IMS™

# INTELLIGENT MOTION SYSTEMS, INC.

*Excellence in Motion™*

# PANTHER LD

## MINIATURE HIGH PERFORMANCE
## MICROSTEPPER DRIVER & POWER SUPPLY

## HARDWARE REFERENCE MANUAL

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## INTRODUCTION

The PANTHER LD is a high performance, low cost microstepping driver with integral power supply that incorporates advanced surface mount and ASIC technology. The PANTHER LD is small, easy to interface and use, yet powerful enough to handle the most demanding applications.

The heart of the PANTHER LD is our IM483 miniature OEM microstepping driver which utilizes our highly integrated IM2000 microstepping controller IC developed at IMS.

IMS recognizes that cost and size are important criteria in many low and medium power applications. The PANTHER LD was developed to meet those needs along with innovative features found only in IMS drivers.

The PANTHER LD allows you to change the number of microsteps per step at anytime. There is no need to reset the drive. Built into the driver are 14 different resolutions in both binary and decimal. This feature will allow the user to rapidly move long distances, yet precisely position the motor at the end of its movement without the expencse of high performance controllers.

Incorporated into the PANTHER LD driver are proprietary circuits that minimizes ripple current while maintaining a 20 KHz chopping rate. This prevents additional motor heating that is common with drivers requiring higher chopping rates. Now low inductance stepper motors can be used to improve high speed performance and peak system efficiency.

## FEATURES

- LOW COST
- EXTREMELY COMPACT 2.3 X 3.9 X 4.4
- INTEGRAL DRIVER & POWER SUPPLY
- HIGH OUTPUT CURRENT (3 AMPS RMS, 4 AMPS PEAK)
- NO MINIMUM INDUCTANCE
- FAULT & POWER INDICATORS
- 10 MHz STEP CLOCK RATE
- OPTICAL ISOLATION
- AUTOMATIC CURRENT REDUCTION
- ANY WAY SHORT CIRCUIT AND OVER TEMPERATURE PROTECTION
- UP TO 51,200 STEPS/REV
- AUTOMATICALLY SWITCHES FROM SLOW TO FAST DECAY FOR UNMATCHED PERFORMANCE
- 14 SELECTABLE RESOLUTIONS -- BOTH IN DECIMAL AND BINARY
- FAULT OUTPUT
- OPTIONAL SIDE OR RACK MOUNTING
- NUMBER OF MICROSTEPS PER STEP CAN BE CHANGED ON THE FLY WITHOUT MOTOR MOVEMENT INTERRUPTION
- 20KHz CHOPPING RATE
- OPTIONAL ON BOARD INDEXER AND ENCODER FEEDBACK

PATENTS PENDING

## PIN FUNCTION

### CONNECTOR P2

| PIN # | DESCRIPTION |
|---|---|
| 1-4 | **Microstep Select Inputs (0-3):** These inputs select the number of microsteps per step. They are non-isolating binary encoded inputs. For more information refer to Section 10. |
| 5 | **Step Clock Input:** A positive going edge on this isolated input advances the motor one increment. The size of the increment is dependent on the Microstep Select Inputs. |
| 6 | **Direction:** This isolated input is used to change the direction of the motor. Physical direction also depends on the connection of the motor windings. For timing information refer to Section 12. |
| 7 | **Enable Input:** This isolated input is used to enable/disable the output section of the driver. When HIGH (open) the outputs are enabled. However, this input does not inhibit the step clock. Therefore when enabled the outputs will update by the number of clock pulses (if any) applied to the driver while it had been disabled. |
| 8 | **Reset:** When LOW, this isolated input will reset the driver (outputs will disable). When released, the driver will be at its initial state (Phase A off, Phase B full on). For more information refer to Section 12. |
| 9 | **Opto Supply (+5 VDC):** This input is used to supply current to the isolated inputs. A higher voltage may be used, but care should be taken to limit the current through the optocoupler. For more information refer to Section 11 |
| 10 | **Fault:** This open collector output indicates a short circuit has occurred. This output is active low. For more information refer to Section 14. |
| 11 | **Ground:** Non-isolated internal driver ground. |
| 12 | **Current Adjust:** Phase Current Adjustment input. A resistor is connected between this input and the ground input (connector P2, Pin 11) to adjust the maximum phase current in the motor. A resistor MUST be connected to this input. Refer to Section 7 for further information and resistor values. |
| 13 | **Reduction Adjust:** Phase Current Adjustment input. A resistor between this pin and pin 12 (Connector P2, Current Adjust) will proportionately reduce the current in both windings approximately 1 second after the last positive edge of the step clock input. The amount of current reduction will depend on the value of the resistor used. For further information refer to Section 13. |

### CONNECTOR P1

| PIN # | DESCRIPTION |
|---|---|
| 1,2 | **A:** Phase A of the Stepping Motor is connected between Pin 1 and 2. For further information refer to Section 8. |
| 3,4 | **B:** Phase B of the Stepping Motor is connected between Pin 3 and Pin 4. For further information refer to Section 8. |
| 5 | **AC Input:** Neutral |
| 6 | **AC Input:** Line |

## ABSOLUTE MAXIMUM RATING

Table 1

| | |
|---|---|
| INPUT VOLTAGE | 90 TO 130 VAC |
| OUTPUT CURRENT | 5 AMPS PEAK |
| HOUSING TEMPERATURE | +60 C |
| STORAGE TEMPERATURE | –40 TO +125 C |
| INPUT CURRENT (INPUT PINS P2:5,6,7,8) | 15 mA |

## ELECTRICAL SPECIFICATIONS

**Table 2**

TA = 25 C, V = 120 VAC

| | TEST CONDITION | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| PHASE OUTPUT CURRENT | RMS | 0.4 | | 3 | A |
| PHASE OUTPUT CURRENT | PEAK | | | 4 | A |
| ACTIVE POWER DISSIPATION | IOUT = 3 AMPS RMS | | | 12 | W |
| INPUT FORWARD CURRENT | (ISOLATED INPUTS) | | 7.0 | 15 | mA |
| INPUT FORWARD VOLTAGE | (ISOLATED INPUTS) | | 1.5 | 1.7 | V |
| INPUT REVERSE BREAKDOWN VOLTAGE | (ISOLATED INPUTS) | 5 | | | V |
| OUTPUT CURRENT | FAULT OUTPUT | | | 25 | mA |
| COLLECTOR-EMITTER VOLTAGE | FAULT OUTPUT | | | 140 | V |
| COLLECTOR-EMITTER SATURATION VOLTAGE | FAULT OUTPUT $I_{CS}$ = 25 mA DC | | | 0.2 | V |

**NOTE:** The aluminum housing is electrically isolated.

## MECHANICAL SPECIFICATIONS

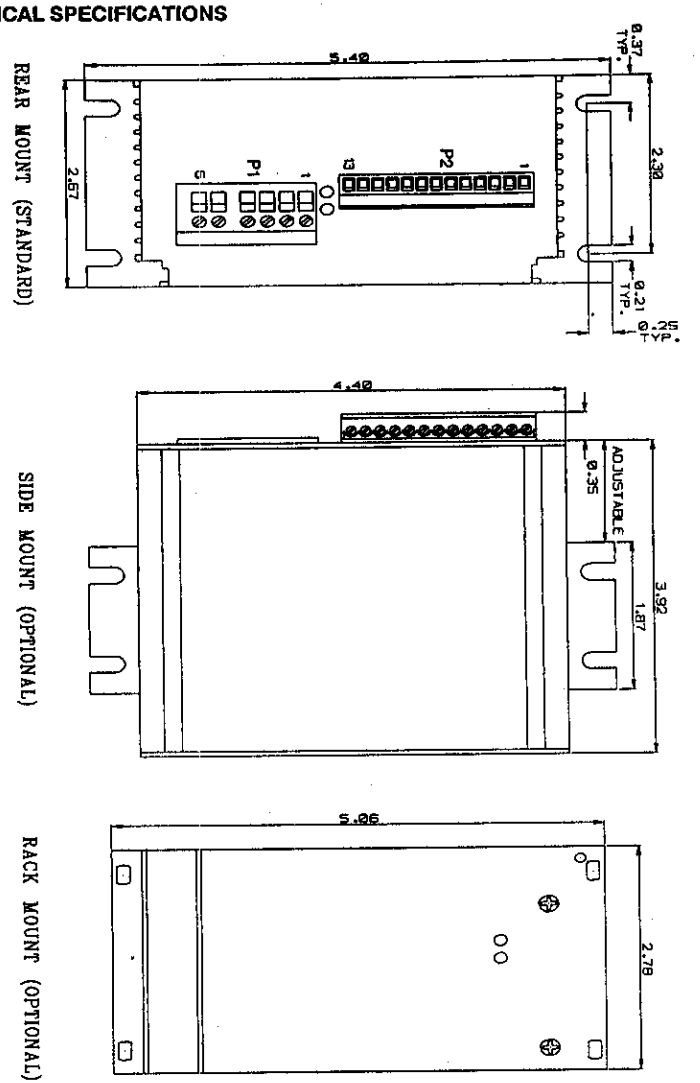



Fig. 1

## THERMAL SPECIFICATIONS

Table 3

| | |
|---|---|
| OPERATING TEMPERATURE | 0 TO +50 C |
| STORAGE TEMPERATURE | -40 TO +125 C |
| HOUSING TEMPERATURE ( MAX ) | +60 C |

## OUTPUT CURRENT

### DETERMINING OUTPUT CURRENT

The motor OUTPUT CURRENT used for MICROSTEPPING is determined differently from that of a HALF/FULL STEP driver.

In the PANTHER LD, a sine/cosine output function is used in rotating the motor. Therefore the output current of the specified motor is equal to the RMS current of the driver.

The CURRENT ADJUSTMENT RESISTOR used to set the output current of the PANTHER LD sets the PEAK output current of the sine/cosine waves. Therefore the specified motor current (which is the RMS value) should be multiplied by 1.4 in order to determine the PEAK value to which the PANTHER LD will be set.

EXAMPLE:

IMS motor number HM200-2232-190 A8 has a specified PHASE CURRENT of 2.7 amps when connected in parallel.

Therefore 2.7 X 1.4 = 3.78 amps

The Resistor Value = OUTPUT CURRENT/.002 or in this example 3.78/.002 = 1,890 ohms.

Table 4 shows commercially available resistors for a given current.

**Note:** Stepper motors can be configured as 4, 6, or 8 leads. Each configuration requires different currents. shown below are the different lead configurations and the procedures to determine their output current

**4 Lead Motors:** Use specified motor current to determine tne current adjustment resistor value.

**6 Lead Motors:** 1) When configuring a 6 lead motor in a half coil configuration ( I.e. connected from one end of the coil to the center tap( higher speed configuration)) use the specified per phase (or unipolar) current rating to determine the current adjustment resistor value.

2) When configuring the motor so the entire coil is used (I.e. connected from end to end with the center tap floating (higher torque configuration)) multiply the per phase (or unipolar) current rating by 0.7. Use this result to determine the current adjustment resistor value.

**8 Lead Motors:** SERIES CONNECTION When configuring the motor windings in series, multiply the per phase (or unipolar) current rating by 0.7. Use this result to determine the current adjustment resistor value.

PARALLEL CONNECTION When configuring the motor windings in parallel, multiply the per phase (or unipolar) current rating by 1.4. Use this result to determine the current adjustment resistor value.

**Note:** After the current has been determined, according to the motor connections above, follow the procedure Determining Output Current above to find the PEAK current value. Then use Table 4 to choose the proper resistor value.

**WARNING!** Although stepping motors will run hot when configured correctly, damage may occur to the motor if a higher than specified current is used. Most specified motor currents are maximum values. Care should be taken when exceeding these ratings.

## SETTING OUTPUT CURRENT

The OUTPUT CURRENT on the PANTHER LD is set by an external 1/8 watt (or higher) resistor between pins 11 and 12 of connector P2. This resistor determines the per phase peak output current of the driver. The PANTHER LD uses a 1mA current source to establish the reference voltage needed to control the output current. The relationship between the output current and the resistor value is as follows:

OUTPUT CURRENT (Amps) = .002 x Resistor Value (ohms)

Table 4 shows the resistor values with respect to output current.

**WARNING!:** A current adjustment resistor is always necessary to keep the drive in a safe operating region. **Do not operate driver without a current adjustment resistor.**

NOTE: When connecting the CURRENT ADJUSTMENT resistor between Pins 11 and 12 of Connector P2 the leads should be as short as possible to help minimize the noise coupled into the driver (See Figure below).

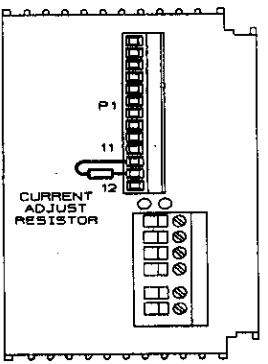



**Fig. 2**

## RESISTOR TABLE

Table 4

| OUTPUT CURRENT | RESISTOR VALUE ( 1% ) |
|---|---|
| 0.4 | 200 |
| 0.6 | 301 |
| 0.8 | 392 |
| 1.0 | 499 |
| 1.2 | 590 |
| 1.4 | 698 |
| 1.6 | 787 |
| 1.8 | 887 |
| 2.0 | 1000 |
| 2.2 | 1100 |
| 2.4 | 1210 |
| 2.6 | 1300 |
| 2.8 | 1400 |
| 3.0 | 1500 |
| 3.2 | 1580 |
| 3.4 | 1690 |
| 3.6 | 1780 |
| 3.8 | 1910 |
| 4.0 | 2000 |

## MOTOR SELECTION

The PANTHER LD is a Bipolar drivers which works equally well with both Bipolar and Unipolar motors,( i.e. 8 and 4 lead motors and 6 lead center tapped motors (see section 8.2, Connecting the Motor)).

To maintain a given set motor current, the PANTHER LD chops the voltage using a constant chopping frequency and a varying duty cycle. Duty cycles that exceed 50% can cause unstable chopping. This characteristic is directly related to the motor's winding resistance. To avoid this situation, it is necessary to choose a motor with a low winding resistance. The lower the winding resistance (hence lower winding inductance) the higher the step rate.

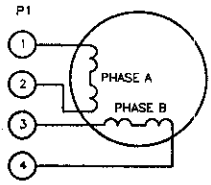
Since the PANTHER LD is a constant current source, it is not necessary to use a motor that is rated at the same voltage as the supply voltage. What is important is that the PANTHER LD is set to the motor's rated current.

The higher the voltage used the faster the current can flow through the motor coils. This in turn means a higher step rate. Care should be taken not to exceed the maximum voltage of the driver.

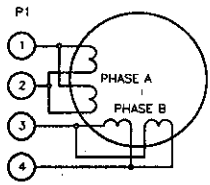
Therefore in choosing a motor for a system design, the best performance for a specified torque is a motor with the lowest possible winding resistance used in conjunction with the highest possible driver voltage.

## CONNECTING THE MOTOR

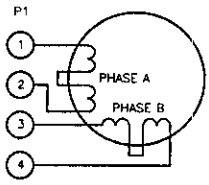
Phase A of the Stepping Motor is connected between pins 1 and 2 on connector P1. Phase B of the Stepping Motor is connected between pins 3 and 4 on connector P1. The following drawings illustrate the connection of 4,6, and 8 Lead Stepping Motors to the PANTHER LD Driver.



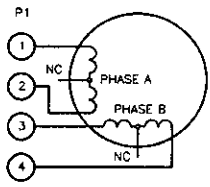

4 LEAD MOTOR



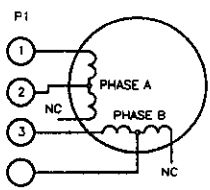

8 LEAD MOTOR
PARALLEL CONNECTION




8 LEAD MOTOR
SERIES CONNECTION




6 LEAD MOTOR
HIGHER TORQUE CONFIGURATION
NC: NO CONNECTION




6 LEAD MOTOR
HIGHER SPEED CONFIGURATION
NC: NO CONNECTION

**Fig. 3**

NOTE: The physical direction of the motor with respect to the direction input will depend on the connection of the motor windings. To reverse the direction of the motor with respect to the direction input, switch the wires on phase A or phase B outputs.

**Warning !! Do not connect or disconnect motor leads with power applied !!**

## CONNECTING POWER

Pins 5 and 6 on connector P1 are used to connect the AC Power to the PANTHER LD. The wire size used to connect the power source to the driver should be at least 18 gage. Heavier wire should be used for longer distances between the power and the driver. The power requirement are as follows:

**Table 5**

## POWER SUPPLY SPECIFICATIONS

AC Input: ..... 90 to 128 VAC.

* Current..... Amps (MAX)

**Warning !! Do not connect or disconnect motor leads with power applied !!**

## FUSE

The Panther LD contains a fuse that is mounted inside the housing.

To replace the fuse the front panel must be removed along with the four allen head screws on the side of the housing.

After removable of the cover and the side screws, slide the enclosed printed circuit board assembly from the housing. The fuse is located just behind the P1 connector. It is only necessary to remove the board assembly approximately 2 inches to access the fuse.

NOTE: When reinstalling the assembly, take care not to destroy the thermal pad attached to the driver module.

Fuse Type: 5mm, 250 volt, 2 amp slow blow

NOTE: Under normal operating conditions it should not be necessary to replace the internal fuse. If the unit operates incorrectly or there is no power indicator present when the unit is powered, the unit should be returned to the factory for service.

## MICROSTEP SELECTION

The number of microsteps per step is selected by the non-isolated inputs on pins 1, 2, 3, and 4 of Connector P2. Table 6 shows the standard resolution values along with the associated inputs for pins 1, 2, 3, and 4.

**Table 6**

| RESOLUTION (Microsteps Per Step) | STEPS/REVOLUTION (1.8°/Step MOTORS) | MICROSTEP Select 0 | MICROSTEP Select 1 | MICROSTEP Select 2 | MICROSTEP Select 3 |
|---|---|---|---|---|---|
| **BINARY** | | | | | |
| 2 | 400 | Ground | Ground | Ground | Ground |
| 4 | 800 | **Floating | Ground | Ground | Ground |
| 8 | 1,600 | Ground | Floating | Ground | Ground |
| 16 | 3,200 | Floating | Floating | Ground | Ground |
| 32 | 6,400 | Ground | Ground | Floating | Ground |
| 64 | 12,800 | Floating | Ground | Floating | Ground |
| 128 | 25,600 | Ground | Floating | Floating | Ground |
| 256 | 51,200 | Floating | Floating | Floating | Ground |
| **DECIMAL** | | | | | |
| 5 | 1,000 | Ground | Ground | Ground | Floating |
| 10 | 2,000 | Floating | Ground | Ground | Floating |
| 25 | 5,000 | Ground | Floating | Ground | Floating |
| 50 | 10,000 | Floating | Floating | Ground | Floating |
| 125 | 25,000 | Ground | Ground | Floating | Floating |
| 250 | 50,000 | Floating | Ground | Floating | Floating |

** Leaving the inputs FLOATING is equivalent to +5VDC (logic) being connected to the input.
The Inputs are internally pulled up to +5VDC via a 10K resistor.

When the number of microsteps per step are changed such that the PANTHER LD does not fall on a full step (i.e. zero crossing of the sine/cosine waveforms) the PANTHER LD will readjust itself at the next pulse that would overshoot the full step position to the full step position. This feature allows the PANTHER LD to readjust the motor to common position no matter what resolution is chosen or when it is changed.

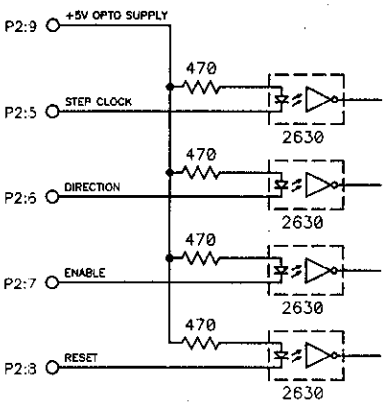
## OPTICALLY ISOLATED INPUTS

The following inputs to the PANTHER LD are Optically Isolated.

**Table 7**

**Connector P2**

| | |
|---|---|
| Step Clock | Pin 5 |
| Direction | Pin 6 |
| Enable | Pin 7 |
| Reset | Pin 8 |




OPTICALLY ISOLATED INPUTS

**Fig. 4**

The Isolated inputs may by powered be a DC voltage other than +5 VDC. In doing so, care should be taken to limit this current, an external resistor should be placed in series with the input pins (5,6,7,8). The value of the resistor should be calculated such that the input current is approximately equal to the value listed in the Electrical Specifications in Table 2.

**WARNING!** If using a voltage other than +5VDC, the current through the optocoupler must NOT exceed the maximum limit.

## TIMING

The Direction and Microstep Resolution Select inputs are syncronized with the positive going edge of the Step Clock input. When the Step Clock input goes high, the Direction and Microstep Select inputs are latched and futher changes to the inputs are ignored until the next rising edge of the Step Clock input.

After these signals are latched, the PANTHER LD looks to see if any changes have occured to the Direction and the Microstep Select inputs. If a change has occurred, the PANTHER LD will execute the change before taking the next step. Only AFTER the change has been executed will the step be taken. If no change has occured the PANTHER LD will simply take the next step. (This feature works as an automatic debounce for the Direction and Microstep Select inputs.)

The minimum pulse width for the Step Clock input is 75 nS. The typical execution time for a Direction or Microstep Select change is 100nS. The typical execution time for a Step input is 100nS.

The Reset and Enable inputs are asynchronous to any input and can be changed at any time.

The Reset requires a minimum pulse width of 500 nS.

The Fullstep output typically occurs 75nS after the positive edge of the Step Clock (excluding changes to the Direction or the Microstep Select inputs).

## AUTOMATIC CURRENT REDUCTION

**Built into the PANTHER LD is the ability to automatically reduce the current in the motor windings after the completion of a move.**

The reduction occurs approximately .5 seconds after the last explosive going edge of the Step Clock input. The PANTHER LD will then revert back to the original current setting at the next positive going edge of the Step Clock input.

**To utilize this feature, a resistor must be connected between pins 12 & 13 on connector P2 (see Figure 5). The value of the resistor will determine the amount of current reduction.**

The amount of current per phase in the reduction mode is related to the value of the current adjust resistor and the current reduction resistor. When the current reduction circuit is activated, the current reduction resistor is paralleled with the current adjustment resistor. This lowers the total resistance value, and thus lowers the per phase output current. The relationship between the output current and the resistor's values is as follows:

$$\text{Output Current Reduced (Amps)} = \frac{.002 \times *R(\text{Current Adjust}) \times R(\text{Current Reduction})}{R(\text{Current Adjust}) + R(\text{Current Reduction})}$$

OR

$$R(\text{Current Reduction}) = \frac{\text{Output Current Reduced} \times R(\text{Current Adjust})}{.002 \times R(\text{Current Adjust}) - \text{Output Current Reduced}}$$

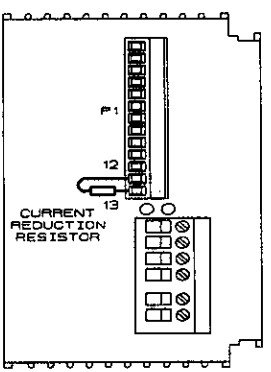



Fig. 5

*Resistor values are in ohms.

NOTE: When connecting the current reduction resistor between pins 12 and 13 of connector P2 , the leads should be as short as possible to help minimize noise coupled into the driver.

## FAULT PROTECTION

The PANTHER LD is internally protected against over temperature and short circuits.

The over temperature protection in the PANTHER LD is built into the power output bridge ICs. This circuit will disable the output if the junction temperature within the IC reaches 150 C. When the temperature has fallen to a safe level the outputs will re-enable.

The short circuit protection consist of PHASE to PHASE, PHASE to GROUND, and +V to PHASE.

If a short circuit is detected by the PANTHER LD, the outputs will be disabled and can not be re-enabled without resetting or powering down the driver. At the same time the open collector FAULT output is turned on, and the Fault LED is activated.

The Fault output is non-isolated and has the ability to sustain the maximum driver voltage. It is capable of sinking up to 25mA and is used to drive the Fault LED. Approximately 10mA is used to drive the Fault LED.

## OPTIONS/ACCESSORIES

| DESCRIPTION | PART NUMBER |
|---|---|
| High Performance Indexer version | PANTHER LI |
| High Performance Indexer and Encoder Feedback version | PANTHER LE |
| Built In RS232 to RS422/485 Connector for LI & LE versions | PANTHER LI2, LE2 |
| GUI Controller Software (Requires †Windows V3.0 or greater) | QuickSTEP™ |
| Side mounting Bracket Kit | PL–SM |
| Rack Mounting Option | –RM |
| Differential Encoder Option for LI & LE versions | –DE |

†Windows is a registered trademark of the Microsoft Corporation.

## WARRANTY

### TWENTY-FOUR (24) MONTH LIMITED WARRANTY

Intelligent Motion Systems, Inc. ("IMS"), warrants only to the purchaser of the Product from IMS (the "Customer") that the product purchased from IMS (the "Product") will be free from defects in materials and workmanship under the normal use and service for which the Product was designed for a period of 24 months from the date of purchase of the Product by the Customer. Customer's exclusive remedy under this Limited Warranty shall be the repair or replacement, at Company's sole option, of the Product, or any part of the Product, determined by IMS to be defective. In order to exercise its warranty rights, Customer must notify Company in accordance with the instructions described under the heading "Obtaining Warranty Service."

This Limited Warranty does not extend to any Product damaged by reason of alteration, accident, abuse, neglect or misuse or improper or inadequate handling; improper or inadequate wiring utilized or installed in connection with the Product; installation, operation or use of the Product not made in strict accordance with the specifications and written instructions provided by IMS; use of the Product for any purpose other than those for which it was designed; ordinary wear and tear; disasters or Acts of God; unauthorized attachments, alterations or modifications to the Product; the misuse or failure of any item or equipment connected to the Product not supplied by IMS; improper maintenance or repair of the Product; or any other reason or event not caused by IMS.

IMS HEREBY DISCLAIMS ALL OTHER WARRANTIES, WHETHER WRITTEN OR ORAL, EXPRESS OR IMPLIED BY LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, **ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE**. CUSTOMER'S SOLE REMEDY FOR ANY DEFECTIVE PRODUCT WILL BE AS STATED ABOVE, AND IN NO EVENT WILL THE IMS BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL, SPECIAL OR INDIRECT DAMAGES IN CONNECTION WITH THE PRODUCT.

This Limited Warranty shall be void if the Customer fails to comply with all of the terms set forth in this Limited Warranty. This Limited Warranty is the sole warranty offered by IMS with respect to the Product. IMS does not assume any other liability in connection with the sale of the Product. No representative of IMS is authorized to extend this Limited Warranty or to change it in any manner whatsoever. No warranty applies to any party other than the original Customer.

IMS and its directors, officers, employees, subsidiaries and affiliates shall not be liable for any damages arising from any loss of equipment, loss or distortion of data, loss of time, loss or destruction of software or other property, loss of production or profits, overhead costs, claims of third parties, labor or materials, penalties or liquidated damages or punitive damages, whatsoever, whether based upon breach of warranty, breach of contract, negligence, strict liability or any other legal theory, or other losses or expenses incurred by the Customer or any third party.

### OBTAINING WARRANTY SERVICE

Warranty service may obtained by a distributor, if the Product was purchased from IMS by a distributor, or by the Customer directly from IMS, if the Product was purchased directly from IMS. Prior to returning the Product for service, a Returned Material Authorization (RMA) number must be obtained. Complete the form at http://www.imshome.com/rma.html after which an RMA Authorization Form with RMA number will then be faxed to you. Any questions, contact IMS Customer Service (860) 295-6102.

Include a copy of the RMA Authorization Form, contact name and address, and any additional notes regarding the Product failure with shipment. Return Product in its original packaging, or packaged so it is protected against electrostatic discharge or physical damage in transit. The RMA number MUST appear on the box or packing slip. Send Product to: Intelligent Motion Systems, Inc., 370 N. Main Street, Marlborough, CT 06447.

Customer shall prepay shipping changes for Products returned to IMS for warranty service and IMS shall pay for return of Products to Customer by ground transportation. However, Customer shall pay all shipping charges, duties and taxes for Products returned to IMS from outside the United States.

# IMS Driver Manual Addendum

## Recommended Wiring

Logic level cables *must not run parallel* to power cables. Power cables will introduce noise into the logic level cables and make your system unreliable.

Logic level cables must be shielded to reduce the chance of EMI induced noise. The shield needs to be grounded at the signal source to AC ground. The other end of the shield *must not* be tied to anything, but allowed to float. This allows the shield to act as a drain.

Motor cabling in excess of 1 foot requires twisted pair shielded cable to reduce the transmission of EMI. The shield must be connected to AC ground at the driver. The other end of the shield *must not* be tied to anything, but allowed to float. This allows the shield to act as a drain.

Power supply leads to the driver need to be twisted. If more than one driver is to be connected to the same power supply, run separate power and ground leads from the supply to each driver.

Recommended Motor and Power Supply Cables:

### Motor Cables

Dual Twisted Pair Shielded (Separate Shields)

| | | |
|---|---|---|
| ≤ 4 Amps RMS per phase motor current | Belden Part #9368 or equivalent | 18 Gauge |
| ≥ 4 Amps RMS per phase motor current | Belden Part #1492A or equivalent | 16 Gauge |

### Power Supply Cables

Twisted Pair (Jacketed)

| | | |
|---|---|---|
| ≤ 4 Amps DC current | Belden Part #9740 or equivalent | 18 Gauge |
| ≥ 4 Amps DC current | Belden Part #8471 or equivalent | 16 Gauge |



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