MC1000A   Optical Chopper
Operating Manual
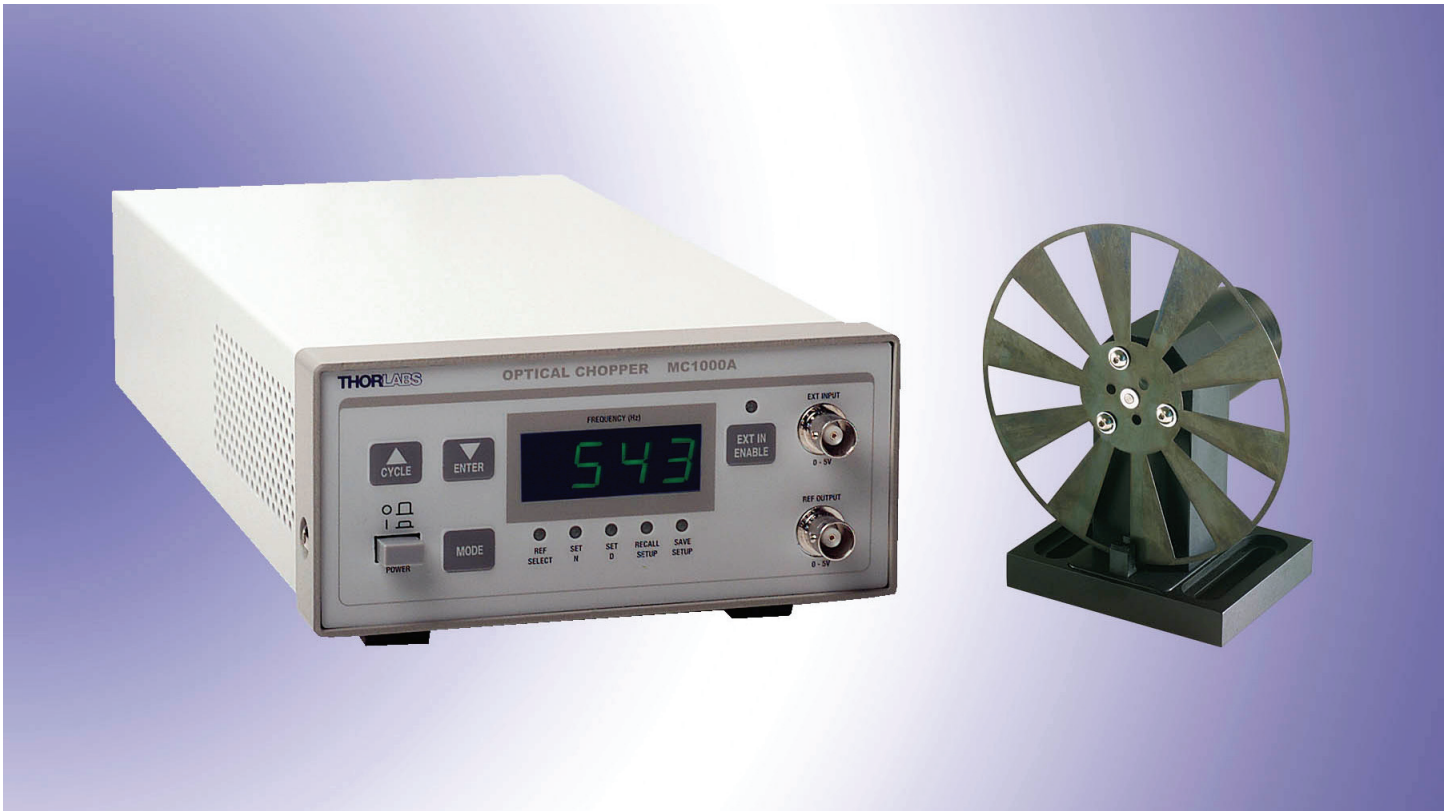
Related Products

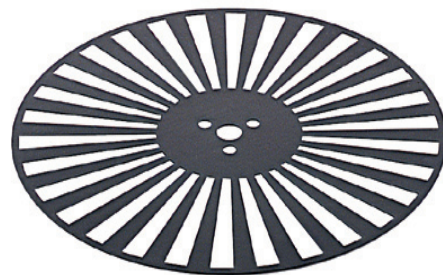| Model	Description
MC1F2	2-slot Replacement Blade, 1 – 99Hz
MC1F10	10-slot Replacement Blade, 25 – 1kHz
MC1F15	15-slot Replacement Blade, 38 – 1.5kHz
MC1F30	30-slot Replacement Blade, 75 – 3kHz
MC1F60	60-slot Replacement Blade, 150 – 6kHz
MC2F57	Dual Slot (5 Inner / 7 Outer) Replacement Blade

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WEEE

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 13th 2005

- marked correspondingly with the crossed out "wheelie bin" logo (see fig. 1)

- 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

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.

Waste treatment on 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.

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.
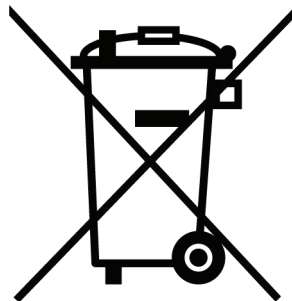
Crossed out "wheelie bin" symbol

Section 1: Safety Warnings

WARNING: TO AVOID ELECTRICAL SHOCK THE POWER CORD PROTECTIVE GROUNDING CONDUCTOR MUST BE CONNECTED TO GROUND. REFER SERVICING TO QUALIFIED PERSONEL.

Thorlabs provides the proper power input cable with each MC1000A for use in the United States. 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.

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

WARNING: ROTATING BLADE. KEEP HANDS CLEAR WHILE THE BLADE IS SPINNING. TURN POWER OFF BEFORE SERVICING.

Section 2: Specifications

2.1 Physical Features:

Dimensions (W x H x D):	5.8" x 2.8" x 12.5" (147mm x 71mm x 317.5mm)
Input and Output Connectors:	BNC's
Frequency Control:	Up / Down Keypad Switches
Mode Control:	Keypad Switch with LED Illuminated Selection
External Control:	Keypad Switch Enable with LED indication
Input Power Connection[1]:	IEC Connector w/ US style power cord
Weight:	5 lbs (9.1 lbs shipped weight)
Operating Temperature:	10 - 40°C
Display Type:	Green LED Segments
No of Digits:	4
Frequency Resolution:	1Hz (10, 15, 30, 60 and 2f blades)
	0.01Hz (2 slot blade)

2.2 Power Supply:

Supply Type:	Linear
Voltage Selection:	Switch Selectable between 115 / 230 VAC
Input Voltage:	100/115VAC +/-10%, 230VAC +/- 10%
Line Frequency:	50 – 60Hz
Input Power:	20VA max
Fuse Ratings:	250mA @ 115VAC
	125mA @ 230VAC
Fuse Type:	IEC60127-2/III (250V, Slow Blow Type 'T')
Fuse Size:	5 x 20mm

2.3 Input / Output Specifications:

Ext. Input Compatibility:	TTL/CMOS
Ext. Input Voltage Range[2]:	0 – 5V
Input High	$\geq$ 2V
Input Low	$\leq$0.8V
Ext. Input Impedance:	200Ω
Ref Out Compatibility:	TTL/CMOS
Ref Out Voltage Range[2]:	0 – 5V typ.
Ref Out Impedance:	200Ω
Min Load Impedance[3]:	500Ω
Ref Out Signals:	Chopping Blade, Synthesizer, Sum and Diff Frequencies
Ref Out Selection:	'Mode' Keypad selection or RS232 command 'O'

2.4 Performance Specifications:

Chopping Frequency:	
MC1F2 (2 slot):	1 – 99Hz
MC1F10 (10 slot)	20 – 1kHz (Default Blade)
MC1F15 (15 slot)	30 – 1.5kHz
MC1F30 (30 slot)	60 – 3kHz
MC1F60 (60 slot)	120 – 6kHz
MC2F57 (2f slot)	14 – 700Hz (Outer)
	10 – 500Hz (Inner)
Phase Jitter (@ max freq):	
MC1F2 (2 slot):	0.05°rms max
MC1F10 (10 slot)	0.42°rms (0.13°rms typ.) (Default Blade)
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:	2x to 15x
Sub-Harmonic:	1/2x to 1/15x

2.5 Communications:

Communications Port:	RS232
Com Connection:	DB9 Female
Required Cable[5]:	DB9 Male to Female

Protocol:
Baud Rate:	19,200 (fixed)
Data Bits:	8
Stop Bits:	1
Parity:	None
Handshaking:	None

2.6 Optical Head Specifications:

Chopping Blade Diameter:	ϕ4.0” (ϕ101.6mm)
Chopping Blade Thickness:	0.010” (0.254mm)
Mounting Base:	¼”-20 (or M8) clearance slots spaced 2.0” (Compatible with Thorlabs 1” breadboard spacing)
Mounting Hole:	¼”-20 with ¼” max screw depth

2.7 Blade Specifications:

Chopping Blade Slots[4]:
MC1F2:	2
MC1F10:	10 (Default Blade)
MC1F15:	15
MC1F30:	30
MC1F60:	60
MC2F57:	7 Outer, 5 Inner

Slot Angle:
MC1F2:	180°
MC1F10:	36° (Default Blade)
MC1F15:	24°
MC1F30:	12°
MC1F60:	6°
MC2F57:	51.4° Outer, 72° Inner

Notes:

1. The MC1000A is supplied with a US style power cord. Units purchased in other countries must supply their own certified rated 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.

5. Do not use a null modem cable.

Section 3: Description

The MC1000A Optical Chopper is a precision instrument utilizing advanced features to meet the most demanding applications. The MC1000A uses a phased-lock loop (PLL) motor speed control design to precisely lock the chopping speed and phase to a reference signal. An internal, crystal-stabilized frequency synthesizer provides an accurate and stable reference frequency for ultra-low long-term frequency drift.

Unlike conventional, open-loop speed control designs, the PLL speed control circuit also allows the MC1000A chopper to be synchronized to external reference signals, including other MC1000A choppers and reference sources such as DSP lock-in amplifiers.

For more advanced measurements, the MC1000A can lock to a harmonic, sub-harmonic, or fractional-harmonic of an external reference frequency. A second PLL circuit is used to multiply the external reference up to the 15th harmonic. This multiplier is followed by a digital divider 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 MC1000A 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. Other applications include pump-probe experiments where the pump beam is modulated at the outer frequency while modulating a probe beam at the inner frequency. The MC1000A provides the sum and difference frequencies of the 2-frequency blade for accurate lock-in detection of the frequency-mixed response.

A high quality, Swiss-made, rare earth magnet DC motor and a photo-etched chopper optical wheel drive the precision. The compact optical head has a wide base for extra stability. The base is slotted for two ¼-20 mounting screws on 2" centers. The interface cable uses standard RJ-45 modular connectors for easy setup.

The MC1000A controller includes a large, 4-digit, easy to read LED display for monitoring the chopper frequency. All of the operating modes are accessible from streamlined, front panel push-button controls. Multiple user setups can be easily saved and recalled from non-volatile memory. An RS-232 serial interface is included as a standard feature for remote interfacing the MC1000A to other equipment.

Thorlabs offers a number of different blades to extend the range of the chopping frequency. A standard 10-slot blade is included with the MC1000A. Two slot, 15 slot, 30 slot, 60 slot and the 2-frequency blades are also available.

Section 4: Parts List

Below is a list of all components shipped with the MC1000A Optical Chopper.

- ❏ MC1000A Control Box
- ❏ MC1000A Optical Chopping Head
- ❏ MC1F10: 10-slot chopping blade
- ❏ 2 meter RJ-45 cable for optical head / control box interface
- ❏ Operating Manual
- ❏ US Power Supply Line Cord
- ❏ 125mA Fuse for use at 230VAC operation (250mA 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

The following items are sold separately:

- ❏ MC1F2: Two Slot Replacement Blade, 1 – 99Hz
- ❏ MC1F15: 15-slot Replacement Blade, 38 – 1.5kHz
- ❏ MC1F30: 30-slot Replacement Blade, 75 – 3kHz
- ❏ MC1F60: 60-slot Replacement Blade, 150 – 6kHz
- ❏ MC2F57: Dual Slot (5 Inner / 7 Outer) Replacement Blade

Section 5: Fuse Replacement / Line Voltage Selection

Thorlabs ships it MC1000A units configure to operate at 115VAC. The line voltage and installed fuse must be changed to operate this unit at 230VAC. To operate at 100VAC, use the 115VAC setting. Follow the instructions below to change the line voltage if necessary.

WARNING: 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.

5.1 Materials Needed

❑ **MC1000A Operating Manual** – The most recent version of this operating manual will be available on Thorlabs web site.

❑ **125mA Type IEC60127-2/III** – (Type 'T' Slow Blow Fuse) The 125mA fuse is required for 230V operation only. Thorlabs supplies a 125mA fuse with all of its MC1000A units and must be installed when operating at 230VAC.

❑ **250mA Type IEC60127-2/III** – (Type 'T' Slow Blow Fuse) The 250mA fuse is installed from the factory. This must be installed when operating the unit at 100 / 115VAC.

❑ **Phillips Head Screwdriver (#2 Preferred)** – We do not recommend using electrically powered screwdrivers.

5.2 Fuse Replacement and Line Voltage Selection

1. **Important** – Disconnect the optical head and any external devices from the MC1000A BNC's.

2. **Important** – Disconnect the power cord. **Do not open the unit if the power cord is connected**. **See warning above.**

3. 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. Do not lose the screws.

4. Carefully remove the cover by sliding toward the rear of the unit.

5. 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 100VAC to 120VAC. Select 220 for operation from 220VAC to 240VAC.

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

7. Remove the line voltage selection screw and reinstall in the appropriate location. See page 11, Figure 2 for details.

8. 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 – 120VAC operation – Use the 250mA Type IEC60127-2/III (5x20mm, 250V, Slow Blow Type 'T')

   ❑ 220 – 240VAC operation – Use the 125mA Type IEC60127-2/III (5x20mm, 250V, Slow Blow Type 'T')

Section 6: Getting Started Quickly

This section is provided for those interested in getting the MC1000A up and running quickly as a basic optical chopper. The more advanced features are described in detail in the following sections.

6.1 Setup

1. Carefully unpack the MC1000A controller, optical head, and accessories. See section 4 for a complete list of parts. If any of the items appear damaged or missing, do not use the MC1000A. Call Thorlabs, or email RMA@thorlabs.com and arrange for a replacement.

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 jack labeled 'OPTICAL HEAD' on the back of the MC1000A controller and plug the other end into modular jack on the optical head.

5. Mount the optical head on a sturdy surface and check that the blade can spin free of any obstruction.

6. Attach the AC line cord to the MC1000A and plug into an AC outlet.

Note: the MC1000A can be operated from 100/115VAC or 230VAC. A voltage selector switch is located inside of the MC1000A controller. If you are not sure what operating voltage your unit is set to, proceed immediately to Section 5.0 for instructions on setting the operating voltage.

6.2 Internal Reference Operating Mode

This MC1000A is most commonly used in the internal reference mode. The chopping speed is set by the internal crystal-stabilized frequency synthesizer.

1. Turn the MC1000A power on. The LED display will go through a startup sequence: first, all of the display segments and LED's are lit, then the firmware rev level is displayed, followed by the current blade setting.

2. The display should show "b 10" for the 10-slot blade. If not, press the '▲' key until the "b 10" message is displayed and then release the button. The unit will time out after a second or two and go into a standby mode with the display showing "oFF". If you miss the timing of this, turn the power switch off then back on again to return to this mode.

3. If the unit comes up in the EXTERNAL REFERENCE Mode (as indicated by the LED above the 'EXT IN ENABLE' key being lit), press the 'EXT IN ENABLE' key to turn it off and return to the internal reference mode.

4. The unit should be in a standby mode with "oFF" displayed on the front panel. Press any of the keys to start the chopper motor.

5. To change the chopper speed, press the '▲' or '▼' keys until the desired speed is shown. Release the key and the unit will adjust its speed and lock onto the set speed within a few seconds.

6.3 External Reference Mode

This mode is very similar to the internal reference mode except that the chopper blade is locked to 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 and follow the above steps.

2. Press the 'EXT IN ENABLE' key to enable the external reference mode.

Note: If the chopper does not lock to the exactly frequency of the external signal check that the harmonic multiplier, N, is set to 1 by pressing the 'MODE' key until the light under the 'SET N' LED is lit. The display should show a 1. If not, press the '▼' key until it reaches 1. Repeat his step for the sub-harmonic divider, D.

Section 7: Description
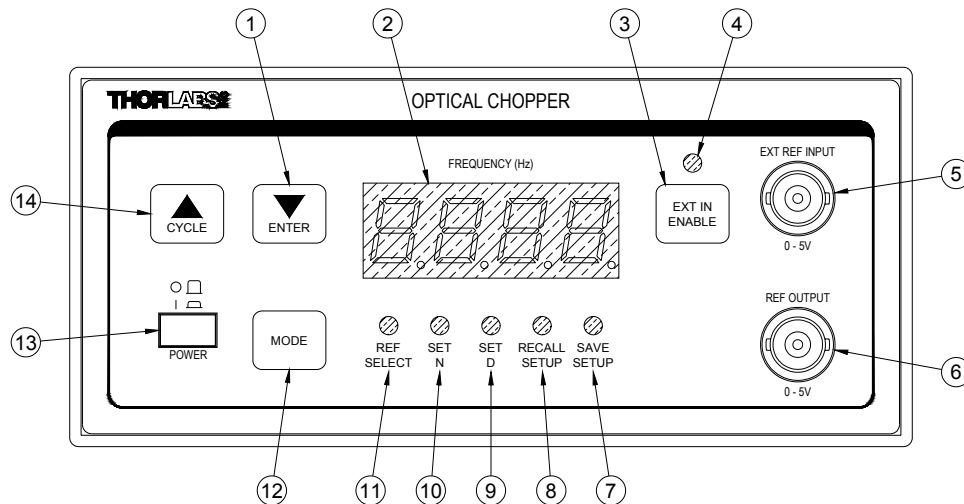
7.1 Controller Front Panel Features

Figure 1 – MC1000A Front Panel

Feature: Description

1.   FREQ DOWN / ENTER Key - This key is used to decrease the chopping frequency when operating in the internal reference mode. It is also used for as an enter key when setting the various operating parameters.

2.   4-Digit LED Display (to display operating frequency and user messages)

3.   EXT IN ENABLE Key - Pressing this key toggles the MC1000 between the internal and external reference mode.

4.   EXT IN LED – This LED will illuminate when the External Input is enabled.

5.   EXT REF IN - the external reference signal is connected to this input BNC (TTL / CMOS logic level).

6.   REF OUTPUT - the reference output signal selected by the REF SELECT mode (CMOS logic level).

7.   SAVE SETUP - When this LED is lit, the user can save the current configuration to one of five setups. Use the FREQ UP / CYCLE key to select the setup number and press the FREQ DOWN / ENTER to save the setup to that number. Note: the setup number will wrap around back to 1 after it reaches 5 when pressing the FREQ UP / CYCLE key.

8.   RECALL SETUP - In this mode, the user can recall one of the five user setups. Select the setup number with the FREQ UP / CYCLE key and press the FREQ DOWN / ENTER to restore the saved configuration.

9.   SET D - This mode allows the user to select a sub-harmonic of the external reference input. The external reference frequency will be divided by this value and used to synchronize the chopper blade. The sub-harmonic can be used with the harmonic multiplier, N, to create fractional harmonics (i.e. chopper frequency, $f_{chopper} = REF_{EXT} * N / D$).

   Note: The Harmonic, N, and sub-harmonic, D, are only available when using the external reference input and a single frequency chopping blade (i.e. 10, 15, or 30 slot blade).

10.   SET N - This mode allows the user to select a harmonic of the external reference input. The external reference frequency will be multiplied by this value and used to synchronize the chopper blade. The harmonic multiplier can be used with the sub-harmonic divider, D, to create fractional harmonics (i.e. chopper frequency, $f_{chopper} = REF_{EXT} * N / D$).

11   REF SELECT - This LED indicates the REF OUT signal mode. Pressing the '▲' or '▼' keys selects the 'REF OUTPUT" signal from a number of sources depending on the operating mode selected.

   Operating Mode   Available sync sources

   Internal Reference Mode: OUT, SYN
   External Reference: OUT
   2-Frequency Blade: OUT, SYN, SUM, DIFF

   Where: OUT = chopper wheel frequency (for the 2-frequency blade, the outer blade frequency)
             SYN = the internal frequency synthesizer (or the harmonic generator for the external mode)
             SUM = sum frequency for the 2 frequency blade
             DIFF = difference frequency for the 2 frequency blade

12   MODE - Pressing this key cycles through the various input modes (REF SELECT, SET N, SET D, RECALL and SAVE). The LED above the legend indicates the currently active mode. Note: the available input modes are dependent on the operating state (i.e. the SET N and SET D are not active when operating in the internal reference mode).

13   POWER button - Press in to power the MC1000 on.

14   FREQ UP / CYCLE Key - This key is used to increase the chopping frequency when operating in the internal reference mode. It is also used for cycling through input options for other operating modes.

7.2 Controller Rear Panel Features
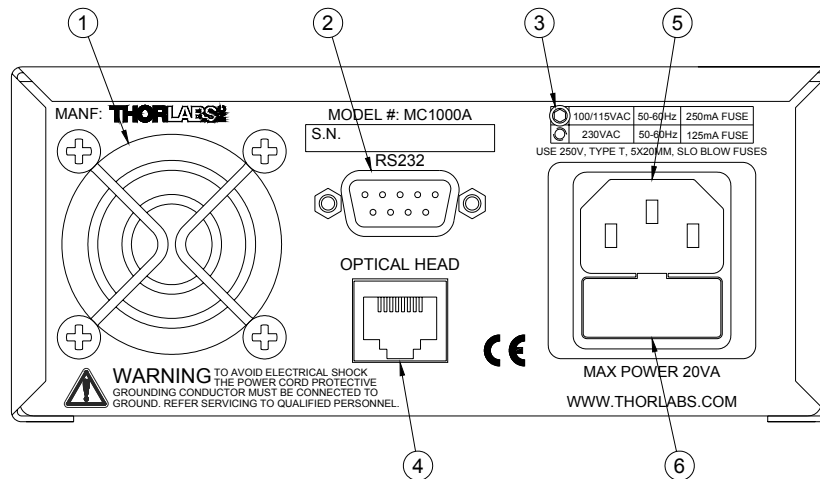
Figure 2 – MC1000A Rear Panel

Feature: Description:

   1   Cooling fan – Do not block when the unit is operating.

   2   RS-232 Serial Port Connector – See section 8 for complete details.

   3   Line Voltage Indicator – This screw indicates the position of the line voltage selector switch located within the unit. If changing the line voltage this screw should be installed in the appropriate position. See section 5 for details.

   4   Modular interface connector for the optical head

   5   AC input receptacle – This input requires an IEC compatible plug with a properly connected ground terminal. Thorlabs supplied a cord for operation in the United States.

   6   Fuse Holder – The system fuse is installed here. See section 5 for more details.

7.3 Optical Head

Figure 3 – MC1000A Optical Head

Feature: Description:

1   Precision Chopper Blade (available in 2,10, 15, 30 or 60 slots, and a 7:5 2-frequency)
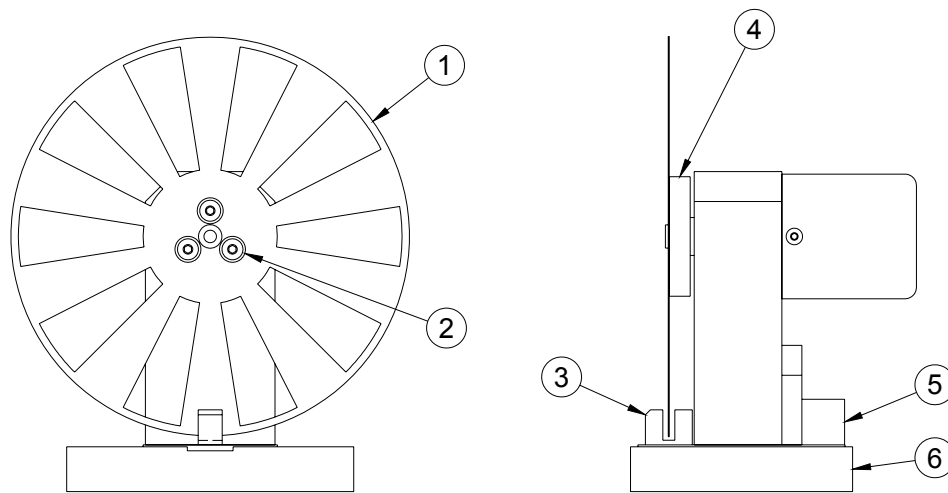
2   1/16" Hex Mounting Screws and lock washers (qty 3)

3   Photo-interrupter Speed Sensor

4   Blade Hub

5   Modular Interface Connector

6   Mounting Base

Section 8: Operating Instructions

8.1 Internal Frequency Synthesizer

The MC1000A 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.

8.1.1 Setup for Internal Reference Frequency

1. Follow the setup procedures in the 'Getting Started Quickly' section.

2. Turn the MC1000A power on.

3. If the 'EXT EN' LED is lit, press button under the LED to return the unit to the internal frequency mode.

4. Set the chopper operating speed as desired using the '▲' or '▼' keys. While holding down these keys, the set speed will be displayed but the motor speed will not change until the key is released.

5. After releasing the keys, the chopper should adjust its speed and lock onto the reference within a few seconds as indicated by the chopper speed shown on the digital display.

8.1.2 Selecting the REFERENCE OUT signal

In the internal frequency mode, the reference output signal can be set to the actual chopper wheel frequency or the internal frequency synthesizer. 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 a photo-interrupter on the optical head that senses 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).

1. Press the 'MODE' key until the 'REF SELECT' LED is lit.

2. Press the '▲' or '▼' key repeatedly until the desired reference output signal is shown. Once the key is released, the selected reference signal will be routed to the front panel BNC labeled REF OUT.

Note: the display prompt for the direct chopper wheel frequency is '⫿UT'. The internal synthesizer display prompt is 'SYN'.

8.1.3 Why doesn't the motor speed exactly match the set speed?

The MC1000A internal frequency synthesizer uses a 1.000MHz crystal oscillator, which is divided down by a 32-bit digital divider to generate the reference signal to lock the chopper wheel to. The MC1000 microprocessor uses an advanced algorithm to match the set speed as closely as possible. However, there are some frequencies that cannot be achieved exactly. This is due to the limitations of dividing the 1.000MHz clock by a 32-bit integer divisor, and does not affect the stability of the chopper frequency.

8.2 External Reference Mode

A major benefit of using a PLL circuit to control the chopper wheel speed is that the chopper can be locked precisely to an external reference signal. This allows the MC1000A to be used in advanced setups, for example, multiple MC1000A 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 MC1000A will accept a TTL or CMOS logic level input as an external reference. The advanced PLL design used in the MC1000A 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.

Note: Having an active external reference attached to the 'EXT REF IN' during MC1000A power up may cause the unit to lock up. If this occurs, remove the external reference connection, and recycle the power. When the unit finishes its startup sequence, attach the external reference signal.

8.2.1 Setup for External Reference Frequency

1. Follow the setup procedures in the 'Getting Started Quickly' section.

2. Turn the MC1000A power on.

3. If the 'EXT EN' LED is not lit, press the 'EXT IN ENABLE' key under the LED until it lights indicating that the unit is in the external reference mode.

4. To have the chopper lock to the fundamental of the external reference frequency (i.e. the chopper speed will equal the external reference frequency, the harmonic multiplier, N, and the sub-harmonic divider, D, must each be set to 1. To check these values, use the 'MODE' key to select the N and D parameters and adjust their values as necessary.

5. The chopper should adjust its speed and lock onto the reference within a few seconds as indicated by the chopper speed shown on the digital display.

8.2.2 Selecting the REFERENCE OUT signal

In the external frequency mode, the only signal available for the reference output signal is the actual chopper wheel frequency. The controller will not allow the 'REF SELECT' option to be changed.

8.3 Harmonic Reference Generation

Harmonic generation is a special feature available when operating in the external reference mode. The MC1000A uses a second PLL circuit to multiply the external reference frequency from 1 to 15 to generate up to the 15th harmonic. The PLL is then followed by a digital divider, which can be programmed from 1 to 15 to divide the reference frequency and create sub-harmonics. Additionally, both the harmonic, and sub-harmonic modes can be used to create fractional reference frequencies. The new frequency is used as the chopper reference for chopping at a variety of frequency combinations, all derived from the external reference.

Note: Harmonic and sub-harmonic modes are not available when using 2-frequency blades.

8.3.1 Setting the Reference Harmonic

1. Press the 'MODE' key until the 'SET N' LED is lit. The current value for N is displayed. Use the '▲ / CYCLE' key to select the desired harmonic. The display will wrap around to 1 after it reaches 15.

2. Once the '▲' key is released, the MC1000 will apply the reference signal to the multiplier circuit and the reference frequency will increase to N * $f_{EXT\ REF}$. If the harmonic frequency exceeds the maximum chopping frequency for the installed blade the unit will eventually time out. In this case, the harmonic value must be lowered.

8.3.2 Setting the Sub-Harmonic

1. Press the 'MODE' key until the 'SET D' LED is lit. The current value for D is displayed. Use the '▲ / CYCLE' key to select the desired harmonic. The display will wrap around to 1 after it reaches 15.

2. Once the '▲' key is released, the MC1000 will apply the reference harmonic multiplier output to the divider circuit and the reference frequency will decrease to $f_{EXT\ REF}$ / D. If the harmonic frequency is lower than the minimum chopping frequency for the installed blade the unit will eventually time out. In this case, the sub-harmonic value must be lowered.

8.3.3 Combining the Harmonic and Sub-Harmonic Modes

The sub-harmonic divider follows the harmonic multiplier. Therefore, the generated reference frequency will always be $f_{EXT\ REF}$ * N / D. There are no special steps to combine these two features since they are always active.

8.4 2-Frequency Chopping

A special two-frequency blade is available from Thorlabs, which has seven slots on the outer portion of the wheel and 5 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.

The MC1000A provides two additional reference outputs in this mode. The SUM, and the DIFFERENCE reference frequencies track the combined signal paths when they are frequency mixed together. The example below illustrates this:

Example: The MC1000A is set to run the outer blade set at 70Hz. The inner blade, by virtue of the ratio of inner to outer slots will be running at 50Hz. If a light path is common to both the inner and outer blades, the signal will see a sum frequency of 120Hz and a difference frequency of 20Hz.

8.4.1 Setting the Chopping Speed in the 2-Frequency Mode

The chopping frequency for the 2-frequency blade is set the same way as described above for the single frequency blades. The only exception is that the harmonic mode (both the harmonic multiplier and sub-harmonic divider) is not available with 2-Frequency operation.

Note: the MC1000A synchronizes the outer portion of the 2-frequency blade to the internal or external synthesizer. The inner portion is chopping at a rate of 5/7 * reference.

Example: Internal Reference (or external reference) frequency = 100Hz

The outer portion of the blade is chopping at 100Hz

The inner portion is chopping at 100Hz * 5 / 7 = 71.42Hz

8.5 Setting the Chopper Blade

The MC1000A supports a number of different chopper blades. In order for the system to operate properly, it is important that the MC1000A be programmed for the blade that is installed on the chopper head. This can only be done during the startup sequence.

When the MC1000A is powered on, it goes through the following startup sequence:

1. A lamp test with all of the display segments and LED's lit for about a second.

2. The firmware revision level is displayed (please take note of this number when calling tech support).

3. The current blade setting is displayed.

At this point, the MC1000A can be set to the appropriate blade if the displayed setting does not match the blade installed on the optical head. The choices are:

- **B   2**   - 2 slot standalone operation
  - REF OUT = displayed frequency
  - External Input and N/D counters not available

- **B 2-2**   - 2 slot synchronized operation
  - Master – no external input – REF OUT = outside frequency
  - Slave – external input enabled – REF OUT = no signal
  - N/D counters not available

- **B 2F**   - 2-frequency blade
  - The display outputs the outer (7 slot), sum, or difference frequency.
  - The N/D counters are not available.

- **B 10**   - 10-slot blade

- **B 15**   - 15 slot blade

- **B 30**   - 30 slot blade

- **B 60**   - 60 slot blade

Use the '▲ / CYCL' key to cycle through the options and select the appropriate blade.

8.6 2-Slot Blade

The 2-slot blade provides very stable low frequency chopping up to a frequency of 99Hz. 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. This may cause some problems in applications were the phase is important, since the chopper phase will lock onto the outer frequency, not the inner.

Note that there are two blade selections for the 2-slot blade. The first setting (B 2) is used when operating the unit stand-alone. The second selection (B2-2) is used to synchronize two optical choppers. The master unit will act as the frequency generator for the second and will output a 'REF OUT' frequency equal to the outer slot frequency. The second chopper is set to the slave by connecting the master 'REF OUT' signal to the 'EXT IN' BNC and enabling external control. The slave will output the displayed frequency.

The /N and /D counters cannot be used with the 2 -slot blade since they will only adjust the outer frequency. Since the ratio is 50:1 the inner (2-slot) frequency will be adjusted minimally.

Section 9: Serial Port

The MC1000 comes standard with a RS-232 serial interface port for remote control and monitoring. The serial port can be connected to a PC running an ASCII terminal emulator program to remotely access the MC1000 features. The MC1000 has an interactive menu, which is accessible from the serial port to control the chopper. For experienced programmers, the chopper serial interface may be incorporated into a user program developed on a serial port system.

9.1 Serial Port Parameters

Baud Rate: 19,200

Data Bits: 8

Stop Bits: 1

Parity: none

Handshake: none

9.2 Serial Port Pin Outs

DB9F pin	Signal
1,7,8,9	no connect
2	TxD (from MC1000)
3	RxD (to MC1000)
4	connected to pin 6
5	Signal Ground
6	connected to 4

9.3 Serial Interface Command Screen

The MC1000 will echo the following screen to the serial port. The current setting is shown in parenthesis after each command. The user can select the various commands by typing the letter enclosed in parenthesis at the beginning of each line and the MC1000 will prompt for the user input. Typing the RETURN key will exit the input mode without changing the value.

```
MC1000 Control Software - Revision x.xx (build xxxx)
Operating Menu

(R)un motor                 (on)
(E)cho panel                (off)
(B)lade                     (B 10)
(I)nternal frequency        (500)
(N) Harmonic Multiplier     (1)
(M) Sub-harmonic divider    (1)
(X) External Reference      (off)
(O) Reference Output        (outer)
```

9.4 Serial Command Summary

Command:	R
Input Parameters:	none
Description:	Toggle the motor between ON and OFF

Command:	E
Input Parameters:	none
Description:	When the echo mode is on the current display on the MC1000 front panel will be sent to the serial port each time it is updated.

Command:	B
Input Parameters:	'0' for 10 slot, '1' for 15 slot, '2' for 30 slot, '3' for 60 slot, '4' for 2-frequency blade, '5' for 2 slot and '6' for 2 slot slave.
Description:	This programs the MC1000 for the chopper blade currently installed on the optical head.

Command:	I
Input Parameters:	20 to 1000 (10 slot), 30 to 1500 (15 slot), 60 to 3000 (30 slot), 120 to 6000 (60 slot), 14 to 700 (2-f blade), and 50 to 4950 (2 slot)
Description:	This sets the internal reference frequency. Note: the range is dependent on the blade.
Note:	The 2 slot blade must be set using the outer blade frequency. There are 100 outer slots and 2 inner slots with a 50:1 ratio. Therefore, to set the blade rotation to 10Hz, the set value must be 10Hz x 50 = 500Hz.

Command:	N
Input Parameters:	1 to 15
Description:	This sets the harmonic multiplier.

Command:	M
Input Parameters:	1 to 15
Description:	This sets the sub-harmonic divisor

Command:	X
Input Parameters:	none
Description:	Toggle between internal and external reference modes

Command:	O
Input Parameters:	'0' for outer (chopper wheel), '1' for internal synthesizer, '2' for SUM freq, '3' for DIFF frequency.
Description:	Set the source for the REF OUT signal. Note, the available options are mode-dependent

Section 10: Maintenance and Troubleshooting

10.1 Cleaning

The MC1000 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).

10.2 Diagnostic Messages

When the MC1000 senses a problem with the chopper operation, it will display various messages to help identify the source of the problem.

LoC   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 problems persists, contact Thorlabs for assistance.

rEF   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.

PLL   This indicates that the harmonic generator PLL could not lock to the external reference. If this problems persists, contact Thorlabs for assistance.

Section 11: Contacts

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THORLABS

Appendix A: Certifications and Compliances

THORLABS GmbH

Konformitätserklärung
Declaration of Conformity
Declaration de Conformité

Thorlabs GmbH
Gauss Strasse 11
D-85757 Karlsfeld / München
Germany

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

MC1000A

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

73/23/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
EN 50371:2002	Safety of Magnetic Fields
DIN EN 61326:97 + A1:98 + A2:2001	EMC of Test and Measurement Equipment
DIN EN 61000-3-2:2000	Harmonic Current Emission
DIN EN 61000-3-3:95 + A1:2001	Voltage Fluctuations and Flicker

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

Karlsfeld, 14. Dezember 2004

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

THORLABS

Certifications and compliances

Category	Standards or description		
EC Declaration of Conformity - EMC	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance is given to the following specifications as listed in the Official Journal of the European Communities:		
	EN 61326		EMC requirements for Class A electrical equipment for measurement, control and laboratory use, including Class A Radiated and Conducted Emissions[1,2] and Immunity.[1,2,3]
		IEC 61000-4-2	Electrostatic Discharge Immunity (Performance criterion B)
		IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance criterion B)
		IEC 61000-4-4	Electrical Fast Transient / Burst immunity (Performance criterion B)
		IEC 61000-4-5	Power line Surge Immunity (Performance criterion C)
		IEC 61000-4-6	Conducted RF Immunity (Performance criterion C)
		IEC 61000-4-11	Voltage Dips and Interruptions Immunity (Performance criterion C)
	EN 61000-3-2		AC power line harmonic emissions
Australia / New Zealand Declaration of Conformity - EMC	Complies with the Radiocommunications Act		
	AS/NZS 2064		Industrial, Scientific, and Medical Equipment: 1992
FCC EMC Compliance	Emissions comply with the Class A Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B[1,2,3].		

[1] Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object.

[2] Minimum Immunity Test requirement.

Certifications and compliances

Category	Standards or description

EC Declaration of Conformity - Low Voltage	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities: Low Voltage Directive 73/23/EEC, amended by 93/68/EEC	
	EN 61010-1/A2:1995	Safety requirements for electrical equipment for measurement control and laboratory use.
Additional Compliance	IEC61010-1/A2:1995	Safety requirements for electrical equipment for measurement, control, and laboratory use.
Equipment Type	Test and measuring	
Safety Class	Class 1 (as defined in IEC 61010-1, Annex H) - grounded product	