thermionics laboratory, inc.

INSTRUCTION MANUAL

TMC MOTOR CONTROLLER
1 OR 2 AXES

Version 2

SERIAL # _____

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TMC Motor Controller 1 or 2 Axis

INSTRUCTION MANUAL

VERSION 2.0

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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 is a programmable stepping motor controller. Control and programming are provided thru the user's computer via a USB communications port. It comes as a single or dual axis unit. Axes drives are available in two sizes, 3.0 or 5.0 amperes.

1.2 FEATURES

- 1 or 2 axes per chassis
- Software selectable drive and holding 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)

- Typically used with 1.8 degree per step motors (200 steps per revolution)
- 20 micro-step resolutions up to 51,200 steps per motor revolution
- 32-bit axis position registers provide ± 2,147,483,648 counts
- 0 to 5 Mhz step clock rate
- Relative, absolute, and continuous motor movement control
- Closed loop operation (with optional incremental encoders)
- Differential or single ended encoder inputs
- Encoder and or limit switch homing functions
- 4 hardware homing routines
- Stall detection and position maintenance (with encoder)
- 3 hardware end limits per axis
- Optional analog input 10bit (0 to +5VDC, 0 to +10VDC, 0-20mA and 4-20mA available)
- USB port interface for host computer control (com drivers for host computer are provided for Windows 98, 2000, XP, VISTA, Win 7 as well as MAC OS X based computers)
- NV RAM for program and variable storage
- MCode software programming with simple 1- and 2-character instructions
- Integrated ASCII terminal/program editor available (*Requires Windows XP Service Pack 2 or Higher)*
- Units are available as 120VAC 50/60 Hz or 230VAC 50/60 Hz
- Bench top cabinet measuring 5.5" high, 5" wide, and 10.5"/13.5" deep (single axis/dual axes)

1.3 CONTENTS

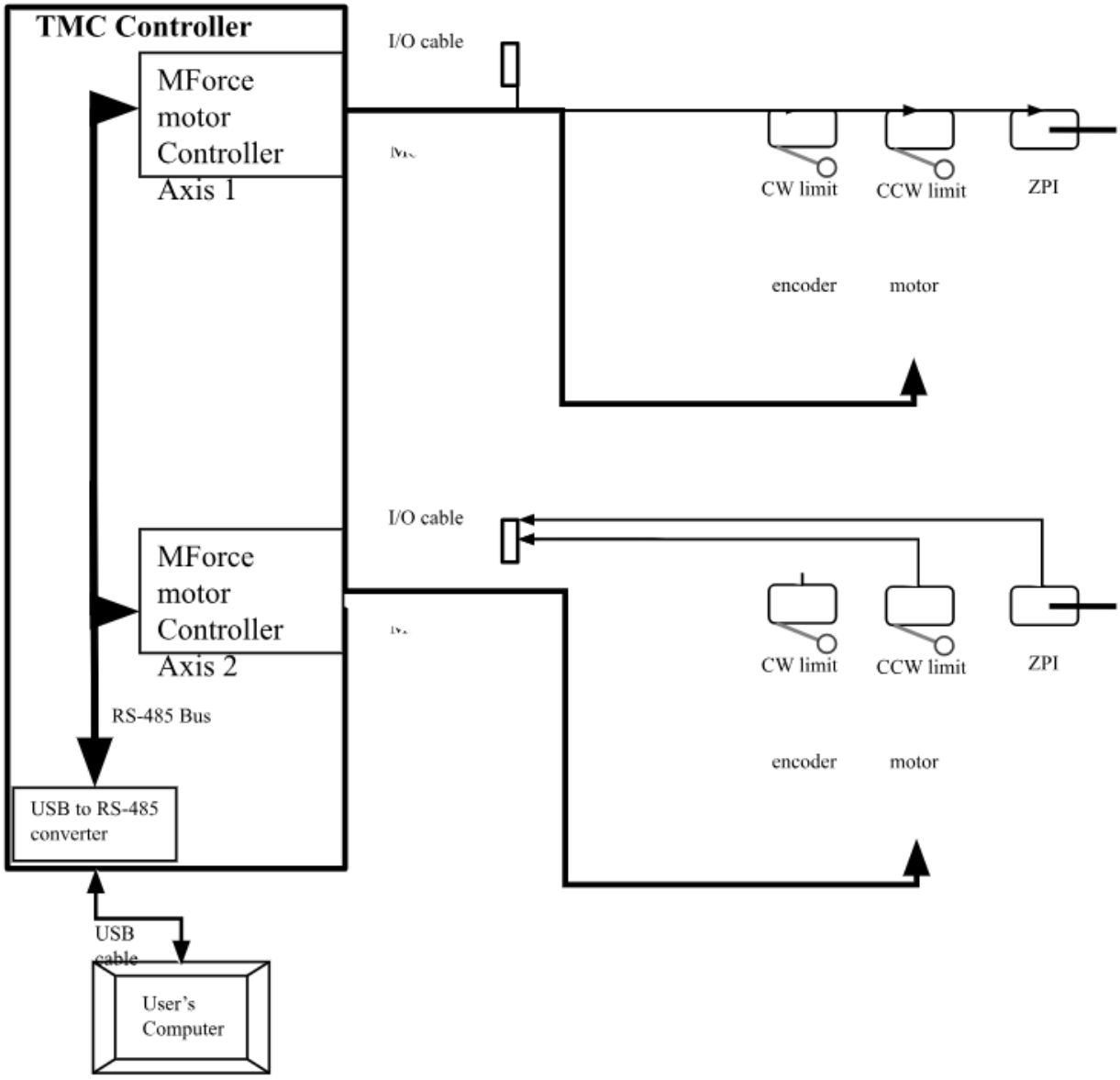
The components of the SMC motor controller are listed below. If you find any part missing from the shipment, please contact Thermionics Northwest.

Qty	Description
1	TMC Driver Unit
1 per axis	15' Interface cable (provided only when limit switches, ZPI or encoder is part of system)
1 per axis	15' stepping motor cable
1	15' USB cable
1	TMC user manual
1	TMC Settings Document
1	MCode Programming and Software Reference manual
1	Communications driver installation CD and instructions

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, for each axis. Each axis is capable of motor control and various I/O functions. Standard TMC operation is dependent on communications with the user's computer.



Section 3 Hardware Overview

3.1 FRONT PANEL CONNECTIONS

- Power ON/Off illuminated switch
- USB connector (type B) – an integral USB to RS- 485 converter communicates via the internal RS-485 bus to the axis controllers.

FRONT PANEL CONNECTIONS
Power ON/Off illuminated switch
USB Connector

3.1 Rear Panel Connections

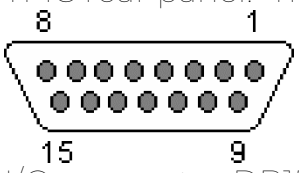
- Axes stepping motor connectors (DB5W5 female) - There is one connector per axis.
- Axes I/O connectors (DB15 female) – These connectors provides user access to clockwise (+) limit switch, counterclockwise (-) limit switch, optical zero position input (ZPI), and incremental encoder connections. There is one I/O connector per axis.
- Fuse – ¼" by 1 ¼" 2-amp slow blow for 120VAC input
  1-amp slow blow (2 fuses) for 240VAC input
- AC Power connection – cord attached

3.2 USB Communications Port

The USB (type B) connector is used to communicate via a user supplied computer. Section 4.11 in this manual provides instructions for loading the required drivers and software that must be loaded on the user's computer to communicate through this port.

3.3 I/O Connections

There is a DB15F (socket) connector for the input and output signals (I/O) for each axis. These connectors are labeled by their axis number (i.e. 1 or 2) on the TMC rear panel. The connection designation for each connector is:



I/O connector DB15F (socket) connection (viewed from back panel)

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. counterclockwise (-) 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 or user supplied home limit (I/O 3)
13. ZPI ground
14. encoder ground
15. CW and CCW limit ground

3.4 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 counterclockwise (-) limit switch. These are provided to protect 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:

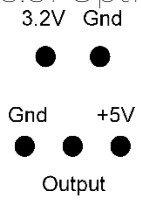
CW (+) limit switch contacts	I/O connector
Common contact (C)	connected to pin 15
Normally closed contact (NC)	connected to pin 7

CCW (-) limit switch contacts	I/O connector
Common contact (C)	connected to pin 15
Normally closed contact (NC)	connected to pin 8

3.5 Hardware Home Limit Input

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

3.51 Optical Home Limit (ZPI)



Optical Sensor (bottom view)

The optical home limit is designed to work with the Honeywell HOA2004 series Optoschmitt sensor. The figure on the right illustrates the sensor connections. If a ZPI is supplied on the equipment provided by Thermionics it is typical prewired. The ZPI is wired as follows:

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

3.52 Mechanical Home limits (user supplied)

In place of the ZPI, any type of mechanical switch can be used for sensing the home position. The user supplied mechanical home limit switch should be wired as follows:

User supplied home limit switch	I/O connector
Normally open contact (NO)	connected to pin 10
Common contact (C)	connected to pin 12

3.6 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.
If an encoder is supplied on the equipment provided by Thermionics it is typical prewired. The Encoder is wired as follows:

Connections for half duplex (single ended) encoders (5 wires)

Encoder connections	I/O connector
channel A	connected to pin 1
channel B	connected to pin 3
index	connected to pin 5
5 VDC supply	connected to pin 9

ground	connected to pin 14

Connections for full duplex encoders (8 wires)

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

3.7 Motor Connectors

Each axis has a five pin DB5W5F hybrid connector that supplies the voltage and current to the motors. When motors are supplied on the equipment provided by Thermionics it is typical prewired as follows:

Motor phase	Motor connector
A\	connected to A1
A	connected to A2
B\	connected to A3
B	connected to A4
Cable shield	connected to A5

Motor output connector DB5W5F (socket) (viewed from back panel)

Section 4 System Setup

4.0 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. Incorrect connections or connection/disconnection while the TMC is powered can cause permanent damage to the TMC, motors or other attached equipment.

4.1 Communications Setup

4.11 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

4.12 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 5: Operation

5.0 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 and two axis units communicate. These are described in the next sections.

5.01 Communicating with Single Axis Systems

- 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.

5.02 Communicating with Two Axes Systems

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 an 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.

5.1 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 counterclockwise 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 counterclockwise direction. The opposite is true when the counterclockwise 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 3.4 of this manual.

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

5.2 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 3.51 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.

5.3 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.

5.4 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.

5.5 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.

Example of speed control program (with direction switch)

```
'Purpose: variable speed control
'Uses I/O 1 to read direction switch that determine motor rotation direction
'Uses center tap of single turn 10K pot that spans 5 volts
S5=9                'sets analog input to accept 0-5Vdc.
S1=0,1              'sets I/O point 1 to general
                        'Purpose output
A=200000                'acceleration set to
                        '2000000 microsteps/sec/sec
D=200000                'deceleration set to
                        '2000000 microsteps/sec/sec
Ms=180              'sets micro step to 108 micro steps/motor step
R3 = 36             'slew multiplier is for 50 rpm
                        'R1 is analog value
                        'R2 is motor direction
                        'R3 is slew multiplier
                        'R4 is computed slew value
PG 1                'initiate program at address 1
   'Main program
LB SU               'startup label. Program executes
                    'On power up
   R1 = I5          'register 1 set to analog
                    'INPUT value
   R1 = R1-23           'deadband removed from R1
 CL z1, R1<0            'calls routine to remove
                    'Negative values
   R2 = I4          'register 2 set to direction I/O value
 CL z2, R2=0            'call routine to set R2 to -1
 CL z3                  'computes new velocity by calling
                    'Sub at label z3
   SL R4            'slew at the value of register 4
    H 10            'wait 10 milliseconds
  BR SU             'branch to the label called ZZ
    E               'end of ZZ routine
 'Subroutines
LB z1
    R1 = 0              'sets negative R1 to 0
    RT                  'return to command
LB z2
```

```
    R2 = -1                    'set direction register to neg.
    RT                         'return to command
LB z3
    R4 = R1*R2       'set direction
    R4 = R4*R3       'computes R4 Slew rate
    RT                         'return to command
    E                  'end
PG     'exit program space
```

Example of 6 position target controller with encoder homing (uses I/Os 1-3 wired to a 7-position binary coded switch)

```
'Purpose: target gearbox position control
'6 target positions 3 to 1 motor to target gear ratio
'Encoder used to home (100-line encoder)

'System configuration
Ms=256      'sets micro step to 256 micro
          'steps/motor step
Ee=1        'sets encoder on
El=100      'sets encoder line count to 100 lines
A=500       'acceleration set to
          '500 microsteps/sec/sec
D=A         'sets deceleration to match acceleration
Hc=15       'sets hold current to 15% (0.45 amps)
Rc=50       'sets hold current to 50% (1.5 amps)
S1=0,1,0    'sets I/O 1 to 3 to general inputs
S2=0,1,0
S3=0,1,0
S4=16,0,0   'sets I/O 4 to output to drive LED
Db=1        'sets dead band to 1 count
Sf=20       'sets stall factor to 20 counts
Sm=1        'sets stall mode on
Pm=0        'sets position maintenance off
Vm=1500     'sets maximum velocity to 1500 counts
R4=0        'sets offset value to R4
'R1 is used to determine change in selector switch
'R2 is defined by selector switch position
'R3 is used in calculating R2
'R4 is used for position offset in home routine
'Main program
PG 1          'starts program at line 1
LB SU         'names program SU
   O4=0       'turns off Home LED
LB Q1         'checks for Sel. Switch not on HOME
  CL Z1       'calls Z1 subroutine
  BR Q2, R2<>0'branches to Q2 if switch is
            'Not on home
```

```
   H 10      'waits for 10 m seconds
  BR Q1      'returns to start of Q1
LB Q2        'checks if Sel. Switch is on
           'HOME R2=1
  CL Z1      'calls subroutine Z1
  BR Q3, R2=0 'branch to Q3 if R2=0
   H 10      'waits for 10 m seconds
  BR Q2      'returns to Q2
LB Q3        'home routine
   R1=R2
   MR 100    'moves 100 counts
   H         'waits for move to finish
   D=D*10    'increases decel x 10
   HI 1      'homes to encoder index
   H         'waits for move to finish
   D=D/10    'decreases decel x 10
   P=R4      'sets position to offset value
   MA 0      'moves to 0 position
   H         'waits for move to finish
   O4=1      'turns on HOME light
LB Q4        'checks for change of Sel. Switch
  CL Z1      'calls subroutine Z1
  BR Q5, R1<>R2 'branches to Q5 if R1 is not = R2
   H 1000     'waits for 1 second
  BR Q4      'branches to Q4
LB Q5        'moves to selected position
   R1=R2     'loads R1 value to R2
  BR Q4, R2=0 'returns to Q4 if R2 is not = R2
   R2=R2-1
  BR Q6, R2=0 'branches to Q6 if selection is target 1
   MA R2*200 'moves to target position
   H         'waits for move to finish
CL Z2        'calls Z2 subroutine
   BR Q4     'returns to Q4
LB Q6        'Moves to position 1
   MA 0      'moves motor to position 0
   H         'waits for move to finish
CL Z2        'calls Z2 subroutine
  BR Q4      'returns to Q4
'Subroutines
LB Z1        'determines value of Sel. Switch
   R2=I1     'I1 is LSB
   R3=I2*2
   R2=R2+R3
   R3=I3*4   'I3 is MSB
   R2=R2+R3  'R2 is now value of 1 to 7
   R2=R2-1   'decrease R2
   RT        'returns to last program line +1
```

```
LB Z2          'blinks HOME light
   O4=0        'turns off HOME light
   H 200       'waits for 200 m seconds
   O4=1        'turns on HOME light
   H 200       'waits for 200 m seconds
    O4=0       'turns off HOME light
   H 200       'waits for 200 m seconds
   O4=1        'turns on HOME light
   RT          'returns to last program line +1
  E            'end of program                    'exit program space
'Exit program space                    'exit program space
```