IMS™

Patent Pending

INTELLIGENT MOTION SYSTEMS, INC.

Excellence in Motion™

SIZES
17, 23 & 34

OPERATING INSTRUCTIONS

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MDrive Motion Control
Revision 031606

Getting Started - MDrive Motion Control

Before you Begin

This Quick Start will allow you to rapidly set-up and connect your system and "Turn" your MDrive Motion Control utilizing the Immediate Mode of the IMS Terminal User Interface Software. However, it is recommended that you read this entire MDrive Motion Control Manual prior to placing the unit into full operation.

Tool and Equipment Required

MDrive Motion Control Unit

IMS MD-CC200-000 Communication Cable or equivalent

IMS Product CD

An Unregulated Power Supply (See specifications for your exact MDrive Motion Control and required voltage.)

Basic Tools: Wire Cutters / Strippers / Screwdriver

Wire for Power Supply (See specifications for your exact MDrive Motion Control.)

An IBM compatible PC with Windows 9x (95/98) or Windows NT (Windows NT4.0 SP6, Windows 2000 SP1, Windows XP)

10 MB hard drive space

A free serial communications port

Connecting the Power Supply

Using the recommended wire (see the specifications for your MDrive Motion Control), connect the DC output of the power supply to the red wire on MDrives with flying leads or Pin #7 on units with pluggable connectors.

Connect the power supply ground to the MDrive's black flying lead or Pin #6 on pluggable units.

Connecting Communications

Connect the Host PC to the MDrive Motion Control using the IMS MD-CC200-000 Communication Cable or equivalent.

Install IMS Terminal Software

Insert the IMS CD into the CD Drive of your PC.

The CD will autostart to the IMS CD Main Page. If the CD does not autostart, click "Start > Run" and type "x:\IMS.exe" in the "Open" box and click OK.

NOTE: "x" is your CD ROM drive letter.

Place your mouse pointer over the MDrive Icon. The text message "MDrive Integrated Motor & Electronics" will be displayed. This verifies you have selected the correct software.

Click the MDrive Motor Icon. This opens the MDrive Index Page.

Place the mouse pointer over the menu and select IMS Terminal (Win9x) or IMS Terminal (WinNT). The displayed text will again verify your selection. Click your selection and the "Setup" dialog box will be displayed.

Click SETUP in the Setup dialog box and follow the on-screen instructions.

Once IMS Terminal is installed the Communications Settings can be checked and/or set.

Establishing Communications

Open the IMS Terminal by clicking Start>Programs>IMS Terminal>IMS Term.

On the Menu Bar click <Edit> <Preferences> to display the "Preferences" Dialog Box.

Click the "Comm Settings" tab at the top of the dialog box. The Comm Settings page will be displayed.

Under "Device" near the bottom of the box verify "MDrive" is selected. All other settings should be left as is.

Click OK.

Apply Power to the MDrive Motion Control

Verify all connections are made and apply power to the MDrive Motion Control. Upon Power-Up the following sign-on message should appear in the Terminal window: "Copyright 2001-2004 by Intelligent Motion Systems, Inc."

If you can see this sign-on message then you are up and running! If the sign-on message does not appear, try using a software reset. Hold down the "Ctrl" key and press "C" (^C). If the sign-on message still does not appear then there may be a problem with either the connections, hardware or software configuration of the MDrive Motion Control or Host PC.

There are indicators at the bottom of the Terminal Window that show whether you are Connected or Disconnected, the current Baud Rate and the type of device (MDrive) for which the IMS Terminal is configured.

These three items may be changed directly from this screen by double clicking on them.

Double Click on "Connected" and the system will disconnect.

Double Click on "Disconnect" and the system will connect.

Testing the MDrive Motion Control Setup

NOTE: The character ∧ is used to indicate a space. Do not type this character but be sure to type the space.

Click anywhere within the Terminal Window (Right Window) to activate it.

The Print instruction <PR> is used to report the values of variables and flags.

Type the following: **PR∧VM** and then press ENTER.

The MDrive Motion Control should return a value of 768000

NOTE: The MDrive Motion Control is not case sensitive. You may type in lower or upper case.

Type **VM∧360000** and press ENTER.

Type **PR∧VM** and press ENTER.

The MDrive Motion Control should return a value of 360000

Type **FD** and press ENTER. (FD = Factory Defaults.)

The "Copyright 2001-2003 by Intelligent Motion Systems, Inc." Message should appear.

CONGRATULATIONS! You are communicating.

Make the MDrive Motion Control Move

NOTE: You may want to put a small piece of tape on the motor shaft so you can see it turn.

Type **MR∧51200** and press ENTER. (MR=Move Relative.) With the Default settings, the MDrive Motion Control should move one revolution in approximately 0.066 seconds or at a velocity of 15 revolutions per sec.

Type **SL∧102400** and press ENTER. (SL = Slew.) With the Default Settings, the MDrive Motion Control should run constantly at a speed of approximately 2 revolutions per second or 120 revolutions per minute.

Type **SL∧0** and press ENTER. The MDrive Motion Control should decelerate to a full stop.

Motion Sample

This is a simple motion program that sets the position counter to zero (0), moves the MDrive Motion Control 102400 microsteps in the plus direction and then prints the position in the Terminal Window.

Type the following: (It is not necessary to type the comments.)

Type **P=0**	'Sets position counter to 0
Press ENTER	
Type **MR∧102400**	'Set motion mode to relative, move relative 102400
Press ENTER	
Type **PR∧P**	'Print position to terminal
Press ENTER	'A position of 102400 will be displayed

NOTE: The program or motion can be stopped by pressing the Escape Button 

or by pressing <Ctrl C> 

+ 

.

The Motion Sample above may also be run from a program. If you wish to run from a program go to **Section 2.2** in this Manual and then go to the heading **"Creating, Downloading and Uploading Programs"**. Take yourself through Creating a New Program, Formatting the Program Text and Downloading a Program to the MDrive Motion Control. At the end of the Download instructions you will be able to run the Program. Note that the Program version of the Motion Sample has examples of setting many of the common variables you will be using on a regular basis.

These are basic commands that verify that your MDrive Motion Control is communicating with your PC. More complex commands and movement may require that your I/O and/or Analog Input be interfaced and configured. Please consult the appropriate sections in this manual for details.

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Part 1: General Information and Hardware Specifications

Introduction to the MDrive17 Motion Control

The MDrive17 Motion Control offers the system designer a low-cost, intelligent motion controller integrated with a NEMA 17 high torque stepping motor and a +12 to +48 VDC microstepping drive.

The MDrive17 Motion Control adds a versatile array of functions by combining a complete programmable motion controller with our already compact and cost effective standard MDrive17, adding little cost and no increase in size. Standard offerings include four +5V logic to +24V logic programmable I/O points, one 10-bit 0 to 5 volt or 4 - 20mA analog input, 0 to 5 MHz step clock rate, microstep resolution up to 51,200 steps per revolution and a full featured easy-to-program instruction set.

The MDrive17 Motion Control communicates using the RS-485 communications protocol, this allows for point-to-point or multi-drop communications using one communications port. Addressing and hardware support up to 62 MDrive nodes in a system. The communications BAUD rate is software selectable and ranges from 4.8 kbps to 115 kbps.

The MDrive17 is also available with an optional closed loop control. The closed loop configuration adds a 512 line (2048 count) internal magnetic rotary encoder with index mark without increasing the length of the unit. Closed loop configuration adds position maintenance, stall detection and find index mark.

Available motor configurations include a single shaft, an optional planetary gearbox, and an external linear actuator only (consult factory for availability). Rotary versions are available in three motor lengths: 13, 15 & 19. Interface connections are accomplished with 12” flying leads.

Feature Summary

- Integrated Microstepping Drive/Motion Controller with Optional Encoder/NEMA 17 High Torque Stepping Motor
- +12 to +48VDC Input Voltage
- Low Cost
- Extremely Compact
- Available Configurations: Single Shaft, External Linear Actuator (Consult Factory for Availability), Integral Encoder, Planetary Gearbox
- Three Motor Stack Lengths Available
- Single Power Supply
- Microstep Resolution up to 51,200 Steps Per Revolution
- Open Loop or Optional Closed Loop Control
- Programmable Motor Run and Hold Current Settings
- Four 0V to 24V Inputs that work with +5V Logic (i.e. TTL, CMOS, etc.) or +24V Logic (i.e. PLC's)
- One Analog 10 Bit, 0 to 5 Volt or 4 - 20mA Analog Input
- 0 to 5 MHz Step Clock Rate, Selectable in 0.59 Hz Increments
- RS-485 Communications Protocol
- Communications BAUD Rate Selectable from 4.8 kbps to 115 kbps
- 62 Software Addresses for Multidrop Communications
- Simple 1 and 2 Character Programming Instructions
- 12” Flying Lead Interface
- Optional Integrated RS-232 to RS-485 Communications Converter Cable

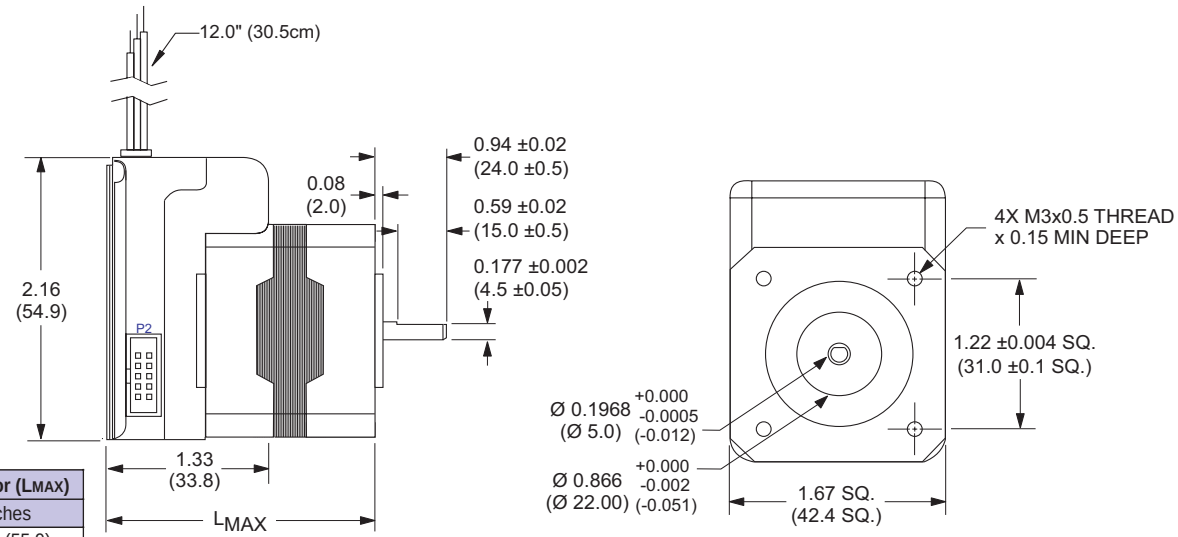
Section Overview

This section contains mechanical, motor and electrical specifications specific to each version of the MDrive17 Motion Control. Shown are:

- Rotary Motor Specifications
- General Specifications
- Power Supply Requirements
- Thermal Specifications

Rotary Motor Specifications

Mechanical Specifications - Dimensions in Inches (mm)



Standard Rotary Motor (LMAX)	
Stack	Inches
1713	2.20 (55.9)
1715	2.43 (61.7)
1719	2.75 (69.8)

Figure 1.1: Rotary MDrive17 Motion Control Mechanical Specifications

MDrive17 Mounting Screws

Care must be observed when installing the mounting screws on ALL MDrive17 versions including Linear Actuators. The mounting holes on the flange are not drilled through and have a maximum depth of 0.150" (3.81 mm).

The warning note and figure below illustrate the maximum safe thread length and maximum torque for mounting all versions of the MDrive17.

WARNING! The mounting holes in the MDrive17 mounting flange **are not through holes**. The maximum length of the screw threads into the motor flange is 0.140" (3.5 mm). (See Below)

MAXIMUM TORQUE! The maximum torque for the M3x0.5 screw is 7.8 lb-in (9 kg-cm) with a thread engagement of 6.5 threads (3.3 mm deep). A lesser thread engagement diminishes the maximum torque.

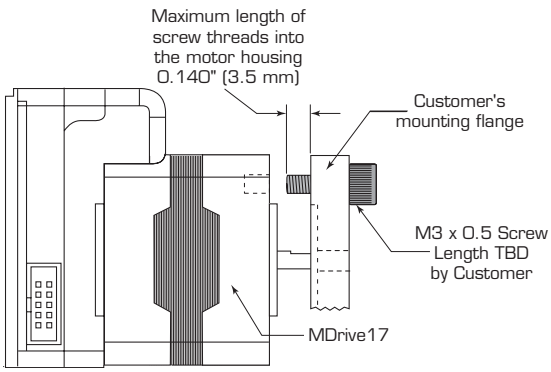


Figure 1.2: MDrive17 Mounting Screw Depth

MDrive Motion Control 1713 Motor Specs and Speed/Torque Curves

MDIF1713	
Holding Torque oz-in (N-cm)	32 (22.6)
Detent Torque oz-in (N-cm)	1.66 (1.17)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.00053 (0.038)
Weight (Motor+Driver) oz (g)	9.8 (227.8)

Table 1.1: Rotary MDIF1713 Motor Specifications

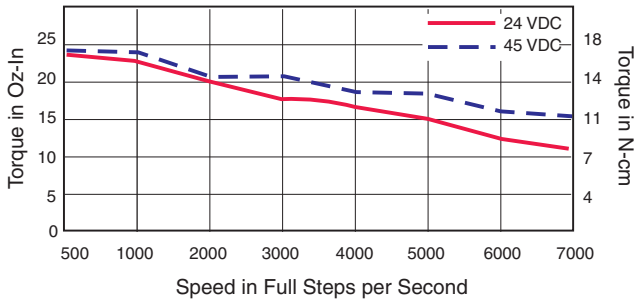


Figure 1.3: Rotary MDrive Motion Control 1713 Speed/Torque Data

MDrive Motion Control 1715 Motor Specs and Speed/Torque Curves

MDIF1715	
Holding Torque oz-in (N-cm)	60 (42.4)
Detent Torque oz-in (N-cm)	2.08 (1.47)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.00080 (0.057)
Weight (Motor+Driver) oz (g)	10.5 (297.7)

Table 1.2: Rotary MDIF1715 Motor Specifications

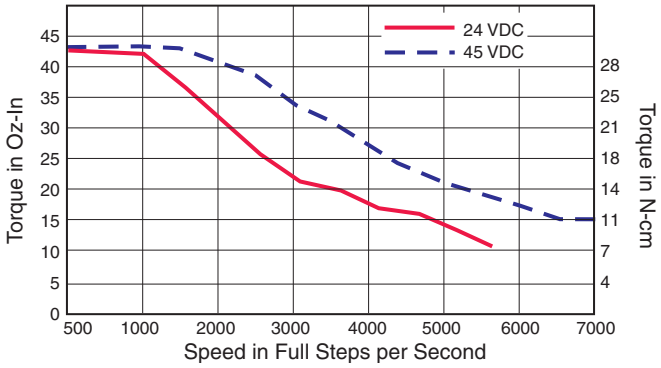


Figure 1.4: Rotary MDrive Motion Control 1715 Speed/Torque Data

MDrive Motion Control 1719 Motor Specs and Speed/Torque Curves

MDIF1719	
Holding Torque oz-in (N-cm)	74.9 (52.9)
Detent Torque oz-in (N-cm)	3.47 (2.45)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.00116 (0.082)
Weight (Motor+Driver) oz (g)	15.1 (428.1)

Table 1.3: Rotary MDIF1719 Motor Specifications

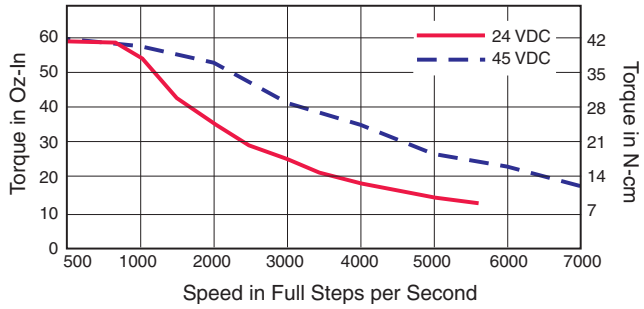


Figure 1.5: Rotary MDrive Motion Control 1719 Speed/Torque Data

General Specifications - MDrive17 Motion Control

Input Voltage (+V)

Range ..... +12 to +48 VDC

> **WARNING!** The maximum +48 VDC Input Voltage of the MDrive17 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive17.

Analog Input

Resolution ..... 10 Bit
Range ..... 0 to +5 Volts or 4 - 20mA

Programmable I/O

Number 4
Interface Type ..... Open Collector
Voltage Range ..... 0 to +24 VDC
Logic Threshold
- Logic 0 ..... <0.8VDC
- Logic 1 ..... >2.2VDC

Output Sink Current ..... 700 mA (2.8 A per group max.)
Protection ..... Over Temp., Short Circuit, Inductive Clamp

Communication

Protocol ..... RS-485, Full/Half Duplex Selectable
BAUD Rate 4800, 9600, 19.2k, 38.4k, 115.2k

Motion

Microstep Resolution – Open Loop Configuration
Number of Settings 14
Steps per Revolution 400, 800, 1000, 1600, 2000, 3200, 5000, 6400, 10000, 12800, 25000, 25600, 50000, 51200

Microstep Resolution – Closed Loop Configuration (Optional)
Steps per Revolution (Fixed) 51200

Encoder (Optional)
Type ..... Internal, Magnetic
Resolution ..... 512 Lines/2048 counts per Revolution

Counters
Type ..... Position(C1), Encoder (C2)
Resolution ..... 32 Bit
Edge Rate (Max) ..... 5 MHz

Velocity
Range ..... ±5,000,000 Steps per Second
Resolution ..... 1 Step per Second

Acceleration/Deceleration
Range ..... 1.5 x 10^9 Steps per Second^2
Resolution ..... 90.9 Steps per Second^2

> **WARNING:** Acceleration/Deceleration time must be ≥ 6 ms for proper MDrive Motion Control operation. $\frac{\Delta v}{a} = t$

> **WARNING:** When using the MDrive Motion Control with optional internal magnetic encoder, no axial force may be applied to the motor shaft without use of a load bearing isolation coupling.

Software

Program and Data Storage ..... Nonvolatile
User Program Space ..... 767 Bytes
User Registers ..... (4) 32 Bit
User Program Labels & Variables 22
Math, Logic And Conditional Functions ..... +, -, x, ÷, <, >, =, <=, >=, & (AND), | (OR), ^ (XOR), ! (NOT)
Branch Functions ..... Branch & Call (Conditional)

Predefined I/O Functions

Inputs ..... Home, Limit +, Limit -, Go, Soft Stop, Pause,Jog +, Jog -, Analog Input
Outputs ..... Moving, Fault

Trip Functions ..... Input, Position
Party Mode Node Addresses 62
Encoder Functions ..... Stall Detect, Position Maintenance, Find Index

Power Supply Requirements

Each MDrive17 Motion Control will require a **maximum power supply current of 2A**. Actual power supply current will depend upon the load and duty cycle.

WARNING:
- DO NOT connect or disconnect power leads when power is applied!
- Disconnect the AC power side to power down the DC power supply.
- For battery operated systems, connect a “transient suppressor” across the power switch to prevent arcs and high voltage spikes.

Recommended IMS Power Supplies

For the MDrive17 Motion Control, below are the recommended IMS power supplies.

IP404 Unregulated Linear Supply

Input Range
- 120 VAC Versions ..... 102-132 VAC
- 240 VAC Versions ..... 204-264 VAC

Output
- No Load Output Voltage* ..... 43 VDC @ 0 Amps
- Continuous Output Rating* ..... 32 VDC @ 2 Amps
- Peak Output Rating* ..... 26 VDC @ 4 Amps

ISP200-4 Unregulated Switching Supply

Input Range
- 120 VAC Versions ..... 102-132 VAC
- 240 VAC Versions ..... 204-264 VAC

Output
- No Load Output Voltage* ..... 41 VDC @ 0 Amps
- Continuous Output Rating* ..... 38 VDC @ 1.5 Amps
- Peak Output Rating* ..... 35 VDC @ 3 Amps

** All measurements were taken at 25°C, 120 VAC, 60 Hz.*

WARNING! The maximum +48 VDC Input Voltage of the MDrive17 includes Motor Back EMF, Power Supply Ripple and High Line.

Thermal Specifications

Because the MDrive consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. The following maximum temperatures apply to the MDrive17:

Heat Sink Temperature - Max ..... 85°C
Motor Temperature - Max ..... 100°C

Introduction to the MDrive23 Motion Control

The MDrive23 Motion Control offers the system designer a low-cost, intelligent motion controller integrated with a NEMA 23 high torque stepping motor and a +12 to +48 VDC microstepping drive.

The MDrive23 Motion Control adds a versatile array of functions by combining a complete programmable motion controller with our already compact and cost effective standard MDrive23, adding little cost and no increase in size. Standard offerings include four +5V logic to +24V logic programmable I/O points, one 10-bit 0 to 5 volt or 4 to 20mA analog input, 0 to 5 MHz step clock rate, microstep resolution up to 51,200 steps per revolution and a full featured easy-to-program instruction set.

The MDrive23 Motion Control communicates using the RS-485 communications protocol, this allows for point-to-point or multi-drop communications using one communications port. Addressing and hardware support up to 62 MDrive nodes in a system. The communications BAUD rate is software selectable and ranges from 4.8 kbps to 115 kbps.

The MDrive23 is also available with an optional closed loop control. The closed loop configuration adds a 512 line (2048 count) internal magnetic rotary encoder with index mark without increasing the length of the unit. Closed loop configuration adds position maintenance, stall detection and find index mark.

Available motor configurations include: single shaft, double shaft with control knob, an optional planetary gearbox, and long life Acme screw linear actuator. Rotary versions are available in three motor lengths: 18, 22 & 31. Interface connections are accomplished using either a 7 position terminal block or optional 12” flying leads.

Feature Summary

- Integrated Microstepping Drive/Motion Controller with Optional Encoder/NEMA 23 High Torque Stepping Motor
- +12 to +48VDC Input Voltage
- Low Cost
- Extremely Compact
- Available Configurations: Single Shaft*, Linear Actuator, Integral Encoder*, Rear Knob for Manual Positioning*, Planetary Gearbox*
- Three Motor Stack Lengths Available*
- Single Power Supply
- Microstep Resolution up to 51,200 Steps Per Revolution
- Open Loop or Optional Closed Loop Control
- Programmable Motor Run and Hold Current Settings
- Four 0V to 24V Inputs that work with +5V Logic (i.e. TTL, CMOS, etc.) or +24V Logic (i.e. PLC's)
- One Analog 10 Bit, 0 to 5 Volt or 4 to 20mA Analog Input
- 0 to 5 MHz Step Clock Rate, Selectable in 0.59 Hz Increments
- RS-485 Communications Protocol
- Communications BAUD Rate Selectable from 4.8 kbps to 115 kbps
- 62 Software Addresses for Multidrop Communications
- Simple 1 and 2 Character Programming Instructions
- Pluggable Terminal Strip or 12” Flying Lead Interface
- Optional Integrated RS-232 to RS-485 Communications Converter Cable

*Rotary Motor Only

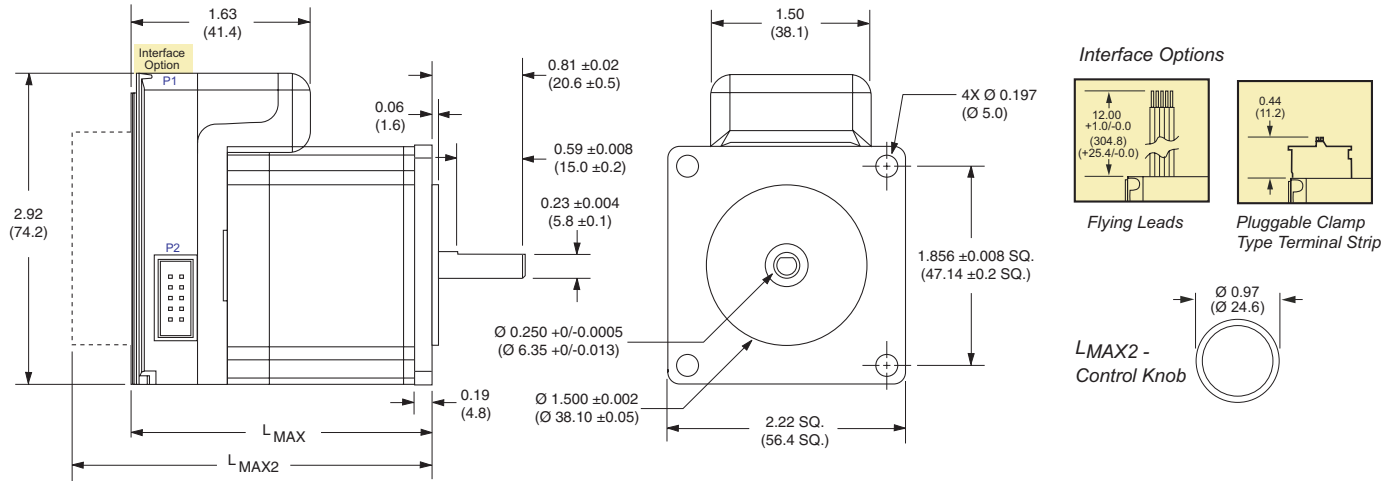
Section Overview

This section contains mechanical, motor and electrical specifications specific to each version of the MDrive23 Motion Control. Shown are:

- Rotary Motor Specifications
- Linear Motor Specifications
- General Specifications
- Power Supply Requirements
- Thermal Specifications

Rotary Motor Specifications

Mechanical Specifications - Dimensions in Inches (mm)



Single Shaft or Encoder Version (L_{MAX})	
Stack	In (mm)
2218	2.63 (66.8)
2222	3.00 (76.2)
2231	3.86 (98.0)

Control Knob Version (L_{MAX2})	
Stack	In (mm)
2218	3.35 (85.1)
2222	3.70 (94.0)
2231	4.57 (116.1)

Figure 1.6: Rotary MDrive23 Motion Control Mechanical Specifications

MDrive Motion Control 2218 Motor Specs and Speed/Torque Curves

MDI2218	
Holding Torque oz-in (N-cm)	90 (64)
Detent Torque oz-in (N-cm)	3.5 (2.5)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.0025 (0.18)
Weight (Motor+Driver) oz (g)	20.1 (569.8)

Table 1.4: Rotary MDI2218 Motor Specifications

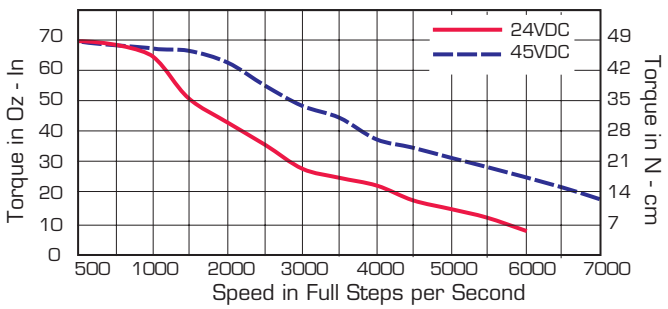


Figure 1.7: Rotary MDrive Motion Control 2218 Speed/Torque Data

MDrive Motion Control 2222 Motor Specs and Speed/Torque Curves

MDI2222	
Holding Torque oz-in (N-cm)	144 (102)
Detent Torque oz-in (N-cm)	5.6 (3.92)
Rotor Inertia oz-in-sec² (kg-cm²)	0.0037 (0.26)
Weight (Motor+Driver) oz (g)	24.4 (691.7)

Table 1.5: Rotary MDI2222 Motor Specifications

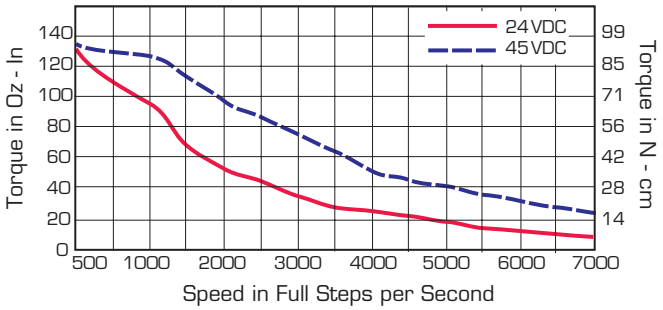


Figure 1.8: Rotary MDrive Motion Control 2222 Speed/Torque Data

MDrive Motion Control 2231 Motor Specs and Speed/Torque Curves

MDI2231	
Holding Torque oz-in (N-cm)	239 (169)
Detent Torque oz-in (N-cm)	9.7 (6.86)
Rotor Inertia oz-in-sec² (kg-cm²)	0.0065 (0.46)
Weight (Motor+Driver) oz (g)	38.5 (1091.5)

Table 1.6: Rotary MDI2231 Motor Specifications

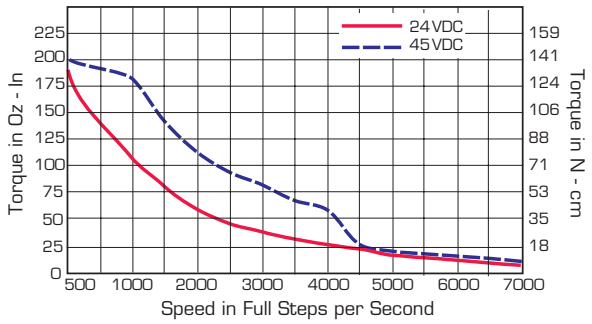


Figure 1.9: Rotary MDrive Motion Control 2231 Speed/Torque Data

Linear Motor Specifications

Mechanical Specifications - Dimensions in Inches (mm)

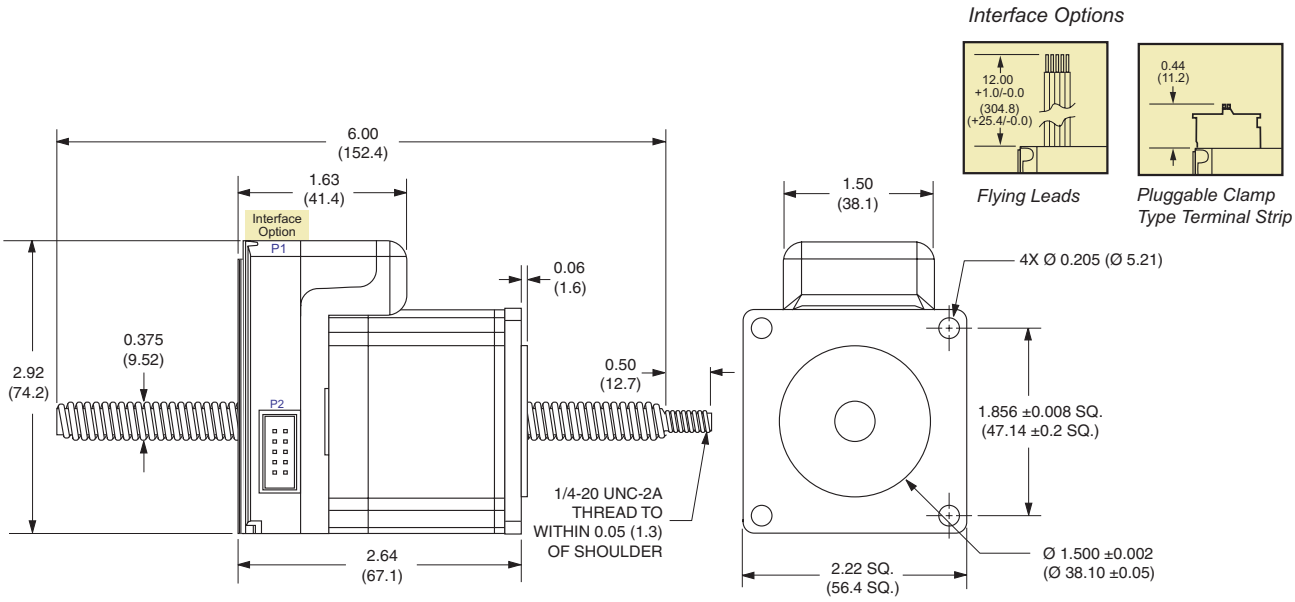


Figure 1.10: Linear Actuator MDrive23 Motion Control Mechanical Specifications

MDI23 Linear Actuator	
Maximum Thrust lbs (kg)	200 (90.7)
Maximum Screw Deflection	±1°
Backlash inches (mm)	0.005 (0.127)
Weight (without screw) oz (g)	20.4 (578.3)

Table 1.7: Linear Actuator MDrive23 Motion Control Motor Specifications

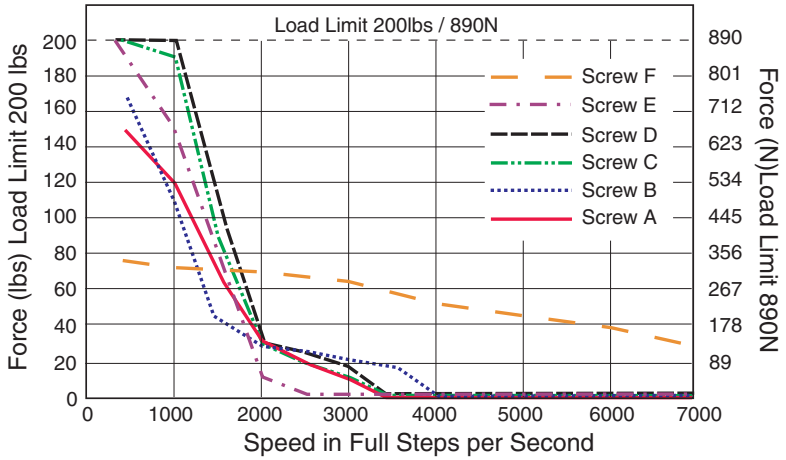


Figure 1.11: Speed-Force Curve - 24VDC (100% Current)

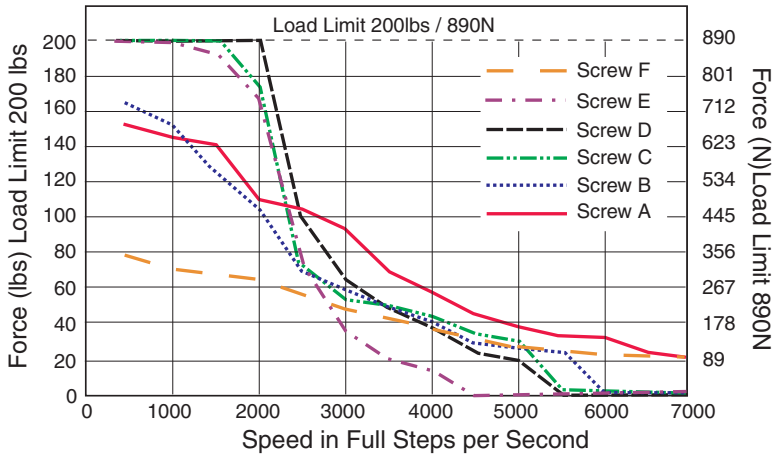


Figure 1.12: Speed-Force Curve - 45VDC (100% Current)

WARNING: The maximum axial load limit for the MDrive23 Linear motor is 200 lbs (90.7 kg). Do not exceed this rating!

WARNING: The Acme screw **MUST NOT** deflect more than ± 1 degree perpendicular to the motor face. Additional support for radial loads may be required!

Acme Screws for MDrive23	
Screw	**Travel/Full Step - Inches (mm)**
F	0.002 (0.0508)
A	0.001 (0.0254)
B	0.000833 (0.021158)
C	0.0005 (0.0127)
D	0.0004167 (0.0105842)
E	0.0003125 (0.0079375)

Table 1.8: Acme Screws for the MDI23 Linear Actuator

General Specifications - MDrive23 Motion Control

Input Voltage (+V)

Range ..... +12 to +48 VDC

> **WARNING!** The maximum +48 VDC Input Voltage of the MDrive23 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive23.

Analog Input

Resolution ..... 10 Bit
Range ..... 0 to +5 Volts or 4 - 20mA

Programmable I/O

Number 4
Interface Type ..... Open Collector
Logic Threshold
Logic 0 ..... <0.8VDC
Logic 1 ..... >2.2VDC
Output Sink Current ..... 700 mA
Protection ..... Over Temp., Short Circuit, Inductive Clamp

Communication

Protocol ..... RS-485, Full/Half Duplex Selectable
BAUD Rate 4800, 9600, 19.2k, 38.4k, 115.2k

Motion

Microstep Resolution – Open Loop Configuration

Number of Settings 14
Steps per Revolution ..... 400, 800, 1000, 1600, 2000, 3200, 5000 , 6400, 10000, 12800, 25000, 25600, 50000, 51200

Microstep Resolution – Closed Loop Configuration (Optional)

Steps per Revolution (Fixed) 51200

Encoder (Optional)

Type ..... Internal, Magnetic
Resolution ..... 512 Lines/2048 counts per Revolution

Counters

Type ..... Position(C1), Encoder (C2)
Resolution ..... 32 Bit
Edge Rate (Max) ..... 5 MHz

Velocity

Range ..... ±5,000,000 Steps per Second
Resolution ..... 1 Step per Second

Acceleration/Deceleration

Range ..... 1.5 x 10^9 Steps per Second^2
Resolution ..... 90.9 Steps per Second^2

> **WARNING:** Acceleration/Deceleration time must be ≥ 6 ms for proper MDrive Motion Control operation. $\frac{\Delta v}{a} = t$

> **WARNING:** When using the MDrive Motion Control with optional internal magnetic encoder, no axial force may be applied to the motor shaft without use of a load bearing isolation coupling.

Software

Program and Data Storage ..... Nonvolatile
User Program Space ..... 767 Bytes
User Registers ..... (4) 32 Bit
User Program Labels and Variables 22
Math, Logic And Conditional Functions ..... +, -, x, ÷, <, >, =, <=, >=, & (AND), | (OR), ^ (XOR), ! (NOT)
Branch Functions ..... Branch & Call (Conditional)

Predefined I/O Functions

Inputs ..... Home, Limit +, Limit -, Go, Soft Stop, Pause, Jog +, Jog -, Analog Input
Outputs ..... Moving, Fault, Stall, Velocity Change

Trip Functions ..... Input, Position
Party Mode Node Addresses 62
Encoder Functions ..... Stall Detect, Position Maintenance, Find Index

Power Supply Requirements

Each MDrive23 Motion Control will require a **maximum power supply current of 2A**. Actual power supply current will depend upon the load and duty cycle.

WARNING:
- DO NOT connect or disconnect power leads when power is applied!
- Disconnect the AC power side to power down the DC power supply.
- For battery operated systems, connect a “transient suppressor” across the power switch to prevent arcs and high voltage spikes.

Recommended IMS Power Supplies

For the MDrive23 Motion Control, below are the recommended IMS power supplies.

IP404 Unregulated Linear Supply

Input Range
- 120 VAC Versions ..... 102-132 VAC
- 240 VAC Versions ..... 204-264 VAC

Output
- No Load Output Voltage* ..... 43 VDC @ 0 Amps
- Continuous Output Rating* ..... 32 VDC @ 2 Amps
- Peak Output Rating* ..... 26 VDC @ 4 Amps

ISP200-4 Unregulated Switching Supply

Input Range
- 120 VAC Versions ..... 102-132 VAC
- 240 VAC Versions ..... 204-264 VAC

Output
- No Load Output Voltage* ..... 41 VDC @ 0 Amps
- Continuous Output Rating* ..... 38 VDC @ 1.5 Amps
- Peak Output Rating* ..... 35 VDC @ 3 Amps

** All measurements were taken at 25°C, 120 VAC, 60 Hz.*

WARNING! The maximum +48 VDC Input Voltage of the MDrive23 includes Motor Back EMF, Power Supply Ripple and High Line.

Thermal Specifications

Because the MDrive consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. The following maximum temperatures apply to the MDrive23:

Heat Sink Temperature - Max ..... 85°C
Motor Temperature - Max ..... 100°C

Introduction to the MDrive34 Motion Control

The MDrive34 Motion Control offers the system designer a low-cost, intelligent motion controller integrated with a NEMA 34 high torque stepping motor and a +24 to +75 VDC microstepping drive.

The MDrive34 Motion Control adds a versatile array of functions by combining a complete programmable motion controller with our already compact and cost effective standard MDrive34, adding little cost and no increase in size. Standard offerings include four +5V logic to +24V logic programmable I/O points, one 10-bit 0 to 5 volt or 4 to 20 mA analog input, 0 to 5 MHz step clock rate, microstep resolution up to 51,200 steps per revolution and a full featured easy-to-program instruction set.

The MDrive34 Motion Control communicates using the RS-485 communications protocol, this allows for point-to-point or multi-drop communications using one communications port. Addressing and hardware support up to 62 MDrive nodes in a system. The communications BAUD rate is software selectable and ranges from 4.8 kbps to 115 kbps.

The MDrive34 is also available with an optional closed loop control. The closed loop configuration adds a 512 line (2048 count) internal magnetic rotary encoder with index mark without increasing the length of the unit. Closed loop configuration adds position maintenance, stall detection and find index mark.

Available motor configurations include: single shaft, double shaft with control knob, an optional planetary gearbox, and long life Acme screw linear actuator. Rotary versions are available in three motor lengths: 24, 31, & 47. Interface connections are accomplished with 12” flying leads.

Feature Summary

- Integrated Microstepping Drive/Motion Controller with Optional Encoder/NEMA 34 High Torque Stepping Motor
- +24 to +75VDC Input Voltage
- Low Cost
- Extremely Compact
- Available Configurations: Single Shaft*, Linear Actuator, Integral Encoder*, Rear Knob for Manual Positioning*, Plantetary Gearbox*
- Three Motor Stack Lengths Available*
- Single Power Supply
- Microstep Resolution up to 51,200 Steps Per Revolution
- Open Loop or Optional Closed Loop Control
- Programmable Motor Run and Hold Current Settings
- Four 0V to 24V Inputs that work with +5V Logic (i.e. TTL, CMOS, etc.) or +24V Logic (i.e. PLC's)
- One Analog 10 Bit, 0 to 5 Volt or 4 to 20mA Analog Input
- 0 to 5 MHz Step Clock Rate, Selectable in 0.59 Hz Increments
- RS-485 Communications Protocol
- Communications BAUD Rate Selectable from 4.8 kbps to 115 kbps
- 62 Software Addresses for Multidrop Communications
- Simple 1 and 2 Character Programming Instructions
- 12” Flying Lead Interface
- Optional Integrated RS-232 to RS-485 Communications Converter Cable

*Rotary Motor Only

Section Overview

This section contains mechanical, motor and electrical specifications specific to each version of the MDrive34 Motion Control. Shown are:

- Rotary Motor Specifications
- Linear Motor Specifications
- General Specifications
- Power Supply Requirements
- Thermal Specifications

Rotary Motor Specifications

Mechanical Specifications - Dimensions in Inches (mm)

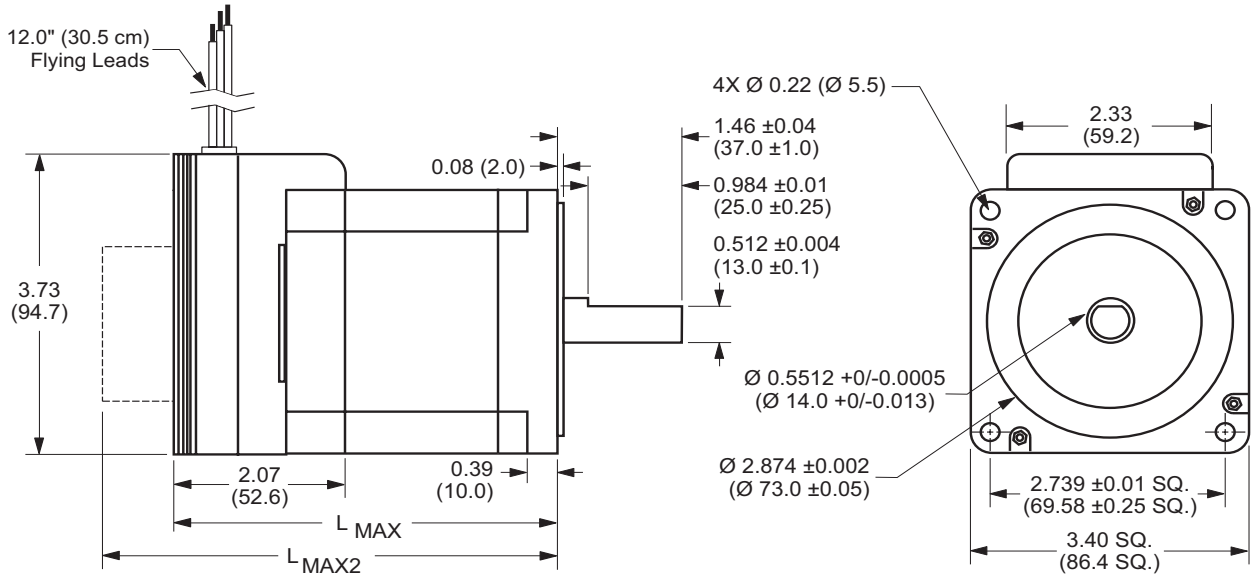
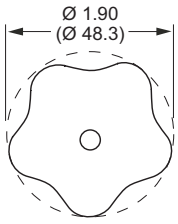


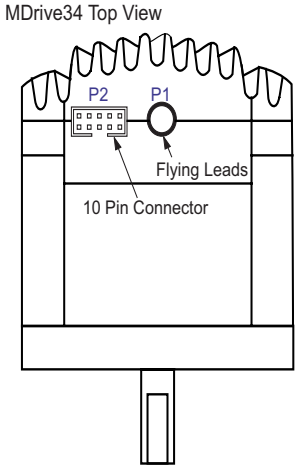
Figure 1.13: Rotary MDrive34 Motion Control Mechanical Specifications

Single Shaft or Encoder Version (L_{MAX})	
Stack	In (mm)
3424	3.81 (96.8)
3431	4.6 (116.8)
3447	6.17 (156.7)

Control Knob Version (L_{MAX2})	
Stack	In (mm)
3424	4.97 (126.2)
3431	5.76 (146.3)
3447	7.34 (186.4)



LMAX2
Control Knob



MDrive Motion Control 3424 Motor Specs and Speed/Torque Curves

MDIF3424	
Holding Torque oz-in (N-cm)	381 (269)
Detent Torque oz-in (N-cm)	10.9 (7.7)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.01416 (1.0)
Weight (Motor+Driver) oz (g)	51.1 (1450)

Table 1.9: Rotary MDIF3424 Motor Specifications

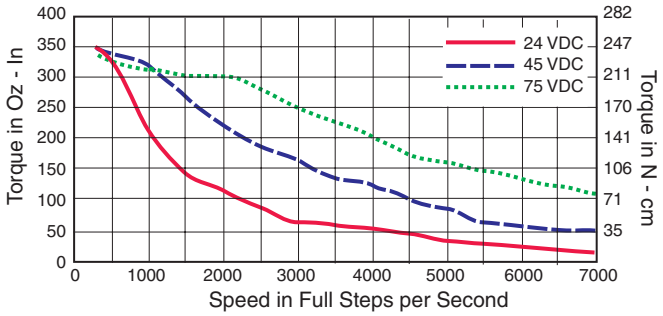


Figure 1.14: Rotary MDrive Motion Control 3424 Speed/Torque Data

MDrive Motion Control 3431 Motor Specs and Speed/Torque Curves

MDIF3431	
Holding Torque oz-in (N-cm)	575 (406)
Detent Torque oz-in (N-cm)	14.16 (10.0)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.02266 (1.6
Weight (Motor+Driver) oz (g)	72.3 (2050)

Table 1.10: Rotary MDIF3431 Motor Specifications

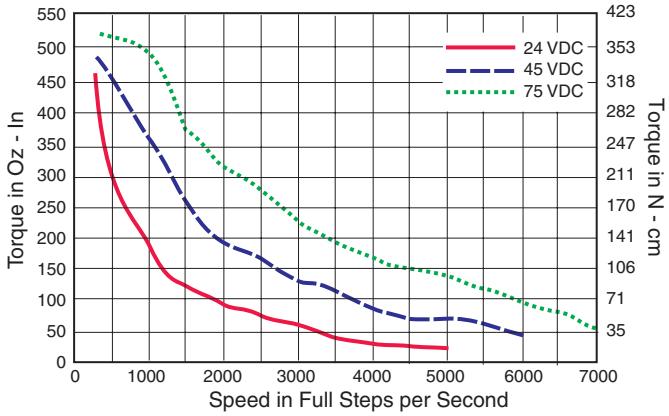


Figure 1.15: Rotary MDrive Motion Control 3431 Speed/Torque Data

MDrive Motion Control 3447 Motor Specs and Speed/Torque Curves

MDIF3447	
Holding Torque oz-in (N-cm)	1061 (749)
Detent Torque oz-in (N-cm)	19.83 (14.0)
Rotor Inertia oz-in-sec^2 (kg-cm^2)	0.04815 (3.4)
Weight (Motor+Driver) oz (g)	128.7 (3650)

Table 1.11: Rotary MDIF3447 Motor Specifications

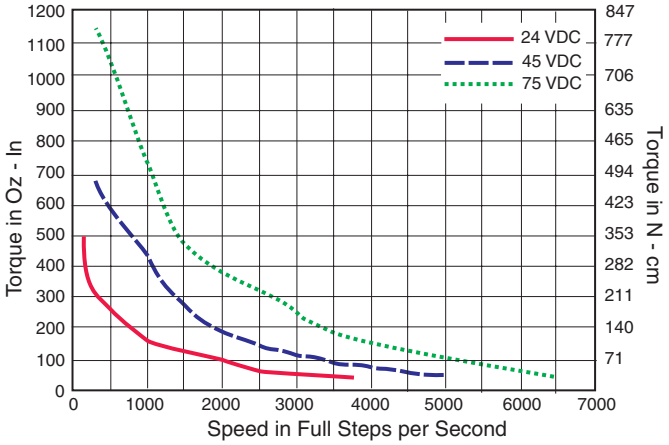


Figure 1.16: Rotary MDrive Motion Control 3447 Speed/Torque Data

Linear Motor Specifications

Mechanical Specifications - Dimensions in Inches (mm)

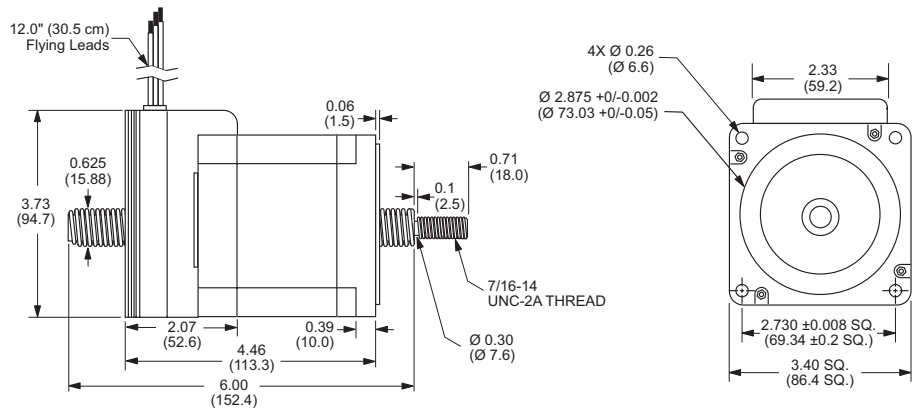


Figure 1.17: Linear Actuator MDrive34 Motion Control Mechanical Specifications

Linear Actuator MDrive Motion Control 3429 Specs and Speed-Force Curves

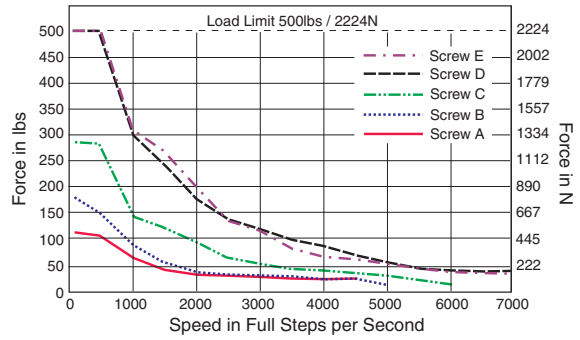


Figure 1.18: Speed-Force Curve - 24VDC (100% Current)

MDI34 Linear Actuator	
Maximum Thrust lbs (kg)	500 (226.8)
Maximum Screw Deflection	±1°
Backlash inches (mm)	0.005 (0.127)
Weight (without screw) oz (g)	89.0 (2523)

Table 1.12: Linear Actuator MDrive34 Motion Control Motor Specifications

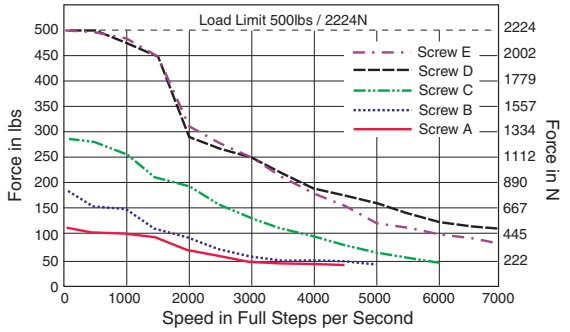


Figure 1.19 Speed-Force Curve - 48VDC (100% Current)

Acme Screws for MDrive34	
Screw	**Travel / Full Step - Inches (mm)**
A	0.005 (0.127)
B	0.0025 (0.0635)
C	0.00125 (0.03175)
D	0.000625 (0.015875)
E	0.0005 (0.0127)

Table 1.13: Acme Screws for the MDI34 Linear Actuator

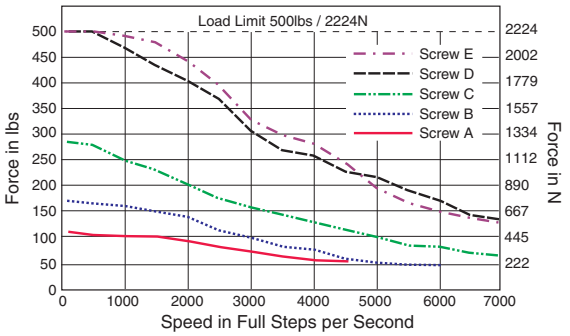


Figure 1.20: Speed-Force Curve - 75VDC (100% Current)

WARNING: The maximum axial load limit for the Drive34 Linear motor is 500 lbs (226.8 kg). Do not exceed this rating!

WARNING: The Acme screw **MUST NOT** deflect more than ± 1 degree perpendicular to the motor face. Additional support for radial loads may be required!

General Specifications - MDrive34 Motion Control

Input Voltage (+V)

Range ..... +24 to +75 VDC

> **WARNING!** The maximum +75 VDC Input Voltage of the MDrive34 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive34.

Analog Input

Resolution ..... 10 Bit
Voltage Range ..... 0 to +5 Volts or 4 to 20mA

Programmable I/O

Number 4
Interface Type ..... Open Collector
Logic Threshold
Logic 0 ..... <0.8VDC
Logic 1 ..... >2.2VDC
Output Sink Current ..... 700 mA
Protection ..... Over Temp., Short Circuit, Inductive Clamp

Communication

Protocol ..... RS-485, Full/Half Duplex Selectable
BAUD Rate 4800, 9600, 19.2k, 38.4k, 115.2k

Motion

Microstep Resolution – Open Loop Configuration
Number of Settings 14
Steps per Revolution 400, 800, 1000, 1600, 2000, 3200, 5000 6400, 10000, 12800, 25000, 25600, 50000 51200

Microstep Resolution – Closed Loop Configuration (Optional)
Steps per Revolution (Fixed) 51200

Encoder (Optional)
Type ..... Internal, Magnetic
Resolution ..... 512 Lines/2048 counts per Revolution

Counters
Type ..... Position(C1), Encoder (C2)
Resolution ..... 32 Bit
Edge Rate (Max) ..... 5 MHz

Velocity
Range ..... ±5,000,000 Steps per Second
Resolution ..... 1 Step per Second

Acceleration/Deceleration
Range ..... 1.5 x 10^9 Steps per Second^2
Resolution ..... 90.9 Steps per Second^2

> **WARNING:** Acceleration/Deceleration time must be ≥ 6 ms for proper MDrive Motion Control operation. $\frac{\Delta v}{a} = t$

> **WARNING:** When using the MDrive Motion Control with optional internal magnetic encoder, no axial force may be applied to the motor shaft without use of a load bearing isolation coupling.

Software

Program and Data Storage ..... Nonvolatile
User Program Space ..... 767 Bytes
User Registers ..... (4) 32 Bit
User Program Labels and Variables 22
Math, Logic And Conditional Functions ..... +, -, x, ÷, <, >, =, <=, >=, & (AND), | (OR), ^ (XOR), ! (NOT)
Branch Functions ..... Branch & Call (Conditional)

Predefined I/O Functions

Inputs ..... Home, Limit +, Limit -, Go, Soft Stop, Pause, Jog +, Jog -, Analog Input
Outputs ..... Moving, Fault

Trip Functions ..... Input, Position
Party Mode Node Addresses 62
Encoder Functions ..... Stall Detect, Position Maintenance, Find Index

Protection

Types ..... Over Voltage

Power Supply Requirements

Each MDrive34 Motion Control will require a **maximum power supply current of 4A**. Actual power supply current will depend upon voltage and load.

WARNING:
- DO NOT connect or disconnect power leads when power is applied!
- Disconnect the AC power side to power down the DC power supply.
- For battery operated systems, connect a “transient suppressor” across the power switch to prevent arcs and high voltage spikes.

Recommended IMS Power Supplies

For the MDrive34 Motion Control, below are the recommended IMS power supplies.

IP804 Unregulated Linear Supply

Input Range
- 120 VAC Versions ..... 102-132 VAC
- 240 VAC Versions ..... 204-264 VAC

Output
- No Load Output Voltage* ..... 76 VDC @ 0 Amps
- Continuous Output Rating* ..... 68 VDC @ 3 Amps
- Peak Output Rating* ..... 64 VDC @ 6 Amps

ISP300-7 Unregulated Switching Supply

Input Range
- 120 VAC Versions ..... 102-132 VAC
- 240 VAC Versions ..... 204-264 VAC

Output
- No Load Output Voltage* ..... 68 VDC @ 0 Amps
- Continuous Output Rating* ..... 63 VDC @ 2 Amps
- Peak Output Rating* ..... 59 VDC @ 4 Amps

** All measurements were taken at 25°C, 120 VAC, 60 Hz.*

WARNING! The maximum +75 VDC Input Voltage of the MDrive34 includes Motor Back EMF, Power Supply Ripple and High Line.

Thermal Specifications

Because the MDrive consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. The following maximum temperatures apply to the MDrive34:

Heat Sink Temperature - Max ..... 85°C
Motor Temperature - Max ..... 100°C

PART 2: CONNECTING, CONFIGURING AND PROGRAMMING THE MDRIVE MOTION CONTROL

SECTION 2.1

Interfacing the MDrive Motion Control

Section Overview

This section will acquaint the user with connecting and using the MDrive Motion Control.

- Layout and Interface Guidelines
- Pin Configuration and Descriptions
- Interfacing Power
- Interfacing RS-485 Communications
- Interfacing Digital I/O
- Interfacing Analog Input

Layout and Interface Guidelines

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 earth. 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 Wiring

The following wiring/cabling is recommended for use with the MDrive:

Recommended Wire Size

Logic Wiring ..... 22 AWG

Power and Ground ..... See Appendix D “Recommended Cable Configurations”

General Practices

The following wire strip length is recommended:

Wire Strip Length ..... 0.250” (6.0 mm)

Pin Configuration and Descriptions

MDrive Motion Control Connector P1 / Flying Leads			
Pin*	**Wire Color**	**Wire Size**	**Function and Description**
1	White/Yellow	AWG 22	Open Collector I/O Point #1, +5 to +24 VDC
2	White/Orange	AWG 22	Open Collector I/O Point #2, +5 to +24 VDC
3	White/Violet	AWG 22	Open Collector I/O Point #3, +5 to +24 VDC
4	White/Blue	AWG 22	Open Collector I/O Point #4, +5 to +24 VDC
5	Green	AWG 22	10-Bit, 0 to +5V Analog Input
6	Black	AWG 20†	Power Ground (Return) MDI17 and MDI23
		AWG 18†	Power Ground (Return) MDI34
7	Red	AWG 20†	+V: +12 to +48 VDC - MDI17 and MDI23
		AWG 18†	+V: +24 to +75 VDC MDI34

* For MDI23 only.

† For supplies 10 feet or less.

Table 2.1: P1 Pin Configuration and Description

WARNING:
- DO NOT connect or disconnect power leads when power is applied!
- Disconnect the AC power side to power down the DC power supply.
- For battery operated systems, connect a “transient suppressor” across the power switch to prevent arcs and high voltage spikes.

Note: Wire and insulation type are subject to the user's application and environment.

MDI Connector P2			
Pin	**Name**	**Wire Size**	**Description**
1-5	N/C	---	No Connect
6	RX +	AWG 22	RS-485 Receive +
7	RX -	AWG 22	RS-485 Receive -
8	TX -	AWG 22	RS-485 Receive -
9	TX +	AWG 22	RS-485 Receive +
10	GND	AWG 22	Communications Ground

Table 2.2: P2 Pin Configuration and Description

Recommended Power Supply Connection

An advantage of the MDrive Motion Control is that only a single unregulated linear or unregulated switching power supply is required to power the control circuitry and motor power.

A maximum of:

2A output ..... MDI17 and MDI23
4A output MDI34

is required from the supply for each MDrive. Note that the actual power required will be based upon the load and duty cycle.

Wiring should be accomplished using shielded twisted pair of appropriately gauged wires (see note below). The shield should be attached to earth at the power supply end and left floating at the MDrive end.

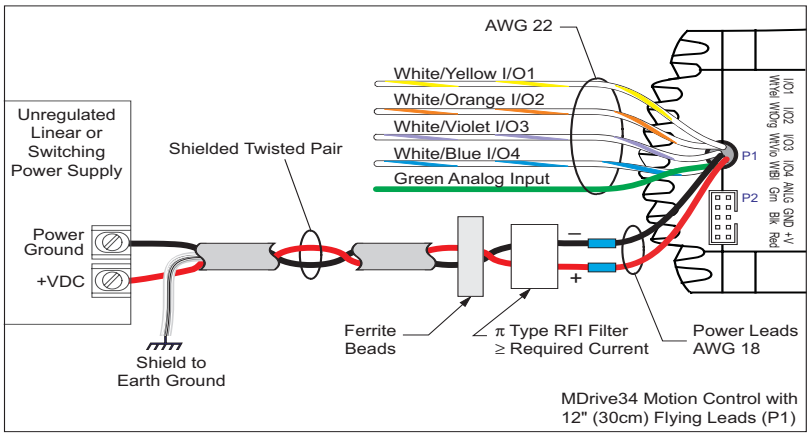


Figure 2.1: Power Supply Interface - MDI with Flying Leads

Note: For more cabling details,see Appendix D "Recommended Cable Configurations" in the back of this manual.

All MDrives are available with 12" Flying Leads.
The MDI23 is also available with Pluggable Connector.

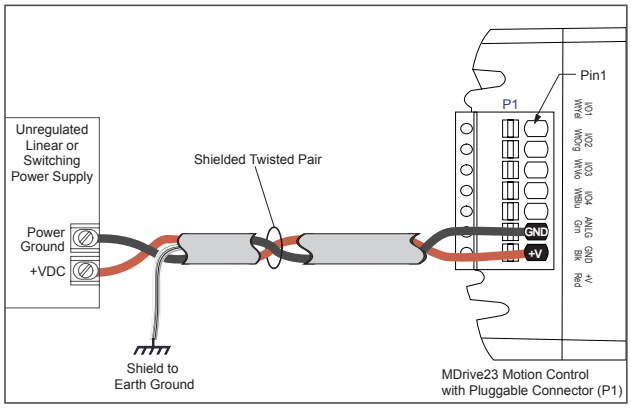


Figure 2.2: Power Supply Interface - MDI23 with 7 pin Pluggable Connector

Securing MDrive Power Leads and Logic Leads

Some applications may require that the MDrive move with the axis motion. If this is a requirement of your application, the motor leads (pluggable or flying) must be properly anchored. This will prevent flexing and tugging which can cause damage at critical connection points in the MDrive electronics.

DO NOT bundle the Logic Leads with the Power Leads.

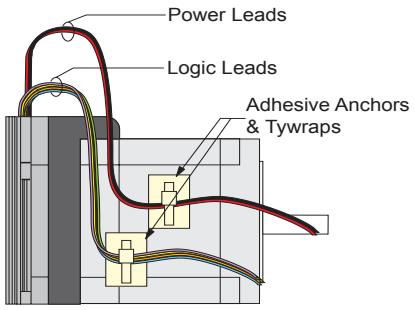


Figure 2.3 Typical MDrive shown with Leads Secured

The MDrive Motion Control communicates to the host using the RS-422/485 protocol. Communications may be configured as either half or full duplex using the EM (Echo Mode) Instruction. RS-422/485 may be used in two ways: either to communicate to a single MDrive Motion Control, or to address up to 62 individually named MDrive nodes in a multidrop system.

Single MDrive

Optionally available for the MDrive Motion Control is a Communications Converter Cable, IMS P/N MD-CC200-000, which has built-in RS-232 to RS-422 conversion circuitry. The 6 foot cable will allow you to connect the serial port of your PC* directly to the MDrive Motion Control.

* If your PC is already equipped with RS-485, the MD-CC200-000 cable is not required.

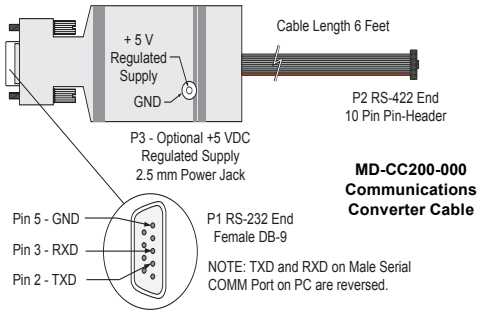


Figure 2.4: Communications Converter Cable

WARNING: DO NOT connect or disconnect the MD-CC200-000 Communications Converter Cable while power is applied!

NOTE: Termination resistors may be required on the Data Cables. (Please see Next Page.)

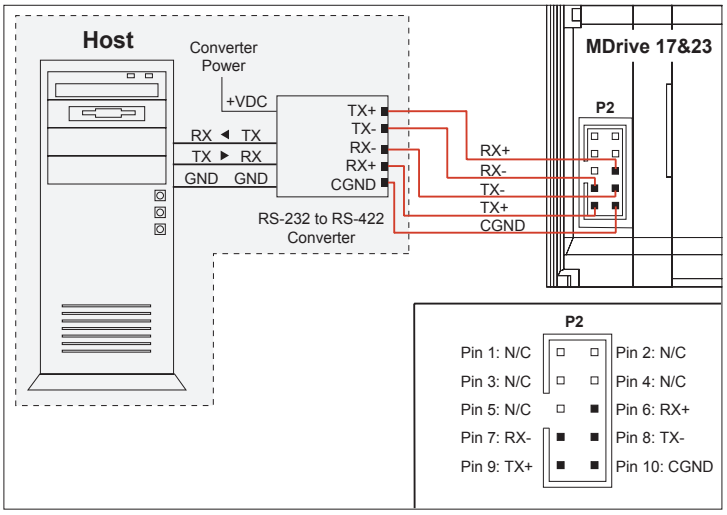


Figure 2.5: RS-422 Interface, Single MDrive17 & 23 Motion Control

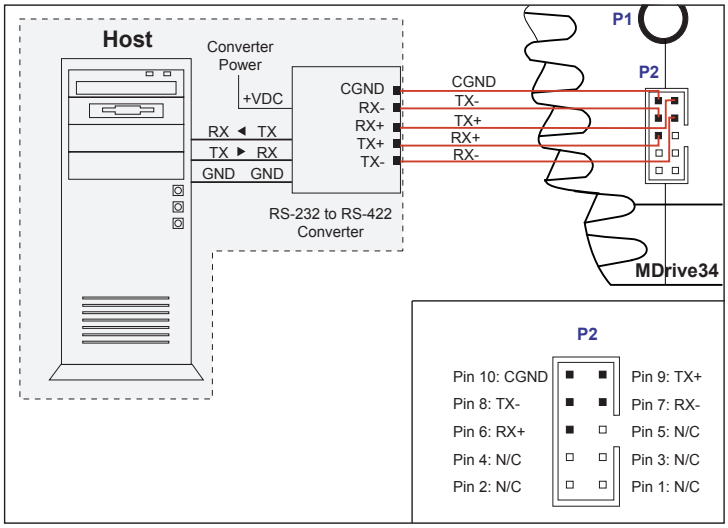


Figure 2.6: RS-422 Interface, Single MDrive34 Motion Control

NOTE: Most PC serial ports are able to provide sufficient power to the MD-CC200-000 when a standard adapter is used. If an external supply is used, it must be a regulated +5VDC, 50mA supply.

RS-485 2 Wire Communication (Half Duplex)

The MDrive Motion Control can be operated in a 2 wire RS-485 communication bus. Before connecting the 2 wire RS-485, download your program and setup instructions using the standard 4 wire RS-422 Communications Cable. If a program is not being used, download and save any setup parameters. To ensure the MDrive responds only to commands specifically meant for it, set the MDrive in Party Mode (Please see Party Mode on the following page). The Echo Mode command (EM) must be set to the value of 1 (EM=1). This will set the MDrive communication into "half duplex" mode. Connect the MDrive in the 2 wire RS-485 configuration.

The following diagram illustrates how to connect the MDrive 4 wire RS-485 to operate as a 2 wire system.

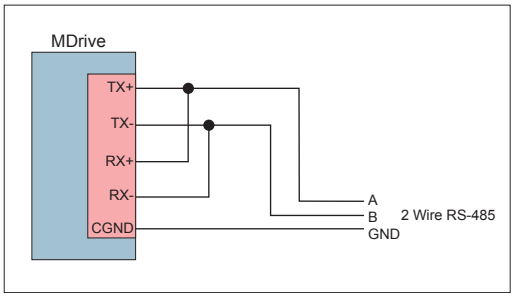


Figure 2.7 RS-485 2 Wire Communications (Half Duplex)

NOTE: The RS-232 to RS-422 cable, Part # MD-CC200-000 cannot be used in a 2 wire RS-485 system. If you wish to monitor the MDrive serial communication from a PC, an RS-232 to RS-422 two wire converter must be used.

Multiple MDrive Motion Control System (Party Mode)

In systems with multiple controllers it is necessary to communicate with the control modules using party mode (PY=1). The MDrive Motion Control nodes in the system are configured in software for this mode of operation by setting the Party Flag (PY) to True (1). It is necessary for all of the nodes in a system to have this configuration selected. When operating in party mode each MDrive Motion Control in the system will need a unique address, or name, to identify it in the system. This is accomplished by using the software command DN, or Device Name. For example, to set the name of an MDrive to "A" you would use the following command: DN=65 or DN="A" (65 is the ASCII decimal equivalent of uppercase A). The factory default name is "!". The asterisk character "*" is used to issue global commands to every device in the system. NOTE: When using the asterisk "*" in Party Mode, typed entries and commands will not be echoed. See Appendix A for ASCII table.

In setting up your system for party operation, the most practical approach is to observe the following steps:

1. Connect the first MDrive Motion Control to the Host PC configured for Single Mode Operation.
2. Establish communications and download program if required.
3. Using the command DN, name the MDrive Motion Control. This can be any upper or lower case ASCII character or number 0-9. (DN="A"{enter}) (Note: The quotation marks before and after the device name are required.)
4. Set the party flag PY=1{enter}.
5. Press CTRL+J to activate the Party Mode.
6. Type the letters **AS** and press CTRL+J (Save device name and Party Mode).
7. Remove power.
8. Repeat steps 1 through 7 for each additional MDrive in the system.
9. After all MDrives are assigned a Device Name the Multiple MDrive Interface can be configured as shown below.

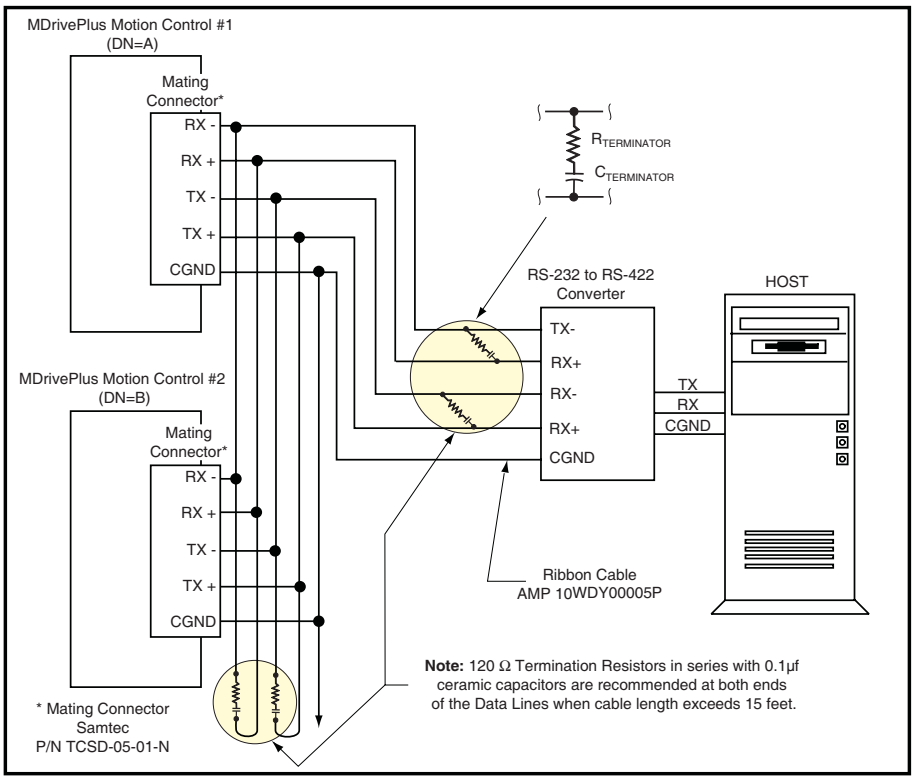


Figure 2.8: RS-485 Interface, Multiple MDrive Motion Control System

Data Cable Termination Resistors

Data Cable lengths greater than 15 feet (4.5 meters) are susceptible to signal reflection and/or noise. IMS recommends 120Ω termination resistors in seres with 0.1µf capacitors at both ends of the Data Cables. An example of resistor placement is shown in the figure above. For systems with Data Cables 15 feet (4.5 meters) or less, the termination resistors are generally not required.

MDI Communication Format

The following communication formats used by MDrive Motion Control (MDI) units, began with firmware version 1.043.

{} The contents between the {} symbols are transmitted.

{0D} Hex equivalent for a CR (Carriage Return).

{0A} Hex equivalent for a LF (Line Feed).

{DN} Represents the Device Name being sent.

{CS} Check Sum; {ACK} 06 Hex; {NAK} 15 Hex

EM = Echo Mode; PY = PartY Mode; CK= ChecK sum

The word {command} represents the immediate command sent to the MDI.

Command Execution Time (CET) is the time the MDI takes to execute a command. This varies from command to command and usually is in the 1-5 millisecond range.

MDI Response to Echo Mode

Dependent on how the Echo Mode is set in conjunction with Party Mode and Check Sum, the MDI will respond differently. The following tables illustrate the various responses based on how the EM, PY and CK parameters are set.

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=0 CK=0	{command)} {D}	{command} (echoed back one character at a time as the character is entered)	CET {0D} {0A} >	The last character sent is the prompt >
EM=1 & PY=0 CK=0	{command} {0D}		CET {0D} {0A}	The last character sent is the LF
EM=2 & PY=0 CK=0	{command} {0D}			No response except to PR and L commands
EM=3 & PY=0 CK=0	{command} {0D}		CET command {0D} {0A}	Queued response. The last character sent is the LF

Table 2.3: MDI Response to Echo Mode when Party and Check Sum are Zero (0)

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=1 CK=0	{DN} {command} {0A}	{command} (echoed back one character at a time as the character is entered)	CET {0D} {0A} >	The last character sent is the prompt >
EM=1 & PY=1 CK=0	{DN} {command} {0A}		CET {0D} {0A}	The last character sent is the LF
EM=2 & PY=1 CK=0	{DN} {command} {0A}			No response except to PR and L commands
EM=3 & PY=1 CK=0	{DN} {command} {0A}		CET command {0D} {0A}	Queued response. The last character sent is the LF

Table 2.4: MDI Response to Echo Mode when Party is One (1) and Check Sum is Zero (0)

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=0 CK=1	{command} {CS} {0D}	{command} (echoed back one character at a time as the character is entered)	CET {ACK} or {NAK} >	The last character sent is the prompt >
EM=1 & PY=0 CK=1	{command} {CS} {0D}		CET {ACK} or {NAK}	The last character sent is ACK or NAK
EM=2 & PY=0 CK=1	{command} {CS} {0D}			No response except to PR and L commands
EM=3 & PY=0 CK=1	{command} {CS} {0D}		CET command {CS} {ACK} or {NAK}	Queued response. The last character sent is the ACK or NAK

Table 2.5: MDI Response to Echo Mode when Party is Zero (0) and Check Sum is One (1)

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=1 CK=1	{DN} {command} {CS} {0A}	{command} (echoed back one character at a time as the character is entered)	CET {ACK} or {NAK} >	The last character sent is the prompt >
EM=1 & PY=1 CK=1	{DN} {command} {CS} {0A}		CET {ACK} or {NAK}	The last character sent is the ACK or NAK
EM=2 & PY=1 CK=1	{DN} {command} {CS} {0A}			No response except to PR and L commands
EM=3 & PY=1 CK=1	{DN} {command} {CS} {0A}		CET command {CS} {ACK} or {NAK}	Queued response. The last character sent is the ACK or NAK

Table 2.6: MDI Response to Echo Mode when Party and Check Sum are One (1)

Using Check Sum

For communication using Check Sum, the following 2 commands demonstrate sending and receiving.

Sending Command

1. Check Sum set to ZERO before first character is sent.
2. All characters (ASCII values) are added to Check Sum, including the Device Name DN (if PY=1), to the end of the command, but not including terminator.
3. Check Sum is 2's complement, then "OR" ed with Hex 80.
   (prevents Check Sum from being seen as Command Terminator).
4. Terminator Sent.

Example command:

MR (space) 1 **NOTE:** Any combination of upper/lower case may be used. In this example, if a lower case <mr> were to be used, the decimal values will change to 109 and 114. Subsequently the Result Check Sum value will change. (Possible entries: MR, mr, Mr, mR.) (M = 77, R = 82, m = 109, r = 114) (See APPENDIX A - ASCII Table.)

77 82 32 49	Decimal value of M, R, <space> and 1
4D 52 20 31	Hex
77+82+32+49=240	Add decimal values together
1111 0000 = 240	Change 240 decimal to binary
0000 1111	1's complement (invert binary)
0001 0000	Add 1 [2's complement]
1000 0000	OR result with 128 (Hex 80)
1001 0000 144	Result Check Sum value

Once the result is reached, add the check Sum value (144 in this example) to your string by typing: `MR 1(Alt Key + 0144)` (Use the symbol of 0144 in your string by holding down the alt key and typing `0144`). You must type the numbers from the Numlock key pad to the right of the keyboard. The numbers at the top of the keyboard will not work.

1. Check Sum set to ZERO.
2. All characters are added to Check Sum.
3. When receiving a Command Terminator, the lower 7 bits of the Check Sum should be equal to ZERO.
   a) If not ZERO, the command is ignored and NAK echoed.
   b) If ZERO, ACK is sent instead of CR/LF pair.
4. Responses to PR commands will be Check Summed as above, but the receiving device should NOT respond with ACK or NAK.

MDrive Motion Control Party Mode Sample Codes

1. Download this segment of code into the first MDrive Motion Control. After downloading the program to the unit, follow the Set Up instructions described earlier. Be sure to set your first unit with the unique Device Name of A (DN="A"). The device name is case sensitive.

```
RC=25          'Run current
HC=5           'Hold current
MS=256         'Microstep selection
A=250000       'Acceleration
D=250000       'Deceleration
PG 1           'Enter program mode
S1=0,0         'Setup I/O 1 as an input low true
LB SU          'Start program upon power up
LB AA          'Label program AA
MR 104400      'Move relative 104400 counts
H              'Hold program execution to complete the move
LB DD          'Label program DD
BR DD,I1=0     'Branch to DD if I1=0
4PR "Bex 1"    'Print device name B to execute program at address 1
H 2000         'Hold program execution 2000 milliseconds
PR "Cex 1"     'Print device name C to execute program at address 1
H 2000         'Hold program execution 2000 milliseconds
BR AA          'Branch to label AA
E
PG             'Exit program, return to immediate mode
```

2. Download this segment of code into your second MDrive Motion Control. After downloading the program to the unit, follow the previous party mode instructions. Be sure to set your second unit with the unique address of B (device name is case sensitive).

```
RC=25          'Run current
HC=5           'Hold current
MS=256         'Microstep selection
A=250000       'Acceleration
D=250000       'Deceleration
PG 1           'Enter program mode
LB BB          'Label program BB
MR 208000      'Move relative 208000 counts
H              'Hold program execution to complete the move
E
PG             'Exit program, return to immediate mode
```

3. Download this segment of code into your third MDrive Motion Control. After downloading the program to the unit, follow the previous party mode instructions. Be sure to set your third unit with the unique address of C (device name is case sensitive).

```
RC=25          'Run current
HC=5           'Hold current
MS=256         'Microstep selection
A=250000       'Acceleration
D=250000       'Deceleration
PG 1           'Enter program mode
LB CC          'Label program CC
MR 300000      'Move relative 300000 counts
H              'Hold program execution to complete the move
E
PG             'Exit program, return to immediate mode
```

MDrive Motion Control Immediate Party Mode Sample Codes

Once Party Mode has been defined and set up as previously described under the heading "Multiple MDrive Motion Control System (Party Mode)", you may enter commands in the Immediate Mode in the IMS Terminal Window. Some examples follow.

Move MDrive A, B or C 10000 Steps

Assuming there are three MDrives set up in Party Mode as shown in the Sample Codes above.

NOTE: When instructed to type **CtrlJ,** that is the 

key + the 

key. It will not display in the Terminal Window so be certain you press the correct keys. **CtrlJ** activates the Party Mode.

The ∧ symbol represents a space. Be certain to type a space where the ∧ symbol indicates.

To move MDrive Unit "A",Press **CtrlJ** and then type: **AMR∧10000** and press **CtrlJ**. MDrive Unit "A" will move 10000 steps.

NOTE: Once you have activated Party Mode with the first **CtrlJ** you do not have to type it before each successive command. However, every command must be followed with a **CtrlJ**.

To print the position type: **APR∧P** and press **CtrlJ**. The position of MDrive Unit "A" will be printed.

To move MDrive Unit "B" type: **BMR∧10000** and press **CtrlJ**. MDrive Unit "B" will move 10000 steps.

To move all three MDrives at the same time type: ***MR∧10000** and press **CtrlJ**. All MDrives will move 10000 steps.

NOTE: The asterisk (*) is a global command which addresses all units. Since three units can not answer together, the asterisk (*) as well as other global commands will not be displayed in the Terminal Window.

To change a Variable in the "C" unit type: **C<variable name><number>** and press **CtrlJ**. The variable will be changed.

To verify the change type: **CPR∧<variable name>** and press **CtrlJ**. The new value will be displayed.

All Commands and Variables may be programmed in this manner.

To take an MDrive out of Party Mode type: **<device name>PY=0** and press **CtrlJ**. That unit will be taken out of Party Mode.

To take all units out of Party Mode type: ***PY=0** and press **CtrlJ**. All units will be taken out of Party Mode.

Interfacing the Digital I/O

The MDrive Motion Control comes standard with a set of four (4) open collector +5 to +24VDC I/O points which may be programmed individually as either general purpose or dedicated inputs or outputs, or collectively as a group.

The digital I/O may be defined as either active HIGH or active LOW. When the I/O is configured as active HIGH, the level is +5 to +24 VDC and the state will be read/set as a "1". If the level is 0 VDC then the state will be read/set as "0". Inversely, if configured as active LOW, then the state of the I/O will be read/set as a "1" when the level is LOW, and a "0" when the level is HIGH. The active HIGH/ LOW state is configured by the third parameter of the I/O Setup (S1-4) variable, which is explained further on. The goal of this I/O configuration scheme is to maximize compatibility between the MDrive Motion Control and standard sensors and switches.

The MDrive Motion Control I/O scheme is a powerful tool for machine and process control.

Uses of the Digital I/O

The I/O may be utilized to receive input from external devices such as sensors, switches or PLC outputs. When configured as outputs, devices such as relays, solenoids, LED's and PLC inputs may be controlled from the MDrive Motion Control.

Each I/O point may be individually programmed to any one of 9 dedicated input functions, 3 dedicated output functions, or as general purpose inputs or outputs. The I/O may be addressed individually, or as a group. The active state of the line or group may also be set. All of these possible functions are accomplished with of the I/O Setup Variable (S1-4).

Interfacing Inputs

The MDrive Motion Control inputs may be interfaced to a variety of sinking devices. A single input may be programmed to be a general purpose user input, or to one of nine dedicated input functions. These may then be programmed to have an active state of either HIGH or LOW.

Additionally, the inputs may read as a group using the "IN" keyword. This will display as a decimal between 0 and 15 representing the 4 bit binary number. Used in this manner, Input 1 is the Least Significant Bit (LSB) and Input 4 will be the Most Significant Bit (MSB).

Interfacing a Single Input Examples

Input Functions		
S1-S4	**Function**	**Active**
0	General Purpose	0/1
1	Home	0/1
2	Limit +	0/1
3	Limit –	0/1
4	GO	0/1
5	Soft Stop	0/1
6	Pause	0/1
7	Jog +	0/1
8	Jog –	0/1

Table 2.7: Input Functions

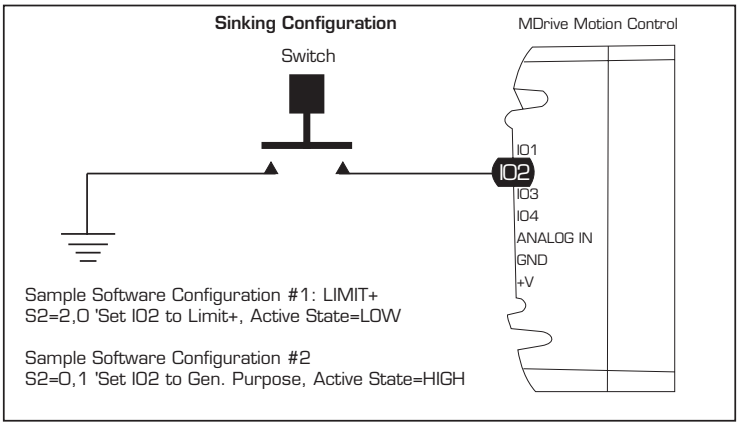


Figure 2.9: Sinking Input Interfaced to a Switch

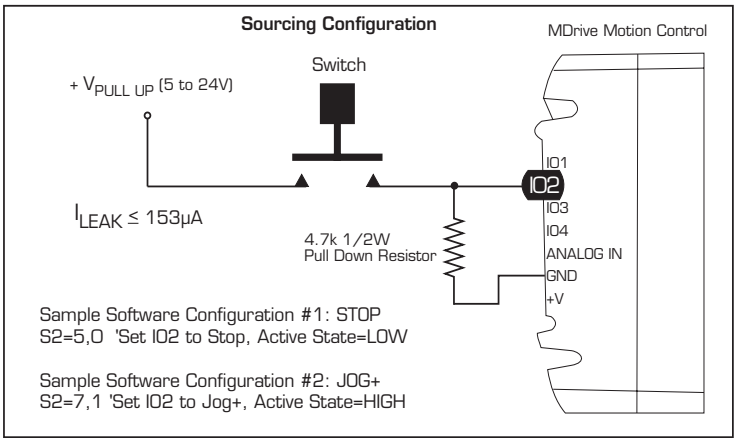


Figure 2.10: Sourcing Input Interfaced to a Switch

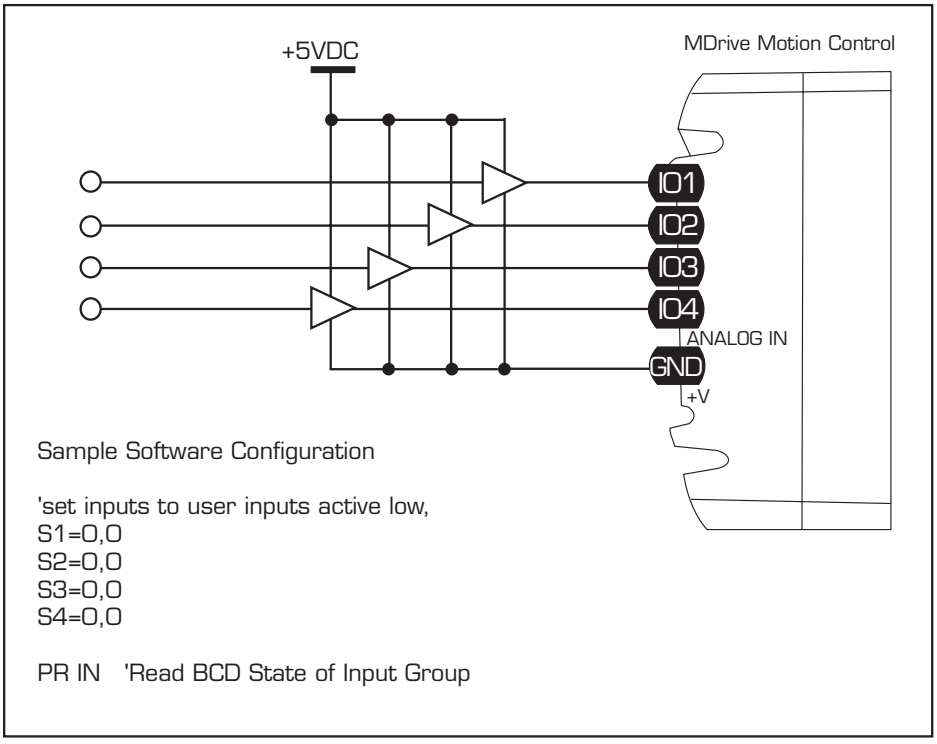


Figure 2.11: TTL Interface to an Input Group

Truth Table - I/O Used as a Group				
DEC	I/O 4	I/O 3	I/O 2	I/O 1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Table 2.8: I/O Group Truth Table

Interfacing Outputs

The MDrive Motion Control Outputs may be configured as either general purpose or set to one of two dedicated functions, Fault or Moving. These outputs will sink up to 700 mA (2.8 A max. per group) and may be connected to +5 to +24VDC. Note that a current limiting resistor may be required to limt the current to 700 mA.

As with the inputs the MDrive Motion Control Outputs may be used singularly or collectively as a group.

Interfacing a Single Output Examples

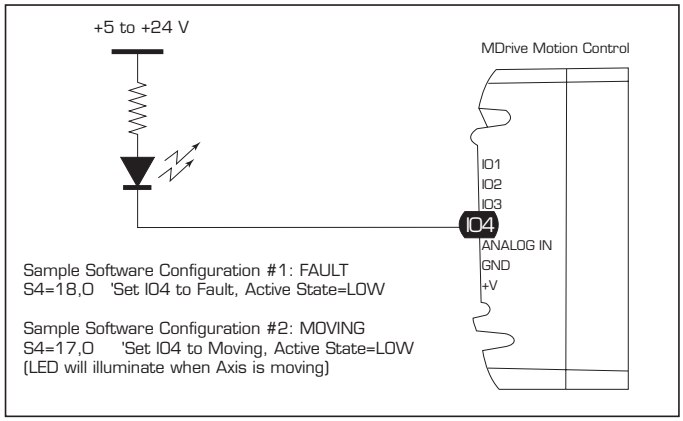


Figure 2.12: Output Interfaced to an LED

Output Functions		
S<point>=	Function	Active
16	General Purpose	0/1
17	Moving	0/1
18	Fault	0/1
19	Stall	0/1
20	Velocity Changing	0/1

Table 2.9: Output Functions

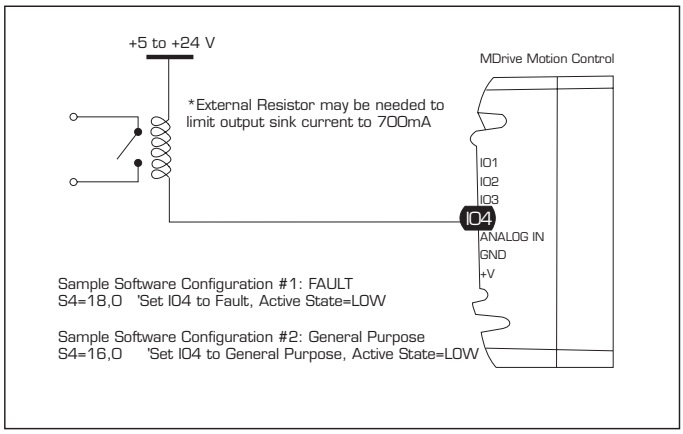


Figure 2.13: Output Interfaced to a Relay

Interfacing Outputs as a Group Example

To write to the outputs as a group the OT instruction is used. This will give you a binary output of 0000 to 1111 from a decimal entry of 0-15. Output 1 will be the Least Significant Bit (LSB), Output 4 will be the Most Significant Bit (MSB).

See the Truth Table on the previous page.

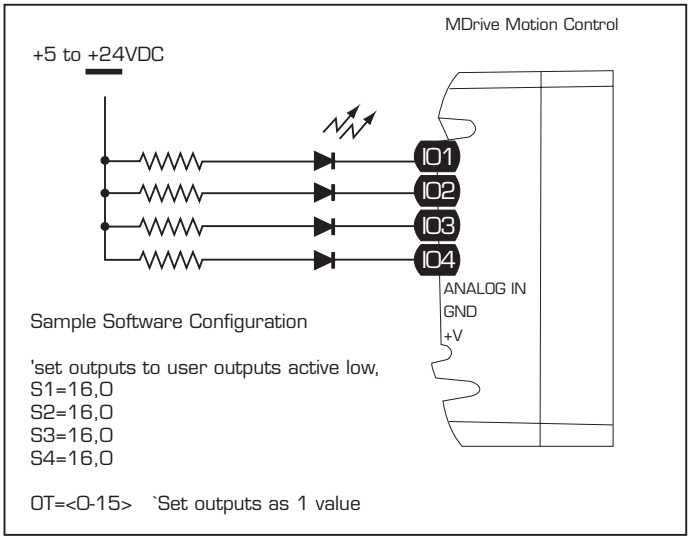


Figure 2.14: Outputs Interfaced to LED's as a Group

Interfacing the Analog Input

The analog input of the MDrive Motion Control is configured from the factory as a 0 to 5V, 10 bit resolution input (S5 = 9). This offers the user the ability to receive input from temperature, pressure or other forms of sensors, and then control events based upon the input.

The value of this input will be read using the I5 instruction, which has a range of 0 to 1024, where 0 = 0 volts and 1024 = 5.0 volts. You may then use the program branch (BR) or subroutine call (CL) instructions to control events within the system.

The MDrive Motion Control may also be configured for a 4 - 20 mA Analog Input (S5 = 10).

Sample Usage

```
'*********Main Program***********

S5=9                 'set analog input to read variable voltage (0 to +5VDC)
PG 100               'start prog. at address 100
LB A1                'label program A1
CL A2, I5<500        'Call Sub A2, If I5 is less than 500
CL A3, I5>524        'Call Sub A3, If I5 is greater than 524
BR A1                'loop to A1

'*********Subroutines************
LB A2                'label subroutine A2
MA 2000              'Move Absolute 2000 steps
H                    'Hold program execution until motion ceases
RT                   'return from subroutine

LB A3                'label subroutine A3
MA -2000             'Move Absolute -2000 steps
H                    'Hold program execution until motion ceases
RT                   'return from subroutine
E                    'End
PG                   'Exit program
```

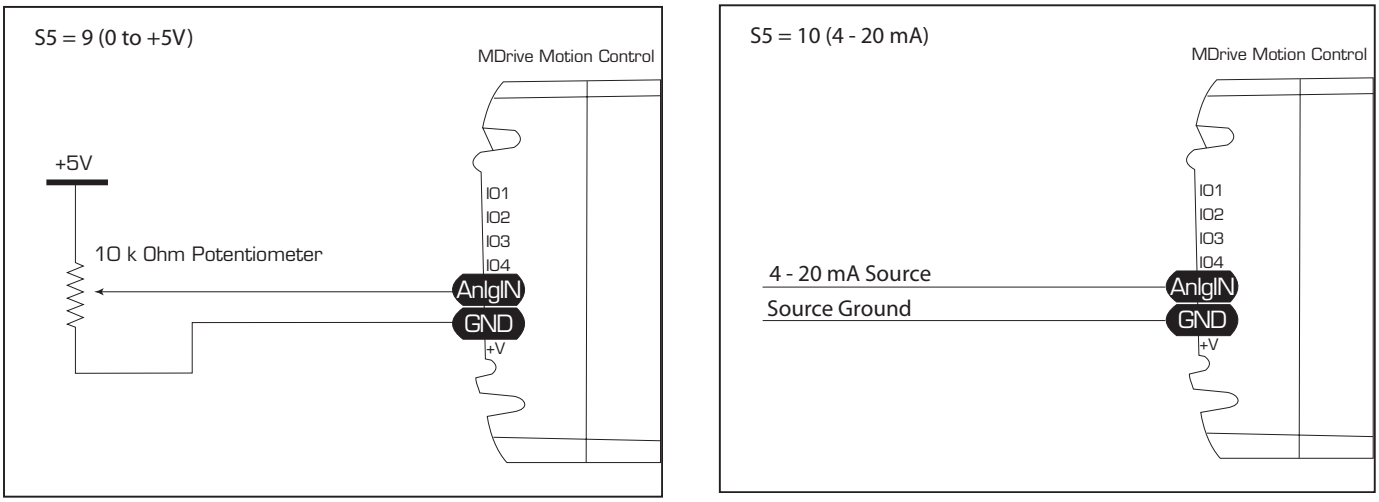


Figure 2.15: Analog Input Interface (0 to +5 VDC / 4 - 20 mA)

SECTION 2.2

MDrive Motion Control Software Introduction

Section Overview

This section will acquaint the user with basics of MDrive Motion Control Programming

- Installing IMS Terminal Software
- Upgrading the MDrive Firmware
- The MDrive Program

Installing and Using IMS Terminal Software

System Requirements

- IBM Compatible PC.
- Windows 9x (95/98) or Windows NT (Windows NT4.0 SP6, Windows 2000 SP1, Windows XP)
- 10 MB hard drive space.
- A free serial communications port.

Installation

The IMS Terminal Software is a programming/communications interface. This program was created by IMS to simplify programming and upgrading the MDrive Motion Control. The IMS Terminal Software is also necessary to upgrade the firmware in your MDrive Motion Control. These updates will be posted to the IMS web site at www.imshome.com as they are made available.

To install the IMS Terminal Software onto your hard drive, insert the IMS Product CD into your CD-ROM Drive. The CD should autostart to the IMS Main Index Page. If the CD does not autostart, click “Start > Run” and type “x:\IMS.exe” in the “Open” box and click OK.

NOTE: “x” is your CD ROM drive letter.

Figure 2.16: IMS CD Main Index Page

1) The IMS Main Index Page will be displayed.

2) Place your mouse pointer over the MDrive Icon. The text message “MDrive Integrated Motor & Electronics” will be displayed. This verifies you have selected the correct software.

3) Click the MDrive Motor Icon. This opens the MDrive Index Page.

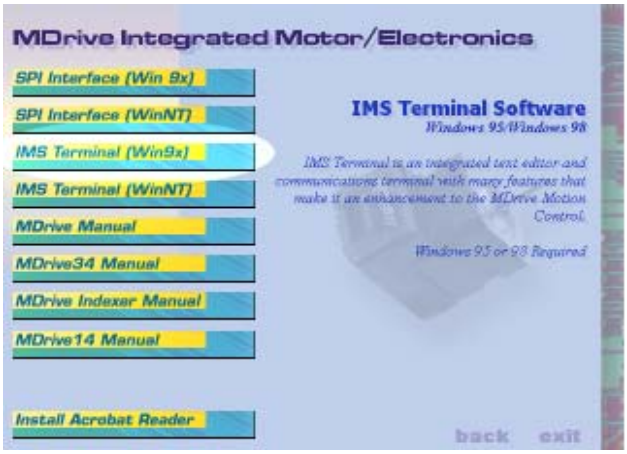


Figure 2.17: IMS CD Software Selection Page

4) Place the mouse pointer over the menu and select IMS Terminal (Win9x) or IMS Terminal (WinNT). The displayed text will again verify your selection. Click your selection and the "Setup" dialog box will be displayed.

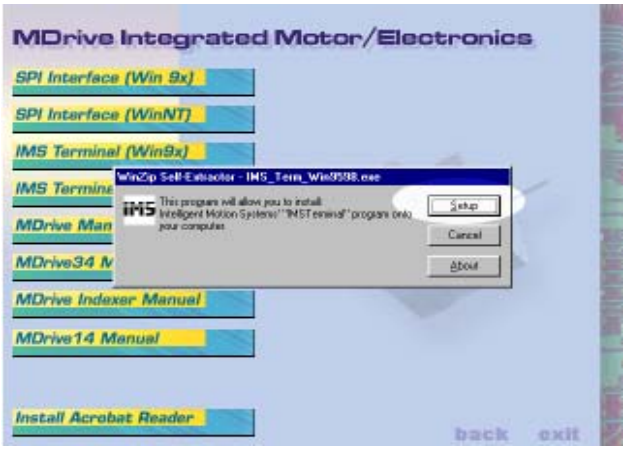


Figure 2.18: IMS CD Software Setup Command

5) Click SETUP in the Setup dialog box and follow the on-screen instructions.
Once IMS Terminal is installed the Communications Settings can be checked and/or set.

Configuring Communications Settings

The communications settings are configured by means of the "Preferences Dialog Box". The preferences dialog gives the user the ability to set the format for font size, font style and color, as well as general communications settings. The optimum communications settings for the MDrive Motion Control are set by default. After the IMS Terminal Software is installed you may start it and perform the configuration.

1) Open the IMS Terminal by clicking Start>Programs>IMS Terminal>IMS Term.

The following screen will be displayed.

The left window is the Program Editing Window. The right window is the IMS Terminal Window. Resident programs and immediate commands can be executed, stopped and tracked from the Terminal Window.

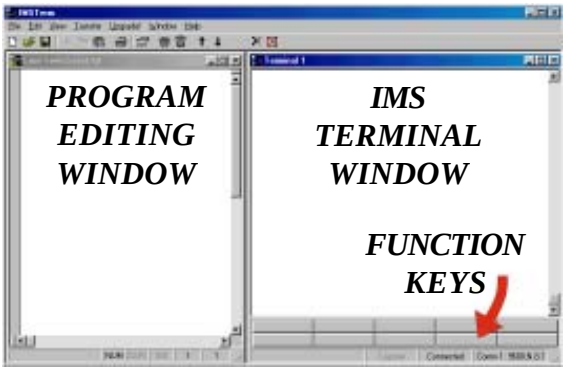


Figure 2.19: Main IMS Terminal Page

2) You must select or verify the Communications Port that you will be using with your MDrive.

a) On the Menu Bar click <Edit> <Preferences> or click the Preferences Button  on the main Tool Bar to display the "Preferences" Dialog Box.

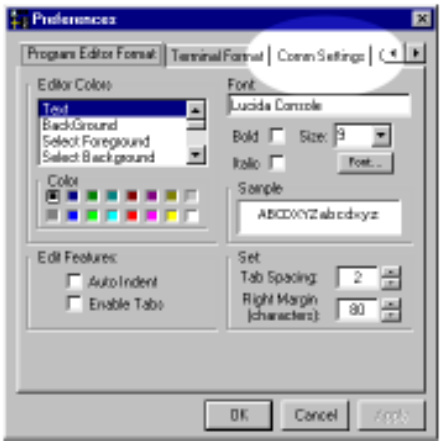


Figure 2.20: Preferences Dialog Box

b) You may also display the Preferences Dialog Box by right clicking in the Terminal Window. A small dialog box will be displayed.

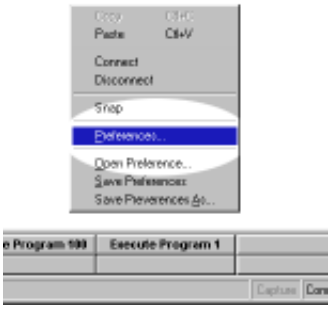


Figure 2.21: Preferences Selection Dialog Box in the Terminal Window

c) Click “Preferences” in the small dialog box to display the Preferences Dialog Box.

The Preferences Dialog Box allows you to select window colors and fonts for the Text Editing Window and Terminal Window as well as Communications Setup.

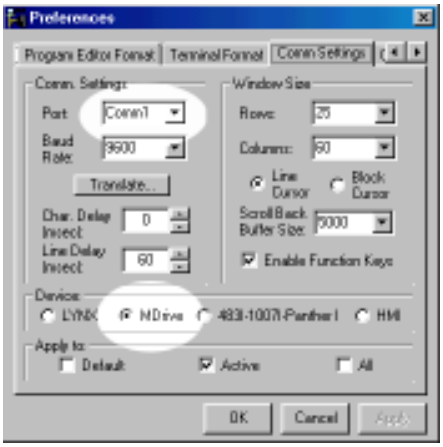


Figure 2.22 The COMM Settings Dialog Box

d) Click the “Comm Settings” tab at the top of the dialog box. The COMM settings page will be displayed.

e) Under “Device” near the bottom of the box verify “MDrive” is selected. The BAUD rate is already set to the MDrive default. Do not change this setting until you have established communications with the MDrive Motion Control. If you change the BAUD rate setting for the MDrive Motion Control, power will have to be cycled for the change to take effect. Ensure that the IMS Terminal preferences are adjusted for the new BAUD settings.

f) Verify the COMM Port you are using.

g) The “Window Size” settings are strictly optional. You may set these to whatever size is comfortable to you.g

h) Click “APPLY” and “OK”. The settings will be saved automatically.

3) Verify all connections are made and apply power to the MDrive. The following sign-on message should appear in the Terminal window: "Copyright 2001-2003 by Intelligent Motion Systems, Inc."

Figure 2.23: Copyright Statement in Terminal Window

If you can see this sign-on message then you are up and running! If the sign-on message does not appear, try using a software reset. Hold down the "Ctrl" key and press "C" (^C). If the sign-on message still does not appear then there may be a problem with either the connections, hardware or software configuration of the MDrive Motion Control or Host PC.

There are also indicators at the bottom of the window (see the figure above) that show whether you are Connected or Disconnected, the current Baud Rate and the type of device (MDrive) for which the IMS Terminal is configured. These three items may be changed directly from this screen by double clicking on them.

Double Click on "Connected" and the system will disconnect. Double Click on "Disconnect" and the system will connect.

Double Click on the Baud Rate and the preferences page will open so you can change it.

Double Click on the "MDrive" and the preferences page will open with the option to change the drive. (For this application you would not change the MDrive.)

Using the IMS Terminal Software

The IMS Terminal software is an easy to setup and use interface for MDrive Motion Control programming. It is also required to upgrade the firmware in the MDrive Motion Control.

N Many of the commands you will be using work in both the Program Editor Window and the Terminal Window. You must have the proper window selected before activating the command.

IMS Terminal Tool Bar

The IMS Terminal Tool Bar is configured with all the necessary functions to operate IMS Terminal.

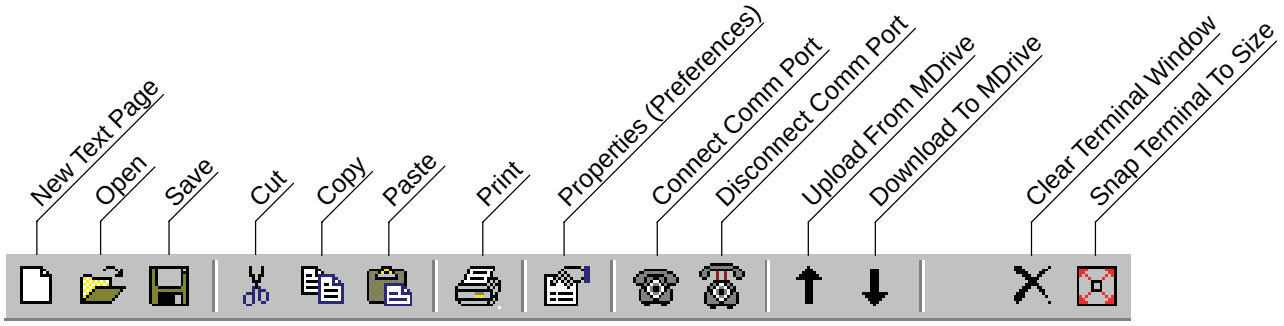


Figure 2.24: The IMS Terminal Tool Bar

Existing programs may be edited in the Program Editor Window from a file on a disk, a file on the hard drive or a file uploaded from an MDrive. You may also create a new program in the Program Editor Window.

NOTE: Your system must be connected and running and perform these steps as they are outlined.

Creating a New Program

Before you create a program you must have a new Program Editor Window open. Follow these steps:

1) Click on the Drop-Down Menu “View”. The following dialog box will be displayed:

Figure 2.25: Drop-Down Menu for New Edit Window

2) Click on “New Edit Window”. The following dialog box will be displayed:

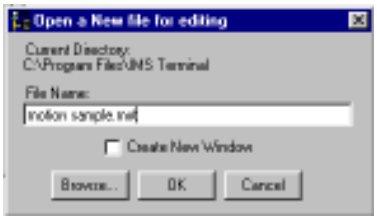


Figure 2.26: Naming the New Program/Program Editor Window

3) You must assign a file name in order to open the new window. If there is no file name the “OK” button will not be highlighted. Name this file <**motion sample.mxt**>. The <mxt> extension designates programs for the MDrive.
4) Click “OK” and the new Program Editor Window will be displayed.

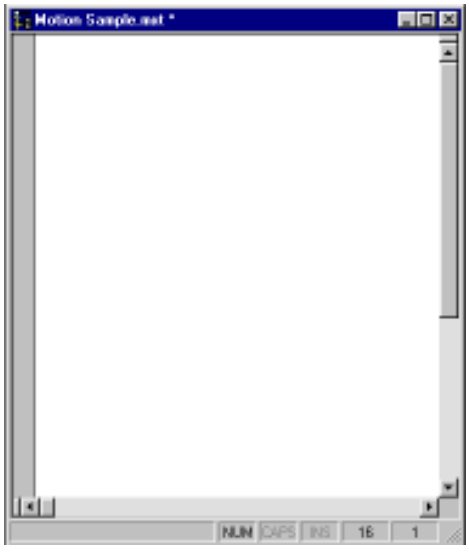


Figure 2.27: New Program Editor Window Named “motion sample.mxt”

Naming the program with the <mxt> extension automatically formats the text color and makes most of the characters appear in upper case. When you type a program the text will be color coded. In complex programs it may be difficult to read the text easily. By formatting indents, the overall appearance and readability will be greatly improved.

Formatting the Program Text

To format the text for indents you need to call up the “Preferences” dialog box. Click the “Program Editor Format” tab at the top of the box. The screen shown below will be displayed. In the “Edit Features” block (See 1 below) click on the small box to the left of “Auto Indent” and verify there is a check mark (✔) in the box. This will enable Automatic Indents. Once you indent your text with the “Tab” key all subsequent lines will adopt the same indent. Simply backspace to return to the left margin. There is also an “Enable Tabs” option. If this box is checked, tabs will be inserted into your text. If the “Tabs” option is disabled, character spaces will be inserted. For this example the “Enable Tabs” will be turned off. In the “Set” block (See 2 below) you may also set the tab spacing. The default is 2 characters. When completed, click “Apply” and then click “OK”.

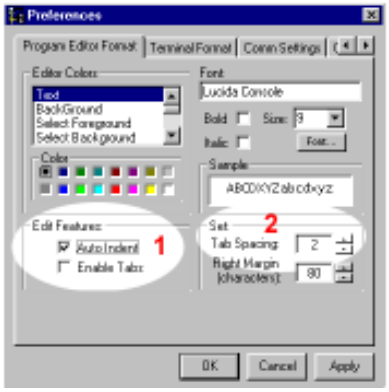


Figure 2.28: Program Editor Preferences

Now you can indent your text. Individual preference will govern how you set up your indents. The format illustrated below is most commonly used. All of the set Variables and Program Modes are left aligned. All the Labels are indented 2 characters or 1 tab. The remaining commands are indented 4 characters or 2 tabs. Indent your text by pressing the “Tab” key.

A program can now be typed into the new Program Editor Window. For this example we will use one of the sample programs found in Appendix C. The program is the first one. It is titled **Motion Sample**.

Type the program in as it is shown in Appendix C. You can type upper or lower case. Be sure to put all spaces in as they are indicated by the ∧ symbol. It is not necessary to put in the comments but they are allowed in the program provided they begin with an apostrophie (‘). NOTE: The total number of Characters and spaces must be limited to 64 per line.

As you type, the text will be automatically formatted and color coded for the MDrive. When you edit or type new commands they will appear black and will then be automatically changed to the proper color and case when you press “Enter”. If you type in all lower case characters, upon pressing “Enter” part or all of the text will be changed to upper case characters. This is an indicator that the syntax was correct and accepted by the IMS Terminal. If the entire command line is changed to red with no uppercase characters it is a bad command. Add tabs where they are desired. When complete, your program should resemble the example below. Be sure to SAVE YOUR PROGRAM by clicking “File>Save”.

NOTE: The indicator lines and labels are not part of the program. They have been added for illustration purposes only.

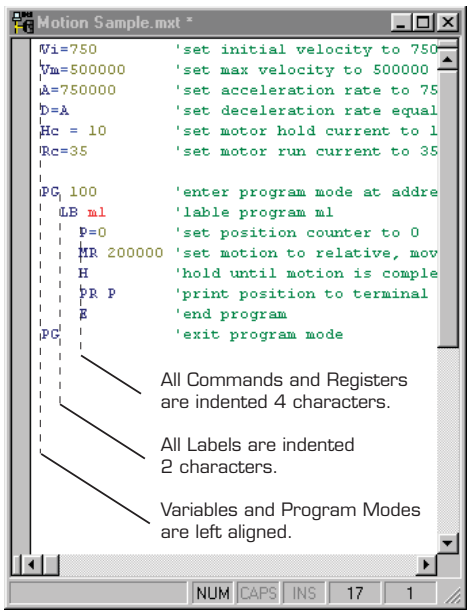


Figure 2.29: Example of Indented Text

In the illustration below the default color coding is Dark Blue, Light Blue, Red, Green, Olive and Brown. Their designations are:

Dark Blue = Key Words

One Upper/One Lower Case = IMS Variables or Flags

All Upper Case = IMS Commands

Light Blue = Numerical Signs

Red = User Defined Data

Green = Remarks

Olive = Numerical Values

Brown = Text Strings in Quotes (Not Shown)

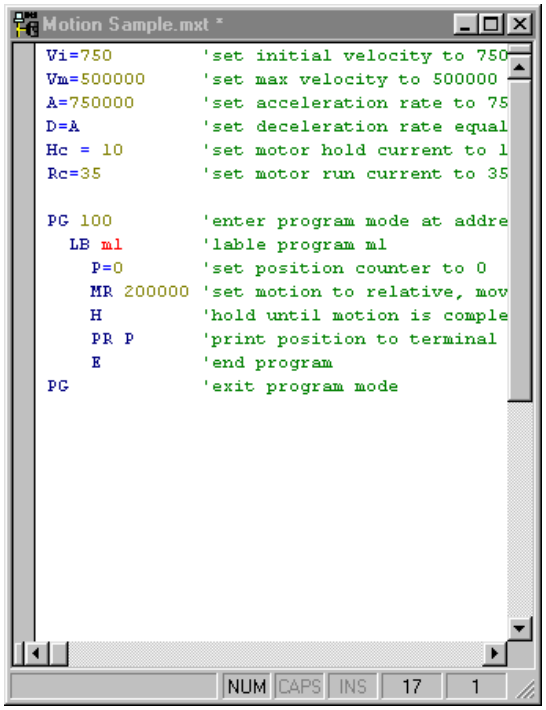


Figure 2.30: Formatted and Color Coded Program Text

The colors may be changed to suit the user's preference. To change the colors call up the “Preferences” page. Click on the “Program Editor Format” tab at the top of the page. In the “Edit Colors” block you can set up your preferential colors for the different parts of your program. These changes will become the defaults after clicking “Apply” and re-saving your program.

NOTE: When typing programs, all Variables must have the Equals Sign <=> between the command and the value. It is acceptable to have blank space on either side of the Equals Sign but the sign must be typed.

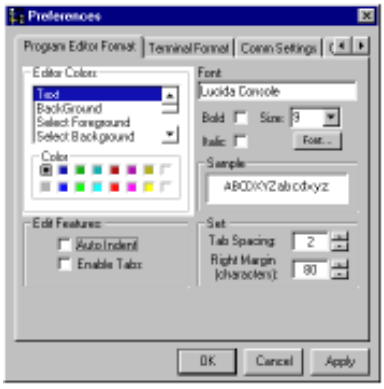


Figure 2.31: Dialog Box for Changing Text Colors in the Program Editor Window

NOTE: Before downloading any programs type **FD** and press ENTER to set the MDrive to the Factory Defaults.

There are two basic sources from which you can download programs to the MDrive Motion Control:

1) Directly from the Program Editor Window of the IMS Terminal.
2) From a file folder located on a hard drive or removable disk.

There are also two ways to enable the download dialog box.

1) Click the menu item “Transfer > Download”. The Download Dialog Box will open.

Figure 2.32: Program Download Drop-Down Menu

2) Click the Download Button  on the Main Tool Bar. The Download Dialog Box will open.

Figure 2.33: Download Dialog Box

Select the “Source Type > Edit Window” option, and click download. The program will transfer to the MDrive Motion Control.

If a Program has been previously created and stored, it may be downloaded to the MDrive Motion Control from the text file by selecting “Source Type > File” on the dialog box and typing in a drive location:\file name in the “File Name” box on the dialog, or by browsing to the file location. Ensure the programs have been saved with the <**mxt**> extension for MDrive.

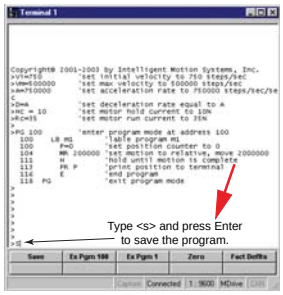


Figure 2.34: Terminal Window Displaying Downloaded Program

3) Once the program is downloaded, type **S** and press ENTER to Save the program. (Always Save your Programs!)
4) Now type **EX 100** and press ENTER. (EX=Execute and 100 is the Program Number.) Your MDrive should move 200000 steps and then print the position.

NOTE: The program can be stopped by pressing the Escape Button  or by pressing <Ctrl C>  +  .

NOTE: The program is not downloaded to the Terminal Window. It is downloaded directly to the MDrive. What is shown in the Terminal Window is an echo of the downloaded program.

NOTE: Because the program is downloaded directly to the MDrive, the unit must be powered up and the sign-on message must be displayed (communicating).

NOTE: When the program is downloaded, the color of all characters will be changed to black and line numbers will be added.

NOTE: After the program is downloaded it must be saved. Type an <s> next to the cursor and press Enter to save the program.

Uploading a Program From the MDrive Motion Control

NOTE: Be certain the program is stopped by pressing the Escape Button 

or by pressing <Ctrl C> 

+ 

.

There are two ways to upload programs from the MDrive Motion Control:

1) Directly to the Program Editor Window of the IMS Terminal.
2) To a file folder located on a hard drive or removable disk.

There are also two ways to enable the upload dialog box.

1) Click the menu item “Transfer > Upload”. The Upload Dialog Box will open.
2) Click the Upload Button  on the Main Tool Bar. The Upload Dialog Box will open. The Upload Dialog box is similar in appearance to the Download Dialog box.

With the Upload Dialog Box open, select the “Destination Type > Edit Window” option, click “Upload”. The program will transfer from the MDrive Motion Control.

Programs may also be uploaded from the MDrive Motion Control directly to a text file by selecting “Destination Type > “File” as the Destination and typing in a drive location:\file name in the “File Name” box on the dialog box.

NOTE: When uploading Program Files from the MDrive they will be slightly changed from the original. The MDrive will upload the Program only with the data within the Program. That is, the data between the two Program Modes (PG). Data such as Variables entered outside the PG Modes will not be uploaded. The uploaded program will also have a header ‘[PROGRAMS] and a footer ‘[END]. These will not affect your program as they are remarked with the apostrophie (‘) or they can be removed during editing.

You may Upload the Program Variables by clicking “Variables” in the Upload Dialog Box. However, this will upload all of the current Variables, not just those associated with the Program.

Setting the Programmable Function Keys

The IMS Terminal has the capability of programming up to 10 Function Keys, a feature typically found in more advanced terminal programs. The Function Keys can be set to provide quick access to commonly used MDrive Immediate mode commands, execute programs, or even hold entire MDrive programs up to 2048 characters.

To access the function key setup dialog box, right-click the function key area at the bottom of the Terminal Window. The window below will be displayed. To setup the function keys:

1) In this example the “Save” command is used. Enter “Save” in the Captions text field, this will be displayed on the function button.

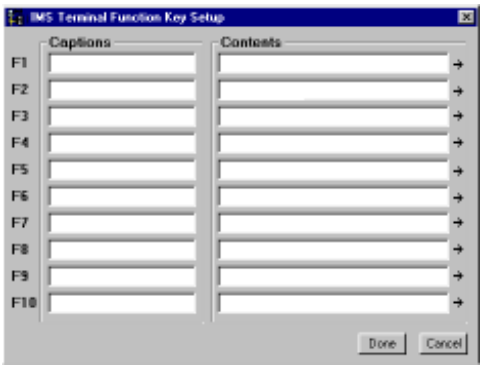


Figure 2.35: Function Key (s) Configuration Page

2) Enter the text string in the Contents field consisting of MDrive Motion Control commands and ASCII control codes. For the “save” command the letter “s” is entered.

Each command must be terminated with a Carriage Return (^M) and a pause time. Typically 50 msec (^m) is sufficient.

A fly-out dialog can be brought up by clicking the arrow on the right of the function key “Contents” field. This enables the programmer to embed common ASCII control codes in the function key text string.

3) Click “Done” to set the function.

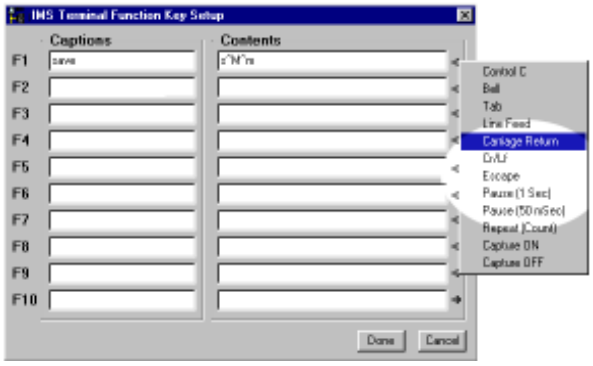


Figure 2.36: Entering Data for the Function Key (s)

To activate the Function, Click the F1 Function Key or press the  key on your keyboard.

Note: Holding the mouse pointer over the function key will display a small identification box which shows the Function Key number and the data it contains. The Function Keys are numbered left-to-right: F1..F5 and F6..F10.

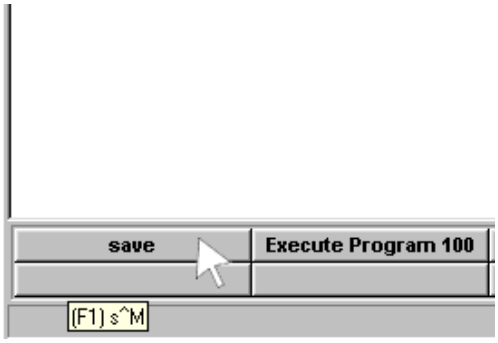


Figure 2.37: Activating a Function Key

Program Troubleshooting

The IMS Terminal offers several tools to help you troubleshoot and analyze programs. They are:

- ❒ Execute in Single Step Mode
- ❒ Execute in Trace Mode
- ❒ The Scroll Back Function
- ❒ The Capture Function

Single Step Mode

The Single Step Mode allows the user to execute a program in the Immediate Mode one line at a time. This will help the user to define problem areas by process of elimination. To use Single Step Mode, do the following:

It is recommended that you List (L) the program in the Terminal Window and either print it on paper or cut and paste it to another Program Edit Window. This will allow you to look ahead and see what line is coming up next.

1) Have the system and the program ready to run.
2) To run in Single Step Mode add a comma and the number two (2) to the execute command.
   Example: The Program Label is <aa>. Type `EX aa,2`. The program will run one line at a time.
3) Each line will be executed and listed in the Terminal Window and the Program will stop.
4) To execute and list the next line, press the Space Bar.
5) Press the Space Bar for each successive line until the program has completed.

While the program is executing, it will stop after each line is listed. At this time you may enter immediate commands such as velocity variables or actual moves as tests within the program. After entering immediate commands you may continue running in Single Step Mode by pressing the Space Bar again.

If you decide to cancel the Single Step Mode press the "Enter" key and the program will run in normal mode and finish or press Escape (Esc) to abort the program.

Trace Mode

The Trace Mode allows the user to run a program and list each line as it is executed. Running Trace Mode in conjunction with the Scroll Back Function or the Capture Function will enhance your program troubleshooting tasks. To run Trace Mode:

1) Have the system and the program ready to run.
2) To run in Trace Mode add a comma and the number one (1) to the execute command.

   Example: The Program Label is <aa>. Type `EX aa,1`. The program will run in Trace Mode and each line will be executed and listed in the Terminal Window.
3) Each line can now be analyzed.

On very large programs all of the lines may not be displayed if the "Scroll Back Buffer" value is set too low. The Scroll Back Buffer can be set to a higher value allowing you to Scroll Back farther in the program .

The Scroll Back Buffer

The “Scroll Back Buffer” function for the IMS Terminal Window can be set to different line values. It allows you to scroll back in the program that has already been displayed in the Terminal Window. It can be very useful when troubleshooting a long program.

To set the Scroll Back Buffer:

1) Open the Preferences Page for the IMS Terminal Window.
2) Click on the “Comm Settings” tab at the top of the page. The following screen will be displayed.
3) In the highlighted area in the figure below you will see a dialog box for “Scroll Back”.
4) To the left of the current value there is a small arrow to drop down the list. The list covers up to 2000 lines. You can select a value up to 2000 lines from the list.
5) If you wish to set the value higher, DO NOT open the drop down list. Simply click on the displayed value to highlight it and type in the new value up to a maximum of 32,000 lines.

NOTE: The Scroll Back Buffer utilizes RAM to store the data. The greater you set the Scroll Back Buffer capacity the greater the amount of RAM used.

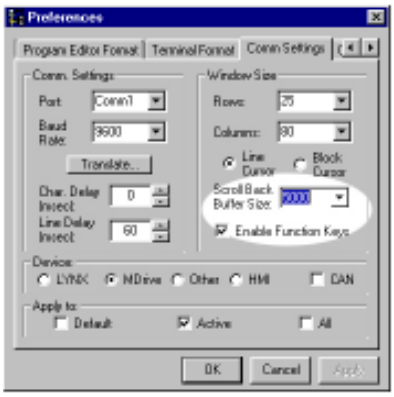


Figure 2.38: Setting the Scroll Back Buffer

The Capture Function

The Capture Function allows you to capture Terminal Communications into a text file for the purpose of troubleshooting. You may have a program that fails after running a number of times. It may be from an accumulation of position errors or other factors. By enabling the Capture Function you can store an entire text file of the received communications to your hard drive for analysis.

Enable the Capture Function

The Capture function may be enabled through the drop-down menu under “Transfer”. When you click on “Capture” a dialog box will be displayed.

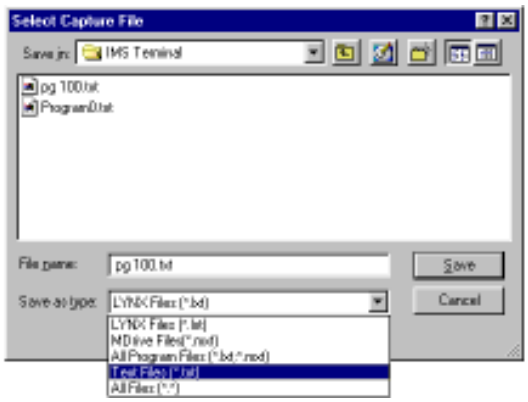


Figure 2.39: The Capture Dialog Box

Give the file you will be capturing a name and be certain to save it as a [.txt] file and click “Save”.

NOTE: The Capture Function may also be enabled through the Fly-Out menu on the Function Key configuration page by inserting it into the command string in the “Contents” line. However, the Capture Function can not be programmed with the Repeat command.

Upon clicking Save, the faded (disabled) Capture title below the Function Keys will change to “Capture ON” and to black letters.

Figure 2.40: Capture OFF Indicator

Figure 2.41: Capture ON Indicator

You are now ready to run the program. The program in this example will cycle five (5) times. The data will scroll up the Terminal Window while a copy of the data is captured into the text file simultaneously.

Once the program stops, return to the “Transfer” Drop-Down menu and click on “Stop Capture”. The data that is currently in the Terminal Window is now also saved as the prenamed text file in the IMS Folder.

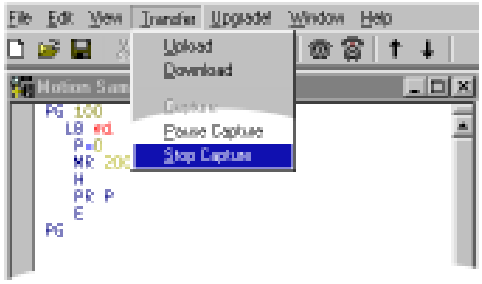


Figure 2.42: Stop Capture Command in Transfer Drop-Down Menu

Upgrading IMS Terminal and the MDrive Motion Control Firmware

Before Upgrading the MDrive Motion Control Firmware

IMPORTANT! It is recommended that you review this procedure in its entirety before performing the upgrade.

It is recommended that the most recent version of IMS Terminal Software be installed on your PC prior upgrading the MDrive Motion Control firmware.

To check if you have the most recent version of IMS Terminal Software, click the “HELP” menu item on the IMS Terminal menu bar and then click “About IMS Terminal”. The following information block will appear.

Figure 2.43: IMS Terminal Information Page

The current version of your IMS Terminal Software will be shown as indicated by the arrow. Compare this version number with the IMS Terminal version number found on the IMS web site at *www.imshome.com/software_interfaces.html.* If a more recent version is shown on the web site, you should download and install it on your system before upgrading the MDrive Motion Control firmware.

NOTE: The file you will be downloading is a self-extracting executable file. Download it to your desktop or a known folder.

To install the most recent version of IMS Terminal Software on your system perform the following steps:

NOTE: Skip Steps 1 & 2 if this is a new installation.

1. Open Windows Explorer and proceed to the folder “Program Files”.
2. Locate the folder named “IMS Terminal” and rename it to “IMS TermOLD". This will preserve any files you want to save which can be retrieved later and it will also ensure a complete new installation of IMS Terminal.
3. Locate the downloaded version of IMS Terminal Software and Double Click the file.
4. A message regarding sharing files will appear. All other applications should be closed. Click OK.
5. In the window that follows, click the button to the left of the message to continue.
6. A dialog box will query you as to which program group you want IMS Terminal to be associated. Click CONTINUE to accept the default.
7. The installation will begin followed by the “Installed Successfully” message box. Click OK and the system is ready.

Upgrading the MDrive Motion Control Firmware

NOTE: Your MDrive Motion Control is configured with the most recent firmware at the time of shipment. The main reason for upgrading is to take advantage of new features that your system may need or to correct minor errors that may be causing problems in your system. Albeit, new features and corrections may be appealing, they may have little or no affect on your system operation. If your system is operating as it should, be hesitant about upgrading the firmware for the sake of “upgrading”. Before performing the upgrade procedure, verify the firmware version in your MDrive Motion Control.

With the system running, type `<pr vr>` in the Terminal Window and press ENTER. The MDrive Motion Control will return the firmware version number. Compare this number with the latest version on the IMS web site at *www.imshome.com/flash_code.html.*

While at the web site, review the Change Summary for that version of the firmware. If none of the changes will help to correct a problem you may be having or improve your system operation, it is not necessary to upgrade.

Many problems are the result of programming errors. Verify that you do not have a programming problem that may mislead you to believe there is a problem with the firmware or your system.

If it is determined that a firmware upgrade is necessary, download the most recent version into a known folder from *www.imshome.com/flash_code.html.*

NOTES:

An isolated communications system free of electrical noise and interference is essential for trouble free communication.

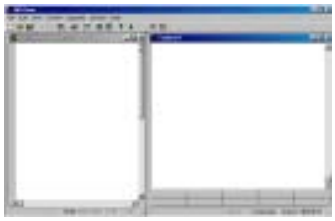
During upgrades, the communication baud rate is switched from 9600 to 19,200 and is more susceptible to electrical noise. Your communications cable should be kept to a minimum length of 6 feet.

When using a laptop PC it is recommended that you power the RS-232 to RS-485 cable with an external +5 VDC power supply. This will fortify communications.

The MDrive Motion Control remains in the Upgrade Mode until the upgrade is complete. Cycling power will not clear the Upgrade Mode.

It is recommended that you use this procedure as it is tailored for the MDrive Motion Control while the on-screen instructions are designed for several different products.

1) Open “IMS Terminal”. The following screen should be displayed. The left panel is the Program Edit Window and the right panel is the Terminal Window. The Firmware Upgrade will superimpose several dialog boxes and instructions over these two windows.



2) Check to see that the terminal window is set for MDrive communication.
   - Right click in the Terminal Window.
   - Click “Preferences” near the bottom of the pop-up menu.
   - A “Preferences” dialog box will be displayed.
   - Click on the “Comm Settings” tab at the top of the box. The following page will be displayed.
   - Confirm that MDrive is selected in the “Devices” block.

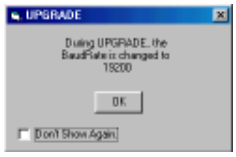
3) Power up the MDrive Motion Control.
   - The sign on message will appear.
     “Copyright 2001-2003 by Intelligent Motion Systems, Inc.”

4) Check and/or reestablish communications if the sign on message does not appear.

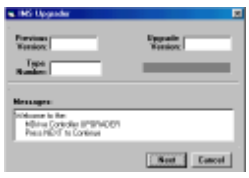
5) Type UG 2956102 in the Terminal Window and then press <enter>. Include the space between the G and the 2.
   - **THE ONLY WAY TO CLEAR THE UPGRADE MODE IS TO COMPLETE THE PROCEDURE. CYCLING POWER WILL NOT CLEAR THE UPGRADE MODE.**
   - The MDrive will return a random symbol character (ô or ö) when it is in the upgrade mode.

6) Click the “Upgrade” menu item on the IMS Terminal menu bar.

7) Message appears: “During upgrade, the baud rate is changed to 19,200.”
   - Click “OK”

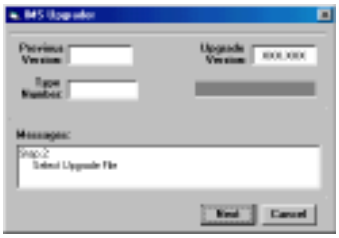


8) Message: “Welcome to the MDrive Motion Controller Upgrader. Press next to continue.
   - **YOU DO NOT NEED TO ENTER DATA IN THE WINDOWS. THIS FILLS IN AUTOMATICALLY AS YOU PROGRESS.**
   - Click “Next”

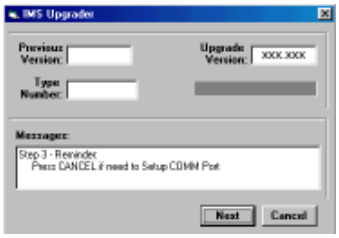


9) The Windows Explorer page “Select MDrive upgrade file” opens.
   - Browse and select the desired version of the upgrade file.
   - Click “Open” or double click the file.

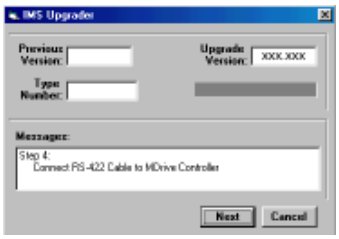
10) Message appears: Step 2 Select upgrade file.
   - The Upgrade Version will now appear in the Upgrade Version window.
   - Click “Next”



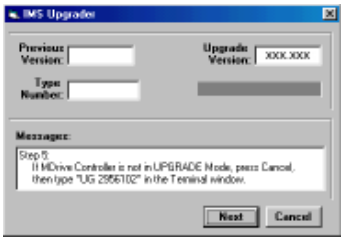
11) Message appears: Step 3 Reminder Press cancel if you need to setup COMM port.
   - **The COMM port has been setup previously. This is just a reminder.**
   - Click “Next”



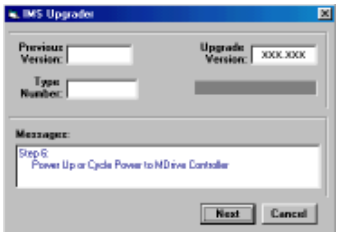
12) Message appears: Step 4 Connect RS-422 cable to the MDrive Controller.
   - **THE RS-422 HAS BEEN CONNECTED PREVIOUSLY. DO NOT PERFORM THIS STEP.**
   - Click “Next”



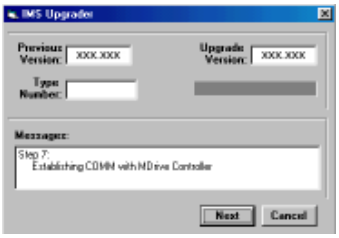
13) Message appears: Step 5 If MDrive Controller is not in the Upgrade mode, press cancel then type ‘UG 2956102’ in the terminal window.
   - **THE MDRIVE CONTROLLER WAS PLACED IN THE UPGRADE MODE PREVIOUSLY. DO NOT ENTER CODE AGAIN.**
   - Click “Next”



14) Message: Step 6 Power up or cycle power to MDrive Controller.
   - **THE UNIT HAS BEEN PREVIOUSLY POWERED UP. DO NOT CYCLE POWER.**
   - Click “Next”

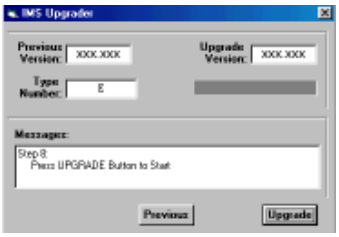


15) Message: Step 7 Establishing COMM with MDrive Controller.
- Wait for step 8 to appear.
- The previous version of firmware will now be displayed in the “Previous Version” window.

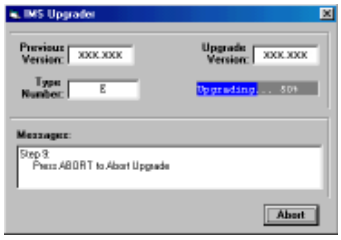


16) Message: Step 8 Press upgrade button to start.
- Click the upgrade button.

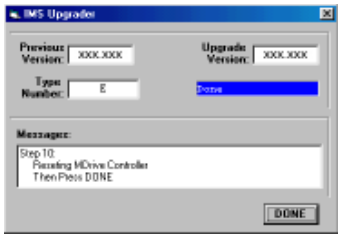
  NOTE: An upper case E will be displayed in the “Type Number” window. This confirms the upgrade is functioning properly.



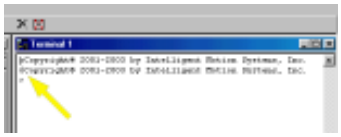
17) Message: Step 9 Press ABORT to abort upgrade.
- **DO NOT ABORT THE UPGRADE. THE MDRIVE REMAINS IN THE UPGRADE MODE AND THE UPGRADE MUST BE COMPLETED.**
- Monitor the progress in the “Upgrading…%” window.
- Step 10 will appear when DONE



18) Message: Step 10 Resetting MDrive Controller. Then Press DONE.
- Click “DONE”
- Upgrade window will close.



19) Press “Control + C” <Ctrl + C> while the Terminal Window is active to reset the MDrive Controller and exit the upgrade mode.
- The sign on message will appear. “Copyright 2001-2003 by Intelligent Motion Systems, Inc.”
- The > cursor will appear.



20) The MDrive Motion Controller firmware has been upgraded.

21) Optional confirmation of the upgrade: Type “PR VR” in the terminal window and press <enter>.
- The new firmware version is displayed.

NOTE:

The IMS Terminal automatically shifts to a 19,200 Baud Rate upon clicking the “Upgrade” command.

NOTE:

In the event of loss of power or disconnection of the RS-232 cable, the unit will maintain the “Upgrade” mode on Power Up. The Upgrade must be completed. **DO NOT** retype “UG 2956102”!

Begin with Step 6 of the above procedure and continue the Upgrade.

MDrive Motion Control Programming

The MDrive programming language consists of simple 1-2 character mnemonics.

Operational Modes

There are two operational modes for the MDrive. Immediate and Program:

1] Immediate: Commands are issued and executed directly to the MDrive Motion Control by user input into the terminal window.

2] Program: Commands and processes are run from within an MDrive program. This mode is also used for program input.

Basic Components of MDrive Motion Control Software

Instructions

An instruction results in an action. There are three types of Instructions:

Motion

Motion instructions are those that result in the movement of a motor. The syntax for these commands is as follows: Type the command followed by a space, and then the velocity or position data. For example, *MA 2000* will move the motor to an absolute position of 2000.

I/O

An I/O instruction results in the change of parameters or the state of an Input or Output. The syntax for these commands are as follows: Type the command followed by a space, then the I/O #, then an equal sign, then the data. Example: *PR I1* will read the state of input 1, *O2=0* will set output 2 to 0.

Program

A program instruction allows program manipulation. The syntax of these vary due to the nature of the command. Some command examples would be: *PG 100*, which toggles the system into program mode starting at address 100; *BR LP, I1=1*, which will Branch to a program labeled LP if Input 1 is true.

System

A system instruction is an instruction that can only be used in immediate mode to perform a system operation such as program execution (EX) or listing the contents of program memory (L). For example: EX 100 will execute a program located at line 100 of program memory space, or EX K1 will execute a program labeled K1.

Variables

Variables are labeled data that allow the user to define or manipulate data. These can also be used with the built-in math functions to manipulate data. There are two classes of variables: factory defined and user defined. There are 22 user program labels and variables available. The syntax for each variable may differ.

Factory Defined Variables

These variables are predefined at the factory. They cannot be deleted. When an FD (Factory Default) instruction is given, these variables will be reset to their factory default values. There are two types of factory defined variables:

- Read/Writable: These factory defined variables can have their value altered by the user to effect events inside or outside of a program. For example A (Acceleration Variable) can be used to set the Acceleration, or P (Position Variable) can be used to set a position reference point.
- Read Only: These factory defined variables cannot be manipulated by the user, but contain data that can be viewed or used to effect events inside a program. For example V (Velocity Variable) registers the current velocity of the motor in steps per second.

User Defined Variables

The VA instruction allows the user to assign a 2 bit character name to a user defined (32 bit value) variable.

The restrictions for this command are:

1) A variable cannot be named after an MDrive Motion Control Instruction, Variable or Flag.
2) The first character must be alpha, the second character may be alpha-numeric.
3) A variable is limited to two characters.

With these the user can define a variable to store and retreive data and perform math functions. When the FD (Factory Defaults) instruction is given, these variables will be deleted! There are two types of user defined variables:

- Global Variables: Global variables are variables that are defined outside of a program. The benefit to using a global variable is that no user program memory is required. For example the user can define a variable called SP for speed by entering VA SP into the terminal. The user can then set that variable to equal the value of the read only variable V (velocity) by entering SP = V into the terminal.
- Local Variables: This type of user defined variable is defined within a program and can only effect events within that program. It is stored in RAM. Examples of this type of variable will be given later in the section. It is worthy of note that a local variable is not static, but is erased and declared again each time a program is executed.

Flags

Flags show the status of an event or condition. A flag will only have one of two possible states: either 1 or 0. Unlike variables, there are only factory defined flags.

Factory Defined Flags

Factory defined flags are predefined at the factory and cannot be deleted. When a FD (Factory Defaults) instruction is given, these flags will be returned to their factory default state. There are two types of factory defined flags:

- Read/Writable: This type of flag is user alterable. They are typically used to set a condition or mode of operation for the MDrive Motion Control. For example EE = 1 would enable encoder operation, or EE = 0 would disable the encoder functions.
- Read Only: Read Only flags cannot be modified by the user. They only give an indication of an event or condition. Typically this type of flag would be used in a program in conjunction with the BR (Branch Instruction) to generate an if/then event based upon a condition. For example the following line of code in a program BR SP, MV = 0 would cause a program to branch to a subroutine named "SP" when the MV, the read only moving flag, is false.

Keywords

Keywords are used in conjunction with the PR and IP instructions to indicate or control variables and flags. For instance, PR UV would print the state of all the user-defined variables to the screen. IP would restore all the factory variables from the EEPROM.

Most Commonly Used Variables and Commands

Variables

NOTE: The following examples illustrate the variables in Motor Steps. When the Encoder is enabled (EE=1) all variables will be programmed in Encoder Counts. (See "Programming with the Optional Encoder Enabled".)

MS

MS (Microsteps Select) defines the resolution of the stepping motor.

- An MDrive rotates 1.8° per step or 200 steps per revolution.
- The MS selection divides the number of MDrive steps to yield a finer resolution.
- An MS value of 256 x 200 would yield 51200 microsteps per revolution. (Each Motor step will be divided into 256 Microsteps.)
- The MS default is 256.
- *To read the MS value, type PR MS and press enter*
- *To write the MS value, type MS=<number> and press enter*
- As we continue you will see that all motion variables use this value.

P

P indicates the Position in either steps or encoder counts depending upon the enable/disable state of encoder functions.

- P takes its reading from C1 (Counter 1) when encoder functions are disabled. The reading is taken from C2 (Counter 2) when encoder functions are enabled.
- *To read the position, type* PR P *or* PR C1/C2 *then press enter*
- *To zero the position, type* P=0 *then press enter*

VI

Initial Velocity in steps per second. (Step size is a function of the value of MS).

- *To read the initial velocity, type PR VI then press enter*
- *To write to the Initial velocity, type VI=<number> then press enter*
- The VI default is 1000

VM

Maximum or final Velocity in steps per second. (Step size is a function of the value of MS).

- *To read the final velocity, type* PR VM *then press enter*
- *To write to the final velocity, type* VM=<number> *then press enter*
- *The default VM Value is 768000*

A

Acceleration in steps per second^2. (Steps per second, per second.)

- The velocity of the motor will increase by the value of the Acceleration Rate every second until it reaches the programmed velocity in SL mode or it reaches VM.
- *To read the acceleration, type* PR A *then press enter*
- *To write to the acceleration, type* A=<number> *then press enter*
- *The Acceleration Default value is 1000000*

D

Deceleration in steps per second^2. (Steps per second, per second.)

- The velocity of the motor will decrease by the value of the Deceleration Rate every second until it reaches the programmed velocity in SL mode or it reaches VI.
- *To read the deceleration, type* PR D *then press enter*
- *To write to the deceleration, type* D=<number> *then press enter*
- *The Deceleration Defaut value is 1000000*

Math Functions

Another powerful feature of the MDrive Motion Control is its ability to perform common math functions and to use these to manipulate data.

Addition ..... K2†=P+R2
Subtraction ..... K3†=R1-P
Multiplication ..... A=A*2
Division ..... A=A/2
†User-defined variable used as an example.

Motion Commands

Motion Commands are those that cause the MDrive to move or affect the movement of the MDrive. There are a few factors that must be considered when programming motion commands. Linear distances, number of revolutions, degrees of rotation and timed moves can be calculated and programmed from these factors.

MA

Move to an Absolute position relative to a defined zero position.

For example, type the following commands followed by pressing enter:

```
P=0             'set the current position to 0 (zero)
MA 20000        'move 20000 steps from 0 in the plus direction
PR P            'the terminal screen will read 20000
MA 3000         'move to 3000 steps from 0 in the plus direction
PR P            'the terminal screen will read 3000
```

Absolute moves are always relative to 0 (zero).

You may program moves in the minus direction by typing the minus sign (-) before the value.

MR

Move the number of steps programmed relative to current position.

For example, type the following commands followed by pressing enter:

```
P=0             'set the current position to 0 (zero)
MR 20000        'move 20000 steps from the current position in the plus direction
PR P            'the terminal screen will read 20000
MR 3000         'move 3000 steps from the current position in the plus direction
PR P            'notice the position read is 23000 and not 3000
```

Relative moves are cumulative and are either added to or subtracted from the current position.

You may program moves in the minus direction by typing the minus sign (-) before the value.

SL

Move at a constant velocity.

```
SL 200000       'the motor moves at a constant velocity 200000 steps per second
```

The Slew Command overrides the VM (Maximum Velocity) parameter.

The value of the Slew Command may be changed “on the fly”.

You may program moves in the minus direction by typing the minus sign (-) before the value.

H

An H (Hold Command) should typically follow any MA or MR commands in a program so that program execution is suspended until the motion is complete.

Below is a usage example.

```
PG 100          'enter program mode at address 100
LB M1           'label program M1
MR 20000        'set mode to relative, move relative 20000 steps
H               'hold until motion completes
MR -20000       'move relative -20000 steps
H               'hold until motion completes
E               'end program
PG              'exit program mode
```

A delay time value (1 to 65000 milliseconds) may be programed with the Hold Command.

(Note: There are circumstances where you may not want to hold up program execution.)

All motion is programmed either Microsteps Per Second or (when the Encoder is enabled) Encoder Counts (Pulses) Per Second.

All Motion is directly affected by the Motion Command and the Program Variables.

Factors

Motor Steps:

All IMS MDrives are 200 step motors. They rotate at 1.8° per clock pulse. 200 steps would equal 1 revolution.

Microsteps: (MS)

Microsteps divide the 200 Motor Steps into smaller steps to improve smoothness and resolution of the MDrive. Using the default setting of 256 for MS, the 200 motor steps are increased to 51200 Microsteps. One motor revolution requires 51200 Microsteps with the MS set at 256. If you were to set the MS to 128, one revolution of the MDrive would now require 25600 Microsteps.

Move Command:

The Move Absolute (MA) and the Move Relative (MR) Commands are programmed in Microsteps or if the Encoder is enabled, Encoder Counts. If the MS was set at 256 and you were to program a move of 51200 Microsteps, the MDrive would turn one full revoution. If the MS was set to 128, one full revolution of the motor would be 25600Microsteps (128 x 200). If you programmed a move of 51200 Microsteps, the MDrive would turn 2 full revolutions.

If the Encoder is enabled the Move Commands use different values. The Encoder has 512 lines and yields 2048 counts or counts per revolution. Therefore, the MR and MA Command values are programmed in Encoder counts. One full revolution would be programmed as MR or MA 2048.

When the Encoder is enabled, the MS value is defaulted to 256. It cannot be changed.

Knowing these factors you can program a multitude of different movements, speeds, and time intervals.

Linear Movement:

You have a rack and pinion or a ball screw to move a linear axis. The rack and pinion or ball screw moves the linear axis 0.1 inches for each revolution. You need to move 7.5 inches.

7.5 inches divided by 0.1 inches = 75 MDrive revolutions.

Assuming an MS of 256 (51200 Microsteps) is programmed, 51200 Microsteps x 75 revolutions requires a move of 3840000 microsteps.

Knowing the values of the Variables as well as the required move, you can calculate the actual time it takes to move the axis the required distance. This is done with a Trapezoidal Profile as shown below.

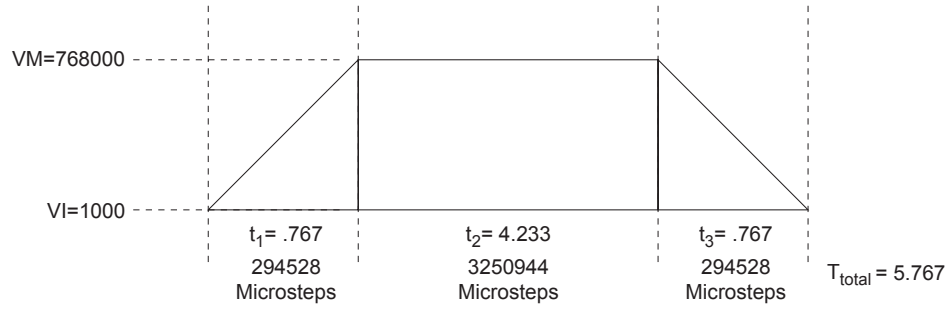


Figure 2.44: Trapezoidal Move Profile

Calculating Axis Speed (Velocity)

There are several steps required to determine the actual axis speed. They are all based on the Trapezoidal Profile above.

Known Values and Parameters:

VM 768000 Steps/Sec.

VI 1000 Steps/Sec.

A 1000000 Steps/Sec^2.

D 1000000 Steps/Sec^2.

MA/MR 3840000 Microsteps

Determine the Acceleration (A) and Deceleration (D) times (t_1 and t_3). Since the Deceleration (D) value is also 1000000 Steps/Sec. the Deceleration time (t_3) will be the same as the Acceleration time (t_1).

$$(t_1 \text{ and } t_3) = \frac{VM-VI}{A} \text{ or } \frac{768000 - 1000}{1000000} = 0.767 \text{ Seconds}$$

Determine the distance (Steps) traveled in t_1 or t_3.

$$\text{Distance} = \frac{VM+VI}{2} \text{ or } \frac{768000 + 1000}{2} \times 0.767 = 294911 \text{ Steps}$$

Determine the t_2 time.

The t_2 time is calculated by dividing the remainder of MA/MR by VM.
The remainder of MA/MR = MA/MR - (t_1 steps + t_3 steps) or 3840000 - 589056 = 3250944.

$$t_2 = \frac{3250944}{768000} = 4.233 \text{ Seconds}$$

Determine the total time. ($t_1 + t_2 + t_3$) or (0.767 + 4.233 + 0.767) = 5.767 Seconds

The linear axis took 5.767 seconds to move 7.5 inches or an average speed of 78 inches/minute.

Note that the average speed includes the Acceleration and Deceleration. The maximum axis speed attained is approximately 90 inches/minute.

$$\frac{768000}{51200} \times 0.1 \times 60 = 90 \text{ IPM}$$

Calculating Rotary Movement

Calculating Rotary Movement

Assume the MS is set to 256. You are using the MDrive to drive a shaft with a timing belt and pulley arrangement. As shown below, the MDrive pulley is 1" in diameter and the shaft pulley is 2.5" in diameter. You must turn the shaft 270°.

- The shaft will rotate 1 full revolution for every 2.5 revolutions of the MDrive.
- 270° is 0.75 of a revolution.
- 0.75 x 2.5 = 1.875 MDrive revolutions to turn the shaft 270°.
- If 51200 Microsteps is 1 MDrive revolution, then the MDrive must be programmed to move 96000 Micro-steps (51200 x 1.875).

You may also do many of the calculations in reverse to calculate MDrive moves to meet a required move of your device. A linear or rotational move as well as speed may be translated into an MDrive command.

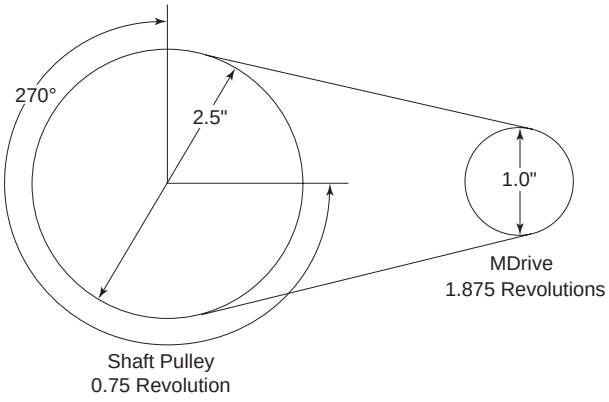


Figure 2.45: Rotary Drive Example 1

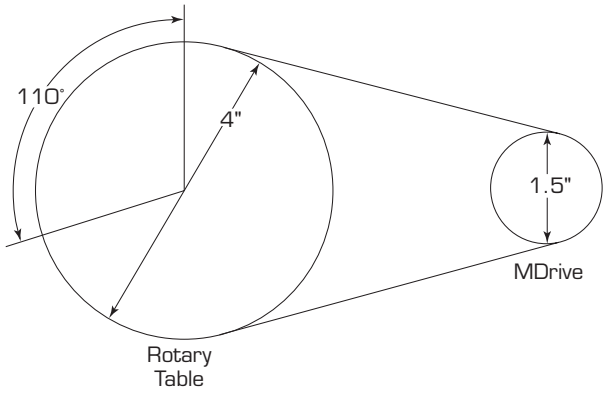


Figure 2.46: Rotary Drive Example 2

In the example above, the belt driven Rotary Table must be turned 110° at 3 RPM. How should the MDrive be set up?

Bear in mind that all the numbers are approximate due to rounding.

Mechanical ratio between the MDrive and the rotary table is 2.666:1. That is, the MDrive must rotate 2.666 revolutions for the table to rotate 1 revolution and the table will rotate 2.666 times slower than the MDrive.

- In order to move the table 110° the MDrive must move 293.3°.

  $110 \times 2.666 = 293.3°$

- If 51200 steps = 1 revolution then 1° = 142.222 steps.

  $\frac{51200}{360} = 142.222 \text{ steps}$

- The MDrive must be programmed to move 41713 steps to rotate 293.3°

  $142.222 \text{ steps} \times 293.3° = 41713 \text{ steps}$

- In order to rotate the table at 3 RPM the MDrive must turn at 8 RPM.

  $3 \text{ RPM} \times 2.666 = 8 \text{ RPM}$

- If you were to set VM at 51200 and MS set at 256 the MDrive will rotate 1 full revolution (51200 steps) in 1 second or 1 RPS. In order to rotate at 8 RPM, the MDrive must rotate at 0.13333 RPS.

  $\frac{8}{60} = 0.133333 \text{ RPS}$

- In order to rotate at 0.13333 RPS the VM must be set at 6827 steps/sec.

  $51200 \times 0.133333 = \text{VM } 6827$

NOTE: These numbers will vary slightly depending on Acceleration and Deceleration rates.

Programming with the Optional Encoder Enabled

An optional 512 line magnetic encoder is available. When the Encoder is enabled (EE=1) the programming also changes. All motion must now be programmed by the encoder counts. The Encoder operates in the "Quadrature" format. That is, there are four Encoder counts for each Encoder line or 2048 counts per revolution (512 × 4 = 2048). (See Figure below.) If you were to program motion using the MR (Move Relative) or MA (Move Absolute) commands the motor would rotate a distance equal to the encoder counts.

Example:

A programmed move of 7168 counts would result in the motor rotating 3.5 revolutions at a velocity controlled by VM.

(7168 ÷ 2048 = 3.5 revolutions)

If you were to program motion using the SL (Slew) command the motor would rotate at a "counts per second" rate based on the programmed value.

Example:

An SL (Slew) rate of 7168 counts was programed. The motor will rotate at 7168 counts/sec., 3.5 RPS, or 210 RPM.

(7168 ÷ 2048 = 3.5 RPS × 60 = 210 RPM)

When the Encoder is enabled, the parameters are also changed to be compatible with the 2048 counts.

The Encoder Enabled defaults are:

VM	30720 Counts/Sec.
VI	40 Counts/Sec.
A	40000 Counts/Sec
D	40000 Counts/Sec.
MS	256 (Default for Encoder Mode. Cannot be changed.)

To enable the Encoder the program syntax is <EE=n> where n is a zero (0) or a one (1). The default is zero (0) which is Encoder disabled. To enable the Encoder, program EE=1.

Any motion will now be programmed in Encoder counts. You can calculate the distance or velocity you need in a similar manner as done previously only with different factors.

NOTE: The Microstep Select is defaulted and locked at 256 in the Encoder Mode to ensure stable, high resolution.

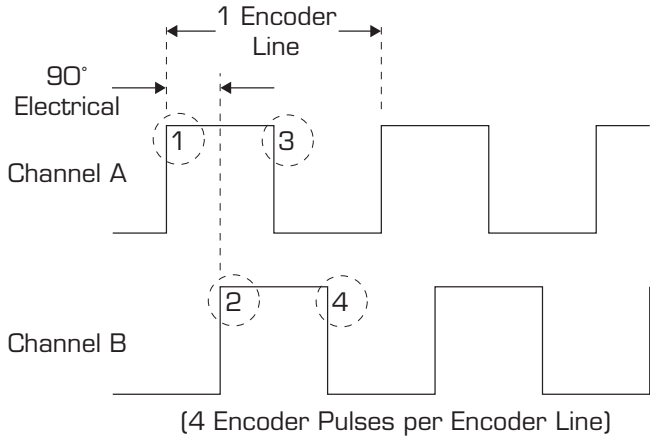


Figure 2.47: Quadrature Encoder Counts

Several Variables work in conjunction with Encoder Enable (EE). They are:

DB	Encoder Deadband
SF	The Stall Factor Variable
SM	The Stall Detection Mode
ST	Stall Flag
PM	Position Maintenance

EE - Encoder Enabled

When the Encoder is enabled, all motion is “closed loop”. That is, motion steps are delivered from the MDrive Electronics to the motor which turns the encoder. The encoder sends counts back to the drive to complete the motion. If you programmed a move of 2048 counts, the MDrive would output an appropriate number of Microsteps provided the Stall Factor (SF) value or other fault is not encountered. If no faults were encountered, the MDrive would output the full amount of Microsteps. Depending on which variables were set, the driver would then wait until the position (plus or minus the Encoder Deadband) was read and confirmed.

DB - Encoder Deadband

The Encoder Deadband is a Variable that is set in Encoder Counts. Motion will be deemed complete when the Encoder Counts are within ± the Deadband variable. With DB=5 the motion of 2048 counts would be complete between 2043 and 2053 counts.

SF - Stall Factor

The Stall Factor is a Variable which is entered in Encoder Counts. The Stall Factor is active only in the EE=1 mode. The Stall Factor might be compared to the “following error” or “lag error” of a servo drive. The Stall Factor is triggered by the number of steps output from the MDrive Electronics to the motor as compared to the number of counts returned by the encoder. The comparison should always be within the value of the Stall Factor, otherwise a fault will occur and the Stall Flag (ST) will be set. If the Stall Detection Mode is active (SM=0), the motion will be stopped.

Example:

A Stall Factor of 30 counts (SF=30) is programmed. A motion command of 2048 counts is programmed. The MDrive reaches a mechanical bind at 2000 counts. The MDrive will keep outputting steps equivalent to 2030 counts (present position plus the SF value) and then the Stall Flag (ST) will be set. The MDrive will be stopped if the Stall Detection Mode (SM=0) is active.

SM - Stall Detection Mode

The Stall Detection Mode can be programmed to stop the MDrive (SM=0) or to allow the MDrive to continue (SM=1) when the Stall Factor (SF) is reached. Whether SM is active or not, the Stall Flag will always be set when the SF is encountered.

ST - Stall Flag

The Stall Flag will be set any time the SF is reached regardless of the state of the Stall Detection Mode (SM). If the Stall Flag is set, the user must reset it to zero (0).

PM - Position Maintenance

Position Maintenance (PM) is active only after the motion has completed. Position Maintenance is used to maintain position when there might be an external force on the drive. If Position Maintenance is enabled (PM=1) and the Stall Detection Mode is enabled (SM=0), the MDrive will be driven back to its final position if it was forced out of position provided the Stall Factor (SF) was not reached.

If Position Maintenance is enabled (PM=1) and the Stall Detection Mode is disabled (SM=1), the MDrive will be driven back to its final position if it was forced out of position regardless of whether the Stall Factor (SF) was reached or not.

There are three other variables, although not directly connected to EE, that do affect the overall operation when in Encoder Mode. They are:

HC - Motor Hold Current

HT - Motor Hold Current Delay Time

MT - Motor Settling Delay Time

HC - Hold Current

When motion is complete, the MDrive Electronics will switch from Motor Run Current (RC) to Motor Hold Current (HC). The Hold Current is set at a lower percentage than the Run Current (RC). However, the Hold Current must be sufficient to overcome an outside force such as an MDrive driving a vertical slide which maintains a load on the MDrive at all times. Actual Hold Current values will vary depending on the application and the load on the MDrive when it is at rest.

HT - Motor Hold Current Delay Time

The Motor Hold Current Delay Time (HT) is a variable that delays the change from Run Current (RC) to Hold Current (HC) at the end of a move. The end of the move is triggered by the MDrive Electronics when it has completed outputting the correct number of steps. Depending on the application, including velocity, deceleration, load and inertia, the MDrive may lag behind a few counts. The HT will allow the MDrive to finish its move before applying the lower HC.

MT - Motor Settling Delay Time

A stepping motor may ring or oscillate in minuscule amounts at the completion of a move until it satisfies the target position. The amount of this “ringing” is dependent on the application including velocity, deceleration, inertia, friction and load. The Motor Settling Delay Time (MT) allows the motor to stop “ringing” before checking the position count. If the MDrive Electronics tried to check the position count during this ringing, it would assume a position error and try to correct an already moving MDrive and possibly cause ringing of a larger magnitude and longevity. Typically, the MT is set between 50 and 100 milliseconds. It is recommended that there is always a Motor Settling Time programmed any time you are in EE=1 mode.

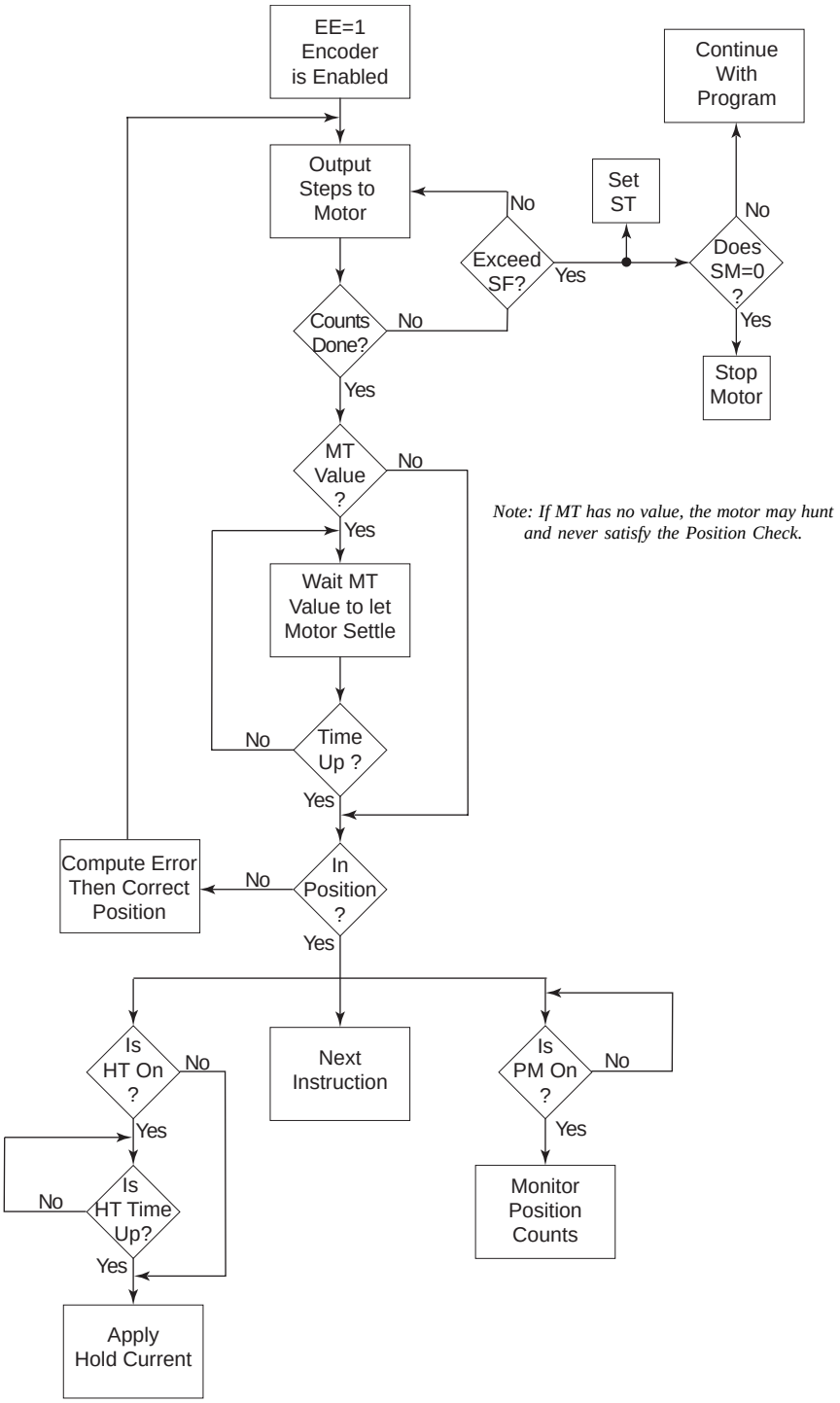


Figure 2.48: EE=1 Flowchart

I/O Commands

S<1-4>
This command configures the Type and Active state of I/O points 1-4.

Using the PR command to read I/O parameters

Read I/O1 Setup – "PR S1"

Read I/O2 Setup – "PR S2"

Setting the I/O parameters

Set IO 3 parameters – "S3=0,1" Sets IO3 as a General Purpose Input, Active High

For example: To set I/O4 as a Jog+ Input/Active Low

S4 =7,0

I<1-4>
Used to read the state of an individual input.

PR I1 will read the state of input 1 and display it to the terminal window.

BR K5, I2=0 will branch to the program address labled K5 when Input 2 is LOW

IN
Used to read the decimal equivalent of the 4 bit binary number represented by all 4 inputs collectively. Note the Input 4 is the Most Significant Bit.

PR IN will print the decimal value of the inputs.

O<1-4>
Used to set the state of an output.

O2=1 will set Output 2 TRUE

OT
Used to set the 4 bit binary equivalent of the decimal number represented by all 4 outputs collectively. Note the Output 4 is the Most Significant Bit.

OT=13 will set the outputs to 1101

System Instructions

The following System Instructions will be used frequently.

CP
The CP Instruction is used to clear Program memory space.

FD
The FD Instruction is used to return the MDrive Motion Control to its factory default state.

<esc>

The ESCAPE key will stop the user program and stop the motor with no decel rate.

<control C>

CONTROL C will reboot the unit. This includes reloading of the programs stored in nonvolatile memory into RAM and executing any programs residing at label SU (Start Up).

Program Instructions

PG
This instruction toggles the MDrive Motion Control into or out of program mode.

Switch to program mode at address 200	PG 200
	xxxxx
Program starting at address 200	xxxxx
	xxxxx
Switch out of program mode	PG

LB

The MDrive Motion Control also offers the user the convenience of naming programs, subroutines and processes to ease in branching from one part of a program to another, or calling a subroutine.

These labels, once set, will act as pointers to locations in program memory space.

The LB, or Label Instruction, allows the user to assign a 2 character name to a program or branch process within a program or subroutine.

The restrictions for this command are:

1] A label cannot be named after a MDrive Motion Control Instruction, Variable or Flag.

2] The first character must be alpha, the second character may be alpha-numeric.

3] A label is limited to to characters.

4] A program labeled SU will run on power-up

Please Note: Any program labeled "SU" will execute on power-up.

Switch to program mode at address 200	PG 200
Label command will name the program	LB K1
	xxxxx
Program named by LB command	xxxxx
	xxxxx
Switch out of program mode	PG

BR

Used to branch conditionally or unconditionally to a routine.

Switch to program mode at address 200	PG 200
Label command will name the program	LB K1
	xxxxx
Program named by LB command	xxxxx
	xxxxx
Unconditional branch to Program Label K1	BR K1
Switch out of program mode	PG

E

Designates the end of a program.

Switches to program mode at address 200	PG 200
Label command will name the program	LB K1
	xxxxx
Program named by LB command	xxxxx
	xxxxx
Unconditional branch to Program Label K1	BR K1
Designates the end of the program	E
Switches out of program mode	PG

H

Delays program execution in milliseconds.

Switches to program mode at address 200	PG 200
Label command will name the program	LB K1
	xxxxx
Program named by LB command	xxxxx
	xxxxx
Delay 2 seconds between re-execution of program	H 2000
Unconditional branch to K1	BR K1
Designates the end of the program	E
Switches out of program mode	P

PRINT

Outputs specified text and parameter values to a terminal or terminal software on a Host PC.

Switches to program mode at address 200	PG 200
Label command will name the program	LB K1
	xxxxx
Program named by LB command	xxxxx
	xxxxx
Prints text in quotes and then POS	PR “Position = ” P
Delay 2 seconds between re-execution of program	H 2000
Unconditional branch to K1	BR K1
Designates the end of the program	E
Switches out of program mode	PG

VAR

Command used to define a variable with 8 alphanumeric characters.

Switches to program mode at address 200	PG 200
Define a variable named CT for Count	VR CT
Label command will name the program	LB K1
Increment CT	IC CT
	xxxxx
Program named by LB command	xxxxx
	xxxxx
Prints text in quotes and then POS	PR
Delay 2 seconds between re-execution of program	H 2000
Branch to K1 while CT <10	BR K1, CT <10
Designates the end of the program	E
Switches out of program mode	PG

Section 2.3

MDrive Motion Control Command Set Summary

Setup Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
BD	Communications BAUD Rate	BAUD	48, 96, 19, 38, 11	BD=<baud>
CK	Check Sum Enable	–	–	CK=<1/0>
DE	Enable/Disable Drive	–	1/0	DE=<1/0>
DN	Device Name	Character	a–z, A–Z, 0–9	DN=<char>
EM	Echo Mode 0 (def)=Full Duplex, 1=Half Duplex	Mode	<0..3>	EM=<mode>
IP	Initial Parameters from EEPROM	–	–	IP
PY	Enable/Disable Party Mode	Mode	1/0	PY=<mode>
UG	Upgrade Firmware	Code	2956102	IMS Term. Upgrader

Miscellaneous Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
AL	All Parameters, Used with PR (Print)	–	–	PR AL
BY	BSY Flag 1=Prog. Running	–	0/1	PR BY
CM	For Internal Use – No User Access			
CR	For Internal Use – No User Access			
CW	For Internal Use – No User Access			
EF	Error Flag	–	0/1	PR EF
ER	Error Number Variable	Number	–	PR ER
FD	Return to Factory Defaults	–	–	FD
IF	Input Variable Pending Flag	–	–	PR IF
IV	Input Into Variable	Number	–	IV <var>
PR	Print Selected Data and/or Text	–	–	PR <data/text string>
R1	User Register 1	Number	Signed 32 bit	R1=<number>
R2	User Register 2	Number	Signed 32 bit	R2=<number>
R3	User Register 3	Number	Signed 32 bit	R3=<number>
R4	User Register 4	Number	Signed 32 bit	R4=<number>
VR	Firmware Version	Number	–	PR VR
UV	Read User Variables	–	–	PR UV

Motion Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
(–)	Do Previously Set Mode to/at This Value	per mode		–<number>
A	Set Acceleration	Steps/Sec^2	1000000000	A=<accel>
D	Set Deceleration	Steps/Sec^2	1000000000	D=<decel>
HC	Set Hold Current	% (Percent)	0 to 100	HC=<percent>
HT	Set Hold Current Delay Time	milliseconds	0–65000	HT=<msec>
JE	Jog Enable Flag	–	0/1	JE<0/1>
LM	Limit Stop Mode	–	1–6	LM=<number>
MA	Set Mode and Move to Abs. Position	±Position	Signed 32 bit	MA <±pos>
MD	Motion Mode Setting	–	–	–

(Continued)

Motion Instructions, Variables and Flags (Continued)

Mnemonic	Function	Unit	Range	Syntax Example
MR	Set Mode and Move to Relative Position	±Distance	Signed 32 bit	MR <±dist>
MS	Set Microstep Resolution	Microsteps/step	MSEL Table	MS=<param>
MT	Motor Settling Delay Time	milliseconds	0–65000	MT=<msec>
MV	Moving Flag	–	–	PR MV
RC	Set Run Current	% (Percent)	1 to 100	RC=<percent>
SL	Set Mode and Slew Axis	Steps/sec	±5000000	SL <velocity>
V	Read Current Velocity	Steps/sec	±5000000	PR V
VC	Velocity Changing Flag	–	–	BR<addr>, VC
VI	Set Initial Velocity	Steps/sec	1–5000000	VI=<velocity>
VM	Set Maximum Velocity	Steps/sec	1–5000000	VM=<velocity>

I/O Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
D1	Set Input 1 Digital Filtering	Milliseconds	0–255	D1=<time>
D2	Set Input 2 Digital Filtering	Milliseconds	0–255	D2=<time>
D3	Set Input 3 Digital Filtering	Milliseconds	0–255	D3=<time>
D4	Set Input 4 Digital Filtering	Milliseconds	0–255	D4=<time>
D5	Set Input 5 Digital Filtering	Milliseconds	0–255	D5=<time>
I1	Read Input 1	–	0/1	PR I1, BR I1,<cond>
I2	Read Input 2	–	0/1	PR I2, BR I2,<cond>
I3	Read Input 3	–	0/1	PR I3, BR I3,<cond>
I4	Read Input 4	–	0/1	PR I4, BR I4,<cond>
I5	Read Input 5 (Analog)	–	0–1024	PR I5, BR I5,<cond>
I6	Read Encoder Index Mark Low true			
IN	Read Inputs 1–4 as One Value	data	0–15	PR IN
O1	Set Output 1 to Logic State	–	0/1	O1=<1/0>
O2	Set Output 2 to Logic State	–	0/1	O2=<1/0>
O3	Set Output 3 to Logic State	–	0/1	O3=<1/0>
O4	Set Output 4 to Logic State	–	0/1	O4=<1/0>
OT	Write Data to Outputs 1–4 as One Value	data	0–15	OT=<data>
S1	Setup IO Point 1	Type, Active	Type Table, 0/1	S1=<type>,<active>
S2	Setup IO Point 2	Type, Active	Type Table, 0/1	S2=<type>,<active>
S3	Setup IO Point 3	Type, Active	Type Table, 0/1	S3=<type>,<active>
S4	Setup IO Point 4	Type, Active	Type Table, 0/1	S4=<type>,<active>
S5	Set/Print I/O Point 5	–	9 = 0–+5 V / 10 = 4–20 mA	S5=<type>
S7	For Internal Use – No User Access			
S8	For Internal Use – No User Access			
TI	Trip on Input	–	–	TI <input>,<addr>
TE	Trip Enable	See Table	<1–4>	TE=<num>

Position Related Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
C1	Set Counter 1	Motor Counts	Signed 32 bit	C1=<counts>
HM	Home to Home Switch	Type	1-4	HM <type>
P	Set/Read Position	Motor/Encoder Counts	Signed 32 bit	P=<counts>
PC	Read Captured Position at Trip	Motor/Encoder Counts	Signed 32 bit	PR PC
TP	Trip on Position	Position	-	TP <pos>, <addr>
TE	Trip Enable	See Table	<0-3>	TE=<num>

Encoder Related Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
C2	Set Counter 2	Encoder Counts	Signed 32 bit	C2=<counts>
DB	Set Encoder Deadband	Encoder Counts	0-65000	DB=<counts>
EE	Enable/Disable Encoder Functions	-	1/0	EE=<1/0>
HI	Home to Encoder Index	Type	1-4	HI=<type>
I6	Read Encoder Index Mark	-	-	I6
PM	Position Maintenance Enable Flag		0/1	PM=<0/1>
SF	Set Stall Factor	Encoder Counts	0-65000	SF=<counts>
SM	Set Stall Mode	0=Stop Motor/1=Don't Stop	1/0	SM=<mode>
ST	Stall Flag	-	0/1	PR ST

Program Instructions, Variables and Flags

Mnemonic	Function	Unit	Range	Syntax Example
BR	Branch (Conditional/Unconditional)	-	-	BR <addr>, <cond>
CL	Call Subroutine (Conditional/Unconditional)	-	-	CL <addr>, <cond>
CP	Clear Program	Address	1-767	CP <addr>
DC	Decrement Variable	-	-	DC <var/ureg>
E	End Program Execution	-	-	E
EX	Execute Program at Address Using Selected Trace Mode		1-767	EX <addr>, <mode>
H	Hold Prog. Execution Blank/0=Motion stops	milliseconds	Blank(0)/1-65000	H=<msec>
IC	Increment Variable	-	-	IC <var>
L	List Program	Address	1-767	L <addr>
LB	Create a Program Address Label Name			
LK	Lock User Program		0/1	LK=<0/1>
OE	On Error Handler 0=Disabled	Address	0/1-767	OE <addr>
PG	Start Program Entry at Specified Address	-	Blank/1-767	PG <addr>
RT	Return from Subroutine	-	-	RT
S	Save to EEPROM	-	-	S
VA	Create A User Variable Name			
UV	Read User Variables	-	-	PR UV

Mathematical Functions

Symbol	Function
+	Add Two Variables and/or Flags
-	Subtract Two Variables and/or Flags
*	Multiply Two Variables and/or Flags
/	Divide Two Variables and/or Flags
<>	Not Equal
=	Equal
<	Less Than
<=	Less Than and/or Equal
>	Greater Than
>=	Greater Than and/or Equal
&	AND (Bitwise)
|	OR (Bitwise)
^	XOR (Bitwise)
!	NOT (Bitwise)

USAGE ABBREVIATIONS DEFINED
Program - For use within a user program
Immediate - Not for use within user program
Read - Use in print statement
Write - Write to a variable

MNEMONIC	FUNCTION	TYPE	USAGE
A	**Acceleration**	**Motion Variable**	**P/I R/W**

DESCRIPTION

The A Variable sets the peak acceleration that will be reached by the MDrive in steps per second^2. That is, steps per second, per second. If the A was set at 76800 microsteps per second^2 the motor would accelerate at a rate of 76800 microsteps per second, every second. If the maximum velocity was set at 768000 microsteps per second it would take 10 seconds to reach maximum speed.

USE	UNITS	RANGE	DEFAULT
A=<accl>	Steps/sec^2 (when EE=0)	0 to 1525878997	1000000
	Counts/sec^2 (when EE=1)	0 to 61035160	40000

EXAMPLE:

A=20000	‘set acceleration to 20000 steps/sec^2
A=D	‘set acceleration equal to deceleration

RELATED COMMANDS: D

MNEMONIC	FUNCTION	TYPE	USAGE
AL	**Retrieve All Parameters**	**Variable**	**I R**

DESCRIPTION

The AL variable is used with the PR (PRINT) instruction to print the value/state of all variables and flags to the terminal program.

USE

PR AL

RELATED COMMANDS: PR

MNEMONIC	FUNCTION	TYPE	USAGE
BD	**BAUD Rate**	**Setup Variable**	**P/I R/W**

DESCRIPTION

This variable sets the baud rate for serial communications with the MDrive. It sets the rate for the RS-485 interface. The baud rate is set by indicating the first two digits of the desired rate as shown in the range section below.

In order for the new BAUD rate to take effect, the user must issue the S (SAVE) instruction and then reset the MDrive. When the MDrive is reset, it will communicate at the new BAUD rate.

48 = 4800 bps, 96 = 9600 bps, 19 = 19200 bps, 38 = 38000 bps, 11 = 115200 bps

Note: If you change the Baud Rate in the MDrive it must be matched in IMS Terminal.

Note: A delay time between the command requests to the MDrive must be considered to allow the MDrive time to interpret a command and answer the host before a subsequent command can be sent. The time between requests is dependent on the command and the corresponding response from the MDrive.

USE	UNITS	RANGE	DEFAULT
BD=<baud>	bits per second	48, 96, 19, 38, 11	9600 bps

EXAMPLE:

BD=96	‘set communications BAUD rate to 9600 bps

RELATED COMMANDS: CK

MNEMONIC	FUNCTION	TYPE	USAGE
BR	**Branch**	**Program Instruction**	**P**

DESCRIPTION

The branch instruction can be used to perform a conditional or unconditional branch to a routine in an MDrive program. It can also be used to perform loops and IF THEN logic within a program.

There are two parameters to a branch instruction. These are used to perform two types of branches:

Conditional Branch

This type of branch first specifies an address or process label where program execution should continue if the second parameter, the condition, is true. The condition parameter may include flags as well as logical functions that are to be evaluated.

Unconditional Branch

In this type of branch the second parameter is not specified, then the execution will continue at the address specified by the first parameter.

USE

BR <addr/label, cond>

EXAMPLE:

```
BR 256, I2      'Branch to program line 256 if  Input 2 is TRUE
BR 120          'Unconditional Branch to program line 120
BR JC, I1=1     'Branch to process labeled JC if input 1 is True
```

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
BY	**Busy Flag (Read Only)**	**Busy Flag**	**P/I R**

DESCRIPTION

This read only status flag will indicate whether or not a Program is executing.

USE	UNITS	RANGE	DEFAULT
PR BY	—	0/1	0

EXAMPLE:

```
PR BY           'read the state of the busy flag
```

RELATED COMMANDS: PR

MNEMONIC	FUNCTION	TYPE	USAGE
C1	**Counter 1 (Motor Counts)**	**Motion Variable**	**P/I R/W**

DESCRIPTION

This variable contains the raw count representation of the clock pulses sent to the MDrive. Counter 1 may be preset if necessary.

USAGE	UNITS	RANGE	DEFAULT
C1=<steps>	Motor Steps	-2147483648 to 2147483647	0

EXAMPLE:

```
C1=20000        'Set Counter 1 to 20000 motor steps
PR C1           'Print the value of C1 to the terminal screen
```

RELATED COMMANDS: C2, P

MNEMONIC	FUNCTION	TYPE	USAGE
C2	**Counter 2 (Encoder Counts)**	**Motion Variable**	**P/I R/W**

DESCRIPTION

This variable contains the raw count representation of the integral 512 line encoder. Counter 2 may be preset if necessary.

USE	UNITS	RANGE	DEFAULT
C2=<counts>	Encoder Counts	-2147483648 to 2147483647	0

EXAMPLE:

```
C2=512          'Set Counter 2 to 512 encoder counts
PR C2           'Print the value of C2 to the terminal screen
```

RELATED COMMANDS: C1, EE, P

MNEMONIC	FUNCTION	TYPE	USAGE
CK	**Check Sum Enable**	**Flag**	**P/I R/W**

DESCRIPTION

CK=1 puts the MDI into Check Sum Mode. When enabled, all communications with the MDI require a Check Sum to follow all commands. The Check Sum is the 2's complement of the 7 bit sum of the ASCII value of all the characters in the command "OR"ed with 128 (hex = 0x80). The command will be acknowledged with a NAK (15) if the Check Sum is incorrect or an ACK (6) when the command is correctly processed (no error).

USE	DEFAULT
CK=<1/0>	0

EXAMPLE:

```
MR 1
77  82  32  49              'Decimal Value
4D  52  20  31              'Hex
77 + 82 + 32 + 49 = 240     'Add decimal values together
1111 0000  240              'Change 240 decimal to binary
0000 1111                   '1's complement
0001 0000                   'Add 1 (results in the 2's complement)
1000 0000                   'OR result with 128
1001 0000  144              'result Check Sum value
```

Once you have the result, add the Check Sum value of 144 to your string, (to create the symbol of 144 in your string press <Alt> 0144). The MDrive should respond with an Ack or Nak (6 Hex for Ack and 15 Hex for Nak).

RELATED COMMANDS: BD

MNEMONIC	FUNCTION	TYPE	USAGE
CL	**Call Subroutine**	**Program Instruction**	**P**

DESCRIPTION

This function can be used to invoke a subroutine within a program. This allows the user to segment code and call a subroutine from a number of places rather than repeating code within a program.

There are two parameters to the CL instruction. The first specifies the program address or label of the subroutine to be invoked if the second parameter, the condition, is true. If the second parameter is not specified, the subroutine specified by the first parameter is always invoked. The condition parameter can include flags as well as logical functions that are to be evaluated.

The subroutine should end with a RT (RET) instruction. The RT instruction will cause program execution to return to the line following the CL instruction.

USE

CL <addr/label, cond>

EXAMPLE:

```
CL 256, I1=1    'Call subroutine at program line 256 if Input 1 is TRUE
CL JK           'Call subroutine labeled JK
```

RELATED COMMANDS: RT

MNEMONIC	FUNCTION	TYPE	USAGE
CM	**Internal Function**	**No User Access**	

MNEMONIC	FUNCTION	TYPE	USAGE
CP	**Clear Program**	**Program Instruction**	**I**

DESCRIPTION

This instruction will clear the program space in the EEPROM as specified by the instruction parameter. Programs are stored directly to the EEPROM and executed from there.

USE

CP <addr/label>

EXAMPLE:

CP 256	‘Clear program space beginning at line 256 to the end of program space
CP	‘Clear all of program space

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
CR	**Internal Function**	**No User Access**	

MNEMONIC	FUNCTION	TYPE	USAGE
CW	**Internal Function**	**No User Access**	

MNEMONIC	FUNCTION	TYPE	USAGE
D	**Deceleration**	**Motion Variable**	**P/I R/W**

DESCRIPTION

The D variable sets the peak deceleration of the MDrive in steps per second^2. That is, steps per second, per second. If the D was set at 76800 microsteps per second^2 the motor would decelerate at a rate of 76800 microsteps per second, every second. If the MDrive was running at a maximum velocity of 768000 microsteps per second it would take 10 seconds to decelerate.

USE	UNITS	RANGE	DEFAULT
D=<decl>	Steps/sec^2 (when EE=0)	0 to 1525878997	1000000
	Counts/sec^2 (when EE=1)	0 to 61035160	40000

EXAMPLE:

D=20000	‘set acceleration to 20000 step/sec^2
D=A	‘set deceleration equal to acceleration

RELATED COMMANDS: A

MNEMONIC	FUNCTION	TYPE	USAGE
D1-D5	**Digital Input Filtering**	**I/O Variable**	**P/I R/W**

DESCRIPTION

This variable will set the digital filtering to be applied to the selected input 1 - 5. The input must be stable for “time” amount of milliseconds before a change in state is available.

USE	UNITS	RANGE
D <1-5>=<time>	Milliseconds	0 to 255

EXAMPLE:

D1=0	‘no debounce
D4=150	‘150 mSec of filtering

RELATED COMMANDS: I1-I5

MNEMONIC	FUNCTION	TYPE	USAGE
DB	**Encoder Deadband**	**Setup Variable**	**P/I R/W**

DESCRIPTION

This variable defines the plus (+) and minus (-) length of the encoder deadband in encoder counts.

When the encoder is enabled, a move is not completed until motion stops within DB.

USE	UNITS	RANGE	DEFAULT
DB=<counts>	Encoder Counts	0 to 65000	1

EXAMPLE:

```
DB=5          'Set Encoder Deadband to ± 5 encoder counts
```

RELATED COMMANDS: EE, C2, SF, SM, ST, PM

MNEMONIC	FUNCTION	TYPE	USAGE
DC	**Decrement Variable**	**Program Instruction**	**P/I**

DESCRIPTION

The DC instruction will decrement the specified variable by one.

USE

DC <var>

EXAMPLE:

```
DC R1         'Decrement User Register 1
```

RELATED COMMANDS: IC

MNEMONIC	FUNCTION	TYPE	USAGE
DE	**Drive Enable Flag**	**Setup Flag**	**P/I R/W**

DESCRIPTION

The DE flag enables or disables the drive portion of the MDrive Motion Control.

USE	DEFAULT
DE= <0/1>	1 (Enabled)

EXAMPLE:

```
DE=0          'Disable drive
DE=1          'Enable drive
```

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
DN	**Device Name**	**Setup Variable**	**P/I R/W**

DESCRIPTION

The DN Variable stores the device name to be used when the MDrive is to be addressed in party mode operation. The name is only used when party mode communications is being used (PY = 1).

All MDrive system nodes will respond if the name in a command is given as "*".

When the name is changed it must be saved into the nonvolatile memory if it is to be used in later sessions without being changed again.

See Appendix A: ASCII table for decimal codes.

USE	UNITS	RANGE	DEFAULT
DN=<"char">	ASCII Characters	a-z, A-Z, 0-9	!

EXAMPLE:

```
DN="A" or 65  'Set the device name to the character A
```

RELATED COMMANDS: PY, S

MNEMONIC	FUNCTION	TYPE	USAGE
E	**End Program Execution**	**Program Instruction**	**P**

DESCRIPTION

Stops the execution of a program.

USE

E

EXAMPLE:

```
PG 100          'Start program at line 100
LB J2           'Label Program J2
MR 20000        'move relative 20000 motor counts
H               'hold until motion stops
MR -20000       'move relative -20000 motor counts
H               'hold until motion stops
E               'End program execution
PG              'exit program mode
```

RELATED COMMANDS: PG, EX

MNEMONIC	FUNCTION	TYPE	USAGE
EE	**Encoder Enable Flag**	**Setup Flag**	**P/I R/W**

DESCRIPTION

The EE flag enables or disables the optional encoder mode of the MDrive Motion Control. When in Encoder Mode, all programming is done by Encoder Counts. The 512 line Encoder generates counts in a Quadrature format which results in 2048 counts per revolution. (See Programming With the Optional Encoder Enabled in Section 2.2.)

USE	DEFAULT
EE= <0/1>	0 (Disabled)

EXAMPLE:

```
EE=0            'Disable encoder mode
EE=1            'Enable encoder mode
```

NOTE: Microstep Select (MS) is set to 256 and cannot be changed in EE=1 mode.

RELATED COMMANDS: DB, C2, SF, SM, ST, PM

MNEMONIC	FUNCTION	TYPE	USAGE
EF	**Error Flag**	**Status Flag**	**P/I R**

DESCRIPTION

The Error flag will indicate whether or not an error condition exists. It is automatically cleared when a new program is executed. The only way to manually clear the EF flag is to read the value of the ER variable or set ER=0

There is an instruction, OE, which allows the user to specify the execution of a subroutine in the program memory when an error occurs. The subroutine might contain instructions to read the ER variable which would clear the EF flag.

USE	RESPONSE
PR EF	0 = No Error Exists
	1 = Error Condition Exists

EXAMPLE:

```
PR EF           'read the state of the error flag
```

RELATED COMMANDS: ER, OE

MNEMONIC	FUNCTION	TYPE	USAGE
EM	**Echo Mode Flag**	**Setup Flag**	**P/I R/W**

DESCRIPTION

The Echo Mode Flag will set the full/half duplex configuration of the RS-485 channel. 0=Full Duplex (default), 1=Half Duplex.

USE	DEFAULT
EM= <0-3>	0 (Full Duplex)

EXAMPLE:

```
EM=0      'Echo all information back over communications line. CR/LF Indicates Command Accepted (Full Duplex).
EM=1      'Don't echo the information, only send back prompt. CR/LF Indicates Command Accepted (Half Duplex).
EM=2      'Does not send back prompt, only responds to PRINT and LIST commands.
EM=3      'Saves Echo in Print Queue then executes Command. Prints after execution.
```

RELATED COMMANDS: BD

MNEMONIC	FUNCTION	TYPE	USAGE
ER	**Error Number Variable**	**Status Variable**	**P/I R/W**

DESCRIPTION

The ER variable indicates the program error code for the most recent error that has occurred in the MDrive Motion Control. The ER variable must be read or set to zero to clear the EF flag.

A Question Mark <?> in place of the normal cursor indicates an ERROR. See Appendix A of this document for a complete listing of MDrive Motion Control Error Codes.

USE	RESPONSE
PR ER	<numerical error code>

EXAMPLE:

```
PR ER     'read the error number
ER 0      'clears <?> on display
```

RELATED COMMANDS: EF, OE

MNEMONIC	FUNCTION	TYPE	USAGE
EX	**Execute Program**	**Program Instruction**	**I**

DESCRIPTION

Execute program at a specified address or label using a selected trace mode. Used in immediate mode.

There are three modes of program execution.

Mode 0 Normal execution, is specified by a mode of 0 (or simply leaving the mode blank).

Mode 1 Trace mode is specified by a mode of 1. This means that the program executes continuously until the program END is encountered, but the instructions are "traced" to the communications port so the user can see what instructions have been executed.

Mode 2 Single step mode is specified by a mode of 2. In this mode, the user can step through the program using the space bar to execute the next line of the program. The program can be resumed at normal speed in this mode by pressing the enter key.

USE	MODES
EX <addr/label>,<mode>	<mode> = 0: run program normally
	<mode> = 1: run program in trace mode
	<mode> = 2: run program in single-step mode

EXAMPLE:

```
EX 127    'execute program at line 127 normally
EX 127,1  'execute program at line 127 in trace mode
```

RELATED COMMANDS: PG, E

MNEMONIC	FUNCTION	TYPE	USAGE
FT	**Factory Test**	**Status Variable**	**I**

DESCRIPTION Factory Test

USE For Factory Use Only

MNEMONIC	FUNCTION	TYPE	USAGE
FD	**Factory Defaults**	**Program Instruction**	**I**

DESCRIPTION

Returns MDI to factory default settings.

USE RESPONSE

FD <IMS Copyright sign on message> "Copyright 2001-2003 by Intelligent Motion Systems, Inc."

EXAMPLE:

FD^M

RELATED COMMANDS:

MNEMONIC	FUNCTION	TYPE	USAGE
H	**Hold Program Execution**	**Program Instruction**	**P**

DESCRIPTION

The hold instruction is used in a program to suspend program execution. If no parameter is specified the execution of the program will be suspended while motion is in progress. This will typically be used following a MA, MR, HI or HM instruction.

A time in milliseconds may be placed as a parameter to the hold instruction, This will suspend program execution for the specified number of milliseconds.

USE

H <time> 'Blank or 0 - hold while moving, 1 - 65000 Milliseconds.

EXAMPLE:

```
'example 1
MA 20000        'move absolute 20000 motor units
H               'hold program execution until motion completes
MA -20000       'move absolute -20000 motor units
H               'hold program execution until motion completes

'example 2
O2=1            'set output 2 HIGH
H 1000          'hold 1 second (1000 Milliseconds)
O2=0            'set output 2 LOW
```

RELATED COMMANDS: PG, E

MNEMONIC	FUNCTION	TYPE	USAGE
HC	**Hold Current**	**Setup Variable**	**P/I R/W**

DESCRIPTION

This variable defines the motor holding current in percent.

USE	UNITS	RANGE	DEFAULT
HC=<PERCENT>	PERCENT	0 TO 100	5

EXAMPLE:

```
HC=5            'Set motor holding current to 5%
```

RELATED COMMANDS: HT, RC

MNEMONIC	FUNCTION	TYPE	USAGE
HI	**Home to Index Mark**	**Motion Instruction**	**P/I**

DESCRIPTION

This instruction will find the the encoder index mark. There are four combinations for this command. (See Use below.)

1) Speed (S): Specifies the direction and speed that the axis will move until the index mark is found (VM).

2) Creep (C): Specifies the direction and speed that the axis will move off the index mark until it becomes inactive again (VI).

When HI is executed, the axis moves in the direction specified by the (S) at VM until it reaches the index mark. It then creeps off of the index in the direction specified by the sign of (C) at VI. Motion is stopped as soon as the index changes state.

USE	TYPES
HI=<type>	1: S- C+, 2: S- C-, 3: S+ C-, 4: S+ C+

EXAMPLE:

HI=2	'Find index mark at VM in the minus direction, Creep off at VI in the minus direction

RELATED COMMANDS: VM, VI, EE, I6, HM

MNEMONIC	FUNCTION	TYPE	USAGE
HM	**Home to Home Switch**	**Motion Instruction**	**P/I**

DESCRIPTION

This instruction will find the selected I/O switch assigned to "Home".

1) Speed (S): Specifies the direction and speed that the axis will move until the switch is activated (VM).

2) Creep (C): Specifies the direction and speed that the axis will move off the switch until it becomes inactive again (VI).

When HM is executed, the axis moves at VM in the direction specified by the sign of speed. It then creeps off of the switch at VI in the direction specified by the sign of creep. Motion is stopped as soon as the switch becomes deactivated.

The diagram on the following page illustrates the different scenarios possible during the Homing (HM) sequence. The diagrams represent the four HM commands. Below are the four combinations of the HM command.

HM=1 Slew at VM in the minus direction and Creep at VI in the plus direction.

HM=2 Slew at VM in the minus direction and Creep at VI in the minus direction.

HM=3 Slew at VM in the plus direction and Creep at VI in the minus direction.

HM=4 Slew at VM in the plus direction and Creep at VI in the plus direction.

The key to the diagrams is as follows.

1 Slew at VM to find the Home Switch.

2 Decelerate to zero (0) after finding the Home Switch.

3 Creep at VI away from the Home Switch.

4 Stop when at the edge of the Home Switch.

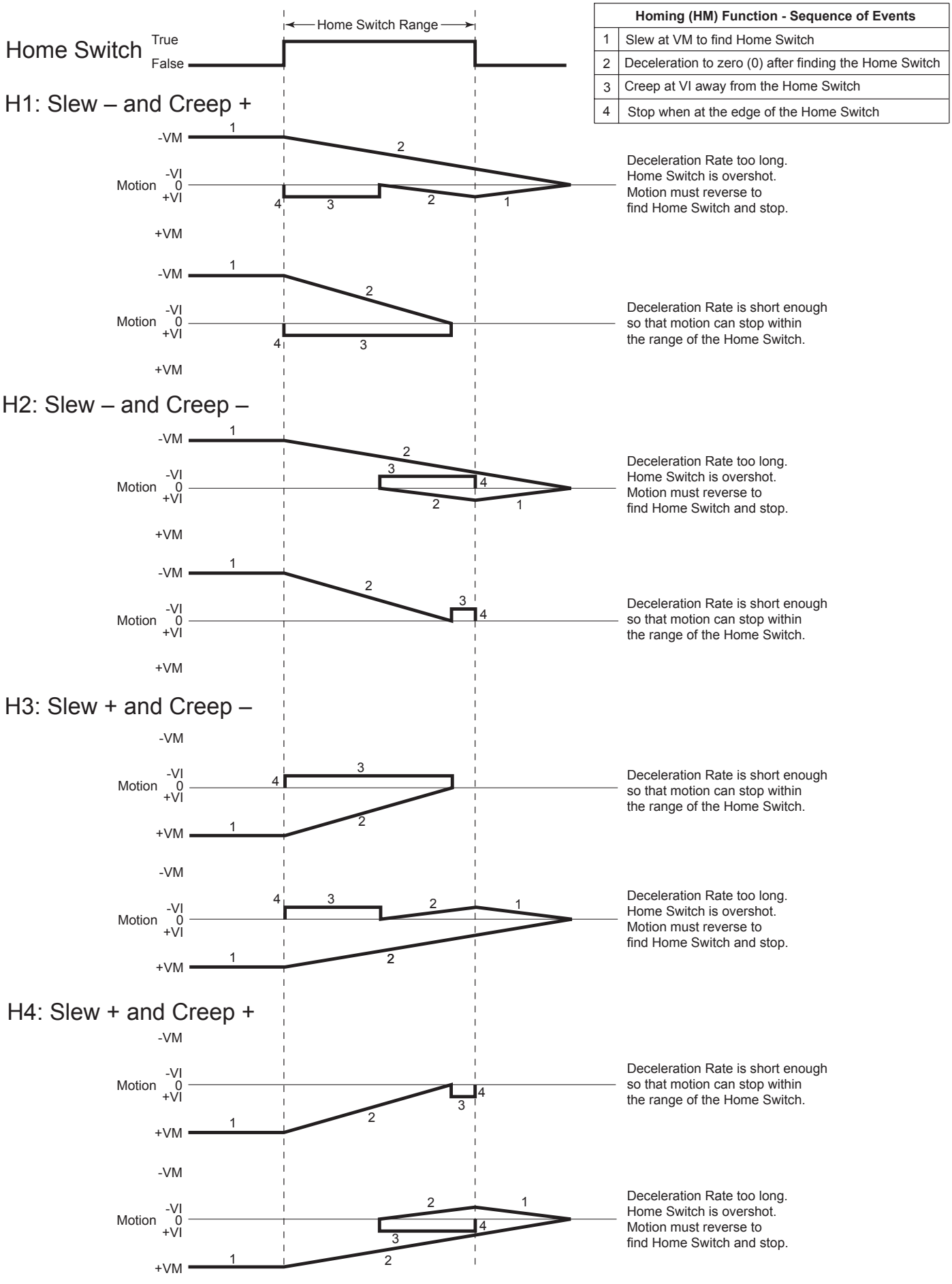
USE	TYPES
HM=<type>	1: S- C+, 2: S- C-, 3: S+ C-, 4: S+ C+

EXAMPLE:

HM=3	'Find home switch at VM in the plus direction, Creep off at VI in the minus direction

RELATED COMMANDS: VM, VI, S1-S4, HI, LM

Homing (HM) Function - Sequence of Events	
1	Slew at VM to find Home Switch
2	Deceleration to zero (0) after finding the Home Switch
3	Creep at VI away from the Home Switch
4	Stop when at the edge of the Home Switch



MNEMONIC	FUNCTION	TYPE	USAGE
HT	**Hold Current Delay Time**	**Setup Variable**	**P/I R/W**

DESCRIPTION

The HT variable sets the delay time in milliseconds between the cessation of motion and when the MDrive Motion Control shifts to the holding current level specified by the HC (Motor Holding Current) variable. The delay time is also effected by the MT (Motor Settling Delay Time) variable in that the total time from motion ceasing to current change is represented by the sum of MT + HT

USE	UNITS	RANGE	DEFAULT
HT=<time>	milliseconds	0 to 65000	500

EXAMPLE:

```
HT=1500          'Set hold current delay time to 1.5 seconds
```

RELATED COMMANDS: HC, MT, RC

MNEMONIC	FUNCTION	TYPE	USAGE
I1 - I4	**Read Input**	**I/O Variable**	**P/I R**

DESCRIPTION

This variable will read the state of the specified input 1 - 4. Can be used with PR (Print), BR (Branch) and Cl (Call Subroutine) instructions. Can also be used with R1-R4 and User Variables.

The value of the bit state will be dependant on active (low/high) state of the input, specified by the S<1-4> variable.

USE

```
PR I<1-4>
BR <addr>, I<1-4>=<1/0>
CL <addr>, I<1-4>=<1/0>
```

EXAMPLE:

```
PR I2            'Print the state of  Input 2 to the Terminal Screen
BR 128, I3=1     'Conditional branch to program line 128 if  Input 3 = 1
CL 432, I4=0     'Call subroutine at line 432 if Input 4 = 0
```

RELATED COMMANDS: IN, O1-O4, PR, S1-S4

MNEMONIC	FUNCTION	TYPE	USAGE
I5	**Read Analog Input**	**I/O Variable**	**P/I R**

DESCRIPTION

This variable will read the value of the voltage seen on the Analog Input. Can be used with PR (Print), BR (Branch) and Cl (Call Subroutine) instructions. The value read will between 0 and 1028.

USE

```
PR I5
BR <addr/label>, I5=<0 - 1028>
CL <addr/label>, I5=<0 - 1028>
```

EXAMPLE:

```
PR I5            'Print the value of  the Analog Input to the Terminal Screen
BR K1, I5=512    'Branch to Program labled K1 if Analog Input = 512
CL 432, I5=0     'Call subroutine at line 432 if  Analog Input = 0
```

RELATED COMMANDS: BR, CL, PR

MNEMONIC	FUNCTION	TYPE	USAGE
I6	**Read Encoder Index Mark**	**I/O Variable**	**P/I R**

DESCRIPTION

This variable will read the on/off state of the Encoder Index Mark. Can be used with PR (Print), BR (Branch) and Cl (Call Subroutine) instructions. The value read will be 0 (off mark) or 1 (on mark).

USE

PR I6

BR <addr/label>, I6=<0/1>

CL <addr/label>, I6=<0/1>

EXAMPLE:

```
PR I6          'Print the on/off state of the encoder index mark
BR K1, I6      'Branch to Program labled K1 if encoder index mark is TRUE
CL 432, I6=0   'Call subroutine at line 432 if I6=0
```

RELATED COMMANDS: BR, CL, PR

MNEMONIC	FUNCTION	TYPE	USAGE
IC	**Increment Variable**	**Program Instruction**	**P/I**

DESCRIPTION

The IC instruction will increment the specified variable by one.

USE

IC <var>

EXAMPLE:

```
IC R4          'Increment User Register 4
```

RELATED COMMANDS: IC

MNEMONIC	FUNCTION	TYPE	USAGE
IF	**Input Variable Pending Flag**	**Setup Flag**	**P/I**

DESCRIPTION

The IF command is automatically set to 1 when IV command is executed. This means that the IF flag reflects an input value from serial port is pending, not that one has been received. IF will be cleared to zero (0) with a carriage return, or can be reset manually.

RELATED COMMANDS: IV

MNEMONIC	FUNCTION	TYPE	USAGE
IN	**Read Inputs 1-4 As 1 Value**	**I/O Variable**	**P/I R**

DESCRIPTION

This keyword will read the binary state (unprocessed by S<1-4>) of inputs 1-4 and print them as a decimal value. When used thus, Input 1 is the Least Significant Bit (LSb) and Input 4 is the Most Significant Bit (MSb). It may be used in conjunction with the R1-R4 (User Registers), PR (Print), BR (Branch) and Cl (Call Subroutine) instructions. The value is a function of the actual state of the IO where 1 = +V and 0 = Ground. (Not a function of the active state defined in S1 to S4 variables).

USE

PR IN

BR IN=<0-15>

CL IN=<0-15>

EXAMPLE:

```
PR IN          'Print the state of  Inputs 1-4 to the Terminal Screen
BR 128, IN=8   'Conditional branch to program line 128 if the binary state of Inputs 1-4 = 8 (1000)
CL 432, IN=13  'Call subroutine at line 432 if the binary state of Inputs 1-4 = 13 (1101)
```

RELATED COMMANDS: I1-5, O1-O5, PR, S1-S4

MNEMONIC	FUNCTION	TYPE	USAGE
IP	**Initialize Parameters**	**Instruction**	**P/I**

DESCRIPTION

The IP instruction will return all of the MDrive Motion Control parameters to their stored values.

USE

IP

EXAMPLE:

```
IP
```

RELATED COMMANDS: CP, S

MNEMONIC	FUNCTION	TYPE	USAGE
IV	**Input into Variable**	**Instruction**	**P/I**

DESCRIPTION

With the IV command, a user may input new variable values. These values must be numeric and will be input into the variable specified in the IV command.

It is the programmer's responsibility to use the PR command to request information from the user. The PR command must be placed before the IV statement. The variable used for the IV may be a system or USER Variable. A USER Variable must be declared prior to the IV command.

USE

IV <var> <var> = Any user or factory defined variable. (Sets IF to 1)

EXAMPLE:

```
LB P1                       'program label 1
PR "Enter New Velocity"     'prints the message to the operator
IV R1                       'value in register 1 will be changed
LB P2                       'program label 2
H 50                        'hold for 50 milliseconds
BR P2, IF=1                 'branch waiting for user to enter new velocity
SL R1                       'slew at new velocity
H 1000                      'hold for 1 second
BR P1                       'branch back to P1
```

RELATED COMMAND: IF

MNEMONIC	FUNCTION	TYPE	USAGE
JE	**Jog Enable**	**Setup Flag**	**P/I R/W**

DESCRIPTION

This command will enable Jog Mode if I/O are set for Jog Plus and/or Jog Minus. States are 0=Disabled, 1=Enabled.

USE	DEFAULT
JE= <0/1>	0 (Disabled)

EXAMPLE:

```
JE=0        'disable jog mode when jog +/- is true motor accels from V1 to VM
JE=1        'enable jog mode when jog +/- is false motor decels from V1 to VM and stops
```

RELATED COMMANDS: VM; A; D; VI; S1-4=7; S1-4=8

MNEMONIC	FUNCTION	TYPE	USAGE
L	**List Program Space**	**Instruction**	**I**

DESCRIPTION

The L instruction will print the contents of program space beginning at the specified address to the end. If no address is specified it will list beginning at line 1.

USE

L

L <addr/label>

EXAMPLE:

```
L 128       'display contents of program space beginning at line 128
```

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
LB	**Label Program/Subroutine**	**Instruction**	**P/I R/W**

DESCRIPTION

The LB, or Label Instruction, allows the user to assign a 2 character name to a program, branch process within a program or subroutine.

The restrictions for this command are:

1] A label cannot be named after an MDrive Motion Control Instruction, Variable or Flag.

2] The first character must be alpha, the second character may be alpha-numeric.

3] A label is limited to two characters.

4] A program labeled SU will run on power-up

USE

LB <char><char>

EXAMPLE:

```
PG 100      'start program at adress 100
LB J0       'Label program J0
```

RELATED COMMANDS: BR, CL, EX, TI, TP, L, CP

MNEMONIC	FUNCTION	TYPE	USAGE
LK	**Lock User Program**	**Setup Flag**	**I R/W**

DESCRIPTION

This flag allows the user to lock the program from being listed or modified. It can only be reset by clearing the entire program space: CP (no address). If CP addr, L (addr) or PG addr are entered, then error 44 (Program Locked) will be set and nothing else will happen.

To clear LK, don't save (S) then do a Ctrl-C or Cycle Power and the LK will be reset to previous unlocked state. (Program is automatically stored in NVM as it is entered.) Or you may clear program (CP). This will clear the program and reset LK to 0 in NVM as well as in local ram.

USE	DEFAULT
LK= <0/1>	0 (Disabled)

RELATED COMMANDS: CP, L

MNEMONIC	FUNCTION	TYPE	USAGE
LM	**Limit Stop Mode**	**Motion Variable**	**R/I R/W**

DESCRIPTION

The LM variable specifies the Limit Stop Mode for the MDrive. There are six LM modes. They are as follows.

LM=1 Normal Limit function with a decel ramp.

The I/O must be set for Limits. If the limit switch in the direction of travel is reached, the motion will decel to a stop. That is, the plus limit works only in the plus direction of travel and the minus limit works only in the minus direction of travel.

In the illustration below, the Limit is activated at a given position but because of the deceleration rate the motion continues for the duration of the deceleration time. This position may be beyond the trip point of the limit and a subsequent move in the same direction will not stop. A crash may be imminent.

If the limit is activated and maintained the software will allow motion *only* in the opposite direction.

If Homing (HM) is active and a limit is reached, the motion will decel to a stop and then reverse direction and seek the Homing Switch. If the Homing Switch is not activated on the reverse and the opposite limit is reached all motion will stop with a decel ramp. (See HM)

It is possible for the Home Switch to be overshot because of long decel time. Whenever the Homing sequence is activated, a small decel rate should be used.

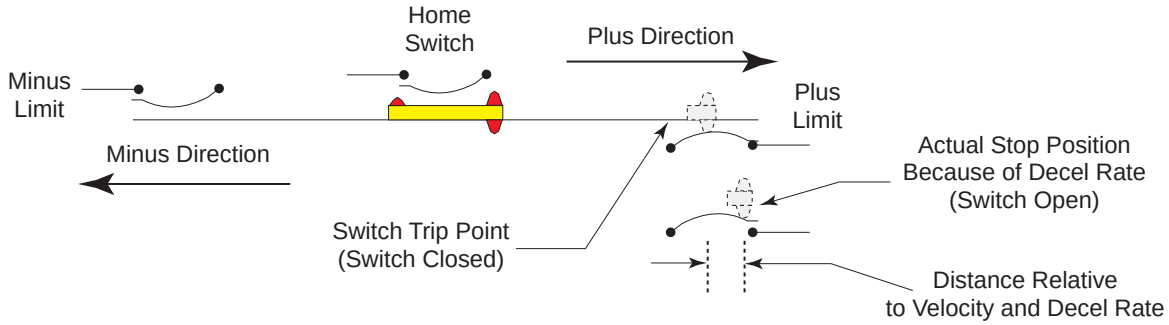
LM=2 A Limit stops all motion with a decel ramp but no Homing.

LM=3 A Limit will stop all motion with a decel ramp and stop program execution.

LM=4 Functions as LM=1 but with no deceleration ramp.

LM=5 Functions as LM=2 but with no deceleration ramp.

LM=6 Functions as LM=3 but with no deceleration ramp.



USE	DEFAULT
LM=<1-6>	1

RELATED COMMANDS: HI, HM, JE, MA, MR, SL

USAGE: **P** = Program **I** = Immediate **R** = Read **W** = Write

MNEMONIC	FUNCTION	TYPE	USAGE
MA	**Move To Absolute Position**	**Motion Instruction**	**P/I**

DESCRIPTION

Set mode for absolute move and move to an absolute position relative to (0) zero. MD (Current Mode) will be set to MA.

If flag is true, then DN will be sent out when move is complete.

USE	UNITS
MA ±pos, <flag>	motor steps (EE=0) or encoder counts (EE=1)

EXAMPLE:

```
MA 51200        'move motor to absolute  position 51200
MA –51200       'move motor to absolute position –51200
```

RELATED COMMANDS: MD, MR, MS, P

MNEMONIC	FUNCTION	TYPE	USAGE
MD	**Motion Mode**	**Motion Variable**	**P/I R**

DESCRIPTION

Indicates what the last motion command was, so that when just a number is entered, then it will read MD to define the new motion.

USE

MD

EXAMPLE:

```
MA 200000       'move absolute 200000 steps, set current mode to MA
-200000         'move absolute -200000 steps

MR 1000000      'move relative 1000000 steps, set current mode to MR
-1000000        'move relative -1000000 steps

SL 20000        'slew 20000 steps/sec. set current mode to SL
-10000          'slew 10000 steps/sec in minus direction

PR MD           return current mode setting
```

RELATED COMMANDS: MD, MR, MS, P, PR, SL

MNEMONIC	FUNCTION	TYPE	USAGE
MR	**Move To Relative Position**	**Motion Instruction**	**P/I**

DESCRIPTION

Set mode for relative move and move a relative distance. MD (Current Mode) will be set to MR

If flag is true, then DN will be sent out when move is complete..

USE	UNITS
MR ±distance, <flag>	motor steps (EE=0) or encoder counts (EE=1)

EXAMPLE:

```
MR 200000       'move motor 200000 steps in the postive direction
MR -50000       'move motor 50000 steps in the negative direction
```

RELATED COMMANDS: MD, MA, MS, P

MNEMONIC	FUNCTION	TYPE	USAGE
MS	**Microstep Resolution**	**Motion Variable**	**P/I R/W**

DESCRIPTION

The MS variable controls the microstep resolution of the MDrive Motion Control. There are 14 parameters that can be used with this variable, 8 binary and 6 decimal. The table below illustrates the parameter settings and their associated resolutions for the 1.8° stepping motor used with the MDrive Motion Control.

The MS parameters given in the table below are the only valid parameters that will be accepted by the MDrive.

USAGE	DEFAULT
MS=<parameter>	256

EXAMPLE:

MS=4 ‘Set Microstep Resolution to 4 Microsteps/Step (800 Steps/Rev)

MS=50 ‘Set Microstep Resolution to 50 Microsteps/Step (10000 Steps/Rev)

PR MS ‘Print the MS setting to the terminal

NOTE: Microstep Select is locked to 256 and cannot be changed when the Encoder is Enabled (EE=1).

Microstep Resolution Settings (MS)	
MS= (Microsteps/Step)	**Steps/Rev**
Binary Microstep Resolution Settings	
2	0 40
4	800
8	0 1,60
16	3,200
32	0 6,40
64	12,800
128	0 25,60
256	51,200
Decimal Microstep Resolution Settings	
5	0 1,00
10	2,000
25	0 5,00
50	10,000
125	0 25,00
250	50,000

Table 2.10: Microstep Resolution Settings

MNEMONIC	FUNCTION	TYPE	USAGE
MT	**Motor Settling Delay Time**	**Motion Variable**	**P/I R/W**

DESCRIPTION

Specifies the motor settling delay time in milliseconds. MT allows the motor to settle following a move. This is the time between moves if consecutive motions are executed.

USE	UNITS	RANGE	DEFAULT
MT=<time>	milliseconds	0 to 65000	0

EXAMPLE:

MT=50 ‘Set motor settling delay time to 50 milliseconds

RELATED COMMANDS: HC, HT, RC

MNEMONIC	FUNCTION	TYPE	USAGE
MV	**Moving Flag**	**Moving Flag**	**P/I R**

DESCRIPTION

Output is true when motor is moving.

USE	UNITS	RANGE	DEFAULT
PR MV		0/1	0

EXAMPLE:

```
PR MV^M        Moving = 1
               Stopped = 0
```

RELATED COMMANDS:

MNEMONIC	FUNCTION	TYPE	USAGE
O1 - O4	**Set Output Logic State**	**I/O Variable**	**P/I W**

DESCRIPTION

This variable will set the logic state of the specified output to 1 or 0.

The value of the bit state will be dependant on the active (low/high) state of the input, specified by the S<1-4> variable.

USE

O<1-4>=<0/1>

EXAMPLE:

```
O4=1           'Set Output 4 to 1
```

RELATED COMMANDS: OT, I1-I4, S1-S4

MNEMONIC	FUNCTION	TYPE	USAGE
OE	**On Error Handler**	**Instruction**	**P/I**

DESCRIPTION

When an error occurs in a program or due to an immediate command, the specified subroutine is called. If a program was running when the fault occurs, once the error routine completes, program execution continues with the instruction after the one that caused the error. 0A program need not be running for the subroutine specified by OE to run.

The ON ERROR function is disabled by setting the address parameter to 0 or resetting the MDrive Motion Control.

USE

OE <address>

EXAMPLE:

```
'the following subroutine will set an output high upon an error
PG 100         'Start sub at address 100
OE E1          'On Error go to E1
LB E1          'label subroutine E1
O3=1           'Set Output 3 to Logic 1
RT             'Return from subroutine
E                  'End program
PG             'Return to immediate mode
```

RELATED COMMANDS: EF, ER

MNEMONIC	FUNCTION	TYPE	USAGE
OT	**Set Ouputs 1-4 As 1 Value**	**I/O Variable**	**P/I W**

DESCRIPTION

The OT variable allows the user to set Outputs 1-4 (unprocessed by S<1-4>) as one 4 bit binary value. The value is entered in decimal, with a range of 0-15 in binary where Output 1 will be the LSb and Output 4 will be the MSb.

Example: OT=12

Output 4 = 1

Output 3 = 1

Output 2 = 0

Output 1 = 0

USE

OT=<0-15>

PR OT

EXAMPLE:

```
OT=7          'Set outputs 1-4 to O1=1, O2=1, O3=1, O4=0
```

RELATED COMMANDS: I1-I4, S1-S4

MNEMONIC	FUNCTION	TYPE	USAGE
P	**Position Counter**	**Motion Variable**	**P/I R/W**

DESCRIPTION

This instruction is used to set or print the value of the MDrive Motion Control position counter. The position will read in Motor Steps from C1 (Counter 1) by default, if encoder functions are enabled, the position counter will read in Encoder Counts from C2 (Counter 2).

The main difference in the relationship of the two counters is that where C1 is variable, the value of each step in terms of distance moved is based upon the MS, or microstep resolution setting, C2 will always be 2048 counts per motor revolution, regardless of the microstep resolution setting.

Modifying P in essence changes the frame of reference for the axis. P will probably be set once during system set up to reference or "home" the system.

USE	UNITS	RANGE
P <±position>	Steps (when EE = 0)	-2147483648 to 2147483647
	Counts (when EE =1)	-2147483648 to 2147483647
PR P		

EXAMPLE:

```
P=0           'Clear position counter, set to 0
PR P          'Print the state of the position counter
```

RELATED COMMANDS: C1, C2

MNEMONIC	FUNCTION	TYPE	USAGE
PC	**Position Capture At Trip**	**Program Instruction**	**I**

DESCRIPTION

Captures motor or encoder position at activation.

USE	UNITS	RANGE
PC	Motor Steps / Encoder Counts	Signed 32 bit

EXAMPLE:

```
PR PC^M       'Display captured position
```

RESPONSE

RELATED COMMANDS:

MNEMONIC	FUNCTION	TYPE	USAGE
PG	**Enter/Exit Program Mode**	**Program Instruction**	**I**

DESCRIPTION

When starting program mode, you must specify at what address to enter the program instructions in the program space. Simply type “PG” again when you have finished entering your program commands to go back to immediate mode.

While in program mode, leading tabs, spaces and blank lines are ignored. This allows the user to format a text file for readability, and then download the program to the MDrive by transferring the text file in a program such as IMSTerminal or Hyperterminal. The example given below could be stored in a text file and downloaded. The lines preceded by an apostrophe (‘) are comments and will be ignored by the MDrive Motion Control.

USE

PG <address>

EXAMPLE:

```
PG 100          ‘Enter program mode, start program at address 100
*********PROGRAM*********
E               ‘End prgram
PG              ‘Exit program, return to immediate mode
```

RELATED COMMANDS: E,

MNEMONIC	FUNCTION	TYPE	USAGE
PM	**Position Maintenance Enable**	**Setup Flag**	**P/I R/W**

DESCRIPTION

This flag will enable the position maintenance functions of an MDrive Motion Control with encoder. The position maintenance velocity will be at the setting for VI (Initial Velocity).

If SM = 0 and PM = 1, Position Maintenance will take place provided the position does not exceed the Stall Factor (SF).

If SM = 1 and PM = 1, Position Maintenance will take place even if the Stall Factor (SF) is exceeded, unless VI is set too high causing the motor to stall.

USE	DEFAULT
PM= <0/1>	0 (Disabled)

EXAMPLE:

```
PM=0            ‘Position Maintenance Disabled (Default)
PM=1            ‘Position Maintenance Enabled
```

RELATED COMMANDS: VI, EE, SM, DB, C2, SF

MNEMONIC	FUNCTION	TYPE	USAGE
PR	**Print Selected Data/Text**	**Instruction**	**P/I**

DESCRIPTION

This instruction is used to output text and parameter value(s) to the host PC. Text should be enclosed in quotation marks while parameters (variables and flags) should not. Text strings and parameters which are to be output by the same PR instruction should be separated by commas. The information being output is followed by a carriage return and line feed unless a semicolon (;) is included at the end of the PR instruction to indicate that the cursor should remain on the same line.

It is important to note that the receive buffer for the MDrive Motion Control is 64 characters, this includes the PR instruction itself, any spaces, text characters, etc. If the buffer length is exceeded ASCII code “OxFF” will echo to the terminal screen.

USE

PR <data/text>

EXAMPLE:

```
PR  “Position =”, P‘print axis position, 18 characters used
‘the terminal will display: Position = 1234567
```

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
PS	**Pause Program Instruction**	**Instruction**	**I**

DESCRIPTION

This instruction is used to pause an executing program and invoke normal deceleration of any motion being executed to Zero. Immediate mode instructions are allowed while a program is in a paused state. To resume the program the RS instruction is used.

USE

PS

EXAMPLE:

```
PS
```

RELATED COMMANDS: RS, S1-S4

MNEMONIC	FUNCTION	TYPE	USAGE
PY	**Party Mode Enable Flag**	**Setup Flag**	**P/I R/W**

DESCRIPTION

The party flag must be set to 1 if the MDrive Motion Control is being used in a multidrop system.

When Party Mode is enabled, each MDrive in the system must be addressed by the host computer by using the device name specified by the DN instruction. This name will precede any command given to a specified unit in the system and be terminated with a Control J (CTRL + J). One CTRL + J must be issued after power up or entering the Party Mode to activate the Party Mode. By default the DN assigned at the factory is the exclamation character (!) .

The global name is the asterisk character (*). Commands preceded by this character will be recognized by every MDrive in the system.

After the Party Mode is enabled, send CTRL + J (^J) to activate it. Type commands with Device Name (DN) and use CTRL + J as the Terminator.

Note: A delay time between the command requests to the MDrive must be considered to allow the MDrive time to interpret a command and answer the host before a subsequent command can be sent. The time between requests is dependent on the command and the corresponding response from the MDrive.

USE	DEFAULT
PY= <0/1>	0 (Disabled)

EXAMPLES:

```
PY=0            'Party Mode Disabled (Default)
PY=1            'Party Mode Enabled

PARTY MODE
DN="X"<enter>       'Enter Device Name
PY=1<enter>         'Set Party Mode
<CTRL+J>            'Activate Party Mode
XPR P<CTRL+J>       'Print Position (MDI responds with present position)
XSL 1000<CTRL+J>    'Slew 1000 step/sec.
XSL 0<CTRL+J>       'Stops Motion
XS<CTRL+J>          'Save parameters
XPY=0<CTRL+J>       'Deactivate Party Mode
PR AL<enter>        'Print all Parameters
S<enter>            'Save parameters
```

RELATED COMMANDS: DN

MNEMONIC	FUNCTION	TYPE	USER
R1 - R4	**User Registers**	**User Variable**	**P/I R/W**

DESCRIPTION

The MDrive Motion Control has four 32 bit user registers to contain numerical data. These registers may contain up to 11 digits including the sign and may be used to store and retrieve data to set variables, perform math functions, store and retrieve moves and set conditions for branches and subroutine calls.

USE	RANGE	DEFAULT
R<x>=<data>	-2147483647 to 2147483647	0

EXAMPLES:

```
R1=50000          'Set Register 1 to 50000
'Subroutine using a register value to perform a math function that will display axis position in revolutions rather than motor steps
'****variable setup*****
MS=256            'set resolution to 256 microsteps/step
P=0               'set position counter to 0
R1=51200/1        '51200 steps = 1 rev
*****Program Content*******
MR R1             'move relative 102400 steps
H                 'Hold execution until motion stops
CL 348            'call subroutine at address 348
'******Sub at address 348******
R2=P              'set Register 2 equal to the position counter
R3=R2/R1          'set Register 3 equal to R2/R1
PR "Position = ", R3, "Revolutions";
H 60000           'hold for 1 minute
RT                'return to prog
```

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
RC	**Run Current**	**Setup Variable**	**P/I R/W**

DESCRIPTION

This variable defines the motor run current in percent.

USE	UNITS	RANGE	DEFAULT
RC=<percent>	Percent	1 to 100	25

EXAMPLE:

```
RC=75             'Set motor run current to 75%
```

RELATED COMMAND: HC

MNEMONIC	FUNCTION	TYPE	USAGE
RS	**Resume Program Instruction**	**Instruction**	**I**

DESCRIPTION

This instruction is used to resume a program that has been paused using the PS instruction. Motion will resume using the normal acceleration profiles.

USE

RS

EXAMPLE:

```
RS
```

RELATED COMMANDS: PS, S1-S4

MNEMONIC	FUNCTION	TYPE	USAGE
RT	**Return From Subroutine**	**Instruction**	**P**

DESCRIPTION

This instruction defines the end of a subroutine. This instruction is required and will be the final instruction in the subroutine executed by the CL instruction. When used, it will return to the program address immediately following the CL instruction which executed the subroutine.

USE

RT

EXAMPLE:

```
'****Program*****
                PG100           'enter program mode at address 100
100             MR 51200        'move relative 51200
105             H               'suspend prog. execution until motion completes
109             CL 238          'Call subroutine at address 238

238             O1=1            'set output 1 to 1
241             RT              'return from subroutine
```

RELATED COMMANDS: CL

MNEMONIC	FUNCTION	TYPE	USAGE
S	**Save to EEProm**	**Instruction**	**P/I**

DESCRIPTION

Saves all variables and flags currently in working memory (RAM) to nonvolatile memory (NVM). The previous values in NVM are completely overwritten with the new values.

When the user modifies variables and flags, they are changed in working memory (RAM) only. If the SAVE instruction is not executed before power is removed from the control module, all modifications to variables & flags since the last SAVE will be lost.

USE

S

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
S1 - S4	**Setup I/O Point Type/Active State**	**I/O Instruction**	**P/I R/W**

DESCRIPTION

This instruction is used to setup the I/O type and active states for I/O points 1 - 4. Each of MDrive Motion Control I/O points 1-4 may be programmed as either general purpose inputs and outputs, or to one of nine dedicated input functions or one of two dedicated output functions.

When programmed as inputs, these points will be sinking and may be programmed such that they are active when pulled to ground, or active when left floating. By default each point is configured as a general purpose input, active when LOW.

There are two parameters attached to this instruction: the type specifies the function of the I/O point. The second parameter sets the active state, which defines the point as LOW or HIGH TRUE.

I/O FUNCTION	FUNCTION	TYPE	ACTIVE STATE PARAMETER
INPUTS			
General Purpose Input	Multiple Usage	0	LOW = TRUE 0
Home Input	For "Homing" Sequence (See HM)	1	HIGH = TRUE 1
Limit + Input	Motion stops with DECEL, sets Motion Error 83, program continues, moves in plus direction ignored. (See OE) (See sample limit switch test program in Appendix C)	2	
Limit - Input	Motion stops with DECEL, sets Motion Error 84, program continues, moves in minus direction ignored. (See OE) (See sample limit switch test program in Appendix C)	3	
GO Input	Initiate Program Start. (Always at address 1)	4	
Soft Stop Input	Program and Motion Stop with DECEL	5	
Pause Input	Pause/Resume Program and Motion	6	
Jog + Input	Activate Plus Jog Input	7	
Jog - Input	Activate Minus Jog Input	8	
OUTPUTS			
General Purpose Output	Multiple Usage	16	
Moving Output	Output set if Motor is Moving (See MV)	17	
Fault Output	Output set if Fault detected (See EF)	18	
Stall	Output set if Stall detected (See ST)	19	
VCHG	Output set if Velocity Changing (See VC)	20	

USE	DEFAULT
S<1-4>=<type>,<active>	<type>=0, <active>=0

EXAMPLE:

```
S1=2,0      'set i/o point 1 to a limit + function, active when LOW
S4=17,1     'set i/o point 4 as moving output, active when HIGH
```

RELATED COMMANDS: I1-4, IN, O1-4, OT, D1-D4, PS, RS, EF, ST, VC, JE

MNEMONIC	FUNCTION	TYPE	USAGE
S5	**Set/Print I/O Point 5**	**I/O Instruction**	**P/I R/W**

DESCRIPTION

This I/O point differs from I/O points 1-4 in that it is factory configured as a 0 - 5 V Analog Input with 10 bit A/D resolution.

I/O FUNCTION	TYPE
0-5V Analog Input	9
4-20 mA Analog Input	10

RELATED COMMANDS: I5, JE

MNEMONIC	FUNCTION	TYPE	USAGE
S7 - S8	**Internal Use Only**	**No User Access**	

MNEMONIC	FUNCTION	TYPE	USAGE
SF	**Stall Factor Variable**	**Encoder Variable**	**P/I R/W**

DESCRIPTION

If the encoder is enabled (EE = 1) and the encoder differs from the motor by more than the specified factor, a STALL is indicated. If SM is set to 0, then the motor will be stopped when a STALL is detected.

USE	UNITS	RANGE	DEFAULT
SF=<counts>	Encoder counts	0 to 65000	10

EXAMPLE:

```
SF=20          'Set the stall factor to twenty counts. If the motor falls behind by more than 20 encoder counts a stall is
detected.
```

RELATED COMMANDS: EE, SM, ST

MNEMONIC	FUNCTION	TYPE	USAGE
SL	**Slew Axis Instruction**	**Motion Instruction**	**P/I**

DESCRIPTION

The SL instruction will slew the axis at the specified velocity in steps/counts per second. The axis will accelerate at the rate specified by the A (Acceleration) variable.

Note that the maximum slew velocity is independant of the maximum velocity specified by the VM variable. If a slew is commanded at a velocity greater than the setting of VM, the axis will accelerate to that velocity regardless of the setting of VM.

USE	UNITS	RANGE
SL <±velocity>	± Steps per sec (when EE=0)	±5000000
	± Counts per sec (when EE=1)	±200000

EXAMPLE:

```
SL 20000       'slew the axis at 20000 units/sec
```

RELATED COMMANDS: A, D, MS, MR

MNEMONIC	FUNCTION	TYPE	USAGE
SM	**Stall Detection Mode Variable**	**Encoder Variable**	**P/I R/W**

DESCRIPTION

The SM variable specifies the action which will be taken by the MDrive Motion Control when a stall is detected. When set to 0 (default) the motion will be stopped upon a stall detection. When SM=1, the motor will continue to move. In either case ST (Stall Flag) will be set.

USE	DEFAULT
SM = <0/1>	0 (Stop Motor)

EXAMPLE:

SM=0	‘stop motor when a stall is detected
SM=1	‘do not stop motor upon a stall

RELATED COMMANDS: EE, SF, ST, PM

MNEMONIC	FUNCTION	TYPE	USAGE
ST	**Stall Flag**	**Encoder Flag**	**P/I R/W**

DESCRIPTION

The ST flag will be set to 1 when a stall is detected. It is the responsibility of the user to reset it to zero (0).

USE

PR ST

BR <addr>, ST=1

CL <addr>, ST=1

EXAMPLE RESPONSE:

ST=0	‘motor not stalled
ST=1	‘motor stalled

RELATED COMMANDS: EE, SF, ST, OE

MNEMONIC	FUNCTION	TYPE	USAGE
TE	**Trip Enable Flag**	**Setup Flag**	**P/I R/W**

DESCRIPTION

This flag will enable or disable specified trip functions.

TE=0	TI Disabled	TP Disabled
TE=1	TI Enabled	TP Disabled
TE=2	TI Disabled	TP Enabled
TE=3	TI Enabled	TP Enabled

USE	DEFAULT
TE= <1-4>	0 (Trips Disabled)

EXAMPLE:

TE=1	‘Enable trip on input functions

RELATED COMMANDS: I1-I4, P, S1-S4, TI, TP

MNEMONIC	FUNCTION	TYPE	USAGE
TI	**Trip on Input**	**Variable**	**P/I R/W**

DESCRIPTION

Sets up an input event (Trip) for the specified input. There are two parameters for the TI variable. The first specifies which input line to monitor. The second specifies the subroutine that should be executed when the input goes to true.

The TE (Trip Enable which Enables/Disables TI) is reset when a Trip occurs. TE must be re-enabled in the main program prior to the next Trip if it is to be repeated.

USE

TI=<input>,<addr/label>

EXAMPLE:

```
TI=2,K1          'execute subroutine labeled K1 when input 2 is active.
```

RELATED COMMANDS: I1-4, S1-4, TP

MNEMONIC	FUNCTION	TYPE	USAGE
TP	**Trip on Position**	**Variable**	**P/I R/W**

DESCRIPTION

Sets up a position event (trip) for the specified position. There are two parameters for the TP variable. The first specifies the position which will cause the event. The second specifies the subroutine that should be executed when the position is detected

The TE (Trip Enable which Enables/Disables TP) is reset when a Trip occurs. TE must be re-enabled in the main program prior to the next Trip if it is to be repeated.

USE

TP=<position>,<addr/label>

EXAMPLE:

```
TP=200000,300    'execute subroutine at address 300 when at postion 200000
```

RELATED COMMANDS: P, TI, PC

MNEMONIC	FUNCTION	TYPE	USAGE
UG	**Upgrade Firmware**	**Instruction**	**I**

DESCRIPTION

Upgrade Firmware Instruction. Upgrade code is 2956102. This will put the MDrive in Upgrade Mode. Once set, the firmware Upgrade MUST be completed.

USE

UG 2956102

RELATED COMMANDS: —

MNEMONIC	FUNCTION	TYPE	USAGE
UV	**Read User Variables**	**Variable**	**P/I R**

DESCRIPTION

Read User Variables is used with the PR (Print) Instruction to read the value of all user variables

USE

PR UV

RELATED COMMANDS: , PR, VA

MNEMONIC	FUNCTION	TYPE	USAGE
V	**Read Only Velocity Variable**	**Motion Variable**	**P/I R**

DESCRIPTION

The velocity variable is used in conjunction with the PR (print) instruction to read the current velocity of the axis in counts per second. This variable can also be used with the BR and CL instructions to set a condition based upon a velocity. This variable can also be used in conjunction with the user registers to compute another velocity.

USE	UNITS
PR V	Steps per Sec (EE=0) or Counts per Sec (EE=1)
BR <addr>, V=<steps or counts/sec>	
CL <addr>, V=<steps or counts/sec>	

RELATED COMMANDS: VI, VM

MNEMONIC	FUNCTION	TYPE	USAGE
VA	**Create User Variable Name**	**Instruction**	**P/I R/W**

DESCRIPTION

The VA instruction allows the user to assign a 2 character name to a user defined variable.

The restrictions for this command are:

1] A variable cannot be named after a MDrive Motion Control Instruction, Variable or Flag.

2] The first character must be alpha, the second character may be alpha-numeric.

3] A variable is limited to two characters.

4] Limited to 22 variables and labels.

USE

VA <char><char>=<value>

EXAMPLE:

```
VA P2          'create user var P2
P2=20000       'set P2 to 20000
```

RELATED COMMANDS: UV

MNEMONIC	FUNCTION	TYPE	USAGE
VC	**Velocity Changing**	**Motion Flag**	**P/I R**

DESCRIPTION

Indicates that the Velocity is changing.

USE

BR <addr>, VC VC = 1 Velocity is changing

VC = 0 No Velocity change

RELATED COMMANDS:

MNEMONIC	FUNCTION	TYPE	USAGE
VI	**Initial Velocity Variable**	**Motion Variable**	**P/I R/W**

DESCRIPTION

Initial velocity for all motion commands. The factory default value is 1000 clock pulses (steps) per second.

The initial velocity for a stepper should be set to avoid the low speed resonance frequency and must be set lower than the pull in torque of the motor. It must also be set to a value lower than VM (Max. Velocity).

VI must be less than VM.

USE	UNITS	RANGE	DEFAULT
VI=<velocity>	Steps per sec (when EE=0)	1 to 5000000	1000
	Counts per sec (when EE=1)	1 to 200000	40

EXAMPLE:

```
VI=2000          'set initial velocity to 2000 steps or counts per second
```

RELATED COMMANDS: VM

MNEMONIC	FUNCTION	TYPE	USAGE
VM	**Maximum Velocity Variable**	**Motion Variable**	**P/I R/W**

DESCRIPTION

The VM variable specifies the maximum velocity in steps/counts per second that the axis will reach during a move command.

VM must be greater than VI.

USE	UNITS	RANGE	DEFAULT
VM=<velocity>	Steps per sec (when EE=0)	1 to 5000000	768000
	Counts per sec (when EE=1)	1 to 200000	30720

EXAMPLE:

```
VM=51200         'set max velocity to 51200 steps/counts per second
```

RELATED COMMANDS: VM

MNEMONIC	FUNCTION	TYPE	USAGE
VR	**Read Only Firmware Version**	**Factory Variable**	**P/I R**

DESCRIPTION

This variable is used in conjuction with the PR instruction to read the version of the firmware installed at the factory. If the Version number is followed by an E, the Mdrive is an Encoder Version. An I will indicate and Index version. Blank will indicate no options.

USE

PR VR

RELATED COMMANDS: —

Appendix A

ASCII TABLE

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	0	NUL	32	20	<space>	64	40	@	96	60	`
1	1	SOH	33	21	!	65	41	A	97	61	a
2	2	STX	34	22	“	66	42	B	98	62	b
3	3	ETX	35	23	#	67	43	C	99	63	c
4	4	EOT	36	24	$	68	44	D	100	64	d
5	5	ENQ	37	25	%	69	45	E	101	65	e
6	6	ACK	38	26	&	70	46	F	102	66	f
7	7	BEL	39	27	'	71	47	G	103	67	g
8	8	BS	40	28	(	72	48	H	104	68	h
9	9	TAB	41	29	)	73	49	I	105	69	i
10	A	LF	42	2A	*	74	4A	J	106	6A	j
11	B	VT	43	2B	+	75	4B	K	107	6B	k
12	C	FF	44	2C	´	76	4C	L	108	6C	l
13	D	CR	45	2D	-	77	4D	M	109	6D	m
14	E	SO	46	2E	.	78	4E	N	110	6E	n
15	F	SI	47	2F	/	79	4F	O	111	6F	o
16	10	DLE	48	30	0	80	50	P	112	70	p
17	11	DC1	49	31	1	81	51	Q	113	71	q
18	12	DC2	50	32	2	82	52	R	114	72	r
19	13	DC3	51	33	3	83	53	S	115	73	s
20	14	DC4	52	34	4	84	54	T	116	74	t
21	15	NAK	53	35	5	85	55	U	117	75	u
22	16	SYN	54	36	6	86	56	V	118	76	v
23	17	ETB	55	37	7	87	57	W	119	77	w
24	18	CAN	56	38	8	88	58	X	120	78	x
25	19	EM	57	39	9	89	59	Y	121	79	y
26	1A	SUB	58	3A	:	90	5A	Z	122	7A	z
27	1B	ESC	59	3B	;	91	5B	[	123	7B	{
28	1C	FS	60	3C	<	92	5C	\	124	7C	|
29	1D	GS	61	3D	=	93	5D	]	125	7D	}
30	1E	RS	62	3E	>	94	5E	^	126	7E	~
31	1F	US	63	3F	?	95	5F	_	127	7F	DEL

Appendix B

Error Codes

A question mark <?> displayed as a cursor indicates an ERROR. To determine what the ERROR is, type <PR ER> in the IMS Terminal Window. The MDrive will respond with an ERROR Number displayed in the Terminal Window. The ERROR Number may then be referenced to this list.

Error Code	Fault
0	No Error
I/O Errors	
1	Reserved
2	Reserved
3	Reserved
4	Reserved
5	Reserved
6	An I/O is already set to this type. Applies to non-General Purpose I/O. Only one (1) I/O may be set to a defined type.
7	Not used
8	Tried to set an I/O to an incorrect I/O type. Tried to set the I/O to an illegal number or to Analog 1-4.
9	Tried to write to I/O not set as General Purpose I/O.
10	Illegal I/O number. Used with Trip on Input.
Data Errors	
20	Tried to set unknown variable or flag. Trying to set an undefined variable of flag. Also could be a typo.
21	Tried to set an incorrect value. Many variables have a range such as the Run Current (RC) which is 1 to 100%. As an example, you cannot set the RC to 110%.
22	VI is set greater than or equal to VM. The Initial Velocity is set equal to, or higher than the Maximum Velocity. VI must be less than VM.
23	VM is set less than or equal to VI. The Maximum Velocity is set equal to, or lower than the Initial Velocity. VM must be greater than VI.
24	Illegal data entered. Data has been entered that the MDrive does not understand.
25	Variable or flag is read only. Read only flags and variables cannot be set.
26	Variable or flag is not allowed to be incremented or decremented. IC and DC cannot be used on variables or flags such as Baud and Version.
27	Trip not defined.Trying to enable a trip that has not yet been defined.
28	WARNING! Trying to redefine a program label or variable. This can be caused when you download a program over a program already saved. It is just a warning to let you know you are redefining a program label or variable that has already been defined. Before downloading a new or edited program, type <FD> and press ENTER to return the MDrive to the Factory Defaults. You may also type <CP> and press ENTER to Clear the Program, then you can download and SAVE the new program.
29	Trying to redefine a built in command, variable or flag.
30	Unknown label or user variable. Trying to Call or Branch to a Label or Variable that has not yet been defined.
31	Program label or user variable table is full. The table has a maximum capacity of 22 labels and/or user variables.
32	Trying to set a label (LB). You cannot name a label and then try to set it to a value. Example: Lable P1 (LB P1). The P1 cannot be used to set a variable such as P1=1000.

Program Errors	
40	Program not running. If HOLD (H) is entered in Immediate Mode and a program is not running.
41	Not Used.
42	Illegal program address. Tried to Clear, List, Execute, etc. an incorrect Program address.
43	Tried to overflow program stack. Calling a Sub-Routine or Trip Routine with no Return.
44	Program locked. User Programs can be Locked with the <LK> command. Once Locked, the program cannot be listed or edited in any way.
Communications Errors	
60	Not used
61	Trying to set illegal BAUD rate. The only Baud Rates accepted are those listed on the Properties Page of IMS Terminal. (4,800, 9,600, 19,200, 38,400, 115,200)
62	IV already pending or IF Flag already TRUE.
Motion Errors	
80	HOME switch not defined. Attempting to do a HOME (H) sequence but the Home Switch has not yet been defined.
81	HOME type not defined. The HOME (HM or HI) Command has been pro grammed but with no type or an illegal type. (Types = 1, 2, 3, or 4)
82	Went to both LIMITS and did not find home. The motion encroached both limits but did not trip the Home switch. Indicates a possible bad switch or a bad circuit.
83	Reached plus LIMIT switch. The LIMIT switch in the plus direction was tripped.
84	Reached minus LIMIT switch. The LIMIT switch in the minus direction was tripped.
85	MA or MR not allowed while in motion. You cannot program a second MOVE command while the MDive is in motion.
86	Stall detected. The Stall Flag (ST) has been set to 1.

APPENDIX C

MDrive Motion Control (MDI) Program Samples

For additional MDI Program Samples, go to www.imshome.com/app_note_MDI.html

Some of these sample programs require digital and analog inputs which can be configured in several different ways. In some cases hardware such as a small mechanical switch, potentiometer or joystick may be needed. For more information please see:

Interfacing the Digital I/O

Interfacing the Analog Input

NOTE: The character ∧ is used to indicate a space. Do not type this character but be sure to type the space.

Motion Sample

This is a simple motion program that sets the position counter to zero (0), moves the MDI 200000 microsteps in the plus direction and then prints the position in the Terminal Window.

CODE	DESCRIPTION
VI∧750	‘set initial velocity to 750 steps/sec
VM∧500000	‘set max velocity to 500000 steps/sec
A ∧750000	‘set acceleration rate to 750000 steps/sec/sec
D=A	‘set deceleration rate equal to A
HC∧10	‘set motor hold current to 10%
RC∧35	‘set motor run current to 35%
PG∧100	‘enter program mode at address 100
LB m1	‘lable program m1
P=0	‘set position counter to 0
MR∧200000	‘set motion to relative, move 2000000
H	‘hold until motion is complete
PR∧P	‘print position to terminal
E	‘end program
PG	‘exit program mode

IF THEN Sample

This program moves the MDI in the plus direction **IF** Input One (1) is low. **IF** Input 1 is high, **THEN** the MDI will reverse direction.

CODE	DESCRIPTION
PG∧100	'Enter program mode at address 100
LB P1	'Label program P1
S1=0,1	'Sets I/O 1 as a general purpose input, active high
LB∧M1	'Label to begin motion profile 1
MR∧200000	'Move relative 200000 steps
H	'Hold until motion is complete
BR∧M1,∧I1=1	'If input is true then branch to label M1
LB∧M2	'Label to begin motion profile 2
MR∧-100000	'Move relative 100000 steps
H	'Hold until motion is complete
BR∧M1,I1=1	'If input is true then branch to label M1
BR∧M2	'Unconditional branch to label M2
E	'End program
PG	'Exit program mode

This is another simple program that runs the MDI until Input One (1) is turned on. When Input One (1) is turned on, the MDI will stop.

CODE	DESCRIPTION
PG∧100	'Enter program mode at address 100
LB∧P1	'Label program ZZ
A=1000000	'Sets acceleration to 1000000 steps/second square
S1=0,1	'Sets I/O 1 as a general purpose input, active high
S5=9	'Sets I/O 5 as a 0-5V analog input
LB∧WT	'Label WT for setting up wait loop
BR∧M1,I1=1	'If input is active then branch to label M1
SL∧0	'Sets slew speed to 0
BR∧WT,I1=0	'If input is inactive then branch to label WT
LB∧M1	'Label for motion profile 1
SL∧15*10000	'Slew the axis at the rate of 0-1024 times 100000
BR∧WT	'Unconditional branch to wait loop to scan input
E	'End program
PG	'Exit programn mode

Integer Math Only (No Decimals)

This program illustrates the math capabilities of the IMS Terminal. No MDI motion occurs.

CODE	DESCRIPTION
VA∧V1=10	'declare gloabal variable V1
VA∧V2=3	'declare gloabal variable V2
VA∧V3	'declare gloabal variable V3
PG∧1	'enter programn mode at address 1
LB∧aa	'label aa
V3=V1+V2	'add values in V1 and V2 put result into V3
PR∧“V3=”V3	'print the value in V3 to the terminal
H∧1000	'hold program execution for 1000 milliseconds
V3=V1*V2	'multiply valuse in V1 and V2 put the result into V3
PR∧“V3=”V3	'print the value of V3 to the terminal
E	'end program
PG	'exit program mode

```
'*******************************************************
'program action
    'V3=V1+V2 produces an answer of 13
    'V3=V1*V2 produces an answer of 30
    'V3=V1/V2 produces an answer of 3
    'try typing different values of V1 and V2 and “ex aa”
    'V1=35<enter>
    'V2=4<enter>
    "EX aa<enter>
    'results
    'V3=V1+V2=39
    'V3=V1*V2=140
    'V3=V1/V2=8
```

Limit Switch Test Program

This program demonstrates the use of limit switches. The MDI will rotate back and forth in both directions with a 250 mS HOLD between each reversal. If Input One (1) is high, the MDI will stop rotating in the plus direction and Error 83 will be printed in the Terminal Window. It will continue to rotate in the minus direction with the HOLD. If Input Two (2) is HIGH, the MDI will stop rotating in the minus direction and Error 84 will be printed to the Terminal Window. It will continue to rotate in the plus direction with the HOLD. Only the direction of travel monitored by the limit switch will be stopped.

Ref: Error Code 83 = Reached the Plus Limit Switch
Error Code 84 = Reached the Minus Limit Switch

CODE	**DESCRIPTION**
S1=2,0	‘set input 1 as positive limit, low true
S2=3,0	‘set input 2 as negative limit, low true
PG∧1	‘enter prog mode at address 1
LB∧aa	‘label aa
VM=51200	‘set max velocity to 51200 steps/sec
MR∧102400	‘move positive 102400 steps
	‘close switch at input 1 to
	‘stop motion in the positive direction
	‘and cause an error 83
	‘NOTE: PROGRAM CONTINUES TO EXECUTE
	‘leave switch open and program runs normal
H	‘hold prog exec until motion complete
H∧250	‘hold prog exec for 250 milliseconds
PR∧Er	‘print error number to terminal window
MR∧-102400	‘move negative 102400 steps
	‘close switch at input 2 to
	‘stop motion in the negative direction
	‘and cause an error 84
	‘NOTE: PROGRAM CONTINUES TO EXECUTE
H	‘hold prog exec until motion complete
H∧250	‘hold prog exec for 250 millisec
PR∧Er	‘print error number to terminal window
BR∧aa	‘branch to label aa
E	‘end prog
PG	‘exit prog mode
	‘hit “Esc” key to stop program

Speed Control Via Analog Input

'This program allows the user to perform speed control using the analog input on the MDI. This program will function with a potentiometer or a joystick.

CODE	**DESCRIPTION**
S5=9	'sets analog input to accept 0-5Vdc.
S1=0,1	'sets I/O point 1 to general purpose output
A=2000000	'acceleration set to 2000000 microsteps/sec/sec
D=2000000	'deceleration set to 2000000 microsteps/sec/sec
R4=20 'deadband value	
PG∧1	'initiate program at address 1
LB∧M1	'startup label. Program executes on power up
LB∧ZZ	'label called ZZ
R1=I5	'register 1 set to analog input value
CL∧ab	'computes new velocity by calling subroutine at label ab.
SL∧R3	'slew at the value of register 3
H∧10	'wait 10 milliseconds
BR∧ZZ	'branch to the label called ZZ
E	'end of ZZ routine
LB ab	'routine to determine direction and remove deadband
R1=R1-508	'offset from joystick center
R2=1	'positive direction
BR∧a1,R1>=0	'get dir of r1
R2=-1	'negative direction
R1=R1*R2	'get absolute value of r1
LB a1	
BR A2,R1<R4	'go to A2 routine if R1 value is less than deadband
R1=R1*1000	'scale multiplier
R3=R1*R2	'resultant R3 value for slew speed
RT	'return to command below call in ZZ routine.
LB A2	
R3=0	'sets slew velocity to zero
RT	
E	'end
PG	'exit program space

APPENDIX D

Recommended Cable Configurations for MDrive

Cable length, wire gauge and power conditioning devices play a major role in the performance of your MDrive.

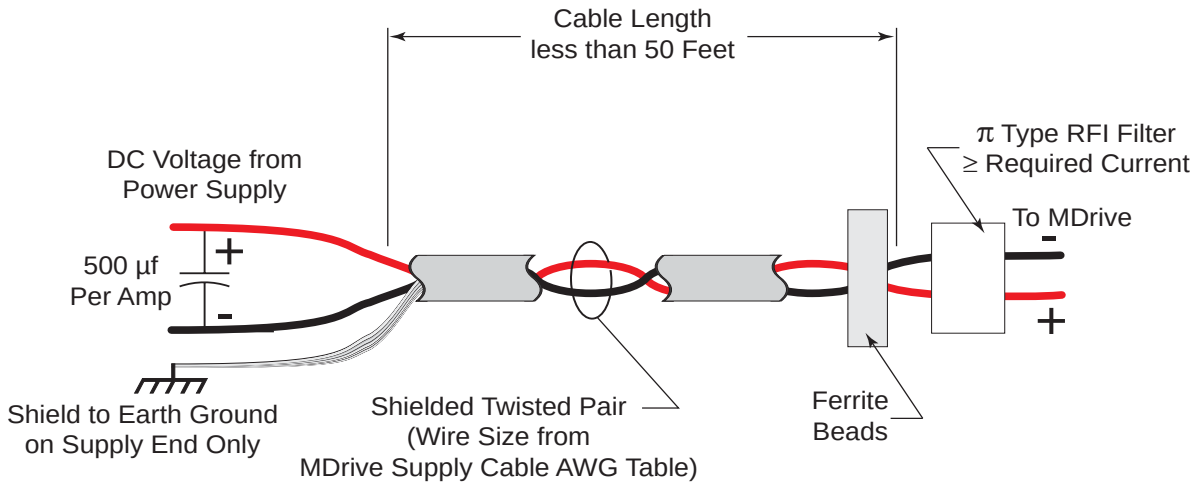
NOTE: These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.

NOTE: The length of the DC power supply cable to an MDrive should not exceed 50 feet.

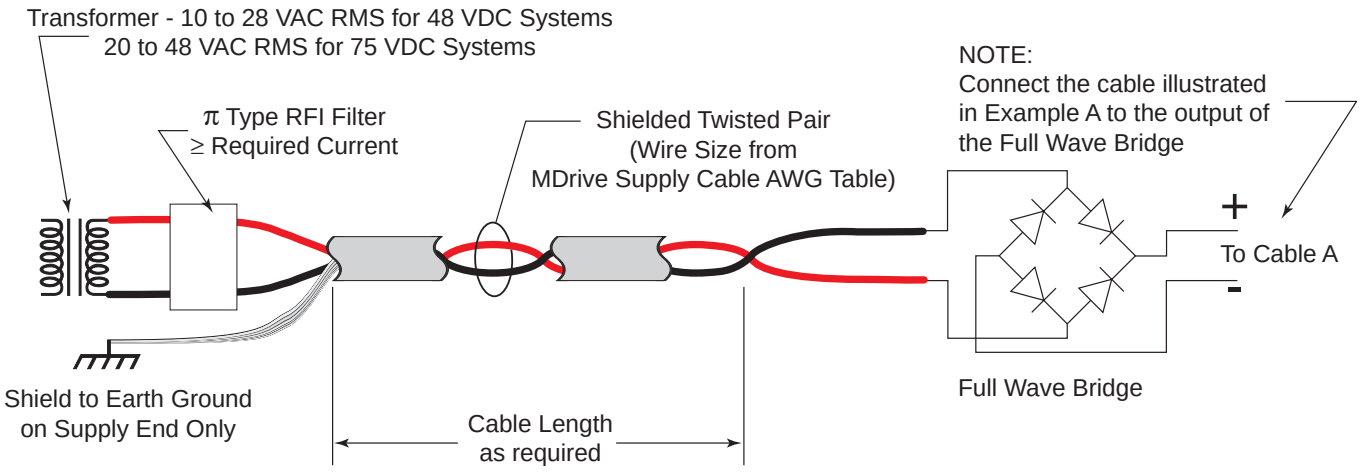
Example A demonstrates the recommended cable configuration for DC power supply cabling under 50 feet long. If cabling of 50 feet or longer is required, the additional length may be gained by adding an AC power supply cable (see Examples B & C).

Correct AWG wire size is determined by the current requirement plus cable length. Please see the MDrive Supply Cable AWG Table at the end of this Appendix.

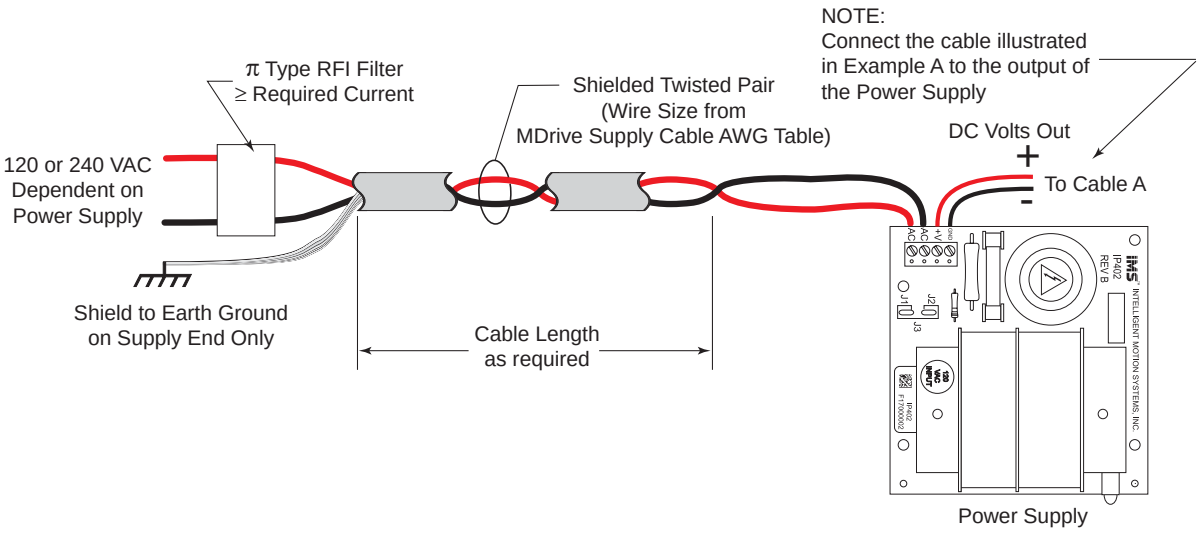
Example A – Cabling Under 50 Feet, DC Power



Example B – Cabling 50 Feet or Greater, AC Power to Full Wave Bridge



Example C – Cabling 50 Feet or Greater, AC Power to Power Supply



NOTE: These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.

MDrive Supply Cable AWG Table					
1 Ampere (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	20	18	18	16
2 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	18	16	14	14
3 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	18	16	14	12	12
4 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	18	16	14	12	12
* Use the alternative methods innustrated in Examples B and C when the cable length is ≥ 50 feet. Also, use the same current rating when the alternate AC power is used.					

MDrive Wire Size

NOTE: Always use Shielded/Twisted Pairs for the MDrive DC Supply Cable and the AC Supply Cable.

Section Overview

This section contains guidelines and specifications for MDrives equipped with an optional Planetary Gearbox, and may include product sizes not relevant to this manual.

Shown are:

- Product Overview
- Selecting a Planetary Gearbox
- Mechanical Specifications

Product Overview

All gearboxes are factory installed.

Mode of Function

Optional Planetary Gearbox operate as their name implies: the motor-driven sun wheel is in the center, transmitting its movement to three circumferential planet gears which form one stage. They are arranged on the bearing pins of a planet carrier. The last planet carrier in each sequence is rigidly linked to the output shaft and so ensures the power transmission to the output shaft. The planet gears run in an internally toothed outer ring gear.

Service Life

Depending on ambient and environmental conditions and the operational specification of the driving system, the useful service life of a Planetary Gerabox is up to 10,000 hours. The wide variety of potential applications prohibits generalizing values for the useful service life.

Lubrication

All Planetary Gearbox are grease-packed and therefore maintenance-free throughout their life. The best possible lubricant is used for our MDrive/Planetary Gearbox combinations.

Mounting Position

The grease lubrication and the different sealing modes allow the Planetary Gearbox to be installed in any position.

Operating Temperature

The temperature range for the Planetary Gearbox is between –30 and +140° C. However, the temperature range recommended for the Heat Sink of the MDrive is 0 to +85º C.

Overload Torque

The permitted overload torque (shock load) is defined as a short-term increase in output torque, e.g. during the start-up of a motor. In these all-metal Planetary Gearbox, the overload torque can be as much as 1.5 times the permitted output torque.

Available Planetary Gearbox

The following lists available Planetary Gearbox by model number, diameter and corresponding MDrive.

Gearbox Diameter	MDrive
32 mm	MDrive14
42 mm	MDrive17
52 mm	MDrive23
81 mm	MDrive34

Selecting a Planetary Gearbox

There are many variables and parameters that must be considered when choosing an appropriate reduction ratio for an MDrive with Planetary Greabox. This Addendum includes information to assist in determining a suitable combination for your application.

Note: ***The MDrive23*** and the numbers and values used in these examples have been chosen randomly for demonstration purposes. Be certain you obtain the correct data for the MDrive you have purchased.

Calculating the Shock Load Output Torque (T_{AB})

Note: The following examples are based on picking "temporary variables" which may be adjusted.

The shock load output torque (T_{AB}) is not the actual torque generated by the MDrive and Planetary Gearbox combination, but is a calculated value that includes an operating factor (C_B) to compensate for any shock loads applied to the Planetary Gearbox due to starting and stopping with no acceleration ramps, payloads and directional changes. The main reason the shock load output torque (T_{AB}) is calculated is to ensure that it does not exceed the maximum specified torque for a Planetary Gearbox.

Note: There are many variables that affect the calculation of the shock load output torque. Motor speed, motor voltage, motor torque and reduction ratio play an important role in determining shock load output torque. Some variables must be approximated to perform the calculations for the first time. If the result does not meet your requirements, change the variables and re-calculate the shock load output torque.

Use the equation compendium below to calculate the shock load output torque.

Factors

- i = Reduction Ratio - The ratio of the Planetary Gearbox.
- n_M = Motor Speed - In Revolutions Per Minute (Full Steps/Second).
- n_{AB} = Output Speed - The speed at the output shaft of the Planetary Gearbox.
- T_N = Nominal Output Torque - The output torque at the output shaft of the Planetary Gearbox.
- T_M = Motor Torque - The base MDrive torque. Refer to MDrive Speed Torque Tables.
- η = Gear Efficiency - A value factored into the calculation to allow for any friction in the gears.
- T_{AB} = Shock Load Output Torque - A torque value calculated to allow for short term loads greater than the nominal output torque.
- C_B = Operating Factor - A value that is used to factor the shock load output torque.
- s_f = Safety Factor - A 0.5 to 0.7 factor used to create a margin for the MDrive torque requirement.

Reduction Ratio

Reduction ratio (i) is used to reduce a relatively high motor speed (n_M) to a lower output speed (n_{AB}).

With: $i = n_M \div n_{AB}$ or: motor speed ÷ output speed = reduction ratio

Example:

The required speed at the output shaft of the Planetary Gearbox is 90 RPM.

You would divide motor speed (n_M) by output speed (n_{AB}) to calculate the proper gearbox ratio.

The MDrive speed you would like to run is approximately 2000 full steps/second or 600 RPM.

NOTE: In reference to the MDrive speed values, they are given in full steps/second on the Speed/Torque Tables. Most speed specifications for the Planetary Gearbox will be given in RPM (revolutions per minute). To convert full steps/second to RPM, divide by 200 and multiply by 60.

Where: 200 is the full steps per revolution of a 1.8° stepping motor.

2000 full steps/second ÷ 200 = 10 RPS (revolutions per second) × 60 Seconds = 600 RPM

For the Reduction Ratio (i), divide the MDrive speed by the required Planetary Gearbox output speed.

600 RPM ÷ 90 = 6.67:1 Reduction Ratio

Referring to the Available Ratio Table at the end of this section, the reduction ratio (i) of the Planetary Gearbox will be 7:1. The numbers in the left column are the rounded ratios while the numbers in the right column are the actual ratios. The closest actual ratio is 6.75:1 which is the rounded ratio of 7:1. The slight difference can be made up in MDrive speed.

Nominal Output Torque

Calculate the nominal output torque using the torque values from the MDrive's Speed/Torque Tables.

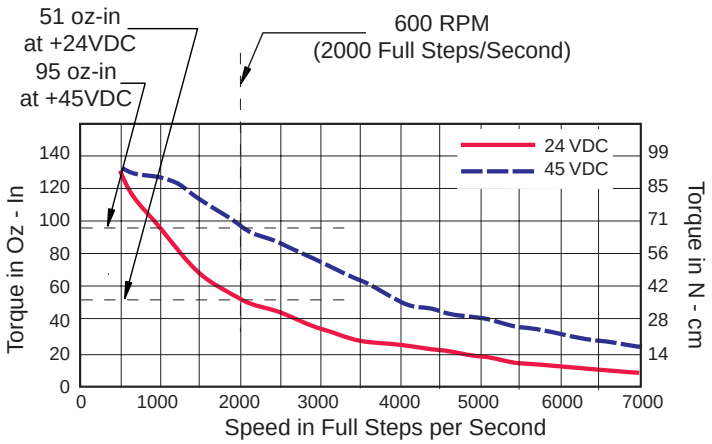
Nominal output torque (T_N) is the actual torque generated at the Planetary Gearbox output shaft which includes reduction ratio (i), gear efficiency (η) and the safety factor (s_f) for the MDrive. Once the reduction ratio (i) is determined, the nominal output torque (T_N) can be calculated as follows:

$T_N = T_M \times i \times \eta \div s_f$ or:

Motor torque × reduction ratio × gear efficiency ÷ safety factor = nominal output torque.

For gear efficiency (η) refer to the Mechanical Specifications for the 7:1 Planetary Gearbox designed for your MDrive.

For motor torque (T_M) see the appropriate MDrive Speed/Torque Table. Dependent on which MDrive you have, the torque range will vary. The torque will fall between the high voltage line and the low voltage line at the indicated speed for the MDrive. (See the example Speed/Torque Table below.)



The Speed/Torque Table above is for an MDrive 2222. This MDrive will produce a torque range of 51 to 95 oz-in in the full voltage range at the speed of 2000 Full Steps/Second (600 RPM).

Please note that this is not the usable torque range. The torque output to the Planetary Gearbox must include a safety factor (s_f) to allow for any voltage and current deviations supplied to the MDrive.

The motor torque must include a safety factor (s_f) ranging from 0.5 to 0.7. This must be factored into the nominal output torque calculation. A 0.5 safety factor is aggressive while a 0.7 safety factor is more conservative.

Example:

The available motor torque (T_M) is 51 to 95 oz-in.

NOTE: You may specify a torque less than but not greater than the motor torque range.

For this example the motor torque (T_M) will be 35 oz-in.

A 6.75:1 reduction ratio (i) has been determined.

Gear efficiency (η) = 80% from the appropriate table for the Planetary Gearbox which is used with an MDrive23.

Nominal output torque would be:

Motor torque ($T_M = 35$) × reduction ratio ($i = 6.75$) × gear efficiency ($\eta = 0.8$) ÷ safety factor ($s_f = 0.5$ or 0.7)

$35 \times 6.75 = 236.25 \times 0.8 = 189 \div 0.5 = 378$ oz-in nominal output torque (T_N)

or

$35 \times 6.75 = 236.25 \times 0.8 = 189 \div 0.7 = 270$ oz-in nominal output torque (T_N)

With the safety factor (s_f) and gear efficiency (η) included in the calculation, the nominal output torque (T_N) may be greater than the user requirement.

Shock Load Output Torque

The nominal output torque (T_N) is the actual working torque the Planetary Gearbox will generate. The shock load output torque (T_{AB}) is the additional torque that can be generated by starting and stopping with no acceleration ramps, payloads, inertia and directional changes. Although the nominal output torque (T_N) of the Planetary Gearbox is accurately calculated, shock loads can greatly increase the dynamic torque on the Planetary Gearbox.

Each Planetary Gearbox has a maximum specified output torque. In this example a 7:1 single stage MD23 Planetary Gearbox is being used. The maximum specified output torque is 566 oz-in. By calculating the shock load output torque (T_{AB}) you can verify that value is not exceeding the maximum specified output torque.

When calculating the shock load output torque (T_{AB}), the calculated nominal output torque (T_N) and the operating factor (C_B) are taken into account. C_B is merely a factor which addresses the different working conditions of a Planetary Gearbox and is the result of your subjective appraisal. It is therefore only meant as a guide value. The following factors are included in the approximate estimation of the operating factor (C_B):

- direction of rotation (constant or alternating)
- load (shocks)
- daily operating time

Note: The higher the operating factor (C_B), the closer the shock load output torque (T_{AB}) will be to the maximum specified output torque for the Planetary Gearbox. Refer to the table below to calculate the approximate operating factor (C_B).

With the most extreme conditions which would be a C_B of 1.9, the shock load output torque (T_{AB}) is over the maximum specified torque of the Planetary Gearbox with a 0.5 safety factor but under with a 0.7 safety factor.

The nominal output torque (T_N) × the operating factor (C_B) = shock load or maximum output torque (T_{AB}).

With a 0.5 safety factor, the shock load output torque is greater than the maximum output torque specification of the MDrive23 Planetary Gearbox.
(378 × 1.9 = 718.2 oz-in.)

With a 0.7 safety factor the shock load output torque is within maximum output torque specification of the MDrive23 Planetary Gearbox.
(270 × 1.9 = 513 oz-in.)

The 0.5 safety factor could only be used with a lower operating factor (C_B) such as 1.5 or less, or a lower motor torque.

Note: All published torque specifications are based on C_B = 1.0. Therefore, the shock load output torque (T_{AB}) = nominal output torque (T_N).

WARNING! Excessive torque may damage your Planetary Gearbox. If the MDrive/Planetary Gearbox should hit an obstruction, especially at lower speeds (300 RPM or 1000 Full Steps/Second), the torque generated will exceed the maximum torque for the Planetary Gearbox. Precautions must be taken to ensure there are no obstructions in the system.

Determining the Operating Factor (C_B)				
Direction of Rotation	**Load (Shocks)**	**Daily Operating Time**		
		3 Hours	8 Hours	24 Hours
Constant	Low*	C_B=1.0	C_B=1.1	C_B=1.3
	Medium**	C_B=1.2	C_B=1.3	C_B=1.5
Alternating	Low†	C_B=1.3	C_B=1.4	C_B=1.6
	Medium††	C_B=1.6	C_B=1.7	C_B=1.9

* Low Shock = Motor turns in one direction and has ramp up at start.
** Medium Shock = Motor turns in one direction and has no ramp up at start.
† Low Shock = Motor turns in both directions and has ramp up at start.
†† Medium Shock = Motor turns in both directions and has no ramp up at start.

System Inertia

System inertia must be included in the selection of an MDrive and Planetary Gearbox. Inertia is the resistance an object has relative to changes in velocity. Inertia must be calculated and matched to the motor inertia. The Planetary Gearbox ratio plays an important role in matching system inertia to motor inertia. There are many variable factors that affect the inertia. Some of these factors are:

The type of system being driven.

Weight and frictional forces of that system.

The load the system is moving or carrying.

The ratio of the system inertia to motor inertia should be between 1:1 and 10:1. With 1:1 being ideal, a 1:1 to 5:1 ratio is good while a ratio greater than 5:1 and up to 10:1 is the maximum.

Type of System

There are many systems and drives, from simple to complex, which react differently and possess varied amounts of inertia. All of the moving components of a given system will have some inertia factor which must be included in the total inertia calculation. Some of these systems include:

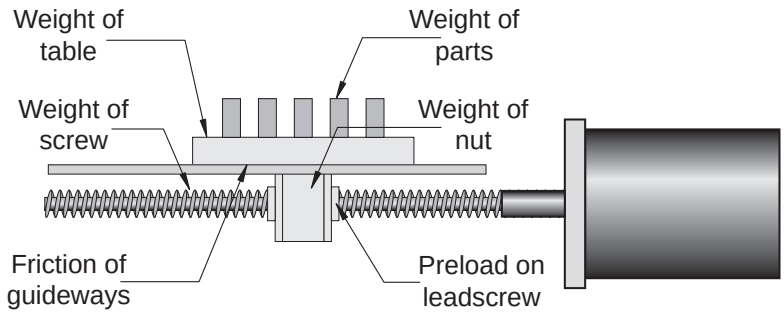
- ❒ lead screw
- ❒ rack and pinion
- ❒ conveyor belt
- ❒ rotary table
- ❒ belt drive
- ❒ chain drive

Not only must the inertia of the system be calculated, but also any load that it may be moving or carrying. The examples below illustrate some of the factors that must be considered when calculating the inertia of a system.

Lead Screw

In a system with a lead screw, the following must be considered:

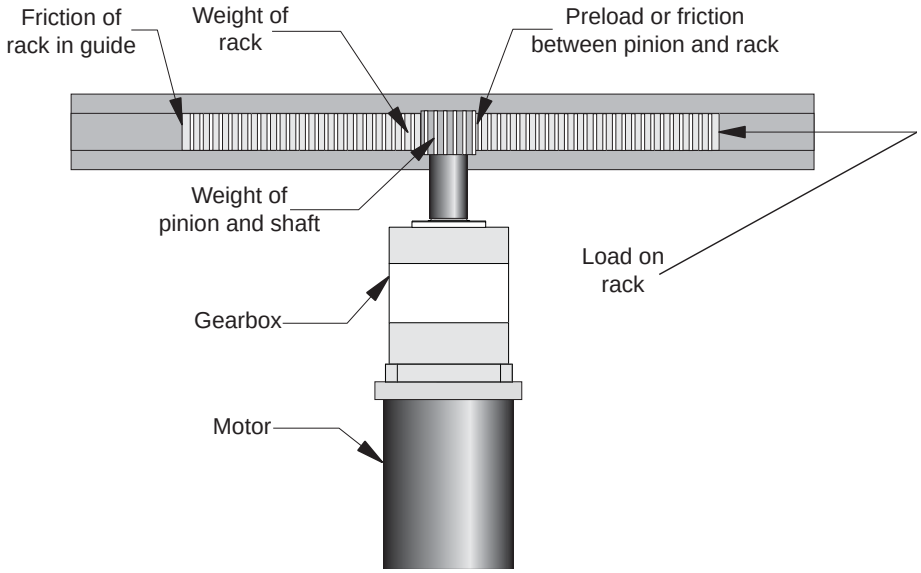
- ❒ the weight and preload of the screw
- ❒ the weight of the lead screw nut
- ❒ the weight of a table or slide
- ❒ the friction caused by the table guideways
- ❒ the weight of any parts



Rack and Pinion

In a system with a rack and pinion, the following must be considered:

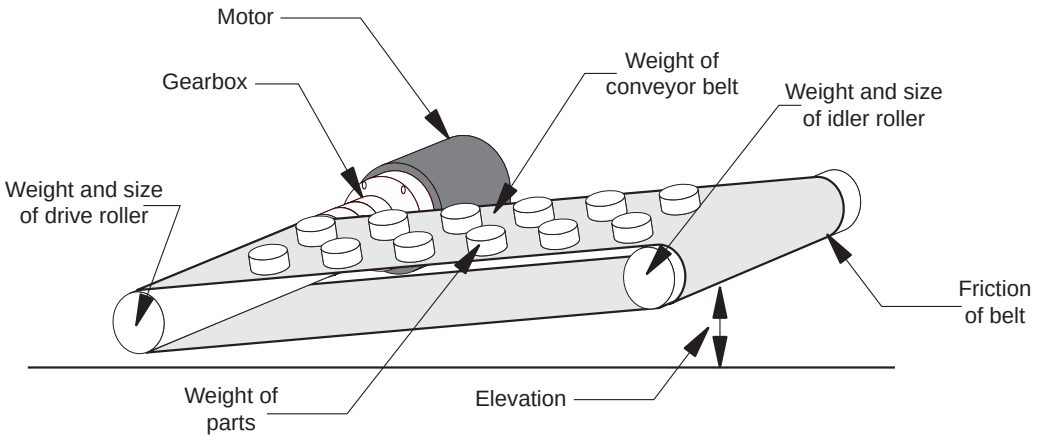
- ❒ the weight or mass of the pinion
- ❒ the weight or mass of the rack
- ❒ the friction and/or preload between the pinion and the rack
- ❒ any friction in the guidance of the rack
- ❒ the weight or mass of the object the rack is moving



Conveyor Belt

In a system with a conveyor belt, the following must be considered:

- ❒ the weight and size of the cylindrical driving pulley or roller
- ❒ the weight of the belt
- ❒ the weight or mass and size of the idler roller or pulley on the opposite end
- ❒ the angle or elevation of the belt
- ❒ any load the belt may be carrying



Rotary Table

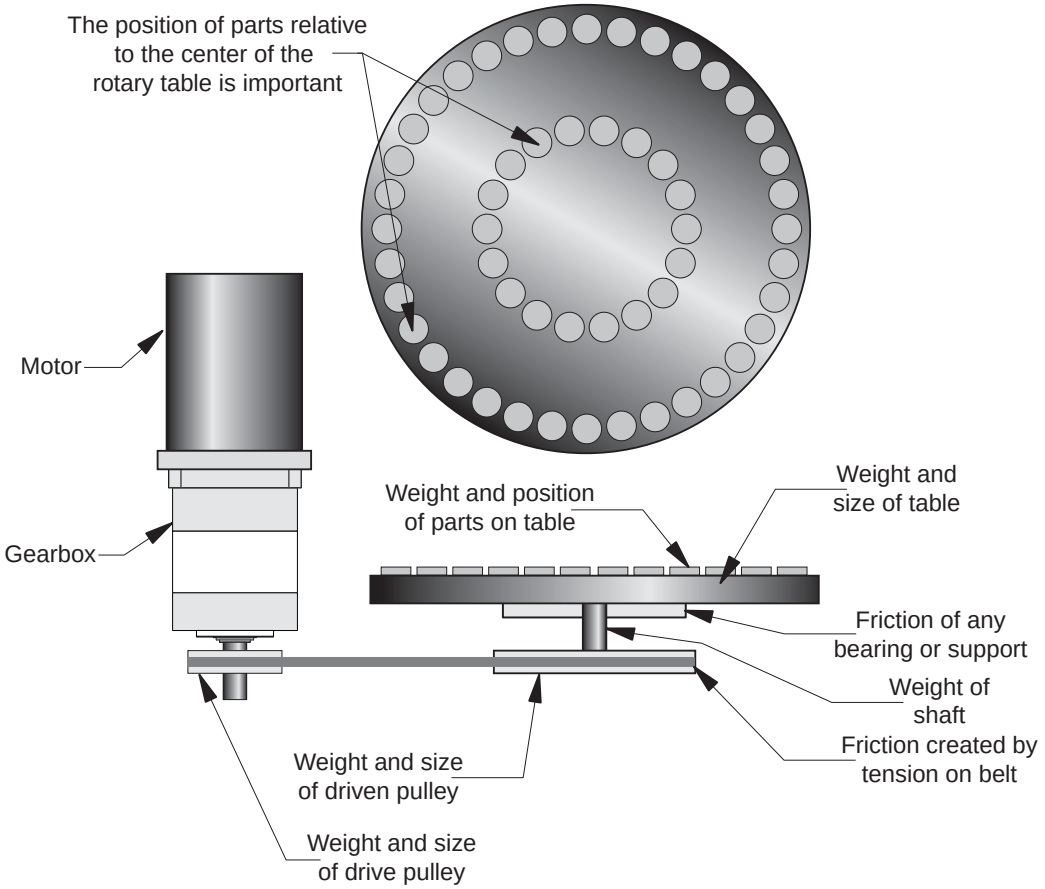
In a system with a rotary table, the following must be considered:

- ❒ the weight or mass and size of the table
- ❒ any parts or load the table is carrying
- ❒ the position of the load on the table, the distance from the center of the table will affect the inertia
- ❒ how the table is being driven and supported also affects theinertia

Belt Drive

In a system with a belt drive, the following must be considered:

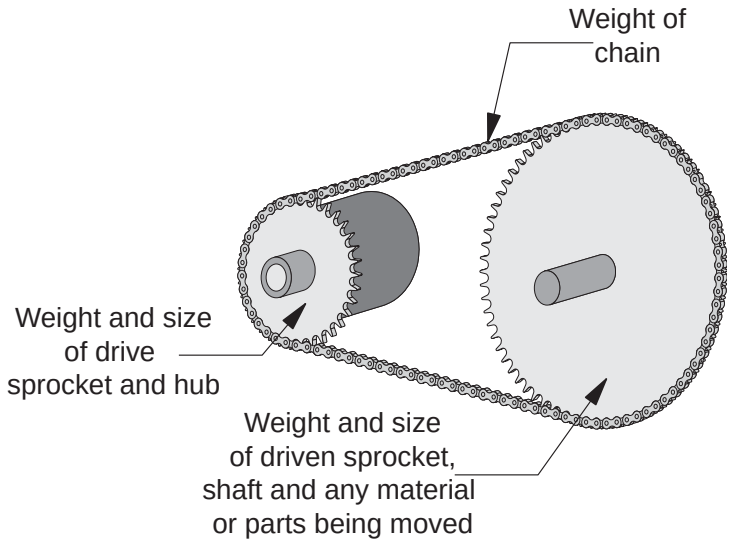
- ❒ the weight or mass and size of the driving pulley
- ❒ the tension and/or friction of the belt
- ❒ the weight or mass and size of the driven pulley
- ❒ any load the system may be moving or carrying



Chain Drive

In a system with a chain drive, the following must be considered:

- ❒ the weight and size of drive sprocket and any attaching hub
- ❒ the weight and size of the driven sprocket and shaft
- ❒ the weight of the chain
- ❒ the weight of any material or parts being moved



Once the system inertia (J_L) has been calculated in oz-in-sec^2, it can be matched to the motor inertia. To match the system inertia to the motor inertia, divide the system inertia by the square of the gearbox ratio. The result is called Reflected Inertia or (J_{ref}).

$$J_{ref} = J_L \div Z^2$$

Where:

J_L = System Inertia in oz-in-sec^2

J_{ref} = Reflected Inertia in oz-in-sec^2

Z = Gearbox Ratio

The ideal situation would be to have a 1:1 system inertia to motor inertia ratio. This will yield the best positioning and accuracy. The reflected inertia (J_{ref}) must not exceed 10 times the motor inertia.

Your system may require a reflected inertia ratio as close to 1:1 as possible. To achieve the 1:1 ratio, you must calculate an Optimal Gearbox Ratio (Z_{opt}) which would be the square root of J_L divided by the desired J_{ref}. In this case since you want the system inertia to match the motor inertia with a 1:1 ratio, J_{ref} would be equal to the motor inertia.

$$Z_{opt} = \sqrt{J_L \div J_{ref}}$$

Where:

Z_{opt} = Optimal Gearbox Ratio

J_L = System Inertia in oz-in-sec^2

J_{ref} = Desired Reflected Inertia in oz-in-sec^2 (Motor Inertia)

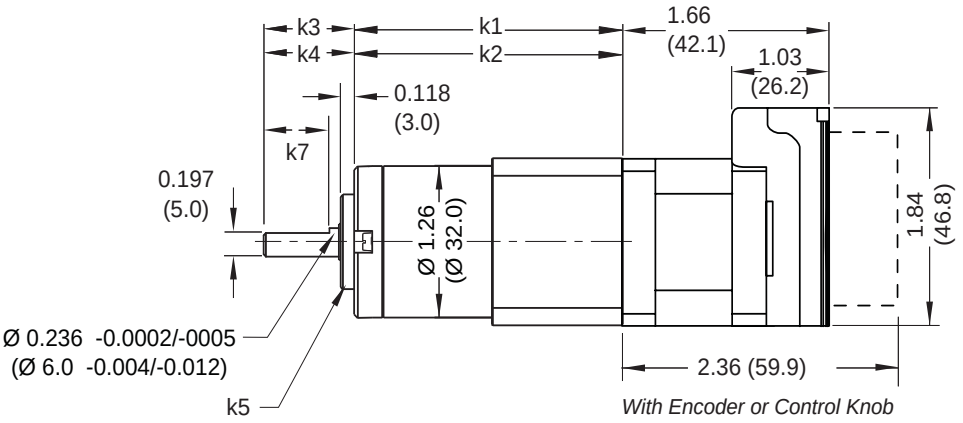
Planetary Gearbox Inertia

In addition to System Inertia, the Planetary Gearbox inertia must also be included when matching system inertia to motor inertia. The Planetary Gearbox inertia varies with the ratio and the number of stages. The table below lists the inertia values for the MDrive14, 17, 23 and 34 Planetary Gearbox. The values are in oz-in-sec^2 (ounce-inches-second squared). To calculate the inertia in kg-cm^2 (kilograms-centimeter squared) multiply oz-in-sec^2 by 70.6154.

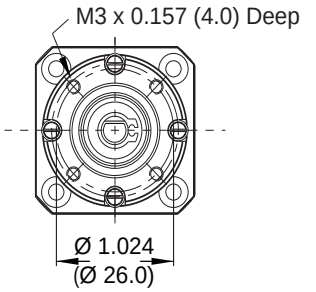
Planetary Gearbox Inertia Moments (oz-in-sec^2)					
Stages	Rounded Ratio	MDrive 14 Gearbox	MDrive 17 Gearbox	MDrive 23 Gearbox	MDrive 34 Gearbox
1-Stage	4:1	0.00002181	0.00006627	0.00025986	0.00233660
	5:1	0.00001614	0.00004362	0.00017461	0.00154357
	7:1	0.00001260	0.00003328	0.00016030	0.00128867
2-Stage	14:1	0.00002110	0.00006245	0.00024230	0.00219499
	16:1	0.00001770	0.00005084	0.00020406	0.00179847
	18:1	0.00001784	0.00005070	0.00020335	0.00182679
	19:1	0.00001586	0.00004149	0.00016512	0.00141612
	22:1	0.00001586	0.00004135	0.00016469	0.00148693
	25:1	0.00001359	0.00003200	0.00013453	0.00177015
	27:1	0.00001600	0.00004121	0.00016441	0.00148693
	29:1	0.00001359	0.00003186	0.00013425	0.00124619
	35:1	0.00001374	0.00003186	0.00013411	0.00126035
	46:1	0.00001388	0.00003186	0.00013411	0.00126035
3-Stage	51:1	0.00002110	0.00006245	0.00024230	0.00218082
	59:1	0.00001770	0.00005084	0.00020406	0.00178431
	68:1	0.00001784	0.00005070	0.00020335	0.00179847
	71:1	0.00001586	0.00004149	0.00016512	0.00147276
	79:1	0.00001784	0.00005070	0.00020335	0.00179847
	93:1	0.00001359	0.00003200	0.00016441	0.00124619
	95:1	0.00001586	0.00004135	0.00020335	0.00147276
	100:1	0.00001600	0.00004121	0.00016441	0.00148693
	107:1	0.00001359	0.00003186	0.00013425	0.00124619
	115:1	0.00001600	0.00004121	0.00016441	0.00148693
	124:1	0.00001359	0.00003186	0.00013425	0.00124619
	130:1	0.00001374	0.00003186	0.00013411	0.00124619
	139:1	0.00001600	0.00004121	0.00016441	0.00144444
	150:1	0.00001374	0.00003186	0.00013411	0.00124619
	169:1	0.00001359	0.00003186	0.00013411	0.00126035
	181:1	0.00001374	0.00003186	0.00013411	0.00124619
	195:1	0.00001359	0.00003186	0.00013411	0.00126035
	236:1	0.00001359	0.00003186	0.00013411	0.00126035
	308:1	0.00001359	0.00003186	0.00013411	0.00126035

MDrive14 ith Planetary Gearbox

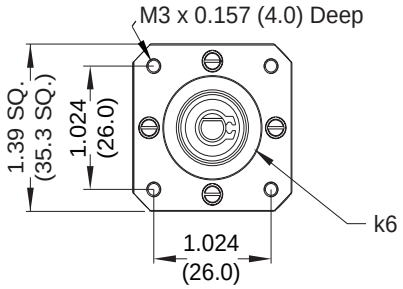
Dimensions in Inches (mm)



Front View
Planetary Gearbox



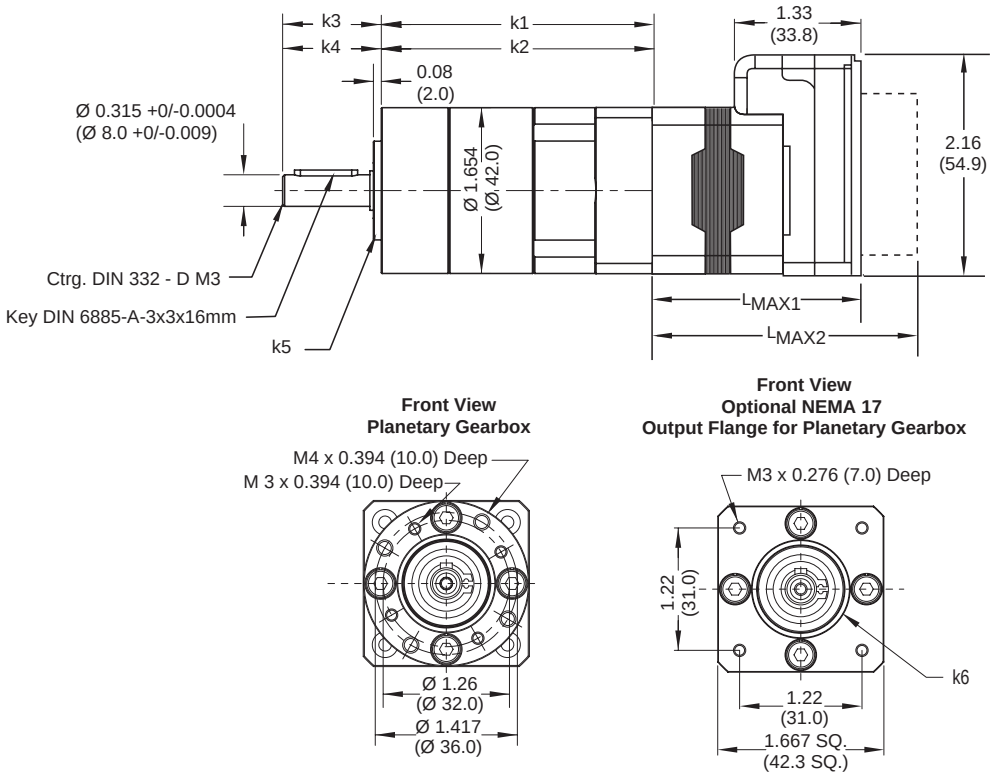
Front View
Optional NEMA 14
Output Flange for Planetary Gearbox



		Planetary Gearbox	1-Stage	2-Stage	3-Stage
Dimensions Inches (mm)	k1	Standard Gearbox	1.969 (50.0) ±0.02 (0.5)	2.343 (59.5) ±0.02 (0.5)	2.717 (60.0) ±0.02 (0.5)
	k2	w/NEMA Flange	2.008 (51.0) ±0.02 (0.5)	2.382 (60.5) ±0.02 (0.5)	2.756 (70.0) ±0.02 (0.5)
	k3	Standard Shaft	0.787 (20.0)		
	k4	Shaft w/NEMA Flange	0.748 (19.0)		
	k5	Standard Locator Diameter	0.787 (20.0) +0/-0.0013 (+0/-0.033)		
	k6	Locator Diameter w/NEMA Flange	0.866 (22.0) +0/-0.0013 (+0/-0.033)		
	k7	Length of Flat on Shaft	0.394 (10.0)		
Parameters		Max Output Torque	106 oz-in (0.75 Nm)	318 oz-in (2.25 Nm)	637 oz-in (4.5 Nm)
		Efficiency	80%	75%	70%
		Max Backlash	1.5°	2.0°	2.5°
Loads		Max Radial Load	9.0 lb-force (40 N)	15.7 lb-force (70 N)	22.0 lb-force (100 N)
		Max Axial Load	2.2 lb-force (10 N)	4.5 lb-force (20 N)	6.7 lb-force (30 N)
Weight		Gearbox Only	5.7 oz (162 gm)	7.5 oz (213 gm)	9.3 oz (264 gm)
		Gearbox w/NEMA Flange	5.9 oz (168 gm)	7.8 oz (221 gm)	9.6 oz (273 gm)

Planetary Gearbox Specifications for MDrive14

Dimensions in Inches (mm)

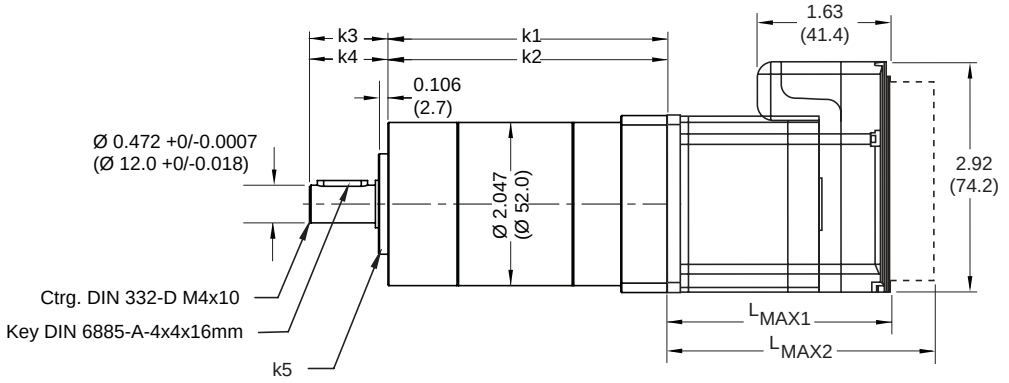


	Planetary Gearbox		1-Stage	2-Stage	3-Stage
Dimensions Inches (mm)	k1	Standard Gearbox	2.736 (69.5) ±0.02 (0.5)	3.248 (82.5) ±0.02 (0.5)	3.760 (95.5) ±0.02 (0.5)
	k2	w/NEMA Flange	2.858 (72.6) ±0.02 (0.5)	3.370 (85.5) ±0.02 (0.5)	3.882 (98.6) ±0.02 (0.5)
	k3	Standard Shaft	0.984 (25.0)		
	k4	Shaft w/NEMA Flange	0.846 (21.5)		
	k5	Standard Locator Diameter	0.984 (25.0) +0/-0.002 (+0/-0.052)		
	k6	Locator Diameter w/NEMA Flange	0.866 (22.0) +0/-0.002 (+0/-0.052)		
Parameters	Max Output Torque		425 oz-in (3.0 Nm)	1062 oz-in (7.5 Nm)	2124 oz-in (15.0 Nm)
	Efficiency		80%	75%	70%
	Max Backlash		0.80°	0.85°	0.90°
Loads	Max Radial Load		36 lb-force (160 N)	52 lb-force (230 N)	67.5 lb-force (300 N)
	Max Axial Load		11 lb-force (50 N)	18 lb-force (80 N)	25 lb-force (110 N)
Weight	Gearbox Only		14.3 oz (406 gm)	17.9 oz (508 gm)	21.5 oz (609 gm)
	Gearbox w/NEMA Flange		14.8 oz (420 gm)	18.5 oz (525 gm)	22.2 oz (630 gm)

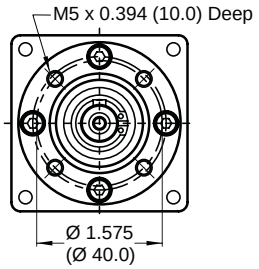
	MDrive17	Size 1713	Size 1715	Size 1719
Length Inches (mm)	L_{MAX1} Single Shaft Version	2.20 (55.9)	2.43 (61.7)	2.75 (69.8)
	L_{MAX2} Encoder or Control Knob Version	2.92 (74.2)	3.15 (80.0)	3.47 (88.1)

Planetary Gearbox Specifications for MDrive17

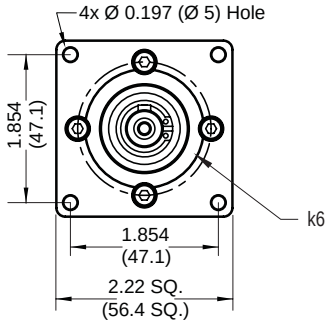
Dimensions in Inches (mm)



Front View
Planetary Gearbox



Front View
Optional NEMA 23
Output Flange for Planetary Gearbox

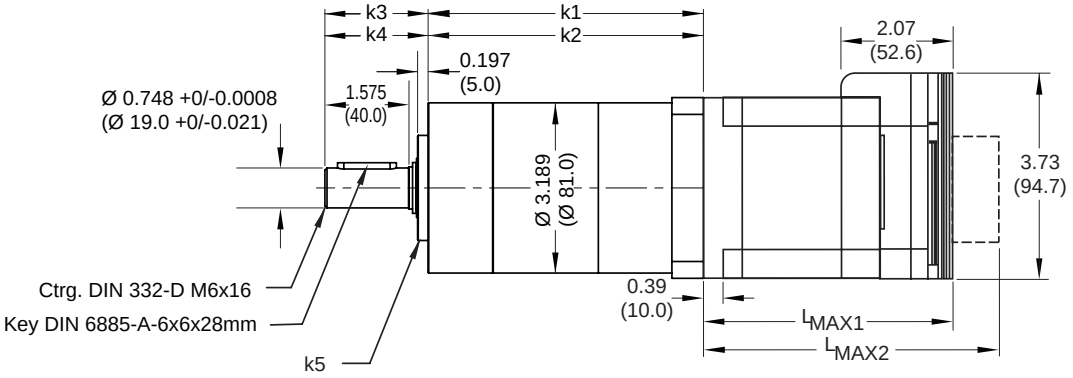


		Planetary Gearbox	1-Stage	2-Stage	3-Stage
Dimensions Inches (mm)	k1	Standard Gearbox	2.976 (75.6) ±0.02 (0.5)	3.531 (89.7) ±0.02 (0.5)	4.087 (103.8) ±0.02 (0.5)
	k2	w/NEMA Flange	3.036 (77.1) ±0.02 (0.5)	3.590 (91.2) ±0.02 (0.5)	4.146 (105.3) ±0.02 (0.5)
	k3	Standard Shaft	0.984 (25.0)		
	k4	Shaft w/NEMA Flange	0.925 (23.5)		
	k5	Standard Locator Diameter	1.260 (32.0) +0/-0.0015 (+0/-0.039)		
	k6	Locator Diameter w/NEMA Flange	1.50 (38.1) +0/-0.0015 (+0/-0.039)		
Parameters		Max Output Torque	566 oz-in (4.0 Nm)	1699 oz-in (12.0 Nm)	3540 oz-in (25.0 Nm)
		Efficiency	80%	75%	70%
		Max Backlash	0.70°	0.75°	0.80°
Loads		Max Radial Load	45 lb-force (200 N)	72 lb-force (320 N)	101 lb-force (450 N)
		Max Axial Load	13 lb-force (60 N)	22 lb-force (100 N)	34 lb-force (150 N)
Weight		Gearbox Only	25.0 oz (711 gm)	32.2 oz (914 gm)	39.4 oz (1117 gm)
		Gearbox w/NEMA Flange	25.9 oz (735 gm)	33.3 oz (945 gm)	40.7 oz (1155 gm)

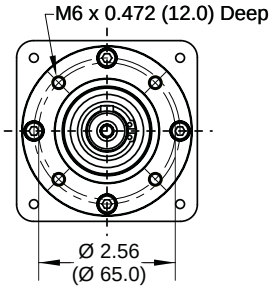
	MDrive23	Size 2218	Size 2222	Size 2231
Length Inches (mm)	L_{MAX1} Single Shaft Version	2.63 (66.8)	3.00 (76.2)	3.86 (98.0)
	L_{MAX2} Encoder or Control Knob Version	3.35 (85.1)	3.70 (94.0)	4.57 (116.1)

Planetary Gearbox Specifications for MDrive23

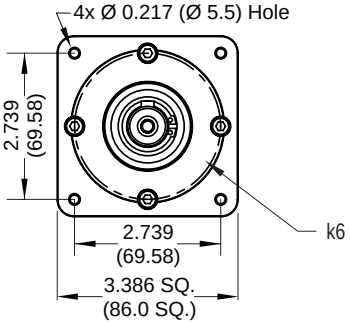
Dimensions in Inches (mm)



Front View
Planetary Gearbox



Front View
Optional NEMA 34
Output Flange for Planetary Gearbox



	Planetary Gearbox		1-Stage	2-Stage	3-Stage
Dimensions Inches (mm)	k1	Standard Gearbox	4.315 (109.6) ±0.02 (0.5)	5.169 (131.3) ±0.02 (0.5)	6.024 (153.0) ±0.02 (0.5)
	k2	w/NEMA Flange	4.433 (112.6) ±0.02 (0.5)	5.287 (134.3) ±0.02 (0.5)	6.142 (156.0) ±0.02 (0.5)
	k3	Standard Shaft	1.929 (49.0)		
	k4	Shaft w/NEMA Flange	1.811 (46.0)		
	k5	Standard Locator Diameter	1.969 (50.0) +0.0006/-0.0004 (+0.015/-0.010)		
	k6	Locator Diameter w/NEMA Flange	2.874 (73.0) +0/-0.0012 (+0/-0.030)		
Parameters		Max Output Torque	2832 oz-in (20.0 Nm)	8496 oz-in (60.0 Nm)	16992 oz-in (120.0 Nm)
		Efficiency	80%	75%	70%
		Max Backlash	1.0°	1.5°	2.0°
Loads		Max Radial Load	90 lb-force (400 N)	135 lb-force (600 N)	225 lb-force (1000 N)
		Max Axial Load	18 lb-force (80 N)	27 lb-force (120 N)	45 lb-force (200 N)
Weight		Gearbox Only	64.4 oz (1827 gm)	89.5 oz (2538 gm)	114.6 oz (3248 gm)
		Gearbox w/NEMA Flange	66.7 oz (1890 gm)	92.6 oz (2625 gm)	118.5 oz (3360 gm)

	MDrive34	Size 3424	Size 3431	Size 3447
Length Inches (mm)	L_{MAX1} Single Shaft or Encoder Version	3.81 (96.8)	4.60 (116.80)	6.17 (156.7)
	L_{MAX2} Control Knob Version	4.97 (126.2)	5.76 (146.3)	7.34 (186.4)

Planetary Gearbox Specifications for MDrive34

Available Ratios

Available Ratios for Planetary Gearbox			
Stages	Rounded Ratio	Fractional Ratio	Decimal Ratio*
1-Stage	4:1	63 / 17	3.7058823529411764
	5:1	57 / 11	5.1818181818181818
	7:1	27 / 4	6.7500000000000000
2-Stage	14:1	3969 / 289	13.7335640138408304
	16:1	270 / 17	15.8823529411764705
	18:1	900 / 49	18.3673469387755102
	19:1	3591 / 187	19.2032085561497326
	22:1	1710 / 77	22.2077922077922077
	25:1	1701 / 68	25.0147058823529411
	27:1	3249 / 121	26.8512396694215000
	29:1	405 / 14	28.9285714285714876
	35:1	1539 / 44	34.9772727272727272
	46:1	729 / 16	45.5625000000000000
3-Stage	51:1	250047 / 4913	50.8949725218807246
	59:1	17010 / 289	58.8581314878892733
	68:1	8100 / 119	68.0672268907563025
	71:1	226223 / 3179	71.1616860648002516
	79:1	27000 / 343	78.7172011661807581
	93:1	107163 / 1156	92.7015570934256055
	95:1	51300 / 539	95.1762523191094619
	100:1	204687 / 2057	99.5075352455031599
	107:1	3645 / 34	107.2058823529411764
	115:1	97470 / 847	115.0767414403778040
	124:1	6075 / 49	123.9795918367346938
	130:1	96957 / 748	129.6216577540106951
	139:1	185193 / 1331	139.1382419233658903
	150:1	23085 / 154	149.9025974025974025
	169:1	45927 / 272	168.8492647058823529
	181:1	87723 / 484	181.2458677685950413
	195:1	10935 / 56	195.2678571428571428
	236:1	41553 / 176	236.0965909090909090
	308:1	19683 / 64	307.5468750000000000

* The Decimal Ratio shown here has been limited to 16 places.

Installing a Driving Device on a Planetary Gearbox

WARNING!

The MDrive and its Heat Sink must not be subjected to any axial or other pressing force as damage may result to the unit and void the Warranty.

When installing a gear, pulley, coupling or other driving device to the output shaft of the Planetary Gearbox, IMS recommends that it be “slip-fit” onto the shaft and properly secured, i.e. with set screws.

DO NOT press fit the device onto the shaft.

NEVER tap or hammer a driving device onto the output shaft of the Planetary Gearbox.

Disconnecting the Planetary Gearbox from the MDrive may void the Warranty.

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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."

NOTE: MDrive Motion Control electronics are not removable from the motor in the field. The entire unit must be returned to the factory for repair.

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.

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