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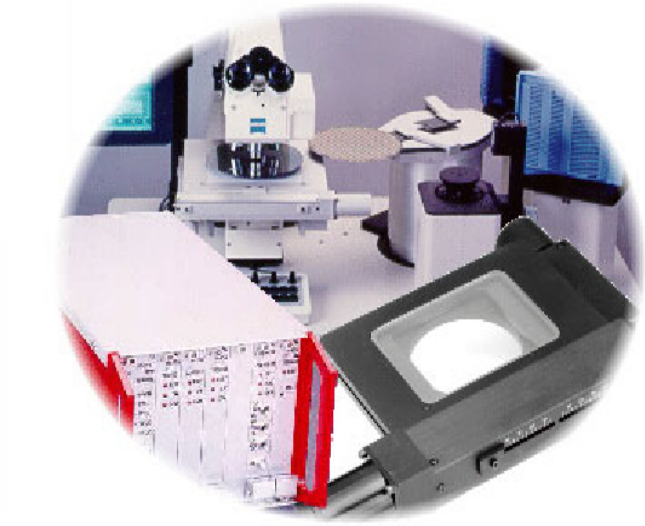
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MAC 2002 Configuration Manual



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Introduction

The MAC 2002 system is the third generation automation controller from LEP. It is a modular system that can easily be configured with different combinations of modules to suit various application requirements. The modular nature of the system facilitates troubleshooting and minimizes down time since a malfunctioning module may be easily swapped with a replacement module by the user.

MAC 2002 System

Architecture



Figure 1

The internal architecture is based on a passive motherboard with dedicated wiring between the rear panel connectors and the corresponding slot on the motherboard. See Figure 1.

The standard MAC 2002 system is configured as shown in Figure 2. Module slot assignments are for X, Y, Z or Autofocus, Filter wheel/Shutter and RS-232 interface. Depending upon your exact configuration the actual slot assignments may differ from those pictured. All MAC 2002 modules feature a quick eject system - simply unlock the fastener at the top of the module and the press the front panel handle down to release a module. A slight inward pressure on the front panel is all that is required to replace the module in the controller.

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Figure 2

System Power Supply

The system power supply, P/N: 73002020 or 73002021 provides the power to the MAC 2002 bus. It derives the operating power from the base power available from the chassis. The MAC 2002 system uses +5, +8v,±15v and +24v for various functions. The following table is a reference for which supplies are most commonly used internally and for what function:

Voltage	**Where used**
+5v	Microprocessors, TTL logic
+8v	Stepper motor standby (at rest) power
±15v	Analog electronics
+24v	Motor drive power, base supply from which other voltages are derived

The front panel of this module has green indicating LED's to show the status of the individual voltages. The LED's provide an important trouble-shooting aid as there is no normal condition where any of the LED's should not be lit.

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Fuses

The MAC 2002 has a single fuse on the mains input which may be accessed from the rear panel of the controller. In the unlikely event that this fuse fails, be sure to replace it with a fuse of equivalent rating.

Mains Voltage/ Frequency	**Fuse Rating and Type**
100-117V 50-60Hz	2.0amp Slow Blow (type TT)
208-240V 50-60Hz	1.0amp Slow Blow (type TT)

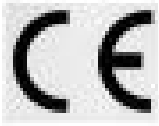
Power Requirement and Ratings

The MAC 2002 controller automatically switches to accommodate any of the international supply voltages. Simply connect the proper line cord to the rear-panel receptacle and switch it on.

Note: All MAC 2002 controllers are shipped from LEP with the appropriate fuse for 100-117v mains voltage 50-60 Hz. The fuse must be changed if the controller is to be used with any other mains voltage.

Listings and Conformance Data

The MAC 2002 system is listed with ETL and tested to UL 3101-1. The system is also CE compliant and has been tested extensively for compliance with international standards for mechanical and electrical safety as well as emission and susceptibility to EMI (electromagnetic interference). To maintain compliance with these standards use only LEP supplied components.





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Connection

Rear Panel Connectors

All connections to the MAC 2002 are made to the rear panel of the controller unit. Each connector is clearly labeled as to its designated function. Cable connections should be completed prior to power up of the controller. To ensure proper connection always tighten screw lock connectors and slide the slide-lock connectors into the locked position. See Figure 3.



Figure 3

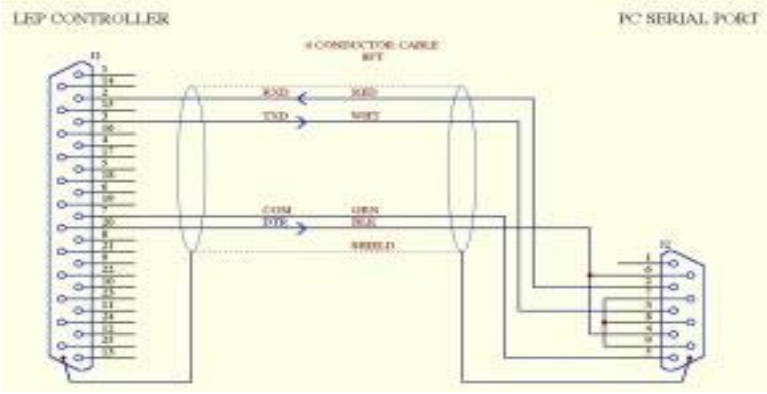
Line Cord

The line cord connection is a standard IEC receptacle. The MAC 2002 switches automatically to accommodate any standard international line voltage and frequency.

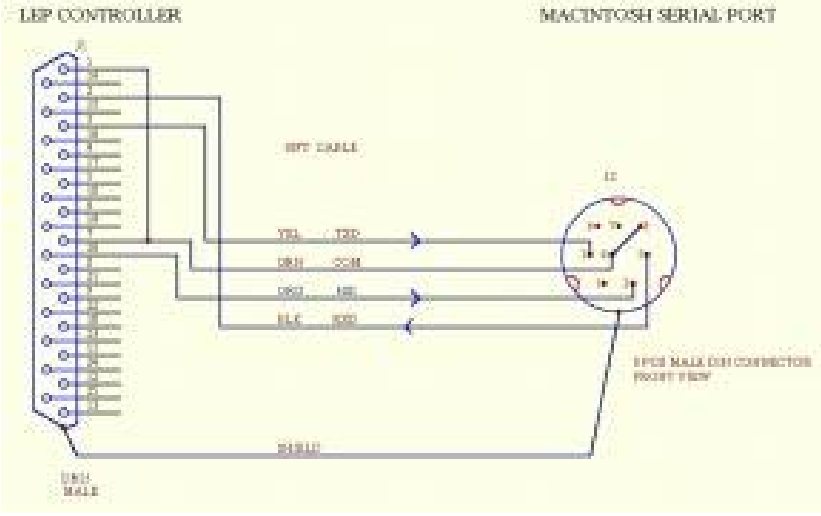
Host Computer Interface Cables

Every MAC 2002 system is supplied with two standard RS232 interface cables which interconnect the rear panel of the controller (25-pin female connector labeled RS232 Computer) and an available serial port of the host computer. No hardware handshaking is provided. For IBM compatible computers, a 25-pin male to 9-pin female cable is used. For compatibility with the Apple Macintosh computers, a 25-pin female to 8-pin mini-DIN cable is supplied.

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PC Interface Cable
P/N: 73A00019



Macintosh Interface Cable
P/N: 73A00025

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MAC2002 Joysticks

The joystick provides manual control of a motor for either an XY stage, robot or focus control. The standard LEP joystick, p/n 73000362, features an XY analog joystick with a rotary 'digipot' on the side for digital control of a third axis.
There are several other joysticks that may be installed with your system. The following table describes the joysticks available for the MAC 2002 system

Part Number	**Description**
73000360	Simple XY joystick
73000361	XYZ joystick
73000362	XY with integrated digipot
73000365	Digipot only
73000366	XYZ joystick with integrated digipot
73000367	XY joystick with 4 user buttons
73000369	XYZ joystick with 4 user buttons

Upon power-up , the MAC 2002 system performs an automatic 'calibration' of the joystick. First the system checks for the presence of the joystick. If a joystick is connected it reads the current position and assigns it the 'zero' position, any deflection from this angle will cause the stage to move. A common problem is that the joystick is slightly deflected on power-up and then released. This makes the stage drift slowly on its own and may cause asymmetrical speed response based on equal deflection of the joystick.

XY deflection stick

Pushing the XY joystick will cause the stage to move in the desired direction. The stage movement velocity is exponential with deflection angle of the joystick. This gives very fine accurate control with small deflections, but also provides for higher speeds during larger movements. The actual direction of movement is configured on the motor controller module. The default speeds for the joystick are set to be usable in all configurations of resolution, however, the joystick speed can be changed by host software if desired.

Digipot

The digipot is a digital input device that is likened to a single axis trackball or mouse. The input is incremental. This means that the movement is directly coupled to the input. For example, if one turn of the knob turns the motor a half turn, then the motor will always turn in this ratio whenever the knob is turned regardless of the speed at which the knob is turned.

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Digipot gain
The digipot gain is set by the three position toggle switch mounted on the back of the joystick housing . This is used for either fine, medium, or coarse type movements of the focus drive.

User Buttons
There are two (four on the 73000367 or 73000369) user defined buttons available on the LEP joystick. The buttons have no direct function on the MAC 2002 system other than the fact that host software can read them via the interface port. A typical application would be the host software executing some type of subroutine based on the switch status.

High Speed Slew Button
The button located on the top of the joystick itself is the high speed slew button. Pressing this button will change the maximum speed of the stage with respect to the joystick deflection.

Centering spring control
The two sliders arranged in line with the X and Y axis of the joystick control the self-centering function of the joystick. Normally these sliders should be left in the engaged position. If they become loose, the stage may creep along slowly and it may appear that there is something wrong.

XY Stage
The X and Y-axis connections are used to connect to an XY stage. Both connectors are electrically equivalent which is a valuable troubleshooting aid since the user may swap cables from one axis to the other to discern if a malfunction is specific to the stage axis or the controller. Internal to the controller, however, each connector is wired to a specific slot on the MAC 2002 motherboard. The leftmost slot (from the front of the controller) is reserved for the X-axis whereas the adjacent slot is dedicated to the Y axis.

One of the most critical steps during installation of the stage is adjustment of the stage travel limits. Depending on the microscope model, adjustment of the limits is required to avoid interference from either the microscope stand or expensive optics. The technique to accomplish this is summarized in this simple procedure:

1· Mount the specimen to the stage and focus the optics near the center of stage travel.
2· Slowly move the stage with the joystick to a point where interference occurs, either with the optics or the microscope stand.
3· Adjust the stage limits for the direction of travel.
4· Repeat for the other axes and directions of travel.

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Once the limits are properly set, the stage insert plate should be leveled to maintain focus over the travel range. The leveling is accomplished using the set screws located at the edge of the insert plate. It is nearly impossible to maintain perfect focus over the entire travel (particularly with high power objectives), however, a good rule of thumb is there should be no need for more adjustment than a quarter turn of the fine focus knob.

Certain systems will have a 9-pin female connector installed immediately below the 15 pin motor connector. This connector is for auxiliary encoder input. In these systems a second encoder feedback is used to provide accurate position information where a rotary encoder is not adequate.

Verification of operation

Once all the connections are made, the system is powered up and the operation is verified. A few quick checks can ensure that the connections are properly set and the system is functioning properly.

Stepper Motor Stage:

When power is applied, the motors become energized. In their energized state, the motor is more difficult to rotate by hand. Deflecting the joystick will cause the motor to rotate, thus, the stage will begin to move. At the end of the travel, the stage should contact the limit switch, stop the motor and illuminate the associated LED (i.e. CW or CCW) on the front panel of the MAC 2002 controller.

DC Motor Stage:

A DC motor stage may be verified in the same manner as the stepper motor stage. If the stage is not moving with a smooth fluid movement or if the stage is vibrating, ensure the configuration DIP switch settings for the X and Y axis are set for a DC stage. See page 16.

Focus Drive Motor:

Similar to the stage, the focus motor may be verified by turning the knob (digital potentiometer) on the side of the joystick housing. As the digipot is rotated, the focus motor should move accordingly. Some LEP focus drives do not provide limit switches; consult the focus drive installation manual for further details on your specific drive.

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MAC 2002 Module Configuration

Each MAC 2002 module requires a unique address (1-254) and may be configured to meet specific application requirements. This is accomplished using DIP switches located on each board. The following sections details the functions of these DIP switches.

Setting the Module Address

The MAC 2002 employs an 8-bit addressing scheme (Sw1 = LSB, Sw8 = MSB). Address 0 is an undefined address, and address 255 is reserved by the interface for special system commands. Outside of the restrictions, a module can be set to any address in the allowed range. The high level interface functions, however, assume that certain modules of a certain type are set for specific addresses. The addresses from 1-32 are reserved for this purpose. This does not mean that you cannot use these addresses for other modules, rather it means that by doing so, high level commands will not function properly. The address DIP switch is located closest to the rear edge connector of the module. See Figure 4.

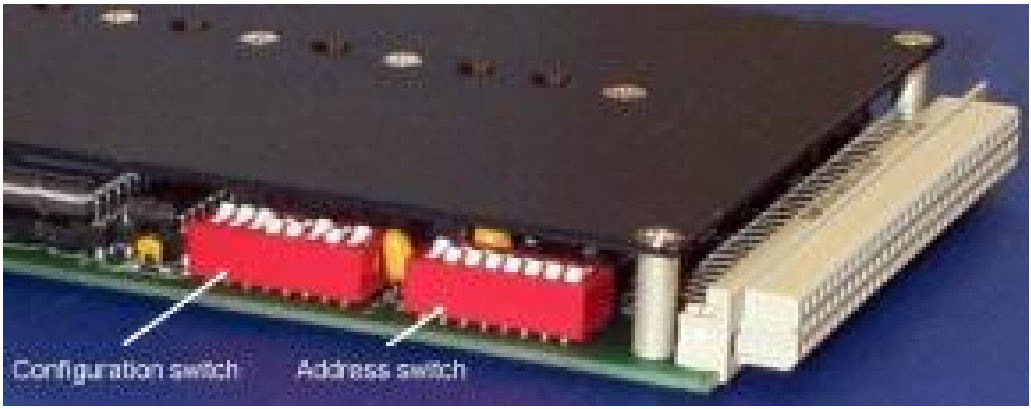


Figure 4

Switch positions have the following binary values:
$S1=2^0$, $S2=2^1$… $S8=2^7$
0 = close 1 = open

Example: The following table is switch settings for a given address:

Address	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
7	1	1	1	0	0	0	0	0
1	1	0	0	0	0	0	0	0
10	0	1	0	1	0	0	0	0

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Address	Module Type	High Level ID	Description
1	MCSTS/MCDCS	X	Stage X axis
2	MCSTS/MCDCS	Y	Stage X axis
3	MCSTS	B	Microscope Z-axis
4	MCSTS/MCDCS	R	Robot Radius 1 axis
5	MCSTS/MCDCS	C	Robot Radius 2 axis
6	MCSTS/MCDCS	Z	Robot Lift axis
7	MCSTS/MCDCS	T	Robot Theta axis
8, 9	DAIO	I/O	Digital I/O ports
10	F LNOF	A	Flat/Notch aligner
11	AFCMS	F	Video autofocus
12		P (1)	Spare
13		P 2	Spare
14		P 3	Spare
15		P 4	Spare
16		P 5	Spare
17	FWSHCST/DC	S (1)	Filter wheel 1
18	FWSHCST/DC	S 2	Filter wheel 2
19	FWSHCST/DC	S 3	Filter wheel 3
20	FWSHCST/DC	S 4	Filter wheel 4
21	FWSHCST/DC	S 5	Filter wheel 5

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Microstepping Motor Controller/Driver

General Description

The MCSTS module, P/N: 73002050, is an integrated motor controller and power driver for standard stepper motors. The module provides a highly stable linear bipolar microstepping output with configurable resolution. The motor current is programmable and an additional voltage boost is automatically applied by the microprocessor for high speed performance.

Configuration DIP Switches

There are three separate DIP switches located on this module. The 8 position address switch, an 8 position configuration switch and a 4 position switch for setting motor current. The address switch is located closest to the rear edge connector of the module with the configuration switch directly to the left.

Microstep Size

The microstep size is selectable from either the configuration DIP switch or from software via the RS-232 interface. Switch positions 1-3 provide this setting according to the table below:

Data	Steps/ revolution	Sw1	Sw2	Sw3
0	40,000	0	0	0
1	20,000	1	0	0
2	10,000	0	1	0
3	5,000	1	1	0
4	2,000	0	0	1
5	1,000	1	0	1
6	500	0	1	1
7	soft select	1	1	1

0 = close 1 = open

The Steps/revolution is valid for a 1.8° stepper motor.
The default resolution in soft select mode is 10,000 steps/rev.

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Joystick Direction
To ensure that the motion axis responds intuitively with respect to the joystick deflection, the joystick direction is configurable. The default setting is set to operate correctly for an LEP stage that is operated on a microscope without image erecting optics.

Sw4	Direction
Open	motor turns CW when joystick is deflected to the right
Closed	motor turns CW when the joystick is deflected to the left

Although there is a default setting it may be that the user may feel more comfort-able with the joystick direction set in the opposite way.

Limit Switch Logic
Standard LEP components, including stages, robots and focus drives use a normally open limit switch arrangement, where the input is pulled low, the limit is active. The default switch setting accommodates LEP products without change. However, the LEP controller offers the flexibility to accommodate other manufacturer's products since the input can be configured to activate the limit condition with an active high signal.

Sw5	Input Logic
Open	active high
Closed	active low (default)

Motor Direction
Similar to joystick direction configuration, the motor direction is also configurable. This configuration essentially changes the sign of the position as it is tracked by the microprocessor.

Sw6	Direction
Open	motor turns CW in the positive direction
Closed	motor turns CCW in the positive direction

Motor boost control
In the default configuration, the motor controller microprocessor applies a 24v boost to a motor after passing a specific speed threshold. Below this level, the motor is operating on the base voltage of 8v at the programmed current level. Configuration of the motor controller for boost voltage applied at all times, should only be used for high impedance motors. *Check with LEP support before changing this setting as damage may result.*

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Sw7	Mode
Open	Boost is enabled at all speeds
Closed	Boost is applied at a specified speed [DEFAULT]

Enable Position Feedback

This important configuration option defines how the motor position is tracked. The configuration provides for setting the controller to operate the motor in either open or closed loop mode. In the open loop mode, the position is tracked according to how many pulses have been generated to rotate the motor. This mode offers very acceptable performance in most applications. The most notable problem with open loop mode is that the recorded position and the actual position may differ, sometimes greatly, if the motor either stalls, skips or if it is physically disturbed.

Closed loop mode is a much more complicated system where the motor is controlled with reference to an encoder input. Typically on the LEP stages, the encoder is a rotary type mounted on the end of the leadscrew shaft. The closed loop mode performance is improved over the open loop mode by correcting for the possibility of motor mispositioning due to missed steps, stalling or physical disturbance.

Sw8	Mode
open	closed loop (encoder feedback required)
closed	open loop

Please note that while a stepper motor will always work in open loop mode, unless you have an encoder, the system will not function in closed loop mode.

Motor Current Program

There is a 4 position DIP switch located near the front panel of the module which is used to set the peak motor current according to the following formula:

Motor current = .2 + .2(number of closed switches) amps

The default setting is 0.8A (800ma) which corresponds to three switches closed.

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DC Servo Motor Controller/Driver

General Description

The MCCDCS module, P/N 73002051 is a complete microprocessor motor controller and servo amplifier system in a single MAC 2002 module. The module employs as dedicated DSP processor to provide high performance motion control for DC servo motors. This module is also fully configurable to meet the specific requirements of various applications.

Configuration DIP switches

There are two separate DIP switches located on this module. The 8 position address switch and a 6 position configuration switch. The address switch is located closest to the rear edge connector of the module with the configuration switch directly to the left.

Joystick Direction

To ensure that the motion axis responds predictably with respect to the joystick deflection direction, the joystick direction is configurable. The default setting is set to operate correctly for an LEP stage that is operated on a microscope without image erecting optics.

Sw1	Direction
Open	motor turns CW when joystick is deflected to the right
Closed	motor turns CW when joystick is deflected to the left

Although there is a default setting it maybe that even on standard LEP components the user may feel more comfortable with the joystick direction set in the opposite way.

Limit Switch Logic

Standard LEP components, including stages, robots and focus drives use a normally open limit switch arrangement, where the input is pulled low, the limit is active. The default switch setting accommodates the LEP stages without change. The input can be configured to activate the limit condition with an active high signal.

Sw2	Input Logic
Open	active high
Closed	active low (default)

Motor Direction

As with the joystick direction configuration, the motor direction is also configurable. This configuration essentially changes the sign of the position as it is tracked by the microprocessor.

Sw3 Direction

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Open motor turns CW in the positive direction
Closed motor turns CCW in the positive direction

Predefined DSP parameters

The 73002051 module has the capability to store up to 8 DSP parameter profiles. These parameter profiles have been optimized for specific LEP DC driven devices. Switch positions 4-6 assign the appropriate DSP parameters according to the table below:

Data	DC Device	Sw4	Sw5	Sw6
0	Last record stored	0	0	0
1	Stage 1	1	0	0
2	Stage 2	0	1	0
3	Robot Arm	1	1	0
4	Robot Rotation	0	0	1
5	Robot Lift	1	0	1
6	Focus Drive	0	1	1
7	User defined	1	1	1

1 = Switch Open 0 = Switch Closed

The parameter profiles define the DSP control loop parameters such as gain, acceleration, velocity, resolution, etc... Refer to the MAC 2002 programming manual for more detailed information; visit our web site at www.ludl.com for the latest available information.

Note: Stage 1 should be used for smaller stages (i.e. 3x2, 4x4, inverted). Stage 2 should be used for larger stages (i.e. > 6x6). If the wrong parameter profile is used, system performance may be adversely affected.

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RS-232 Interface

General Description

The RS-232 interface module, P/N: 73002040 provides the link to communicate with the MAC 2002 modules from an external host system using a standard RS-232 serial port. A high-level ASCII or a low-level binary protocol is available; see the MAC 2002 programming manual for details regarding these two communication formats.

Upon power up of the controller, the BUSY LED is illuminated for approximately 10 seconds while the controller is conducting an internal initialization routine. It is recommended that the user refrain from use of the joystick or RS-232 serial communication until completion of this routine.

Configuration DIP switches

There is a single 8 position DIP switch on the RS-232 interface module used to configure the serial communication parameters. The following tables detail the function of the DIP switch:

Baud Rate	**Sw1**	**Sw2**	**Sw3**	
19200	open	open	open	
9600	open	open	closed	**(Default)**
4800	closed	open	open	
2400	closed	open	closed	
1200	open	closed	open	
600	open	closed	closed	
300	closed	closed	open	
150	closed	closed	closed	

The serial parity bit is also switch selectable; switch number 4 represents parity select and switch number 5 represents parity check. There are always 8 data bits and 2 stop bits. [9600,8,N,2]

Parity	**Sw4**	**Sw 5**	
Odd	open	open	
Even	closed	open	
None	n/a	closed	**(Default)**

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Switches 6 and 7 program a delay between transmission of the serial data. When the both switches are closed there is no delay, when both are open there is a 1.5 ms delay.

Switch 8 sets the power up communication mode:

Mode	**Sw8**	
Low Level	open	**(Default)**
High Level	closed	

Digital/Analog I/O

General Description

The DAIO module is a general purpose I/O module that supports 6 open collector outputs, 2 source drive outputs (24v DC), 8 TTL inputs, (4) 8-bit analog (0-5v) inputs and either 3 or 4 analog outputs. The standard 73002060 module is configured for 4 analog outputs, 0-10v 8 bits per channel. For applications which may benefit from a higher resolution analog output, the 73002061 module is available and is configured for (1) 16-bit analog 0-10v output and (2) 8-bit 0-10v analog outputs.

If you ordered your MAC 2002 controller with this module, a wire harness specific to your application is included and appropriately labeled on the rear panel. Common applications of the DAIO module would be remote control of an illumination source, detecting the status of an interlock switches, and vacuum control/sense in wafer handling applications. These are just a few applications; contact LEP technical support for details regarding other uses.

Configuration DIP switches

There is a single 4 position DIP switch on the DAIO module which is not assigned any functions at this time. The default configuration is all 4 switches in the closed position.

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Stepper Motor Filter/Shutter Controller

General Description

The stepper motor filter wheel/shutter controller (FWSHCST), p/n: 73002080, is a microprocessor controlled half step motor driver capable of operating up to two six position filter wheels and three high speed shutters.

LEP stepper motor filter wheels are available in two configurations - a single six position wheel or a dual wheel which may accommodate up to twelve filter positions in a single unit. 25 mm and 32 mm filter aperture versions are available for each configuration. The filter wheel is driven by the stepper motor via a timing belt and an integral home position (Hall effect) sensor is utilized for automatic initialization. The maximum speed is 100 ms between adjacent filter positions, although, the operating speed is software programmable and DIP switch configurable. Microscope specific mounting flanges are available which simplify mechanical integration of LEP filter wheels with most microscopes offered by Leica, Olympus, Nikon and Zeiss. Filters can be easily inserted and removed from the filter wheel while the entire assembly is mounted on the microscope due to the hinged construction of the filter wheel.

Up to three high speed shutters may be controlled using the same module. The drive electronics utilize a bi-level drive, supplying an initial high opening voltage for high-speed action (< 5ms to open or close) followed by a lower holding voltage which allows shutters to be held open indefinitely without damage. Manufactured specifically for high temperature applications, these shutters have proven to be extremely durable under heavy usage due to their simple design.

New features have been added to LEP Filter Wheel/Shutter modules which add to their versatility:

1• High speed synch mode where a TTL output signal may trigger an image capture after a filter position change.
2• Sequencer macro function to simplify repetitive filter movements.
3• External TTL signals may be used for shutter synchronization.

The MAC 2002 programming manual details the specifics of implementing these new functions.

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Connections

Connections are made at the rear panel of the MAC 2002 frame via a DB-15 female connector labeled Filter wheel 1 and Filter wheel 2. Each filter wheel/ shutter combination requires a separate 15 pin cable. All MAC 2002 filter wheels are manufactured with a single internal shutter; auxiliary shutters may be added to the system by connecting to a 4 pin port on the filter wheel housing or, if available, one of the DB-15 filter wheel connectors.

Front Panel Control Functions

The 73002080 module allows manual control of key filter wheel/shutter functions using four switches located on the front panel. A user may control the state (i.e. open or closed) of two shutters simply by using the toggle switches which are labeled SH1 and SH2. Note that software control supersedes the front panel switch setting. Indicator LED's on the front panel illuminate to signify that a shutter is open and darken when the shutter is closed. The filter position of filter wheel 1 only may be changed using the toggle switch labeled MU; the wheel will respond with a sequential movement dependent on the direction which the switch was toggled. Filter wheel 1 may be re-initialized to the "HOME" position by depressing the push button switch labeled HO.

Configuration DIP switches

There are two separate DIP switches located on this module. The 8 position address switch and a 6 position configuration switch. The address switch is located closest to the rear edge connector of the module with the configuration switch directly to the left.

Filter wheel speed

The filter wheel speed is configurable using Sw1 and Sw2. Both switches closed would correspond to the fastest filter change, where as both switches open would be the slowest speed. Due to the higher inertia of the 32 mm filter wheel it is recommended that Sw1=closed and Sw2=open; this will program a lower start speed and mitigate possibility of stalling the stepper motor.

External shutter trigger and Sequencer trigger.

The standard LEP shutter may be triggered using an external TTL signal generated from another device. This can be used to synchronize the exposure time for both devices.

When the sequencer macro function is utilized, the active level of the input trigger signal is also defined by this switch. The active level is configurable

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using the DIP switch setting or may be superseded by software control:

Sw3	Input Logic
Open	active high
Closed	active low (default)

For more detailed information on using the external shutter trigger and synchronization mode, refer t o the MAC 2002 programming manual.

High speed synch output
Upon completion of a filter position change a TTL output signal may trigger an external device. The active level of the synch output signal is configurable using the DIP switch setting or may be superseded by software control:

Sw4	Output Logic
Open	active high
Closed	active low (default)

Note: Switch 5 and 6 are reserved switches which must be in the open position for the filter wheel to operate properly.

DC Servo Filter/Shutter Controller

General Description

The FWSHCDC module, P/N 73002081 is a complete microprocessor motor controller and servo amplifier system in a single MAC 2002 module. The module employs as dedicated DSP processor to provide high performance motion control for the DC servo motors used in LEP high speed filter wheels. Similar to its stepper motor controller counterpart, this module is capable of operating up to two six position filter wheels and three high speed shutters. The major advantage to the DC filter wheel system is speed - 25 ms between adjacent filter positions as opposed to 100 ms with the stepper filter wheel systems. Also, the DC filter wheel system operates as a closed loop system. This means the filter position is controlled with reference to feedback from an encoder input. The closed loop mode performance is improved over the open loop mode used by the stepper filter wheel by correcting for the possibility of motor mispositioning due to missed steps, stalling or physical disturbance.

The cable connections, front panel control functions, and configuration switch settings for the 73002081 (FWSHCDC) module are identical to that of the 73002080 (FWSHCST) module. Please reference pages 19-21 for details.

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Dual Motor Controller/Driver

General Description

The MCSTD module, P/N 73002054, is unipolar microprocessor controlled half step motor driver which controls up to two individual stepper motors. This module features configurable end limit inputs, configurable relative motor direction and manual front panel control for both the primary and secondary motor. Motor resolution is limited to step increments which are one half that of a full step. (e.g. 400 steps/rev for a 1.8° stepper motor). Please contact LEP for information regarding motor compatibility for custom system integrations.

Front Panel Control Functions

The 73002054 modules allows manual control of motor movement and direction of rotation using two toggle switches (labeled Motor 1 and Motor 2) located on the front panel. Note that software control supersedes the front panel switch setting. Indicator LED's on the front panel illuminate to signify that an end limit has been reached or when the device is BUSY executing a software command.

Configuration DIP switches

Limit Switch Logic

Standard LEP components, including stages, robots and focus drives use a normally open limit switch arrangement, where the input is pulled low, the limit is active. The default switch setting accommodates LEP products without change. However, the LEP controller offers the flexibility to accommodate other manufacturer's products since the input can be configured to activate the limit condition with an active high signal.

Sw2	Input Logic
Open	active high
Closed	active low (default)

Motor Direction

To ensure that the motion of an axis responds predictably with respect to a software command, the relative motor direction is configurable. This configuration essentially changes the sign of the position as it is tracked by the micro-processor.

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Sw3	Direction
Open	Primary motor turns CW in the positive direction
Closed	Primary motor turns CCW in the positive direction

Sw4	Direction
Open	Secondary motor turns CW in the positive direction
Closed	Secondary motor turns CCW in the positive direction

Note: Switch 1, 5 and 6 are reserved switches which must be in the closed position for the module to operate properly.

Video Autofocus Controller

General Description

The AFSC module, P/N: 73002085 is a video image processing module which uses the video signal contrast for focus optimization. The system accepts RS-170, RS-330, NTSC, or PAL video (color or monochrome) and utilizes either a 73002050 stepper module or a 73002051 DC module to drive the focus motor over a programmed range of focus travel. This focus scanning range will ultimately determine focusing speed, anywhere from 1 to 4 seconds, with a resolution up to .01 microns and repeatability better than two times the depth of field.



Figure 5

The 73002085 module is located to the immediate right of the associated

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drive module (see Figure 5). This configuration allows the modules to utilize a local communication bus in an effort to mitigate any communication delays.

An extensive command set is available for setting all focus parameters, i.e. image averaging, search speed, delay between measurements, and scan distance in addition to all control codes of a standard motor drive. The system power up defaults are normally adequate for all focusing functions except the more critical such as those involving low light levels, unstable microscopes, and very low contrast images.

The autofocus module uses only a portion of the video image for contrast measurements. This focus window is superimposed on the video image output of the controller and defined through software commands or from the front panel. The size of the window is very important to ensure repeatable and accurate focusing. A window which is too large with excessive video contrast may overflow measurements resulting in inaccurate focusing, whereas, a window which is too small may provide insufficient signal resulting in poor focusing repeatability.

Connections

Integration of the autofocus system with existing equipment is relatively straight-forward. Refer to your focus drive installation manual for the proper mechanical connection of the focus motor to your microscope.

First, connect the 15-pin focus motor connector to the rear panel of the controller labeled FOCUS; ensure the slide lock is engaged since loose connections may cause the system to malfunction. Then connect the camera output to the BNC connector labeled VIDEO IN (75 ohm impedance standard) and connect the output to the video monitor to the VIDEO OUT BNC. In the event you are not using the MAC 2002 controller as a pass through for the video signal, the two position video termination jumper located near the edge connector of the 73002085 module should be moved to the outer position.

Front Panel Control Functions

The AFSC module allows manual control of the focus window, scanning range, and focusing using the front panel controls:

The three position toggle switch labeled High, Med, and Low allows the user to select the default focus scanning range which is appropriate for the objective currently being used.
The push button labeled FOC is used to manually initiate the focusing sequence.

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By turning the small slotted screws inside the access holes labeled HP and VP, the horizontal position and the vertical position, respectively, of the focus window may be adjusted. Similarly, the horizontal size and vertical size may be adjusted using HS and VS respectively.

Maximizing Performance:

To obtain maximum performance of the autofocus, there are several key issues that should be addressed. The most important factor is the video image itself. The video image should not be too bright to wash out the contrast. Conversely, it should not be too dim so there is noise and/or low contrast. The persistence of the video camera is also important. An ISIT camera, for example, has a very slow reaction time and will cause the autofocus to improperly focus because it measures very fast. The objective lens used is very important since it contributes to two factors that influence the focus. The depth of focus is determined by the objective and consequently affects the range where there is contrast. The objective also provides contrast based on the optical characteristics of the lens. At very high magnification, a high numerical aperture lens will provide a very shallow depth of focus which, depending upon the sample and optical quality, can produce washed-out low-contrast images. Finally, the image content is a determining factor in the focus performance. The autofocus will have difficulty focusing on a bare specimen with little or no contrast.

The performance of the autofocus with videos that have low contrast, high noise, slow response, or low levels can be improved by altering the focusing parameters. The parameters that affect the focus are: focus search range, number of focus measurements within the search range (sampling rate), number of frames to count before taking a measurement, and scan speed.

The search range is programmable for the coarse and fine searches for each high, medium, and low focus range. This is useful if your microscope focus mechanism provides too little or too much focus travel. This indirectly changes the resolution of the autofocus measurement since this range is divided by the number of measurements taken in the scan.

The profile distance defines the resolution of the autofocus. The autofocus will first search the fine range; if a valid focus point is not found it will search the coarse range, and then the fine range again taking ‘n’ number of measurements for each range. If no valid focus is found during the scan sequence the Z-axis position will be returned to the original position prior to focusing. The total distance traveled during a scan is equal to the product of the profile distance (in steps) and the sampling rate. The range and number of measurements should be set so that the coarse range will travel through the focus plane but not crash the objective lens into the specimen. The fine range should be set so that the resolution is less than the depth of focus for the particular lens.

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When focusing, a programmable delay may be added before the actual contrast reading. This may be used to allow time for the mechanical focus system to stabilize and slow video response (e.g. of a SIT or ISIT camera) to catch up. In addition the focus scan speed is also programmable. The scan speed may be decreased to compensate for unstable mechanical assemblies or fluid samples that must be moved slowly or increased to minimize time delays.

Configuration DIP switches

Focusing mode
The 730002085 module may use one of two different focusing algorithms. The default mode is selected during power-up, however, the mode may be changed using a software command (see MAC2002 programming manual for details). The new continuous profile algorithm may use faster search speeds and larger search ranges resulting in a lower total search time particularly for lower power objectives, however it requires a fast response camera (e.g. CCD camera).

Sw1	Focusing Mode
Open	Continuous contrast profile while moving at a constant speed
Closed	Discrete contrast-profile (identical to the MAC2000 algorithm)

Limit constrained focusing
When using the continuous contrast profile algorithm, the low focus range may be defined via software commands or limit switches (if available).

Sw2	Low focus range
Open	Use the end limit switches
Closed	Use the programmed low focus range **(Default)**

Video Selection
This switch is used to configure the autofocus module for the specific type of video input used in your system:

Sw3	Video Input
Open	PAL
Closed	NTSC **(Default)**

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Contrast Signal Diagnostic

The 73002085 module allows the user to display a bar graph on the video screen which represents the relative contrast signal measurement. This may be used to confirm proper operation of the module by manually scanning a Z distance confirming the peak of the bar graph coincides with a focused image within the focus window.

Sw4	Diagnostic Mode
Open	Bar graph is displayed
Closed	Bar graph is not displayed **(Default)**

Manual Focus Window Control

The front panel 'trim pots' allow manual control of the size and position of the focus window. Once set, it may desireable to limit changes to the focus window settings:

Sw5	Manual Control
Open	Front panel 'trim pots' disabled
Closed	Front panel 'trim pots' enabled

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Warranty Information

Warranty Time Period and Limitations

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Units returned to **LEP** that have been subject to abuse, misuse, damage or accident; have been connected, installed or adjusted contrary to the instructions furnished by **LEP** or repaired by unauthorized persons will not be covered by this warranty.

This warranty becomes null and void if you fail to pack equipment in a manner consistent with the original product packaging and damage occurs during product shipment.

LEP reserves the right to discontinue models; change specifications, price or design of this device at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees or agents.

LEP shall not be liable in any way for consequential damages resulting from use of this device.

This warranty is in lieu of all other representations or warranties expressed or implied and no agent or representative of **LEP** is authorized to assume any other obligation in connection with the sale and purchase of this device.

All instruments are delivered with serial tags located on the rear panel or bottom of the unit. These serial numbers are used to track the manufacturing date and the revision level. If this serial number is removed for any reason, the warranty is void.

Warranty Repair Coverage

LEP under this warranty is limited to repairing or replacing the defective device when returned to the factory, shipping charges prepaid, within one (1) year from date of original purchase. Such repair service will include all labor as well as

any necessary adjustments and/or replacement parts.

If replacement parts are used in making repairs, theses parts may be

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remanufactured, and/or may contain remanufactured materials. If it is necessary to replace the entire system, it may be replaced with a remanufactured system.

Application Support

For application specific support, please contact your reseller, systems integrator, software manufacturer, or dealer directly. If additional technical support is required, your service provider should contact **LEP** with a detailed description of the problem, system configuration, and any available troubleshooting information.

How to Obtain Service

You may visit our web site at www.ludl.com simply choose the appropriate contact group and we will promptly respond to your inquires.

When returning any **LEP** equipment for repair you must first obtain an RMA (Return Merchandise Authorization) number from one of our Customer Service Representatives. The unit should be packed in its original packing materials and a detailed problem report should be enclosed. The accompanying paperwork should reference the RMA# and all items which were shipped to **LEP**.

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