# MC1000

# Opto-Mechanical Chopper

## Operating Manual

**MODEL MC1000 OPTICAL CHOPPER**

FREQUENCY

1000

FREQ UP
CYCLE

FREQ DOWN
ENTER

EXT REF INEXT E

PWR

REF OUT

PHASE ADJ

REF    SET    SET  RECALISAVE
SELECT N      D    SETUISETUP
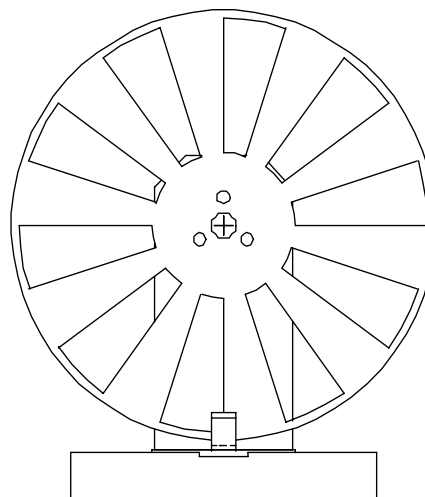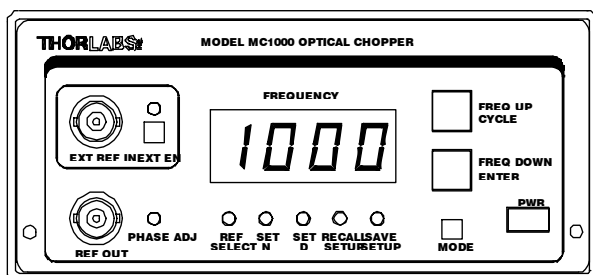
MODE

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# Table of Contents

# Getting Started Quickly

This section is provided for those interested in getting the MC1000 up and running quickly as a basic optical chopper. The more advanced features are described in detail in the following sections.

## Setup

- Carefully unpack the MC1000 controller, optical head, and accessories. If any of the items appear damaged, do not use the MC1000. Call Thorlabs, or email RMA@thorlabs.com and arrange for a replacement.
- Remove the 3 mounting screws and lock washers from the chopper blade hub using the 1/16" hex key (provided).
- 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.
- Attach the modular cord into jack labeled OPTICAL HEAD on the back of the MC1000 controller and plug the other end into modular jack on the optical head.
- Mount the optical head on a sturdy surface and check that the blade can spin free of any obstruction.
- Attach the AC line cord to the MC1000 and plug into a AC outlet.

Note: the MC1000 can be operated from 100-120VAC or 220-240VAC. A voltage selector switch is located inside of the MC1000 controller. If you are not sure what operating voltage your unit is set to, proceed immediately to Section 6.0 for instructions on setting the operating voltage.

## Internal Reference Operating Mode

This MC1000 is most commonly used in the internal reference mode. The chopping speed is set by the internal crystal-stabilized frequency synthesizer.

- Turn the MC1000 power on. The LED display will go through a startup sequence: first, all of the display segments and LEDs are lit, then the firmware rev level is displayed, then the current blade setting is displayed.
- The display should show "b 10" for the 10-slot blade. If not, press the FREQ UP button 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.
- If the unit comes up in the EXTERNAL REFERENCE Mode (as indicated by the LED above the EXT EN key being lit), press the EXT EN key to turn it off and return to the internal reference mode.
- 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.
- To change the chopper speed, press the FREQ UP or FREQ DOWN key 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.

## 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.

- To enable external reference mode, attach a TTL or CMOS logic level reference signal to the EXT REF BNC on the front panel and follow the above steps.
- Press the EXT EN 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 FREQ DOWN key until it reaches 1. Repeat his step for the sub-harmonic divider, D.

# Section 1.0 Overview

The MC1000 Optical Chopper is a precision instrument utilizing advanced features to meet the most demanding applications. The MC1000 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 MC1000 chopper to be synchronized to external reference signals, including other MC1000 choppers and reference sources such as DSP lock-in amplifiers. The phase of the MC1000 chopper wheel is continuously adjustable from $-\pi$ to $+\pi$
($-180°$ to $+180°$.)

For more advanced measurements, the MC1000 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 MC1000 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 MC1000 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 drives the precision, photo-etched chopper optical wheel. 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 MC1000 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 MC1000 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 MC1000. Two slot, 15 slot, 30 slot, 60 slot and the 2-frequency blade are also available.

# Section 2.0  Description

## Optical Head

The optical head consists of a precision photo-etched chopper wheel, a high-quality Swiss DC motor, a machined aluminum housing, and the photo-interrupter motion detection electronics. The key features of the chopper head are highlighted in Figure 1.

FRONT VIEW                    SIDE VIEW
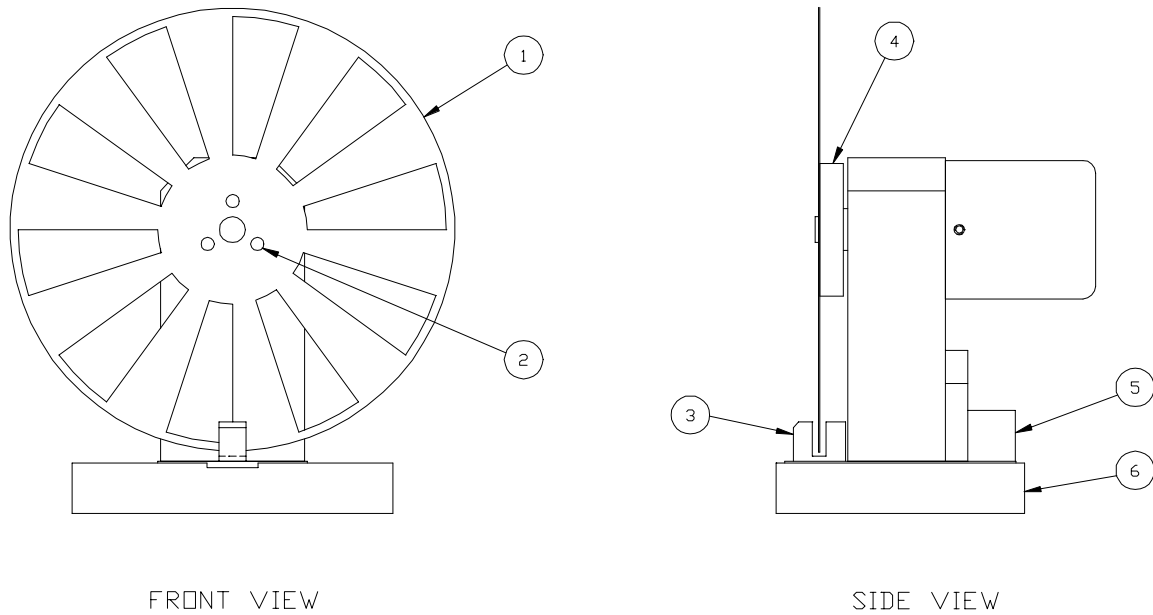
Figure 1. Optical Head Features

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

## Controller Front Panel Features



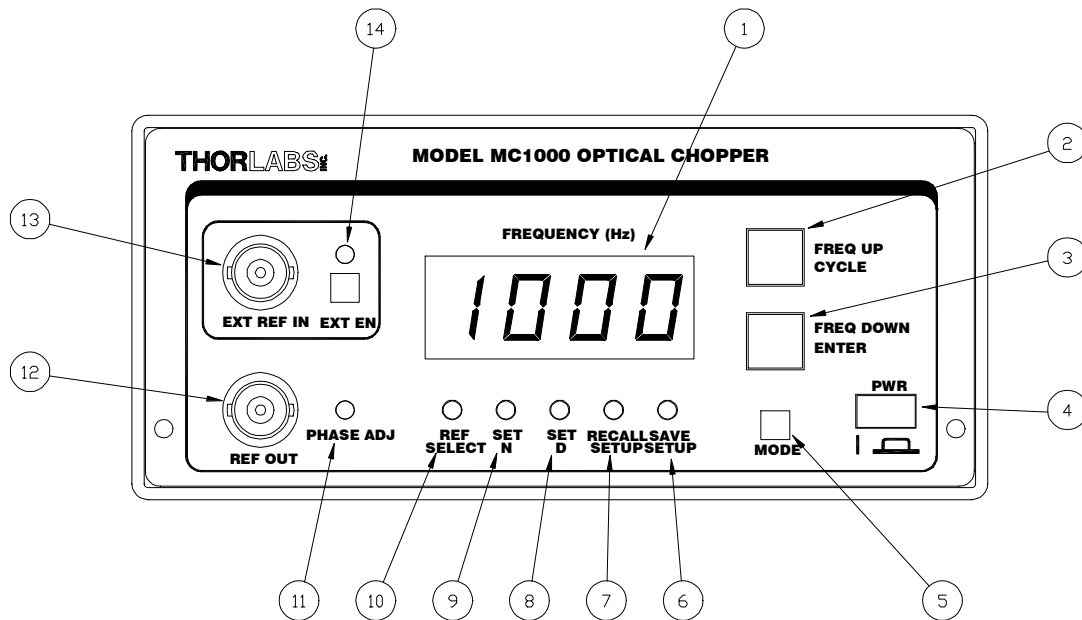Figure 2. Front Panel

Feature      Description

   1   4-Digit LED Display (to display operating frequency and user messages)

   2   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.

   3   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.

   4   PWR button - Press in to power the MC1000 on.

   5   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).

   6   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.

   Also, the setup will be saved to the displayed setup number by default if a short timeout period expires. If this is not desired, press the MODE key to escape out of the SAVE SETUP mode.

7   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.

8   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).

9   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).

10  REF SELECT - This key allows the REF OUT signal to be selected 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

11  PHASE ADJ - a 12-turn pot to continuously adjust the chopper wheel phase from $-\pi$ to $+\pi$.

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

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

14  EXT EN - Pressing this key toggles the MC1000 between the internal and external reference mode. When the unit is in the external reference mode, the LED next to this key is lit.

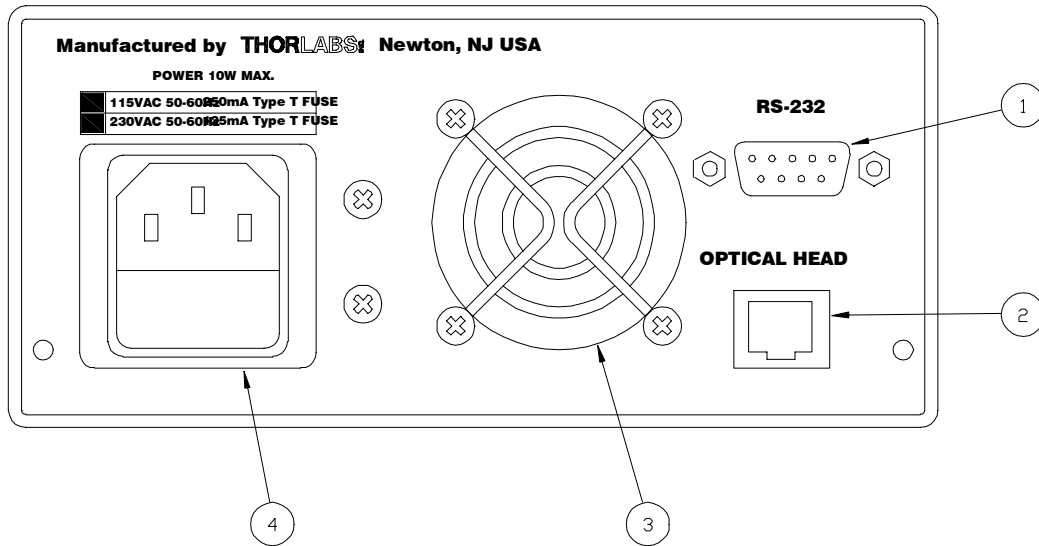## Controller Rear Panel Features



Figure 3. Rear Panel

Feature     Description

  1   RS-232 Serial Port Connector

  2   Modular interface connector for the optical head

  3   Cooling fan

  4   AC input and fuse receptacle

## Section 3.0 Operating Instructions

### Internal Frequency Synthesizer

The MC1000 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

1. Follow the setup procedures in Getting Started Quickly section.
2. Turn the MC1000 power on.
3. If the EXT EN LED is lit, press the under the LED to return the unit to the internal frequency mode.
4. Set the chopper operating speed as desired using the FREQ UP or FREQ DOWN 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.

#### 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 FREQ UP / CYCLE 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'.

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

The MC1000 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 an 32-bit integer divisor, and does not effect the stability of the chopper frequency.

## 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 MC1000 to be used in advanced setups, for example, multiple MC1000 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 MC1000 will accept a TTL or CMOS logic level input as an external reference. The advanced PLL design used in the MC1000 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 MC1000 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.*

### Setup for External Reference Frequency

1. Follow the setup procedures in Getting Started Quickly section.
2. Turn the MC1000 power on.
3. If the EXT EN LED is not lit, press the 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. The 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.

### 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.

## Harmonic Reference Generation

Harmonic generation is a special feature available when operating in the external reference mode. The MC1000 uses a second PLL circuit to multiply the external reference frequency from 1 to 15 to generate up to the 15$^{th}$ 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.*

### 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 FREQ UP / CYCLE key to select the desired harmonic. The display will wrap around to 1 after it reaches 15.
2. Once the FREQ UP 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.

### 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 FREQ UP / CYCLE key to select the desired harmonic. The display will wrap around to 1 after it reaches 15.
2. Once the FREQ UP 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.

### 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.

## 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 MC1000 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 MC1000 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.

### 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 MC1000 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

## Setting the Chopper Blade

The MC1000 supports a number of different chopper blades. In order for the system to operate properly, it is important that the MC1000 be programmed for the blade that is installed on the chopper head. This can only be done during the startup sequence.

When the MC1000 is powered on, it goes through the following startup sequence:

1. A lamp test with all of the display segments and LEDs 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 MC1000 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 = displayed frequency
- 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 FREQ UP / CYCLE to cycle through the bladed options and select the appropriate blade.

## 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 can not 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.

## Adjusting the Chopper Phase

The angular phase of the chopper wheel is continuously adjustable from $-\pi$ to $+\pi$ (-180° to +180°). The phase adjustment applies to all operating modes and is independent of the chopping frequency.

A 12-turn trim pot is provided on the front panel, labeled PHASE ADJ. Use a small slotted screwdriver to adjust the phase as needed. When turning the PHASE ADJ pot quickly, it is normal to see the chopper phase overshoot a bit, but it should settle within 5 to 10 seconds. When tweaking the phase, it helps to turn the adjustment slowly to minimize this effect.

## Phase Adjustment-Related Stability Issues

If the phase adjustment is set too close to either adjustment extremes (-180° or +180°), the unit may have difficulty locking to the set frequency. An example of such would be that the locked frequency is some harmonic of the set

point (e.g. set the unit for 100Hz but the chopper locks to 150Hz). This might happen when changing the frequency after setting the phase to an extreme.

If this occurs, adjust the phase back towards the center of the adjustment range until the unit locks to the correct frequency. Then, you should be able to re-adjust the phase to the -180° or 180° setting.

## Section 4.0 Serial Interface

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.

### Serial Port Parameters

Baud Rate: 19,200
Data Bits: 8
Stop Bits: 1
Parity: none
Handshake: none

### 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 |

### 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)
```

## 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 5.0 Specifications

*Optical Head Dimensions:*



FRONT VIEW      SIDE VIEW      TOP VIEW
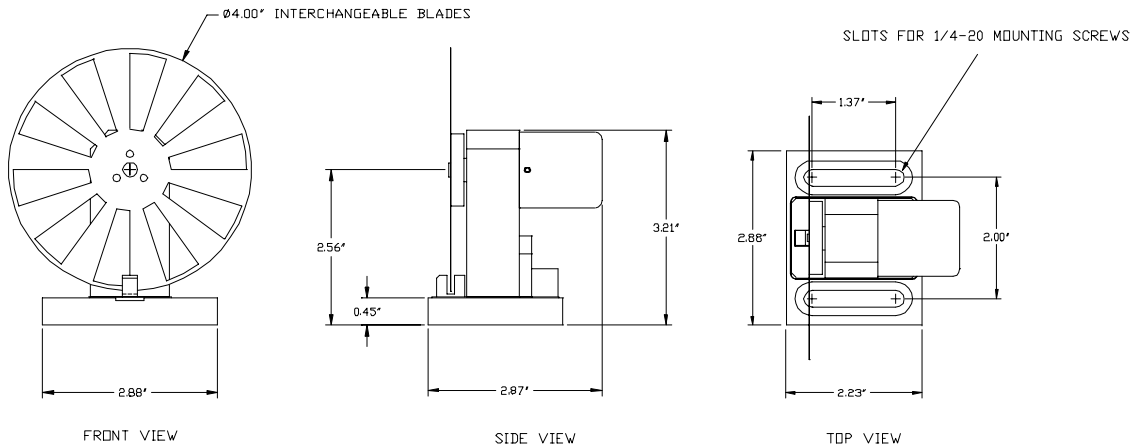
## *Performance Specifications*

Chopping Frequency:

| | |
|---|---|
| 2 Slot Blade | 1 - 99Hz |
| 10 Slot Blade | 25 - 1000Hz |
| 15 Slot Blade | 38 - 1500Hz |
| 30 Slot Blade | 75 - 3000Hz |
| 60 Slot Blade | 150 - 6000Hz |
| 2-f Blade | 14/10 - 700/500  (outer/inner) |

| | |
|---|---|
| Frequency Drift: | <20 ppm / $^\circ$C |
| Phase Jitter (at 1kHz): | 0.2$^\circ$ RMS |
| Phase Adjustment: | -180$^\circ$ to +180$^\circ$ (-$\pi$ to +$\pi$) |
| Harmonic Chopping: | 1 - 15$^{th}$ |
| Sub-Harmonic Chopping: | 1/1 to 1/15$^{th}$ |
| Display: | 4 Digit LED, high-intensity Orange, 0.56" high digits |
| Reference Input: | TTL /CMOS logic level, front panel BNC |
| Reference Output: | TTL /CMOS logic level, front panel BNC |
| Operating Voltage: | 100-120VAC, 220-240VAC, 50/60Hz switch selectable |
| Operating Temperature: | 10 to 40$^\circ$ C |

Size (W x H x L):      5.6" x 2.5" x 11"

## Section 6.0 Maintenance & Troubleshooting

### Setting the Line voltage

The MC1000 is shipped from the factory configured for 100-120VAC operations. The MC1000-EC is shipped from the factory configured for 220-240VAC operations. If the operating voltage needs to be changed, follow the procedure below:

1. Turn the MC1000 power switch OFF and remove the AC line cord.
2. Remove the two Philips head screws from the front panel and slide the cover back a few inches from the base.
3. Locate the voltage select switch on the controller PCB. It is a round switch labeled with 110 / 220 on the top. Using a screwdriver, rotate the switch until the desired voltage is aligned with the pointer on the switch.
4. Slide the cover back and fasten the front plate with the two screws.

### Fuse Replacement

The main fuse is located inside the AC receptacle on the back cover. To replace the fuse, remove the ACV line cord and pry the fuse holder out of the receptacle. Replace the fuse with the type fuse indicated on the rear panel.

### 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).

### 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.

## Technical Support

You may use any of the following methods to contact Thorlabs in case of difficulty or if you have questions regarding your MC1000. Please take not of the firmware revision level to help us in your assistance.

www.thorlabs.com

Our website will have up to date application notes and frequently asked questions regarding our products.

techsupport@thorlabs.com

You can send a detailed email message and one of our application engineers will respond promptly (within 1 business day).

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