X-FWR-E Series User's Manual

Motorized filter wheels with built-in controllers and motor encoders

Disclaimer

Zaber's devices are not intended for use in any critical medical, aviation, or military applications or situations where a product's use or failure could cause personal injury, death, or damage to property. Zaber disclaims any and all liability for injury or other damages resulting from the use of our products.

Precautions

Zaber's motion control devices are precision instruments and must be handled with care. In particular, moving parts must be treated with care. Avoid axial loads in excess of the rated thrust load, axial and radial impact, dust and other contaminants and damage to the drive components. These will reduce the performance of the device below stated specifications.

Device Resolution

For the X-FWR-E filter wheel, changing the device resolution (T:37) from default is not recommended. Some possible resolution settings will result in a rounding error for the distance between optic positions, which could result in misalignment of the optics over multiple revolutions of the wheel.

Conventions used throughout this document

- Fixed width type indicates communication to and from a device. The ↵ symbol indicates a carriage return, which can be achieved by pressing enter when using a terminal program.
- An ASCII command followed by (T:xx) indicates a legacy T-Series Binary Protocol command that achieves the same result. For example,

`move abs 10000` (`T:20:10000`) shows that a move abs ASCII command can also be achieved with Binary command number 20.

Not all ASCII commands have an equivalent Binary counterpart.

Quick Tutorial

We recommend using Zaber Console to communicate with the device(s). For other software options, see the Software page. Please refer to the ASCII Protocol Manual and/or Binary Protocol Manual for more detailed information on the available commands.

Initial Set-up

1. Daisy chain all integrated devices together using the RS-232 "Prev" and "Next" connectors (see Daisy-Chaining Devices for more details). Next, supply power to one or more devices. Many products share power through the daisy-chain cables. The power indicator on each should light up.
2. Turn the knob to move a device. Most devices will only move in one direction until they reach a home sensor at one limit of travel. Then they will move in both directions over full travel.
3. Download and install Zaber Console. Start Zaber Console and select the communications port the first controller is connected to. For instructions on how to find the available communication ports on your system, please refer to: Appendix A - Available Communications Ports.
4. From the Console, issue a renumber (T:2) command to all devices (Zaber Console may prompt you to do this also). The first device in the chain (closest to the computer) will become Device 1, the next will become Device 2, and so on.

Initialization

Every time the device is powered up or reset, the device should be returned to the home position. This is achieved by sending the home (T:1) command to the individual unit or all units. Until this is done, most devices will only allow motion in one direction, towards the sensor.

If it is not possible in your application to home the device after every power-up, see the tools parking (T:65) command. Parking allows the device to be turned off and then used at a later time without first having to home the axes.

Using the Device

Several commonly used ASCII commands, and their Binary equivalents, are shown below. For a full list of available commands, please refer to the Command Reference section below.

Command	Description
/1 1 get pos↵ (T:60)	Query the current position of Device #1 Axis #1.
/1 1 move abs 10000 ↵ (T:20:10000)	Move Device #1, Axis #1 to position 10000 microsteps.
/2 1 move rel -12800↵ (T:21:-12800)	Move Device #2, Axis #1 in the negative direction by 12800 microsteps.
/1 stop↵ (T:23)	Decelerate and stop ALL axes on Device 1. An axis number of 0 or no axis number implies all axes on the device, or the device itself.
/move vel 153600 ↵ (T:22:153600)	Move ALL devices and ALL axes in the positive direction at the speed 153600. A device address of 0 or no device address implies all devices in the chain.

Modifying Device Settings

Here are some examples if you would like to customize particular device settings. Refer to the ASCII Settings or Command Reference section for detailed descriptions of each setting.

Command	Description
/1 set maxspeed 100000↵ (T:42:100000)	Set the speed of all axes on the device.
/1 get maxspeed↵ (T:53:42)	Query the axes' speed.
/1 system restore↵ (T:36)	Restore all the settings of Device 1 to the default.

Built-In Help

Zaber X-Series devices feature a built-in help guide, providing a quick and easy reference for all Commands and Settings that the device has. To access the help, send: /1 help↵ (for help with Device 1). The device number must be specified in the help command. This feature is only available in the ASCII protocol.

The device will respond with a detailed description on how to access specific information about commands and replies, as shown below:

```
@01 0 OK IDLE WR 0

#01 0 COMMAND USAGE:

#01 0  '/stop'    stop all devices

#01 0  '/1 stop'   stop device number 1

#01 0  '/1 2 stop'   stop device number 1 axis number 2
```

```
#01 0

#01 0 Type '/help commands' for a list of all top-level commands.

#01 0 Type '/help reply' for a quick reference on reply messages.

#01 0 Visit www.zaber.com/support for complete instruction manuals.
```
To access help for a specific command, for example the move command, send:

```
/1 help move↵

@01 0 OK IDLE -- 0

#01 0 move abs {x}            Move to absolute position

#01 0 move rel {x}            Move by relative position

#01 0 move vel {x}            Move at constant velocity

#01 0 move min               Move to minimum position

#01 0 move max               Move to maximum position
```
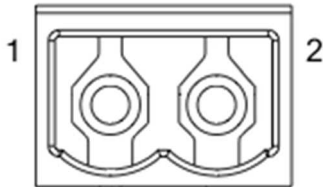
Device Overview

Connectors

All images are shown looking into the device.

Power

Pin	Description
1	24 - 48V
2	GND (Note: Zaber's power supplies ground this pin to AC Earth)

Note: To prevent damage to the device due to static buildup, the device should be properly grounded. The power supplies Zaber provides for X-Series devices are non-isolated and thus ground the device chassis to Earth via the negative terminal of the power supply. If for any reason you are using an isolated power supply, please ensure your device is grounded by connecting the negative terminal of the power connector to AC Earth.

RS-232 Communications
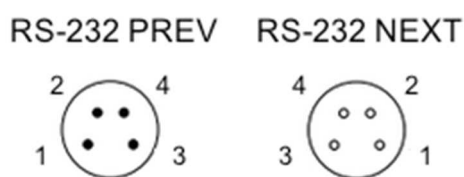
Pin	Previous	Next
1	Power	Power
2	Ground	Ground
3	Receive	Transmit
4	Transmit	Receive

Default Settings:

- Baud Rate: 115200
- Protocol: Zaber ASCII

Specifications

- Supported Protocols: Zaber ASCII, Zaber Binary
- Supported Baudrates: 9600, 19200, 38400, 57600, 115200
- Bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: None

Indicators

Green - Power

- On: Controller is operational.
- Blinking at 2Hz: The power supply voltage or device temperature is out of range.
- Fading in and out slowly: The device is parked. See the tools parking (T:65) command.

Red - Error

- On/blinking: Device has lost its settings, or an error has occurred. Please contact Zaber Technical Support.

Yellow - Communication/Busy

- On: Device is moving, or data is being transferred.
- Blinking: Device is under manual control via the knob (in Velocity mode). The blinking rate is proportional to movement speed.
- Blinking at fixed rate: Packet corruption has occurred for ASCII commands sent with a checksum.

Blue - Slip/Stall

- On: The device is slipping.
- On-Off cycle every 2 sec: The device has stalled and stopped.
- Flashes: The stationary device has been forced out of position (2 short flashes every 1 sec), or the encoder has encountered a read error and raised the FQ warning flag (5 short flashes every 2 sec).

Installation

The X-FWR-E can be connected to a computer as follows:

1. Either plug the M8 to D-SUB serial adaptor (X-SDC) into the computer's serial port, or the M8 to USB adaptor (X-USBDC) into one of your computer's USB ports, then attach the device to the adaptor. For the USB adaptor, new computers will often be able to install the necessary drivers automatically when the cable is plugged in for the first time. If the computer reports that the driver installation was unsuccessful, you can download the drivers for Windows, Mac, or Linux here. Installation instructions and troubleshooting information are available for each operating system here. You may need to use a cable extension to reach your computer. There is no need to power-down or reboot the computer.

2. Connect the power plug of your power supply to the power connector of the unit. The green LED should light up indicating the unit has power.
3. Additional devices can simply be daisy-chained to the first. See Daisy-Chaining Devices below.
4. Install software from the Software page. For the initial setup, using Zaber Console is recommended.

As a simple first test, try entering:

/renumber↵ (T:2)
/1 home↵ (T:1)
/1 move rel 10000↵ (T:21:10000)

The parameter of 10000 in the move command above specifies 10000 microsteps. To see the microstep size (default resolution) for the device and how it translates to displacement, first go to the product overview page, find your device, click through to the device's webpage, and click on the "Series Specs" tab. The microstep size (default resolution) will be shown in the list of product specs either in the "Group Specifications" section or the "Comparison" section.

Daisy-Chaining Devices

Multiple devices can be connected together in a chain through the Prev and Next connectors. This allows any number of devices to be controlled from a single connection to a computer, reducing cabling demands. In addition, X-Series devices carry power through the daisy chain, so in most cases a power supply only needs to be connected to one device in the chain. Whenever a device is added or removed from a chain, a renumber (T:2) command should be sent to prevent device-address conflicts.

To daisy-chain X-Series devices with T-Series and A-Series devices:

- Ensure all devices are set to the same communication protocol and baud rate before connecting them. If any T-Series devices will be in the chain, then the communication protocol must be Binary at 9600 baud rate.
- Connect any X-Series devices at the start of the chain (closest to the computer). This configuration will reduce the number of adaptor cables required.
- Connect a T-XDC (or S-XDC for daisy-chaining an A-MCB2) adaptor cable to the Next port of the last X-Series device in the chain, and to the Prev port of the T-Series or A-Series device.
- Power supplied to an X-Series device will not be transmitted to any T-Series or A-Series devices in the chain.
- Contact Zaber Technical Support for assistance selecting connecting cables when daisy-chaining multiple series.

Physical Installation

Mounting the Device

To mount the X-FWR-E filter wheel to an optical breadboard, a single optic post can be used as shown. Alternatively, using the AP134 post mounts, the device can be mounted to two posts either horizontally or vertically.

Mounting example using a single metric optical post to provided M6 threaded hole.

Mounting example using the AP134 post mount adaptors.

Mounting example using the AP134 post mount adaptors and optical mounting feet.

Exchanging Filter Holders

Remove the X-FWR-E housing lid using a 2.5mm hex key to remove the four cover screws.

Use the 2.5mm hex key to remove the three screws holding the filter holder and slide the holder upwards and out of the case.

Place the new filter holder in position, ensuring that the two dowel pins and three screw holes line up. Tighten the three M3 screws firmly to hold the new wheel in place and prevent the screws from loosening during operation. Re-install the housing lid. If the new holder fits filters of a different size, ensure the correct apertures are open and the covers are installed on the unused aperture size.

To update the settings for the X-FWR-E filter wheel for your newly installed filter holder, send the tools detectholder command to automatically configure the device. You can also manually set the filter holder ID by sending set filter.holderid (T:81) with the ID value for your installed wheel.

Optic Installation

Optics can be installed in to the filter holders using the provided retaining rings. To access the filter holder, remove the housing lid using a 2.5mm hex key.

Restoring Settings or Updating Firmware

When new firmware is installed on the X-FWR-E, or a restore settings command is sent, the settings for the installed filter holder may be lost. You can send the tools detectholder command to automatically re-configure the device or set the filter holder ID by sending set filter.holderid (T:81) with the ID value for your installed wheel.

Manual Control

Most X-Series motion control products have an integrated, depressible knob with 20 detents per revolution, allowing devices to be controlled without the use of a computer. There are two manual movement modes available: Velocity and Displacement. Switch between these modes by holding down the knob for 1 second or by configuring the knob.mode (T:109) setting.

On power-up, the device will only travel towards the motor from its start-up position until the home position is reached. Once the device has been homed, the full range of travel becomes available.

Velocity Mode

Turn the knob clockwise to move the device in the positive direction (extend) or counter-clockwise for negative direction (retract). Each detent of the knob increases the speed of the carriage.

There are 16 speeds in each direction. The velocity profile and maximum speed can be configured via the knob.speedprofile (T:112) and knob.maxspeed (T:111) settings. The device stops and resets the knob upon arriving at the end of travel.

Displacement Mode

Turn the knob clockwise to move the device in the positive direction (extend), counter-clockwise for negative direction (retract). Each detent of the knob moves the device a fixed number of microsteps, specified by the knob.distance (T:110) setting. If knob.distance (T:110) is set to 0, each detent of the knob will move to the next index position, similar to move index (T:78) movements. The device moves at the speed specified by the maxspeed (T:42) setting, or the slower of maxspeed (T:42) and limit.approach.maxspeed (T:41) if the device has not been homed. If there are fewer than knob.distance (T:110) microsteps to the end of travel and another move is requested, the device will move to the end of travel and then stop.

Summary of knob functionality

- Turning the knob:

  Moves the device in the direction of knob turn.

- Pressing the knob:

  Decelerates and stops the device (identical to a stop (T:23) command).
  Instantly stops the device, if the device is already decelerating.
- Pressing and holding the knob for 1 sec:

  Toggles between Velocity Mode and Displacement Mode.

Trajectory Control and Behaviour

This section describes the behaviour of the device trajectory when a movement command is issued.

Software Position Limits

The travel range of the device is limited by the Minimum Position and Maximum Position settings. The factory settings for the devices are configured to match the physical travel range. If a customized range is desired, it can be changed by configuring the limit.min (T:106) and limit.max (T:44) settings to appropriate values.

Minimum Position
   When the Current Position is less than the Minimum Position value, the device cannot move in the negative direction(towards the motor).
Maximum Position
   When the Current Position is greater than the Maximum Position value, the device cannot move in the positive direction(towards the motor).

Movement Speed

The movement speed of the device depends on device status and various speed settings. If the device has not been initialized by the home (T:1) command or by moving towards the home end of the device, movement speed will be constrained to fail-safe values. The home status of the device can be determined by reading the limit.sensor.triggered (T:53) setting (the binary command additionally requires a value of 103).

Movement speed of the device is specified below:

move vel (T:22)
   The device will move at the specified speed regardless of home status.
Knob movement in Velocity Mode
   The device will move at the specified speed regardless of home status.
   The speed is specified by the knob.speedprofile (T:112) and knob.maxspeed (T:111) settings.
Other movement commands - when the device has not been homed
   The device will move at the slower of the maxspeed (T:42) and limit.approach.maxspeed (T:41) settings.
Other movement commands - when the device has been homed
   The device will move at the speed specified by the maxspeed (T:42) setting.

Quick Command Reference

All X-Series devices ship with the ASCII Protocol enabled by default but the Binary Protocol is also supported.

ASCII Protocol

The following table offers a quick command and setting reference for the X-FWR-E. Follow the links to view a detailed description of each instruction or refer to the ASCII Protocol Manual.

Quick Commands

Parameters in square brackets, e.g. [clr], indicate that the parameter is optional.
Parameters in italics, e.g. *value*, indicate that data, typically a number, needs to be provided.
Parameters separated by a pipe, e.g. abs|rel, indicate that one of the parameters in the set need to be provided.

Command	Scope	Parameter(s)	Returns	Firmware Versions	Description
estop	Axis		0	6.06+	Instantly stops motorized movement.
get	Device and Axis	*setting*	*value*	6.06+	Retrieves the current value of the device or axis setting.
help	Device	commands reply warnflags enums *command ... enum*	0	6.06+	Displays the help information for the system.
home	Axis		0	6.06+	Moves the axis to the home position.
move	Axis	abs|rel|vel *value* min|max stored *number* index *number* (6.21+) sin *amplitude period [count]* (6.22+) sin stop (6.22+)	0	6.06+	Moves the axis to various positions along its travel.
renumber	Device	*value*	0	6.06+	Renumbers all devices in the chain.
set	Device and Axis	*setting value*	0	6.06+	Sets the device or axis setting *setting* to the *value*.
stop	Axis		0	6.06+	Decelerates the axis and brings it to a halt.
stream	Device	Refer to the documentation	Refer to the documentation	6.12+	Performs an action related to streamed, interpolated motion.
system reset	Device		0	6.06+	Resets the device, as it would appear after power up.

	Scope			Firmware	Description
system restore	Device		0	6.06+	Restores common device settings to their default values.
tools detectholder	Axis		0	6.22+	Detects the currently installed filter holder.
tools echo	Device	(*message*)	0	6.06+	Echoes the provided message (if any) back to the user.
tools gotolimit	Axis	*limit dir action update*	0	6.06+	Moves the axis to a limit sensor and performs the provided actions.
tools parking	Device	state|park|unpark	0|1	6.06+	Parking allows the device to be turned off and used at a later time without first having to home.
tools setcomm	Device	*rs232baud protocol*	0	6.06+	Sets RS232 baud rate and communication protocol for RS232 and USB.
tools storepos	Axis	*number* [*position*|current]	0|*position*	6.06+	Stores a number of positions for easy movement.
trigger	Device	Refer to the documentation	0	6.06+	Configures actions to be performed on the device when a certain condition is met.
warnings	Axis	[clear]	0	6.06+	Displays the active device and axis warnings, optionally clearing them if applicable.

Quick Device Settings

The settings listed below can be inspected and modified with the get and set commands described above.

Setting	Scope	Writable	Firmware Versions	Description
accel	Axis	Yes	6.06+	Sets the acceleration used to modify the speed.
cloop.counts	Axis	Yes	6.06+	The number of counts generated by the encoder for one full revolution.
cloop.displace.tolerance	Axis	Yes	6.19+	The minimum deviation in the position of a stationary axis that will register as a displacement.
cloop.mode	Axis	Yes	6.06+	The closed-loop (slip, stall, and displacement detection and recovery) control mode.
cloop.stalltimeout	Axis	Yes	6.06+	The amount of time to wait after a stall/displacement condition, in milliseconds.

cloop.steps	Axis	Yes	6.06+	The number of full steps required for the motor to complete one revolution.
comm.address	Device	Yes	6.06+	The device address.
comm.alert	Device	Yes	6.06+	The device will send alert messages when this setting is 1.
comm.checksum	Device	Yes	6.06+	The device includes checksums in its messages if this setting is set to 1.
comm.protocol	Device	Yes	6.06+	The communications protocol used by the device on the current interface.
comm.rs232.baud	Device	Yes	6.06+	The baud rate used by RS232 Prev and Next interfaces.
comm.rs232.protocol	Device	Yes	6.09+	The protocol used by RS232 Prev and Next interfaces.
deviceid	Device	No	6.06+	The device ID for the unit.
driver.current.hold	Axis	Yes	6.06+	Current used to hold the motor in position, in 20 mA DC increments.
driver.current.max	Axis	No	6.16+	Maximum legal value of driver.current.hold and driver.current.run.
driver.current.run	Axis	Yes	6.06+	Current used to drive the motor, in 14.1 mA RMS (20 mA peak) increments.
driver.temperature	Axis	No	6.06+	The current temperature of the axis driver, in degrees Celsius.
encoder.count	Axis	Yes	6.06+	The recorded counts of the axis encoder.
encoder.error	Axis	No	6.17+	Position error measured by encoder.
encoder.index.count	Axis	Yes	6.06+	The recorded counts of the axis encoder index pulse.
encoder.pos	Axis	No	6.17+	Position measured by encoder.
filter.holderid	Axis	Yes	6.22+	The ID of the installed filter holder.
knob.dir	Axis	Yes	6.06+	Sets the movement direction for the knob.
knob.distance	Axis	Yes	6.06+	Sets how far the device moves with each step of the knob in displacement mode, in units of microsteps.
knob.enable	Axis	Yes	6.06+	Disable the use of the knob when set to 0.
knob.maxspeed	Axis	Yes	6.06+	The maximum speed that can be reached using the knob in velocity mode.
knob.mode	Axis	Yes	6.06+	Sets the mode of the manual control knob.
knob.speedprofile	Axis	Yes	6.06+	Sets the profile to be used per increment when in velocity mode.
limit.approach.maxspeed	Axis	Yes	6.06+	Maximum speed used when approaching a limit sensor.
limit.cycle.dist	Axis	Yes	6.20+	The length of one full rotation.
limit.detect.decelonly	Axis	Yes	6.06+	Deceleration used when stopping after a limit sensor has triggered.
limit.detect.maxspeed	Axis	Yes	6.06+	Maximum speed used when moving away from a limit sensor.
limit.home.action	Axis	Yes	6.06+	Automatic limit switch action.

limit.home.pos	Axis	Yes	6.06+	The updated position of the sensor, when triggered.
limit.home.posupdate	Axis	Yes	6.06+	Position update to occur when sensor is triggered.
limit.home.preset	Axis	Yes	6.06+	The default position of the home sensor.
limit.home.state	Axis	No	6.06+	The state of the home sensor.
limit.home.triggered	Axis	No	6.06+	Whether the home sensor has been triggered previously.
limit.max	Axis	Yes	6.06+	The maximum position the device can move to, measured in microsteps.
limit.min	Axis	Yes	6.06+	The minimum position the device can move to, measured in microsteps.
limit.start.pos	Axis	Yes	6.19+	Start up position of the axis.
maxspeed	Axis	Yes	6.06+	The maximum speed the device moves at.
motion.accelonly	Axis	Yes	6.06+	Sets the acceleration used to increase the speed.
motion.decelonly	Axis	Yes	6.06+	Sets the deceleration used when decreasing the speed.
motion.index.dist	Axis	Yes	6.21+	The distance between consecutive index positions.
motion.index.num	Axis	No	6.22+	The current index number.
pos	Axis	Yes	6.06+	The current absolute position of the device.
resolution	Axis	Yes	6.06+	Microstep resolution
stream.numbufs	Device	No	6.14+	The number of stream buffers provided in the device.
stream.numstreams	Device	No	6.14+	The number of streams provided in the device.
system.access	Device	Yes	6.06+	Sets the access level of the user.
system.axiscount	Device	No	6.06+	The number of axes in the device.
system.led.enable	Device	Yes	6.06+	Enables the front panel LEDs.
system.serial	Device	No	6.15+	The serial number of the device.
system.voltage	Device	No	6.06+	The voltage being applied to the device.
version	Device	No	6.06+	The firmware version of the device.
version.build	Device	No	6.17+	The build number of the device's firmware.

Binary Protocol

The following table offers a quick command reference for the X-FWR-E. For convenience, you may sort the table below by instruction name, command number, or reply number. Follow the links to view a detailed description of each instruction or refer to the Binary Protocol Manual.

Instruction Name	Command#	Command Data	Command Type	Reply Data
Reset	0	Ignored	Command	None
Home	1	Ignored	Command	Final position (in this case 0)
Renumber*	2	Ignored	Command	Device ID

Command	Code	Data	Type	Reply Data
Read Register	5	Register Address	Command	Data
Set Active Register	6	Register Address	Setting	Register Address
Write Register	7	Data	Command	Data
Move Tracking	8	n/a	Reply	Tracking Position
Limit Active	9	n/a	Reply	Final Position
Manual Move Tracking	10	n/a	Reply	Tracking Position
Manual Move	11	n/a	Reply	Final Position
Slip Tracking	12	n/a	Reply	Tracking Position
Unexpected Position	13	n/a	Reply	Final Position
Store Current Position*	16	Address	Command	Address
Return Stored Position	17	Address	Command	Stored Position
Move To Stored Position	18	Address	Command	Final Position
Move Absolute	20	Absolute Position	Command	Final Position
Move Relative	21	Relative Position	Command	Final Position
Move At Constant Speed	22	Speed	Command	Speed
Stop	23	Ignored	Command	Final Position
Restore Settings*	36	Peripheral ID	Command	Peripheral ID
Set Microstep Resolution*	37	Microsteps	Setting	Microsteps
Set Running Current*	38	Value	Setting	Value
Set Hold Current*	39	Value	Setting	Value
Set Device Mode*	40	Mode	Setting	Mode
Set Home Speed*	41	Speed	Setting	Speed
Set Target Speed*	42	Speed	Setting	Speed
Set Acceleration*	43	Acceleration	Setting	Acceleration
Set Maximum Position*	44	Range	Setting	Range
Set Current Position	45	New Position	Setting	New Position
Set Home Offset*	47	Offset	Setting	Offset
Set Alias Number*	48	Alias Number	Setting	Alias Number
Return Device ID	50	Ignored	Read-Only Setting	Device ID
Return Firmware Version	51	Ignored	Read-Only Setting	Version
Return Power Supply Voltage	52	Ignored	Read-Only Setting	Voltage
Return Setting	53	Setting Number	Command	Setting Value
Return Status	54	Ignored	Read-Only Setting	Status
Echo Data	55	Data	Command	Data
Return Firmware Build	56	Ignored	Read-Only Setting	Build Number
Return Current Position	60	Ignored	Read-Only Setting	Position
Return Serial Number	63	Ignored	Read-Only Setting	Serial Number
Set Park State*	65	Park State	Setting	Position

Return Digital Input Count	67	Ignored	Read-Only Setting	Pin Count
Return Digital Output Count	70	Ignored	Read-Only Setting	Pin Count
Return Analog Input Count	75	Ignored	Read-Only Setting	Pin Count
Return Analog Output Count	77	Ignored	Read-Only Setting	Pin Count
Move Index	78	Index Number	Command	Final Position
Set Index Distance	79	Distance	Setting	Distance
Set Cycle Distance	80	Distance	Setting	Distance
Set Filter Holder ID	81	Filter Holder ID	Setting	Filter Holder ID
Return Encoder Count	82	Ignored	Read-Only Setting	Encoder Count
Set Auto-Reply Disabled Mode*	101	Auto-Reply Mode	Setting	Auto-Reply Mode
Set Message ID Mode*	102	Message ID Mode	Setting	Message ID Mode
Set Home Status	103	Home Status	Setting	Home Status
Set Auto-Home Disabled Mode*	105	Auto-Home Disabled Mode	Setting	Auto-Home Disabled Mode
Set Minimum Position*	106	Minimum Position	Setting	Minimum Position
Set Knob Disabled Mode*	107	Knob Disabled Mode	Setting	Knob Disabled Mode
Set Knob Direction*	108	Direction	Setting	Direction
Set Knob Movement Mode*	109	Movement Mode	Setting	Movement Mode
Set Knob Jog Size*	110	Jog Size	Setting	Jog Size
Set Knob Velocity Scale*	111	Velocity Scale	Setting	Velocity Scale
Set Knob Velocity Profile*	112	Velocity Profile	Setting	Velocity Profile
Set Acceleration Only*	113	Acceleration	Setting	Acceleration
Set Deceleration Only*	114	Deceleration	Setting	Deceleration
Set Move Tracking Mode*	115	Tracking Mode	Setting	Tracking Mode
Set Manual Move Tracking Disabled Mode*	116	Tracking Mode	Setting	Tracking Mode
Set Move Tracking Period*	117	Tracking Period	Setting	Tracking Period
Set Closed-Loop Mode*	118	Closed-Loop Mode	Setting	Closed-Loop Mode
Set Slip Tracking Period*	119	Tracking Period	Setting	Tracking Period
Set Stall Timeout*	120	Timeout	Setting	Timeout
Set Baud Rate*	122	Baud Rate	Setting	Baud Rate
Set Protocol*	123	Protocol	Setting	Protocol
Convert To Ascii*	124	Baud Rate	Command	Baud Rate
Error	255	n/a	Reply	Error Code

* The settings for these commands are saved in non-volatile memory, i.e. the setting persists even if the device is powered down. To restore all settings to factory default, use command 36.

Troubleshooting X-Series Motion Devices

The following sections contain tips for troubleshooting common problems. If the device is unable to communicate, and it is operating erratically, a manual factory reset can be performed through the following steps. Note that this will reset most settings.

1. Power Off the device
2. Push and hold the knob for the first Axis (if applicable)
3. Power On the device
4. Continue to hold the knob in until the blue LED is lit (~5 seconds), then release.

The device has been returned to its factory defaults and can be configured as per the steps in Initial Setup.

Front Panel Indicators

Green LED On
> The device is powered on and is operating normally.

Green LED Fades In and Out
> The device is parked.
> Issue a tools parking unpark (T:65) command, or home (T:1) the device.

Green LED Flashes Slowly
> The operating conditions of the device are outside of the recommended range.
> This will occur when the supply voltage is either over or under the recommended range, the internal temperature has exceeded the set limit, or the driver has been disabled. Check the following:

> - The input voltage is within the operational range of the device. This can be read from the device with the get system.voltage command.
> - The device temperature is within range. This can be read from the device with the get system.temperature command.
> - The driver is not disabled. If the driver is disabled the result of the warnings command will contain the FD flag.

Green LED Off
> The device is not powered.
> Check the supply connections and power adaptor for correct operation.

Red LED On or Flashing.
> A critical error has occurred.
> Please contact Zaber Technical Support.

Blue LED On or Flashing.
> The device has slipped or stalled.
> Please see the Slipping and Stalling section below.

Yellow LED Always Off or Flashes but No Reply.
> There are communication errors.
> Please see the Communication Errors section below.

Manual Control

Turning the knob either way results in no movement
> The knob may have been disabled.
> Check that the knob.enable (T:107) setting is correct.
> Restore the default parameters through the system restore (T:36) command.

The device won't cover the full range of travel.

The device hasn't been homed.

Turn the knob anti-clockwise until the device reaches the fully retracted position (closest to the motor). The device will home and the full range of travel available.

Unexpected Behaviour

The device doesn't respond to a move command.

The device needs to be homed before use.

Send the home (T:1) command.

The device is moving on its own and running against the ends of travel.

The position encoder has de-synchronized.

Reset the device by power cycling it or sending the system reset (T:0) command, then re-initialize it with the home (T:1) command.

The device is moving very slowly. It used to move faster.

The speed settings may have been changed inadvertently.

Send a system restore (T:36) command.

The device makes louder than normal noise during travel and is frequently slipping.

This condition happens if the thrust needed is more than the thrust available from the device. Check the following:

- The force on the device is less than the maximum thrust.
- The voltage matches the specified voltage. Read the voltage using the get system.voltage command. Voltage less than the specified voltage for the device will reduce the device's maximum thrust.

Test the following:

- Try a slower target velocity. Stepper motors produce more thrust when moving slowly.
- Try a lower acceleration and deceleration.
- Clean the screw and lightly re-grease it with a grease that does not degrade plastics.

The device has repeatability errors smaller than 4 full steps.

If steps aren't being skipped, friction or loose parts may still cause some variation when returning to a position.

Please contact Zaber Technical Support.

The device doesn't cover the full range of travel, or runs into the end.

A setting might have been inadvertently changed.

- home (T:1) the device to see if this corrects the behaviour.
- Send a system restore (T:36) command.

Communication Errors

There is no communication with the device; the Yellow LED does not come on or flash.

There are several things that should be checked:

- Make sure the correct serial port is selected. Try selecting other serial ports in the software.
- Check the baud rate, hand shaking, parity, stop bit, etc. when configuring the serial communications software. The required settings are listed in the RS-232 Communications section above.

- Make sure there are no bent pins in the ends of all the data cables
- Make sure the device is powered. The Green LED should be on.
- If the computer is a laptop running on batteries, try plugging in the power. Some laptops disable the serial ports when running on batteries.
- Make sure a null modem adaptor or cable is not being used.
- Make sure the correct adaptors(if any) are being used. Refer to the pinouts in the RS-232 Communications section above.
- If the problem was encountered when trying to control the device with custom software, try using one of the demo programs from the Zaber website to verify that the hardware is functioning properly.

Two or more devices both respond to commands sent to device 1.

Most devices are shipped with their device number set as 1. If you connect the devices through Zaber Console, you will be prompted to renumber them. If you aren't able to install and open Zaber Console, send the renumber (T:2) command in the software you are using to set all of the device numbers to different values.

The Yellow LED comes on briefly when sending a command, but the device does not move and does not reply.

Check baud rate, hand shaking, parity, stop bit, etc. are set as per the RS-232 Communications defaults.

The device numbers may not be what is expected, issue a renumber (T:2) command. Make sure that the computer does not transmit anything else while the devices renumber.

If using the Binary Protocol, check the following:

- 6 bytes are transmitted and that the device number and command are valid.
- The software does not transmit any control characters such as line feed and spaces.
- That the serial port is not configured with a termination character (it often defaults to linefeed).

If problems are encountered when using custom software, try using one of the demo programs from the Zaber website to verify that the hardware works.

The device does not behave as expected when software sends it a series of commands.

The computer might be set to Unicode. This is common for languages that use non-Latin based characters. Go to Control Panel/Regional and Language Options/Advanced. Select a language for non-unicode programs. This should be English or another Latin based character language.

Check what is being sent out of the serial port. stackoverflow.com has a list of some tools to monitor serial ports.

In Binary mode, the device does not send replies but otherwise works.

Auto-reply might have been disabled via T:101.

Send a system restore (T:36) command.

If the problem is encountered when trying to control the device with custom software:

- Use a demo program from the Zaber website to verify that the hardware is functioning properly.
- Make sure that the receiving part of the code or commercial package is correct.
- Check the serial port settings are correct.
- Check connectors for bent or broken pins.

In Binary mode, the device sometimes returns fewer than 6 bytes.

This typically indicates a problem with the serial port settings. Some serial ports are set to automatically recognize and remove specific control characters such as carriage returns when they appear in the RS-232 receive buffer.

Check that the settings are correct and are not removing or replacing characters.

Slipping and Stalling

The device moves smoothly, but only moves for a short time then stops. The Blue LED is flashing but the device is not actually slipping or stalling.

The internal encoder counter needs to be re-initialized. Reset the device by power cycling it or sending system reset (T:0) command, then re-initialize it with the home (T:1) command.

Ground the device and avoid operating it under statically noisy environment.

The device makes noise but does not move. The Blue LED is flashing.

The device is stalling.

Try removing all external loads. If the device now extends and retracts normally, the problem is excessive load. Try to reduce the load and ensure the load is less than the maximum thrust. A higher thrust or torque can be achieved by lowering the speed of the device using the maxspeed (T:42) setting.

If a device is stalling with no external load at default speed and acceleration settings then it requires servicing.

Warranty and Repair

For Zaber's policies on warranty and repair, please refer to the Ordering Policies.

Standard products

Standard products are any part numbers that do not contain the suffix ENG followed by a 4 digit number. Most, but not all, standard products are listed for sale on our website. All standard Zaber products are backed by a one-month satisfaction guarantee. If you are not satisfied with your purchase, we will refund your payment minus any shipping charges. Goods must be in brand new saleable condition with no marks. Zaber products are guaranteed for one year. During this period Zaber will repair any products with faults due to manufacturing defects, free of charge.

Custom products

Custom products are any part numbers containing the suffix ENG followed by a 4 digit number. Each of these products has been designed for a custom application for a particular customer. Custom products are guaranteed for one year, unless explicitly stated otherwise. During this period Zaber will repair any products with faults due to manufacturing defects, free of charge.

How to return products

Customers with devices in need of return or repair should contact Zaber to obtain an RMA form which must be filled out and sent back to us to receive an RMA number. The RMA form contains instructions for packing and returning the device. The specified RMA number must be included on the shipment to ensure timely processing.

Email Updates

If you would like to receive our periodic email newsletter including product updates and promotions, please sign up online at www.zaber.com (news section). Newsletters typically include a promotional offer worth at least $100.

Contact Information

Contact Zaber Technologies Inc by any of the following methods:

Phone	1-604-569-3780 (direct)
	1-888-276-8033 (toll free in North America)
Fax	1-604-648-8033
Mail	#2 - 605 West Kent Ave. N., Vancouver, British Columbia, Canada, V6P 6T7
Web	www.zaber.com
Email	Please visit our website for up to date email contact information.

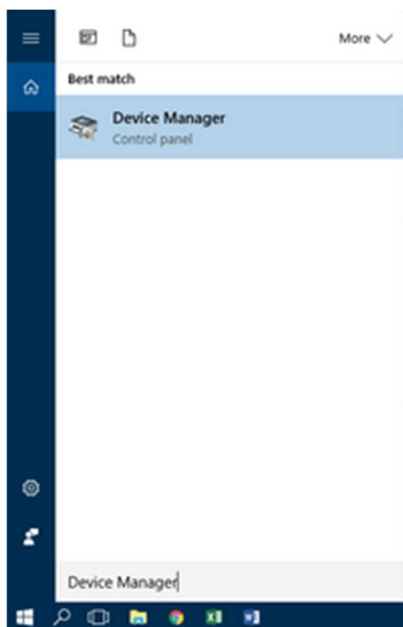The original instructions for this product are available at https://www.zaber.com/manuals/X-FWR-E.
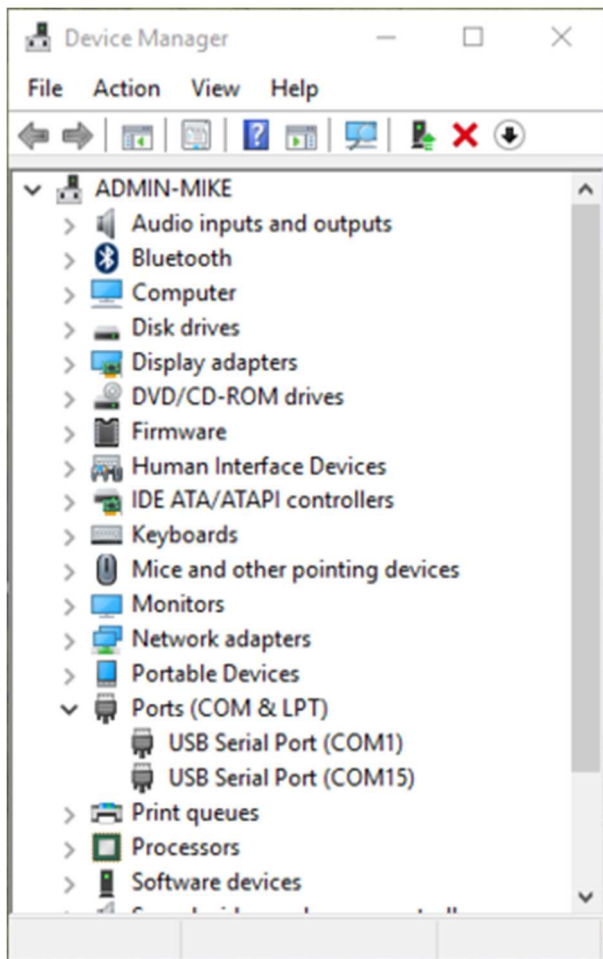
Appendix A - Available Communications Ports

Finding Installed Serial Ports

Windows

1. Open Search or Run from the Start Menu or Taskbar, type "Device Manager" and press enter.

2. Expand the Ports (COM & LPT) category.

- o In this example there are two serial ports available (COM1 and COM15), which are both USB adaptors.

Linux

1. Finding devices
   - o Open a terminal and execute the following command:

```
dmesg | grep -E ttyU¥?S↵
```

   - o The response will be similar to the following:
     ```
     [ 2.029214] serial8250: ttyS0 at I/O 0x3f8 (irq = 4) is a 16550A
     [ 2.432572] 00:07: ttyS0 at I/O 0x3f8 (irq = 4) is a 16550A
     [ 2.468149] 0000:00:03.3: ttyS4 at I/O 0xec98 (irq = 17) is a 16550A
     [ 13.514432] usb 7-2: FTDI USB Serial Device converter now attached to ttyUSB0
     ```
   - o This shows that there are 3 serial ports available: ttyS0, ttyS4 and ttyUSB0 (a USB adaptor)
2. Checking port permissions
   - o Using the ports found above, execute the following command

```
ls -l /dev/tty{S0, S4, USB0} ↵
```

   - o The permissions, given below, show that a user has to be root or a member of the dialout group to be able to access these devices
     ```
     crw-rw---- 1 root dialout 4, 64 Oct 31 06:44 /dev/ttyS0
     crw-rw---- 1 root dialout 4, 68 Oct 31 06:45 /dev/ttyS4
     crw-rw---- 1 root dialout 188, 0 Oct 31 07:58 /dev/ttyUSB0
     ```

3. Checking group membership

   `groups↵`

   - The output will be similar to the following:
     `adm cdrom sudo dip plugdev users lpadmin sambashare`
     Notice that dialout is not in the list
   - A user can be added to the dialout group with the following command

   `sudo adduser $USER dialout↵`

   - Group membership will not take effect until the next logon.

OSX

1. Finding devices
   - Open a terminal and execute the following command:

   `ls /dev/cu.*serial*`

   - The response will be similar to the following:
     `/dev/cu.usbserial-FTB3QAET`
     `/dev/cu.usbserial-FTEJJ1YW`
   - This shows that there are two serial ports available, both of which happen to be USB adaptors.
   - There may be other devices that match this query, such as keyboards or some web cameras. To determine which one corresponds to your USB serial cable, try repeating the command with and without the cable connected to the computer, to see which one appears and disappears.

Appendix B - Adjusting Device Performance

For customers requiring very fast adjacent optic change times, some optimizations can be made to the device and computer settings.

COM port settings

If you are using an X-USBDC to connect the device to a computer, COM port settings on the computer may add a small delay to each movement. To check and adjust this setting, follow these steps:

Windows

1. Ensure you are using a baud rate of 115200 (the default for Zaber ASCII communication).
2. Open the Control Panel and Select "Device Manager".
3. Under "Ports (COM & LPT)" right click on the COM for used by the device and select "Properties".
4. Under the "Port Settings" tab, click "Advanced..."
5. Select 1ms in the drop down menu for the "Latency Timer".

Note: If your device is connected directly to a native serial port on the computer, this delay will not be present.

Adjusting acceleration

The adjacent optic change time for the X-FWR-E filter wheel can be reduced by increasing the device acceleration. The maximum acceleration setting will depend on the running current setting, the mass of the installed optics, and the amount of vibration possible (a firmly mounted device will vibrate less). Acceleration (Accel (T:43)) setting values up to 1400 may be possible. Device running current (driver.current.run (T:38)) can be adjusted up to 100 for improved motor torque. The device may run slightly warmer with an increased running current. See the Quick Command Reference for more information on adjusting device settings.

Product Drawing

ZABER
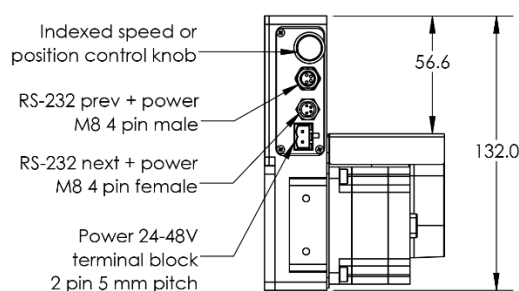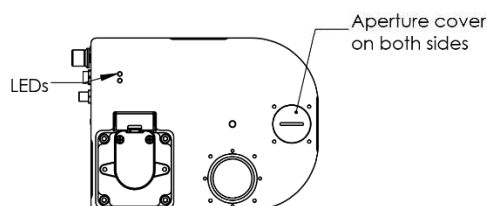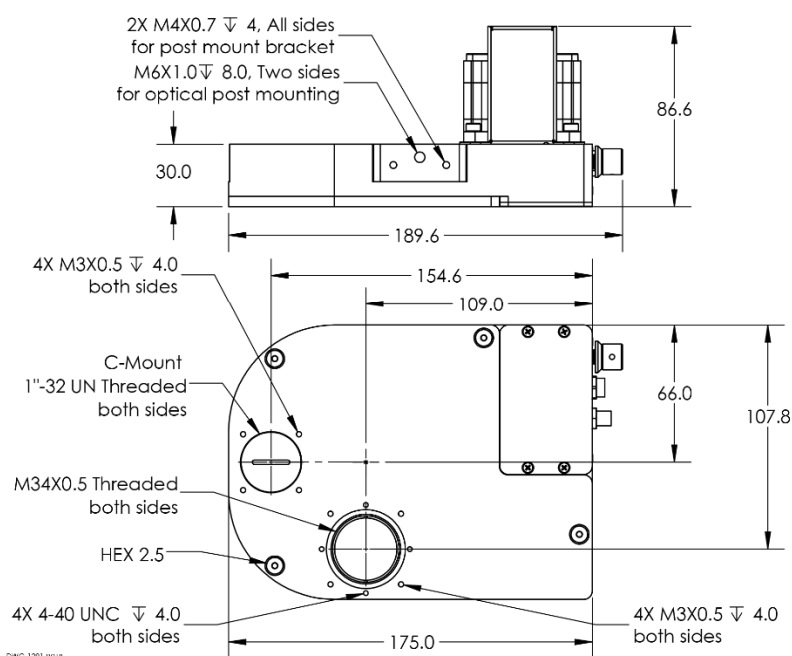X-FWR-E Motorized Filter Wheel With Interchangable Filter Wheels
dimensions in mm
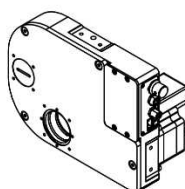
Model Number*	# Of Positions	Lens Thread
X-FWR06A-E02-FH0625	10	M27X0.5
X-FWR06A-E02-FH0632	7	M32.5X0.5

Included accessories:
- One of FH0625 or FH0632 filter holders
- 4X Aperture covers for 25 & 32 mm apertures

*See product page for more details at www.zaber.com

Specifications

Specification	Value	Alternate Unit
Microstep Size (Default Resolution)	0.010714285 °	186.996 µrad
Built-in Controller	Yes	

Specification	Value	Alternate Unit
Range	360 °	
Accuracy (unidirectional)	0.4 °	6.980000 mrad
Repeatability	< 0.1 °	< 1.745 mrad
Backlash	< 0.19 °	< 3.316 mrad
Encoder Resolution	400 CPR	1600 states/rev
Encoder Type	Rotary quadrature encoder	
Communication Interface	RS-232	
Communication Protocol	Zaber ASCII (Default), Zaber Binary	
Compatible Optic Thickness	6.5 mm	0.3 "
Maximum Current Draw	650 mA	
Power Supply	24-48 VDC	
Power Plug	2-pin Screw Terminal	
Angular Motion Per Motor Rev	119.999992 °	
Motor Steps Per Rev	200	
Motor Type	Stepper (2 phase)	
Motor Rated Current	2100 mA/phase	
Inductance	3.2 mH/phase	
Default Resolution	1/56 of a step	
Data Cable Connection	Locking 4-pin M8	
Motor Frame Size	NEMA 23	
Mechanical Drive System	Synchronous belt	
Limit or Home Sensing	Magnetic home sensor	
Manual Control	Yes	
Mounting Interface	M6 threaded hole for optic post, M3 holes for AP134 post mount adaptor	
Vacuum Compatible	No	
Operating Temperature Range	0-50 °C	
RoHS Compliant	Yes	
CE Compliant	Yes	

Comparison

Part Number	Compatible Optic Diameter	Number of Optics	Adjacent Optic Change Time	Weight
X-FWR06A-E02-FH0625	25 mm, 1 "	10	57 ms	1.508 kg (3.325 lb)
X-FWR06A-E02-FH0632	31-32 mm	7	65 ms	1.503 kg (3.314 lb)

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