FW-1000 Filter Wheel Manual

> The Filter Wheel Drive Card is available in two configurations, as part of the TG-1000 Tiger Controller or as a Standalone FW-1000-SA unit. Operation is identical except for the save settings command, see RAM Save/RAM Write.

Warnings

1. Ensure power switch is in the OFF position before plugging in the power cord.
2. Do not unplug or plug-in devices or cables when the power is on.
3. Do not open the unit, there are no user serviceable parts 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 the internal circuit boards.
5. Do not insert fingers or other items into the filter wheel filter opening while the unit is in operation, injury and/or permanent damage to the system may occur.
6. Do not position equipment so that it is difficult to access the power switch.
7. In the event of device failure, contact ASI.

Description

FW-1000 Filter Wheel

The FW-1000 uses a unique drive mechanism to achieve 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 filter wheel controller allows for flexible control of one or two filter wheels, either with serial RS-232 commands, or using TTL triggers and preprogrammed sequences.

The filter wheel can be mounted on just about any microscope. For the photo port, the filter wheel 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.

Legacy Devices

The original stand alone controller and Shutter Control Box are no longer supported.

If you don't see your device on this page, please check the Old FW-1000 Control Box Manual.

FW-1000-SA Control Box
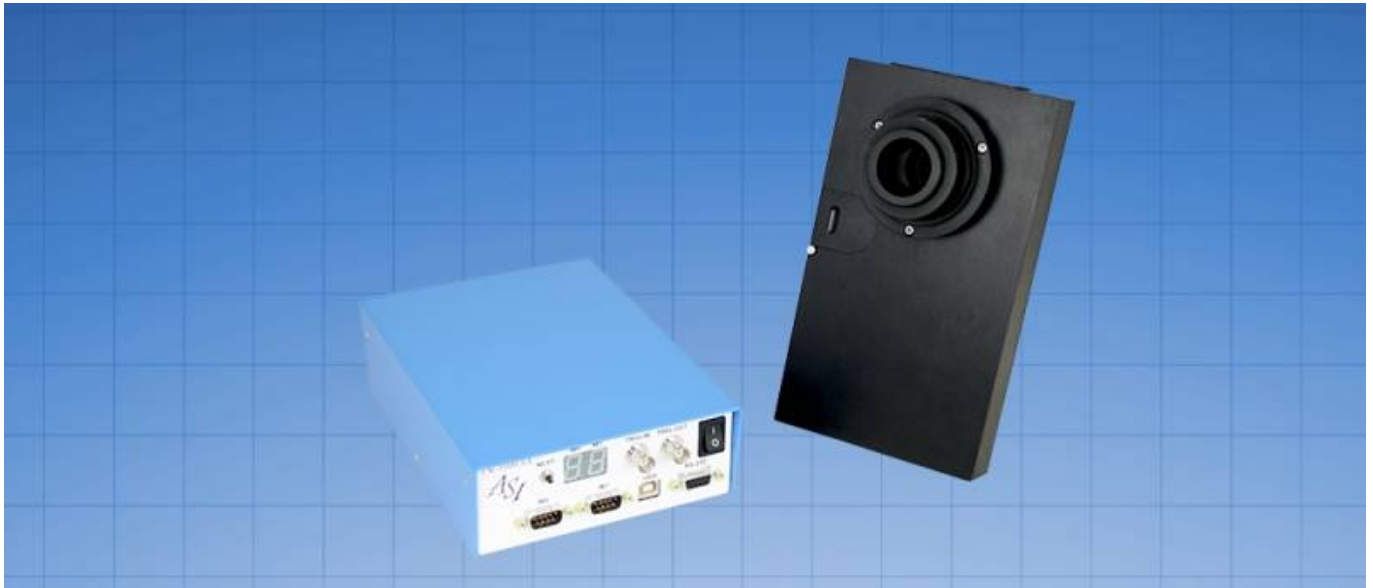
The FW-1000-SA Stand Alone Control Box provides a simplified and economical unit that only provides control for one or two filter wheels. It can simultaneously move both wheels to the next set of filter positions. And it can be controlled by pressing the next button, using TTL triggering, or sending serial commands.

You can use either USB or an RS-232 cable to send serial commands to the FW-1000-SA from the host computer.

The stand alone unit uses the GTS120A24-R7B external power supply.

Electrical Characteristics for FW-1000-SA Control Box

```
GTS120A24-R7B:
AC Input:  100-240 VAC, 47-63Hz, 1.4A/115VAC  0.7A/230VAC
AC In-rush Current (Cold Start):  35/115AC   70A/230VAC
Working Temp: -30 ~70C
Working Humidity:20%-90% RH non-condensing
DC Output: 24V 5.0A 120W MAX
```

Controller Box Power Connector Pinout
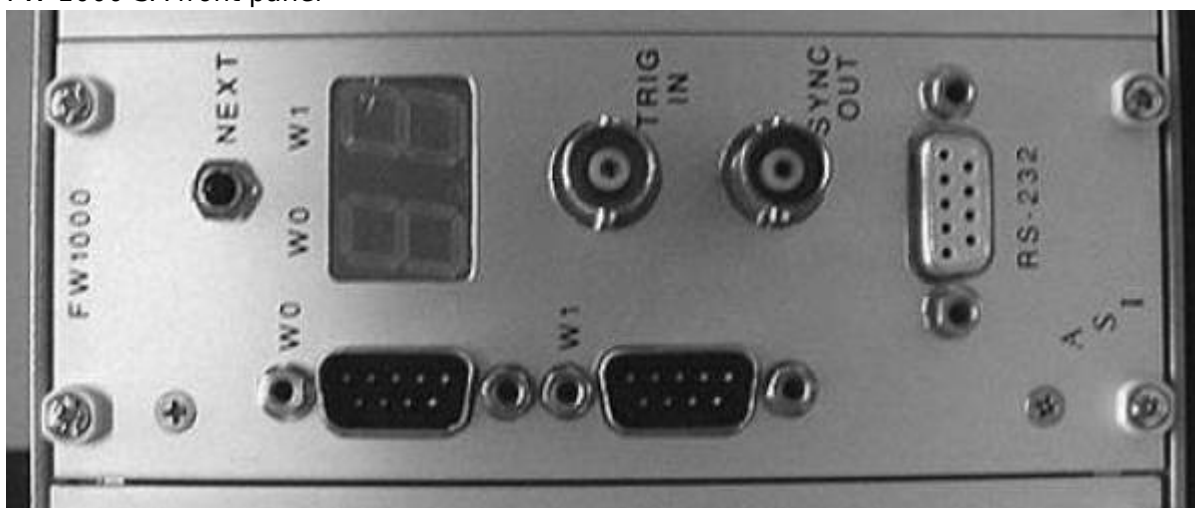
```
Pin 1:+24V
Pin 2:GND
Pin 3:GND
Pin 4:+24V
```

Controller Box Fuse Replacement: 5.0 A Fast Blow 250 VAC, 5x20mm

FW-1000-SA Front Panel / Filter Wheel Control Panel

FW-1000-SA front panel

Tiger FW card front panel

The FW-1000 Filter Wheel Control Panel provides control for two filter wheels, W0 and W1. The filter wheels 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 seven-segment 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".

NEXT Button

Each press of the NEXT button advances the filter wheel(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 seven-segment 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.

TRIG IN / SYNC OUT

A TTL input may be connected to the TRIG IN BNC Connector for triggered sequencing of the filter wheel(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.

RS-232

A 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. The baud rate limited to 9600.

USB

The FW-1000-SA has a USB to UART Bridge Virtual COM chip onboard, it lets user send serial commands over USB. The baud rate limited to 9600.

Download the Silicon Labs drivers to connect to the FW-1000-SA stand alone controller.

Installation

Installation of Filters

Older Systems: Filters should be loaded into the wheel prior to installation on the microscope. For older systems, change the filters through the port on the side opposite the motor on older models with a split ring (shown in picture below). 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.
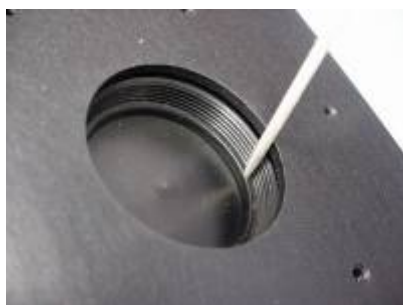
Current Systems: For current filter wheels, use the side loading port by loosening the thumbnail lock screw to remove the slide door tab. Use the ring load tool (see image below) by inserting the two tool pins (on the flat bottom) into the two slots on the rings, and press the ring firmly on to the ring

tool. Then use the ring tool to screw the ring in to firmly hold the optical filter glass or blank in place. Depending on the microscope, it may be necessary to remove the filter wheel from the system to have access to the filter holders.

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 filter wheel to the microscope using the mounting adapters supplied for your installation. The motor side on the filter wheel 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 filter wheel.
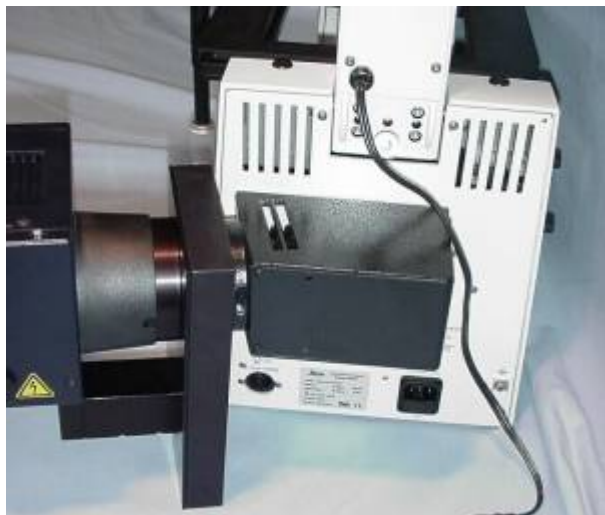
Emission Installations
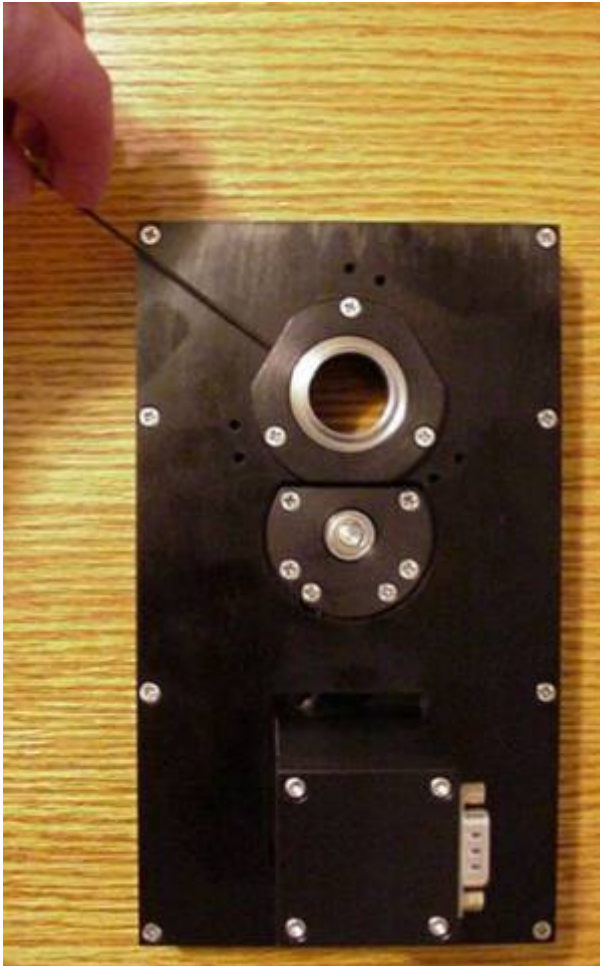
Camera orientation adjustment on C-Mount

In emission applications, the filter wheel is mounted between the photoport of the microscope and the camera. If you ordered your filter wheel for this application, an adapter specific to your microscope will be installed on one side of the filter wheel 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 filter wheel 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.

Excitation Installations

Excitation Installation

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

> **Warning:** When using the filter wheel in this manner, a heat filter must be installed between the lamp housing and the filter wheel 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

FW-1000-SA

Ensure the power switch is in the off position (O). Plug the AC power cord into stand along power supply. Plug the 4 pin connector from the stand alone power supply into the back of the controller. Attach the cable between the filter wheel and the controller. Connect the RS-232 Null Modem serial cable OR the USB cable between the computer and the controller. Attach optional TTL cables to Trig In or Trig Out. Once all cables are secure, turn the power on by moving the power switch to the ON position (-).

FW-1000 Operation and Programming

Quick Start Procedure

Before installation on the microscope – check out the basic operation of the filter wheel 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 filter wheel to the "W0" connector on the controller with the cable provided. Power up the filter wheel. Upon initialization, the wheel(s) will rotate to HOME.

Communicating with the FW-1000-SA filter wheel controller

For the FW-1000-SA stand alone filter wheel controller, the RS-232 serial port is used for communication. The serial port also provides direct control of the filter wheel(s) as well as diagnostic information. Connect the provided "Null Modem" serial cable from the COM port on the computer to the RS-232 connector on the front panel of the FW-1000 controller. You can also use a USB cable to connect to the controller (the recommended way).

> You can use ASI Console to connect to the stand alone filter wheel controller.

The FW-1000-SA controller uses the following RS-232 communication settings, set up your serial terminal program accordingly.

> Default Serial Settings: 9600 Baud Rate, 8 Data Bits, No Parity, 1 Stop Bit, No Flow Control

Communicating with Tiger Controller filter wheel card

In the TG-1000 Tiger controller, the filter wheel control card is treated mostly as any other card.

Connect to the Tiger controller as you normally would, see Tiger RS-232 Communication.

> You can use Tiger Control Panel to connect to the Tiger controller and communicate with the TGFW card.

The TGFW card uses the following RS-232 communication settings, set up your serial terminal program accordingly.

> Default Serial Settings: 115200 Baud Rate, 8 Data Bits, No Parity, 1 Stop Bit, No Flow Control

Note that the filter wheel has a different line termination than all other Tiger cards. Serial commands to the filter wheel should be terminated by \r\n (<CR><LF>) whereas the order is reversed for Tiger and MS2000 controllers. Note that the command set is also completely different from the Tiger and MS2000 controllers. If you are using Micro-Manager there is a property in the comm card to set the correct setting for any manual commands sent.

Serial Command Terminator	
Controller Type	**Command Terminator**
FW-1000-SA	<LF><CR> or \n\r
TGFW	<CR><LF> or \r\n

Operation

When the controller is turned on, the following messages should be displayed in your serial terminal:

`RESET`
`MOTOR 1 NOT RESPONDING`
`0>`
	Power up initialization
	Printed when only one Filter Wheel is attached
	Command Prompt

The W0 digit of the numeric display on the controller should read 0 , corresponding to the HOME position of the filter wheel. 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 this TYPESET ; Controller printout is shown in this TYPESET

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 filter wheel 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. Note there is one command that is different in TG-1000 than for other controllers, RAM Save / RAM Write.

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 filter wheel 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 32). 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.
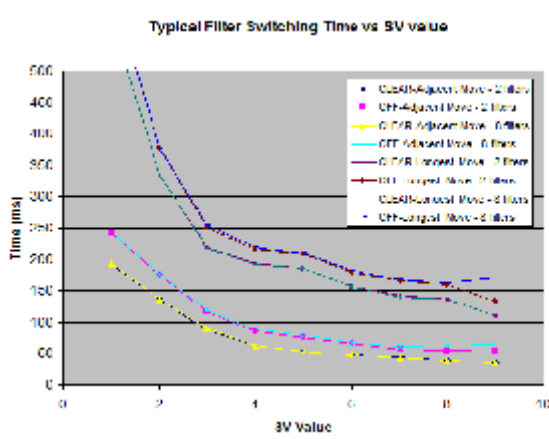
The user can expect significantly longer lifetime from the friction drive elements in the filter wheel if slower speeds are used. Running for extended periods of time with SV=8 or 9 may cause errors and overheating of the driver. The table below shows the values of the AU, AD, VR and KA parameters that 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 normally leaves the factory with the correct offset programmed into the controller for the wheel purchased. If 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. If you have two wheels send FW 0 or FW 1 to select the desired wheel.
3. Issue the OF command (without a number) to see the present offset setting.
4. Issue the HO command to Home the wheel.
5. Note whether the filter at position zero is centered in the housing aperture. If so, you are almost done and skip to the RAM save step (Step 8).
6. Often the offset value will be written on the label, if so start with that value as your guess. 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. Assuming you've changed the OF setting, issue the RAM Save command to save your setting to flash memory. For stand-alone filter wheels the command is RS but on TG-1000 "Tiger" controllers it is RW.
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 FW-1000 controller can be remotely upgraded to the most recent firmware available.

The FW-1000-SA stand alone controller uses ASI Console to update firmware.

The Tiger-based filter wheel uses Tiger Controller Console to update firmware.

Please contact ASI if you're interested in upgrading your firmware, the ASI website has a contact page.

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 seven-segment display.

Filter Wheel Error Codes

A list of recent errors are available through the Dump Errors (DE) command.

Error Codes		
Name	Number	Notes
OVERSHOT	10	Plus axis number.
DRIVER_HOT	25	
RUN_AWAY	30	Plus axis number, followed by mode. See mode table below.
LARGE_OVERFLOW	50	Plus axis number.
SLIP_ERROR	70	Plus axis number.
PAST_ERROR	80	Plus axis number.
ERROR_OVERFLOW	90	Plus axis number.
KP_ERR_OVERFLOW	100	Plus axis number.
KV_SPD_OVERFLOW	110	Plus axis number.
KI_SUM_OVERFLOW	120	Plus axis number.
ERR_INTEGRAL_OF	125	Plus axis number.
KD_TRM_OVERFLOW	130	Plus axis number.
KA_TRM_OVERFLOW	140	Plus axis number.
ENCODER0_ERROR	160	Plus error number.
ENCODER1_ERROR	170	Plus error number.
MOVE_OVERTIME	180	Plus axis number.

FW-1000 ASCII Command Set

The FW-1000 Filter Wheel responds to RS-232 serial commands. You can connect to the FW-1000-SA controller using a USB cable or RS-232 cable. All characters are echoed by the controller except for the ? command and control characters. The <DEL> and <BS> characters are not interpreted, so

mistyping will result in erroneous commands.

The serial communication settings documentation contains the RS-232 serials settings for each controller.

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

Syntax : ?
The ? command is immediately processed (no serial terminator required) and a single digit Busy Status is returned.

Note: When sending the command, do not add <CR><LF> or <LF><CR> to the end of the command, the response is a single byte (with no terminators such as <CR> or <LF>). See the Python script below for an example.

The returned digit has the following meaning for the stand alone **FW-1000-SA** unit:

MS-2000 Busy Status	
Code	**Description**
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.
4	At least one wheel has not completed initialization. Supported in version 3.3 and later.
5	Error - requires a reset (F70) or power cycle to recover. Supported in version 3.3 and later.
6	Unknown status - inform ASI you received this status. Supported in version 3.3 and later.

The return digit(s) have the following meaning for a **TGFW** filter wheel card in a **Tiger** controller:

Tiger Busy Status	
Code	**Description**
0	Neither wheel moving (not busy).
7	At least one wheel is off target.
8	A runaway on at least one wheel was detected.

Tiger Busy Status

Code	Description
9	At least one wheel did not settle on target on time.
10	An overflow was detected.
11	A homing error was detected.
12	At least one wheel is busy.
13	An unknown command was issued.
14	At least one wheel is disabled.
15	A large overflow was detected.
16	The current wheel is off target.

Python Busy Status Script

fwbusy.py

```python
# /// script
# dependencies = ["pyserial>=3.5"]
# ///
import serial

# This script uses the FW-1000-SA as an example

def main() -> None:
    with serial.Serial("COM4", 115200, write_timeout=1, timeout=5) as serial_port:
        command = b"?"  # no "\n\r" at the end
        serial_port.write(command)
        response = serial_port.read(size=1)  # response is a single byte
        print(f"{command = }\n{response = }")

        command = b"HA\n\r"  # requires "\n\r" at the end
        serial_port.write(command)
        response = serial_port.read_until(b">")
        print(f"{command = }\n{response = }")

if __name__ == "__main__":
    main()
```

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

Reset

Syntax : F70

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

Filter Wheel Number

Syntax : FW n
Sets the current filter wheel 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.

Halt

Syntax : HA
Stops all motor movement; Halts protocol execution.

Number of Filters

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

Number of Pulses/Revolution (Spin/SYNC mode only)

Syntax: NP n
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.

RAM Defaults

Syntax: RD
Restore factory default parameters.

RAM Save / RAM Write

Syntax for FW-1000: RS
Syntax for TG-1000: RW
Save current parameters to non-volatile (flash) memory.

RAM Restore

Syntax: RR
Recall last saved parameters.

Dump RAM

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

Dump Flash

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

Pulse Length

Syntax: PL n
Sets the pulse length of the Sync Out signal to n milliseconds.

Pulse Phase (Spin/SYNC mode only)

Syntax: PH n
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.

Start

Syntax: ST
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. Use Halt command HA to stop the routine.

Go to protocol n

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

Verbose Mode

Syntax: VB n

The serial output is changed based on the verbose mode.

N	Description
0	Normal mode – prompt and error messages only.
1	Encoder position information.
2	Show move times and motion-error maximums.
3	Debug mode shows process steps.
4	Other verbose debug info.
5	No serial output in response to some commands. Supported in version 2.0f and later.
6	No prompt characters (e.g., 0>) output in response to any commands. Supported in version 2.0g and later.
7	Same as mode 6 with addition of no "MOTOR x NOT RESPONDING" reports on boot. Supported in version 3.3 and later.

Version Number

Syntax: VN
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.

List

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

Dump Errors

Syntax: DE n
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.

DE 0 dumps the error buffer and DE -1 clears the error buffer.

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

Home

Syntax: HO
Causes current wheel to seek its home position.

Move Position

Syntax: MP n

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

Offset

Syntax: OF n
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.

Protocol Position

Syntax: P[m] n
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.

Protocol Delay

Syntax: D[m] n
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.

Acceleration Up

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

Acceleration Down

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

Lock Mode

Syntax: LM n
Determines the servo behavior upon completion of a move.

N	Description
0	Default – servo remains active for 200ms after completion of a move and then is turned off.
1	Servo is always active. You cannot position the wheel by hand in this state.

Spin

Syntax: SF n
Initiates the Spin/SYNC mode.

N	Description
0	Stops the spinning Wheel.
1	Starts the current wheel spinning.
2	Starts both wheels spinning together available in Tiger firmware version 3.2+ only , not in standalone FW-1000
3	Similar to n=1, except Spins wheel in reverse direction available in Tiger firmware version 3.2+ only , not in standalone FW-1000

Speed Variables

Syntax: SV n
Selects a consistent set of preset acceleration and speed parameters. Supported in version 2.4 and later.

N	Description
0	Default - directly set and saved AU, AD, and VR parameters are used.
1	Slowest and smoothest switching speed.
2 to 8	Intermediate switching speeds.
9	Fastest and but least reliable switching speed.

Velocity Run

Syntax: VR n
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 to Encoder

Syntax: GO n
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 parameters affect the motor positioning algorithm. Change these at your own risk!

PID Proportional constant

Syntax: KP n
Default 350

PID Integral constant

Syntax: KI n
Default 0

PID Derivative constant

Syntax: KD n
Default 500

Acceleration constant

Syntax: KA n
Default 1200

Velocity constant

Syntax: KV n
Default 70

Current feedback constant

Syntax: KR n
Default 0

Filter Wheel Modes

The states in the filter wheel state machine.

Modes
1 - RAMP_UP
2 - RUN
3 - SPIN
4 - PLATEAU
5 - RAMP_DOWN
6 - FINISH
7 - IDLE
8 - HOLD
9 - SLIP_ERR

Serial Command Cheatsheet

Filter Wheel Serial Commands		
Property	**Command**	**Notes**
Commands that do not depend on the current wheel		
Busy	?	Returns a integer busy code
Reset	F70	Resets the filter wheel processor
Select Wheel	FW n	Sets the currently selected wheel
Halt	HA	Stops all motor movement and halts protocol
Number of Filters	NF n	Set at the factory, typically will be 6 or 8
Number of Pulses	NP n	Sets the number of sync pulses/revolution
RAM Defaults	RD	Restore factory default parameters
RAM Restore	RR	Recall last saved parameters
Pulse Length	PL n	Sets the pulse length of the Sync Out signal to n ms
Pulse Phase	PH n	Sets the relative phase of the Sync Out pulses
Start	ST	Starts timed protocol from current position
Go to Protocol	Gn	Change protocol settings to n
Verbose Mode	VB n	Serial output is based on the verbose mode
Version Number	VN	Returns the version number of the firmware
List	LI	Trajectory information about last completed move
Dump Errors	DE n	Dump the error buffer if n = 0, use -1 to clear the buffer
Dump RAM	DR	Dumps the working variables stored in RAM
Dump Flash	DF	Dumps the variables in the non-volatile (flash) memory
Commands that apply to the currently selected wheel		
Home	H0	Move to home position
Move Position	MP n	Move filter wheel to position n
Offset	OF n	Sets the home index offset to n
Protocol Position	P# n	Sets protocol entry m to filter position n
Protocol Delay	D# n	Sets the delay time for protocol entry # to n ms
Acceleration Up	AU n	Sets the acceleration value in encoder counts/second/msec
Acceleration Down	AD n	Sets the deceleration value in encoder counts/second/msec
Lock Mode	LM n	Determines the servo behavior upon completion of a move
Spin Mode	SF n	Initiates the Spin/SYNC mode
Speed Preset	SV n	Sets the speed parameter preset
Velocity Run	VR n	Sets the maximum velocity in encoder counts/second
Go to Encoder	G0 n	Moves to absolute encoder position n, range of n is +/-32768
PID and Motor Tuning for current wheel - change at your own risk!		
PID Proportional	KP n	Motor PID proportional constant
PID Integral	KD n	Motor PID integral constant
PID Derivative	KI n	Motor PID derivative constant
Acceleration constant	KA n	Acceleration constant
Velocity constant	KV n	Velocity constant
Current feedback constant	KR n	Current feedback constant

Appendix

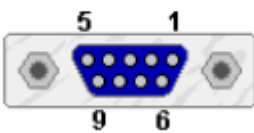## Filter Wheel Control Panel Pin-Outs
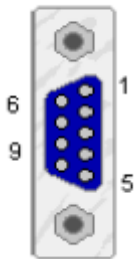
Tiger FW Control Panel

FW-1000-SA

PIN	Signal	INFORMATION
W0 & W1 Filter Wheel Connectors		
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
RS-232 Serial Connector		
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

RS-232 Serial Connector

PIN	SIGNAL	INFORMATION
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

Cleaning & Maintenance

Cleaning should be done with a 70% isopropyl alcohol solution. Maintenance should only be done by ASI, or an ASI approved technician - no user serviceable parts inside.

> ⚠️ If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

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