FW-1000 Filterwheel

Instruction Manual

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Electrical Characteristics

AC Input: 90-264 VAC, 3.3 A (peak), 50/60 Hz

AC In-rush Current (Cold Start): 77 A (maximum), at 240 VAC

Fuse Replacement: 2.0 A Fast Blow 250 VAC

(Spare fuse located in Power Jack on Back Panel)

WARNINGS

1. Ensure power switch is in the OFF position before plugging in the power cord.

2. Do not unplug or plug-in devices / cables when power is on.

3. Do not remove the front or back panels; no user serviceable parts are inside.

4. Do not insert hand or non-isolated tools into Control Box even with power off. Stored charge on capacitors could result in personal electrical shock or damaging of electrical components if contact is made to internal circuit boards.

5. In the event of device failure, contact ASI: (541) 461-8181
   (800) 706-2284
   International: 011-541-461-8181

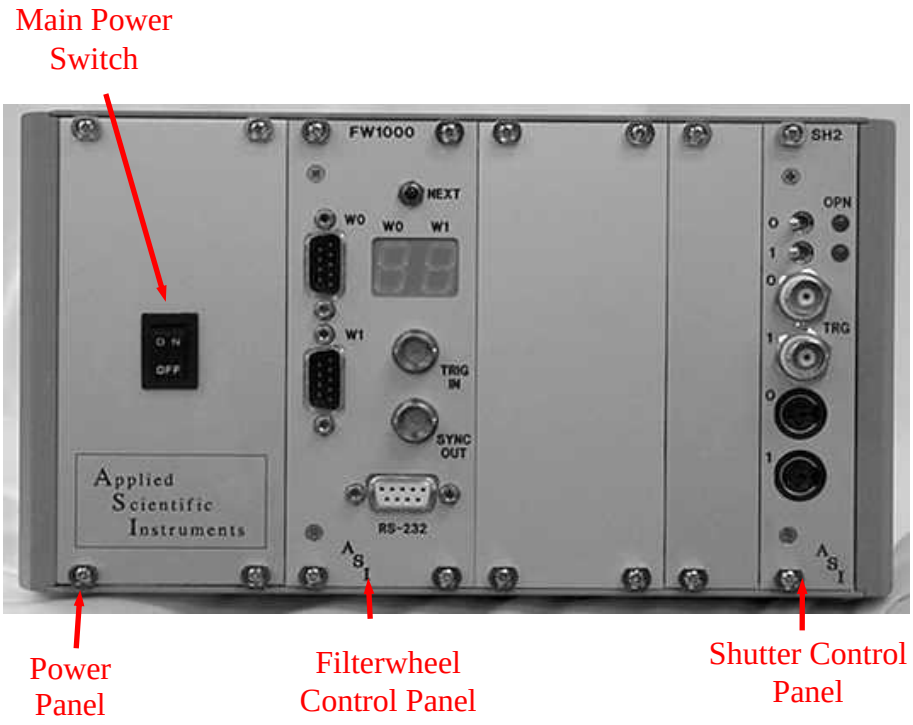
Description

FW-1000 Filterwheel

The FW-1000 uses a unique drive mechanism to give the lowest vibration possible when rotating to different filter positions. The dynamic balancing requires a powerful servo motor with precise control in order to obtain simultaneously fast switching speeds and low vibration.

The filterwheel controller allows for flexible control of the wheel, either with serial RS-232 commands, or using TTL triggers and preprogrammed sequences.

The filterwheel can be mounted on just about any microscope. For the photo port, the filterwheel occupies the space allotted for the C-mount adapter on the microscope. An optional C-mount flange is mounted on the motor side of the wheel and the appropriate optional photo port adapter for the microscope is mounted on the other side. For an excitation filter, optional microscope specific lamp adapters are provided.



FW-1000 Control Box

The FW-1000 control box provides a simple unit that houses multiple control panel cards and allows for future expansion. The Main Power Switch energizes the appropriate internal power supplies to energize the panels inserted into the unit. A FW-1000 system can be supplied with just a Filterwheel Control Panel, or with the optional Shutter Control Panel as seen in the photo above.

A FW-1000 Filterwheel Control Panel can handle two filterwheels and simultaneously move both wheels to the next set of filter positions. It may be controlled by the button or Trigger input on the panel. A Shutter Control Panel can handle two shutters, including the optional built-in shutters available with FW-1000 filterwheels. Both filterwheels and shutters may be controlled by computer commands via the RS-232 connector on the Filterwheel Control Panel. The shutters may also be controlled via the switches or TTL Trigger inputs on the Shutter Control panel.

Filterwheel Control Panel

The FW-1000 Filterwheel Control Panel provides control for two filterwheels, W0 and W1. The filterwheels are connected to the controller via the *W0 and W1 DB-9 Male Connectors* on the front panel. Upon power-up, any connected wheel will attempt to locate its HOME position and, if successful, its corresponding *LED numeric display* will indicate the wheel position. If no wheel is detected, the display digit will remain off. In the event of an unrecoverable error, the display will show the letter "E."

1.1.1 NEXT Button

Each press of the *NEXT* button advances the filterwheel(s) to the next pre-programmed filter position(s). In the event of an error, i.e., when an "E" is displayed on the LED display, holding the NEXT button down for 3 seconds will initiate a system reset. Holding the NEXT button down for more than 6 seconds will initiate a programmed sequence – equivalent to the serial **`ST`** command.

1.1.2 TRIG IN / SYNC OUT

A TTL input may be connected to the *TRIG IN BNC Connector* for triggered sequencing of the filterwheel(s). The *SYNC OUT BNC Connector* provides a TTL pulse as soon as the wheel(s) reach the commanded position(s). The *SYNC OUT* also provides flexible synchronization pulses when using the filter wheel in the *Spin/SYNC* mode of operation.

1.1.3 RS-232

The *RS-232 DB-9 Female Connector* may be connected to a host computer with a null modem cable for programming or controlling the FW-1000 card. This port can also be used to control shutters attached through the optional Shutter Control Panel.

Shutter Control Panel

The FW-1000 Shutter Control Panel provides for control for two shutters, 0 and 1. The shutters are connected to the controller with the *0 and 1 6-Pin Mini-Din Female Connectors* on the front panel. Upon power up, any connected shutter will go to its default position of *OPEN* or *CLOSED* depending on the position of the shutter's toggle switch and the type of shutter (normally-open or normally-closed). It should be noted that the panel/card will be set for either a normally-open or a normally-closed shutter at the factory. This setting can be changed using the *Shutter Setup* command (see page 27). The Shutter Control Panel is controlled internally through the Filterwheel Control Panel's RS-232 computer control serial port.

1.1.4 TOGGLE Switches

The two toggle switches for shutter 0 and 1 at the top of the panel allow manual override control of the shutter. When the toggle switch is placed in the left position, the shutter control is in the RS-232 controlled state that defaults to the de-energized position of the shutter at power up. When the toggle switch is moved to the right position, the control panel will energize the shutter for that switch. It should be noted that the switch must be in the LEFT position to be able to control the shutter through the Filterwheel Control Panel's RS-232 computer control port.

1.1.5 LEDS

If the shutter has a built-in internal position sensor, the corresponding *LED* will indicate the shutter is in its OPEN position if lit. If no internal position sensor is detected, the LED will always remain unlit.

1.1.6 TRG

A TTL input may be connected to the *TRIG IN BNC Connector* for external control of each shutter. A +5vdc signal applied to the internal pin of the *TRG IN BNC connector* (the outer connector is ground) will override any computer controls and energize the shutter.

1.1.7 Order of Precedence

Whether it be computer serial control, toggle switch control, or TRG TTL control of a shutter, an energize signal from any one of them will dominate, and that shutter will remain energized until all control sources return to their de-energized state.

Installation

Installation of Filters

As outlined below in figures 1 and 2, the filters should be loaded into the wheel prior to installation on the microscope. Change the filters through the port on the side opposite the motor. Depending on the microscope, it may be necessary to remove the coupling adapter to the microscope to have better access to the filter holders.

ASI FW-1000 filterwheels use a split retaining ring to hold filters, as shown below:

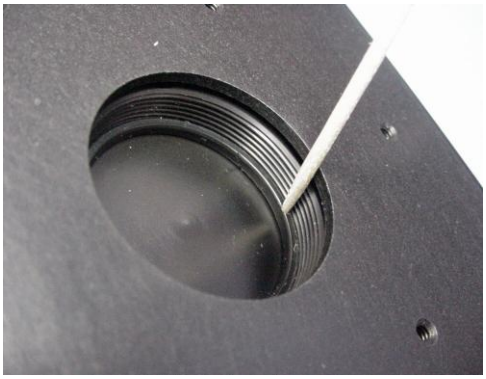


Figure 1: Insert tooth pick, or other small tool, into hole on split retaining ring.

Figure 2: Twist ring clockwise to tighten, or counter clockwise to remove ring.

When correctly tightened, the threads and split-ring lock the filter securely in place. When removing, you can use a toothpick to "pop" the ring out of the threads and then spin the ring out.

Please note the correct orientation / direction of the filter when installing it in place; most filter manufacturers inscribe an arrow that points in the direction the photons are expected to travel.

Loading the wheel for minimum vibration and switching impulse

The ASI system is designed to work smoothly with the wheel fully loaded with filters. However, absolute minimum switching impulse will occur when the wheel is loaded with four 3mm thick filters (total filter mass about 17gm). For best results, attempt to maintain a balanced wheel. The filters and slugs should be distributed evenly about the wheel axis to keep second-order vibration minimized. For the fastest two color switching, place the two filters to be used in positions zero and one, and balance the wheel with filters or slugs in positions four and five. Bear in mind that any cumulative indexing errors that may occur are corrected whenever the wheel turns between the zero and one position. Hence, it is desirable to load commonly used filters in these positions so that the correction will naturally take place regularly.

Installation of Adapters

Attach the filterwheel to the microscope using the mounting adapters supplied for your installation. The motor side on the filterwheel is located away from the microscope body for most installations. Attach the camera, detector, or lamp housing to the adapter on the motor side of the filterwheel.

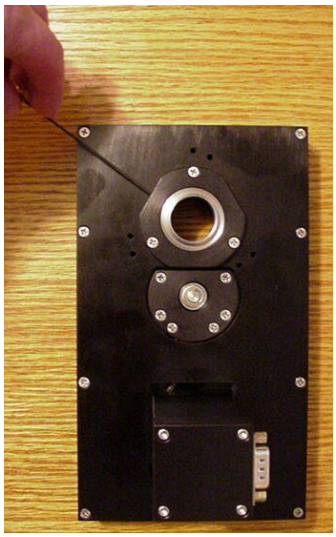


Figure 3: Camera orientation adjustment on C-Mount

1.1.8 Emission Installations

In emission applications, the filterwheel is mounted between the photoport of the microscope and the camera. If you ordered your filterwheel for this application, an adapter specific to your microscope will be installed on one side of the filterwheel case. This adapter would mate with a photoport on your microscope. A male C-mount adapter shown in figure 3 will be installed on other side of the filterwheel case to mount a camera. The stainless steel portion of the C-mount adapter can be rotated to correctly position the camera. To rotate the C-mount adapter, use the 0.05" Allen wrench to loosen two of the three setscrews as shown in figure 3. After correctly positioning the camera, re-tighten these setscrews.

1.1.9 Excitation Installations

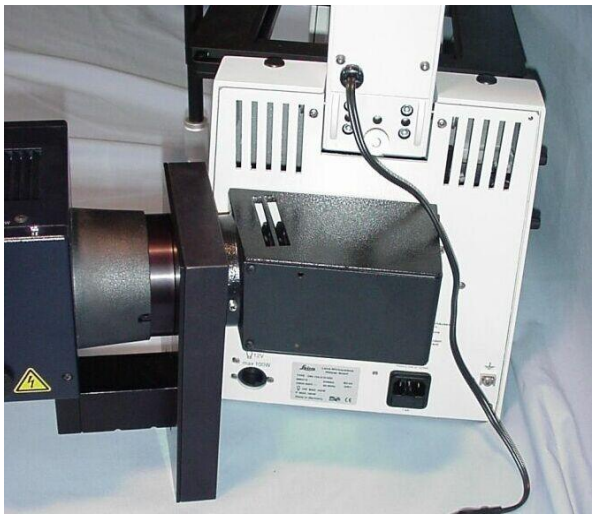


Figure 4: Excitation Installation

As shown in figure 4, the filterwheel may be mounted between the lamp housing and the microscope lamp housing port to control the excitation wavelength.

WARNING: When using the filterwheel in this manner, a heat filter must be installed between the lamp housing and the filterwheel or damage to the wheel will occur. If your lamp housing does not have a heat filter built into it, a heat filter must be ordered from ASI. This filter will be installed between the lamp housing adapter and the wheel.

Installation of Cables

Plug the AC power cord into the rear of the controller. Attach the cable between the filterwheel and the controller. Connect the serial cable between the computer and controller.

Figure 5: Power cord connection to rear of controller

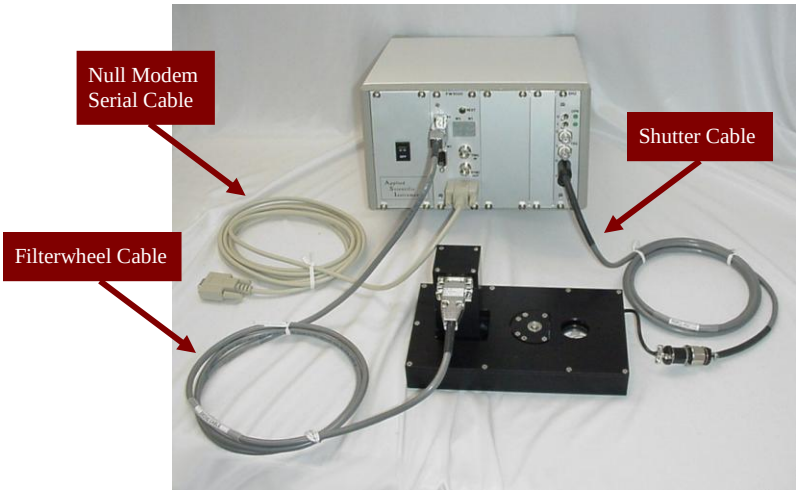


Figure 6: Cable connections on front of controller

FW-1000 Operation and Programming

Quick Start Procedure

Before installation on the microscope – check out the basic operation of the filterwheel and load your desired filters. The following Quick Start Procedure will walk you through these steps.

Plug the controller into an AC outlet and connect the filterwheel to the "W0" connector on the controller with the cable provided. Power up the filterwheel. Upon initialization, the wheel(s) will rotate to HOME.

The RS-232 serial link allows you to easily set up the filterwheel for your stand-alone or programmed operation. The serial link also provides direct control of the filterwheel(s) as well as diagnostic information. The Microsoft® Windows® HyperTerminal program provides a suitable commonly-available interface for talking to the controller. Using HyperTerminal, set up the connection as "Direct to Com1." Connect the provided "Null Modem" serial cable from COM1 on the computer to the RS-232 connector on the front panel of the FW-1000 controller.

The FW-1000 controller uses the following RS-232 communication settings:

9600 Baud; 8 data bits; No Parity; 1 stop bit; No Flow Control

Set up HyperTerminal accordingly. In the ASCII setup section, be sure the checkbox "Send line ends with line feeds" is not checked.

When the controller is turned on, the following messages should be displayed in HyperTerminal:

RESET	(Power up initialization)
MOTOR 1 NOT RESPONDING	(If you only have one filterwheel attached, you get this message)
0>	(Command Prompt)

The "W0" digit of the numeric display on the controller should read "0", corresponding to the HOME position of the filterwheel. The "W1" digit should remain off if only one wheel is attached.

Try a few of the following commands; what you send is shown in **RED**:

0>MP *n* *n*	Move wheel "0" to filter position *n*, where *n* is any valid filter position.
0>HO	Cause the wheel(s) to seek HOME
0>P1 1	Read the value of P1 (the second programmed filter position) Control indicates P1 for wheel "0" is set to 1

0>P1 3 3	Set the P1 value for wheel "0" to position 3 Control indicates P1 for wheel "0" is set to 3
0>ST	Start a pre-programmed, timed move sequence.
0>HA	Halt the move sequence
0>JK ERR	Invalid command "**JK**" returns "**ERR**" string.

Press the "Next" button on the controller. The wheel(s) will advance to the next position of pre-programmed sequence each time the button is pressed.

If you have more than one filterwheel attached to the controller, change the active wheel with:

0>FW 1 1	Now all input will refer to wheel "1" where appropriate
1>	The prompt indicates your commands are directed to wheel "1"

See the command list at the end of this manual for a complete description of the FW-1000 command set.

Programmed Sequences

The FW-1000 controller allows you to set up a series of filter positions that can be repeatedly sequenced in the order you desire. The sequence may be run with pre-set delays, with the front panel button, or with a TTL pulse connected to the front panel BNC connector. Alternatively, you may move both wheels to a pre-programmed position with the serial command, **`Gn`**, where *n* is the desired protocol position number.

Presently you may program up to 8 filterwheel positions for each wheel. You may also program a delay value for each step. The delay is used only when executing a time sequence using the **`ST`** (Start) serial command, and does not affect TTL-commanded sequencing. The wheel(s) will move to each programmed position in turn. The sequence will restart at the P0 position following the last position command (Pn) whose position for both wheels was not "-1". Initially, all programmed wheel positions are set to -1 except for P0 and P1 which are set to HOME (0) and to Position 1, respectively, for each wheel. The delay values are initialized with a value of 500 milliseconds for all positions.

The table below illustrates an example program sequence of five positions:

Command	Delay	Command	Wheel 0	Wheel 1
D0	500	P0	0	0
D1	500	P1	1	1
D2	500	P2	2	1
D3	500	P3	2	4
D4	500	P4	3	0
D5	500	P5	-1	-1
D6	500	P6	-1	-1
D7	500	P7	-1	-1

In this example, the P2, P3, and P4 positions for wheel 0 are changed to positions 2, 2, and 3 respectively. The P2, P3, and P4 positions for wheel 1 are changed to positions 1, 4, and 0 respectively. For successive TTL pulses (or button pushes) the wheels will advance as follows:

Pulse #	Wheel 0 Position	Wheel 1 Position
	0	0
1	1	1
2	2	1
3	2	4
4	3	0
5	0	0
6	1	1
7	2	1
Etc.	Etc.	Etc.

If you were to issue the serial command "**G4**" with the set-up above, the controller will move the wheels to the "P4" protocol position (i.e. Wheel 0, position 3 and Wheel 1, position 0). A subsequent TTL trigger would advance to P0 (i.e. Wheel 0, position 0 and Wheel 1, position 0).

If the serial command "**ST**" is issued, the wheels will advance from position to position with 500 ms delays between moves, moving continuously until the "**HA**" command.

Note: There is a HOME index on the encoder wheel located between the HOME (0) and the first (1) filter position. Each time the wheel passes this point, the position encoders are readjusted if necessary. This ensures that the wheel does not drift off its indexed position after many successive filter changes. The user should implement protocols that move the wheel across the index position (between positions 0 and 1) at least once in the course of the protocol cycle to ensure that the wheel does not drift from the indexed positions. The wheel will move the minimum distance between positions, so filter changes between the following positions will re-index the wheel: 0&1, 0&2, 0&3, 0&4, 7&1, 7&2, 6&1. Hence, it is recommended that you place your most commonly used filters in the HOME (0), 1, 2 and 7 positions.

Adjusting the Wheel Switching Speed

The FW-1000 controller is shipped with default speed settings that yield modest switching speeds and fairly smooth operation. Typical adjacent-filter switching time is about 60 milliseconds as shipped. The user has full control of the motion control parameters to affect faster switching speeds if desired, or slower speeds for even less vibration if that is necessary.

Establish communication with a host computer so you can program the controller. Issue the command "**VB 2**." This sets the verbose mode so that switching time, total move time, and maximum errors during move and settling are displayed following a move. Now if you issue a move command, following its completion, you will see the status line telling how long the move took.

0>HO	HOME the wheel – should be at position 0
0>VB 2	Set controller to Verbose mode 2.
0>MP 1	Move to position 1

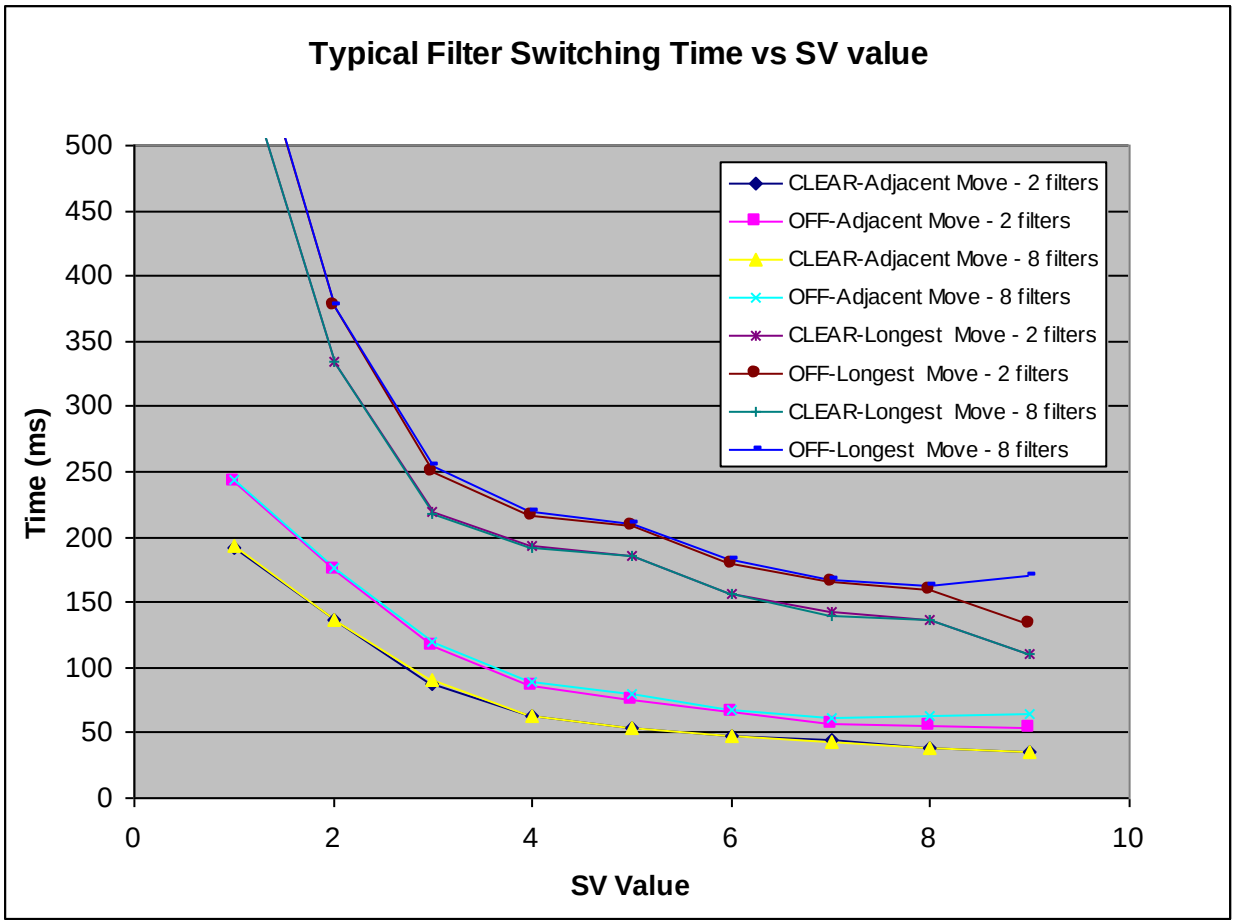
0>t:68 T:129 Em:10 Ef:-11

The line above shows that is took 68 milliseconds to get to position, and 129 milliseconds before all motors were completely turned off. **Em** and **Ef** show the maximum trajectory errors (in encoder counts) during the move into position, and during the settling period respectively.

You can change the run velocity **VR**, the up and down acceleration, **AU** and **AD**, or the servo motion parameters to affect the speed changes you desire (see page 25). You can see how your changes affect the switching speed and move errors when you make test moves. Once you are satisfied with your changes, you can save the settings to non-volatile (flash) memory with the serial command "**RS**." Afterwards, each time you power up the controller, your settings will be used.

If you try to use settings that are beyond the capability of the motor and the controller to follow, you will get errors when a move is initiated. Under these circumstances, change the offending parameter to a more reasonable value, HOme the wheel to clear the error condition, and try again.

Rather than setting all of the motion control parameters yourself, you may also use one of the preset combinations using the **SV** command. The chart below shows typical switching times for the filter wheel for each of the nine presets available with the **SV** command. The graph shows both the time to obtain a clear aperture (CLEAR) and the time before the motors have completed motion (OFF). Times for switching to an adjacent position and the time for the longest possible move are shown. The effect of the number of filters loaded in the wheel shows up as a slightly longer settling time when the fastest switching speeds are used.



The user can expect significantly longer lifetime from the friction drive elements in the filter wheel if slower speeds are used. Running for extended periods of time with SV=8 or 9 may cause errors and overheating of the driver. The table below shows the values of the AU, AD, VR and KA parameters that are set for the various SV values. The filter wheel default parameters are equivalent to SV=5, shown in bold.

SV	1	2	3	4	5	6	7	8	9
AU	10	20	50	100	**150**	200	300	400	500
AD	10	20	50	100	**150**	150	150	200	250
VR	1000	2000	3000	3000	**3000**	3600	4000	4000	5000
KA	5	15	35	35	**35**	35	35	35	35

Adjusting the Filter Offset

The controller leaves the factory with the correct offset programmed into the controller for the wheel purchased. If, for some reason, you are using a different wheel or the correct offset is no longer programmed into the controller, you can use the following steps to reset it correctly.

1. Set up the wheel so that the filters can be observed in the aperture in the housing.
2. Set up serial communications to the controller and verify operation.
3. Issue the **OF** command (without a number) to see the present setting.
4. Issue the **HO** command to Home the wheel.
5. Note whether the filter at position zero is centered in the housing aperature. If so, you are done. Save the setting (Step 8) if you have changed the setting.
6. Otherwise, make a guess at the correct value for the offset between 1 and 128 for 8-position wheel and 1-170 for 6-position wheel. Adjust your guess based upon your last try. Issue the offset command with your guess; e.g., **OF 65**.
7. Issue the **HO** command to Home the wheel and go to Step 5.
8. Issue the **RS** (Ram Save) command to save your setting to flash memory.
9. Turn the controller off – Wait a few seconds and turn the controller back on. The wheel should "Home" upon power–up and filter "0" should be centered in the housing aperture.

Spin/Sync Operation

In some applications the user may wish to continuously spin the filter wheels to obtain relatively rapid switching of filter sets. For instance, with an 8 position filter wheel, filled with alternating 340nm and 380nm filters, switching speeds of about 10ms between filters is possible for calcium ratio experiments. The filter wheel has flexible sync pulse output that can be used to trigger data acquisitions synchronized with the filters reaching alignment. This provides a relatively inexpensive and simple way of achieving fast switching times for applications such as ratio imaging or photometry. The following serial commands are applicable to spin/sync operation:

VR Sets rotation speed in encoder counts/sec. (One turn is 1024 counts)

SF Starts or stops the wheel spinning.

NP Specifies the number of sync pulses per revolution of the wheel.

PH Specifies the relative phase of the sync pulses.

PL Specifies the duration of the sync pulses.

See the programming manual section for details of these commands.

A simple way to verify operation of the spin/sync mode of operation is to use the SYNC output to power a LED light source. Properly adjusted, the LED should appear illuminated when viewed through the rotating wheel. The phase and pulse length of the sync pulse can be changed while the wheel is spinning so optimal timing can be verified. Observing the LED near the edges of the aperture can check for bleed-through from adjacent positions. Once the LED is observed cleanly in the aperture without any bleed through around the edges, the phase and pulse length parameters can be saved and the sync pulse will serve as the sampling gate for the detector.

Firmware Upgrades

The FW1000 controller can be remotely upgraded to the most recent firmware available. Please check the ASI website http://www.asiimaging.com/ for details.

Error Conditions

Servo or encoder error conditions are reported on the RS-232 port. Usually intermittent errors can be ignored. When unrecoverable motion errors occur, the motors will be turned off and the error condition will be indicated by an "**E**" on the LED display. This condition can be cleared by pressing the NEXT button to reset the controller, or by sending a HOME command to the offending motor.

The temperature of the driver transistors is monitored as well. If overheating occurs, the motors will be turned off and an "**H**" will be displayed on the LED display.

FW-1000 ASCII Command Set

The FW-1000 controller responds to RS-232 serial commands. All characters are echoed by the controller except for the *?* and control characters. The <*DEL*> and <*BS*> characters are not interpreted, so mistyping will result in erroneous commands. The FW-1000 controller uses the following RS-232 communication settings:

9600 Baud; 8 data bits; No Parity; 1 stop bit; No Flow Control

If a command is not understood by the controller, the string "**ERR**" is returned.

Commands that accept an input parameter return the current value of that parameter. If a new value is given in the command, the new value will be returned; if no value is given in the command, the current value will be returned. For example consider the velocity run command.

0>VR 3195	Sending only the command returns the current value.
0>VR 2000 1995	Sending the command with a new value, the program returns the working value (in this case there was a rounding difference from what was specified).
0> VR 1995	

The command response is terminated with a <LF> <CR> followed by the prompt characters "*0*>" or "*1*>" depending on which wheel is actively taking commands.

The only exception to this standard is the busy query command described below.

? *Busy Query*

The "*?*" command is immediately processed (no <CR> or <LF> required) and a single digit Busy Status is returned. The returned digit has the following meaning:

0	Neither wheel moving (not busy).
1	One wheel moving, but within tolerance for clear light path.
2	Two wheels moving, but both are within tolerance for a clear light path.
3	At least one wheel not in tolerance for a clear light path.

The following commands apply to *both* or *neither* wheel, and do not depend on the currently selected wheel:

F70 *Reset*

Resets the filterwheel processor. Resulting behavior is equivalent to cycling power. Supported in version 2.1b and later.

FW n *Filterwheel Number*

Sets the current Filterwheel for subsequent commands. Prompt shows currently selected wheel, e.g., **0>** is result of *FW 0* command. If the selected wheel is HOMED and ready to go, the FW command returns the selected wheel as normal. If the wheel is not ready for any reason, the response *ERR* is returned. Example:

0>FW 1 1	Normal – switch to FW 1
1>FW 0 ERR	FW 0 not ready
0>	Although FW 0 not ready – can still change FW 0 parameters.

HA *Halt*

Stops all motor movement; Halts protocol execution.

NF n *Number of Filters*

Sets the number of slots in the wheel, e.g., 6 or 8.
(Normally set at the factory.)

NP n *Number of Pulses/Revolution (Spin/SYNC mode only)*

Sets the number of synchronization pulses/revolution of the filter wheel. The pulses will be uniformly spaced and are synchronized with wheel's position encoder. Default setting is 1.

RD *RAM Defaults*

Restore factory default parameters.

RS *RAM Save*

RW *RAM Write (TG-1000 only)*

Save current parameters to non-volatile (flash) memory.

RR *RAM Restore*

Recall last saved parameters.

DR *Dump RAM*

Dumps the working variables stored in RAM to the RS-232 port.

DF *Dump Flash*

Dumps the variables stored in the non-volatile (flash) memory to the RS-232 port.

PL n *Pulse Length*

Sets the pulse length of the Sync Out signal to *n* milliseconds.

PH n *Pulse Phase (Spin/SYNC mode only)*

Sets the relative phase of the Sync Out pulses when in the Spin/Sync mode of operation. The phase is expressed in encoder counts. There are 1024 counts in a full revolution.

ST *Start*

Starts timed protocol. The protocol will start at the current protocol position. After a reset, this is the position P0. Use the **Gn** command to set the initial position before starting the protocol.

Gn *Go to protocol n*

Causes the wheel(s) to move to settings for Protocol Setting *n*, where *n* is a number in the range [0-7].

VB n *Verbose Mode*

Selects information stream from processor to RS-232

n=0 normal mode – prompt and error messages only.
n=1 encoder position information.
n=2 show move times and motion-error maximums.
n=3 debug mode shows process steps.
n=4 other verbose debug info.
n=5 no serial output in response to some commands.
Supported in version 2.0f and later.
n=6 no prompt characters (e.g., **0>**) output in response to any commands.
Supported in version 2.0g and later.
n=7 Reserved.

VN *Version Number*

Returns the Version Number of the firmware.

The following diagnostic commands are included for completeness, but may not be included in future releases of the firmware.

LI *List*

Sends trajectory information to the serial port about the last completed move.

DE [n] *Dump Errors*

Sends the logged error buffer to the serial port. Errors are reported whenever the motors are turned on to full power. This is expected and common when running with modest to fast switching speeds.

n=-1 Clears the error buffer.

The following commands set parameters that apply only to the currently selected wheel:

HO *Home*

Causes current wheel to seek its home position.

MP n *Move Position*

Move to filter position *n*, where *n* is a valid filter position.

OF n *Offset*

Sets the home index offset for the wheel to *n*. The value n should be in the range [0-128] such that a HO command returns the wheel centered on the optical axis. Once determined, this value should be saved to flash.

P[m] n *Protocol Position*

Sets protocol entry *m* to filter position *n* where *m* is a number in the range [0-7] and *n* is a valid filter position.

D[m] n *Protocol Delay*

Sets the delay time prior to execution of move to protocol entry *m* to the value *n* where *m* is a number in the range [0-7] and *n* is the delay time in milliseconds.

AU n *Acceleration Up*

Sets the acceleration value in encoder counts/sec/msec. Default is 150. Increase up to 400 for faster acceleration but more vibration.

AD n *Acceleration Down*

Sets the de-acceleration value in encoder counts/sec/msec. Avoid values greater than 200 or excessive driver current can result in overheating.

LM n *Lock Mode*

Determines the servo behavior upon completion of a move.

n=0 Default – servo remains active for 200ms after completion of a move and then is turned off.

n=1 Servo is always active. You cannot position the wheel by hand in this state.

SF n *Spin*

Initiates the Spin/SYNC mode.

n=0 Stops the spinning Wheel.

n=1 Starts the current wheel spinning.

n=2 Starts both wheels spinning together – uses Wheel 0 speeds for both. (n=2 not yet implemented)

SV n *Speed Variables* Supported in version 2.4 and later.

Selects a consistent set of preset acceleration and speed parameters.
n=0 Default - directly set and saved AU, AD, and VR parameters are used.
n=1 Slowest and smoothest switching speed.
n=2 to 8 Intermediate switching speeds.
n=9 Fastest and but least reliable switching speed.

VR n *Velocity Run*

Sets the maximum run velocity in encoder counts/sec. Default is 2000. Increase up to 4000 for faster top speed but more vibration. For spinning the filter wheel, can be increased up to a maximum of 12500. Expect some servo errors at high speeds.

GO n *Go*

Moves to absolute encoder position *n.* The range of *n* is +/-32768. The motor will move the commanded distance, but the final position will reflect the current location between 0 and 1023 of the wheel's rotation.

The following commands are used to control shutters with an SH-2 controller in the same cabinet as the FW-1000 controller. The parameter *n* may have any value from zero to (2N-1), where N is the number of shutter controller cards in use.

SO n *Shutter Open*

Opens shutter number *n.*

SC n *Shutter Close*

Closes shutter number *n.*

SQ [n] *Shutter Query*

Returns a decimal status byte from a shutter control register. The *n* parameter is optional in the *Shutter Query* command. If no *n* is specified, then the command returns the status byte from the most recently used shutter controller. If no shutter commands have been issued since the last system startup, then the command returns the status byte from the controller of shutters 0 and 1. If no SH-2 Card is present, 0 is returned.

In the descriptions of Bit 0 and Bit 1 below, an energized, normally open shutter is closed; a de-energized, normally open shutter is open; an energized, normally closed shutter is open; and a de-energized normally closed shutter is closed. In other words, a de-energized shutter is always in its normal state.

The binary equivalent can be decoded as follows:

Bit 0 1 = Shutter 0 is de-energized;
0 = Shutter 0 is energized.
Bit 1 1 = Shutter 1 is de-energized;
0 = Shutter 1 is energized.
Bit 2 1 = Shutter 0 is closed or has no sensor;
0 = Shutter 0 is open and has a sensor.
Bit 3 1 = Shutter 1 is closed or has no sensor;
0 = Shutter 1 is open and has a sensor.
Bit 4 SH2 Card is present.

SS x *Shutter Setup*

Supports shutter control. Normally, the *SC* command causes the controller to energize a shutter, and *SO* causes the controller to de-energize it. Most shutters are normally-open; i.e., open, unless energized by the controller via the *SC* command. The *SS* parameter *x* is a binary number representing eight bit positions, i.e., an integer in the range 0…255. Within *x*, if some bit_k is set, then shutter *k* is normally-closed. With this setting in effect, the effects of *SO* and *SC* are reversed. Instead of *SC* causing the controller to energize the shutter, *SO* energizes it, and vice-versa. Once determined, this value may be saved to non-volatile (flash) memory using the *RS* command.

The default value of *x* is zero, denoting that all shutters are normally-open.

Examples: **SS 2** is correct if Shutter 1 is normally closed, because *x* has Bit 1 set.
SS 3 is correct if shutters 0 and 1 are normally closed, because *x* has Bits 0 and 1 set.

The following parameters affect the motor positioning algorithm. Change these at your own risk.

KA n *Acceleration constant* - Default 1200

KV n *Velocity constant* – Default 70

KP n *Error proportional constant* – Default 350

KI n *Error integral constant* – Default 0

KD n *Error derivative constant* – Default 500

KR n *Current feedback constant* – Default 0

Appendix

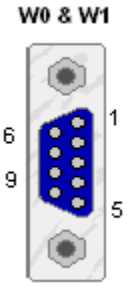
W0 & W1 Filterwheel Connectors		
PIN	**Signal**	**INFORMATION**
1	Motor +	0-24 VDC, 6 Amps Max
2	Motor -	0-24 VDC, 6 Amps Max
3	Ground	Ground
4	ENC A	Input: Std TTL
5	ENC B	Input: Std TTL
6	Motor +	0-24 VDC, 6 Amps Max
7	Motor-	0-24 VDC, 6 Amps Max
8	Index	Input: Std TTL
9	+5 Vdc	6 Amps Max

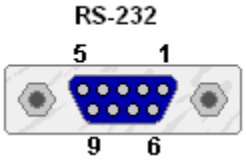
RS-232 Serial Connector		
PIN	**SIGNAL**	**INFORMATION**
1	N.C.	No Connect
2	TX	Follows RS-232 standard
3	RX	Follows RS-232 standard
4	N.C.	No Connect
5	GND	Ground
6	N.C.	No Connect
7	N.C.	No Connect
8	N.C.	No Connect
9	N.C.	No Connect

TRIG IN		
PIN	**SIGNAL**	**INFORMATION**
1	TTL Next Pulse	Input: Std TTL
2	GND	Ground

SYNC OUT		
PIN	**SIGNAL**	**INFORMATION**
1	SYNC OUT	Output: Std TTL
2	GND	Ground

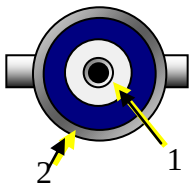
Filterwheel Control Panel Pin-Outs





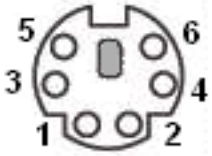
Shutter Control 0 & 1 Connectors		
PIN	**SIGNAL**	**INFORMATION**
1	Shutter +	~5msec 60vdc peek at start, 5vdc Holding Voltage when energized
2	Shutter -	Controlled Ground
3	Position Sensor LED +	+5 vdc
4	Position Sensor GND	Ground
5	Position Sensor Return	+5vdc TTL Signal
6	Position Sensor +5vdc	+5 vdc

TRIG IN / SYNC

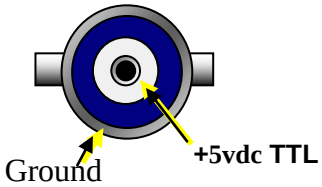


Shutter Control Panel Pin-Outs

Shutter Control 0&1



TRG BNC



TRG 0 & 1 BNC Connectors		
PIN	**SIGNAL**	**INFORMATION**
1	Energize Shutter	Input: Std TTL Pulse
2	GND	Ground

Shutter Specifications

Methods of Control	Serial Interface, TTL Signal and Front Panel Toggle Switch
Number of Shutter Channels per Card	Two
0%-to-100% Opening Time from Trigger (N.C. shutter)	8 ms
100%-to-0% Closing Time from Trigger (N.O. shutter)	7 ms
Minimum 50%-to-50% Open Time (N.C. shutter)	5 ms
Minimum 50%-to-50% Closed Time (N.O. shutter)	13 ms
Minimum Total Window 0%-to-0%	14 ms
Minimum Trigger Width	7 ms
Peak Unsustained Repetition Rate	40 Hz
Maximum Sustained Repetition Rate	5 Hz

Jumper Settings for Shutter

On filterwheel jumper JP4, connect 1-2 and 3-4.

On the shutter card jumper J1, connect 1-2, 3-4, and 5-6.

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