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Model 3501 User's Manual

Optical Chopper

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Contents

I	Warranty	3
II	Introduction	4
III	Safety and Preparation for Use	6
IV	Quick Start	8
V	Operation	9
VI	Rack Mount Kit	21
VII	Computer Control	22
VIII	Command Summary	24
IX	Troubleshooting	41
X	AC Operating Voltages	43
XI	Specifications	45

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I Warranty

New Focus, Inc. guarantees the chopper head to be free of defects for 90 days from the date of shipment. All other parts of the Model 3501 Optical Chopper are guaranteed to be free of defects for one year from the date of shipment. This is in lieu of all other guarantees, expressed or implied, and does not cover incidental or consequential loss.

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II Introduction

The Model 3501 Optical Chopper is designed to interrupt light paths in optical experiments at frequencies from 4 Hz to 6.4 kHz. Both single and dual beam experiments can be performed across a broad range of chopping frequencies. The chopper has a crystal controlled frequency synthesizer that serves as an internal reference frequency for locking the chopper to a particular chopping frequency. Reference frequencies can also be provided through the Sync Input to allow the chopper to lock to an external source. A block diagram of the optical chopper system is shown in Figure 1.

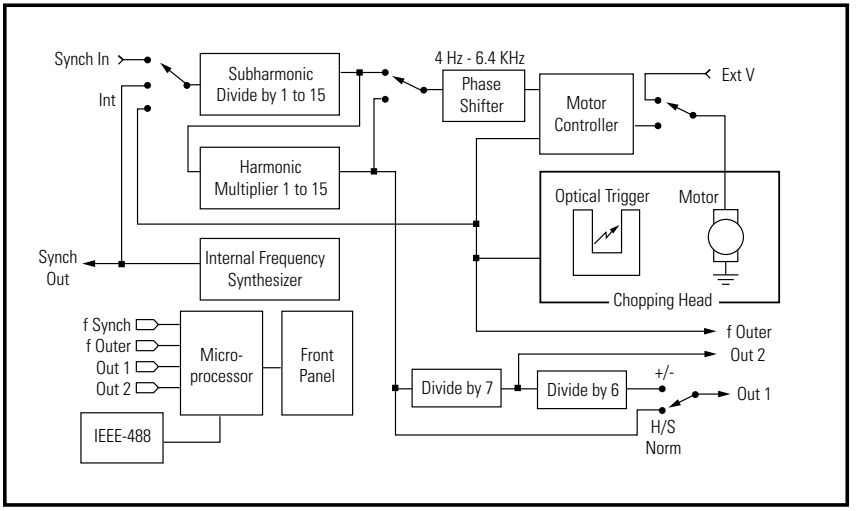
Several measures ensure that jitter and drift of the chopping frequency is reduced to a minimum. Precision photo-etched wheels are mounted on a high quality DC motor. The motor head has a photo-sensor for monitoring the chopping frequency of the outer part of the wheel (F_{outer}). The chopper controller then actively stabilizes the motor speed to match the desired chopping frequency. This technique minimizes phase noise at the chopping frequency and provides for long-term stable chopping with a minimum of frequency drift.

Figure 1 shows a block diagram of the Model 3501 Optical Chopper system. Programmable divide/multiply circuitry allows for harmonic or subharmonic locking of the chopper to the reference frequency. In addition, the phase of the chopping frequency may be varied over a -180 to +179 degree range with respect to the reference frequency. A variety of TTL level outputs are available for use in triggering lock-in amplifiers, oscilloscopes, photon counters or boxcar averagers.

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Fig. 1

Block diagram of the Model 3501 Optical Chopper.



The chopping frequency, as well as a number of other operating parameters, can be viewed on the front panel display, and cursor keys provide easy adjustment of operating parameters. From the front panel the user can store and recall up to nine instrument set-ups. An IEEE-488 interface provides remote operation of all instrument functions.

The chopper head can be mounted on a 1/2"-diameter post or bolted directly to a standard optical bench. The Model 3501 Optical Chopper is supplied with four chopper wheels and a wheel cover. The Model 3510 Rack Mount Kit, an accessory that is sold separately, enables the chopper controller to be mounted in a rack (see Page 21).

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Mounting the Chopper Head

The Model 3501 Optical Chopper head may be secured to standard optical benches using 1/4-20 or M6 bolts. The bolts pass through the mounting plate perpendicular to the plane of the optical bench. The chopper head can be rotated off-axis by loosening the 1/4-20 set screws on the side of the motor mount. Do not over-tighten the set screws.

The Model 3501 Optical Chopper head may also be mounted on standard optical bench rods. First loosen the two 1/4-20 set screws which secure the mounting plate to the head. Remove the mounting base. Insert the 1/4-20 knob (supplied with the chopper) into the base of the head. This knob is inserted into the same hole occupied by the dowel on the mounting plate. Slide the motor mount onto the optical bench rod and tighten the knob. Do not over-tighten the knob.

Mounting the Wheel

Remove power from the control unit before attempting to change the chopper wheel. Secure the chopper head to a work surface. Remove the four 4-40 screws that secure the retaining cap over the wheel, while taking care not to bend the wheel. Install the replacement wheel, retaining cap and 4-40 screws. Do not over-tighten the screws.

Control Cable

Connect the 6-wire cable from the connector at the side of the chopper head to the MOTOR connector at the back of the control unit.

WARNING: Do not connect or disconnect the chopper head while the control unit is powered or damage to components may occur. Always shut off the instrument and allow the motor to stop before disconnecting the cable.

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Line Voltage Selection

The instrument may be damaged if operated with the line voltage selector set at the wrong voltage or with the wrong fuses installed in the power entry module. When the instrument ships from the factory, it will be programmed for the standard AC voltage in the user's country. To select a different operating voltage refer to the AC Operating Voltages section (Page 43).

Grounding

The line cord is a three-wire power cord for connection to the power mains and a protective ground. The chassis is connected to the protective ground to reduce the risk of electric shock. To avoid potential electrical shock, use only mains that provide a protective ground.

Wheel Hazard

WARNING: The moving wheel may inflict injury. The operator should assure the safety of personnel who may be exposed to this hazard.

Safety is important! The chopper wheel can cause injury if it is touched while rotating. This is especially critical if you find yourself reaching into your optical set-up with the lights off. You may want to use the chopper wheel cover to reduce the chance of injury.

Environment

The Model 3501 Optical Chopper may be operated in an ambient of 0 to 40 degrees C. It is recommended to avoid direct sunlight on the LED display.

WARNING: Hazardous voltages, capable of causing death, are present inside this instrument. Do not operate the instrument with the covers removed.

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IV
Quick Start

Before operating the Model 3501 Optical Chopper, please review the previous section to make sure the chopper is ready for use.

1. Mount the chopper head securely on an optical bench.
2. Mount the 42/30 wheel on the head. Avoid bending the wheel. The wheel should be free to turn without contact to the optical sensor or nearby equipment.
3. Connect the cable between the chopper head and the connector marked MOTOR on the back panel of the control unit.
4. Check that the correct line voltage has been selected and the proper fuse inserted into the mains power entry module at the back panel of the control unit. Connect the instrument to the power mains.
5. After insuring the safety of nearby personnel, switch on the instrument.
6. Recall instrument set-up "0" (factory default setting). Press SET until "RECALL" is lit. Press the up/down arrow keys until "0" appears in the display window. Press the left or right arrow key to recall set-up "0".
7. The instrument will lock at 84 Hz within 1 minute.
8. To choose a particular chopping frequency, press the Set key until the FREQ LED is lit, and then use the up/down arrows keys to adjust the chopping frequency.

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V
Operation

This section describes operation of the chopper, starting with an overview of the front panel functions. This is followed by a description of the chopper back panel and the chopper head.

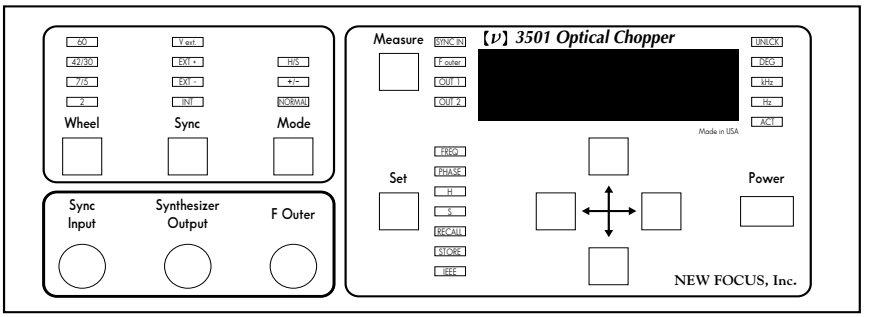


Fig. 2

Front panel of the Model 3501 chopper controller.

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Wheel

The user may select from single or double slot wheels to perform single or dual path experiments. Different wheel apertures may be selected to accommodate the chopping frequency of interest. The table below summarizes wheel choices and chopping frequency ranges.

Wheel Type (slots)	Lowest Frequency (F_{outer})	Highest Frequency (F_{outer})
60	120 Hz	6.40 kHz
42/30	84 Hz	4.48 kHz
7/5	14 Hz	746 Hz
2	4 Hz	213 Hz

F_{outer} is the chopping frequency as measured by an optical pick-up on the chopper head. If a wheel has two sets of slots, F_{outer} refers to the chopping frequency of the slots on the outer edge of the wheel.

To change the wheel type, push the Wheel key until the LED lights under the desired wheel type.

Sync

The user may synchronize the chopping frequency to the chopper's internal synthesizer (INT), or the rising edge (EXT+) or falling edge (EXT-) of an externally-supplied Sync Input signal. When V_{ext} is selected, the user may drive the motor directly with an analog voltage applied at V_{ext} on the back panel. When using V_{ext} or INT, a signal applied to the Sync Input has no effect on the chopper.

To change the Sync source, press the Sync key until the LED under the desired Sync source lights.

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Mode

The Mode setting changes the reference signals available at OUT1 and OUT2 on the back panel as follows:

Mode	F_{outer}	OUT1	OUT2
H/S	$[H/S]\cdot F_{sync}$	$[H/S]\cdot F_{sync}$	$[H/(7\cdot S)]\cdot F_{sync}$
+/-	F_{sync}	$F_{outer} - F_{inner}$	$F_{outer} + F_{inner}$
NORMAL	F_{sync}	$5\cdot F_{outer}$	F_{inner}

To change the Mode, push the Mode key until the LED under the desired Mode lights.

F_{outer} is the chopping frequency of the outer set of slots as measured by an optical pick-up on the chopper head. F_{inner} is the chopping frequency of the inner set of slots. For wheels with only one set of slots F_{outer} is the chopping frequency, and F_{inner} is not defined.

F_{sync} is the frequency of the Sync source. In INT Sync mode, F_{sync} is the frequency of the chopper's internal frequency synthesizer. In EXT+ or EXT- Sync mode, F_{sync} is the frequency of the externally supplied signal at the Sync Input.

Set

The Set key selects which instrument parameter is modified by the cursor keys. Press SET until the LED lights under the desired parameter. The up arrow and down arrow keys will then change the parameter value. In some cases, the left arrow and right arrow keys select the significant digit to be modified.

FREQ The user may set the synthesizer frequency depending on the Sync source selected. When EXT-, EXT+ or V_{ext} sync has been selected, the frequency may range from 4.00 Hz to 99.9 kHz.

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When INT Sync is selected, the synthesizer frequency will be restricted to the working range of the particular chopping wheel. In H/S mode this range will be modified by the setting of H and S. In this case, the range limits may be calculated as follows:

$$F_{upper} = F_{outer}\,[highest] \cdot (S/H) \text{ and}$$

$$F_{lower} = F_{outer}\,[lowest] \cdot (S/H),$$

where S,H = 1 - 15.

Setting FREQ The synthesizer frequency may be set to three significant digits. The significant digit to be modified may be selected by the left arrow and right arrow keys. The magnitude of the digit may be changed with the up arrow and down arrow keys. If the display overflows or underflows, the display will change the Hz/kHz LEDs and the decimal point to maintain three significant digits of resolution.

PHASE The phase delay may be set from +179.0° to -180.0°. The phase shift is always referred to the chopping frequency F_{outer}. In NORMAL and +/- modes $F_{outer} = F_{sync}$. In H/S mode $F_{outer} = [H/S] \cdot F_{sync}$.

When the phase adjustment is active, the DEG LED will be lit. The left arrow and right arrow keys select the significant digit to be modified, and this digit will blink. The up arrow and down arrow keys change the magnitude of the digit.

H In H/S mode the user may lock the chopper to a harmonic of the sync frequency. H is set to the harmonic of interest. Use the up arrow and down arrow keys to set H from 1 to 15.

S The user may lock the chopper to a subharmonic of the sync frequency. S is set to the subharmonic of interest. Use the up arrow and down arrow keys to set S from 1 to 15. S and H may be set in any combination. Changing S only has an effect when the chopper is in H/S mode.

STORE The user may store an instrument set-up in one of two ways. First, the control unit will retain the control settings when the power is removed.

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When power is restored, the instrument will recall the last control settings used.

Second, the user may utilize one of nine programmable instrument set-ups. To store an instrument set-up press the Set key until STORE is lit. Then, use the up arrow and down arrow keys to select instrument set-ups 1-9. Press the left arrow or right arrow key to store the instrument's settings at the selected instrument set-up. The display will blink to indicate that the storage process is complete. Location 0 is reserved for the factory default settings: 42/30 wheel, internal sync, normal mode, 84 Hz, IEEE address 12.

RECALL The user may recall instrument set-ups in one of two ways. First, the control unit will retain the control settings when the power is removed. When power is restored, the instrument will recall the last control settings used.

Second, the user may utilize one of ten programmable instrument set-ups. To recall a previously stored instrument set-up, use the up arrow and down arrow keys to select instrument set-ups 0-9. Press the left arrow or right arrow key to recall the selected instrument set up. The display will blink when the recall process is complete. Location 0 is reserved for the factory default settings.

Default settings Recalling set-up '0' will restore the instrument to the factory default settings: 42/30 wheel, internal sync, normal mode, 84 Hz, IEEE address 12.

IEEE The user may select the Model 3501's device address on the IEEE-488 bus. The factory default setting is 12. Use the up arrow or down arrow key to change the device address.

Measure

The Measure key selects which frequency measurement—OUT1, OUT2, F_{outer} or F_{sync}—is displayed on the front panel. The instrument will continue to measure and update the display until another function key is pressed.

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To change the Measure parameter, press the Measure key until the LED lights under the desired parameter.

Sync Input

The user may connect a TTL level sync frequency at the Sync Input. EXT+ or EXT- sync must be selected and the frequency must remain within the limits defined above in the FREQ section. The UNLCK LED will blink if the Sync Input frequency is outside the limits.

Synthesizer Output

The instrument provides the user with a TTL level square wave output for use in experiments. The Synthesizer Output frequency is adjusted by setting the FREQ parameter from the front panel or via IEEE-488. With INT sync active, the frequency will be limited as given above in the FREQ section. With EXT+, EXT- or V_{ext}, the Synthesizer Output ranges from 4.00 Hz to 99.9 kHz.

F_{outer}

The instrument provides the user with a TTL level square wave generated from an optical pick-up on the chopper head.

ACT

The ACT LED indicates when the IEEE-488 interface is busy.

UNLCK

The red UNLCK LED indicates when the chopper is not synchronized to an internal or external sync frequency. The UNLCK LED will blink when an external sync frequency exceeds the limits for a particular wheel.

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OUT1

The function of the OUT1 output depends on the instrument's operating mode. In H/S mode, the instrument provides a TTL level pulse at frequency $[H/S]\cdot F_{sync}$. In +/- mode the frequency at OUT1 is $F_{outer} - F_{inner}$, and in NORMAL mode the frequency is $5\cdot F_{outer}$.

OUT2

The function of the OUT2 output depends on the instrument's operating mode. In H/S mode, the instrument provides the user with a TTL level pulse at frequency $[H/(7\cdot S)]\cdot F_{sync}$. In +/- mode the frequency at OUT2 is $F_{outer}+F_{inner}$, and in NORMAL mode the frequency is F_{inner}.

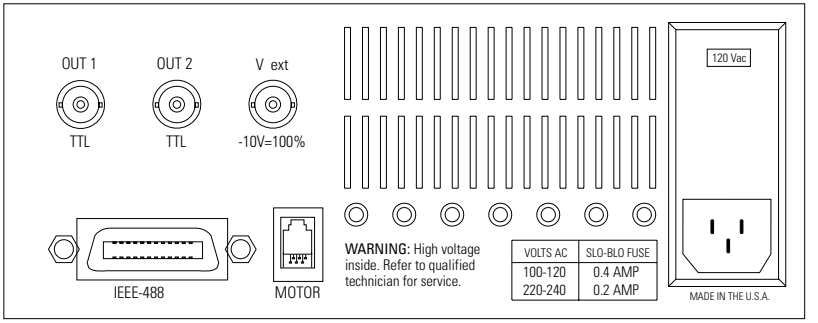


Fig. 3

Back panel of the chopper controller.

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V_{ext}

When V_{ext} sync is selected, the user may drive the chopper motor directly with a DC input voltage. 0 to -10 V DC corresponds to 0 to 100% of the highest motor speed.

MOTOR

Use the supplied cable to connect the chopping head to the chopper controller at the back panel.

IEEE-488

The instrument may be programmed remotely via IEEE-488. Use a standard cable to connect the instrument to the host computer system.

Power entry module

The AC power is connected at the power entry module on the back panel. The line voltage and power cord have been chosen at the factory to match the country of consignment. If it is necessary to change the mains voltage, consult the section on AC Operating Voltages (Page 43).

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Cable

The cable that connects the control unit to the chopper head is a six conductor reverse RJ11 type IDC telephone cable. Connect the cable from the connector on the side of the chopper head to the MOTOR connector on the back panel of the control unit. The instrument has been tested with cable lengths up to 25 feet, but the chopper is supplied with a shorter cable. Replacement cables and longer cables may be purchased from electronics parts suppliers such as Digi-Key (Part # H2662-14-ND).

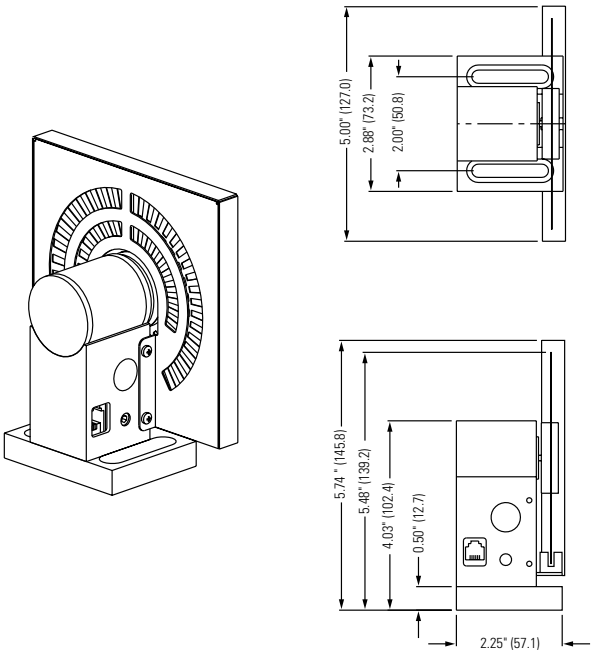


Fig. 4

Chopper head with wheel cover.

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Mounting the Chopper Head

The Model 3501 Optical Chopper head may be secured to standard optical benches using 1/4-20 or M6 bolts. The bolts pass through the mounting plate perpendicular to the plane of the optical bench. This mounting method provides the advantage of allowing the wheel to be rotated off-axis by loosening the 1/4-20 set screws on the side of the motor mount. Do not over-tighten the set screws.

The Model 3501 Optical Chopper head may also be mounted on standard optical bench rods. First loosen the two 1/4-20 set screws that secure the mounting plate to the head. Remove the head. Insert the 1/4-20 knob into the base of the head. This knob is inserted into the same hole occupied by the dowel on the mounting plate. Slide the head onto the optical bench rod and tighten the knob. Do not over-tighten the knob.

Chopper Motor

The operating life of the chopper motor is limited. Long term use of the motor at high speed will result in faster wear and shorter life. Contact New Focus for details about replacing the motor, if this becomes necessary.

Mounting the Wheel

Remove power from the control unit before attempting to change the chopper wheels. Secure the chopping head to a work surface. Remove the four 4-40 screws that secure the retaining cap over the wheel, while taking care not to bend the wheel. Install the replacement wheel, retaining cap and 4-40 screws. Do not over-tighten the screws.

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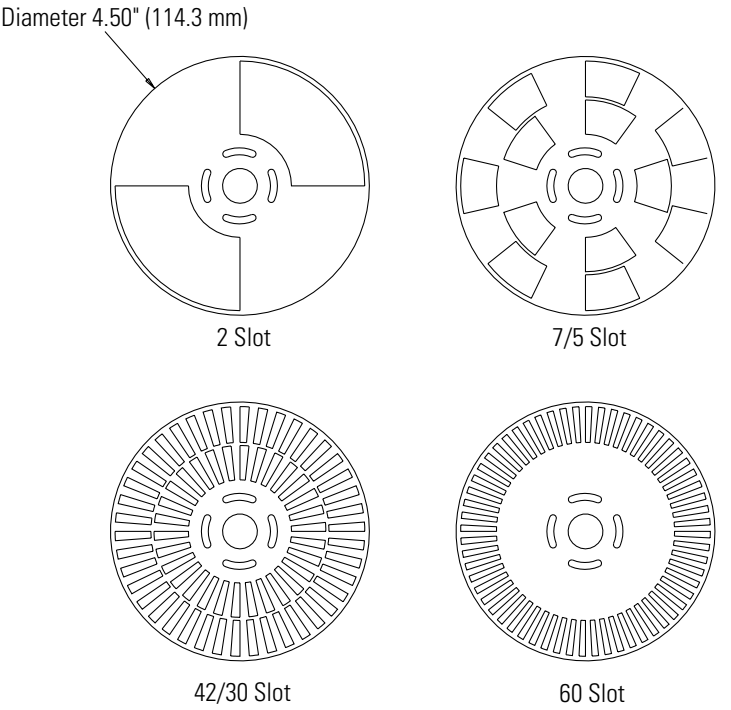


Fig. 5

The four chopper wheels that are supplied with the chopper.

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Wheel Cover

The wheel cover attaches to the chopper head with 4 screws. The wheel cover is made of .030" aluminum with an anti-reflective black anodized coating. Two concentric slots, etched in both faces of the cover, allow apertures up to .3 and .4-inches wide over most of the chopping wheel surface. The wheel cover dimensions are 5" x 5" x 0.5".

The wheel cover is provided for safety. The chopper wheel can cause injury if it is touched while rotating. This is especially critical if you find yourself reaching into your optical set-up with the lights off.

The wheel cover is also provided to reduce the generation of stray light that could interfere with your measurements. The chopper head uses an infrared sensor to detect chopper wheel motion. The source in this sensor emits energy in the 870 - 950 nm wavelength range. The wheel cover will greatly reduce the amount of sensor-radiated IR light picked up by your detector.

To install the wheel cover, first install a wheel on the chopper hub. Then, slide the wheel cover over the top of the wheel while spreading the 2 mounting flanges apart enough to avoid contact with the painted motor surface. (The motor is .060 - .080" wider than the mounting base.) Once the mounting flanges are lowered past the motor, align one of the 4 flange holes with a threaded hole in the motor base and loosely attach the cover to the base with one of the 4-40 x 3/8" mounting screws. Loosely fasten the 3 remaining screws. Tighten the 4 screws after they are installed.

The cover must be removed to change the chopping wheel. Remove the 4 screws holding the cover to the base. From the motor side of the chopping wheel, move the cover away from the motor while spreading the mounting flanges apart. Now slide the cover up over the motor.

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VI Rack Mount Kit

The Model 3510 Rack Mount Kit is a chopper accessory (not supplied with the Model 3501 Optical Chopper) that allows one or two chopper controllers to be mounted in a standard rack. The kit consists of 2 short ears, 1 long ear, 1 rack plate, and 6 6-32 flathead screws. The figure below illustrates how to use the rack mount kit to mount a single chopper controller or two chopper controllers side by side.

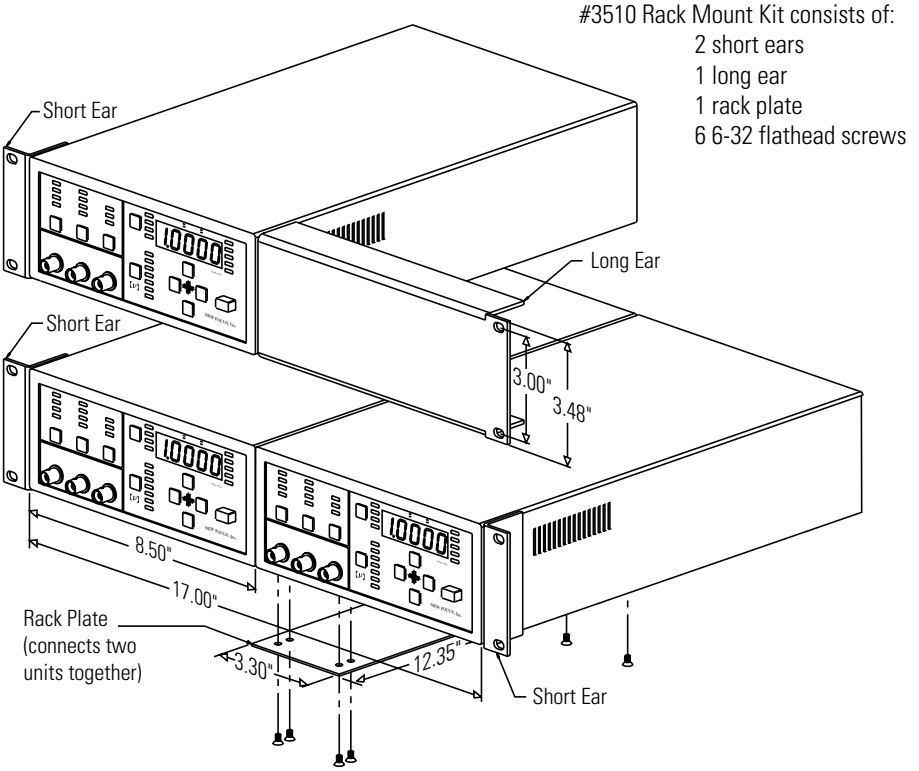


Fig. 6

Model 3510 rack mount kit.

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VII Computer Control

The Model 3501 Optical Chopper may be programmed remotely by IEEE-488 interface. The Model 3501 supports the IEEE-488.1 (1978) interface standard, and any computer that supports this interface may be used. A total of fifteen commands are available that enable any front panel operation to be performed remotely.

Before communicating with the chopper controller, set the IEEE-488 device address. This parameter may be selected by pressing the Set key until the IEEE LED is lit. Use the arrow keys to change the device address. The default device address is 12. Use a standard IEEE-488 cable to connect the instrument to the host computer.

ACT LED

The ACTive LED flashes whenever data is sent or received on the communications interface.

Line Terminators

For IEEE-488 operation, the correct line termination is line feed and EOI ('end or identify'). Generally, line terminations are set during the installation of the IEEE-488 interface card. Consult the manufacturer's installation instructions for details.

Command Syntax

Use ASCII characters to communicate with the Model 3501. Commands may be issued either in upper or lower case.

Some commands can be used to set operating parameters, some commands can be used to query operating parameters, and some commands can do both. A command (e.g., WHL?) consists of a mnemonic (WHL) and a optional suffix (?). The three letter mnemonic (WHL) specifies the parameter or action

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to be taken by the Model 3501. The suffix "?" indicates the command is a query that requests data from the Model 3501. The "WHL2" command is used to set the type of wheel being used, and in this case, "2" is taken as a parameter value.

Do not include decimal points in numerical data. So, to set the chopper frequency to 1.23 kHz, send the command OSC123000. To set the phase to -90 degrees, send the command PHS-900.

Multiple commands on a single line must be separated by a semicolon (;).

Data to Host

Data returned by the chopper controller to the host computer consist of a mnemonic, a data value and a line terminator. The mnemonic specifies the parameter (WHL = wheel) or the quantity measured (FR1 = F_{sync} frequency). Data is returned by the chopper with decimal points included (e.g., 1230.0).

Data to the host will be followed with a line termination (line feed and EOI). The line termination may be set when installing IEEE-488 into the host computer. Consult the manufacturer's installation guide for details.

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VIII Command Summary

Commands that may be queried are followed by a '?'.

A '*' indicates that the command contains an index (e.g., FR1,FR2,...).

A bracket [ ] indicates that the command accepts a data value. Data ranges are given in parenthesis. Do not use a decimal point or comma in data. For example, 5.00 is sent as 500.

Some commands can be used both to set and query an operating parameter. For instance, the PHS command can be used to set the chopping phase (PHS900) or to read the value of the phase (PHS?).

The next two pages contain an index and brief description of all fifteen commands. Then, the pages that follow give detailed information about each command. There, examples are given showing the command text followed by the response from the chopper. For instance, the example for IDN? appears as follows:

```
IDN?

—>NEW FOCUS 3501 CHOPPER
```

Command Index

FR*?	Measures frequency. 1 - F_{sync}, 2 - F_{outer}, 3 - OUT1, 4 - OUT2.
HAR[ ]?	Sets the harmonic multiplier H (1 - 15).
IDN?	Identification query. Returns "NEW FOCUS 3501 CHOPPER".
KEY*	Duplicates the action of pressing a front panel key: 0 - Right arrow, 1 - Down arrow, 2 - Up arrow, 3 - Left arrow, 4 - Set, 5 - Measure, 6 - Mode, 7 - Sync, 8 - Wheel.

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MEM*	Accesses instrument set-up memory. 0 - Store, 1 - Recall. Use with STO and RCL commands.
MOD*?	Selects the instrument mode. 0 - H/S, 1 - +/-, 2 - NORMAL.
MSK[ ]?	Enables condition required for SRQ (service request). Bit 0 - Unlock, Bit 1 - Data Ready.
OSC[ ]?	Sets the synthesizer frequency to three significant digits. (4.00 Hz - 99.9 kHz in EXT mode; range automatically limited in INT mode).
PHS[ ]?	Sets the phase delay (-180.0 - +179.0).
RCL[ ]?	Selects instrument set-up for recall (0-9). 0 - factory default set-up. Use with MEM1 command.
SET*	Selects the parameter modified by the arrow keys: 0 - Oscillator frequency, 1 - Phase, 2 - Harmonic multiplier, 3 - Subharmonic divide ratio, 4 - Recall set-up, 5 - Store set-up, 6 - GPIB device address.
STA?	Returns status register. Bit 0 - Unlock, Bit 1 - Data Available. The same information is available during a Serial Poll.
STO[ ]?	Selects instrument set-up for storage (1-9). Use with MEM0 command.
SUB[ ]?	Sets subharmonic divide ratio S (1 - 15).
WHL*?	Selects the wheel. 0 - 60 slots, 1 - 42/30 slots, 2 - 7/5 slots, 3 - 2 slots.

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Command `FR*?`

Description Frequency query.

Explanation The FR* command is used to query the following frequencies associated with the Measure key on the chopper front panel: F_{sync}, F_{outer}, OUT1, and OUT2. Data is returned in Hz.

`FR1?` - F_{sync}

`FR2?` - F_{outer}

`FR3?` - OUT1

`FR4?` - OUT2

Example The chopping frequency is 1.23 kHz, and the chopper is in NORMAL mode.

```
FR1?
—>FR11230.0
FR2?
—>FR21230.0
FR3?
—>FR36150.0
```
(The frequency at OUT1 is 6.15 kHz.)

【ν】

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Command

HAR[ ]?

Description

Set and query H.

Explanation

The HAR command sets and queries the harmonic multiplier H, which is used in H/S mode. The data may range from 1 to 15.

Example

```
HAR2          (Sets H to 2.)
HAR?
—>HAR2
```

【ν】

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Command	**IDN?**
Description	Identification query.
Explanation	Returns the following string identifying the chopper: "NEW FOCUS 3501 CHOPPER"
Example	IDN? —>NEW FOCUS 3501 CHOPPER

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Command KEY*

Description Duplicates the action of pushing a front panel button.

Explanation The KEY command duplicates the action of pushing one of the 9 black front panel buttons. The nine options are as follows:

KEY0 - Right arrow

KEY1 - Down arrow

KEY2 - Up arrow

KEY3 - Left arrow

KEY4 - Set

KEY5 - Measure

KEY6 - Mode

KEY7 - Sync

KEY8 - Wheel

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Command `MEM*`

Description Store and recall instrument set-ups.

Explanation The MEM command, along with the STO and RCL commands, is used to store and recall one of the 9 instrument set-ups.

After selecting which instrument set-up number to use (1 through 9) using the STO command, MEM0 will store the current instrument set-up.

After selecting which instrument set-up to recall using the RCL command, MEM1 recalls the selected set-up.

`MEM0` - Store instrument set-up.

`MEM1` - Recall instrument set-up.

Example

`STO5`	(Selects location #5 for storing the current chopper set-up.)
`MEM0`	(Activates storage to location #5.)
`RCL1`	(Selects location #1 for recalling a chopper set-up.)
`MEM1`	(Activates recall of the set-up stored in location #1.)

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Command `MOD*?`

Description Select and query the mode of operation.

Explanation The MOD command allows the user to query the chopper's operating mode and to set the chopper operating mode as follows:

`MOD0` - H/S

`MOD1` - +/-

`MOD2` - NORMAL

Example

```
MOD2          (Puts the chopper into NORMAL operating mode.)
MOD?
—>MOD2
```

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Command `MSK[ ]?`

Description Enables condition required for SRQ.

Explanation The MSK command sets or clears bits in the SRQ (service request) enable mask. A Service Request will be generated whenever either of the following bits is set. D0 (the rightmost bit) is for Unlock, and D1 (the next bit to the left) is for Data Available.

The MSK? query returns the SRQ enable mask.

Example

```
MSK1          (Generates a SRQ on Unlock.)
MSK?
—>MSK00000001
MSK10         (Generates a SRQ when data is available.)
MSK?
—>MSK00000010
MSK11         (Generates a SRQ on Unlock or when data is available.)
MSK?
—>MSK00000011
```

【v】

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Command

`OSC[ ]?`

Description

Set and query the synthesizer frequency.

Explanation

The OSC command sets and queries the internal synthesizer. In INT Sync mode setting the synthesizer frequency will set the chopping frequency. In INT Sync mode the data supplied by the OSC command is limited by the chopper wheel minimum and maximum chopping frequencies. In the other modes of operation, the data may range from 4.00 to 99.9 kHz.

Only three digits of resolution are available. The data is entered in Hz, and no decimal point should be included.

Example

```
OSC54300          (Sets the internal synthesizer to 543 Hz.)
OSC?
OSC543.00
```

【ν】

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Command `PHS[ ]?`

Description Set and query the phase delay.

Explanation The PHS command sets and queries the phase shifter. The data may range from -180.0 to +179.0 degrees. Do not use a decimal point in the data.

Example

```
PHS-1234          (Sets the phase shift to -123.4 degrees.)
PHS?
—>PHS-123.4
PHS222            (Sets the phase shift to 22.2 degrees.)
```

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Command `RCL[ ]?`

Description Selects instrument set-up for recall.

Explanation The RCL command will select a formerly stored instrument set-up. The RCL? query will return the recall set-up number. The data may range between 0 and 9. Recall of set-up '0' will restore the Model 3501 to factory default settings. RCL is used with MEM1 to recall the instrument set-up.

Example

```
RCL0        (Select factory default set-up for recall.)
MEM1        (Perform recall operation.)
RCL4        (Select instrument set-up #4 for recall.)
RCL?
—>RCL4
MEM1        (Perform recall operation.)
```


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Command `SET*`

Description Selects the parameter to be modified by the arrow keys.

Explanation The set command selects which parameter is activated so that it can be changed by the arrow keys.

`SET0` - Synthesizer frequency

`SET1` - Phase

`SET2` - H

`SET3` - S

`SET4` - Recall

`SET5` - Store

`SET6` - IEEE-488 device address

【ν】

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Command **STA?**

Description Returns the status register.

Explanation The STA query returns the 8-bit status register. The status register indicates when the instrument is unlocked (first bit) and when the data is available (second bit). Since some commands require a wait before the data is available (e.g., FR1?), the user may wish to poll the instruments to determine when to collect the data. Note: A serial poll of the instrument provides the same information without generation of additional data ready messages.

The bits in the status register are arranged from right to left as shown below (i.e., D0 is the rightmost bit). A value of 1 indicates the bit has been set, and a value of 0 indicates the bit is clear. Format of the bits in the status register:

D0 - Unlock (sampled)

D1 - Data available

D2 - Synthesizer locked (sampled)

D3 - Multiplier locked (sampled)

D4 - Motor locked (sampled)

D5 - Latched master unlock

D6 - Reserved for calibration

D7 - Reserved for calibration

The master unlock bit (D5) will be cleared when the status register is read with the STA? command. The master unlock will be set if the motor, multiplier, or synthesizer has been unlocked between the last and the current reading of the status register.

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Command `ST0[ ]?`

Description Selects instrument set-up for storage.

Explanation The STO command selects the instrument set-up number in which to store the current chopper set-up. The STO? query will return the selected instrument set up number. The data may range from 1 to 9. STO is used with MEMO to store the instrument set-up.

Example

```
ST09          (Select instrument set-up #9 for storage.)
STO?
—>ST09
MEMO          (Perform storage operation.)
```

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Command `SUB[ ]?`

Description Set and query S.

Explanation The SUB command sets and queries S, the subharmonic divide ratio which is used in H/S mode. The data may range from 1 to 15.

Example

```
SUB7          (Sets S to 7.)
SUB?
—>SUB7
```


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Command `WHL[ ]?`

Description Set and query the type of chopping wheel being used.

Explanation The WHL command sets and queries the type of chopping wheel that is being used:

`WHL0` - 60 slots

`WHL1` - 42/30 slots

`WHL2` - 7/5 slots

`WHL3` - 2 slot

Example

```
WHL1          (Selects the 42/30 slot wheel.)
WHL?
—>WHL1
```

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IX
Troubleshooting

When the instrument is properly connected to the power mains and a chopper head, and the unit is turned on, the front panel LEDs will blink and the display will show 'PASS' before recalling the last control set up. The motor should begin turning and come to speed within about 1 minute.

If nothing happens

Check that the power cord is connected at the power entry module.

Check that the chopping head is connected to the control unit. Do not connect the chopping head when the control unit is powered.

Fuse

Check the fuses in the power entry module. Disconnect the power cord at the power entry module. Open the cover of the power entry module using a small-blade screwdriver or similar tool. Slide the fuse holders out and examine the fuses. Replace a blown fuse with the appropriate type and current rating. (For additional details, see page 44.)

Mains Voltage

Make sure that the power entry module is set for the correct mains voltage. To set the mains voltage, refer to AC Operating Voltages (page 43).

Fails test at start up

This indicates a failure of the battery-backed memory. Consult with the factory for a replacement battery. Instrument settings will not be maintained when power is removed.

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Motor fails to turn

With power removed from the control unit, check that the wheel is free to turn without obstructions. Also, this condition may be caused by a broken cable between the control unit and the head. Substitution of a known functional cable is the best solution. (See Page 17 for details on replacement cables.)

Note that the life of the motor is limited. Long term high speed use of the motor will result in faster wear and shorter life. Because of this limited lifetime, the chopper head has a 90 day warranty, while all other parts have a one year warranty.

Motor oscillates wildly

Recall the factory default settings. This will place the instrument into known conditions. If the oscillation stops, then the Sync Input signal may have been unstable. Verify the stability of Sync Input with an oscilloscope or frequency counter. The Sync Input frequency may have been outside of operating limits which are determined by the mode, H, S and the wheel type. Refer to the section on FREQ for more details.

Observe F_{outer} on an oscilloscope. If the cable or optical sensor is damaged, the signal will remain high or low. If this is the case replace the cable between the head and the control unit.

Check for the correct setting of Wheel on the front panel.

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X AC Operating Voltages

The Model 3501 Optical Chopper can operate at 100, 120 , 220, or 240 V AC at AC frequencies of 47-63 Hz. The unit is configured at the factory for the standard AC voltage in the purchaser's country. To select a different operating voltage, please refer to Fig. 7 (page 44) and follow the directions below:

1. Disconnect the power cord.
2. Open the cover of the power entry module on the rear panel with a small-blade screwdriver or similar tool.
3. Insert the tool into the voltage selection slot and remove the wheel from the unit.
4. Turn the wheel and re-insert into the module so the desired voltage is shown. Do not attempt to rotate the wheel while it is still in the power entry module; the wheel must be removed, turned, and then re-inserted.
5. Close the cover.
6. Verify that the proper voltage is showing through the module's window.

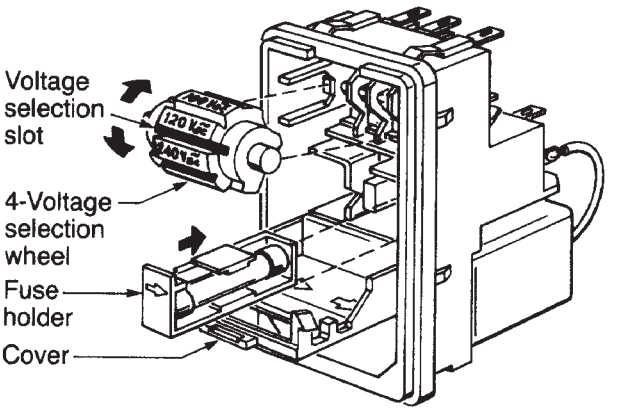
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The power entry module requires two 5x20 mm, slow-blow fuses, such as Littlefuse's® Slo-Blo® 239 series: one for the hot line and the other for the neutral line. Replacement fuses should be as follows:

AC Voltage	Fuse Rating	Littlefuse
100 V AC	0.4 A	239.400
120 V AC	0.4 A	239.400
220 V AC	0.2 A	239.200
240 V AC	0.2 A	239.200

Figure 7

Power entry module for the Model 3501 Optical Chopper.



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Chopping Frequency

Wheel	Min. Freq. (F_{outer})	Max. Freq. (F_{outer})	Jitter (µs p-p) @ Min. Freq.	Jitter (µs p-p) @ Max. Freq.
60	120 Hz	6.40 kHz	60	2
42/30	84 Hz	4.48 kHz	50	2
7/5	14 Hz	746 Hz	500	3
2	4 Hz	213 Hz	500	5

Internal Synthesizer

Stability	100 ppm after one hour warm-up.
Drift	Less than 10 ppm/°C.
Accuracy	< 1/5 of least significant digit.
Resolution	4.00 Hz - 99.9 kHz, 3 significant digits.
Range limits (INT)	Upper: [Highest wheel frequency]·S/H. Lower: [Lowest wheel frequency]·S/H.
Range limits (EXT)	4.00 Hz - 99.9 kHz.

Reference Input

Sync Input	TTL level pulse, with same frequency limits as internal oscillator.

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Reference Output

Sync Out	TTL level square wave, may be used as free running oscillator when using EXT+, EXT- or V_{ext} sync.
F_{outer}	TTL level square wave at the chopping frequency.
OUT1	TTL level pulse: $5 \cdot F_{outer}$ in NORMAL mode $F_{outer} - F_{inner}$ in +/- mode $[H/S] \cdot F_{outer}$ in H/S mode.
OUT2	TTL level pulse: F_{inner} in NORMAL mode $F_{outer} + F_{inner}$ in +/- mode $[H/(7 \cdot S)] \cdot F_{sync}$ in H/S mode.

Phase Shifter

Range: -180.0° to +179.0°
Resolution: 0.1°, increasing to 0.25° at 6.4 kHz.

Harmonic Locking

Subharmonic (S): 1 - 15
Harmonic (H): 1 - 15
S and H may be set in any combination.

Operation

Mode	S	H	OUT1	OUT2
H/S	1-15	1-15	$[H/S] \cdot F_{sync}$	$[H/(7 \cdot S)] \cdot F_{sync}$
+/-	1	12	$F_{outer} - F_{inner}$	$F_{outer} + F_{inner}$
NORMAL	1	5	$5 \cdot F_{outer}$	F_{inner}

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External Voltage Control

0 to -10.0 V DC for 0 to 100% of maximum chopping frequency.

Wheel Apertures

Wheel	Outer Aperture (inches)	Inner Aperture (inches)
60	.09	—
42/30	.14	.12
7/5	.60	.59
2	1.25	—

General

Dimensions:	8.5 x 4 x 14.5 inches
Weight:	14 pounds
Power:	90-240 V AC, 50-60 Hz, 35 W

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