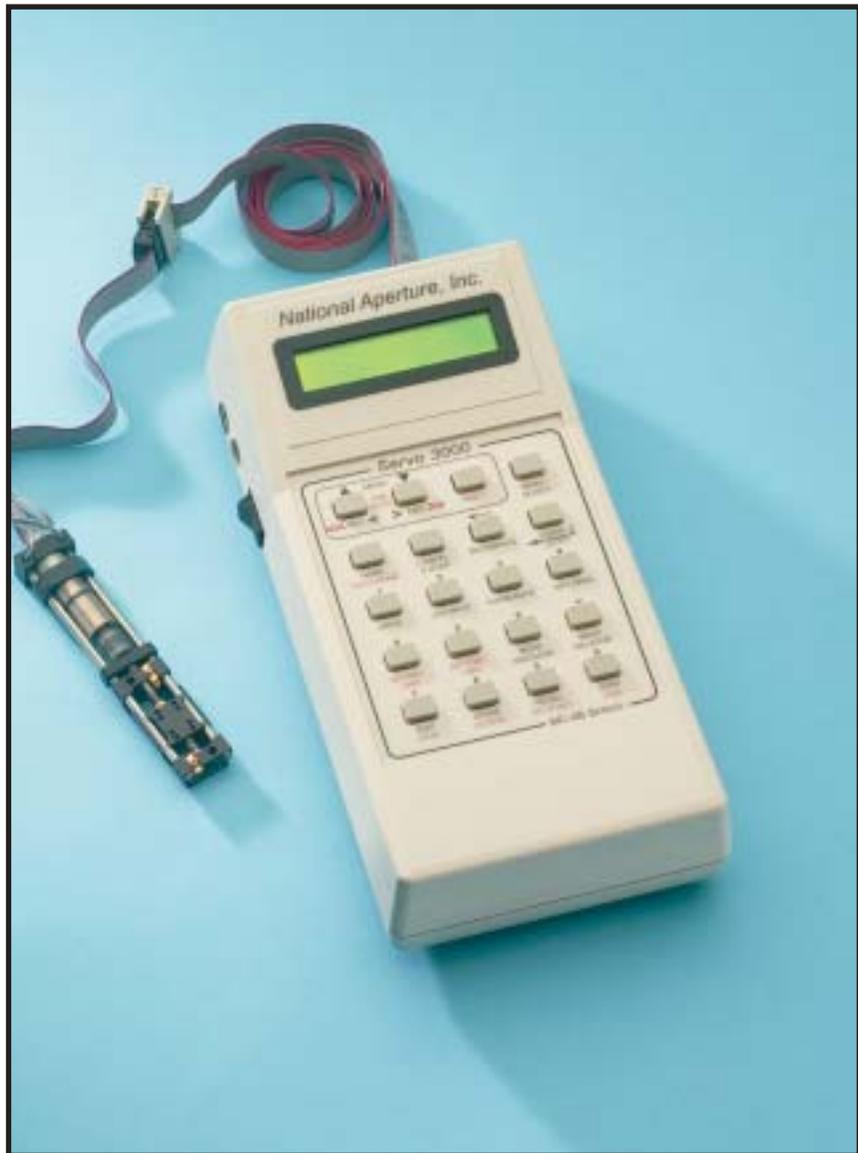




MicroMini™ Controller

MC-4B Series User Manual



Version 2.1

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Overview

The MC-4B Micropositioning Controller from NAI is a closed-loop position controller. The term "closed-loop" means that motor position and velocity are maintained over a wide range of speeds. The MC-4B will control any 6-12 volt DC brush type motor equipped with a quadrature incremental encoder.

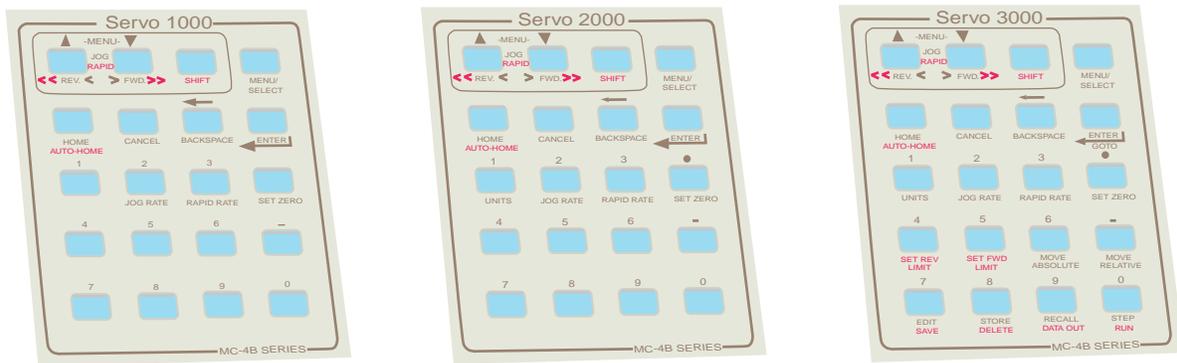
The MC-4B was designed as a low-cost, quick-setup solution to the need for precise position control of light-load motorized positioners, especially the MicroMini™ Stages from NAI. Most configurations of the MicroMini™ Stages feature a 10 position magnetic encoder built into the motor.

The MC-4B series of motion controllers feature the National Semiconductor LM628 dedicated motion control coprocessor, an 8051-family microcontroller, nonvolatile SRAM for long-term data storage, and socketed EPROM to allow field upgrades to firmware. Dual, independently adjustable speeds span a range from 1 to 13,333 counts per second.

The MC-4B Servo 1000 displays position information in quadrature encoder units. Default is 40 counts per motor revolution. The motor/stage is moved by the operator.

The MC-4B Servo 2000 adds stage calibration to allow display of position in selectable units such as inches, centimeters, mils, and microns for linear stages and degrees, minutes, seconds, and radians for rotary stages. It also adds point to point measurement capability.

The MC-4B Servo 3000 further adds positional motion capability, with absolute and relative moves requested from the keypad and entered in the desired units, and a storage array allows up to 100 trajectories to be preset for later playback, stepwise or automated, with Pause, Wait, and Loop options for each location. These trajectories may be entered manually or read from the current stage position, with a choice of automatic incrementing or direct entry of the array index. Also featured are user-configurable PID coefficients, backlash compensation, position error threshold, and option switches. A serial port provides interconnection to a host computer for text loading and storage of programs.



Keypad Overlays for Upgrades

MC-4B PRODUCT FEATURES

A) MC-4B BASIC FEATURES **SERVO 1000**

Hardware features

Embedded Micro controller

Motion Control by National LM628 Motion Control Processor

Shielded plastic case with ground jack for low EMI applications

2-Line, 16-column Alphanumeric Liquid Crystal Display

Editing keys

Numeric keys for data entry

Setup menu key

Backlash condition indication

Basic unit display (quadrature encoder counts)

Configuration and System Settings stored in non-volatile RAM

Encoder line count entry through Setup menu

Encoder polarity setting (normal or reverse) through Setup menu

Home key for canned-cycle homing

Jog buttons, Forward and Reverse motion keys

Rapid motion override function

Jog Rate selection of nine available jog rates

Rapid Rate key to select one of nine available rapid rates

Origin to zero position register and offset position display

Sign reversal option for position display through Setup menu

Stage type selection (linear or rotary) through Setup menu

PID coefficient settings through Setup menu

Field-upgradeable firmware

B) UPGRADE TO **SERVO 2000** (SECTIONS A AND B)

Angular units: arc-seconds, arc-minutes, degrees, and radians

Linear units: inches, mils, millimeters, and microns

Calibration entries (counts per unit) for linear and rotary motion through Setup menu

UNITS key for quick selection of positional units of measure

Step Jog option

Measurement, point to point

C) UPGRADE TO **SERVO 3000** (SECTIONS A, B AND C)

Move Absolute

Move Relative

Two modes of position storage: Consecutive ("sequential") and Random Access ("as entered")

Recall Position for access of up to 100 positions

One Touch Position Recall for first 20 stored locations

Store Position with a capacity of 100 in each mode

Auto/Step function for playback of sequences of stored positions

Automatic Backlash compensation; user definable

Edit Position key to enter target position, velocity, acceleration, etc.

Cancel key for emergency stopping the automatic positioning

Following Error, Velocity, Acceleration (Trapezoidal Profile), Entry through Setup menu

Forward and Reverse Soft Limit keys for setting software limits

RS-232 serial port for loading of programs

Specifications

Input Power:	15 VDC, 1 Amp, Center Negative via 110 or 220 VAC wall transformer
Duty Cycle:	50%
Display:	two-line, 16 column alphanumeric LCD
Control:	Pushbutton jog, dual button high speed
Jog Rate:	adjustable with 9 levels
High Speed Rate:	adjustable with 9 levels
Cable:	3 foot, 10 conductor IDC ribbon cable (included)
Application:	All MM-3M and MM-4M Motorized MicroMini™ Stages using a 10mm or 13mm motor.
Compatibility:	Any 6-12 VDC brush type motor (750 mA max.) with standard TTL compatible quadrature incremental encoder.
Dimensions:	8.75" x 4.25" x 2.625"
Firmware:	Field upgradeable to 2nd and 3rd level by direct code input.

Connecting the MC-4B Controller

1. Plug the stage motor cable into the motor connector, located on the right side at the back end of the controller.
2. Plug in the MC-4B wall transformer on the left side of the controller, near the power switch.
3. Plug the MC-4B wall transformer into an AC outlet.
4. Turn on the power switch. The LCD screen will display the firmware name and version and the serial number of your MC-4B. After about one second, this will be replaced by a reading of the motor position on the lower line and the text, "Not Homed" on the upper line.
5. If you need to reduce electromagnetic interference from your controller, you may connect a grounding lead to the miniature banana jack located behind the display.

Default Settings

The MC-4B comes with factory default settings so that you may start testing your stage and controller immediately. Check these settings, referring to “Settings and Operations “How To’s” section to be sure you are aware of the valuable options available to you. Also refer to MC-4B “Factory Settings” table in Appendix. To restore Default Settings, turn off your controller, hold down MENU, SET ZERO, and STEP keys, then power up.

Settings and Operation, Short Form

Section I (How-To's) SERVO 1000 use this section (I) only.

- Make a **MENU Entry**
Customizing Operational Settings of your MC-4B at the First Level

- Set **STAGE TYPE OPTION**
- SET **HOMING DIRECTION**
- SET **Sense of READING**
- SET **ENCODER POLARITY**
- SET **BACKLASH DIRECTION**
- SET **DIRECTION OF JOG KEYS**

Customizing Default Values of your MC-4B at the First Level:

- SET **ENCODER LINES PER REVOLUTION**
- SET **BACKLASH COMPENSATION**

Customizing PID Parameters (Servo-loop Configuration) of your MC-4B at the First Level:

- SET **PID Kp** ("PROPORTIONAL GAIN")
- SET **PID Ki** ("INTEGRAL GAIN")
- SET **PID Kd**
- **PID iLIMIT**
- **PID DERIV TSAMP**

Procedures for accomplishing common tasks with the MC-4B:

- **MOVE THE STAGE**
- **SET THE JOG RATE**
- **SET THE JOG RATE MULTIPLIER**
- **SET THE RAPID RATE**
- **HOME THE STAGE**
- **RESET THE POSITION READING**

SECTION II (How-To's) SERVO 2000 USE SECTIONS I AND II.

Customizing your MC-4B at the Second Level:

- **CALIBRATE THE STAGE**

Procedures for accomplishing common tasks with the MC-4B:

- **SET THE UNITS**
- **CHOOSE JOG STYLE**
- **SET THE JOG STEP SIZE**
- **CHOOSE LOCKED-JOG OR FREE-JOG OPTIONS**
- **MEASURE BETWEEN TWO POINTS**

SECTION III (How-To's) SERVO 3000 USE SECTIONS I, II AND III.

Customizing Operational Settings of your MC-4B at the Third Level:

- **NODE NUMBER**
- **SELECT POSITION STORAGE PLACEMENT MODE**

Customizing Default Values of your MC-4B at the Third Level:

- **SET FOLLOWING ERROR**
- **SET BACKLASH COMPENSATION**
- **SET ACCELERATION**
- **SET JOG STEP ACCELERATION**
- **SET VELOCITY FOR IMMEDIATE MOVES**

Procedures for accomplishing common tasks with the MC-4B:

- **MAKE AN ABSOLUTE MOVE**
- **MAKE A RELATIVE MOVE**
- **EMERGENCY STOP**
- **STORE A POSITION**
- **RECALL A POSITION**
- **SEND TO A STORED POSITION**
- **EDIT A MEMORY LOCATION**
- **ONE-TOUCH MEMORY MOVE**
- **SET THE HOME OFFSET**
- **SET SOFTWARE LIMITS**
- **CLEAR SOFTWARE LIMITS**

SECTION IV (How-To's) SERVO 3000 ONLY

- **SETUP SERIAL INTERFACE**

Settings and Operation, "How-To's"

Section I (How-To's) Servo 1000 use this section (I) only.

- **Make a MENU Entry**

The MC-4B Servo 1000 provides for several numerical entries by the user; the position reading is one example, and several configurations available through the MENU/SELECT key also take entries.

When an entry is presented, a default value is displayed on the upper line. When the first numerical key or the minus sign is pressed, the character for that key replaces the default number. The BACKSPACE key allows deletion of the most recent character keyed in.

To accept the entry, press and release ENTER, or to revert to the default value, press CANCEL. When entering a number in the setup menu, the new entry is accepted when the FWD or REV keys are used to scroll to the next or previous item.

Customizing "Operational Settings" of your MC-4B at the First Level

- **SET STAGE TYPE OPTION**

The first screen in the display will read:

```
Rotary Motion  
>Linear Motion
```

A choice of Rotary Motion allows the controller to recognize the rotary stage, with its single limit switch, to disable emergency stopping at the limit and to properly home it in case the option to "Home to Reverse End" is chosen below.

- **SET HOMING DIRECTION**

Pressing the FWD key changes the screen to read:

```
Home to Rev End  
>Home to Fwd End
```

The ">" indicates that the lower line's option is selected, that is, homing moves the carriage to the forward limit switch, closest to the motor. Pressing the MENU/SELECT key moves this to the upper line, places the ">" before the upper line, so homing will move the carriage to the reverse limit switch, farthest from the motor.

The MENU/SELECT key works the same way for the settings that follow.

- **SET SENSE OF READING**

Pressing the FWD key again changes the screen to read:

```
Reverse Display
>Normal Display
```

The default is for stage positive carriage motion to be toward the forward end. Changing the selection by pressing the MENU/SELECT key inverts the sense, so that motion toward the forward end reads as negative and motion away from the forward end reads positive.

- **SET ENCODER POLARITY**

Pressing the FWD key a third time changes the screen to read:

```
Reverse Encoder
>Normal
```

If your stage motor has reverse polarity or reversed encoder channels, the motor will run out of control because of the resulting positive feedback. Changing this setting should correct that, so the motor runs in the expected direction, at the expected speed.

- **SET BACKLASH DIRECTION**

Pressing the FWD key a fourth time changes the screen to read:

```
Rev Backlash
>Normal
```

Normally, stage carriage motion toward the forward end of the stage is the most accurately read from the motor's encoder. Motion in the opposite direction therefore entails backlash. To use a stage whose backlash direction is the reverse of this, press MENU/SELECT to select Reverse Backlash. For more about backlash, refer to the description of "Backlash Compensation" below.

[Backlash Indication: In the MC-4B Servo 1000, whenever the stage is moved in the reverse (out of the "windup") direction, backlash is indicated in the display by a left-pointing arrow. This arrow begins as a "<" when the backlash is a single count, changes to double thickness at two counts of backlash, then fills to a solid triangle when the backlash exceeds two counts.]

- **SET DIRECTION OF JOG KEYS**

Pressing the FWD key a fifth time changes the screen to read:

```
Rev Dir Key
>Normal
```

Sometimes it may be convenient to reverse the direction the stage carriage moves in response to the direction keys. Pressing MENU/SELECT selects Reverse Direction Keys, so that the FWD key moves the carriage away from the motor and the REV key moves it toward the motor. (This applies to all linear stages except the MM-3M-ST.)

Section I

Customizing “Default Values” of your MC-4B at the First Level

The following menu items contain numerical entries. Refer to “Make a MENU Entry” above, for instructions.

- **SET ENCODER LINES PER REVOLUTION**

Pressing the FWD key a seventh time presents the entry for encoder lines per revolution. The default value for this is 10. If your stage is unable to run continuously at the maximum high speed setting, lowering the value here will rescale the motor velocity feedback to correct the problem. On the other hand, raising the value of encoder lines per revolution makes greater top speed possible.

- **SET BACKLASH COMPENSATION (indicator only, on Servo 1000)**

In the MENU find Backlash Comp and enter the closest value you find to be your worst-case true system backlash. See “Backlash Direction” above for an explanation of the indicator.

Customizing "PID Parameters" (Servo-loop Configuration) of your MC-4B at the First Level

The following items are the PID settings, made available for fine-tuning the motor control. They should not be changed unless absolutely necessary to achieve stability.

- **SET PID K_P *** ("PROPORTIONAL GAIN")
Pressing the FWD key an eighth time presents the entry for the PROPORTIONAL coefficient. This is the factor used to provide motor drive proportional to the position error, and appears at the motor shaft as a spring constant. The default value for K_p is 600.
- **SET PID K_I *** ("INTEGRAL GAIN")
Pressing the FWD key a ninth time presents the entry for the INTEGRAL coefficient. This is multiplied by the integral of the position error, which increases with time. Since certain loads could equal the force of the motor in the case of proportional correction alone, the purpose is to increase motor drive as required to attain the force necessary to reduce the position error to zero. The default value for K_i is 400.
- **SET PID K_D ****
Pressing the FWD key a tenth time presents the entry for the DERIVATIVE coefficient. This is multiplied by the instantaneous velocity of the position error, to damp out overshoot and oscillation. The default value of K_d is 1000
- **PID iLIMIT ****
Pressing the FWD key an eleventh time presents the entry for the INTEGRAL Limit. A sustained position error, integrated over time, could result in an excessively large sum called "integral windup", resulting in dramatic overshoot and long settling times. The default value of iLimit is 1000.
- **PID DERIV TSAMP ****
Pressing the FWD key a twelfth time presents the entry for the SAMPLE PERIOD (tSamp). This is used in conjunction with PID K_d for setting damping. The default setting of 0 results in a 370 microsecond sample period. A nonzero entry results in a 370 additional microseconds times the entry value, and may be as high as 255, for a sample period 94,815 microseconds long.

*These can be reset by the user to refine motion and position.

**Factory settings rarely need to be changed.

Section I

Procedures for accomplishing common tasks with the MC-4B:

- **MOVE THE STAGE**

(Normally, the stage will move with the factory settings.)

To move the carriage of a standard stage toward the motor, press the FWD key, while pressing the REV key moves the carriage away from the motor. If you hold the SHIFT key before pressing either FWD or REV, the stage will begin immediately to move at the selected high speed. If you are already moving the stage using FWD or REV, pressing SHIFT will accelerate the stage to the higher speed, at which it will continue to run until:

1. you release SHIFT, causing the stage motion to decelerate back to the jog speed
2. you release the FWD or REV key, causing the stage to stop

If the stage runs at a high speed, out of control, toward one end or the other, the motor encoder signals may be reversed. To change the encoder feedback direction, refer to the section below, "Customizing the MC-4B Controller".

- **SET THE JOG RATE**

The Jog Rate is the speed at which the stage moves when the FWD or REV key is pressed. Press and release the JOG RATE key. The upper line will show a row, from 1 to 9 long, of box-like symbols, indicating the choice of speed currently in use. Use one of the numerical keys to change the selection: pressing 1 will select the lowest speed, pressing 2 selects the next speed, and this continues with the rest of the number keys up to 9. Each time a numerical key is pressed the display reflects the new speed selection. Once you are ready to accept a choice of speed, press and release ENTER, and the display will return to its normal readings.

- **SET THE JOG RATE MULTIPLIER**

Go to the MENU item:

```
VMode Jog X 1,4,
```

Type in a number that will give an appropriate jog speed range for your gearhead and your application.

- **SET THE RAPID RATE**

The Rapid Rate is the speed at which the stage moves when the SHIFT key is held while the FWD or REV key is pressed.

Press and release the RAPID RATE key. The upper line will show a row, from 1 to 9 long, of box-like symbols, indicating the choice of high speed currently in use. Use one of the numerical keys to change the selection: pressing 1 will select the lowest speed, pressing 2 selects the next speed, and this continues with the rest of the number keys up to 9. Each time a numerical key is pressed the display reflects the new speed selection. Once you are ready to accept a choice of speed, press and release ENTER, and the display will return to its normal readings.

Note: When testing a stage with your MC-4B for the first time, it is best to be moderate in selection of a high speed; start out with a high speed setting of 5 or 6.

- **HOME THE STAGE**

Any meaningful positioning of the stage depends on its being HOMED. The MC-4B provides both manual and automatic HOMING.

To HOME the stage carriage manually, press and hold the HOME key. The carriage will move toward the forward end of the stage at a visible speed until it reaches the chosen (default) limit switch. Upon contact with the switch, the position will immediately reset to "zero". The stage will be sent back to the chosen offset, and redefined as zero (your correct HOME position). The phases of the HOMING cycle will be displayed in the upper line until the last phase is complete, then the upper display line is cleared. Releasing the HOME key at any time will stop the HOMING cycle.

To HOME the stage carriage AUTOMATICALLY, press and hold the SHIFT key, press the HOME key, then release both keys. HOMING, as described above, will proceed until complete. Pressing the CANCEL key at any time will stop the homing cycle.

- **RESET THE POSITION READING**

The positional reading may be referenced to any physical position of the stage carriage by using the SET ZERO key. First, move the carriage to the desired position. Second, press and release the SET ZERO key. The upper line will allow entry of a number of counts to correspond to this position, or it may simply be left at zero.

See "More about the Servo 1000 Controller" section.

See also "Upgrading to a Higher Product Level"

Section II (How-To's) Servo 2000 use Section I and II.

Customizing your MC-4B at the Second Level:

- **CALIBRATE THE STAGE**

For the Linear Stage go to "Counts per inch" in the MENU and enter the correct setting for your drive train (see Appendix E).

For the Rotary Stage go to "Counts per rev." and enter the correct setting for your drive train (see Appendix E).

If you wish do an ultrafine calibration, take a precise measurement of slider/rotor displacement, using metrology instruments and calculate the exact counts per unit.

Procedures for accomplishing common tasks with the MC-4B:

- **SET THE UNITS**

Press and release the UNITS key, and observe the position reading on the lower display line as it changes from raw counts to inches. Further pressing UNITS will switch the display to mils, millimeters, microns, and finally back to raw counts.

- **CHOOSE JOG STYLE** (Stepped Jog Option is available in this upgrade)

The first setting in the Servo 2000 main menu is the option of stepped jogging. The screen reads:

```
>Step Jog
  VMode Jog (See "Section I")
```

Selecting "Step Jog" changes the action of the unshifted FWD and REV keys from constant speed to incremental steps at a rate of 10-20 steps per second. It allows a single step at the will of the user. (See "Servo 2000 Keys",) CAUTION: The Auto Backlash feature functions with Step Jog , but **not** with VMode Jog.

- **SET THE JOG STEP SIZE**

Press and release JOG RATE. Try the numerical keys in ascending order and notice that the reading displayed on the upper line doubles in value at each successive numerical value. (See "Servo 2000 Keys")

CAUTION: Selecting a large jog step will require reducing jog step acceleration.

Note: The jog steps are not exact when accumulated. This is necessary to maintain the jog step frequency without hesitation. True increments can be achieved by the MOVE RELATIVE function in the Servo 3000 Upgrade.

- **CHOOSE LOCKED-JOG OR FREE-JOG OPTIONS**

Locked stops can be applied to jog mode moves. The screen for this option reads:

```
Locked Jog  
>Free Jog
```

Locked Jog option, if selected, locks the stage at the position where a jog mode move has stopped. This is useful when it is desirable to keep the stage at a particular position if subjected to other forces.

If Free Jog option is selected, the motor is free to move after the jog mode move has stopped, allowing manual adjustments to position in stages having an exposed drive coupler.

TIP: If the Locked Jog stop option is selected, the CANCEL key may be used to release the motor from the servo loop.

- **MEASURE BETWEEN TWO POINTS**

Measurements can be made between any two stage positions using the following method:

Choose a **starting point** for your measurement

Press **SHIFT+2**. (This will store a temporary **reference point**.)

Go to the **second point**

Hold **SHIFT+3**.

The difference between the points will be displayed on the top line during keydown.

The **reference point** will remain the same until replaced, making it possible to get numerous measurements from the same reference point without pressing **SHIFT+2** each time

See "More about the Servo 2000 Controller" section.

See also "Upgrading to a Higher Product Level"

Section III (How-To's) Servo 3000 use Sections I, II and III.

Customizing "Operational Settings" of your MC-4B at the Third Level:

The following five menu items are common to all product levels. See "Customizing the MC-4B" in Section I above, for complete descriptions.

- Homing Direction
 - Sense of Reading
 - Reversed Encoder
 - Reverse Backlash
 - Reverse Direction Keys
- **NODE NUMBER** (only for networking)
This entry is the controller's identity number, for use in networking multiple MC-4B controllers on a serial cable. In a network, each controller would have its own node number from 1 to 99, and all commands from the host begin with a node number if meant for a particular controller, or begin with zero if meant as a broadcast to all of them. It may be left at zero if the controller is not going to be used in a network.
 - **SELECT POSITION STORAGE PLACEMENT MODE**
The fifth setting is the mode selection for numbering of locations for position storage. The screen reads:

```
Store by Entry  
>Sequential
```

In "Store by Entry" mode, pressing the STORE key presents an entry prompt for the desired location number. When the entry is made, the current position is stored there, with an option to "overwrite" or "insert before" if occupied. (If inserted before, the current location will be moved up one number along with anything else that is stacked above it.)

If "Sequential" is chosen, the memory location will be incremented and the current position stored automatically at the end. Insertions cannot be made in this mode.

More detail about the STORE key can be found under "Keypad Guide, Servo 3000".
CAUTION: Each storage mode has its own memory bank, i.e., stored positions are exclusive to each mode.

Customizing the "Default Values" of your MC-4B at the Third Level:

The following five menu items are common to all product levels. See "Customizing the MC-4B at the First Level" in Section I above, for complete descriptions.

- Encoder Lines per Revolution
- PID Kp
- PID Ki
- PID Kd
- PID iLimit

- **SET FOLLOWING ERROR**

This entry is in raw encoder counts. When actual motor position lags behind the instantaneous target position by this amount, the motion control processor assumes an obstruction and shuts down the motor drive for protection. If a move was in progress as part of a sequence, the position index is not advanced to the next location, therefore the move may be re-attempted after investigating the cause of the following error shutdown. The following error can be decreased to increase the obstruction-stall sensitivity.

- **SET BACKLASH COMPENSATION**

In the Servo 2000 and Servo 3000 this entry is in the chosen unit of measure, whereas in the Servo 1000 it is in raw counts only. In the Servo 3000 it is AUTOMATIC even in the jog mode.

- **SET ACCELERATION**

Scrolling to this item presents the entry for Base Acceleration, to be used when an immediate move is requested through the MOVE ABSOLUTE key or the MOVE RELATIVE key. This is also the rate of acceleration or deceleration during jogging when the shift key is pressed or released. The unit of measure is that chosen through the UNITS key (raw encoder counts is the simplest).

- **SET JOG STEP ACCELERATION**

This setting will allow high acceleration values for making short jog steps more reliable. The value chosen will probably be much higher than allowable for base acceleration (above).

- **SET VELOCITY FOR IMMEDIATE MOVES**

Scrolling to this item presents the entry for Base Velocity, to be used whenever an immediate move is requested through the MOVE ABSOLUTE key or the MOVE RELATIVE key. The unit of measure is that chosen through the UNITS key. For details about acceptable values of Velocity, see “Factory Settings” table Appendix A.

Procedures for accomplishing common tasks with the MC-4B:

- **MAKE AN ABSOLUTE MOVE**

Press the MOVE ABSOLUTE key, make an entry for target position, then hit the GOTO key. The factory PID settings should enable the stage to make a move, but refinement is recommended

- **MAKE A RELATIVE MOVE**

Press the MOVE RELATIVE key, make an entry for an incremental move size, then hit the GOTO key.

- **EMERGENCY STOP**

Hit CANCEL key.

Section III

- **STORE A POSITION** (destination) into a specified Memory Location
 1. If "Store by Entry" was chosen, pressing the STORE key presents an entry prompt for the location number or index, and when the entry is made, the current positional value is stored there. If the location about to receive this value has already been written, that is, a position value has been stored there before, the user is offered the choice of replacing the location's existing value with the current position, or clearing a space for it by shifting all memory content to higher locations. The Execute attribute is initialized to ON.
 2. If "Sequential" was chosen instead, the current index will be incremented and the current position stored automatically. This current index is initialized by using the RECALL key. The Execute attribute is initialized to ON.
- **RECALL A POSITION**

Press the recall button, hit the desired two digit memory location and the display will show the stored position. (To DELETE a stored memory location, see "More about Servo 3000".)

TIP: To scroll through memory locations, recall any location then use up and down arrow keys. .
- **SEND TO A STORED POSITION**

Once recalled hit ENTER/ GOTO and the stage will go there.
- **EDIT A MEMORY LOCATION**

This function allows the attributes of a move to be individually tailored based on the requirements of that move (velocity, etc.). It even considers the role of a move in automatic and step-through sequencing. This mode can be accessed by hitting the EDIT key after recalling a memory location. See "Servo 3000 Topics". See also, "EDIT Menu" Appendix C.
- **ONE-TOUCH MEMORY MOVE** (Caution: Hot Key mode takes over the numerical keypad.)

The first setting (for the purpose of convenience) in the Servo 3000 main menu is the option of single-keystroke position recall. For this option the menu selection should read:

```
>One Touch Mode
Normal Mode
```

In the one-touch, or single-keystroke mode, a stored position may be traveled to by simply pressing the numerical key corresponding to its index. Holding SHIFT while pressing a numerical key adds 10 to the index, providing a total index range of 0 to 19 accessible through one-touch mode.

[In the normal mode, the location must be recalled, then the GOTO key is required to make the move.]

TIP: To escape One-Touch Hot Key mode; press MENU once.
- **SET THE HOME OFFSET**

From the MENU key choose "Homing Offset" enter an appropriate absolute value that represents the distance from the limit switch from which the stage is to be HOMED.

- **SET SOFTWARE LIMITS**

Go to each stop point at the far ends of your desired range and proceed as follows:
When you have gone as far in the positive direction as you wish to allow, hit SHIFT + SET FWD. LIMIT. Do the same in the negative direction using SHIFT + SET REV. LIMIT.

- **CLEAR SOFTWARE LIMITS**

The third and fourth settings in the Servo 3000 main menu are the actions of clearing the forward and reverse soft limits. The screen reads:

```
(a number)  
>Fwd Limit OFF
```

```
(a number)  
>Rev Limit OFF
```

Using MENU/SELECT to highlight the number into the upper line will make that the effective software position limit in the chosen direction. While the upper line is highlighted the numerical entry there may be changed, if desired.

Using MENU/SELECT to highlight the lower line, "...Limit OFF" bypasses the software position limit in the chosen direction.

Section IV (How-To's)

Serial Interface Setup (Servo 3000 only)

Interconnect the controller serial port with a serial port jack on your intended host computer using a null modem cable. To set up a communications application for use with the controller, make the following settings:

Baud rate = 4800

Data bits = 8

Parity = None

Stop Bits = 2

Flow Control = none

Port = (port used for cabling to the controller)

Note: If you intend to network more than one controller to a host, see Appendix G for cabling..

Serial Interface Command Syntax

Commands sent to the MC-4B Servo 3000 through the serial port all begin with a two-digit node number. A command with a node number of "00" is processed by the controller regardless of its own node number, whereas a command beginning with "01" to "99" is only processed by a controller having that node number.

The next character is the command code itself. Below is a table of command codes and their descriptions.

? : Query

A Query requests a specified parameter from the controller. The available query parameters are:

a : Acceleration - The controller returns its current acceleration setting in the currently selected units of measure.

u : Units - The controller returns its currently selected units of measure.

v : Velocity - The controller returns its current velocity setting in the currently selected units of measure.

A : Automatic

This must be followed by a two-digit location index, for a beginning location, and this may be optionally followed by a comma and another two-digit location index, for an ending location. The controller executes the program starting at the specified beginning location. If an ending location was given, this is where execution ends; otherwise, execution ends at the last executable location or the first location to have the End Program attribute.

C : Clear

This must be followed by a two-digit location index, for a beginning location, and this may be optionally followed by a comma and another two-digit location index, for an ending location. The controller clears storage locations starting at the specified beginning location. If an ending location was given, this is the last one cleared; otherwise, the last one cleared is location 99.

Before the controller proceeds to clear the specified range of storage locations, it sends this confirmation back to the terminal:

```
01: Press 'Y' to confirm
```

Pressing “y” or “Y” confirms your intention to clear the storage locations; any character cancels the operation.

D : Dump

This must be followed by a two-digit location index, for a beginning location, and this may be optionally followed by a comma and another two-digit location index, for an ending location. The controller lists the program starting at the specified beginning location. If an ending location was given, this is where the listing ends; otherwise, the listing ends on the last executable location or the first location to have the End Program attribute.

A typical listing looks like this:

```
01UIN
01L00 A+0.000000 in v+0.258672 in a+1.055879 in P1*
01L01 R+0.05 in v+0.258672 in a+1.055879 in P1L3C*
01L02 A+0.38 in v+0.258672 in a+1.055879 in P1*
01L03 A+0.164 in v+0.258672 in a+1.055879 in P1E*
```

For more description of the listed lines, see “L : Line”, below.

L : Line

This must be followed by a two-digit location index, to identify the location. Following this should be the coordinate, the velocity, and the acceleration, all in the current units of measure. The coordinate must begin with “A” for an absolute target or “R” for a relative displacement. At the end of the line are the control flow attributes, described below.

Pnnn - Pause for nnn seconds; where n = 0 to 255. (not used together with Wait)

W - Wait for user to hit **ENTER** (not used together with Pause)

Lnnn - Loop nnn times; where n = 0 to 255. This line would be the beginning of a loop. The count specified is the number of times execution returns to this location to repeat, so a value of 1 would cause two passes through this location.

Section IV

C - Continue; this term is borrowed from the Fortran language to signify the end of a loop. When this location is reached, execution flow jumps back to a previous location having the Lnnn attribute.

E - End Program; execution stops here.

*** - This location is to be included in execution.**

A typical line is shown below:

```
01L03 A+0.164 in v+0.258672 in a+1.055879 in P1 *
```

S : Step

This must be followed by a two-digit location index, to identify the location. The controller moves the stage to the position in this location, at the velocity and acceleration stored in this location.

U : Units

This command changes the controller's currently selected units of measure. It must be followed by an abbreviation from the following table:

N	Raw Counts
IN	Inches
MIL	Milli-inches
MM	Millimeters
UM	Microns
SEC	Arc-Seconds
MS	Arc-Minutes and Arc Seconds
DMS	Degrees, Minutes, and Seconds
DD	Decimal Degrees
RAD	Radians
MRAD	Milli-radians

More Commands

(Please also refer to Appendix J on page 46 "MC-4B Serial Communication and Command Syntax Reference".)

Where *XX* is the node number;

XXH	Initiates Homing routine
XXR	Resets current position to "0"
XXInn	Sets new target position (<i>nn</i>) in current memory location
XXM	Stores current position at current memory location
XXann	Move Absolute
XXsnn	Move Relative

Global:

ESC key works the same as pressing Cancel on all controllers on the network.

Programming Using Serial Interface

The following is a sample of a program listing:

```
01UIN
01L00 A+0.000000 in v+0.258672 in a+1.055879 in P1*
01L01 R+0.05 in v+0.258672 in a+1.055879 in P1L3C*
01L02 A+0.38 in v+0.258672 in a+1.055879 in P1*
01L03 A+0.164 in v+0.258672 in a+1.055879 in P1E*
```

We will analyze this program one line at a time. The first line sets up the units of measure to be used. The first two characters are the node identity of the controller, followed by “U”, for Units. Finally there is abbreviation for the units, “IN”, which as the table above shows stands for inches. A units line of this form should begin any program.

The four lines of the program body all begin with the two-character node identity, “L” for Line, and the two-digit location index. After this is the coordinate. If the coordinate begins with “A”, it is an absolute position, the target to which the stage is to travel. If instead the coordinate begins with “R”, it is a displacement or increment, for a relative move.

Next is the Velocity value, beginning with “v”, and the Acceleration value, beginning with “a”.

Note: While the listing always includes the current units of measure for each value, you do not need to give the units if you are entering a line manually from a terminal.

At the end of the line may be attributes, as defined under *Serial Interface Command Syntax, Line*. Location 01, for instance, ends in “P1L3C*”, meaning it has one second of dwell, begins a 3-pass loop, and is also the end of the loop.

Text Transfer of Programs

You may list a program in your controller by sending it the Dump command (see Dump, above) from your terminal program, or by holding **SHIFT** on the controller and pressing **RECALL**. If text transfer or logging is available you may save the listing to a text file.

If you want to write up the program in a text file and send it to the controller, it is recommended to set your terminal program for No Flow Control and a delay of two milliseconds between lines. This has been found to produce the best results.

For Support e-mail: wweber@nationalaperture.com

UPGRADING PRODUCT LEVELS

Upgrading to a Higher Product Level

The code for higher levels of the MC-4B are contained in the firmware of every unit. When an upgrade is purchased, a numerical password unique to the serial number of your controller is supplied. To apply it, hold the **SHIFT** key, then press **MENU/SETUP**. Key in the supplied password from the keypad and press **ENTER**. If it was entered correctly, the lower line will display the new product level for about one second, after which the features included in that product level will become available. Remove the keypad overlay and attach the proper overlay for the new product level.

To obtain the **serial number** of your unit turn the unit off then reboot, and the number will be displayed for a few seconds.

More about the Servo 1000 Controller

MC-4B Servo 1000 Features

The MC-4B Servo 1000 has the capability of moving a motor stage in the forward and reverse directions at both low and high speeds. The position is displayed and continually updated in encoder count units.

To accommodate the Servo 1000 features, the configuration menu adds:

- Selection of jog speed
- Selection of high speed
- Auto HOMING
- Resetting current position
- Backlash setting

Keypad Guide, Servo 1000

The **REV** key applies negative voltage to the motor for reverse motion. The display reads a decreasing numerical value as the motor moves.

The **FWD** key applies positive voltage to the motor for forward motion, the display reads an increasing numerical value as the motor moves. Holding the **SHIFT** key while pressing either **FWD** or **REV** selects high-speed motor operation. **MENU/SELECT** presents a list of configuration options for customizing the operation of the MC-4B controller.

Holding the **HOME** key moves the stage carriage forward until it closes, backs the carriage slowly away from the limit switch until it opens, and finally advances the carriage slowly until the limit switch closes once more. Releasing the **HOME** key at any time stops the homing operation.

Pressing the **HOME** key while holding the **SHIFT** key performs the same sequence as if the **HOME** key is being held, except that the operation continues after the keys are released. Pressing **CANCEL** at any time will stop the homing sequence.

CANCEL can also be used to quit early while using the menu functions or making a numerical entry.

BACKSPACE is used for corrections while making a numerical entry.

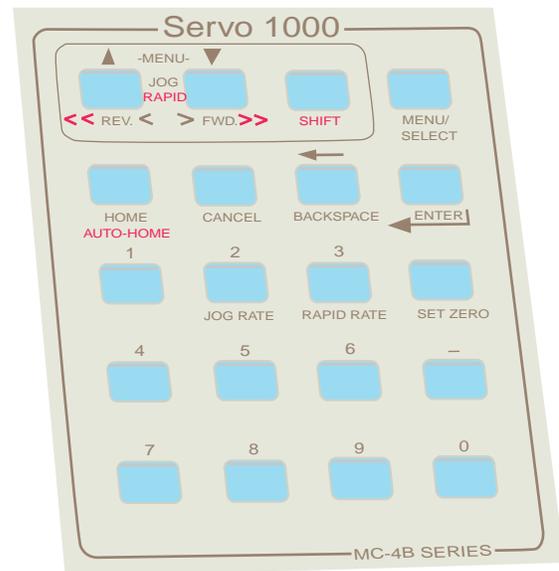
ENTER accepts numerical entries and setup changes made in the menu functions.

JOG RATE sets the speed to be used when running the motor through the **REV** and **FWD** keys. The numerical keys 1 through 9 select the speed, and the selection is displayed as a correspondingly long row of symbols.

RAPID RATE works the same as **JOG RATE**, except that the speed chosen is applied when the **SHIFT** key is held for high-speed motion.

Pressing **SET ZERO** resets the motion control position register to zero. Following this, the user may enter the amount of offset to be added to the position reading.

See section on “Upgrading to a Higher Product Level”.



More about the Servo 2000 Controller

MC-4B Servo 2000 Features

The MC-4B Servo 2000 adds the capability of measurement units. The selection of units depends on the type of stage; linear stages would use linear units such as inches and millimeters while rotary stages would use angular units such as degrees and radians.

Two other features included in the Servo 2000 are jogging by steps and automatic backlash compensation.

To accommodate the Servo 2000 features, the configuration menu adds:

- Selection of stepped jog or velocity mode jog
- Option of jog mode backlash compensation
- Calibration factor, linear and angular

Keypad Guide, Servo 2000

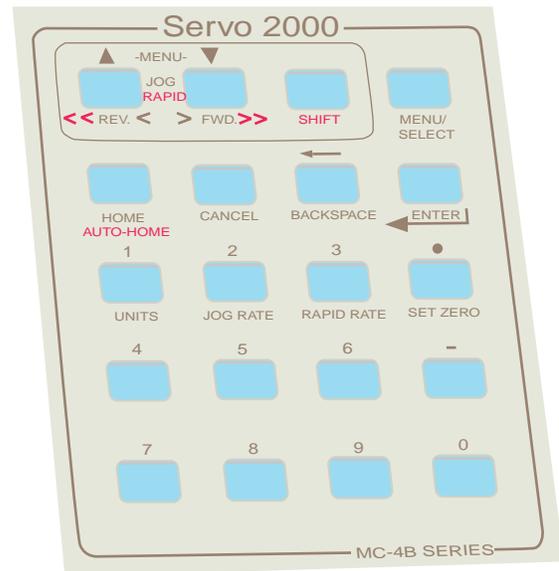
The Servo 2000 adds the UNITS key, for toggling through the applicable units-of-measure for the type of stage in use. If your MC-4B is configured for a linear stage, the units can be raw counts, inches, mils, millimeters, or microns. If instead, the controller is set up for a rotary stage, the choice of displayed units will be raw counts, arc-seconds, arc-minutes and seconds, degrees and minutes and seconds, decimal degrees, radians and milli-radians.

When the Stepped Jog option is selected, the action of the JOG RATE key changes: instead of showing a row of symbols, the size of the jog step is given in the chosen unit of measure. The sizes are as follows:

1. 1 count
2. 2 counts
3. 4 counts
4. 8 counts
5. 16 counts
6. 32 counts
7. 64 counts
8. 128 counts
9. 256 counts

The action of the unshifted FWD and REV keys changes as well, so that instead of moving continuously, the motor periodically moves by the interval selected using JOG RATE, as long as the key is held. Pressing SHIFT moves the motor in high-speed velocity mode, and releasing SHIFT returns the motor action to the regular stepwise motion.

See section on “Upgrading to a Higher Product Level”.



More about the Servo 3000 Controller

MC-4B Servo 3000 Features

The MC-4B Servo 3000 adds the capabilities of moving the stage carriage to a specific target, at a user-determined velocity, displacing the stage carriage by a specified distance (called a Relative move), storing an array of target positions in memory for subsequent recall, and programming a sequence of target positions in memory for subsequent recall, and programming a sequence of target positions together with optional time delays (Pauses) or waits for an operator keystroke, and iterative sequences (Looping).

In addition, software limits may be placed for collision protection and communication with an external computer or master controller is provided through the RS-232 serial port.

To accommodate the Servo 3000 features, the configuration menu adds:

- Selection of one-touch or normal memory recall
- Clearing of soft limits
- Selection of explicitly entered or automatically incremented index for position storage
- Entry of velocity for use in immediate moves
- Entry of threshold following error for protective motion shutdown
- Entry of network node identity number, for use in connecting multiple MC-4B controllers on a serial cable.

Keypad Guide, Servo 3000

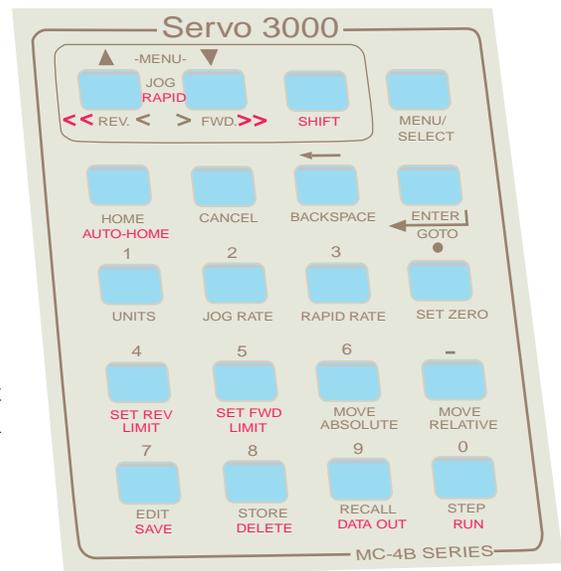
The MC-4B Servo 3000 adds the following keys:

CANCEL has expanded functionality in the Servo 3000. Pressing **CANCEL** while a move is in progress halts the move. If the move is part of a sequence, the current index is not advanced, so the move may be re-attempted after any problems with it have been dealt with.

SET REV LIMIT places a reverse software limit at the current position. Moves and jogging are not allowed past this point in the reverse direction. In the case of a position mode move, the target position is replaced by this limit if it lies beyond it in the reverse direction. If jogging, motion in the reverse direction will be stopped when this limit is reached.

SET FWD LIMIT places a forward software limit at the current position. Moves and jogging are not allowed past this point in the forward direction. In the case of a position mode move, the target position is replaced by this limit if it lies beyond it in the forward direction. If jogging, motion in the forward direction will be stopped when this limit is reached.

When the **MOVE ABSOLUTE** key is pressed, an entry is presented for a target destination. After this entry is accepted, the stage carriage will move to this position at the configured velocity.



More about the Servo 3000 Controller

When the **MOVE RELATIVE** key is pressed, an entry is presented for a target displacement. After this entry is accepted, the stage carriage will move by this amount at the configured velocity.

Note: For details about configuring a default velocity, see “Velocity for Immediate Moves”, below.

The **STORE** key places the current stage position into a specified memory location. How this location is specified depends on the Position Storage Index Mode setting.

If Store by Entry is chosen, pressing the **STORE** key presents an entry prompt for the location number or index, and when the entry is made, the current positional value is stored there. If the location about to receive this value has already been written, that is, a position value has been stored there before, the user is offered the choice of replacing the location’s existing value with the current position, or clearing a space for it by shifting all memory content to higher locations. The Execute attributes are initialized to ON.

If Sequential is chosen instead, the current index will be incremented and the correct position stored automatically. This current index is initialized by using the **RECALL** key. The Execute attributes are initialized to ON.

The **EDIT** key is for editing a position memory location. A location consists of the following fields (see “Edit Menu” Appendix C):

The following “Attributes” will determine the characteristics of a memory location, including the velocity and acceleration of an individual memory move, or the role of that location in a program sequence.

Location to edit: Shows location number open for editing.

Coordinate: This is the positional value, entered and displayed in the chosen units-of-measure.

Velocity: Travel to the specified position proceeds at the velocity entered here, in the chosen units-of-measure.

Acceleration: Travel to the specified position ramps up to the specified velocity at the beginning of the move, and slows to a stop at the end of the move, according to the acceleration entered here, in the chosen units-of-measure.

Relative/Absolute: If Absolute is chosen, the coordinate specified is a target position. If Relative is selected, the specified coordinate is a displacement, to be added to the current position.

Pause/Wait: If Pause is selected, the move, when executed in the **RUN** mode, is followed by a pause of the specified number of seconds. If the entry is zero, execution continues immediately to the next location having the Executable attribute set. If Wait is selected, the move, when executed in the **RUN** mode, is followed by a prompt for the operator to press **ENTER** for the program to continue. For more about **RUN** mode see “STEP/RUN,” below.

Loop Count: A number may be entered to specify how many times execution is to return to this location. The default is 0. Which means the move is not repeated. This applies only when this location is reached while being executed in the **RUN** mode.

More about the Servo 3000 Controller

End Loop: A loop can be made to include memory locations further along in the numbering system by turning an “End Loop” to ON at the desired location.

End Program: An “ON” setting will cause all higher memory locations to be excluded from the STEP and RUN modes. When this location is reached by STEP, the next location traveled to will be zero, or the first location to have the Executable attribute set. If this location is reached by RUN, execution is stopped.

More detail about location editing is given below.

The **DELETE** function is requested by holding **SHIFT** while pressing **STORE**. The **DELETE** function offers a choice of deleting a single location or clearing all locations. If delete of a single location (**DELETE LOCATION**) is selected, a prompt for the two-digit location is presented, and when the location is keyed in and entered the deletion is completed. If clearing of all locations is selected instead, a confirmation screen is presented to ascertain the user’s intention, and if this is confirmed, all locations are set to zero, with the End Program, and Unwritten attributes set.

The **RECALL** key presents an entry for the two-digit index, and when both digits are keyed in, the entry value is assigned to the current index and the position value of that location is displayed.

At this phase of operation, the user may use **ENTER** to travel to the position, use **EDIT** to edit some fields at the location, or press **RECALL** again to view the position of another location. The **FWD** and **REV** keys may also be used to scroll through locations and view their positions.

The **DATA OUT** function is requested by holding **SHIFT** while pressing **RECALL**. If you have a computer connected to your controller through the serial port, you may list the contents of all written memory locations using a terminal emulator application. Since many such applications include ASCII download and upload, this provides a way of saving a program or set of coordinates long-term.

The **STEP** key allows moves to the stored positions in a sequence. Any locations having the “Execute Point” turned OFF are skipped over. The first location traveled to is the current index, most recent one to be accessed with the **RECALL** key. Once the last Executable location or one with the End Program attribute is reached, the current index wraps around to zero or the first Executable location.

The **RUN** function is executed by pressing the **STEP** key while holding the **SHIFT** key. Under this function, moves are made to the Executable locations automatically, in sequence. Waits, Pauses and Looping are all included in the **RUN** mode.

Servo 3000 Special Topics

About Velocity Entries

The range of velocity for a standard stage motor ranges from about 1 count per second up to 13,333 counts per second (20,000 rpm using a 10mm mini motor).

A speed slower than this can be attained, although motion would probably be rather unsteady. The top speed, however, is determined by the controller's available supply voltage and the motor characteristics.

Absolute and Relative Moves

To move the stage carriage to a specified place, press the **MOVE ABSOLUTE** key. The lower line continues to display the current position, while the upper line displays zero, both displays being in the currently selected units-of-measure. Now enter the target position from the keypad. If it is to be negative, type the minus sign first. If it is fractional, you may type the decimal point, without any leading zero, followed by the rest of the decimal number. If the number is an integer, a decimal point is not necessary. The **BACKSPACE** key can be used to make corrections.

Once you have keyed in the entry for the target position, press **GOTO**. The stage carriage will now move to this target at the configured velocity.

To move the stage carriage over a specified distance, press the **MOVE RELATIVE** key. The lower line continues to display the current position. If this is the first time you requested a relative move, the upper line displays zero. Both displays are in the currently selected units-of-measure. Now enter the desired distance from the keypad. If it is to be in the negative direction, type a minus sign first. If it is fractional, you may type the decimal point, without any leading zero, followed by the rest of the decimal number. If the number is an integer, a decimal point is not necessary. The **BACKSPACE** key can be used to make corrections.

Once you have keyed in the entry for the target displacement, press **GOTO**. The stage carriage will now move over to your specified distance from the current position at the configured velocity. If you press **MOVE RELATIVE** again the upper line will redisplay the target displacement from the relative move you have just made, making possible any number of equally spaced moves.

Recalling Positions

If you have your controller set for one-touch recall mode, you can move the stage to any of the first 20 stored positions by pressing a numeric key. If you want to recall a position from 0 to 9, press that exact key: **0** for location 0, **1** for location 1, and so on up to 9. If you want a location from 10 to 19, hold **SHIFT** while pressing the numerical key: **0** for location 10, **1** for location 11, and so on up to 19.

If you have your controller set for normal recall mode, press the **RECALL** key, then key in the location number. After you make the entry, the position value is displayed and pressing the **GOTO** key will send the stage to that position in the currently selected units-of-measure, with the location index to the far left.

Now you have a choice. If this is where you want to move the stage, press **ENTER** and the carriage travels to that position. If there is anything you want to change about the position, press **EDIT** to start the position editor. If there are other locations you want to examine, you may press **RECALL** again and key in another index to view the position value of another location. Another way to examine other locations is to use the **FWD** and **REV** keys to scroll through locations and view their positions.

Any locations that were never stored to, or have been cleared by a **CLEAR ALL** request, will display "-----" instead of a position value. Scrolling by means of the **FWD** and **REV** keys passes by these locations, except for the last one 99. If **SHIFT** is held while pressing the **FWD** or **REV** keys to scroll through the locations, the only ones seen are those having the Executable attribute set. For more details on this, see descriptions below of Execute Point attribute, under "**Programming Exercises**".

APPENDIX

MC-4B Factory Settings

Priority	Parameter	Servo 1000	Servo 2000	Servo 3000	NAI default setting	Setting Range
	One-time (infrequent) settings					
X	Acceleration, base			✓	25600	1 to 0.9 x 10 ⁹
*	Backlash compensation	✓	✓	✓	20	0 to 0.9 x 10 ⁹
†	Backlash direction	✓	✓	✓	Normal	
*	Calibration (counts per inch)		✓		51200	1 to 0.9 x 10 ⁹
†	Encoder lines per revolution	✓	✓	✓	10	1 to 0.9 x 10 ⁹
†	Encoder polarity	✓	✓	✓	Normal	
X	Following error			✓	1000	1 to 32767
*	Home offset			✓	0	-0.9 x 10 ⁹ to 0.9 x 10 ⁹
†	Homing direction	✓	✓	✓	Fwd End	
*	Jog free or locked (after stop)		✓	✓	Free	
X	Jog key direction	✓	✓	✓	Normal	
X	Jog multiplier	✓	✓	✓	x 1	1 to 65536
X	Jog step acceleration			✓	512021	1 - 0.9 x 10 ⁹
*	Jog style (step or v-mode/continuous)		✓	✓	V	
	Node number			✓	1	1 to 99
†	PID Deriv TSamp	✓	✓	✓	0	0 to 255
†	PID ILimit	✓	✓	✓	1000	0 to 32767
†	PID KD (derivative gain)	✓	✓	✓	1000	0 to 32767
X	PID KI~ (integral gain)	✓	✓	✓	400	0 to 32767
X	PID KP (proportional gain)	✓	✓	✓	600	0 to 32767
*	Position storage placement mode			✓	By Entry.	
X	Sense of reading	✓	✓	✓	Normal Display	
*	Stage type (Rotary, Linear)	✓	✓	✓	Linear	
X	Velocity base			✓	13333	1 to 0.9 x 10 ⁹
	Table Top User settings					
	Jog rate	✓	✓	✓		
	Memory recall mode (one-touch...)			✓	Normal	
	Rapid rate	✓	✓	✓		
	Units		✓	✓		

Note: The above table shows encoder count units, but the data on the MC-4B display will be in whatever units are chosen.

Priority Ratings:

*Top priority new user operational settings for performance.

†Unlikely settings

XTouch-ups

Choosing Your Settings:

The above settings are chosen for a typical NAI MicroMini™ stage with a 10 mm motor and a 16:1 gearhead. With a 64:1 gearhead, for example, the demands are different, i.e., the lower load on the motor allows or requires; higher velocity, higher acceleration, lower proportional gain, lower integral gain, more backlash compensation, less following error, higher home offset,..

To restore Default Settings, turn off your controller, hold down MENU, SET ZERO, and STEP keys, then power up.

TROUBLESHOOTING and SET-UP ASSISTANCE

Problem	Possible Cause and remedy
Stage runs at full speed out of control to one end.	Encoder direction (menu item) reversed: either because of menu control accident or use with motor of convention other than NAI stages.
Keypad doesn't take entries, or move commands – seems to be locked up	The controller was left in “One Touch Mode” where the number pad becomes dedicated. Low voltage problems in outlet
Locations do not store where you want to put them.	“Sequential” storage mode engaged; use “By Entry” mode
Location numbers in memory are not the same as you left them.	You may have switched storage modes; each has its own 1-99 memory bank. You actually have 198 locations, total. You may have “inserted before” an existing memory location, causing the location to move up a place in the numbering system. (“By Entry” only)
Lock-up	Possible spike – reboot.
Sluggish takeoff and landing	Low base acceleration setting
Sluggish jog steps	Low Jog Step Acceleration setting
Erratic jog steps	Jog step acceleration set too high for the jog step size.
Stops abruptly	Excessive base acceleration
Stage stops before move is completed, re-starts when GoTo is pressed.	Following error related: a) Possible obstruction to motion, including lubrication problems. b) Acceleration and/or velocity too high for current gear-load combination or following error allowance. c) Following error set too low; stall threshold may vary “day-to-day”
Limits don't stop the stage.	Wires to stage limits disconnected or reversed. Conductor # 10 (if ribbon), or black conductor (if round cable) should have continuity to fwd (motor) end of stage by way of connecting stage rail.
Stage overshoots destination before arriving.	P and I gains may be too low, but raising it too high may make the stage jittery. The low resolution encoders may be expected to overshoot 5-8 counts, thereby losing some backlash take-up, shown by the indicator.

OFFER: \$25.00 per new addition to this list.

LIMIT – one per customer, unless you can talk us into more.

(Must make good sense)

“EDIT” Menu
(Servo 3000 only)
For Memory Location Attributes

MENU	EXPLANATION
----- Location to Edit	The memory location of the point chosen to edit 1 - 99
>Execute Point Skip Point	Role of this move in the STEP and RUN functions.
----- Coordinate	Destination to achieve, in whatever units have been chosen on the keypad.
----- Velocity/sec	Velocity of the move to this programmed location only (overrides default base velocity)
----- Accel/sec	Acceleration of the move to the programmed location (overrides default base acceleration)
Move Absolute >Move Relative	Relative move or absolute (relative, if incrementing a large number of equal steps) The “Loop” function can be used to repeat steps at one point during a Step or Run program.
>Pause __sec Wait	A Pause needs a value in seconds. This will invoke a time delay during a “Run” A Wait will invoke a stop point during a “Run” and need for operator to approve continuation. The “Step” function ignores these.
Loop count 0	Turning on and inserting a number n (default 0) will cause the action in this memory location to repeat n times (play back n + 1 times) in “Run” mode. The “Step” function ignores this.
OFF End Loop	If it is turned ON, a whole batch of moves will recycle n times starting with the last preceding point calling for looping n>0 times . No nesting - but there can be several loops of this kind.
OFF End Program	This will allow the user to stop the STEP and RUN functions at any desired spot other than the highest stored location.
Save & Exit >Discard & Exit	For the protection of operator settings, this un-does any accidental edits by default.

Press EDIT Key, then use up and down arrow keys to scroll through attributes. Press MENU key to toggle selection.
To scroll through memory locations, recall any location then use up and down arrow keys. When you find the one you are looking for, hit EDIT to enter edit mode.

MC-4B "MENUS"

"MENU/SELECT" Key

Press MENU, then use up and down arrow keys to scroll. Press "MENU" key again to toggle selection.

Press ENTER when finished making selections and entering values, or press CANCEL to ignore changes.

Servo 1000 MENU
Rotary Motion
>Linear Motion
Home to Rev End
>Home to Fwd End
Reverse Display
>Normal Display
Reverse Encoder
>Normal
Rev Backlash
>Normal
Reverse Dir Key
>Normal

VMode Jog X 1,4,

Backlash Comp

Enc Lns per Rev

PID Kp

PID Ki

PID Kd

PID iLimit

PID derivative tSamp

Servo 2000 MENU
Step Jog
>VMode Jog
Rotary Motion
>Linear Motion
Locked Jog
>Free Jog
Home to Rev End
>Home to Fwd End
Reverse Display
>Normal Display
Reverse Encoder
>Normal Rev Backlash
>Normal
Reverse Dir Key
>Normal
VMode Jog X 1,4,...

Backlash Comp

Counts per Inch

Enc Lns per Rev:

PID Kp

PID Ki

PID Kd

PID iLimit

PID derivative tSamp

Servo 3000 MENU	Explanation
One Touch Mode	"One Touch" 20 hot keys;
>Normal Mode	locations 0-9 and SHIFT+0-9
Step Jog	Jog discreet increments
>VMode Jog	Constant slow velocity
Clear Fwd Limit	Remove soft limits
>Escape	(in menu only)
Clear Rev Limit	Remove soft limits
>Escape	(in menu only)
Store By Entry	Store at user-choice location
>Sequential	Store at end of bank
Rotary Motion	Stage type.
>Linear Motion	
Locked Jog	Servo-locked when stopped.
>Free Jog	Free wheeling after jog move
Home to Rev End	User preference
>Home to Fwd End	
-----	This is how far from the limit
Homing Offset	switch after re-home.
Reverse Display	+ and (-) signs reversed
>Normal Display	on position
Reverse Encoder	Encoder may read opposite
>Normal	commanded motor direction
Rev Backlash	Reverse end of stage up,
>Normal	gravity pulling in fwd direction
Reverse Dir Key	Jog keys will work
>Normal	in either direction.
-----	Jog sensitivity multiplier.
VMode Jog X 1,4,...	Apply any convenient factor:
-----	1,2,3,4,5,.....

Base Velocity	

Base Accel	
-----	Adjusts hardness and
Jog Step Accel	responsiveness of jog steps.
-----	Distance the stage must
Backlash Comp	travel,when reversing
-----	direction, before motion is
-----	reengaged
-----	Encoder counts per inch of
Counts per Inch	travel - can be found empirically
-----	Allowed difference between com
Following Error	manded position and actual
-----	position
-----	Actual number of lines on the
Enc Lns per Rev:	encoder; <i>not quadrature.</i>
-----	See "How to's
PID Kp	
-----	See "How to's
PID Ki	
-----	See "How to's
PID Kd	
-----	See "How to's"
-----	See "How to's"
PID iLimit	
-----	See "How to's"
PID derivative tSamp	

APPENDIX E

Example Servo Settings

Suggested for MC-4B with typical NAI stage configurations

	MM-3M-F, Ex. 1 in. travel 10 mm motor, 16:1 gear	MM-3M-F, Ex. 1 in. travel 64:1 gear, AntiBacklash High linearity	MM-3M-F, Ex. "A-B", 1 in. travel	MM-3M-R Rotary, 16:1 gear	MM-3M-R Rotary, 64:1 gear	MM-3M-RA Rotary Ultra Low Wobble 16:1 gear	MM-3M-RA Rotary Ultra Low Wobble 64:1 gear	MM-4M-F, 25mm travel 10 mm motor, 16:1 gear	MM-4M-Ex. 1 in. travel 13 mm motor, ~14:1 gear	MM-4M-R Rotary Stage 13 mm motor, ~14:1 gear	
Menu Setting	MM-3M	MM-3M	MM-3M	MM-3M	MM-3M	MM-3M	MM-3M	MM-3M	MM-4M	MM-4M	
Rotary or Linear	Linear	Linear	Linear	Rotary	Rotary	Rotary	Rotary	Rotary	Linear	Linear	Rotary
Homing Offset	25,600	102,400									
VMode Jog X 1,4	1	4									
Base Velocity	13,333	13,333									
Base Acceleration	25,600	25,600									
Backlash Comp.	20	35									
Counts per inch/ Counts per rev.	51,200	204,800	204,800	51,200	204,800	51,200	204,800	51,200	70,634	79,464	
Following Error	1000	1000									
PID K _P	600	600									
PID K _I	400	400									

Note: The above table shows encoder count units, but the data on the MC-4B display will be in whatever units are chosen.

Typical MC-4B settings for various stage configurations (as applicable to levels)

Please request updates for more data.

Calibration Settings for Standard Stage Product

Linear Stages:

MM-3M-EX, MM-3M-F, MM-3M-ST and MM-4M-F
(10mm Motor, 10 Position Encoder and 80 TPI Lead Screw)

<u>Gear Head</u>	<u>Counts Per Inch</u>	<u>Counts Per Centimeter</u>
16:1	51,200	20,157
64:1	204,800	80,630
256:1	819,200	322,520
1,024:1	3,276,800	1,290,079

MM-4M-EX

(13mm Motor, 16 Position Encoder and 80TPI Lead Screw)

<u>Gear Head Nominal Centimeter</u>	<u>Gear Head Actual</u>	<u>Counts Per Inch</u>	<u>Counts Per</u>
14:1	13.795918367:1	70,635	27,809

Rotary Stages:

MM-3M-R

(10mm Motor, 10 Position Encoder and 80:1 Table)

<u>Gear Head</u>	<u>Counts Per 360 Degrees</u>
64:1	204,800
256:1	819,200
1,024:1	3,276,800

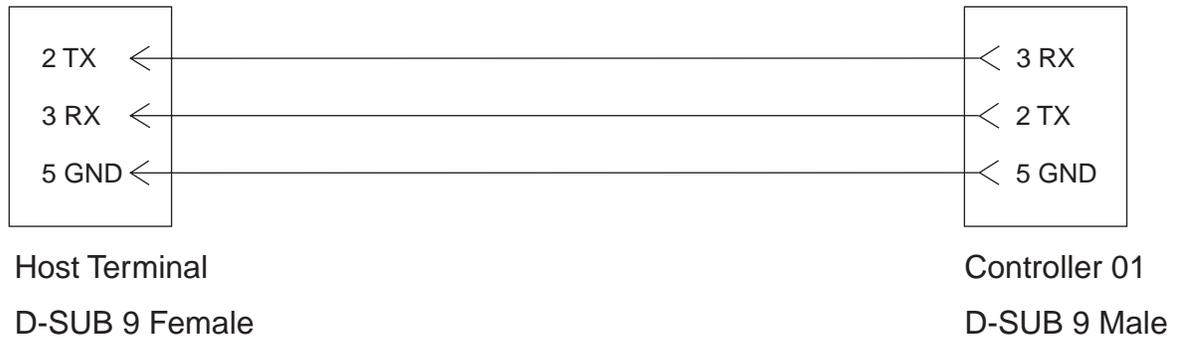
MM-4M-R

(13mm Motor, 16 Position Encoder and 90:1 Table)

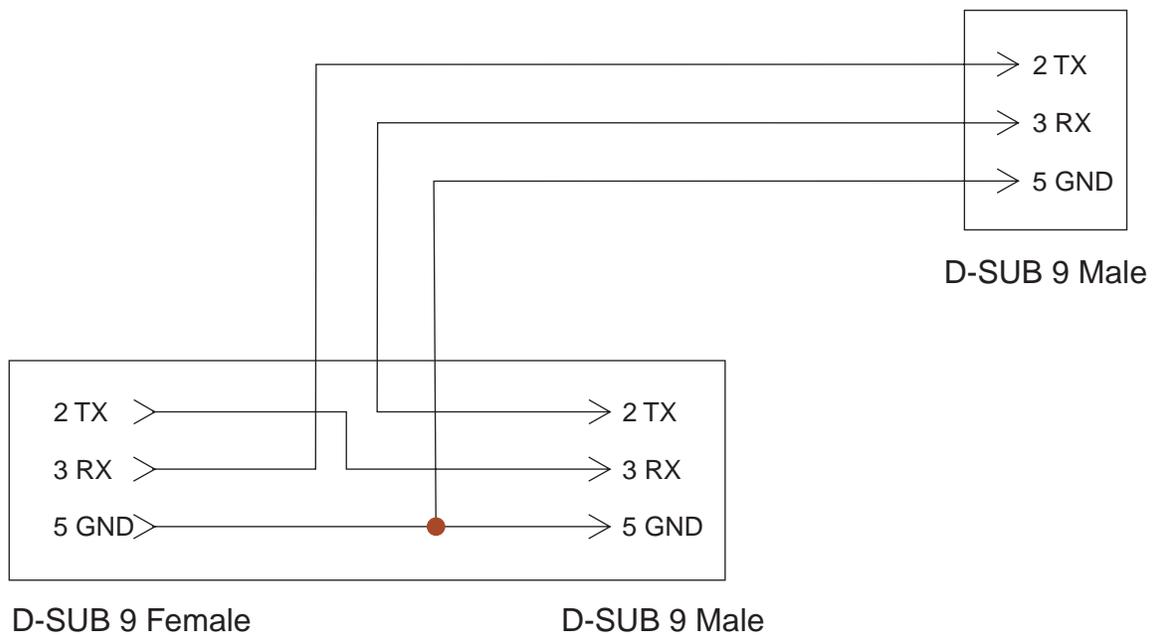
<u>Gear Head Nominal</u>	<u>Gear Head Actual</u>	<u>Counts Per 360 Degrees</u>
14:1	13.795918367:1	79,465

RS-232 Cabling

Standard Null Modem Cable



Network Cable



Motor Connector Pin Assignments:

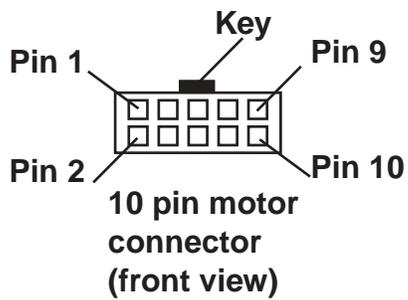
Motor Type: DC, Brush Type

Connector Type: Dual Row IDC

Mating Part: Panduit P/N 057-010-115S (male pin socket with mounting flange)

Note: Mating connectors may be purchased from National Aperture, Inc.

Pin #	Name	Pin #	Name
1	Motor -/+	6	Motor +/-
2	Encoder+V	7	Limit ground
3	Encoder Ch A	8	Limit VCC + 5V
4	Encoder Ch B	9	Reverse limit
5	Ground (case)	10	Forward limit



APPENDIX I

Programming Exercises (Servo 3000)

(Refer to “EDIT Menu”, Appendix C.)

The following examples demonstrate the programming features of the MC-4B Servo 3000. First (A) is a straight-line program and later (B to E) we demonstrate the use of program flow-control attributes, such as looping, delays, and user intervention:

Any memory locations you have programmed will, by default, play in a RUN or STEP operation, in order, according to the location number value. Any of these locations can be later **excluded** from the playback, as will be shown.

To **check your memory** for stored points, first press CANCEL to make sure you are out of all interfering modes. To scroll through your memory locations, press RECALL, then 0, then ENTER, then FWD or REV arrow. If you wish to **clear entire memory** and/or set up in inches, see “Setting Up for Programming and Clearing Memory” below.

Caution: see “By entry” and “Sequential” STORE modes to avoid confusion.

Either take the stage to the desired positions in the desired order and store each one, then proceed as follows, or program entirely from the keypad as follows:

Hint: Use short moves in the range of 0.02 to 0.10 in. to start (Encoder counts may be more convenient for testing).

Keypad Programming Exercises

• *Straight-line Programming Exercise*

A. To utilize the *position and trajectory functions*, create the following example:

1. Press **EDIT** , **0**, and press **ENTER**. The screen reads:

```
00: *0           [You are about to edit positions starting with memory location 00:]  
Location to Edit
```

2. Then press **FWD** (this scrolls down). The screen will change to read:

```
>Execute Point  
Skip Point  
[To “not play this location”, press MENU/SELECT to toggle it, so it points to “Skip Point”.]
```

3. Now press **FWD** again. The screen should read:

```
00: *nnnn -  
Coordinate  
Enter position value you want in the units shown  
[The “*” indicates that the Execute Point attribute is ON.]
```

4. Then press **FWD** to go on to the next field. The screen should read:

```
00:*nnnn  
Velocity /sec  
  (where nnnn in the default velocity as set in the main MENU)
```

5. Press **FWD** to go on to the next field. The screen should read:

```
00:*nnnn  
Accel /sec2  
  (where nnnn in the default base acceleration as set in the main MENU)
```

6. Press **FWD** to go on to the next field. The screen should read:

```
Move Relative  
>Move Absolute  
  [This means that the value in the Coordinate field is a target position, rather than an  
  amount of displacement.]
```

7. Scroll to and select “Save and Exit”, or press shortcut; **SHIFT+SAVE** to save settings.

The above example can be repeated for subsequent locations. Try 7 different points (00: to 06:), just changing the settings to give the desired position, velocity, and, in some cases, acceleration of the move in each memory location.

Now try your program out executing **STEP**, then **RUN**.

• *Exercising Program Flow Control.*

B. To utilize the *timing functions*, create an example using your existing program as follows:

1. Press **EDIT**, 2. Press **FWD** repeatedly to go on to the following field:

```
>Pause 0 sec    [You are inserting a time delay after location 02:]  
Wait  
  [Press MENU/SELECT, if necessary, to move the “>” to the upper line.]  
  Type “1”, for a pause duration of one second.
```

2. Press **EDIT** then 3, then **ENTER**. Press **FWD** to go on to the following field:

```
Pause 0 sec    [You are inserting a user-resumable break after location 03:]  
>Wait
```

3. Scroll to and select “Save and Exit”, or press shortcut **SHIFT+SAVE** to save settings.

Try your program out again, executing **STEP** and then **RUN**. Note that **STEP** does not execute the user breaks and time delays, but **RUN** does.] A user-break (**WAIT**) requires the user to press **ENTER** before resuming.]

APPENDIX I

C. To utilize the cycling (loop) function, repeating only one memory-location move, create an example using your existing program as follows:

[Note: the repeated move must be “relative” move, not “absolute” when looping only one location]

1. Press **EDIT, 4, ENTER**. Press **FWD** to go on to the following field:

```
>Move Relative
Move Absolute
```

[Press **MENU/SELECT**, to move the “>” to the upper line]

2. Press **FWD** again to go on to the following field:

```
Loop count 0 [This 0 means that position does not repeat. It only plays back once.]
Set the value to 3, to get the move (location 04:) to occur 4 times (one original + 3 loops).
```

3. Scroll to and select “Save and Exit”, or press shortcut **SHIFT+SAVE** to save settings.

Try your program out again, executing RUN. Note that memory location 04: repeats 4 times.

D. To include other memory locations in your loop, create an example using the next 2 locations in a cycle:

[Note: the looped moves cannot be nested; so, the multi-move loops may as well be “absolute”, since any “relative” component will play only once in each cycle. But; several of these multiple loops can be created; their natural separations occur at the first “End Loop” points encountered as shown below.]

1. Press **EDIT, 4, ENTER**. Press **FWD** to go on to the following field:

```
Move Relative
>Move Absolute [Select “absolute”]
```

2. Press **EDIT, 6, ENTER**. Press **FWD** to go on to the following field:

```
OFF*           Change to           On*
End Loop       End Loop
```

[You have just created a loop involving 04:, 05: and 06:]

3. Scroll to and select “Save and Exit”, or press shortcut **SHIFT+SAVE** to save settings.

Try your program out again, executing RUN.
Note that sequence 04: 05: 06: plays 4 times.

E. To End a Program at a point other than the highest executable location, modify your existing program as follows:

[Note: If you END in the middle of a multi-loop, only the first “loop” location will repeat]

1. Press **EDIT** , **3**, **ENTER**. Press **FWD** to go on to the following field:

OFF*	Change to	On*
End Program		End Program

[You have just ended your program at location 03:]

2. Scroll to and select “Save and Exit”, or press shortcut **SHIFT+SAVE** to save settings.

RUN your program again. Note that the sequence ends at 03:.

At his point you should try going through your locations, changing parameters such as velocity, location, loop counts, etc. This exercise will help you to become familiar with the valuable and powerful features of the Servo 3000.

SETTING UP FOR PROGRAMMING AND CLEARING MEMORY

To set up the controller in inches and clear all position memories off the board, do the following:

To set up inch units:

1. Press the **UNITS** key until the display is in inches.
2. Press **MENU/SELECT** and scroll down to the Base Velocity field. Type in “.26” and press **ENTER**.

To clear position storage memory:

1. Hold **SHIFT** and press **STORE**. The display reads:

```
Clear All  
>Delete One
```

2. Press **MENU/SELECT** to toggle it, so it points to “Clear All”, then press **ENTER**. The screen reads:

```
Yes, do it  
>No! Cancel!
```

3. Press **MENU/SELECT** to toggle it, so it points to “Yes, do it” then press **ENTER**. Now all locations are initialized (in whichever mode is active; “By entry” or “Sequential”).

APPENDIX J

MC-4B Serial Communication Command And Syntax Reference

All commands begin with a 2-column node index from 01 to 99. If the node index is "00" all MC-4B units on the network will be selected at once, as a broadcast.

nn!p : **Set Parameter**

```
|| |
|| |
|| \-----Parameter
||     a = default acceleration in counts
||     b = backlash compensation in counts
||     e = allowable following error in counts
||     h = homing offset
||     j = acceleration for jogging steps
||     v = default velocity in counts
|| \-----Node Index: 01 to 99; 00 for broadcast
```

nn?p : **Query Parameter**

```
|| |
|| |
|| \-----Parameter
||     a = default acceleration in current units
||     p = PID coefficients
||     s = list all main menu settings
||     u = current units of measure for display
||     v = default velocity in current units
||     x = current motor position in current units
|| \-----Node Index: 01 to 99; 00 for broadcast
```

nnAss[ee] : **Auto-Run Program**

```
|| | |
|| | | \-----ending location for Auto-Run. Optional
|| | \-----starting location for Auto-Run.
|| \-----Node Index: 01 to 99; 00 for broadcast
```

nnCss : **Clear Program Locations to End**

```
|| |
|| | \-----starting location for Clear Program.
|| \-----Node Index: 01 to 99; 00 for broadcast
```

nnDss[ee] : **Dump Program Listing**

```
|| | |
|| | | \-----ending location for listing. Optional
|| | \-----starting location for listing. Optional
|| \-----Node Index: 01 to 99;
```


APPENDIX J

nnSss : **Step Program at Location**

```
|| | |
|| | | \-----location to execute
|| | |
|| | | \-----Node Index: 01 to 99; 00 for broadcast
```

nnUuu : **Set Current Units of Measure**

```
|| | |
|| | | \-----units
|| | |
|| | | \-----Node Index: 01 to 99; 00 for broadcast
```

If the units name is for rotary motion and the MC-4B unit is set for Linear motion, the setting will change to Rotary motion. If the units name is for Linear motion and the MC-4B is set for Rotary motion, the setting will change to Linear motion.

nnasxxxxx : **Move to Position x**

```
|| | | \_____/
|| | | |
|| | | | \-----position in encoder counts
|| | | | \-----sign: '+' or '-'
|| | | |
|| | | | \-----Node Index: 01 to 99; 00 for broadcast
```

nnasxxxxx : **Displace by x Counts**

```
|| | | \_____/
|| | | |
|| | | | \-----displacement in encoder counts
|| | | | \-----sign: '+' or '-'
|| | | |
|| | | | \-----Node Index: 01 to 99; 00 for broadcast
```

Accessories

Remotes:

Using the MC-4B with the Remote Joystick Option

The Remote Joystick module allows jogging and rapid-traversing of the MC-4B controller from a distance, and can be a control center for two MC-4B units.

At the ends of the Joystick case are two modular jacks resembling telephone jacks. The jack on the lefthand side is the horizontal, or “X”, output. The other jack, on the righthand side is the vertical, or “Y”, output. Which jack to use is a matter of preference, but in a two-axis application there may be an obvious X-Y relationship between motor outputs.

On righthand side of the MC-4B controller are also two modular jacks. Connect the cable from the Joystick to the jack closer to the miniature DIN socket.

The MC-4B responds to the joystick input as it would to the jogging keys. Moving the joystick lever halfway from the center causes the MC-4B to jog forward or reverse, depending on which direction the lever was moved. The speed will be what was selected for Jog Rate. Pushing the lever the rest of the way accelerates the MC-4B to the speed selected for Rapid Rate. If your controller seems to be responding backwards, turn it around; you had it upside down. If the controller lags noticeably behind the joystick, increase the Base Acceleration value.

Using the MC-4B with the Encoder Option

The remote Encoder module offers direct proportional control of the motor. Using the Jog Rate Multiplier, the rate of motor counts per Remote Encoder detent may be configured.

Connect the cable to the modular jack on the side of the Encoder case. On righthand side of the MC-4B controller locate similar modular jacks and connect the cable to the one farther from the miniature DIN socket.

Rotating the Encoder dial to the right should cause the motor to move in the positive direction, and vise-versa. With a Jog Rate multiplier value of 1, the motor will move one count for each detent of the Encoder dial, while a value of 4 would produce 4 counts of motor movement per Encoder dial detent, and so on. The Jog Rate Multiplier setting should be reasonable, so that the motor can keep up with the dial rotation.

APPENDIX L

Technical Support

Applications

603-893-7393

603-893-7857 FAX

support@nationalaperture.com

wweber@nationalaperture.com

National Aperture, Inc.

26 Keewaydin Drive

Suite B

Salem, NH 03079

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