Chapter 7. MAINTENANCE & TROUBLESHOOTING

Chapter Objectives

The information in this chapter will enable you to:

- Maintain the system's components to ensure smooth, efficient operation
- Isolate and resolve system hardware and software problems

Maintenance

The following system components require periodic maintenance:

- The Motor
- The Drive

Spare Parts Table

Table 7-1 provides a list of recommended spare parts to use with the SD/IFX system.

Function	Part Number
Indexer	IFX
Transformer Power Cable	71-010680-01
Transformer-to-M.B. Cable	71-010677-01
SD/IFX Motherboard Kit	SDXMBKIT
Appropriate Drive: SD2 Drive SD3 Drive	 SD2 SD3
Appropriate Transformer: TO116 TO119 TO120	 TO116 TO119 TO120

Table 7-1. Recommended Spare Parts for the SD/IFX System

Motor Maintenance

You should inspect all mechanical parts of the motor regularly to ensure that no bolts or couplings have become loose during normal operation. This will prevent minor problems from developing into more serious problems.

The ball bearings used in the Compumotor-supplied RM-Series motors are not sealed against severe environments, but are permanently lubricated and do not require any maintenance.

You should inspect the motor cable or leads periodically for signs of wear. This inspection interval is duty-cycle, environment, and travel-length dependent. You should not apply excessive tensile force to the cable. Do not bend the cable beyond a one-inch radius of curvature during normal operation. Tighten all cable connectors.

Drive Maintenance

Check that the drive heatsink is free of particles and has a free flow of air over its entire surface. Enclosures must be connected to earth ground through a grounding electrode conductor to provide a low-impedance path for ground-fault or noise-induced currents. All earth ground connections must be continuous and permanent.

Troubleshooting

This section discusses methods to identify, isolate, and resolve problems that may occur with your SD/IFX System.

Problem Isolation

When your system does not function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you accomplish this, you can effectively begin to resolve the problem.

Try to determine if the problem is mechanical, electrical, or software-related. *Can you repeat or re-create the problem?* Do not attempt to make quick rationalizations about problems. Random events may appear to be related, but they are not necessarily contributing factors to your problem. You must carefully investigate and decipher the events that occur before the subsequent system problem.

You may be experiencing more than one problem. You must solve one problem at a time. Log (document) all testing and problem isolation procedures. You may need to review and consult these notes later. This will also prevent you from duplicating your testing efforts.

Isolate each system component and ensure that each component functions properly when it is run independently. You may have to remove your system components and re-install them component-by-component to detect the problem. If you have additional components available, you may want to use them to replace existing components in your system to help identify the source of the problem.

Once you have isolated the problem, take the necessary steps to resolve it. Refer to the problem solutions contained in this chapter. If your system's problem persists, contact Parker Compumotor's Applications Department at (800) 358-9070.

Motor Fails to Move

Test the motor to see if it has holding torque. If there is no holding torque, here are some probable causes:

- There is no AC power.
- Current selection DIP switches are not set properly (see the motor current selection table in Chapter 6, Hardware Reference).
- There are bad connections or bad cables. Disconnect the power connector, then use an ohm meter to monitor continuity between the motor to drive cable.
- The drive may be disabled through software (`ST1` command)
- The drive fuses may be blown. Disconnect AC power from the drive, remove the drive from the rack, and inspect the fuses on the SD drive card. **If the fuses are blown, return the unit for repair.**

If the unit has holding torque and the motor shaft still fails to move, here are some probable causes:

- The limit switches have been tripped or are faulty. Make sure that your limit switches are OFF or that the limits are disabled (`LD3` command).
- The load is jammed. You should *hear* the drive attempting to move the motor. Remove AC power from the driver and verify that you can move the load manually away from the point of the jam.
- Indexer parameters are incorrectly set up. If certain parameters are out of range or are missing, the motor will not move when you issue the Go (`G`) command.

Use `R`, `RA`, `RB`, `RS` status commands to determine what is preventing the move. Also check `A`, `V`, and `D` commands to make sure that all the parameters are set properly. The following are additional troubleshooting techniques:

- Check the motor for damage. Also check the motor leads/cable to see if they are damaged or shortened. These conditions may cause the drive to fault.
- Ohm the motor and cables to make sure that shorts do not exist between phases or earth GND. The resistance across each motor phase should be consistently low and similar to each other. The resistance between motor phases and between each phase and earth ground should be infinite.

Motor Stalls

A motor stall during acceleration may be caused by one or more of the following factors:

- The torque requirements may be excessive.
- The acceleration ramp may be too steep.
- The load inertia and motor inertia may be grossly mismatched.

Lower acceleration may be required.

If the motor stalls during the constant velocity portion of a move, the shaft and/or coupler may be damaged or binding due to improper coupling or excessive motor load.

A stall may occur if the DIP switch setting for the motor current selection is incorrect. The motor may not be receiving enough current to operate.

A stall may also be detected in the closed-loop mode if the encoder resolution (**ER**) is not set properly, or if the encoder input channels (A and B) are reversed.

Motor Fails to Run at High Speeds

The motor may fail to run at high speeds due to the following factors:

- It is possible that the motor may not produce enough torque to move a given load at these velocities. Check the torque/speed curve in Chapter 6 and make sure you are trying to run the motor in the proper range.

- The maximum rates at which the IFX indexer produces pulse trains is provided in Table 7-2. Dividing the maximum frequency by the set SD Drive resolution (steps/rev) will give the maximum speed in revolutions per second. At the highest indexer resolution, you will not be able to reach maximum speed.

Resolution Setting	Max. Velocity	Max. Pulse Train
200 steps/sec	325.42 rps*	65KHz
400 steps/sec	162.71 rps*	65KHz

* These are the max. indexer speeds; the motor cannot actually attain this.

Table 7-2. Maximum IFX Pulse Trains

Motor Is Jerky or Weak

Check that there are no mechanical problems at the load causing highly variable loading condition. Disconnect the motor from the load and run it without a load connected. *Keep in mind that the motor will run best with a load of equal inertia; with no load, it will not attain full speed.*

Try to manually turn the motor shaft; this will determine if the motor is maintaining full holding torque. Check the DIP switches for proper current settings.

Motor Overheats

If the motor exceeds its maximum motor case temperature rating, failure will eventually result. Check your DIP Switch settings to ensure that the current setting is correct for the motor you are using (refer to Chapter 6 for proper settings).

Motor Shaft Develops Signs of Wear

The motor shaft may wear prematurely if there is foreign material rubbing against the shaft, or if the load is not coupled properly.

I/O Switch failure

If you are having problems using the Trigger (TR) and Go Home (GH) commands, and the Trigger, Home, CW, CCW, and Sequence Select inputs, you should check your wiring for proper installation (refer to the I/O wiring diagram in Chapter 6). Use an Ohm meter to verify proper connection of the switches and inputs. If the hardware connection seems correct, you can manually change the input switches and use the IS command to verify if the IFX recognizes the input change. (The IS command provides a hardware status of the IFX inputs.) If the status does not change, check the hardware settings and wiring.

Remote Sequencing (BCD Inputs) failure

If you are having problems trying to run sequences from BCD interfaces, the first thing you must verify is the hardware interface. Use the Ohm meter to verify proper wiring. Then use the IS command to read the status of the inputs. Change the input setting and check the Input Status (IS) again to make sure that the IFX recognized the change in the sequence select input. Make sure that your BCD input is calling the proper sequences. Check Chapter 6, Hardware Reference, for the Sequence Select Table. If you have a problem running a sequence from the remote input, try running the sequence using the XR command before attempting to run it using BCD input.

Reducing Electrical Noise

This section discusses the sources and methods of suppressing electrical noise.

Electrical Noise

When the SD/IFX system is operated in an environment in which there is excessive electrical noise, special care must be taken to eliminate sources of possible noise interference. Potential sources of electrical noise include inductive devices such as solenoids, relays, motors, and motor starters when they are operated by a hard contact. For further information on avoiding electrical noise, refer to the technical data section of the *Compumotor Programmable Motion Control Catalog*.

Noise suppression devices may be necessary when sources of electrical noise are connected to the same AC power source or are in close proximity to electronic equipment. You may also need to install noise suppression devices if you have multiple drives attached to the same AC power source. Figure 7-1 shows some recommended suppression devices for most small loads. For best results, install these devices as close as possible to the inductive load.

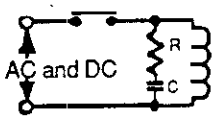
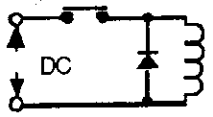
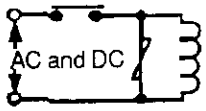
RC	DIODE	VARISTOR (MOV)
		
1. Can be saved for both AC and DC circuits 2. Use 500-1000 ohm for R and 0.1 - 0.2 microF @ 200V for C	For DC circuit only	Can be used for both AC and DC circuits

Figure 7-1. Noise Suppression Devices

Sources of Electrical Noise

Noise-related difficulties can range in severity from minor positioning errors to damaged equipment from runaway motors crashing through limit switches. In microprocessor-controlled equipment, the processor constantly retrieves instructions from memory in a controlled sequence. If an electrical disturbance occurs, it may cause the processor to misinterpret an instruction or access the wrong data. This can be catastrophic to the program and force you to reset the processor.

Since electrical noise is not visible, it is very difficult to detect. You can be certain, however, that noise is generated from the following sources:

- Power line noise
- Externally conducted noise
- Transmitted noise
- Ground loops

The following electrical devices are particularly apt to generate unwanted electrical noise conditions:

- Coil-driven devices (conducted and power line noise)
- SCR-fired heaters (transmitted and power line noise)
- Motors and motor drives (transmitted and power line noise)
- Welders: electric (transmitted and power line noise)

Note that the SD drive must be considered another source of electrical noise.

POWER LINE NOISE

Power line noise is usually easy to resolve due to the wide variety of line filtering equipment that is available to the motion control industry. Only the most severe electrical noise problems will require you to use an isolation transformer. Remember that the SD/IFX system uses a transformer. You will have to use line filtering equipment when other devices connected to the local power line are switching large amounts of current (especially if the switching occurs at a high frequency).

Any device that has coils is likely to disrupt the power line when it is switched off. Surge suppressors, such as metal oxide varistors (MOVs) are capable of limiting this type of electrical noise. A series RC network across the coil is also an effective means of eliminating the problem (resistance: 500 to 1,000 Ω; capacitance: 0.1 to 0.2 μF). Coil-driven devices (inductive loads) include relays, solenoids, contractors, clutches, brakes, and motor starters.

EXTERNALLY CONDUCTED NOISE

Externally-conducted noise is similar to power line noise, but the disturbances are created on signal and ground wires that are connected to the indexer. This kind of noise can get into logic circuit ground or into the processor power supply and scramble the program. The problem in this instance is that control equipment often shares a common DC ground wire that may be connected to several devices (such as a DC power supply, programmable controller, remote switches, etc.). When a source of noise like a relay or solenoid is attached to the DC ground, it may cause disturbances within the indexer.

To solve the noise problem caused by DC mechanical relays and solenoids, you must connect a diode backwards across the coil to clamp the induced voltage kick that the coil will produce. The diode should be rated at four times the coil voltage and ten times the coil current. Using solid state relays is another way to eliminate this problem. See Figure 7-1.

Multiple devices on the same circuit should be grounded together at a single point.

Furthermore, power supplies and programmable controllers often have DC common tied to Earth (AC power ground). As a rule, it is preferable to have the indexer signal ground or DC common floating with respect to Earth. This prevents sources of electrical noise that are grounded to Earth from sending noise into the indexer. When you cannot float the signal ground, you should make the Earth ground connection at only one point.

In many cases, optical isolation may be required to completely eliminate electrical contact between the indexer and a noisy environment. Solid state relays provide this type of isolation.

TRANSMITTED NOISE

Transmitted noise is picked up by external connections to the indexer, and in severe cases can attack an indexer with no external connections. The rack enclosure will typically shield the electronics from this, but openings in the enclosure for connections and front panel controls may *leak*.

When high current contacts are open, they draw an arc, producing a burst of broad spectrum radio frequency noise that can be picked up on a limit switch or other wiring. High-current and high-voltage wires have an electrical field around them and may induce noise on signal wiring, especially when they are tied in the same wiring bundle or conduit.

When this kind of problem occurs, it is time to think about shielding signal cables or isolating the signals. A proper shield surrounds the signal wires to intercept electrical fields, but this shield must be tied to Earth to drain the induced voltages. At the very least, wires should be run in twisted pairs to limit straight line antenna effects.

Most Compumotor cables have shields tied to Earth, but in some cases the shields must be grounded at installation time. Connections external to the rack must be shielded.

Even the worst noise problems in environments near 600 amp welders and 25kW transmitters have been solved using enclosures, conduit, optical isolation,and single point ground techniques.

GROUND LOOPS

Ground Loops are the most mysterious noise problems. They seem to occur most often in systems where a control computer is using RS-232C communication. Symptoms like garbled transmissions and intermittent operation are typical.

The problem occurs in systems where multiple Earth ground connections exist, particularly when these connections are far apart.

Suppose an IFX is controlling an axis, and the limit switches use an external power supply. The IFX is controlled by a computer in another room. If the power supply Common is connected to Earth, the potential exists for ground loop problems. This is because most computers have their RS-232C signal common tied to Earth. The loop starts at the SD/IFX system limit switch ground, goes to Earth through the drive, and on to Earth at the computer. From there, the loop returns to the SD/IFX system through RS-232C signal ground. If a voltage potential exists between drive Earth and remote computer Earth, ground current will flow through the RS-232C ground creating unpredictable results.

The way to test for and ultimately eliminate a ground loop is to lift or *cheat* Earth ground connections in the system until the symptoms disappear.

Defeating Noise

The best time to handle electrical noise problems is before they occur. When a motion system is in the design process, the designer should consider the following set of guidelines for system wiring in order of importance:

- Put surge suppression components on all electrical coils: Resistor/capacitor filters, MOVs, Zener and clamping diodes.
- Shield all remote connections, use twisted pairs. Shield should be tied to Earth at one end.
- Put all electrical components in an enclosure. Keep noisy devices outside. Watch internal temperature.
- Ground signal common wiring at one point. Float this ground from Earth if possible.
- Tie all mechanical grounds to Earth at one point. Run chassis and motor grounds to the frame, and the frame to Earth.
- Isolate remote signals. Solid state relays or opto isolators are recommended.
- Filter the power line. Use common RF filters, and use an isolation transformer for worst case.

A noise problem must be identified before it can be solved. The obvious way to approach a problem situation is to eliminate potential noise sources until the symptoms disappear, as in the case of ground loops. When this is not practical, use the above guidelines to *shotgun* the installation.

References

Information about the equipment referred to may be obtained by calling the numbers listed below.

- Corcom line filters, (312) 680-7400
- Opto-22 optically isolated relays, (714) 891-5861
- Crydom optically isolated relays, (213) 322-4987
- Potter Brumfield optically isolated relays, (812) 386-1000
- General Electric MOVs (315) 456-3266
- Teal Electronics Corporation–specializing in power line products–(800) 888-TEAL.

RS-232C Communications Troubleshooting

Guidelines for troubleshooting 3 wire RS-232C communications are as follows:

- Make certain the transmit (pin 2) of the host is wired to the receive (TB4 pin 1) of the SD/IFX unit. Also make sure that the receive (pin 3) of the host is wired to the transmit (TB4 pin 2) of the SD/IFX unit.

  NOTE: Try switching the receive and transmit wires on either the host or peripheral if you fail to get any communication.

- If you have a daisy-chained system, make sure PL3 (daisy-chain output) is connected properly to PL2 (daisy chain input) of the successive SD/IFX units in the chain. Also, check the back of each motherboard to ensure that Jumper LK2 is set to position **B** on all daisy-chained units except for the last unit in the chain. LK2 of the last unit must be set to position **A**.

- Some serial ports require handshaking. Typically, you can disable the handshaking function by jumpering RTS to CTS (usually pins 4 and 5) and DSR to DTR (usually pins 5 and 25). Refer to your computer or terminal user guide for exact instructions.

- Configure the host and peripheral to the same baud rate, number of data bits, number of stop bits, and parity.

  NOTE: The IFX is configureable in Baud Rate only. Refer to Chapter 2, Getting Started, for instructions on changing the baud rate.

- If you receive double characters (for instance, if you type **A** and receive **AA**) your computer is set to half-duplex. Consult your computer or terminal emulator user manual for instructions on how to change the set-up to full-duplex.

- Use DC common or signal ground as your reference. *DO NOT use earth ground.*

- Cable lengths should not exceed 50 feet unless you are using some form of line driver, optical coupler, or shield. As with any control signal, be sure to shield the cable to earth ground at one end only.

Returning The System

If you must return your SD/IFX system to effect repairs or upgrades, use the following steps:

STEP 1 Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined by Parker Compumotor to be out of warranty.

STEP 2 Before you ship the drive to Parker Compumotor, have someone from your organization with a technical understanding of the SD/IFX system and its application include answers to the following questions:

- What is the extent of the failure/reason for return?
- How long did it operate?
- How many units are still working?
- How many units failed?
- What was happening when the unit failed (i.e., installing the unit, cycling power, starting other equipment, etc)?
- How was the product configured (in detail)?
- What, if any, cables were modified and how?
- With what equipment is the unit interfaced?
- What was the application?
- What was the system sizing (speed, acceleration, duty cycle, inertia torque, friction, etc.)?
- What was the system environment (temperature, enclosure, spacing, unit orientation, contaminants, etc.)?
- What upgrades, if any, are required (hardware, software, user guide)?

STEP 3 Call Parker Compumotor for a Return Material Authorization (RMA) number. Returned products cannot be accepted without an RMA number. The phone number for Parker Compumotor Applications Department is (800) 358-9070.

STEP 4 Ship the unit to:

Parker Compumotor Corporation
5500 Business Park Drive
Rohnert Park, CA 94928
Attn: RMA # xxxxxxx

APPENDICES

Command Listing

A	(Acceleration)
B	(Buffer Status)
BS	(Buffer Size Status)
C	(Continue)
CG	(Correction Gain)
CR	(Carriage Return)
D	(Distance)
DB	(Dead Band)
DW	(Dead Band Window)
E	(Enable Communications)
ER	(Encoder Resolution)
F	(Disable Communications)
FR	(Encoder Functions Report)
FSA	(Set Indexer to Incremental/Absolute Mode)
FSB	(Set Indexer to Motor/Encoder Step Mode)
FSC	(Enable/Disable Position Maintenance)
FSD	(Stop on Stall)
FSE	(Turn on Output 2 on Stall Detect)
FSF	(Kill Motion on Trigger)
FSG	(Turn on Output 1 When Within Dead Band)
FSH	(Enable Stall Detection)
G	(Go)
GH	(Go Home)
^H	(Delete)
H±	(Set Direction)
IS	(Input Status)
K	(Kill)
L	(Loop)
LD	(Limit Disable)
LF	(Line Feed)
MC	(Mode Continuous)
MN	(Mode Normal)
MPA	(Mode Position Absolute)
MPI	(Mode Position Incremental)
MR	(Motor Resolution)
N	(End of Loop)
O	(Output)
OR	(Report Homing Function)
OSB	(Back Up to Home)
OSC	(Define Active State of Home)
OSH	(Reference Edge of Home)
PR	(Absolute Position Report)
PS	(Pause)
PX	(Report Absolute Encoder Position)
PZ	(Set Absolute Counter to Zero)
"	(Quote)
Q1	(Enter Velocity Profiling Mode)
Q2	(Exit Velocity Profiling Mode)
R	(Request Indexer Status)
RA	(Limit Switch Status Report)
RB	(Loop, Pause, Shutdown, Trigger Status Request)
RC	(Closed Loop Status)
RM	(Rate Multiplier in Velocity Streaming Mode)
RS	(Status of Sequence Execution)
RV	(Revision Level)
S	(Stop)
SS	(Software Switch Function Report)
SSA	(RS-232C Echo Control)
SSG	(Clear/Save the Command Buffer On Limit)
SSH	(Clear/Save the Command Buffer on Stop)
ST	(Shutdown)
STM	(Defaults [and status])
SV	(Servoing Parameter)
T	(Time)
TR	(Wait for Trigger)
TS	(Trigger Input Status)
U	(Pause and Wait for Continue)
V	(Velocity)
VS	(Set Start/Stop Velocity)
W1	(Signed Binary Position Report)
W3	(Hexadecimal Position Report)
XC	(Sequence Checksum)
XD	(Sequence Definition)
XE	(Sequence Erase)
XP	(Set Power-up Sequence Mode)
XQ	(Sequence Interrupt Run Mode)
XR	(Run a Sequence)
XRP	(Sequence Run with Pause)
XSD	(Sequence Status Definition)
XSP	(Sequence Status Power-up)
XSR	(Sequence Status Run)
XSS	(Sequence Status)
XT	(Sequence Termination)
XU	(Upload Sequence)
XZ	(Set Power-up Sequence to Zero)
Y	(Stop Loop)
Z	(Reset)

ASCII Table

DEC	HEX	GRAPHIC	DEC	HEX	GRAPHIC	DEC	HEX	GRAPHIC
ØØØ	ØØ	NUL	Ø52	34	4	1Ø4	68	h
ØØ1	Ø1	SOH	Ø53	35	5	1Ø5	69	i
ØØ2	Ø2	STX	Ø54	36	6	1Ø6	6A	j
ØØ3	Ø3	ETX	Ø55	37	7	1Ø7	6B	k
ØØ4	Ø4	EOT	Ø56	38	8	1Ø8	6C	l
ØØ5	Ø5	ENQ	Ø57	39	9	1Ø9	6D	m
ØØ6	Ø6	ACK	Ø58	3A	:	11Ø	6E	n
ØØ7	Ø7	BEL	Ø59	3B	;	111	6F	o
ØØ8	Ø8	BS	Ø6Ø	3C	<	112	7Ø	p
ØØ9	Ø9	HT	Ø61	3D	=	113	71	q
Ø1Ø	ØA	LF	Ø62	3E	>	114	72	r
Ø11	ØB	VT	Ø63	3F	?	115	73	s
Ø12	ØC	FF	Ø64	4Ø	@	116	74	t
Ø13	ØD	CR	Ø65	41	A	117	75	u
Ø14	ØE	SO	Ø66	42	B	118	76	v
Ø15	ØF	S1	Ø67	43	C	119	77	w
Ø16	1Ø	DLE	Ø68	44	D	12Ø	78	x
Ø17	11	DC1	Ø69	45	E	121	79	y
Ø18	12	DC2	Ø7Ø	46	F	122	7A	z
Ø19	13	DC3	Ø71	47	G	123	7B	{
Ø2Ø	14	DC4	Ø72	48	H	124	7C	|
Ø21	15	NAK	Ø73	49	I	125	7D	}
Ø22	16	SYN	Ø74	4A	J	126	7E	~
Ø23	17	ETB	Ø75	4B	K	127	7F	DEL
Ø24	18	CAN	Ø76	4C	L			
Ø25	19	EM	Ø77	4D	M			
Ø26	1A	SUB	Ø78	4E	N			
Ø27	1B	ESC	Ø79	4F	O			
Ø28	1C	FS	Ø8Ø	5Ø	P			
Ø29	1D	GS	Ø81	51	Q			
Ø3Ø	1E	RS	Ø82	52	R			
Ø31	1F	US	Ø83	53	S			
Ø32	2Ø	SPACE	Ø84	54	T			
Ø33	21	!	Ø85	55	U			
Ø34	22	"	Ø86	56	V			
Ø35	23	#	Ø87	57	W			
Ø36	24	$	Ø88	58	X			
Ø37	25	%	Ø89	59	Y			
Ø38	26	&	Ø9Ø	5A	Z			
Ø39	27	`	Ø91	5B	[			
Ø4Ø	28	(	Ø92	5C	\			
Ø41	29	)	Ø93	5D	]			
Ø42	2A	*	Ø94	5E	^			
Ø43	2B	+	Ø95	5F	_			
Ø44	2C	,	Ø96	6Ø	'			
Ø45	2D	-	Ø97	61	a			
Ø46	2E	.	Ø98	62	b			
Ø47	2F	/	Ø99	63	c			
Ø48	3Ø	Ø	1ØØ	64	d			
Ø49	31	1	1Ø1	65	e			
Ø5Ø	32	2	1Ø2	66	f			
Ø51	33	3	1Ø3	67	g			

Warranty

The items described in this document are hereby offered for sale at prices to be established by Parker Hannifin Corporation, its subsidiaries and its authorized distributors. This offer and its acceptance by any customer ("Buyer") shall be governed by all of the following Terms and Conditions. Buyers order for any item described in its document, when communicated to Parker Hannifin Corporation, its subsidiary or an authorized distributor ("Seller") verbally or in writing, shall constitute acceptance of this offer.

1. Terms and Conditions of Sale
All descriptions, quotations, proposals, offers, acknowledgements, acceptances and sales of Seller's products are subject to and shall be governed exclusively by the terms and conditions stated herein. Buyer's acceptance of any offer to sell is limited to these terms and conditions. Any terms or conditions in addition to, or inconsistent with those stated herein, proposed by Buyer in any acceptance of any offer by Seller, are hereby objected to. No such additional, different or inconsistent terms and conditions shall become part of the contract between Buyer and Seller unless expressly accepted in writing by Seller.

Seller's acceptance of any offer to purchase by Buyer is expressly conditional upon Buyer's assent to all the terms and conditions stated herein, including any terms in addition to, or inconsistent with those contained in Buyer's offer. Acceptance of Seller's products shall in all events constitute such assent.

2. Payment
Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Amounts not timely paid shall bear interest at the rate of 1-1/2% for each month or a portion thereof that Buyer is late in making payment. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer's receipt of the shipment.

3. Delivery
Unless otherwise provided on the face hereof, delivery shall be made F.O.B.Seller's plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller's delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

4. Warranty
Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of five years from the date of shipment to Buyer. All other items shall be free from defects in material or workmanship for a period of one year from the date of shipment to buyer. THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTABILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED. NOTWITHSTANDING THE FOREGOING, THERE ARE NO WARRANTIES WHATSOEVER ON ITEMS BUILT OR ACQUIRED WHOLLY OR PARTIALLY, TO BUYER'S DESIGNS OR SPECIFICATIONS.

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Any designs, tools, patterns, materials, drawings, confidential information, or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Sellers shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

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Unless otherwise indicated on the face hereof, all prices and changes are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the terms sold hereunder. If any such taxes must be paid by Seller if Seller is liable for the collection of such tax, the amount for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

10. Indemnity for Infringement of Intellectual Property Rights
Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets, or similar rights except as provided in the Part 10. Seller will defend and indemnify Buyer against allegations of infringement of US patents, US trademarks, copyrights, trade dress, and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in any action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at his sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it non-infringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination, or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights. If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses, or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret, or any similar right.

11. Force Majeure
Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials, and any other cause beyond Seller's control.

12. Entire Agreement/ Governing Law
The terms and conditions set forth herein, together with any amendments, modifications, and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder of this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

GLOSSARY

Absolute Positioning
Refers to a motion control system employing position feedback devices (absolute encoders) to maintain a given mechanical location.

Absolute Programming
A positioning coordinate reference wherein all positions are specified relative to some reference, or "home" position. This is different from incremental programming, where distances are specified relative to the current position.

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 position and actual position of a motor or mechanical system. Motor accuracy is usually specified as an angle representing the maximum deviation from expected position.

Address
Multiple devices, each with a separate address or unit number, can be controlled on the same bus, . The address allows the host to communicate individually to each device.

Ambient Temperature
The temperature of the cooling medium, usually air, immediately surrounding the motor or another device.

ASCII
American Standard Code for Information Interchange. This code assigns a number to each numeral and letter of the alphabet. In this manner, information can be transmitted between machines as a series of binary numbers.

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 bits transmitted per second. Typical rates include 300, 600,1200, 2400, 4800, 9600, 19,200. This means at 9600 baud, one character can be sent nearly every millisecond.

BCD
Binary Coded Decimal is an encoding technique used to describe the numbers 0 through 9 with four digital (on or off) signal lines. Popular in machine tool equipment, BCD interfaces are now giving way to interfaces requiring fewer wires—such as RS-232C.

Bipolar
The Drive current is bi-directional through each motor phase. There are two motor phases: Phase A (A+/A-) and Phase B (B+/B-).

Bit
Abbreviation of Binary Digit, the smallest unit of memory equal to 1 or 0.

Block Diagram
A simplified schematic representing components and signal flow through a system.

Bode Plot
A graph of system gain and phase versus input frequency which graphically illustrates the steady state characteristics of the system.

Break Frequency
Frequency(ies) at which the gain changes slope on a Bode plot. (Break frequencies correspond to the poles and zeroes of the system.)

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.

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.

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.

Crossover Frequency
The frequency at which the gain intercepts the 0 dB point on a Bode Plot. (Used in reference to the open-loop gain plot.)

Daisy-Chain
A term used to describe the linking of several RS-232C devices in sequence such that a single data stream flows through one device and on to the next. Daisy-chained devices are distinguished by device addresses, which serve to indicate the desired destination for data in the stream.

Damping
An indication of the rate of decay of a signal to its steady state value. Related to settling 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.

Data Bits
Since the ASCII character set consists of 128 characters, computers may transmit only seven bits of data. However, most computers support an eight bit extended ASCII character set.

DCE
Data Communications Equipment transmits on pin three and receives on pin two.

Dead Band
A range of input signals for which there is no system response.

Decibel
A logarithmic measurement of gain. If G is a system gain (ratio of output to input), then 20 log G equals gain in decibels (dB).

Delimiter
A character (space or carriage return) used to separate fields in a command.

Detent Torque
The minimal torque present in an unenergized motor. The detent torque of a Compumotor or step motor is typically about one percent of its static energized torque.

Drive
The power electronics portion of the system. This unit controls the power to the motor, providing full-step or half-step operation.

DTE
Data Communications Equipment transmits on pin two and receives on pin three.

Duty Cycle
For a repetitive cycle, the ratio of on time to total cycle time.
Duty Cycle = *On Time* ÷ *On Time + Off Time*

Efficiency
The ratio of power output to power input.

Encoder
A device which translates mechanical motion into electronic signals used for monitoring position or velocity.

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).

Full Duplex
The terminal will display only received or echoed characters.

Gain
The ratio of system output signal to system input signal.

Half Duplex
In half duplex mode, a terminal will display every character transmitted. It may also display the received character.

Hand Shaking Signals
RST: Request To Send
CTS: Clear To Send
DSR: Data Set Ready
DTR: Data Terminal Ready

Holding Torque
Sometimes called static torque, it specifies the maximum external force or torque that can be applied to a stopped, energized motor without causing the rotor to rotate continuously.

Home
A reference position in a motion control system, usually derived from a mechanical datum. Often designated as the "zero" position.

Hysteresis
The difference in response of a system to an increasing or a decreasing input signal.

IEEE-488
A digital data communications standard popular in instrumentation electronics. This parallel interface is also known as GPIB, or General Purpose Interface Bus.

Incremental Motion
A motion control term that is used to describe a device that produces one step of motion for each step command (usually a pulse) received.

Incremental Programming
A coordinated system where position or distances are specified relative to the current position.

Indexer
The control electronics portion of the system, providing communication with the external I/O. It allows you to program sequences and direct motion control.

Inertia
A measure of an object's resistance to a change in velocity. The larger an object's inertia, the larger the torque that is required to accelerate or decelerate it. Inertia is a function of an object's mass and its shape.

Inertial Match
For most efficient operation, the system coupling ratio should be selected so that the reflected inertia of the load is equal to the rotor inertia of the motor.

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.

Logic Ground
An electrical potential to which all control signals in a particular system are referenced.

Mini-stepping
An electronic control technique that proportions the current in a step motor's windings to provide additional intermediate positions between poles. Produces smooth rotation over a wide speed range and high positional resolution.

Motherboard
A printed circuit board that provides electrical and communication connections between internal electronic rack-mount components and external system components. The motherboard is mounted on the back of the rack assembly.

Null Modem
A simple device or set of connectors which switches the receive and transmit lines of a three wire RS-232C connector.

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
Refers to a motion control system where no external sensors are used to provide position or velocity correction signals.

Opto-Isolated
A method of sending a signal from one piece of equipment to another without the usual requirement of

common ground potentials. The signal is transmitted optically with a light source (usually a Light Emitting Diode) and a light sensor (usually a photosensitive transistor). These optical components provide electrical isolation.

Oscillator
An electronic device that produces pulses at preset rates to control the drive's velocity output.

Parallel
Refers to a data communication format wherein many signal lines are used to communicate more than one piece of data at the same time.

Parity
An RS-232C error detection scheme which can detect an odd number of transmission errors.

Phase Angle
The angle at which the steady state input signal to a system leads the output signal.

Phase Margin
The difference between 180 degrees and the phase angle of a system at its crossover frequency.

PLC
Programmable logic controller. An industrial control device that turns on and off outputs based upon responses to inputs.

Pole
A frequency at which the transfer function of a system goes to infinity.

Pulse Rate
The frequency of the step pulses applied to a motor driver. The pulse rate multiplied by the resolution of the motor/drive combination (in steps per revolution) yields the rotational speed in revolutions per second.

Quadrature
A type of incremental encoder output in which the two square wave outputs are offset by 90°.

Ramping
The acceleration and deceleration of a motor. May also refer to the change in frequency of the applied step pulse train.

Rated Torque
The torque producing capacity of a motor at a given speed. This is the maximum torque the motor can deliver to a load and is usually specified with a torque/speed curve.

Relative Accuracy
Also referred to as "Step to Step Accuracy," this specification tells how microsteps can change in size. In a perfect system, microsteps would all be exactly the same size, but drive characteristics and the absolute accuracy of the motor cause the steps to expand and contract by an amount up to the relative accuracy figure. The error in not cumulative.

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 required for a motor's shaft to rotate one complete revolution.

Ringing
Oscillation of a system following a sudden change in state.

RS-232C
A serial data communications standard for encoding a string of information on a single line in a time sequential format. The standard specifies the proper voltage and timing requirements so that different manufacturers' devices are compatible.

Sequence
A series of motion control commands. These commands are created, stored, and executed from the indexer's EEPROM.

Short-Circuit
A defect in a winding that causes part of the normal electrical circuit to be bypassed. This frequently results in reducing the resistance or impedance to such an extent (near zero) as to cause overheating of the circuit, and subsequent burnout.

Slew
In motion control, the portion of a move made at a constant non-zero velocity.

Speed
Used to describe the linear or rotational velocity of a motor or other object in motion.

Start Bits
RS-232C character transmissions begin with a bit which signals the receiver that data is now being transmitted.

Static Torque
The maximum torque available at zero speed.

Step Angle
The angle the shaft rotates upon receipt of a single step command.

Stiffness
The ability to resist movement induced by an applied torque. Is often specified as a torque displacement curve, indicating the amount a motor shaft will rotate upon application of a known external force when stopped.

Stop Bits
When using RS-232C, one or two bits are added to every character to signal the end of a character.

Synchronism
A motor rotating at a speed correctly corresponding to the applied step pulse frequency is said to be in synchronism. Load torques in excess of the motor's capacity (rated torque) will cause a loss of synchronism. This condition is not damaging to a step motor.

Text/Echo (Off/On)
This setup allows received characters to be re-transmitted back to the original sending device. Echoing characters can be used to verify or "close the loop" on a transmission.

Torque
Force tending to produce rotation.

Torque-to Inertia Ratio
Defined as a motor's holding torque divided by the inertia of its rotor. The higher the ratio, the higher a motor's maximum acceleration capability will be.

Transfer Function
A mathematical means of expressing the output to input relationship of a system.

TTL
Transistor-Transistor Logic. Describes a common digital logic device family that is used in most modern digital electronics. TTL signals have two distinct states that are described with a voltage—a logical "zero" or "low" is represented by a voltage of less than 0.8 volts and a logical "one" or "high" is represented by a voltage from 2.5 to 5 volts.

XON/XOFF
Two ASCII characters supported in some serial communication programs. If supported, the receiving device transmits an XOFF character to the host when its character buffer is full. The XOFF character directs the host to stop transmitting characters to the device. Once the buffer empties the device will transmit an XON character to signal the host to resume transmission.

Zero
A frequency at which the transfer function of a system goes to zero.

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