THORLABS

MC2000, MC2000-EC

Optical Chopper

Operating Manual

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Part 1. Safety Warnings

<table>
<tr><td>⚠</td><td>Warning Electrical Shock</td><td>⚠</td></tr>
</table>

To avoid electrical shock the power cord protective grounding conductor must be connected to ground. Refer servicing to qualified personnel.

The unit must be powered off, unplugged from the AC input power source, and disconnected from all external devices before removing the cover and replacing the fuse. Failure to do so may cause serious injury to the user since high voltages exist within the unit.

Thorlabs provides the proper 120 VAC power input cable with each MC2000 for use in the United States and the appropriate 230 VAC input cable with each MC2000-EC for use in Europe. If using this unit anywhere else, the user will need to supply a properly grounded power cable to power the unit. If something should go wrong with the unit, do not attempt to fix. Call a Thorlabs representative and arrange for repair. The unit should never be opened unless changing the fuse or line voltage as described in Section 5.

Thorlabs ships all units configured to operate in the United States (i.e. line voltage 115 VAC, 60 Hz and 250 mA fuse installed). It may be necessary to change the line voltage to 230 VAC and replace the fuse with a 125 mA Slow Blo fuse. Care must be taken when configuring the unit. See Section 5 for complete details.

<table>
<tr><td>⚠</td><td>Warning Rotating Blade!</td><td>⚠</td></tr>
</table>

Keep hands clear while the blade is spinning. Turn power off before servicing.

Part 2. Product Overview

The MC2000 Optical Chopper is a precision instrument utilizing advanced features to meet the most demanding applications. The MC2000 uses a phased-locked loop (PLL) motor speed control design to precisely maintain the chopping speed and phase to a reference signal. An internal, crystal-stabilized, frequency synthesizer provides an accurate and stable reference frequency for long-term stable performance.

Unlike conventional, open-loop speed control designs, the PLL speed control circuit also allows the MC2000 chopper to be synchronized to external reference signals, including other MC2000 choppers and reference sources such as DSP lock-in amplifiers.

For more advanced measurements, the MC2000 can lock to a harmonic, sub-harmonic, or fractional-harmonic of an external reference frequency. The on board microprocessor is used to multiply the external reference up to the 15th harmonic or to divide the reference down to the 15th sub-harmonic. By combining both the frequency multiplication and division together, a fractional harmonic can be obtained.

The MC2000 also supports 2-frequency chopping from a single chopper blade. A special blade is available with 7 outer slots and 5 inner slots. This slot combination allows a single beam to be split and individually modulated for ratio metric experiments. Another example application is a pump-probe experiment where the pump beam is modulated at the outer frequency while modulating a probe beam at the inner frequency. The MC2000 provides the sum and difference frequencies of the 2-frequency blade for accurate lock-in detection of the frequency-mixed response.

A high quality, rare earth magnet, DC motor and a photo-etched optical chopper wheel are the top two design elements responsible for this device's high precision. The compact optical head has a wide base for extra stability. The base is slotted for two 1/4"-20 mounting screws on 3" centers. The interface cable uses circular snap-on connectors for easy setup.

The MC2000 controller includes a 240 x 128 pixel graphics display for setting and monitoring chopper functionality. All of the functions are accessible through a front panel control knob with turn and push control. Multiple user setups can be easily saved and recalled from non-volatile memory. A USB interface is included as a standard feature for remote PC control of the MC2000.
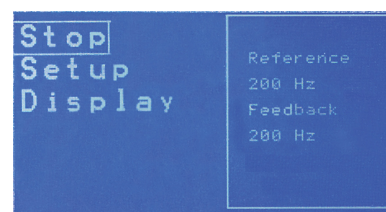
Thorlabs offers a number of different blades to extend the range of the chopping frequency. A standard 10-slot blade is included with the MC2000. 2-slot, 15-slot, 30-slot, 60-slot, and 2-frequency blades are also available.

Front Panel Description

Ext Input
The external reference signal is connected to this input BNC (TTL / CMOS logic level).

Control Knob
This knob is used to highlight and select menu items.

Ref Output
The reference output signal selected by the reference out menu (CMOS logic level).

Power
Press to toggle power

LCD Display
The controller menus are displayed here.
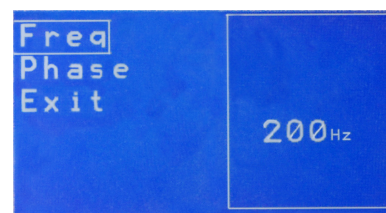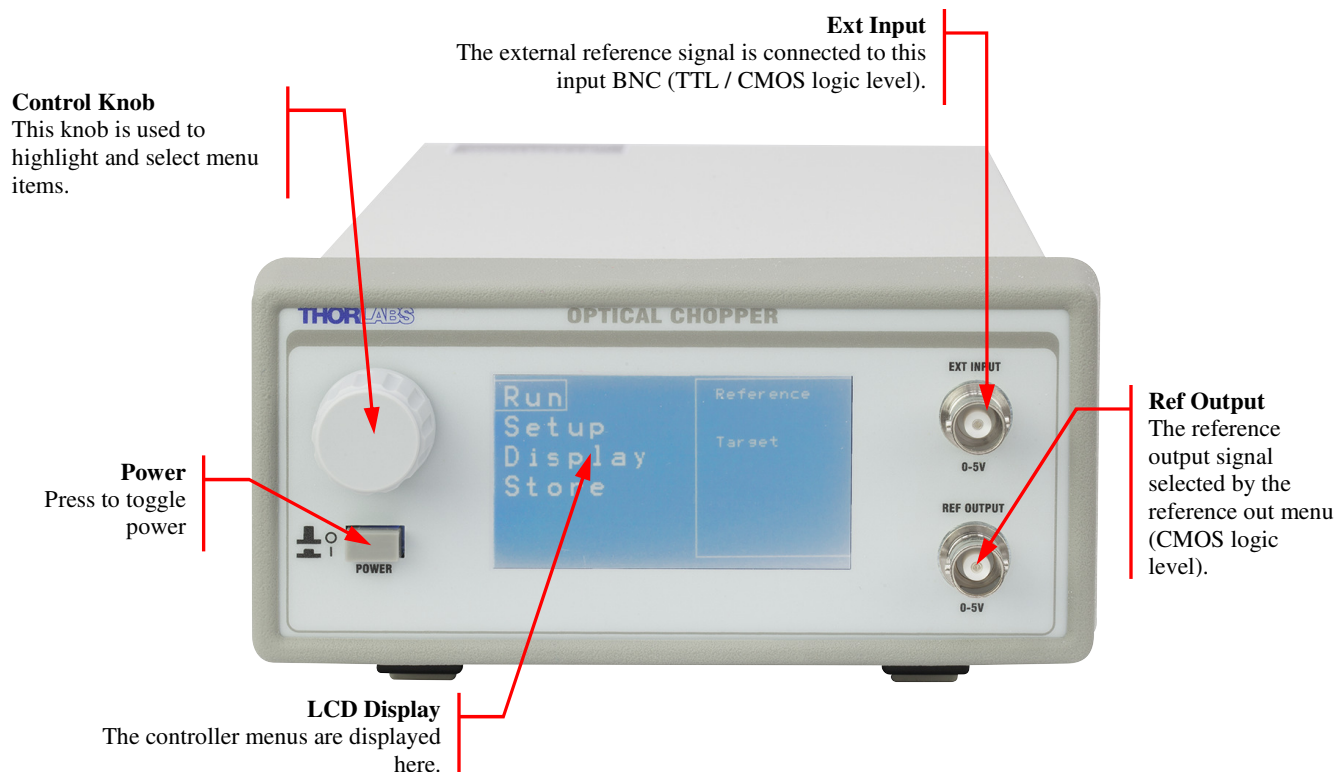
Figure 1:   Front Panel

Rear Panel Description

AC input receptacle
Requires an IEC compatible plug with ground terminal. Cord supplied for US operation.

Modular Interface
Connector for the optical head

Cooling Fan
Do not block when the unit is operating.

Fuse Holder
The system fuse is installed here.

USB 2.0 Port
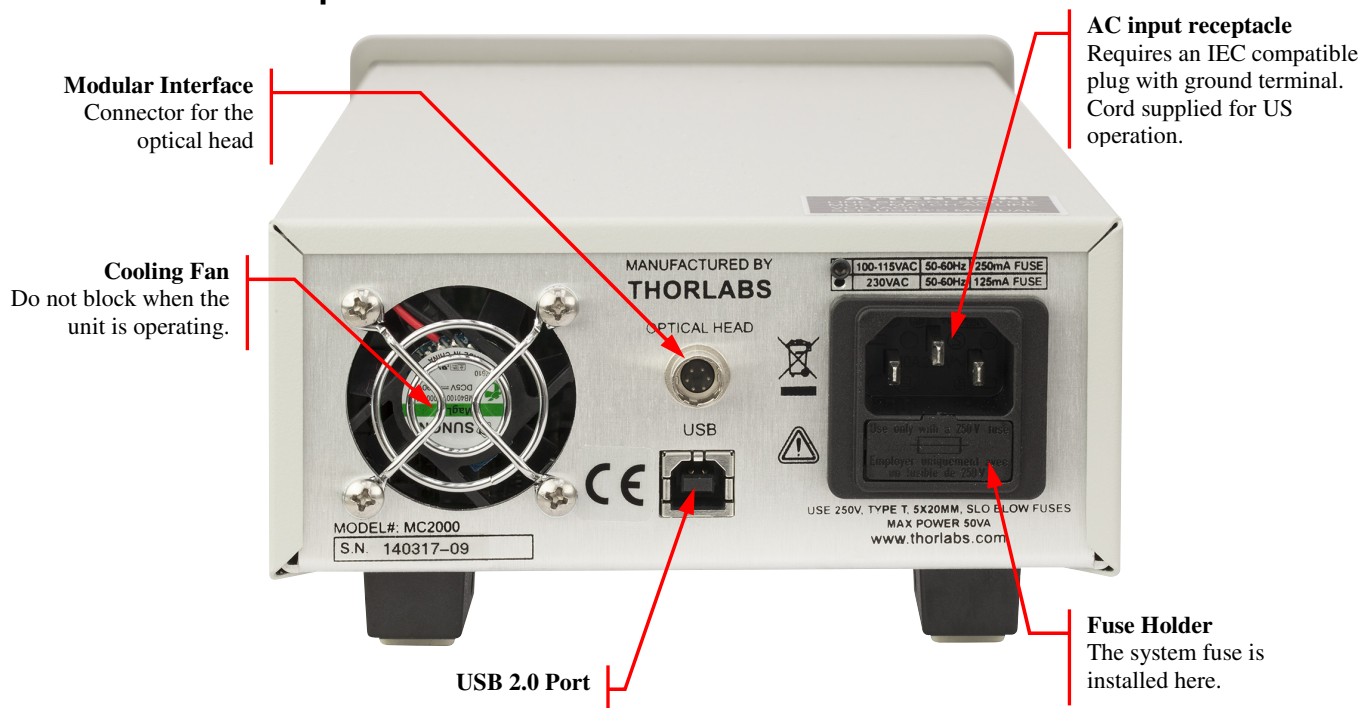
Figure 2:   Rear Panel

Part 3. Setup

1. Carefully unpack the MC2000 controller, optical head, and accessories. See below for a complete list of parts. If any of the items appear damaged or missing, do not use the MC2000. Call Thorlabs, or email RMA@thorlabs.com and arrange for a replacement.

   Parts List:

   - MC2000 Control Box
   - MC2000 Optical Chopping Head
   - MC1F10: 10-slot chopping blade
   - 2 meter mini circular cable for optical head / control box interface
   - This Operating Manual
   - Power Supply Line Cord: 120 VAC with the MC2000 or 230 VAC with the MC2000-EC
   - 125 mA Fuse for use at 230 VAC operation (250 mA fuse installed in unit)
   - 1/16" Allen Key for blade replacement
   - 0.05" Allen Key for hub alignment.
   - (3X) 4-40 x 1/8" Phillips Pan Head Screws with Internal Tooth Washers

2. Remove the 3 mounting screws and lock washers from the chopper blade hub using the 1/16" hex key provided.

3. Unpack the 10-slot blade and install onto chopper blade hub using the 3 screws and washers removed in the previous step. Tighten the screws securely with the hex wrench.

4. Attach the modular cord into the circular connector labeled 'OPTICAL HEAD' on the back of the MC2000 controller and plug the other end into the circular connector on the optical head.

5. Mount the optical head on a sturdy surface in an area free of obstructions. Make sure the blade can spin freely.

6. Attach the AC line cord to the MC2000 and plug into an AC outlet.

Note: the MC2000 can be operated from 100/115 VAC or 230 VAC. A voltage selector switch is located inside of the MC2000 controller. If you are not sure what operating voltage your unit is set to, proceed immediately to Part 8. Fuse Replacement and Line Voltage Selection on page 20 for instructions on setting the operating voltage.

Part 4.   Basic Operation

4.1.   Internal Reference Operating Mode

The MC2000 is most often used in the internal reference mode where the chopping speed is set internally.

1. Turn the MC2000 power on. The LCD display will show the Thorlabs logo and firmware revision number before changing to the top-level menu list. The display will then show the current menu, menu options, and operating status of the unit. By turning the front panel control knob, different menu items can be highlighted. Push the control knob to select the highlighted item.

2. Set the MC2000 parameters to the following for quick internal operation:

   - Blade – (MC1F10)

   - Ref. In – (INTERNAL)

   - Freq. – Set to the desired frequency

   - Phase – Set to the desired phase

   - Harm N – Set the N harmonic to 1

   - Harm D – Set the D harmonic to 1

3. Highlight and select Run Mode. The unit will adjust its speed and lock onto the set speed within a few seconds.

Note that all menu parameters can be changed in standby mode, while only frequency, phase and N/D harmonic parameters can be changed in run mode. The unit always powers up in standby mode.

4.2.   External Reference Mode

This mode allows the user to control the chopper blade with a logic-level external reference signal.

1. To enable external reference mode, attach a TTL or CMOS logic level reference signal to the 'EXT REF INPUT' BNC on the front panel. Turn the MC2000 power on.

2. Set the MC2000 parameters to the following for quick external operation:

   - Blade – (MC1F10)

   - Ref. In – (EXTERNAL)

   - Freq. – Set to the desired frequency

   - Phase – Set to the desired phase

   - Harm N – Set the N harmonic to 1

   - Harm D – Set the D harmonic to 1

3. Highlight and select Run Mode. The unit will adjust its speed and lock onto the external reference speed within a few seconds.

4.3. Reference-Out Signal

The MC2000 supports a number of different reference out signals. For reference output selection, highlight and select the external reference out signal from the following menu list. This list is described in more detail in the following sections.

- TARGET – The reference out signal synthesized internally from a unit's crystal clock

- ACTUAL – The reference out signal obtained from the feedback sensor reading the outer slots on a chopper wheel

- INNER – Reference out signal obtained from the feedback sensors reading the inner slots of a two slotted chopper wheel. (Note: This menu item is only displayed when a two-slot blade is selected.)

- OUTER – Reference out signal obtained from the feedback sensor reading the outer slots of a two slotted chopper wheel. (Note: This menu item is only displayed when a two slot blade is selected.)

- SUM – The reference out signal obtained from the two frequency blade 5/7 sum

- DIFF – The reference out signal obtained from the two frequency blade 5/7 difference

Part 5.   Advanced Operating Instructions

5.1. Internal Frequency Synthesizer

The MC2000 is most frequently used in this mode where the chopper wheel frequency is locked to an internal crystal stabilized frequency reference. The PLL motor speed control circuit maintains a precise lock to the frequency and phase of the internal reference frequency creating an ultra-stable chopping signal. The chopper wheel phase can be continuously adjusted.

Setup for Internal Reference Frequency

Follow the setup procedures for internal reference operating mode in Part 4: Basic Operation on page 9.

Selecting the REFERENCE OUT signal

In the internal frequency mode, the reference output signal can be set to the actual chopper wheel frequency (ACTUAL) or the internal frequency synthesizer (TARGET). In most cases, such as when selecting a reference for a lock-in amplifier, the chopper wheel frequency will be used since it provides a direct measurement of the chopper phase and frequency. The chopper wheel reference is derived from two photo-interrupters on the optical head that sense the motion of the chopper blade.

The internal frequency synthesizer has slightly less phase jitter than the chopper wheel reference since it is not affected by external disturbances. Therefore, there may be cases where using the internal synthesizer as the reference output yields better performance (i.e. when synchronizing multiple choppers).

5.2. External Reference Mode

A major benefit of using a PLL circuit to control the chopper wheel speed is the chopper can be locked precisely to an external reference signal. This allows the MC2000 to be used in advanced setups, for example, multiple MC2000 choppers can be synchronized to a single reference signal, or master-slave combinations where one chopper is the master reference and a second chopper is slaved off the reference output of the first. The latter example provides a convenient way to measure long decay time fluorescence and other similar types of experiments.

The MC2000 will accept a TTL or CMOS logic level input as an external reference. The advanced PLL design used in the MC2000 even accepts reference signals that do not have a 50% duty cycle. A special feature of the external reference mode, locking to harmonics and sub-harmonics of the reference signal, is described in the following section.

Setup for External Reference Frequency

Follow the setup procedures for external operating mode in Part 4: Basic Operation on page 9.

Selecting the REFERENCE OUT signal

In the External frequency mode, the reference output signal (ACTUAL) can be set to the actual chopper wheel frequency or the internal frequency synthesizer (TARGET). Most cases in this mode, only the actual chopper wheel frequency will ever be used.

5.3. Harmonic Reference Generation

Harmonic generation is a special feature available when operating in the external reference mode. The on board microprocessor is used to multiply the external reference up to the 15th harmonic or to divide the reference down to the 15th sub-harmonic. By combining both the frequency multiplication and division together, a fractional harmonic can be obtained. The new frequency is used as the chopper reference for chopping at a variety of frequency combinations, all derived from the external reference.

Setup for External Reference Frequency

Follow the setup procedures for external operating mode in Part 4: Basic Operation on page 9.

Setting the Reference Harmonic

Highlight and select the reference harmonic N menu item and enter a scroll bar value between 1 and 15.

Setting the Sub-Harmonic

Highlight and select the reference harmonic D menu item and enter a scroll bar value between 1 and 15.

Combining the Harmonic and Sub-Harmonic Modes

The sub-harmonic divider follows the harmonic multiplier. Therefore, the generated reference frequency will always be

$$ f_{EXT} = f_{REF} \, \frac{N}{D} . \qquad\qquad (eq. 1) $$

There are no special steps to combine these two features since they are always active.

Selecting the REFERENCE OUT signal

In the Harmonic frequency mode, a fractional harmonic reference output signal

$$ (ACTUAL) \frac{N}{D} , $$

or the internal frequency synthesizer (TARGET) can be selected. Most cases in this mode, only the (ACTUAL) fractional harmonic reference output signal will ever be used.

5.4. Two-Frequency Chopping

A special two-frequency blade is available from Thorlabs, which has seven slots on the outer portion of the wheel and five slots on the inner part of the wheel. This unique prime number combination allows the same chopper to discriminately chop two different light paths. This can be used in ratio metric measurements and pump-probe type experiments.

Selecting the REFERENCE OUT signal

The MC2000 provides two additional reference outputs in this mode. The sum (SUM), and the difference (DIFF) reference frequencies track the combined signal paths when they are frequency mixed together. The example below illustrates this:

For example, the MC2000 is set to run the outer blade set at 70 Hz. The inner blade, by virtue of the ratio of inner to outer slots will be running at 50 Hz. If a light path is common to both the inner and outer blades, the signal will see a sum frequency of 120 Hz and a difference frequency of 20 Hz.

Setting the Chopping Speed in the Two Frequency Mode

The chopping frequency for the two-frequency blade is set the same way as described above for the single frequency blades.

Note: The MC2000 synchronizes the outer portion of the two-frequency blade to the internal synthesizer or external reference. The inner portion is chopping at a rate given by, 5/7 * reference

$$f_{Inner} = f_{REF} \; \frac{5}{7}, \qquad \qquad \textit{(eq. 2)}$$

For example, if the internal reference (or external reference) frequency is 100 Hz, the outer portion of the blade would be chopping at 100 Hz and the frequency of the inner portion could be found using equation 2,

$$f_{Inner} = 100 Hz \frac{5}{7} = 71.42 Hz \, .$$

5.5. Two-Slot Blade

The 2-slot blade provides very stable low frequency chopping up to a frequency of 99 Hz. To accomplish the high stability required, an outer blade frequency with a 50:1 ratio is used to minimize the jitter. The optical chopper uses this outer frequency to lock the blade to either the internal or external frequency generator. In applications where phase is important, the MC2000 uses a dual photo-interrupter arrangement on the head to track the phase of the inner slot.

Note: On September 21, 2011, a new style of the 2-slot blade (MC1F2) was released that contains an outer-most 2-slot ring. Devices with firmware 3.12 and later *require* the new style blade for proper operation; devices with 3.11 or older are compatible with both style blades. If you would like to update to the latest firmware but own old style blades, please contact Thorlabs Tech Support (email: techsupport@thorlabs.com) for a free MC1F2 blade exchange.

Setup for Two-Slot Blade Reference Frequency

Follow the setup procedures for external operating mode in Part 4: Basic Operation on page 9.

Selecting the REFERENCE OUT signal

If operated as a stand-alone unit, the external reference out signal will most likely be set to the inner (INNER) mode. This will set the external reference out and display information to the inner slot frequency and phase of the blade.

If two units are to be synchronized in a master-slave configuration, the master unit will act as the frequency generator for the slave by connecting the reference out (REF OUT) of the master to reference in (REF IN) of the slave.

Master:

- Blade – (MC1F2)
- Ref. In – (INTERNAL)
- Ref. Out – (OUTER)
- Freq. – Set to the desired frequency.
- Phase – Set to the desired phase.

Slave:

- Blade – (MC1F2)
- Ref. In – (EXTERNAL)
- Ref. Out – (INNER)
- Freq. – Set to the desired frequency.
- Phase – Set to the desired phase.

Part 6.   Remote Communications

The MC2000 may also be controlled by a command line language through the USB port. This is offered to enable operation through a terminal interface or for those who may want to write their own program to control the system.

6.1.   Installing the USB Drivers

Prior to running the command line interface, the USB drivers must be installed. The MC2000 must not be connected to the PC while installing the drivers. Insert the CD that was supplied with your unit into your PC. From the dialog box that is displayed, select the Install Drivers button. If the dialog box is not displayed, browse to the CD and run CD-Starter.exe. Follow the onscreen prompts to install the driver. After the driver is installed, attach the MC2000 to the PC and power it on. Your PC will then detect the new hardware and will prompt you when the installation is complete.

6.2.   Command Line Interface

Once the USB drivers have been installed and the unit connected to the PC and powered on, configure the terminal emulator as follows:

- Baud Rate = 115.2K Bits Per Second
- Data Bits = 8
- Parity = None
- Stop Bits = 1
- Flow Control = None

If the connection is correct you will see the following after pressing the "Enter" key.

> *Command error CMD_NOT_DEFINED*

Followed immediately by the prompt:

> >

The basic structure of the interface is a keyword followed by either an equals sign "=" or a question mark "?". The "=" or "?" will determine if the string is a command or a query. All strings (commands and queries) must be terminated by a carriage return (CR) or pressing the ENTER key on the computer.

The command structure is as follows:

> *Keyword=argument(CR)*

Where "keyword" defines the function and "argument" is a numerical value followed by a carriage return (CR). See listing below.

The query structure is as follows:

Keyword?(CR)

The "keyword" defines the function and the question mark (?) indicates a query. The string is terminated with a carriage return (CR). See listing below. There are a few exceptions to this which are noted below.

The prompt symbol ">" will appear on power up and after a command is accepted by the system indicating it is ready to receive another command line.

6.3. Commands

The following list shows all of the available commands and queries, and summarizes their functions:

Command	Syntax*	Description
Get Commands	?	List the available commands.
Get Identification	id?	Returns the model number and firmware version.
Set Frequency	freq=*n*	Set the desired internal reference frequency.
Get Frequency	freq?	Returns the internal reference frequency.
Set Blade Type	blade=*n*	Set the blade type (*n* is number indicated in section 6.4).
Get Blade Type	blade?	Return the blade type (see section 6.4 for more details).
Set Harmonic Multiplier	nharmonic=*n*	Set Harmonic Multiplier applied to external reference frequency (1-15).
Get Harmonic Multiplier	nharmonic?	Returns the Harmonic Multiplier.
Set Harmonic Divider	dharmonic=*n*	Set the Harmonic Divider applied to external reference frequency (1-15).
Get Harmonic Divider	dharmonic?	Returns the Harmonic Divider.
Set Phase	phase=*n*	Set the Phase adjust (0-360°).
Get Phase	phase?	Returns the Phase adjust.
Set Enable	enable=*n*	Set Enable (0=disabled, 1=enabled).
Get Enable	enable?	Get Enable.
Set Reference	ref=*n*	Set the reference mode (0=internal, 1=external).
Get Reference	ref?	Returns the reference mode.
Set Ref Output	output=*n*	Set the output reference mode (0=target, 1=actual).
Get Ref Output	output?	Returns the output reference mode.
Set Display Intensity	intensity=*n*	Set the Display Intensity (1-10).
Get Display Intensity	intensity?	Returns the Display Intensity.
Get Reference Frequency	input?	Returns the current supplied external reference frequency.
Restore	restore	Restore the factory default parameters.
Get Verbose	verbose?	Returns the verbose mode.
Set Verbose	verbose=*n*	When verbose mode is set to 1, status messages are output on the USB.
Set Language	text=*n*	*n* = 0 sets text to English, *n* = 1 sets text to Chinese.

* *All commands and queries are in lower case letters.*

If the keyword, format, or argument is incorrect or out of range, the unit will return an error string. The function is determined by the value set with the mode command in the above table.

6.4. Blade Indexes

Blade type can be gotten or set through the command line interface using the commands "blade?" and "blade=*n*", respectively. These commands do not denote blade type using product names. Rather, they index blade type using the numbers from 0 to 7. The following table provides the mapping:

Blade	Index
MC1F2	0
MC1F6	1
MC1F10	2
MC1F15	3
MC1F30	4
MC1F60	5
MC1F100	6
MC1F57	7

Part 7.   Maintenance and Troubleshooting

7.1. Cleaning

The MC2000 should only be cleaned with a soft cloth and mild soap detergent or isopropyl alcohol. Do not use a solvent-based cleaner.

The optical chopper wheel may build up a layer of dust over time on the leading edges of the wheel. To clean the wheel, remove it from the optical head and wipe it clean with a cloth dampened in isopropyl alcohol. To help prevent the chopper wheel from rusting in high humidity environments, wipe the blade with a clean rag sprayed with a light lubricating rust inhibitor (e.g. WD40 or similar).

7.2. Diagnostic Messages

When the MC2000 senses a problem with the chopper operation, it will display various messages to help identify the source of the problem.

- **Freq. Not Locked**   This indicates that the chopper speed could not lock to the set frequency or the external reference. If this occurs, check the unit has been set to the correct blade (as indicated on power up). If this problem persists, contact Thorlabs for assistance.

- **Phase Not Locked**   This indicates that the chopper phase could not lock to the set phase setting. If this problem persists, contact Thorlabs for assistance.

- **No Int. Reference**   This message is displayed when the unit is set to external reference but it does not detect an external reference input. Check that your external reference source is connected to the BNC labeled EXT REF IN.

Part 8.   Fuse Replacement and Line Voltage Selection

Thorlabs ships the MC2000 unit configured to operate at 100/115 VAC. The line voltage and installed fuse must be changed to operate this unit at 230 VAC. Follow the instructions below to change the line voltage if necessary.

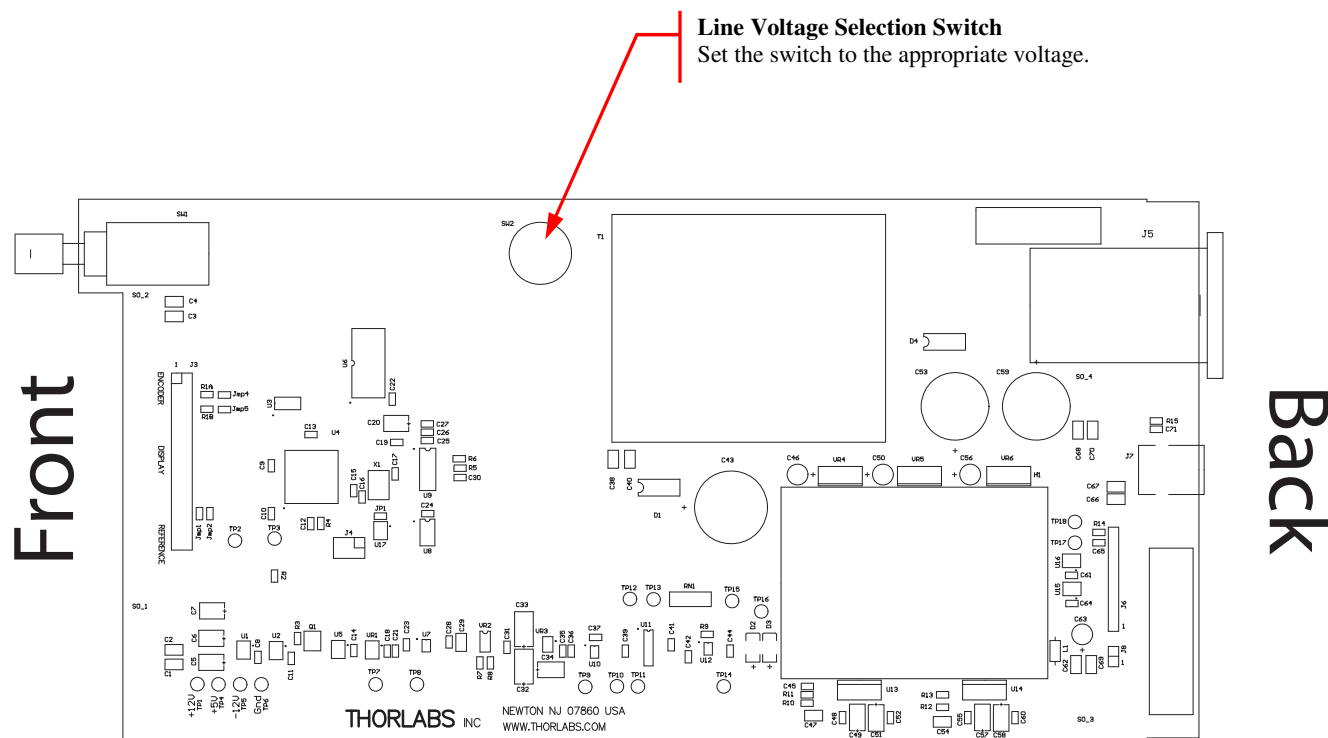| ⚡	**Warning Electrical Shock**	⚡
	The unit must be powered off, unplugged from the AC input power source, and disconnected from all external devices before removing the cover and replacing the fuse. Failure to do so may cause serious injury to the user since high voltages exist within the unit.	

8.1. Materials Needed

- MC2000 Operating Manual

- 250 mA Type IEC60127-2/III, Type 'T' Slo-blo Fuse – The 250 mA fuse is installed from the factory and must be installed when operating the unit at 100/115 VAC.

- 125 mA Type IEC60127-2/III, Type 'T' Slo-blo Fuse – Thorlabs supplies a 125 mA fuse to be installed when operating at 230 VAC.

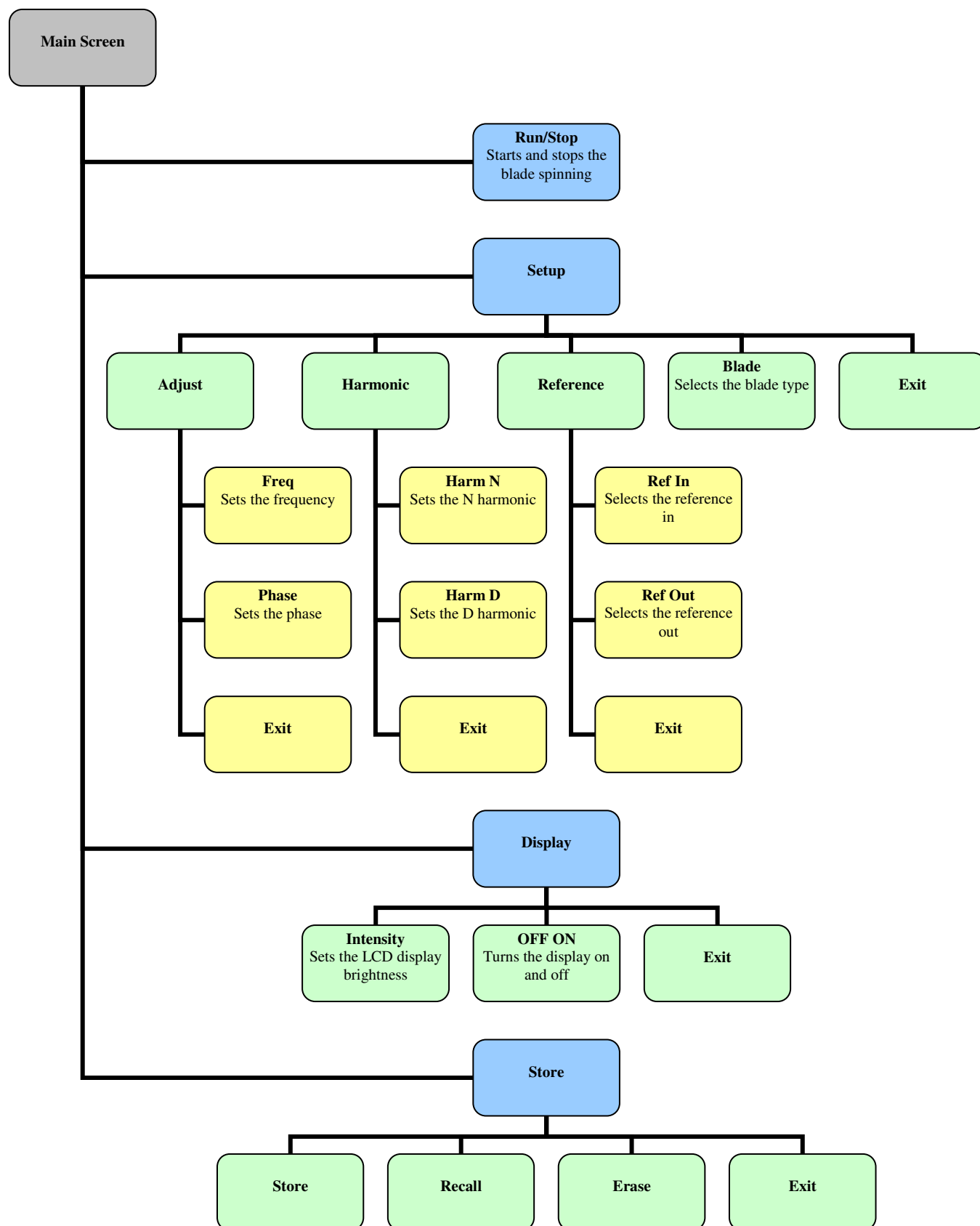- Phillips Head Screwdriver (#2 Preferred) – Motorized screwdrivers are not recommend.

8.2. Fuse Replacement and Line Voltage Selection

1. **Important!** – Make sure the power cord, optical head, and any external devices are disconnected before continuing. See warning above.

2. Remove the two screws securing the enclosure cover with a Phillips head screwdriver. The screws are located on the bottom side, rear corners of the unit. Place the screws in a safe location.

3. Carefully remove the cover by sliding it toward the rear of the unit.

4. To change the line voltage, locate the line select switch behind the power switch. Select the appropriate line voltage by adjusting the switch to either 110 or 220. Select 110 if operating at 100 to 120 VAC. Select 220 for operation from 220 to 240 VAC.

5. Replace the enclosure cover and secure with the enclosure screws.

6. Locate the fuse holder below the power input connector. Slide the fuse tray out using a flat head screwdriver. Remove the fuse and replace with the appropriate value as described below:

   - 100 – 120 VAC operation – Use the 250 mA fuse

   - 220 – 240 VAC operation – Use the 125 mA fuse

Line Voltage Selection Switch
Set the switch to the appropriate voltage.

Figure 3:   Circuit Board Layout with 110/220 VAC Switch

Part 9.   Visual Menu Structure

Main Screen

Run/Stop
Starts and stops the blade spinning

Setup

Adjust   **Harmonic**   **Reference**   **Blade** Selects the blade type   **Exit**

Freq Sets the frequency   **Harm N** Sets the N harmonic   **Ref In** Selects the reference in

Phase Sets the phase   **Harm D** Sets the D harmonic   **Ref Out** Selects the reference out

Exit   **Exit**   **Exit**

Display

Intensity Sets the LCD display brightness   **OFF ON** Turns the display on and off   **Exit**

Store

Store   **Recall**   **Erase**   **Exit**

Part 10. Specifications

| Performance Specifications	
Chopping Frequency	
MC1F2 (2 slot)	1 – 99 Hz
MC1F10 (10 slot, Default Blade)	20 – 1 kHz
MC1F15 (15 slot)	30 – 1.5 kHz
MC1F30 (30 slot)	60 – 3 kHz
MC1F60 (60 slot)	120 – 6 kHz
MC2F57 (2f slot)	Outer: 14 – 700 Hz Inner: 10 – 500 Hz
Phase Jitter (@ max freq)	
MC1F2 (2 slot)	0.05° rms Max
MC1F10 (10 slot, Default Blade)	0.42° rms (0.13° rms Typ.)
MC1F15 (15 slot)	0.68° rms (0.27° rms Typ.)
MC1F30 (30 slot)	1.10° rms (0.45° rms Typ.)
MC1F60 (60 slot)	1.10° rms (0.78° rms Typ.)
MC2F57 (2f slot)	0.38° rms (0.08° rms Typ.)
Frequency Drift	<20 ppm/°C
Chopping Range	
Harmonic	2 to 15x
Sub-Harmonic	1/2 to 1/15x
Input/Output Specifications	
Ext. Input Compatibility	TTL/CMOS
Ext. Input Voltage Range[2]	0 – 5 V
Input High	>2 V
Input Low	<0.8 V
Ext. Input Impedance	200Ω
Ref Out Compatibility	TTL/CMOS
Ref Out Voltage Range[2]	0 – 5 V Typ.
Ref Out Impedance	200Ω
Min Load Impedance[3]	500Ω
Ref Out Signals	Inner/Outer Slot Chopping Blade, Synthesizer, Sum and Diff Frequencies
Ref Out Selection	Selectable Menu or USB command 'O '

Communications	
Communications Port	USB
Protocol	USB (RS232 Emulated)
Baud Rate	115,200 (fixed)
Data Bits	8
Stop Bits	1
Parity	None
Handshaking	None

Optical Head Specifications	
Chopping Blade Diameter	Ø4.0" (Ø101.6 mm)
Chopping Blade Thickness	0.010" (0.254 mm)
Mounting Base	1/4"-20 (or M8) Clearance Slots Spaced 3.0" (Compatible with Thorlabs Breadboards)
Mounting Hole	1/4"-20 with 1/4" Max Screw Depth

| Blade Specifications	
Chopping Blade Slots[4]	
MC1F2	2
MC1F10 (Default Blade)	10
MC1F15	15
MC1F30	30
MC1F60	60
MC2F57	7 Outer, 5 Inner
Slot Angle	
MC1F2	180°
MC1F10 (Default Blade)	36°
MC1F15	24°
MC1F30	12°
MC1F60	6°
MC2F57	51.4° Outer, 72° Inner

Physical Features	
Dimensions (W x H x D)	6.0" x 2.9" x 11.4" (164 mm x 73 mm x 290 mm)
Input and Output Connectors	BNC
Menu Control	Twist / Push-Button Knob
Input Power Connection [1]	IEC Connector
Weight	5 lbs (9.1 lbs Shipped Weight)
Operating Temperature	10 – 40 °C
Display Type	240 x 124 Pixel LCD Graphics Display
Frequency Resolution	1 Hz (10, 15, 30, 60 and 2f blades) 0.01Hz (2 slot blade)
Power Supply	
Supply Type	Linear
Voltage Selection	Switch Selectable between 115 / 230 VAC
Input Voltage	100/115 VAC ± 10%, 230 VAC ± 10%
Line Frequency	50 – 60 Hz
Input Power	20 VA Max
Fuse Ratings	250 mA @ 115 VAC 125 mA @ 230 VAC
Fuse Type	IEC60127-2/III (250 V, Slo-blo Type 'T')
Fuse Size	5 x 20 mm

1) *The MC2000 is shipped with a 120 VAC US style power cord while the MC2000-EC is shipped with a 230 VAC power cord.*

2) *The reference output and external input is short circuit protected by limiting the current to 25mA. Over and Under voltage protection is available, but continued use will degrade or damage the unit.*

3) *The Min Load Impedance represents the smallest allowable terminating resistance. Applying lower impedances will cause the short circuit protection to limit the output voltage. Continued use in this mode will cause circuit degradation and eventual circuit failure.*

4) *The MC1F10 blade is supplied with the unit. All other blades specified may be purchased separately through Thorlabs, Inc.*

Part 11.   Drawings
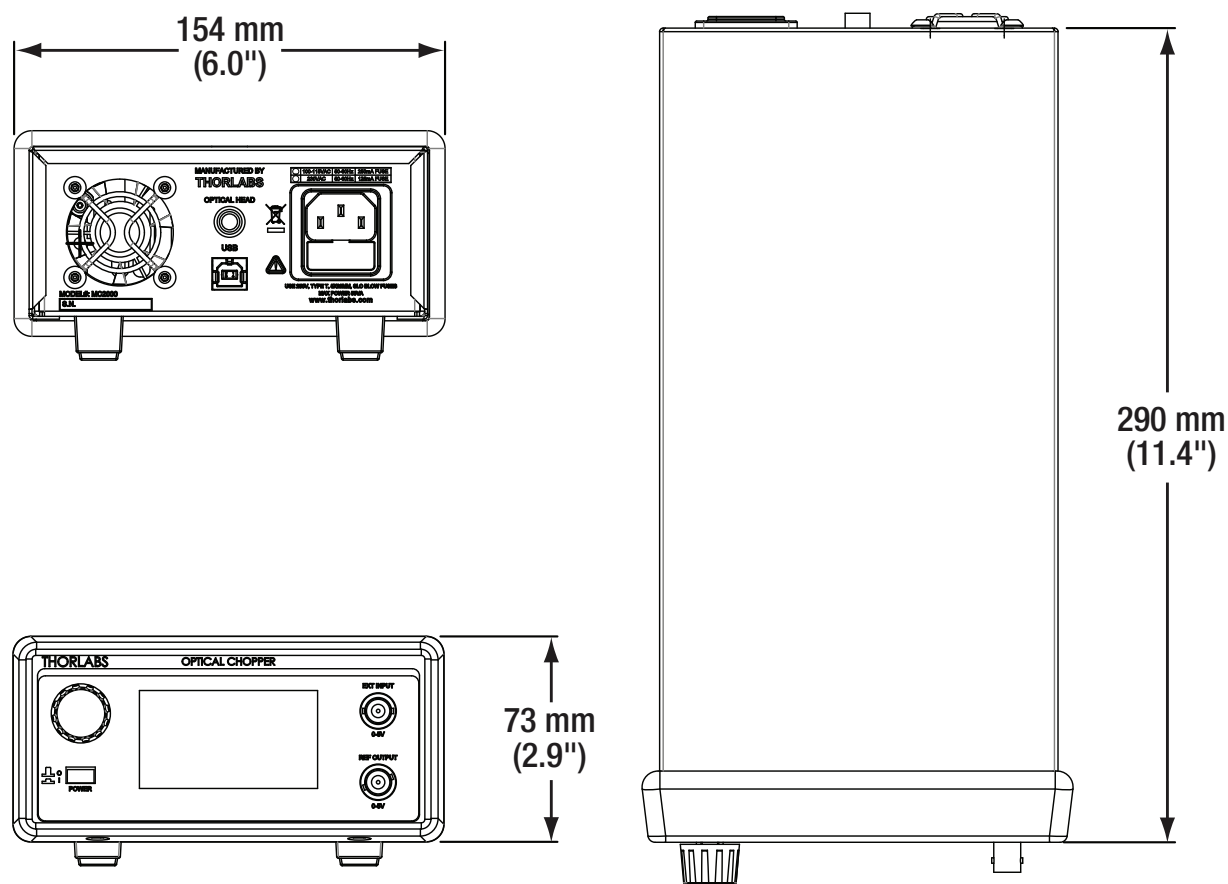
Figure 4:   Console Dimensional Drawing
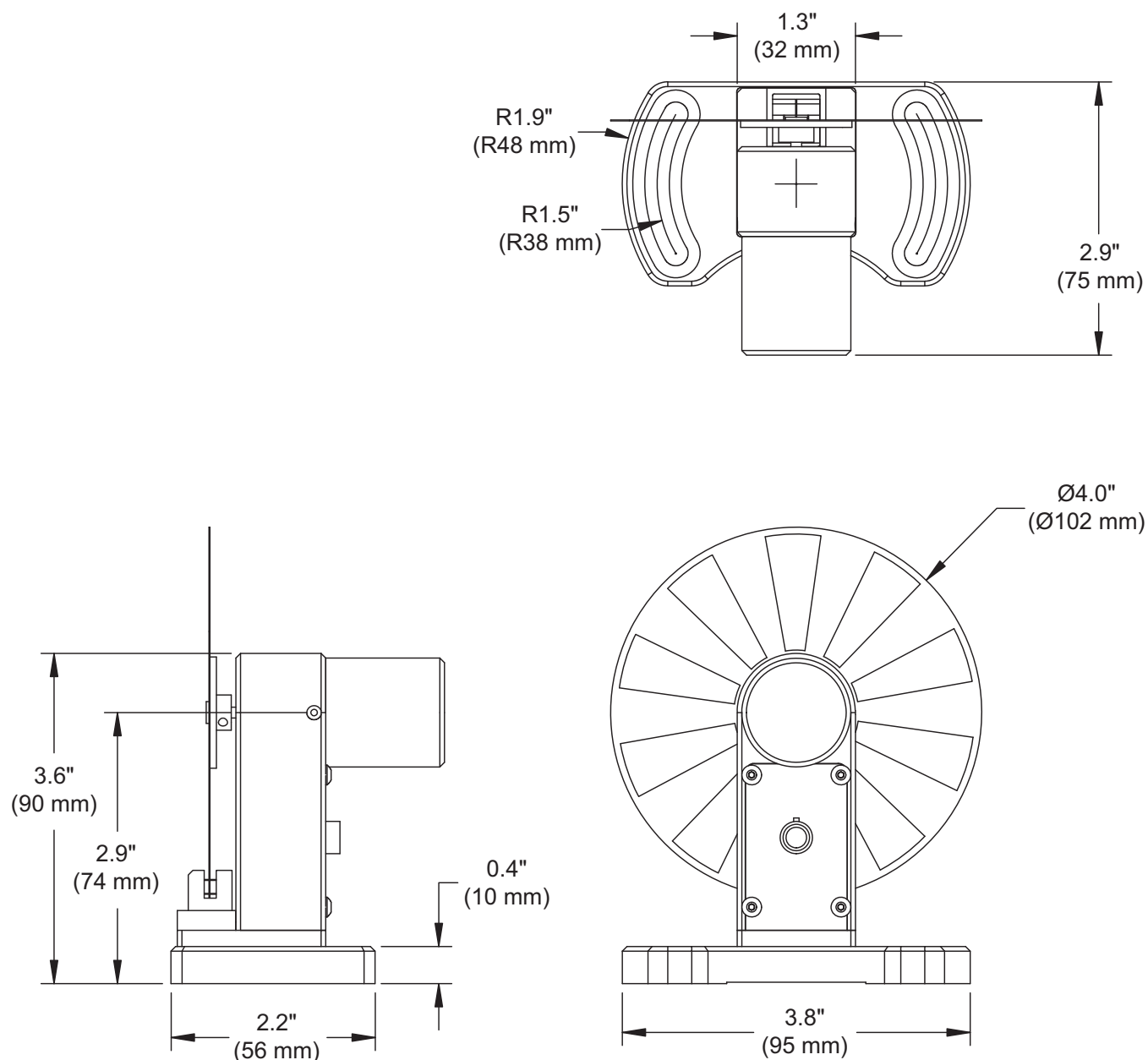
Figure 5:   Chopper Head Dimensional Drawing

Part 12. Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out "wheelie bin" logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated

Wheelie Bin Logo

As the WEEE directive applies to self contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

12.1. Waste Treatment is Your Own Responsibility

If you do not return an "end of life" unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

12.2. Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of live products will thereby avoid negative impacts on the environment.

Part 13. Certificate of Conformity

Konformitätserklärung
Declaration of Conformity
Déclaration de Conformité

Thorlabs Inc
435 Rt 206
Newton, NJ
USA

erklärt in alleiniger Verantwortung, dass das Produkt:
declares under it's own responsibility, that the product:
déclare sous notre seule responsabilité, que le produit:

MC2000

mit den Anforderungen der Normen
fulfills the requirements of the standard
satisfait aux exigences des normes

72/73/EEC	Low Voltage Directive 19.02.1973
93/68/EEC	Change of Low Voltage Directive
DIN EN 61010-1:2001	Safety of Test and Measurement Equipment
EMC 89/336/EEC	Electromagnetic Compatibility Directive
DIN EN 61326-1: 2006	Safety of Magnetic Fields
CISPR 11:2007	Conducted Emissions – Voltage – Class A
CISPR 11:2007	Radiated Emissions – Class A
DIN EN 61326:97 + A1:98 + A2:2001 + A3:2003	EMC of Test and Measurement Equipment
DIN EN 61000-4-2	Electrostatic Discharge Immunity
DIN EN 61000-4-3	Radiated RF Electromagnetic Field Immunity
DIN EN 61000-4-4	Electrical Fast Transient/Burst Immunity
DIN EN 61000-4-5	Power Line Surge Immunity
DIN EN 61000-4-6	Conducted RF Immunity (Criterion B)
DIN EN 61000-4-11	Voltage Dips, Interruptions and Variations

übereinstimmt und damit den Bedingungen entspricht.
and therefore corresponds to the regulations of the directive.
et répond ainsi aux dispositions de la directive.

Dachau, 21.August 2009

Ort und Datum der Ausstellung
Place and date of issue
Lieu et date d'établissement

Name und Unterschrift des Befugten
Name and signature of authorized person
Nom et signature de la personne autorisée

MC2000

72/73/EEC	Low Voltage Directive 19.02.1973
93/68/EEC	Change of Low Voltage Directive
DIN EN 61010-1:2001	Safety of Test and Measurement Equipment

Performed by John Craig Bowers @ Thorlabs Newton NJ   7/8/09

EMC 89/336/EEC	Electromagnetic Compatibility Directive
92/31/EEC	Amended
93/68/EEC	Amended
DIN EN 61326-1: 2006	Safety of Magnetic Fields
CISPR 11:2007	Conducted Emissions – Voltage – Class A
CISPR 11:2007	Radiated Emissions – Class A
DIN EN 61326:97 + A1:98 + A2:2001 + A3:2003	EMC of Test and Measurement Equipment
DIN EN 61000-4-2	Electrostatic Discharge Immunity
DIN EN 61000-4-3	Radiated RF Electromagnetic Field Immunity
DIN EN 61000-4-4	Electrical Fast Transient/Burst Immunity
DIN EN 61000-4-5	Power Line Surge Immunity
DIN EN 61000-4-6	Conducted RF Immunity (Criterion B)
DIN EN 61000-4-11	Voltage Dips, Interruptions and Variations

Performed at MET Laboratories Baltimore,MD USA
Witnessed by MET Laboratories 7/13/09 – 7/17/09
(MET REPORT: EMC27316-EURO)

I hereby confirm that the above listed tests were performed on an **MC2000** between 7/8/09 – 7/17/09, and passed with satisfactory results.

....8/20/09
John Craig Bowers – Design Engineer Thorlabs, Inc Newton NJ

Part 14.   Thorlabs Worldwide Contacts

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