ZABER

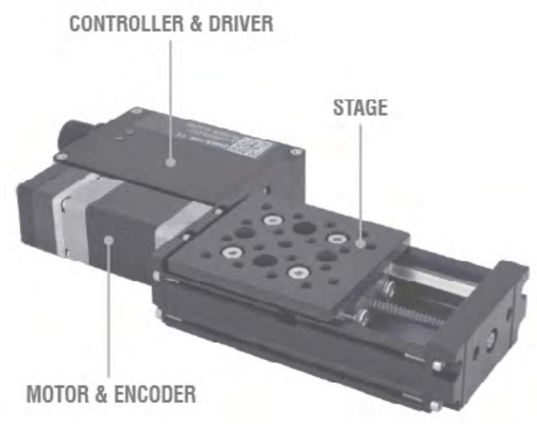
ZABER TECHNOLOGIES

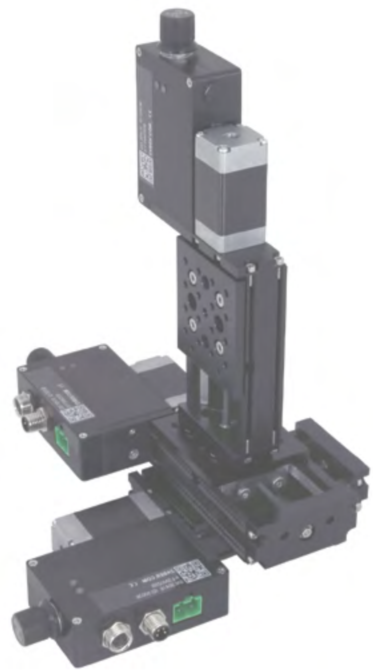
Simplifying Motion Control

Includes Technical Articles & Customer Spotlights

SEPTEMBER 2018 CATALOGUE   WWW.ZABER.COM

Contents





Company Profile

Zaber Technologies designs and manufactures a wide range of high precision positioning devices.
www.zaber.com

How Zaber Got Its Start

Zaber Technologies was founded in 1997 by a group of friends with diverse interests in electro-mechanical systems, programming, and physics. Back then, precision linear actuators all used DC motors with gearboxes and encoders, and they required complicated motion control cards, bulky controllers, separate driver amplifiers, and special power supplies. Precision motion control was expensive, difficult to set up, and cumbersome to use.

Zaber's founders recognized the need for an inexpensive, integrated solution for motion control. They wanted to make motion control products that were easy to set up and ready to use right out of the box, so they created the world's first precision linear actuator with a built-in controller. It was based on a stepper motor instead of a DC motor, gearbox, and encoder combination. The integration of all control and drive electronics in the same package became the foundation of Zaber's product line.

Where We Are Today

Since the introduction of our first linear actuator, the T-LA28, we have expanded our offerings to include over 100 motion control products distributed worldwide. Researchers, engineers, distributors, systems integrators, and OEMs have come to appreciate our innovative products and excellent support. We continue to advance our in-house manufacturing processes allowing us to build, test, and ship most of our products within 1–5 business days.

Our Focus

Integrating your feedback into our products

When you talk, we listen. We continually expand and improve our product line based on your feedback and requests.

Providing excellent service and support

We strive to offer the best service and technical support in the industry. We believe that these are the key ingredients in creating and sustaining a positive relationship with you.

Offering the best price-to-performance ratio on the market

We make products that strike a unique balance between quality, performance, and economy.

Simplifying motion control

Most of our products are ready to plug into a computer and run right out of the box. Our software is quick to install and easy to use. No one likes paperwork, so we also try to make ordering and servicing as painless as possible.

Our Service

30-day satisfaction guarantee

All of Zaber's standard products are backed by a 30-day satisfaction guarantee. If for any reason you are not satisfied with your purchase, you may return items in saleable, unmarked condition within 30 days of the purchase date for a refund, less applicable shipping costs. No questions asked, and no restocking fee.

One-year warranty

All our products are warrantied against defects in manufacture and design for one full year from the purchase date. For products covered by warranty, we will repair or replace the defective device free of charge. The customer is only responsible for the cost of the return shipping to Zaber; we will pay for the shipping back to the customer.

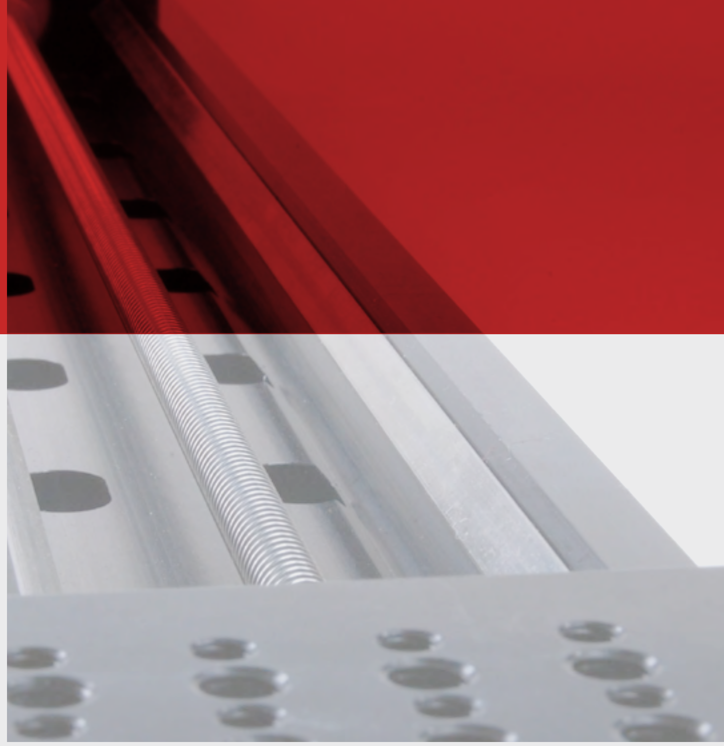
Quantity discounts available

For applications that require higher quantities of devices, including OEM requirements, Zaber can offer quantity pricing. For larger quantities, either in a single delivery, or deliveries spaced over a longer period, please email us at contact@zaber.com, or call 1-888-276-8033 to speak with the Applications Engineering Team about your requirements.

Flat rate shipping within Canada and the United States

Zaber offers flat rate shipping within Canada and the United States with delivery within 2–3 business days. See www.zaber.com/ordering for more details and shipping rates.

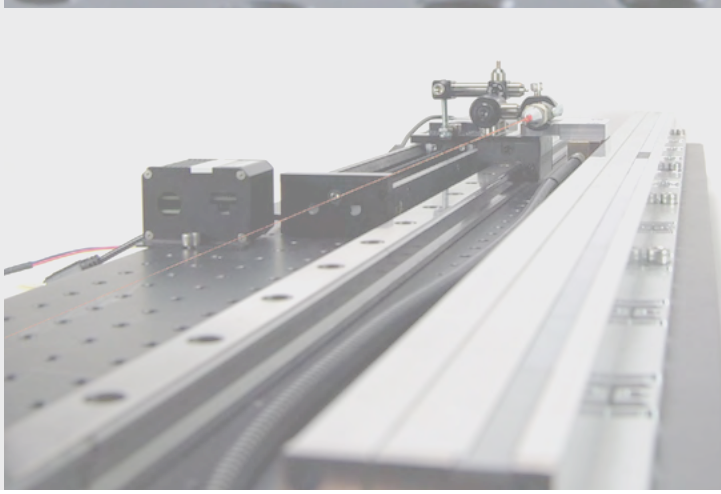
Design Spotlight: Prototyping



Prototyping and Testing

As we get started designing a new product, one of our first steps is to build rough prototypes of the product or different sections of the product. We'll whip up some parts in the machine shop and build things like drive assemblies so we can have something in our hands as fast as possible. These concept prototypes are not usually pretty, but we always learn a lot that we couldn't tell from a computer model or from calculations. Just by holding it in your hands, you learn a lot from how it feels and moves. It's common to find some detail that has to be changed when assembling the device for the first time. Then, we test for performance and lifetime, and to see where the weak links are. Building early-stage prototypes is also motivational. It gives you a sense of accomplishment, and it's rewarding when you discover, "hey, this might actually turn into a decent product." Those are some of the times when I can't wait to get into work in the morning.

– Jesse Schuhlein, Research and Development

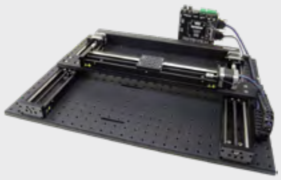


Automate Positioning Tasks Quickly and Easily

- Motorized positioners with optional built-in controllers, drivers, motor encoders, and linear encoders
- Daisy-chain and control devices from a single computer connection (USB or Serial)
- Multiple products can share a single power supply
- Free software with source code

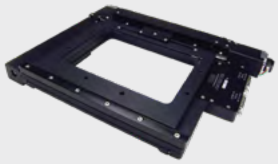
Multi-Axis Devices

Multi-axis systems with built-in controllers



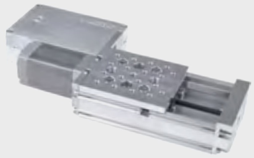
Gantry systems

Micromanipulators



Microscope stages

Vacuum Devices



Vacuum stages and actuators with built-in controllers

Linear Devices

Linear actuators with built-in controllers

Miniature linear stages with built-in controllers

Vertical lift stages with built-in controllers

Long-travel linear stages with built-in controllers

High speed direct drive stages with built-in controllers

Gripper Systems

Grippers with built-in controllers

Filter Wheels

Filter Wheels with built-in controllers

Rotary Devices

Rotary stages with built-in controllers

Joysticks

Programmable joysticks

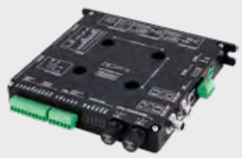
Tilt Devices

Optic mounts with built-in controllers

Motorized goniometers with built-in controllers

Controllers

Single axis stepper motor controllers



Two-axis stepper motor controllers with 2D coordination

When you talk, we listen; we continually expand and improve our product line based on your feedback.
www.zaber.com

Expandable Design

Automating more than one axis?

You can daisy-chain up to 99 Zaber devices to a single RS-232 or USB port. Power can be transmitted through the data cables of T-Series and X-Series devices, allowing multiple devices of the same series to be powered from a single power supply. Minimal hardware and cabling make Zaber products easy to set up and help reduce clutter on the workbench.

Versatile Software

Zaber software is easy to use

It automatically recognizes all your devices and allows you to communicate with each one. You can easily set up automated routines, and the source code can be modified for advanced customization. Libraries with APIs are available in many popular languages including LabVIEW, Visual Basic, C#, Excel, and C. All of our software is available for free download on our support website: www.zaber.com/software

Two simple RS-232 command options

The command protocol is how the software speaks with the devices. T-Series devices can use Zaber's straightforward Binary protocol for control, and information on the commands is in the product manuals on the support website here: www.zaber.com/support. A-Series and X-Series devices can use either Binary or Zaber's intuitive ASCII protocol. Information about the two protocols and how to change between them can be found here:

- **Binary:** www.zaber.com/manuals/BinaryProtocol
- **ASCII:** www.zaber.com/manuals/ASCIIProtocol

Easy Installation

Step 1

Connect the Zaber controller (built into the device or stand-alone) to your computer via USB or RS-232 port using the cables included if you ordered an accessory kit.

Step 2

Connect the power supply to your Zaber device.

Step 3

Send instructions or automate your set-up using the Zaber Console — our free, open-source software — or write your own application based using our programming libraries.

Questions?

Our technical support team is here for you

At Zaber, we specialize in motion control technology. When you contact us, you'll be speaking with an experienced member of our Applications Engineering Team who knows our products inside and out. If you need help with your products, we can guide you. User manuals and troubleshooting guides are available online. Plus, all our products are covered by a 30-day satisfaction guarantee and a one-year warranty.

About Our Products

Built-in controllers simplify your set-up

Many of our devices are designed with built-in controllers and drivers (and some with encoders), which reduces your cost, overall device footprint, and cable clutter. Don't want the integrated controllers? We have versions compatible with our external controllers too.

The choice is yours: enjoy complete automation through computer control, or use manual control

Zaber devices are perfect for automating your positioning needs. Our free software allows you to send single commands or complex sequences. Most models offer a manual control knob so that when you want to, you can position your device by hand as well. The speed varies depending on how far you turn the knob in either direction, and the computer will continue to track the device's position throughout a manual move.

We've got the accessories you need

Zaber products use standard 15 V or 24 V-48 V wall-mounted power supplies, and we offer suitable alternatives to match the input voltage in different regions around the world. Kit versions of Zaber products come complete with a power supply, a six-foot data cable, a serial port adaptor, and a USB cable. Devices are also available for purchase without accessories. We can also help you choose the right cables, power supplies, or any other optional items. Accessories for each device are listed on our website, www.zaber.com.

The environment is important to us

It's important to us to minimize any negative impact we may have on the environment and on the health and safety of our communities. We are continually improving our devices to reduce the use of any hazardous substances, and our products are RoHS compliant. The packaging we use is recyclable in most regions. If you have any suggestions for how we can further reduce the environmental impact of our products or activities, we would be happy to hear from you!

Integrated motor, controller, and driver in a small package.

Control options include computer, joystick, and manual control knobs.

Most devices are available as kits containing common accessories required for set-up, such as USB and Serial connectors, power, and an extension cable for daisy-chaining.

Daisy-chaining Data and Power to Reduce Cabling

By Sofia Moreno, Applications Engineering Team

Setting up motion control systems can be time consuming, costly, and complex. At Zaber, we focus on simplifying motion control. One way our systems can save you time and money is by reducing the number of cables required for a multi-axis system. While there are a few ways to reduce cabling, in this case we will be discussing daisy-chaining both data and power for multiple Zaber devices.

Daisy-chaining refers to the connection of several devices in a linear series, as shown in Figure 1. Zaber's motor controllers can share both data and power through a daisy-chain, which is the most efficient way to reduce cabling.

OVERVIEW OF ZABER PRODUCTS

Considerations to keep in mind when daisy-chaining data and power will be discussed in detail, but first – in order to specify the individual daisy-chaining capabilities of Zaber devices – we will describe how daisy-chaining works within each series that we currently offer. Each series is identified by the first letter of a device's name: Zaber T-Series, A-Series, and X-Series. Each series shares some common features, including connectors, communication, protocols, and power. For example, a T-LA60A actuator belongs to the T-Series, an A-BAR300BLC linear actuator belongs to the A-Series, and an X-LRM050A linear stage belongs to the X-Series. Further details regarding each series will be discussed in later sections.

Figure 1: Daisy-chain example.

When we use the term device, we mean either a stand-alone controller or a positioner with a built-in controller and driver. An example of a Zaber device is illustrated in Figure 2. Stand-alone controllers are designed for use with Zaber's peripherals, which are positioners without a built-in controller, but these controllers can also be used with compatible third-party motors.

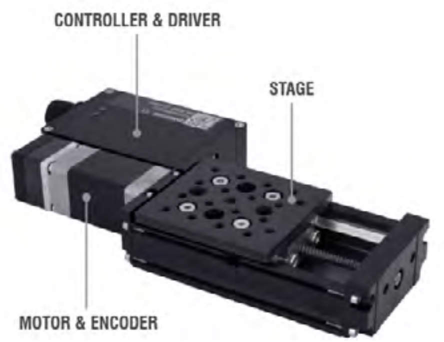


Figure 2: Zaber device anatomy.

Daisy-Chaining Data

In order to send and receive messages from the same serial port on a computer, all of the devices in the daisy-chain need to be set to the same protocol and baud rate. There are two protocols: Zaber ASCII and Zaber Binary. A detailed description and comparison of both can be found in our short technical article Simplifying Controls Protocols: www.zaber.com/simplifying-control-protocols

All Zaber devices use RS-232 serial communication, and all can communicate in the Zaber Binary protocol at a baud rate of 9600 bits per second. While T-Series devices are limited to these settings, the A-Series and X-Series have additional communication options, as shown in Figure 3. More information about each series can be found in the Series Reference Table: www.zaber.com/SeriesReferenceTable.pdf

Baud rate is a speed measurement for communication. It specifies the number of bits per second that are transferred over the serial port. For example, a baud rate of 9600 baud is 9600 bits per second. This means that the serial port is sampling each data line at 9600 Hz. As you can see, A- and X-Series devices have a slight advantage over T-Series devices because they can communicate at higher speeds.

	T-Series	A-Series	X-Series
Default Protocol	Binary	Binary	ASCII
Default Baud Rate	9600	9600	115200
Available Protocols	Binary	Binary ASCII	Binary ASCII
Available Baud Rates	9600	9600 19200 38400 57600 115200	9600 19200 38400 57600 115200

Figure 3: Default and available protocols and baud rates.

Daisy-Chaining Power

The table in Figure 4 shows the voltage ranges required to power a device within each series, as well as whether they can daisy-chain power. Each series is unique in terms of daisy-chaining power, and in every case the voltage and current output of a power supply can affect the performance of the connected device.

	T-Series	A-Series	X-Series
Power Supply	12 – 16 VDC	24 – 48 VDC	24 – 48 VDC
Daisy-chain Power	Yes, only with T-Series devices	No	Yes, only with X-Series devices (high current supplies can power up 3 axes)

Figure 4: Voltage ratings for different series.

Considerations for powering daisy-chained devices include:

- Can the devices daisy-chain power?
- What is the recommended voltage for each device?
- What is the maximum current draw[1] or motor rated current[2]?
- Which series are daisy-chained together?
- In what order should they be connected if there is more than one series in a daisy-chain?

The recommended voltage and maximum current draw for a device, or in the case of peripherals the motor rated current and recommended voltage for a stand-alone controller, can be found online in the 'Series Specs' section of each device or peripheral.

DAISY-CHAINING FOR SPECIFIC SERIES

T-Series:

T-Series devices use L/R drivers, for which power supply voltage should match the motor's rated voltage. Most T-Series motors have a voltage rating of about 12 VDC, and the power supplies have a narrow voltage range of 12 – 16 VDC. Zaber offers power supplies with 15 VDC for all T-Series devices because these devices have better performance when powered at 15 VDC compared to 12 VDC. This allows you to daisy-chain T-Series devices and share power without worrying about different voltage levels. The only consideration remaining is the sum of the maximum current draw of each device in a chain, which will determine whether the power supply selected is suitable. For example, the maximum current required would determine whether the devices need a power supply with higher amperage, or if additional power supplies are needed. Figure 5 shows an example of a T-Series daisy-chain, which is able to use only one power supply and one computer connection because data and power are shared through the daisy-chain.

A-Series:

While A-Series devices can daisy-chain data, such that a series of connected devices require just a single connection to the computer, they are not capable of sharing power in a daisy-chain. Therefore, a power supply must be connected to each A-Series device. Similar to the X-Series, A-Series devices have the option to be powered with 24 – 48 VDC, which we will discuss in a later section.

Figure 5: T-Series daisy-chain; sum of maximum current draw is 1.5 A, as each device draws 0.5 A max.

[1] The maximum current that the device will draw. A power supply must be rated for at least the maximum total current draw of the devices connected to it.

[2] Indicates the rated maximum current per phase of the motor used in motorized motion control devices.

X-Series:

Similar to the T-Series, X-Series devices can daisy-chain power with other X-Series devices. In addition to considering the maximum current draw of X-Series devices in a daisy-chain, you must also consider what voltage level will result in the best performance and whether better performance is attained by separating daisy-chains.

To illustrate this, Figure 6 shows a daisy-chain of devices that all require the same voltage level, while Figure 7 shows one possible solution when two devices each require a different voltage level.

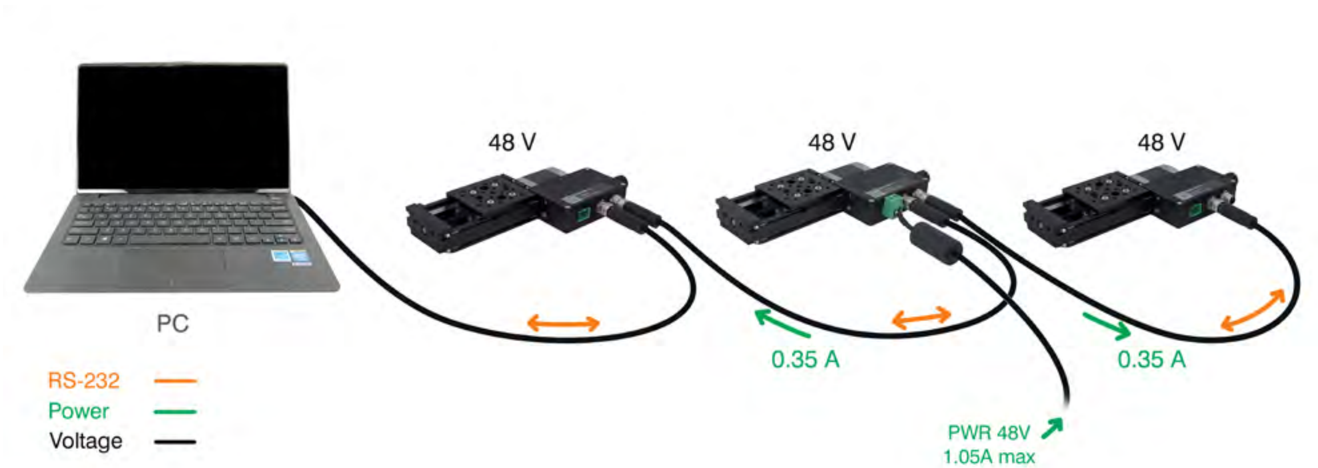


Figure 6: X-Series daisy-chain; sum of maximum current draw is 1.05 A, as each device draws 0.35 A max.

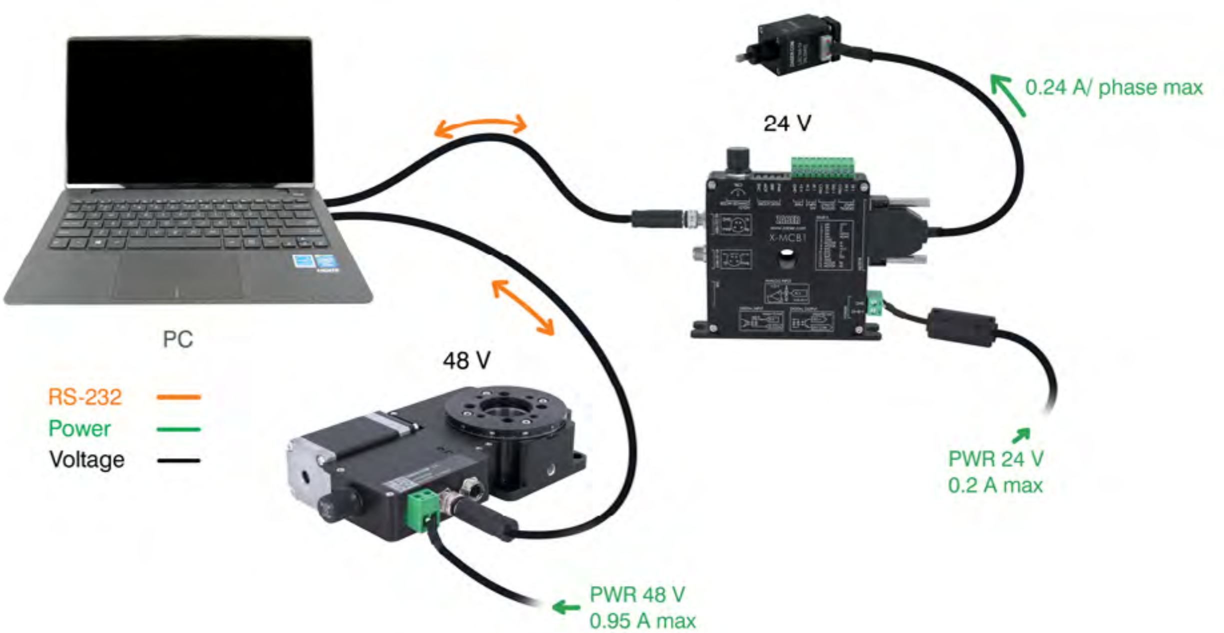


Figure 7: X-Series daisy-chain with devices that require different supply voltages. *If this solution applies to your application, please contact us.

Voltage for A-Series and X-Series:

A-Series and X-Series devices use chopper drives. Unlike the L/R driver used in the T-Series, chopper drives don't need to match the voltages of the motor and the power supply. This allows them to use a low voltage motor (3 – 6 VDC) with a higher voltage power supply, which results in higher speed capacity than T-Series devices. However, there can be a noticeable difference in performance when powering A- and X-Series devices with either 24 VDC or 48 VDC. The 'Series Specs' section on each product's web page lists the recommended power supply voltage and often has performance charts for both 24 VDC and 48 VDC. Below are examples of the performance of a smaller motor, NEMA[3] 8 (Figure 8), and a larger motor, NEMA 17 (Figure 8), each powered with 24 VDC and 48 VDC.

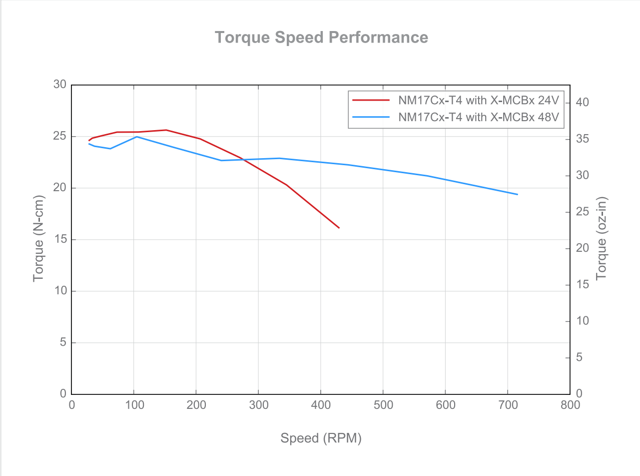


Figure 9: Performance chart of NM17CS-T4 stepper motor with an X-MCB1, a stand-alone controller, powered with 24 and 48 V.

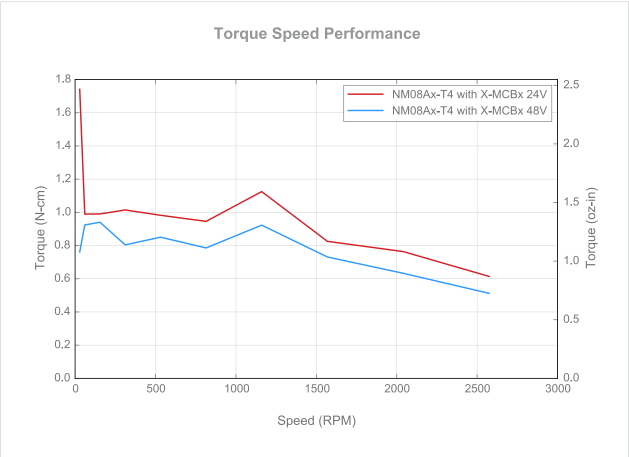


Figure 8: Performance chart of NM08AS-T4 stepper motor with an X-MCB1, a stand-alone controller, powered with 24 and 48 V.

For devices that use smaller motors, such as NEMA 8 motors, we recommend using 24 VDC for best performance. This is because smaller motors typically have a higher maximum speed than larger motors. In addition, many Zaber controllers have a maximum speed capacity of about 3000 RPM, which is less than the maximum speed for smaller motors. Although smaller motors won't reach their maximum speed, a power supply of 24 VDC will result in higher torque and similar maximum speed compared to a 48 VDC supply. Therefore, most devices and peripherals with smaller stepper motors perform better with a 24 VDC supply when using a Zaber device. This is illustrated in the performance chart in Figure 8. For most devices with larger motors, using a 48 VDC power supply gives the best performance. Their maximum speed is typically close to or less than 3000 RPM, and the higher voltage is required to reach those speeds. This is illustrated in the performance chart in Figure 9.

[3] NEMA stands for "National Electrical Manufacturers Association", which is an association that creates standards developed by manufacturers to provide descriptions of how things should be made and named. NEMA labels stepper motors in relation to the size of the motor's faceplate in tenths of inches. For example, NEMA 8 has a 0.8 in. x 0.8 in. faceplate. Standardizing stepper motors ensures that motors from different manufacturers will fit the same mounting and makes changing components easier.

T-Series, A-Series, and X-Series combined:

When daisy-chaining devices from different series, all the considerations listed previously contribute to the order in which the devices should be daisy-chained for best performance. When combining different Zaber series, we recommend X-Series devices be connected at the beginning of a daisy-chain (closest to the computer), but it is possible to connect the X-Series devices further down the chain if necessary. Figure 10 illustrates a multi-axis system that uses devices from all three series.

To narrow down the necessary accessories and power supplies, we recommend using our Quick Set-up Tool. This tool helps to configure devices that will be connected in series. The Quick Set-up Tool will also recommend the necessary accessories if they're not already included in the part numbers. Figure 11 shows an example of a 2-axis configuration on the Quick Set-Up Tool. In Section 1, a 2-axis system using two X-LSM050A stages are entered without accessory kits. As you can see, the Quick Set-up Tool suggests including a power supply and data cables, and it lists the part numbers that it added to the setup in Section 2.

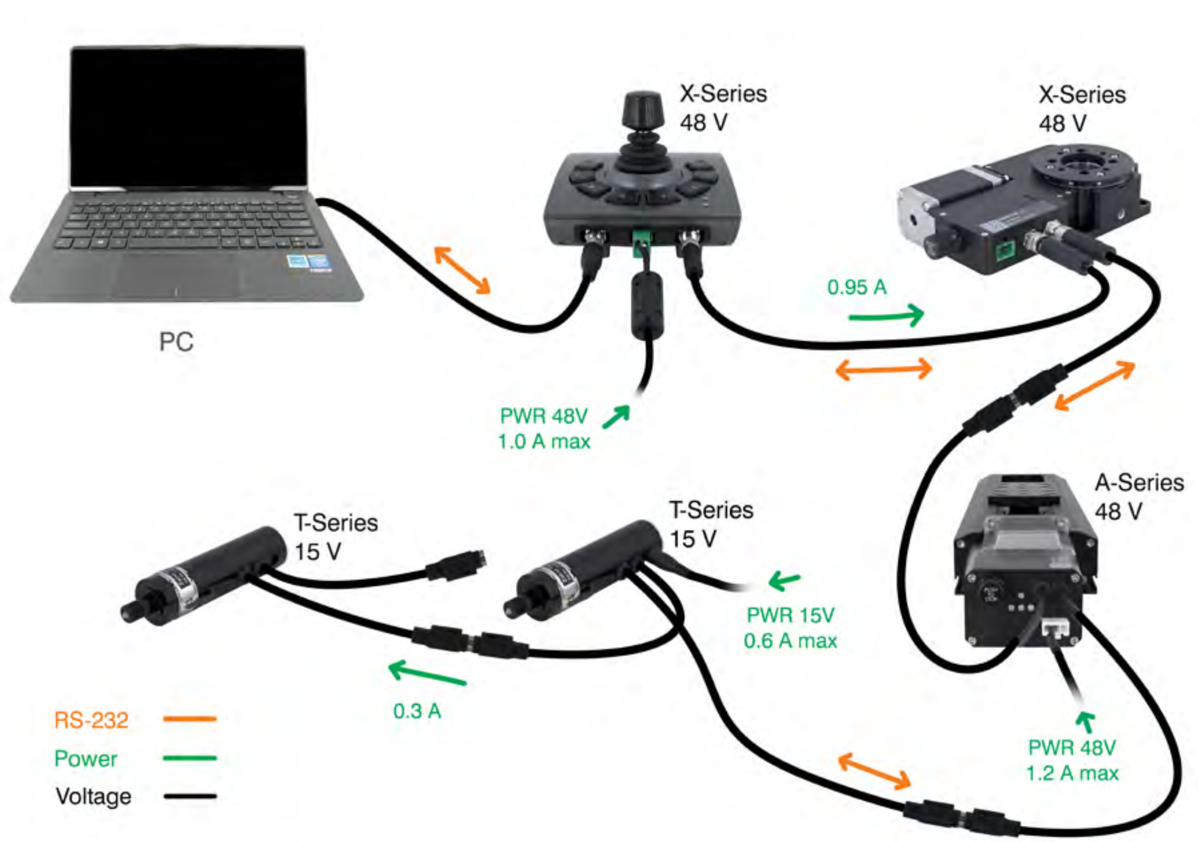


Figure 10: Multiple series in a daisy-chain. X- and T-Series devices can share power with the next X- or T-Series devices, respectively, but each A-Series device requires its own power supply regardless. Daisy-chaining data allows this system to use a single connection to the computer.

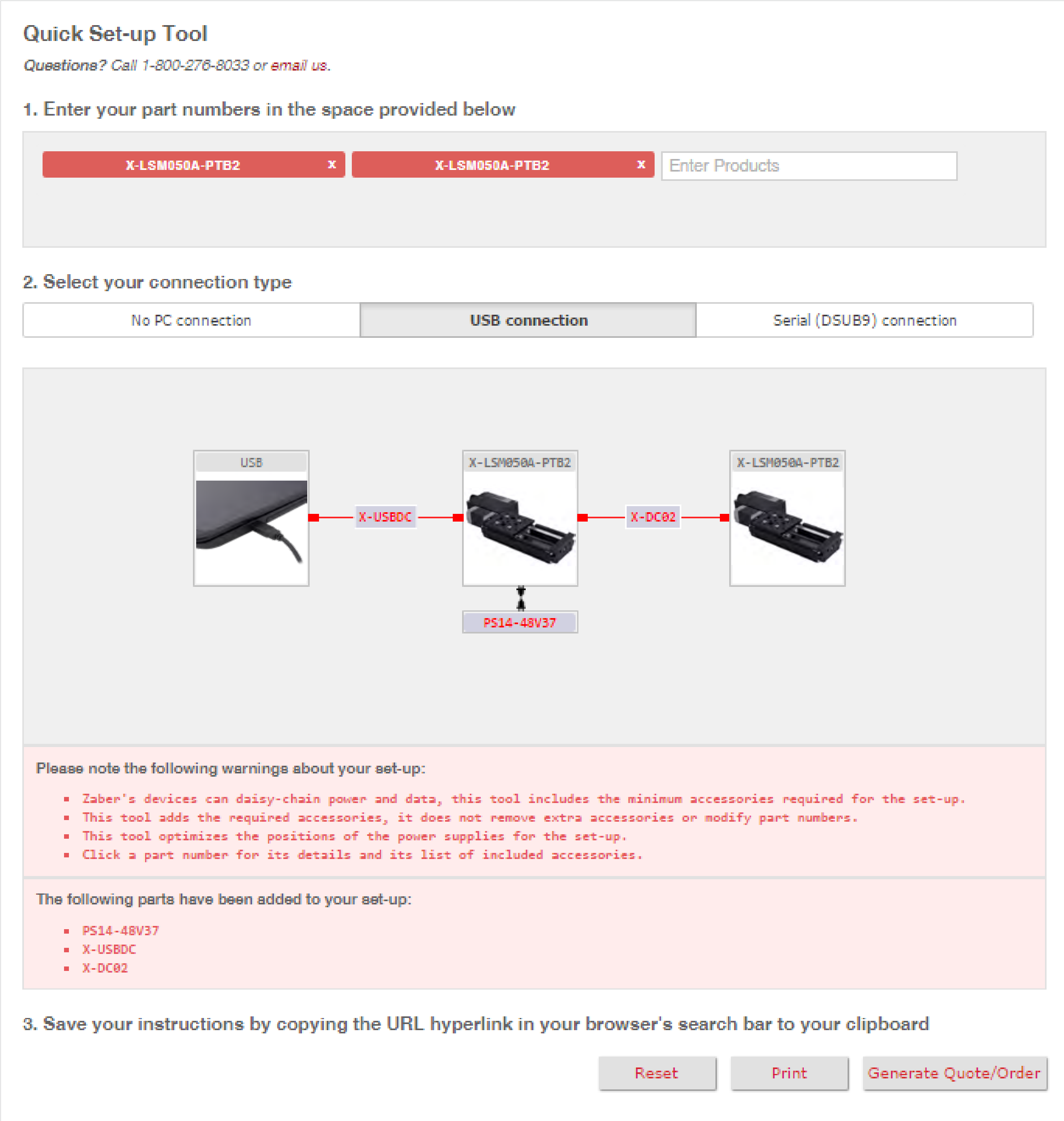


Figure 11: Quick Set-Up Tool, 2-axis example.

DISCUSSION/CONCLUSION

Daisy-chaining Zaber devices reduces the number of accessories required for a series of devices, saving time and money. As discussed in this article, there are considerations about the interaction of specific devices with one another, and by following our guidelines, you can make a more efficient workflow of Zaber devices that results in fewer power supplies, better serial communication, and a cleaner workspace.

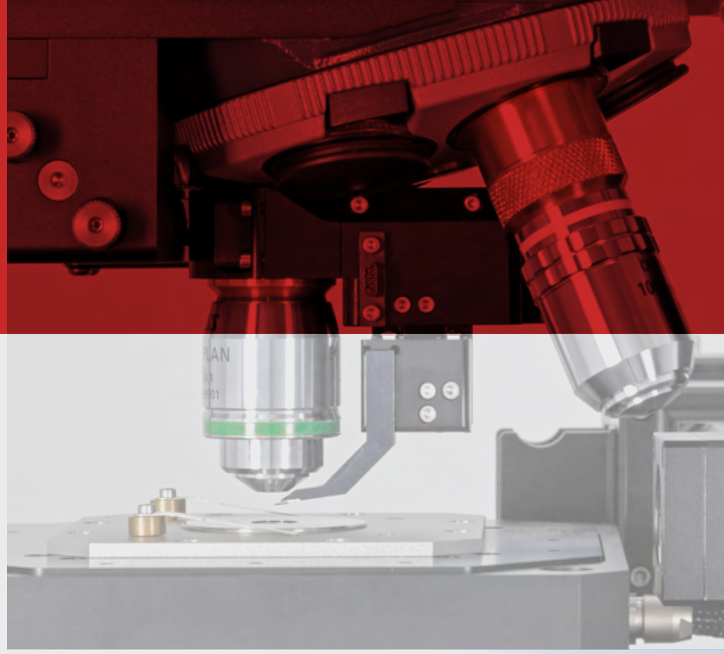
If you find you need help deciding which accessories are suitable and which ones are required, please contact our support team:

1-888-276-8033 (Toll Free Canada/USA)
1-604-569-3780 (Direct)
contact@zaber.com

> "Zaber devices...
> result in fewer power supplies, better serial communication,
> and a cleaner workspace."

Sofia Moreno is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications.
For more information, please visit www.zaber.com.

Customer Spotlight: WITec GmbH



WITec GmbH

WITec is a manufacturer of high performance optical and scanning probe microscopy systems solutions for scientific and industrial applications. A modular product line allows the combination of different microscopy techniques such as Raman, NSOM, or AFM in one instrument for flexible analyses of optical, chemical, and structural properties of a sample. The instruments are distributed worldwide and are mainly used in materials sciences, life sciences, and nanotechnology. WITec's headquarters are based in Ulm, Germany, and Knoxville, TN, USA.

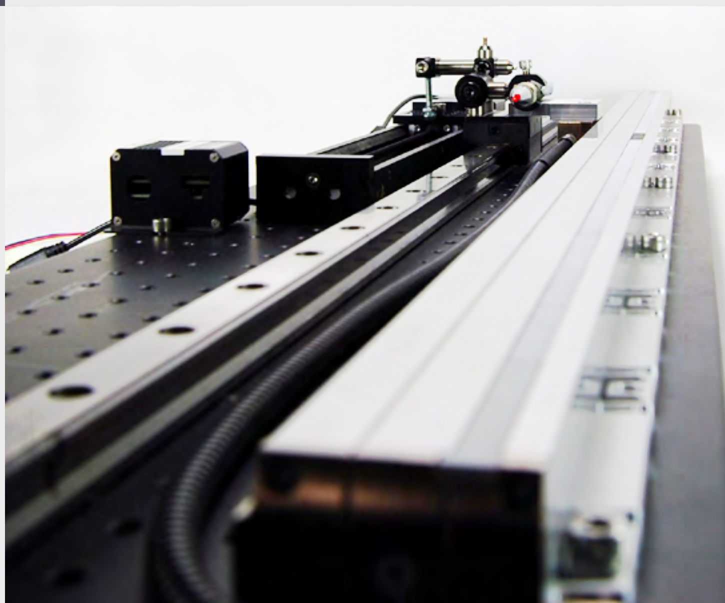
www.witec.de

We integrate three Zaber T-LA28A-S actuators in our Scanning Near-Field Optical Microscope alpha300 S for moving the inverted microscope's objective in three axes. An additional actuator is used for conveniently moving a filter slider. The T-LA28A-S gives us a resolution of 100 nm, perfectly matching our demanding requirements in high-resolution microscopy. We favour the Zaber actuators because they can be easily activated by our microscope control electronics and software, and because we can easily connect several actuators in one system.

– WITec GmbH

WITec focus innovations

Linear Motion



A-BAR-E High Thrust Electric Cylinders with Motor Encoders

- 200 or 300 mm travel
- 540 N peak thrust; up to 65 mm/s speed
- Lead screw or ball screw driven; inline and parallel drive configurations
- Available with built-in controllers and/or motor encoders for slip/stall detection

Product Description

Zaber's A-BAR-E products are computer controlled, motorized, ball screw (or lead screw) driven electric cylinders with optional integrated controllers and motor encoders. Each device is available in either an inline or parallel drive (pictured) configuration. They are stand-alone devices requiring only a standard 48 V power supply. A manual knob on devices with built-in controllers permits manual control.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient 6-pin mini-DIN cables on the stage allow for direct interconnection between devices in close proximity. For longer distances, we offer standard cable extensions.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the actuator reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

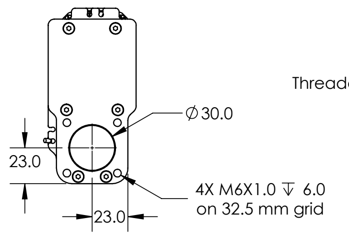
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop. During a manual move the device's position is constantly transmitted to the computer and is displayed by the software.

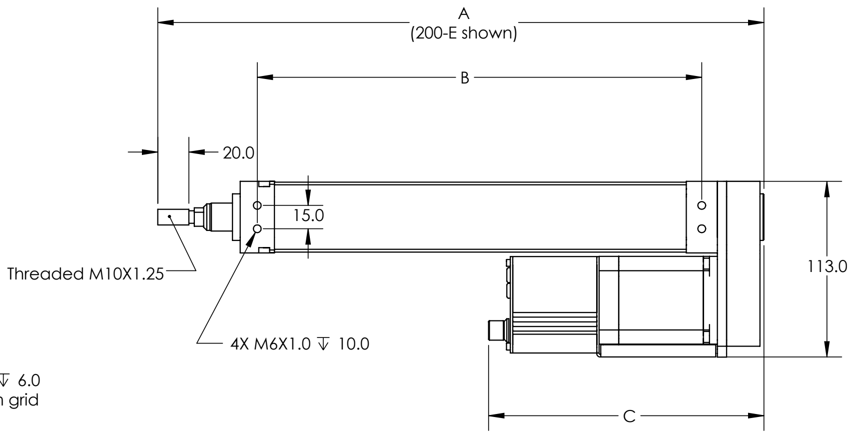
A-BAR-E Dimensions

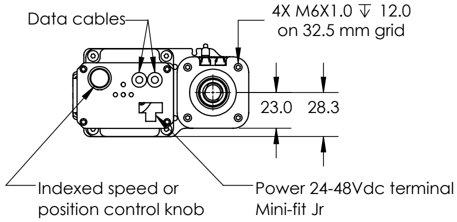
Measurements in millimetres (mm)

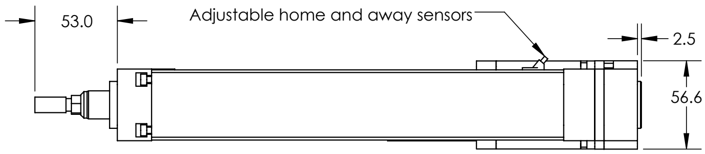
Model Number*	Travel	A	B	C
200	203.2	390.0	286.0	161.7
200-E	203.2	390.0	286.0	177.2
300	304.8	490.0	386.0	161.7
300-E	304.8	490.0	386.0	177.2

*See product page for complete list of available models at www.zaber.com



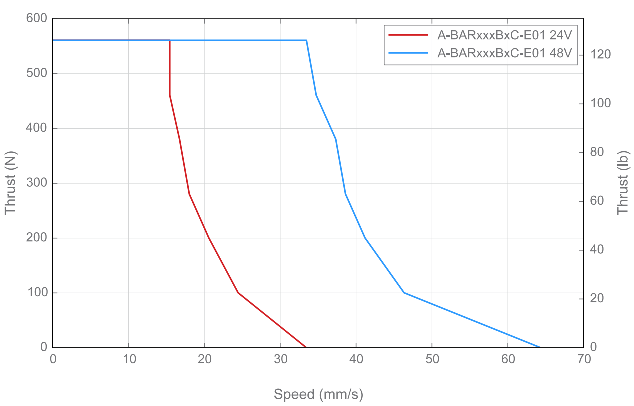






A-BAR-E Performance Charts

Thrust Speed Performance



A-BAR-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Peak Thrust (N)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Current Draw (mA)	Weight (kg)
A-BAR200BLC-E01	203.2	0.248	70	< 30	540	< 120	0.151	65	1100	2.66
A-BAR300BLC-E01	304.8	0.248	102	< 30	540	< 120	0.151	65	1100	3.00
A-BAR200BPC-E01	203.2	0.248	70	< 30	540	< 120	0.151	65	1100	2.72
A-BAR300BPC-E01	304.8	0.248	102	< 30	540	< 120	0.151	65	1100	3.06

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

- Built-in controller and optional motor encoder
- Excellent thrust, speed, and accuracy
- Daisy-chain and control multiple devices through a single serial port

X-NA-E Micro Linear Actuators

Product Description

Zaber's X-NA-E linear actuators are computer controlled and offer 0.05 μm resolution, with either 25 mm or 50 mm travel. Each actuator comes with a hardened ball tip that you can remove if you prefer to use the built-in threaded tip or a flat tip.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. An industry standard 3/8″ (9.5 mm) diameter micrometer shank allows the X-NA-E to fit many popular stages. The plunger of the X-NA-E actuator does not rotate.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

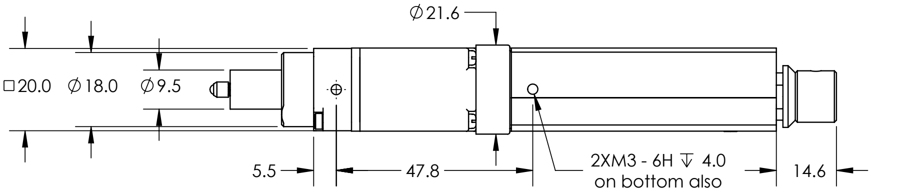
X-NA-E Dimensions

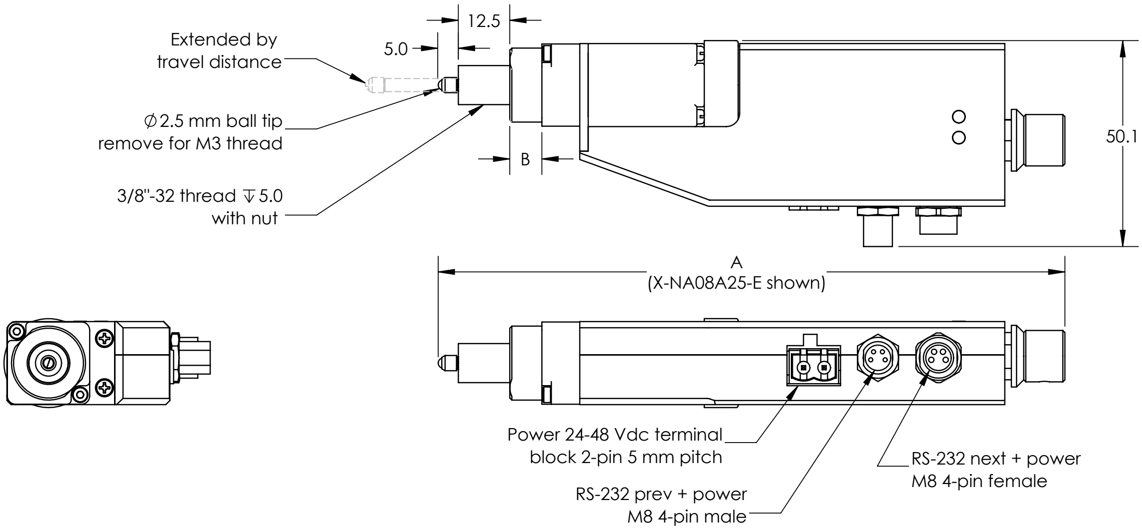
Measurements in millimetres (mm)

Model Number*	Travel	A **	B
X-NA08A25-E	25.4	152.2	7.8
X-NA08A50-E	50.8	177.6	33.2

*See product page for complete list of available models at www.zaber.com

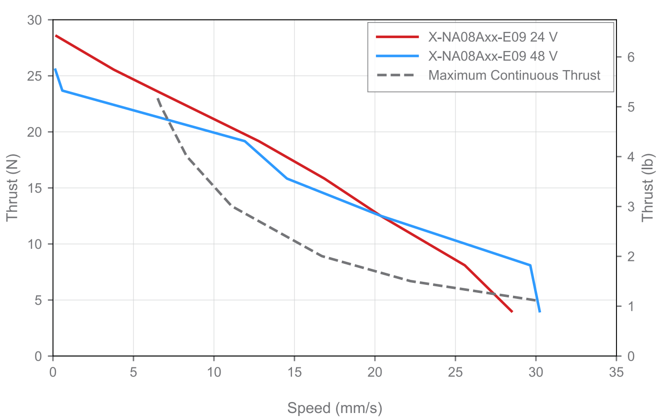
**Subtract 13.1 mm knob length from 'A' for -S versions without manual control





X-NA-E Performance Charts

Thrust Speed Performance



X-NA-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Minimum Speed (μm/s)	Maximum Speed (mm/s)	Weight kg)
X-NA08A25-E09	25.4	0.048	15	< 1	< 4	0.029	30	0.18
X-NA08A50-E09	50.8	0.048	30	< 1	< 4	0.029	30	0.20

1. Complete, up-to-date specs available at www.zaber.com.
2. More compact models with no potentiometer available.

- Built-in controller in a tiny package
- Excellent thrust, speed, and accuracy
- Daisy-chain and control multiple devices through a single serial port

T-NA Micro Linear Actuators

Product Description

Zaber's T-NA linear actuators are computer controlled and offer 0.05 μm resolution, with either 25 mm or 50 mm travel. Each actuator comes with a hardened ball tip that you can remove if you prefer to use the built-in threaded tip or a flat tip.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple T-Series products to share a single power supply. An industry standard 3/8″ (9.5 mm) diameter micrometer shank allows the T-NA to fit many popular stages. The plunger of the T-NA actuator does not rotate.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the actuator reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

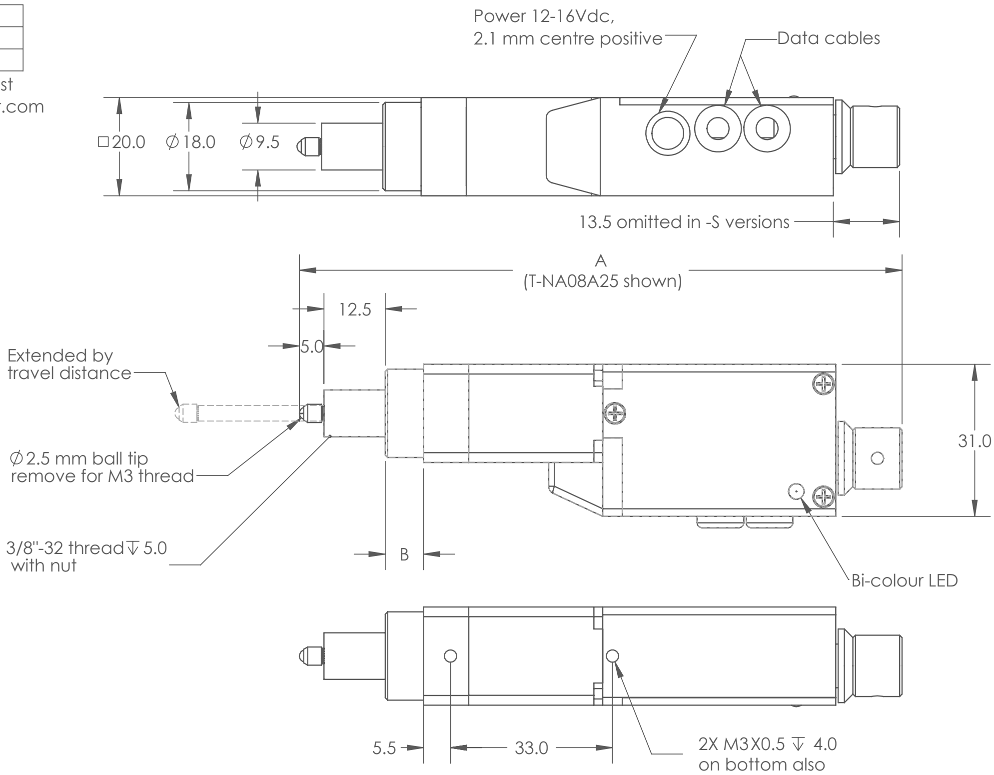
An optional knob provides smooth manual control at variable speeds in both directions for versatile operation. During a manual move the device's position is constantly transmitted to the computer and is displayed by the software.

T-NA Dimensions

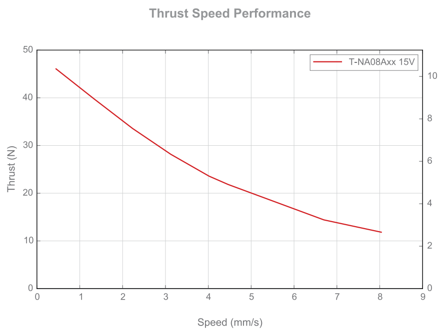
Measurements in millimetres (mm)

Model Number*	Travel	A	B
T-NA08A25	25.4	122.8	7.8
T-NA08A50	50.8	147.8	33.2

*See product page for complete list of available models at www.zaber.com



T-NA Performance Charts



T-NA Specifications								
Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Weight (kg)
T-NA08A25	25.4	0.048	15	< 1	< 4	0.22	8	0.13
T-NA08A50	50.8	0.048	30	< 1	< 4	0.22	8	0.15

1. Complete, up-to-date specs available at www.zaber.com.
2. More compact models with no potentiometer available.

We just used [a Zaber] actuator during a CAT scan to compress 25.4 mm diameter polyurethane tubing at 1 mm increments up to 10 mm and study the compression. It works perfectly! Thank you so much for all your help [with setting up the scripts in the Zaber Console].

– Michael Navitsky, Penn State University

- Built-in motor and controller
- Standard mounting interface replaces most manual micrometers
- Manual control knob lets you move the actuator at variable speeds
- Daisy-chain and control multiple devices through a single serial port

T-LA Miniature Linear Actuators

Product Description

Zaber's T-LA linear actuators are computer controlled, with up to 60 mm travel and 0.1 μm resolution. T-LA actuators keep their position even with no power applied, and if the actuator is idle, power to the motor is automatically removed so it can stay cool.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple T-Series products to share a single power supply. An industry standard 3/8″ (9.5 mm) diameter micrometer shank allows the T-LA to fit many popular stages. The plunger of the T-LA actuator does not rotate.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the actuator reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

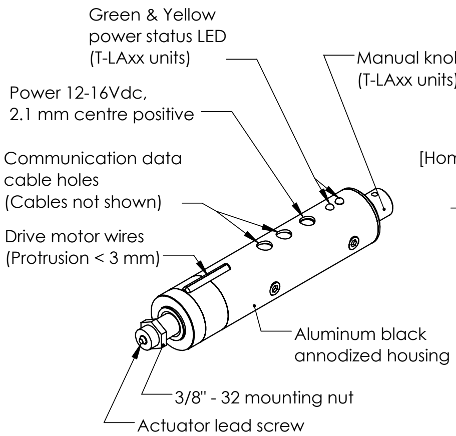
An optional knob provides smooth manual control at variable speeds in both directions for versatile operation. During a manual move the device's position is constantly transmitted to the computer and is displayed by the software.

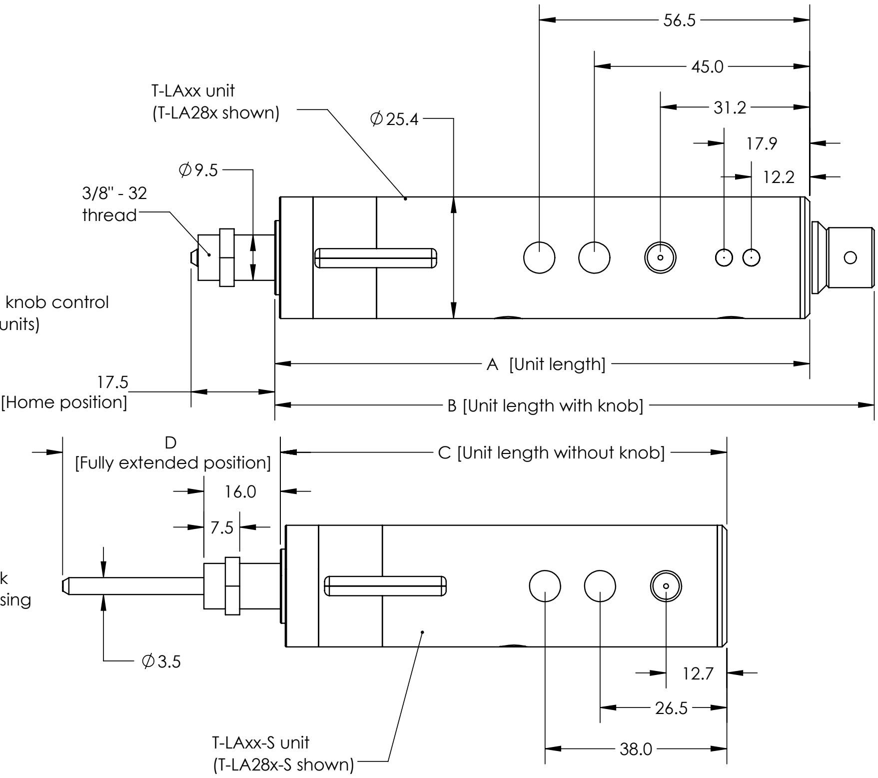
T-LA Dimensions

Measurements in millimetres (mm)

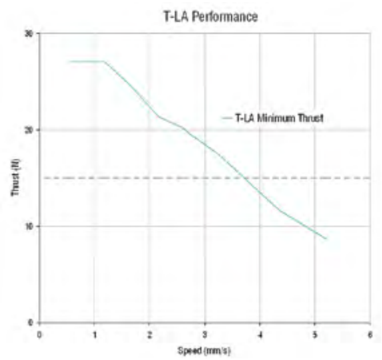
Model Number*	Travel	A	B	C	D
T-LA13A	12.5	N/A	125.5	111.8	30.5
T-LA13A-S	12.5	93.3	N/A	N/A	30.5
T-LA28A	28.0	N/A	125.5	111.8	45.5
T-LA28A-S	28.0	93.3	N/A	N/A	45.5
T-LA60A	59.5	N/A	160.5	146.8	77.5
T-LA60A-S	59.5	128.3	N/A	N/A	77.5

*See product page for complete list of available models at www.zaber.com





T-LA Performance Charts



T-LA Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Weight (kg)
T-LA13A	13	0.099	24	< 4	< 6	0.93	4	0.14
T-LA28A	28	0.099	24	< 4	< 6	0.93	4	0.14
T-LA60A	60	0.099	36	< 4	< 6	0.93	4	0.15

1. Complete, up-to-date specs available at www.zaber.com.
2. More compact models with no potentiometer available.

LAC Compact Motorized Actuators

- Compact size: great for applications with limited space
- Resolution down to 0.024 μm
- Designed for use with Zaber's stepper motor controllers
- Threaded tip for multiple mounting options

Product Description

The LAC linear actuators are Zaber's most compact actuators. They have a resolution of 0.024 μm and a travel length of 10 mm. Each actuator comes with a hardened ball tip that you can remove if you prefer to use the built-in threaded tip (M3) or a flat tip.

Installation

The LAC Series actuators are designed to connect directly to Zaber's stepper motor controllers (purchased separately). Zaber's stand-alone controllers and devices with built-in controllers can all be daisy-chained to communicate over a single computer connection. This simplifies set-up and reduces cable clutter.

Computer Control

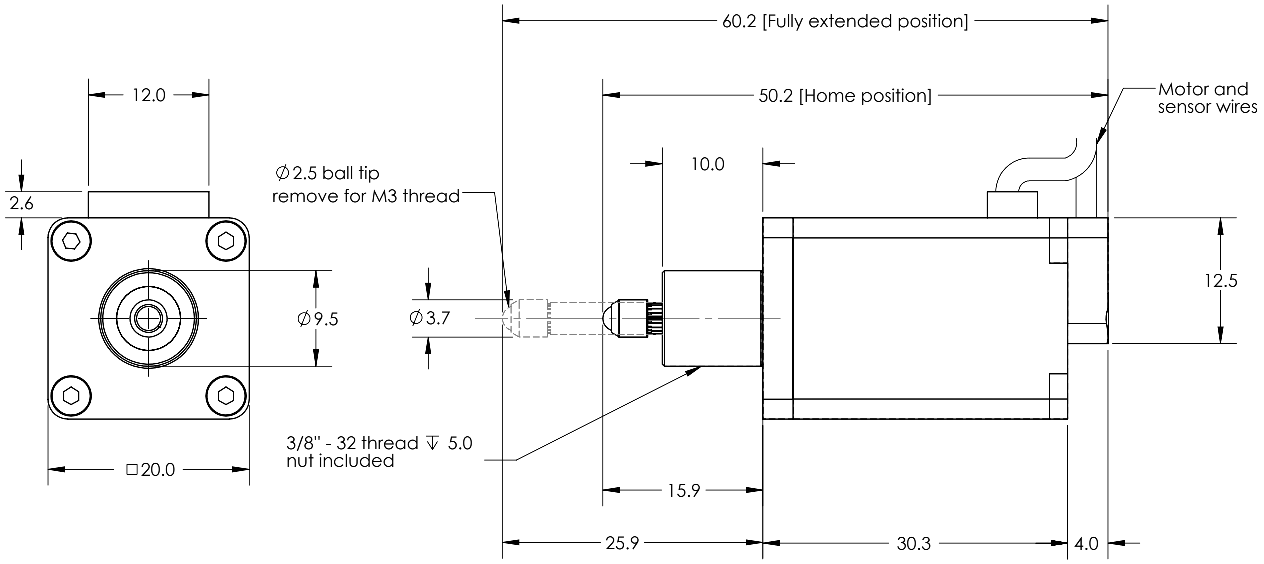
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the controller reports the new position of the actuator. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

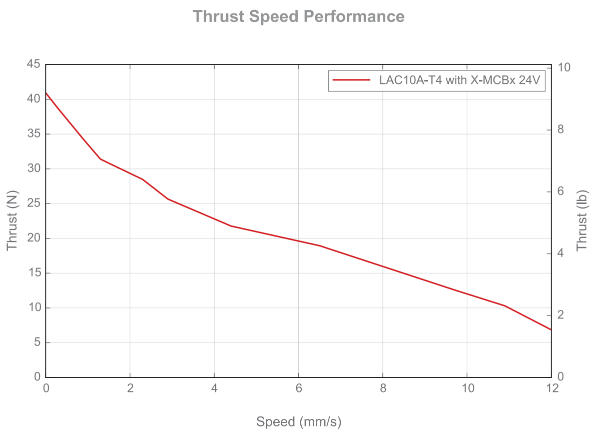
Zaber's stepper motor controllers include an indexed knob that provides convenient manual control via user-selectable modes. In velocity mode, each increment of the knob increases or decreases the speed by a fixed amount. In displacement mode, each increment of the knob moves the device by a user-configurable distance. You can also issue a stop command by depressing the knob during any operation. The knob allows for versatile control even without a computer.

LAC Dimensions

Measurements in millimetres (mm)



LAC Performance Charts



LAC Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Weight (kg)
LAC10A-T4	10	0.024	10	< 1.5	< 2	0.0145	12	0.076

1. Complete, up-to-date specs available at www.zaber.com.

A big part of what I like about working at Zaber is getting to know customers and learning about their new and novel applications. In particular, designing custom products for OEMs can be a fulfilling experience. It's exciting seeing customers' products become successful with Zaber's devices inside.

– Jesse Schuhlein, Research and Development

NA Motorized Linear Actuators

- Available in several sizes for a variety of thrusts and speeds
- Resolution down to 0.05 μm
- Designed for use with Zaber's stepper motor controllers
- Threaded tip for multiple mounting options

Product Description

Zaber's NA actuators offer a wide range of size, thrust, and speed options not available in our actuators with built-in controllers. The NA Series actuators are available with travel ranges from 16 mm to 60 mm and thrust up to 1200 N (270 lb), and they have a threaded tip for push/pull operation.

Installation

The NA Series actuators are designed to connect directly to Zaber's stepper motor controllers (purchased separately). Zaber's stand-alone controllers and devices with built-in controllers can all be daisy-chained to communicate over a single computer connection. This simplifies set-up and reduces cable clutter.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the controller reports the new position of the actuator. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

Zaber's stepper motor controllers include an indexed knob that provides convenient manual control via user-selectable modes. In velocity mode, each increment of the knob increases or decreases the speed by a fixed amount. In displacement mode, each increment of the knob moves the device by a user-configurable distance. You can also issue a stop command by depressing the knob during any operation. The knob allows for versatile control even without a computer.

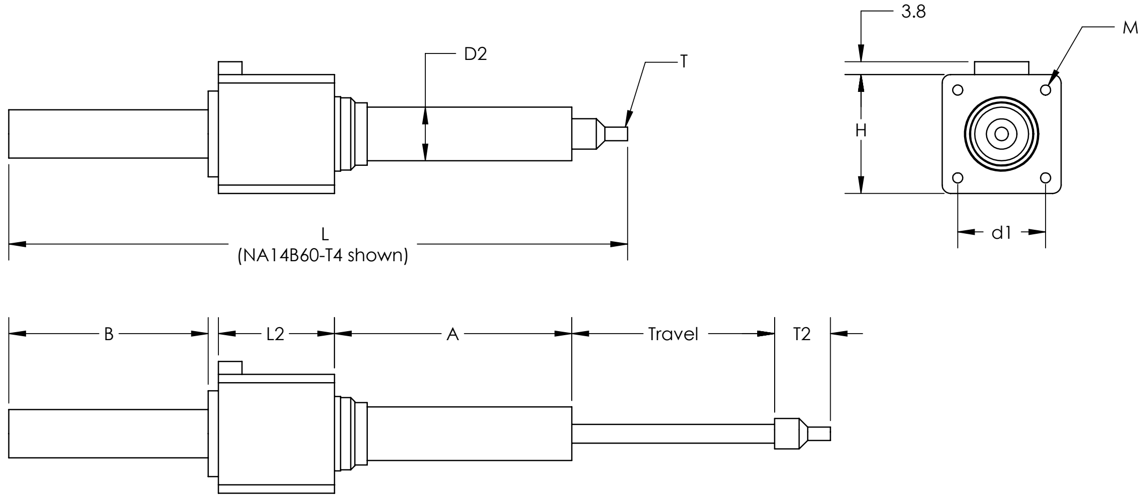
NA Dimensions

Measurements in millimetres (mm)

Model Number*	Travel	A	B	L	d1	D2	H	L2	M**	T	T2
NA08A16-T4 & NA08B16-T4	16.0	20.5	18.7	80.2	15.4	9.0	20.0	27.0	M2	#4-40	11.5
NA08A30-T4 & NA08B30-T4	30.0	33.0	32.7	106.7	15.4	9.0	20.0	27.0	M2	#4-40	11.5
NA11B16-T4	16.0	26.8	16.0	86.9	23.0	14.0	28.2	32.2	M2.5	M3	8.8
NA11B30-T4	30.0	39.5	28.0	111.4	23.0	14.0	28.2	32.2	M2.5	M3	8.8
NA11B60-T4	60.0	70.5	60.6	175.9	23.0	14.0	28.2	32.2	M2.5	M3	8.8
NA14B16-T4	16.0	25.8	16.0	95.8	26.0	15.9	35.2	34.4	M3	M4	16.5
NA14B30-T4	30.0	38.6	29.0	121.5	26.0	15.9	35.2	34.4	M3	M4	16.5
NA14B60-T4	60.0	70.2	60.4	183.1	26.0	15.9	35.2	34.4	M3	M4	16.5
NA23C60-T4	60.0	74.5	65.5	208.4	47.1	28.0	56.4	45.2	5.2	1/4"-20	22.2
NA34C60-T4	60.0	80.0	65.5	266.2	69.3	40.0	86.3	78.6	6.5	7/16"-14	38.6

*See product page for complete list of available models at www.zaber.com

**In NA08, NA11 and NA14 models, "M" is a threaded hole; in NA23 and NA34 models, "M" is a through-hole diameter.

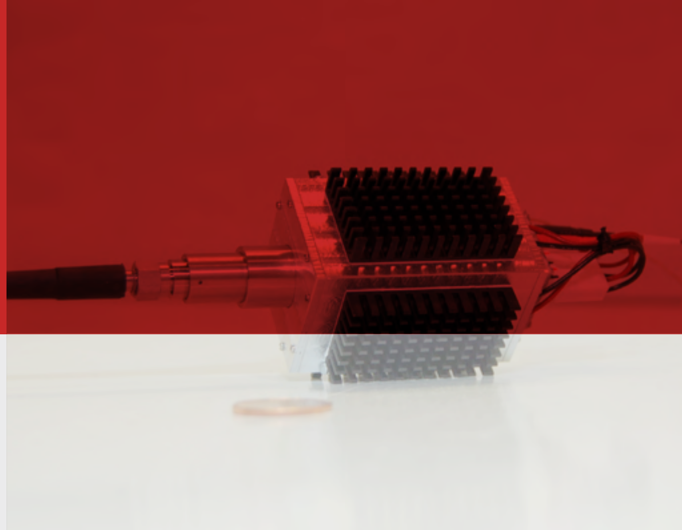


NA Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Minimum Speed (μm/s)	Maximum Speed (mm/s)	Weight (kg)
NA08A16-T4	16	0.0476	20	< 5	< 15	0.447	26	0.07
NA08A30-T4	30	0.0476	20	< 5	< 15	0.447	26	0.08
NA08B16-T4	16	0.0953	20	< 5	< 15	0.893	52	0.07
NA08B30-T4	30	0.0953	20	< 5	< 15	0.893	52	0.08
NA11B16-T4	16	0.0992	25	< 5	< 18	0.930	52	0.15
NA11B30-T4	30	0.0992	25	< 5	< 18	0.930	52	0.16
NA11B60-T4	60	0.0992	36	< 5	< 18	0.930	52	0.17
NA14B16-T4	16	0.0953	25	< 5	< 20	0.893	52	0.15
NA14B30-T4	30	0.0953	25	< 5	< 20	0.893	52	0.22
NA14B60-T4	60	0.0953	36	< 5	< 20	0.893	52	0.23
NA23C60-T4	60	0.1984	36	< 5	< 30	0.930	80	0.75
NA34C60-T4	60	0.1984	45	< 10	< 65	0.930	30	2.64

1. Complete, up-to-date specs available at www.zaber.com.

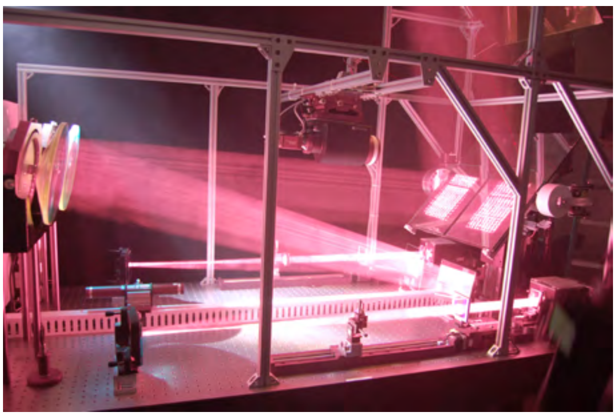
Customer Spotlight: LaserMotive Inc.



LaserMotive Inc.

LaserMotive's customers have had problems delivering *safe*, reliable electrical power in quantity and over distance to meet growing energy demands in extreme environments, where using traditional copper wires to deliver energy may be too difficult, slow, expensive, or dangerous. LaserMotive transmits electrical power with a unique technology that enables next generation lifestyle convenience for consumers' portable electronics, and solves power delivery challenges for industry customers in the power utility, commercial aircraft, telecom, unmanned aerial vehicle, and other markets.

www.lasermotive.com



We have been using our development platform laser transmitter (first used to win the 2009 NASA Centennial Challenge in Power Beaming) for a series of demonstrations of our wireless power delivery via laser. That laser transmitter uses a pair of Zaber's T-LSR450D linear slides to drive the focus element. The high speed and accuracy of the T-LSR450D enable us to meet the requirements for keeping our laser beam focused on any moving receiver.

– Tom Nugent, President, LaserMotive Inc.

LaserMotive
Power Delivery via Laser

Direct Drive Linear Motors – Overview and Selection Process

By Albert David, Applications Engineering Team

Linear motors, one kind of direct drive motion technology, take the stator and rotor concept of a rotary motor and unroll it into a linear configuration. While this is not a new technology, advances in the past few decades – including increased efficiency, greater power density, and more advanced controls – have made this drive type ideal for high precision motion control solutions. Growing popularity and usage in applications requiring precision motion control have also sparked a reduction in the cost of the technology and made linear motors a more economical option for many applications.

As the technology has developed, the number of options and configurations have also increased, with each type of linear motor featuring a completely different set of performance characteristics. While this has widened the number of requirements that linear motors can meet, it can also make it more challenging to specify the most suitable product.

To help make this process simpler, we'll start by explaining the mechanics of a direct drive linear motor and contrast it with a more traditional indirect drive system. With this foundation, we'll look at different types of linear motors, highlighting their benefits, to help identify the kinds of applications for which each is suitable. Finally, we'll cover some of the unique benefits provided by Zaber's direct drive linear motor devices. Figure 1 is an example of a Zaber linear motor stage with an integrated controller and driver.

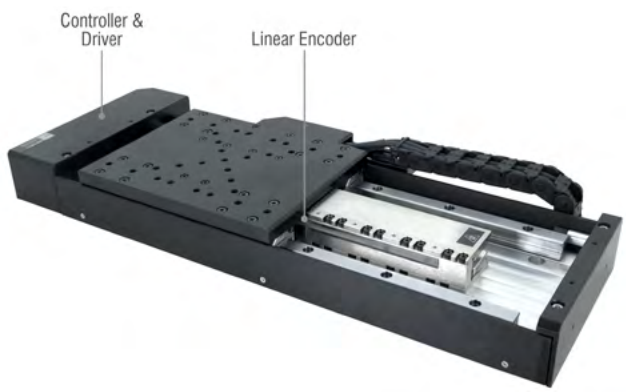


Figure 1: Example of a Zaber linear motor stage (X-LDQ-AE) with a built-in controller, driver, and linear encoder.

LINEAR MOTORS VS ROTARY MOTORS

To explain linear motors, first let's briefly describe motors in general. Electric motors create motion by generating an electromagnetic field that interacts with another magnetic field, typically generated by a permanent magnet. The electromagnetic field is varied by controlling current in the coils (also called windings) in order to control the movement.

The rotating part of the motor is called the 'rotor', and the stationary part is the 'stator'. Zaber uses brushless motors, where the permanent magnet is part of the rotor, and the windings make up the stator, as seen in Figure 2a. The permanent motor may have as few as two poles (i.e. North and South), but often has some multiple of the two. As the current to the coils is varied, the magnetic field cycles through which pole is attracted, causing the rotation.

With a linear motor, both the stator and rotor are in-line with each other. Picture the motor being unrolled, as seen in Figure 2b, resulting in a flat, linear motor, seen in Figure 2c. Exactly how they are laid out, and which of the components move versus which are stationary, determines the type of linear motor. The coil that current is running through is typically called the 'forcer' for linear motors. Rather than producing a torque, a linear force along the stage's travel length is generated as the current is varied to the forcer.

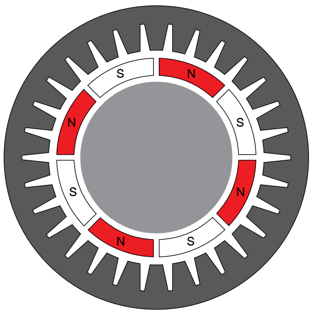


Figure 2a: Typical rotary motor.

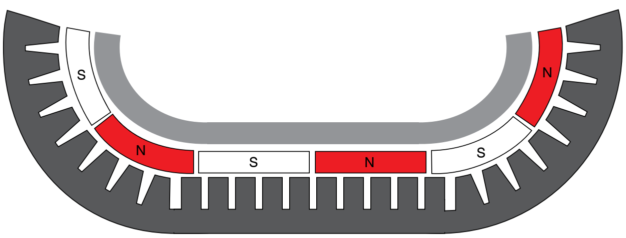


Figure 2b: "Un-rolling" a rotary motor.

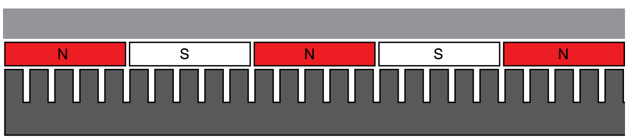


Figure 2c: Linear motor.

DIRECT DRIVE VS INDIRECT DRIVE

When a rotary motor is used in a motion control device, typically that rotation is not the kind of motion that's actually required; any or all of the direction, speed, and force may need to be different. In order to redirect the motion, mechanical parts such as gears, lead screws or ball screws, couplers, belts, and pulleys are used. Each of these components introduce friction or inaccuracy into the system, reducing the efficiency and limiting the precision. We can call these 'indirect drive' systems. These systems may use position feedback to improve accuracy but can use a variety of different encoders and motor types and can be run without position feedback.

In contrast, devices that use linear motors are called 'direct drive' because they do not have a mechanical conversion between the motor force and the required travel. This ensures the maximum efficiency and accuracy but also means that the right motor with proper specifications must be chosen as there is no mechanism to amplify the force or extend the travel range of the motor. Additionally, while linear motors are capable of creating precise and accurate motion, they require equally precise position feedback (using a linear encoder) and an advanced driver with a servo control loop to get the most performance out of the drive.

By eliminating the mechanical conversion components in a linear stage, direct drive devices are typically able to offer:

- Smaller minimum incremental move
- Higher accelerations and maximum speeds due to higher efficiency
- Zero backlash
- Higher precision
- Longer lifetime due to zero friction in the drive mechanism

While these characteristics make direct drive devices excellent for many positioning and motion control applications, there are some considerations where an indirect drive option may be more suitable because direct drive devices:

- Lack “power off” stability
- Can generate significant heat at the load and require temperature management (such as limiting duty cycle)
- Have a higher price
- May be larger than an indirect drive device with similar thrust

DIFFERENT KINDS OF LINEAR MOTORS

Different types of linear motors exist because each one compromises one aspect of performance in order to excel in another. There are four main attributes in which there is a trade-off in performance: flux density, flux leakage, moving mass, and cogging torque.

Flux Density is the magnitude of the magnetic field that can be generated within a certain space. High flux density devices provide superior force or allow a similar force in a more compact size.

Flux Leakage is an indicator of how well the electrical field is contained within the motor. Low flux leakage is typically preferable in order to prevent the magnetic field from affecting other components of the system. Flux leakage also indicates lower electrical efficiency of the motor.

Moving Mass is the mass of the moving components of the motor. Higher moving mass means lower acceleration for two motors that each have the same force output.

Cogging Force (also known as detent force) is present in any linear motor that uses iron and is the attraction of the iron to the permanent magnets. When the motor is powered and moving, it results in a cyclical force ripple over the range of travel.

In addition to these four main attributes, size and cost also vary between the different solutions available.

It is challenging to cover every type or configuration of linear motor in a short article, so the following section will focus on three distinguishing traits that are relevant for high-accuracy positioning systems: (1) flat vs U-shaped motor tracks, (2) moving coil vs moving magnet tracks, and (3) iron-core vs ironless forcers. Keep in mind that most, but not all, linear motors consist of the same main components: magnet tracks lined with permanent magnets, a forcer, and a high resolution linear encoder.

Flat vs U-shaped

Flat linear motors, as shown in Figure 3a, have a single magnet track. They generally have a lower profile and reduced cost, since they only require one magnet track. Flat linear motors generally have higher flux leakage and lower force to weight ratio. U-shaped motors, as shown in Figure 3b, have an additional magnet track, opposite the first magnet track, with the forcer moving in-between the tracks.

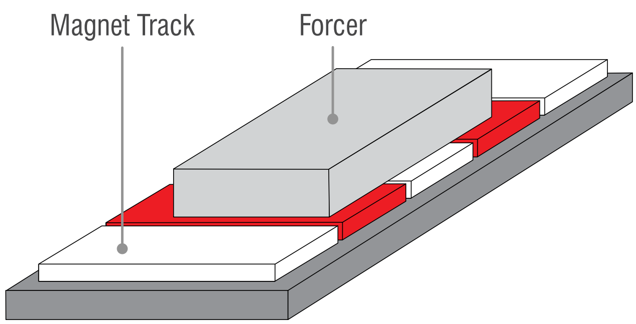


Figure 3a: Flat linear motor.

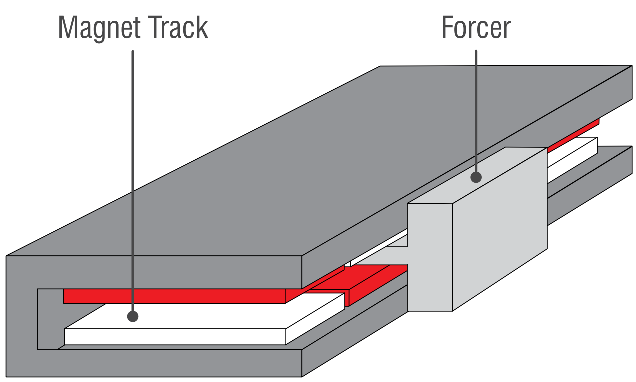


Figure 3b: U-shaped linear motor.

Moving Coil vs Moving Magnet Track

In brushless rotary motors, the windings are typically the stator because if they were part of the moving rotor the wires to it would wind up. In linear motors, this is not a consideration; the travel is limited and linear so the wires to the forcer cannot wind up. While the forcer can be the stationary 'stator', linear motors can also be set up where the forcer is moving. Typically these two kinds of systems are called either moving coil or moving magnet track motors.

Moving coil linear motors, as shown in Figure 4a, are typically used in longer travel devices in order to keep the moving mass low. The travel of any linear motor stage is limited to the length of its magnet track. For short travel stages the magnet track is also short, which keeps it relatively light and suitable for a moving magnet track stage. For long travel stages, the magnet track is long and becomes very heavy, and it makes more sense to move the coil. A downside of the moving coil linear motor is that the cables to the forcer are also always moving, so cable management is required. In general, moving coil linear motors have lower moving mass for greater acceleration.

For requirements with limited travel range, moving magnet track systems, as shown in Figure 4b, may be better as they are able to achieve higher precision. This is possible because the moving portion of the motor is electrically and thermally uncoupled, meaning it is thermally more stable and has less electrical noise. Also the stationary forcer, which heats up when current is running through it, is mounted to the base of the system, which acts as a heat sink and ensures the entire system has better thermal stability.

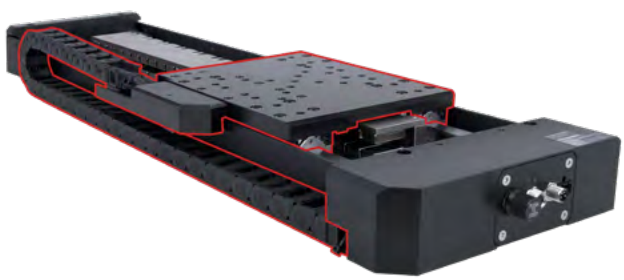


Figure 4a: Moving coil.

Figure 4b: Moving magnet track.

Iron-core vs Ironless

A typical iron-core motor has an iron backplate mounted to the forcer, and the coils are wound around iron laminations, as shown in Figure 5a and Figure 5b. Adding iron to the forcer reduces flux leakage and increases the flux density and the force output. The addition of iron to the motors also introduces cogging forces, as well as load to the bearings due to the attractive forces to the permanent magnets. A variation of the iron-core configuration is called slotless iron-core, where the coils of the forcer are not wound around iron laminations. This helps mitigate the cogging forces but also reduces the flux density. Motors without an iron-core are called ironless linear motors, shown in Figure 5c and Figure 5d, and can be used when velocity stability is more important than high force. For moving coil linear motors, the iron core can be heavy, so ironless forcers offer lower moving mass.

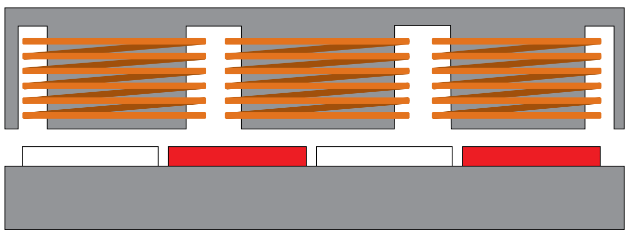


Figure 5a: Side view of a flat linear motor.

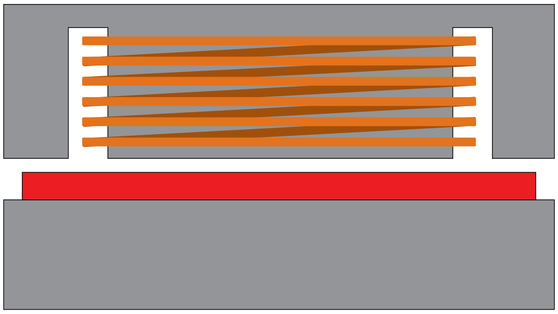


Figure 5b: Looking into a flat linear motor.

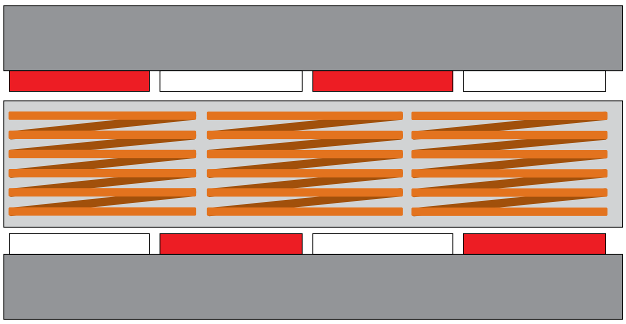


Figure 5c: Side view of a U-shaped linear motor.

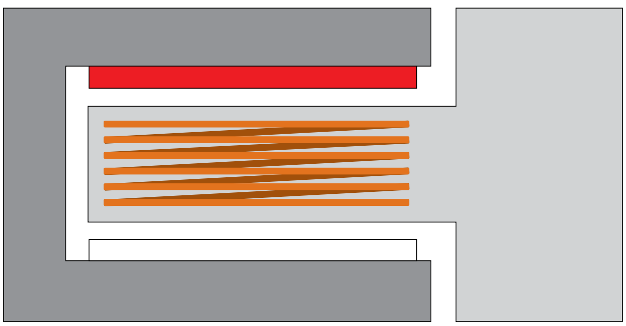


Figure 5d: Looking into a U-shaped linear motor.

WHY CHOOSE ZABER?

Zaber's linear motor devices use configurations that offer excellent performance. They combine the high accuracy, precision, speed, and acceleration that is required for many applications. Specifically, our devices:

- Use U-shaped motor designs for low flux leakage and increased flux density.
- Have ironless linear motors which are lighter and offer better precision and velocity stability during motion.
- Are available in moving coil or moving magnet track configurations.
- Have built-in controllers, drivers, and high resolution encoders.
- Are shipped pre-tuned, with free software to quickly and easily adjust tuning parameters.

At Zaber Technologies our mission statement is to Simplify Motion Control. As such, Zaber is the first company to build the controller and driver into the device. Having an integrated controller eliminates the need to find a controller that's compatible with the type of motor; it reduces cabling and allows the device to be shipped pre-tuned. Zaber's linear motor products can also daisy-chain data and power to multiple devices, further minimizing connections and simplifying control.

Another main benefit of these devices is that for most linear motor devices, once the controller is connected, the servo control loop still needs to be tuned. This can be a complicated process requiring a reasonably in-depth understanding of feedback loops. Using Zaber devices simplifies this process, as the controller is pre-set with most of the system parameters. Zaber also offers a friendly tuning interface, shown in Figure 6, to get the stages running quickly and easily without requiring any background in servo control; only the mass of the load is needed. For those with more familiarity and comfort with tuning servo controllers, a more advanced interface with many control options is available. In addition, we have an Oscilloscope tab as shown in Figure 7, which can help visualize the servo control settings defined in the servo tuning tab.

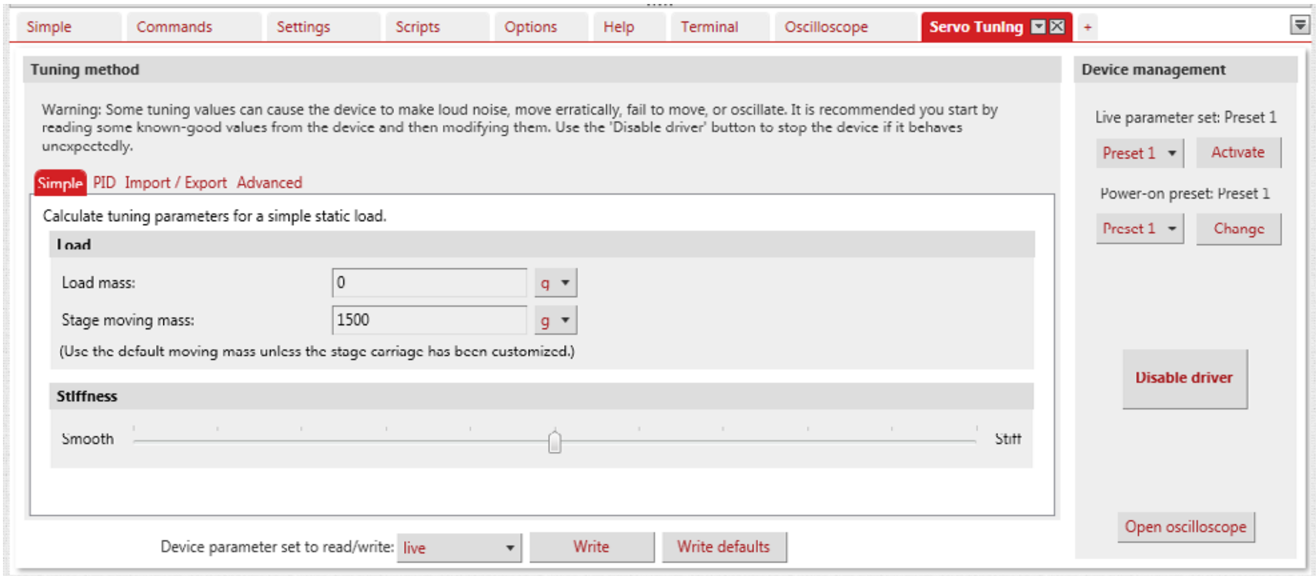


Figure 6: Zaber Console Servo Tuning tab.

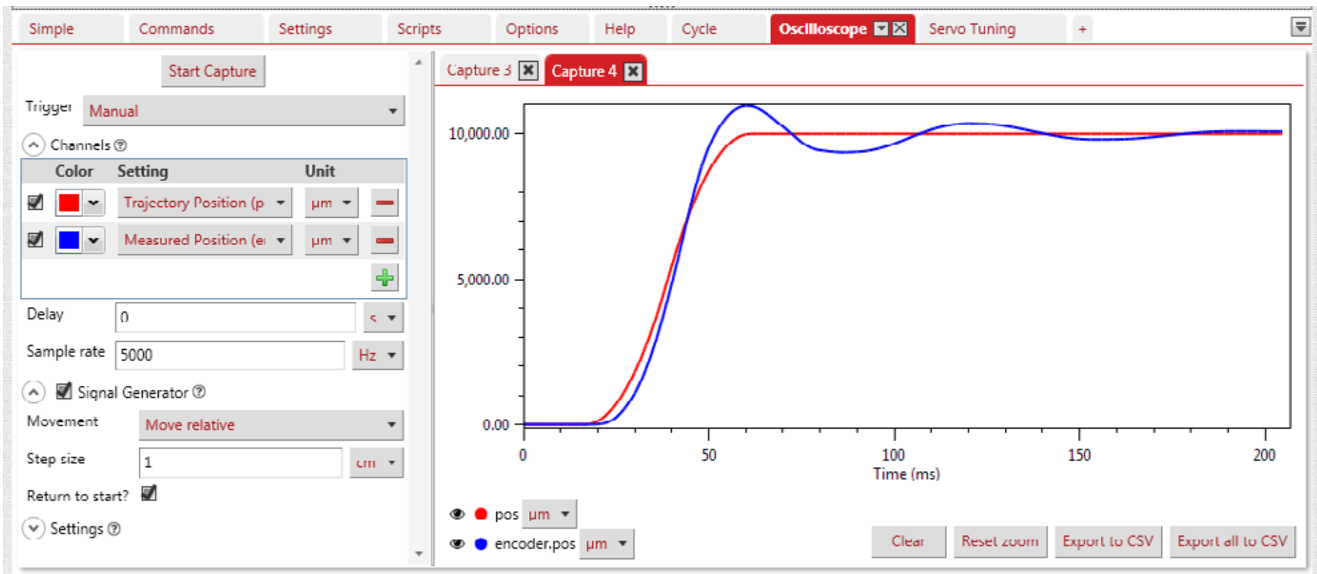


Figure 7: Zaber Console Oscilloscope tab.

CONCLUSION

The options for precision positioning devices may seem daunting, but Zaber's Applications Engineering Team is here to help you select the best product for your set-up. With our wide range of standard and customized stepper and linear motor devices, we can meet the requirements of most systems, and if you need products outside our range, we are happy to make some recommendations for you.

Why choose Zaber?
Zaber's linear motor devices use configurations that offer excellent performance. They combine the high accuracy, precision, speed, and acceleration that is required for many applications.

Albert David is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications.
For more information, please visit www.zaber.com.

- Minimum incremental move of 50 nm
- Up to 1.5 m/s speed and up to 2 g acceleration
- Each stage calibrated for improved accuracy
- Up to 2.5 µm accuracy over 1000 mm travel
- Zero backlash
- Integrated linear encoder provides high accuracy closed loop servo positioning

X-LDQ-AE Linear Motor Stages with Built-in Controllers

Product Description

Zaber's X-LDQ-AE Series devices are computer-controlled, motorized linear stages with high precision and speed capabilities. The built-in controller and linear encoder allows pre-tuned closed-loop servo positioning with adjustable tuning parameters. Like all of Zaber's products, the X-LDQ-AE Series is designed to be 'plug and play' and very easy to set up and operate.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

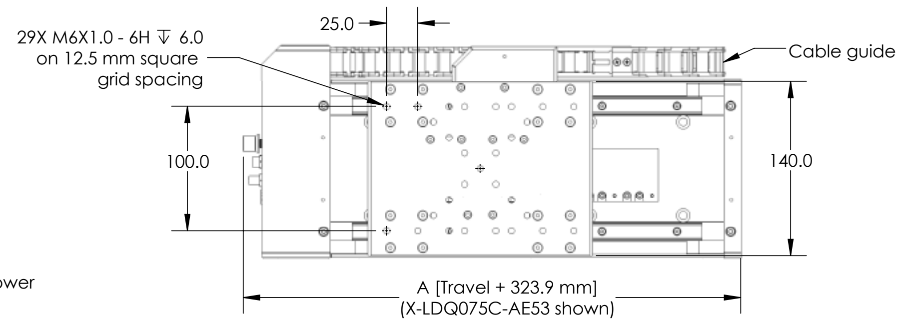
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

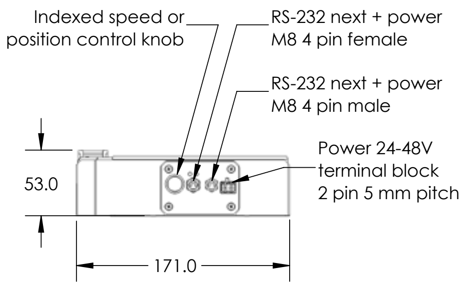
X-LDQ-AE Dimensions

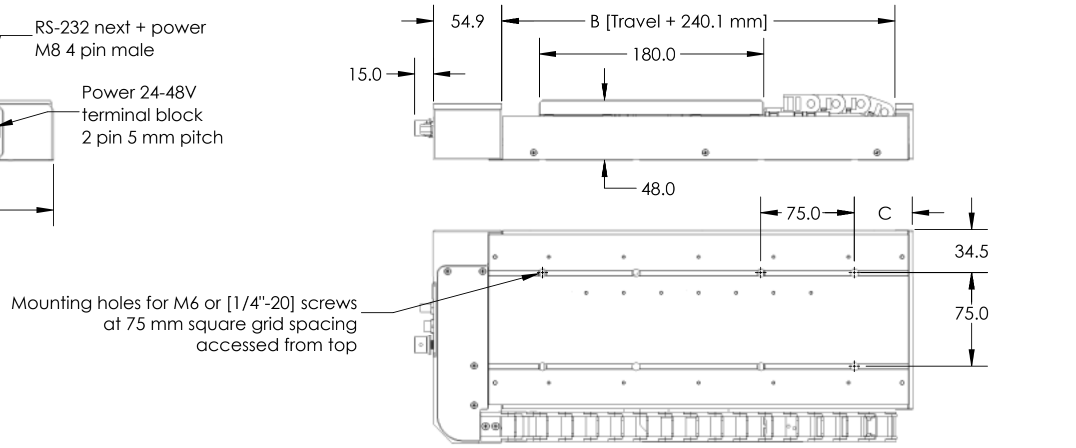
Measurements in millimetres (mm)

Model Number*	Travel	A	B	C
X-LDQ0075C-AE53	75.0	398.9	315.1	46.5
X-LDQ0150C-AE53	150.0	473.9	390.1	46.5
X-LDQ0300C-AE53	300.0	623.9	540.1	59.0
X-LDQ0450C-AE53	450.0	773.9	690.1	59.0
X-LDQ0600C-AE53	600.0	923.9	840.1	59.0
X-LDQ1000C-AE53	1000.0	1323.9	1240.1	71.5

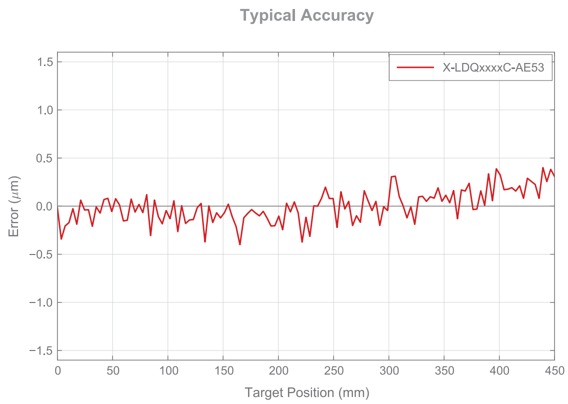
*See product page for complete list of available models at www.zaber.com







X-LDQ-AE Performance Charts



X-LDQ-AE Specifications

Model	Travel Range (mm)	Minimum Incremental Move (nm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Maximum Speed (mm/s)	Maximum Acceleration (m/s^2)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Weight (kg)
X-LDQ0075C-AE53	75	50	2.5	< 0.3	0	1500	19.62	200	3000	6.4
X-LDQ0150C-AE53	150	50	2.5	< 0.3	0	1500	19.62	200	3000	7.3
X-LDQ0300C-AE53	300	50	2.5	< 0.3	0	1500	19.62	200	3000	9.4
X-LDQ0450C-AE53	450	50	2.5	< 0.3	0	1500	19.62	200	3000	10.9
X-LDQ0600C-AE53	600	50	2.5	< 0.3	0	1500	19.62	200	3000	13.2
X-LDQ1000C-AE53	1000	50	2.5	< 0.3	0	1500	19.62	200	3000	18.6

1. Complete, up-to-date specs available at www.zaber.com.

X-LDM-AE Ultra Precision Linear Motors with Built-in Controllers

- Non-contact ironless linear motor for ultra precision, high dynamics and zero backlash
- Direct position measurement from 1 nm resolution linear encoder
- Up to 1.2 m/s speed and up to 3.5 g acceleration
- 60, 110, 210 mm travel options
- 80 nm repeatability, 1 μm accuracy, 25 nm minimum incremental move

Product Description

Zaber's X-LDM-AE Series devices are computer-controlled, motorized linear stages suited for applications demanding outstanding precision, throughput, and reliability. A centrally mounted linear encoder results in 1 μm position accuracy and consistent movement steps down to 25 nm. X-LDM-AE devices feature oversized ironless linear motors, providing high speed and acceleration, while minimizing heat generation to improve repeatability. Both the drive and encoder are non-contact and have no moving cables, resulting in an extremely robust system. Like all of Zaber's products, the X-LDM-AE Series is designed to be 'plug and play' and very easy to set up and operate.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

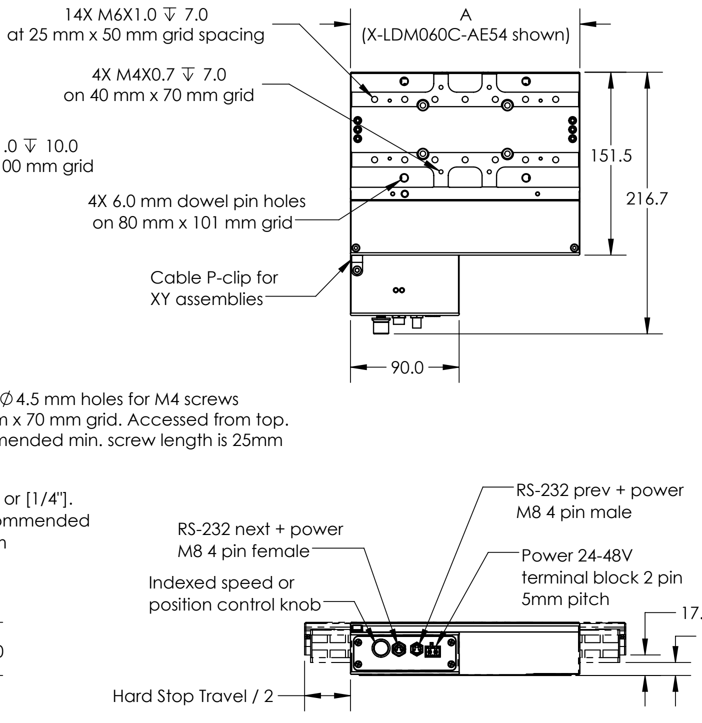
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

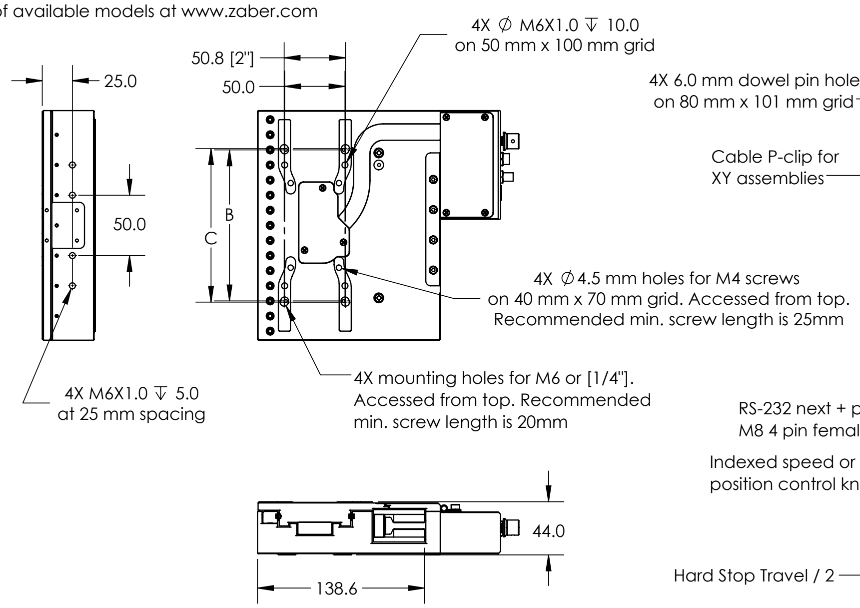
X-LDM-AE Dimensions

Measurements in millimetres (mm)

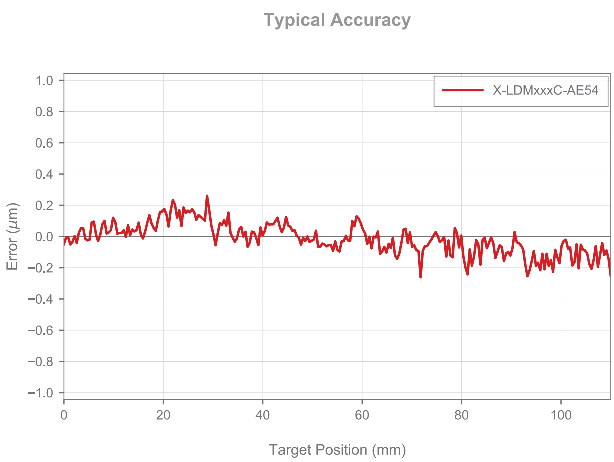
Model Number*	Nominal Travel	Hard Stop Travel	A	B	C
X-LDM060C-AE54	60.0	76.0	190.0	125.0	127.0 [4"]
X-LDM110C-AE54	110.0	126.0	245.0	150.0	152.4 [6"]
X-LDM210C-AE54	210.0	226.0	345.0	175.0	177.8 [7"]

*See product page for complete list of available models at www.zaber.com





X-LDM-AE Performance Charts



X-LDM-AE Specifications

Model	Travel Range (mm)	Minimum Incremental Move (nm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Maximum Speed (mm/s)	Maximum Acceleration (m/s^2)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Weight (kg)
X-LDM060C-AE54	60	25	1	< 0.08	0	1200	34.3	120	1200	3.76
X-LDM110C-AE54	110	25	1	< 0.08	0	1200	24.5	120	1200	4.84
X-LDM210C-AE54	210	25	1	< 0.08	0	1200	14.7	120	1200	6.60

1. Complete, up-to-date specs available at www.zaber.com.

X-DMQ-DE Direct Drive Linear Stages with Linear Encoders

- 12 mm travel, 15.5 N peak thrust with adjustable force control mode
- Integrated 200 nm resolution linear encoder provides closed-loop, high precision position control
- Daisy-chains with other X-Series products to share data and a single power supply
- Built-in controller; up to 1400 mm/s, 25 Hz full-travel

Product Description

Zaber's X-DMQ-DE Series devices are computer-controlled, direct drive linear stages with high acceleration and precision capabilities in a compact size. At only 30 mm high, these miniature stages are excellent for applications where a low profile is required. The X-DMQ-DE's innovative design allows speeds up to 1400 mm/s and loads up to 10 kg. They are stand-alone devices requiring only a standard 24–48 V power supply.

Closed-Loop Operation

X-DMQ-DE stages use built-in linear encoders to provide position verification and correction. Each stage is calibrated in-house and shipped with an inspection report showing the device's positioning characteristics. The linear encoder is used for both final position correction and stall detection.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

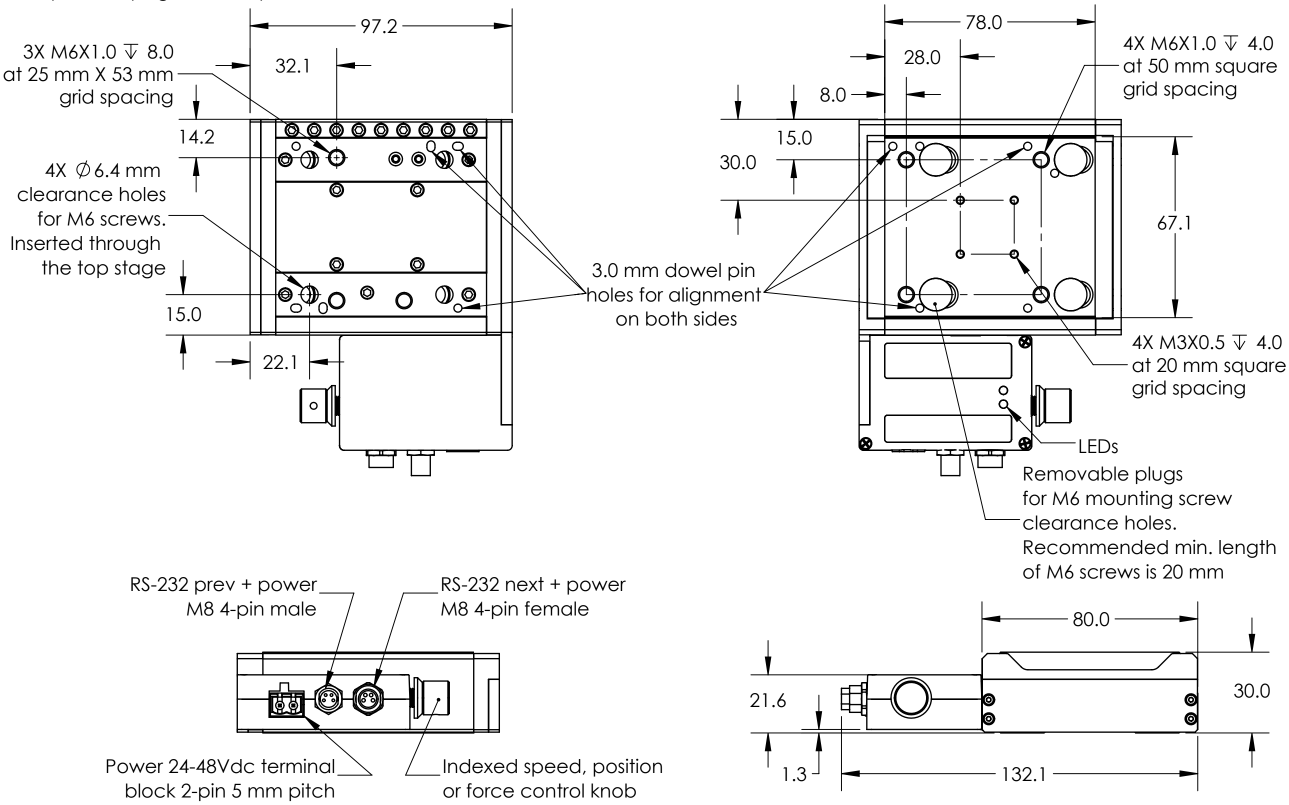
Manual Control

An optional indexed knob provides convenient manual control for versatile operation even without a computer. This knob can be set to manually control position, velocity, or force output in programmable increments.

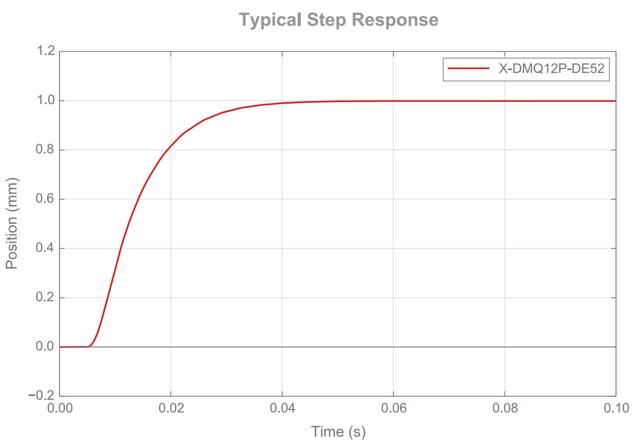
X-DMQ-DE Dimensions

Measurements in millimetres (mm)

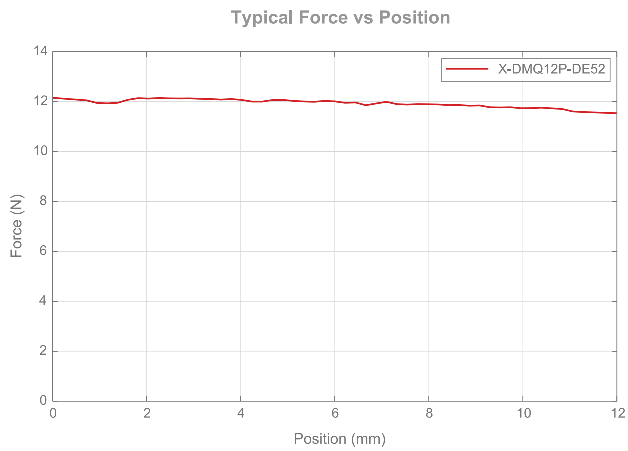
*See product page for complete list of available models at www.zaber.com



X-DMQ-DE Performance Charts



*Step response tested with 0.5 kg load.



X-DMQ-DE Specifications

Model	Travel Range (mm)	Accuracy (µm)	Repeatability (µm)	Encoder Resolution (nm)	Force Constant (N/amp)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Peak Thrust (N)	Weight (kg)
X-DMQ12P-DE52	12	2.2	< 0.5	200	12.6	0.122	1400	100	15.5	0.76

1. Complete, up-to-date specs available at www.zaber.com.

Microstepping Tutorial

MICROSTEPPING THEORY

A bipolar stepper motor has two windings. The current through each winding is varied in order to rotate the stepper motor. When considering stepper motor drive techniques, a “phase diagram” is a useful visualization tool. The current through one winding I_a is plotted against the current through the other winding I_b. Modes of operation such as full stepping, half stepping, microstepping, and operation at different current limits can be easily visualized on such a diagram. In addition, it is possible to visualize changes in both power consumption and torque as a function of angular position. Simple stepper motor controllers are only capable of driving a winding with full positive current, no current, or full negative current. Given these available outputs it is only possible to implement full stepping, half stepping, or wave stepping.

FULL STEPPING

In full stepping operation, the current required in each winding is either -Imax or +Imax. A step sequence of 4 full steps makes up one complete step cycle. Note that these full step positions are the same as the odd numbered positions from the half stepping sequence.

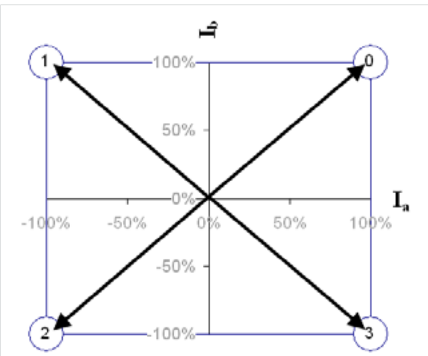
HALF STEPPING

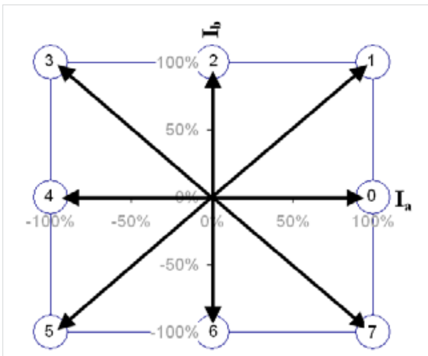
In a half stepping operation, the current required in each winding is either -Imax, 0, or +Imax. A step sequence of 8 half steps makes up one complete step cycle.

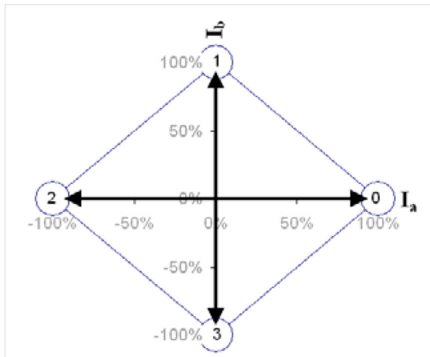
WAVE STEPPING

Wave stepping is another method of full stepping, but with reduced power requirements (and corresponding torque output) since only one winding is powered at a time. The current required in each winding is either -Imax, 0 or +Imax. A step sequence of 4 full steps makes up one complete step cycle. Note that these full step positions are the same as the even numbered positions from the half stepping sequence.

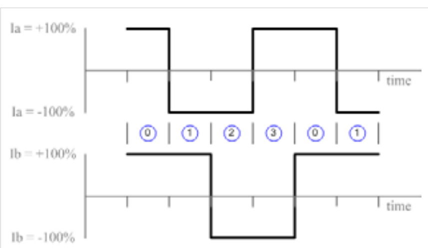
PHASE DIAGRAM

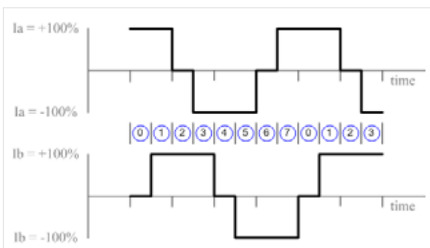


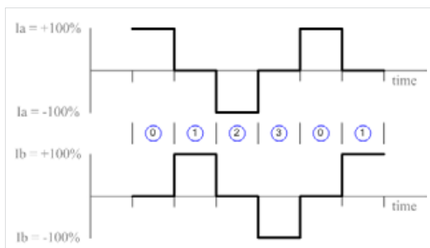




TIMING DIAGRAM





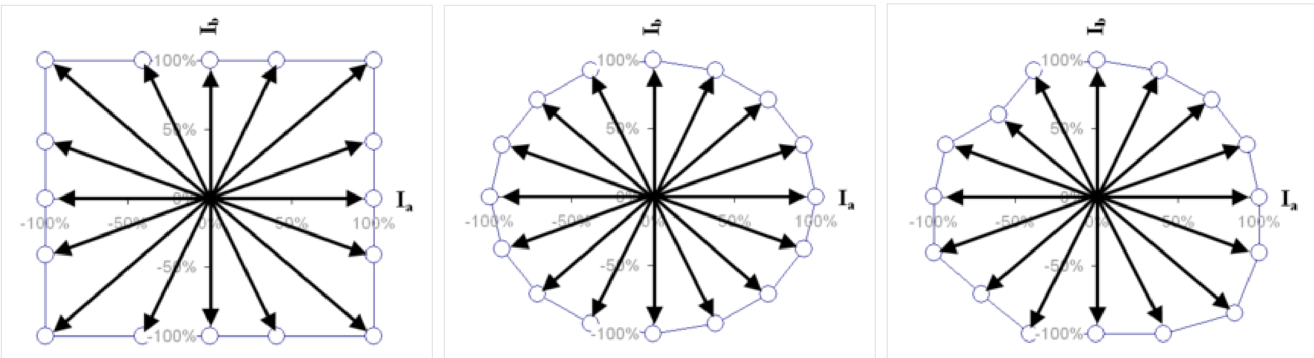


The arrows in each phase diagram are called "phasors". The angle theta that the phasor moves from one position to the next is the step or microstep angle. On a phase diagram, 90° corresponds to one full step and 360° corresponds to a "full step sequence". A full step sequence is a sequence of steps or microsteps which, when repeated, will produce continuous rotation of the motor. Assuming adequate torque, any continuous path which traverses the 4 quadrants of the phase diagram with at least one point per quadrant will suffice to rotate the stepper motor. If the controller is designed with the capability to control the magnitude of the current in each winding, then microstepping can be implemented. The phase diagrams below all show different implementations of "divide by 4" microstepping. Note that it is the phasor angle (not its length) that determines the microstep position. The phasor length affects power consumption and available torque as we will see later.

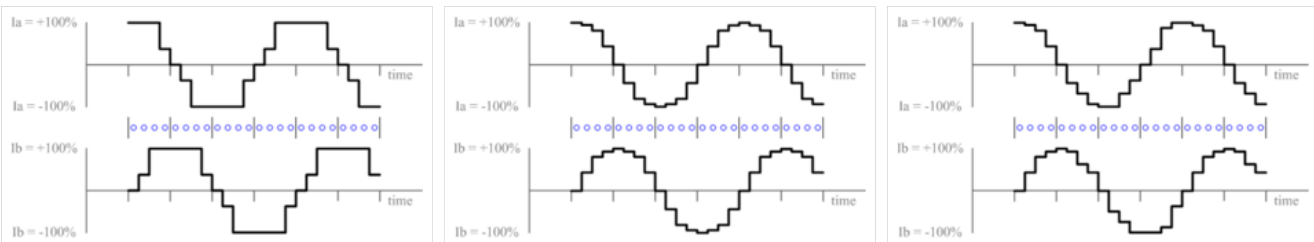
MICROSTEPPING - SQUARE PATH
This method of microstepping provides the highest peak torque if you are limited by available supply voltage.

MICROSTEPPING - CIRCULAR PATH
This method is also referred to as sine cosine microstepping and is usually what people are referring to when they talk about microstepping, though in fact it is only one method.

MICROSTEPPING - ARBITRARY PATH
There would be little reason to use a method such as this. It is presented only to illustrate the possibilities. Although it looks very strange compared to the other two methods, in theory it will produce the same angular rotation of an ideal motor. Only the available thrust would differ.



PHASE DIAGRAM



TIMING DIAGRAM

While it is convenient to think of the I_a and I_b axes as representing full step positions, it should be recognized that this is an arbitrary choice and any 4 positions in the phase diagram that are 90° apart from each other could be considered full step positions. However, for the sake of simplicity, let us consider the positive I_a axis to represent theta = 0°. As theta increases, the phasor moves counter-clockwise from this position. At theta = 90° the phasor lies along the positive I_b axis, one full step from its starting position. Any angle theta between 0 and 90° represents a possible microstep position (a position between full step positions). If you wish to implement "divide by 10" microstepping, then you must generate values of I_a and I_b that correspond to values of theta equal to 0, 9, 18, 27 ... 81, 90°, etc.

$$theta = Tan^{-1}(I_b/I_a)$$

There are many values of I_a and I_b that could be chosen to produce the same phasor angle theta. The choice of phasor length is typically decided based on the motor power rating and the application's torque requirements. Power and torque are both related to phasor length. The power draw at any given angular position is given by the formula:

$$power = I_a^2R + I_b^2R$$

where R is the winding resistance (both windings should have the same resistance)

The length of the phasor is given by the formula:

$$phasor\_length = Sqrt(I_a^2 + I_b^2) = Sqrt(Power/R)$$

Thus the phasor length gives an indication of the power draw at each microstep angle. Torque is directly proportional to current (assuming magnetic saturation is not reached). Thus, the available torque is directly proportional to phasor length, and the phase diagram gives an indication of how torque may vary with microstep position.

Aside: note that phasor length is proportion to torque and to Sqrt(Power). Therefore torque is proportional to Sqrt(Power). In other words, a 2x increase in torque requires a 4x increase in power (assuming magnetic saturation is not reached).

A phasor of constant length is typically used for smoothest operation (minimum torque ripple) and constant power output. This results in a circular path around the phase diagram, the phasor length being the radius of the circle. This technique is referred to as "sine cosine microstepping" because the target values for I_b and I_a are proportional to sin(theta) and cos(theta) respectively. In practice, the term microstepping usually refers to sine cosine microstepping, but in theory, sine cosine microstepping is only one method of microstepping. As mentioned above, a functioning microstepping algorithm may be designed around any arbitrary path which traverses the 4 quadrants of the phase diagram and has at least one point per quadrant.

The maximum continuous power output of a motor is usually specified by the manufacturer. This places an upper limit on phasor length, $sqrt(I_a^2 + I_b^2)$. The effective limit that this places on I_a and I_b will depend on the geometry of the path chosen around the phase diagram.

One must also consider the limitations of the power supply being used to drive the motor. In voltage-controlled products, the maximum values of I_a and I_b may be limited by the power supply voltage (I=V/R). In this case, using a square phase profile is a way to achieve higher torque without requiring a higher voltage power supply.

Zaber devices are driven in circular phase path to achieve smooth motion and constant power output. The current limit is user configurable and specifies the value of I_a at theta = 0. In some Zaber devices (T-Series), square phase mode is also available. Square phase mode offers about 40% higher torque for the same current limit.

However there is a price to pay and that is torque ripple. You can see that as you move around the phase diagram along a square path, the torque (proportional to the length of the phasor) will be constantly increasing and decreasing. This results in less smoothness of operation and less microstepping accuracy. Generally, it is easier to achieve higher torque simply by increasing the current limit. However, sometimes, your maximum current limit is restricted by your supply voltage, or the capabilities of your controller. In this case, reduced smoothness and accuracy may be an acceptable compromise for additional torque.

SOURCES OF ERROR IN MICROSTEPPING SYSTEMS

Stepper motor control systems are usually open loop. That is, the controller does not have position feedback and therefore is not aware of the "actual" position of the motor. Therefore, it is important to be aware of possible sources of error that will result in the actual position being different from the calculated position.

QUANTIZATION ERROR

In any digital controller, it is impossible to achieve infinitely variable I_a and/or I_b. Only discrete or "quantized" values are possible. The number of discrete values depends on the resolution achievable by the controller. For example, if the maximum current output of the controller is 1 A, and the controller has a resolution of 0.1 A, then there are 10 possible current values for I_a and/or I_b, not including 0. The number of discrete values possible determines how close mathematically the phasor can be set to a particular length and microstep angle. The error between the desired phasor angle and the actual phasor angle achieved is the quantization error.

A maximum quantization error equivalent to 0.5 microsteps is a typical design requirement in any microstepping control algorithm. Note that by adjusting the phasor end point to a nearby I_a,I_b point rather than sticking to a strictly circular or square profile can often reduce the quantization error, but may add some torque ripple. Thus, the current resolution you require for I_a and I_b will be determined by the number of microsteps per step you want to achieve, the quantization error you can tolerate, and the torque ripple you can tolerate.

In Zaber's stepper motor control algorithm, our design requirements were 128 microsteps per step with a quantization error less than 0.5 microsteps, and a torque ripple less than 2.5%. Determining how many discrete current values are required for I_a and I_b is a task best left to a spreadsheet application, such as Excel. Even then, it requires a certain degree of trial and error. As it turns out, 80 discrete current settings (between 0 and the running current) are required to achieve 128 microsteps per step with a quantization error less than 0.5 microsteps, and a torque ripple less than 2.5%. The resulting quantization error at each microstep position is plotted below in Figure 1.

DETENT ERROR

Detent torque is the maximum torque that can be applied to an unenergized stepper motor without causing continuous rotation. If you plotted torque versus shaft angle as you slowly rotate the stepper motor with no current in either winding, then you would find that the torque is approximately sinusoidal with shaft angle. The detent torque is just the amplitude of the sine curve. In an ideal motor, the torque curve would be perfectly sinusoidal. What is commonly referred to as "detent error" isn't due to the existence of the detent torque per se but due to the non-sinusoidal component of the detent torque. The shape of the torque curve is affected by motor pole geometry. In that sense, detent error is really pole geometry error. Because different motor manufacturers use different pole geometries, this error can vary from one manufacturer to another as well as from one motor to another.

MOTOR POLE PLACEMENT ERROR

Motor pole placement error results in a varying step size. There is typically an error that repeats every 4 steps (one complete step cycle), as well as an error that repeats every full revolution. This has an obvious effect on microstepping. The microstep size within large steps will be proportionally larger than the microstep size in small steps. Pole placement error in a typical motor is less than 0.5 steps of cumulative error over half a revolution of the motor. Given that a typical motor has 200 steps per revolution, that translates to an error in step size of roughly +/- 0.5%. It is possible to eliminate pole placement error in any application simply by moving in increments of one full revolution of the motor. If that is not possible, then some error can be eliminated by moving in increments of 4 steps. However, moving in increments of 4 steps or full revolutions is clearly not microstepping. Therefore, all microstepping applications invariably suffer from some pole placement error.

LEAD SCREW PITCH ERROR

Many motorized systems convert rotary motion to linear motion via lead screw. Stepper motor applications are no exception. In these types of systems, any error in the lead screw pitch will contribute to the total system error.

STICKTION AND BACKLASH ERROR

In microstepping systems, mechanical sticktion and backlash are frequently much larger than the microstep resolution. There are many systems on the market capable of microstepping at 256 microsteps per step, but there is little point to this if mechanical sticktion in the system will be on the order of 5 to 10 microsteps at that microstep resolution.

SOURCES OF FAILURE IN MICROSTEPPING SYSTEMS

This discussion has centred on the challenges of designing a microstepping system, but there are also challenges when implementing a system. If the load on a stepper motor exceeds its maximum torque, then the motor poles will not follow the changing magnetic field and the motor stalls. To avoid this type of failure, microstepping systems must either keep the load below the maximum torque, or include position sensors to detect and compensate for stalls.

X-LRQ-DEC Motorized Linear Stages with Linear Encoders

- Optional built-in controller; daisy-chains with other Zaber products
- Optional integrated linear encoder with 50 nm resolution provides stall detection and position correction
- Each stage calibrated for improved accuracy
- Up to 205 mm/s speed and up to 300 N thrust; 100 kg load capacity
- Optional stainless steel dust cover

Product Description

Zaber's X-LRQ-DEC Series devices are computer-controlled, motorized linear stages with high stiffness, load, and lifetime capabilities in a compact size. An optional integrated linear encoder combined with stage calibration provides high accuracy positioning over the full travel of the device. Each device is available in either an inline or parallel drive configuration. At only 48 mm high, these stages are excellent for applications where a low profile is required. The X-LRQ-DEC's innovative design allows speeds up to 205 mm/s and loads up to 100 kg. Like all of Zaber's products, the X-LRQ-DEC Series is designed to be 'plug and play' and very easy to set up and operate. These stages can bolt together into an XY system, and with the addition of our AB104 bracket, vertical mounting for XYZ configurations is possible. The flexible stainless steel dust cover protects the internal lead screw and bearings.

Closed-Loop Operation

X-LRQ-DEC stages use built-in linear encoders to provide position verification and correction. Each stage is calibrated in-house and shipped with an inspection report showing the device's positioning characteristics. The linear encoder is used for both final position correction and stall detection.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

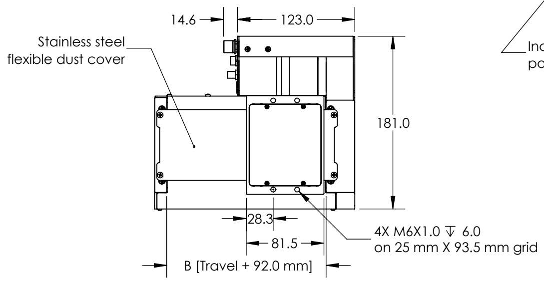
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

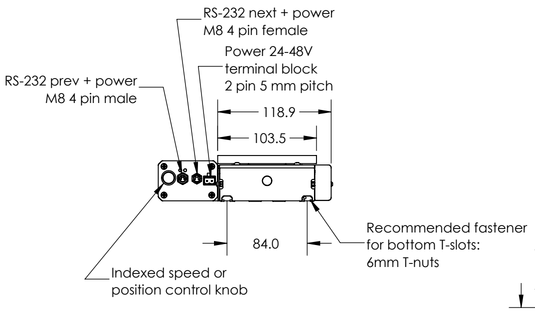
X-LRQ-DEC Dimensions

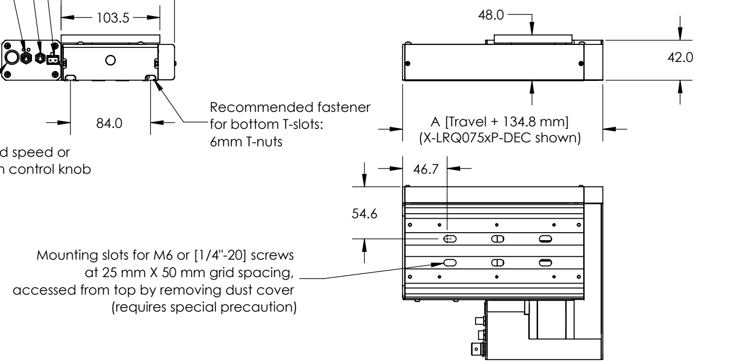
Measurements in millimetres (mm)

Model Number*	Travel	A	B
X-LRQ075xP-DEC	75.0	209.8	167.0
X-LRQ150xP-DEC	150.0	284.8	242.0
X-LRQ300xP-DEC	300.0	434.8	392.0
X-LRQ450xP-DEC	450.0	584.8	542.0
X-LRQ600xP-DEC	600.0	734.8	692.0

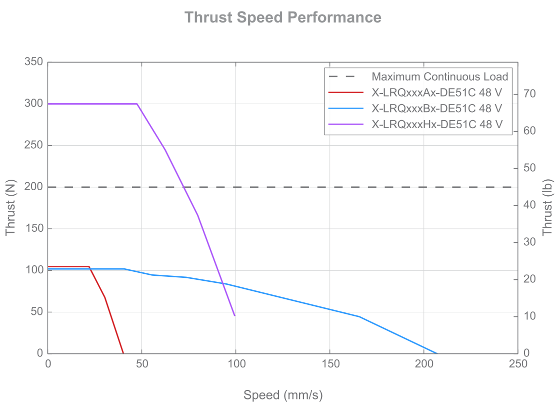
*See product page for complete list of available models at www.zaber.com

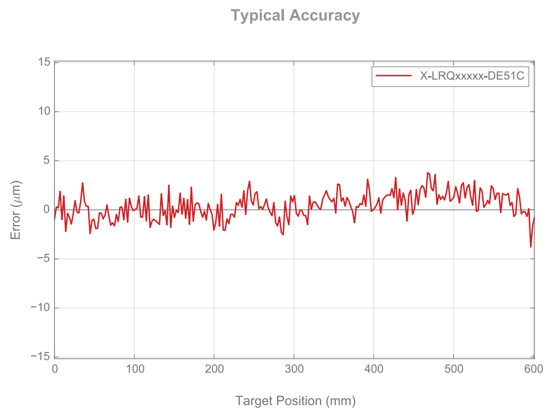






X-LRQ-DEC Performance Charts





X-LRQ-DEC Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (No Load) (μm)	Maximum Speed (mm/s)	Peak Thrust (N)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Weight (kg)
X-LRQ075AL-DE51C	75	0.099	13	< 2.5	< 8	40	110	1000	3000	2.51
X-LRQ075BL-DE51C	75	0.496	15	< 3.5	< 11	205	100	1000	3000	2.51
X-LRQ075HL-DE51C	75	0.195	15	< 3	< 11	100	300	1000	3000	2.51
X-LRQ150AL-DE51C	150	0.099	13	< 2.5	< 8	40	110	1000	3000	2.93
X-LRQ150BL-DE51C	150	0.496	15	< 3.5	< 11	205	100	1000	3000	2.93
X-LRQ150HL-DE51C	150	0.195	15	< 3	< 11	100	300	1000	3000	2.93
X-LRQ300AL-DE51C	300	0.099	13	< 2.5	< 8	40	110	1000	3000	3.77
X-LRQ300BL-DE51C	300	0.496	15	< 3.5	< 11	205	100	1000	3000	3.77
X-LRQ300HL-DE51C	300	0.195	15	< 3	< 11	100	300	1000	3000	3.77
X-LRQ450AL-DE51C	450	0.099	13	< 2.5	< 8	40	110	1000	3000	4.61
X-LRQ450BL-DE51C	450	0.496	15	< 3.5	< 11	205	100	1000	3000	4.61
X-LRQ450HL-DE51C	450	0.195	15	< 3	< 11	100	300	1000	3000	4.61
X-LRQ600AL-DE51C	600	0.099	13	< 2.5	< 8	40	110	1000	3000	5.41
X-LRQ600BL-DE51C	600	0.496	15	< 3.5	< 11	205	100	1000	3000	5.41
X-LRQ600HL-DE51C	600	0.195	15	< 3	< 11	100	300	1000	3000	5.41

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

- Hardened steel construction and integrated recirculating ball bearing guide
- 50 kg load capacity; up to 15 μm accuracy over 200 mm
- Exceptional stiffness and thermal stability
- Optional integrated linear encoder with 50 nm resolution

X-LRM-DE Steel Motorized Stages with Linear Encoders

Product Description

Zaber's X-LRM-DE Series devices are motorized linear stages with optional integrated controllers and linear encoders. The X-LRM-DE's hardened steel construction and recirculating ball bearing guide provide exceptional rigidity and thermal stability. An integrated linear encoder combined with stage calibration provides high accuracy positioning over the full travel of the device. These stages are stand-alone devices requiring only a standard 24–48 V power supply. High stiffness makes the X-LRM-DE ideal for multi-axis configurations or applications where excellent stability under cantilever loads is required.

Closed-Loop Operation

X-LRM-DE stages use built-in linear encoders to provide position verification and correction. Each stage is calibrated in-house and shipped with an inspection report showing the device's positioning characteristics. The linear encoder is used for both final position correction and stall detection.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the unit allow for secure connection between units.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

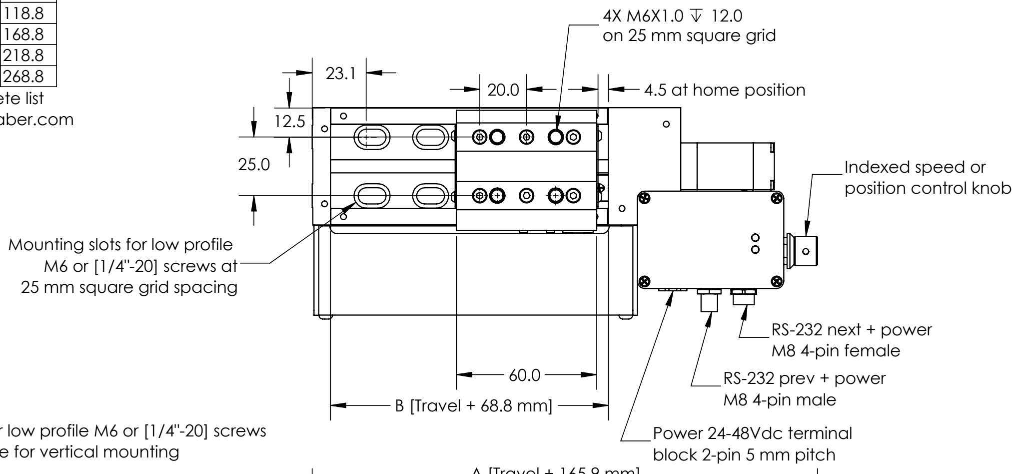
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

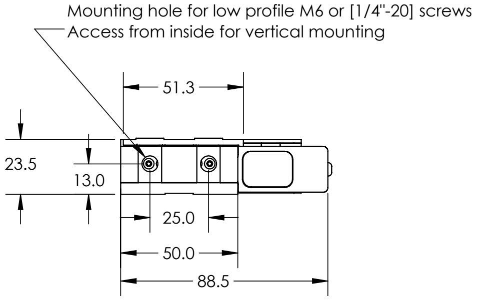
X-LRM-DE Dimensions

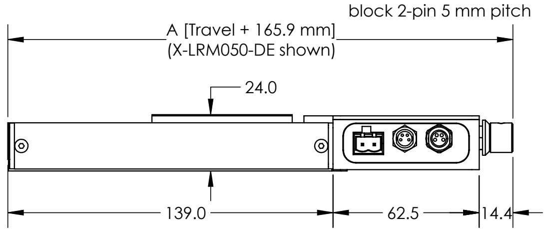
Measurements in millimetres (mm)

Model Number*	Travel	A	B
X-LRM025-DE	25.0	190.9	93.8
X-LRM050-DE	50.0	215.9	118.8
X-LRM100-DE	100.0	265.9	168.8
X-LRM150-DE	150.0	315.9	218.8
X-LRM200-DE	200.0	365.9	268.8

*See product page for complete list of available models at www.zaber.com

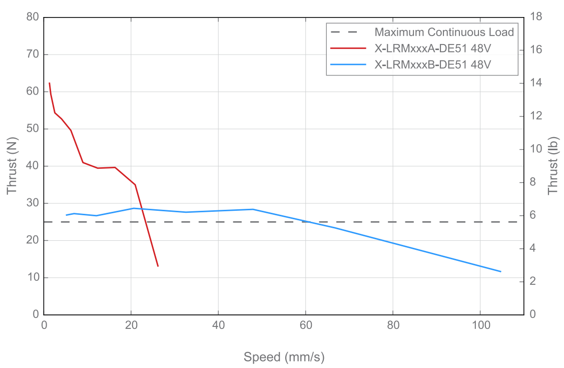




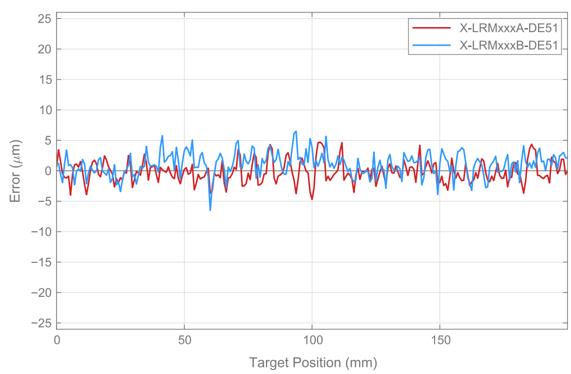


X-LRM-DE Performance Charts

Thrust Speed Performance



Typical Accuracy



X-LRM-DE Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Minimum Speed (μm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LRM100A-DE51	100	0.048	15	< 4	< 5	0.029	25	500	1500	50	1.14
X-LRM100B-DE51	100	0.191	15	< 4	< 5	0.116	100	500	1500	50	1.14
X-LRM150A-DE51	150	0.048	15	< 4	< 5	0.029	25	500	1500	50	1.32
X-LRM150B-DE51	150	0.191	15	< 4	< 5	0.116	100	500	1500	50	1.32
X-LRM200A-DE51	200	0.048	15	< 4	< 5	0.029	25	500	1500	50	1.50
X-LRM200B-DE51	200	0.191	15	< 4	< 5	0.116	100	500	1500	50	1.50

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-LRT-EC High Load, Closed-loop Linear Stages

- High torsional and cantilever stiffness
- 500 kg load capacity; up to 1500 mm travel
- Up to 360 mm/s; 1200 N thrust
- Optional motor encoder
- Stainless steel dust cover

Product Description

Zaber's X-LRT-EC Series devices are high load, closed-loop motorized linear stages with an integrated motor encoder and stainless steel dust cover. These stages are stand-alone devices requiring only a standard 24–48 V power supply. High stiffness makes the X-LRT-EC ideal for multi-axis configurations or applications where excellent stability under cantilever loads or high stiffness is required.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the unit allow for secure connection between units.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

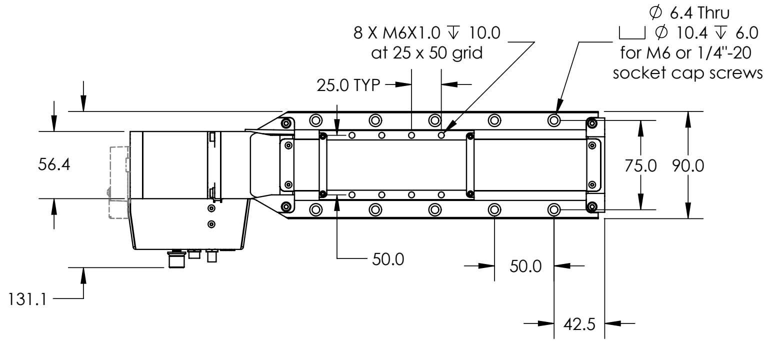
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

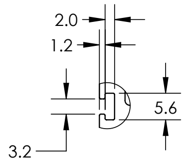
X-LRT-EC Dimensions

Measurements in millimetres (mm)

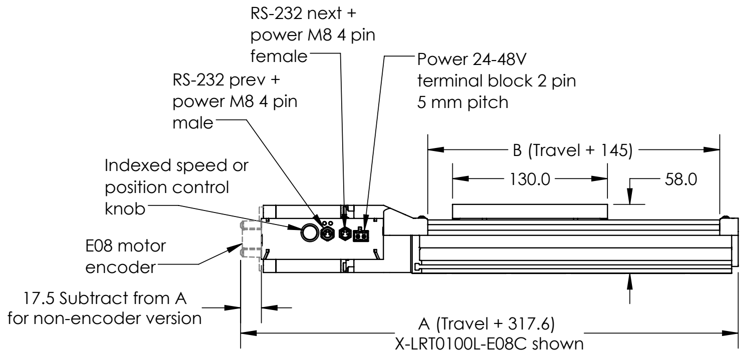
Model Number*	Travel	A	B
X-LRT0100xL-(E08)C	100	417.6	245
X-LRT0250xL-(E08)C	250	567.6	395
X-LRT0500xL-(E08)C	500	817.6	645
X-LRT0750xL-(E08)C	750	1067.6	895
X-LRT1000xL-(E08)C	1000	1317.6	1145
X-LRT1500xL-(E08)C	1500	1817.6	1645

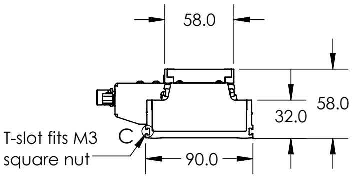
*See product page for complete list of available models at www.zaber.com





DETAIL C
SCALE 1 : 1





End opposite motor

X-LRT-EC Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LRT100AL-E08C	100	0.124	25	< 2	< 6	0.076	20	5000	120	1200	3.65
X-LRT100BL-E08C	100	0.496	25	< 2	< 10	0.303	90	5000	120	600	3.65
X-LRT100DL-E08C	100	1.984	25	< 4	< 32	1.21	360	5000	120	180	3.65
X-LRT100HL-E08C	100	0.391	45	< 4	< 20	0.239	71	5000	120	1200	3.65
X-LRT250AL-E08C	250	0.124	63	< 2	< 6	0.076	20	5000	120	1200	4.41
X-LRT250BL-E08C	250	0.496	63	< 2	< 10	0.303	90	5000	120	600	4.41
X-LRT250DL-E08C	250	1.984	63	< 4	< 32	1.21	360	5000	120	180	4.41
X-LRT250HL-E08C	250	0.391	113	< 4	< 20	0.239	71	5000	120	1200	4.41
X-LRT500AL-E08C	500	0.124	125	< 2	< 6	0.076	20	5000	120	1200	5.76
X-LRT500BL-E08C	500	0.496	125	< 2	< 10	0.303	90	5000	120	600	5.76
X-LRT500DL-E08C	500	1.984	125	< 4	< 32	1.21	360	5000	120	180	5.76
X-LRT500HL-E08C	500	0.391	225	< 4	< 20	0.239	71	5000	120	1200	5.76
X-LRT750AL-E08C	750	0.124	188	< 2	< 6	0.076	20	5000	120	1200	7.08
X-LRT750BL-E08C	750	0.496	188	< 2	< 10	0.303	90	5000	120	600	7.08
X-LRT750DL-E08C	750	1.984	188	< 4	< 32	1.21	360	5000	120	180	7.08
X-LRT750HL-E08C	750	0.391	338	< 4	< 20	0.239	71	5000	120	1200	7.08
X-LRT1000AL-E08C	1000	0.124	250	< 2	< 6	0.076	20	5000	120	1200	8.39
X-LRT1000BL-E08C	1000	0.496	250	< 2	< 10	0.303	90	5000	120	600	8.39
X-LRT1000DL-E08C	1000	1.984	250	< 4	< 32	1.21	360	5000	120	180	8.39
X-LRT1000HL-E08C	1000	0.391	450	< 4	< 20	0.239	71	5000	120	1200	8.39
X-LRT1500AL-E08C	1500	0.124	375	< 2	< 6	0.076	15	5000	120	1200	11.03
X-LRT1500BL-E08C	1500	0.496	375	< 2	< 10	0.303	60	5000	120	600	11.03
X-LRT1500DL-E08C	1500	1.984	375	< 4	< 32	1.21	240	5000	120	180	11.03

1. Complete, up-to-date specs available at www.zaber.com.
2. Models with external control and/or with linear encoders available.

- Optional built-in controller; daisy-chains with other Zaber products
- Optional, 500 CPR, motor encoder provides slip/stall detection and recovery
- Up to 840 mm/s speed and up to 300 N thrust; 100 kg load capacity
- Inline and parallel drive configurations
- Stainless steel dust cover

X-LRQ-EC Motorized Linear Stages with Motor Encoders

Product Description

Zaber's X-LRQ-EC Series devices are computer-controlled, motorized linear stages with high stiffness, load, and lifetime capabilities in a compact size with an integrated motor encoder and stainless steel dust cover. At only 48 mm high, these stages are excellent for applications where a low profile is required. The X-LRQ-EC's innovative design allows speeds up to 840 mm/s and loads up to 100 kg. Like all of Zaber's products, the X-LRQ-EC Series is designed to be 'plug and play' and very easy to set up and operate. These stages can bolt together into an XY system, and with the addition of our AB104 bracket, vertical mounting for XYZ configurations is possible.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

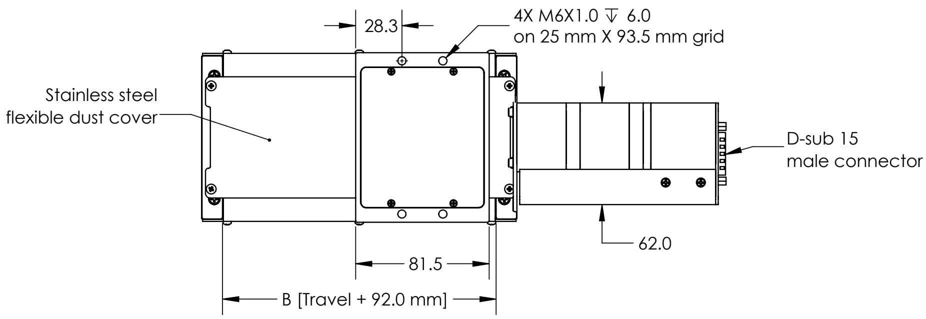
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

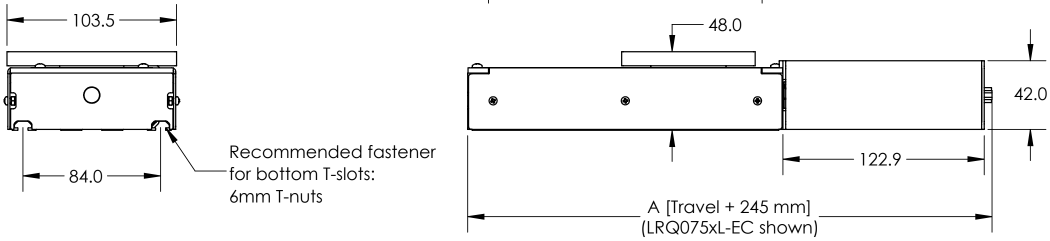
X-LRQ-EC Dimensions

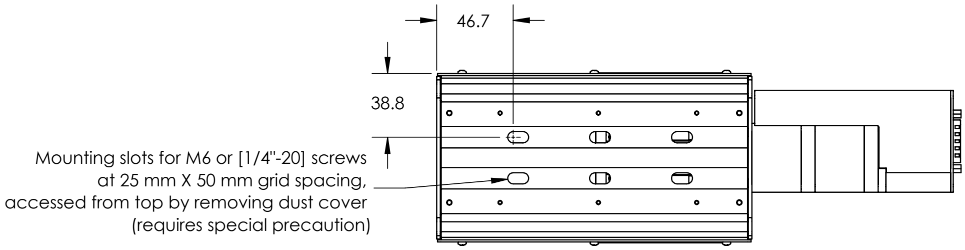
Measurements in millimetres (mm)

Model Number*	Travel	A	B
LRQ075xL-EC	75.0	320.0	167.0
LRQ150xL-EC	150.0	395.0	242.0
LRQ300xL-EC	300.0	545.0	392.0
LRQ450xL-EC	450.0	695.0	542.0
LRQ600xL-EC	600.0	845.0	692.0

*See product page for complete list of available models at www.zaber.com







X-LRQ-EC Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (No Load) (µm)	Maximum Speed (mm/s)	Peak Thrust (N)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Weight (kg)
X-LRQ075AL-E01C	75	0.099	23	< 3.5	< 16	40	110	1000	3000	2.38
X-LRQ075BL-E01C	75	0.496	23	< 3.5	< 25	205	100	1000	3000	2.38
X-LRQ075DL-E01C	75	1.984	108	< 4	< 80	840	25	1000	3000	2.38
X-LRQ075HL-E01C	75	0.195	32.5	< 5	< 30	100	300	1000	3000	2.38
X-LRQ150AL-E01C	150	0.099	45	< 3.5	< 16	40	110	1000	3000	2.76
X-LRQ150BL-E01C	150	0.496	32	< 3.5	< 25	205	100	1000	3000	2.76
X-LRQ150DL-E01C	150	1.984	115	< 4	< 80	840	25	1000	3000	2.76
X-LRQ150HL-E01C	150	0.195	45	< 5	< 30	100	300	1000	3000	2.76
X-LRQ300AL-E01C	300	0.099	90	< 3.5	< 16	40	110	1000	3000	3.67
X-LRQ300BL-E01C	300	0.496	43	< 3.5	< 25	205	100	1000	3000	3.67
X-LRQ300DL-E01C	300	1.984	130	< 4	< 80	840	25	1000	3000	3.67
X-LRQ300HL-E01C	300	0.195	70	< 5	< 30	100	300	1000	3000	3.67
X-LRQ450AL-E01C	450	0.099	135	< 3.5	< 16	40	110	1000	3000	4.48
X-LRQ450BL-E01C	450	0.496	68	< 3.5	< 25	205	100	1000	3000	4.48
X-LRQ450DL-E01C	450	1.984	145	< 4	< 80	840	25	1000	3000	4.48
X-LRQ450HL-E01C	450	0.195	100	< 5	< 30	100	300	1000	3000	4.48
X-LRQ600AL-E01C	600	0.099	150	< 3.5	< 16	40	110	1000	3000	5.26
X-LRQ600BL-E01C	600	0.496	98	< 3.5	< 25	205	100	1000	3000	5.26
X-LRQ600DL-E01C	600	1.984	160	< 4	< 80	840	25	1000	3000	5.26
X-LRQ600HL-E01C	600	0.195	130	< 5	< 30	100	300	1000	3000	5.26

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

- Built-in controller and encoder
- Optional motor encoder provides slip/stall detection and automatic recovery
- Up to 1 m/s travel speed
- 75 mm to 600 mm travel; 20 kg load capacity

X-LSQ-E Motorized Linear Stages with Motor Encoders

Product Description

Zaber's X-LSQ-E stages are computer controlled and come with built-in motor encoders. Stage travel ranges are from 75 mm to 600 mm. Zaber's innovative stage design allows for speeds up to 1 m/s and loads up to 20 kg. These stages are ready for assembly in XY or XYZ configuration with no additional hardware required. See Multi-Axis section for more information.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices. The chain also shares power, so multiple X-Series products can use a single power supply.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

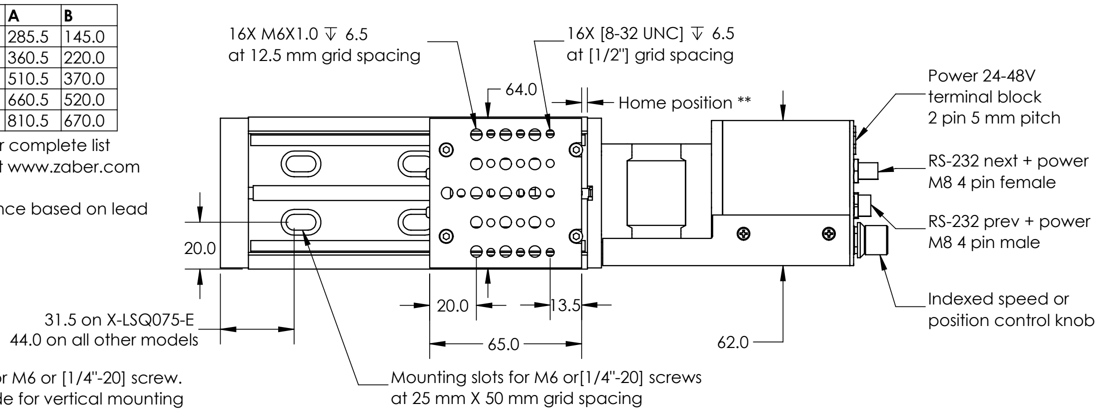
X-LSQ-E Dimensions

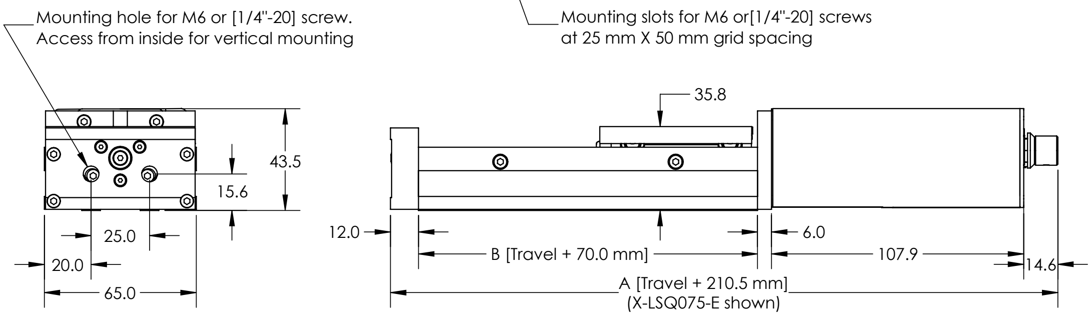
Measurements in millimetres (mm)

Model Number*	Travel	A	B
X-LSQ075-E	75.0	285.5	145.0
X-LSQ150-E	150.0	360.5	220.0
X-LSQ300-E	300.0	510.5	370.0
X-LSQ450-E	450.0	660.5	520.0
X-LSQ600-E	600.0	810.5	670.0

*See product page for complete list of available models at www.zaber.com

**Home position distance based on lead lead screw pitch:
A - 2.0 +/-0.4 mm
B - 2.2 +/-0.4 mm
D - 2.8 +/-0.4 mm





X-LSQ-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Peak Thrust (N)	Weight (kg)
X-LSQ075A-E01	75	0.099	35	< 2	< 9	0.061	53	200	147	1.2
X-LSQ075B-E01	75	0.496	45	< 2	< 13	0.303	280	200	75	1.2
X-LSQ075D-E01	75	1.984	80	< 4	< 73	1.211	1000	200	18	1.2
X-LSQ150A-E01	150	0.099	45	< 2	< 9	0.061	53	200	147	1.4
X-LSQ150B-E01	150	0.496	50	< 2	< 13	0.303	280	200	75	1.4
X-LSQ150D-E01	150	1.984	100	< 4	< 73	1.211	1000	200	18	1.4
X-LSQ300A-E01	300	0.099	90	< 2	< 9	0.061	53	200	147	1.8
X-LSQ300B-E01	300	0.496	65	< 2	< 13	0.303	280	200	75	1.8
X-LSQ300D-E01	300	1.984	145	< 4	< 73	1.211	1000	200	18	1.8
X-LSQ450A-E01	450	0.099	135	< 2	< 9	0.061	53	200	147	2.3
X-LSQ450B-E01	450	0.496	75	< 2	< 13	0.303	280	200	75	2.3
X-LSQ450D-E01	450	1.984	185	< 4	< 73	1.211	1000	200	18	2.3
X-LSQ600A-E01	600	0.099	150	< 2	< 9	0.061	42	200	147	2.9
X-LSQ600B-E01	600	0.496	90	< 2	< 13	0.303	225	200	75	2.9
X-LSQ600D-E01	600	1.984	230	< 4	< 73	1.211	800	200	18	2.9

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-BLQ-E Belt-Driven Motorized Linear Stages with Motor Encoders

- Many travel ranges, from 70 mm to 3000 mm
- Up to 2.0 m/s speed, 20 N thrust, and 20 kg load capacity
- Encoder position feedback with slip/stall detection and automatic recovery

Product Description

Zaber's X-BLQ-E stages are computer controlled and come with integrated motor encoders. With travel lengths up to 3 m, 10 μm repeatability, and a maximum speed of 2.0 m/s, X-BLQ-E stages are perfect for rapid positioning over large distances.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices. The chain also shares power, so multiple X-Series products can use a single power supply.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

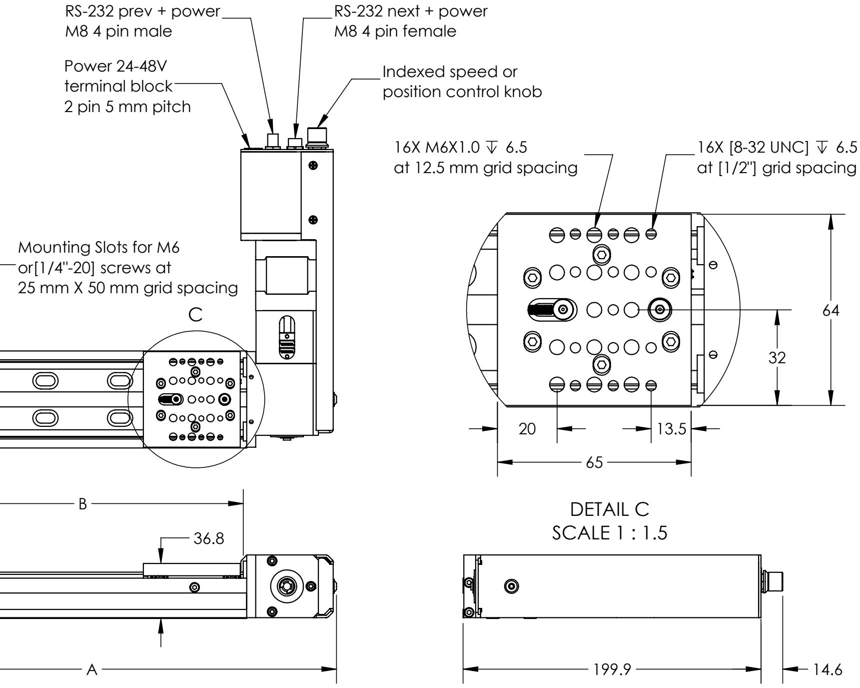
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

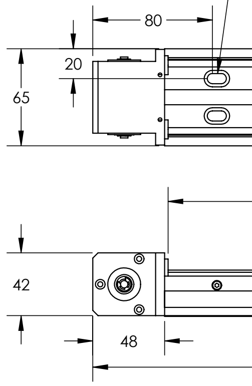
X-BLQ-E Dimensions

Measurements in millimetres (mm)

Model Number*	Travel	A	B
X-BLQ0070-E	70.0	253.2	140.3
X-BLQ0145-E	145.0	328.2	215.3
X-BLQ0295-E	295.0	478.2	365.3
X-BLQ0445-E	445.0	628.2	515.3
X-BLQ0595-E	595.0	778.2	665.3
X-BLQ1045-E	1045.0	1230.2	1117.3
X-BLQ1495-E	1495.0	1680.2	1567.3
X-BLQ2095-E	2095.0	2280.2	2167.3
X-BLQ3000-E	3000.0	3186.2	3073.3

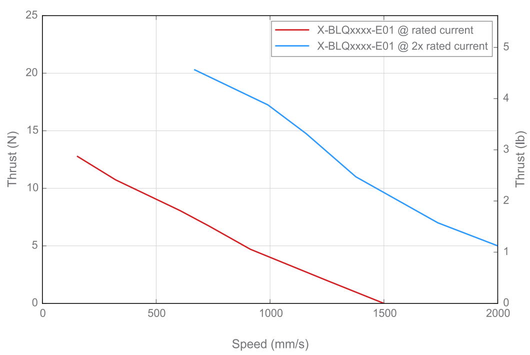
*See product page for complete list of available models at www.zaber.com





X-BLQ-E Performance Charts

Thrust Speed Performance



X-BLQ-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed* (m/s)	Maximum Centred Load (N)	Peak Thrust* (N)	Weight (kg)
X-BLQ0070-E01	70	4.218	200	< 10	< 50	2.6	1.1	200	20	1.65
X-BLQ0145-E01	145	4.218	200	< 10	< 50	2.6	1.6	200	20	1.85
X-BLQ0295-E01	295	4.218	400	< 10	< 50	2.6	2.0	200	20	2.15
X-BLQ0445-E01	445	4.218	600	< 10	< 50	2.6	2.0	200	20	2.25
X-BLQ0595-E01	595	4.218	700	< 10	< 50	2.6	2.0	200	20	2.55
X-BLQ1045-E01	1045	4.218	1000	< 10	< 50	2.6	2.0	200	20	3.6
X-BLQ1495-E01	1495	4.218	1500	< 10	< 50	2.6	2.0	200	20	4.0
X-BLQ2095-E01	2095	4.218	2000	< 10	< 50	2.6	2.0	200	20	5.0
X-BLQ3000-E01	3000	4.218	3000	< 10	< 50	2.6	2.0	200	20	6.4

* Measured at maximum running current.

1. Complete, up-to-date specs available at www.zaber.com.

- Hardened steel construction and integrated recirculating ball bearing guide
- 50 kg load capacity
- Up to 8 μm accuracy and 50 nm resolution
- Exceptional stiffness and thermal stability
- Optional motor mounted encoder provides slip/stall detection and automatic recovery

X-LRM-E Steel Motorized Linear Stages with Motor Encoders

Product Description

Zaber's X-LRM-E Series devices are motorized linear stages with integrated controllers. The X-LRM-E's hardened steel construction and recirculating ball bearing guide provide exceptional rigidity and thermal stability. These stages are stand-alone devices requiring only a standard 24–48 V power supply. High stiffness makes the X-LRM-E ideal for multi-axis configurations or applications where excellent stability under cantilever loads is required. See Multi-Axis section for more information.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

The stages connect to the USB 2.0 or RS-232 port of any computer and can be daisy-chained with any other Zaber product, several devices per chain. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for easy and secure connection between products.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

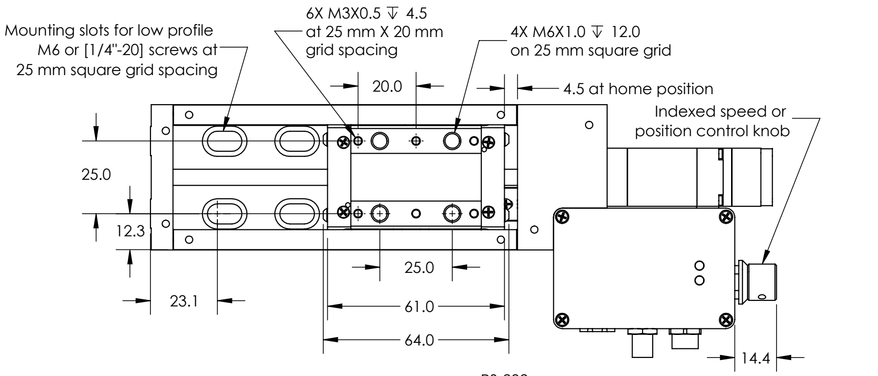
An optional indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

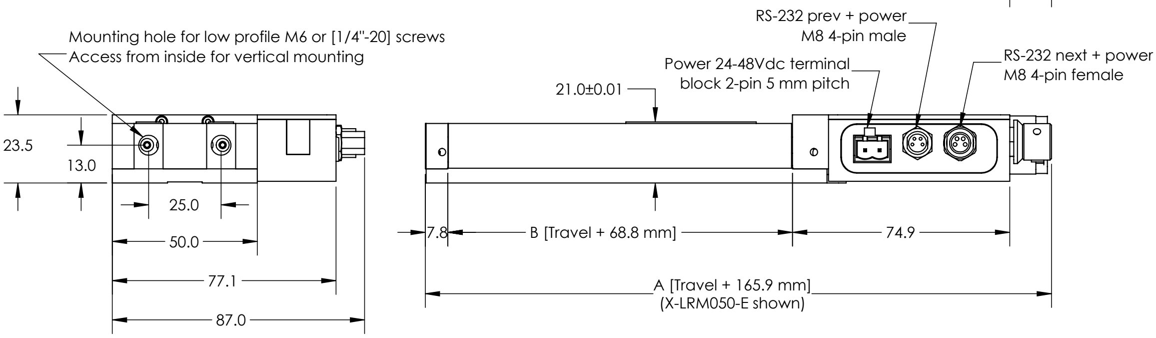
X-LRM-E Dimensions

Measurements in millimetres (mm)

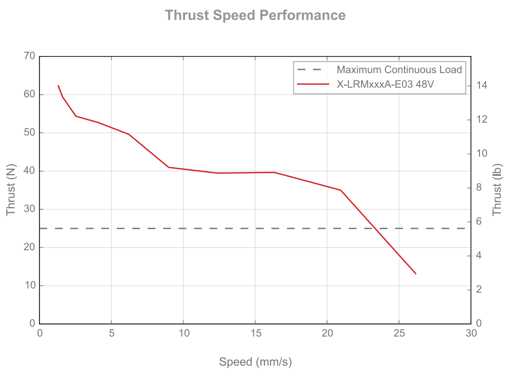
Model Number*	Travel	A	B
X-LRM025-E	25.0	190.9	93.8
X-LRM050-E	50.0	215.9	118.8
X-LRM100-E	100.0	265.9	168.8
X-LRM150-E	150.0	315.9	218.8
X-LRM200-E	200.0	365.9	268.8

*See product page for complete list of available models at www.zaber.com





X-LRM-E Performance Charts



X-LRM-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LRM025A-E03	25	0.048	8	< 1	< 5	0.029	25	500	1500	50	0.75
X-LRM025B-E03	25	0.191	8	< 3	< 12	0.116	100	500	1500	25	0.75
X-LRM050A-E03	50	0.048	15	< 1	< 5	0.029	25	500	1500	50	0.83
X-LRM050B-E03	50	0.191	15	< 3	< 12	0.116	100	500	1500	25	0.83
X-LRM100A-E03	100	0.048	30	< 1	< 5	0.029	25	500	1500	50	0.98
X-LRM100B-E03	100	0.191	30	< 3	< 12	0.116	100	500	1500	25	0.98
X-LRM150A-E03	150	0.048	45	< 1	< 5	0.029	25	500	1500	50	1.15
X-LRM150B-E03	150	0.191	45	< 3	< 12	0.116	100	500	1500	25	1.15
X-LRM200A-E03	200	0.048	60	< 1	< 5	0.029	25	500	1500	50	1.31
X-LRM200B-E03	200	0.191	60	< 3	< 12	0.116	100	500	1500	25	1.31

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-LSM-E Miniature Motorized Linear Stages with Motor Encoders

- Built-in controller and motor encoder
- Very compact with high speed, thrust, and accuracy
- Optional motor encoder provides slip/stall detection and automatic recovery
- Up to 104 mm/s speed and up to 55 N thrust; 10 kg load capacity

Product Description

Zaber's X-LSM-E Series devices are computer-controlled, motorized linear stages with high thrust and speed capabilities in a compact size. They are stand-alone devices requiring only a standard 24–48 V power supply. At only 21 mm high, these miniature stages are excellent for applications where a small profile is required. The X-LSM-E's innovative design allows speeds up to 104 mm/s and loads up to 10 kg. These stages are ready for assembly in XY or XYZ configuration with no additional hardware required. See Multi-Axis section for more information.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

These stages connect to the RS-232 port or USB port of any computer, and can be daisy-chained with any other Zaber products. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An optional indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

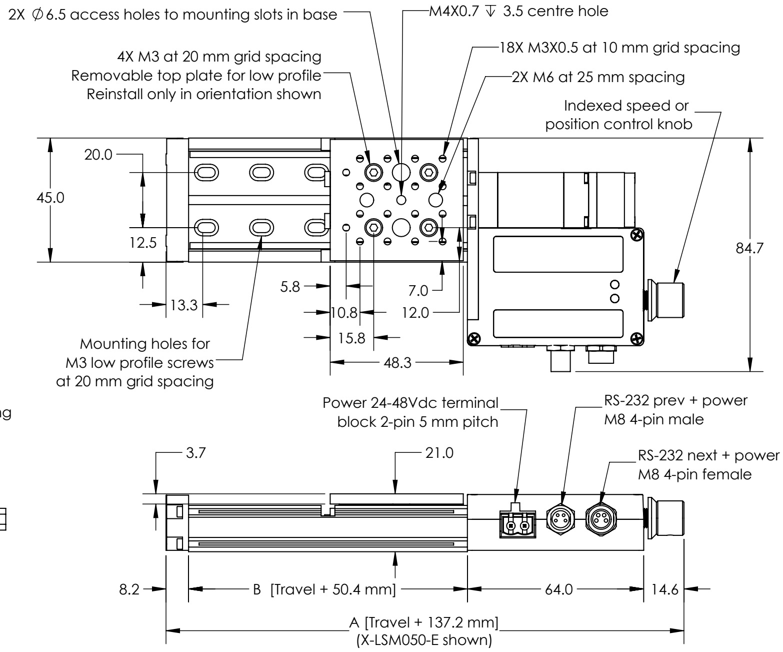
X-LSM-E Dimensions

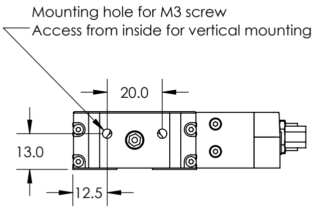
Measurements in millimetres (mm)

Model Number*	Travel	A**	B
X-LSM025-E	25.4	162.6	75.8
X-LSM050-E	50.8	188.0	101.2
X-LSM100-E	101.6	238.8	152.0
X-LSM150-E	152.4	289.6	202.8
X-LSM200-E	203.2	340.4	253.6

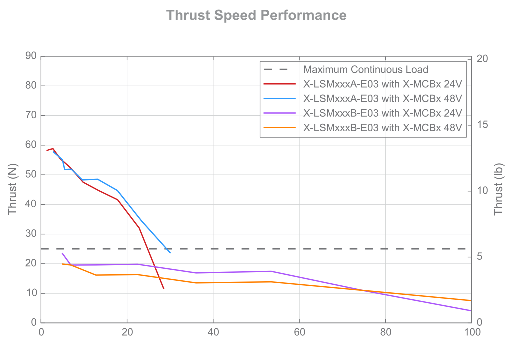
*See product page for complete list of available models at www.zaber.com

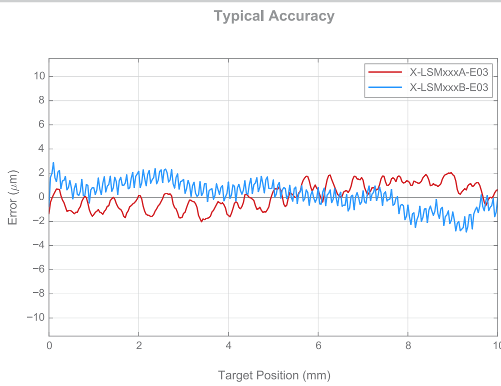
**Subtract 13.1 mm knob length from 'A' for -S versions without manual control





X-LSM-E Performance Charts





X-LSM-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LSM025A-E03	25.4	0.048	15	< 3	< 12	26	100	300	55	0.35
X-LSM025B-E03	25.4	0.19	15	< 6	< 16	104	100	300	25	0.35
X-LSM050A-E03	50.8	0.048	20	< 3	< 12	26	100	300	55	0.36
X-LSM050B-E03	50.8	0.19	25	< 6	< 16	104	100	300	25	0.36
X-LSM100A-E03	101.6	0.048	35	< 3	< 12	26	100	300	55	0.39
X-LSM100B-E03	101.6	0.19	45	< 6	< 16	104	100	300	25	0.39
X-LSM150A-E03	152.4	0.048	50	< 3	< 12	26	100	300	55	0.43
X-LSM150B-E03	152.4	0.19	65	< 6	< 16	104	100	300	25	0.43
X-LSM200A-E03	203.2	0.048	60	< 3	< 12	26	100	300	55	0.46
X-LSM200B-E03	203.2	0.19	85	< 6	< 16	104	100	300	25	0.46

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available; more compact models with no manual knob available.

- Ideal for single axis applications
- 3 kg load capacity; 50 N-cm cantilever load
- Up to 65 mm/s speed; 25 N peak thrust
- Our most affordable linear stage with optional built-in controller
- Optional motor encoder provides slip/stall detection and automatic recovery

X-LHM-E Motorized Linear Stages with Motor Encoders

Product Description

Zaber's X-LHM-E motorized linear stages offer a compact size and affordable price tag. These stages are ideal for light centred-load, single-axis applications. At only 23 mm high, these stages are excellent for applications where a small profile is required. Like all of Zaber's products, the X-LHM-E Series is designed to be "plug and play" and very easy to set up and operate.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

These stages connect to the RS-232 port or USB port of any computer, and they can be daisy-chained with any other Zaber products. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking 4-pin M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An optional indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer.

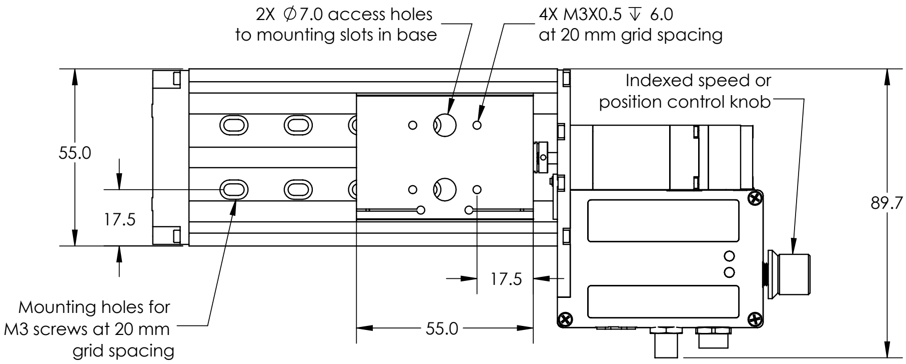
X-LHM-E Dimensions

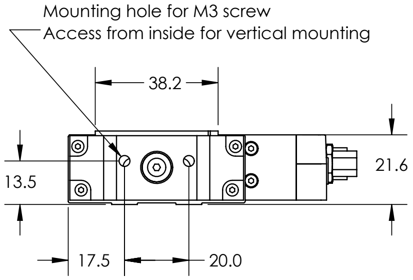
Measurements in millimetres (mm)

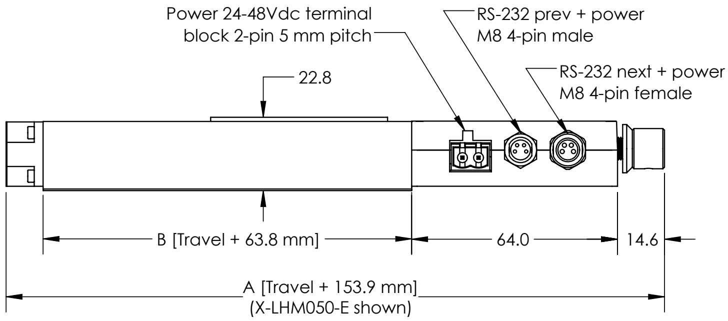
Model Number*	Travel	A**	B
X-LHM025-E	25.4	179.3	89.2
X-LHM050-E	50.8	204.7	114.6
X-LHM100-E	101.6	255.5	165.4
X-LHM150-E	152.4	306.3	216.2
X-LHM200-E	203.2	357.1	267.0

*See product page for complete list of available models at www.zaber.com

**Subtract 13.1 mm knob length from 'A' for -S versions without manual control

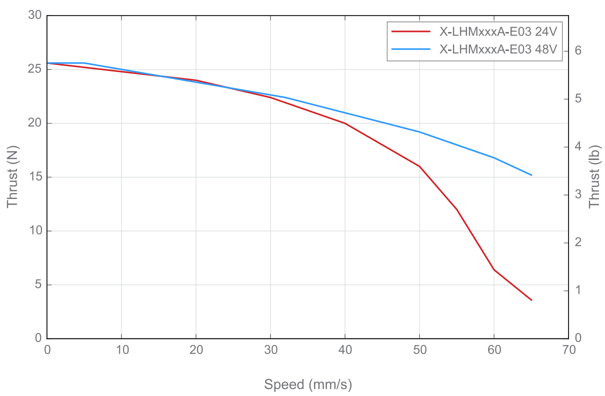






X-LHM-E Performance Charts

Thrust Speed Performance



X-LHM-E Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LHM025A-E03	25.4	0.124	50	< 4	< 30	1.2	65	30	50	25	0.36
X-LHM050A-E03	50.8	0.124	75	< 4	< 30	1.2	65	30	50	25	0.42
X-LHM100A-E03	101.6	0.124	125	< 4	< 30	1.2	65	30	50	25	0.48
X-LHM150A-E03	152.4	0.124	175	< 4	< 30	1.2	65	30	50	25	0.52
X-LHM200A-E03	203.2	0.124	225	< 4	< 30	1.2	65	30	50	25	0.58

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available; more compact models with no manual knob available.

- Built-in controller
- Mount multiple stages in XY or XYZ configuration
- Daisy-chain and control multiple stages through a single serial port
- Manual control knob lets you move the stage at variable speeds

T-LS Motorized Linear Stages

Product Description

Zaber's T-LS motorized linear translation stages are computer controlled, have 0.1 μm resolution, and have either 13 mm or 28 mm travel. They mount together in XY configuration (without an angle bracket) or in XYZ configuration with our AB90 angle bracket. See Multi-Axis section for more information.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple T-Series products to share a single power supply. Convenient 6-pin mini-DIN cables on the stage allow for direct interconnection between devices in close proximity. For longer distances, we offer standard cable extensions.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the stage reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW.

Manual Control

An optional knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. During a manual move the device's position is constantly transmitted to the computer and is displayed by the software.

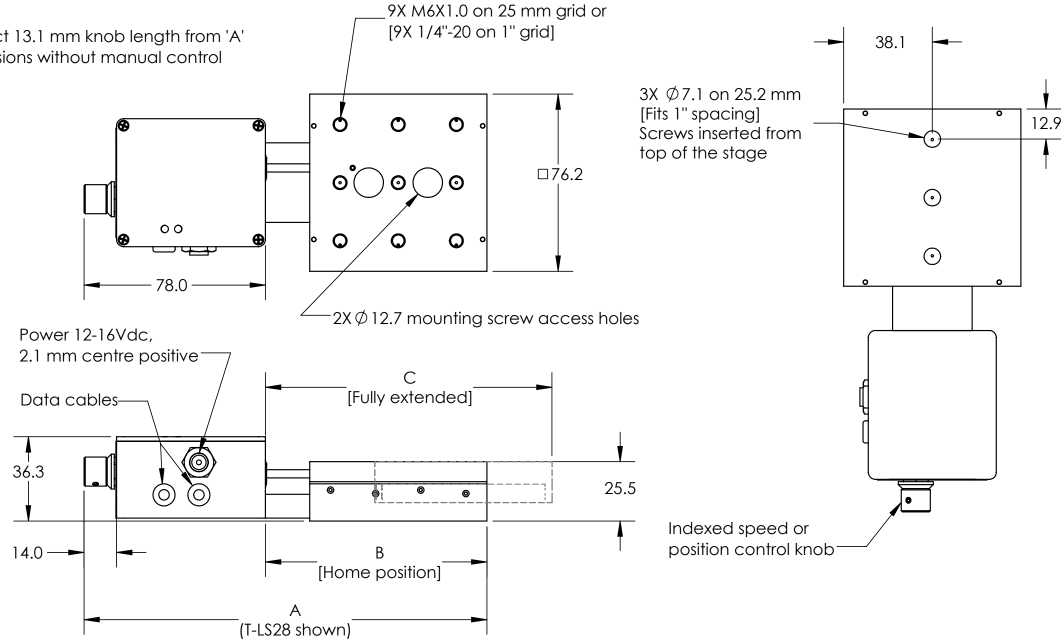
T-LS Dimensions

Measurements in millimetres (mm)

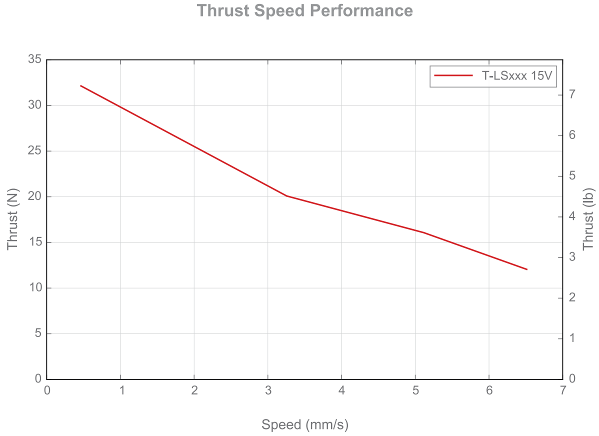
Model Number*	Travel	A**	B	C
T-LS13	13.0	157	76.2	91.2
T-LS28	28.0	173.2	95.2	123.2

*See product page for complete list of available models at www.zaber.com

**Subtract 13.1 mm knob length from 'A' for -S versions without manual control



T-LS Performance Charts



T-LS Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
T-LS13E	13	0.099	29	< 2	< 14	0.93	6.5	100	125	32	0.57
T-LS13M	13	0.099	29	< 2	< 14	0.93	6.5	100	125	32	0.57
T-LS28E	28	0.099	29	< 2	< 14	0.93	6.5	100	125	32	0.59
T-LS28M	28	0.099	29	< 2	< 14	0.93	6.5	100	125	32	0.59

1. Complete, up-to-date specs available at www.zaber.com.
2. More compact models with no manual knob available.

LSA Micro Motorized Linear Stages

- Compact size: great for applications with limited space
- 10 or 25 mm travel
- Designed for use with Zaber's stepper motor controllers
- Easily mounts in XY and XYZ configurations

Product Description

Zaber's LSA Series stages are designed to fit into the smallest spaces without sacrificing performance or features. Small but powerful, these stages have up to 10 mm/s speed and up to 3.5 kg thrust. With a microstep size of less than 25 nm and less than 1 μm repeatability, they allow for reliable ultra-fine positioning. The LSA stages are wired with a male D-sub 15 connector for plug-and-play use with Zaber's stepper motor controllers. Our kits include free software and all of the accessories that you will need to get the stage running right out of the box.

Installation

The LSA Series stages are designed to connect directly to Zaber's stepper motor controllers (purchased separately). Zaber's stand-alone controllers and devices with built-in controllers can all be daisy-chained to communicate over a single computer connection. This simplifies set-up and reduces cable clutter.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the controller reports the new position of the actuator. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW.

Manual Control

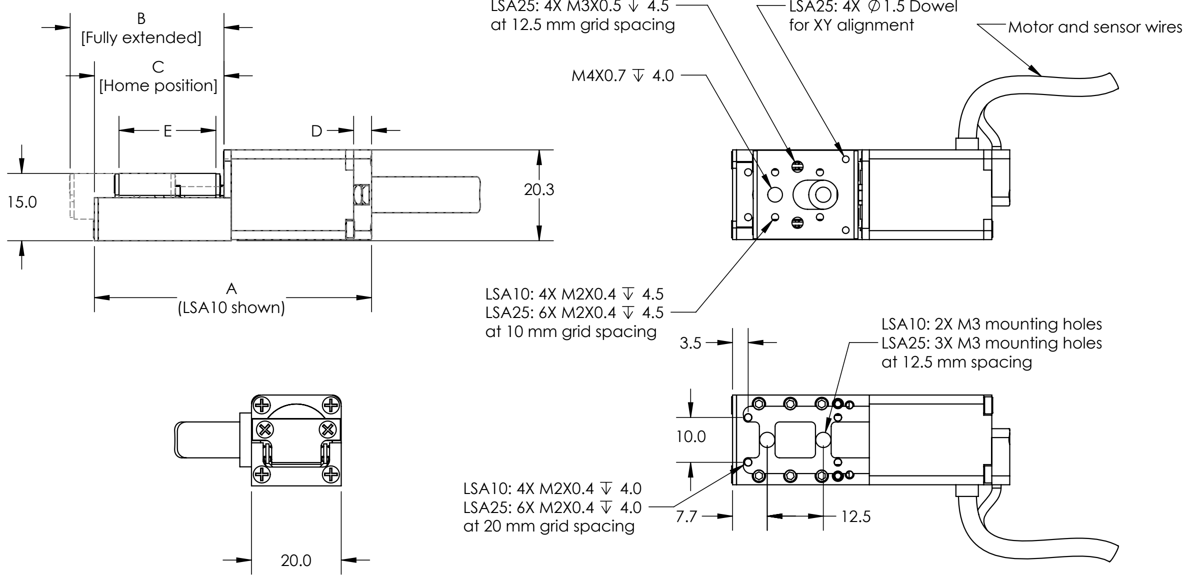
Zaber's stepper motor controllers include an indexed knob that provides convenient manual control via user-selectable modes. In velocity mode, each increment of the knob increases or decreases the speed by a fixed amount. In displacement mode, each increment of the knob moves the device by a user-configurable distance. You can also issue a stop command by depressing the knob during any operation. The knob allows for versatile control even without a computer.

LSA Dimensions

Measurements in millimetres (mm)

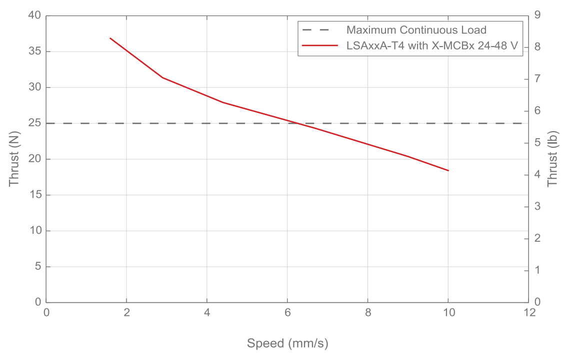
Model Number*	Travel	A	B	C	D	E
LSA10	10.0	61.8	34.3	28.9	4.0	21.6
LSA25	25.0	96.3	62.7	48.4	19.0	35.0

*See product page for complete list of available models at www.zaber.com

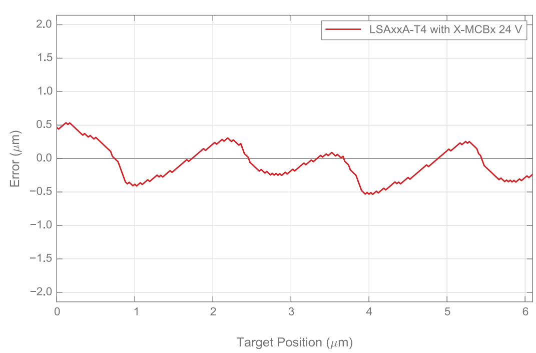


LSA Performance Charts

Thrust Speed Performance



Typical Microstepping Accuracy



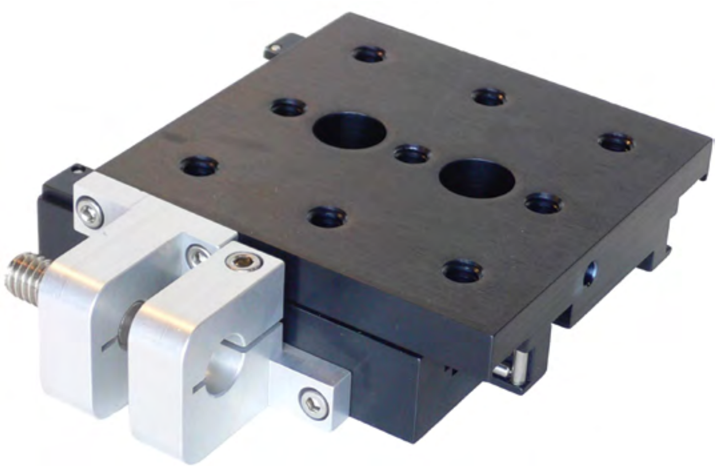
LSA Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
LSA10A-T4	10	0.024	18	< 1	< 5	10	25	100	35	0.12
LSA25A-T4	25	0.024	24	< 1	< 5	10	30	125	35	0.13

1. Complete, up-to-date specs available at www.zaber.com.

I finally got a chance to work with the Zaber stages we ordered a while ago. I am very impressed – the documentation is excellent, and the devices actually work like they are supposed to, and they reply to commands as documented. A real pleasure!

– Martin Grill, Research Engineer, SRI International



TSB Manual Translation Stages

- Compatible with Zaber's manual micrometers and T-NA, T-LA, and NA11 actuators
- Available with a manual micrometer head
- Reversible mounting bracket allows left-hand or right-hand operation
- Brackets have a convenient clamping mechanism for easy adjustments

Product Description

Zaber's TSB ball bearing translation stages without manual micrometer heads are available in two sizes, offering either 28 mm or 60 mm of travel. The models with manual micrometer heads are also available in two sizes, offering either 25 mm or 50 mm of travel and 0.01 mm resolution. The TSB translation stages can be mounted directly in XY configuration, or in XYZ configuration with an angle bracket. TSB stages ensure smooth and accurate motion: they are made from precision-machined anodized aluminum, with precision-ground rails and ball bearings. Choose from either metric M6 mounting holes on 25 mm spacing, or imperial 1/4″-20 mounting holes on 1″ spacing.

Installation

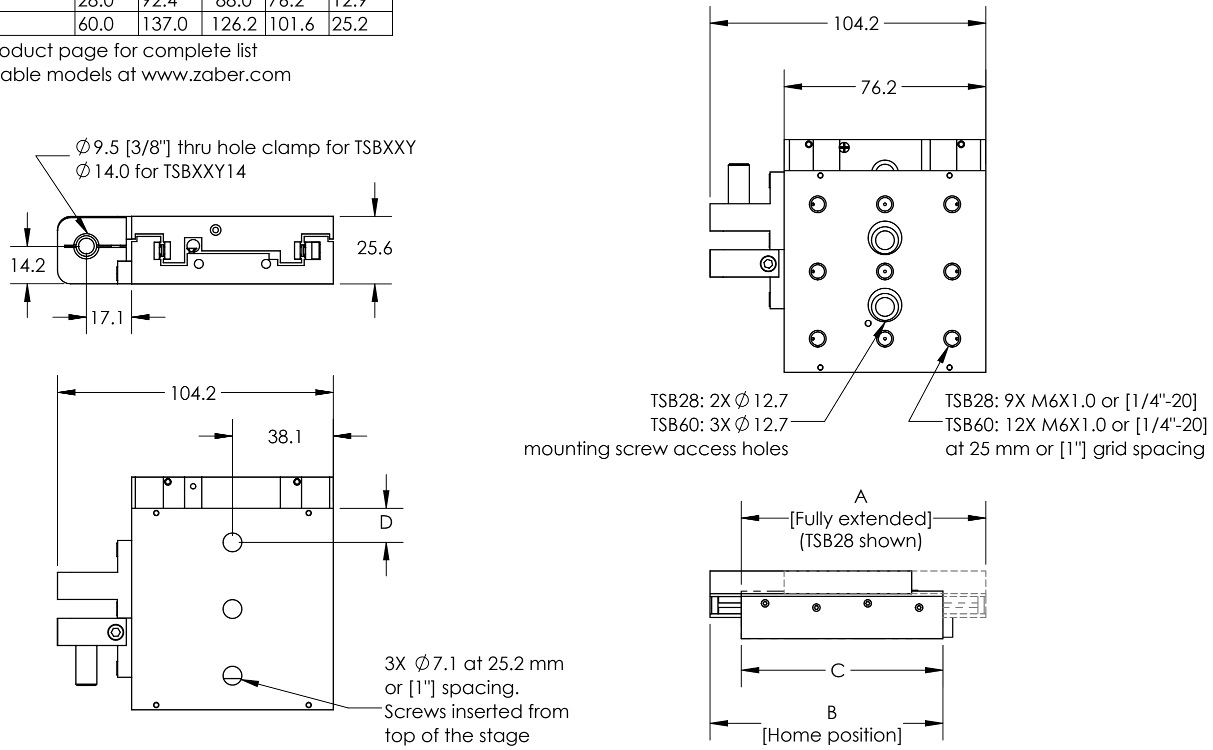
Each stage includes a pair of actuator mounting brackets that include a convenient clamping mechanism to grip actuators, and are easily adjusted or locked in place. The mounting brackets are compatible with Zaber actuators: the standard 9.5 mm brackets fit our T-NA and T-LA Series of actuators; if you want to use our NA11 actuators, we offer 14 mm brackets with the TSB28x14 and TSB60x14 stages. TSB stages can be mounted directly in XY configuration. Optional AB90 angle brackets are available for mounting in XYZ configuration. The TSB28x-MH25 and TSB60x-MH50 stages come with the appropriate mounting bracket and a manual micrometer head.

TSB Dimensions

Measurements in millimetres (mm)

Model Number*	Travel	A	B	C	D
TSB28	28.0	92.4	88.0	76.2	12.9
TSB60	60.0	137.0	126.2	101.6	25.2

*See product page for complete list of available models at www.zaber.com



TSB Specifications

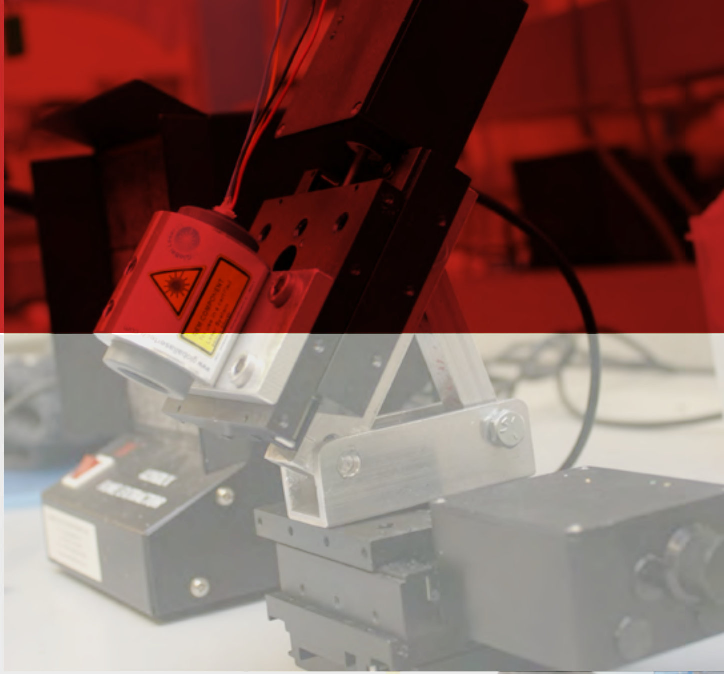
Model	Travel Range (mm)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Stage Parallelism (μm)	Manual Micrometer Head	Mounting Thread
TSB28E	28	100	125	< 100	No	1/4″-20
TSB28E14	28	100	125	< 100	No	1/4″-20
TSB28E-MH25	25	100	125	< 100	Yes	1/4″-20
TSB28M	28	100	125	< 100	No	M6
TSB28M14	28	100	125	< 100	No	M6
TSB28M-MH25	25	100	125	< 100	Yes	M6
TSB60E	60	100	125	< 100	No	1/4″-20
TSB60E14	60	100	125	< 100	No	1/4″-20
TSB60E-MH50	50	100	125	< 100	Yes	1/4″-20
TSB60M	60	100	125	< 100	No	M6
TSB60M14	60	100	125	< 100	No	M6
TSB60M-MH50	50	100	125	< 100	Yes	M6

1. Complete, up-to-date specs available at www.zaber.com.

I'm constantly impressed, surprised, and intrigued by the variety of applications our customers employ our motion products in. It's rewarding to work together with them to find the perfect solution for their requirements, and to see the end result of these projects. With new products constantly being developed by our engineering teams, it's exciting to see the growing range of requirements we can satisfy.

– Mike McDonald, Sales and Support

Sponsorship Spotlight: UW_NRG



University of Waterloo Nanorobotics Group

The University of Waterloo Nanorobotics Group (UW_NRG) is an undergraduate student group focused on the research and development of cutting-edge micro-scale manipulation technology. Formed in 2007, its members come from a range of disciplines, including Nanotechnology, Electrical, Computer, and Software Engineering, and work together on the design, simulation, and fabrication of small MEMS components. The group participates annually in various competitive events and presents at numerous technical seminars, conferences, and community outreach events to build awareness of nanotechnology.

http://csclub.uwaterloo.ca/~uwnrg/

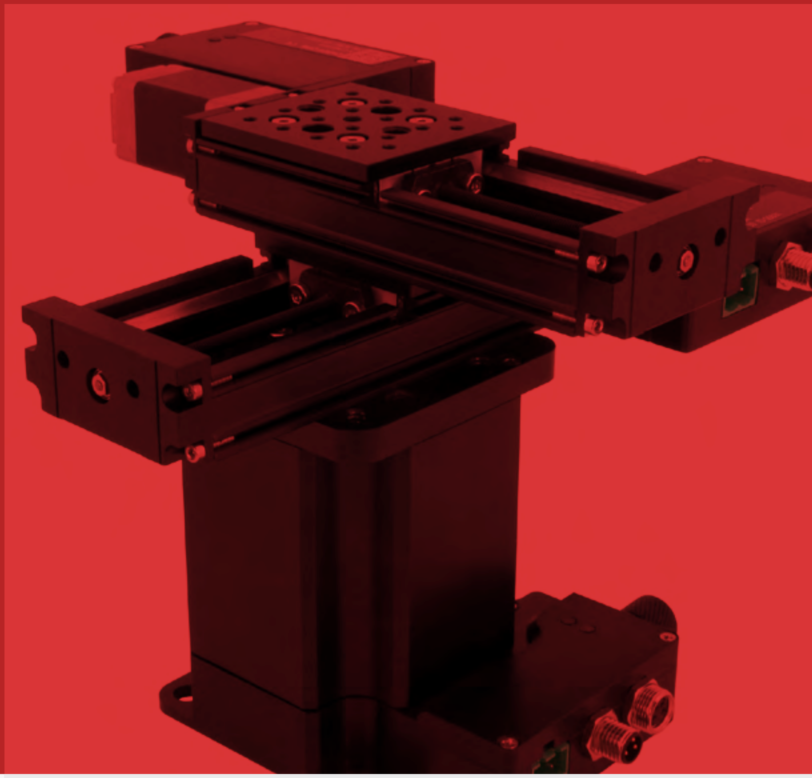
The UW_NRG group is currently using Zaber's stages with built-in controllers and drivers in their research. They compete annually in the Mobile Microrobotics Challenge at the International Conference on Robotics and Automation (ICRA).

After a successful year of hard work, UW_NRG utilized our latest rendition of EMMA to take home first place at the 2013 International Conference on Robotics and Automation in Karlsruhe, Germany.

– UW_NRG

UW_NRG

Vertical Motion



- 20 or 40 mm of travel
- 10 kg load capacity, 20 kg peak thrust
- Optional built-in controller; daisy-chains with other Zaber products
- Up to 48 mm/s speed
- 55 or 85 mm retracted height

X-VSR Vertical Lift Stages

Product Description

Zaber's X-VSR Series vertical lift stages are computer-controlled, stepper actuator driven platforms capable of moving 10 kg loads. They deliver exceptional travel and load capacity with a compact size, measuring only 55 mm (X-VSR20) or 85 mm (X-VSR40) tall when closed. The small footprint also allows direct mounting onto Zaber's LST and LSQ Series of linear stages.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices. The chain also shares power, so multiple X-Series products can use a single power supply.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

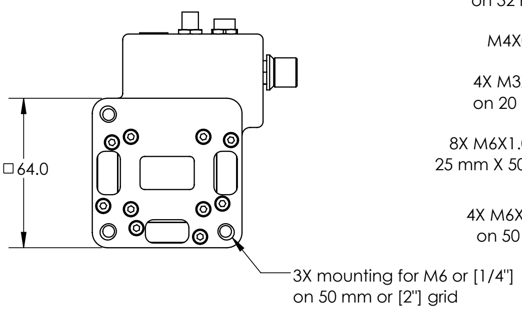
An optional indexed knob provides convenient manual control for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

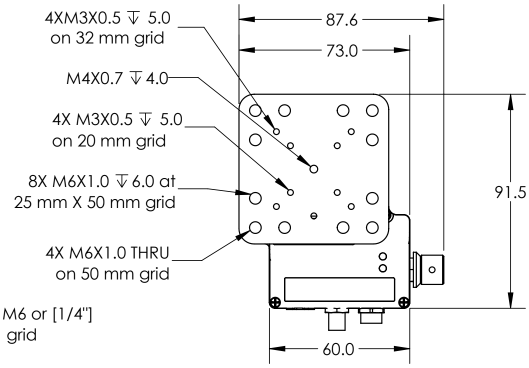
X-VSR Dimensions

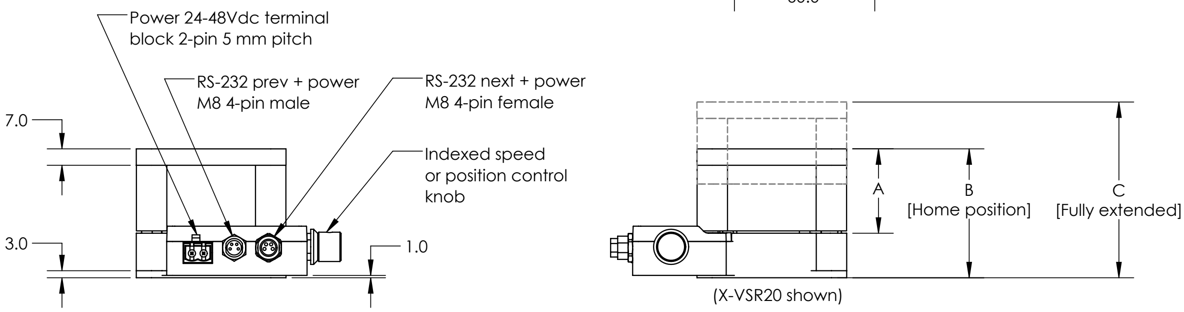
Measurements in millimetres (mm)

Model Number*	Travel	A	B	C
X-VSR20	20.0	36.0	55.0	75.0
X-VSR40	40.0	66.0	85.0	125.0

*See product page for complete list of available models at www.zaber.com



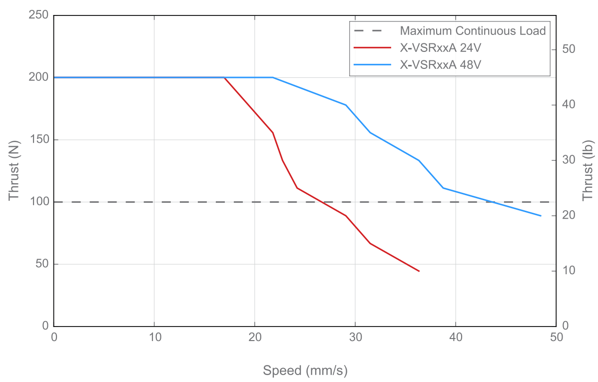




(X-VSR20 shown)

X-VSR Performance Charts

Thrust Speed Performance



X-VSR Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Loaded Backlash (µm)	Maximum Speed (mm/s)	Peak Thrust (N)	Maximum Continuous Thrust (N)	Weight (kg)
X-VSR20A	20	0.095	35	< 1	< 10	48	200	100	0.573
X-VSR40A	40	0.095	35	< 1	< 10	48	200	100	0.813

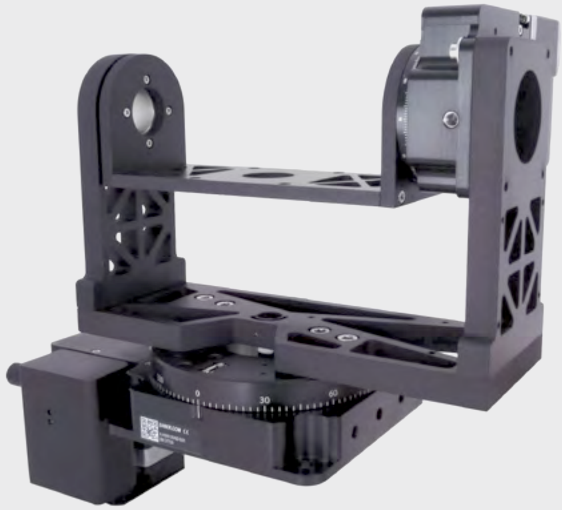
1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

Custom Product Spotlight: Gimbal Systems

Custom Gimbal Systems

Zaber’s gimbal systems are easily customizable for any application sizes. Device cables can be connected through a slip ring, which allows daisy-chaining power and data to the stages without tangling wires as the stage rotates. Options include rotary stages with external controllers or built-in controllers, motor encoders, or direct encoders.

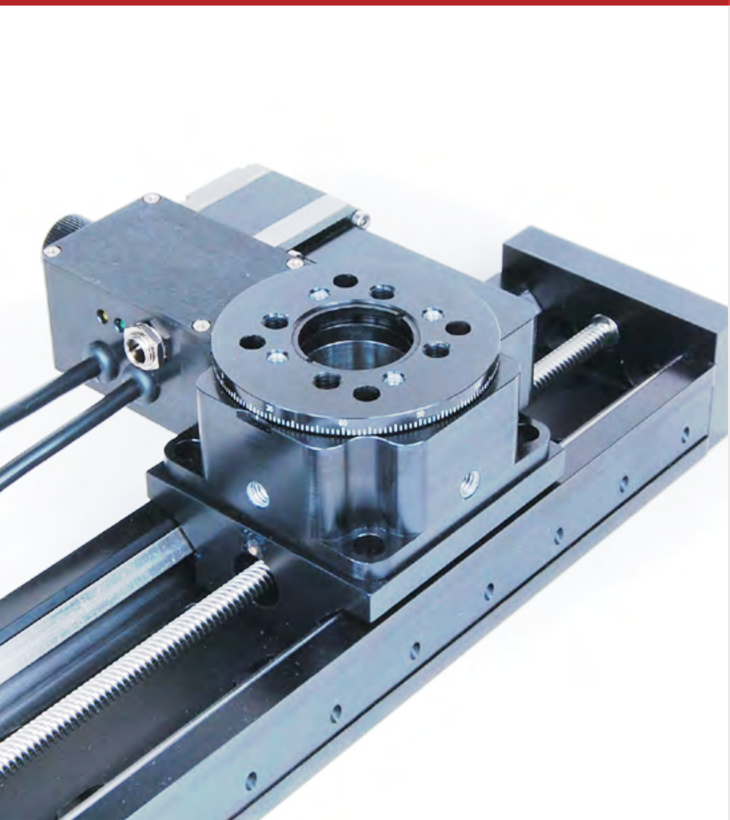
Our product customization team is able to complete most customizations within a two-week period. Contact us with your requests.



The gimbal system above consists of an X-RSB for the lower axis with an X-RSW driving the upper axis. The devices are daisy-chained together through a slip ring, which allows daisy-chaining power and data to the X-RSW without tangling wires as the stage rotates. This setup can easily be customized to accommodate different size working envelopes or be mounted to work with an X-RST for higher accuracy systems.

The system to the left is a high-load, fine-accuracy gimbal. Two X-RST120AK-DE50 rotary stages are used to position the platform to fractions of a degree in both the azimuth and elevation axes. The height and spacing of the gimbal can be customized for each application. A slip ring can be added to eliminate cable tangling during rotation.

Rotary Motion



X-RST-DE Motorized Rotary Stages with Direct Encoders

- Continuous 360° rotation stage with optional built-in controllers
- Optional direct reading encoder for position correction; stage accuracy to 0.01°
- 50.8 mm (2″) aperture
- Speed up to 24 °/s; torque up to 10 N·m

Product Description

Zaber's X-RST-DE devices are worm gear driven, continuous 360° rotation stages with optional built-in controllers and direct reading encoders. Rated for a 50 kg centred load capacity and 10 N·m of torque, these stages are ideal for high load, high precision, angular positioning applications. These stages can be daisy-chained with any other Zaber devices. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply.

Closed-Loop Operation

X-RST-DE stages use optional direct reading encoders with 0.2 arc sec resolution, enabling stage accuracy to 0.01° and allow position correction. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on these devices allow for easy and secure connection and power sharing between X-Series products.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

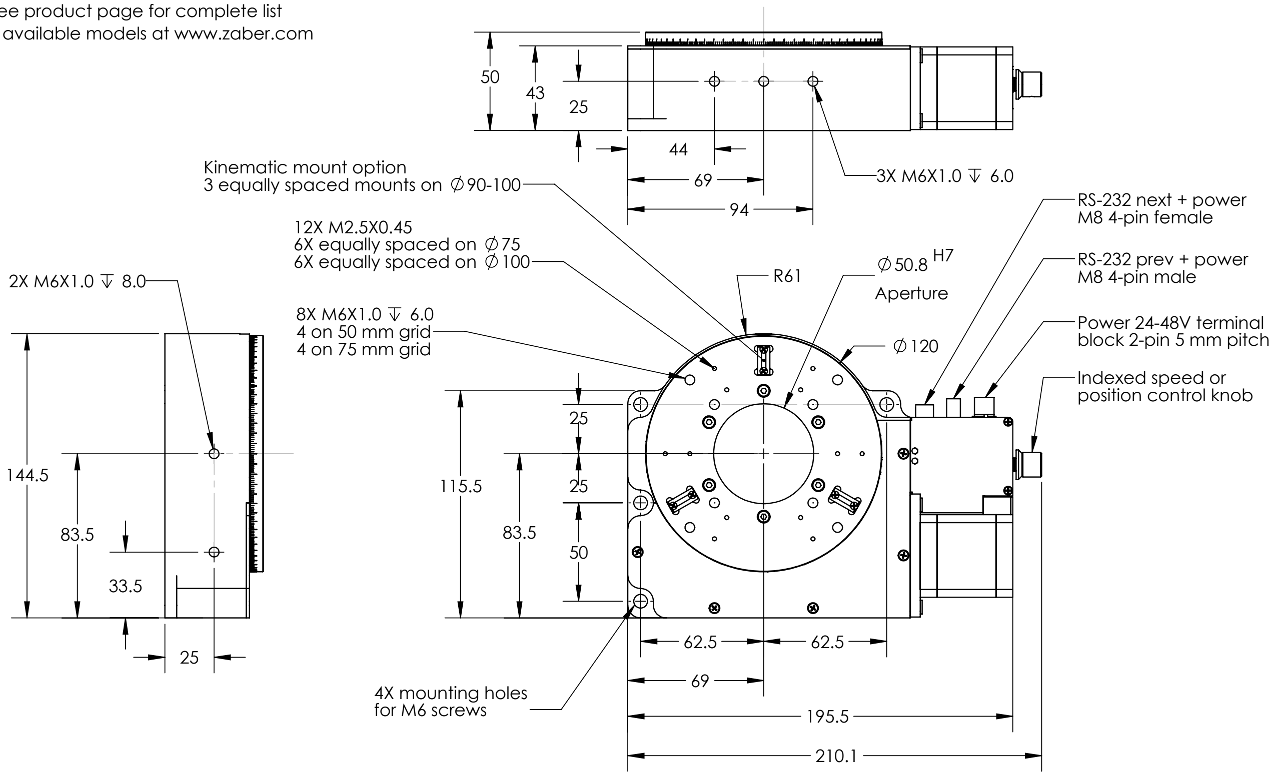
Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

X-RST-DE Dimensions

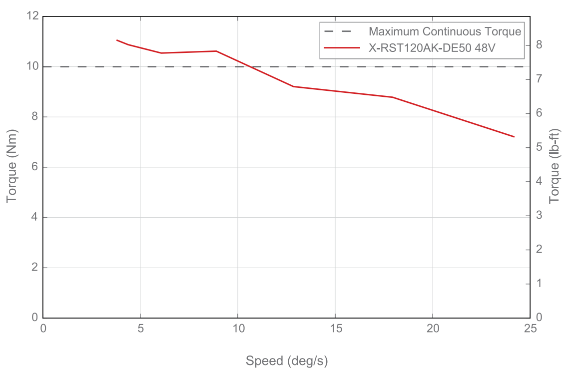
Measurements in millimetres (mm)

*See product page for complete list
of available models at www.zaber.com



X-RST-DE Performance Charts

Torque Speed Performance



X-RST-DE Specifications

Model	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Continuous Torque (N·m)	Weight (kg)
X-RST120AK-DE50	0.00015625	500	0.01	< 0.005	< 0.005	0.000095	24	10	2.46

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-RST-E Motorized Rotary Stages with Motor Encoders

- Continuous 360° rotation stage with optional built-in controllers
- Optional motor mounted encoder provides slip/stall detection and automatic recovery
- 50.8 mm (2″) aperture
- Speed up to 24 °/s; torque up to 10 N·m

Product Description

Zaber's X-RST-E devices are worm gear driven, continuous 360° rotation stages with optional built-in controllers and motor encoders. Rated for a 50 kg centred load capacity and 10 N·m of torque, these stages are ideal for high load, high precision, angular positioning applications. These stages can be daisy-chained with any other Zaber devices. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on these devices allow for easy and secure connection and power sharing between X-Series products.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

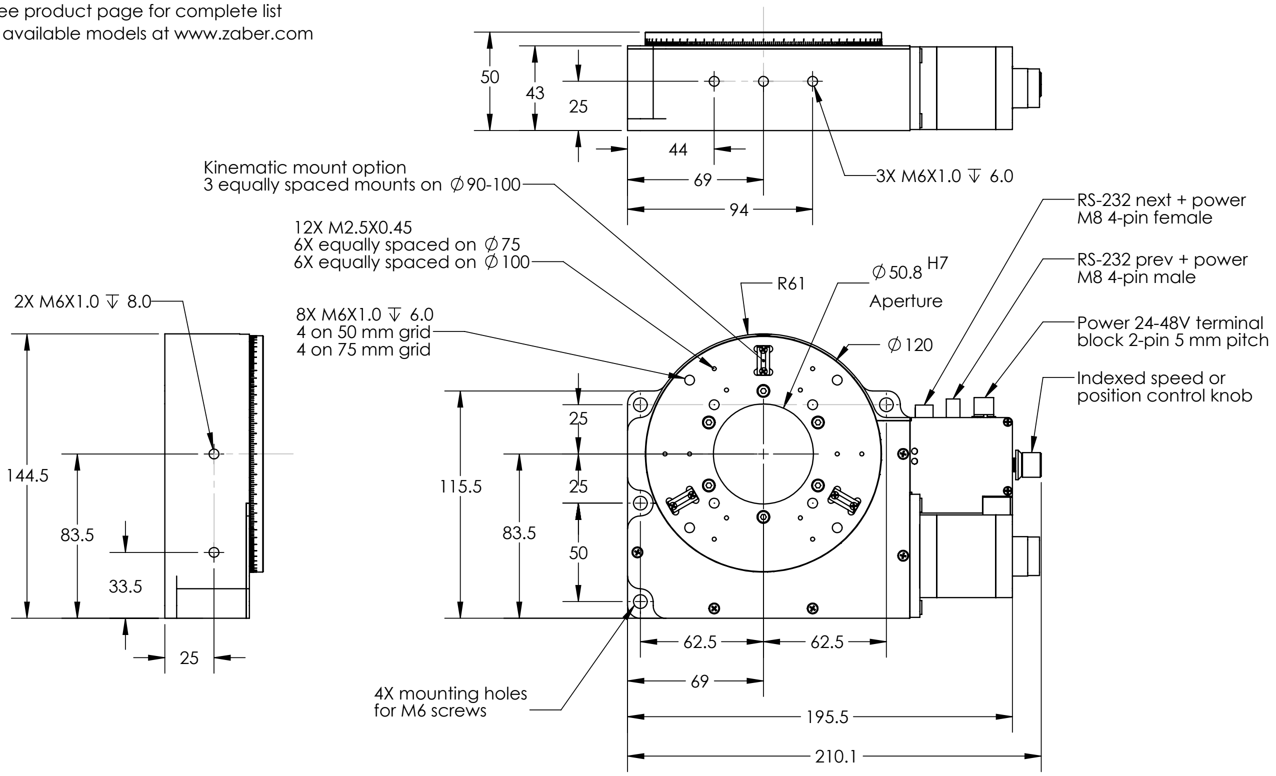
Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

X-RST-E Dimensions

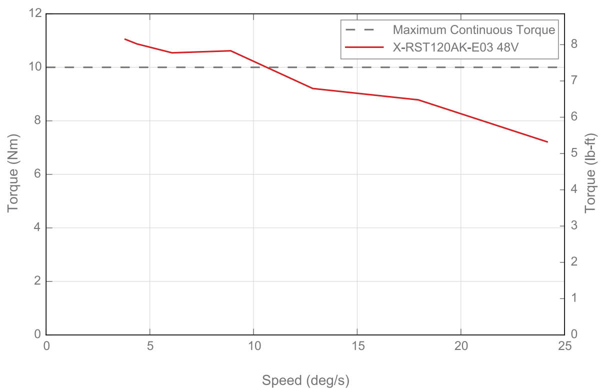
Measurements in millimetres (mm)

*See product page for complete list of available models at www.zaber.com



X-RST-E Performance Charts

Torque Speed Performance



X-RST-E Specifications

Model	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Continuous Torque (N·m)	Weight (kg)
X-RST120AK-E03	0.00015625	500	0.16	< 0.005	< 0.05	0.000095	24	10	2.41

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

- Continuous 360° rotation stage
- Speed up to 1800 °/s
- Optional motor encoder provides slip/stall detection and automatic recovery
- Multiple motor configurations
- Optional built-in controller; daisy-chains with other Zaber products

X-RSB-E Motorized Rotary Stages with Motor Encoders

Product Description

Zaber's X-RSB-E Series rotation stages have a 60 mm or a 120 mm table diameter and a straight through aperture. They feature a compact footprint, low profile, and a load capability of up to 50 kg. With a maximum speed of 300 rpm, these rotation stages are ideal for the rapid positioning of light loads to within a fraction of a degree. The X-RSB-E stage is designed for plug-and-play use with any of Zaber's stepper motor controllers.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices connect to the RS-232 port or USB port of any computer, and they can be daisy-chained with any other Zaber products. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices. Like all of Zaber's products, the X-RSB-E Series is designed to be 'plug and play' and very easy to set up and operate.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control and Configurations

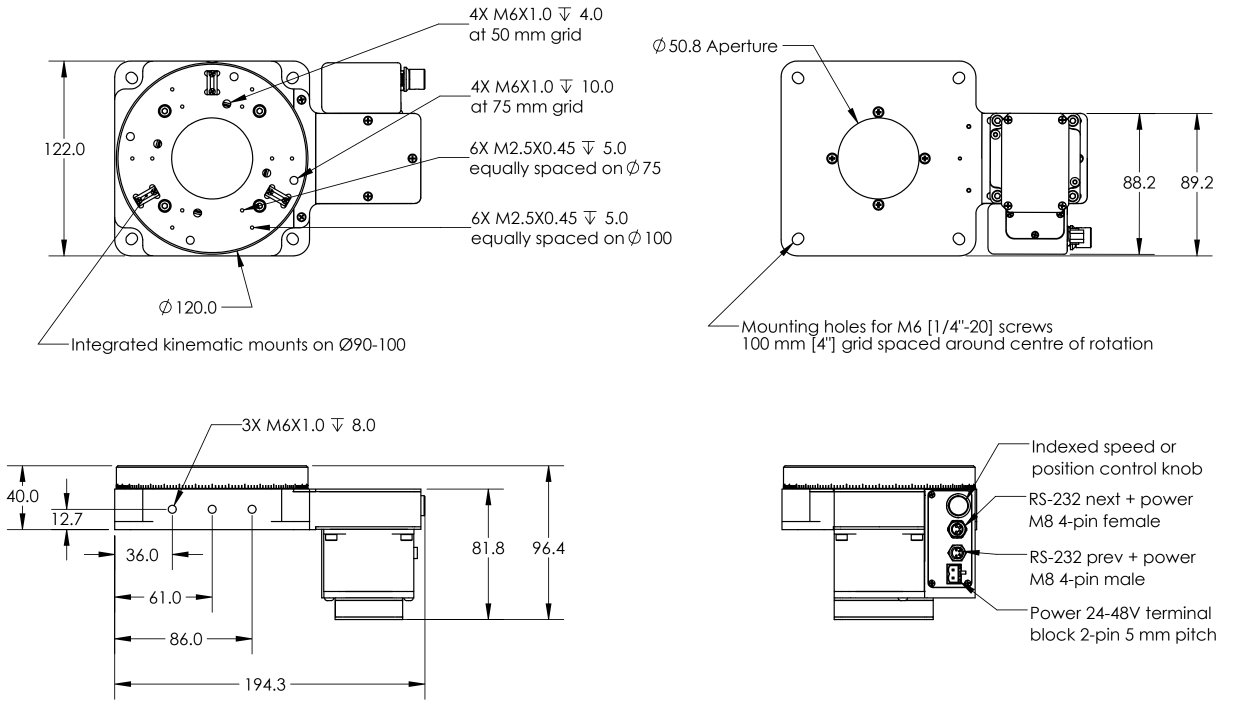
The X-RSB-E are stand-alone devices requiring either a standard 24 V or 48 V power supply. There are two motor configurations available: up and down. Motor up configurations allow flush mounting of the device to a flat surface, and motor down configurations allow for a full 360° movement of loads that extend past the edge of the stage top. An indexed knob provides convenient manual control for versatile operation even without a computer.

X-RSB-E Dimensions

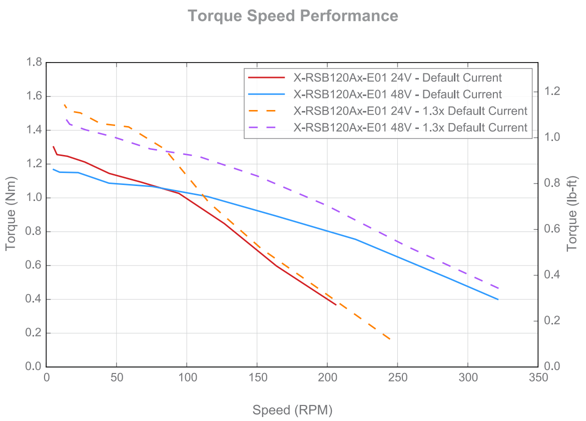
Measurements in millimetres (mm)

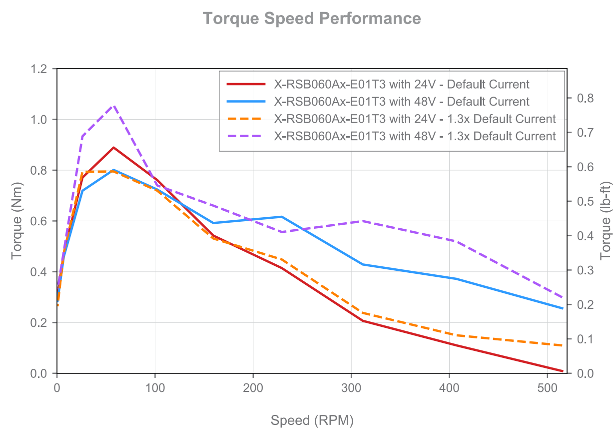
*See product page for complete list of available models at www.zaber.com

X-RSBxD-E shown below



X-RSB-E Performance Charts





X-RSB-E Specifications

Model	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Torque (N·cm)	Weight (kg)
X-RSB060AD-E01	0.0056	200	0.2	< 0.01	< 0.1	0.026	3000	80	0.88
X-RSB060AU-E01	0.0056	200	0.19	< 0.01	< 0.1	0.026	3000	80	0.88
X-RSB120AU-E01	0.0056	500	0.19	< 0.02	< 0.19	0.026	1800	120	2.14
X-RSB120AD-E01	0.0056	500	0.19	< 0.02	< 0.19	0.026	1800	120	2.14

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-RSW-E Motorized Rotary Stages with Motor Encoders

- Continuous 360° rotation stage with optional built-in controllers
- Optional motor encoder provides slip/stall detection and automatic recovery
- Speed up to 75 rpm, torque up to 2.25 N·m
- Through-hole for 1″ optics

Product Description

Zaber's X-RSW-E devices are worm gear driven, continuous 360° rotation stages with optional built-in controllers and motor encoders. These stages are capable of speeds up to 75 rpm, and torque up to 2.25 N·m. These stages can be daisy-chained with any other Zaber devices. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on these devices allow for easy and secure connection and power sharing between X-Series products.

Computer Control

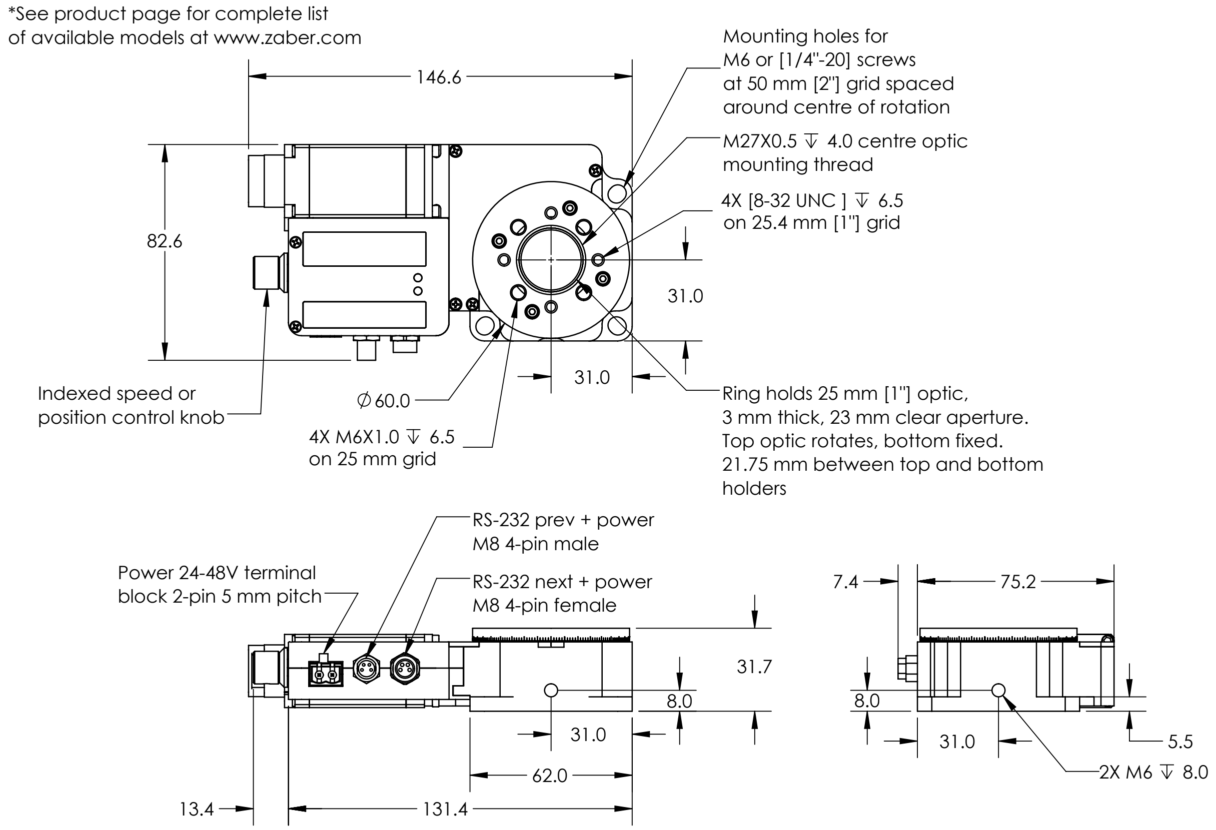
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

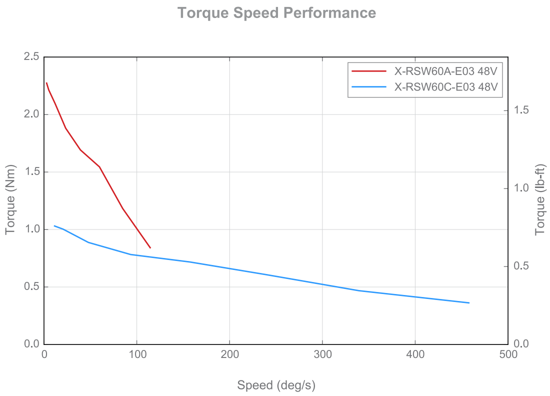
An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

X-RSW-E Dimensions

Measurements in millimetres (mm)



X-RSW-E Performance Charts



X-RSW-E Specifications

Model*	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Continuous Torque (N·cm)	Weight (kg)
X-RSW60A-E03	0.00023	200	0.08	< 0.02	< 0.04	0.00014	115	225	0.67
X-RSW60C-E03	0.00094	200	0.08	< 0.02	< 0.04	0.00057	450	105	0.67

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-RSM-E Miniature Motorized Rotary Stages with Motor Encoders

- Continuous 360° rotation stage with optional built-in controller
- Optional motor mounted encoder provides slip/stall detection and automatic recovery
- 0.02° repeatability; 21 mm height
- < 0.04° backlash; 0.14° accuracy

Product Description

Zaber's X-RSM-E devices are miniature, worm gear driven, continuous 360° rotation stages with optional built-in controllers and motor encoders. These stages have 0.02° of repeatability and 50 N load capacity. These stages can be daisy-chained with any other Zaber devices. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Convenient locking, 4-pin, M8 connectors on these devices allow for easy and secure connection and power sharing between X-Series products.

Computer Control

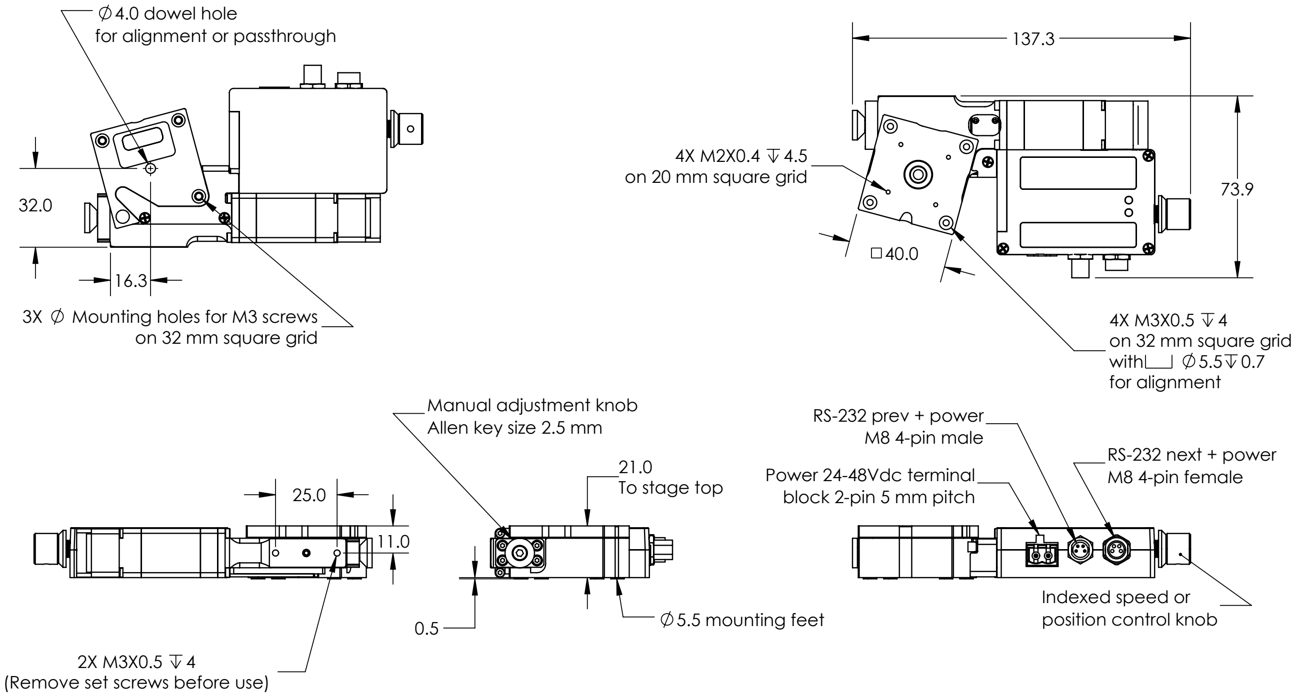
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

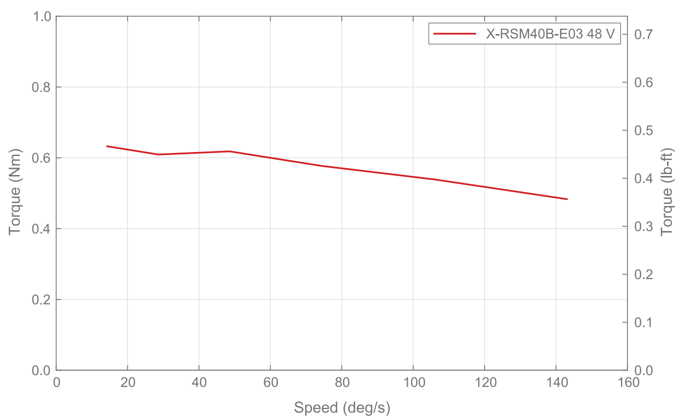
X-RSM-E Dimensions

Measurements in millimetres (mm)



X-RSM-E Performance Charts

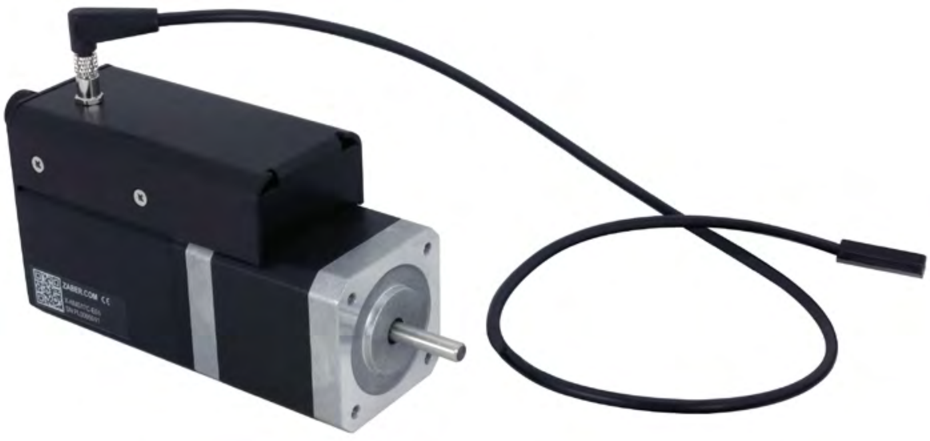
Torque Speed Performance



X-RSM-E Specifications

Model	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Continuous Torque (N·cm)	Weight (kg)
X-RSM40B-E03	0.00047	50	0.14	< 0.02	< 0.04	0.00029	120	60	0.28

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.



X-NMS-E Stepper Motors with Motor Encoders

- NEMA 17 stepper motor with built-in controller
- Home sensor and small magnet included, optional magnet away sensor
- Up to 25,600 microsteps per revolution; up to 2,650 rpm speed; 30 N-cm torque
- Optional motor mounted encoder provides slip/stall detection and automatic recovery
- Daisy-chains data and power with X-Series products

Product Description

These NEMA size 17 stepper motors have a built-in controller and optional motor encoder. A detachable home sensor with mounting screw and a small magnet are included. An additional, optional away sensor is also available. They are standalone devices requiring only a standard 24–48 V power supply.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices connect to the RS-232 port or USB port of any computer, and they can be daisy-chained with any other Zaber products. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like “move rel” to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

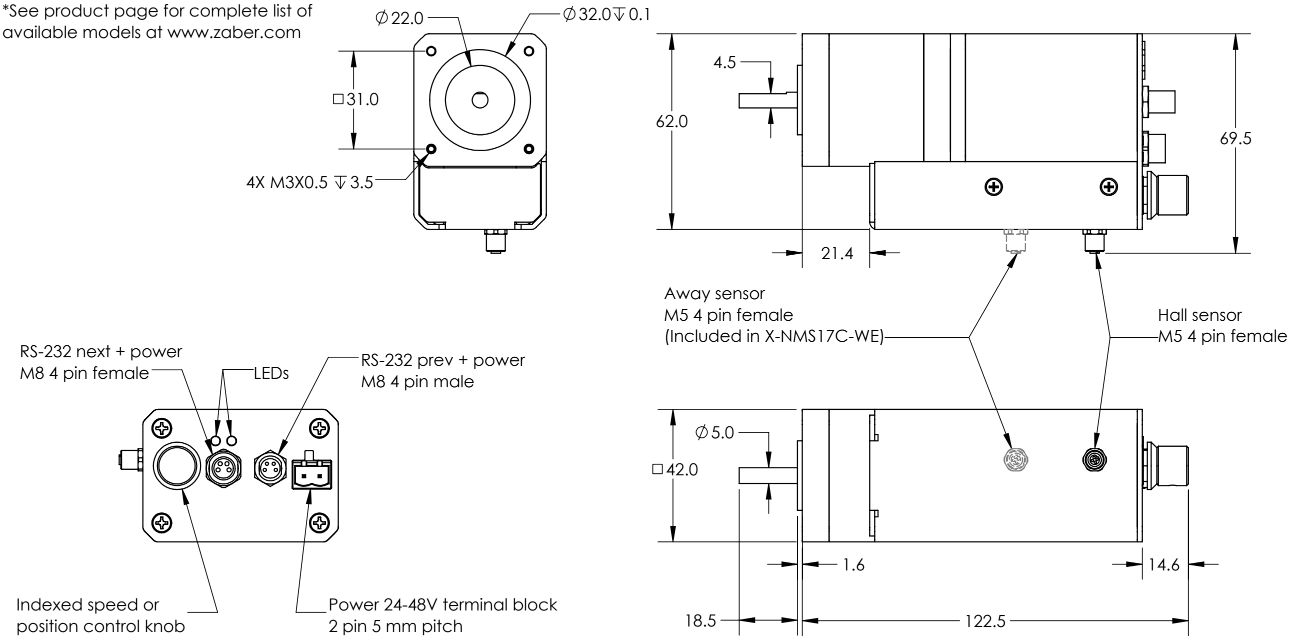
An indexed knob provides convenient manual control for versatile operation even without a computer.

X-NMS-E Dimensions

Measurements in millimetres (mm)

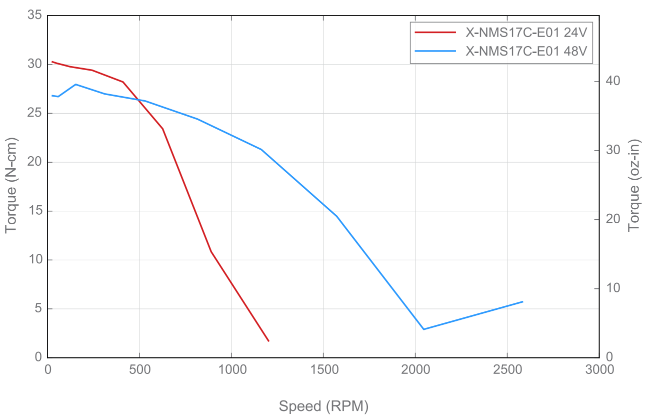
Model Number*	Hall Sensor	Away Sensor
X-NMS17C-E	Included	-
X-NMS17C-WE	Included	Included

*See product page for complete list of available models at www.zaber.com



X-NMS-E Performance Charts

Torque Speed Performance

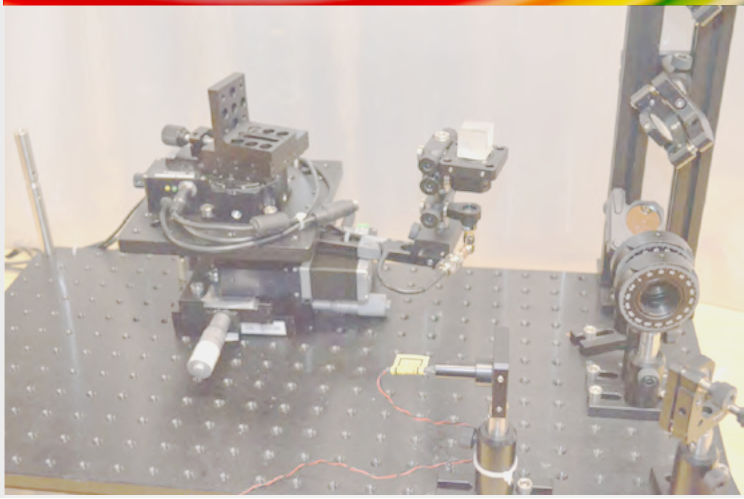


X-NMS-E Specifications

Model	Microstep Size (Resolution) (°)	Accuracy (°)	Repeatability (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Torque (N⋅cm)	Weight (kg)
X-NMS17C-E01	0.0281	0.25	< 0.1	0.0172	15900	30	0.58
X-NMS17C-WE01	0.0281	0.25	< 0.1	0.0172	15900	30	0.61

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

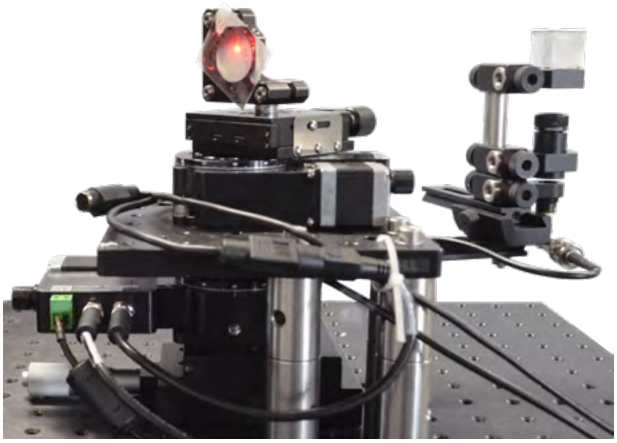
Customer Spotlight: CLEARink Displays



CLEARink Displays

CLEARink Displays aims to develop reflective display modules that combines the daylight readability of paper with the colourful video performance of digital displays. Formed in 2012, CLEARink's technology was originally developed at the University of British Columbia (UBC).

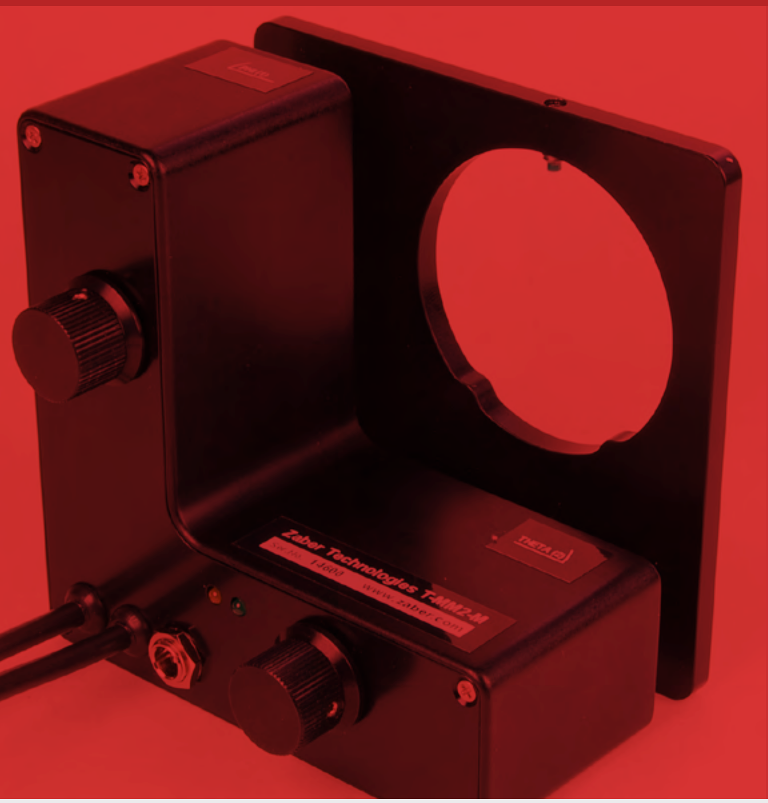
www.clearinkdisplays.com

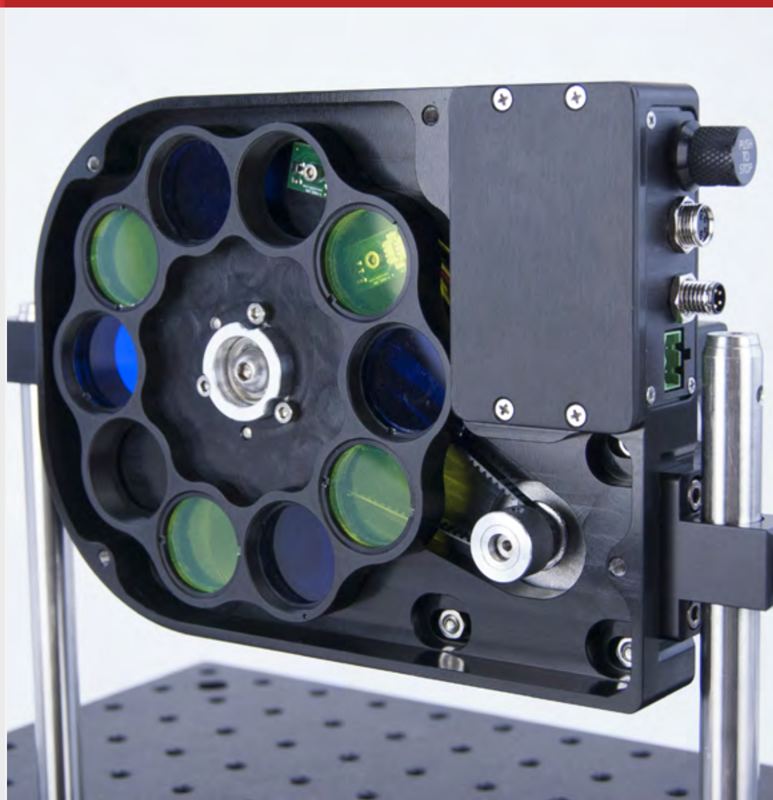


CLEARink Displays uses two Zaber devices in their goniometric reflectance apparatus. The apparatus measures the reflectance of display samples over a range of sample and photodetector angles. The apparatus consists of a laser light source, a number of mirrors, two polarizers, a photodetector, and two Zaber rotary stages. The sample being measured is mounted vertically to the top rotary device, allowing the angle of reflected light to change between 0° and 90°. The photodetector and beam splitter are mounted on the bottom rotary device, allowing the reflected light intensity to be mapped from -90° to 90°.

CLEARink

Optical Mounts





- Smooth, high speed filter changes; adjacent filter change time of 57 ms
- Interchangeable filter holders with 7 or 10 positions, 25 or 32 mm optics
- Daisy-chains with other X-Series products to share data and a single power supply
- Built-in controller; mounting provided for optical cage systems and C-mount components

X-FWR-E Motorized Filter Wheels

Product Description

Zaber's X-FWR-E Series devices are computer-controlled, motorized filter wheels with high speed filter change capabilities, a low profile, and interchangeable filter holders. Each filter wheel includes a filter holder (FH0625 for 10 x 25 mm filter positions or FH0632 for 7 x 32 mm filter positions). These devices are stand-alone devices requiring only a standard 48 V power supply.

Closed-Loop Operation

With the motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move index"), and enter the desired optic position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An indexed knob provides manual optic changes in both directions for versatile operation even without a computer.

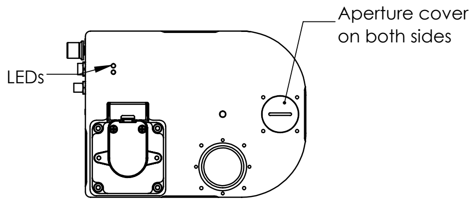
X-FWR-E Dimensions

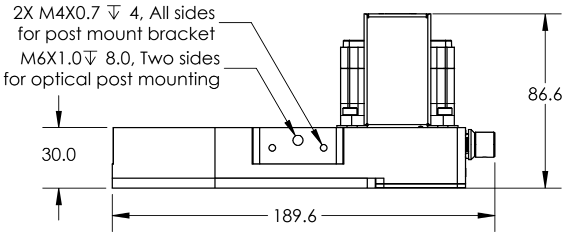
Measurements in millimetres (mm)

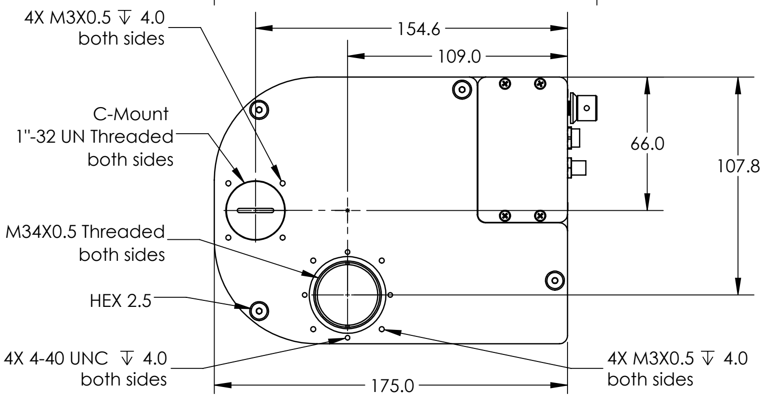
Model Number*	# Of Positions	Lens Thread
X-FWR06A-E02-FH0625	10	M27X0.5
X-FWR06A-E02-FH0632	7	M32.5X0.5

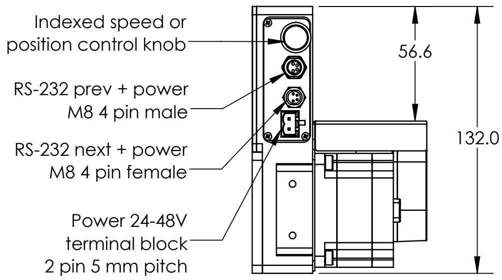
Included accessories:
- One of FH0625 or FH0632 filter holders
- 4X Aperture covers for 25 & 32 mm apertures

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









X-FWR-E Specifications

Model	# of optics	Adjacent Optic Change Time (ms)	Optic Diameter (mm)	Accuracy (˚)	Repeatability (˚)	Weight (kg)
X-FWR06A-E02-FH0625	10	57	25	0.4	< 0.1	1.5
X-FWR06A-E02-FH0632	7	65	32	0.4	< 0.1	1.5

1. Complete, up-to-date specs available at www.zaber.com.

T-OMG Motorized Gimbal Optic Mounts

- Two-axis gimbal optic mount with built-in controller
- Holds 1″ (25 mm) optics
- +/- 7° travel in each axis
- Compact design weighs only 350 g (0.73 lb)

Product Description

The T-OMG is a high-resolution, computer-controlled, two-axis optic mount. It is a stand-alone device requiring only a 15 V power supply. Two built-in controllers allow for easy, independent manipulation of each axis of rotation.

Installation

One or more gimbal optic mounts can be connected to the RS-232 port or a USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple T-Series products to share a single power supply.

Computer Control

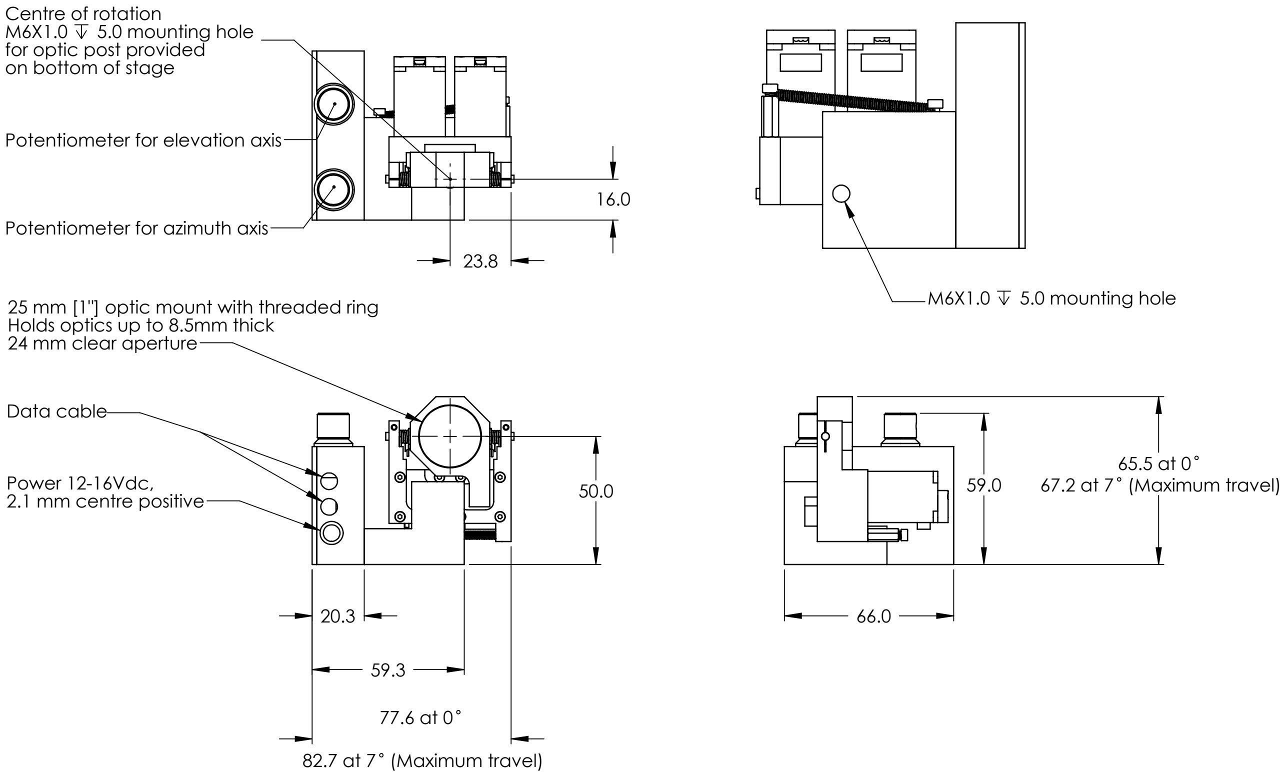
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the gimbal optic mount reports the new position of each axis. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

A knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. During a manual move the device's position is constantly transmitted to the computer and is displayed by the software.

T-OMG Dimensions

Measurements in millimetres (mm)



T-OMG Specifications

Model	Axis	Travel Range (°)	Microstep Size (Resolution) (°)	Accuracy (°)	Repeatability (°)	Maximum Speed (°/s)	Weight (kg)
T-OMG	Axis 1 (Azimuth)	+/- 7	0.00012	0.055	< 0.007	11	0.35
	Axis 2 (Elevation)	+/- 7	0.00006	0.0275	< 0.004	7	0.35

1. Complete, up-to-date specs available at www.zaber.com.

T-MM Motorized Mirror Mounts

- Two-axis kinematic mount (+/- 5.27° tilt) with built-in controller
- Holds 2˝ (50 mm) optics
- Optional adaptors: C-mount, 1˝ (25 mm), and 1/2˝ (12.5 mm) optics

Product Description

The T-MM is a computer-controlled, two-axis mirror mount with 1.5 μrad (0.000086°) resolution. It is a stand-alone device requiring only a 15 V power supply. It has a built-in controller for each axis, so that you can easily control each axis independently.

Installation

One or more mirror mounts can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple T-Series products to share a single power supply.

Computer Control

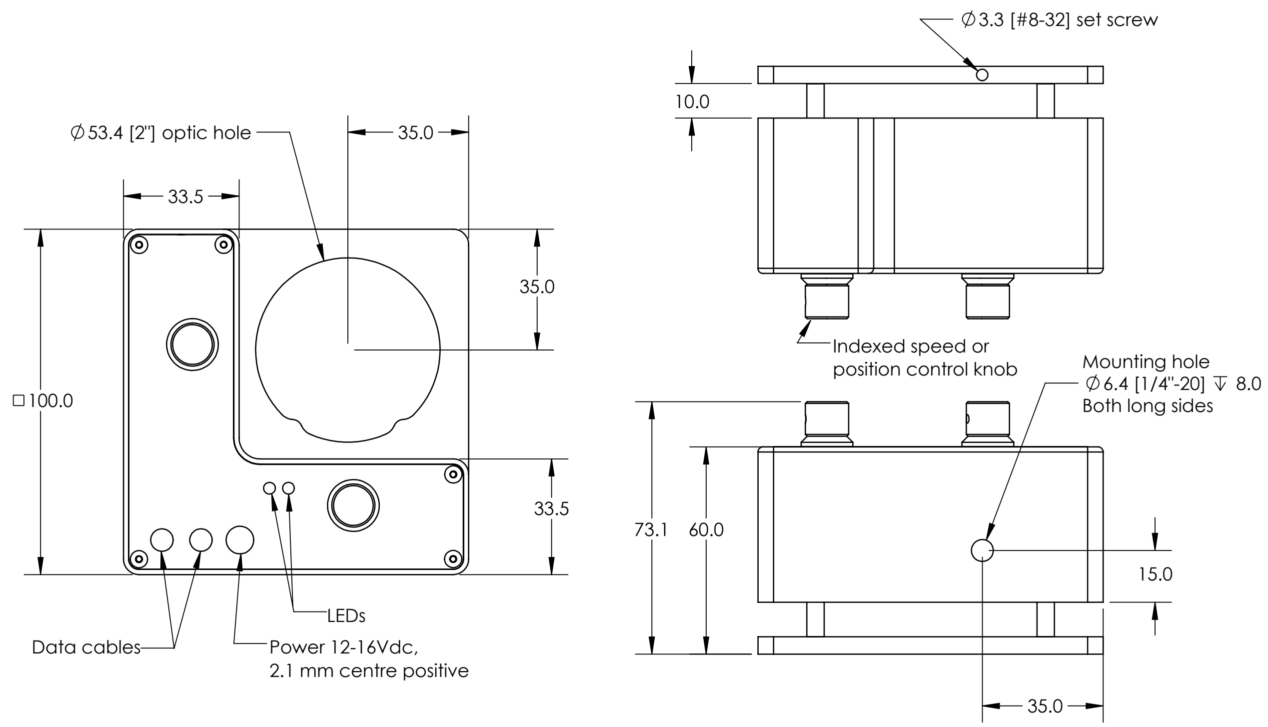
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like “move absolute”), and enter the desired position. After the move, the mirror mount reports the new position of each axis. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

A knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. During a manual move the device’s position is constantly transmitted to the computer and is displayed by the software.

T-MM Dimensions

Measurements in millimetres (mm)



T-MM Specifications

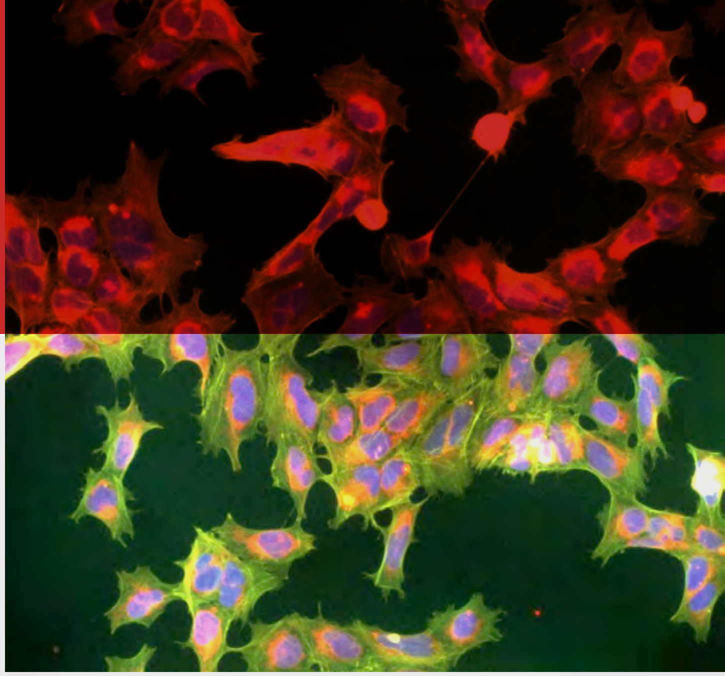
Model	Travel Range (°)	Microstep Size (Resolution) (°)	Accuracy (°)	Repeatability (°)	Backlash (°)	Maximum Speed (°/s)	Weight (kg)
T-MM2	+/- 5.27	0.000086	0.06	< 0.015	< 0.03	3.44	0.55

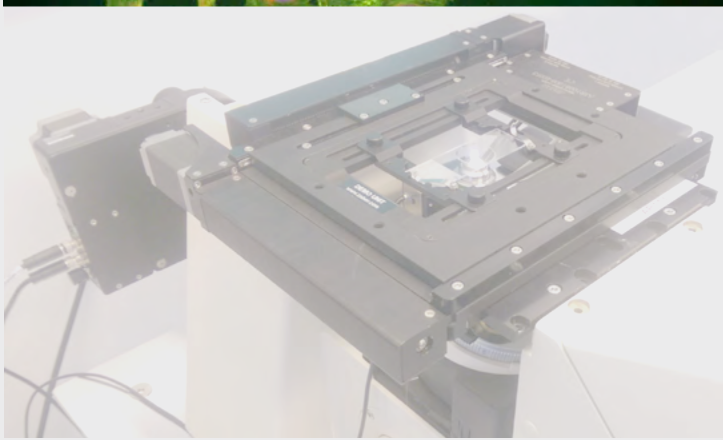
1. Complete, up-to-date specs available at www.zaber.com.

I'd like to compliment your company's excellent customer service/support. I've been extremely impressed by my representative's timely replies and helpful answers – rising above and beyond merely answering my questions to provide assistance. The paragraph in which he explained how the XYZ assemblies were created would have been a sufficient answer to my query, but he followed through and uploaded a composite model for me. This saved me time in discovering what I wanted to evaluate about your products, and I can easily imagine a scenario where it would have done something that a customer had neither the knowledge or ability to do (manipulate imported assemblies into a single composite one). Customer service to myself and my company are almost as important as the products themselves, and after this positive experience, we'll be sure to order our linear stages from your company.

– Lee Christoffers, Applied Optimization Inc.

Distributor Spotlight: Laser 2000 UK

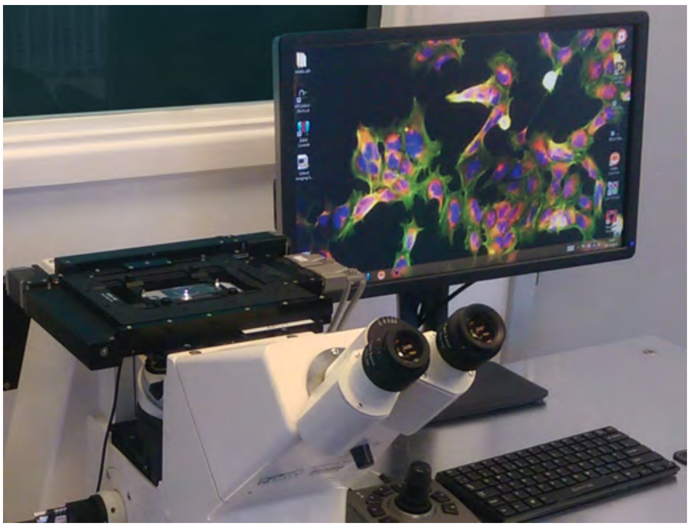




Laser 2000 UK

Laser 2000 supplies state-of-the-art photonic and optoelectronic products. Their range includes motion control, optical filters, LED light sources, lasers, laser safety, cameras, adaptive optics, and much more. With over 25 years of experience in the market, they help to find the best possible solution to your application. Laser 2000 (UK) exclusively distributes Zaber products to the UK and Ireland.

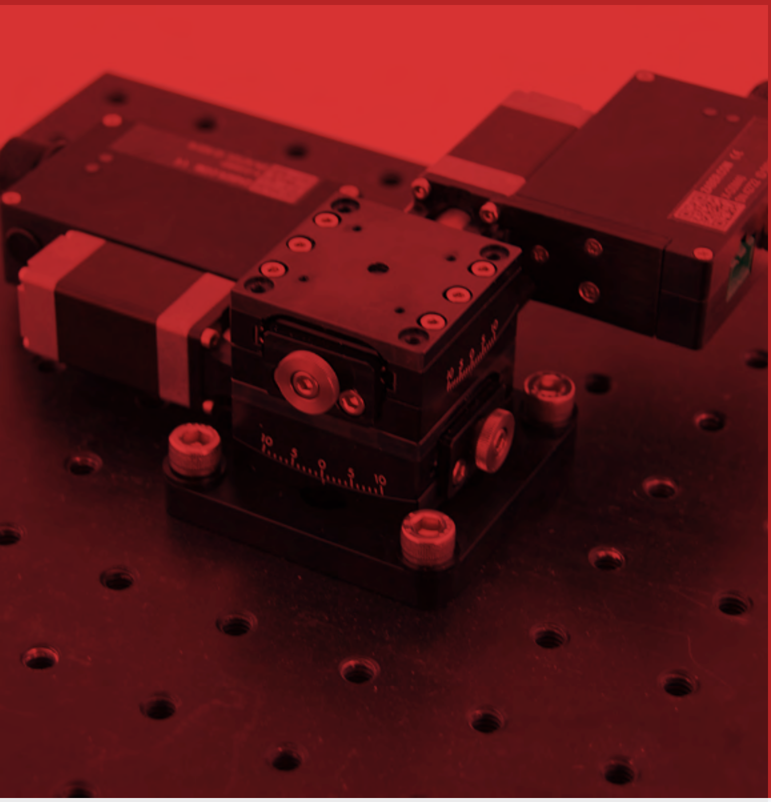
www.laser2000.co.uk

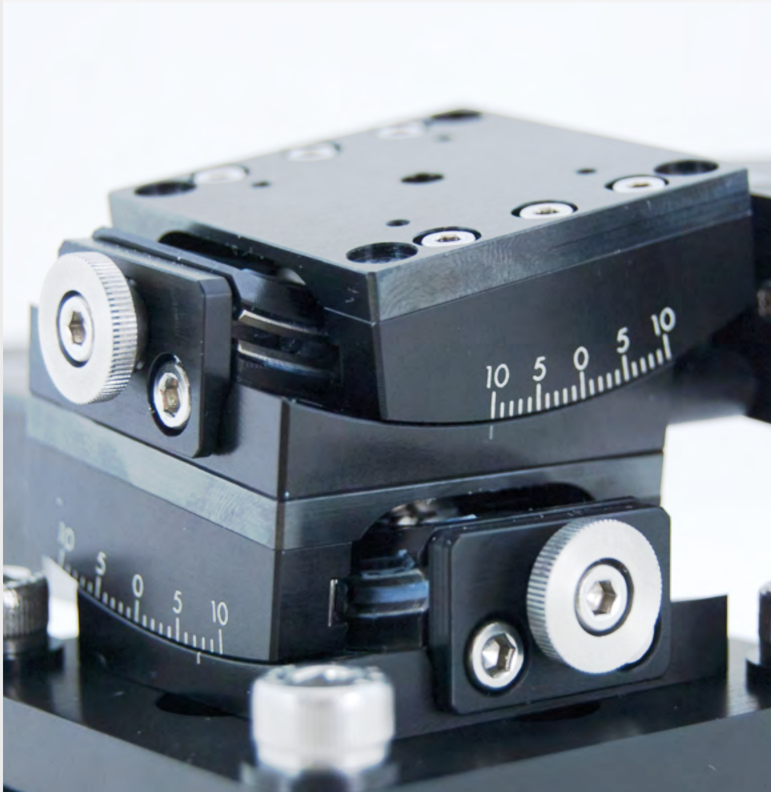


Laser 2000 integrated Zaber's ASR Series XY microscope stage with an inverted epifluorescence microscope to enable automated scanning of two epithelial cell samples from a human embryonic kidney. Multiple fluorescent stains were employed to allow for bright and high-contrast images that depict the internal structure of the cells. In order to excite multiple fluorescent stains at precise intervals, Zaber's X-FWR-E motorized filter wheel was mounted between the microscope lamp housing and the excitation port. By combining Zaber's filter wheel with their XY stage and controlling both via standard μManager software, fluorescence channels were switched at high rates, resulting in short multi-channel capture times and high throughput.

LASER 2000

Goniometers





X-GSR-E Large Diameter Goniometers with Motor Encoders

- Integrated, 500 CPR, motor mounted encoder provides slip/stall detection and automatic recovery
- Up to 80 deg/s speed and up to 60 Nm of torque
- 50 kg centred load capacity
- 150 mm and 225 mm centre of rotation options allow for two axes of motion about a common centre of rotation

Product Description

Zaber's X-GSR-E Series devices are computer-controlled, motorized goniometers with a large diameter of rotation and long travel. With a low, narrow profile and asymmetric mounting options, these stages excel at angular scanning applications where keeping a clear view of the central target is critical. Curved crossed-roller supports give these devices smooth motion and the roller cam drive provides exceptional accuracy and eliminates backlash. These are stand-alone devices requiring only a standard 48 V power supply.

Closed-Loop Operation

The motor encoders provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

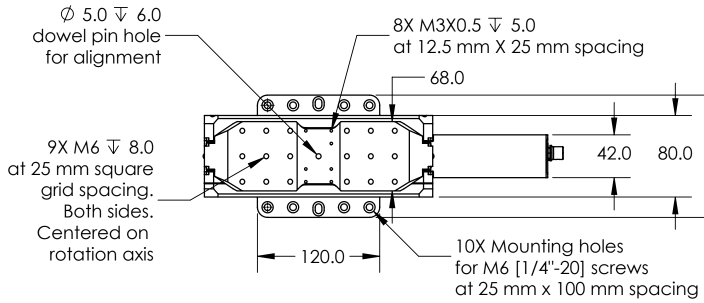
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

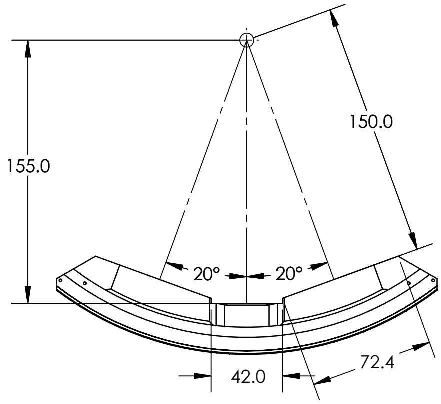
Manual Control

An indexed knob provides convenient manual control for versatile operation even without a computer.

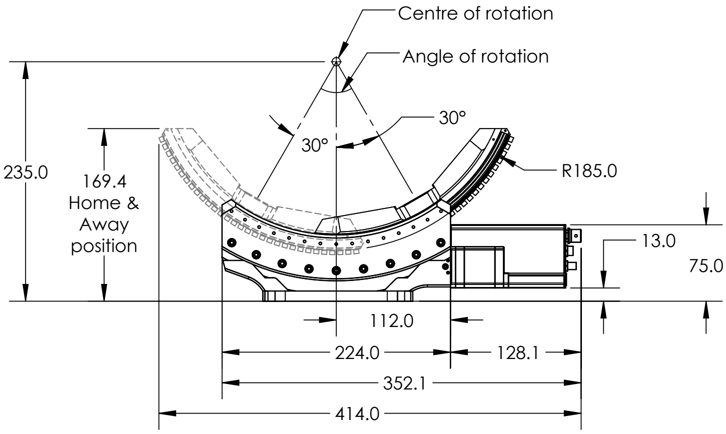
X-GSR-E Dimensions

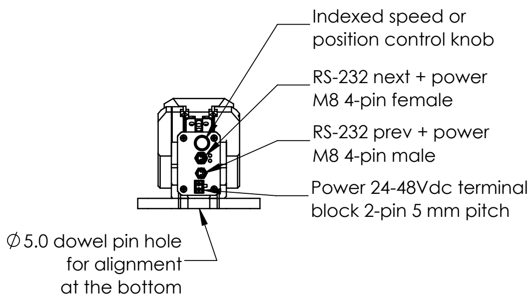
Measurements in millimetres (mm)





Stage top details





X-GSR-E Specifications

Model	Microstep Size (˚)	Maximum Centred Load (N)	Minimum Speed (˚/s)	Maximum Speed (˚/s)	Range (˚)	Backlash (˚)	Accuracy (˚)	Repeatability (˚)	Weight (kg)
X-GSR150-E01	0.0001875	400	0.0001138	80	60	< 0.018	0.05	< 0.005	4.1
X-GSR225-E01	0.0001406	500	0.0000858	60	60	< 0.012	0.04	< 0.005	5.04

1. Complete, up-to-date specs available at www.zaber.com.

- Stackable for a common centre of rotation
- 30 N load capacity; low profile, small footprint
- Daisy-chains with other X-Series products to share data and a single power supply
- Optional motor encoder provides slip/stall detection and automatic recovery

X-GSM-E Motorized Goniometers with Motor Encoders

Product Description

Zaber's X-GSM-E Series devices are computer-controlled, motorized goniometers with optional built-in controllers and motor encoders in a compact size. These stages are excellent for applications where a small profile is required. They can mount to a flat surface or stack together to share a common centre of rotation for two axes of angular motion. These are stand-alone devices requiring only a standard 48 V power supply.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired distance. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

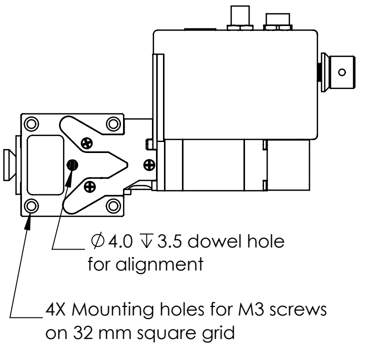
An indexed knob provides convenient manual control for versatile operation even without a computer.

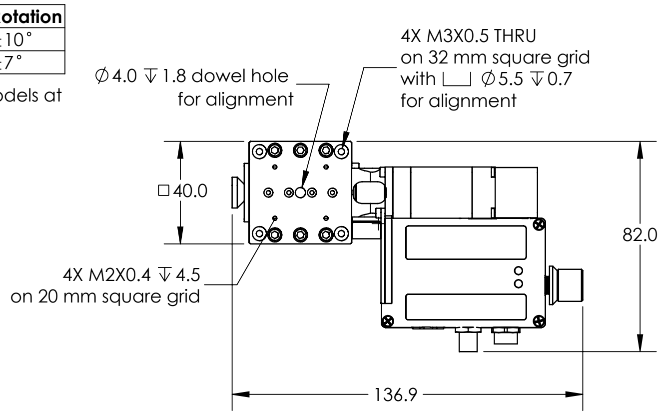
X-GSM-E Dimensions

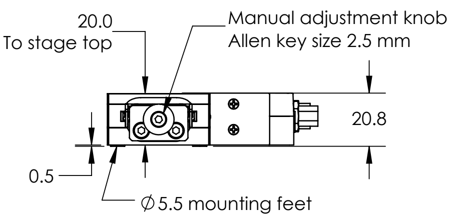
Measurements in millimetres (mm)

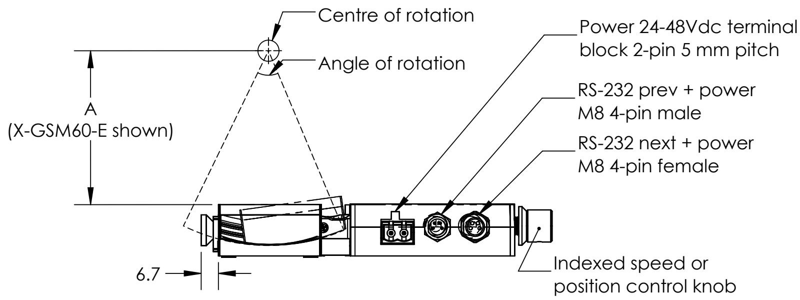
Model Number*	A (Distance To Centre Of Rotation)	Rotation
X-GSM40-E	40.0	±10°
X-GSM60-E	60.0	±7°

*See product page for complete list of available models at www.zaber.com







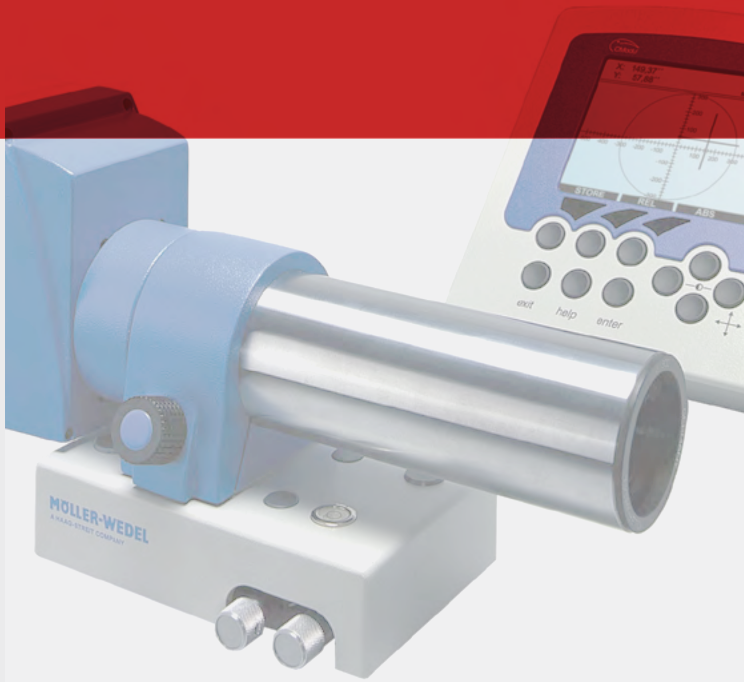


X-GSM-E Specifications

Model	Microstep Size (˚)	Maximum Centred Load (N)	Minimum Speed (˚/s)	Maximum Speed (˚/s)	Range (˚)	Backlash (˚)	Accuracy (˚)	Repeatability (˚)	Weight (kg)
X-GSM40-E03	0.0001626	30	0.00009923	30	+/- 10	< 0.01	0.06	< 0.005	0.285
X-GSM60-E03	0.0001131	30	0.00006906	30	+/- 7	< 0.01	0.06	< 0.005	0.285

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

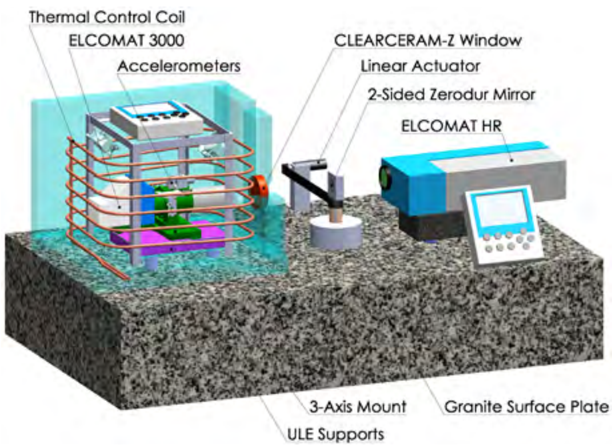
Customer Spotlight: Vermont Photonics



Vermont Photonics

Vermont Photonics supplies precision optical metrology equipment such as electronic and visual autocollimators, collimators, telescopes, dioptometers, alignment telescopes, refractometers, and more. They have been the exclusive U.S. agent for Möller-Wedel Optical GmbH for nearly 30 years. Since its introduction, the ELCOMAT line of electronic autocollimators has become known as the standard for high-accuracy non-contact angle measurement.

www.vermontphotonics.com



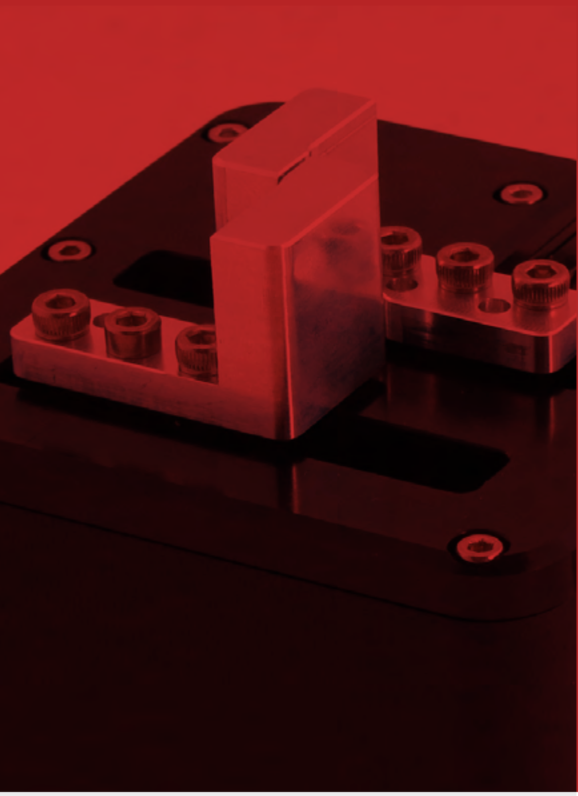
Vermont Photonics utilizes the T-LA28A linear actuator for several applications in calibrating high-accuracy electronic autocollimators, such as the ELCOMAT 3000. The T-LA28A is used to set the mirror angle for a thermally-controlled, high-precision angular calibration station. The success of this station was crucial for the next stage of development with the ELCOMAT 3000 for Vermont Photonics' aerospace customer.

We use Zaber's linear actuators because they are very easy to control and integrate into hardware, cost-effective, and reliable. They simply get the job done.

– Vermont Photonics

VERMONT PHOTONICS

Grippers



- Easily measure size of objects and finger position without extra programming
- Maintains grip even if power is lost
- Daisy-chains with other X-Series products to share a single power supply
- Motor encoder with position feedback and optional built-in controller

X-GLP-E Parallel Grippers

Product Description

Zaber's X-GLP-E Series of products are computer-controlled electric grippers with motor-mounted encoders. They are stand-alone devices requiring only a standard 24 V power supply. The motor encoder allows for closed-loop operation, detecting when the fingers have gripped an object and providing feedback about the object's size.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

Gripper devices connect to the USB or RS-232 port of any computer and can be daisy-chained with several devices per chain. They can be chained with any other Zaber products. Convenient locking, 4-pin, M8 connectors on the device allow for easy and secure connection. The chain also shares power, so multiple X-Series products can share a single power supply.

Computer Control

To control gripper position, simply transmit on the RS-232 port the device number of the device you want to move, a simple move command and the position desired. The gripper will automatically detect when it has gripped a part and its size. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

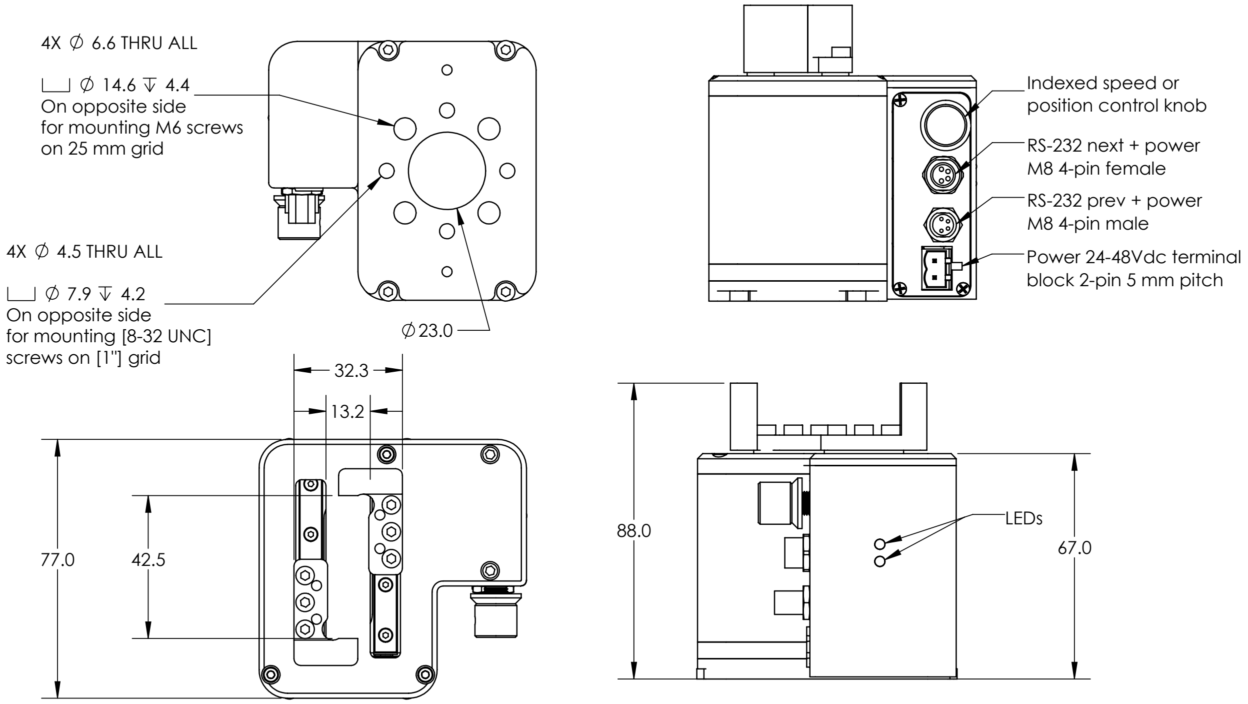
Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and distance mode. Linear, quadratic and cubic speed profiles are available. Speed profiles and distance per detent can be specified and are easily configurable.

X-GLP-E Dimensions

Measurements in millimetres (mm)

*See product page for complete list
of available models at www.zaber.com



X-GLP-E Specifications						
Model*	Travel Range (mm)	Microstep Size (Resolution) (µm)	Repeatability (µm)	Backlash (No Load) (µm)	Maximum Speed (mm/s)	Peak Thrust (N)
X-GLP040B-E03	40	0.248	< 4	< 40	75	10

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

Customer Spotlight: Kyoto University

Kyoto University

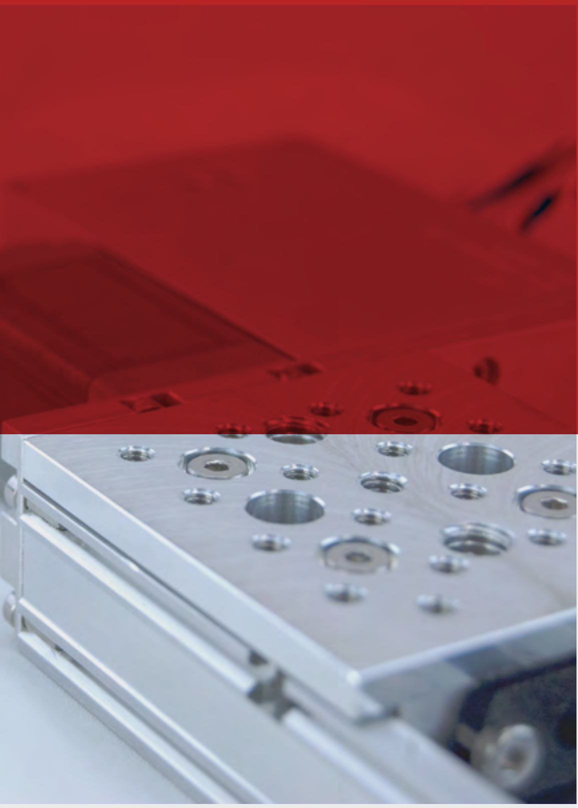
The Department of Astronomy at Kyoto University conducts research in the fields of stellar physics, galactic physics, and theoretical astrophysics. Specific research interests by faculty members include black holes, X-ray astronomy, variable stars and transient objects, and starburst galaxies. Kyoto University is located in Kyoto, Japan.

www.kusastro.kyoto-u.ac.jp

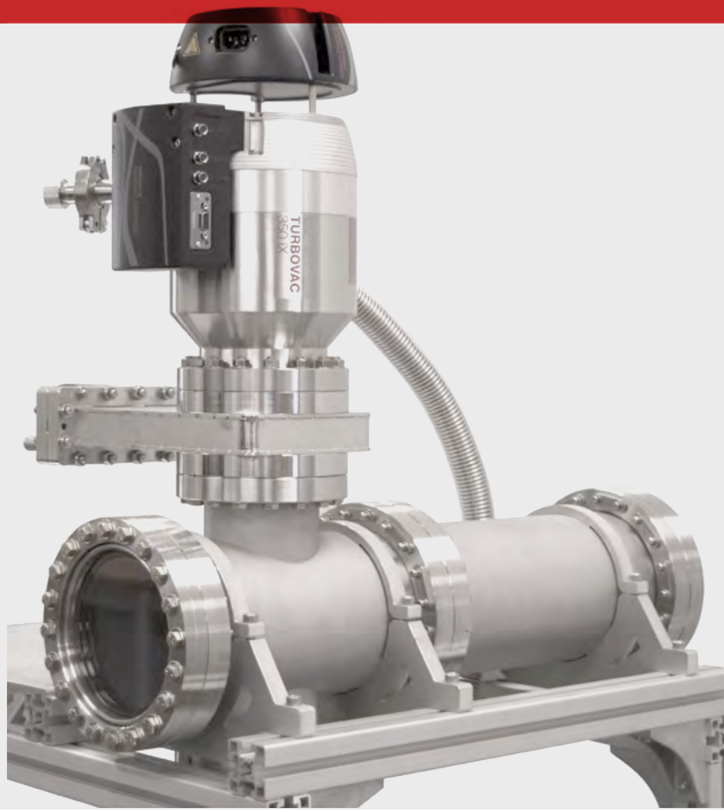
Kyoto University's Department of Astronomy has integrated a custom version of Zaber's T-NA08A25 actuators into their project – a 3.8 m New Technology Optical Infrared Telescope, which will be installed in the Okayama Astrophysical Observatory in Okayama, Japan. This telescope assembles 18 segment mirrors designed to perform as a single 3.8 m diameter large mirror. Actuators automating each segment are feedback-controlled around the clock, moving each unit within 10 Hz.

京都大学
KYOTO UNIVERSITY

Vacuum



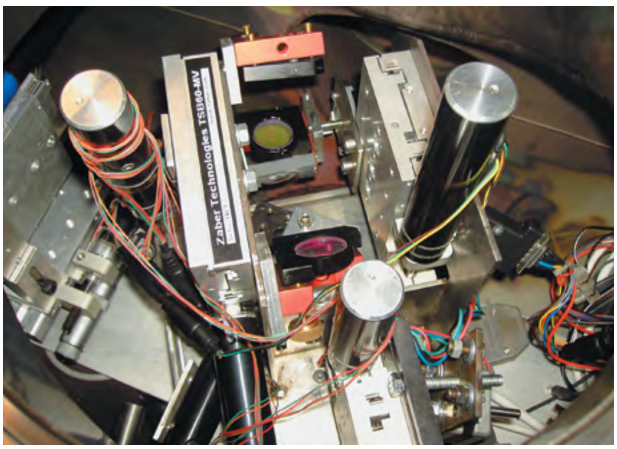
Customer Spotlight: University College Dublin



University College Dublin Physics Department

UCD School of Physics is the only Physics school on the Island of Ireland in the top 200 Physics Schools worldwide according to the 2015 Shanghai rankings. With high levels of research funding, the future is very bright for the School of Physics, which consistently excels in the impact of its research.

www.ucd.ie/physics/



The image to the left shows Zaber's low vacuum actuators and translation stages set up inside a vacuum chamber to precisely drive the target and optics.

We use Zaber actuators because they are so easy to daisy-chain in a vacuum, and we can think about the experiments we want to do without having to worry about complex wiring or programming. They save us time and money. I would happily recommend them.

– Dr. Fergal O'Reilly, Research Physics & Innovation Officer

Motion Device Design Considerations for Vacuum Applications

By Albert David, Applications Engineering Team

Do you remember the large, heavy, color TV sets that were used until the early 2000's? Many of us have been using vacuum technology without even knowing it. Those large TV's all required a high vacuum cathode ray tube (CRT) to allow electrons to fly freely without colliding with other molecules.

One of the earliest significant uses for vacuum was to manufacture cathode ray tubes in the early 1900's, but the first use of CRTs was in an oscilloscope known as the cathode ray oscilloscope. As technology has advanced, the use of vacuum systems has flourished into a variety of different applications, such as electron tube manufacturing and optical coating. It was then discovered that many applications could achieve better results within vacuum than under standard atmospheric pressures, and in some cases achieve results that were otherwise impossible at the time. With the proliferation of vacuum applications, we have also seen an increased demand for vacuum compatible positioning equipment.

This article will outline the basics of a vacuum system and present considerations to keep in mind when gathering requirements for your application. It will focus on motion control and what is essential to achieve reliable performance without compromising the vacuum requirements.

Figure 1: Typical Zaber vacuum device anatomy.

WHAT IS A VACUUM AND WHY IT IS NECESSARY

A vacuum, in engineering or applied physics, is an area with a lower than standard atmospheric pressure. In markets such as photonics and optics, industrial manufacturing, and life sciences, there are an increasing number of processes that must be performed under vacuum conditions. Ideal vacuums provide clean and contaminant free environments for research and manufacturing, such as optical coating, semiconductor manufacturing, and electron beam welding.

There are several standardized units used to specify pressure, including Torr, milliBar (mBar), and pascals (Pa). Defining a vacuum pressure in terms of standard atmospheric pressure is also common. The relationship between these common units are found in Table 1.

	Atmosphere	Torr	mBar	Pa
Atmosphere	1	760	1013.25	101325
Torr	1.32×10^{-3}	1	1.33	133.32
mBar	9.87×10^{-4}	7.50×10^{-1}	1	100
Pa	9.87×10^{-6}	7.50×10^{-3}	0.01	1

Table 1: Vacuum unit relationship

Figure 2: One of Zaber's vacuum chambers.

Zaber Technologies currently manufactures low vacuum and high vacuum products. Our low vacuum devices are compatible under vacuum conditions as low as 10^{-3} Torr, while our high vacuum devices are acceptable down to vacuum pressures as low as 10^{-6} Torr. Higher levels of vacuum – such as ultra-high vacuum (UHV) that is designed to reach 10^{-9} Torr – have more stringent requirements relative to low and high vacuum. UHV will not be discussed in detail in this article since our current focus within vacuum systems are in the low and high vacuum pressure range.

Different applications require specific vacuum ranges. Low vacuum applications include brazing, sintering, and mass spectrometry. High vacuum applications involve optical equipment as well as thin film coating and scanning electron microscopy. Some UHV applications include larger particle accelerators and photo electric research.

There are many applications that use vacuum levels ranging from atmospheric pressure down to 10^{-1} Torr, in which standard Zaber products can be used. This is dependent on the application's requirements. Some applications include the use of carbon dioxide lasers and manufacturing neon and fluorescent lamps or incandescent light bulbs.

WHAT TO CONSIDER WHEN SELECTING A VACUUM COMPATIBLE POSITIONER?

There are several considerations that need to be addressed in order to achieve the desired vacuum level as well as a clean and contaminant free environment. Among these considerations are outgassing, material selection, heat management, virtual leaks, and cable management. This article will cover the basic considerations of vacuum systems and how we, at Zaber, have optimized our vacuum product lineup.

Outgassing

Outgassing is the release of molecules that have adsorbed onto a surface, absorbed into a material, or that are inherent as a property of the material. Adsorption is a collection of molecules that create a thin film on the surface of a material. Absorption is when a foreign substance is “soaked in” to a material. Any surface within a vacuum is considered a potential source of outgassing since surfaces are active areas for adsorption and absorption to occur.

Controlling outgassing is one of many challenges when maintaining a vacuum system. Outgassing vapours can deposit on sensitive optical equipment, create impurities in coatings, or contaminate a sample.

The outgassing rate, in combination with the pump down rate, determines the length of time it will take to reach the desired vacuum level as well as what vacuum level is achievable. Outgassing rate is defined by:

$$\frac{\text{Pressure} \bullet \text{Volume}}{\text{Surface Area} \bullet \text{Time}}$$

Water, grease, oil, and organic materials are a few of the more common outgassing vapours. The outgassing of volatile condensable materials such as hydrocarbons is often more of a concern than other types of molecules such as water vapour. Hydrocarbon vapours can condense on optical components and interfere with their operation, while water vapour generally does not condense and is effectively pumped out of the chamber.

When designing a device to go into a vacuum chamber, regardless of the material used, the outgassing rate is still Pressure x Volume per **Surface Area** per Time. Since the exposed surface area can adsorb a thin film of molecules, which will affect outgassing and pump down time, it is highly recommended to minimize the surface area as much as possible. This becomes a larger consideration in UHV systems.

Material Selection

As mentioned in the section on outgassing, materials will inherently outgas; therefore, material selection will play a large role in achieving the required vacuum level.

Materials have a property known as vapour pressure. The vapour pressure relates the temperature with the pressure exerted by a vapour in a closed system. If the pressure exerted is high, this will restrict your vacuum system from reaching a low vacuum level. Your ideal material should have a low vapour pressure, which results in low outgassing, and, therefore, a lower vacuum pressure.

A few examples of materials that have a high vapour pressure, and should be avoided:

- Porous ceramics
- Porous metals
- Plastics
- Adhesives
- Standard lubricants
- Standard oils
- Standard grease
- Organic material

> “Controlling outgassing is one of many challenges when maintaining a vacuum system.”

Some materials with a low vapour pressure, and are good choices for vacuum:

- Stainless steel
- Austenitic steel
- Aluminum
- PEEK
- PTFE
- Kapton
- Bronze*

Standard stepper motors are generally not suitable for vacuum applications as their bearings can be coated with an oil or grease that has a high vapour pressure, and their wires can be insulated with PVC. Replacing the PVC insulated wires to PTFE/Teflon coated wires will help reduce outgassing. Vacuum motors often have their windings replaced for high temperature windings, and their paints and oils are removed and replaced with vacuum compatible greases, similar to the one shown in Figure 3.

Figure 3: High vacuum compatible stepper motor.

*Alloys such as brass or bronze contain zinc, which has relatively high vapour pressure when compared to stainless steel. The vapour pressure of zinc is less than 10^{-11} Torr at 50˚ C, or 10^{-6} Torr at ~180˚ C. This emphasizes the importance of material selection given the application requirements.

In addition to motor wires, other electrical wires such as data cables should be replaced since standard wires are generally PVC insulated.

Standard sensors may also contain PVC insulated wires as well as plastic housings that have a high vapour pressure. These should be replaced with vacuum compatible sensors.

One unique advantage to using stepper motors in a vacuum is that they can be used without an encoder. Minimizing the amount of electronics in a vacuum chamber is good practice, since electronics can fail in many ways including overheating.

At Zaber we carefully scrutinize all materials that are built into our products. We replace our motors with vacuum compatible stepper motors that use Teflon leads, special windings, and vacuum compatible lubricant and greases. All of our daisy-chaining cables also utilize Teflon insulated wires.

When electronics are required in a vacuum chamber, such as our built-in controllers (as seen in Figure 1), they must be prepared for the expected vacuum level. We replace any electrolytic capacitors with tantalum, and have the PCB's specially treated and manufactured to further reduce outgassing. An example of a high vacuum PCB is shown in Figure 4.

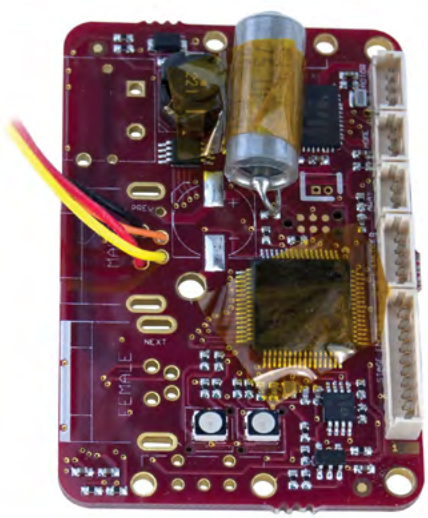


Figure 4: High vacuum compatible PCB.

During manufacturing, our vacuum PCB's are populated using a low residue flux, cleaned with isopropyl alcohol multiple times prior to assembly, and coated for additional protection.

Standard Zaber devices use aluminum components that are hardened through a process called anodizing. Our vacuum devices are un-anodized because the anodized layer creates a porous surface that traps gasses and moisture more easily, resulting in more outgassing and longer pump down times. Figure 5 is an example of an un-anodized extrusion.

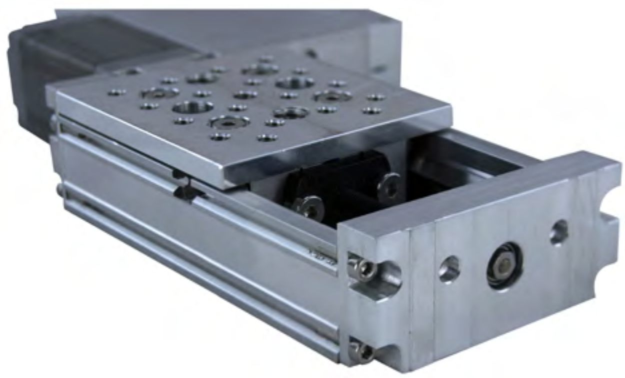


Figure 5: Un-anodized extrusion.

Heat Management

Without the fluid medium of air to dissipate heat by convection, electrical components in a vacuum must be carefully designed and monitored to avoid overheating. Exceeding the rated temperature for a motor or PCB can cause damage, make performance unreliable, and limit its lifetime.

As mentioned in the material selection section, Zaber's vacuum motors are made to withstand a higher operating temperature within a vacuum, but they can exceed the rated temperatures without proper care.

Zaber's vacuum devices use conduction as their primary source for heat dissipation. Mounting these devices directly to the chamber will help heat to dissipate faster.

In addition, we have optimized our PCBs and firmware to ensure that our devices maintain a temperature that produces reliable performance and optimal overall lifetime. This includes modifications to the PCB housing to increase heat sinking and modified firmware to control heat generation. When selecting a vacuum compatible Zaber device for your application, it is recommended that you contact our Applications Engineering Team to determine an appropriate duty cycle and running current combination. An example of a run current vs duty cycle plot can be found in Figure 6 below.

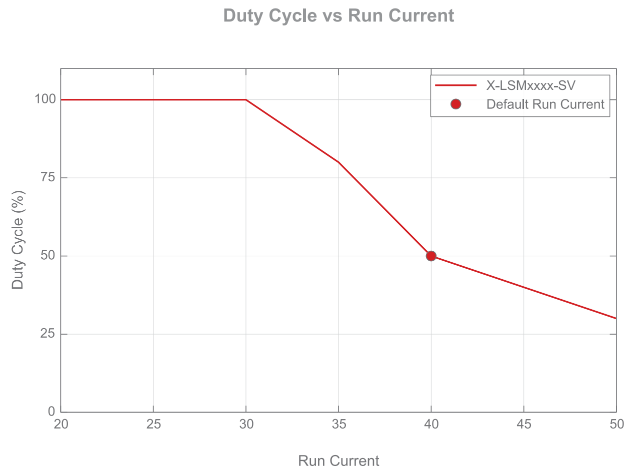


Figure 6: Run current vs duty cycle plot for the X-LSM-SV.

Our X-Series vacuum devices have an integrated temperature sensor on their controllers; however, it is also recommended to add a sensor to the motor to monitor the temperature. For example, a K-type thermocouple (as seen in Figure 7 below) or other temperature sensor may be mounted to the motor to monitor temperature in order to reduce the risk of overheating.

Figure 7: K-Type thermo couple mounted to a motor.

Virtual Leaks

A virtual leak is a small pocket of trapped gas in a device that is linked to the larger vacuum chamber through a small channel. This causes a slow outgassing process that can prevent the vacuum chamber from reaching the desired pressure. An example of a virtual leak is a threaded hole with a fastener that is not vented. Figure 8 shows the difference between a blind hole, a vented screw, and a through hole.

At Zaber, we carefully design our devices to minimize virtual leaks. We use vented screws and integrate venting paths in threaded holes to avoid trapped gasses. When possible, we use a through hole rather than a blind hole. We also integrate venting slots on the controller housing, allowing trapped gasses to escape more quickly.

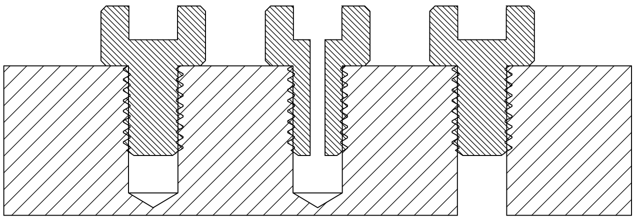


Figure 8: Blind hole (left), vented screw (middle), through hole (right).

Cable Management

Because we have optimized our built-in controllers to withstand low and high vacuum pressure, they can be daisy-chained in a vacuum chamber. This means that multiple devices can share one power supply and a single connection to a computer, which reduces the number of wires to your feedthrough.

Our vacuum devices are shipped with flying leads, which can be crimped, tied, or soldered together to create a daisy-chain, with only four feedthrough wires (2 power, 2 data) required for multi-axis motion in a vacuum chamber.

Alternatively, we can provide vacuum compatible connectors (see Figure 9). Please contact Zaber's Applications Engineering Team for more details.

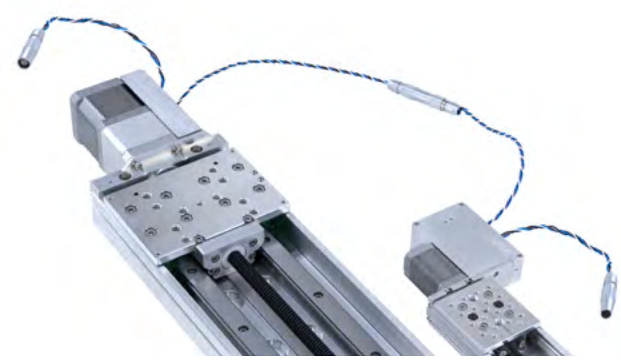


Figure 9: Two high vacuum devices in a daisy-chain with vacuum connectors.

Set-up As Easy As 1-2-3

Setting up and controlling multiple Zaber devices in a vacuum chamber requires only a few steps (see Figure 10).

1. Connect data and power cables between computer and vacuum chamber.
2. Devices with built-in controllers receive power and data in the vacuum chamber via 4 feedthrough wires.
3. Send instructions or automate your set-up using Zaber Console.

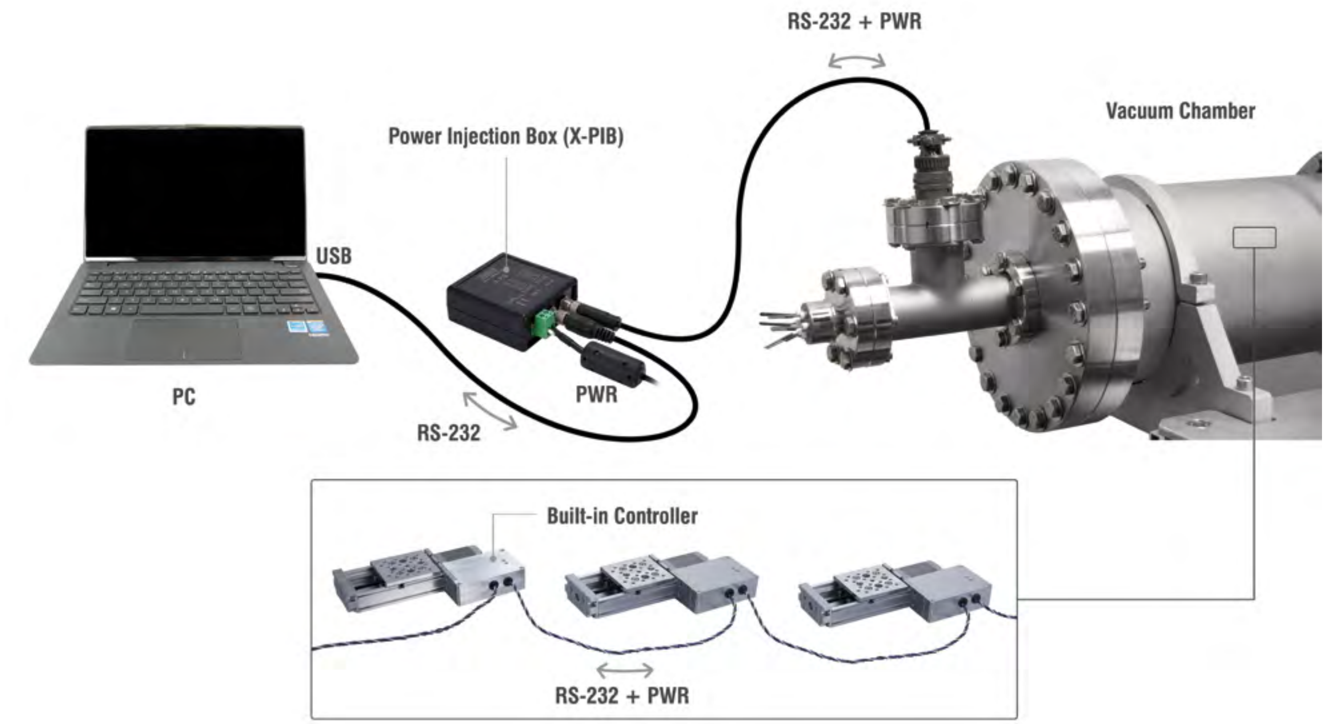


Figure 10: Three devices with built-in controllers daisy-chained in a vacuum chamber.

Cleaning, Handling, and Packaging

As you decrease the vacuum pressure, the level of care and cleaning becomes increasingly important. Devices exposed to air are at risk of contamination due to adsorption on the surface.

Cleanroom gloves should always be worn when handling vacuum devices since bare hands can introduce oil, dirt, and other organic material. This can contaminate a vacuum chamber and produce unwanted excess outgassing.

Each component for Zaber's low vacuum devices are degreased and cleaned using isopropyl alcohol, then assembled using cleanroom gloves.

All components for our high vacuum devices are ultrasonically cleaned prior to assembly. In addition to ultrasonically cleaning the components, the devices are assembled in a class 100 (ISO class 5) cleanroom. The parts do not leave the cleanroom until the finished products are packaged and ready to ship. When our high vacuum devices are ready to ship, they are packaged in Ultra Low Outgassing (ULO®) polyethylene bags inside our cleanroom and double bagged, allowing the end user to remove the outer bag prior to inserting the device into their cleanroom. Figure 11 shows an example of a high vacuum device double bagged in ULO®.

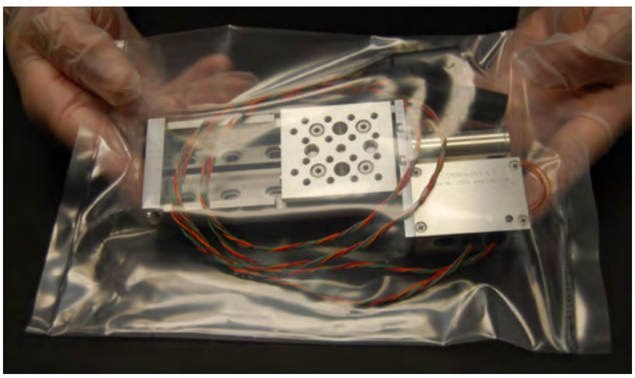


Figure 11: High vacuum device double ULO® bagged.

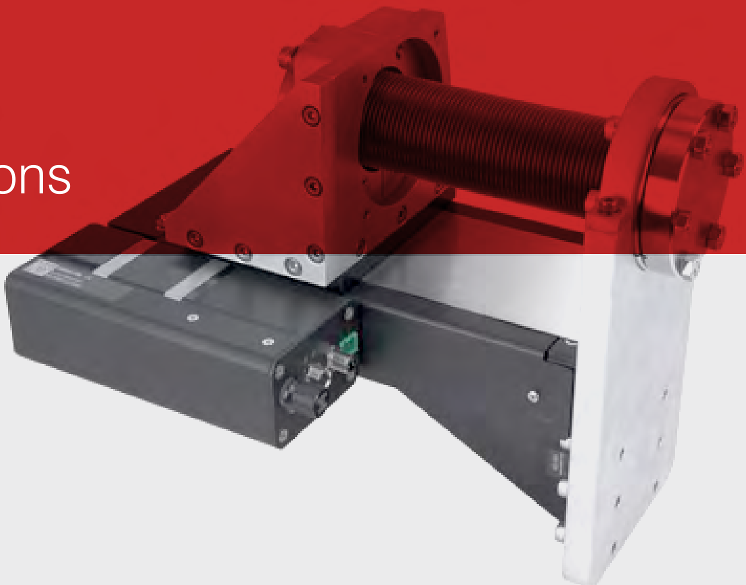
CONCLUSION

At Zaber Technologies we are conscious of the strict requirements that vacuum systems and applications need. These considerations have been integrated into our vacuum product lineup in order to provide precision motion control without compromising vacuum application's requirements. We are confident in our ability to provide reliable performance in low and high vacuum while maintaining our approach to simplifying motion control.

> "By optimizing our built-in controllers…we are able to introduce our daisy-chaining features to our vacuum products."

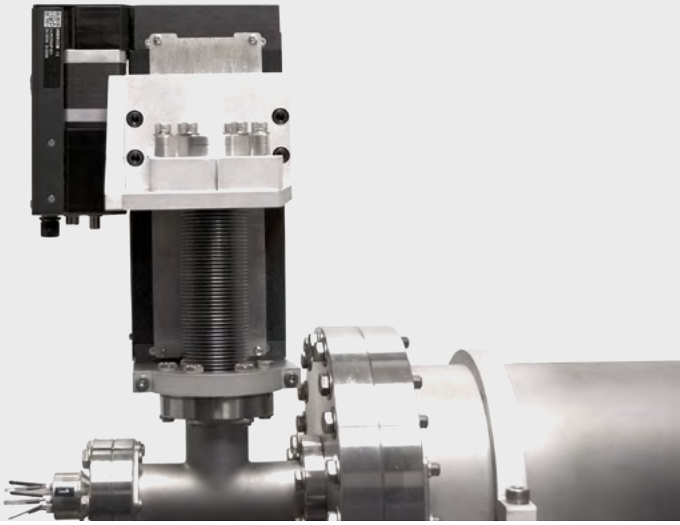
Albert David is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications.
For more information, please visit www.zaber.com.

Custom Product Spotlight: Vacuum Device Customizations



Custom Vacuum Materials

Vacuum applications have strict material selection requirements. Applications may be more or less sensitive to contamination, moisture, and certain chemicals due to outgassing. Depending on your needs, we can customize our vacuum products to use alternative materials. We have experience using alternative leadscrews, lead nuts, bearings, greases, adhesives, etc.

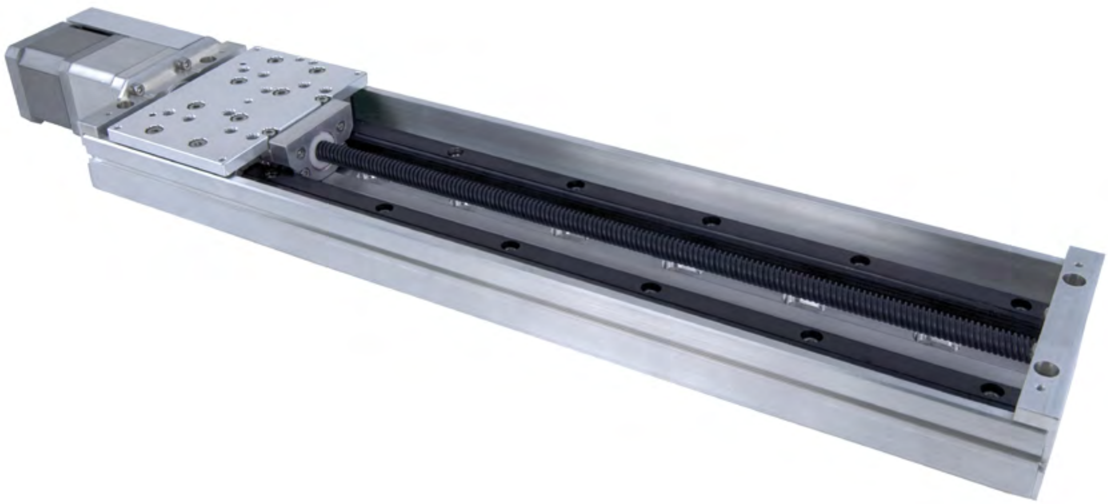


Ultra-High Vacuum Bellows

As vacuum chambers reach very low pressures (below 10^{-7} Torr), they become even more sensitive to small amounts of outgassing, which requires a stricter material selection process. A good solution in this case is to use bellows to keep motorized positioners outside of the chamber and couple their motion to components inside the chamber. In this example, you can see one of Zaber's X-LRQ-EC stages mated to a 2.75 inch conflat, edge welded bellows. This combination allows for 100 mm of linear travel in an ultra high vacuum environment.

Vacuum Compatible Connectors

The daisy-chaining capability of Zaber devices with built-in vacuum compatible controllers makes setting up motion control in a vacuum chamber a much easier process. Often this daisy-chain is connected by crimping or soldering the wires from one device to the next. To make the process even simpler, we offer the option of using vacuum compatible connectors on the daisy-chaining cables. These connectors are secure while being simple to connect, and they make a set-up more versatile by allowing the devices to be disconnected more easily.



X-LRQ-SV Vacuum-Compatible Motorized Linear Stages

- Optional built-in controller
- Low and high vacuum models available
- Daisy-chains data and power with other X-Series devices inside the vacuum chamber
- Only four feedthrough wires required to control all units in the daisy-chain via serial port

Product Description

Zaber's X-LRQ-SV Series devices are computer-controlled, vacuum-compatible, motorized linear stages with high stiffness, load, and lifetime capabilities in a compact size. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. They are stand-alone devices requiring only a standard 24–48 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are treated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires. These stages are ready for assembly in XY or XYZ configuration with no additional hardware required. See Multi-Axis section for more information.

Computer Control

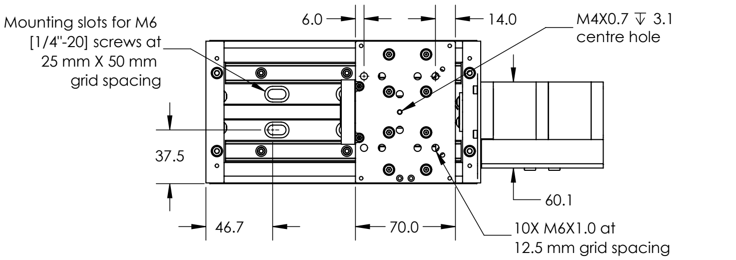
We provide free software so you can easily control your Zaber devices. Zaber's intuitive Windows software makes it easy to control the speed and position of the device and change the device settings. After completing a move command, the stage will report its position through the RS-232 link. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

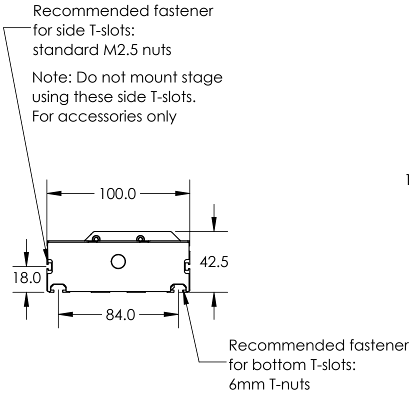
X-LRQ-SV Dimensions

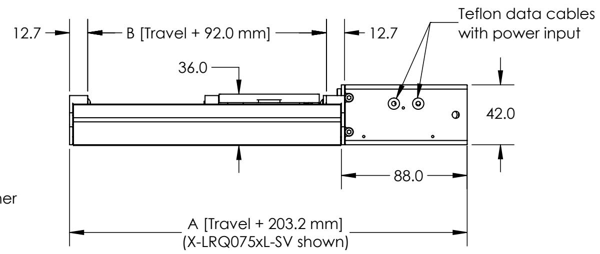
Measurements in millimetres (mm)

Model Number*	Travel	A	B
X-LRQ075xL-SV	75.0	278.2	167.0
X-LRQ150xL-SV	150.0	353.2	242.0
X-LRQ300xL-SV	300.0	503.2	392.0
X-LRQ450xL-SV	450.0	653.2	542.0
X-LRQ600xL-SV	600.0	803.2	692.0

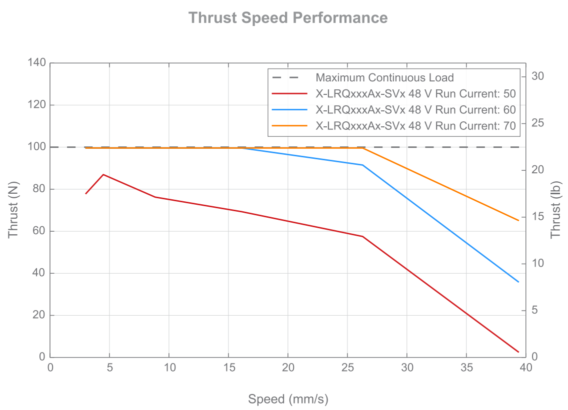
*See product page for complete list of available models at www.zaber.com

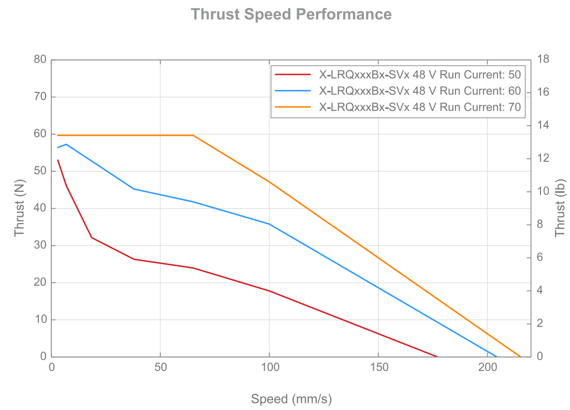






X-LRQ-SV Performance Charts





X-LRQ-SV Specifications

Model*	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LRQ075AL-SV2	75	0.099	23	< 2.5	< 8	35	1000	3000	100	2.27
X-LRQ075BL-SV2	75	0.496	15	< 2.5	< 21	205	1000	3000	60	2.27
X-LRQ150AL-SV2	150	0.099	45	< 2.5	< 8	35	1000	3000	100	2.64
X-LRQ150BL-SV2	150	0.496	25	< 2.5	< 21	205	1000	3000	60	2.64
X-LRQ300AL-SV2	300	0.099	90	< 2.5	< 8	35	1000	3000	100	3.4
X-LRQ300BL-SV2	300	0.496	35	< 2.5	< 21	205	1000	3000	60	3.4
X-LRQ450AL-SV2	450	0.099	135	< 2.5	< 8	35	1000	3000	100	4.15
X-LRQ450BL-SV2	450	0.496	60	< 2.5	< 21	205	1000	3000	60	4.15
X-LRQ600AL-SV2	600	0.099	150	< 2.5	< 8	35	1000	3000	100	4.86
X-LRQ600BL-SV2	600	0.496	90	< 2.5	< 21	205	1000	3000	60	4.86

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-LSM-SV Miniature Vacuum-Compatible Motorized Linear Stages

- Optional built-in controller
- Low and high vacuum models available
- Daisy-chains data and power with other X-Series devices inside vacuum chamber
- Only four feedthrough wires required to run up to four devices

Product Description

Zaber's X-LSM-SV Series devices are computer-controlled, vacuum-compatible, motorized linear stages with high thrust and speed capabilities in a compact size. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. They are stand-alone devices requiring a standard 24–48 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are treated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires. These stages are ready for assembly in XY or XYZ configuration with no additional hardware required. See Multi-Axis section for more information.

Computer Control

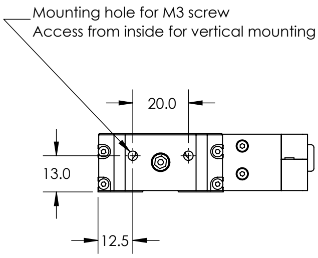
We provide free software so you can easily control your Zaber devices. Zaber's intuitive Windows software makes it easy to control the speed and position of the device and change the device settings. After completing a move command, the stage will report its position through the RS-232 link. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

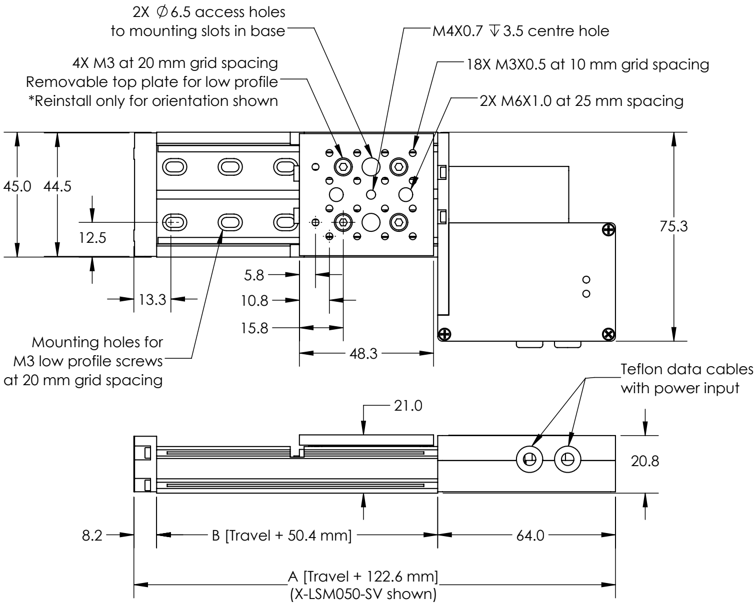
X-LSM-SV Dimensions

Measurements in millimetres (mm)

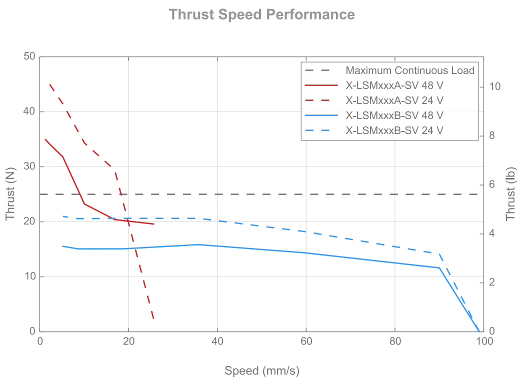
Model Number*	Travel	A	B
X-LSM025-SV	25.4	148.0	75.8
X-LSM050-SV	50.8	173.4	101.2
X-LSM100-SV	101.6	224.2	152.0
X-LSM150-SV	152.4	275.0	202.8
X-LSM200-SV	203.2	325.8	253.6

*See product page for complete list of available models at www.zaber.com





X-LSM-SV Performance Charts



X-LSM-SV Specifications

Model*	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Maximum Speed (mm/s)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Peak Thrust (N)	Weight (kg)
X-LSM025A-SV2	25.4	0.048	15	< 3	< 12	24	100	300	35	0.39
X-LSM025B-SV2	25.4	0.19	15	< 6	< 16	100	100	300	15	0.39
X-LSM050A-SV2	50.8	0.048	20	< 3	< 12	24	100	300	35	0.40
X-LSM050B-SV2	50.8	0.19	25	< 6	< 16	100	100	300	15	0.40
X-LSM100A-SV2	101.6	0.048	35	< 3	< 12	24	100	300	35	0.43
X-LSM100B-SV2	101.6	0.19	45	< 6	< 16	100	100	300	15	0.43
X-LSM150A-SV2	152.4	0.048	50	< 3	< 12	24	100	300	35	0.47
X-LSM150B-SV2	152.4	0.19	65	< 6	< 16	100	100	300	15	0.47
X-LSM200A-SV2	203.2	0.048	60	< 3	< 12	24	100	300	35	0.50
X-LSM200B-SV2	203.2	0.19	85	< 6	< 16	100	100	300	15	0.50

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-VSR-SV Vacuum-Compatible Motorized Vertical Stages

- Optional built-in controller
- Low and high vacuum models available
- Daisy-chains data and power with other X-Series devices inside vacuum chamber
- Only four feedthrough wires required to run up to four devices

Product Description

Zaber's X-VSR-SV Series devices are computer-controlled, vacuum-compatible, motorized vertical lift stages capable of moving 10 kg loads. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. They are stand-alone devices requiring a standard 24–48 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are treated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires. These stages are ready for assembly in XY or XYZ configuration with no additional hardware required. See Multi-Axis section for more information.

Computer Control

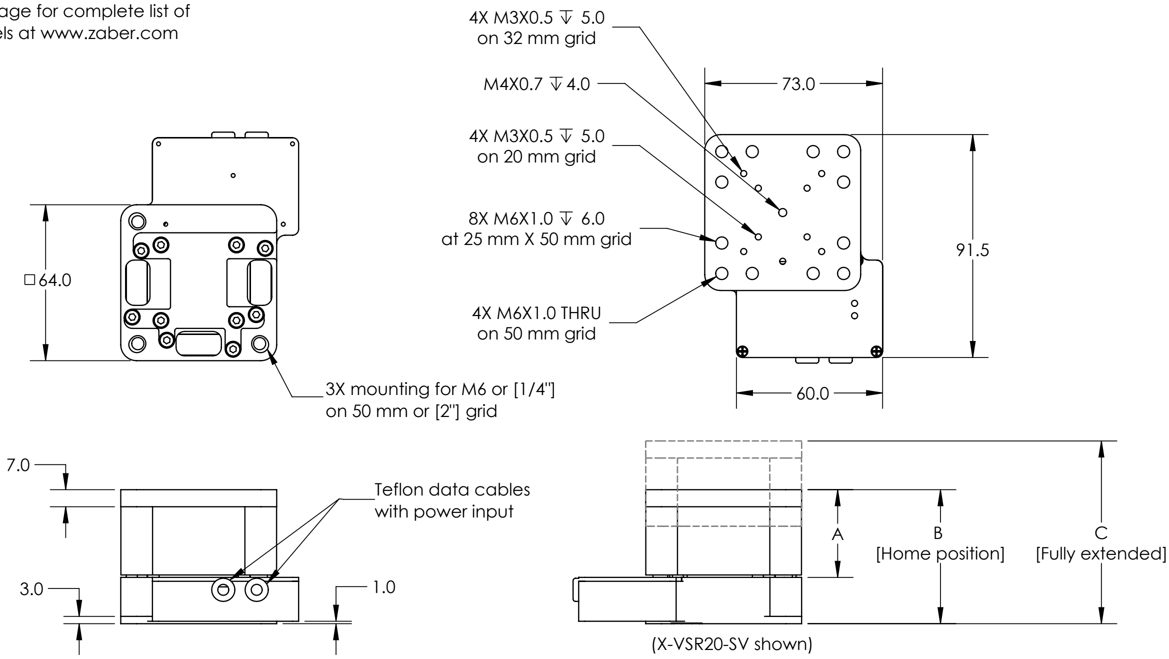
We provide free software so you can easily control your Zaber devices. Zaber's intuitive Windows software makes it easy to control the speed and position of the device and change the device settings. After completing a move command, the stage will report its position through the RS-232 link. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

X-VSR-SV Dimensions

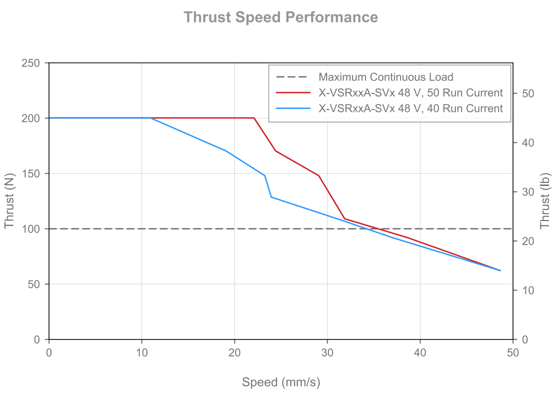
Measurements in millimetres (mm)

Model Number*	Travel	A	B	C
X-VSR20-SV	20.0	36.0	55.0	75.0
X-VSR40-SV	40.0	66.0	85.0	125.0

*See product page for complete list of available models at www.zaber.com



X-VSR-SV Performance Charts



X-VSR-SV Specifications

Model*	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Maximum Speed (mm/s)	Maximum Continuous Thrust (N)	Peak Thrust (N)	Weight (kg)
X-VSR20A-SV2	20	0.095	35	< 1	< 35	48	100	200	0.56
X-VSR40A-SV2	40	0.095	35	< 1	< 120	48	100	200	0.77

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-RSW-SV Vacuum-Compatible Motorized Rotary Stages

- Optional built-in controller
- Low and high vacuum models available
- Daisy-chains data and power with other X-Series devices inside vacuum chamber
- Only four feedthrough wires required to run up to four devices

Product Description

Zaber's X-RSW-SV Series devices are computer-controlled, vacuum-compatible, motorized rotary stages in a very compact size. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. They are stand-alone devices requiring only a standard 24–48 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are treated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires.

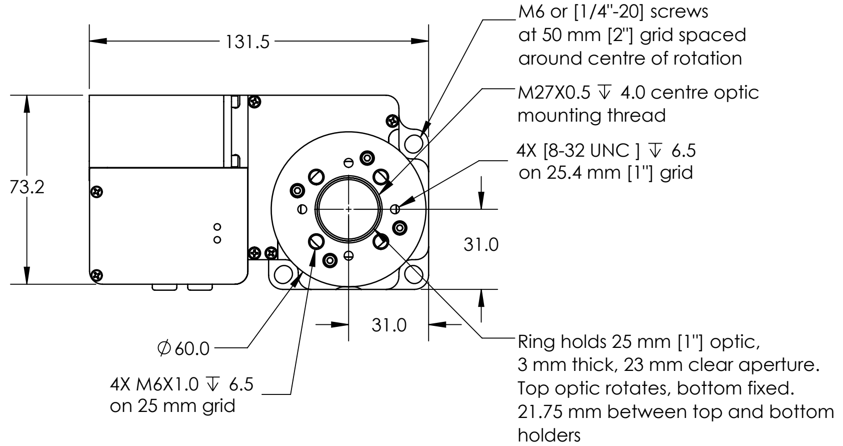
Computer Control

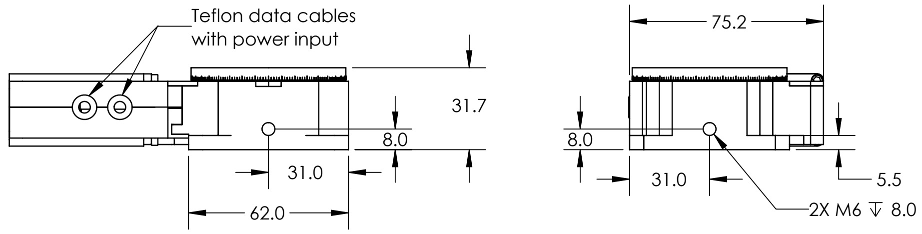
We provide free software so you can easily control your Zaber devices. Zaber's intuitive Windows software makes it easy to control the speed and position of the device and change the device settings. After completing a move command, the stage will report its position through the RS-232 link. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

X-RSW-SV Dimensions

Measurements in millimetres (mm)

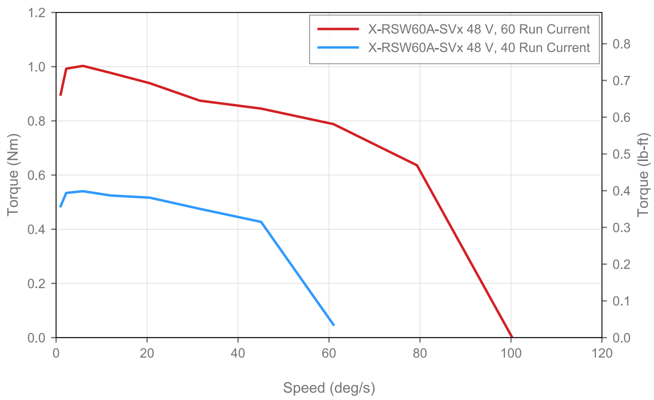
*See product page for complete list of available models at www.zaber.com





X-RSW-SV Performance Charts

Torque Speed Performance



X-RSW-SV Specifications

Model*	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Peak Torque (N·cm)	Weight (kg)
X-RSW60A-SV2	0.00023	200	0.14	< 0.02	< 0.04	0.000143	100	100	0.72

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

X-RSM-SV Mini Vacuum-Compatible Motorized Rotary Stages

- Optional built-in controller
- Low and high vacuum models available
- Daisy-chains data and power with other X-Series devices inside vacuum chamber
- Only four feedthrough wires required to run up to four devices

Product Description

Zaber's X-RSM-SV Series devices are computer-controlled, vacuum-compatible, motorized rotary stages in a very compact size. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. They are stand-alone devices requiring only a standard 24–48 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are treated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

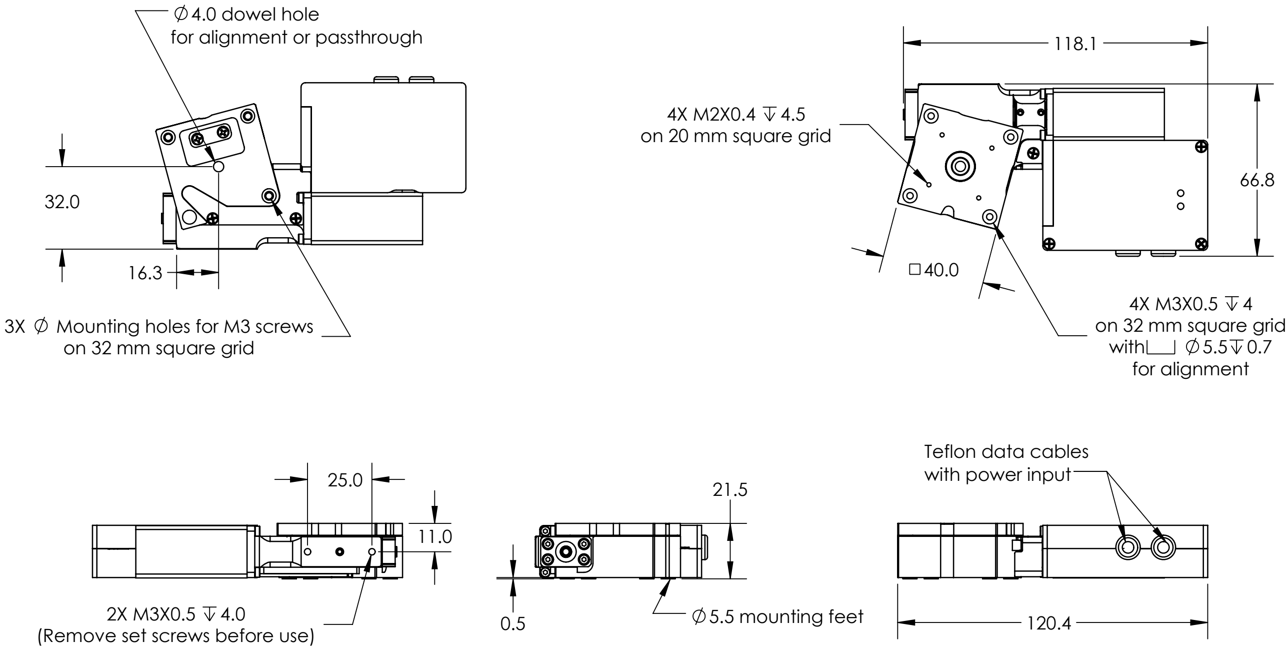
One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires.

Computer Control

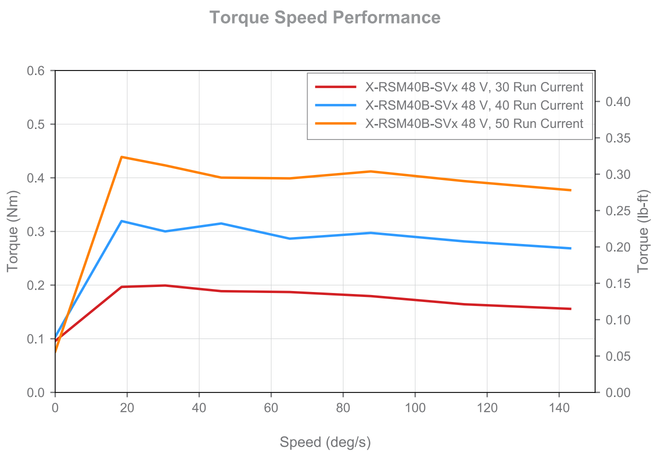
We provide free software so you can easily control your Zaber devices. Zaber's intuitive Windows software makes it easy to control the speed and position of the device and change the device settings. After completing a move command, the stage will report its position through the RS-232 link. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

X-RSM-SV Dimensions

Measurements in millimetres (mm)



X-RSM-SV Performance Charts



X-RSM-SV Specifications

Model*	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Maximum Continuous Torque (N·cm)	Weight (kg)
X-RSM40B-SV2	0.00047	50	0.14	< 0.02	< 0.04	0.000286	120	20	0.30

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.

- Optional built-in controller
- Stackable for a common centre of rotation
- Low and high vacuum models available
- Daisy-chains data and power with other X-Series devices inside vacuum chamber
- Only four feedthrough wires required to run up to four devices

X-GSM-SV Vacuum-Compatible Motorized Goniometers

Product Description

Zaber's X-GSM-SV Series devices are computer-controlled, vacuum-compatible, motorized goniometers in a compact size. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. They are stand-alone devices requiring only a standard 24–48 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are treated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires.

Computer Control

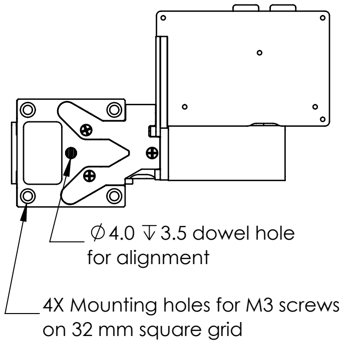
We provide free software so you can easily control your Zaber devices. Zaber's intuitive Windows software makes it easy to control the speed and position of the device and change the device settings. After completing a move command, the stage will report its position through the RS-232 link. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

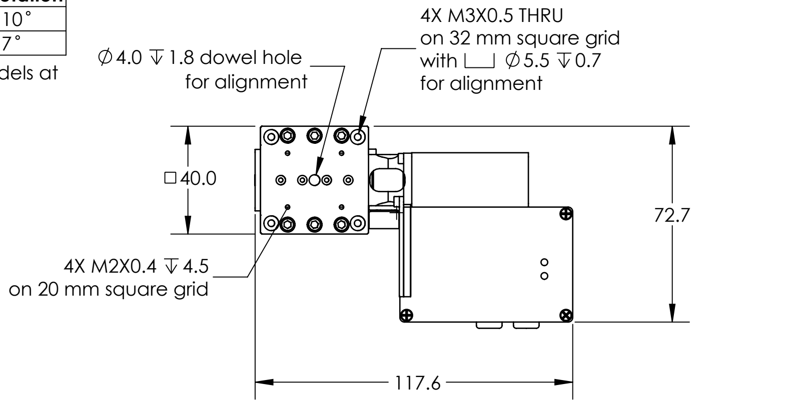
X-GSM-SV Dimensions

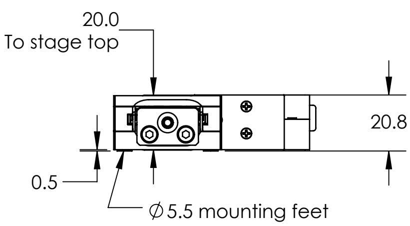
Measurements in millimetres (mm)

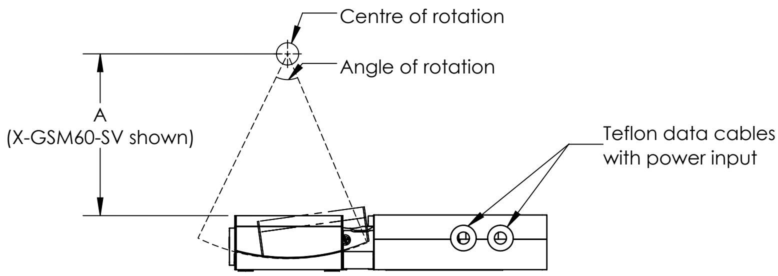
Model Number*	A (Distance To Centre Of Rotation)	Rotation
X-GSM40-SV	40.0	±10°
X-GSM60-SV	60.0	±7°

*See product page for complete list of available models at www.zaber.com







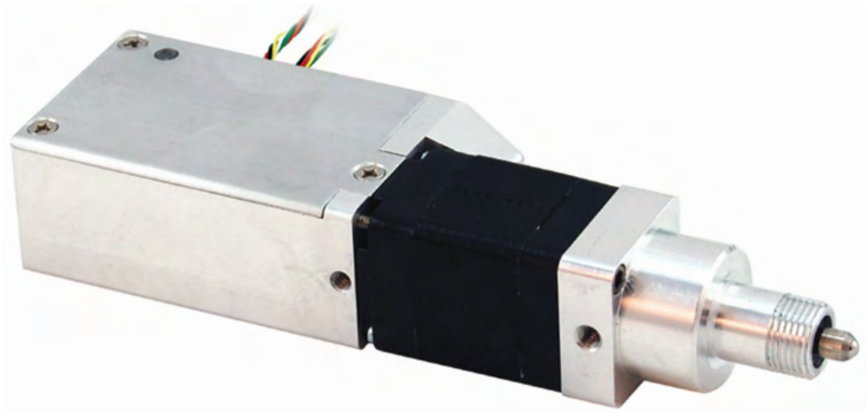


X-GSM-SV Specifications

Model*	Microstep Size (Resolution) (°)	Maximum Centred Load (N)	Accuracy (°)	Repeatability (°)	Backlash (°)	Minimum Speed (°/s)	Maximum Speed (°/s)	Range (°)	Weight (kg)
X-GSM40-SV2	0.0001626	30	0.06	< 0.005	< 0.01	0.00009923	30	+/- 10	0.320
X-GSM60-SV2	0.0001131	30	0.06	< 0.005	< 0.01	0.00006906	30	+/- 7	0.320

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.
2. Externally controlled models available.



T-NA-SV Vacuum-Compatible Miniature Linear Actuators

- Built-in controller
- Low and high vacuum models available
- Daisy-chains data and power with other T-Series products inside vacuum chamber
- Only four feedthrough wires required to run up to four devices

Product Description

Zaber's T-NA-SV Series miniature linear actuators are computer controlled, have 0.05 μm resolution, and offer either 25 mm or 50 mm travel. The low vacuum models (-SV1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-SV2) are designed for use down to pressures of 10^{-6} Torr. Each actuator comes with a hardened ball tip that you can remove if you prefer to use the built-in threaded tip or a flat tip. They are stand-alone devices requiring only a standard 15 V power supply. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum circuit boards are Parylene coated for vacuum compatibility, and all blind holes in the devices are vented. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. Up to four devices can be controlled in a vacuum chamber using only four feedthrough wires. An industry standard 3/8″ (9.5 mm) diameter micrometer shank allows the T-NA-SV to fit many popular stages. The plunger of the T-NA-SV actuator does not rotate.

Computer Control

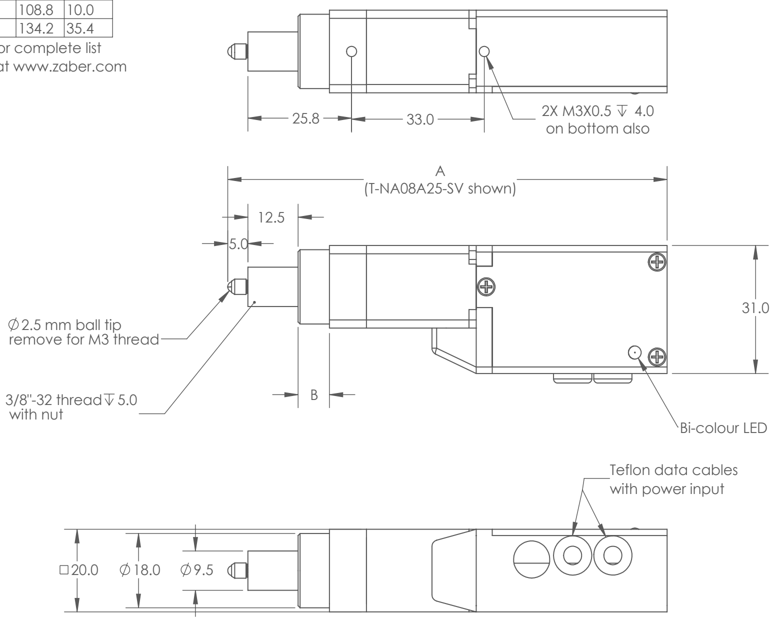
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the actuator reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

T-NA-SV Dimensions

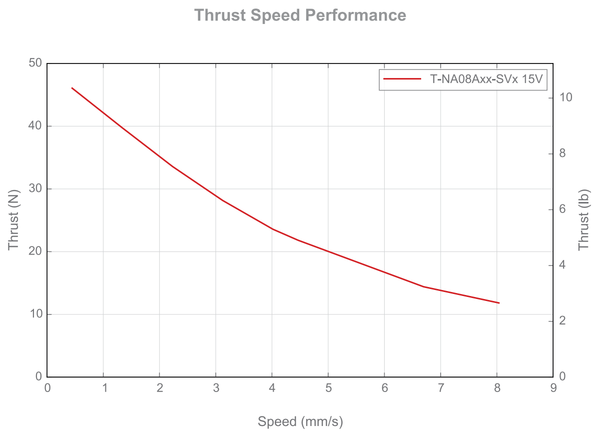
Measurements in millimetres (mm)

Model Number*	Travel	A	B
T-NA08A25-SV	25.4	108.8	10.0
T-NA08A50-SV	50.8	134.2	35.4

*See product page for complete list of available models at www.zaber.com



T-NA-SV Performance Charts



T-NA-SV Specifications

Model*	Travel Range (mm)	Vacuum Rating (Torr)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Minimum Speed (µm/s)	Maximum Speed (mm/s)	Weight (kg)
T-NA08A25-SV2	25.4	10^{-6}	0.048	15	< 1	< 4	0.22	8	0.13
T-NA08A50-SV2	50.8	10^{-6}	0.048	30	< 1	< 4	0.22	8	0.15

*Specs listed here apply to low vacuum (-SV1) stages, rated for 10^{-3} Torr, and high vacuum (-SV2) stages, rated for 10^{-6} Torr.
1. Complete, up-to-date specs available at www.zaber.com.

We use Zaber actuators because they are so easy to daisy-chain in a vacuum, and we can think about the experiments we want to do without having to worry about complex wiring or programming. They save us time and money. I would happily recommend them.

– Dr. Fergal O'Reilly, Research Physics and Innovation Officer, Physics Department, University College Dublin

T-MM-V Low Vacuum Motorized Mirror Mounts

- Rated for 10^{-3} Torr
- Two-axis mirror mount (+/- 5.27° tilt) with built-in controller
- Holds 2˝ (50 mm) optics
- Optional adaptors: C-mount, 1˝ (25 mm), and 1/2˝ (12.5 mm) optics

Product Description

The T-MM-V is a vacuum-compatible, computer-controlled, two-axis mirror mount with 1.5 μrad (0.000086°) resolution. It is a stand-alone device requiring only a 15 V power supply. It has a built-in controller for each axis, so that you can easily control each axis independently.

Installation

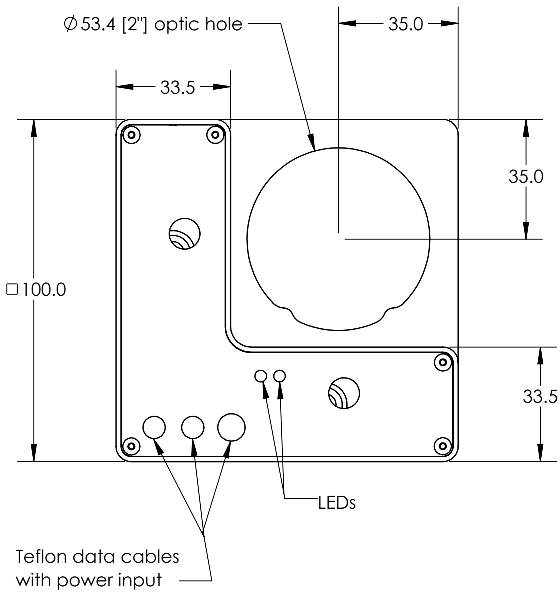
One or more mirror mounts can be connected to the RS-232 port or USB port of any computer. Multiple devices can be daisy-chained to a single port. The daisy-chain also shares power, making it possible for multiple T-Series products to share a single power supply.

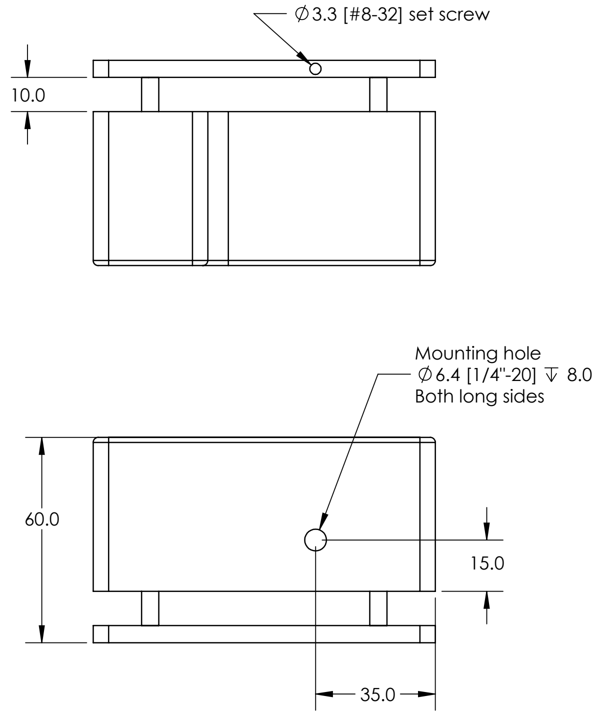
Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like “move absolute”), and enter the desired position. After the move, the mirror mount reports the new position of each axis. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

T-MM-V Dimensions

Measurements in millimetres (mm)





T-MM-V Specifications

Model	Travel Range (°)	Microstep Size (Resolution) (°)	Accuracy (°)	Repeatability (°)	Backlash (°)	Maximum Speed (°/s)	Vacuum Rating (Torr)	Weight (kg)
T-MM2-V	+/- 5.27	0.000086	0.06	< 0.015	< 0.03	3.44	10^{-3}	0.55

1. Complete, up-to-date specs available at www.zaber.com.

LSA-V Vacuum Micro Motorized Linear Stages

- Compact size: great for applications with limited space
- 10 or 25 mm travel
- Low and high vacuum models available

Product Description

Zaber's LSA-V Series vacuum-compatible stages are designed to fit into the smallest spaces without sacrificing performance or features. Small but powerful, these stages are capable of up to 10 mm/s speed and up to 3.5 kg thrust. With a microstep size of less than 25 nm and less than 1 μm repeatability, they allow for reliable ultra-fine positioning. The low vacuum models (-V1) are designed for use down to pressures of 10^{-3} Torr, and the high vacuum models (-V2) are designed for use down to pressures of 10^{-6} Torr. Components are chosen for low outgassing, and vacuum-compatible greases and motors are used in both low and high vacuum devices. High vacuum parts are cleaned ultrasonically or by hand with isopropyl alcohol and assembled in a Class 100 cleanroom. High vacuum devices are double-bagged in Ultra Low Outgassing (ULO®) polyethylene bags.

Installation

The LSA-V Series stages are designed to be wired for plug-and-play use directly with Zaber's stepper motor controllers (purchased separately). Zaber's stand-alone controllers and devices with built-in controllers can all be daisy-chained to communicate over a single computer connection. This simplifies set-up and reduces cable clutter.

Computer Control

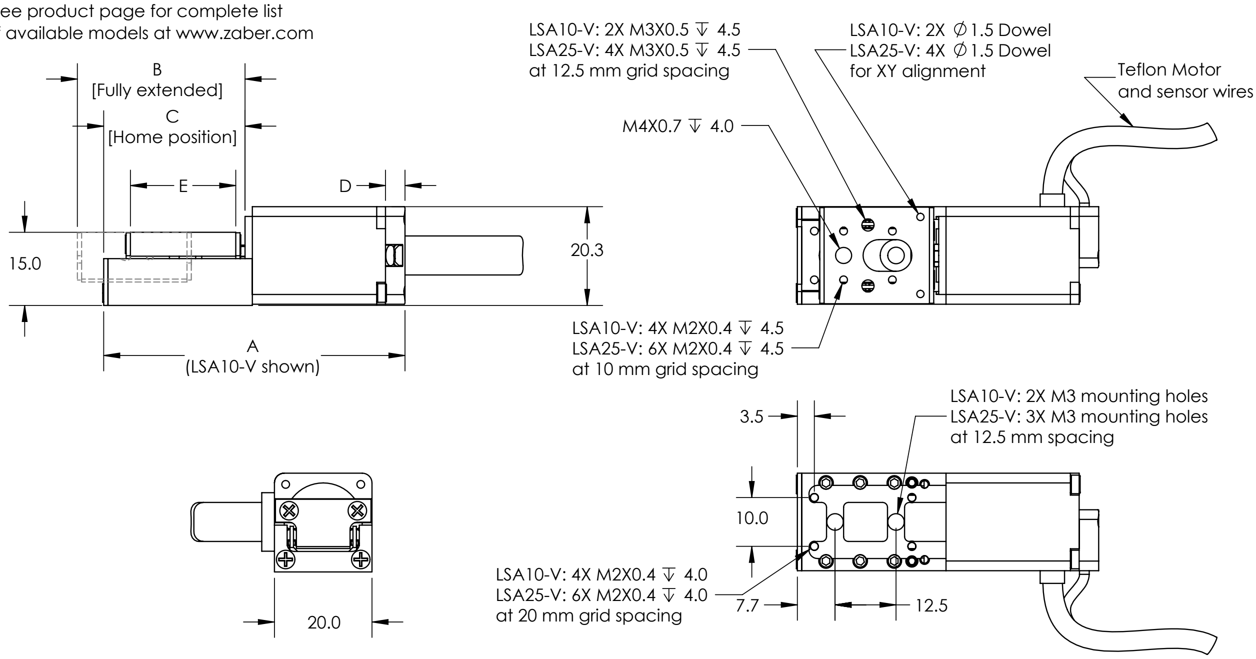
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the controller reports the new position of the actuator. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

LSA-V Dimensions

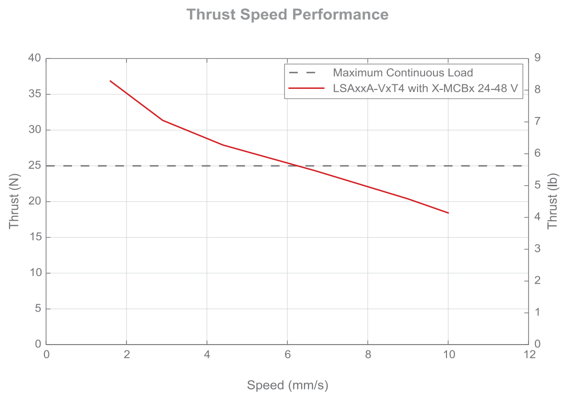
Measurements in millimetres (mm)

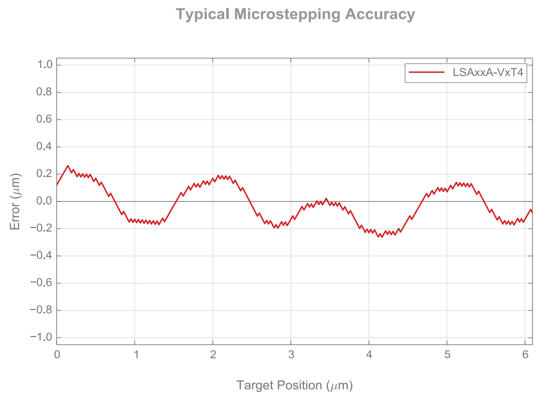
Model Number*	Travel	A	B	C	D	E
LSA10-V	10.0	61.8	34.4	29.0	4.0	21.6
LSA25-V	25.0	98.6	62.8	48.5	21.3	35.0

*See product page for complete list of available models at www.zaber.com



LSA-V Performance Charts



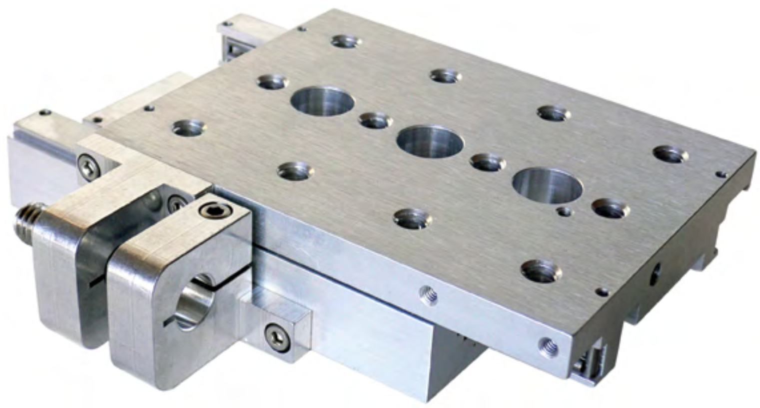


LSA-V Specifications

Model*	Travel Range (mm)	Microstep Size (Resolution) (μm)	Accuracy (μm)	Repeatability (μm)	Backlash (μm)	Maximum Speed (mm/s)	Maximum Continuous Thrust (N)	Peak Thrust (N)	Weight (kg)
LSA10A-V2T4	10	0.024	18	< 1	< 10	10	25	35	0.10
LSA25A-V2T4	25	0.024	24	< 1	< 10	10	25	35	0.14

*Specs listed here apply to low vacuum (-V1) stages, rated for 10^{-3} Torr, and high vacuum (-V2) stages, rated for 10^{-6} Torr.

1. Complete, up-to-date specs available at www.zaber.com.



TSB-V Low Vacuum Translation Stages

- Compatible with Zaber's T-NA-SV1 actuators (shown upper right)
- Reversible mounting bracket allows left-hand or right-hand operation
- Brackets have a convenient clamping mechanism for easy adjustments

Product Description

Zaber's low vacuum TSB-V ball bearing translation stages are available in two sizes, offering either 28 mm or 60 mm of travel. TSB-V stages ensure smooth and accurate motion: they are made from precision-machined aluminum, with precision-ground rails and ball bearings. Choose from either metric M6 mounting holes on 25 mm spacing, or imperial 1/4″-20 mounting holes on 1″ spacing. These stages use vacuum-compatible greases and non-anodized components. They are designed for use down to pressures of 10^{-3} Torr.

Installation

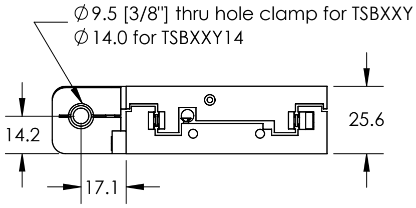
Each stage includes a pair of actuator mounting brackets that include a convenient clamping mechanism to grip actuators and are easily adjusted or locked in place. The mounting brackets are compatible with Zaber actuators: the standard 9.5 mm brackets fit our T-NA-SV1 Series of actuators. TSB-V stages can be mounted directly in XY configuration. Optional AB90-V angle brackets are available for mounting in XYZ configuration.

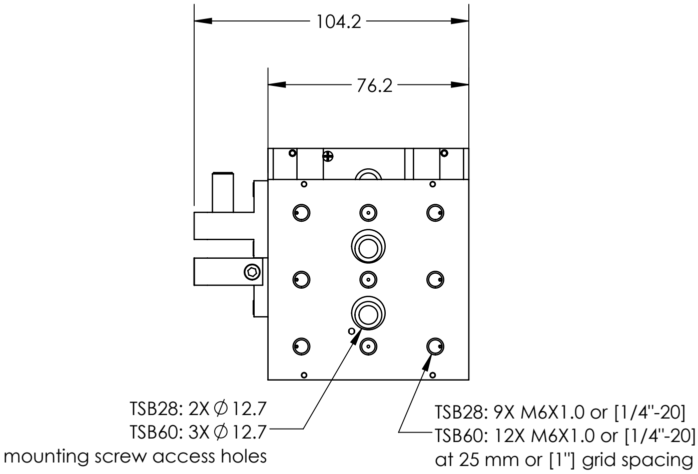
TSB-V Dimensions

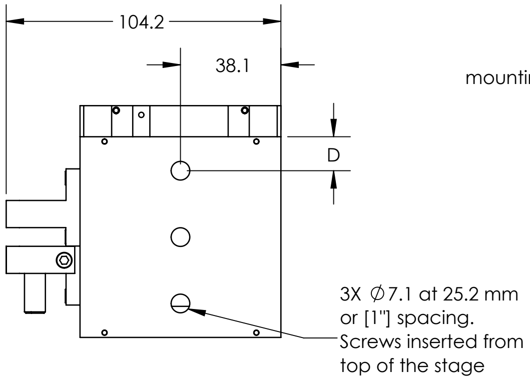
Measurements in millimetres (mm)

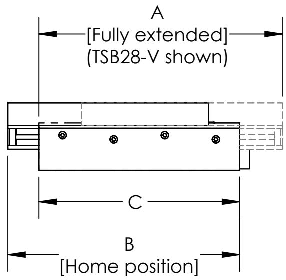
Model Number*	Travel	A	B	C	D
TSB28-V	28.0	92.4	88.0	76.2	12.9
TSB60-V	60.0	137.0	126.2	101.6	25.2

*See product page for complete list of available models at www.zaber.com







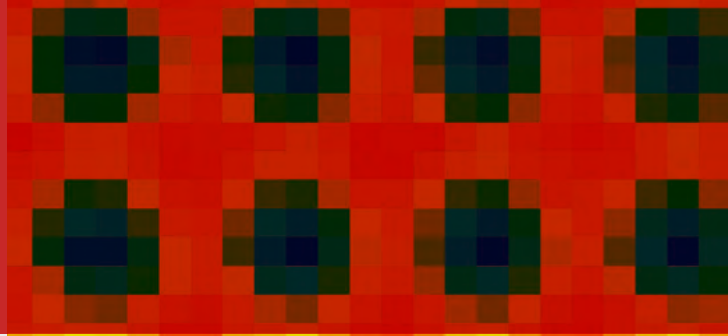


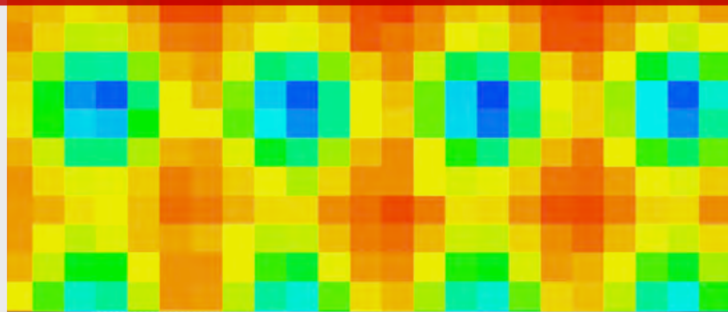
TSB-V Specifications

Model	Travel Range (mm)	Maximum Centred Load (N)	Maximum Cantilever Load (N·cm)	Stage Parallelism (µm)	Vacuum Rating (Torr)	Mounting Thread
TSB28E-V	28	100	125	< 100	10^{-3}	1/4″-20
TSB28M-V	28	100	125	< 100	10^{-3}	M6
TSB60E-V	60	100	125	< 100	10^{-3}	1/4″-20
TSB60M-V	60	100	125	< 100	10^{-3}	M6

1. Complete, up-to-date specs available at www.zaber.com.

Customer Spotlight: University of Sheffield



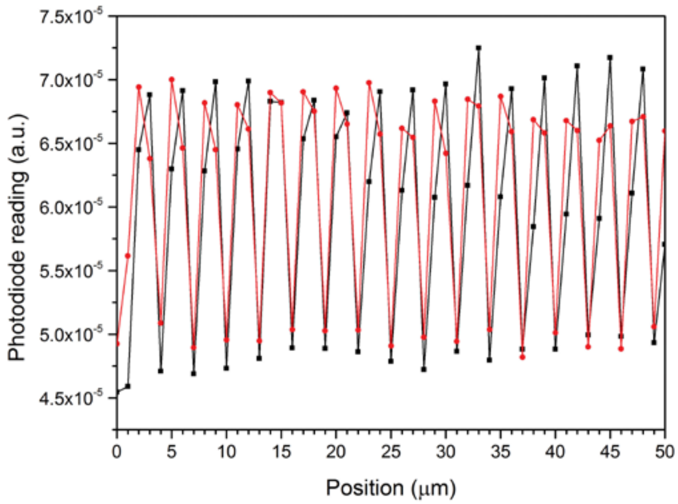


University of Sheffield

The University of Sheffield is a research university in the city of Sheffield in South Yorkshire, England. It is widely recognized as a leading research and teaching university both in the UK and in the world.

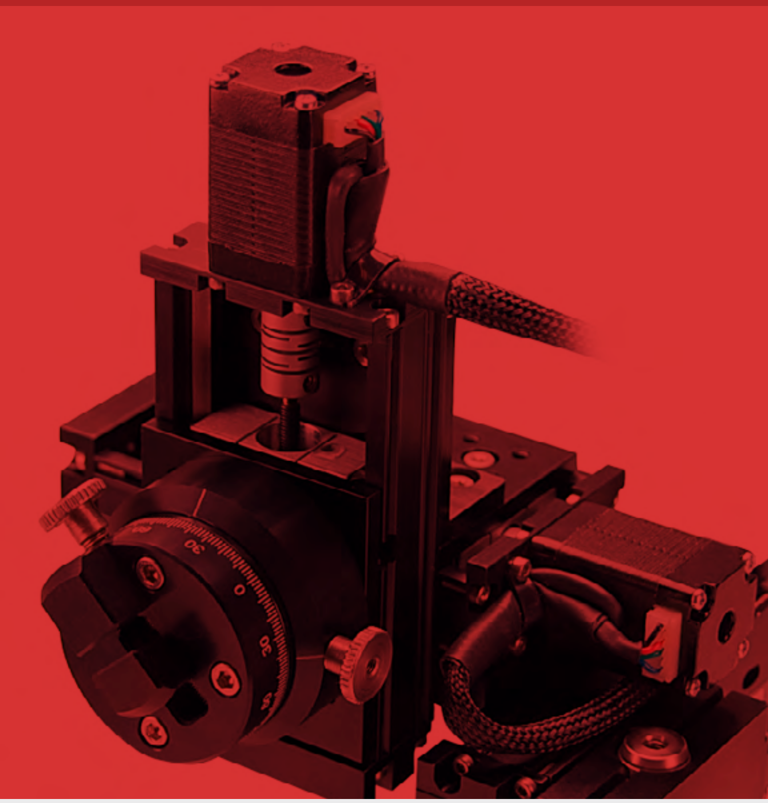
www.sheffield.ac.uk

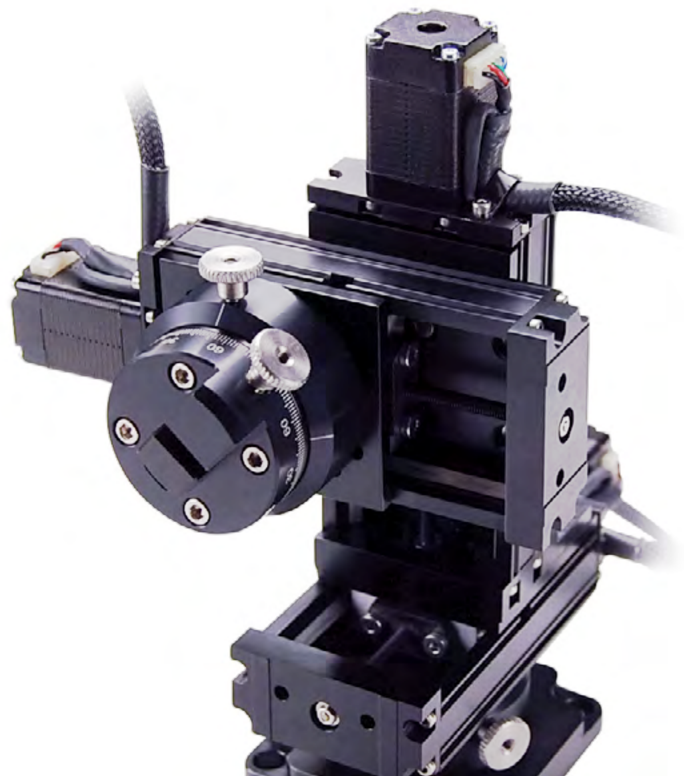
The University of Sheffield is using Zaber's XY system to gather data using a sawtooth scan profile. Scans (on right) are of a 3 micron grid laid over a photodiode, to test the repeatability of the stages and the size of a laser spot. The stages will be used to perform high-resolution laser beam induced current mapping of perovskite solar cells, so that current generation can be compared to the structure of the material.



The University Of Sheffield.

Micromanipulators





- Adjustable probe holder
- Up to 14 mm/s speed and 15 N thrust
- Plug and play controllers and joystick included
- 25 mm travel XYZ with resolution finer than 0.05 μm
- Programmable or joystick-activated 4th virtual axis to allow approach along probe angle

M-LSM Motorized Micromanipulators

Product Description

Zaber's M-LSM motorized micromanipulators are stand-alone devices that are either joystick or computer controlled. These devices are pre-configured as right or left handed, with either a flat base or optical post bracket. The mounting options are designed for breadboards or optical posts, which can be metric or imperial. An adjustable probe holder allows mounting of probe diameters between 2 and 13 mm.

Installation

These devices are stand-alone and do not require a computer for basic operation. For computer control, one or more devices can be connected to the RS-232 port (or USB port with optional adaptor) of any computer. Multiple devices can be daisy-chained to a single port. Convenient 6-pin mini-DIN cables on each stage allow for direct interconnection between devices in close proximity. For longer distances, we offer standard cable extensions.

Computer Control

We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the stage reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

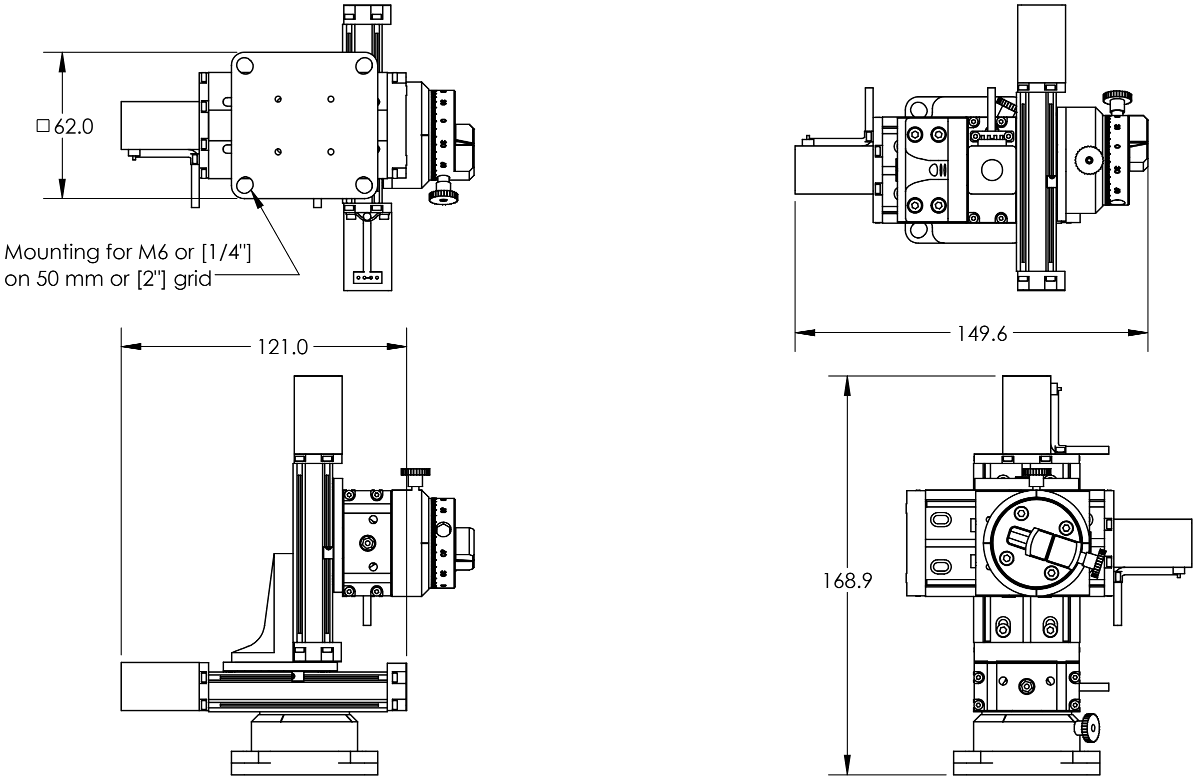
Manual Control

Zaber's joystick is pre-programmed to control the three axes of an M-LSM device. All eight buttons of the joystick can be programmed to store a location, recall a location, or perform a host of other functions. The joystick can also be used in conjunction with a computer for additional power and flexibility.

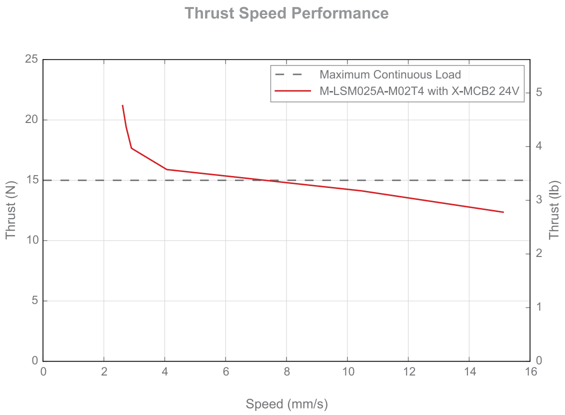
M-LSM Dimensions

Measurements in millimetres (mm)

*See product page for complete list
of available models at www.zaber.com



M-LSM Performance Charts



M-LSM Specifications

Model	Travel Range (mm)	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (No Load) (µm)	Maximum Speed (mm/s)	Probe Diameter Range (mm)	Probe Angle Range (°)	Joystick Control	Weight (kg)
M-LSM025A025A025A-M02T4	25.4	0.048	15	< 3	< 12	14	2–13	360	Velocity Mode	0.952

1. Complete, up-to-date specs available at www.zaber.com.

Customer Spotlight: Reviewed.com

Reviewed.com

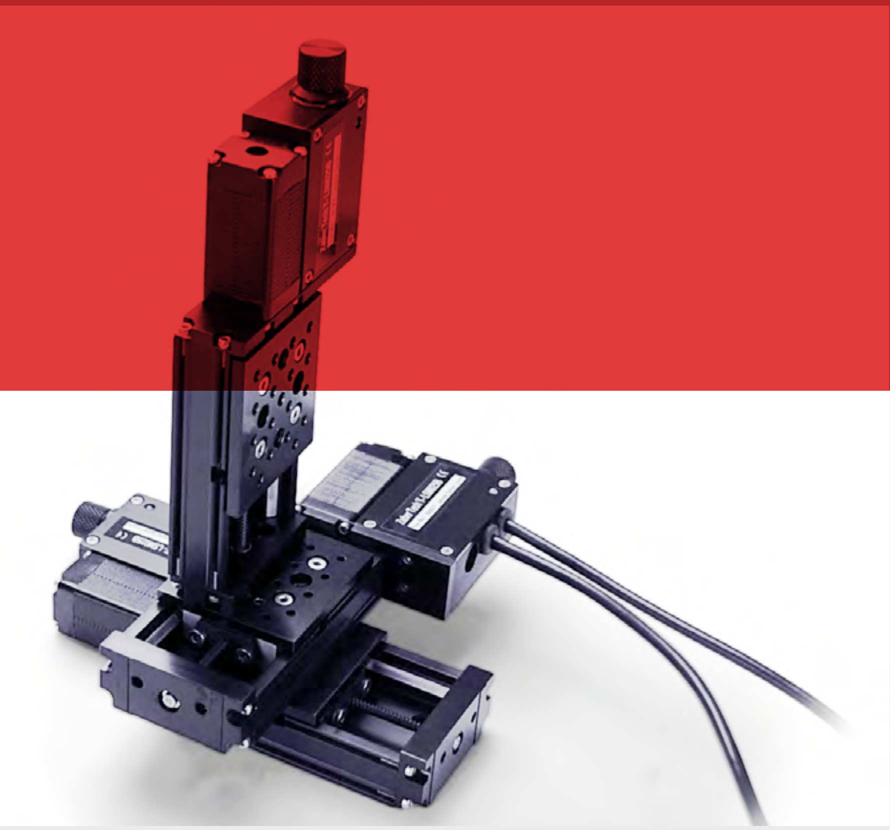
DigitalCameraInfo.com features free, fun, and unbiased reviews to help people decide which digital camera would be best for them. Each DigitalCameraInfo.com review features a standard 44-point analysis that considers the camera's image quality, handling, portability, control, ease of use, and other key areas. DigitalCameraInfo.com uses Zaber devices to test digital cameras and camcorders.

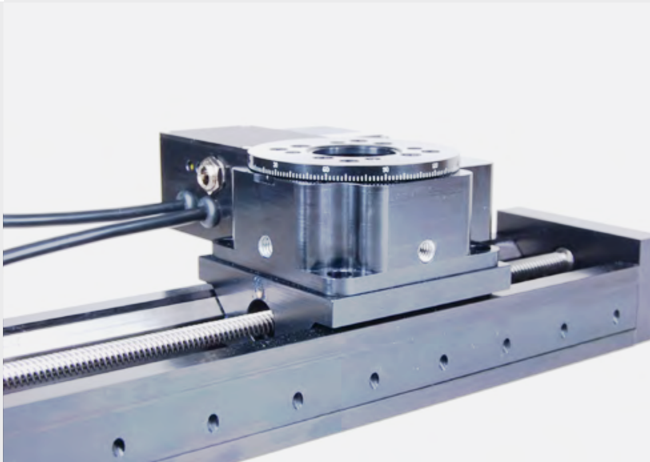
www.reviewed.com

To test image stabilization, we use a T-LSR075A linear slide and a rotary stage, produced by the Canadian company Zaber. We mount the cameras and camcorders on these stands using a standard tripod mount. These devices allow us to apply shake to cameras and camcorders in a precisely controlled way, meaning that we can mimic human hand shake without the unpredictable nature of real humans. We use a custom Zaber script to control these devices to produce the required levels of movement to accurately mimic human hand shake.

– Reviewed.com

Multi-Axis & Gantry Systems





Driving Parallel Axes with Lockstep Movement

By Mike McDonald, Applications Engineering Team

Many applications require multiple directions, or axes, of movement. Systems with one positioner per axis will be sufficient for many of these applications. Figure A shows one such positioning system with three positioners. This is typically called an 'XYZ' or 'Cartesian' system. In this case, we refer to the lower horizontal positioner as moving in the X-axis. The Y-axis makes up the second horizontal axis, and the Z-axis defines vertical motion. When the Y- and Z-axes are relatively short, or when the load they carry is relatively low, a Cartesian system is a good solution.

CANTILEVERED LOAD

As the travel range of these axes lengthen they begin to apply a force at a distance, called a cantilevered load, on the X-axis. Each stage has a rated tolerance for the maximum cantilevered loading on it. If the rating is exceeded, there can be several effects on the performance of the system:

- Reduced lifetime from bearings and rails wearing more quickly
- Lowered maximum speed and thrust due to friction
- Loosening of pre-tuned components, reducing precision

Figure A: An XYZ system using the Zaber X-LRM-E linear stages.

Even if the rating is not exceeded, cantilevered loads cause deflection, which affects accuracy of the multi-axis system. The amount of deflection depends on the stiffness rating of the stage. Zaber's technical support can help you determine how much of a consideration the aforementioned effects are for your application.

GANTRY SYSTEMS

If the cantilever loading does need to be addressed, a second support on the X-axis can be added, parallel to the first. This will balance the cantilevered load and greatly reduce the stiffness error. We typically call these kinds of solutions Gantry systems, and Figure B shows a potential configuration.

Figure B: A custom gantry system using a long travel Zaber A-LST linear stage with a matching passive rail. This is a good solution when positioning accuracy isn't as critical.

Passive Rail Support Gantries

One option for an additional support is to use a passive rail, which is a stage without the motor or drive mechanism. Gantry systems that use passive rails are simple and cost-effective solutions. Passive rail versions of most of Zaber's linear stage series are available, and there are a range of third-party companies that make suitable solutions as well.

There are potential limitations to passive rail gantries though. Passive rails add friction to the system, so the lowered maximum speed and thrust is not fully resolved. If there is only one passive rail, the friction from it will act at a distance from the axis that is driven, which creates a twisting force. The twist is similar to a cantilevered load, and if the distance between the axes is large, it creates similar concerns.

Synchronized Stage Gantries

Another option is to have both parallel stages driven. With this solution, both the cantilevered and frictional loads are balanced, so there are no longer any off-balanced loads. A key to having both axes driven is to ensure that they are driven synchronously. If they are not 'in-sync', then they will create a twist that can damage the system. There are two ways to synchronize the axes, either mechanically or digitally.

Mechanical Synchronization

To synchronize at the mechanical level, you must couple the drive mechanism of the axes together. Using mechanical synchronization is the most robust method for pairing two axes, as there is a physical guarantee that they remain synchronized. A common method is to connect two lead screws using a timing-belt and pulleys to ensure they move together, and use one motor to drive both. This solution ensures that both axes are being driven together, and it is suitable for many applications. An example of a gantry using this method is shown in Figure C.

There are limitations to consider with this method:

- The power from one motor is being split between two axes, so the speed and thrust are less than a non-gantry solution.
- A pulley typically occupies the space that a motor-mounted encoder would use, so it's difficult to incorporate position feedback with this method.
- Specific mechanics to fit the size of your system are required, such as a timing belt between the pulleys, which can require tensioning.

Zaber offers a range of standard gantry systems that use mechanical synchronization. These systems include all of the mounting and connecting components, and they are shipped pre-aligned and assembled.

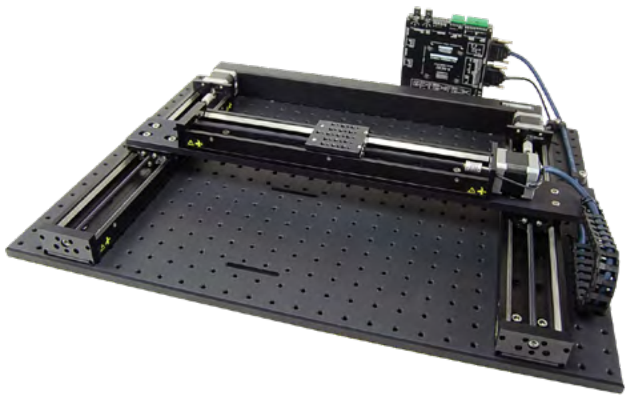


Figure C: Zaber's standard G-LSQ series of gantry systems. These are pre-assembled, aligned, and an easy solution to add to many applications.

"To synchronize at the mechanical level, you must couple the drive mechanism of the axes together."

Digital Synchronization

With digital synchronization, both parallel stages have their own motors connected to a multi-axis driver/controller. The controller must have the capability to ensure the positions of the two axes always move together. Power is doubled with two motors, generating higher thrust and reaching higher speeds. This is especially useful for applications that require parallel vertical axes, where high thrust is needed to overcome gravity. Fewer components are required to physically synchronize the axes, making digitally synchronized systems more flexible to set-up. It is also easy to mount encoders with this solution so that feedback ensures the accuracy. While digital synchronization isn't as robust against twisting as mechanical synchronization, incorporating encoder feedback in the system helps to catch twisting before it occurs. This will be discussed in more detail later.

The lockstep command in Zaber's ASCII protocol allows you to drive multiple motorized axes in sync with each other using a Zaber multi-axis controller. Figure D shows a system that is made possible using the lockstep commands.

Figure D: Using lockstep allows customers to create a wider variety of gantry systems by removing the need for mechanical connections between the parallel drives.

We'll be focusing on digitally synchronized systems that use the lockstep commands in the remainder of this article. We'll discuss optimally mounting systems together, how to set up and use the lockstep command set, and considerations for managing twisting in the system.

If you're interested in learning more about other types of gantry systems, please contact our Applications Engineering Team at contact@zaber.com, and see the Application Note on the Advantages of Gantry Systems.

MOUNTING AND ALIGNMENT

While careful alignment is important during the assembly of any multi-axis system, it's doubly so for systems that use two parallel axes. In addition to ensuring that the X-, Y-, and Z-axes are perpendicular, you must also ensure the parallelism of the two X-axes. If the X-, Y-, and Z-axes aren't perpendicular, the coordinates you specify won't be accurate, but the system will move. If the two X-axes aren't parallel, there will be binding between the axes from the cross-member as they either narrow or widen, which can stall the movement. Following the steps below is one way to ensure the parallelism and perpendicularity of the axes.

Step 1 – Mount Parallel Axes Loosely

Fasten the parallel axes to the mounting surface. Fasten one of the parallel axes firmly, but leave the fasteners on the second one loose. This loose mounting of one stage will makes it easier to ensure parallelism later.

Step 2 – Home the Parallel Axes

After mounting, home each axis individually using the home command. This step ensures that both stages are at their reference position as you mount the system together. It's not critical, as the lockstep command can accommodate a positional difference (see *Setting Up and Moving* section for more details), but it ensures you can get the full travel range from the stages.

Step 3 – Connect the Cross-member

Next, mount the cross-member at 90° to the fixed axis. The cross-member may be a plate or piece of extrusion to which the Y-axis will mount, or the Y-axis stage may be directly mounted to the X-axes. Either way, use a square to ensure that the long edge of the cross-member is perpendicular to the base of the first X-axis stage. Firmly fasten the cross-member down to this stage.

Step 4 – Tighten the System

With one side perpendicular, repeat the squaring process between the cross-member and the loosely mounted stage. Mount the stage loosely enough so that it can be adjusted until the stage and cross-member are perpendicular. Once perpendicular, firmly fasten the cross-member to the loosely-mounted stage.

Step 5 – Test the Movement

The two X-axis stages should now be parallel, but before firmly fastening the second axis, we can confirm they are parallel by moving the stages throughout the travel range. To do this, set-up the system in lockstep mode (see *Setting Up and Moving* section below for details) before continuing. The parallel axes will then move together, and while they move, fasten the loosely mounted stage more firmly. Continue to move the stages together throughout the travel, tightening fasteners until all are tight. This step ensures that the system is not binding at any point in the travel.

ENABLING LOCKSTEP AND SYNCHRONIZED MOVEMENT

With the carriages aligned and fastened together, we can now switch the axes from independent movement to synchronized movement by enabling lockstep.

Device 1 in this example is a multi-axis controller set to communicate using the Zaber ASCII protocol, and the parallel axes are both connected to it. The command to enable lockstep is:

```
/1 lockstep 1 setup enable 1 2
```

Once enabled, the synchronized pair will stay locked together until the `lockstep 1 setup disable` command is sent. Even if the controller is powered off and on again, the axes will remain paired.

With lockstep enabled, individual axis movement commands will be rejected. Only lockstep movement commands are allowed for these axes, which address both axes and move both axes together. For example, to move both axes forward by 5000 microsteps, you would send the command:

```
/1 lockstep 1 move rel 5000
```

When you enable lockstep, you specify which axes you're including in the set. In the first command, we paired axes 1 and 2. The order in which these are specified is important because the first axis listed will be considered the primary axis. Any commands to move to an absolute position will use the primary axis position for the reference position.

So, if the current positions of the axes were 10000 for axis 1 and 12000 for axis 2, the command:

```
/1 lockstep 1 move abs 15000
```

moves both axes forward by 5000 microsteps to the positions 15000 and 17000 respectively. Thus, a certain difference will be maintained between the two positions, which is established based on the positions of the axes when you enabled the lockstep set. This difference is known as the offset value, and in the above example, it is 2000 microsteps.

Knowing the offset, the controller can enforce the travel limits of both axes. A movement command to a position within the travel range for the primary axis, but outside the second axis's travel range, would be rejected. Likewise, the limit sensors of both axes are respected. When the home command:

```
/1 lockstep 1 home
```

is sent, both axes will retract until the home sensor of either one is detected, then both will stop. The positions of the axes will then be updated such that the settings of the stage whose sensor was detected are followed, the offset value of the lockstep pair is applied, and the travel limits of both axes are enforced.

TWIST CORRECTION AND TOLERANCE

While driving parallel motors in synchronized lockstep is a flexible and powerful solution, there is a limitation when compared to mechanical synchronization. With mechanical synchronization you have a physical guarantee that the stages will stay synchronized. You can run the system in open-loop without any issues. If you are relying on drive-synchronization from lockstep in open-loop, and one of the motors stalls, then the positions can become de-synchronized, and a twist in the system can develop. Twist in the system can result in incorrect positioning and high-loads on the system, which can loosen the mechanical tuning.

By adding encoders to each of the parallel axes, we can change from open-loop control to closed-loop control. This adds the same stall-detection capability that encoders add to any system. By being able to detect stall conditions on either axis, the system can stop both axes when only one stalls. This reduces the load that twist can exert on the system. Knowing the position of both axes, the controller can then move one axis independently to correct the positioning.

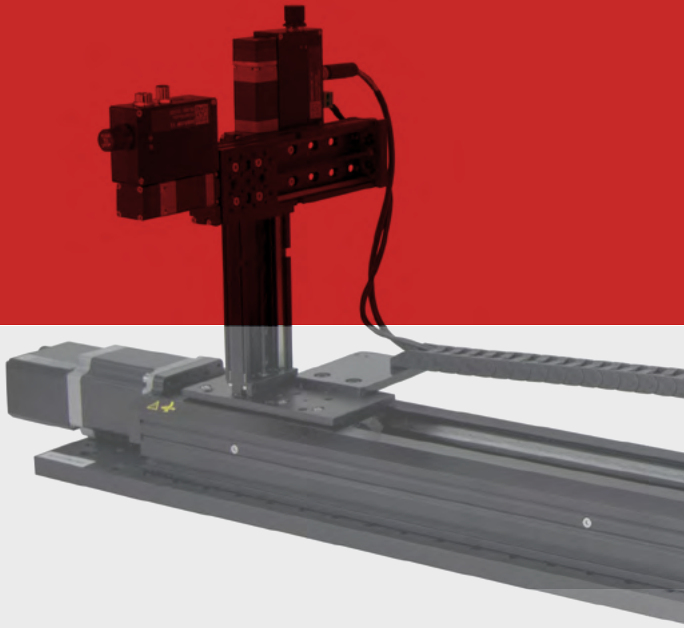
In addition to being able to detect stall, a benefit of encoders is that the controller can quickly detect twist in the system during movement. The position of each axis is monitored, and if one gets too far ahead or behind the other, the system can stop and correct the difference. The tolerance for how much twist is acceptable in a system will vary from application to application, depending on the rigidity of the connection between the axes, the distance between them, the loading, and the speed at which the stages are being driven. The allowable twist can be set by adjusting the lockstep.tolerance setting.

In conclusion, the best solution for a multi-axis system will depend on the requirements, such as loading and travel. When cantilevered loads become a large consideration, gantries are often the best solution, and there are several ways to implement them. Digitally synchronized parallel axes using the lockstep feature to create a gantry is a flexible solution that enables a variety of configurations.

To find out what the best solution is for your application, contact Zaber's Applications Engineering Team at contact@zaber.com to discuss your requirements. For more detail on the lockstep feature, please see the ASCII protocol manual here: www.zaber.com/wiki/Manuals/ASCII_Protocol_Manual#lockstep

Mike McDonald is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications. For more information, please visit www.zaber.com.

Custom Product Spotlight: Multi-Axis Systems



Multi-Axis Systems

Zaber's stages can be assembled into many different configurations of XY, XYZ, and XYZ/rotation. You can select your own combination of product family, travel, and lead screw pitch in each axis to build the system you need. We ship multiple stages un-assembled to avoid damage to the moving parts.

Models with external controllers, built-in controllers, motor encoders, linear encoders, and dust covers are available. Common customizations include cable tracking, framing and cut-away breadboards. Our product customization team is able to complete most customizations within a two-week period. Contact us with your requests.

- From 13 mm up to 1000 mm travel per axis
- Integrated motors and built-in controllers
- Daisy-chain and control multiple devices through a single serial port
- Additional hardware unnecessary for most configurations

XY Two-Axis Stages

Product Description

Zaber's stages can be assembled into many different configurations of XY, XYZ, and XYZ/rotation. You can select your own combination of product family, travel, and lead screw pitch in each axis to build the system you need. We ship multi-axis stages un-assembled to prevent damage to the moving parts. Models with motor encoders are also available. Please refer to the individual product family web pages for specifications.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer, and can be daisy-chained with any other Zaber products. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

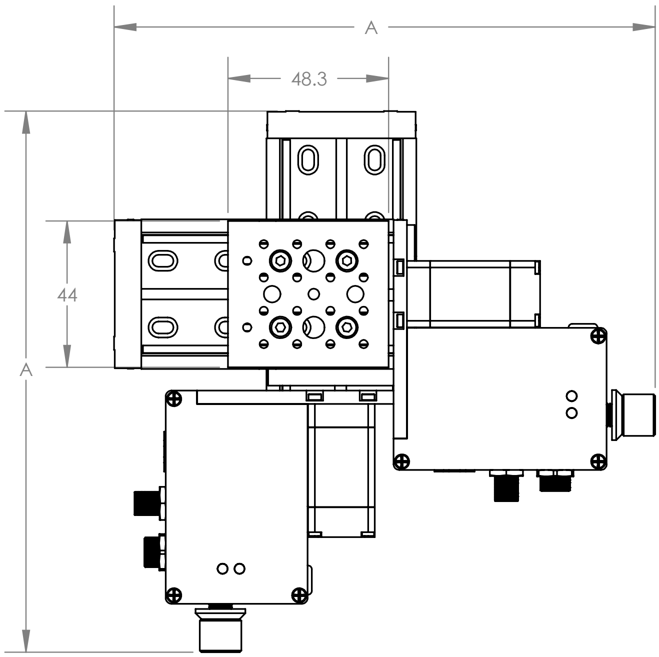
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

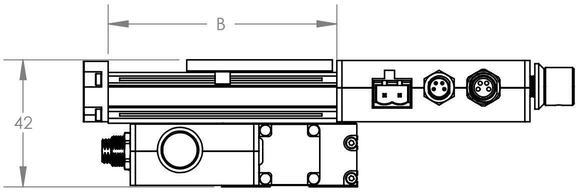
Manual Control

Optional indexed knobs provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

XY Dimensions

Measurements in millimetres (mm)





Model Number	A	B
X-XY-LSM025	162.6	75.8
X-XY-LSM050	188.0	101.2
X-XY-LSM100	238.8	152.0
X-XY-LSM150	289.6	202.8
X-XY-LSM200	340.4	253.6

* Subtract 13.1 mm knob length from 'A' for -S versions without manual control.

** Height dimension can be reduced by 3.7 mm by removing top plate on the X- axis

Multi-Axis Systems: XY Series*

Zaber's XY systems are made up of two linear stages. They come packaged with all the accessories you will need to operate them in XY configuration. The stages in the XY Series are powered by a standard power supply and connect to the RS-232 port of any computer.

*Complete, up-to-date specs available at www.zaber.com.

Thank you for all your help so far; it has been very satisfying. Your helpfulness and good service is one of the reasons we chose Zaber as an XY-table supplier for our project.

– Alexander E. Hansen, Student at the Faculty of Technology, Sør-Trøndelag University College

- From 13 mm up to 450 mm travel per axis
- Integrated motors and built-in controllers
- Daisy-chain and control multiple devices through a single serial port
- Additional hardware unnecessary for most configurations

XYZ Three-Axis Stages

Product Description

Zaber's stages can be assembled into many different configurations of XY, XYZ, and XYZ/rotation. You can select your own combination of product family, travel, and lead screw pitch in each axis to build the system you need. We ship multiple stages un-assembled to avoid damage to the moving parts. Models with motor encoders are also available. Please refer to the individual product family web pages for specifications.

Installation

One or more devices can be connected to the RS-232 port or USB port of any computer, and can be daisy-chained with any other Zaber products. The daisy-chain also shares power, making it possible for multiple X-Series products to share a single power supply. Convenient locking, 4-pin, M8 connectors on the device allow for secure connection between devices.

Computer Control

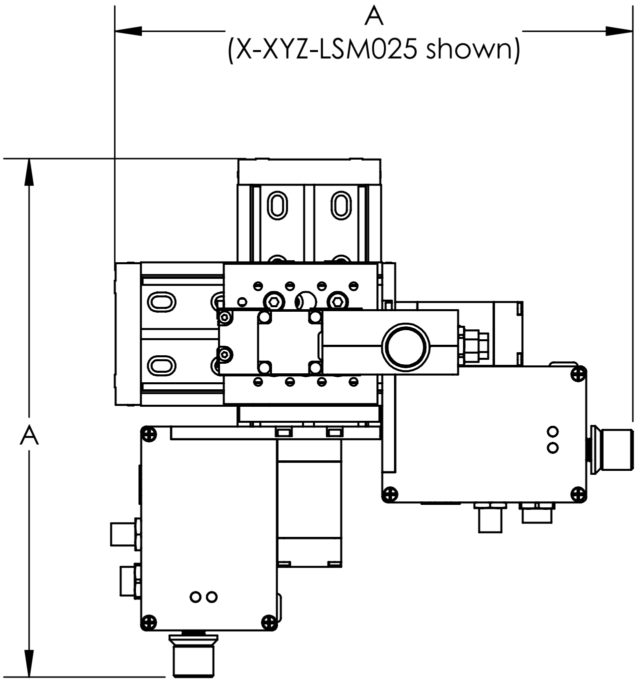
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

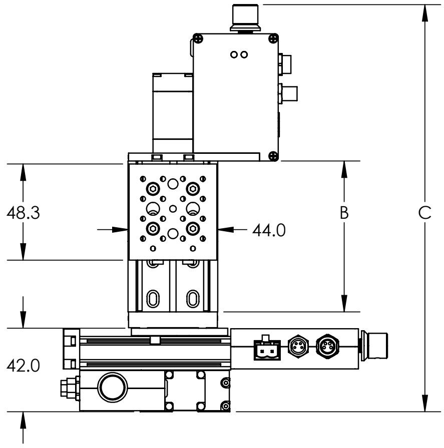
Manual Control

Optional indexed knobs provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. Press and hold to switch between velocity mode and position mode, turn to move the stage, and press to stop.

XYZ Dimensions

Measurements in millimetres (mm)





Model Number*	Travel	A**	B	C***
X-XYZ-LSM025	25.0	162.6	75.8	204.6
X-XYZ-LSM050	50.0	188.0	101.2	230.0
X-XYZ-LSM100	100.0	238.8	152.0	280.8
X-XYZ-LSM150	150.0	289.6	202.8	331.6
X-XYZ-LSM200	200.0	340.4	253.6	382.4

*See product page for complete list of available models at www.zaber.com

**Subtract 13.1 mm knob length from 'A' for -S versions without manual control

*** 'C' dimension can be reduced by 7.4 mm by removing top plates on X- and Y-axes

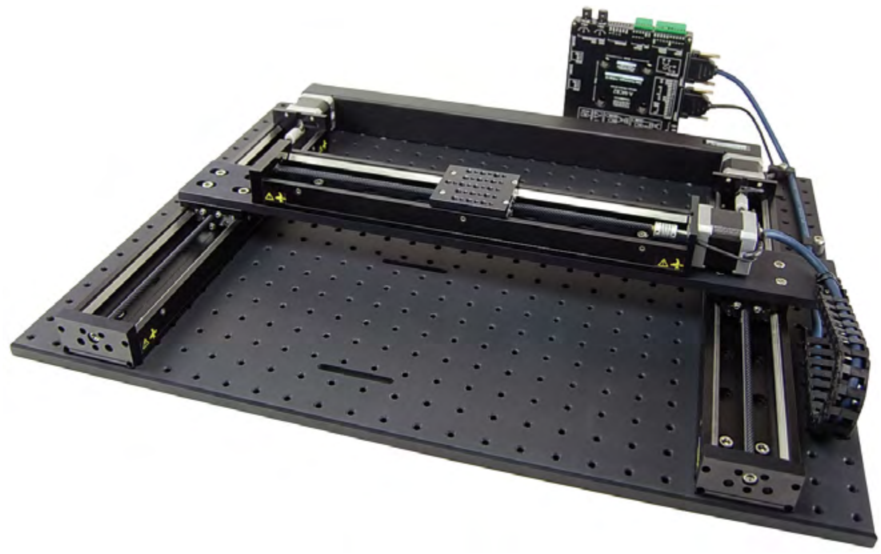
Multi-Axis Systems: XYZ Series*

Zaber's XYZ systems are made up of three linear stages. They come packaged with all the accessories you will need to operate them in XYZ configuration. The stages in the XYZ Series are powered by a standard power supply and connect to the RS-232 port of any computer.

*Complete, up-to-date specs available at www.zaber.com.

I must say that zaber.com has the best information I've ever seen from a company selling research equipment. It's really nice that you supply all the source code and clear specification of how to communicate with the devices.

– Hjalmar Turesson, Post-Doctoral Student, Rutgers State University, Newark Campus



- 150, 300, or 450 mm travel per axis (custom lengths available)
- Up to 330 mm/s speed or 100 N thrust depending on lead screw choice
- High load capacity: up to 180 N centred load and 800 N·cm cantilever load
- Customizable: add another Zaber stage for a Z-axis
- Designed for use with X-MCB2 stepper motor controllers

G-LSQ Gantry Systems

Product Description

Zaber's G-LSQ gantries are designed for multi-axis applications where high loads require the additional support of parallel lower axis stages or where access is required to the entire area under the system. A synchronized lead screw design provides low backlash and high stiffness for precision positioning. G-LSQ gantry systems include a baseplate with M6 mounting holes on a 25 mm grid and an integrated cable management system. They ship fully assembled and ready to operate.

Installation

The G-LSQ gantries are designed to connect directly to Zaber's X-MCB2 stepper motor controllers. The X-MCB2 controllers can be daisy-chained with each other or any other Zaber product.

Computer Control

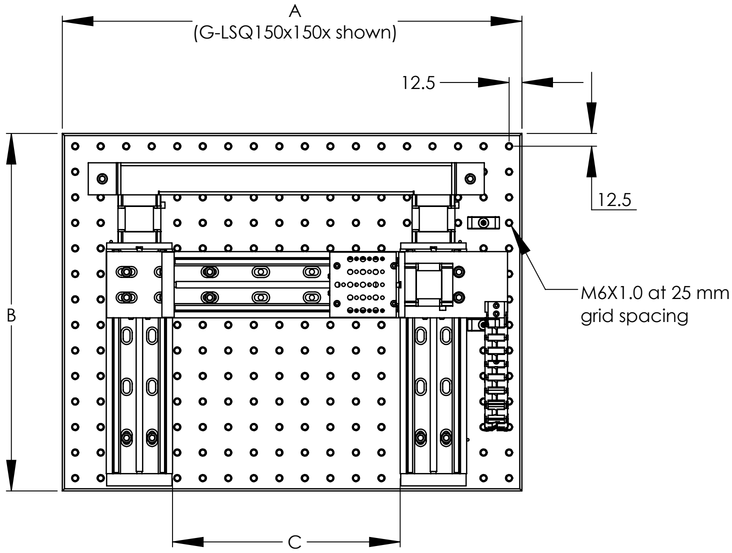
We provide free software so you can easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the stage reports its new position. Built-in scripting allows you to easily set up complex automation routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

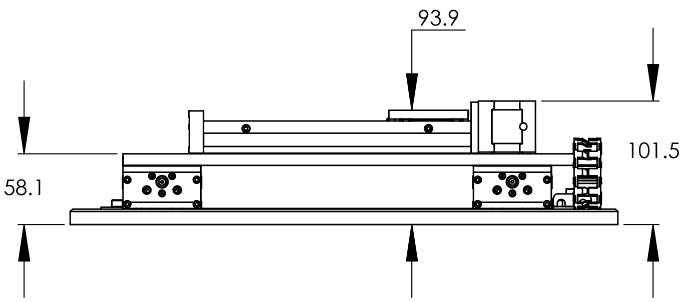
Manual Control

Two convenient knobs on the X-MCB2 controller permit smooth manual control of both axes. During a manual move the stage's position is constantly transmitted to the computer and is displayed by the software. The knobs on the X-MCB2 controller allow you to use the G-LSQ gantry even without a computer.

G-LSQ Dimensions

Measurements in millimetres (mm)





Model Number*	A	B	C
G-LSQ150x150x	450.0	350.0	223.0
G-LSQ300x300x	650.0	500.0	418.0
G-LSQ450x450x	775.0	650.0	537.0
G-LSQ600x600x	900.0	800.0	691.0

*See product page for complete list of available models at www.zaber.com

Gantry Systems*

Zaber’s standard gantry systems, such as the G-LSQ (see dimension drawing above), are made up of three linear stages and provide two-axis (XY) motion. A fourth stage can be added for a Z-axis. These systems come packaged with all the accessories you will need for operation. The stages in our gantry systems are powered by a standard power supply and connect to the RS-232 or USB port of any computer. We can also make customized gantries with most of our linear stages – you can choose the combination of product family, travel, and lead screw pitch to meet your needs. Exact final gantry system specifications will vary depending on your selections.

*Complete, up-to-date specs available at www.zaber.com.

Streamed and Interpolated Multi-axis Motion

By Mike McDonald, Applications Engineering Team

The X-MCB2 two-axis stepper motor controller is one of Zaber's multi-axis controllers with the ability to use streamed and interpolated multi-axis motion. This article discusses the implications and capabilities of this new feature and how it can be used. It is not meant as a detailed resource for the commands, and the ASCII command reference should be referred to for that purpose.

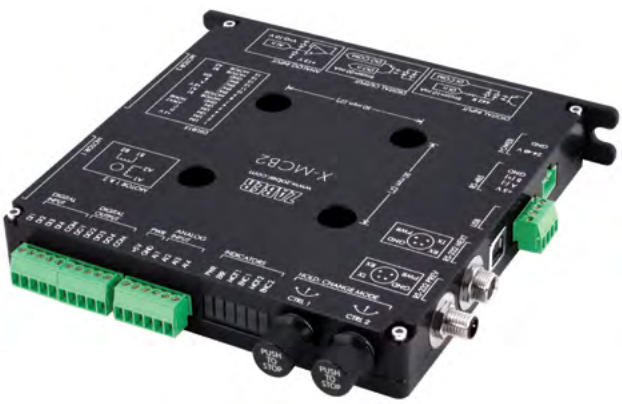
PRE-EMPTIVE COMMANDS VS STREAMED COMMANDS

Most commands in Zaber's protocols excluding the stream set of commands are pre-emptive, which means that the commands will be run as soon as a controller receives them.

For instance, when a movement command is sent, the stage will immediately accelerate from a stop up to the targeted speed and move towards the requested position. If a new command is then sent that isn't compatible with the current command being executed, the newer command will take precedence and pre-empt the existing command.

If the stage mentioned above receives another movement command while halfway through the first command, it will immediately change course to target the new position, pre-empting the first movement. Another example is if the speed setting is changed midway through a movement, the stage will immediately accelerate or decelerate to reach the new speed target.

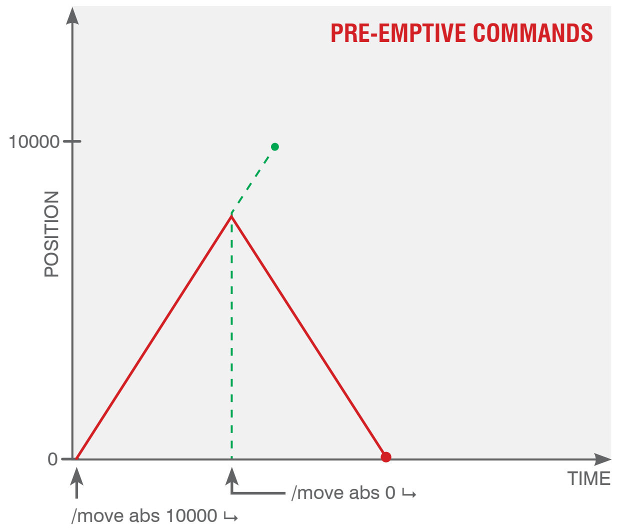
In contrast, streamed commands are executed in the order that they are received, with each command completing before the next command begins. The timing of when they are received doesn't matter – only the order. In the example above, where two movement commands are sent in series, streamed movement commands ensure that both points are reached.

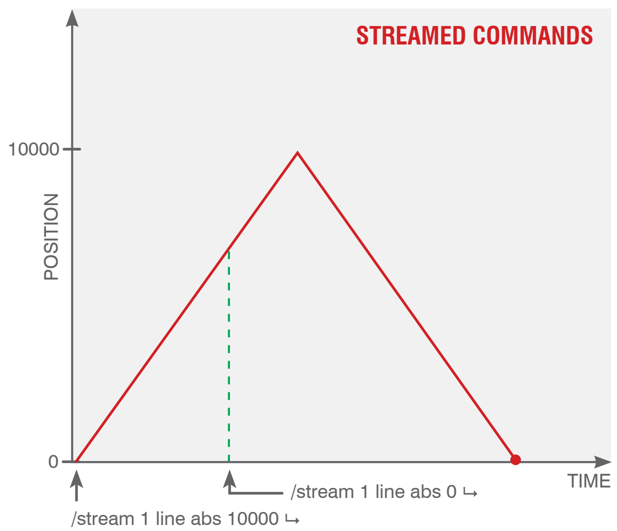


Zaber's X-MCB2 two-axis stepper motor controller.

Pre-emptive commands force the user to coordinate the timing of when commands should be sent. If it's important for a movement to complete before continuing, then the user must continually poll the device to see when the state has changed from **BUSY** to **IDLE** so that they know when they can send the next command. In contrast, streamed commands allow much more certainty on the timing, as the responsibility is offloaded from the user to the controller.

Diagrams illustrating pre-emptive and streamed commands are shown on the next page.





Command Queue

To manage how a stream of commands is executed, the controller creates a queue of received streamed commands when the stream is set-up. The queue gets smaller as commands are executed, and fills up as more commands are sent. If the queue empties completely, the device will treat this as an end of the commands and decelerate to a stop. A warning flag is set to indicate this, as it may be a result of commands not being sent fast enough.

Conversely, if the queue fills up completely, the controller will respond with **AGAIN** to any additional streamed commands. The user should continue to send the last command to the controller until some of the previous ones have completed and the queue is no longer full.

While streamed commands are useful when movements are predictable, pre-empting is sometimes desired when movements needs to be more dynamic. To accommodate this, pre-emptive commands will still interrupt streamed commands. For example, a stop command will still stop streaming motion as soon as the controller receives it. This way, you can combine both types of movements based on the requirements of your system. Any movements set up in triggers may also interrupt the streamed commands.

INDEPENDENT VS INTERPOLATED MOTION COMMANDS

One advantage of using streamed commands instead of pre-emptive ones is that it allows movements to be much more predictable. This lends itself to coordinating the motion of multiple axes together, which is one of the main reasons that streamed commands have been introduced.

Non-streamed commands are either addressed to a single axis or the same command is sent to every axis, and, either way, each axis will interpret and execute the command separately. Speeds and accelerations are also axis independent. The result is that while each axis has a known path, it's difficult to predict or control the combined path of more than one axis.

Streamed movement commands may address multiple axes, and the positions, speeds, and accelerations of the axes will be interpolated to make a determinate multi-axis path. The different paths are known as geometric motion primitives.

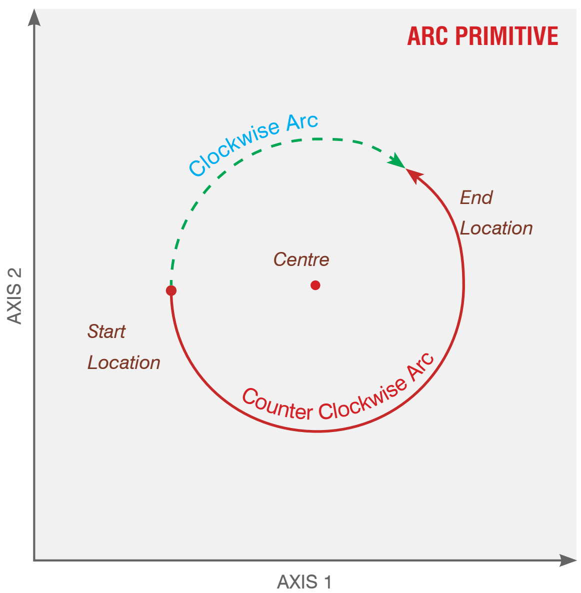
Geometric Motion Primitives

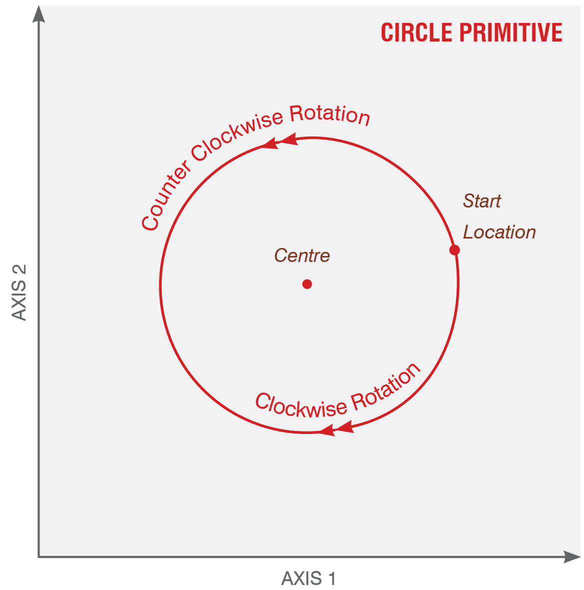
A **geometric motion primitive** is a building block shape. The primitives that are currently available are lines, arcs, and circles. These primitives can be combined in series to make up more arbitrary shapes or series of movements.

The **line** primitive will move one or more axes to an end point, or by a desired amount. The **arc** primitive will move a circular arc to a targeted end point, with the direction of movement and the centre of the arc defined by the user.

The **circle** primitive makes a complete revolution which only requires a direction and a centre, as the end point will be the same as the start point. Using these three building blocks, you can closely approximate other shapes and curves.

Diagrams illustrating each motion primitive are provided below and on the top-right.





Converting from NC Code

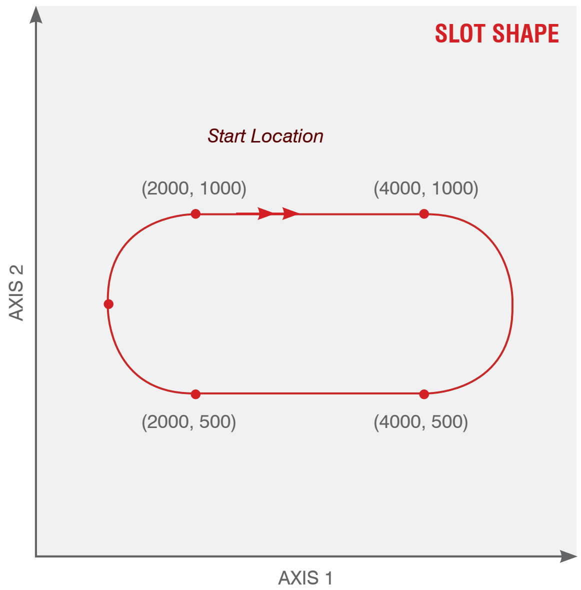
Line, arc, and circle primitives are standard in numerical motion control (NC). Each shape also has direct equivalents in G-code, the most widely used NC code. A sample of G-code that moves in a slot shape is provided:

G-CODE FOR SLOT SHAPE

```
...
G0 X2000 Y1000
G1 X4000 Y1000
G2 X4000 Y500 I4000 J750
G1 X2000 Y500
G2 X2000 Y1000 I2000 J750
...
```

All values are absolute and in microstep units.

The G0 and G1 commands both represent line movements, while the G2 and G3 commands create arcs in clockwise or counterclockwise direction, respectively. G-code does have some variation in whether absolute or relative points are used, and whether arcs are defined by a radius or a centre point, so care should be taken with the coordinates if they're used with Zaber controllers. A sample of stream commands that correspond to the above g-code are provided below. A plug-in for Zaber Console that allows easy conversion from G-Code to Zaber commands is available here: www.zaber.com/wiki/Software/Zaber_Console/Plug_Ins/GCodeTranslator




```
/01 stream 1 setup live 1 2 8 ↵

/01 stream 1 line abs 2000 1000 8 ↵

/01 stream 1 line abs 4000 1000 8 ↵

/01 stream 1 arc abs cw 4000 750 4000
500 8 ↵

/01 stream 1 line abs 2000 500 8 ↵

/01 stream 1 arc abs cw 2000 750 2000
1000 8 ↵
...
```

Note that the end point and centre point of the arcs are reversed from the g-code.

ADDITIONAL STREAMED COMMANDS

In addition to the motion primitives, there are other stream commands that can be added to the queue and executed in order.

Waiting and I/O Controls

Wait commands allow you to add more timing control into a stream. Wherever a wait command is inserted in the stream, the movement will slow to a stop, wait for a condition to be met, and then continue on with the next command. The condition can either be a certain amount of time elapsing, or a certain value on one of the X-MCB2's digital or analog input pins. The input isn't checked until the moment when the axes come to a stop.

In addition to waiting on inputs, you can also toggle the X-MCB2's digital outputs in the stream. If a command to toggle the output is between two motion commands, the output will toggle without any interruption in the motion. Some situations where this might be useful include triggering a sensor to take a reading, turning a laser on or off, or triggering a camera to capture a photo, all with accurate positioning and without stopping motion.

Setting Physical Constraints

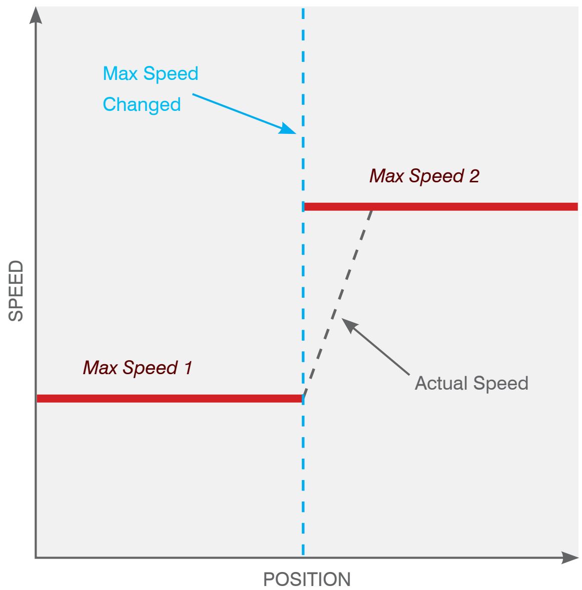
The speed and acceleration settings for the stream can also be changed mid-stream. These settings are independent of the settings of individual axes, and they relate to the combined movement of all axes in the stream.

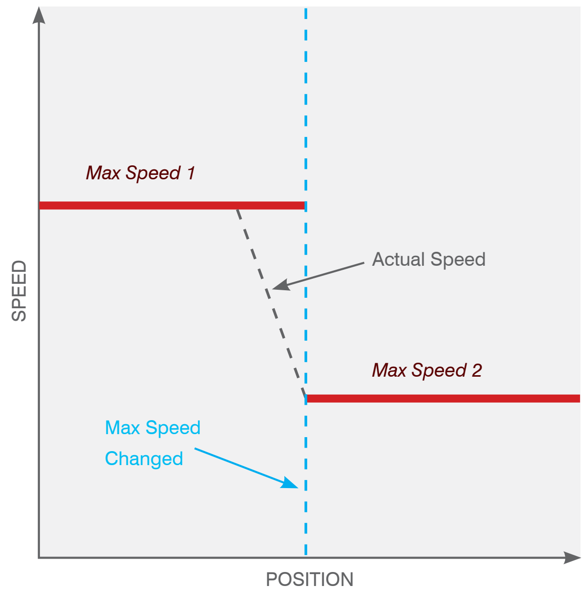
If a command to change the setting is in the stream of commands, it will take effect so that all of the constraints are obeyed before and after the setting change.

As an example, if the speed is initially 5000 but is set to 3000 between two streamed movements, the stage will start to decelerate near the end of the first movement so that it reaches 3000 by the time the second movement starts. The constraint in this case is that the speed of 3000 is a maximum, and the updated setting should not be exceeded during any part of the second movement.

Conversely, if the new setting were 8000, the acceleration would occur during the second movement in order to obey the first movement's maximum speed constraint over its full length.

Diagrams illustrating speed settings are provided below.





In addition to the maximum speed, there are two acceleration settings that are obeyed: tangential acceleration for changing the speed, and centripetal acceleration for changing direction (for arcs and circles).

You can read more about the complete command set here: www.zaber.com/ASCII-protocol-manual-stream
Information about potential uses is available here: www.zaber.com/application-notes/2d-interpolation-lines-arcs-and-circles

Feel free to contact our Applications Engineering Team at contact@zaber.com if you have any questions about this article, if you have a potential application in mind, or need any other additional information.

Mike McDonald is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications. For more information, please visit www.zaber.com.

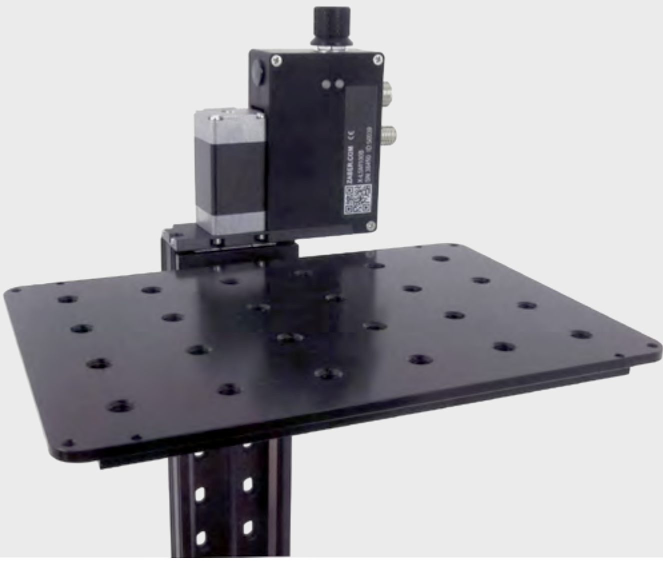
If you found the above information interesting, consider subscribing to our newsletter to receive product announcements, user tips, and special promotions (typically worth $100 off a selected product). Subscribe online at www.zaber.com.

Custom Product Spotlight: Accessories

At Zaber, we are able to customize our accessories, which includes brackets, mounting hardware, gripper fingers, cables and connectors.

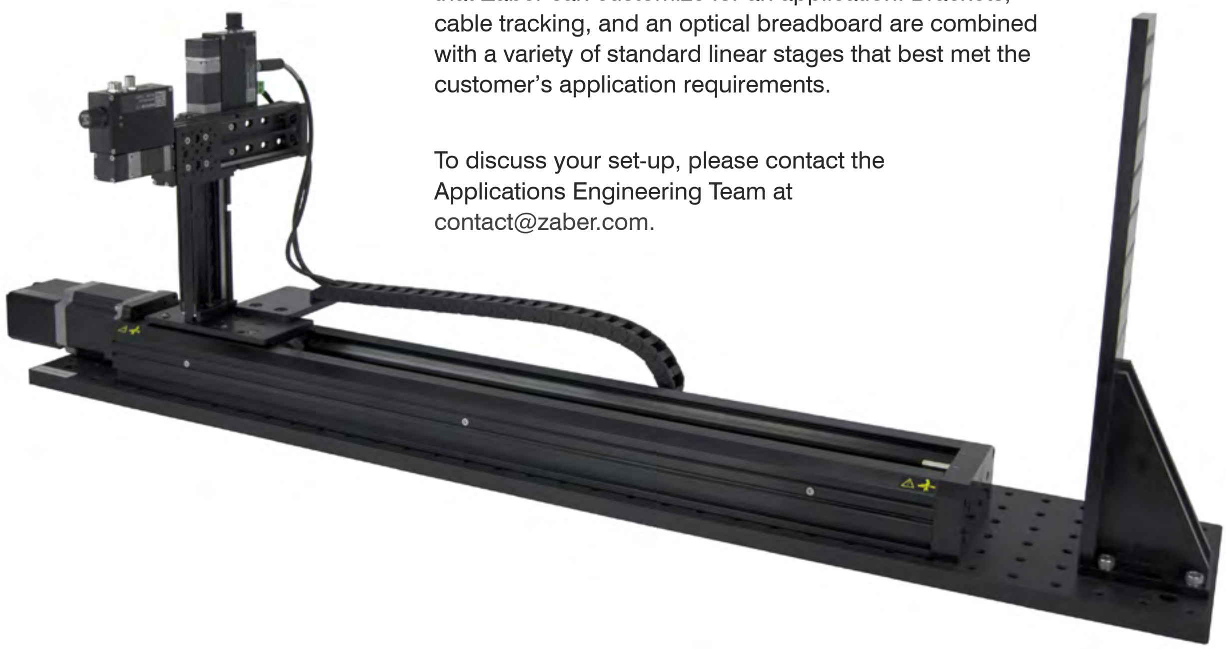
With the help of our in-house machine shop, our product customization team is able to complete most customizations within a two-week period.

Contact us with your requests.

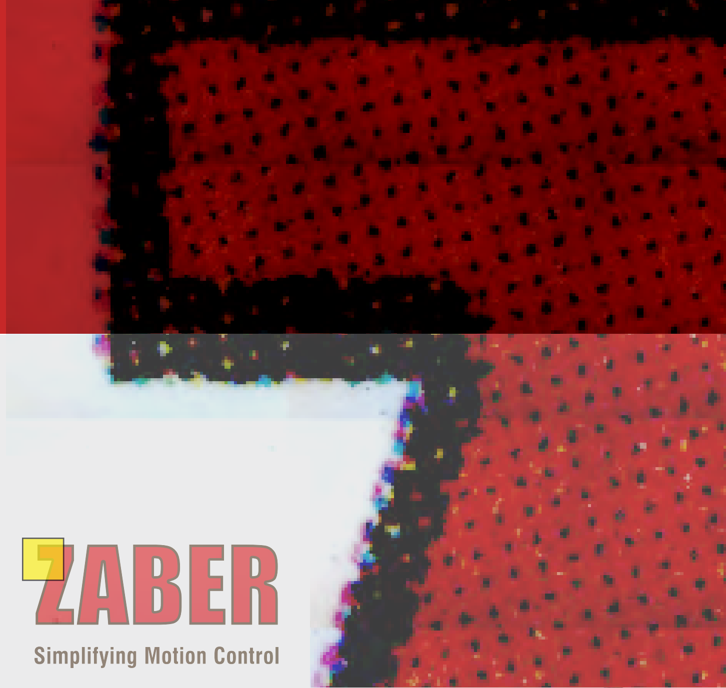


This system shows a variety of non-standard accessories that Zaber can customize for an application. Brackets, cable tracking, and an optical breadboard are combined with a variety of standard linear stages that best met the customer's application requirements.

To discuss your set-up, please contact the Applications Engineering Team at contact@zaber.com.

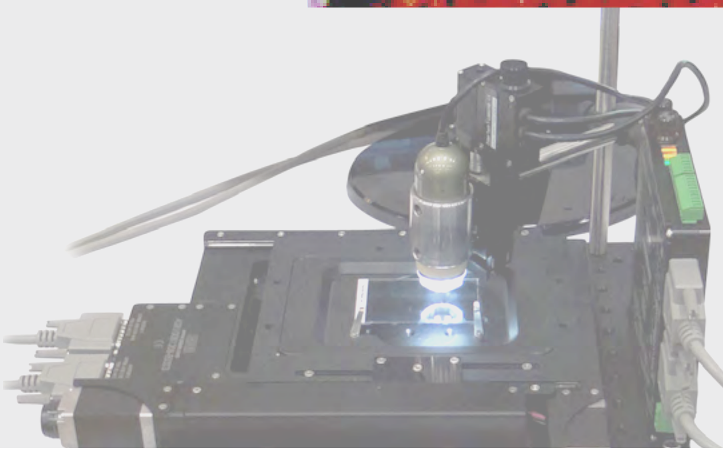


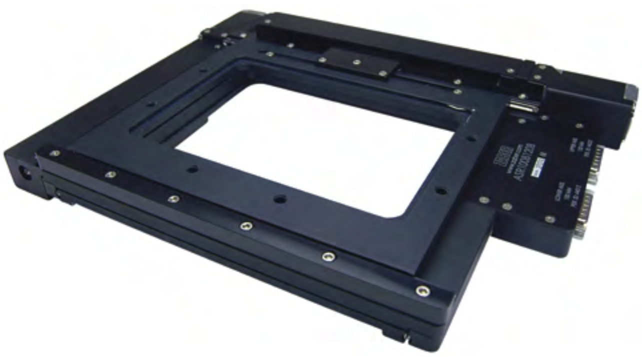
Design Spotlight: ASR



ASR Stage

The ASR is the first product we designed from the ground up as a two-axis stage. We knew that many of our customers were using pairs of our linear stages in XY configurations to achieve planar motion. While this approach does provide a great deal of flexibility, we knew we could come up with a better solution – a purpose-built multi-axis stage. The goal for the project was to design an XY stage with excellent accuracy, high stiffness, and a low overall height. It also needed to have a large aperture and be mountable to most common microscopes. When the dust settled, we ended up with the ASR. This stage is accurate to 12 µm over 120 mm, uses crossed roller bearings for maximum stiffness, and is one of the lowest profile XY stages available, with only 42 mm in overall height. Since releasing the first ASR stage, we have added a shorter travel model and optional motor encoders.



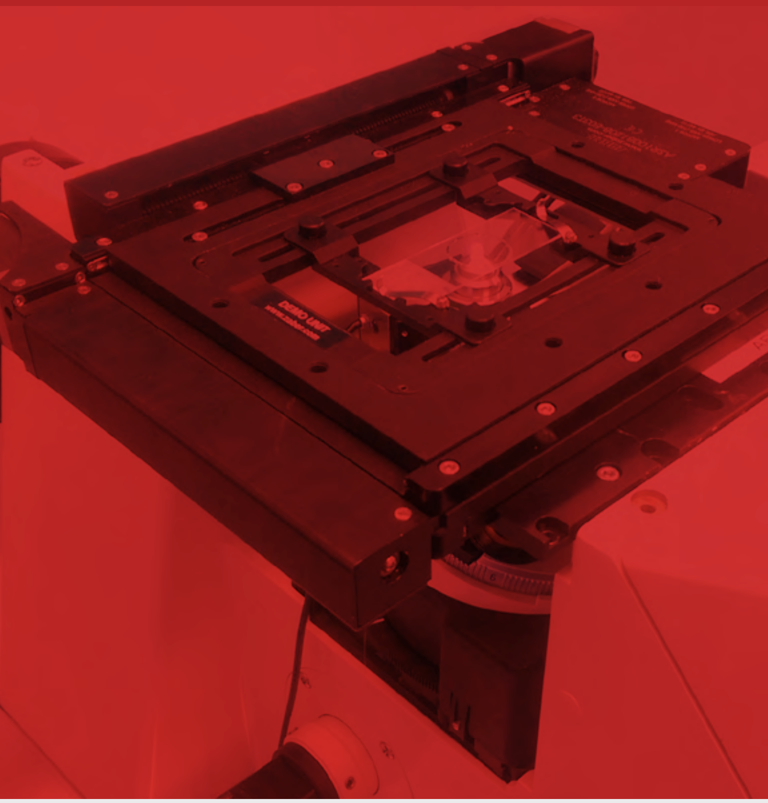


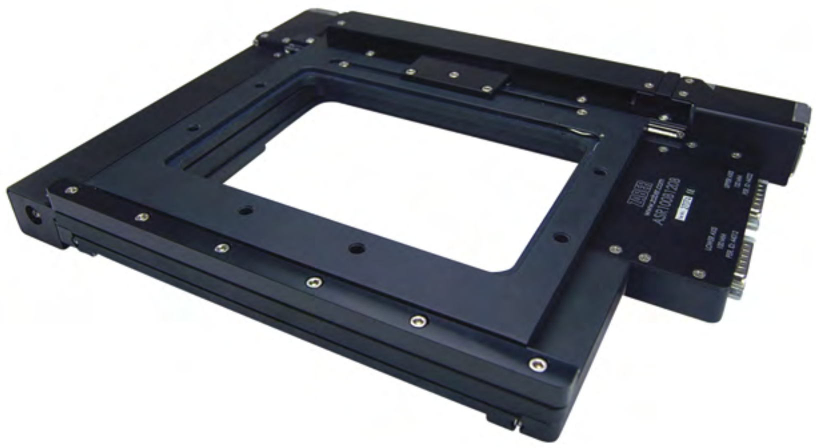
This stage is especially well suited for scanning and imaging applications. During development, we were so keen to see what the ASR could do that we set up a scanning station using an ASR stage, a two-axis controller, and a small USB microscope. For a set-up that would cost less than $7,000 in total, we were astonished to see what could be accomplished. The results of a scan of a business card at 220 times magnification are shown above (top right). The images we captured were aligned based only on the target positions of the stage – no image stitching algorithms were used.

– David Goosen, Research and Development

For more information on Image Stitching, please visit www.zaber.com/ImageStitching

Scanning & Microscope Stages





ASR-E Motorized XY Microscope Stages

- 12 µm full-travel accuracy; 2 µm repeatability; 85 mm/s speed
- 50 mm up to 305 mm travel per axis
- Designed for use with Zaber's stepper motor controllers

Product Description

Zaber's ASR-E Series stages are designed as replacements for manual stages on upright and inverted microscopes or for stand-alone operation as scanning stages. The extremely low profile and small footprint of ASR-E stages allow them to be incorporated into many different types of scanning systems and easily mounted to most common microscope platforms. Stage movement is handled by crossed roller bearings and hardened stainless steel rails, resulting in excellent smoothness, longevity, and stiffness.

Closed-Loop Operation

With the optional motor encoders, these stages provide position verification and feedback with slip/stall detection and automatic recovery. Upon detection of any slipping or stalling, the stages report the stall and can be set to automatically recover their position. Several modes of recovery behaviour are available.

Installation

The ASR-E Series microscope stages are designed to connect directly to Zaber's stepper motor controllers (purchased separately). Zaber's controllers and devices with built-in controllers can all be daisy-chained to communicate over a single computer connection. This simplifies set-up and reduces cable clutter. Mounting adaptors are available for breadboards and most common microscopes. Custom adaptors and plates are available upon request.

Computer Control

Our free Zaber Console software allows you to easily control your Zaber devices. Simply select the device you want to move, select a command (like "move absolute"), and enter the desired position. After the move, the stage reports its new position. Built-in scripting allows you to easily set up complex automation routines. The ASR-E is supported by MetaMorph and µManager, which are both microscopy automation and image analysis software.

Manual Control

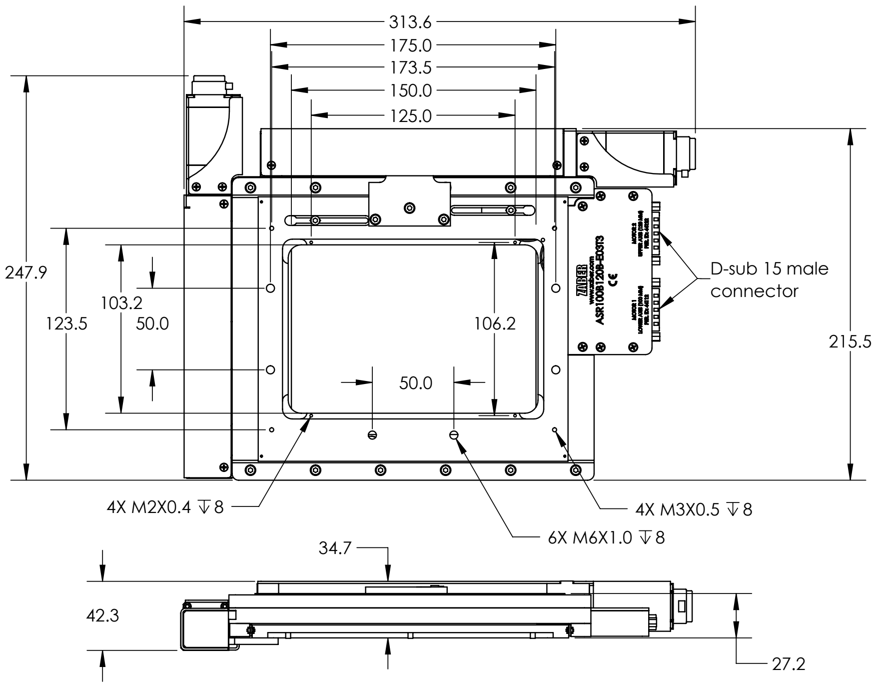
Zaber's controllers include convenient knobs that permit smooth manual control. During a manual move the stage's position is constantly transmitted to the computer and is displayed by the software. The knob allows you to use the stage even without a computer.

ASR-E Dimensions

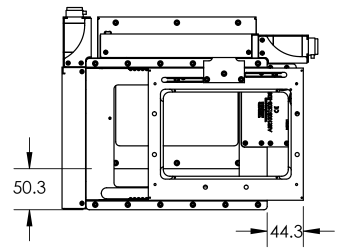
Measurements in millimetres (mm)

Model Number*	Travel	Footprint	Aperture
ASR050B050B-E03T3	50.0 x 50.0	205.6 x 236.6	75.0 x 75.0
ASR100B120B-E03T3	100.0 x 120.0	247.9 x 313.6	103.2 x 150.0

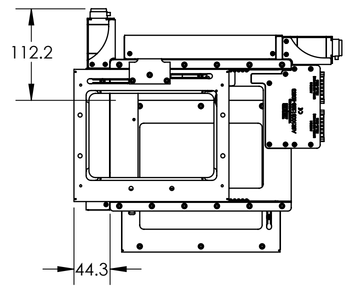
*ASR100B120B-E03T3 model shown. See ASR page for dimensions of all models at www.zaber.com



Minimum Travel Position



Maximum Travel Position



1. Adaptor plates required for mounting in most applications.

ASR-E Specifications

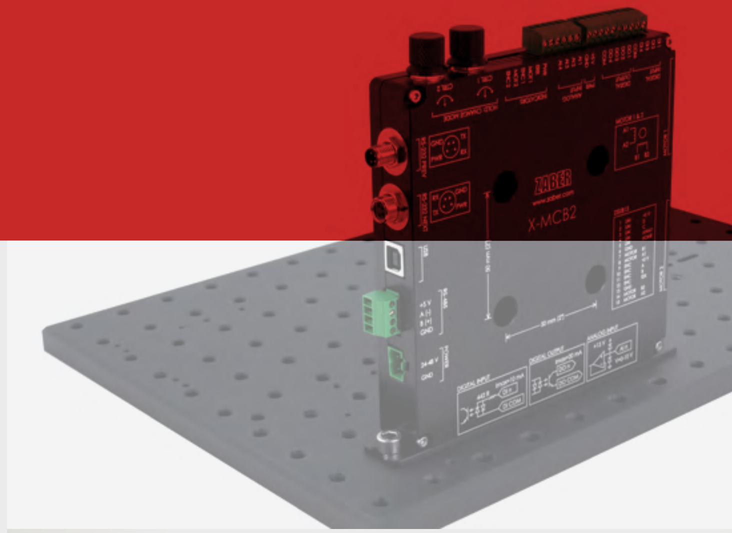
Model	Microstep Size (Resolution) (µm)	Accuracy (µm)	Repeatability (µm)	Backlash (µm)	Maximum Speed (mm/s)	Flatness (µm)	Peak Thrust (N)	Weight (kg)
ASR050B050B-E03T3	0.156	12	< 2	< 4	85	8	95	1.82
ASR100B120B-E03T3	0.156	40	< 2	< 4	85	15	95	3.0
ASR205B205B-E03T3	0.156	50	< 2	< 10	85	25	95	6.65
ASR305B305B-E03T3	0.156	80	< 2	< 10	85	50	95	10.35

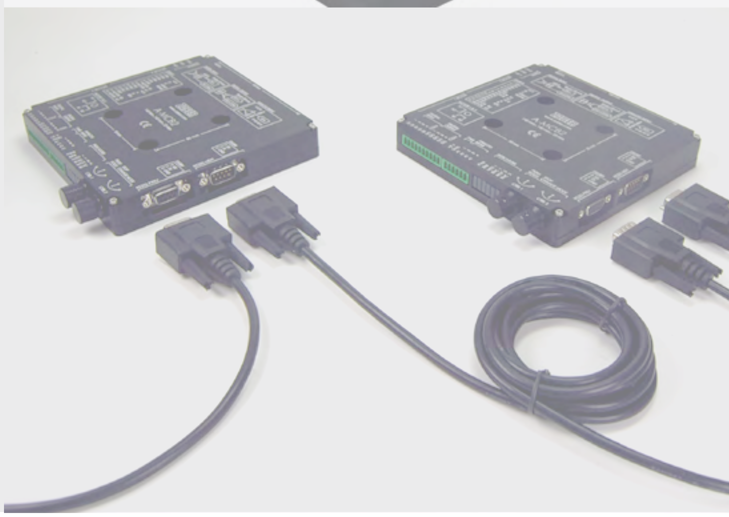
1. Complete, up-to-date specs available at www.zaber.com.

Customization is the best part of my job, as it is extremely stimulating. I always feel that anything is possible with our capabilities of changing any part of the software, electronics, or hardware. Client requirements can vary greatly, from custom brackets and cabling to different stage lengths, and having the ability to consult rapidly with the product design engineering team and production team allows us to meet many of those requirements. For example, sometimes stages need to be redesigned to fit within tight spaces, while other times we will have to design a complete custom stage to fit an OEM's needs.

– Frank van Vuuren, Research and Development

Design Spotlight: X-MCB2

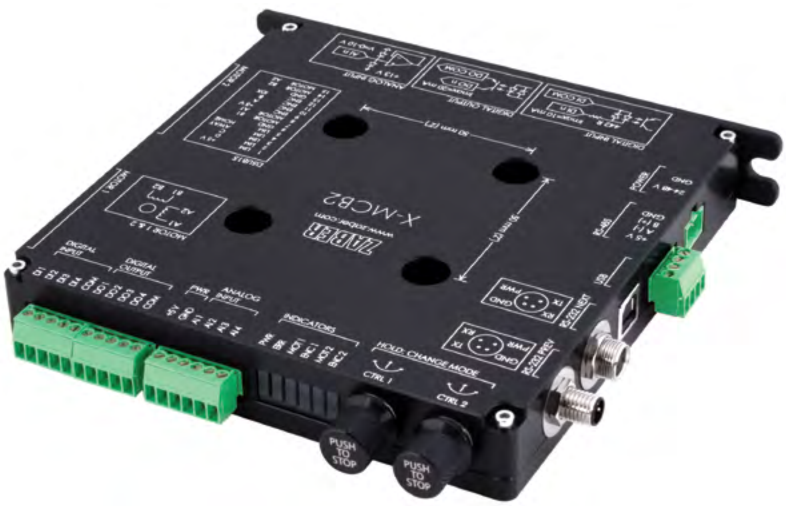




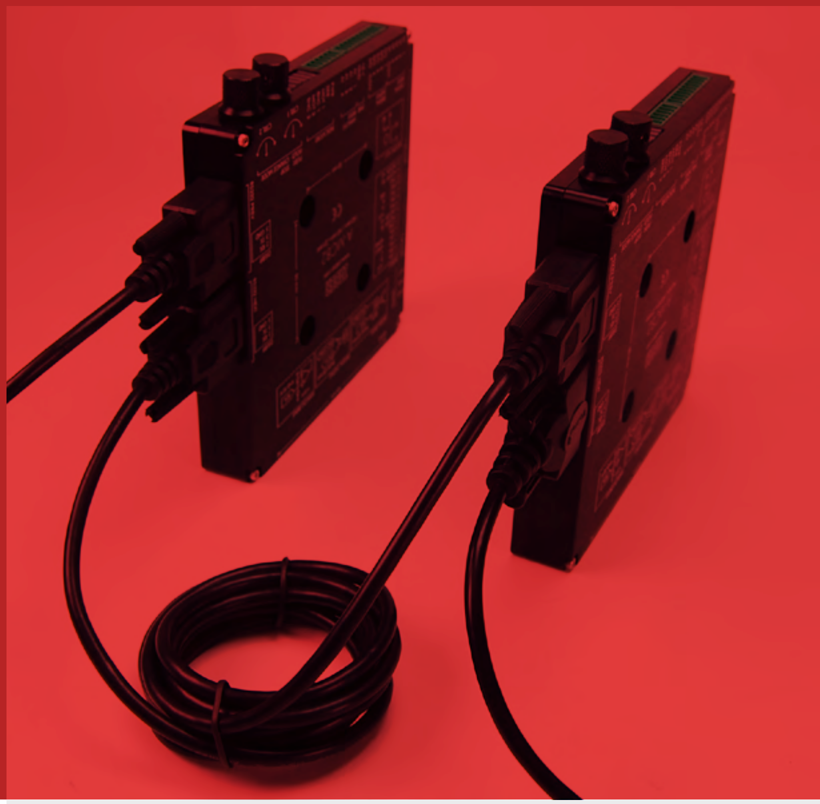
X-MCB2 Two-Axis Stepper Motor Controller

The X-MCB2 builds on its predecessor – the A-MCB2, which was a pioneer in many ways for Zaber's compact motion controllers. It carries forward all of the features introduced in the A-MCB2, including user programmable I/O, a USB interface, and communication using Zaber's intuitive ASCII protocol. The X-MCB2 maintains 100% compatibility with our existing products while offering even more new features such as robust locking connectors, easy set-up with other X-Series devices, and the ability to daisy-chain power. With its advanced multi-axis coordination features, the X-MCB2 is geared to be a great tool for scientists, system integrators, and tinkerers alike.

– Nathan Dyer, Firmware and Electronics



Controllers & Joysticks



Using Triggers to Simplify Automation

By Albert David, Applications Engineering Team

Triggers allow you to set up actions that occur when a certain condition has been met or an event has occurred. They allow you to add flexibility to processes, reduce communication delays for time-sensitive applications, and make it easier to coordinate timing and positioning of devices with other components within a system.

Triggers are available on A-Series and X-Series controllers using Zaber's ASCII protocol. This article will cover the types of triggers used on Zaber's controllers and outline the process of setting up several common applications using triggers.

TYPES OF TRIGGERS

Zaber's controllers have three types of triggers, which are differentiated by the conditions that activate them: **event-based**, **distance-based**, and **time-based**.

Event triggers are the most flexible. The condition that activates these triggers can be set to compare digital inputs or analog inputs, the position, or another setting to an input value. When activated, event-based triggers can be configured with up to two actions, such as toggling outputs, changing settings, or sending movement commands.

Distance triggers are activated when a specified distance interval is travelled, and the action triggered toggles a digital output value. Distance triggers are only available on controllers with I/O ports.

Time triggers are similar to distance triggers in that they also toggle a digital output. However, the condition for time triggers is an elapsed time interval rather than a travelled distance interval.

Like distance triggers, time triggers are also only available on controllers with I/O ports.

Each type of trigger can be enabled or disabled. When enabling triggers, you also have the option to specify a "count", which sets the number of times the trigger will execute before being automatically disabled.

APPLICATION EXAMPLES

Endless Rotation of a Rotary Stage

All of Zaber's controllers have a minimum and maximum position setting, and movement is constrained to stay within these bounds. On linear devices, these settings prevent the carriage from hitting physical stops. On rotary devices, physical stops do not exist, allowing for full 360 degree motion. The minimum and maximum position setting will still limit motion after several full rotations, however. To achieve endless rotation, a trigger can be set up to remove this limitation.

The following example describes a set-up that uses a trigger to create continuous motion in a certain direction. The trigger will activate when the current position of the rotary stage is more than a full rotation from the 0 position. The triggered action will subtract a full rotation from the stage's current position.

Using this strategy, when a movement is sent that has the final position as more than a full rotation, the trigger will reset the position with each rotation, thereby preventing the final position from ever being reached. A second trigger can also be configured for continuous rotation in the opposite direction.

The steps to set up triggers are detailed below:

Device Information	
Device	X-MCB1 with RSW60A-T3
Microstep Size	0.000234375°
360° Position	1536000 microsteps

First, set up the conditions to activate the triggers after a full rotation in either direction.

```
/01 trigger 1 when 1 pos >= 1536000

/01 trigger 2 when 1 pos <= -1536000
```

Next, set up the actions to increment or decrement the position.

```
/01 trigger 1 action a 1 pos += -1536000

/01 trigger 2 action a 1 pos += 1536000
```

Enable both triggers so that they become active. A count can be used here to specify the number of rotations you would like to move. Instead of continuous rotation, this can also be used to enable a longer duration of motion than the limits would otherwise allow.

```
/01 trigger 1 enable

/01 trigger 2 enable 100
```

Sending a movement command that moves past the full rotation mark will start the continuous rotation.

```
/01 0 move abs 3072000
```

> “Triggers allow you to set up actions that occur when a certain condition has been met”

High Frequency Cycling

Some applications require cycling or moving between two points continuously. Often, it is important to control both the size of a cycle as well as the frequency with which they complete.

Using movement commands to create this kind of motion has two limitations. First, each command takes a certain amount of time to send from the computer. Second, there is often a small variability in the timing of when commands are sent. Both limitations are on the order of milliseconds, so for low frequency (1 Hz or lower) applications, neither is a major consideration. However, they can be a limiting factor at higher frequencies.

Once triggers are set up, they no longer require communication to function, which makes it possible for higher frequency cycling applications to be more accurate.

The example below describes how triggers can be set up for a specific requirement.

Device Information	
Device	X-MCB2 with LSM050B-T4
Microstep Size	0.1905 μm
Maximum Speed	104 mm/s
Maximum Acceleration	8000 mm/s

Example Application Requirements	
Amplitude	0.5 mm
Frequency	25 Hz

The purpose of this particular set-up is to define the two end points of the motion. A point being reached or exceeded acts as a condition to trigger the stage to move to the other position. That position will have a similar condition that sends the stage back to the first point.

To accomplish this, first set up the conditions to activate the triggers when each end is reached. Our example will cycle between the 1 mm and 1.5 mm positions, which are found using the microstep size of the device.

```
/01 trigger 1 when 1 pos <= 5249

/01 trigger 2 when 1 pos >= 7874
```

Next, configure the actions for the triggers to send absolute movements to the opposite points.

```
/01 trigger 1 action a 1 move abs 7874

/01 trigger 2 action a 1 move abs 5249
```

Enable the triggers, and send the stage to one of the points to begin cycling.

```
/01 trigger 1 enable

/01 trigger 2 enable

/01 1 move abs 7874
```

These triggers will set the amplitude of your motion. Frequency can then be set by adjusting the target speed and acceleration. For example, to achieve a 25 Hz motion you must complete a cycle in 40 ms. For each quarter-cycle, this leaves 10 ms to cover 0.25 mm. There will be multiple speed and acceleration combinations that can achieve this, but an easy option is to set the peak speed to be reached at the end of the quarter-cycle so that it is constantly accelerating over that time period. For this example, this would give an acceleration value of 5000 mm/s^2 and a target speed of 50 mm/s, which are both within the ratings for the LSM050B-T4 model.

Triggering a Camera

Triggers can be incorporated into applications involving cameras by using a controller's digital output as an automated shutter release for a camera. Many cameras have a digital input that, when switched, can capture an image. While any type of trigger can be used, in this case, distance triggers are the easiest option as they can coordinate images and positions without having to consider timing.

First, set up a trigger with a distance-based condition.

```
/01 trigger dist 1 1 1000
```

Then, enable the trigger to execute 500 times before disabling.

```
/01 trigger dist 1 enable 500
```

At every 1000 microstep interval, digital output 1 will toggle, switching between high and low states. The connected camera will likely capture an image only when the line switches from low to high. In this case, you should set your distance condition to half the desired distance between images. In this example, the line will only go from low to high every 2000 microsteps: 1000 microsteps, 3000 microsteps, 5000 microsteps, and so on.

More Information

The examples in this article illustrate only a few potential uses for triggers; they are designed to add flexibility and ease of use to a wide variety of applications. Please refer to the Zaber ASCII Protocol Manual to learn more about other conditions and actions that can be created. If you have a potential application in mind, or if you have any questions about triggers, please feel free to email our Applications Engineering Team at contact@zaber.com.

Albert David is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications. For more information, please visit www.zaber.com.

Incorporating Sensor Feedback

By Mike McDonald, Applications Engineering Team

While Zaber's devices work best in high precision positioning applications, many systems will require stages to move in relation to output from a sensor. You can incorporate sensor feedback into your system with a Zaber device in a few ways.

One way to have your stage respond to feedback is to continuously send **Move at Constant Speed** commands.

This command moves the stage at a speed based on the data value you send; the data value can have positive or negative values which will move the stage either forward or in reverse. The stage will continue to move at that speed and direction until it receives another command. You can use the output of your sensor to vary the data value. You can update this speed with a frequency of around 50 Hz (based on the communication speed), with X-Series devices over 100 Hz.

An example set-up could be a force sensor on the tip of one of our T-NA08A25 actuators. You can set a target force for it to apply then create a script with a negative feedback loop.

While the measured force is lower than the target, the data value you send to the Move at Constant Speed will be positive. As the measured force approaches the target, the data value will decrease, until it's met when you would send a data value of 0. If the measured force is higher than the target, the data sent would be negative and the actuator would retract.

IO ports of an X-MCB2 two-axis controller

With the X-MCB2 two-axis controller you have access to digital and analog inputs so that you can directly connect the sensors to the controller. You could then either read those values in over your serial connection and use them to send your commands, or you could set up triggers to use the feedback without even having a computer connection.

If you have any questions or would like to learn more about triggering, please contact us to speak with the Applications Engineering Team.

See below for an example script written for Zaber Console to use the analog input for proportional speed feedback:

```
//C# sample script for using feedback with
analog input of X-MCB2 controller
//analog input expects voltage range 0-10V
//this script assumes your target force to
apply equates to a 5V analog input
#template(simple)
var targetForce = 5;
Conversation.Request("move vel", 500);
//loop will continue to run until Cancel button
is pressed
while (!IsCanceled)
{
//gets the current value of Analog Input 1
var currentForce = Convert.
ToDouble(Conversation.Request("io get ai 1").
Data);
//compares current input to target value
var forceDiff = targetForce - currentForce;
//uses move velocity command with speed
proportional to difference, retracting if
negative
Conversation.Request("move vel", Convert.
ToInt32(100 * forceDiff));
}
Conversation.Request("stop");
```

- Drives two axes of bipolar stepper motors or actuators with up to 1.41 A_{rms} (2.0 A peak) per phase and high resolution, customizable microstepping
- Four isolated digital inputs, four isolated digital outputs, and four analog inputs
- Zaber's intuitive ASCII protocol simplifies complex automation tasks
- Axes can be locked together to move simultaneously or coordinated to move together in a virtual axis

X-MCB2 Two-Axis Stepper Motor Controllers

Product Description

Zaber's X-MCB2 stepper motor controller is capable of controlling and driving two axes of bipolar stepper motors or actuators independently or in coordinated 2D linear and circular interpolation. The axes can be locked together to move simultaneously as if they were a single axis, carrying out all motion in parallel. Each axis may be equipped with its own quadrature encoder and multiple limit sensors (home, away, etc.). In addition, the controller provides 4 channels each of isolated digital input, isolated digital output, and analog input. An intuitive ASCII interface allows the user to easily communicate with the device through Zaber Console (our free software) or third party terminal programs. It uses lines, circles, and arcs as geometric primitives, while obeying velocity, acceleration and timing constraints. The result is an easy-to-use set of 2D commands and seamless transition between lines and curves.

Installation

Set-up is a snap. Just connect the controller to a computer via USB port or RS-232 serial port, and plug in a compatible motor or actuator. Multiple devices can be daisy-chained to a single port. Only one power supply is needed to power the entire chain of devices.

Computer Control

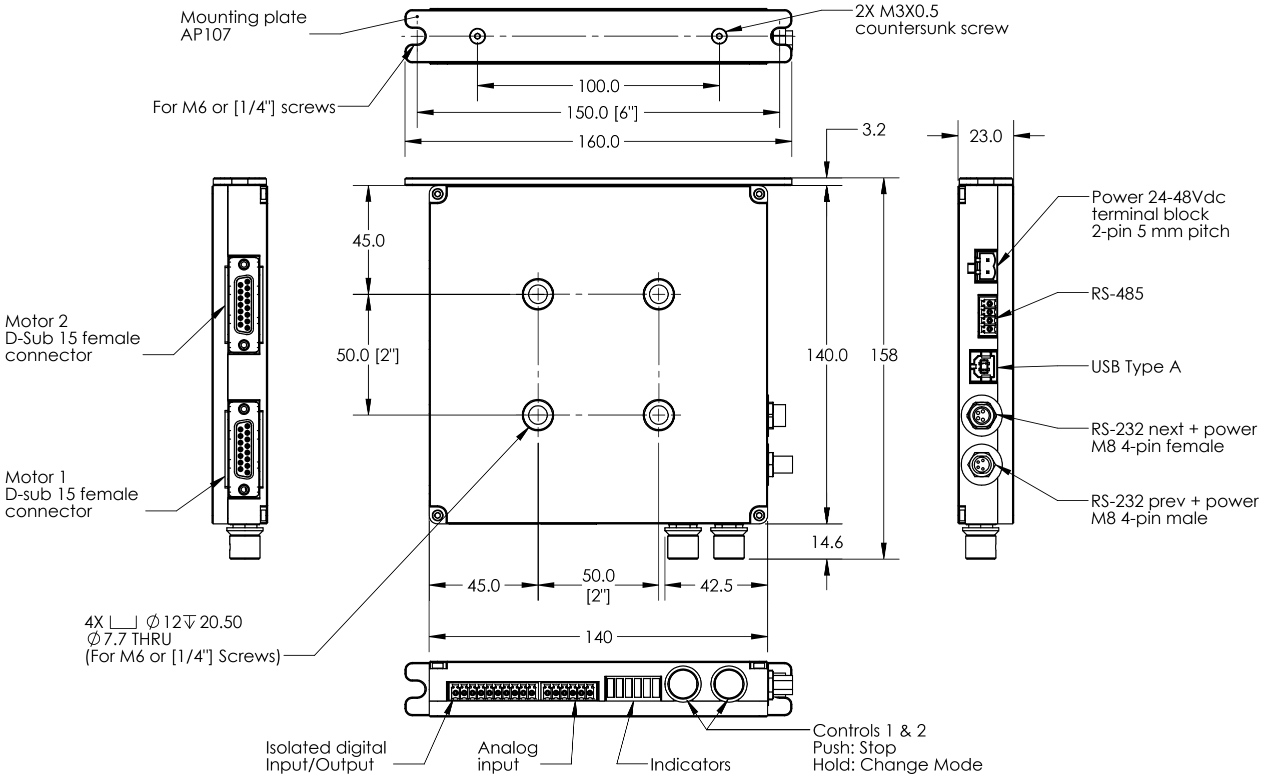
We provide free software so you can easily control your Zaber devices. It automatically recognizes all your devices and allows you to communicate with each one. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired position. You can also change a variety of device settings, such as the running current and hold current, to suit your application's needs. Built-in scripting allows you to easily set up automated routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

Two indexed knobs provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. In velocity mode, turning the knob starts the device moving at a constant speed. Every increment increases or decreases the speed by a configurable amount. In displacement mode, each increment of the knob moves the device by a configurable distance. Pushing the knob for 1 second switches between displacement and velocity mode. You can also issue a stop command by depressing the knob during any operation.

X-MCB2 Dimensions

Measurements in millimetres (mm)



X-MCB2 Specifications

Model	Maximum Current per Phase (mA)	Input Voltage (VDC)	Operating Temperature (°C)	Communication Protocol	Motor Connector	Manual Control	Microstepping Range (microsteps per step)	Encoder Input
X-MCB2	1410	24–48	0–50	ASCII, Binary	D-Sub 15	Indexed knob/ push switch	1–256	Quadrature

1. Complete, up-to-date specs available at www.zaber.com.

X-MCB1 Stepper Motor Controllers

- Drives any bipolar stepper motor or actuator with up to 1.41 A_{rms} (2.0 A peak) per phase and high resolution, customizable microstepping
- Two isolated digital inputs, two isolated digital outputs, and two analog inputs
- Zaber's intuitive ASCII protocol simplifies complex automation tasks
- Designed for easy mounting to panels, breadboards, lab benches, and enclosures

Product Description

The X-MCB1 stepper motor controller is designed with powerful, yet easy-to-use features. It can drive any bipolar stepper motor or actuator up to 1.41 A_{rms} (2.0 A peak) per phase. Microstepping resolution of the drive can be set at any value between 1 and 256 microsteps per step, allowing both customizability and fine resolution movement. The controller includes isolated digital inputs and outputs, as well as analog inputs for interfacing with the physical world. Zaber's intuitive ASCII protocol makes the device easy to communicate with and to set-up scripts and programs for. The X-MCB1 has been designed to be backwards-compatible with all of Zaber's devices.

Installation

Set-up is a snap. Just connect the controller to a computer via USB port or RS-232 serial port, and plug in a compatible motor or actuator. Multiple devices can be daisy-chained to a single port.

Computer Control

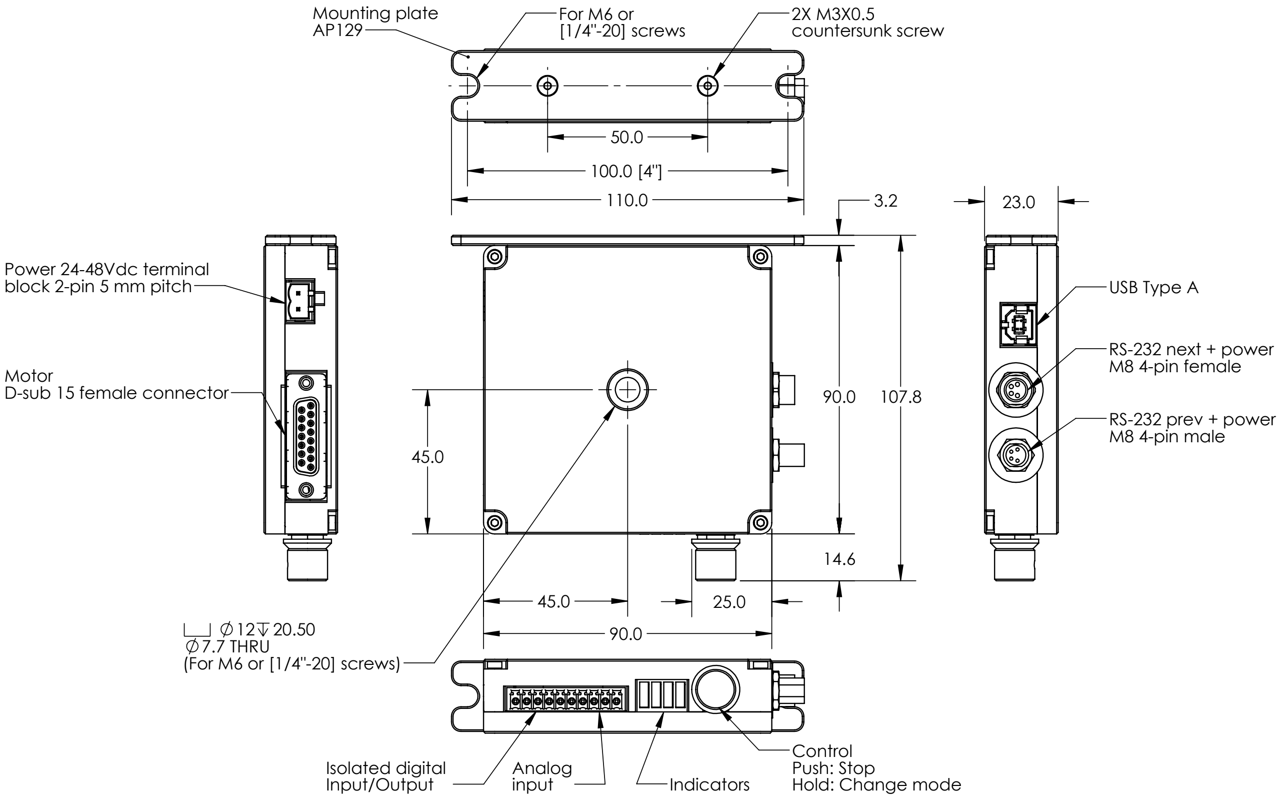
We provide free software so you can easily control your Zaber devices. It automatically recognizes all your devices and allows you to communicate with each one. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired position. You can also change a variety of device settings, such as the running current and hold current, to suit your application's needs. Built-in scripting allows you to easily set up automated routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

Manual Control

An indexed knob provides smooth manual control at variable speeds in both directions for versatile operation even without a computer. In velocity mode, turning the knob starts the device moving at a constant speed. Every increment increases or decreases the speed by a configurable amount. In displacement mode, each increment of the knob moves the device by a configurable distance. Pushing the knob for 5 seconds switches between displacement and velocity mode. You can also issue a stop command by depressing the knob during any operation.

X-MCB1 Dimensions

Measurements in millimetres (mm)



X-MCB1 Specifications

Model	Maximum Current per Phase (mA)	Input Voltage (VDC)	Operating Temperature (°C)	Communication Protocol	Motor Connector	Manual Control	Microstepping Range (microsteps per step)	Encoder Input
X-MCB1	1410	24–48	0–50	ASCII, Binary	D-Sub 15	Indexed knob/ push switch	1–256	Quadrature

1. Complete, up-to-date specs available at www.zaber.com.

X-MCA Compact Stepper Motor Controllers

- Controls any bipolar stepper motor or actuator with up to 1.0 A_{rms} (1.4 A peak) per phase and high resolution, customizable microstepping
- Zaber's intuitive ASCII protocol simplifies complex automation tasks
- Support linear and motor-mounted encoders for closed-loop control
- Designed for easy mounting to panels, breadboards, lab benches, and enclosures

Product Description

The X-MCB1 stepper motor controller is a high resolution, small form factor stepper motor controller for bipolar stepper motors and actuators up to 1.0 A_{rms} (1.4 A peak) per phase. This is our most compact stand-alone controller available. It has been designed to fit in tight spaces and provide a range of mounting options including 90 degree stacking and 35 mm DIN rail mounting via optional accessories AB158 and AB159. The controller includes isolated digital inputs and outputs, as well as analog inputs for interfacing with the physical world. Zaber's intuitive ASCII protocol makes the device easy to communicate with and to set-up scripts and programs for. The X-MCA has been designed to be backwards-compatible with all of Zaber's devices.

Installation

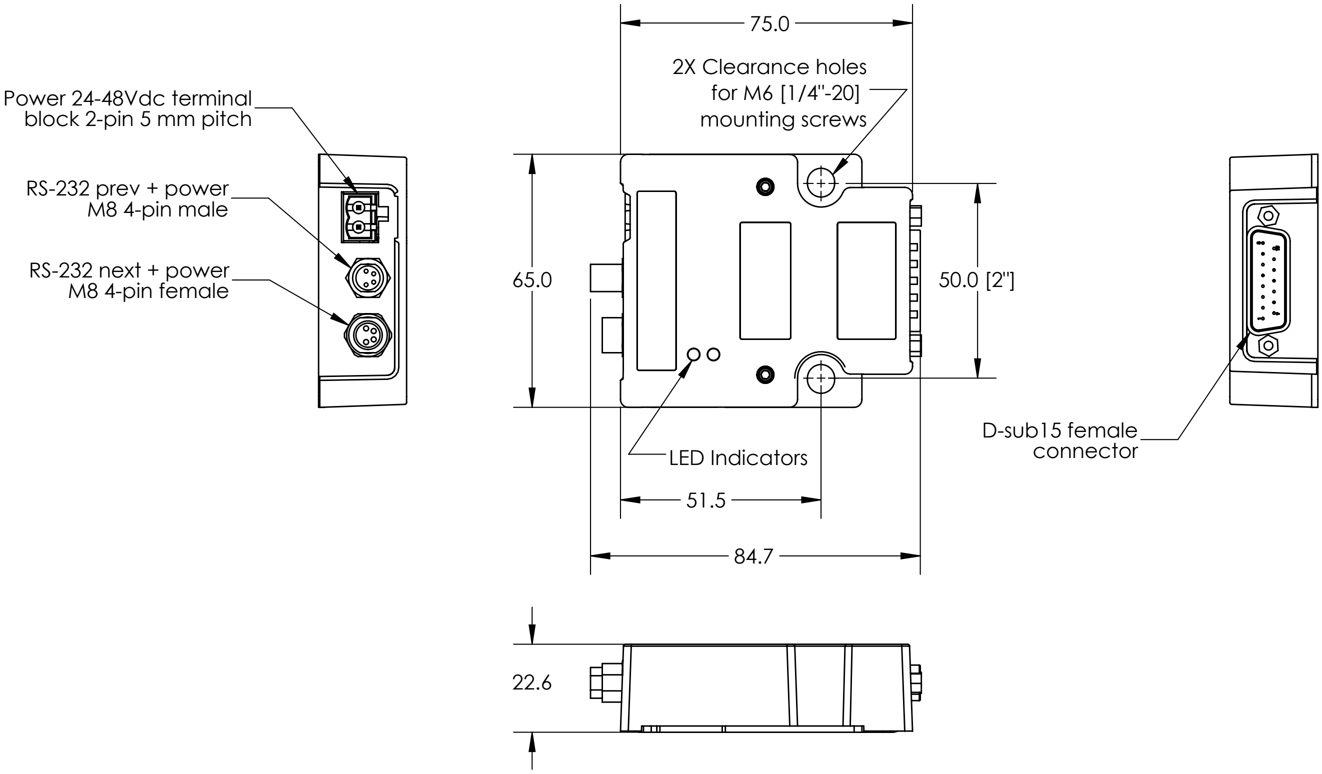
Set-up is a snap. Just connect the controller to a computer via USB port or RS-232 serial port, and plug in a compatible motor or actuator. Multiple devices can be daisy-chained to share power and data through a single port. Only one power supply is needed to power the entire chain of devices.

Computer Control

We provide free software so you can easily control your Zaber devices. It automatically recognizes all your devices and allows you to communicate with each one. Simply select the device you want to move, select a command (like "move rel" to move by a distance relative to the current position), and enter the desired position. You can also change a variety of device settings, such as the running current and hold current, to suit your application's needs. Built-in scripting allows you to easily set up automated routines. Programming libraries are available in a variety of other languages, including .NET, C, Python, and LabVIEW. For LabVIEW users, we offer a free, certified LabVIEW driver.

X-MCA Dimensions

Measurements in millimetres (mm)



X-MCA Specifications

Model	Maximum Current per Phase (mA)	Input Voltage (VDC)	Operating Temperature (°C)	Communication Protocol	Motor Connector	Manual Control	Microstepping Range (microsteps per step)	Encoder Input
X-MCA	1000	24–48	0–50	ASCII, Binary	D-Sub 15	None	1–256	Quadrature

1. Complete, up-to-date specs available at www.zaber.com.

Manual Control Using a Joystick

By Nancy Chu, Applications Engineering Team

A joystick can be a useful complement to many motion control applications. Joysticks, in this context, typically allow for graduated velocity and position control and commonly have buttons that can be mapped to commands, offering the freedom to operate your devices without a computer connection. In this article, we will look at the features of Zaber's X-JOY3 joystick and the steps to set it up. We will also explore some applications that benefit from implementing a joystick control, and look at the different capabilities you can use for your next system.

ZABER X-JOY3 FEATURES

The X-JOY3 is Zaber's 3-axis joystick. It is compatible with all of Zaber's devices and can be daisy-chained with them to share power and data, keeping cabling simple and minimal. Later, we'll go through how to configure the joystick, but first let's look at an overview of the X-JOY3 features.

Figure 1: X-JOY3 in a daisy-chain.

Joystick Knob

The joystick knob offers manual control of three axes, shown in Figure 2: Axis 1 [Left|Right], Axis 2 [Up|Down], and Axis 3 [Counterclockwise|Clockwise]. For each knob axis, you can specify the following:

- *Target Device/Axis:* The address of the motor that you want the knob axis to control, including the device number, and, if the device controls more than one motor, the axis number.
- *Axis Direction:* Coordinates the direction of movement of a device and the knob that controls it.
- *Maximum Speed:* The speed at which the motor will move when the knob is moved to the maximum in an axis.
- *Resolution:* The number of speed increments in an axis to reach the maximum speed.
- *Speed Profile:* The way the speed changes over the travel as you move the knob through increments. The options are linear, squared, or cubed. The linear profile means each increment increases speed by the same amount. Squared and cubed profiles allow finer speed control at low speeds.

Figure 2: Top-down view of the X-JOY3 anatomy.

Keys

Each of the X-JOY3's 8 keys, shown in Figure 2, can be programmed to send commands to any device connected downstream in the daisy-chain. The commands can be set to target a specific device or axis in the chain or all the devices.

Each button has four available key events to which commands can be mapped. As shown in Figure 3, event 1 occurs as soon as the key is pushed; event 2 occurs if the button is released shortly after pressed; event 3 occurs if the button is held; and event 4 occurs when the button is released after being held. You can map commands to one or more of these events, and you can map multiple commands to a single event.

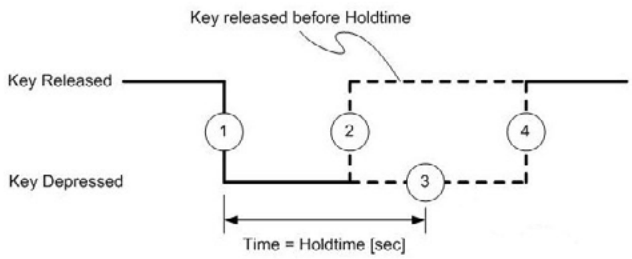


Figure 3: X-JOY3 key events.

The keys come preprogrammed with the following commonly used functions so that you can get started using the joystick immediately:

Key	Short Press	Long Press
1	Stop all axes	Home all axes
2	Send alerts* 1, 2	Send alerts* 1, 3, 4
3	Move to saved position	Save current position
4	Move to saved position	Save current position
5	Move to saved position	Save current position
6	Axis 1 low speed	Axis 3 high speed
7	Axis 2 low speed	Axis 3 high speed
8	Axis 3 low speed	Axis 3 high speed

*When comm.alert is set to 1

Table 1: Commonly used functions.

Each of these can be moved, changed, or removed. We will explain how in a later section.

Alerts

As shown in Table 1, the joystick can be set to send alerts. Alerts are responses sent upstream from the joystick, which are intended to convey information to a computer if one is connected. If the setting 'comm.alert' is set to 1 on the joystick, then any key event can be set to send an alert response. In cases where you have more complex actions that can't be easily mapped to a button, you can write a computer program that watches for these responses in order to do these functions.

SET-UP AND CONFIGURATION

Once you have a joystick and devices, you're ready to setup and configure the system. To get started with your X-JOY3, we recommend using Zaber Console for the initial setup. Zaber Console is our free, open-source, and easy-to-use software, which you can download from here: www.zaber.com/wiki/Software/Zaber_Console

Daisy-chaining

Once Zaber Console is installed, all it takes to get started are three steps:

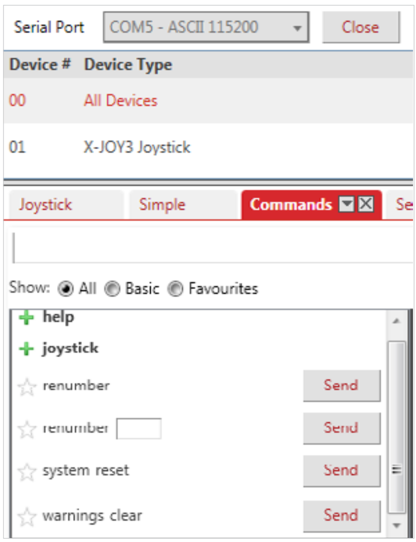
Configuring Behaviour

The X-JOY3 works with Zaber's easy-to-use ASCII protocol by default, and we'll be using this protocol in the following instructions and examples. The X-JOY3 can also be configured with Zaber's Binary protocol; please refer to the Binary Protocol manual for details, or contact Zaber's customer support for more information.

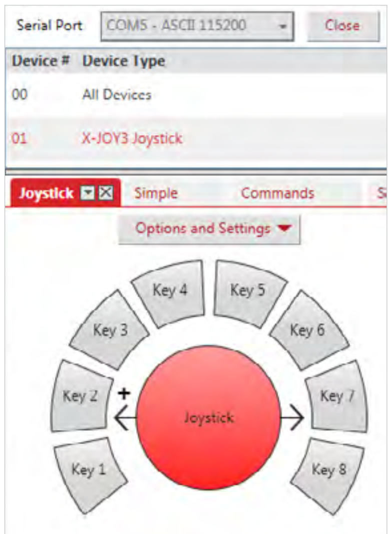
To understand how to configure the manual knob and keys on the X-JOY3, let's take a look at some of the ASCII commands they use:

Joystick Commands
Set the device that a joystick axis controls: `/device joystick 1|2|3 target device axis`
Example: Set joystick axis 1 (left|right) to control the second device connected in the daisy-chain `/1 joystick 1 target 2 1`
Key Commands
Add a command to a key: `/device joystick 1|2|3 target device axis`
Example: Set key 1 to send a home command when it is held down for more than one second `/1 key 1 3 add home`

1. Connect the Joystick to the computer as the first device in the daisy-chain, and connect the devices you would like to control after it.



2. Open Zaber Console; open the COM port; and send a renumber command to All Devices. This will set the Joystick as device 1, and the next devices as 2, 3, and 4. The joystick knob axes control these device numbers by default.



3. Select the X-JOY3 from the device list, and click on the Joystick tab.

For more information on connecting devices, see Daisy-chaining Data and Power:
www.zaber.com/daisy-chaining-data-and-power-to-reduce-cabling

There are other commands and settings used to configure the joystick, and they are all outlined in detail in the X-JOY3 manual. While editing settings on the joystick can be done directly by using Zaber Console's Commands, Settings, or Terminal Tabs (or through any of the libraries Zaber supports for various programming languages), the easiest way is by using the Joystick tab in Zaber Console.

Using Zaber Console's Joystick Tab

The joystick tab in Zaber Console is specifically designed to simplify X-JOY3 configuration by offering intuitive graphical control.

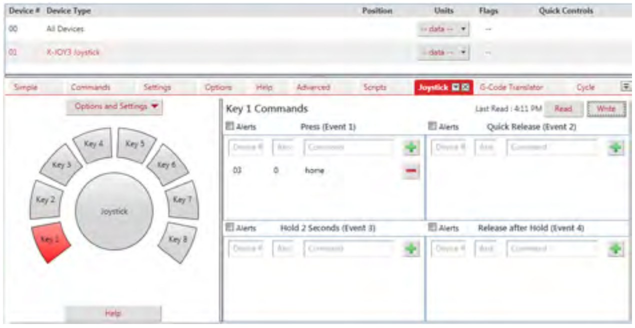


Figure 4: Zaber Console's Joystick tab.

To adjust the joystick settings, first click on the round Joystick button shown in Figure 4. You can choose a knob axis, and then you'll have controls for each of the settings mentioned earlier. After making changes, make sure you press the Write button to apply them before configuring the next axis.

Click any of the eight Key buttons shown in Figure 4 to configure the functions that the selected key will execute. For each key there are four panes, one for each event, and these have editable fields that match the ASCII message format. You can populate the fields by typing in the device and axis numbers and entering a command. Press the button with a plus sign to add the command. Once you have added a command to the key, you can drag it to other events or press the button with a minus sign to remove it. To upload all of the commands to the joystick, press the Write button in the top right corner.

The Options and Settings control offers a list of options, which includes saving and loading configurations, clearing keys, and restoring the settings to default. Figure 5 shows how you can clear some or all of the keys and how you can save a configuration that can be loaded later.

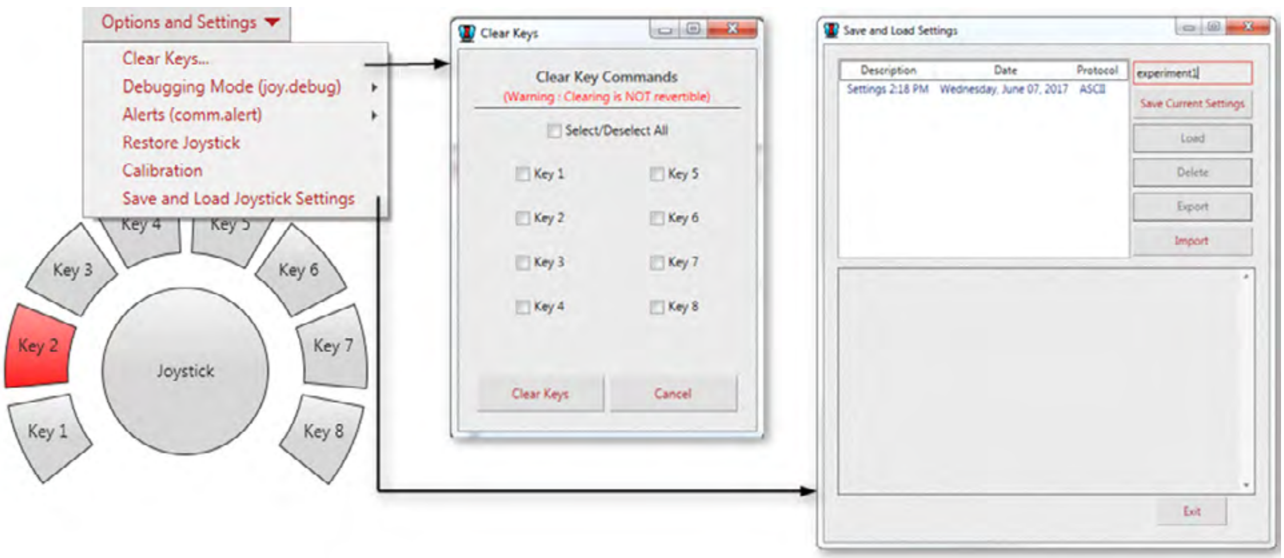


Figure 5: Options and Settings on the Joystick Tab.

Using a Script to Configure in Zaber Console

In some cases, you may want to load a number of commands at once. While you can do this using the Joystick tab, if you're familiarized with the protocol, it may be faster to use a script. In the Zaber Console Script tab, you can program a list of commands to the X-JOY3 keys and/or joystick. The following example shows a simple script written in C# to program multiple keys at the same time.

```
#template(Simple)

//Create a conversation with the X-JOY3,
//which is device 1
var xjoy = PortFacade.GetConversation(1);

//Clear anything stored in key 1 event 3
xjoy.Request("key 1 3 clear");

//Program key 1 event 3 to home all axes
xjoy.Request("key 1 3 add 0 home");

//Clear key 3 event 2
xjoy.Request("key 3 2 clear");

//Program key 3 event 2 to set the speeds
//of device 2 and 3 to different values
xjoy.Request("key 3 2 add 2 set maxspeed
100000");
xjoy.Request("key 3 2 add 3 set maxspeed
200000");
```

USE CASES AND EXAMPLES

Now that we have reviewed features and configuration of the X-JOY3, let's look at a few practical examples to demonstrate where the a joystick can save time and effort.

Enclosed Environments (Vacuum or Pressure Chambers)

Zaber offers a variety of vacuum-rated devices, which are used in controlled, low-pressure chambers. This prevents you from being able to use manual control knobs on devices to adjust them by hand. By connecting a joystick outside the chamber, users are given the ability to make these manual movements without a computer connection. For more information on vacuum devices, see Design Consideration for Vacuum Applications: www.zaber.com/motion-device-design-considerations-for-vacuum-applications

Multi-axis Control and Toggling (3+ devices)

While the X-JOY3 has three axes of manual control, some systems to which it will connect will have more than three motors. Rather than using two joysticks, you can set-up buttons on the joystick to switch which axis the joystick knob targets.

Figure 6: 4-Axis system with XY, rotation, and gripping.

Figure 6 shows an example of a 4-axis system, made up of two linear stages, one rotary stage, and a gripper. You can map the left/right and up/down knob axes to control the linear stages, and then have a button that switches control of the clockwise/counterclockwise knob axis between rotating the gripper and opening/closing it.

Figure 7: Two XYZ systems with one joystick.

Figure 7 shows a system of two separate XYZ setups that are daisy-chained together. While the system has 6 axes in total, you can use one joystick by setting a single key that switches the targeted devices between the first set of axes and the second set.

To share a joystick knob axis between two devices, simply configure two key events to toggle the control between one device and the other. Figure 8 shows an example in which Key 4 is programmed so that event 2 sets Joystick Axis 1 (Left and Right) to control device 2, and event 3 sets it to control device 3.

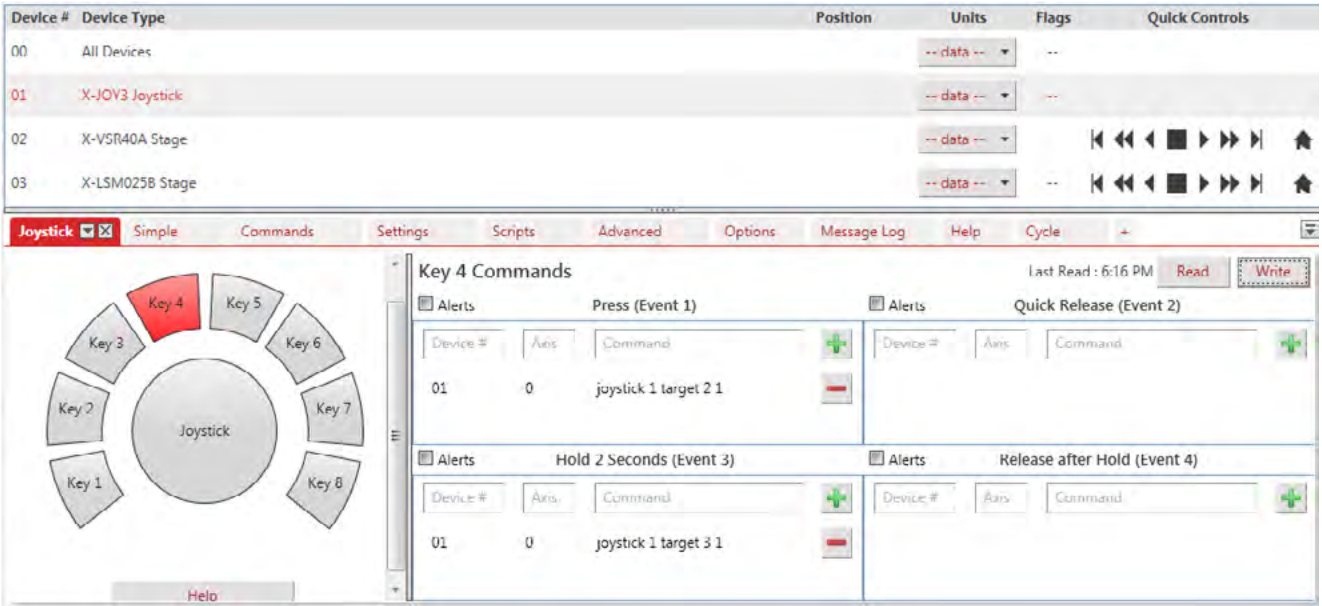


Figure 8: Configuring key 4 to toggle control.

Virtual Axis Control for Micromanipulators

For some XY applications, users need to move along a straight line in a direction between X and Y. This direction is called a virtual axis. This is a common requirement in micromanipulators, such as Zaber's M-LSM shown in Figure 9, where a probe may be held at an angle. A user may then want to insert the probe into a sample by moving along a virtual axis corresponding to the angle. Zaber's two-axis X-MCB2 controller supports this kind of movement. For example, to set up a virtual axis 30° between axis 1 and axis 2, you would send:

```
/02 virtual 1 setup angle 1 2 30
```

Once a virtual axis is set up, you can configure one axis of the joystick knob to move along the virtual path similarly to controlling any other axis:

```
/01 joystick 1 target 3 virtual 1
```

We include an X-JOY3 with our M-LSM micromanipulator orders when they are purchased with accessory kits.

Raster Scan with a Stream Buffer

A common use for XY systems is to move through a series of lines to scan an area or stop at an array of positions and perform an action at each stop. These kinds of movements are known as raster scans. In cases where having a computer connection is not feasible, raster scan movements can be saved to a stream buffer and run using a X-JOY3 key. For more information on streams, see Streamed and Interpolated Multi-Axis Motion: www.zaber.com/streamed-and-interpolated-multi-axis-motion

Figure 9: Zaber's Micromanipulator bundle includes the X-JOY3.

The following script stores a raster scan on an X-MCB2 controller and programs key 8 on the X-JOY3 to call the scan. At each position, it will turn on a digital output to trigger some action, wait for a period, then turn it off. Once this script is run, you will be able to initiate the raster scan by clicking key 8.

```
#template(Simple)

var xjoy = PortFacade.GetConversation(1);     //X-JOY3 is device 1
var xmcb2 = PortFacade.GetConversation(2);    //X-MCB2 is device 2

var col_dist = 2000;                     //Distance in microsteps between each column in grid
var row_dist = 2000;                     //Distance in microsteps between each row in grid
var sittime = 500;                       //Time in milliseconds of pause at each position
var digitaloutput = 1;                   //Which digital output pin to turn on at each
                                         //position
int col_num = 12;                        //Number of columns in raster
int row_num = 8;                         //Number of rows in raster
int col_count = 0;
int row_count = 0;

xmcb2.Request("home");
xmcb2.PollUntilIdle();

xjoy.Request("key 8 2 clear");                //Clears Key 8 event 2
xmcb2.Request("stream buffer 1 erase");       //Clears stream buffer
xmcb2.Request("stream 1 setup disable");      //Disables stream 1 setup
xmcb2.Request("stream 1 setup store 1 2");    //Start storing using stream 1

while (row_count < row_num){
   xmcb2.Request("stream 1 line abs " + (col_dist) + " " + (row_dist));
   xmcb2.Request("stream 1 io set do 1 1");                  //Set DO1 high
   xmcb2.Request("stream 1 wait ", sittime);
   xmcb2.Request("stream 1 io set do 1 0");                  //Set DO1 low
   row_count++;
   while (col_count < col_num){
      xmcb2.Request("stream 1 line rel " + (col_dist) + " " + (0));
      xmcb2.Request("stream 1 io set do 1 1");               //Set DO1 high
      xmcb2.Request("stream 1 wait ", sittime);
      xmcb2.Request("stream 1 io set do 1 0");               //Set DO1 low
      col_count++;
   }
   row_dist = row_dist + row_dist;
   col_count = 0;
}

xmcb2.Request("stream 1 setup disable");

//Program the key 8 to start and call the stream
xjoy.Request("key 8 2 add 2 stream 1 setup live 1 2");
xjoy.Request("key 8 2 add 2 stream 1 call 1");
```

Trigger A Script Using Alerts

Most of the examples we've looked at have focused on cases in which it's helpful to have either manual control or keys when you don't have a computer connection available. There are also uses for the joystick in conjunction with a computer script or program.

In particular, the Alert function is useful in sending information upstream from the joystick, back to the computer. Every key event on the joystick can be set to send an alert message to the connected COM port. The script or program can watch for these alerts, and based on which key event occurs, it can run a number of different programs. For example, if you're using the joystick to move a digital camera that is connected to a computer, you can write a script on the computer that captures an image when a particular key alert is received. This would allow you to focus on your subject rather than returning to the computer every time you wanted to capture an image.

To enable alerts for a particular key event, first enable alerts on your device:

```
/1 set comm.alert 1
```

Next, enable alerts for the key events you'd like to respond. For example, to have key 2 event 1 send an alert, send:

```
/1 key 2 1 alert 1
```

Now, when key 2 is pressed, the following alert will be sent back to the computer port:

```
!01 0 key 2 1
```

DISCUSSION/CONCLUSION

We've discussed a number of applications and uses for Zaber's X-JOY3 joystick, but there are many more ways the features can be used. If you have an application where you think it may be useful, or if you have any questions, please contact our Applications Engineering Team at contact@zaber.com. For additional information and troubleshooting, you can refer to our Joystick Manual (www.zaber.com/wiki/Manuals/X-JOY3), Zaber Console Joystick Guide (www.zaber.com/wiki/Software/Zaber_Console/Joystick_Setup_Tab), and our Zaber Console ASCII manual (www.zaber.com/wiki/Manuals/ASCII_Protocol_Manual).

Feel free to contact our Applications Engineering Team at contact@zaber.com if you have any questions about this article, if you have a potential application in mind or need any other additional information.

Nancy Chu is a member of the Applications Engineering Team at Zaber Technologies Inc. Zaber designs and manufactures motorized precision linear actuators, linear slides, and other motion control products used for optics and photonics, industrial automation, biomedical, and many other applications.
For more information, please visit www.zaber.com.

- Controls up to three axes, each with programmable sensitivity and velocity profile
- Compact bench-top design for manual control with or without a computer
- Eight programmable buttons for functions like storing and recalling positions
- X-Series devices have locking, 4-pin, M8 connectors

X-JOY3 Programmable Joystick

Product Description

The X-JOY3 is ideal for XY or XYZ applications requiring manual control. The joystick is intuitive to use, and the buttons are pre-programmed with commands to home the devices, save positions, and switch between coarse and fine positioning. Each button can also be reprogrammed to send commands to any daisy-chained device. After programming, the joystick can be operated with or without a computer attached.

Installation

To set up the joystick, simply place it in a daisy-chain upstream of the devices you wish to control, and plug in power. One or more devices can be connected to the RS-232 or USB port of any computer. Convenient locking, 4-pin, M8 connectors on these devices allow for easy and secure connection and power sharing between X-Series products.

Computer Control

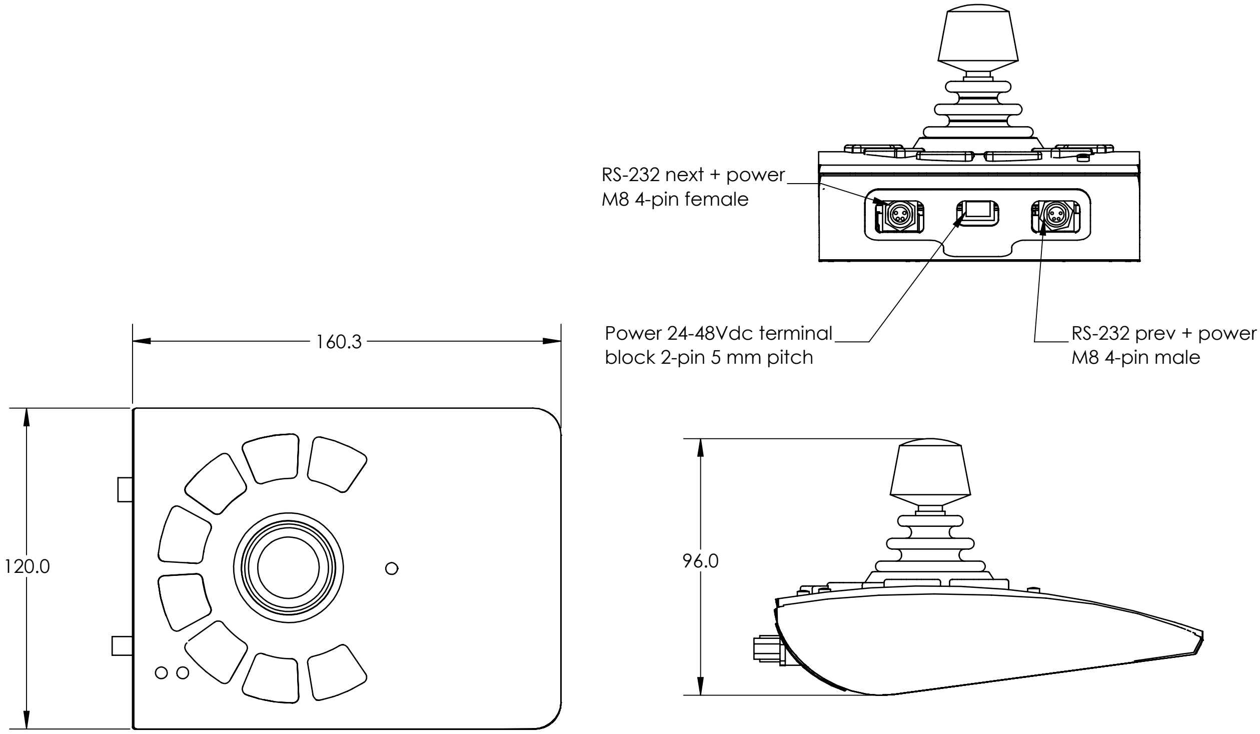
Connecting the joystick to a computer allows the eight buttons to be programmed. For more sophisticated applications, you can use the X-JOY3's buttons to trigger actions in your own computer scripts. Both the computer and the joystick can simultaneously control connected devices through the daisy-chain.

Manual Control

One axis is controlled by moving the joystick from left to right, another by moving the joystick from front to back, and a third by rotating the handle. By programming the joystick, you can specify which connected device corresponds to each axis.

X-JOY3 Dimensions

Measurements in millimetres (mm)



X-JOY3 Specifications					
Model	Communication Protocol	Current Draw (mA)	Length (mm)	Width (mm)	Height (mm)
X-JOY3	ASCII, Binary	50	170	120	96

1. Complete, up-to-date specs available at www.zaber.com.
2. The X-JOY3 does not have a built-in motor controller. In order to use it for manual control of a motor without a built-in controller, an external controller such as an X-MCB2 or X-MCB1 is necessary.

One of our primary goals at Zaber has always been to hire people who will enjoy their work. Our hobbies and interests are reflected in the roles we play within the company, and many of us would be doing much the same work whether we were being paid to or not. People who work happy work better, and that is reflected in the quality of our products and customer service.

– Rob Steves, President

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Glossary

Accuracy (Unidirectional)

The maximum error possible when moving between any two positions, when both positions are approached from the same direction.

Backlash (Hysteresis)

The maximum difference in the actual position possible when a target position is approached from opposite directions.

Maximum Cantilever Load

The maximum torque that may be applied about the axis of motion.

Maximum Centred Load

The maximum allowable force that can be applied at the centre of the stage, perpendicular to the stage surface. In the case of a mirror mount, it is the maximum weight that can be mounted to the face plate of the mirror mount.

Maximum Speed

The maximum speed at which a motorized device can move under no load. Note that the speed is a function of load and the maximum speed can only be achieved at low loads.

Maximum Torque

The maximum recommended continuous operating torque of a rotary motion device. Note that this may be less than the maximum torque the device is capable of exerting. Exceeding this force will result in reduced lifetime.

Microstep Size (Default Resolution) (μm)

The calculated linear distance traveled for each microstep of motor movement at default settings. This distance is equal to the default microstep resolution (1/64 on most devices) multiplied by the distance traveled during one full step of the motor.

Microstep Size (Default Resolution) (°)

The calculated angular displacement for each microstep of motor movement at default settings. This displacement is equal to the default microstep resolution (1/64 on most devices) multiplied by the angular displacement traveled during one full step of the motor.

Minimum Speed

The minimum speed that a motorized device can be set to.

Motor Connection

The connector type provided on a motor or motorized device to interface with a motor controller.

Peak Thrust

The maximum force that a motorized device can exert in the direction of travel. Note that thrust is a function of speed and the maximum thrust is obtained at the lowest speeds.

Repeatability

The maximum deviation in actual position when repeatedly instructing a device to move to a target position 100 times, approaching from the same direction every time, under stable thermal conditions.

Stage Parallelism

The degree of parallelism of the stage top and the base of the stage. This is measured as the maximum deviation in height of the stage top, measured while the device is stationary.

Travel Range

The maximum physical range of travel of a motion control device.