LA2000

MODEL 62

LINEAR SERVO AMPLIFIER

USER'S MANUAL

Version 3.01

Motion Control Systems, Inc.
New River, Virginia

www.motioncontrol.org

Table of Contents

1. IMPORTANT SAFETY NOTICE

Read this section before attempting to operate this system.

WARNING: Identify conditions and/or procedures, which could result in personal injury or death.

CAUTION: Identify conditions and/or procedures, which can result in permanent damage to equipment.

1.1 SAFETY GROUND

This product must be grounded. The power cord supplied with the product is for 115 VAC outlets. If the user wishes to provide a different cord for 230 VAC, the cord must have a ground connection. In addition, any device (e.g. motor, control device, etc.) connected to this system must be grounded.

WARNING: Operation without proper grounding can result in a potentially fatal electric shock. Any accessible components (e.g. case, switches, knobs) or peripheral devices are considered "live" if left in an ungrounded condition.

1.2 HAZARDOUS VOLTAGES WARNING

WARNING: Dangerous voltages exist at several places within the enclosure. Disconnect power before and during any disassembly or servicing. Only qualified personnel should service this product.

WARNING: Dangerous voltages exist at the motor supply terminals. Exercise caution when connecting to these terminals, and be sure that no bare conductors are exposed.

1.3 LIFE SUPPORT POLICY

WARNING: Motion Control Systems, Inc. products are not authorized for use as critical components in life support systems without the express written consent of the president of Motion Control Systems, Inc. A critical component is any component whose failure or malfunction could result in the failure of the life support system or the reduction of its safety or effectiveness.

2. GENERAL

2.1 Introduction

The LA2000 is a four quadrant velocity servo amplifier intended to control three phase permanent magnet synchronous motors (commonly called brushless DC motors, since some of their characteristics are similar to ordinary DC motors). The LA2000 motor controller uses a very "quiet" linear power stage and is intended for applications where electromagnetic interference or acoustical noise must be kept to a minimum.

Under normal operation, a brushless motor controller must "know" the position of the rotor in order to commutate the motor to produce torque. The LA2000 obtains rotor position information from a quadrature encoder or Hall Effect sensors.

Systems are intended for computer control through a high level command syntax. This feature allows them to be easily integrated into computer controlled testing or manufacturing equipment. For other applications, see Section 6.1 Control Section.

The motor controller unit is intended for cabinet mounting. See Section 3.2 Mounting, for a mounting diagram.

2.2 Warranty

Motion Control Systems, Inc. (MCS) warrants that all products it manufactures shall be free from defects in materials and workmanship for a period of ninety (90) days from the date of shipment, provided that such products have been subjected to proper and normal use, and further provided that MCS receives written notice from the purchaser setting forth the nature and extent of the defect within the warranty period. The obligations of MCS under this warranty are limited to, at its option, the repair or replacement, free of charge, of any product covered by this warranty. The product must be returned with prior written consent to MCS, or as it may direct, with transportation charges prepaid by the purchaser.

MCS shall in no event be liable for any breach of warranty in an amount exceeding the purchase price, nor for any special, consequential, or incidental damages.

This warranty is in lieu of any and all other warranties, expressed, implied, or statutory including implied warranties of merchantability or fitness.

Normal procedure requires that defective products be shipped prepaid and with prior written consent to MCS for repair. However, under certain extreme circumstances and at the purchaser's request, MCS can provide on-site service. The cost of this service is $750.00 per day plus travel and lodging expenses, with a $250.00 per day surcharge during weekends and holidays. A purchase order must be issued and received by MCS prior to departure of MCS service personnel.
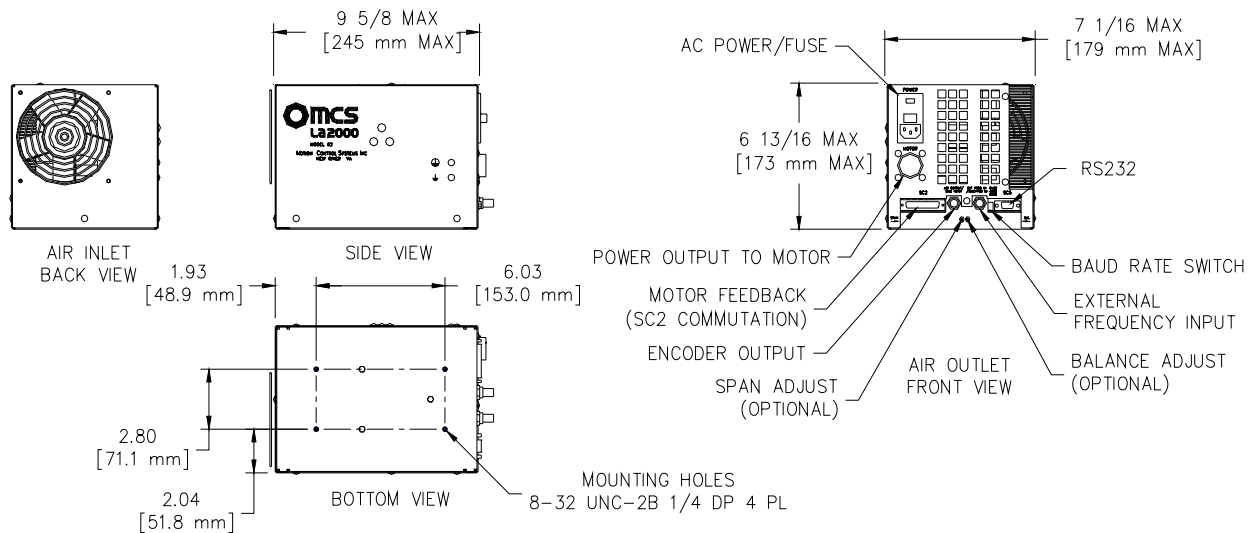
3. INSTALLATION

3.1 Unpacking

Remove the unit from its shipping container. Inspect the unit for shipping damage. Check the system configuration information at the rear of this manual before attempting to connect or operate the unit.

> CAUTION: Do not attempt to operate the unit if there is damage, or if it is improperly configured. Instead, contact MCS.

3.2 Mounting

The amplifier mounts through 4 tapped holes on the bottom of the unit. The holes are for screws size 8-32. Be sure not to block the front (air exhaust) or the back (air inlet) of the controller. All connections to the amplifier are on the front on the unit, therefore be sure to leave enough room at the front of the unit for wiring. Below is a diagram of the mounting hole locations. See Appendix A1 for a more detailed drawing.

9 5/8 MAX
[245 mm MAX]

7 1/16 MAX
[179 mm MAX]

AC POWER/FUSE

6 13/16 MAX
[173 mm MAX]

RS232

AIR INLET
BACK VIEW

SIDE VIEW

POWER OUTPUT TO MOTOR

BAUD RATE SWITCH

1.93
[48.9 mm]

6.03
[153.0 mm]

MOTOR FEEDBACK
(SC2 COMMUTATION)

EXTERNAL
FREQUENCY INPUT

ENCODER OUTPUT

AIR OUTLET
FRONT VIEW

BALANCE ADJUST
(OPTIONAL)

2.80
[71.1 mm]

SPAN ADJUST
(OPTIONAL)

2.04
[51.8 mm]

BOTTOM VIEW

MOUNTING HOLES
8-32 UNC-2B 1/4 DP 4 PL

3.3 Ambient Conditions

Select a location free of excessive dust, coolants, vibration, corrosives, condensation, flammable materials, etc. Select a location having a non-condensing ambient temperature between 0 and 40°C, and humidity below 80%. Although the motor controller is protected by a thermistor, ambient temperature must be kept as low as possible, since high temperatures can degrade performance and reliability.

3.4 Air Flow Requirement

The motor controller has a built-in fan for cooling, which exhausts out of the front of the unit. Do not obstruct the fan, or any other vents, as this may cause the unit to overheat.

3.5 System Wiring

Use the System Wiring diagram in Appendix C as a reference when connecting the system.

> CAUTION: The system must be connected with the power OFF, unless otherwise instructed.

3.6 Power Supply

An IEC connector is provided on the front of the unit for power entry. Units are field configurable for 115/230 VAC operation through the power entry module. To change the input voltage configuration, pull down the top latch of the module and remove the fuse holder/voltage selector. Put the fuse holder/voltage selector back in the module with the desired input voltage reading right side up through the window. Below is a drawing of the module with the latch closed and opened.
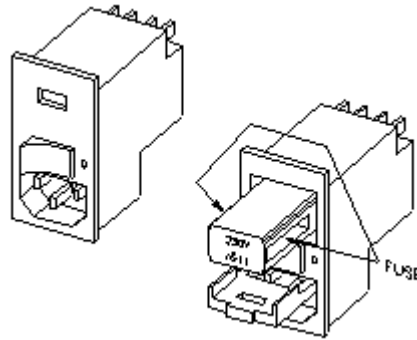
3.7 Motor Phase Sequence Convention

Designate the motor leads as "W," "V," and "U" such that the sequence W-V-U causes positive rotation of the motor when rotating in the CW (clockwise) direction. The CW direction is defined by looking at the direction of shaft rotation from the non-lead side of the motor. The lead side is the side of the motor or spindle at which the motor lead wires exit. If you view the output of the motor while it is disconnected from the controller and being spun clockwise by hand, the output on an oscilloscope should look as follows:
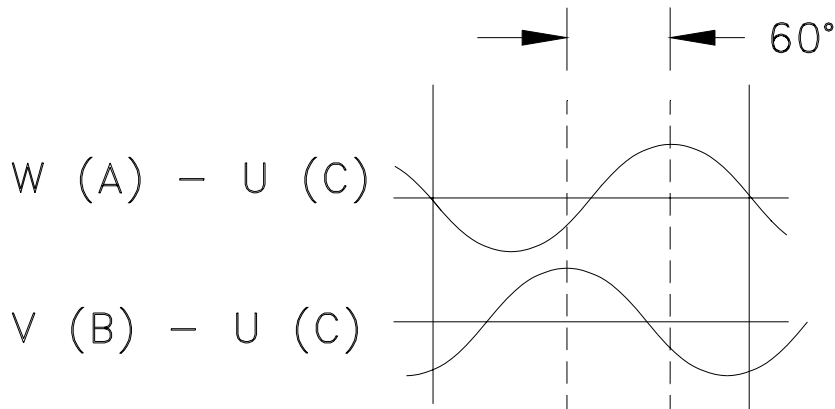
Motors manufactured by MCS will have the W, V, and U motor phase leads marked or color coded as follows:

    W   white
    V   black
    U   red

Some motors manufactured by MCS will have all phase windings distinct. In this case, the motor will have six motor power leads, two per phase. This permits either a wye or delta connection. Such a motor will have its leads designated as U1, V1, W1, U2, V2, W2. Table 3.1 shows the different configurations for the leads in wye and delta connections.

<div align="center">

Table 3.1
Motor Connection

</div>

For Wye connection:	For Delta Connection:
phase W: W1	phase W: U2, W1 (connect together)
phase V: V1	phase V: W2, V1 (connect together)
phase U: U1	phase U: V2, U1 (connect together)
U2, V2, W2 (connect together)	

3.8 Motor Power Connection

The power to the motor is supplied through a CPC plastic connector on the front panel. This connector is intended for connection to three-lead motors. Table 3.2 shows the pin out for the motor power connector.

<div align="center">

Table 3.2
Motor Power Connector

</div>

Pin	3-Lead Motor
1	Phase W
6	Phase V
8	Phase U
14	Ground

Mating Connector: AMP 206044-1   Mating Pins: AMP 6636102

3.9 Encoder Connection

The amplifier has a 5V, 750 mA (max) power supply available for powering an encoder. The encoder connects to connector SC2 on the front of the unit. Connections are shown below in Table 3.3. Use differential encoder outputs whenever possible to reduce the effects of ambient electromagnetic interference. Use the "**CONFIG?**" command to determine if your system is configured for single ended or differential inputs. See Section 4.2.3.2 Commands for the Configuration Mode, if you need to change the configuration.

Table 3.3
Encoder Connections

Designation	SC2 pin
+5V supply	1
Data A	2
Data B	3
Index	4
Data /A	20
Data /B	21
/Index	12
Encoder Common	9

To determine the correct convention of the A and B inputs, apply power to the encoder and rotate the shaft or rotor in the CW direction. The A input should lead the B input by transitioning from 0 to 1 while B is at 0. To determine whether the system is set up properly, rotate the motor in the CW direction. While the motor is rotating, issue the "DIR?" command to the serial interface. If the system responds with "CW" then the encoder is wired properly. If it responds "CCW," switch the encoder A and B inputs. It is important that the command is issued while the spindle is rotating smoothly, because the motor momentarily reversing could result in the wrong status reported back. To view both the A and B inputs, use a breakout fixture for the SC2 connector. The Individual BNC outputs can be measured at the front panel BNC output (But not both at the same time).

Correct encoder outputs for CW rotation (as viewed at the input of SC2):
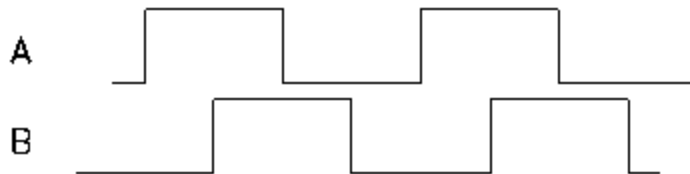
3.10 Hall Effect Timing

Hall Effect devices are used by the controller to determine the position of the rotor with respect to the stator. The proper phasing of the Hall sensors is essential to proper motor operation. To determine the correct phase, rotate the motor CW and display the waveforms described below on an oscilloscope to determine whether the Hall Effect devices are properly phased.
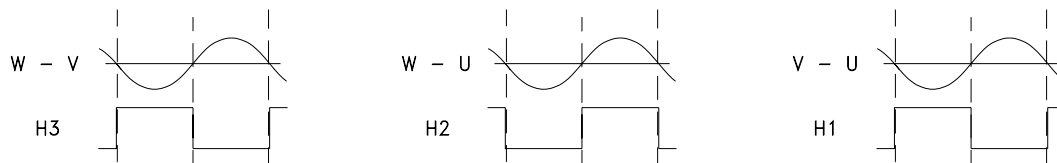
For motors manufactured by MCS, the correct phasing is as follows:

Wire Color	Pin Connection
Red (+5V)	SC2-1
Black (GND)	SC2-9
Yellow (H1)	SC2-15
Green (H2)	SC2-16
White (H3)	SC2-17

3.11 Interlocks

There are two types of interlocks, internal and external. Internal interlocks are those protecting the motor controller. External interlocks are those related to the user's equipment and are connected to the drive through the SC2 connector. All interrupts are active high, which means that for a no-fault condition there must be 0V (logic common) at the input of the controller. Unused interlocks can be disabled by connecting them to ground or using the "**DISFAULTS:WXYZ**" command (see Section 4.2.3.2 Commands for the Configuration Mode). Table 3.4 shows the pin outs of the interlocks and their functions.

Table 3.4 Interlocks

Interlock	Pin	Function
Auxiliary Interlock	SC2-7	Disables the controller
Main Air Sense	SC2-14	Stops the controller
Bearing Air Sense	SC2-18	Stops the controller
Clamp Air Sense	SC2-19	Disables the controller
Amp Overtemp	Internal	Disables the controller
Logic Power Fault	Internal	Disables the controller
Transformer Overtemp	Internal	Disables the controller

Logic Common is available on SC2-8, 9, and 25.

Auxiliary Interlock: The normal use for this interlock is to run wires from pin 7 and logic common out along any cable connected to SC2 and connect the wires after the last connector. This will cause the system to fault if the cable becomes disconnected or severed. This interlock is also compatible with Motor thermistors if your motor is equipped with this type of over temperature detector.

Main Air Sense, Bearing Air Sense, Clamp Air Sense: These are all customer configurable interlocks. If not used, they may be tied to logic common or disabled through the "**DISFAULTS:WXYZ**" command.

Amp Overtemp: This is an internal fault, which will disable the controller if the temperature on the heatsink reaches 60°C. If this fault occurs, verify that the fan inlet or outlet is not obstructed and that the ambient temperature does not exceed 40°C.

Logic Power Fault: This fault occurs if the internal logic voltages exceed their limits.

Transformer Overtemp: This fault disables the transformer when it reaches approximately 100 °C.

3.12 Initial Adjustments

Before attempting to operate the system, some adjustments to the motor and to the controller may be necessary. Read each section thoroughly before attempting each adjustment. In particular, understand the Motor Phase Sequence Convention (Section 3.7) before making the adjustments.

Most motor controllers provided as systems will not need adjustment. However, MCS recommends that the user verify that the adjustments meet the application's requirements.

3.12.1 Commutation Adjustment for Encoder Systems

Commutation adjustment requires the mechanical alignment of the encoder index to an optimal angular location with respect to the motor. This adjustment allows the system to use the minimum current to produce a given torque. Make initial adjustments only if the unit is configured to use the encoder index output. This configuration is specified using the "**TYPE:07**" command from the configuration menu.

> NOTE: If the motor and encoder were shipped as a completely assembled system, MCS has already made the adjustment. In this case, further adjustments will not be necessary.

> NOTE: A "breakout fixture" on connector SC2 is helpful for this adjustment. It may also be convenient to configure the BNC output to be the index on the front panel.

> CAUTION: Use care when making this adjustment, since encoders are delicate instruments. A mis-adjustment of the index could cause reduced torque and motor heating.

The index input is edge-sensitive and will detect active-high or active-low index pulses. The index input will detect the falling edge for CW motor rotation or the rising edge for CCW rotation. (see Section 3.7 Motor Phase Sequence Convention).

To set the index, power up the system and rotate the motor shaft (or rotor) in the CW direction. You should observe a once-per-revolution index pulse. Set the motor shaft position near the present index. This will minimize the adjustment required.

Go to the configuration menu (Type **CONFIGURE**) and change the commutation type to 1 (Type **TYPE:01**). Write to the eeprom (**WRITE**) and cycle power to the drive. Set the torque to about 25% (**TORQ:025**), and enable the amplifier (**EN**). The motor will seek a position and lock there. Set the index to this position. Test the adjustment by turning the motor a few degrees, and see that it returns to the index position. Disable the amplifier (**DIS**). Change the commutation back to 7 (**CONFIGURE**, **TYPE:07**), and then write to the eeprom (**WRITE**). Cycle power to the drive and verify operation.

3.12.2 Commutation Adjustment for Hall Effect Systems

When using a motor with Hall Effect devices and an encoder, this configuration is specified using the "**TYPE:06**" command from the configuration mode. It is normally not necessary to adjust the timing of the Hall Effect sensors, but certain occasions warrant it. To adjust the timing on the Hall sensors use the "**ANGLE:XXX**" command from the configuration mode. The standard timing angle is 270. To adjust in the CCW direction, use a number slightly less than 270. To adjust in

the CW direction, use a number slightly larger. For applications requiring a different angle for each direction, use the "**OFFSET:XX**" command. For example, you may find that better performance is achieved in the CW direction with an ANGLE of 285 while in the CCW direction better performance is realized with an ANGLE of 255. This would be require "**ANGLE:270**" and "**OFFSET:15**" to be programmed in the unit. This adjustment cannot be made while the motor is running. To adjust, disable the controller and enter the desired value. Be sure to use small increments, as large changes could cause improper system operation and excessive motor and amplifier heating. When you find the correct value, be sure to save the setting by entering the configuration mode and writing to the EEPROM with the "**SAVE**" command.

> WARNING: MCS strongly recommends against adjusting this value since improper adjustment can cause reduced torque, motor heating, amplifier heating or a runaway condition. When modifying the **angle** or **offset**, use the **overspeed** and a lower **torque** limit to prevent problems that may result from improper motor commutation.

3.13 Encoder Outputs

The encoder output BNC is selectable through software. Use the command "**BNCOUT:X**" to select the desired output, with X equaling A, B, or I. This command is accessible in the Normal and Configuration Modes. At power-up, the state of this output is determined by writing to the EEPROM after selecting the appropriate signal. The output is TTL level and is capable of driving a 50W load (terminator).

4. USER INTERFACE

4.1 General

The Model 62 can be controlled using the RS232 interface, or the external enable and request signals. When using serial communications, the drive responds to high-level commands from the host computer. Motor and controller status information is available through commands.

There are several options for enabling the drive. The external enable and torque inputs can be configured to suit a variety of input needs. See Section 4.3 External Input Modes for more information on these modes.

In this section, "host" refers to any computer, terminal, etc. "System" refers to this amplifier servo system, which is under the control of the "host."

4.2 Serial Communications

4.2.1 Hardware Description

The serial interface meets EIA RS-232C specifications. A DB-9 connector (labeled "SC5 RS232") is available on the front of the unit. Communication parameters for the system are 8 data bits, 1 stop bit, and no parity. The LA2000 does not use any type of hardware or software handshaking. If hardware handshaking is enabled on the host system, those pins must be disabled. Baud rate is selectable through a dip switch on the front of the unit. The template on the front panel indicates the proper direction for each baud rate. The LA2000 requires a null modem cable in order to communicate. If one is not available, Pins 2 and 3 should be crossed in the cable. Table 4.1 shows the pin out for the RS232 connector.

Table 4.1
RS232 Connector Pin Out
Mating Connector DB9P (male)

Amplifier		Connect to	Standard Serial Port		
Pin	Function		DB25	DB9	Function
1	Ground	------------	1		Shield
2	Receive	------------	3	3	Transmit
3	Transmit	------------	2	2	Receive
4	Term. Rec.				
5	Ground	------------	7	5	Ground
6	At 0 Speed				
7	Term. Xmit				
8	At Speed				
9	+5V				

NOTE: The LA2000 RS-232 interface does not employ hardware handshaking.

4.2.2 Command Syntax

Commands are ASCII strings, terminated by a carriage-return character (ASCII 0DH). Multiple commands are entered as one string by separating them with semicolons. The maximum command length is 100 characters. Characters after the 100 character maximum are ignored until another carriage-return character is entered. A carriage-return at the end of the command string will initiate the action of decoding the entire command string.

If a command string cannot be accepted due to transmission or syntax errors, the system will respond with an error code followed by a "?" and a line feed character (ASCII 0AH). Descriptions for the error codes are given in Table 4.2 below. If the command string is accepted, the system will respond with a line feed character.

Some commands require the system to respond with certain information. These responses are in the form of ASCII strings terminated by a carriage-return and line feed character sequence. The interpretation of the error code is as follows:

Table 4.2

Code (dec.)	Meaning
0	Unrecognized Command
2	Invalid Torque Request
3	Invalid Speed Request
4	Transmit Buffer Full
5	Input String Too Long
6	Invalid Word Size
7	Invalid Stop Setting
8	Other Invalid Setting
9	Can Not Unclamp
15	Power-Up

4.2.3 Command Summary

Commands are not case-sensitive. In the following descriptions, any quotes shown are not part of the commands or responses. Commands are divided into three sections, where each represents a different mode of operation (**Normal, Configuration,** and **Diagnostic**). There is also a quick reference, which briefly lists the commands in Section 9.

4.2.3.1 Commands for Normal Mode

ACCEL:XXXXX   Sets the acceleration rate in RPM/sec. XXXXX is a 5-digit number from 00001 to 20000. Note that 00000 is invalid and defaults to 00001.

ACCEL?   Returns the value of **ACCEL:XXXXX** command.

ATSPD?   Returns a "**YES**" if the motor is within the speed range as set by the **SPD:XXXXX** command.

BNCOUT:X   Selects the output from the front panel BNC output. X equaling A, B, or I selects the appropriate encoder signal for output.

CCW   Commands counterclockwise rotation.

CLAMP	Causes the motor or spindle chuck clamp to lock down onto the work piece or disk.
CLAMPRUN	Performs a CLAMP and a RUN command in sequence.
CONFIG?	Responds with system configuration information in the following form:

Speed:
Torque:
Direction:
Acceleration:
Acceleration: (on/off)
Topspeed: Stop Speed:
Frequency: (internal/external)
System Control: (local/remote)
Polecount:
Encoder Linecount:
Commutation Type:
Angle:
Deceleration:
Encoder Type: (Differential / Single-ended)
BNC Output: (A, B, or I)

CONFIGURE	Enters the Configuration Mode.
CW	Commands clockwise rotation.
DECEL:XXXXX	Sets the rate at which the system decelerates after a stop command is given. XXXXX is a number in RPM/sec between 00001 and 20000.
DIR?	Requests direction status. Returns CW for clockwise and CCW for counterclockwise.
DISABLE or DIS	Disables the unit. Similar to STOP, except the motor coasts to zero speed, rather than being braked to a stop.
DIAGNOSTIC	Enters the Diagnostic mode.
DUMPX	These commands allow the user to view the internal parameter settings of the EEPROM. X is a number from 1 to 4.
ENABLE or **EN**	Commands the controller to enable after a DISABLE command. Similar to RUN.
ENABLE?	Requests the enable status. The system responds with an ASCII string: "ENABLED" or "DISABLED."
FAULT?	Requests the system fault status. The system responds with the ASCII string "FAULT" if there is a fault condition, otherwise it responds with "OK."

FLT?   Requests system fault status. The system responds with the ASCII string "xy."

The first character ("x") is decoded as follows:

Bit	Meaning if Set
7 (MSB)	General Fault
6	Reserved
5	Reserved
4	Reserved
3	Auxiliary #1 Fault
2	Logic Power Fault
1	Amplifier Over Temperature
0	Reserved

The second character ("y") is decoded as follows:

Bit	Meaning if Set
7 (MSB)	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Over Speed Fault
2	Main Air Fault
1	Clamp Air Pressure Fault
0	Bearing Air Pressure Fault

FLTA?   Same as the FLT? command except the word is ASCII.

FLTQREAD?   Returns the first value of a queue of stored values from previous faults. The returned values are interpreted just as those returned by the FLT? Command. This command allows for a review of faults, which occur and clear before a standard FLT? command can be issued.

HOME   This command sets the position feedback to a value that is +/- one half the number of counts per revolution, with the index position being 0. For example if there are a total of 2048 counts per revolution then this command would return a value from 1023 to -1024. This command is useful when you want to reset the POSITONQ feedback value after velocity control or after a long move.

ID?   Requests the controller to send back its identification information as an ASCII string. The system responds with :

LA2000
MODEL: "62"
SERIAL: "A"
VERSION: "B"
CONFIG CODE: "C"

"A" is an ASCII string containing the serial number as shown on the nameplate. "B" is the installed software version number.
"C" the installed config code for the amplifier.

LOCAL	In systems with a hand held terminal, the terminal becomes the controller of the system when this command is issued.
LOKDLY:XXXXX	Sets the time interval defined as the time that the motor is at speed to the time that the ATSPD? command will return an acknowledgment that the motor is at speed. Input a longer time interval to ignore speed overshoots. XXXXX is an arbitrary counter value, between 00001 and 10000, where each count is about 30 msec. The default power-up value is 00001.
OFFSET:XX	Sets a direction dependent amount of offset from 0 to 99 to be added or subtracted to the base motor commutation angle as input with the ANGLE:XXX command. OFFSET is added to ANGLE for CW motor rotation and subtracted from ANGLE for CCW motor rotation (See section 3.12.2).
RAMPIN	Activates the acceleration ramping as set by the ACCEL:XXXXX command. The default power-up state is RAMPIN.
RAMPOUT	Deactivates the acceleration ramping as set by the ACCEL:XXXXX command.
READY?	Requests the ready status. The system responds with the ASCII string "YES" if ready, otherwise "NO."
REMOTE	In systems with a hand held terminal, this command disables inputs from the terminal and leaves the system controlled by the RS232 interface. (see also the LOCAL command).
RUN	Commands the motor to accelerate to the requested speed. Same as the ENABLE command.
SPEED:XXXXX	Sets the requested speed to XXXXX RPM. Where XXXXX is a 5-digit number from the Stop Speed to 32000. If a speed is requested that is less than the Stop Speed, the drive will respond with the invalid speed request error code.
SPD:XXXXX	Same as the SPEED:XXXXX command.
SPEED?	Returns the value of the SPEED:XXXXX command.
SPDAVG:XXX	Sets the number of speed readings that are averaged when calculating speed values that are used internally or returned by the SPD? command. XXX is a value from 001 to 010 and the default power-up value is 001. Commands that use motor speed in their calculations are slowed by values higher than 001. This is particularly noticeable when reading the Motor-At-Speed and the Speed=0 bits in the STAT? byte.
SPD?	Requests the current speed. The system responds with an ASCII string "XXXXX.X", where X is a digit from 0 to 9. XXXXX.X is the speed in RPM.
STAT?	Requests system status. The system responds with an ASCII string "xy". The first character "x" is decoded as follows:

Bit	Meaning if Set
7 (MSB)	System Fault
6	Reserved
5	Direction Status, 1 = CCW, 0 = CW
4	Motor at Speed, 1 = at speed
3	Speed = 0
2	Reserved
1	System Ready
0	System Enabled

The second character "y" is decoded as follows:

Bit	Meaning if Set
7 (MSB)	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	Reserved
0	Chuck is Clamped

STATA? Same as the STAT? command except the returned data is in ASCII.

STOP Commands the motor to decelerate to zero speed and the controller to disable when the motor speed is less than the stop speed. Adjust the disable speed threshold with the STOPS:XXXXX command.

STOPUNCLAMP Performs a STOP and UNCLAMP in sequence.

STOPS:XXXXX Sets the speed at which the motor controller disables after a receiving a STOP command. XXXXX is the motor speed in RPM. The power-up default value is 00030 RPM.

TORQUE:XXX Sets the torque limit to XXX percent of full scale. XXX is a 3-digit number from 000 to 100.

TORQ:XXX Same as the TORQUE:XXX command.

TORQUE? Returns the value of the TORQUE:XXX command.

UNCLAMP Causes the motor or spindle chuck to open or unclamp the disk or work piece. Sending this command while the motor or spindle is rotating results in an error.

ZERO? Requests the zero speed status. The system responds with the ASCII string "YES" if the system speed is zero and "NO" if the motor is still turning.

4.2.3.2 Commands for Configuration Mode

In order for configuration changes to take effect every time the controller is powered up, be sure to use the WRITE command to save the configuration information.

ANALOGIN   Configures the drive for Analog mode. The torque request is external, as is the enable signal.

ANALOGOUT   Returns the drive to Normal mode. The torque request is internal and the drive is operating from the RS232 interface.

ANGLE:XXX   Sets the motor commutation angle from 0 to 359 in electrical degrees (See section 3.12.2) **.**

BNCOUT:X   Selects the output for the front panel BNC output. X equaling A, B, or I selects the appropriate encoder signal for output.

DISFAULTS:WXYZ   Enables or disables certain faults based on the hex numbers WXYZ. The hex numbers WXYZ are transmitted to the controller as characters (0-9, A-F) using standard hex notation.

                          W corresponds to:

Weight	Meaning
8	Reserved
4	Reserved
2	Reserved
1	Reserved

                          X corresponds to:

Weight	Meaning
8	Auxiliary Fault
4	Reserved
2	Reserved
1	Reserved

                          Y corresponds to:

Weight	Meaning
8	Reserved
4	Reserved
2	Reserved
1	Reserved

                          Z corresponds to:

Weight	Meaning
8	Overspeed
4	Main air Fault
2	Clamp Air Pressure Fault
1	Bearing Air Pressure Fault

To disable a fault, add up the weights of the faults you want to disable for each of the four hexadecimal characters. Check System Configuration (Section 10) for the faults that were installed when unit was shipped.

ENCODERCOUNT:XXXXX   Sets the encoder line count.

ENCODERTYPE:X   Selects whether the encoder is single-ended or differential. If X is an S then the drive is in single-ended mode, and if X is a D the drive will be configured for differential inputs.

EXTEN   Causes the drive to be enabled using the external enable signal on pin SC2-6. The amplifier will also use the external direction input on pin SC2-15 to determine what direction to run. A "0" on the direction input selects CCW rotation, a "1" selects CW.

EXIT   Exits from the Configuration mode back to the Normal mode.

FLLEXTERNAL   Sets the FLL request frequency input to the front panel BNC.

FLLINTERNAL   Sets the FLL request frequency input to the internal synthesizer.

INTEN   Causes the system to accept enable and direction commands over the RS232 interface as opposed to the external inputs.

LOCALIN   On power up, starts off in LOCAL mode as opposed to REMOTE.

LOCALOUT   On power up, starts off in REMOTE mode as opposed to LOCAL.

MINSPDIN   Configures the drive for a special mode that is applicable only when the drive is in external frequency input mode. The command allows the user to use the stop speed to set up a minimum speed at which the drive will enable. If the external frequency is above the stop speed, the drive will enable and operate normally; frequencies below this speed will stop the drive. The derivation of what frequency input corresponds to which speed is given in Section 6.1.1 Velocity Loop Control.

MINSPDOUT   Configures the drive for normal operation with external frequency.

OVERSPEED:XXXXX   Sets the speed in RPM at which an overspeed fault will occur.

POLES:XX   Sets the motor pole count.

POWERUPVALS   Sets the current Speed, Torque, Acceleration, and Direction parameters as the system defaults. Use the WRITE command afterward to make the changes effective on power-up.

READ   Retrieves old configuration data and wipes out any new configuration data.

STOPS:XXXXX   Sets the speed at which the motor controller disables after receiving a STOP command.

TOPSPEED:XXXXX Sets the top selectable speed for the motor.

TYPE:XX Selects type of commutation. If you are using a motor with an encoder and Hall Effect devices this number is 06. If you are using a motor with only an encoder the commutation type is 07. Type 01 is temporarily used when setting up the encoder position for type 07 commutation. See section ??? for more details.

      WARNING: It is important that this number is correct. The amplifier employs a different commutation scheme for a motor with Hall Effect devices.

WRITE Writes the new values of the configuration to the EEPROM. Use this before exiting the Configuration mode. The unit must be powered down and powered back up again for the new configuration to be valid.

4.2.3.3 Commands for Diagnostic Mode

COMMUTATION? Requests the type of commutation used by the system. This number should be 6 if you are using a motor with Hall Effect devices and an encoder; it should be 7 if the motor only has an encoder.

EXIT Exits from Diagnostic mode back to Normal mode.

POLES? Requests the configuration pole count.

4.3 External Input Modes

4.3.1 TTL Interface

The Model 62 has the ability to accept external direction, enable, and frequency request signals. This allows for a very simple user interface to the drive. In order to configure the drive for using the external enable and direction signals, use the "EXTEN" command in the configuration mode. If the drive is also configured for external frequency operation then the speed will correspond to the external frequency input (see Section 6.1.1 Velocity Control Loop). If the internal frequency synthesizer is selected the motor controller will go to whatever speed is the power-up default, which is set with the "POWERUPVALS" command in the configuration mode. To enable the drive pull SC2-6 to logic common. A logic 1 (+5V) corresponds to CCW rotation, while a 0 or logic common will cause CW rotation.

4.3.2 Analog Interface

The analog interface option allows the drive to be interfaced through standard +/- 10V analog signals. Control loops must be closed external to the drive, as torque control is the primary mode of operation with the input voltage corresponding to the amplitude level of the current in the motor. The scaling is 1V = 1A. Positive signals cause CW rotation, and negative signals cause CCW rotation. "ANALOGIN" is the command, which puts the drive into this mode. The drive is enabled through SC2-6, and the torque input is SC2-5.

CAUTION: When running in the Analog Interface mode, there is no torque limiting done internal to the amplifier. This could cause runaway conditions and damage to the drive, so be sure that any external loop is properly set up before enabling the drive with full current.

5. OPERATION

5.1 Power-Up

WARNING: Before powering up for the first time, be sure that the system has been installed correctly. Refer to the Installation section.

CAUTION: Improper installation may cause damage to the unit.

Applying power sets the internal scale factors and auxiliary outputs to the power-up configuration. The configuration is dependent on the default settings for your system. These values are listed in Section 10 System Configuration Information (back folder). You are able to change the default Speed, Acceleration, Torque, and Direction values by using the POWERUPVALS command. See Section 4.2.3.2 Commands for the Configuration Mode.

In encoder equipped systems, when the unit is enabled after power-up, it goes into an encoder initialization state. In this state, the motor is locked in a known position to initialize the position counter. This state lasts about 10-15 seconds, after which the commutation logic automatically goes into its normal operating mode.

CAUTION: After the lockup state the motor could turn in the wrong direction momentarily. If this is not allowable in the system, MCS suggests using Hall Effect devices along with the encoder to ensure proper startup.

This does not apply to Hall Effect systems, since absolute position is always known.

5.2 Normal Operation

5.2.1 Communications Controlled Systems

After the amplifier has powered up, it is ready to accept commands. Refer to Section 4.2.3 Command Summary. Input a speed (SPEED:XXXXX) and direction (CW or CCW) command, followed by a RUN command in order to start motor rotation.

Under normal operation, the amplifier can be in either an Enabled, a Stop, or a Disabled state. When Enabled, the system is in servo and the amplifier is controlling motor currents in such a way as to hold the motor at or accelerate it to its set speed.

When in the Stop state, the motor is commanded to decelerate to the stop speed (see STOPS:XXXXX command description) and disable. If the motor kicks back in the wrong direction at the end of a stop, increase the stop speed. If the motor spins down too long, decrease the stop speed.

When in the Disabled state, the amplifier is effectively commanding zero motor current, allowing the motor to spin freely. In this state, the amplifier does not transfer power to or from the motor.

5.2.2 Interlocks

Interlock circuits continually monitor certain conditions external and internal to the unit. The interlocks disable the amplifier if these conditions stray outside of specified limits. In addition to the standard interlocks, the user can configure auxiliary inputs to monitor specific external conditions. Those conditions that cause the interlocks to disable the amplifier are called FAULT conditions. After receiving a fault condition, the LA2000 will disable or stop and enter a FAULT state.

The FAULT state is latching: the unit will stay in this state, even after the removal of the fault-causing condition. While in the FAULT state, the LA2000 will not accept a RUN or ENABLE command until a STOP or DISABLE command is issued. If after a STOP or DISABLE command the amplifier is still in FAULT mode, the fault is still present in the system.

6. THEORY OF OPERATION

The amplifier can be thought of as consisting of two sections: control and power. The power section channels energy from the power input to the motor; the control section directs the power. These sections are further explained below.

6.1 Control Section
(See Section 11 for a control level schematic)

6.1.1 Velocity Control Loop

The Frequency Lock Velocity Control provides extremely accurate speed control using a combination of frequency and phase lock methods. Frequency and phase comparisons between a reference pulse-train and a feedback pulse-train result in internal command voltages that control the motor speed. The Frequency Lock Velocity Control generates a torque command voltage that is proportional to the difference between the two frequencies, causing the motor to accelerate or decelerate until the two frequencies are equal.

In most systems that use the Frequency Lock Velocity Control, incremental encoders are used to generate the feedback pulse-train. The reference pulse-train is generated by either an internal frequency synthesizer or an external TTL pulse-train. The external reference is input through a BNC connector that is located on the front of the controller. The selection of the internal synthesizer or external input is made by the FLLINTERNAL and FLLEXTERNAL commands.

When using an external reference frequency, the formula for the frequency is f = (speed request in RPM * encoder line count)/60 Hz.

Example: The external reference frequency for a system using a 1024 line encoder and turning at 3600 RPM is 61.440 kHz.

6.1.2 Commutation Section

The LA2000 is a three phase drive for sinusoidally wound DC brushless motors. This means that the voltage generated across each phase by turning the rotor at a constant speed has a sinusoidal waveform. The magnitude of the generated voltage is proportional to the angular velocity of the rotor. Phase B and phase C voltages lag phase A voltage by 120 and 240 electrical degrees, respectively. In order to develop constant torque from the motor, sinusoidal currents must be injected into each motor winding in phase with the generated voltages. For this, the angular position of the rotor must be known at all times. The LA2000 determines the rotor position by converting the output signals of an encoder to a digital word that represents the absolute rotor position. This word is then converted to three phase words that are each multiplied with a velocity error signal to generate the three sinusoidal current request signals.

6.1.3 Motor Phase Current Control Loop Section

The current control loops compare the three phase current requests from the velocity loop and commutation section with the actual motor phase currents and generate three current error signals that request output voltage from the power stage.

6.2 Power Section

The power section consists of the Main Power Supply and the Power Amplifier Stage.

The Main Power Supply is a transformer isolated, full-wave rectified, unregulated, bipolar DC power supply. It provides a source of power for the three motor output phases.

Each motor phase also has its own amplifier stage. These power stages consist of level-shifting circuitry and power semiconductor devices, which amplify the current error signals. The voltage that is applied to the motor terminals induces currents, which generate torque and motor rotation.

7. SERVICING

Servicing procedures are not recommended. Do not attempt to service the LA2000 without consulting MCS first.

7.1 Troubleshooting

The following troubleshooting instructions are intended to solve simple problems. If they are not adequate in solving the problem, contact MCS.

Nothing happens when the power switch is turned on

Problem   No power to the LA2000
Solution   Be sure that one end of the power cord is plugged into the rear panel receptacle and that the other end is plugged into an appropriate active outlet.

Problem   Fuse is blown
Solution   Disconnect the power to the LA2000 and remove the fuse from the power entry module. Test the fuse for continuity and replace it if there is none. Check external wiring, specifically the motor phase outputs. When the controller blows fuses it usually means that something is shorted out. The replacement must have the same current and voltage rating as the fuse that was removed.

No serial (RS232) communications

Problem   Incorrect communications parameters
Solution   Verify that the communication parameter settings on the host PC are: a) 8 data bits, b) 1 stop bit, and c) no parity. Also confirm that the baud rate setting on the host matches that of the LA2000.

Problem   Receive and transmit lines reversed on the communications cable
Solution   Reverse the signals at pins 2 and 3 on the LA2000 side of the cable.

Logic Power Fault

Problem   The internal logic power supplies are outside of specification
Solution   Check all external wiring and make sure that there are no excessive loads on any of the logic power outputs.

Amp Overtemp Fault

Problem   The amplifier heat sink has exceeded a high temperature threshold
Solution   If the amplifier has recently faulted, determine whether the air exiting from the rear of the LA2000 is hot or whether it has an unusual smell. At the same time, verify that the cooling fan is working and unobstructed. Disable the LA2000 and allow the amplifier to cool. Verify that the motor commutation was adjusted correctly (see Section 3.12), and that the motor turns smoothly when the LA2000 is enabled.

The LA2000 enables but the motor does not turn

Problem   Commanded speed is zero
Solution   See section 3.12 and make sure that you have entered a non-zero speed request. The default speed request is zero.

Problem   The LA2000 is still in the encoder setup state
Solution   The LA2000 is in a setup state for 10 seconds after it has been enabled for the first time after power-up. During the setup state the motor locks into a position and does not rotate. The setup state can be extended indefinitely by shorting SC2 pin 10 to logic common (SC2-25). This input is used during the encoder adjustment procedure. Be sure that SC2-10 is not connected to logic common for normal operation.

Problem   The motor feedback device (encoder) is not wired to SC2 correctly
Solution   See Section 3.9 and verify connections to SC2.

Problem   The commutation is not adjusted properly
Solution   Verify correct commutation adjustment (see Section 3.12).

Problem   The motor leads are not wired properly
Solution   See Section 3.8 and verify the wiring to the motor.

LA2000 enables, but motor is locked up

Problem   The encoder line count or the pole count does not match the system requirements
Solution   See Section 10, System Configuration Information, for the correct encoder line count for your system.

Problem   The phase relationship on the encoder inputs is reversed
Solution   Check to see if the phase relationship between the encoder outputs is correct. The correct inputs to the amplifier are B leading A when the motor is turning in a counterclockwise direction.

Problem   All three Hall Effect devices are not present
Solution   Check system wiring to be sure that all Hall Effect devices are present and switching.

8. SPECIFICATIONS

8.1 General

Fuse: 10A, 250V, Time Delay

Power Requirements: 120VAC, 8A or 230VAC, 4A

Power Output: 10A (peak), 4A (cont), 75V nom bus at full load, 720VA

Dimensions: Width: 6.6875 in. (169.9 mm)
                     Height: 6.3125 in. (160.3 mm)
                     Depth: 8.3125 in. (211.1 mm)
                     Weight: 16.25 lbs. (7.37 kg)

8.2 Front Panel Connectors

8.2.1 RS-232 Serial Connector

Pin Connections:

Pin   Function
1   Ground
2   Receive
3   Transmit
4   Handheld Terminal Receive
5   Ground
6   At Zero Speed
7   Handheld Terminal Transmit
8   At Speed
9   +5V

Mating Connector: DB-9 P (male)

8.2.2 SC2 Commutation Connector

        Note: This connector has different functions in encoder equipped systems and
                     resolver equipped systems.

Pin Connections for Encoder Systems:

Pin   Signal
1   Encoder +5V
2   Encoder A input
3   Encoder B input
4   Encoder Index
5   External Torque Input
6   External Enable Input
7   Aux. Interlock
8   Ground
9   Encoder Ground

10	Set up (Encoder)	
11	Clamp Output	For units with serial numbers under 6200200
		0V = clamp 4V = unclamp
		For units with serial numbers 6200200 and over
		0V = clamp 15V = unclamp
12	Encoder !I Input	
13	External Direction Input	
14	Main Air Fault	
15	Hall Effect Sensor 1 Input	
16	Hall Effect Sensor 2 Input	
17	Hall Effect Sensor 3 Input	
18	Bearing Air Fault	
19	Clamp Air Fault	
20	Encoder !A Input	
21	Encoder !B Input	
22	-15V	
23	+15V	
24	A, B quad output	
25	Ground	

Pins 22-2315V Supplies
Max Source Current: 250mA

Mating Connector: DB-25 S (female)

8.2.3 Motor Power Connector

Mating Connector:
Plug: AMP 206044-1
Contacts: AMP 6636102

Pin Connections:

Pin	3-Lead Motor
1	Phase W
6	Phase V
8	Phase U
14	Ground

8.3 Component Locations

The binder pocket includes a drawing of the control pc card component layout.

9. COMMANDS QUICK REFERENCE

This section provides a condensed guide to the commands in the normal operating mode for communications controlled systems.

NOTE: Refer to section 4.2.3 for more complete descriptions.

ACCEL:XXXXX   Set acceleration rate

ATSPD?   Query motor At-Speed status

CCW   Command counterclockwise rotation

CLAMP   Clamp the chuck

CW   Command clockwise rotation

DIR?   Query direction status

DIS   Command controller to disable

EN   Command controller to enable

ENABLE?   Query enable status

FAULT?   Query fault status

FLT?   Query fault status

FLTQREAD?   Read next value in FLT? queue

ID?   Return system identification

LOCAL   Activate hand held terminal

LOKDLY:XXXXX   Set ATSPD? time delay

OSPD:XXXXX   Set over speed limit

RAMPIN   Activate acceleration ramp

RAMPOUT   Deactivate acceleration ramp

READY?   Query ready status

REMOTE   Return control to RS232 communications

RUN   Run

SPD:XXXXX   Set speed

SPDAVG:XXX	Set number of speed readings per average for SPD?
SPD?	Query current speed
STAT?	Query system status
STOP	Stop
STOPS:XXXXX	Set the stop/disable threshold speed
TORQ:XXX	Set maximum torque
UNCLAMP	Release the chuck
ZERO?	Query zero speed status

10. DRAWINGS

(click on drawing number to view)

<u>Outline and Mounting Drawing:</u>

1404030   LA2000 Model 62 Outline, Mounting dimensions and Connector Locations

<u>System Wiring Diagrams</u>:

1404040 Connection Diagram for RS-232 Controlled Encoder Commutated Systems with Six
          Step Startup

1404050 Connection Diagram for RS-232 Controlled Encoder Commutated Systems

1404060 Connection for sine / sine + 120 Commutated Systems

<u>Printed Circuit Board Drawing:</u>

1013803   Control Card Component Layout