



# User Manual

V-412.XX6211EO HIGH-LOAD LINEAR STAGE

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# 1 Legal Information



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## 2 Introduction

### 2.1 About this Document

#### 2.1.1 Objective and Target Group

This user manual contains the information needed for the intended use of the V-412.xx6211E0.

Basic knowledge of closed-loop systems, motion control concepts, and applicable safety measures is assumed.






#### 2.1.2 Explanation of Symbols

This chapter explains the symbols and markings used by PI in their user manuals.

##### Typographic Conventions

Symbol / label	Meaning
1. 2.	Action consisting of one or several steps with strict sequential order
►	Action consisting of one or more steps without relevant sequential order
■	Lists
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)

##### Symbols Used

Symbol / label	Meaning
	Warning of electrical voltage
	Hazard symbol for a hot surface
	Risk of crushing
	Entanglement hazard
	General hazard symbol



#### **DANGER**

##### **Dangerous situation**

Failure to comply could lead to death or serious injury.

► Precautionary measures for avoiding the risk.

**WARNING****Dangerous situation**

Failure to comply could lead to serious injury.

- Precautionary measures for avoiding the risk.

**CAUTION****Dangerous situation**

Failure to comply could lead to minor injury.

- Precautionary measures for avoiding the risk.

**NOTICE****Dangerous situation**

Failure to comply could lead to material damage.

- Precautionary measures for avoiding the risk.

**Information**

Additional information on the V-412.xx6211E0 that can affect your application.

**2.1.3 Figures**

For better understandability, the colors, proportions and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

**2.1.4 Downloading Manuals****Information**

If a manual is missing or problems occur with downloading:

- Contact our [customer service department \(p. 7\)](#).

**Downloading Manuals**

1. Open the website [www.pi.ws](http://www.pi.ws).
2. Search the website for the product number (e.g., V-412).
3. Click the corresponding product to open the product detail page.
4. Click the **Downloads** tab.  
→ *The manuals are shown under **Documentation**.*
5. Click the **ADD TO LIST** button for the desired manual and then click **REQUEST**.
6. Fill out the request form and click **SEND REQUEST**.  
→ *The download link will then be sent to the email address entered.*

**2.2 European Declarations of Conformity**

For the V-412.xx6211E0, declarations of conformity were issued according to the following European statutory requirements:

- Low Voltage Directive
- EMC Directive
- RoHS Directive

The standards applied for certifying conformity are listed below.

- Safety (Low Voltage Directive): EN 61010-1
- EMC: EN 61326-1
- RoHS: EN IEC 63000

## 2.3 Customer Service Department

For enquiries and orders, contact your PI miCos representative or send us an [email](#).

If you have any questions concerning your system, provide the following information:

- Product and serial numbers of all products in the system
- Firmware version of the controller (if applicable)
- Version of the driver or the software (if applicable)
- Operating system on the PC (if applicable)

If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

### Customer service address:

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Römerstraße 1  
76228 Karlsruhe  
Germany

[service@pi.de](mailto:service@pi.de)  
[www.pi.de](http://www.pi.de)

## 2.4 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

In order to fulfil the responsibility as the product manufacturer, PI miCos undertakes environmentally correct disposal of all PI miCos equipment free of charge, if it was made available to the market after August 13, 2005.

Any old PI miCos equipment can be sent free of charge to the following address:

PI miCos GmbH  
Freiburger Straße 30  
79427 Eschbach  
Germany

[info@pimicos.de](mailto:info@pimicos.de)  
[www.pi.de](http://www.pi.de)



## 3 Safety

### 3.1 Intended Use

The V-412.xx6211E0 is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil, lubricants, and liquids.

In accordance with its design, the V-412.xx6211E0 is intended for positioning, adjusting and shifting loads in one axis at various velocities. The V-412.xx6211E0 is **not** intended for applications in areas, in which a failure would present severe risks to human beings or the environment.

The V-412.xx6211E0 is intended for operation with a horizontally aligned motion axis.

The intended use of the V-412.xx6211E0 is only possible when completely mounted and connected. The thermal protection sensor built into the V-412.xx6211E0's motor must be evaluated and monitored. The V-412.xx6211E0 must be operated with suitable electronics. The electronics are not in the scope of delivery of the V-412.xx6211E0.

The V-412.xx6211E0 may not be used for purposes other than those stated in this user manual. The V-412.xx6211E0 may only be used in compliance with the technical specifications and instructions in this user manual.

### 3.2 General Safety Instructions

If the protective earth conductor is missing or not properly connected, risk of dangerous touch voltages on the V-412.xx6211E0 in the event of malfunction or failure of the system. If there are touch voltages, touching the V-412.xx6211E0 leads to serious injuries or death by electric shock.

- ▶ [Connect the V-412.xx6211E0 to a protective earth conductor before startup \(p. 17\).](#)
- ▶ Do not remove the protective earth conductor during operation.
- ▶ If the protective earth conductor has to be removed temporarily (e.g., for modification), reconnect the V-412.xx6211E0 to the protective earth conductor before restarting.

The V-412.xx6211E0 contains permanent magnets that could impair the function of heart pacemakers and electronic implants.

- ▶ Make sure that people with heart pacemakers and / or electronic implants do not have access to the V-412.xx6211E0.

The magnets in the V-412.xx6211E0 can damage parts susceptible to magnetic influences, e.g., magnetic data carriers and electronic devices.

- ▶ Make sure that there are no objects sensitive to magnets within a radius of at least 10 cm around the V-412.xx6211E0.

The magnets in the V-412.xx6211E0 can attract magnetizable parts, e.g., loose screws. Objects attracted can damage the V-412.xx6211E0.

- ▶ Make sure that there are no movable, magnetizable objects within a radius of at least 10 cm around the V-412.xx6211E0.

Mechanical forces can destroy the V-412.xx6211E0.

- ▶ Avoid knocks that affect the V-412.xx6211E0.
- ▶ Do not drop the V-412.xx6211E0.



The V-412.xx6211E0 is built according to state-of-the-art technology and recognized safety standards. Improper use of the V-412.xx6211E0 may result in personal injury and/or damage to the V-412.xx6211E0.

- ▶ Use the V-412.xx6211E0 only for its intended purpose and when it is in perfect condition.
- ▶ Read the user manual.
- ▶ Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for installing and operating the V-412.xx6211E0 correctly.

## 3.3 Organizational Measures

### 3.3.1 User Manual

- ▶ Always keep this user manual available with the V-412.xx6211E0. The latest versions of the user manuals can be [downloaded \(p. 6\)](#) at [www.pi.ws](http://www.pi.ws).
- ▶ Add all information from the manufacturer such as supplements or technical notes to the user manual.
- ▶ If you give the V-412.xx6211E0 to a third party, also include this user manual as well as other relevant information provided by the manufacturer.
- ▶ Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can lead to serious or fatal injuries and damage to equipment.
- ▶ Only install and operate the V-412.xx6211E0 after you have read and understood this user manual.

### 3.3.2 General Personnel Qualification

The V-412.xx6211E0 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

## 4 Product Description

### 4.1 Model Overview

High-load linear stage; ironless 3-phase linear motor; 52 to 610 mm travel range (see table); 400 N load capacity; 2000 mm/s maximum velocity; incremental linear encoder, 20 µm signal period, sin/cos, 1 V peak-peak

Product number	Travel range
V-412.036211E0	52 mm (2")
V-412.056211E0	102 mm (4")
V-412.096211E0	204 mm (8")
V-412.136211E0	305 mm (12")
V-412.176211E0	407 mm (16")
V-412.216211E0	508 mm (20")
V-412.256211E0	610 mm (24")

### 4.2 Product Labeling

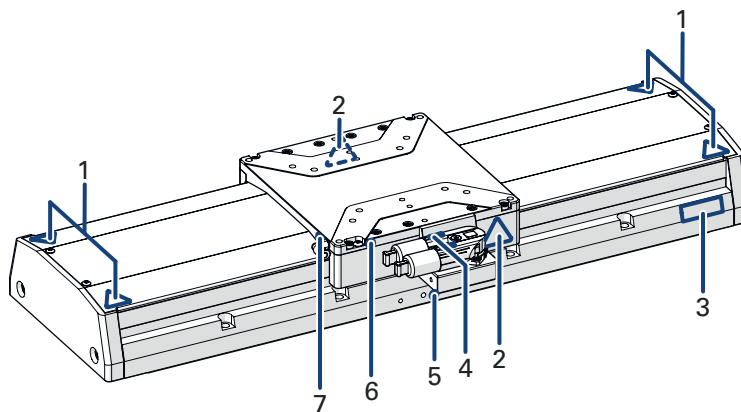


Figure 1: Product labeling on the V-412.xx6211E0

1. Warning symbol: Risk of crushing
2. Warning symbol: Hot surface
3. Type plate
4. Connector labeling
5. Protective earth connector
6. Functional earth
7. Purge air connection labeling

### 4.2.1 Type Plate

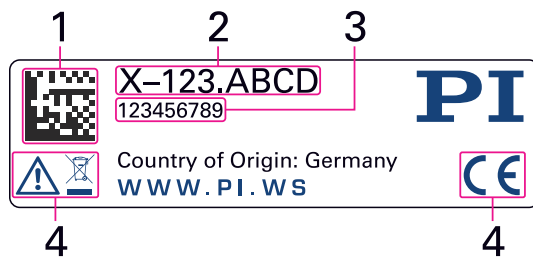


Figure 2: Type plate of the V-412.xx6211E0

1. Data matrix code (example; contains the serial number)
2. Product number (example)
3. Serial number (example), individual for each V-412.xx6211E0
4. Warning and conformity symbols ([old equipment disposal \(p. 7\)](#), [CE mark \(p. 6\)](#))

## 4.3 Overview

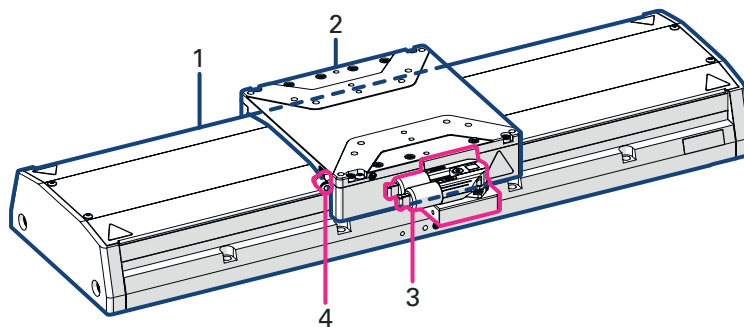


Figure 3: Elements of the V-412.xx6211E0

1. Base body with drive
2. Motion platform
3. Drive and linear encoder connector
4. Purge air connector

### 4.3.1 Base Body

The base body is the basis of the positioner. The V-412.xx6211E0 [is mounted onto a surface via the base body \(p. 16\)](#).

The base body comprises the following subassembly (subassemblies):

#### Reference switch

The [reference switch \(p. 34\)](#) is a sensor whose fixed position serves as the reference point for incremental sensor signals.

#### Limit switches

The [limit switches \(p. 34\)](#) are sensors at each end of the travel range that enable the electronics to abort motion in order to prevent the motion platform from colliding with the mechanical hard stop.

#### Incremental linear encoder

The V-412.xx6211E0's linear encoder is an incremental sensor: It measures the position of the motion platform relative to a known reference point. Linear encoders measure the actual

position directly. Therefore, drive errors such as nonlinearity, backlash or elastic deformation cannot influence position measuring.

### 4.3.2 Drive

The drive of the V-412.xx6211E0 is a 3-phase magnetic linear motor. The linear motor transfers the drive force to the motion platform directly and free of friction.

#### Motor

The motor generates the force required to move the fixed load.

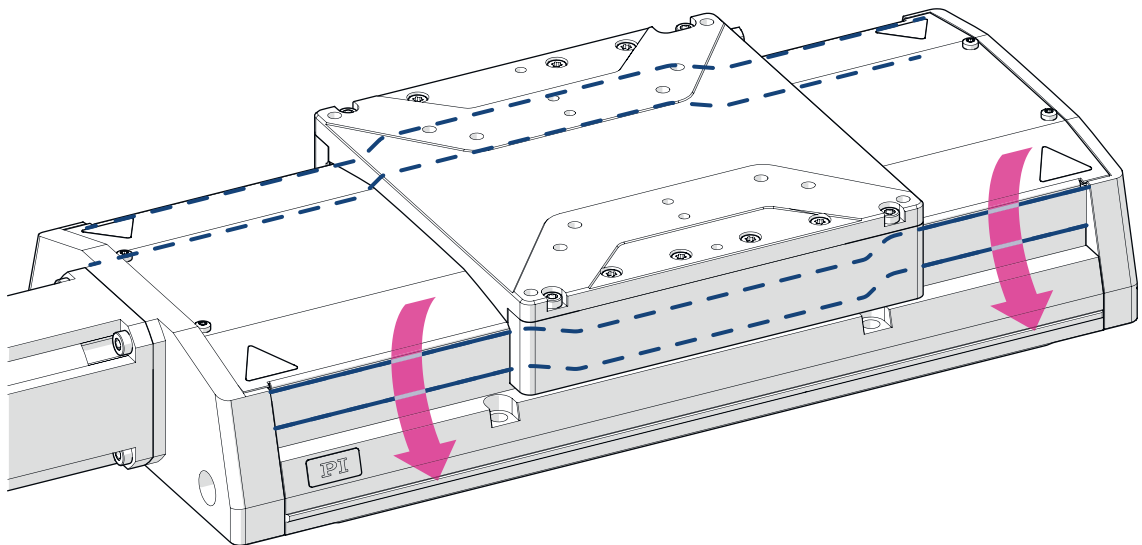
In the case of the V-412.xx6211E0, overheating is prevented using [temperature sensors \(p. 35\)](#).

### 4.3.3 Purge Air System

The purge air system protects the drive and guides of the V-412.xx6211E0 against surrounding dust.

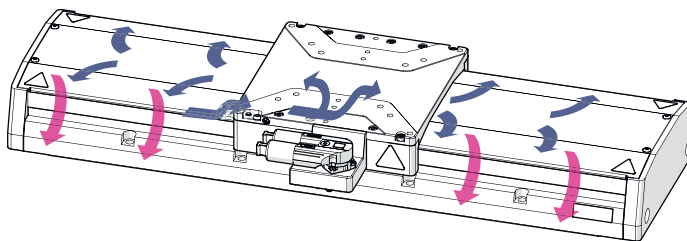
The purge air system comprises the following subassembly (subassemblies):

#### Passive dust protection



The passive dust protection consists of covering strips that seal the openings on the side of the V-412.xx6211E0's base body and therefore reduces the amount of dust that can penetrate.

#### Active dust protection



The active dust protection consists of a purge air connector on the base body of the V-412.xx6211E0, which creates a slight overpressure in the V-412.xx6211E0 and therefore reduces the amount of dust that can penetrate.

4.4 Direction of Motion

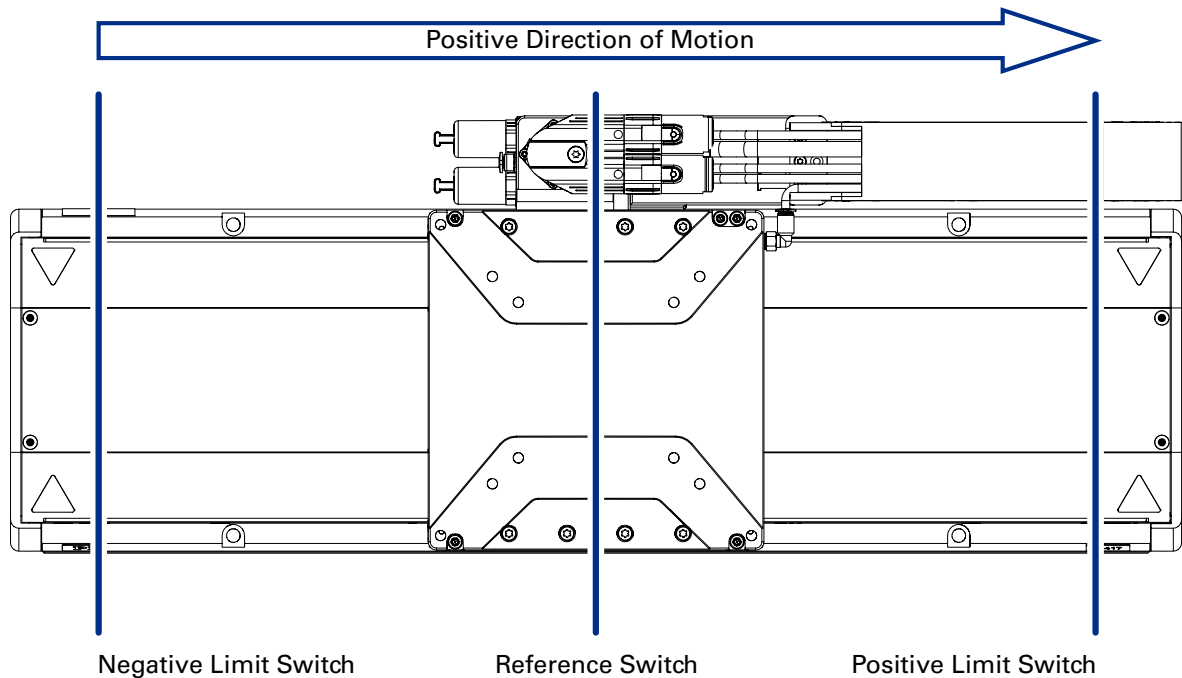


Figure 4: Schematic representation of the direction of motion, reference switch, and limit switches. The exact position of the reference switch and the limit switches may vary.

4.5 Scope of Delivery

Product number	Description
V-412.xx6211E0	Linear stage according to the <a href="#">order (p. 10)</a>
For V-412.xx6211E0 with xx = 03, 05, 09, 13: V412B0036	Mounting kit for fixing the V-412.xx6211E0, consisting of <ul style="list-style-type: none"><li>■ 10 socket head screws, ISO 4762 M6×30</li><li>■ 2 dowel pins, ISO 2338 4h8×12</li><li>■ 10 flat washers, ISO 7092, D11 d6.4 h1, 6 mm</li></ul>
For V-412.xx6211E0 with xx = 17, 21, 25: V412B0037	Mounting kit for fixing the V-412.xx6211E0, consisting of <ul style="list-style-type: none"><li>■ 16 socket head screws, ISO 4762 M6×30</li><li>■ 2 dowel pins, ISO 2338 4h8×12</li><li>■ 16 flat washers, ISO 7092, D11 d6.4 h1, 6 mm</li></ul>
MP188EK	Short instructions for high-load positioners with electric motors
Declaration of Incorporation of Partly Completed Machinery	Declaration of incorporation for the product according to the Machinery Directive (also <a href="#">included (p. 6)</a> in this user manual)

## 4.6 Suitable Electronics

The V-412.xx6211E0 must be connected to suitable electronics that supply the necessary voltage for operating and if required, to evaluate the sensor and limit switch signals. The following electronics are suitable:

Product number	Description
G-901.R519[x]	ACS controller with ACS driver module, 2 / 3 / 4 axes, intermediate circuit voltage 96 V / 2000 W
On request	ACS modular controller
	Also compatible with other 3rd-party controllers and servo drivers

Note that the cables required for connecting the V-412.xx6211E0 to the electronics must be ordered separately.

To order, contact our [customer service department \(p. 7\)](#).

## 5 Unpacking

The V-412 is delivered with the transport safeguard installed.



### CAUTION



#### Risk of crushing by moving parts!

Risk of minor injuries from crushing between the moving parts of the V-412.xx6211E0 or the load and a fixed part or obstacle.

- ▶ Transport the V-412.xx6211E0 only when the transport safeguard is attached.
- ▶ Bring the V-412.xx6211E0 to the intended place of use.
- ▶ Remove the transport safeguard afterwards.

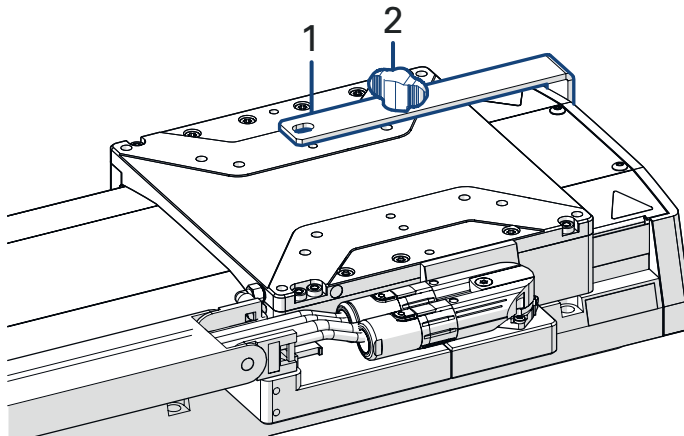


Figure 5: V-412.xx6211E0 with transport safeguard

1. Transport safeguard
2. Wing screw with M6x10 thread

### Unpacking the V-412.xx6211E0 and Transporting it to its Intended Place of Use

1. Unpack the V-412.xx6211E0 with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our [customer service department \(p. 7\)](#) immediately.
4. Transport the V-412.xx6211E0 to the intended place of use.
5. Remove the transport safeguard **after** transporting the V-412.xx6211E0 to its intended place of use:
  - a) Unscrew and remove the wing screw.
  - b) Remove the transport safeguard.
6. If the V-412.xx6211E0 was supplied with ESD protective caps on the connectors: Do **not** remove the ESD protective caps.
7. Keep the transport safeguard in case the V-412.xx6211E0 needs to be transported later. Keep all packaging materials in case the product needs to be returned.

## 6 Installation

### 6.1 Mounting the V-412.xx6211E0



#### CAUTION



#### Risk of crushing by moving parts!

Risk of minor injuries from crushing between the moving parts of the V-412.xx6211E0 or the load and a fixed part or obstacle.

- ▶ Use safeguards to protect limbs in areas where they could be caught by moving parts.
- ▶ Maintain the safety distances according to DIN EN ISO 13857 when installing protective structures.

#### NOTICE



#### Damage due to collisions!

Collisions can damage the V-412.xx6211E0, the load to be moved, and the surroundings.

- ▶ Make sure that collisions are not possible between the V-412.xx6211E0, the load to be moved, and the surroundings in the motion range of the V-412.xx6211E0.
- ▶ Do not place any cables or other objects in areas where they could be caught by moving parts.

#### NOTICE



#### Damage due to mechanical stress on the cable!

The cable will break from excessive bending or crushing. A broken cable will lead to failure of the V-412.xx6211E0 or damage to the V-412.xx6211E0 or the electronics.

- ▶ Install the V-412.xx6211E0 so that the cable cannot be bent or crushed too strongly.

#### 6.1.1 Mounting the V-412.xx6211E0 from Above

##### Overview

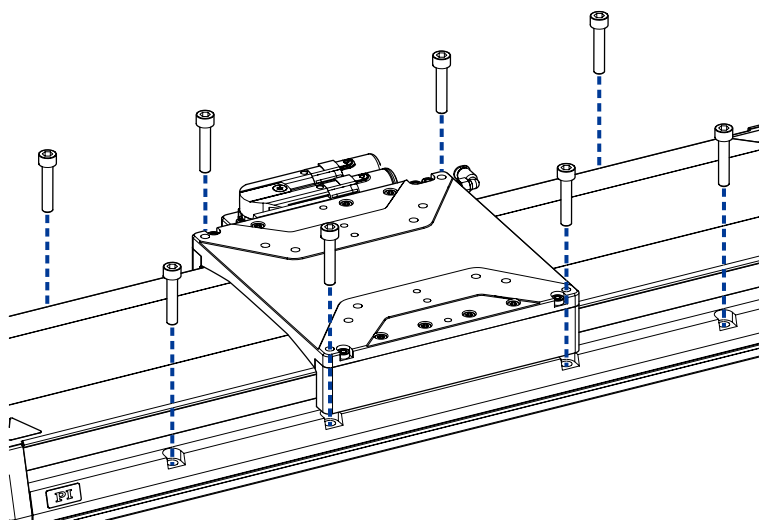


Figure 6: Mounting the V-412.xx6211E0 onto an underlying surface

##### Tools and Accessories

- [Mounting kit for mounting the V-412.xx6211E0 \(p. 13\)](#)



- Suitable torque wrench

#### Requirements

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have provided a suitable underlying surface with the holes necessary for the screws and if required, locating pins. For the position and depth required for the holes, see ["Dimensions" \(p. 37\)](#).
  - The surface flatness is  $\leq 2 \mu\text{m}$ .
  - For applications with large temperature fluctuations: The surface should have the same or similar thermal expansion properties as the V-412.xx6211E0.
- ✓ You have accounted for the space required to route cables according to regulations and without bending them.
  - The cable routing does **not** obstruct the motion of the V-412.xx6211E0.
  - The cable does **not** rub against sharp edges during movements of the V-412.xx6211E0.
- ✓ If necessary: You have [removed \(p. 15\)](#) the transport safeguard.

#### Mounting the V-412.xx6211E0 onto an Underlying Surface

1. If necessary: Insert the locating pins into the corresponding holes in the underlying surface.
2. Align the V-412.xx6211E0 on underlying surface so that the corresponding mounting holes in the V-412.xx6211E0 and underlying surface in line.
3. Put the V-412.xx6211E0 onto the underlying surface so that the locating pins can be inserted into the corresponding locating holes of the V-412.xx6211E0.
4. If necessary: Allow access to the mounting holes in the base body of the V-412.xx6211E0. Measure:
  - [Push the motion platform by hand \(p. 27\)](#)
5. If necessary, use a flat washer with each screw and insert the screws through the washer into the mounting hole.
6. Tighten the screws in all accessible mounting holes completely.  
Recommended torque: 3 Nm
7. If necessary: Repeat steps 4 to 6 for all concealed mounting holes.
8. Check that the V-412.xx6211E0 is fixed firmly to the underlying surface.

## 6.2 Connecting the V-412.xx6211E0 to the Protective Earth Conductor

The V-412.xx6211E0 must be connected to the protective earth conductor via the drive connector. For this purpose, the protective earth connector of the motor plug on the drive electronics side must be connected to an earth connection.

In addition, the protective earth connector on the V-412.xx6211E0's base body must be connected to a protective conductor point in the surroundings.

The following description offers an example of how to connect the protective earth conductor to the base body of the V-412.xx6211E0.

**DANGER****Risk of electric shock if the protective earth conductor is not connected!**

If the protective earth conductor is missing or not properly connected, risk of dangerous touch voltages on the V-412.xx6211E0 in the event of malfunction or failure of the system. If there are touch voltages, touching the V-412.xx6211E0 leads to serious injuries or death by electric shock.

- ▶ Connect the V-412.xx6211E0 to a protective earth conductor before startup.
- ▶ Do not remove the protective earth conductor during operation.
- ▶ If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the V-412.xx6211E0 to the protective earth conductor before restarting.

**Information**

- ▶ Pay attention to the applicable standards for connecting the protective earth conductor.

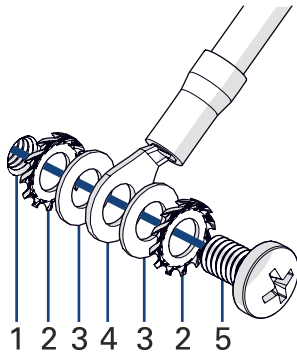
**Overview**

Figure 7: Protective earth connector on the V-412.xx6211E0

1. Protective earth connector on the V-412.xx6211E0 indicated by the protective earth symbol
2. Lock washer
3. Flat washer
4. Cable lug of the protective earth conductor
5. Screw, M4x8 ISO 7045

**Tools and Accessories**

- Suitable protective earth conductor:
  - Cable cross section  $\geq 0.75 \text{ mm}^2$
  - Contact resistance  $< 0.1 \text{ } \Omega$  at 25 A at all points relevant for attaching the protective earth conductor
- Suitable screwdriver
- Optional: Suitable aid (e.g., liquid adhesive) for securing the screw connection

**Requirements**

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).

**Connecting the V-412.xx6211E0's Base Body to the Protective Earth Conductor**

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Attach the cable lug of the protective earth conductor to the protective earth connector of the V-412.xx6211E0 as shown in the illustration.
3. Tighten the screw with a torque of 1.2 Nm to 1.5 Nm.

4. Make sure that the contact resistance is  $<0.1 \Omega$  at 25 A at all points relevant for attaching the protective earth conductor.
5. If there is any vibration in your application, secure the screw connection for the protective earth conductor in a suitable manner (e.g., with liquid adhesive) to prevent it from unscrewing by itself.

## 6.3 Building a Multi-Axis System

### NOTICE



#### Impermissibly high load on the positioners!

In a multi-axis system, the stage used for the upper axis must also be moved. Impermissibly high loads impair the motion and can damage the positioners.

- Pay attention to the [maximum permissible forces \(p. 32\)](#) that may act on the motion platform.
- In the case of multi-axis systems, include the masses of the positioners to be moved when calculating the load.

### 6.3.1 Building an XY Multi-Axis System

The V-412.xx6211E0 can be used in XY systems.

#### Tools and Accessories

- [Mounting kit for mounting the V-412.xx6211E0 \(p. 13\)](#)
- Suitable torque wrench

#### Requirements

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ The lower V-412.xx6211E0 is properly fixed [on an underlying surface \(p. 16\)](#).
- ✓ You have accounted for the space required to route cables according to regulations and without bending them.
- ✓ The positioners are not connected to the electronics.

#### Building an XY Multi-Axis System

1. Turn the upper positioner 90° and mount it onto the lower positioner.  
Proceed as described under [Mounting the Load \(p. 19\)](#).

## 6.4 Mounting the Load

### NOTICE



#### Impermissibly high load on the V-412.xx6211E0

An impermissibly high load on the V-412.xx6211E0 impairs the motion and can damage the V-412.xx6211E0.

- Pay attention to the [maximum permissible forces \(p. 32\)](#) that may act on the V-412.xx6211E0.
- In the case of multi-axis systems, include the masses of the positioners to be moved when calculating the load.

**NOTICE****Excessively long screws and locating pins**

Screws and locating pins that are inserted too deeply can damage the V-412.xx6211E0.

- ▶ Pay attention to the depth of the mounting and locating holes.
- ▶ Only use screws and locating pins of the correct length for the respective mounting holes.

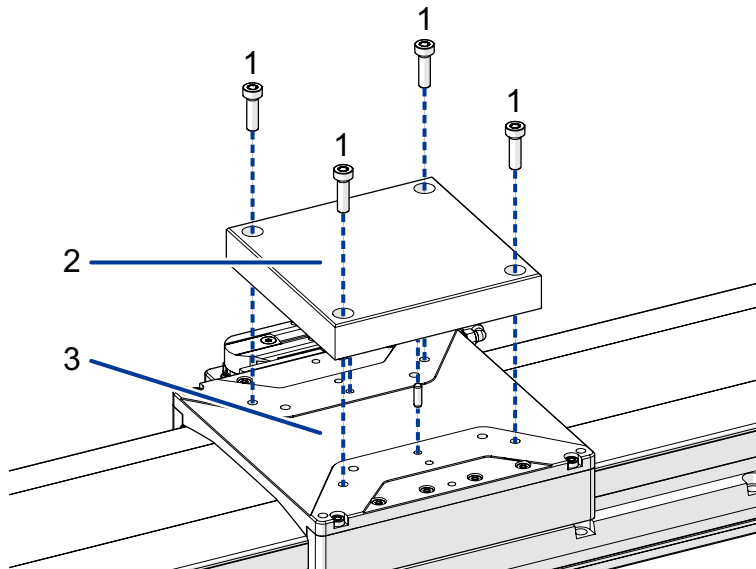
**Overview**

Figure 8: Mounting the load onto the V-412.xx6211E0

1. Screws
2. Load
3. Motion platform of the V-412.xx6211E0

**Tools and Accessories**

- At least 3 screws with suitable [dimensions \(p. 37\)](#)
- Suitable tool for tightening the screws
- Optional: 2 suitably dimensioned dowel pins as locating pins for aligning the load on the V-412.xx6211E0

**Requirements**

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have mounted the V-412.xx6211E0 [onto the surface \(p. 16\)](#) properly.
- ✓ The V-412.xx6211E0 is not connected to the electronics.
- ✓ You have prepared the load so that it can be fixed to the mounting holes in the motion platform:
  - The gap between the center of gravity of the load and the center of the motion platform is as small as possible in all directions.
  - At least three points are provided for fixing the load on the motion platform.

**Mounting the Load onto the V-412.xx6211E0**

1. If necessary: Insert the locating pins into the corresponding holes in the motion platform.
2. Align the load on the motion platform so that the mounting holes selected in the platform can be used to mount the load.

3. Place the load onto the motion platform so that the locating pins are inserted into the corresponding locating holes in the load.
4. Tighten the screws in all mounting holes.  
Respect the tightening torques for screws
5. Check that the load is sitting firmly on the motion platform.

## 6.5 Connecting the V-412.xx6211E0

### NOTICE



#### Damage due to incorrect connection of the V-412.xx6211E0!

Connecting unsuitable electronics or the wrong cable can lead to damage to the V-412.xx6211E0 or the electronics.

- ▶ Make sure that the electronics support the drive type of the V-412.xx6211E0 and have been configured accordingly.
- ▶ Use cables from PI miCos only to connect the V-412.xx6211E0 to the electronics.
- ▶ Pay attention to correct [pin assignment \(p. 39\)](#).

#### Tools and Accessories

- [Suitable electronics \(p. 14\)](#)
- Cable set suitable for the electronics used
- If necessary: Suitable screwdriver for the locking screws of the connectors.
- Optional: Purge air connector with the following properties:  
Pressure: 2 to 6 bar (200 to 600 kPa); purge air hose: outer diameter 4 mm; air quality as stated in the [specifications \(p. 32\)](#)

#### Requirements

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ If necessary: The V-412.xx6211E0's base body is connected to the [protective earth conductor \(p. 17\)](#).
- ✓ You have read and understood the user manual for the electronics.
- ✓ You have installed the electronics properly.
- ✓ The electronics are switched off.

#### Connecting the V-412.xx6211E0

1. If necessary: Remove the ESD protective caps from the connectors of the V-412.xx6211E0.
2. All of the V-412.xx6211E0's connections must be made in the following order:
  - a) Optional: Purge air connector  
Permissible pressure: 2 to 6 bar (200 to 600 kPa)
  - b) Drive connector
  - c) Linear encoder connector
3. Secure the connectors against unintentional removal.
4. If necessary: Turn the drive and encoder connector carefully to a position suitable for your installation conditions.  
The drive and encoder connector of the V-412.xx6211E0 can be turned up to 180° (in steps of approximately 7°).

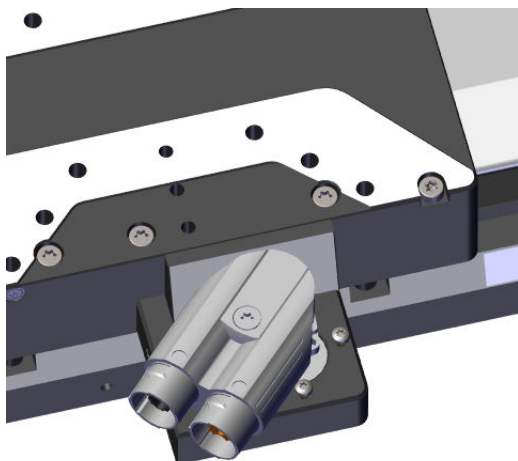


Figure 9: Rotating the V-412.xx6211E0's drive/sensor connectors

## 7 Startup and Operation

### 7.1 Determining the Operating Parameters

#### Temperature dependency of the nominal current:

It is necessary for the controller to monitor the nominal current to avoid damaging the V-412.xx6211E0. To guarantee this, it is necessary to adjust the nominal current to the ambient temperature at the place of application. See [Calculating the Nominal Current According to the Ambient Temperature \(p. 23\)](#).

#### 7.1.1 Calculating the Nominal Current According to the Ambient Temperature

The nominal current in the [data table \(p. 32\)](#) only applies when operating at room temperature. The nominal current needed for operating the V-412.xx6211E0 must be adjusted when the ambient temperature rises.

##### Calculating the Nominal Current

1. Calculate the nominal current according to the ambient temperature as follows:

$$I(T) = I(T_{\text{ref}}) \cdot \sqrt{\frac{T_{\text{max}} - T}{T_{\text{max}} - T_{\text{ref}}}}$$

##### Variables:

$I(T)$  = Nominal current, depending on the ambient temperature  $T$

$T$  = Ambient temperature

$I(T_{\text{ref}})$  = Nominal current, determined at reference temperature  $T_{\text{ref}}$ , refer to [Specifications \(p. 32\)](#)

$T_{\text{ref}}$  = Reference temperature (20 °C)

$T_{\text{max}}$  = Maximum temperature of positioner components (110 °C)

The nominal force  $F(T)$  at ambience temperature  $T$  is:

$$F(T) = F(T_{\text{ref}}) \cdot \left( \frac{I(T)}{I(T_{\text{ref}})} \right)$$

whereby  $F(T_{\text{ref}})$  is the nominal force determined at reference temperature  $T_{\text{ref}}$ , see [Specifications \(p. 32\)](#)

### 7.2 Starting and Operating the V-412.xx6211E0



#### **DANGER**



#### **Risk of electric shock if the protective earth conductor is not connected!**

If the protective earth conductor is missing or not properly connected, risk of dangerous touch voltages on the V-412.xx6211E0 in the event of malfunction or failure of the system. If there are touch voltages, touching the V-412.xx6211E0 leads to serious injuries or death by electric shock.

- ▶ Connect the V-412.xx6211E0 to a protective earth conductor before startup.
- ▶ Do not remove the protective earth conductor during operation.
- ▶ If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the V-412.xx6211E0 to the protective earth conductor before restarting.

**CAUTION****Risk of crushing by moving parts!**

Risk of minor injuries from crushing between the moving parts of the V-412.xx6211E0 or the load and a fixed part or obstacle.

- ▶ Use safeguards to protect limbs in areas where they could be caught by moving parts.
- ▶ Maintain the safety distances according to DIN EN ISO 13857 when installing protective structures.

**CAUTION****Risk of catching by moving parts!**

Risk of minor injury if hair, jewelry or clothing get caught by moving parts.

- ▶ Fit safeguards around all areas with moving parts.
- ▶ Never work with the unprotected V-412.xx6211E0 if you have long hair, loose jewelry or clothing.

**CAUTION****Burning due to hot surface!**

The drive of the V-412.xx6211E0 and the surroundings can heat up during operation. Touching the drive and surrounding parts can result in minor injuries from burning.

- ▶ Make sure that the hot drive and the surrounding parts cannot be touched.

**NOTICE****Operating voltage excessively high or incorrectly connected!**

Operating voltages that are too high or incorrectly connected can cause damage to the V-412.xx6211E0.

- ▶ Pay attention to the [operating voltage range \(p. 36\)](#), which is specified for the V-412.xx6211E0.
- ▶ Pay attention to correct [pin assignment \(p. 39\)](#).

**NOTICE****Unintentional change in position due to missing self-locking!**

The V-412.xx6211E0's drive does not have self-locking. For the models of the V-412 without holding brake, the following therefore applies:

The V-412.xx6211E0 can move unintentionally when the servo control is switched off, e.g., when deactivating the servo mode or switching the electronics off. Unintentional changes in position can damage the V-412.xx6211E0, the load to be moved, and the surroundings.

- ▶ If you want to operate the positioner with a vertically or obliquely aligned motion axis: Attach suitable gravity compensation (not included in the scope of delivery).
- ▶ Before switching off or rebooting the controller, take suitable precautionary measures to ensure that unintentional changes in the position of the motion platform are not possible.

**NOTICE****Damage due to collisions!**

Collisions can damage the V-412.xx6211E0, the load to be moved, and the surroundings.

- ▶ Stop the motion immediately if an electronics malfunction occurs.
- ▶ If possible, adapt the travel range limits of your mechanical system in the software that you use for commanding the motion.



**NOTICE****Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the V-412.xx6211E0. Oscillation is indicated by a humming noise and can be caused by the following:

- The load and/or dynamics during operation differ considerably from the calibration settings.
- ▶ If you notice oscillation, stop the V-412.xx6211E0 immediately.

**Requirements**

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have [installed \(p. 16\)](#) the V-412.xx6211E0 correctly.
- ✓ The V-412.xx6211E0 is connected to the [protective earth conductor \(p. 17\)](#).
- ✓ You have removed the [transport safeguard \(p. 15\)](#).
- ✓ You have read and understood the user manual for the electronics used.
- ✓ If a digital controller is used: You have read and understood the manual for the PC software used.
- ✓ The electronics and if required, the PC software, have been installed (see the user manual for the electronics).

**V-412.xx6211E0 Startup**

1. Start the electronics (refer to the user manual for the electronics).
2. Configure the electronics for the V-412.xx6211E0 during startup:
  - Configure the electronics using the parameters of the V-412.xx6211E0.
3. Start a few motion cycles for testing purposes (refer to the user manual for the electronics).

## 8 Maintenance

For the V-412.xx6211E0, run the maintenance measures specified below on a regular basis. No further maintenance measures are required. There is no need for relubrication as, upon delivery, the guides of the V-412.xx6211E0 are lubricated for life.

### NOTICE



#### Damage due to improper maintenance!

Improper maintenance can lead to misalignment and failure of the V-412.xx6211E0.

- ▶ Loosen screws only according to the instructions in this manual or the instructions of our [customer service department \(p. 7\)](#).

### 8.1 Maintenance Run

The maintenance run serves to distribute the existing lubricant.

The following intervals for the maintenance run depend on the operating conditions and the period of use:

- After 500 operating hours or at least after one 1 year
- If the V-412.xx6211E0 is moved over a small travel range (<20 % of the entire travel range) during industrial operation: After every 2000 motion cycles

#### Doing a Maintenance Run

1. Make sure that collisions between the V-412.xx6211E0, the load to be moved, and the surroundings are not possible over the entire travel range of the V-412.xx6211E0. If necessary, remove the load from the V-412.xx6211E0 for the maintenance run.
2. Do a maintenance run over the entire travel range:
  - a) Command the V-412.xx6211E0 to the end of a travel range and from there to the opposite end of the travel range (see manual for the electronics).
  - b) If necessary: Command the V-412.xx6211E0 to a position where the load can be mounted onto the V-412.xx6211E0 again, and [mount the load back onto the V-412.xx6211E0 \(p. 19\)](#).

### 8.2 Cleaning

### NOTICE



#### Damage due to unsuitable cleaning agents!

Some cleaning agents can cause rusting on the V-412.xx6211E0 or dissolve plastics, paints or adhesives.

- ▶ Do **not** clean with water or acetone.

#### Auxiliary Materials Required

- Soft, lint-free cloth
- Mild cleaning agent or disinfectant

If you have any questions on the auxiliary materials recommended for the V-412.xx6211E0, contact our [customer service department \(p. 7\)](#).

#### Requirements

- ✓ You have disconnected the V-412.xx6211E0 from the electronics.

**Cleaning the V-412.xx6211E0**

1. Dampen the cloth with the cleaning agent or disinfectant.
2. Carefully wipe the surfaces of the V-412.xx6211E0.

**8.3 Moving the Motion Platform by Hand**

It may be necessary to move the motion platform manually,

- to allow access to the mounting holes in the positioner's base body for the mounting screws,
- to move the motion platform away from the mechanical hard stop and make the V-412.xx6211E0 operational again.

**Requirements**

- ✓ You have disconnected the V-412.xx6211E0 from the electronics.

**Moving the Motion Platform by Hand**

1. Exert a steady force on the motion platform to move it.

## 9 Troubleshooting

The positioner does not move	
Cable not connected correctly	▶ Check the cable connections.
The electronics or mechanics were replaced	▶ Run the <a href="#">startup (p. 23)</a> once again.
Electronics not connected correctly	▶ <a href="#">Check all connecting cables (p. 21)</a> .
Defective electronics	▶ Check the electronics.
Excessive load	▶ Reduce the acceleration and velocity. ▶ Adapt the servo-control parameters, see the user manual for the electronics. ▶ Reduce the load, see <a href="#">"Specifications" (p. 32)</a> .
Motion platform has triggered the limit switch	▶ If you are using a controller from PI: Switch on the servo mode for the affected axis again in the PC software. ▶ Command the axis to move away from the limit switch.
The positioner was connected to the switched-on electronics	▶ Switch the electronics off and on again or restart them with the <b>RBT</b> command or with the corresponding PC software function.
Incorrect configuration	▶ Check the V-412.xx6211E0's parameter settings in the electronics connected and make the appropriate corrections.
Incorrect command or incorrect syntax	▶ Send the <b>ERR?</b> command in the PI electronics and check the error code .
Incorrect axis or channel commanded	▶ Make sure that the electronics use the correct axis respectively channel identifier.
Commanded axis is not referenced	▶ Do a reference move for the axis as described in the user manual for the controller.
Reduced positioning accuracy	
Warped base body	▶ <a href="#">Mount the V-412.xx6211E0 onto an even surface (p. 16)</a> .
Increased wear due to small motion over a long period of time	▶ <a href="#">Perform a maintenance run (p. 26)</a> .
Target position is approached too slowly or with overshoot	▶ Check whether the servo control parameter settings correspond to the selected closed-loop control mode; see user manual for the controller. ▶ If necessary, correct the settings of the servo control parameters.
The target position is not kept stable due to inappropriately set speed / acceleration	▶ Correct the corresponding servo control parameter settings (see the user manual for the controller).
Uncontrolled oscillation	
Large changes to the load or the alignment of the V-412.xx6211E0	▶ Switch off the servo control system or the controller immediately. ▶ Check whether the servo control parameter settings correspond to the selected closed-loop control mode; see user manual for the controller.

- ▶ If necessary, correct the settings of the servo control parameters.

If the problem is not listed in the table or cannot be solved as described, contact our [customer service department \(p. 7\)](#).

## 10 Transportation

Pay attention to the [ambient conditions and classifications \(p. 36\)](#) when transporting the V-412.xx6211E0.



### CAUTION



#### Quetschgefahr durch bewegte Teile!

Zwischen den bewegten Teilen des V-412.xx6211E0 oder der Last und einem feststehenden Teil oder Hindernis besteht die Gefahr von leichten Verletzungen durch Quetschung.

► Transportieren Sie den V-412.xx6211E0 nur mit angebrachter Transportsicherung.

### NOTICE



#### Mechanical overload due to transportation without safeguard

An impermissible mechanical load on the V-412.xx6211E0 due to transportation without a safeguard can damage the V-412.xx6211E0 and lead to loss of accuracy.

► Transport the V-412.xx6211E0 only with the transport safeguard attached.

► Ship the V-412.xx6211E0 only in the original packaging and with the transport safeguard attached.

### 10.1 Attaching the Transport Safeguard

#### Overview

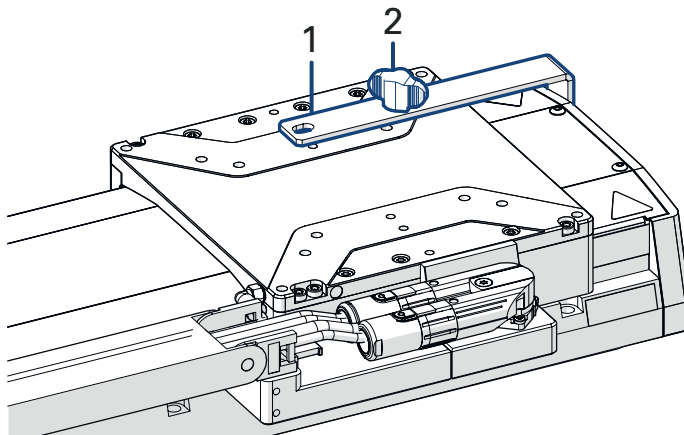


Figure 10: V-412.xx6211E0 with transport safeguard

1. Transport safeguard
2. Wing screw with M6x10 thread

#### Tools and Accessories

- [Transport safeguard with wing screw \(p. 15\)](#)

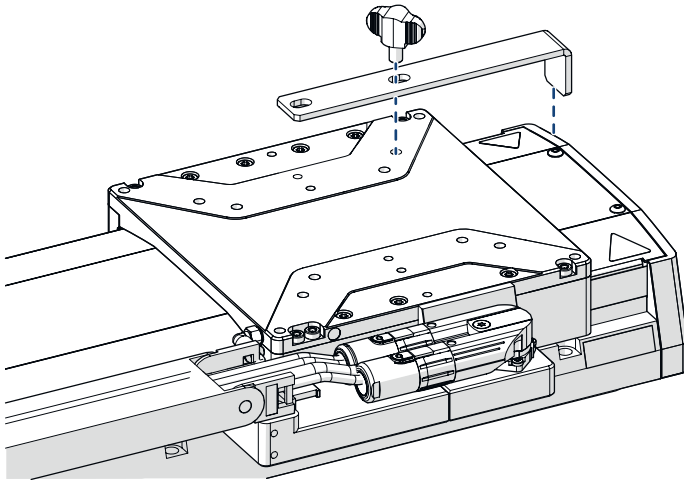
#### Requirements

- ✓ The V-412.xx6211E0 was [disconnected from the electronics \(p. 21\)](#).

#### Attaching the transport safeguard

1. Push the motion platform to [one end of the travel range \(p. 27\)](#).
2. Attach the transport safeguard to the V-412.xx6211E0 (as shown in the figure).

3. Align the transport safeguard so that one of its holes is over a mounting hole in the motion platform.
4. Use the wing screw to fasten the transport safeguard to the motion platform.



## 10.2 Packing the V-412.xx6211E0

1. Pack the V-412.xx6211E0 in the original packaging.
2. If the V-412.xx6211E0 is to be sent, use a stable outer box.

# 11 Technical Data

Subject to change. You can find the latest product specifications on the product web page at [www.pi.ws](http://www.pi.ws).

## 11.1 Specifications

### 11.1.1 Technical Data V-412

Motion	V-412.xx6211E0
Active axes	X
Travel range in X	xx = 03: 52 mm xx = 05: 102 mm xx = 09: 204 mm xx = 13: 305 mm xx = 17: 407 mm xx = 21: 508 mm xx = 25: 610 mm
Maximum velocity in X, unloaded	2000 mm/s
Straightness / Flatness	xx = 03 (52 mm travel range): $\pm 1.5 \mu\text{m}$ xx = 05 (102 mm travel range): $\pm 2.5 \mu\text{m}$ xx = 09 (204 mm travel range): $\pm 4 \mu\text{m}$ xx = 13 (305 mm travel range): $\pm 6 \mu\text{m}$ xx = 17 (407 mm travel range): $\pm 8 \mu\text{m}$ xx = 21 (508 mm travel range): $\pm 9 \mu\text{m}$ xx = 25 (610 mm travel range): $\pm 10 \mu\text{m}$
Pitch / Yaw	xx = 03 (52 mm travel range): $\pm 9 \mu\text{rad}$ xx = 05 (102 mm travel range): $\pm 14 \mu\text{rad}$ xx = 09 (204 mm travel range): $\pm 19 \mu\text{rad}$ xx = 13 (305 mm travel range): $\pm 29 \mu\text{rad}$ xx = 17 (407 mm travel range): $\pm 39 \mu\text{rad}$ xx = 21 (508 mm travel range): $\pm 48 \mu\text{rad}$ xx = 25 (610 mm travel range): $\pm 58 \mu\text{rad}$



Positioning	V-412.xx6211E0
Minimum incremental motion in X	0.01 $\mu\text{m}$
Positioning accuracy in X, uncalibrated	xx = 03 (52 mm travel range): $\pm 3 \mu\text{m}$ xx = 05 (102 mm travel range): $\pm 4 \mu\text{m}$ xx = 09 (204 mm travel range): $\pm 8 \mu\text{m}$ xx = 13 (305 mm travel range): $\pm 10 \mu\text{m}$ xx = 17 (407 mm travel range): $\pm 12 \mu\text{m}$ xx = 21 (508 mm travel range): $\pm 14 \mu\text{m}$ xx = 25 (610 mm travel range): $\pm 15 \mu\text{m}$
Bidirectional repeatability in X	1 $\mu\text{m}$
Integrated sensor	Absolute linear encoder
Sensor signal	EnDat 2.2
Drive properties	V-412.xx6211E0
Drive type	Ironless 3-phase linear motor
Nominal voltage	300 V
Nominal current, RMS	2.3 A
Peak current, RMS	7.55 A
Drive force in X	33 N
Peak force in X	151 N
Force constant	19.9 N/A
Motor constant	4 N/ $\sqrt{\text{W}}$
Time constant	0.19 ms
Resistance phase-phase	8.96 $\Omega$
Inductance phase-phase	1.4 mH
Back EMF phase-phase	8.1 V·s/m
Pole pitch N-N	30.5 mm

Mechanical properties	V-412.xx6211E0
Permissible push force in Y	200 N
Permissible push force in Z	400 N
Permissible torque in $\theta_x$	20 N·m
Permissible torque in $\theta_Y$	15 N·m
Permissible torque in $\theta_Z$	20 N·m
Moved mass in X, unloaded	1700 g
Guide	Recirculating ball bearing guide
Overall mass	xx = 03 (52 mm travel range): 5 kg xx = 05 (102 mm travel range): 5.6 kg xx = 09 (204 mm travel range): 6.7 kg xx = 13 (305 mm travel range): 7.9 kg xx = 17 (407 mm travel range): 9 kg xx = 21 (508 mm travel range): 10.2 kg xx = 25 (610 mm travel range): 11.3 kg
Material	Aluminum, black anodized; stainless steel
Miscellaneous	V-412.xx6211E0
Operating temperature range	5 to 40 °C
Connector	M15 9-pin (m)
Sensor connector	M15 15-pin (m)
Recommended controllers / drivers	G-901.R519, ACS modular controller

### 11.1.2 Reference Switch Specifications

Type	Optical sensor, encoder index
Supply voltage	+5 V
Signal output	0 V / +5 V (TTL level)
Signal logic	Index in middle of the travel range, differential pulse via one sensor signal period.

### 11.1.3 Limit Switch Specifications

Type	Hall sensor
Supply voltage	+5 V
Signal output	0 V / +5 V (TTL level)
Signal logic	N/C contact, NPN

### 11.1.4 Temperature Sensor Specifications

#### NTC Temperature Sensor

The V-412.xx6211E0 is equipped with an NTC temperature sensor for monitoring the coil temperature. The electrical resistance of the NTC temperature sensor decreases considerably as temperature increases. The controller must cut the power supply to the motor (switching threshold: 295  $\Omega$ ) when the critical temperature (130  $^{\circ}\text{C}$ ) is reached.

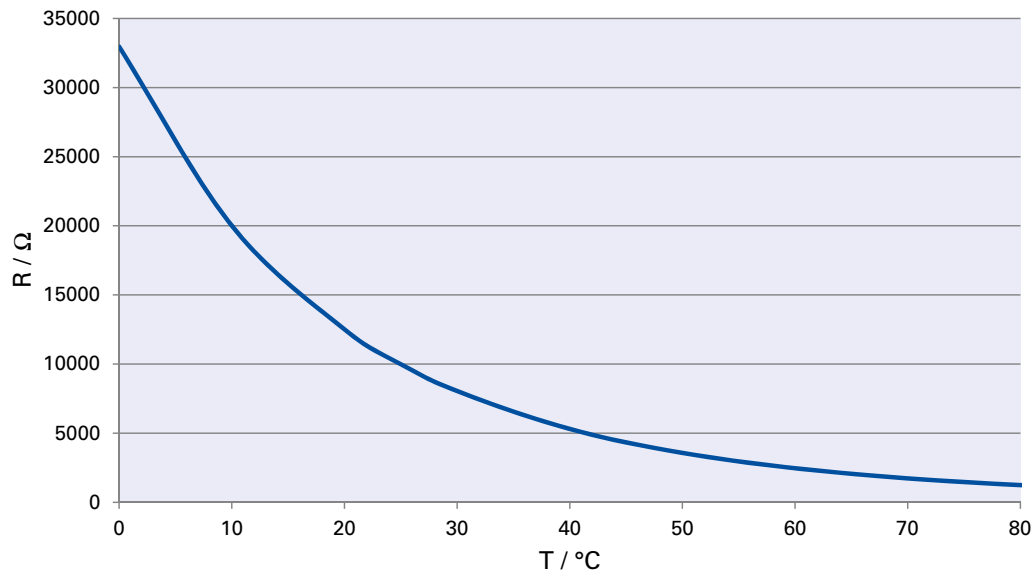


Figure 11: NTC temperature sensor of the V-412.xx6211E0, electrical resistance over temperature, 0 $^{\circ}\text{C}$  to 80 $^{\circ}\text{C}$

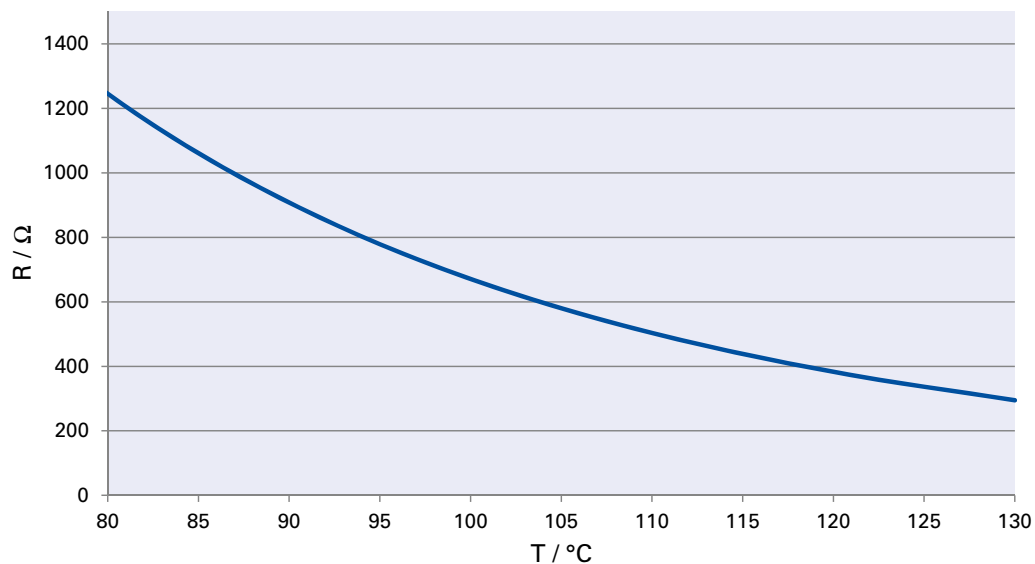



Figure 12: NTC temperature sensor of the V-412.xx6211E0, electrical resistance over temperature, 80 $^{\circ}\text{C}$  to 130 $^{\circ}\text{C}$

Temperature (°C)	Electrical resistance ( $\Omega$ )
0	32957
10	20000
20	12511
25	10000
30	8045
40	5304
50	3578
60	2470
70	1739
80	1246
90	908
100	671
110	504
120	383
130 (critical temperature)	295 (switching threshold)

## 11.2 Maximum Ratings

The V-412.xx6211E0 is designed for the following operating data:

Maximum operating voltage	Maximum operating frequency	Maximum peak current, RMS
		
300 V	–	10.6 A

## 11.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the V-412.xx6211E0 must be observed:

Area of application	For indoor use only
Maximum altitude	2000 msl
Relative humidity	Max. 80 %, not condensing
Storage temperature	-20 °C to 60 °C
Transport temperature	-20 °C to 60 °C
Overvoltage category	II
Supply voltage fluctuations	Max. $\pm 10$ % of the nominal voltage
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP30

## 11.4 Dimensions

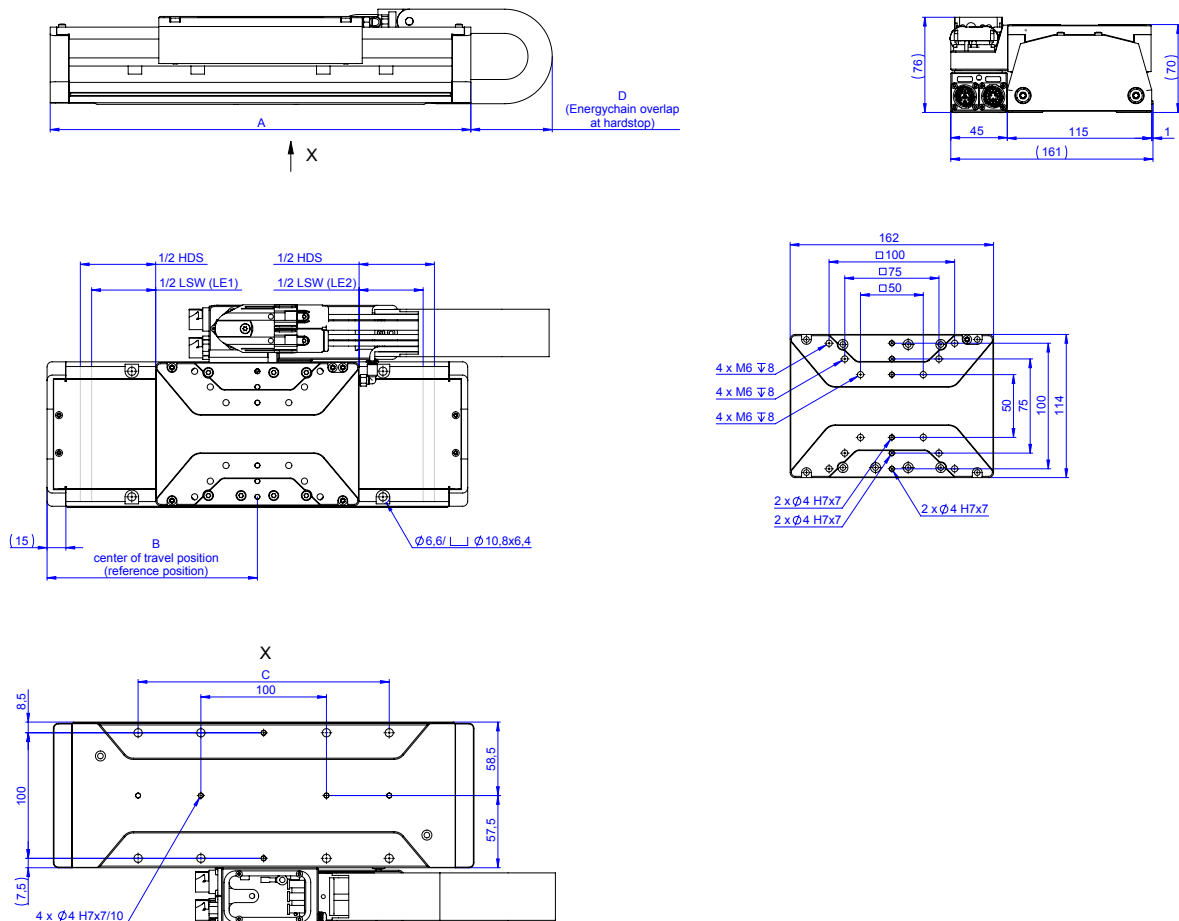


Figure 13: Dimensions of the V-412.xx6211E0

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

BASIS MODELL	TRAVEL NOMINAL	LIMITSWITCH to LIMITSWITCH LSW		HARDSTOP to HARDSTOP HDS	A	B	C	D
		V-412.xxx2xxEx	V-412.xxx0xxEx					
<b>V-412.03</b> xxxx	52 (2")	52 - 55	-	78	285	142,5	100	93
<b>V-412.05</b> xxxx	102 (4")	102 - 105	-	110	329	164,5	100, 200	93
<b>V-412.09</b> xxxx	204 (8")	204 - 207	-	214	433	216,5	100, 200, 300	97
<b>V-412.13</b> xxxx	305 (12")	305 - 308	-	315	534	267	100, 200, 300, 400	92
<b>V-412.17</b> xxxx	407 (16")	407 - 410	-	419	638	319	100, 200, 300, 400, 500	95
<b>V-412.21</b> xxxx	508 (20")	508 - 511	-	519	738	369	100, 200, 300, 400, 500, 600	91
<b>V-412.25</b> xxxx	610 (24")	610 - 613	-	621	840	420	100, 200, 300, 400, 500, 600, 700	95

# 12 Appendix

## 12.1 Pin Assignment

### 12.1.1 Drive Connector

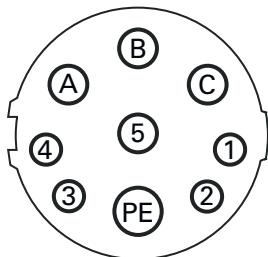


Figure 14: M15 9 (m)

Pin	Function
A	Phase 1
B	Phase 2
C	Phase 3
PE	Protective earth
1	Output: Temperature sensor (NTC) (+)
2	Output: Temperature sensor (NTC) (-)
3	Not connected
4	Not connected
5	Outer shielding

12.1.2 Sensor Connector

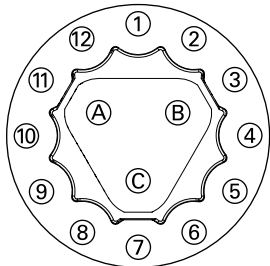


Figure 15: M15 15 (m)

Pin	Function
1	Output: Encoder signal sine (+)
2	Output: Encoder signal sine (-)
3	Output: Encoder signal cosine (+)
4	Output: Encoder signal cosine (-)
5	Output: Reference switch (+)
6	Output: Reference switch (-)
7	Service: Calibration
8	Negative limit switch
9	Positive limit switch
10	Input: Power supply
11	Ground
12	Not connected
A	Not connected
B	Not connected
C	Outer shielding



## Glossary

### **Lateral Force**

Also: Lateral load capacity

Maximum permissible force orthogonally to the positioning direction. This value is directly valid for the motion platform or the slider with mounting rails at the product. The value is reduced when the force acts above the platform/slider.

### **Limit Switch**

Each limit switch sends its signal to the controller on a dedicated line. The controller then interrupts the motion avoiding that the positioner moves until the hard stop and gets damaged. PI positioners have mechanical, noncontact optical or Hall effect limit switches.

### **Linear Encoder**

The linear encoder is an incremental sensor for detecting changes in position. Signals from the sensor are used for axis position feedback. After the controller is switched on, referencing must be done before absolute target positions can be commanded and reached.

### **Load Capacity**

Maximum load in the vertical direction when the V-412.xx6211E0 is mounted horizontally. The contact point of the load is at the center of the motion platform.

### **Reference Switch**

Many of the positioners are equipped with a direction sensing reference switch positioned approx. in the middle of the travel range. It is recommended to approach the reference switch always from the same direction to obtain best position repeatability.

Function: Optical, magnetic

### **Sensor Resolution**

The sensor can be the critical element of position resolution so it may be necessary to specify the sensor resolution separately. Rotary encoder: Impulses per screw rotation. Linear encoder: Smallest motion still detected by the sensor system.

### **Specifications**

The performance specifications are checked before dispatch. The performance specifications apply to room temperature ( $22 \pm 3$  °C), systems in closed-loop operation are calibrated at this temperature. It may be necessary to reset the operating parameters when operating at considerably lower or higher temperatures.