thermionics laboratory, inc.

INSTRUCTION MANUAL

TMC MOTOR CONTROLLER
3-6 AXES

Version 2

SERIAL # _____

10.2024
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TMC Motor Controller 3-6 Axis

INSTRUCTION MANUAL

VERSION 2.0

TABLE OF CONTENTS

Section 1: Introduction

1.0 OVERVIEW

Congratulations on your selection of the Thermionics Stepping Motor Controller as your motion control solution! This unit is capable of providing many years of service with minimal care and maintenance. This manual is a tool to aid you in maximizing the potential of the TMC control system.

1.1 PRODUCT DESCRIPTION

The TMC stepping motor controller comes in various configurations. It can be supplied with 1 to 6 axes of motor control. Axes drives are available in two sizes, 3.0 or 5.0. The controller comes in a rack mount chassis. It can be operated as a stand alone unit with the optional hand held terminal or with a computer using the USB communications port.

1.2 SPECIFICATIONS

- 1 to 6 axes per chassis
- Software selectable drive current (per axis):

3.0 drive - up to 3.0 amperes (4.2 amperes peak)
5.0 drive - up to 5.0 amperes (7.0 amperes peak)

- Software selectable holding current (per axis)
- Motor resolutions: 200 and 400, micro-stepping available
- Optional remote hand held terminal provides continuous status and position display
- 32 bit axis position registers provide ± 2,147,483,648 billion counts
- Velocity settings: up to 5 million pulses per second
- Position display in steps, inches, millimeters, centimeters, degrees, radians, or revolutions
- Relative, absolute, continuous, and jogging motions
- Closed loop operation (with optional incremental encoders)
- Encoder and or limit switch homing functions
- 4 hardware homing routines (with optional hardware position input)
- Programmable backlash correction (with encoder)
- Hardware and software emergency stop
- 3 hardware end limits per axis
- USB port interface for host computer control (with RS-422/485 drivers loaded on host computer)
- 3.27” tall x 19”wide x 16”deep rack mount chassis
- 120/240 VAC (switch selectable) 50/60 Hz, Amperage depends on size and number of axis

1.3 SYSTEM COMPONENTS

The components of the SMC motor controller are listed below. If you find any part missing from the shipment, please contact Thermionics Northwest.

Qty	Description
1	TMC Rack Mount Driver Unit
1	Hand held terminal with 10' cable (optional)
1	AC power cable
1 per axis	15' Interface cable (with DB15 connectors)
1 per axis	15' stepping motor cable
1	15' USB cable
1	TMC user manual
1	Communications driver installation CD

Section 2: System Overview

2.0 TMC CONTROLLER

The Thermionics TMC system consists of a motor control box which uses an MForce motor controller/driver, made by *Intelligent Motion Systems (IMS),* for each axis. Each axis is capable of motor control and various I/O functions. TMC operational control is provided through the optional Hand Held Terminal, MCode commands sent from a user's computer or with custom developed software stored in each axis controller.

2.011 TMC HANDHELD TERMINAL

The Handheld Users Terminal is usually supplied in TMC controllers that have 3 or more axes. Through the terminal the user can control motor functions, many system settings, and monitor positional data. The Hand Terminal is described in section 7 or this manual.

2.012 MCODE COMMANDS

MCode is the native language used to setup, control and program IMS controllers. MCode is explained in the *Programming and Software Reference* manual which is provided with the TMC unit. It is also available for download at: http://www.imshome.com/downloads/manuals.html

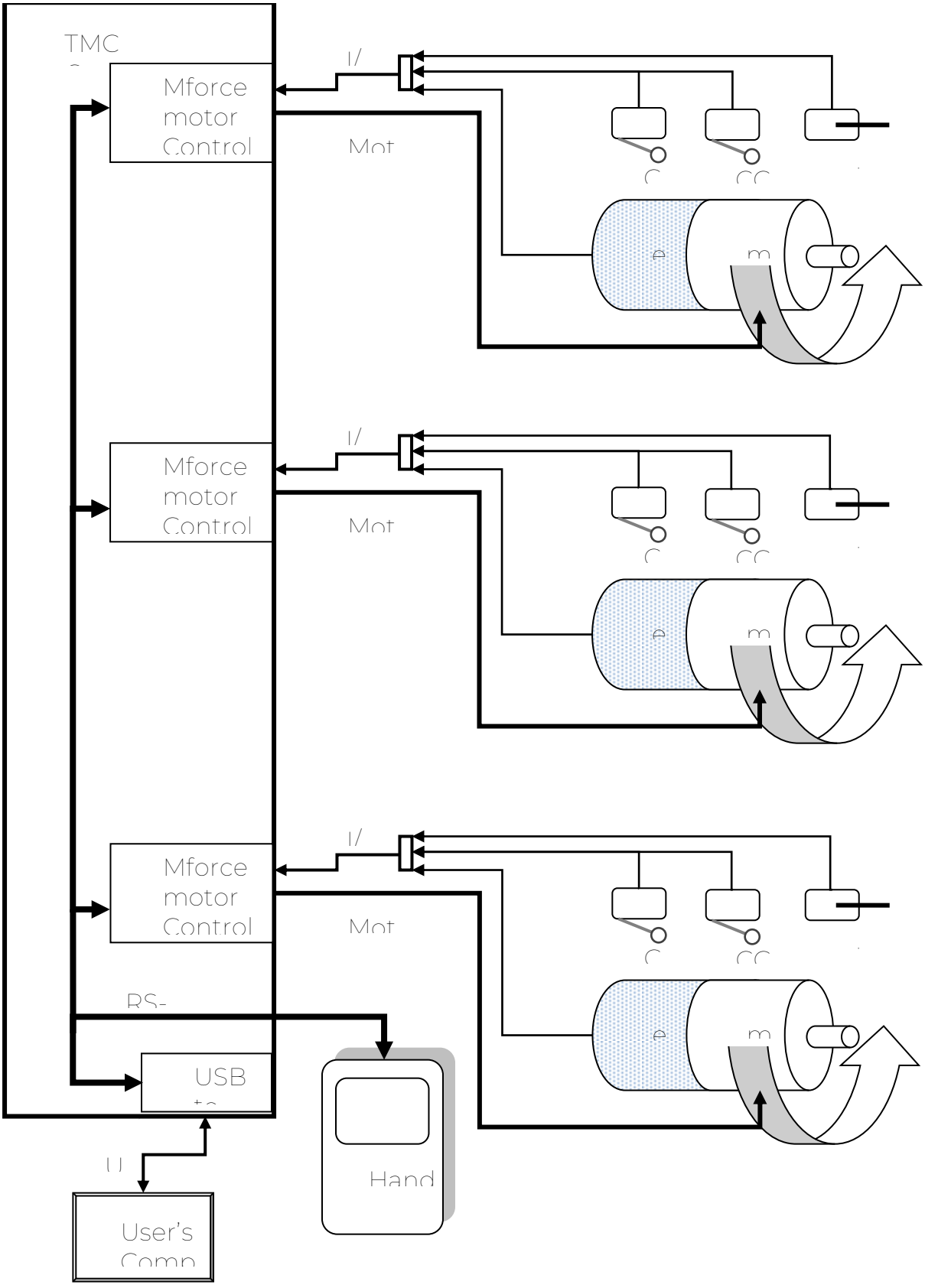
2.3 TERMINAL SOFTWARE

The basic way to communicate with each axis is through terminal software. IMS provides free terminal software that is optimized to work with the MForce controllers which control each axis of the TMC. IMS Terminal is available for downloaded at:
http://www.imshome.com/downloads/software_interfaces.html

2.4 CUSTOM DEVELOPED SOFTWARE

Software can be written in MCode and downloaded and stored in each MForce controller. When called this stored software can perform motor control functions. There are programming instructions and examples in the *Programming and Software Reference* manual.

2.02 TMC Functional Diagram



Section 3 Safety

3.1 PERSONNEL SAFETY

Only individuals who understand the contents of this manual, the IMS MDrive Software Reference Manual and all other relevant documentation are authorized to work on or with the TMC motor controller and related equipment. Working on or with this equipment includes operating, programming and adjusting the settings. These individuals must be able to detect and prevent improper actions and settings that may be dangerous to personnel and or equipment. They must be aware of the consequences of setting and changing parameter values and how these values effect the operation of mechanical, electrical and electronic equipment. They must have enough training, knowledge and experience to detect and avoid potential dangers. They must also be familiar with and follow the safety standards, procedures, and regulations that apply to the location where the TMC and related equipment is installed and operated.

3.2 INTENDED USE

The drive systems described here are products for general use that conform to the state of the art in technology and are designed to prevent any dangers. However, drives and drive controllers that are not specifically designed for safety functions are not approved for applications where the functioning of the drive could endanger persons.

The possibility of unexpected or unbraked movements can never be totally excluded without additional safety equipment. For this reason personnel must never be in the danger zone of the drives unless additional suitable safety equipment prevents any personal danger. This applies to operation of the machine during production and also to all service and maintenance work on drives and the machine. The machine design must ensure personal safety. Suitable measures for prevention of property damage are also required. In all cases the applicable safety regulations and the specified operating conditions, such as environmental conditions and specified technical data, must be observed.

The drive system must not be commissioned and operated until completion of installation in accordance with the specifications in this manual. To prevent personal injury and damage to property damaged drive systems must not be installed or operated.

Changes and modifications of the drive systems are not permitted and if made no warranty and liability will be accepted. The drive system must be operated only with the specified wiring and approved accessories. In general, use only original accessories and spare parts.

The drive systems must not be operated in an environment subject to explosion hazard (ex area). not avoided, can result in death, serious injury, or equipment damage.

Failure to follow these instructions can result in death or serious injury.

Section 4 Hardware Overview

4.0 MOUNTING THE TMC CHASSIS

The TMC series controllers are manufactured to fit into a standard 19" electronics rack chassis or they can be used as a table top unit. We recommend shelf supports be utilized to handle the chassis weight in an electronics rack.

All of the necessary hardware is provided to make the connections between the controller, the hand held terminal, motors, end limit switches and USB port.

4.1 HAND HELD TERMINAL

The optional hand held terminal attaches to the front panel of the controller chassis with a 10 foot cable. The connection is labeled Hand Held Terminal. Use a screwdriver to tighten the two mounting screws on the connector. The TMC hand held terminal allows the controller to be operated as a completely standalone unit. Operation of the hand held terminal is described in Section 7.

4.2 REAR PANEL CONNECTIONS AND SETTINGS

A - Voltage selector switch - select 230V or 115V to match supply input voltage
B - Fuse – ¼" by 1 ¼" 15 amp slow blow
C - Ethernet connection – standard 8P8C (often called RJ45) connection. This port is used only to communicate with the Hand Terminal. It is not required. It is only used for custom systems.
D - USB (type B) – communicates directly to RS-485 party line with the axis controllers.
E - Axis 1 to 6 I/O connectors (DB15 female) – These connectors provide user access to: clockwise (+) limit switch, counter clockwise (-) limit switch, optical zero position input (ZPI), and incremental encoder connections. There is one I/O connector per axis.
F - Axis 1 to 6 stepping motor output connectors (DB5W5). There is one connector per axis.
G - Hardware E-Stop connector.
H - AC Power connection – cord provided

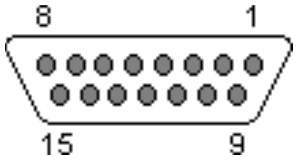
4.3 USB COMMUNICATIONS PORT

This connection is used to communicate via the user's computer. A CD is provided with communications drivers that must be loaded on the user's computer to communicate through this port. (Note: this connection is used exclusively with the hand terminal turned off or removed from the TMC controller.)

4.4 I/O CONNECTIONS

Each axis has a unique I/O connector. Each is a DB15F (socket) connector labeled by its axis number (i.e. 1 to 6) on the TMC rear panel. The position designation for each connector is:

1. encoder channel A+
2. encoder channel A-
3. encoder channel B+
4. encoder channel B-
5. encoder index +
6. encoder index –
7. clockwise (+) limit switch signal (I/O 1)
8. counter clockwise (-) limit switch signal (I/O 2)
9. encoder 5 VDC supply
10. ZPI 5 VDC supply
11. ZPI 3.2VDC (220 ohms to 5VDC)
12. ZPI output signal (I/O 3)
13. ZPI ground
14. encoder ground
15. CW and CCW limit ground



I/O connector DB15F (socket) position layout on back panel

4.5 HARDWARE END LIMITS

Hardware end limits will cause the motor to stop moving when a limit switch contacts open. Each axis supports a clockwise (+) limit switch and a counter clockwise (-) limit switch. These are provided to protect delicate equipment from being damaged. The limit switches are typically mounted at each end of travel. When the motor travel activates a limit switch the motor is stopped and will not move any further in the same direction.

The limits are prewired in the typical Thermionics installation. The limits are wired as follows:

CW (+) limit switch contacts	I/O connector
Common (C)	connected to position 15
Normally closed (NC)	connected to position 7
CCW (-) limit switch contacts	I/O connector
Common (C)	connected to position 15
Normally closed (NC)	connected to position 8

4.6 HARDWARE HOME LIMIT INPUT

The home limit can be used as a reference position to reset an axis positional counter.

4.61 OPTICAL HOME LIMIT (ZPI)

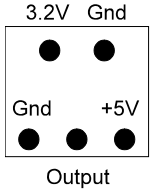


Figure 2.3 -Optical Sensor (bottom view)

The optical home limit is designed to work with the Honeywell HOA2004 series Opto-schmitt sensor. The figure on the right illustrates how to connect the switch.

The ZPI is prewired in the typical Thermionics installation. The ZPI is wired as follows:

HOA2004 sensor	I/O connector
+5 VDC	position 10
3.2V	position 11
Output	position 12
Gnd	position 13
Gnd	position 13

4.62 MECHANICAL HOME LIMITS

Any type of mechanical switch can be used for sensing the home position. The normally open (NO) switch contact is connected to I/O position 10 and the common (C) switch contact is connected to I/O position 12.

4.7 INCREMENTAL ENCODER INPUT

The TMC controller is capable of using information provided by an incremental encoder to accurately control the axis position. The index of the

encoder can be used in conjunction with the hardware home position inputs or the end limit switch inputs to achieve very accurate positioning.
The encoder is prewired in the typical Thermionics installation. The encoder is wired as follows:

Encoder with differential outputs (8 wires)

Encoder connections	I/O connector
channel A+	position 1
channel A-	position 2
channel B+	position 3
channel B-	position 4
index +	position 5
index –	position 6
5 VDC supply	position 9
ground	position 14

Encoder with single-ended outputs (5 wires)

Encoder connections	I/O connector
channel A	position 1
channel B	position 3
index	position 5
5 VDC supply	position 9
ground	position 14

4.8 MOTOR CONNECTORS

Each axis has a five position DB5W5 hybrid connector that supplies the output connections required for the stepper motors.

The motors are prewired in the typical Thermionics installation. The motors are wired as follows:

Encoder with differential outputs (8 wires)

Motor connections	Motor output connector
Phase A-	position A1
Phase A+	position A2
Phase B-	position A3
Phase B+	position A4

Note: Chassis ground is connected to position A5. This is connected to the cable shield and should not be connected to the motor.

Motor output connector DB5W5 (socket) position layout on back panel

4.9 HARDWARE EMERGENCY STOP

Activating the hardware emergency stop, also referred to as the E-Stop, will cause all motors to immediately stop.

A normally closed switch or button can be attached to position 2 and 3 of the CPC connector located on the back panel of the driver unit.

Note: The black CPC connector shipped with the unit must be attached to deactivate the E-Stop.

4.10 AC POWER CONNECTOR AND VOLTAGE SELECTOR SWITCH

Determine and install if needed the proper AC power plug for your region to the provided power cable.

Plug the power cable provided into the power connector on the rear of the unit.

Adjust the voltage selector switch to 115V or 230V to match the supply voltage.

4.11 TMC SENSOR CONNECTIONS

Encoder connections 6 position Molex Connector

Pin #	Signal
1	not connected
2	Channel B
3	5 VDC
4	Index
5	Channel A
6	Ground

4.111 LIMIT SWITCH CONNECTIONS 6 POSITION MOLEX CONNECTOR

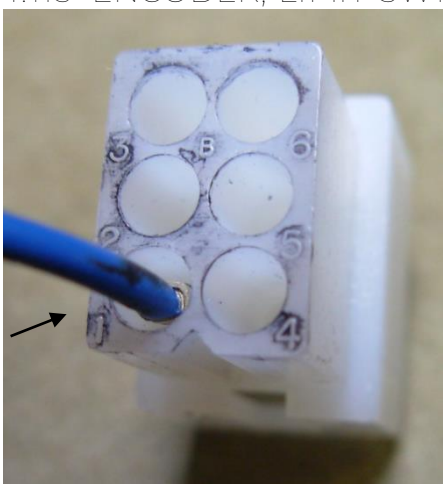
Pin #	Signal	Limit Switch wire
1	CW (+) switch – normally closed (NC)	Green
2	CCW (-) switch – normally	Green

	closed (NC)	
3	not connected	-
4	CW (+) switch – common (C)	Yellow
5	CCW (-) switch – common (C)	Yellow
6	not connected	-

4.112 ZERO POSITION INDICATOR (ZPI) CONNECTIONS 6 POSITION MOLEX CONNECTOR

Pin #	Signal	Limit Switch wire
1	Ground	Green
2	Detector Output (signal)	Blue
3	VCC (5 VDC)	White
4	Anode (3.3V DC)	Red
5	not connected	-
6	Ground	Black

4.113 ENCODER, LIMIT SWITCH AND ZPI CONNECTORS PIN ASSIGNMENTS



Connector: Molex - P.N. 03-06-2061 Plug 6 position (pins) 0.062”spacing
View from wire/cable side of connector

Section 5: System Setup

5.0 CABLING

There is a motor cable for each axis. An I/O cable is also supplied for each axis that is configured with hardware limit switches, ZPI or an encoder. A USB cable is also supplied.

IMPORTANT NOTE: Before turning on the power to the controller always make sure that the components are securely and properly connected.

5.1 COMMUNICATIONS SETUP

5.11 CONFIGURING THE COMMUNICATION PORT

Communications between the customer supplied computer and the TMC is through the USB connection. Inside the TMC, the USB signals are converted to the RS422 communications bus by a model U485G converter made by U.S. Converters.

The user supplied computer will require the proper driver for the U485G converter. The driver can be downloaded from the supplied CD or by going to the US Converter's website:

Installation of the communications drivers from the CD

1) Insert the CD and view the folders
2) Open the ftdi_drivers_manuals folder
3) Open the 3_Driver installation guides folder
4) Open the pdf file that corresponds to the user computer operating system For example if the user computer has the Windows XP operating system open the file named *3_Windows Installation Guide XP_AN104FTDI.pdf*
5) Follow the directions in the pdf file to load the drivers.
6) Take note of the COM number for the USB Serial Port in the COM Port section of Device Manager. This number will need to match the port number setting in the IMS Terminal program

Installation of the communications drivers from the web site

1) Download the software from the US Converters web site at:
http://www.usconverters.com/index.php?main_page=page&id=15&chapter=0
2) At the website:
Go to the section USB to RS485 and RS422
Find the row for U485G
Select Drivers/Data Sheet.zip
3) Select Save
4) Save to a location on your Hard Drive
5) Unzip the downloaded folder by copying the contents of the zip folder into a new folder
6) Open the pdf file that corresponds to the user computer operating system
For example if the user computer has the Windows XP operating system open the file named *3_Windows Installation Guide XP_AN104FTDI.pdf*
7) Follow the directions in the pdf file to load the drivers.
8) Take note of the COM number for the USB Serial Port in the COM Port section of Device Manager. This number will need to match the port number setting in the IMS Terminal program
5.12 Installing and Configuring Terminal Software

Terminal software makes it possible to communicate with the TMC motor controller. Each axis, in the TMC, is controlled and driven by an MForce controller/driver made by Intelligent Motion Systems Inc (IMS). We recommend using IMS Terminal which is a free terminal software package provided by IMS. IMS Terminal requires Microsoft Windows XP service pack 2 or higher.

Installation of the IMS Terminal software from the CD

1) Insert the CD and view the folders
2) Open the IMS_Term folder
3) Double click “setup.exe”
4) Follow the on-screen prompts to complete the installation of IMS Terminal

Installation of IMS Terminal software from web site

1) Download the software from the IMS web site at
http://www.imshome.com/downloads/software_interfaces.html.
2) Extract to a location on your hard drive.
3) In the folder location of the extracted files, double click “setup.exe”
4) Follow the on-screen prompts to complete the installation of IMS Terminal

A copy of the MDrive Software Reference Manual is located on the TMC CD and is labeled MCode[1].pdf
Section 6 of the MDrive Software Reference Manual describes the operation of IMS Terminal program.

Configuring the IMS Terminal software for the first time

Refer to Section 6.1.5 and 6.1.6 of the MDrive software Reference Manual on how to configure the terminal software.
The only thing that will need to be set, to begin communicating with the TMC, is the Comm port in the IMS Terminal program “Terminal” screen so it matches the USB Serial Port number in the COM Port section of Device Manager on the user computer. To do this:

1) Verify or change the Comm port setting in the IMS Terminal
The path to the COM port setting in IMS Terminal is:
Select Edit
Click on Preferences
Click on the Comm Settings Tab
The COM number setting is in the Port window
Once you have selected the correct com port, click ok.
2) Verify hardware and cable connections and apply power to the TMC.
3) If IMS Terminal program “Terminal Screen” is not already “connected”, connect to the device by clicking the “connect” icon on the button bar, or by double clicking the disconnected field on the status bar of the terminal window.
4) Key in ctrl+c.
5) The sign-on message below should appear:
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The sign-on message indicates that you are up and running. You may now begin to issue immediate mode commands and/or download programs to your device!

Section 6: Operation from Users Computer

6.0 CONTROLLER OPERATION

All TMC stepping motor controllers are configured and tested at Thermionics so they are ready to operate without having to set any parameters. The TMC settings document, shipped with the controller, lists the settings resident in each axis of the TMC as it was shipped from Thermionics.

There are distinct differences in the way that single axis (that is not configured for the optional Hand Terminal) and multiple axis units communicate. These are described in the next sections.

6.01 COMMUNICATING WITH SINGLE AXIS SYSTEMS (NOT CONFIGURED FOR HAND TERMINAL)

- Start the IMS Terminal software.
- If IMS Terminal program "Terminal Screen" is not already "connected", connect to the device by clicking the "connect" icon on the button bar, or by double clicking the disconnected field on the status bar of the terminal window.
- Turn on the power switch on the TMC front panel.
- The Sign on message should display on the "Terminal" screen.

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Type in a command and then press the Enter key. As each character is typed the TMC will echo it back. commands for single axis systems are executed by the controller with the <ENTER> key or C/R character.

6.02 COMMUNICATING WITH MULTIPLE AXES SYSTEMS (AND SINGLE AXIS CONFIGURED FOR HAND TERMINAL)

When Party Mode is enabled, each device in the system must be addressed by the host computer by using the device name (specified by the MCode DN instruction). This name will precede any command given to a specified axis and be terminated with a Control J (CTRL + j buttons pressed simultaneously) or a L/F. One CTRL + J must be issued after power up or entering the Party Mode to activate the Party Mode.

Each multi axes TMC is initially set for the following commands that effect the Party Mode communications :

- Party Mode is set on (PY=1). This allows the axes to be address one axis at a time.

- The Echo Mode state is set to 2 (EM=2). The axes will only return information to the terminal window when given the MCode Print (PR) or List (L) commands.
- The Device Name (DN) for each axis is their labeled number. For example the axis labeled 1 has the device name (DN= "1") and the axis labeled 2 has the device name (DN="2") etc.

In the MDrive Software Reference Manual see section 4 for a summary and section 5 for complete instructions on MCode commands and settings.

Because the Party Mode is enabled, select CTRL + J to activate it at power up.
To send a command, to a TMC axis, type the axis device name then the MCode command followed by CTRL + J.
To address all of the axes at once use the global device name which is the asterisk character (*).

Below are some examples of how party mode is implemented:

To move the axis labeled "1", press CTRL + J and then type:
1MR 10000 and press CTRL+J. device "1" will move 10000 steps.

To print the position of axis "1"type:
1PR P and press CTRL+J. The position of device "1" will be printed.

To move axis"2" type:
2MR 10000 and press CTRL+J. Device "2" will move 10000 steps.

To move all axes at the same time type:
*MR 10000 and press CTRL+J. All axes will move 10000 steps.

To take a axis out of party mode and take put it into echo mode 0 type:
<device name>EM=0 and press CTRL+J. The axis will be in echo mode 0
<device name>PY=0 and press CTRL+J. That axis will be taken out of party mode. Now this axis will communicate the same as a single axis controller. To avoid communications conflicts between the axes and the Terminal program it is important that to have no more than one axis out of party mode at a time.

To return an axis to party mode and put it back in echo mode 2 type:
PY=1 and press ENTER. That axis will be returned to party mode.
Press CTRL=J <device name>EM=2 and press CTRL+J. The axis will be back in echo mode 2.

6.1 HARDWARE END LIMITS SETTINGS

Axes that use hardware end limits are configured to use digital inputs 1 & 2.

When supplied, on the equipment provided by Thermionics, the axes with the limit switches are typically configured as follows:

S1=2,1,0 – Input 1 set for clockwise end limit, active high
S2=3,1,0 – Input 2 set for counter-clockwise end limit, active high

With this configuration once a limit switch is met the motor will decelerate and stop. When the clockwise limit is met the motor will not move in the clockwise direction but will move in the counter clockwise direction. The opposite is true when the counter clockwise limit switch is met. When both limit switches are met the motor will not move in either direction.

Limit switch wiring is explained in section 4.5 of this manual.

IMPORTANT NOTE: When an axis is configured as above the motor will not move unless the limit switches are connected.

6.2 ZERO POSITION INDICATOR (ZPI) SETTINGS

The home limit input is used as a reference position where the axis positional counter can be reset.

Axes that use ZPI are configured to use digital inputs 1 & 2.
When supplied, on the equipment provided by Thermionics, the axes with the ZPI are typically configured as follows:

S3 = 1,0,1

ZPI wiring is explained in section 4.51 of this manual. The command for homing with a ZPI is the HM command. See section 5 of the MDrive Software Reference Manual for a description of *S3* and *HM* commands.

6.3 MCODE PROGRAMMING

Section 3 of the MDrive Software Reference Manual gives a detailed theoretical description how MCode software works. The instructions in it are a necessary overview.

6.4 MCODE COMMANDS

Section 4 of the MDrive Software Reference Manual gives a summary of the MCode commands.

Section 5 gives a full description for each of the MCode commands, settings and flags.

Please Note: The TMC uses the commands that have *MForce* and *MForce (Plus2 expanded features)* listed under the "Compatible with Motion Control products:" listing.

6.5 INSTALLED PROGRAMS

Some special use TMC controllers are shipped from Thermionics with a resident program installed in one or both axes. Examples of these special uses are variable speed controller or target position controller. The TMC settings document, shipped with the controller, lists any programs resident in each axis of the TMC as it was shipped from Thermionics.

Section 7: Hand Terminal Operation

7.0 HAND TERMINAL

The optional hand terminal can control 1 to 6 axes. The function trees and flow charts below explain the functions of the hand terminal.

7.1 TMC HAND TERMINAL FUNCTION TREE (COMPRESSED VIEW)

1. F1 Move Axis (set up and executes axis or axes moves)
   - 1.1. F1 Single Axis (set up and executes single axis moves)
     - 1.1.1. Select Single Axis (select axis for single axis move)
       - 1.1.1.1. F1 Enter (confirm selected axis)
       - 1.1.1.2. F2 Refresh (clear selected axis)
       - 1.1.1.3. F4 Return (return to next higher menu)
       - 1.1.1.4. F5 Stop All (stops all motors)
     - 1.1.2. F1 Jog (momentary or continuous move)
       - 1.1.2.1. F1 Move + (moves selected axis in + direction.)
       - 1.1.2.2. F2 Move - (moves selected axis in - direction)
       - 1.1.2.3. F3 Stop move (stops all motors)
       - 1.1.2.4. F4 Return (return to next higher menu)
       - 1.1.2.5. F5 Stop All *(stops all motors)*
     - 1.1.3. F2 Move Relative (moves axis a set distance)
       - 1.1.3.1. F1 Set distance (user selects target distance)
         - 1.1.3.1.1. F1 Enter (enters and saves selected value)
         - 1.1.3.1.2. F4 Return (return to next higher menu)
         - 1.1.3.1.3. F5 Stop All (stops all motors)
       - 1.1.3.2. F2 Move + (moves in + direction to target distance)
       - 1.1.3.3. F3 Move - (moves in – direction to target distance)
       - 1.1.3.4. F4 Return (return to higher menu)
       - 1.1.3.5. F5 Stop All *(stops all motors)*
     - 1.1.4. F3 Move Absolute (moves axis a to a selected position)
       - 1.1.4.1. F1 Set Targets (user input of 6 positions)
         - 1.1.4.1.1. F1 Save (saves positions & return to prior screen)
         - 1.1.4.1.2. F2 Cancel (cancel selected & return to prior screen)
         - 1.1.4.1.3. F3 Clear (clears all positions & sets them to zero)
       - 1.1.4.2. F2 Move to next position (moves from present to next position)
       - 1.1.4.3. F3 Move to prior position *(moves to prior position)*
       - 1.1.4.4. F4 Return (return to higher menu)
       - 1.1.4.5. F5 Stop All *(stops all motors)*
     - 1.1.5. F4 Return (return to higher menu)
     - 1.1.6. F5 Stop All *(stops all motors)*
   - 1.2. F2 Multiple Axes (sets up and executes multiple axes moves)
     - 1.2.1. F1 Two axis Jog *(X and Y axis Moves)*

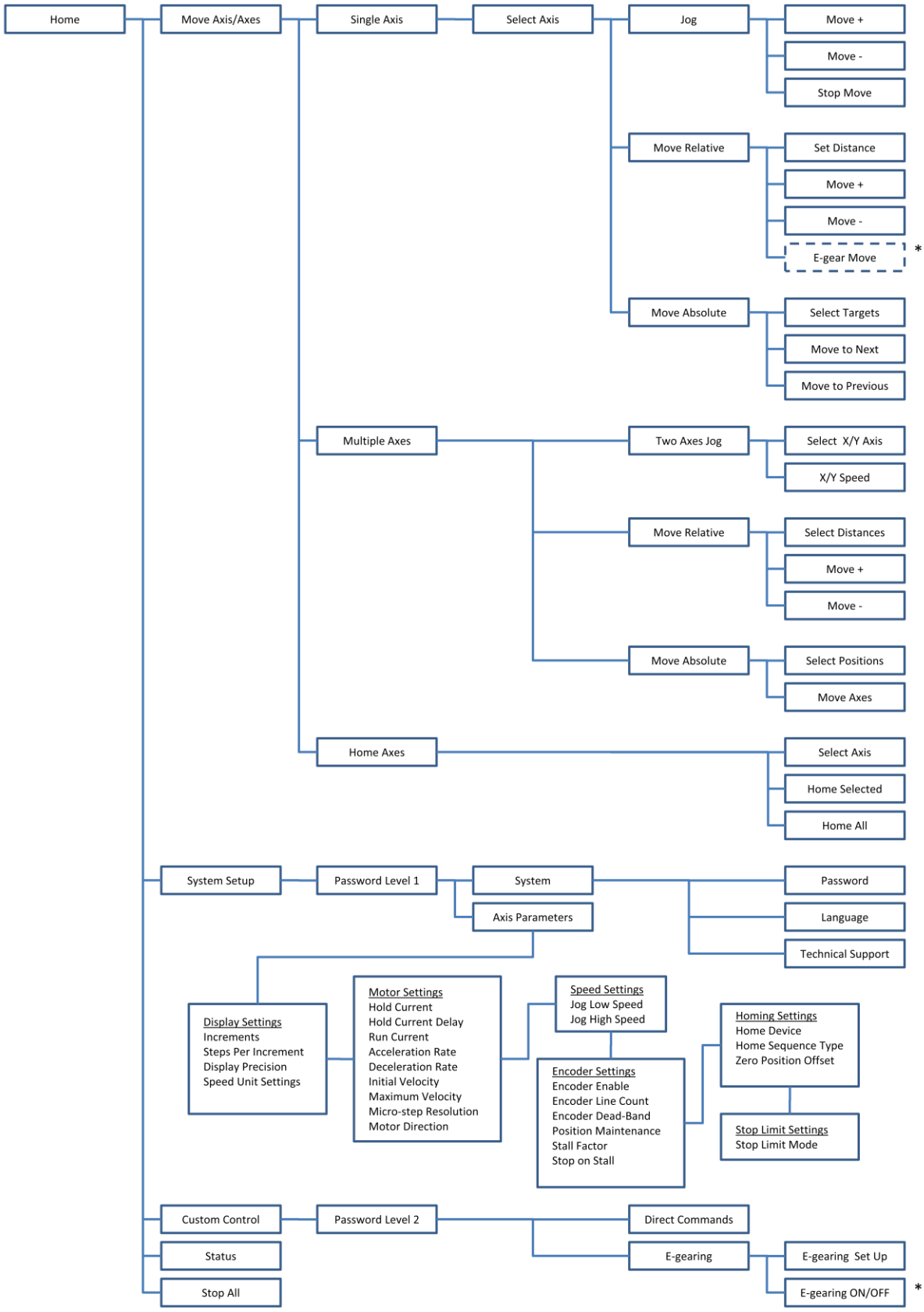
1.2.1.1. F1 Select X/Y Axes (selects *set up screen for X Y moves*)
1.2.1.1.1. F4 Return (return to higher menu)
1.2.1.1.2. F5 Stop All (stops all motors)
1.2.1.2. F2 X/Y Speed (selects set up screen for low or High Speed)
1.2.1.2.1. F1 Selects X/Y Axes (selects *set up screen for X Y moves*)
1.2.1.2.2. F2 X/Y Speed (saves speed & return to higher menu)
1.2.1.2.3. F4 Return (returns to higher menu)
1.2.1.2.4. F5 Stop All (stops all motors)
1.2.1.3. F4 Return (return to higher menu)
1.2.1.4. F5 Stop All *(stops all motors)*
1.2.2. F2 Move Relative (moves multiple axes set distances)
1.2.2.1. F1 Set Distances (selects target distance set up screen)
1.2.2.1.1. F1 Set Distance (selects distance numeric entry screen)
1.2.2.1.1.1. F1 Enter (saves value & returns to higher menu)
1.2.2.1.1.2. F4 Return (returns to higher menu)
1.2.2.1.1.3. F5 Stop All (stops all motors)
1.2.2.1.2. F2 Down (selects next axis)
1.2.2.1.3. F3 Up (selects prior axis)
1.2.2.1.4. F4 Return (returns to higher menu)
1.2.2.1.5. F5 Stop All (stops all motors)
1.2.2.2. F2 Move + (moves target distances in + direction)
1.2.2.3. F3 Move - (moves target distances in - direction)
1.2.2.4. F4 Return (return to higher menu)
1.2.2.5. F5 Stop All *(stops all motors)*
1.2.3. F3 Move Absolute (moves multiple axes to selected positions)
1.2.3.1. F1 Set Positions (user input of target positions)
1.2.3.1.1. F1 Set Positions (selects position numeric entry screen)
1.2.3.1.1.1. F1 Enter (saves value & returns to higher menu)
1.2.3.1.1.2. F4 Return (returns to higher menu)
1.2.3.1.1.3. F5 Stop All (stops all motors)
1.2.3.1.2. F2 Down (selects next axis)
1.2.3.1.3. F3 Up (selects prior axis)
1.2.3.1.4. F4 Return (returns to higher menu)
1.2.3.1.5. F5 Stop All (stops all motors)
1.2.3.2. F2 Move Axes (moves axes to selected positions)
1.2.3.3. F4 Return (return to higher menu)
1.2.3.4. F5 Stop All *(stops all motors)*
1.3. F3 Home Axes *(homes axis/axes)*
1.3.1. F1 Select axis (user selects which axis to home)
1.3.1.1. F1 Enter (saves axis & returns to higher menu)
1.3.1.2. F2 Refresh (clears chosen axis)
1.3.1.3. F4 Return (return to higher menu)
1.3.1.4. F5 Stop All *(stops all motors)*
1.3.2. F2 Home selected (executes homing function to selected axes)
1.3.3. F3 Home all (executes homing function to all axes)
1.3.4. F4 Return (return to higher menu)
1.3.5. F5 Stop All *(stops all motors)*
1.4. F4 Return (return to higher menu)

1.5. F5 Stop All *(stops all motors)*
2. F2 System Setup (system functions and parameters)
2.1. Enter Password (enter password screen)
2.1.1. F1 Enter (password entered & proceed to next menu)
2.1.2. F4 Return (return to higher menu)
2.1.3. F5 Stop All *(stops all motors)*
2.2. F1 System (access to system settings)
2.2.1. F1 Password (opens change password screen)
2.2.1.1. F1 Save (saves new password)
2.2.1.2. F2 Access Level (selects level 1 or 2 password)
2.2.1.3. F4 Return (return to higher menu)
2.2.1.4. F5 Stop All *(stops all motors)*
2.2.2. F2 Language (opens language selection screen)
2.2.2.1. F1 Save (saves selected language)
2.2.2.2. F4 Return (return to higher menu)
2.2.2.3. F5 Stop All *(stops all motors)*
2.2.3. F3 Technical Support (technical support contact information)
2.2.3.1. F4 Return (return to higher menu)
2.2.3.2. F5 Stop All *(stops all motors)*
2.2.4. F4 Return (return to higher menu)
2.2.5. F5 Stop All *(stops all motors)*
2.3. F2 Axis Parameter (view and modify system parameters)
2.3.1. F1 Next (displays next set of settings)
2.3.2. F2 Prior (displays prior set of settings)
2.3.2.1. Display Settings (coordinates, precision, speed units)
2.3.2.1.1. Select Axis (select axis to view or change)
2.3.2.1.2. Increment (steps, inches, mm, cm, deg., rad., or rev.)
2.3.2.1.3. Steps Per Increment (motor or encoder steps per coordinate)
2.3.2.1.4. Display Precision (0, 0.0, 0.00, or 0.000)
2.3.2.1.5. Speed Display Units (second, minute or hour)
2.3.2.1.6. Default (reset to defaults)
2.3.2.2. Motor Settings *(motor parameters)*
2.3.2.2.1. Select Axis (select axis to view or change)
2.3.2.2.2. Motor Holding Current *(MDrive command HC)*
2.3.2.2.3. Hold Current Delay Time *(MDrive command T)*
2.3.2.2.4. Motor Run Current (*MDrive command* RC)
2.3.2.2.5. Acceleration Rate *(MDrive command A)*
2.3.2.2.6. Deceleration Rate *(MDrive command D)*
2.3.2.2.7. Initial Velocity *(MDrive command VI)*
2.3.2.2.8. Maximum Velocity (MDrive command VM)
2.3.2.2.9. Micro-Step Resolution *(MDrive command MS)*
2.3.2.2.10. Motor Direction for + (clockwise or counter clockwise)
2.3.2.3. Speed Settings (Steps/Second) *(speed parameters)*
2.3.2.3.1. Select Axis (select axis to view or change)
2.3.2.3.2. Jog Low Speed (steps per second)
2.3.2.3.3. Jog High Speed *steps per second)*

2.3.2.4. Encoder Settings *(encoder parameters)*
2.3.2.4.1. Select Axis (select axis to view or change)
2.3.2.4.2. Encoder Enable (MDrive command EE)
2.3.2.4.3. Encoder Line Count *(MDrive command EL)*
2.3.2.4.4. Encoder Dead-Band *(MDrive command DB)*
2.3.2.4.5. Position Maintenance *(MDrive command PM)*
2.3.2.4.6. Stall Factor (MDrive command SF)
2.3.2.4.7. Stop on Stall (MDrive command SM)
2.3.2.5. Homing Settings *(homing parameters)*
2.3.2.5.1. Select Axis (select axis to view or change)
2.3.2.5.2. Home Device (limit switch/ZPI – HM or Encoder - HI)
2.3.2.5.3. Home Sequence Type (MDrive selection for HM or HI 1 to 4)
2.3.2.5.4. Zero Position Offset (position offset in steps from home)
2.3.2.6. Stop Limit Settings (stop limit parameters)
2.3.2.6.1. Select Axis (select axis to view or change)
2.3.2.6.2. Stop Limit Mode (MDrive selection for LM)
2.3.3. F3 Save or Reset (save or reset axis parameters)
2.3.3.1. F1 Single Axis (selects save screen)
2.3.3.1.1. F1 Save (save individual axis MDrive commands)
2.3.3.1.2. F2 Reset (resets non MDrive commands)
2.3.3.1.3. F4 Return (returns to higher menu)
2.3.3.1.4. F5 Stop All (stops all motors)
2.3.3.2. F3 Save All Axes (selects save all screen)
2.3.3.2.1. F1 Save (saves all axis MDrive commands)
2.3.3.2.2. F2 No saving) (returns to higher menu without
2.3.3.2.3. F5 Stop All (stops all motors)
2.3.3.3. F2 Reset All Axes (save or reset multiple axes)
2.3.3.3.1. F1 Save (reset non MDrive commands)
2.3.3.3.2. F2 No resetting) (returns to higher menu without
2.3.3.3.3. F5 Stop All (stops all motors)
2.3.3.4. F4 Return (return to higher menu)
2.3.3.5. F5 Stop All *(stops all motors)*
2.3.4. F4 Return (return to higher menu)
2.3.5. F5 Stop All *(stops all motors)*
2.4. F4 Return (return to higher menu)
2.5. F5 Stop All *(stops all motors)*
3. F3 Custom Control (special motor control options)
3.1. Enter Password (enter password screen)
3.1.1. F1 Enter (password entered & proceed to next menu)
3.1.2. F4 Return (return to higher menu)
3.2. F5 Stop All *(stops all motors)*
3.3. F1 Direct Command (direct Mcode commands to controllers)
3.4. F2 E-gear settings (sets up multiple axis “gear ratio” moves)
3.4.1. F1 Set Up (selects E-gearing set up screen)
3.4.1.1. F4 Return (return to higher menu)

3.4.1.2. F5 Stop All *(stops all motors)*
3.4.2. F2 ON/OFF (toggles E-gearing function on and off)
3.4.3. F4 Return (return to higher menu)
3.4.4. F5 Stop All *(stops all motors)*
3.5. F4 Return (return to higher menu)
3.6. F5 Stop All *(stops all motors)*
4. F4 Status (displays current axis information)
4.1. F1 Clear Errors *(clears axes errors)*
4.2. F2 Startup Position (saves current positions to power-up values)
4.3. F3 Clear Startup (power-up positions will be 0)
4.4. F4 Return (return to higher menu)
4.5. F5 Stop All *(stops all motors)*
5. F5 Stop All *(stops all motors)*

7.1 Hand Terminal Flow Chart



7.2 TMC HAND TERMINAL FUNCTION TREE (expanded view)

Key to symbols used below

F1 to F5 - Hand Terminal function keys

Value chosen by user in existing window (values are examples)

Value determined elsewhere (values are examples)

*, ** - annotation

(description)

Information Displayed on Screen

1. F1 Move Axis/Axes (set up and executes axis/axes moves and homing functions)

1.1. F1 Single axis (set up and executes single axis moves)

1.2.

1.2.1. Select Single Axis (axis selection screen pops up when single axis move is selected)

(select the desired axis with the ↑ or ↓ arrow keys and confirm by pressing enter.)

Axis 1
Axis 2
Axis 3

1.2.1.1. F1 Enter (confirm axis selected)

1.2.1.2. F2 Refresh (clears selected axis)

1.2.1.3. F4 Return (return to next higher menu)

1.2.1.4. F5 Stop All (stops all motors)

1.2.2. F1 Jog (execute momentary or continuous move)

(displays current position)

Current Position

(*position is based on the Axis Query - Current Coordinate of the selected axis.
* precision is based on 2.3.2.1.4. Display precision.
** measured unit is based on 2.3.2.1.2. Increment.)

(displays Low speed jog rate)

Low Speed
1000*

*speed rate is based on 2.3.2.3.2. Jog Low Speed
*precision is based on 2.2.2.1.4. Display precision
** unit is based on 2.3.2.1.2. Increment
***time unit is based on 2.3.2.1.5 Speed Display Units)

(displays High speed jog rate)

High Speed 20000*

*speed rate is based on 2.3.2.3.3. Jog High Speed
*precision is based on 2.2.2.1.4. Display precision
** unit is based on 2.3.2.1.2. Increment
***time unit is based on 2.3.2.1.5 Speed Display Units)

Momentary
Continuous

Low Speed
High Speed

Low Speed/High Speed* 1000** steps*** per sec.****

(*user toggles between Low Speed or High Speed.
**speed rate is based on 2.2.2.3. Jog Low Speed or Jog High Speed
** precision is based on 2.2.2.1.4. Display precision
***Type of coordinate is based on 2.2.2.1.2. Coordinates
****time unit is based on 2.2.2.1.5 Speed Units Display settings)

Jogging +*

(displays active move)
(This window is displayed only when the Axis Query - Moving Status for the selected
axis is VM=1
* + or – displayed depending on whether 1.1.1.1. F1 Move + or 1.1.1.2 F2 Move – executed
move)

1.1.1.1. F1 Move + (moves selected axis in + direction.)

Example: If Low Speed/High Speed is toggled to Low
and 2.2.2.2.10. Motor Direction for + is set for CW (+1)
and 2.2.3.2. Jog Low Speed is 2000
and 2000 x +1= 2000
then:

§nSL_2000§ (command sent on com bus)

Note if 2.2.2.2.10. Motor Direction for + is set for CCW (-1)
In the prior example
2000 x -1= -2000
Then:

§nSL_-2000§ (command sent on com bus)

1.1.1.2. F2 Move - (moves selected axis in - direction)
Example: If Low Speed/High Speed is toggled to Low
and 2.2.2.2.10. Motor Direction for + is set for CW (+1)
and 2.2.3.2. Jog Low Speed is 2000
and -2000 x +1= -2000
then:

§nSL_-2000§ (command sent on com bus)

Note if 2.2.2.2.10. Motor Direction for + is set for CCW (-1)
In the prior example
-2000 x -1= 2000
Then:

§nSL_2000§ (command sent on com bus)

1.1.1.3. F3 Stop move (stops move)
§nSL_0§ (command sent on com bus)

1.1.1.4. F4 Return (return to next higher menu)

1.1.1.5. F5 Stop All *(stops all motors)*

1.1.2. F2 Move Relative (moves axis a set distance)
Target distance 5.50* inches** (displays target distance)
(*Target distance is based on 1.1.2.1. F1 Set distance
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Current Position 1.77* inches** (displays current position)
(*position is based on the Axis Query - Current Coordinate of the selected axis.
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Continuous Move On OFF (*toggles continuous mode on or off*)
(This mode defaults to OFF. When toggled ON the controllers are continually commanded

to move back and forth between Move+ and Move- until the user selects OFF.
This mode does not start until F2 Move + or F3 Move – are selected.
The axis completes each moves (Axis Query - Moving Status" for the axis is VM=0)
before the command is given for the next move.)

E-gearing ON*
(*this box is displayed when the E-gearing is activated 3.2,)

Moving +* (displays active move)
(This window is displayed only when the Axis Query "Moving Status" for the selected
axis is VM=1
* + or – displayed depending on whether 1.12.2. F2 Move + or 1.1.2.3. F3 Move - executed
move)

1.1.2.1. F1 Set distance (user selects target distance)
Target Distance 5.50* *inches***
(*user selects target distance here
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

1.1.2.2. F2 Move + (moves in + direction)
Example: If 1.1.2.1. Target Distance is 5.50
and 2.2.2.2.10. Motor Direction for + is set for CW (+1)
and 2.2.2.1.3. Steps Per Coordinate is 512000
and since 5.50 x +1 x 512000 = 2560000 (move size)
then:
§nMR_2560000§ (command sent on com bus)

1.1.2.3. F3 Move - (moves in - direction)
Example: If 1.1.2.1. Target Distance is 5.50
and 2.2.2.2.10. Motor Direction for + is set for CW (+1)
and 2.2.2.1.3. Steps Per Coordinate is 512000
and since- 5.50 x +1 x 512000 = -2560000 (move size)
then:
§nMR_-2560000§ (command sent on com bus)

1.1.2.4. F4 Return (return to higher menu)

1.1.2.5. F5 Stop All *(stops all motors)*

1.1.3. F3 Move Absolute (moves axis a to a selected position)

Selected Position A* 1000** steps*** (displays current or selected target position)
(Position information is blank when 1.1.3 F3 Move Absolute is first opened.
*position is the Target Position of the currently selected target based on current
chosen position when 1.1.3.2. F2 Move to Next Position or 1.1.3.3. F3 Move to Prior
Position are selected.
**precision is based on 2.2.2.1.4. Display precision
***Type of coordinate is based on 2.2.2.1.2. Coordinates)

Current Position 526* steps** (displays current position)
(*position is based on the Axis Query - Current Coordinate of the selected axis.
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Moving to position A* (displayed only during move)
(*Displays the target number being moved to.)

1.1.3.1. F1 Select Target Positions *(user input of 6 positions)*

Position A 100* mm** (user selects A position target distance)
Position B 20* mm** (user selects B position target distance)
Position C 502* mm** (user selects C position target distance)
Position D -100* mm** (user selects D position target distance)
Position E -250* mm** (user selects E position target distance)
Position F -5020* mm** (user selects F position target distance)
(*user selects target distance here
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Clear all positions (returns all position values to 0)

1.1.3.2. F2 Move to Next Position *(to next position)*
(i.e. moves from A to F)
(The first move after the 1.1.3. F3 Move Absolute window is opened will be to A)
Example: If the position prior to move is A the next position will be B.
and position B is 20
and 2.2.2.1.3. Steps Per Coordinate is 20157
and since 20x20157=403140 (target position in steps)
then:
§nMA_403140§ (command sent on com bus)

1.1.3.3. F3 Move to Prior Position *(moves to prior position)*
(i.e. moves from A to F)
(The first move after the 1.1.3. F3 Move Absolute window is opened will be to F)
(move commands the same as example in 1.1.3.2. F2 Move to Next Position but with the move proceeding to prior target position)

1.1.3.4. F4 Return (return to higher menu)

1.1.3.5. F5 Stop All *(stops all motors)*

1.1.3.6.

1.1.4. F4 Return (return to higher menu)

1.1.5. F5 Stop All *(stops all motors)*

1.2. F2 Multiple Axes (sets up and executes multiple axes moves)

1.2.1. F1 Two axis Jog (X and Y axis Moves with ← →↑↓ keys)

(This Type move uses the Hand Terminal arrow keys to execute moves. The move is commanded to start when an arrow key is depressed and commanded to stop when the key is released. It will work on one of the eight arrow keys at a time. The first arrow key depressed controls movement until it is depressed. The corner arrow keys command both axes to move at the same time.)

Example of up/down or left right arrow commands:

If	Low Speed/High Speed	is	toggled to High
and	1.2.1.1. Assign axis to X moves ← →	is	axis 2
and	2.2.2.2.10. Motor Direction for + (axis 2)	is	set for CW (+1)
and	1.2.1.1. Assign axis to Y moves ↑↓	is	axis 4
and	2.2.2.2.10. Motor Direction for + (axis 4)	is	set for CW (-1)
and	1.2.1.1. Set Axis →	is	CW
and	1.2.1.1. Set Axis ↑	is	CW
and	2.2.3.3. Jog High Speed	is	500000
and	since 500000 x +1=	500000 will be used for axis 2	
and	since 500000 x -1=	-500000 will be used for axis 4	

then:

§2SL_500000§ (command sent on com bus when → key is pressed)

Followed by:

§2SL_0§ (command sent on com bus as soon as key is released)

---

or

§2SL_-500000§ (command sent on com bus when ← key is pressed)

Followed by:

:§2SL_0§ (command sent on com bus as soon as key is released)

or

§4SL_-500000§ (command sent on com bus when ↑ key is pressed)

Followed by:

§4SL_0§ (command sent on com bus as soon as key is released)

---

or

§2SL_-500000§ (commands sent on com bus when up left key is pressed)

and

§4SL_-500000§

Followed by:

§2SL_0§ (command sent on com bus as soon as key is released)

and

§4SL_0§

X position10.03* mm** (displays current X position)

(*position is based on the Axis Query - Current Coordinate of the selected axis.

* precision is based on 2.2.2.1.4. Display precision

**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Y position -20.5* mm** (displays current Y position)

(*position is based on the Axis Query - Current Coordinate of the selected axis.

* precision is based on 2.2.2.1.4. Display precision

**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Low Speed/High Speed* 1000** steps*** per sec.****

(*user toggles between Low Speed or High Speed.

**speed rate is based on 2.2.2.3. Jog Low Speed or Jog High Speed

** precision is based on 2.2.2.1.4. Display precision

***Type of coordinate is based on 2.2.2.1.2. Coordinates

****time unit is based on 2.2.2.1.5 Speed Units Display settings)

Jogging X* (displayed during move only)

(This window is displayed only when one of the arrow keys is pressed

*window will display:

Jogging X when ← or → button is pressed

or Jogging Y when ↑ or ↓ button is pressed

or Jogging X and Y when a corner arrow button is pressed)

1.2.1.1. F1 Select axes (sets up axes for X Y moves)

Assign axis to x moves (← →) 1 2 3... *(determines x axis)*

Assign axis to y moves (↑↓) 1 2 3 ... *(determines y axis)*

Set → for CW or CCW (determines direction of x axis moves)

Set ↑ for CW or CCW (determines direction of y axis moves)

1.2.1.2. F4 Return (return to higher menu)

1.2.1.3. F5 Stop All *(stops all motors)*

1.2.2. F2 Move Relative (moves multiple axes set distances)

Current Position (displays current axis positions)

Axis 1 526.0* mm**

Axis 2 20.7* mm**

Axis 3 -47.9* deg.**

Axis 4 -2.0* mm**

Axis 5 526.9* mm**

Axis 6 39888* steps**

(*position is based on the Axis Query - Current Coordinate of the selected axis.
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Continuous Move On OFF (user selects toggles continuous mode on or off)
(This mode defaults to OFF. When toggled ON the controllers are continually commanded
to move back and forth between Move+ and Move- until the user selects OFF.
This mode does not start until F2 Move + or F3 Move – are selected.
All of the axes complete their moves (Axis Query "Moving Status" for the all axes is MV=0)
before the command is given for the next move.)

Moving + (or -) (displayed during move only)
(This window is displayed only when the Axis Query "Moving Status" for the any axes
is MV=1.)

1.2.2.1. F1 Select Target Distances (user select target distances for axes)

(user can choose any combination of one to all available axes
Notes: The axes shown correspond to the axis available in the TMC. The boxes of the axes chosen will light up.)

Target Distance	
Axis 1 150* mm**	(user selects target distance for axis 1)
Axis 2 mm**	(user selects target distance for axis 2)
Axis 3 -80* deg.**	(user selects target distance for axis 3)
Axis 4 mm**	(user selects target distance for axis 4)
Axis 5 mm**	(user selects target distance for axis 5)
Axis 6 -17500* steps**	(user selects target distance for axis 6)

(*user selects target distance on selected axis here
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

1.2.2.2. F2 Move + (moves in + direction)

Example: If 1.2.2.1 Target Distance Axis 1 is 150
and 2.2.2.2.10. Motor Direction for + (axis 1) is set for CW (+1)
and 2.2.2.1.3. Steps Per Coordinate (axis 1) is 20157
and since 150 x +1 x 20157 = 3023550 (axis 1 move size)

and 1.2.2.1 Target Distance Axis 3 is -80
and 2.2.2.2.10. Motor Direction for + (axis 3) is set for CW (+1)
and 2.2.2.1.3. Steps Per Coordinate (axis 3) is 142
and since -80 x +1 x 142 = -11360 (axis 3 move size)

and 1.2.2.1 Target Distance Axis 6 is -17500
and 2.2.2.2.10. Motor Direction for + (axis 6) is set for CW (+1)
and 2.2.2.1.3. Steps Per Coordinate (axis 6) is 1
and since -17500 x +1 x 1 = -17500 (axis 6 move size)
then:

§1MR_3023550§ (command sent on com bus)
and
§3MR_-11360§ (command sent on com bus)
and
§6MR_-17500§ (command sent on com bus)

1.2.2.3. F3 Move - (moves in - direction)

(move same as 1.2.2.2 F2 Move + with move size x -1
Example:
§1MR_-3023550§ (command sent on com bus)
and

§3MR_11360§ (command sent on com bus)
and
§6MR_17500§ (command sent on com bus)

1.2.2.4. F4 Return (return to higher menu)

1.2.2.5. F5 Stop All *(stops all motors)*

1.2.3. F3 Move Absolute (moves multiple axes to selected positions)

Current Position (displays current axis positions)
Axis 1 526.0* mm**
Axis 2 20.7* mm**
Axis 3 -47.9* deg.**
Axis 4 -2.0* mm**
Axis 5 526.9* mm**
Axis 6 39888* steps**

(*position is based on the Axis Query - Current Coordinate of the selected axis.
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Moving Axes (displayed only during move)
(This window is displayed only when the Axis Query "Moving Status" for the any
axes is MV=1.)

1.2.3.1. F1 Select Target Positions (user input of target positions))
(user can choose any combination of one to all available axes
Notes: The axes shown correspond to the axis available in the TMC.
The boxes of the axes chosen will light up.)

Target Position
Axis 1 100* mm** (user selects target position for axis 1)
Axis 2 mm** (user selects target position for axis 2)
Axis 3 -25* deg.** (user selects target position for axis 3)
Axis 4 mm** (user selects target position for axis 4)
Axis 5 mm** (user selects target position for axis 5)
Axis 6 -5020* steps** (user selects target position for axis6)

(*user selects target position on selected axis
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinates)

Clear all positions (returns all position values to blank)

1.2.3.2. F2 Move Axes (moves all of the selected axes)
Example: If 1.2.3.1. Position Axis 1 is selected to be 100
and 2.2.2.1.3. Steps Per Coordinate (axis 1) is 20157
and since 100 x 20157 = 20175700 (target position in steps)

and 1.2.3.1. Position Axis 3 is selected to be 25
and 2.2.2.1.3. Steps Per Coordinate (axis 3) is 142
and since 25 x 142 = 3550 (target position in steps)

and 1.2.3.1. Position Axis 6 is selected to be -5020
and 2.2.2.1.3. Steps Per Coordinate (axis 6) is 1
then: since -5020 x 1 = -5020 (target position in steps)

§1MA_20175700§ (command sent on com bus)
and
§3MA_3550§ (command sent on com bus)
and
§6MA_-5020§ (command sent on com bus)

1.2.3.3. F4 Return (return to higher menu)

1.2.3.4. F5 Stop All *(stops all motors)*

1.3. F3 Home Axes *(homes axis/axes)*

Homing (displayed during move only)
(This window is displayed only when 1.3.2. F2 or 1.3.3. F3 have been selected and
Axis Query "Moving Status" for any axes is MV=1.)

Homing completed (displayed when moves are completed)
(This window is displayed only after "Homing" window has been displayed and Axis
Query "Moving Status" for the all axes is MV=0.)

1.3.1. F1 Select axis
Axis 1 2 3 4 ... (user selects which axis to home)

Reset* selected axis position to _____** *(allows user to reset axis position)*

*(*user chooses to reset axis position value)
(**user chooses the new position value- defaults to 0)*

Are you sure you want to reset the position value/counter on axis *_n*_* to *nnn***? Yes
(This window is displayed only when the RESET Button has been selected)

(*The selected axis is displayed)
(**The position value that the user chose is displayed)
(Selecting YES will run the following command)

example: If user selected axis 5 and a position value of 500 the following command is sent:
§5P=500§ (command sent on com bus)

1.3.2. F2 Home selected axis *(home selected axes)*
(command as follows for each selected axis)

Home command for all axis where 2.2.2.4.2. Encoder Enable (EE) =0
example: If 2.2.2.5.3. Home Sequence Type (1,2,3 or 4) is 1
§nHM_1§ (command sent on com bus)

Monitor the axis to determine when the move is completed
§nPR_MV§ (axis will return 1 while moving and 0 when complete)

Once the move is complete, MV=0, reset the counter to zero position offset based on
The value this axis has at 2.2.2.5.4. Zero Position Offset
(example if the axis homed has a Zero Position Offset value of 2500, command as follows)
§nC1=2500§

Home command for all axis where 2.2.2.4.2. Encoder Enable (EE) =1
example: If 2.2.2.5.3. Home Sequence Type (1,2,3 or 4) is 3
§nHI_3§ (command sent on com bus)

Monitor the axis to determine when the move is completed
§nPR_MV§ (axis will return 1 while moving and 0 when complete)

Once the move is complete, MV=0, reset the counter to zero position offset based on
The value this axis has at 2.2.2.5.4. Zero Position Offset
(example if the axis homed has a Zero Position Offset value of 500, command as follows)
§nC2=500§

1.3.3. F3 Home all *(home all axes)*
(command as follows for all available axis)

Home command for all axis where 2.2.2.4.2. Encoder Enable (EE) =0

example: If 2.2.2.5.3. Home Sequence Type (1,2,3 or 4) is 1
§nHM_1§ (command sent on com bus)

Monitor each axis one at a time to determine when the moves are completed
§nPR_MV§ (axes will return 1 while moving and 0 when complete)

Once each move is complete, MV=0, reset the counters for each axis to zero position
offset based on
The value each axis is at 2.2.2.5.4. Zero Position Offset
(example if the axis homed has a Zero Position Offset value of 200, command as follows)
§nC1=200§

Home command for all axis where 2.2.2.4.2. Encoder Enable (EE) =1
example: If 2.2.2.5.3. Home Sequence Type (1,2,3 or 4) is 2
§nHI_2§ (command sent on com bus)

Once each move is complete, MV=0, reset the counters for each axis to zero position offset
based on
The value each axis is at 2.2.2.5.4. Zero Position Offset
(example if the axis homed has a Zero Position Offset value of 2200, command as follows)
§nC1=2200§

1.3.4. F4 Return (return to higher menu)

1.3.5. F5 Stop All *(stops all motors)*

1.4. F4 Return (return to higher menu)

1.5. F5 Stop All *(stops all motors)*

2. F2 System Setup (system functions and parameters)

2.1. F1 System Parameters (access to system functions and parameters)

Version number (displays QSI configuration version)

2.1.1. F1 Password (input of user passwords – 2 levels)

Enter password _____

(level one password needed to change parameters in 2.2 or 2.3
Level two password needed to use 3. Direct Motor Commands)

2.1.2. F2 Language *(choose language)*

English

_____

(user selects Hand Terminal language)
(for future languages)

2.1.3. F3 Technical Support (technical support information)

Contact
Thermionics Northwest, Inc.
231-B Otto Street
Port Townsend, WA 98368
Telephone: 800-962-2310 or 360-385-7707
Fax: 360-385-6617
email: support@thermionics.com

2.1.4. F4 Return (return to higher menu)

2.1.5. F5 Stop All *(stops all motors)*

2.2. F2 Axis Parameter

2.2.1. F1 Next (displays next set of settings)

2.2.2. F2 Prior (displays prior set of settings)

2.2.2.1. Display Settings (coordinates, precision, speed units)
2.2.2.1.1. Select Axis 1,2,3,...
2.2.2.1.2. Increment steps, inches, millimeters, centimeters, degrees, radians, revolutions (choose one)
2.2.2.1.3. Steps Per Coordinate _____
2.2.2.1.4. Display Precision 0, .0, .00, .000, .0000 (choose one)
2.2.2.1.5. Speed Unit Settings second, minute, hour (choose one)
2.2.2.1.6. Reset Display Defaults (steps, 0, seconds)

Setting	range	default
Steps Per Coordinate	1 to 512,000,000	1

Note on resolution and speed

Resolution

The ratio of the actual commanded steps per motor revolution is dependent on
the following variables:

With encoder 2.2.2.4.2. Encoder Enable (EE=1)

The motor resolution is 4 times the EL setting
(Example: If 2.2.2.4.3. Encoder Line count (EL) is 100
4 x 100 = 400
then the motor steps per motor revolution is 400)

Without encoder 2.2.2.4.2. Encoder Enable (EE=0)

The Motor resolution is the motor step count times the MS setting
(Example: If the motor is a 1.8 degree per step motor it has200 step count
and 2.2.2.2.9 Micro Step Resolution (MS) is 256
200 x 256 = 51200
then the motor steps per revolution is 51200)

The hand terminal can be configured to display and control each motor axis using
the following coordinates (at 2.2.2.1.2. Coordinates):
Steps, inches, millimeters, centimeters, degrees, radians, revolutions.
The user needs to define the steps per coordinate for each axis. The hand terminal uses this setting to calculate move instructions and positional information
for each axis.

(Examples of how to calculate the value for 2.2.2.1.3. Steps Per Coordinate:
example 1
If 2.2.2.1.2 Coordinate is set for inches
and 2.2.2.4.2 Encoder Enable(EE) is 1
and 2.2.2.4.3 Encoder lines (EE) is 100
and The axis motor turns an 8 pitch screw (8 turns per inch)
4 x100 x 8 = 3200
then 2.2.2.1.3. Steps Per Coordinate should be set for 3200

example 2
If 2.2.2.1.2. Coordinate is set for radians
and 2.2.2.4.2. Encoder Enable(EE) is 0
and the motor is a 1.8 degree per step motor it has200 step count
and 2.2.2.2.3. Micro Step Resolution is 128
there are 2π (6.283) radians per revolution
200 x 128 ÷ 6.283 = 4074.486 rounded to whole number is =4074
then 2.2.2.1.3. Steps Per Coordinate should be set for 4074)

Speed
The following factors have an effect on the speed of axis movement:
2.2.2.2.7. Initial Velocity (steps/sec) (VI)
2.2.2.2.5. Acceleration rate (steps/sec^2) (A)
2.2.2.2.5. Maximum Velocity (steps/sec) (VM)
2.2.2.2.5. Deceleration rate (steps/sec^2) (D)

The step units are either motor/micro step counts, when EE=0, or encoder step counts when EE=1. When the user changes the state of EE for a given controller that controller automatically changes the 4 speed factors to match the step size difference. This change is internally controlled in the IMS controllers.

(Example: An axis has the following settings : EE=0

MS=256
VI=1000
A=1000000
VM=768000
D=1000000

When the user changes EE to EE=1 with an encoder line count of EL=100 The micro-step value (MS) will not change but the 4 speed values will change. In this example the
speed values will change by the ratio of 128(rounded down to an integer). This is based on the
original motor step count of 51200 (200motor steps x 256 micro-steps (ms=256)) divided by the
encoder step count of 400 (4 X encoder line count (EL=100)). The new settings will be:

EE=1
EL=100
MS=256
VI=7
A=7812
VM=6000
D=7812

This example will be reversed when EE is changed from EE=1 to EE=0)

degrees, radians, revo

2.2.2.2. Motor Settings (motor parameters)
2.2.2.2.1. Select Axis 1,2,3,...
2.2.2.2.2. Motor Holding Current (%) _____
2.2.2.2.3. Hold Current Delay Time (m sec.) _____
2.2.2.2.4. Motor Run Current (%) _____
2.2.2.2.5. Acceleration Rate (step/sec.^{2}) _____
2.2.2.2.6. Deceleration Rate (step/sec.^{2}) _____
2.2.2.2.7. Initial Velocity (steps) _____
2.2.2.2.8. Maximum Velocity (steps) _____
2.2.2.2.9. Micro-Step Resolution (micro steps) _____
2.2.2.2.10. Motor Direction for + CW or CCW

Setting		range	default
Motor Holding Current (HC)		0 to 100	30
Hold Current Delay Time ms (T)		0 or 2-65535	500
Motor Run Current (RC)		0 to 100	75
Acceleration Rate (A)	if EE=0	91 to 61,035,160	40,000
Acceleration Rate (A)	if EE=1	91 to 1,525,878,997	1,000,000

Deceleration Rate (D)	if EE=0	91 to 61,035,160	40,000
Deceleration Rate (D	if EE=1	91 to 1,525,878,997	1,000,000

Initial Velocity (VI)	if EE=0	5,000,000	1,000
Initial Velocity (VI)	if EE=1	200,000	40

Maximum Velocity (VM)	if EE=0	5,000,000 768,000
Maximum Velocity (VM)	if EE=1	200,000 30720

Micro-Step Resolution (MS)	1, 2, 4, 5, 8, 10, 16, 25, 32, 50, 64, 100, 108, 125, 127, 128, 180, 200, 250 or 256	256

2.3.2.2.10. Motor Direction variable is a Hand Terminal Variable. It determines if + direction is clockwise or counterclockwise. This variable defaults to CW. If set for CCW the move size for all move except Move Absolute is multiplied by -1.

2.2.2.3. Speed Settings (Steps/Second) *(speed parameters - VM)*

2.2.2.3.1. Select Axis 1,2,3,...

2.2.2.3.2. Jog Low Speed (steps per sec.) _____

2.2.2.3.3. Jog High Speed (steps per sec.) _____

2.2.2.3.4. Slew Velocity Minimum (steps per sec.) _____

2.2.2.3.5. Slew Velocity Maximum (steps per sec.) _____

Setting	range	default
Jog Low Speed (VM) if EE=0	5,000,000	7,680
Jog Low Speed (VM) if EE=1	200,000	307

Jog High Speed (VM) if EE=0	5,000,000	768,000
Jog High Speed (VM) if EE=1	200,000 30720	

Slew Velocity Minimum (VM) *if EE=0*	*5,000,000*	*7,680*
Slew Velocity Minimum (VM) *if EE=1*	*200,000*	*307*

Slew Velocity Maximum (VM) if EE=0	5,000,000	768,000
Slew Velocity Maximum (VM) if EE=1	200,000	30720

2.2.2.4. Encoder Settings (encoder parameters)

2.2.2.4.1. Select Axis 1,2,3,...

2.2.2.4.2. Encoder Enable (No = 0, Yes = 1) _____

2.2.2.4.3. Encoder Line Count (counts) _____

2.2.2.4.4. Encoder Dead-Band (counts) _____

2.2.2.4.5. Position Maintenance (No = 0, Yes = 1) _____

2.2.2.4.6. Stall Factor (counts) _____

2.2.2.4.7. Stop on Stall (No = 1, Yes = 0) _____

Setting	range	default
Encoder Enable (EE)	0 or 1	0
Encoder Line Count (EL)	10 – 5120	100
Encoder Dead-Band (DB)	0 -65,000	1
Encoder Position Maintenance (PM)	0 or 1	1
Stall Factor (SF)	0 -65,000	15
Stop on Stall (SM)	0 or 1	1

2.2.2.5. Homing Settings (homing parameters)

2.2.2.5.1. Select Axis 1,2,3,...

2.2.2.5.2. Home Device Limit Switch/ZPI or Encoder

2.2.2.5.3. Home Sequence Type (1,2,3 or 4) _____

2.2.2.5.4. Zero Position Offset (C1, C2) _____

*(*This selection Defaults to HM. If Limit Switch/ZPI is selected as the Home Device than HM command is used for homing. If encoder is selected than HI command is used.*)*

Setting	range	default
Home Sequence Type (1,2,3 or 4)	1 to 4	1
Zero Position Offset (C1) if EE=0	−2,147,483,648 to 2,147,483,648	0
Zero Position Offset (C2) if EE=1	−2,147,483,648 to 2,147,483,648	0

2.2.2.6. Stop Limit Settings (stop limit parameters)

2.2.2.6.1. Select Axis 1,2,3,...

2.2.2.6.2. Stop Limit Mode (1 to 6) _____

Setting	range	default
Stop Limit Mode (LM)	1 to 6	1

2.2.2.7. Current Error Flags (displays and resets error codes)

Axis 1 Error _____
Axis 2 Error _____
Axis 3 Error _____
....
Hand Terminal Error _____
Reset Error/s

(Displays current errors)

(query error status in controllers for each axis with the following command:

§nPR_ER§ (command sent on com bus)

Once queried and recorded, the following command clears the error flag:

§nER=0§ (command sent on com bus)

*(*Resets errors in motor controllers with the following command:

§*ER=0§ (command sent on com bus)

2.2.3. F3 Save or Reset axis parameters
(user with password level 1 can save or delete axis settings)

2.2.3.1. F1 Single Axis (save or reset parameters on single axis)

Select Axis 1 2 3 4 ...
*(*user selects axis*)*

SAVE Current Settings
*(*user chooses to Save current settings*)*

Are you sure you want to save the changes to the operating parameters on axis _*n*_? Yes
(This window is displayed only when the SAVE Button has been selected)
(The selected axis is displayed)
*(*Selecting YES will permanently save the current setting in 2.2.2.1. to 2.2.2.6.)

RESET Setting to Default Values
*(*user chooses to reset settings to defaults*)*

Are you sure you want to reset the operating parameters on axis _*n*_ to the default values? Yes
(This window is displayed only when the RESET Button has been selected)
(The selected axis is displayed)
*(*Selecting YES will reset the setting in 2.2.2.1. to 2.2.2.6. to the Default values*)*

2.2.3.2. F2 All Axes (save or reset parameters on all axes)

SAVE Current Settings
*(*user chooses to Save current settings*)*

Are you sure you want to save the changes to the operating parameters on ALL axes? Yes

(This window is displayed only when the SAVE Button has been selected)
*(*Selecting YES will permanently save the current setting in 2.2.2.1. to 2.2.2.6.)

RESET Setting to Default Values
*(*user chooses to reset settings to defaults*)*

Are you sure you want to reset the operating parameters on ALL axes to the default values? Yes
(This window is displayed only when the RESET Button has been selected)
*(*Selecting YES will reset the setting in 2.2.2.1. to 2.2.2.6. to the Default values*)*

2.2.4. F4 Return (return to higher menu)

2.2.5. F5 Stop All *(stops all motors)*

2.3. F4 Return (return to higher menu)

2.4. F5 Stop All *(stops all motors)*

3. F3 Custom Control (special motor control options)
(all of the Custom Control functions require user with password level 2)

3.1. F1 Direct Command (NOT YET DEVELOPED)
(Opens edit window for creating and sending direct commands and programs to the axes controllers.)

3.1.1. F4 Return (return to higher menu)

3.1.2. F5 Stop All *(stops all motors)*

3.2. F2 E-gearing (sets up multi axis "gear ratio" moves)
(This function sets up a primary axis and secondary axis or axes. E-gearing is only used in the single axis 1.1.2. Move Relative function.) When toggled on, the secondary axes are commanded to move when the primary drive moves. The secondary axes can be set to move at the same rate or in a fixed ratio of the primary axis. They can also be set to move in the same direction or the opposite direction of the primary axis.

Notes on E-gearing
E-gearing is a function that moves multiple axes at the same time at different rates and directions. The user defines one axis as the primary axis. Any of the other axes can be selected as secondary axis. The secondary axes move at a user selected ratio of the primary drive. An E-gear move starts and stops motor moves in the primary and all of the secondary axes at virtually the same time.

The user assigns the E-gearing parameters in the E-gearing set up table (3.3.1.). These parameters are primary axis, secondary axis/axes and the secondary gear factor and direction. The gear factor is a ratio of the rate and distance that the secondary axis will move compared to the primary axis movement. The direction selection determines if the secondary axis move is in the same or opposite direction of the primary axis. As an example if a secondary axis has been set up with a gear factor of 0.5, and a direction of opposite then that axis motor will rotate half as fast, half as many degrees and will rotate in the opposite direction as the primary axis.

The E-gearing is performed in the Single Axis Move Relative function (1.1.2.).
E-gearing Operation
E-gearing is activated when all of the following conditions are met:
The Single axis Move relative (1.1.2.) window is opened
E-gearing is set ON in the E-gearing selection screen (3.2)
A primary and secondary Drive/s are selected in the E-gearing set up window (3.2.1.)
The drive selected in Single axis move (1.1.) is the E-gearing primary drive
A display saying "E-gearing is ON" is displayed in the Move Relative (1.1.2.) window while E-gearing is activated.

The e-gearing function temporarily changes the following IMS controller settings of each secondary axis:
A (acceleration rate)
D (deceleration rate)
VI (initial velocity)
VM (maximum velocity)

Each E-gearing move also uses one or both of the following IMS commands for the primary and secondary axes moves:
MR (move relative in the positive direction)
-MR (move relative in the negative direction)

E-gearing calculations
Note :The terms *PDR*, *SDR*, and *SGM* are explained and used below for clarity. They are not commands.

For the Primary axis
Query the primary axis controller to determine the values for EE, EL and MS.
If EE=1 the PDR(primary drive rate)=EL
If EE=0 the *PDR*=MS x 50

Query the primary axis to determine the values for A, D, VI, and VM.

For each Secondary axis
Query the secondary axis to determine the values for EE, EL and MS.
If EE=1 the SDR(secondary drive rate)=EL
If EE=0 the *SDR*=MS x 50

Calculate the Secondary Gear Multiplier for each secondary axis (*SGM*) as follows:
SGM(secondary gear multiplier)=Gear Factor* ÷ (PDR ÷ SDR)
(*Use Gear Factor 3.2.1. for secondary axis being calculated.)
Note: each secondary axis has it's own individual *SGM*

Copy the original A, D, VI and VM values to the IMS controller R1, R2, R3 and R4 registers.

Calculate the temporary A, D, VI, and VM values for each secondary axis.
primary A x *SGM* =temporary secondary A
primary D x *SGM* =temporary secondary D
primary VI x *SGM* = temporary secondary VI
primary VM x *SGM* = temporary secondary VM

Change the secondary drive's A, D, VI, and VM settings to the calculated temporary values.

The MR value is calculated and sent to the primary and secondary axes when the F2 Move+ (1.1.2.2.) or F3 Move- (1.1.2.3.) buttons are selected.
The calculation for the primary axis MR value is the same as described in 1.1.2.2. and 1.1.2.3..
The calculation for each of the secondary axis is:
Primary axis MR x SGM x direction sign* x motor direction**
*direction sign is +1 if direction for secondary axis is "same"(3.2.1)
direction sign is -1 if direction for secondary axis is "opposite"3.2.1)
` **if motor direction (2.2.2.2.10) is CW multiply by +1 if CCW multiply by -1
When exiting the single axis move relative window (1.1.2) change each secondary axis's A, D, VI and VM values back to the original saved values.

E-gearing ON* OFF* Primary axis = 2**
(*displays the status of the E-gearing function 3.2.2., ON or OFF
** displays Primary Drive 3.2.1.)

3.2.1. F1 Set up (Sets up axes gearing)

Primary Drive Axis 2
(user selects axis)

Axes	state	gear factor	direction
1	secondary*	0.65***	same****
2	primary*	*1***	*same***
3	no connection*		
4	no connection*		
5	secondary*	1.25***	opposite****
6	no connection*		

*(*user selects axis E-gear state: primary, secondary or no connection
** Primary by default has a gear factor of 1 and direction is same (+1).
***user selects gear factor which is multiple of primary axis factor of 1
****user selects rotational direction of the secondary axis to be the same (+1) or opposite (-1) of the primary axis)*

3.2.2. F2 ON/OFF (Toggles E-gearing ON and OFF)

Example of E-gearing move function, calculations and commands.
For this example let us assume that the user has entered the values in the above E-gearing set up table (3.2.1.) For this example let us assumed that the following axis IMS controllers have the following settings:

Axis 2 EE is 1
EL is 100
MS is 256
A is 8000
D is 8000
VI is 100
VM is 4000

Axis 1 EE is 0
EL is 100
MS is 256
A is 1000000
D is 1000000
VI is 1000
VM is 25600

Axis 5 EE is 1
EL is 100
MS is 256
A is 8000
D is 8000
VI is 100
VM is 4000

These setting are determined by querying each axis for each of the above values

Example
§2PR EE§ (query encoder values for axis 2)

For this example let us also assume that motor direction (2.2.2.2.10) setting are:
Axis 1 is CW
Axis 2 is CW
Axis 5 is CCW

Also in this example for the primary drive (axis 2) the let us assume that Steps Per Coordinate(2.2.2.1.3) is:
8000

From the home page of the hand terminal the user selects:
F1 Move Axis (1.)
then F1 Single axis (1.1.)
then under Select axis(1.1) axis 2 (which is the primary axis in this example)
then F2 Move relative (1.1.2.)

The hand terminal determines that::
A. the E-gearing function(3.2.2.) is toggled ON
B. the Primary Axis (3.2.1) is axis 2
C. one or more axis are assigned as secondary axes(2.3.1)

Since , A,B and C are true:
The hand terminal calculates the PDR (primary drive rate)
Since EE=1
And EL=100
PDR= 100

The hand terminal calculates the SDR (secondary drive rate) for each secondary axis (3.2.1)
For axis 1 Since EE=0 SDR= 256 (MS value) x 50 = 12800
For axis 5 Since EE=1 SDR=100 (EL value) =100

The hand terminal calculate the SGM (secondary drive multiplier) for each secondary axis (3.2.1.)
for axis 1 SGM= 0.65 (gear factor) ÷ {100(PDR) ÷ 12800(SDR)] = 83.2
for axis 5 SGM=1.25 (gear factor) ÷ {100(PDR) ÷ 100(SDR)] = 1.25

For all axes the A, D, VI, and VM values are stored in RI, R2, R3, and R4
The values are stored in all of the drives with:
§*R1=A§ (saves acceleration value to register 1)
§*R2=D§ (saves deceleration value to register 2)
§*R3=VI§ (saves initial velocity value to register 3)
§*R4=VM§ (saves maximum velocity value to register 4)

For each of secondary drive the temporary A, D, VI and VM values are calculated and loaded on their IMS controllers
For axis 1:
Since SGM=83.2
the primary A =8000 the axis 1 temporary A is 83.2 x 8000 = 665600

send §1A=665600§ (sets temporary acceleration to secondary drive 1)

the primary D= 8000 the axis 1 temporary D is 83.2 x 8000 = 665600
send §1D=65600§ (sets temporary deceleration to secondary drive 1)

the primary VI=100 the axis 1 temporary VI is 83.2 x 100 = 8320
send §1VI=8320§ (sets temporary initial velocity to secondary drive 1)

the primary VM=4000 the axis 1 temporary VM is 83.2 x 4000 = 332800
send §1VM=33280§ (sets temporary maximum velocity to secondary drive 1)

For axis 5:

Since SGM=1.25
the primary A =8000 the axis 5 temporary A is 1.25 x 8000 = 10000
send §5A=10000§ (sets temporary acceleration to secondary drive 5)

the primary D= 8000 the axis 5 temporary D is 1.25 x 8000 = 10000
send §5D=10000§ (sets temporary deceleration to secondary drive 5)

the primary VI=100 the axis 5 temporary VI is 1.25 x 100 = 125
send §5VI=125§ (sets temporary initial velocity to secondary drive 5)

the primary VM=4000 the axis 5 temporary VM is 1.25 x 4000 = 5000
send §5VM=5000§ (sets temporary maximum velocity to secondary drive 5)

From the hand terminal the user selects:
F1 Set distance (1.1.2.1.) For this example let us assume the user types in the value of:
7.50 (the incremental units have been set for inches)

From the hand terminal the user selects:
F2 Move + (1.1.2.2.)

The calculations for the primary drive move size:

primary drive (axis 2)
If 1.1.2.1. Target Distance (axis 2) is 7.50
and 1.1.2.1. Move + is +1*
and 2.2.2.2.10. Motor Direction for + (axis 2) is set for CW (+1)
and the Steps Per Coordinate(2.2.2.1.3) is 8000
and since 7.50 x +1 x+1 x 100 x8000 = +6000000 the move size for axis 2 is 60000
*Note If F3 Move- (1.1.2.3.) was selected instead of F2 Move+ this value would be -1

secondary drive (axis 1)
Since the primary move size is +60000
and the SDR (secondary drive rate) is 83,2
and 2.2.2.2.10. Motor Direction for + (axis1) is set for CW (+1)
and since 600000x +1 x 83.2 = +4992000 the move size for axis 1 is 4992000

secondary drive (axis 5)
Since the primary move size is +60000
and the SDR (secondary drive rate) is 1.25
and 2.2.2.2.10. Motor Direction for + (axis1) is set for CCW (-1)
and since 60000 x -1 x 1.25 = -75000 the move size for axis 5 is -75000

Move the primary and each secondary axis using values from the calculating examples above:
On primary drive §2MR_60000§
and
On 1st secondary drive §1MR_4992000§
and
On 2nd secondary drive §5MR_-75000§

Monitor the primary and secondary axes one at a time to determine when the moves are completed
§nPR_MV§ (axes will return 1 while moving and 0 when complete)

When F4 Return (1.1.2.4.) is selected, reset and save the original A, D, VI and VM values as follows:

§*A= R1§ (returns acceleration from register 1)
§*D=R2§ (returns deceleration from register 2)
§*VI=R3§ (returns initial velocity from register 3)
§*VM=R4§ (returns maximum velocity from register 4)
§*S§ (save values)

3.2.3. F4 Return (return to higher menu)

3.2.4. F5 Stop All *(stops all motors)*

4. F4 Status (displays current axis status information)

Status screen is toggled on and off when the @ key is pressed

Current Position	Limit	Error
Axis 1 526.0* mm**	CW***	0****
Axis 2 20.7* mm**	-***	0****
Axis 3 -47.9* deg.**	-***	86****
Axis 4 -2.0* mm**	-***	0****
Axis 5 526.9* mm**	-***	0****
Axis 6 39888*steps**	-***	0****

(*position is based on the Axis Query - Current Coordinate.
* precision is based on 2.2.2.1.4. Display precision
**Type of coordinate is based on 2.2.2.1.2. Coordinate
***Limit is based on the Axis Query – CW Limit Switch and CCW Limit Switch
****Error is based on the Axis Query – Error Messages)

4.1.1. F4 Return (return to higher menu)

4.1.2. F5 Stop All *(stops all motors)*

5. F5 Stop All *(stops all motors)*