FWF-4 Fast Filter Wheel
FWC-C/4 Filter Wheel Controller
User's Manual

Version 2.2
December 2008

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1. Receiving and unpacking instructions

Important

As with any freight, damage can be caused during transportation. Your receiving dept will know to report any exterior packaging damage to the freight company before signing receipt documents.

Sciencetech cannot be held responsible for damage caused by a third party carrier.

2. Input Fuse selection and replacement

The system is set up for use as either 115Vac/230Vac operation. The factory default is 115 Vac, fuse type T-300mA, and 50/60Hz. The AC power is connected through the plug and switch located on the back panel. If another ac input voltage is to be applied (i.e. 230Vac), then the proper fuses and voltage selection MUST be done before operation. Refer to the figure 1 below and follow these steps to replace ac input fuse.

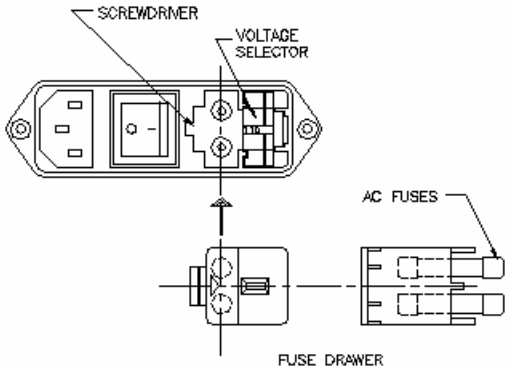


Figure 1. AC Input Module

1. Using a small flat screwdriver, fully remove “fuse drawer” by gently prying it out as shown above
2. Remove “voltage selector”, rotate such that the “230” appears to the outside and is properly oriented, and re-insert
3. Remove and replace ac input fuses to proper values (as indicated on back panel)
4. Re-insert fuse drawer and push in until it “snaps” into its final position

3. Introduction

Sciencetech's FWF-4 is a motorized fast filter wheel unit. The wheel can hold four filters, 3" in diameter, up to 10 mm thick. It is driven by a 1.8° stepping motor with a 1:2 de-multiplication to allow use of the full filter aperture with no f/# restrictions. The micro-stepping motor operation permits precise filter positioning at each position with high reproducibility.

The FWC-C/4 filter wheel control unit allows computer control of the filter wheel movement via an RS232 interface.

4. Operation of FWC-C/4 filter wheel controller

NOTE: The system is set up for 115Vac/230Vac operation. The factory default is 115Vac, T-300mA, 50/60Hz

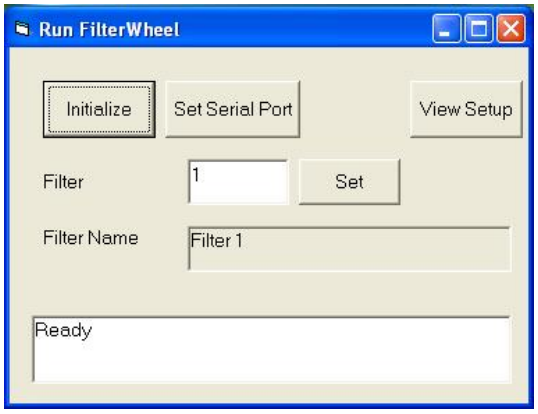
The FWC-C/4 filter wheel control box features remote computer control of the selection of filters through sciencetech software. All computer commands must be preceded with 3, as shown below. The RS232 connector on the back panel connects to the remote computer, and the 9-pin D-sub connector goes to filter wheel.

Turn on

* The system looks for the end switch for indexing. During this seek the LED displays "0".
* When found, the controller disables the end switch to allow cyclic operation (filter # 4 to # 1 by 4-3-2 -1).

Computer control

Sciencetech provides a nice gui interface for controlling the filterwheel such as the one pictured below. When the software is started up the filterwheel will home itself and then move to the position of the first filter. It may be necessary to set the com port first by clicking the “Set Serial Port” button. After this you may initialize the filterwheel by clicking on the “Initialize” button.



To move the filter wheel, type the desired filter number into the “Filter” dialogue box and then press the “Set” button.

A host computer can control the FWF-4 through a standard serial port with any basic communications program such as hyperterminal. Please use the following settings to control the filterwheel:

- 9600 baud
- 8 data bits
- No parity
- 1 stop bit
- No software handshake
- Standard hardware handshake: DTR (pin # 20) and CTS (pin # 5).
- When opening: set DSR and CD timeouts = 0

The instruction format is ASCII, preceded with 3 and closed with the enter button [CR]. Instructions ARE case sensitive. The main instructions to be used by the operator are:

3M####	Move the filter wheel #### steps (The position of each filter is stored in a configuration file called “*filter.cfg*” in the filterwheel program directory).
3F-	Home the filter wheel (K switch must be turned on by 3K0)
3K#	# can be either a 1 (turn end switch off) or a 0 (turn endswitch on)

See the protocol file for the microprocessor that controls the unit for details about the format of the instructions.

To execute a filter wheel reset from the computer, execute the following command sequence:

A	abort all movements (it does not require a "3" header: it is a global instruction)
3K0	enable end switches
3U1	select micro-step mode
3V1	select step time multiplication factor
3T1000	select 1000 µs step time base
3F-	move towards end switch. Microprocessor response: 3-E when the end switch is found
3K1	disable end switches for cyclic operation

Warning. If any direct move operation (M, G, F: see the protocol file) is issued after initialization, the system will lose track of its position: a reset operation must be issued from the control panel or the reset sequence must be issued by the computer.

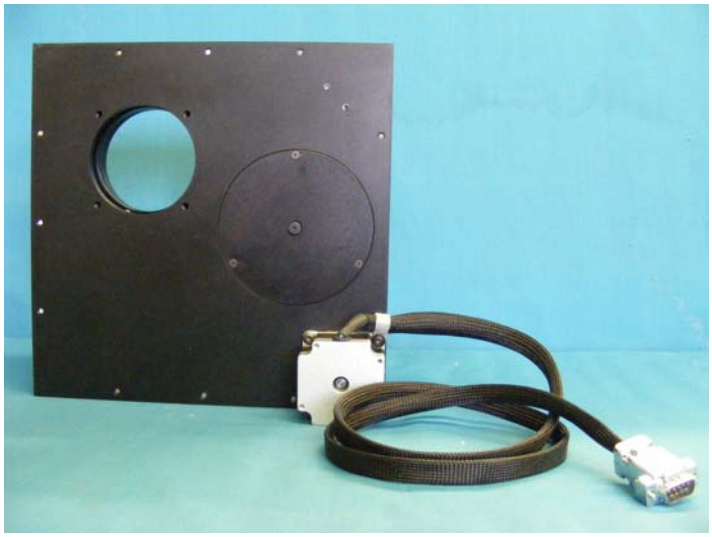
<u>Simultaneous computer/manual control</u>

The controller can be operated by either the computer or the operator. Pushbutton or computer filter position commands can be issued in any order.

Note: There are four filters in FWF-4 fast filter wheel. Thus all commands referring to the total number of filters should be 4.

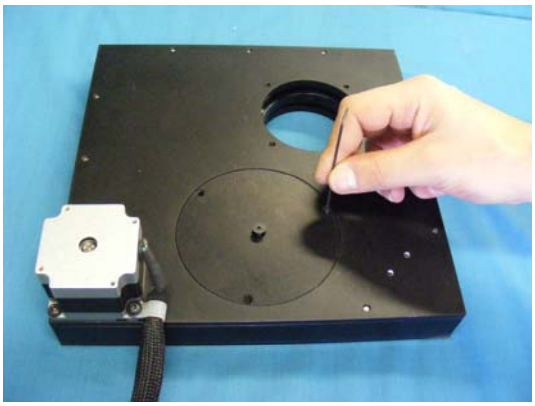
5. Filter mounting and replacement

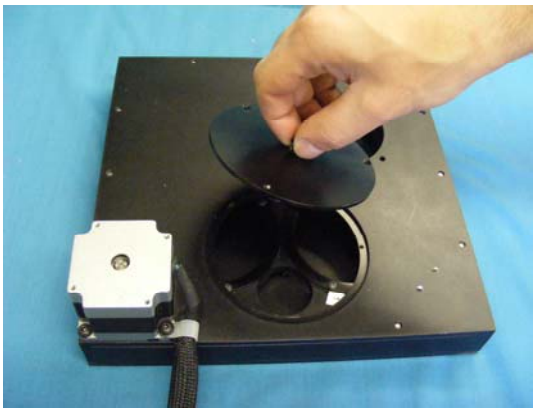
The front panel of the filter wheel assembly is shown below. The numbering of the filter position on the wheel is clockwise when you look at the front panel. There are four mounting holes surrounding the filter hole on the front of the filter wheel.



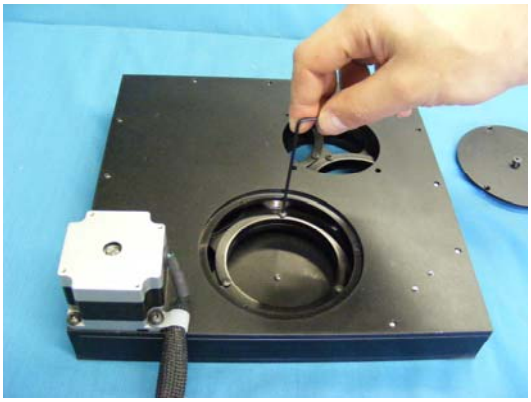
To change filters:

1. Remove the filter replacement lid on the front panel by unscrewing the 3 flathead screws which secure the lid in place (Use a 5/64" hex key). This will let the user access the filter holders on the wheel. When the power is off, the wheel can be turned manually and you can find the filter position needed to be changed.

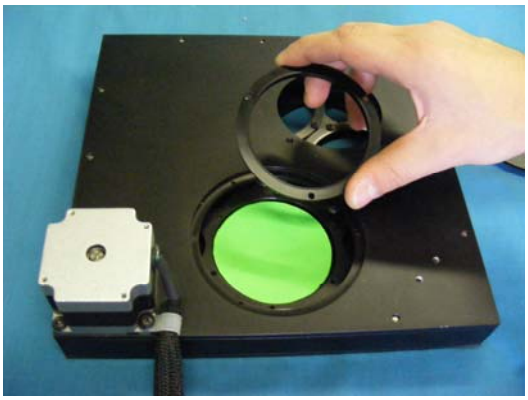




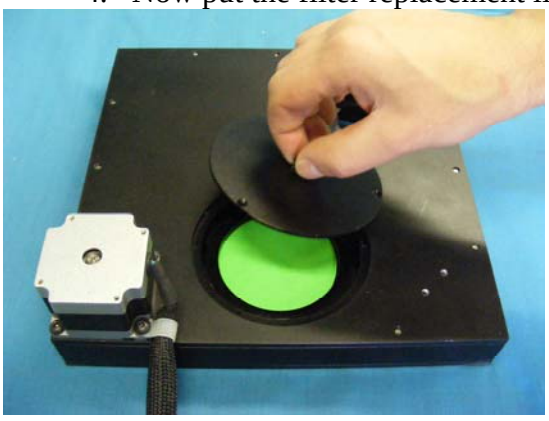
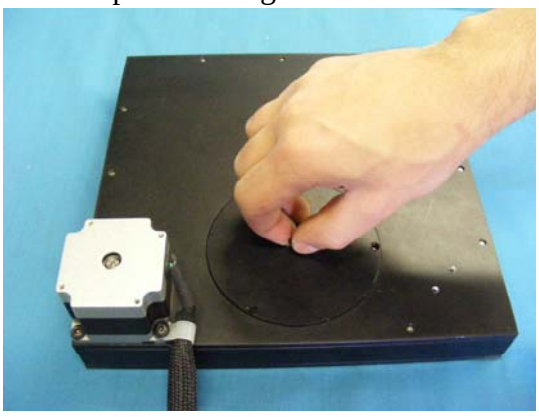
2. Remove the circular retaining ring from the filter holder by unscrewing the 3 buttonhead screws which secure the ring in place (Use a 3/32” hex key)




3. Place your filter into the filter hole then place the retaining ring back onto the filter and tighten the screws.

4. Now put the filter replacement lid back into place and tighten the screws.

5. Specifications

Filter size:	3" diameter, up to 10 mm thick
Clear aperture:	3" diameter

6. Appendix

Communication protocol for stepper motor control microprocessor.

Version 4.10 December 1st, 1999 Print date: December 11, 2008

Microprocessor instructions

Serial port setup
- 9600 baud
- 8 data bits
- No parity
- 1 stop bit
- No software handshake
- Standard hardware handshake: DTR (pin # 20) and CTS (pin # 5).
- When opening: set DSR and CD timeouts = 0

General instruction format
Several controllers can be daisy chained into the same serial port. Each controller is identified by a value from 0 to 3.
Notes:
- The handshaking is also daisy chained: the CTS line goes down (disabled) when the RTS line goes down (another controller is not available) or when the internal buffer is full.
- Two wiring solutions are possible: internal box wiring and special cables to several boxes each with one controller.
- The unit # is assigned using the present 2 DIP switches.

[CR] stands for carriage return.
1. Into microprocessor. All instructions must follow the format:
   a. Started with a single digit from 0 to 3 that identifies the controller to be used. If no leading digit is sent, it is meant as an instruction for controller # 0 to allow the spectrometer software to be backwards compatible. Throughout this proposal, the controller identifying digit is indicated by the character #.
   b. Closed with a [CR].

c. All blank spaces and line feeds are not significant.
d. All command alphabetic characters in capital letters.
e. All numbers are sent in ASCII (not binary).
f. An error response will be produced when:
   i. The first (instruction) character (other than blank spaces or line feeds) is not recognized.
   ii. All characters other than the first one that are not the number leading - or + sign (for signed values) or a digit.
   iii. A digit before a sign character.
   iv. A sign character is present in a unsigned value.
   v. More digits than required by the variable.
g. The digit sign is optional. If not present in a signed value, it is assumed to be positive.
h. Zeros before other nonzero digit are ignored.
i. Word format:
   i. Unsigned: several digits starting with the most significant one.
   ii. Signed: the ASCII character of the sign "+" or "-" (if missing, a positive number is assumed) followed by several digits.

   If less digits than necessary are sent, they are assumed to be the least significant ones (e.g., if 75 is sent for a digit between 1 and 9999, it is read as 75, not as 7500).

2. The microprocessor provides no echo except for the abort instruction.
   All instructions and responses are buffered: the instruction/response is sent only after a [CR] is received to avoid scrambling messages.
   If the instruction does not execute immediately, a delayed answer is given.

Error return format

3. The end switch error message can be produced at any time. Its format is "[#]E*", where "#" is the controller number (none or 0 for controller # 0) and "*" is "+" of "-" depending on the switch.
4. Any 💻-p instruction that has a valid digit (i.e., one corresponding to a connected controller) as the first character but that violates the instruction format rules is returned in the format:
   "[#]**..*"?[CR][LF]

where **..* stands for the sent instruction.
[] stands for optional (controller # ≠ 0).

5. Delayed response. After completing an instruction addressed to it that requires delayed response, the 💻-p returns the completion message, including the controller identifier (except for controller # 0).

INSTRUCTIONS

1. **A**. Abort move, find switch or interval move. Stop all the motors immediately. If the motor is operating in accelerated mode (G), stop the motor using deceleration.

Computer: A[CR]
💻-p delayed: none

Action: abort any motor operation (M, G, or F) for all motors.

2. **C**. Motor winding manual setting.

a. **CAn**. Set current in winding A. -127 <= n <= 127.
Computer: [#]CAn[CR]
💻-p delayed: none

b. **CBn**. Set current in winding B. -127 <= n <= 127.
Computer: [#]CBn[CR]
💻-p delayed: none

E.g., to shut off the motor transmit CA0[CR], CB0[CR]. A cycle of 8 half steps = 4 full steps = 3.6☜ would be (90 = 127/🔔2):

CA	127	90	0	-90	-127	-90	0	90
CB	0	90	127	90	0	90	127	90

3. **F**. Find end-switch.

Computer: [#]F+[CR] or [#]F-[CR] to find either switch.
💻-p delayed: normal: [#]+D[CR][LF] or [#]-D[CR][LF]
error: none

Action: move the stage until the desired end-switch is found. Find overrides Move (constant speed) or G (accelerated move) (immediate execution).

If the motor is disconnected, the end switches are set thus all operation instructions will generate immediate end switch responses.

4. **G**. Move steps with under acceleration: q=-9999999 to +9999999 (up to 7 digits). q is a signed word. Move the stage q motor 💻-steps. The 3 acceleration tables are in the ROM: the first one is the step period per 💻-step, the second one is the step period per half-step, and the third one is the distance for each decrement of 1 💻s in the half-step period. The acceleration/deceleration is symmetrical: the motor accelerates up to half the distance or up to when the half-step period equals p. If the period reaches p, it stays at constant period p until it is necessary to decelerate.
If G0 is issued, do an 🗐 move in the positive direction until the positive end switch is reached or an abort command (A) is issued.

Computer: [#]Gq[CR]
Error: [#]GE[CR][LF] if M or F is active.
💻-p delayed: normal: [#]MD[CR][LF]
error: [#]+E[CR][LF] if the far end switch is set.
[#]-E[CR][LF] if the near end switch is set.

Action: step the motor q (💻) motor steps, return normal message. If at any time the end switch turns on compare the sign of the end switch with that of q. If they are opposite, continue. If they are the same, stop and return error message. If an M or F instruction is active, an error message is returned.

5. **K**. End switch control. It is used for cyclic operation: filter wheel drive and direct drive spectrometer drive.

a. **K0**. End switch is enabled (for linear operation and to

find the zero in circular operation).
Computer: [#]K0[CR]
💻-p delayed: none

Action: enable the recognition of the end switch signal.

b. **K1**. End switch is disabled (for circular operation).
Computer: [#]K1[CR]
💻-p delayed: none

Action: the status of the two end switches is ignored: the motor continues to run even if the end switch in that direction is set, no message is issued.

Default: end switches disabled after startup.

6. **L**. Read the number of 💻-steps since the reset operation.

7. **M**. Move steps with no acceleration: m=-9999999 to +9999999 (up to 7 digits). m is a signed word. Move the stage m motor steps (or 💻-steps, controlled by the step size as selected by the U instruction). The time is controlled by the V, T instructions: time per step (💻s) = V*T.
If M0 is issued, do an 🗐 move in the positive direction until the positive end switch is reached or an abort command (A) is issued. M0 is equivalent to F+.

Computer: [#]Mm[CR]
Echo: None if executed
Error: [#]ME[CR][LF] if M, G or F is active.
Delayed: normal: [#]MD[CR][LF]
error: [#]+E[CR][LF] if the far end switch is set.
[#]-E[CR][LF] if the near end switch is set.

Action: step the motor m motor steps, return normal message. If at any time the end switch turns on compare the sign of the end switch with that of m. If they are opposite, continue. If they are the same, stop and return error message. If an M, G or F instruction is active, an error

message is returned.

8. **P**. Set the minimum half-step period for maximum speed (G instruction). p=1 to 99999 in 💻sec units. p is an unsigned word.

Computer: [#]Pp[CR]
Echo: None if executed
Error: [#]P?[CR][LF] if p > v*t (see below). ??????
💻-p delayed: none

Action: deposit p in 💻-p memory ☺$_{min}$. Use the next time a new accelerated move (G) is started. Immediate update. Valid at all time.
Default: 200.

9. **Q**. Motor winding control.

a. **Q0**. All windings off (for manual motion).
Computer: [#]Q0[CR]
💻-p delayed: none

Action: disable (turn off) all stepper motor windings off.

b. **Q1**. Windings on.
Computer: [#]Q1[CR]
💻-p delayed: none

Action: enable stepper motor windings.

Default: windings on.

10. **R**. Software revision

Computer: [#]S[CR]
💻-p delayed: none

Action:
Return #.**[CR] # main revision
** upgrades

11. **S**. Shutter control. This is only filter wheel controller #3.

a. **3S0**. Close shutter.
Computer: 3S0[CR]
μ-p delayed: none

Action: the shutter in the filter wheel is closed.

b. **3S1**. Open shutter.

Computer: 3S1[CR]
μ-p delayed: none
Action: the shutter in the filter wheel is opened. If the front panel switch is in close position, returns 3S1?.

c. **3S.** Shutter query.

Computer: 3S[CR]
μ-p delayed: none

Action: returns 3S0 or 3S1.

12. **T**. Set the time per step during end switch find (F) and fixed speed move (M) operations. t=100 to 9999. The step time has a resolution of 2μs, i.e. step time(μs) = 2*Int(t/2). t is an unsigned word.

Computer: [#]Tt[CR]
μ-p delayed: none

Action: deposit t in μ-p memory. Immediate update (t is fetched before every step). Default: 1000. Subsequent RESET does not change T value.

13. **U**. Set/reset microstep. It affects end switch find (F) and fixed speed move (M) operations.

a. **U0**. Set system to half step.
Computer: [#]U0[CR]
μ-p delayed: none

b. **U1**. Set microstep: 10 💻-steps per full step (5 💻-steps per half step). It uses sine/cosine tables.
Computer: [#]U1[CR]
💻-p delayed: none

Action: deposit u in one 1-byte 💻-p memory. Update after the motor operation (if any) has been completed. G or W commands and UP/DOWN wheel changes will set U=1. Default: 1. When the system is changed back from 💻-step to half step, the position of the motor is maintained, i.e., subsequent half steps are not within detente positions but from whatever "analog" position the motor was in the 💻-step mode. This allows position tracking if switching back and forth between modes.

14. **V**. Set the multiplier for the time per stage step (or microstep) during end switch find (F) and both accelerated (G) and fixed speed move (M) operations, i.e., the time per single step is t * (1 to 999). v=1 to 999 in t units. v does not affect the find end-switch step time that is set at t, i.e., v=1. v is an unsigned word.

Computer: [#]Vv[CR]
💻-p delayed: none

Action: deposit v in 💻-p memory. Immediate update (v is fetched before every step). Default: 1. Subsequent RESET does not change V value.

15. **W**. Filter wheel.

Computer: [#]W*[CR]
💻-p delayed: none

Action:
Wn select filter # n. Update display. Answer: 3WD.
W filter position query. Answer: W1 to W6

16. **X**. Auxiliary digital control line #1 (in JP1: serial

port header).

a. **X0**. Control line to ground (logic 0).
Computer: [#]X0[CR]
💻-p delayed: none

Action: ground control line.

b. **X1**. Raise control line (logic 1).
Computer: [#]X1[CR]
💻-p delayed: none

Action: raise control line.

Default: Control line grounded.

17. **Y**. Auxiliary control line #2. Same as #1 but with **Y0**, **Y1** (in JP1: serial port header).

18. **Z**. Auxiliary control line #3. Same as #1 but with **Z0**, **Z1** (in JP1: serial port header).