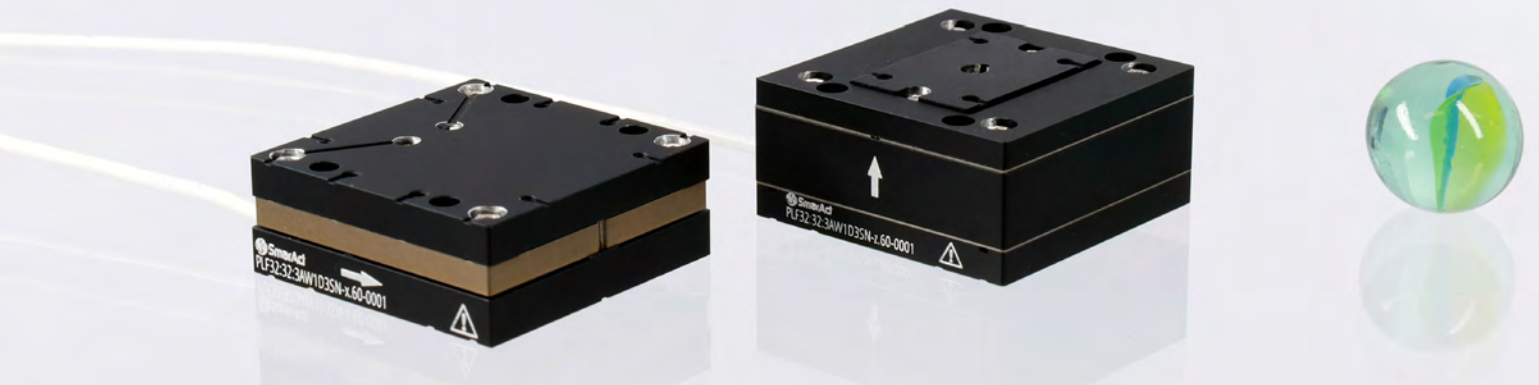




SMARFLEX®

Nanoprecision Flexure Stages

SMARFLEX® - NANOPRECISION FLEXURE STAGES



SMARFLEX nanopositioning scanner stages use the advantages of piezo-driven mechanical flexures to realize highly precise positioning tasks up to several 100 μm .

High Resolution

Integrated position sensing provides closed-loop positioning with sub-nm resolution.

Highly Dynamic

Because of the small mass to driving force ratio, a highly dynamic motion can be realized.

Friction-Free Motion

Because flexures are free of friction, no maintenance of wear parts is required. Furthermore, this leads to motion with very high repeatability.

Minimized Parasitic Motion

FEM-optimized flexures precisely guide the motion and reduce motion orthogonal to the intended direction.

Vibration-Free Motion

The motion principle is based on lever amplified piezo actuators enabling a continuous and vibration free motion.

Compact and Lightweight

Flexures allow for a very compact design and are often manufactured from a single piece of material. This reduces their weight and footprint.

Vacuum Compatibility

Because flexures are free of friction, no grease is required and only ultra-high vacuum compatible parts can be used.

Non-Magnetic Materials

Flexure stages are available in non-magnetic material versions.

Compatibility

Control unit and mechanical interfaces are compatible with SMARSLIDE® and SMARSHIFT® technologies allowing to combine all advantages from different driving technologies.

Customization

SMARFLEX positioners are customizable to a large degree. If required, further performance analysis of custom-made positioners can be carried out in the SMARFLEX laboratory.

Maximum Flexibility for Your Precision Applications - SMARFLEX by SmarAct

You have a vision – we provide the tailor-made technology! With **SMARFLEX**, we rely on high-precision flexure-based actuators that are completely backlash-free and extremely durable. These compliant mechanisms enable ultra-precise motion without friction or wear, making them perfect for demanding applications in micro- and nanopositioning.

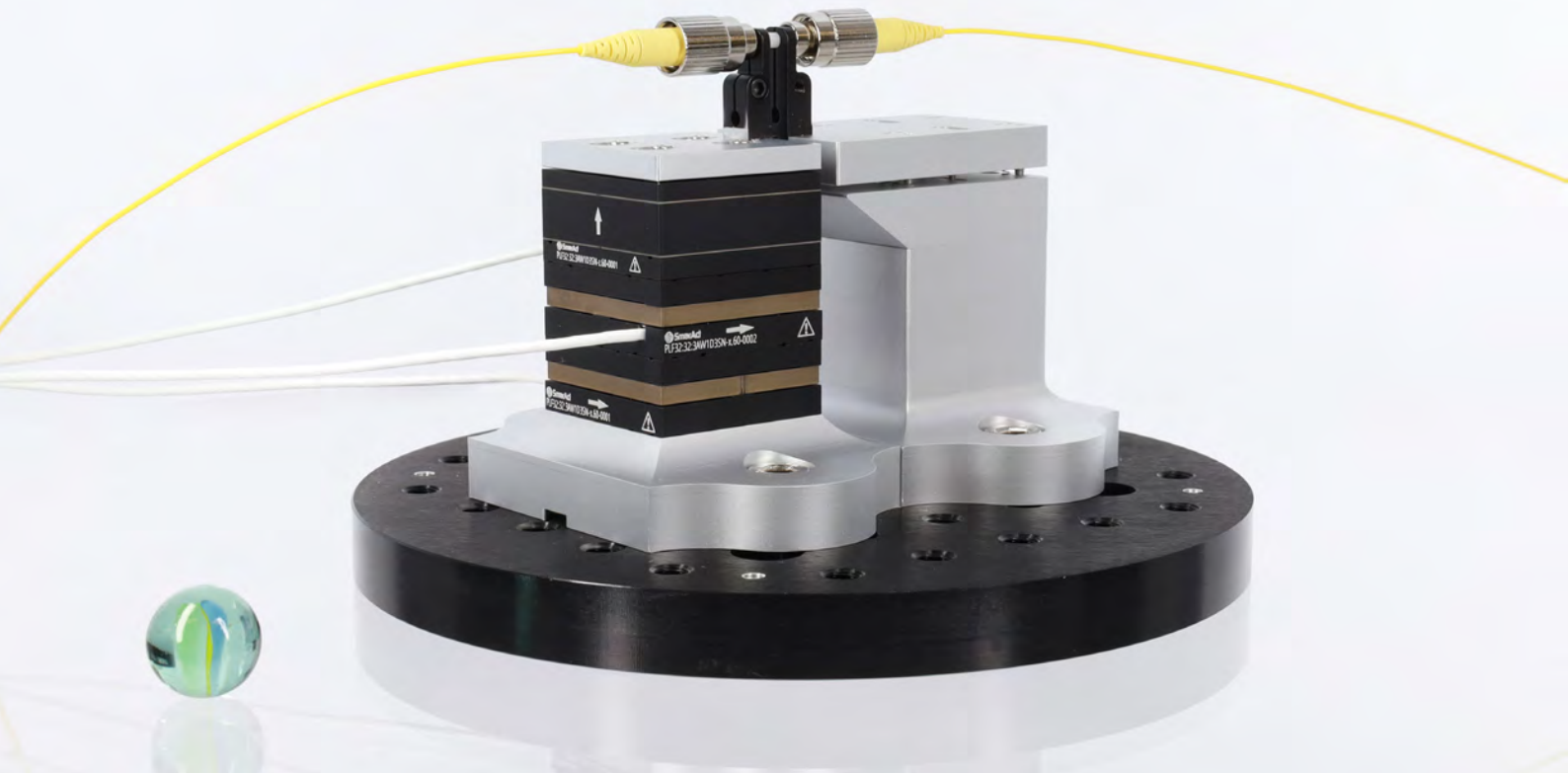
Thanks to our fully in-house development and production, we achieve short development cycles and can quickly deliver custom prototypes. This allows you to efficiently test, optimize, and seamlessly integrate your solutions into your processes. Whether in semiconductor manufacturing, photonics, or life sciences, **SMARFLEX** takes your applications to the next level.

Piezo Scanner Stages

		PLF3232-x.60	PLF3232-z.60	PLF5252-x.200
Mechanical	Scan Range [μm]	> 60		> 200
	Stiffness [$\text{N}/\mu\text{m}$]*	0.5	0.3	0.1
	Scan Tilt [μrad]**	± 3.5	± 50	± 5
	Max. Normal Force [N]	5.0		
	Weight [g]	30		90
	Dimensions [mm], (L x W x H)	32 x 32 x 12	32 x 32 x 15	52 x 52 x 15
Material	Base Material	Titanium(-Ti) / Aluminum base (-Al)		
Open-Loop	Open-Loop Resolution [nm]	MCS2: <1		
Closed-Loop	Sensor Resolution [nm]	MCS2: 1 (S)		
Vacuum Options		HV (10^{-6} mbar)		
Non-Magnetic Option		Yes (- NM)		
Piezo Capacitance [μF]*		1		5
Resonance Frequency [Hz]* 0g		950		300
Resonance Frequency [Hz]* 25g		500	450	220
Resonance Frequency [Hz]* 100g		290	240	150

* Tolerance $\pm 20\%$

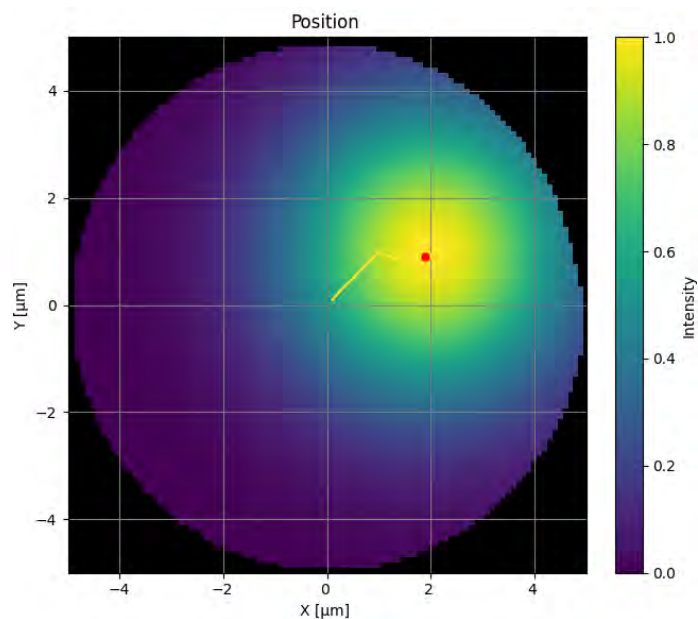
** Typical value. Equal for both rotational axes orthogonal to direction of motion. With respect to center position.



Application Example: Fiber-Coupler


In this application example, we demonstrate how a stack of three piezo-driven flexure stages from the **SMARFLEX PLF** product series optimizes the coupling of light between two optical single-mode fibers. For a significant coupling, the fiber modes must overlap well within their mode-field diameters, which is only about a few micrometers in size. By coupling laser

light into the left fiber, while measuring the output of the right fiber using a photodiode, the transmission is recorded. After an initial first-light search using the waveform generator firmware feature, a dedicated alignment firmware feature quickly aligns the fibers using a gradient search algorithm.



Scanner Stage Control Systems

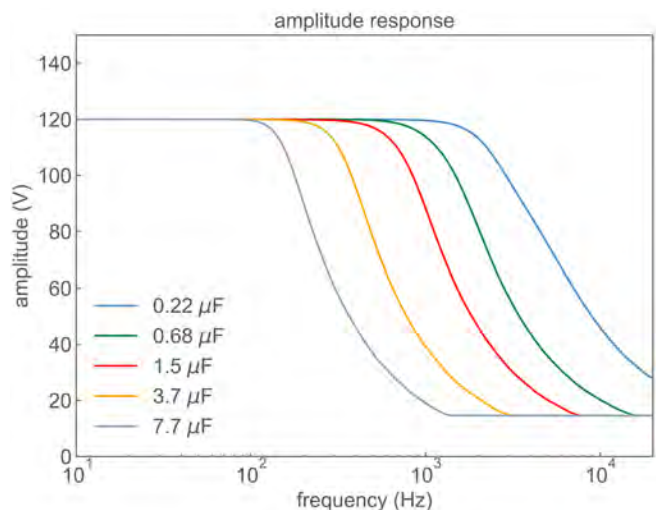
MCS2 Control System

SMARFLEX nanopositioning scanner stages are driven by systems that are specifically designed to meet their challenging control demands. These systems offer an exceptional performance regarding positional resolution and noise as well as an optimized control-loop scheme to allow fast and precise closed-loop motion. Naturally, the control systems are seamlessly integrated into the well-known MCS2 concept. Scanner stage control systems are marked by the scanner driver technology icon  on their housing.

The control systems are available in rack and tabletop housing. In its basic configuration, the scanner stage controller consists of a 3-channel main controller module and an USB or Ethernet communication interface. Other configurations also feature analog and digital I/O modules. Single systems with up to 18 channels can be built using the rack controller variant. Building a mixed system with stick-slip and scanner stage channels is possible as well.

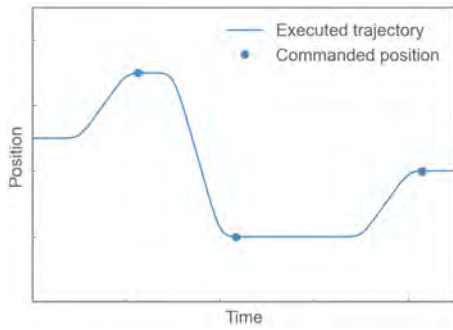


Specifications		
General	Channels	3 to 18
	Move Modes	Open-Loop / Closed-Loop
	Interfaces	USB / Ethernet / EtherCAT®
	I/O	Analog / Digital
Amplifier	Resolution	20 bit
	Output Voltage	-20 to 100 V
	Max. Output Current	250 mA



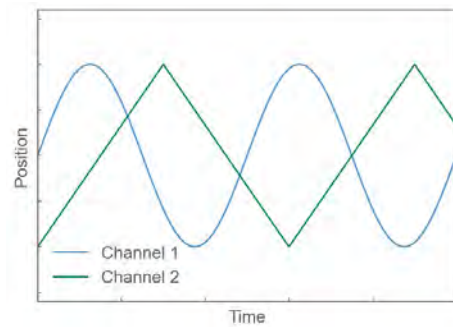
Motion Control Options

SMARFLEX scanner stage control systems offer a variety of ways to command a movement. Point-to-point movements in open-loop and closed-loop operation as well as closed-loop trajectory streaming are already well known from other SmarAct control systems. In addition, scanner stage control systems offer the possibility to define multi-channel closed-loop or open-loop movements using an arbitrary waveform generator.



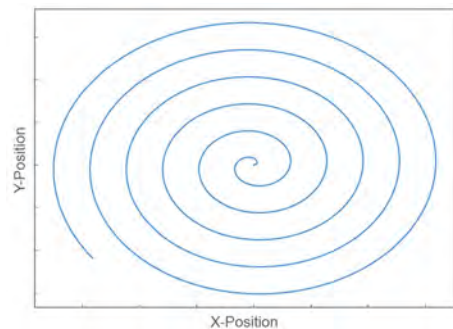
Point-to-Point Movement

Point-to-point movements in open-loop and closed-loop operation are the simplest control option available. Commanding a point-to-point movement requires nothing more than defining target position, velocity and acceleration prior to executing the movement.

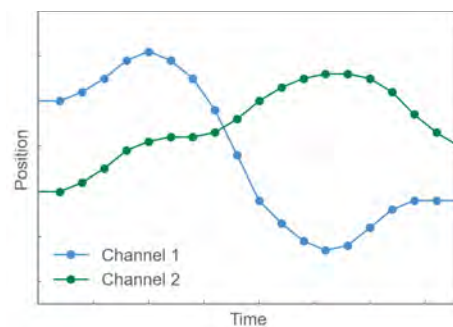


Arbitrary Waveform Generator

An arbitrary waveform can be generated, requiring just a few configuration parameters. The arbitrary waveform generator supports functions such as sine, sawtooth, step and many others. The generator uses the full potential of the **SMARFLEX** nano positioning scanner stages by enabling very fast and precise movements.



Due to the cross-channel synchronization and the possibility of modulating amplitude and frequency, there are many possible use cases. For example, the two channels of an X/Y stage can be configured to perform a fast spiral scan with a constant linear velocity (CLV) within a plane. Of course, raster scan patterns such as line or snake scan are also available.



Trajectory Streaming

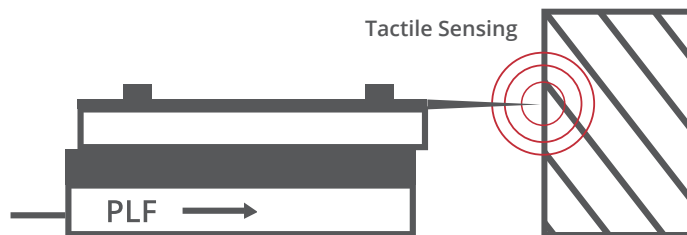
Closed-loop trajectory streaming can be used to move several channels in sync along a user definable trajectory. The trajectory is provided by a host system and streamed to the control system with a stream rate of up to 1kHz.

Features and Firmware Modules

High-Sensitivity Tactile Sensing - No Additional Sensors Needed

Unlock new possibilities with our tactile sensing component! Transform scanner piezo positioners with integrated sensors into ultra-sensitive tactile sensors - without extra hardware.

The component generates a trigger signal when a mechanical blockage is detected while performing a closed-loop movement or when an external device „touches“ the scanner stage. This trigger can then be used to start or stop a movement.

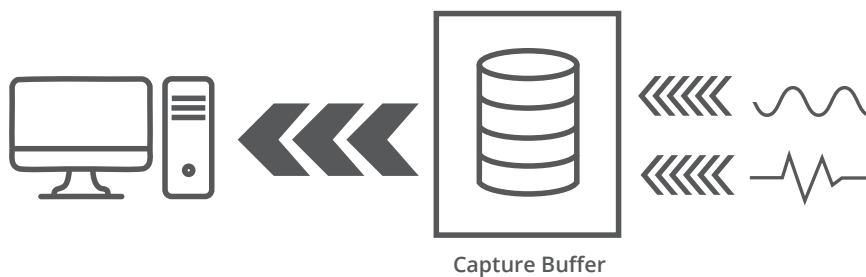


Experience precision sensing made simple - perfect for probing and automated positioning.

High-Speed Capture Buffer

The optional capture buffer firmware module allows controller data to be captured at a configurable capture rate. It can be used when reading data via regular property polling is not fast enough. The capture rate goes up to the internal position

update rate of 50 kHz. The data to be captured is configurable. The current- and target positions of any channel are available plus auxiliary analogue input values of an I/O module.

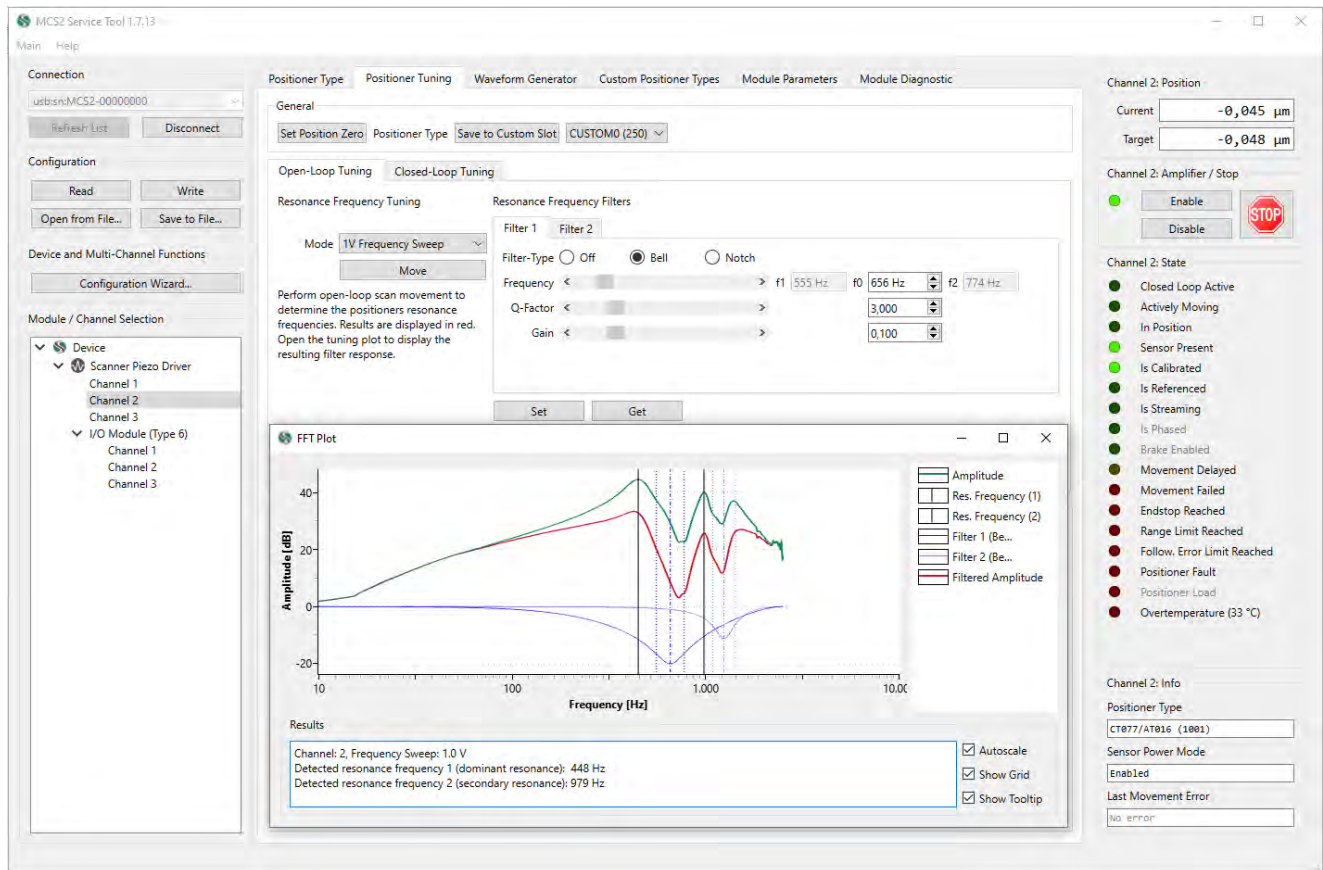


A reliable solution for precise motion analysis, tracking and system monitoring.

System Setup and Tuning with MCS2 Service Tool

The MCS2 Service Tool provides all essential functions for setup, tuning, test and diagnostic in a single application. The tool is available for Windows and Linux operating systems. All the necessary configuration steps can be carried out with this tool. Tuning functions with graphical assistance allow

the user to perfectly adapt the control-loop to the respective application. Test functions for closed-loop and open-loop point-to-point movements and waveform generator movements are available. Diagnostic functions for sensors and actuators complete the range of functions.



SmarAct Positioner ID System

The Scanner Piezo Driver supports the SmarAct Positioner ID System for seamless integration of connected stages. Each scanner stage is equipped with an ID chip that stores identification and configuration data, allowing for automatic detection and setup -simplifying system configuration and reducing setup time.

Sensor Power Save Mode

This firmware feature is especially beneficial for stages with incremental sensors used in vacuum environments. When the stage is idle, the mode adjusts the duty cycle of the position sensor's LED, significantly reducing heat dissipation and minimizing the overall thermal load on the stage and positioning system.

Analog Low-Noise Piezo Actuator Driver

The **SMARFLEX** Analog Low-Noise Piezo Actuator Driver is a compact, single-board module designed for driving piezoelectric stack actuators. It amplifies an analog input signal with a fixed gain while delivering strong current drive, enabling it to handle substantial loads even at high frequencies. At the same time, its low output noise makes it ideal for demanding applications.

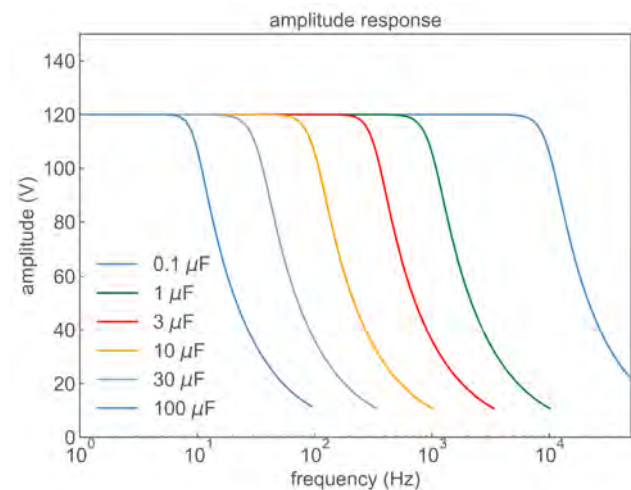
Heat generated during operation is efficiently dissipated via the integrated heat sink. For enhanced thermal management, the module can also be mounted to a larger heatsink. Naturally, it includes multiple protection features to safeguard both the module and the connected actuator from potential damage. A fully enclosed version will be available soon.

Specifications	
Channels	1
Analog Input	-2 V to 10 V
Gain	10 V/V
Driver Output	-20 V to 100 V
Output Current	450 mA *
Output Noise	< 30 μ V _{RMS} **
Power Supply	12 V / 24 V
Power Dissipation	20 W (45 W ***)
Protection Features	Overcurrent, Overtemperature, Short-Circuit
Dimensions	90 x 110 mm (with Heatsink)

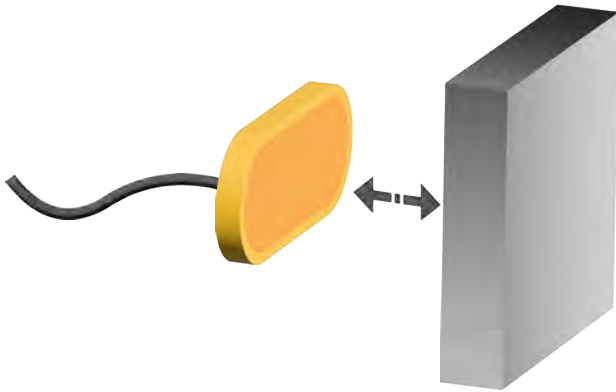
* Options with a lower current limit are available for protection of the attached piezo actuator

** Measured with a 1 μ F load with 20 MHz bandwidth

*** Requires additional cooling



NEW: SmarAct Capacitive Sensing Technology



Our capacitive sensing technology achieves an outstanding accuracy of better than 1 nm, ensuring ultra-stable and highly repeatable position measurements. Even the smallest displacements are captured with absolute reliability.

Optimized for travel ranges below 100 μm , our sensors provide the ideal solution for applications demanding the highest precision in confined spaces. With no heat dissipation and non-magnetic materials, they are perfectly suited for environments where thermal influences and magnetic interference must be eliminated.

Each positioner including a capacitive sensor undergoes in-house calibration, ensuring absolute accuracy right from the start - no additional referencing needed. Combined with their excellent linearity, the SmarAct capacitive sensors seamlessly integrate with our high-performance motion systems to elevate your measurement capabilities.

Example: Integration of Capacitive Sensors into a 12 μm x 12 μm Scanner

Specifications	
Scan Range [μm]	> 12 μm
Max Normal Force [N]	5
Dimension [mm]	60 x 60 x 28,5
Weight [g]	150
Resonance frequency X/Y [Hz]	2100
Material	Aluminium
Open-loop Resolution MCS 2 [nm]	< 1
Closed-loop Resolution MCS 2 [nm]	< 1 (C)
Vacuum Option	UHV, HV
Non-Magnetic	Yes (-NM)

For applications requiring the highest positioning performance, our parallel-kinematic XY scanner with a 12 μm x 12 μm travel range and direct piezo drive offers unmatched precision and dynamic response. Perfectly suited for precision microscopy and lens alignment, this system benefits from our capacitive sensing technology, ensuring nanometer stability and real-time accuracy.

This innovation perfectly complements our portfolio, reinforcing SmarAct's commitment to precision engineering and enabling our customers to push the boundaries of what's possible.



With the development and production of market-leading solutions in the field of high-precision positioning, automation and metrology, the SmarAct Group reliably accompanies their customers in achieving their goals. The broad product portfolio – from single positioning stages to complex parallel kinematics, miniaturized robots, control systems and measurement technology – is complemented by automated microassembly solutions. Even the most challenging customer requirements can be met by maximum adaptability and complete in-house production.

Since its founding in 2005, SmarAct has steadily grown from a small team of engineers to a group of companies with three independent business units and over 270 highly skilled members. Today, SmarAct relies on years of experience and, above all, on a very passionate team with unconditional customer focus.

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