOWS ONE SHIELDED PAIR FOR CLARITY)

STEP 3 A REMOVE THE FOIL SHIELD FROM THE WIRE.  
 B CUT THE SHIELD WIRE FLUSH WITH THE FOIL SHIELD.  
 C PLACE HEATSHRINK OVER THE END OF THE FOIL SHIELD AND SHIELD WIRE TO KEEP THE SHIELDS FROM TOUCHING.  
 D USE STRIPPING PLIERS TO STRIP INSULATION 4.6 [.18] FROM INDIVIDUAL WIRES.

STEP 4 A FOR CRIMP CONNECTORS:  
 B INSERT FILLER PLUGS IN M,L,K,J,H,G & V UNTILL THEY ARE FLUSH WITH THE PLUG.  
 C INSERT WIRES INTO THE CRIMP CONTACTS AND CRIMP. INSERT THE CRIMP CONTACTS INTO THE PLUG BODY, WITH USE OF GUIDE PINS, ACCORDING TO THE CONNECTION CHART.

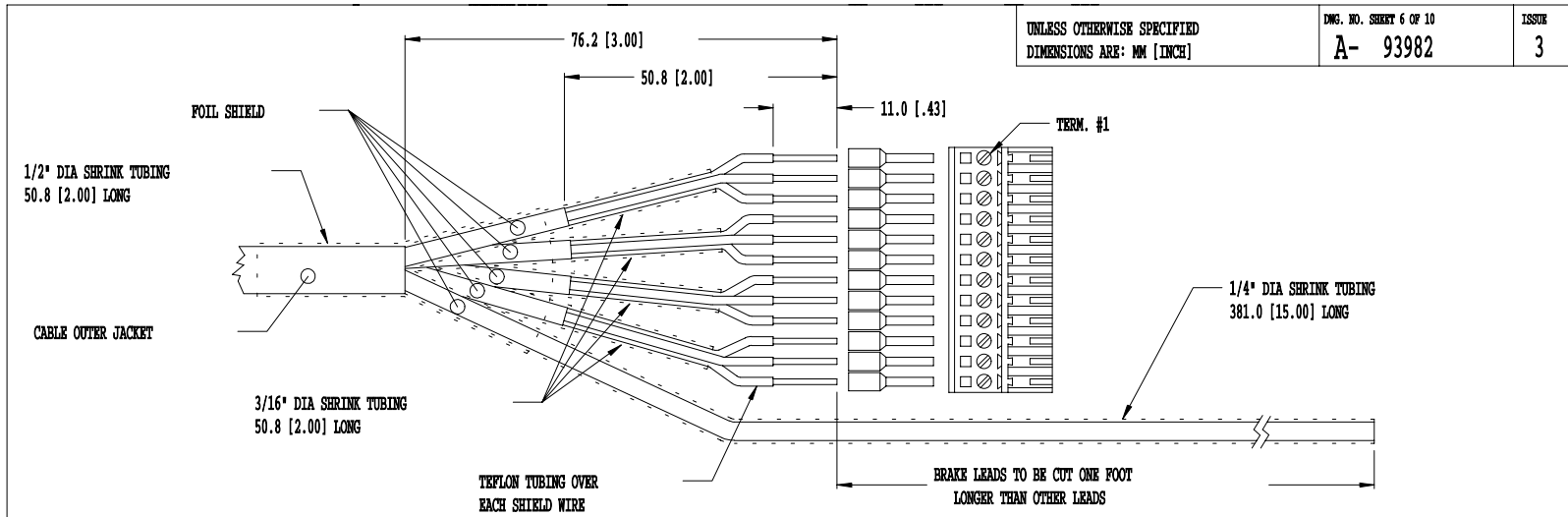
STEP 4 A FOR SOLDER CONTACTS:  
 INSERT THE WIRES INTO THE SOLDER CUPS AND SOLDER.

STEP 5 A POSITION THE 5/8" DIA X 76.2 [3.00] LONG HEAT SHRINK TUBING AND FIBERGLASS SLEEVING AS PICTURED ON SHEET #4. APPLY HEAT TO SHRINK TUBING.  
 B SLIDE THE BACKSHELL ALONG THE CABLE TO PLUG BODY.  
 C HOLD PLUG BODY SECURE AND SCREW BACKSHELL ONTO PLUG BODY.  
 D TIGHTEN CABLE CLAMP.  
 E POSITION THE 5/8" DIA X 25.4 [1.00] LONG SHRINK TUBING AS PICTURED ON SHEET #4. APPLY HEAT TO SHRINK TUBING.

STEP 6 PLACE LABEL IN APPROXIMATE LOCATION AS SHOWN ON SHEET #4. REFER TO NOTE BELOW CONNECTION CHART, SAME AS USED IN STEP 4 A, FOR CORRECT LABEL MARKING.

NOTE: FOR CABLE ASSEMBLY GC-RB-D/D-XX ....SEE SHEET #9 OR 10

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												DWG. NO. 93982 SCALE 1:1	SHEET 5 OF 10 A- 3



CONNECTOR ASSEMBLY PROCEDURE

- STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE A SECTION OF 1/2" DIA HEAT SHRINK TUBING ONTO THE CABLE.
- STEP 2 STRIP THE CABLE OUTER JACKET BACK, 381 [15.0]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDS.
- STEP 3 ACCORDING TO THE CONNECTION CHART, SELECT ONE OF THE WIRE PAIRS AND COMPLETE THE FOLLOWING OPERATIONS. SEE NOTE #1.
  - A REMOVE THE FOIL SHIELD FROM THE WIRE.
  - B COVER SHIELD WIRE WITH TEFLON TUBING.
  - C COVER THE THREE LEADS WITH HEAT SHRINK.
  - D USE STRIPPING PLIERS TO STRIP INSULATION FROM INDIVIDUAL WIRES, 11.0 [.43].
  - E CRIMP FERRULES ONTO EACH OF THE THREE WIRES.
  - F INSERT WIRES INTO 12 POSITION CONNECTOR.

- STEP 4 PERFORM STEP 3 FOR EACH REMAINING PAIRS.
- STEP 5 SLIDE THE HEATSHRINK TUBING, FROM STEP #1, ONTO THE END OF THE CABLE AND SHRINK, AS SHOWN ABOVE.

NOTE:  
1. FOR CABLE ASSEMBLY GC-RB-D/D-XX ....SEE SHEET #9 OR 10

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ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives				ASSEMBLY GUIDE			
								RADFORD, VIRGINIA				FOR RESOLVER CABLES			
								DWG. NO.	OK. DATE	ISS.	ISSUE NO.	SCALE	DWG. NO.	SHEET 6 OF 10	ISSUE
								TDG	11-01-93			1:1	A- 93982	3	





(W/SOLDERED MOTOR CONNECTOR)  
 GOLDLINE RESOLVER CABLE WITH THERMOSTAT (GC-R-D/D-XX)

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE: MM [INCH]	DWG. NO. SHEET 8 OF 10 A- 93982	ISSUE 3
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PARTS LIST

CABLE				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#4	4 PAIR	A-81948	BELDEN	8725
MOTOR CONNECTOR AND ACCESSORIES				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#5	MATING PLUG	A-42867-1419	SCOURIAU	851-06EC14-19S50
DIGITAL DRIVE CONNECTOR C2 AND ACCESSORIES				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#1	12 POS. CONNECTOR	A-93899-012	WEIDMULLER	161573
#3	FERRULE	A-82570-004		4629.WEIDMULLER
	CRIMP TOOL	N/A		90125WEIDMULLER

CONNECTION CHART

MOTOR CONNECTION ITEM #5	* CABLE ITEM #4	DD CONNECTOR C2 ITEM #1
TERMINAL A	RED	TERMINAL 4
TERMINAL B	BLACK	TERMINAL 5
N/C	SHIELD	TERMINAL 6
TERMINAL C	WHT/YEL	TERMINAL 8
TERMINAL D	WHT/GRN	TERMINAL 7
N/C	SHIELD	TERMINAL 9
TERMINAL E	WHT/RED	TERMINAL 2
TERMINAL F	WHT/BLK	TERMINAL 1
N/C	SHIELD	TERMINAL 3
TERMINAL N		
TERMINAL P		N/C
TERMINAL R		
TERMINAL S		N/C
TERMINAL T	GREEN	TERMINAL 10
TERMINAL U	WHITE	TERMINAL 11
N/C	SHIELD	TERMINAL 12

SEE SHEET 2 AND 3 FOR CONNECTOR DETAILS.  
 \* THIS CABLE ASSEMBLY TO BE LABELED \*GC-R-D/D-XX\*.

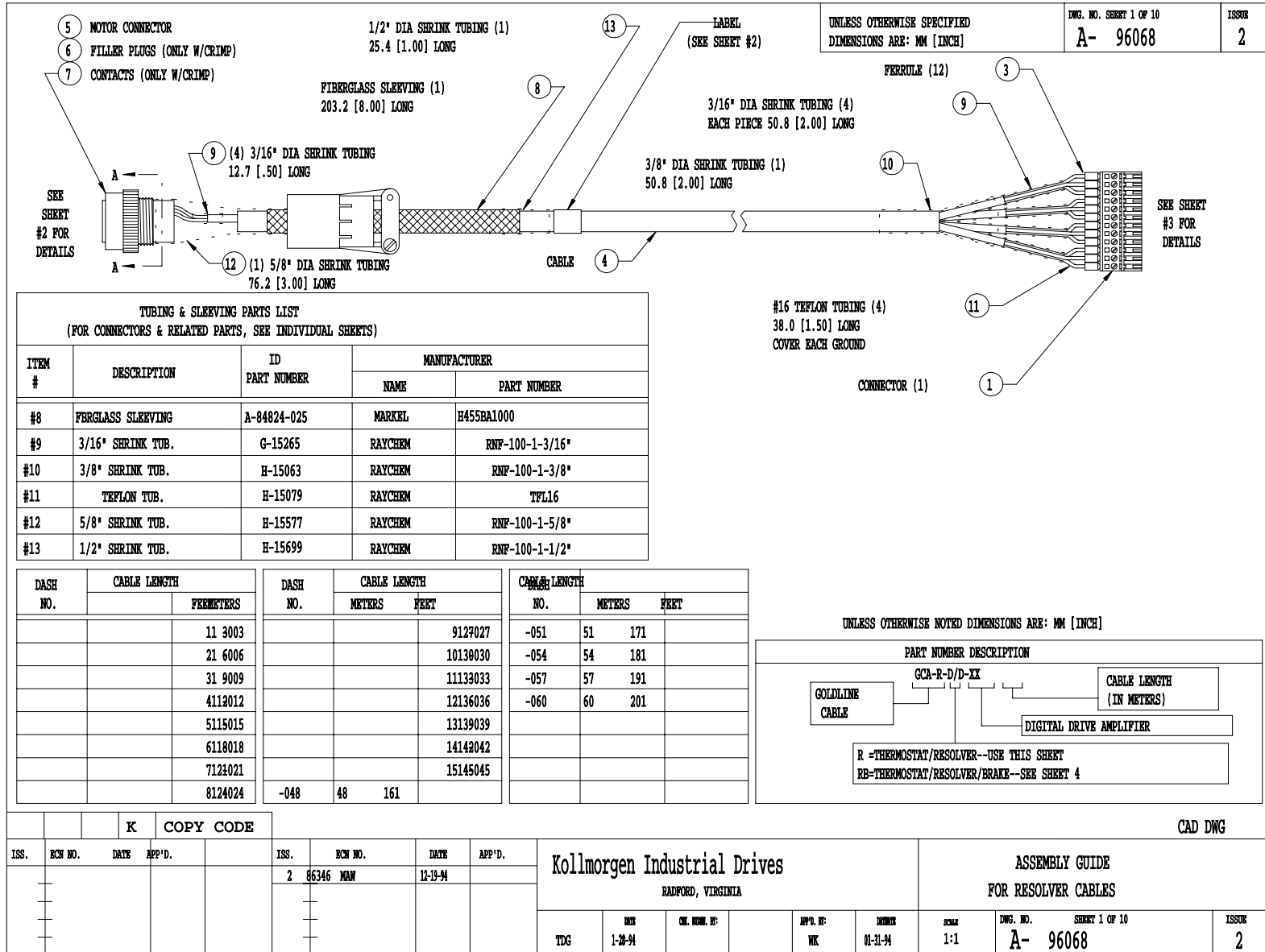


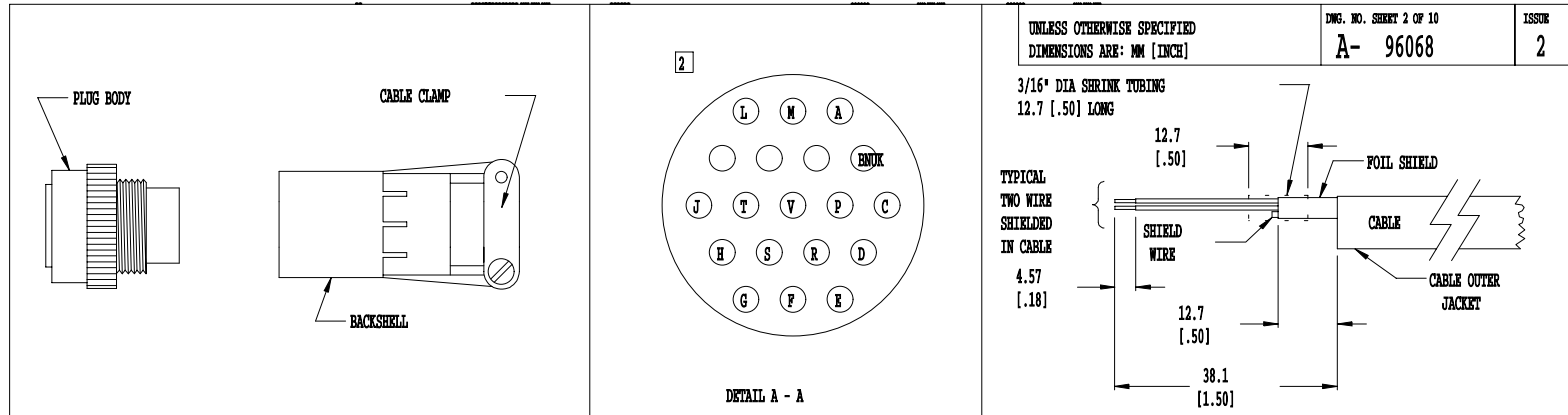
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DWG. NO.		CHK. DATE		REV.		ISSUED. NO.		SCALE		DWG. NO.		SHEET 8 OF 10		ISSUE		1:1      A- 93982      3							



(W/SOLDERED MOTOR CONNECTOR) GOLDLINE RESOLVER CABLE WITH THERMOSTAT AND BRAKE (GC-RB-D/D-XX)										UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE: MM [INCH]	DWG. NO. SHEET 10 OF 10 <b>A- 93982</b>	ISSUE <b>3</b>																																																						
PARTS LIST					CONNECTION CHART																																																													
CABLE										<table border="1" style="width:100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>MOTOR CONNECTION ITEM #5</th> <th>* CABLE ITEM #4</th> <th>DD CONNECTOR C2 ITEM #1</th> </tr> <tr> <td>TERMINAL A</td> <td>RED 1</td> <td>TERMINAL 4</td> </tr> <tr> <td>TERMINAL B</td> <td></td> <td>TERMINAL BLK 1</td> </tr> <tr> <td>N/C</td> <td></td> <td>TERMINAL SHIELD</td> </tr> <tr> <td>TERMINAL C</td> <td></td> <td>TERMINAL RED 2</td> </tr> <tr> <td>TERMINAL D</td> <td></td> <td>TERMINAL BLK 2</td> </tr> <tr> <td>N/C</td> <td></td> <td>TERMINAL SHIELD</td> </tr> <tr> <td>TERMINAL E</td> <td></td> <td>TERMINAL RED 3</td> </tr> <tr> <td>TERMINAL F</td> <td></td> <td>TERMINAL BLK 3</td> </tr> <tr> <td>N/C</td> <td></td> <td>TERMINAL SHIELD</td> </tr> <tr> <td>TERMINAL N</td> <td>RED 4</td> <td rowspan="2">CUSTOMER BRAKE HOOK-UP</td> </tr> <tr> <td>TERMINAL P</td> <td>BLK 4</td> </tr> <tr> <td>N/C</td> <td>SHIELD</td> <td></td> </tr> <tr> <td>TERMINAL R</td> <td rowspan="2">SEE NOTE #1</td> <td></td> </tr> <tr> <td>TERMINAL S</td> <td>N/C</td> </tr> <tr> <td>TERMINAL T</td> <td>RED 6</td> <td>TERMINAL 10</td> </tr> <tr> <td>TERMINAL U</td> <td>BLK 6</td> <td>TERMINAL 11</td> </tr> <tr> <td>N/C</td> <td>SHIELD</td> <td>TERMINAL 12</td> </tr> </table>					MOTOR CONNECTION ITEM #5	* CABLE ITEM #4	DD CONNECTOR C2 ITEM #1	TERMINAL A	RED 1	TERMINAL 4	TERMINAL B		TERMINAL BLK 1	N/C		TERMINAL SHIELD	TERMINAL C		TERMINAL RED 2	TERMINAL D		TERMINAL BLK 2	N/C		TERMINAL SHIELD	TERMINAL E		TERMINAL RED 3	TERMINAL F		TERMINAL BLK 3	N/C		TERMINAL SHIELD	TERMINAL N	RED 4	CUSTOMER BRAKE HOOK-UP	TERMINAL P	BLK 4	N/C	SHIELD		TERMINAL R	SEE NOTE #1		TERMINAL S	N/C	TERMINAL T	RED 6	TERMINAL 10	TERMINAL U	BLK 6	TERMINAL 11	N/C	SHIELD	TERMINAL 12
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MOTOR CONNECTOR AND ACCESSORIES																																																																		
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#1	12 POS. CONNECTOR	A-93899-012	WEIDMULLER	161573																																																														
#3	FERRULE	A-82570-002	WEIDMULLER	6907.0																																																														
	CRIMP TOOL	N/A	WEIDMULLER	901250																																																														
NOTE:										SEE SHEET 5 AND 6 FOR CONNECTOR DETAILS. * THIS CABLE ASSEMBLY TO BE LABELED *GC-RB-D/D-XX*.																																																								
										CAD DWG																																																								
Kollmorgen Industrial Drives RADFORD, VIRGINIA										ASSEMBLY GUIDE FOR RESOLVER CABLES																																																								
DWG. NO. TDG    CK. DATE 11-01-93    REV. NO.    REV. NO.										SIZE 1:1    DWG. NO. <b>A- 93982</b> SHEET 10 OF 10    ISSUE <b>3</b>																																																								





UNLESS OTHERWISE SPECIFIED  
DIMENSIONS ARE: MM [INCH]

DWG. NO. SHEET 2 OF 10  
**A- 96068**

ISSUE  
**2**

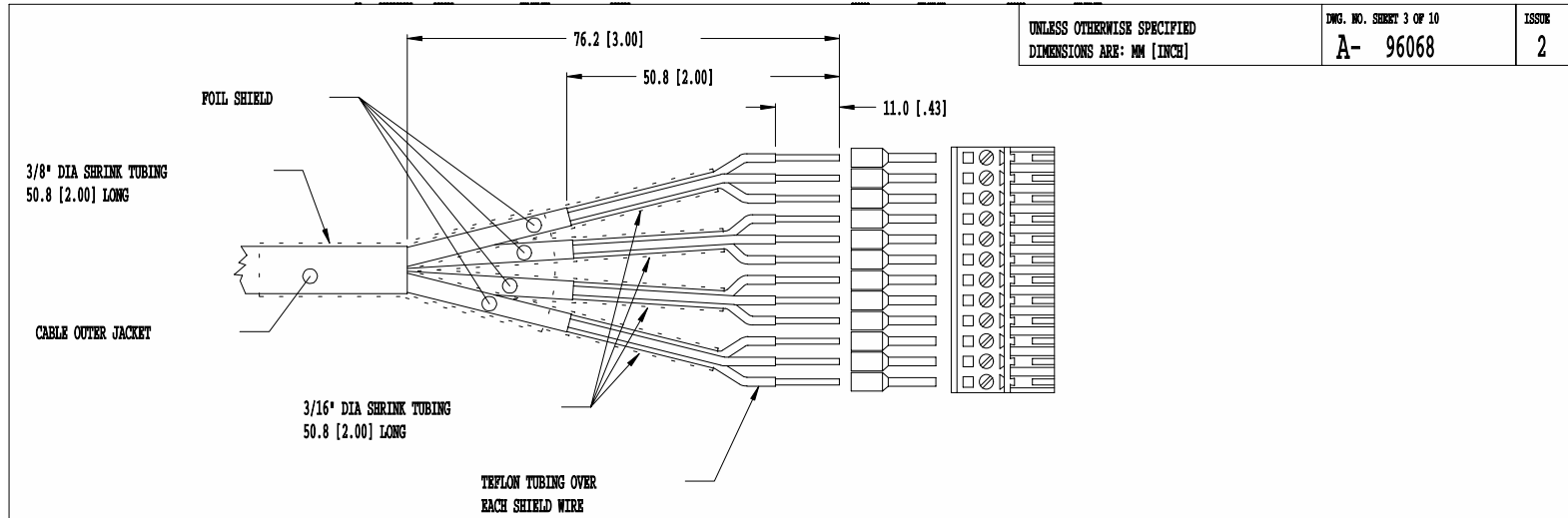
**CONNECTOR ASSEMBLY PROCEDURE**

- STEP 1** BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE THE FOLLOWING ITEMS ONTO THE CABLE: 1/2" DIA SHRINK TUBING, FIBERGLASS SLEEVING, BACKSHELL AND 5/8" DIA SHRINK TUBING.
- STEP 2** STRIP THE OUTER CABLE JACKET BACK 38.1 [1.50]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDED WIRES. (THE DIAGRAM ONLY SHOWS ONE SHIELDED PAIR FOR CLARITY)
- STEP 3 A** REMOVE THE FOIL SHIELD FROM THE WIRE.  
**B** CUT THE SHIELD WIRE FLUSH WITH THE FOIL SHIELD.  
**C** PLACE HEATSHRINK OVER THE END OF THE FOIL SHIELD AND SHIELD WIRE TO KEEP THE SHIELDS FROM TOUCHING.  
**D** USE STRIPPING PLIERS TO STRIP INSULATION 4.6 [.18] FROM INDIVIDUAL WIRES.
- STEP 4 A** FOR CRIMP CONNECTORS:  
**B** INSERT FILLER PLOGS IN: M, L, K, J, H, G & V UNTIL THEY ARE FLUSH WITH THE PLOG.  
**C** INSERT WIRES INTO THE CRIMP CONTACTS AND CRIMP. INSERT THE CRIMP CONTACTS INTO THE PLOG BODY, WITH USE OF GUIDE PINS, ACCORDING TO THE CONNECTION CHART.

- STEP 4 A** FOR SOLDER CONTACTS:  
 INSERT THE WIRES INTO THE SOLDER CUPS AND SOLDER.
- STEP 5 A** POSITION THE 5/8" DIA HEAT SHRINK TUBING AND FIBERGLASS SLEEVING AS PICTURED ON SHEET #1. APPLY HEAT TO SHRINK TUBING.  
**B** SLIDE THE BACKSHELL ALONG THE CABLE TO PLOG BODY.  
**C** HOLD PLOG BODY SECURE AND SCREW BACKSHELL ONTO PLOG BODY.  
**D** TIGHTEN CABLE CLAMP.  
**E** POSITION THE 1/2" DIA SHRINK TUBING AS PICTURED ON SHEET #1. APPLY HEAT TO SHRINK TUBING.
- STEP 6** PLACE LABEL IN APPROXIMATE LOCATION AS SHOWN ON SHEET #1. REFER TO NOTE BELOW CONNECTION CHART, SAME AS USED IN STEP 4 A, FOR CORRECT LABEL MARKING.

**NOTE:**  
 1. FOR CABLE ASSEMBLY GCA-R-D/D-XX .....SEE SHEET #7 OR 8

				K	COPY CODE				CAD DWG				
ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives RADFORD, VIRGINIA				ASSEMBLY GUIDE FOR RESOLVER CABLES	
												DWG. NO.	SHEET 2 OF 10
								SCALE	DWG. NO.	SHEET 2 OF 10	ISSUE		
								1:1	<b>A- 96068</b>		<b>2</b>		



CONNECTOR ASSEMBLY PROCEDURE

STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE A SECTION OF 3/8" DIA HEAT SHRINK TUBING ONTO THE CABLE.

STEP 2 STRIP THE CABLE OUTER JACKET BACK, 381 [15.0]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDS.

STEP 3 ACCORDING TO THE CONNECTION CHART, SELECT ONE OF THE WIRE PAIRS AND COMPLETE THE FOLLOWING OPERATIONS. SEE NOTE #1.

- A REMOVE THE FOIL SHIELD FROM THE WIRE.
- B COVER SHIELD WIRE WITH TEFLON TUBING.
- C COVER THE THREE LEADS WITH HEAT SHRINK.
- D USE STRIPPING PLIERS TO STRIP INSULATION FROM INDIVIDUAL WIRES, 11.0 [.43].
- E CRIMP FERRULES ONTO EACH OF THE THREE WIRES.
- F INSERT WIRES INTO 12 POSITION CONNECTOR.

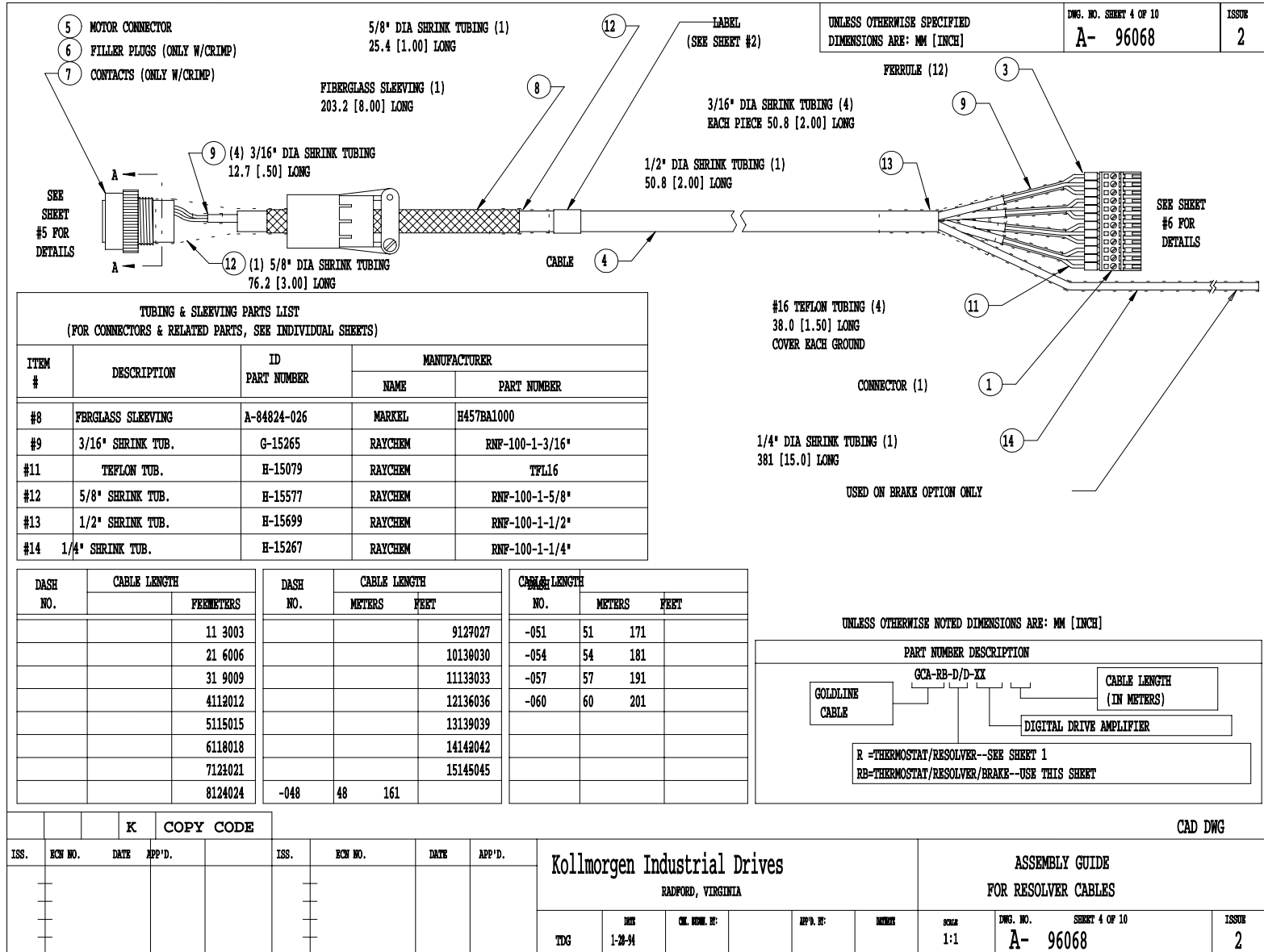
STEP 4 PERFORM STEP 3 FOR EACH REMAINING PAIRS.

STEP 5 SLIDE THE HEATSHRINK TUBING, FROM STEP #1, ONTO THE END OF THE CABLE AND SHRINK, AS SHOWN ABOVE.

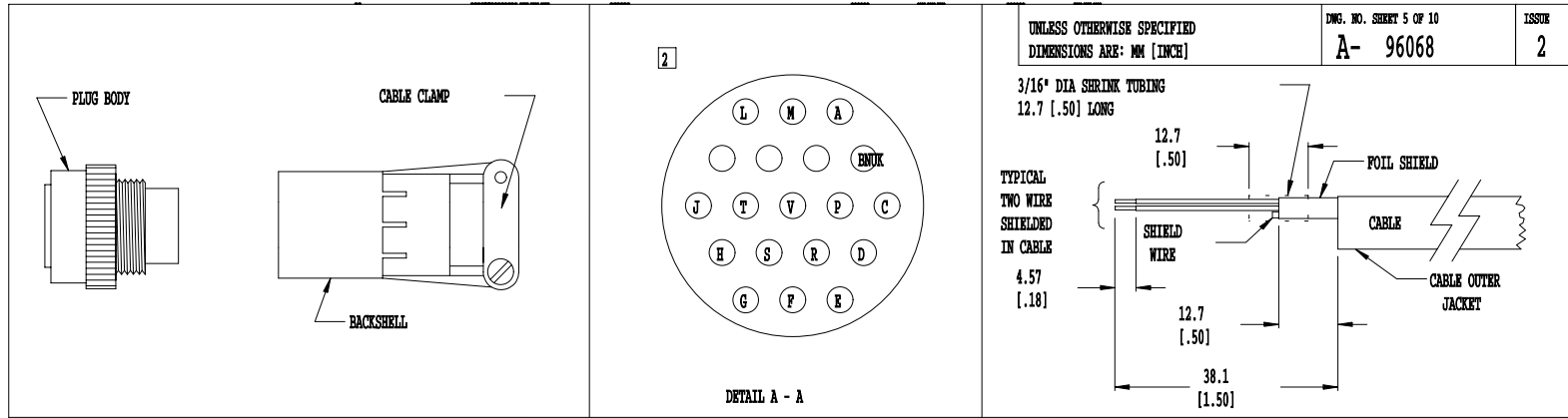
NOTE:

- 1. FOR CABLE ASSEMBLY GCA-R-D/D-XX .....SEE SHEET #7 OR 8

				K COPY CODE								CAD DWG			
ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives				ASSEMBLY GUIDE			
								RADFORD, VIRGINIA				FOR RESOLVER CABLES			
								DWG. NO.	CHK. REVISE	DATE	ISSUE NO.	SCALE	DWG. NO.	SHEET 3 OF 10	ISSUE
								A- 96068	1-20-94			1:1	A- 96068	3 OF 10	2







CONNECTOR ASSEMBLY PROCEDURE

STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE THE FOLLOWING ITEMS ONTO THE CABLE: 5/8" DIA X 76.2 [3.00] LONG SHRINK TUBING, FIBERGLASS SLEEVING, BACKSHELL AND 5/8" DIA X 25.4 [1.00] LONG SHRINK TUBING.

STEP 2 STRIP THE OUTER CABLE JACKET BACK 38.1 [1.50]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDED WIRES. (THE DIAGRAM ONLY SHOWS ONE SHIELDED PAIR FOR CLARITY)

STEP 3 A REMOVE THE FOIL SHIELD FROM THE WIRE.  
 B CUT THE SHIELD WIRE FLUSH WITH THE FOIL SHIELD.  
 C PLACE HEATSHRINK OVER THE END OF THE FOIL SHIELD AND SHIELD WIRE TO KEEP THE SHIELDS FROM TOUCHING.  
 D USE STRIPPING PLIERS TO STRIP INSULATION 4.6 [.18] FROM INDIVIDUAL WIRES.

STEP 4 A FOR CRIMP CONNECTORS:  
 B INSERT FILLER PLUGS IN:M,L,K,J,H,G & V UNTIL THEY ARE FLUSH WITH THE PLUG.  
 C INSERT WIRES INTO THE CRIMP CONTACTS AND CRIMP. INSERT THE CRIMP CONTACTS INTO THE PLUG BODY, WITH USE OF GUIDE PINS, ACCORDING TO THE CONNECTION CHART.

STEP 4 A FOR SOLDER CONTACTS:  
 INSERT THE WIRES INTO THE SOLDER CUPS AND SOLDER.

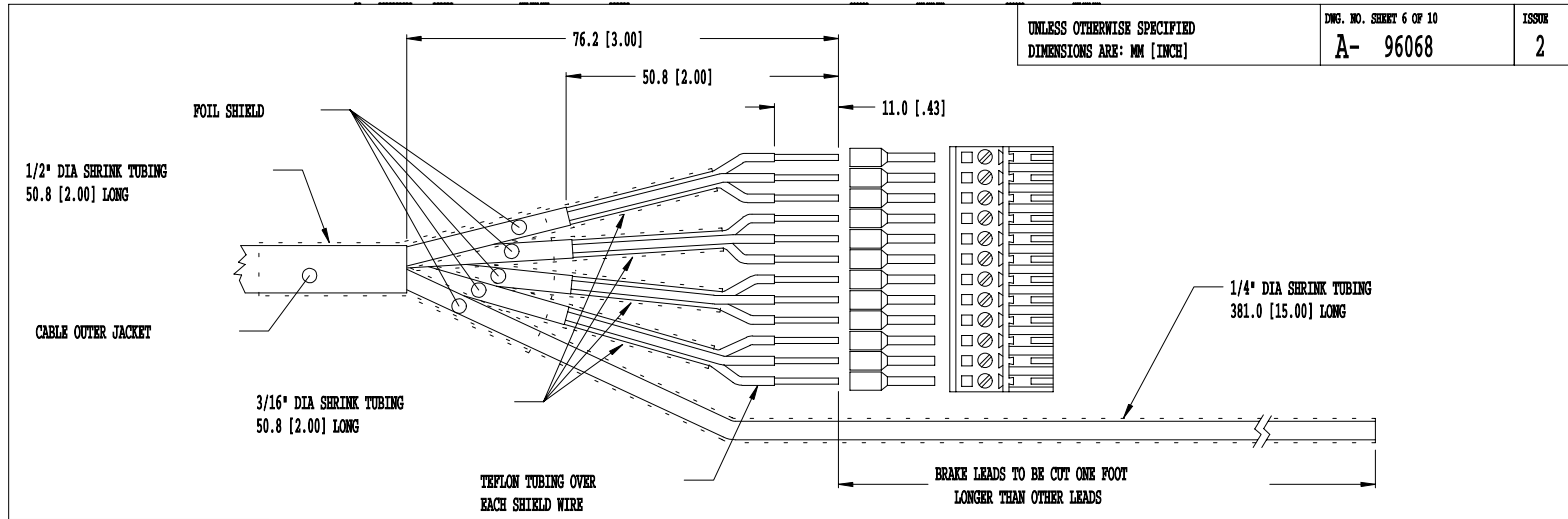
STEP 5 A POSITION THE 5/8" DIA X 76.2 [3.00] LONG HEAT SHRINK TUBING AND FIBERGLASS SLEEVING AS PICTURED ON SHEET #4. APPLY HEAT TO SHRINK TUBING.

B SLIDE THE BACKSHELL ALONG THE CABLE TO PLUG BODY.  
 C HOLD PLUG BODY SECURE AND SCREW BACKSHELL ONTO PLUG BODY.  
 D TIGHTEN CABLE CLAMP.  
 E POSITION THE 5/8" DIA X 25.4 [1.00] LONG SHRINK TUBING AS PICTURED ON SHEET #4. APPLY HEAT TO SHRINK TUBING.

STEP 6 PLACE LABEL IN APPROXIMATE LOCATION AS SHOWN ON SHEET #4. REFER TO NOTE BELOW CONNECTION CHART, SAME AS USED IN STEP 4 A, FOR CORRECT LABEL MARKING.

NOTE: FOR CABLE ASSEMBLY GCA-RB-D/D-XX ...SEE SHEET #9 OR 10

				K COPY CODE				CAD DWG						
ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives RADFORD, VIRGINIA				ASSEMBLY GUIDE FOR RESOLVER CABLES		
												DWG. NO. SHEET 5 OF 10 A- 96068	SCALE 1:1	ISSUE 2



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE: MM [INCH]	DWG. NO. SHEET 6 OF 10 A- 96068	ISSUE 2
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**CONNECTOR ASSEMBLY PROCEDURE**

STEP 1 BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE A SECTION OF 1/2" DIA HEAT SHRINK TUBING ONTO THE CABLE.

STEP 2 STRIP THE CABLE OUTER JACKET BACK, 381 [15.0]. THIS WILL EXPOSE THE INDIVIDUAL FOIL SHIELDS.

STEP 3 ACCORDING TO THE CONNECTION CHART, SELECT ONE OF THE WIRE PAIRS AND COMPLETE THE FOLLOWING OPERATIONS. SEE NOTE #1.

- A REMOVE THE FOIL SHIELD FROM THE WIRE.
- B COVER SHIELD WIRE WITH TEFLON TUBING.
- C COVER THE THREE LEADS WITH HEAT SHRINK.
- D USE STRIPPING PLIERS TO STRIP INSULATION FROM INDIVIDUAL WIRES, 11.0 [.43].
- E CRIMP FERRULES ONTO EACH OF THE THREE WIRES.
- F INSERT WIRES INTO 12 POSITION CONNECTOR.

STEP 4 PERFORM STEP 3 FOR EACH REMAINING PAIRS.

STEP 5 SLIDE THE HEATSHRINK TUBING, FROM STEP #1, ONTO THE END OF THE CABLE AND SHRINK, AS SHOWN ABOVE.

**NOTE:**

- 1. FOR CABLE ASSEMBLY GCA-RE-D/D-XX ...SEE SHEET #9 OR 10

K COPY CODE								CAD DWG							
ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives RADFORD, VIRGINIA							
								ASSEMBLY GUIDE FOR RESOLVER CABLES							
								DR. BY TDG	CHK. BY 1-28-94	DATE	ISS. BY	SCALE 1:1	DWG. NO. A- 96068	SHEET 6 OF 10	ISSUE 2

(W/CRIMPED MOTOR CONNECTOR)  
 GOLDLINE RESOLVER CABLE WITH THERMOSTAT (GCA-R-D/D-XX)

UNLESS OTHERWISE SPECIFIED  
 DIMENSIONS ARE: MM [INCH]

DWG. NO. SHEET 7 OF 10  
 A- 96068

ISSUE  
 2

PARTS LIST

CABLE				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#4	4 PAIR	A-81948	BELDEN	8725
MOTOR CONNECTOR AND ACCESSORIES				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#5	MOTOR HOUSING	A-93613-001	POWELL	IN75-69622-14S
#7	CRIMP CONTACT	A-93614-001	POWELL	10-40556
#6	FILLER PLUG	A-93615-001	POWELL	10-405996-16
#7	REDUCER	A-93616-001	POWELL	10-74696-16
		N/A	BENDLERIMP TOOL	M22520/1-01
DIGITAL DRIVE CONNECTOR C2 AND ACCESSORIES				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#1	12 POS. CONNECTOR	A-93899-012	WEIDMULLER	161573
#3	FERRULE	A-82570-004	WEIDMULLER	4629.0
	CRIMP TOOL	N/A	WEIDMULLER	901250

CONNECTION CHART

MOTOR CONNECTION ITEM #5	* CABLE ITEM #4	DD CONNECTOR C2 ITEM #1
TERMINAL A	RED	TERMINAL 4
TERMINAL B	BLACK	TERMINAL 5
N/C	SHIELD	TERMINAL 6
TERMINAL C	WHT/YEL	TERMINAL 8
TERMINAL D	WHT/GRN	TERMINAL 7
N/C	SHIELD	TERMINAL 9
TERMINAL E	WHT/RED	TERMINAL 2
TERMINAL F	WHT/BLK	TERMINAL 1
N/C	SHIELD	TERMINAL 3
TERMINAL N		
TERMINAL P		N/C
TERMINAL R		
TERMINAL S		N/C
TERMINAL T	GREEN	TERMINAL 10
TERMINAL U	WHITE	TERMINAL 11
N/C	SHIELD	TERMINAL 12

SEE SHEET 2 AND 3 FOR CONNECTOR DETAILS.  
 \* THIS CABLE ASSEMBLY TO BE LABELED \*GCA-R-D/D-XX\*.

CABLE LENGTH

CAD DWG

ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.

Kollmorgen Industrial Drives  
 RADFORD, VIRGINIA

ASSEMBLY GUIDE  
 FOR RESOLVER CABLES

REV. NO.	CHK. DATE	REV.	REV. NO.	SCALE	DWG. NO.	SHEET 7 OF 10	ISSUE
TDG	1-20-94			1:1	A- 96068		2

(W/CRIMPED MOTOR CONNECTOR)  
 GOLDLINE RESOLVER CABLE WITH THERMOSTAT (GCA-R-D/D-XX)

UNLESS OTHERWISE SPECIFIED  
 DIMENSIONS ARE: MM [INCH]

DWG. NO. SHEET 7 OF 10  
 A- 96068

ISSUE  
 2

PARTS LIST

CABLE				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#4	4 PAIR	A-81948	BELDEN	8725

MOTOR CONNECTOR AND ACCESSORIES				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#5	MOTOR HOUSING	A-93613-001	POWELL	IN75-69622-14S
#7	CRIMP CONTACT	A-93614-001	POWELL	10-40556
#6	FILLER PLUG	A-93615-001	POWELL	10-405996-16
#7	REDUCER	A-93616-001	POWELL	10-74696-16
		N/A	BENDLERIMP TOOL	M22520/1-01

DIGITAL DRIVE CONNECTOR C2 AND ACCESSORIES				
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER	
			NAME	PART NUMBER
#1	12 POS. CONNECTOR	A-93899-012	WEIDMULLER	161573
#3	FERRULE	A-82570-004	WEIDMULLER	4629.0
	CRIMP TOOL	N/A	WEIDMULLER	901250

CONNECTION CHART

MOTOR CONNECTION ITEM #5	* CABLE ITEM #4	DD CONNECTOR C2 ITEM #1
TERMINAL A	RED	TERMINAL 4
TERMINAL B	BLACK	TERMINAL 5
N/C	SHIELD	TERMINAL 6
TERMINAL C	WHT/YEL	TERMINAL 8
TERMINAL D	WHT/GRN	TERMINAL 7
N/C	SHIELD	TERMINAL 9
TERMINAL E	WHT/RED	TERMINAL 2
TERMINAL F	WHT/BLK	TERMINAL 1
N/C	SHIELD	TERMINAL 3
TERMINAL N		
TERMINAL P		N/C
TERMINAL R		
TERMINAL S		N/C
TERMINAL T	GREEN	TERMINAL 10
TERMINAL U	WHITE	TERMINAL 11
N/C	SHIELD	TERMINAL 12

SEE SHEET 2 AND 3 FOR CONNECTOR DETAILS.  
 \* THIS CABLE ASSEMBLY TO BE LABELED 'GCA-R-D/D-XX'.

CABLE LENGTH

CAD DWG

ISS.	ECN NO.	DATE	APP'D.	ISS.	ECN NO.	DATE	APP'D.	Kollmorgen Industrial Drives RADFORD, VIRGINIA				ASSEMBLY GUIDE FOR RESOLVER CABLES			
								DR. BY:	CHK. BY:	DATE:	ISS. BY:	SCALE:	DWG. NO.	SHEET 7 OF 10	ISSUE
								TDG	1-28-94			1:1	A- 96068		2

(W/CRIMPED MOTOR CONNECTOR)								UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE: MM [INCH]		DWG. NO. SHEET 9 OF 10 <b>A- 96068</b>		ISSUE <b>2</b>	
GOLDLINE RESOLVER CABLE WITH THERMOSTAT AND BRAKE (GCA-RB-D/D-XX)													
PARTS LIST						CONNECTION CHART							
CABLE													
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER										
			NAME	PART NUMBER									
#4	6 PAIR	A-96027-004	CAROL	C0573									
MOTOR CONNECTOR AND ACCESSORIES													
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER										
			NAME	PART NUMBER									
#5	MOTOR HOUSING	A-93613-001	POWELL	IN75-69622-14S									
#7	CRIMP CONTACT	A-93614-001	POWELL	10-40556									
#6	FILLER PLUG	A-93615-001	POWELL	10-405996-16									
#7	REDUCER	A-93616-001	POWELL	10-74696-16									
		N/A	BENDLINE	282070601									
DIGITAL DRIVE CONNECTOR C2 AND ACCESSORIES													
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER										
			NAME	PART NUMBER									
#1	12 POS. CONNECTOR	A-93899-012	WEIDMULLER	161573									
#3	FERRULE	A-82570-002		6907.WEIDMULLER									
	CRIMP TOOL	N/A		90125WEIDMULLER									

MOTOR CONNECTION ITEM #5	* CABLE ITEM #4	DD CONNECTOR C2 ITEM #1
TERMINAL A	RED 1	TERMINAL 4
TERMINAL B	BLK 1	TERMINAL 5
N/C	SHIELD	TERMINAL 6
TERMINAL C	RED 2	TERMINAL 8
TERMINAL D	BLK 2	TERMINAL 7
N/C	SHIELD	TERMINAL 9
TERMINAL E	RED 3	TERMINAL 2
TERMINAL F	BLK 3	TERMINAL 1
N/C	SHIELD	TERMINAL 3
TERMINAL N	RED 4	CUSTOMER BRAKE HOOK-UP
TERMINAL P	BLK 4	
	SHIELD N/C	
TERMINAL R	SEE NOTE #1	N/C
TERMINAL S		
TERMINAL T	RED 6	TERMINAL 10
TERMINAL U	BLK 6	TERMINAL 11
N/C	SHIELD	TERMINAL 12

SEE SHEET 5 AND 6 FOR CONNECTOR DETAILS.  
\* THIS CABLE ASSEMBLY TO BE LABELED 'GCA-RB-D/D-XX'.

NOTE:

CABLE LENGTH

1. RESOLVER END: CUT-OFF REMAINING PAIR 12.7MM (1/2") FROM CABLE JACKET AND FOLD BACK OVER JACKET, PLACE UNDER HEAT SHRINK.
- MOTOR END: CUT-OFF REMAINING PAIR EVEN WITH CABLE JACKET.

Kollmorgen Industrial Drives

RADFORD, VIRGINIA

ASSEMBLY GUIDE

FOR RESOLVER CABLES

(W/SOLDERED MOTOR CONNECTOR)										UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE: MM [INCH]		DWG. NO. SHEET 10 OF 10 A- 96068		ISSUE 2	
GOLDLINE RESOLVER CABLE WITH THERMOSTAT AND BRAKE (GCA-RB-D/D-XX)															
PARTS LIST					CONNECTION CHART										
CABLE															
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER												
			NAME	PART NUMBER											
#4	6 PAIR	A-96027-004	CAROL	C0573											
MOTOR CONNECTOR AND ACCESSORIES															
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER												
			NAME	PART NUMBER											
#5	MATING PLUG	G-10158	BENDIX	MS3106E-22-14S											
DIGITAL DRIVE CONNECTOR C2 AND ACCESSORIES															
ITEM #	DESCRIPTION	ID PART NUMBER	MANUFACTURER												
			NAME	PART NUMBER											
#1	12 POS. CONNECTOR	A-93899-012	WEIDMULLER	161573											
#3	FERRULE	A-82570-002	WEIDMULLER	6907.0											
	CRIMP TOOL	N/A	WEIDMULLER	901250											

MOTOR CONNECTION ITEM #5	* CABLE ITEM #4	DD CONNECTOR C2 ITEM #1
TERMINAL A	RED 1	TERMINAL 4
TERMINAL B		TERMINAL BLK 1
N/C		TERMINAL SHIELD
TERMINAL C		TERMINAL RED 2
TERMINAL D		TERMINAL BLK 2
N/C		TERMINAL SHIELD
TERMINAL E		TERMINAL RED 3
TERMINAL F		TERMINAL BLK 3
N/C		TERMINAL SHIELD
TERMINAL N	RED 4	CUSTOMER BRAKE HOOK-UP
TERMINAL P	BLK 4	
N/C	SHIELD	
TERMINAL R	SEE NOTE #1	
TERMINAL S		N/C
TERMINAL T	RED 6	TERMINAL 10
TERMINAL U	BLK 6	TERMINAL 11
N/C	SHIELD	TERMINAL 12

SEE SHEET 5 AND 6 FOR CONNECTOR DETAILS.  
\* THIS CABLE ASSEMBLY TO BE LABELED 'GCA-RB-D/D-XX'.

NOTE:  
1. RESOLVER END: CUT-OFF REMAINING PAIR 12.7MM (1/2") FROM CABLE JACKET AND FOLD BACK OVER JACKET, PLACE UNDER HEAT SHRINK.  
MOTOR END: CUT-OFF REMAINING PAIR EVEN WITH CABLE JACKET.

CABLE LENGTH

CAD DWG

DWG. NO. SHEET 1 OF 6  
**A-**  
 ISSUE  
 296069

THIS DRAWING CONTAINS THE INFORMATION NECESSARY TO FABRICATE MOTOR CABLES TO BE USED WITH S/D-3 THRU 20 AMP UNITS TO USE WITH THE FOLLOWING MOTORS (IF THEY HAVE THREADED CONNECTORS).

2

FOR ALL 40X (EXC. 406C) MOTORS: SEE SHEET 3 & 4  
 FOR 602A, 602B, 604A & 606A MOTORS: SEE SHEET 5 & 6

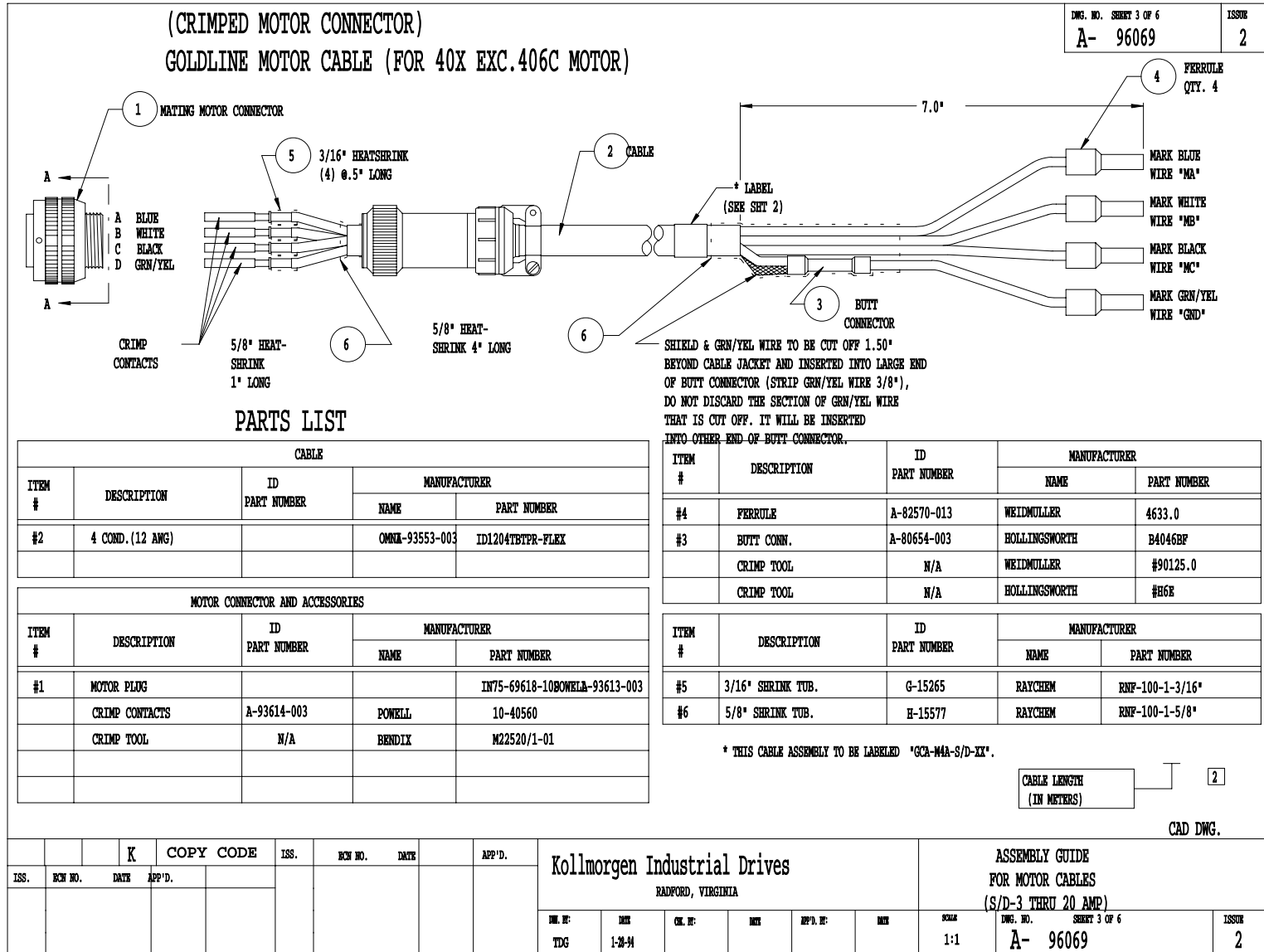
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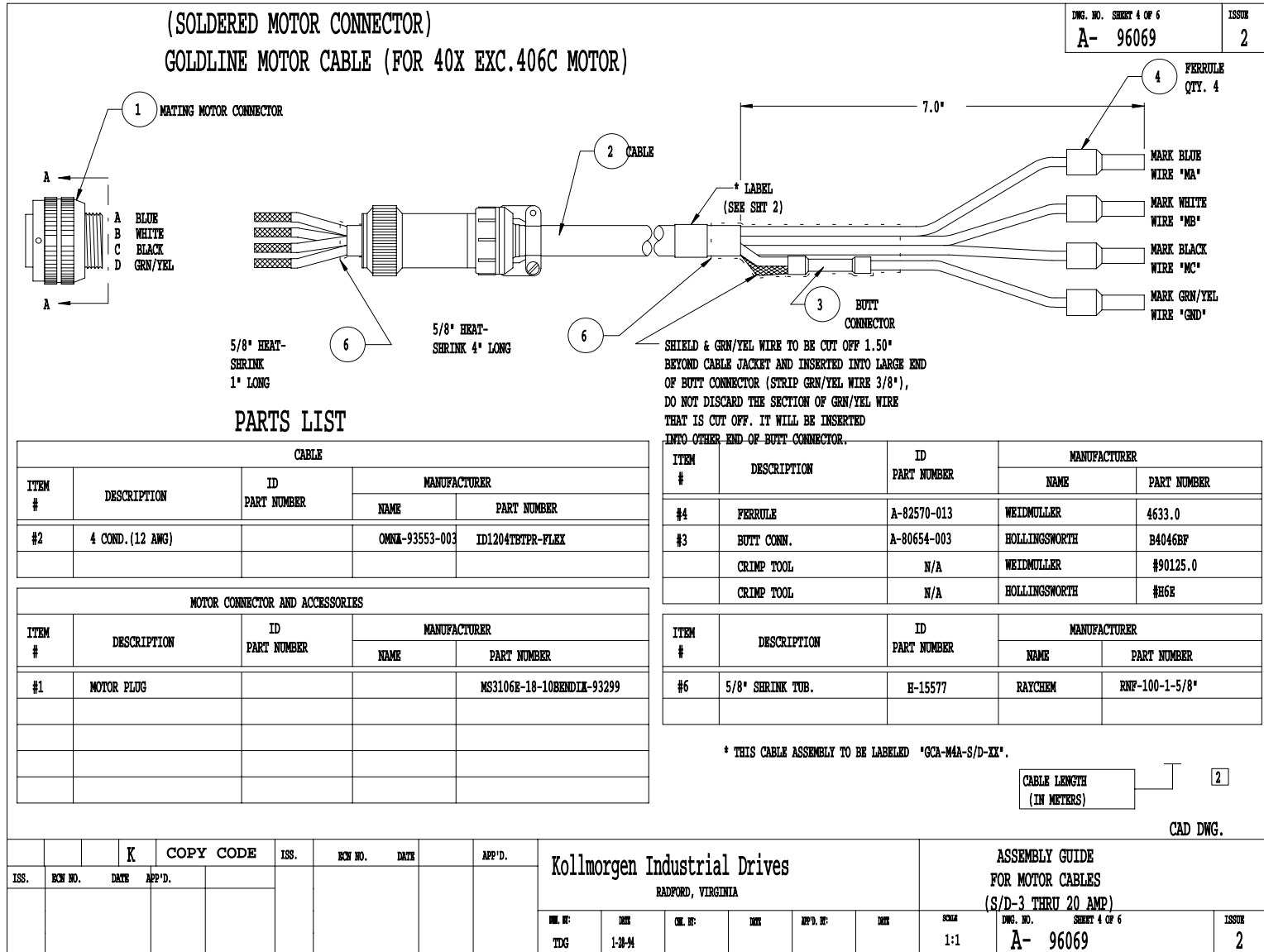
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		FEET		METERS	FEET		METERS	FEET	
		10 303			902727	-51	\$1	170	GOLDLINE CABLE (W/THREADED CONNECTORS) --- GCA-MXX-S/D-XX --- CABLE LENGTH (IN METERS) --- SMART DRIVE AMPLIFIER M4A= 40X (EXC. 406C) M6A= 602A, 602B, 604A, or 606A 2
		20 606			1003830	-54	\$4	180	
		30 909			1103333	-57	\$7	190	
		401212			1203636	-60	\$0	200	
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		601818			1404242				
		702121			1504545				
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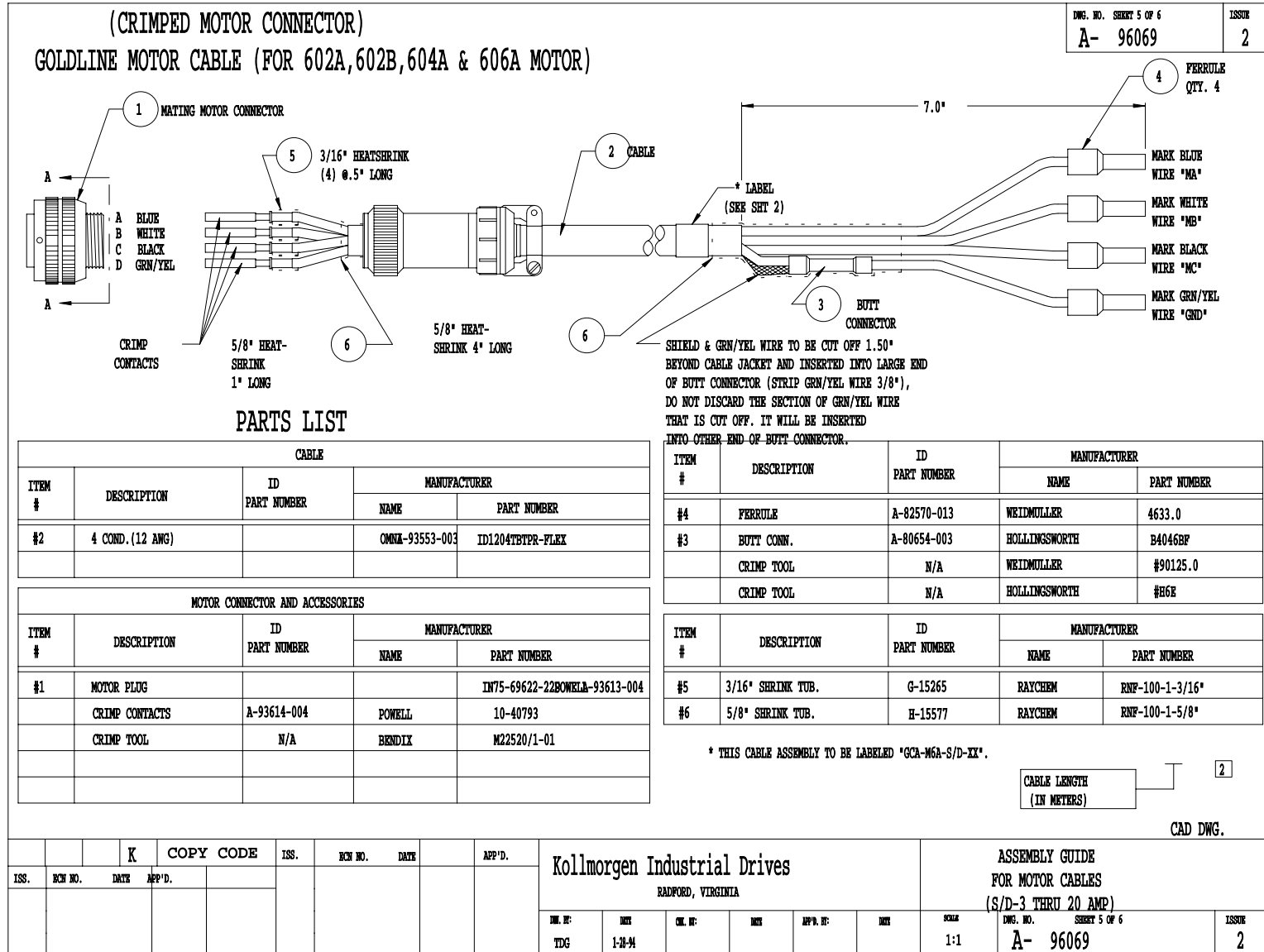
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ISS.	REV. NO.	DATE	APP'D.	2	66027	AWL	8-10-94	RADFORD, VIRGINIA				DWG. NO.	SHEET 1 OF 6	ISSUE	
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								TDG	1-28-94	1:1	A- 96069		2		

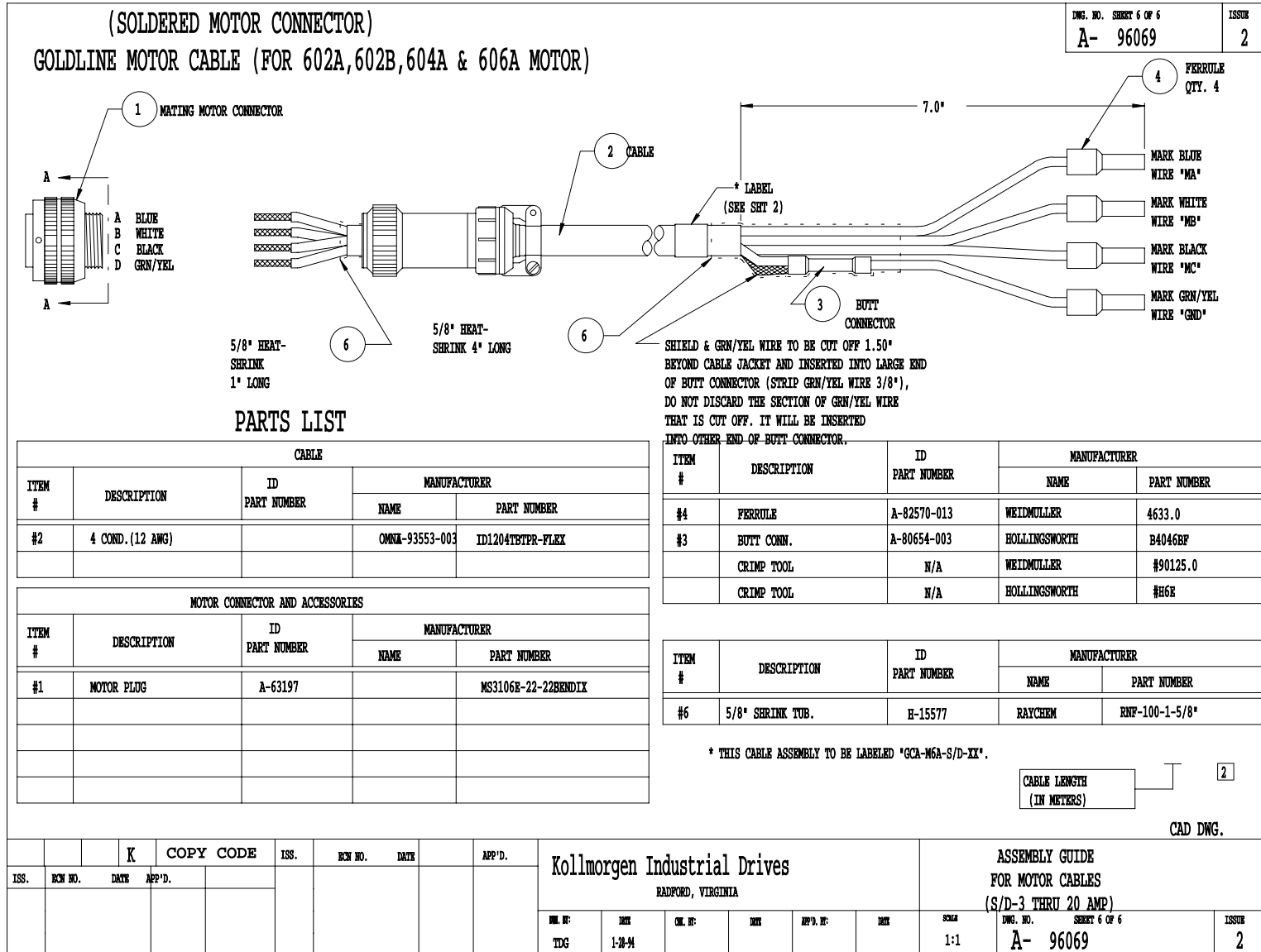
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DWG. NO. SHEET 2 OF 6	ISSUE																																								
A- 96069	2																																								
<b>CONNECTOR ASSEMBLY PROCEDURE</b>																																									
<p><b>STEP 1</b> BEFORE ANY OUTER JACKET HAS BEEN REMOVED FROM THE CABLE, SLIDE THE FOLLOWING ITEMS ONTO THE CABLE: 12.7MM (1/2") SHRINK TUBING, BACKSHELL AND 15.88MM (5/8") SHRINK TUBING.</p> <p><b>STEP 2</b> STRIP THE OUTER CABLE JACKET BACK 38.1MM (1.5"). THIS WILL EXPOSE THE SHIELD AROUND THE INDIVIDUAL WIRES. (THE DIAGRAM ONLY SHOWS ONE WIRE FOR CLARITY)</p> <p><b>STEP 3 A</b> CUT &amp; DISCARD THE SHIELD FROM THIS END OF CABLE.  <b>B</b> USE STRIPPING PLIERS TO STRIP INSULATION 4.57MM (.18") FROM INDIVIDUAL WIRES.</p> <p><b>STEP 4 A</b> FOR CRIMP CONNECTORS:  <b>B</b> INSERT WIRES INTO THE CRIMP CONTACTS AND CRIMP.  <b>C</b> INSERT THE CRIMP CONTACTS INTO THE PLUG BODY, WITH USE OF GUIDE PINS, ACCORDING TO THE CONNECTION CHART.</p> <p><b>STEP 4 A</b> FOR SOLDER CONNECTORS:          INSERT WIRES INTO THE SOLDER CUPS AND SOLDER.</p>	<p><b>STEP 5</b> A POSITION THE 5/8" HEAT SHRINK TUBING AND APPLY HEAT TO SHRINK TUBING, AS SHOWN ON FOLLOWING SHEETS.          B SLIDE THE BACKSHELL ALONG THE CABLE TO PLUG BODY.          C HOLD PLUG BODY SECURELY AND SCREW BACKSHELL ONTO PLUG BODY,          D TIGHTEN CABLE CLAMP.          E POSITION THE 1/2" SHRINK TUBING AND APPLY HEAT TO SHRINK TUBING, AS SHOWN ON FOLLOWING SHEETS.</p> <p><b>STEP 6</b> PLACE LABEL IN APPROXIMATE LOCATION AS SHOWN ON FOLLOWING SHEETS.</p>	<p><b>NOTE:</b></p> <p>1. FOR CABLE ASSEMBLY GCA-M4A-S/D-XX...SEE SHEET #3 OR 4          FOR CABLE ASSEMBLY GCA-M6A-S/D-XX...SEE SHEET #5 OR 6</p>																																							
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# GLOSSARY

## **Absolute Position**

Position referenced to a fixed zero position.

## **Absolute Positioning**

Refers to a motion control system employing position feedback devices (absolute encoders) to maintain a given mechanical location.

## **AC Adjustable-Speed Drive**

All equipment required to adjust the speed or torque of AC electric motor(s) by controlling both frequency and voltage applied to the motor(s).

## **AC Servo Drive**

A servo drive used to control either or both synchronous or induction AC motors.

## **Acceleration**

The change in velocity as a function of time. Acceleration usually refers to increasing velocity and deceleration describes decreasing velocity.

## **Accuracy**

A measure of the difference between expected outcome and actual outcome of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

## **Actuator**

A device which creates mechanical motion by converting various forms of energy to mechanical energy.

## **Adaptive Control**

A technique to allow the control to automatically compensate for changes in system parameters such as load variations.

## **Ambient Temperature**

The temperature of the normal environment, usually air, immediately surrounding the referenced device.

## **Amplifier**

Electronics which convert low level command signals to high power voltages and currents to operate a servomotor, also called a drive.

## **ASCII**

(American Standard Code for Information Interchange) This code assigns a number to each numeral letter of the alphabet. In this manner, information can be transmitted between machines as a series of binary numbers.

## **Back EMF (BEMF)**

The voltage generated when a permanent magnet motor is rotated. This voltage is proportional to motor speed and is present regardless of whether the motor winding(s) are energized or de-energized.

## **Bandwidth**

The frequency range in which the magnitude of the system gain expressed in dB is greater than -3 dB.

## **Baud Rate**

The number of binary bits transmitted per second on a serial communications link (such as RS-232).

## **Bit (Binary Digit)**

A unit of information equal to 1 binary decision or having only a value 0 or 1.

## **Bode Plot**

A plot of the magnitude of system gain in dB and the phase of system gain in degrees versus the sinusoidal input signal frequency in logarithmic scale.

**Brownout**

Low-line voltage at which the device no longer functions properly.

**Brush**

Conducting material which passes current from the DC motor terminals to the rotating commutator.

**Brushless Servo Drive**

A servo drive used to control a permanent magnet synchronous AC motor. May also be referred to as an AC Servo Drive also called an amplifier.

**Bus**

A group of parallel connections carrying pre-assigned digital signals. Buses usually consist of address and data information and miscellaneous control signals for the interconnection of microprocessors, memories, and other computing elements. Also used in reference to the DC MAIN BUS referring to the high-voltage, high-power DC rail supply.

**Byte**

A group of 8 bits treated as a whole with 256 possible combinations of ones and zeros, each combination representing a unique piece of information.

**Class B Insulation**

A NEMA insulation specification. Class B insulation is rated to an operating temperature of 130 degrees centigrade.

**Class H Insulation**

A NEMA insulation specification. Class H insulation is rated to an operating temperature of 180 degrees centigrade.

**Closed Loop**

A broadly applied term relating to any system where the output is measured and compared to the input. The output is then adjusted to reach the desired condition. In motion control, the term is used to describe a system wherein a velocity or position (or both) transducer is used to generate correction signals by comparison to desired parameters.

**Cogging**

A term used to describe non-uniform angular velocity. Cogging appears as a jerkiness especially at low speeds.

**Command Position**

The desired angular or linear position of an actuator.

**Commutation**

A term which refers to the action of steering currents or voltage to the proper motor phases so as to produce optimum motor torque. In brush type motors, commutation is done electromechanically via the brushes and commutator. In brushless motors, commutation is done by the switching electronics using rotor position information typically obtained by hall sensors, a tachsyn, a resolver or an encoder.

**Commutator**

A mechanical cylinder consisting of alternating segments of conductive and insulating material. This cylinder used in DC motors passes currents from the brushes into the rotor windings and performs motor commutation as the motor rotates.

**Compensation**

The corrective or control action in a feedback loop system which is used to improve system performance characteristics such as accuracy and response time.

**Compensation, Feedforward**

A control action which depends on the command only and not the error to improve system response time.

**Compensation File**

A DOS type computer file containing data for the drive which is pertinent to the configuring the drive for the motors characteristics.

**Compensation, Integral**

A control action which is proportional to the integral or accumulative time error value product of the feedback loop error signal. It is usually used to reduce static error.

**Compensation, Lag**

A control action which causes the lag at low frequencies and tends to increase the delay between

the input and output of a system while decreasing static error.

**Compensation, Lead**

A control action which causes the phase to lead at high frequencies and tends to decrease the delay between the input and output of a system.

**Compensation, Lead Lag**

A control action which combines the characteristics of lead and lag compensations.

**Compensation, Proportional**

A control action which is directly proportional to the error signal of a feedback loop. It is used to improve system accuracy and response time.

**Compliance**

The amount of displacement per unit of applied force. Used to refer to "springy-ness" of the load.

**Computer Numerical Control**

A computer-based motion control device programmable in a numerical word address format. A computer numerical control (CNC) product typically includes a CPU section, operator interface devices, input/output signal and data devices, software and related peripheral apparatus.

**CR-LF**

A short-hand method of referring to the ASCII line termination sequence characters; Carriage Return and Line Feed.

**Critical Damping**

A system is critically damped when the response to a step change in desired velocity or position is achieved in the minimum possible time with little or no overshoot.

**Daisy Chain**

A term used to describe the linking of several devices in sequence such that a single signal stream flows through one device and on to the next.

**Damping**

An indication of the rate of decay of a signal to its steady state value. Related to setting time.

**Damping Ratio**

Ratio of actual damping to critical damping. Less than one is an underdamped system and greater than one is an overdamped system.

**DC Adjustable-Speed Drive**

All equipment required to adjust the speed or torque of DC motor(s) by controlling the voltages applied to the armature and/or field of the motors.

**DC Drive**

An electronic control unit for running DC motors. The DC drive converts AC line current to a variable DC current to control a DC motor. The DC drive has a signal input that controls the torque and speed of the motor.

**Dead Band**

A range of input signals for which there is no system response.

**Decibel (dB)**

A logarithmic measurement of gain. If  $G$  is a systems gain (ratio of output to input) then  $20 \log G =$  gain in decibels (dB).

**Demag Current**

The current level at which the motor magnets will be demagnetized. This is an irreversible effect which will alter the motor characteristics and degrade performance.

**Detent Torque**

The maximum torque that can be applied to an de-energized stepping motor without causing continuous rotating motion.

**Differential**

An electrical input or output signal which uses two lines of opposite polarity referenced to the local signal ground.

**Drive**

This is the electronics portion of the system that controls power to the motor.

**Drive, Analog**

Usually referring to any type of motor drive in which the compensation is accomplished with components such as resistors and capacitors.

**Drive, Digital**

Usually referring to any type of motor drive in which the tuning or compensation is done digitally. Input may be an analog or digital signal.

**Drive, PWM**

A motor drive utilizing Pulse-Width Modulation techniques to control power to the motor. Typically a high efficiency drive that can be used for high response application.

**Drive, SCR**

A DC motor drive which utilizes internal silicon controlled rectifiers as the power control elements. Usually used for low bandwidths, high power applications.

**Drive, Servo**

A motor drive which utilizes internal feedback loops for accurate control of motor current and/or velocity.

**Duty Cycle**

For a repetitive cycle, the ratio of an on time to total cycle time.

**Dynamic Braking**

A passive technique for stopping a permanent magnet brush or brushless motor. The motor windings are shorted together through a resistor which results in motor braking with an exponential decrease in speed.

**Efficiency**

The ratio of power output to power input.

**Electrical Time Constant**

The ratio of armature inductance to armature resistance.

**Electronic Gearing**

A technique used to electrically simulate mechanical gearing. Causes one closed loop axis to be slaved to another open or closed loop axis with a variable ratio.

**EMI: Electro-Magnetic Interference**

EMI is noise which, when coupled into sensitive electronic circuits, may cause problems.

**Encoder**

A type of feedback device which converts mechanical motion into electrical signals to indicate actuator position. Typical encoders are designed with a printed disc and a light source. As the disc turns with the actuator shaft, the light source shines through the printed pattern onto a sensor. The light transmission is interrupted by the patterns on the disc. These interruptions are sensed and converted to electrical pulses. By counting these pulses, actuator shaft position is determined.

**Encoder, Absolute**

A digital position transducer in which the output is representative of the absolute position of the input shaft within one (or more) revolutions.

**Encoder, Incremental**

A position encoding device in which the output represents incremental changes in position.

**Encoder, Linear**

A digital position transducer which directly measures linear position.

**Encoder Marker**

A ounce-per-revolution signal provided by some incremental encoders to specify a reference point within that revolution. Also known as Zero Reference signal or index pulse.

**Encoder Resolution**

A measure of the smallest positional change which can be detected by the encoder.

**Explosion-proof**

A motor classification that indicates a motor is capable of withstanding internal explosions without bursting or allowing ignition to reach beyond the confines of the motor frame.

**Fall Time**

The time for the amplitude of system response to decay to 37% of its steady-state value after the removal of a steady-state step input signal.

**Feed Forward**



A technique used to pre-compensate control a loop for known errors due to motor, drive, or lead characteristics. Provides improved response.

**Feedback**

A signal which is transferred from the output back to the input for use in a closed loop system.

**Field Weakening**

A method of increasing the speed of a motor; reducing stator magnetic field instantly by reducing magnet winding current.

**Filter (Control Systems)**

A transfer function used to modify the frequency or time response of a control system.

**Flutter**

Flutter is an error of the basic cycle of an encoder per one revolution.

**Following Error**

The positional error during motion resulting from use of a position control loop with proportional gain only.

**Form Factor**

The ratio of RMS current to average current. This number is a measure of the current ripple in a PWM or other switch mode type of controller. Since motor heating is a function of RMS current while motor torque is a function of average current, a form factor greater than 1.00 means some fraction of motor current is producing heat but not torque.

**Four Quadrant**

Refers to a motion system which can operate in all four quadrants i.e. velocity in either direction and torque in either direction. This means that the motor can accelerate, run, and decelerate in either direction.

**Friction**

A resistance to motion caused by surfaces rubbing together. Friction can be constant with varying speed (coulomb friction) or proportional to speed (viscous friction) or present at rest (static friction).

**Full Load Current**

The armature current of a motor operated at its full load torque and speed with rated voltage applied.

**Full Load Speed**

The speed of a motor operated with rated voltage and full load torque.

**Gain**

The ratio of system output signal to system input signal.

**Hall Sensors**

A feedback device which uses magnetic sensing to determine information.

**Home Position**

A reference position for all absolute positioning movements. Usually defined by a home limit switch and/or encoder marker. Normally set at power up and retained for as long as the control system is operational.

**Host Computer**

An auxiliary computer system which is connected to a controller or controllers. The host computer in distributed control systems is frequently involved with controlling many remote and distributed motion control devices. It may also be used for off-line tasks such as program preparation, storage, and supervisory control and evaluation.

**HP: Horsepower**

One horsepower is equal to 746 watts. Since Power = Torque x Speed, horsepower is a measure of a motor's torque and speed capability (e.g. a 1 HP motor will produce 35 lb.-in. at 1800 rpm).

**Hunting**

The oscillation of the system response about a theoretical steady-state value.

**Hysteresis**

The difference in response of a system to an increasing or a decreasing input signal.

**I/O: Input/Output**

The reception and transmission of information between control devices. In modern control systems, I/O has two distinct forms: switches, relays, etc., which are in either an on or off state, or analog signals that are continuous in nature such as speed, temperature, flow, etc.

**Incremental Motion**

A motion control term referring to distance moved relative to present position, not a constant reference position.

**Inertia**

The property of an object to resist changes in velocity unless acted upon by an outside force. Higher inertia objects require larger torques to accelerate and decelerate. Inertia is dependent upon the mass and shape of the object.

**Inertial Match**

An inertial match between motor and load is obtained by selecting the coupling ratio such that the load moment of inertia reflected to the motor shaft is equal to the motor moment of inertia.

**Inrush Current**

The current surge generated when a piece of equipment such as a servoamplifier is connected to an AC line. This surge is typically due to the impulse charging of a large capacitor located in the equipment.

**Instability**

Undesirable motion of an actuator that is different from the command motion. Instability can take the form of irregular speed or hunting of the final rest position.

**Lead Ball Screw**

A lead screw which has its threads formed as a ball bearing race; the carriage contains a circulating supply of balls for increased efficiency.

**Lead Screw**

A device for translating rotary motion into linear motion, consisting of an externally threaded screw and an internally threaded carriage (nut).

**Least Significant Bit**

The bit in a binary number that is the least important, or having the least weight.

**Limits**

Properly designed motion control systems have sensors called limits that alert the control electronics that the physical end of travel is being approached and that motion should stop.

**Linearity**

For a speed control system, it is the maximum deviation between actual and set speed expressed as a percentage of set speed.

**Logic Ground**

An electrical potential to which all control signals in a particular system are referenced.

**Loop, Feedback Control**

A control method that compares the input from a measurement device, such as an encoder or tachometer, to a desired parameter, such as a position or velocity and causes action to correct any detected error. Several types of loops can be used in combination (i.e. velocity and position together) for high performance requirements.

**Loop Gain, Open**

The product of the forward path and feedback path gains.

**Loop, Position**

A feedback control loop in which the controlled parameter is motor position.

**Loop, Velocity**

A feedback control loop in which the controlled parameter is mechanical velocity.

**Master Slave Motion Control**

A type of coordinated motion control where the master axis position is used to generate one or more slave axis position commands.

**Mechanical Time Constant**

The time for an unloaded motor to reach 63.2% of its final velocity after the application of a DC armature voltage.

**Most Significant Bit**

The bit in a binary number that is the most important or that has the most weight.

**Motor, AC**

A device that converts electrical alternating current into mechanical energy. Requires no commutation devices such as brushes. Normally operated off

commercial AC power. Can be single- or multiple-phase.

**Motor, AC Asynchronous or Induction**

An AC motor in which speed is proportional to the frequency of the applied AC. Requires no magnets or field coil. Usually used for non-precise constant speed applications.

**Motor, AC Synchronous**

Another term for brushless DC motor.

**Motor, DC**

A device that converts electrical direct current into mechanical energy. It requires a commutating device, either brushes or electronic. Usually requires a source of DC power.

**Motor, DC Brushless**

A type of direct current motor that utilizes electronic commutation rather than brushes to transfer current.

**Motor, DC Permanent Magnet**

A motor utilizing permanent magnets to produce a magnetic field. Has linear torque speed characteristics.

**Motor, DC Wound Field**

A direct current utilizing a coil to produce a magnetic field. Usually used in high power applications where constant horsepower operation is desired.

**Motor, Stepping**

A specialized AC motor that allows discrete positioning without feedback. Normally used for non-critical, low power applications, since positional information is easily lost if acceleration or velocity limits are exceeded. Load variations can also cause loss of position.

**Negative Feedback**

The type of feedbacks used in a closed loop system where the output value is inverted and combined with the input to be used to stabilize or improve system characteristics.

**Open Collector**

A term used to describe a signal output that is performed with a transistor. An open collector output acts like a switch closure with one end of the switch at ground potential and the other end of the switch accessible.

**Open-Loop System**

A system where the command signal results in actuator movement but, because the movement is not sensed, there is no way to correct for error. Open loop means no feedback.

**Operator Interface**

A device that allows the operator to communicate with a machine. This device typically has a keyboard or thumbwheel to enter instructions into the machine. It also has a display device that allows the machine to display messages.

**Optically Isolated**

A system or circuit that transmits signals with no direct electrical connection. Used to protectively isolate electrically noisy machine signals from low level control logic.

**Oscillation**

An effect that varies periodically between two values.

**Overshoot**

The amount of the parameter being controlled exceeds the desired value for a step input.

**Phase Margin**

The difference between 180 degrees and the phase angle of a system at the frequency where the open loop gain is unity.

**PID**

Proportional-Integral-Derivative. An acronym that describes the compensation structure that can be used in a closed-loop system.

**PLC**

Programmable Logic Controller. An industrial control device that turns on and off outputs based upon responses to inputs.

**Point to Point Move**

A multi-axis move from one point to another where each axis is controlled independently. (No coordination between axes is required.)

**Pole**

A frequency at which the transfer function of a system goes to infinity.

**Pole Pair, Electromechanical**

The number of cycles of magnetic flux distribution in the air gap of a rotary electromechanical device.

**Position Error**

The difference between the present actuator (feedback) value and the desired position command for a position loop.

**Position Feedback**

Present actuator position as measured by a position transducer.

**Power**

The rate at which work is done. In motion control,  $\text{Power} = \text{Torque} \times \text{Speed}$ .

**Process Control**

A term used to describe the control of machine or manufacturing processes, especially in continuous production environments.

**PWM**

Pulse Width Modulation. An acronym which describes a switch-mode control technique used in amplifiers and drivers to control motor voltage and current. This control technique is used in contrast to linear control and offers the advantage of greatly improved efficiency.

**Quadrature**

Refers to signal characteristics of interfaces to encoders. Specifically, that property indicates the ability to determine direction and multiply the feedback data rate by a factor of 4.

**Ramping**

The acceleration and deceleration of a motor.

**Rated Torque**

The torque producing capacity of a motor at a given speed. This is the maximum continuous torque the motor can deliver to a load and is usually specified with a torque/speed curve.

**Regeneration**

The action during motor deceleration, or braking, in which the motor acts as a generator and takes kinetic energy from the load, converts it to electrical energy, and returns it to the amplifier.

**Repeatability**

The degree to which the positioning accuracy for a given move performed repetitively can be duplicated.

**Resolution**

The smallest positioning increment that can be achieved. Frequently defined as the number of steps or feedback units required for a motor's shaft to rotate one complete revolution.

**Resolver**

A position transducer utilizing magnetic coupling to measure absolute shaft position over one revolution.

**Resonance**

The effect of a periodic driving force that causes large amplitude increases at a particular frequency. (Resonance frequency.)

**RFI**

Radio Frequency Interference.

**Ringling**

A temporary oscillation of a system following sudden change in state.

**Rise Time**

The time required for a signal to rise from 10% of its final value to 90% of its final value.

**RMS Current**

Root mean square current. In an intermittent duty cycle application, the RMS current is equal to the

value of steady state current which would produce the equivalent resistive heating over a long period of time.

### **RMS Torque**

Root Mean Square Torque. For an intermittent duty cycle application, the RMS torque is equal to the steady state torque which would produce the same amount of motor heating over long periods of time.

### **Rotor**

The rotating part of a magnetic structure. In a motor, the rotor is connected to the motor shaft.

### **Serial Port**

A digital data communications port configured with a minimum number of signal lines. This is achieved by passing binary information signals as a time series of "1"s and "0"s on a single line.

### **Servo Amplifier/Servo Drive**

An electronic device which produces the winding current for a servo motor. The amplifier converts a low level control signal into high voltage and current levels to produce torque in the motor.

### **Servo System**

An automatic feedback control system for mechanical motion in which the controlled or output quantity is position, velocity, or acceleration. Servo systems are closed loop systems.

### **Settling Time**

The time required for a step response of a system parameter to stop oscillating or ringing and reach its final value.

### **Shunt Resistor**

A device located in a servoamplifier for controlling regenerative energy generated when braking a motor. This device dissipates or "dumps" the kinetic energy as heat.

### **Single Point Ground**

The common connection point for signal grounds in a control wiring environment. Also called a star-ground.

### **Speed**

In motion control, the concept used to describe the linear or rotational velocity of a motor or other object in motion.

### **Speed Regulation**

For a speed control system, speed regulation is the variation in actual speed expressed as a percentage of set speed.

### **Stall Torque**

The torque available from a motor at stall or zero rpm.

### **Stator**

The non-rotating part of a magnetic structure. In a motor the stator usually contains the mounting surface, bearings, and non-rotating windings or permanent magnets.

### **Stiffness**

The ability to resist movement induced by an applied torque. It is often specified as a displacement curve, indicating the amount a motor shaft will rotate upon application of a known external force when stopped.

### **Tachometer**

A feedback transducer which produces an analog voltage signal proportional to rotational velocity.

### **Torque**

The rotary equivalent to force. Equal to the product of the force perpendicular to the radius of motion and distance from the center of rotation to the point where the force is applied.

### **Torque Constant**

A number representing the relationship between motor input current and motor output torque. Typically expressed in units of torque/amp.

### **Torque Ripple**

The cyclical variation of generated torque given by the product of motor angular velocity and number of commutator segments.

### **Torque-to-Inertia Ratio**

Defined as a motor's torque divided by the inertia of its rotor, the higher the ratio the higher the acceleration can be.

**Transducer**

Any device that translates a physical parameter into an electrical parameter. Tachometers and encoders are examples of transducers.

**Trapezoidal Profile**

A motion profile in which the velocity vs. time profile resembles a trapezoid. Characterized by constant acceleration, constant velocity, and constant deceleration.

**TTL**

Transistor-Transistor Logic.

**Variable Frequency Drive**

An electronic device used to control the speed of a standard AC induction motor. The device controls the speed by varying the frequency of the winding current used to drive the motor.

**Vector Control**

A method of obtaining servo type performance from an AC motor by controlling two components of motor current.

**Velocity**

The change in position as a function of time. Velocity has both a magnitude and a direction.

**Voltage Constant (or Back EMF Constant)**

A number representing the relationship between Back EMF voltage and angular velocity. Typically expressed as V/Krpm.

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