

## MP160E V-551 Linear Stage User Manual

Version: 1.1.3

Date: 12.06.2020



### This document describes the following products:

- **V-551.2D**  
Precision linear stage, 160 mm width, 60 mm travel range, 150 N load capacity, PIOne linear encoder with sin/cos signal transmission, 2  $\mu\text{m}$  sensor signal period, ironless 3-phase linear motor
- **V-551.4D**  
Precision linear stage, 160 mm width, 130 mm travel range, 150 N load capacity, PIOne linear encoder with sin/cos signal transmission, 2  $\mu\text{m}$  sensor signal period, ironless 3-phase linear motor
- **V-551.7D**  
Precision linear stage, 160 mm width, 230 mm travel range, 150 N load capacity, PIOne linear encoder with sin/cos signal transmission, 2  $\mu\text{m}$  sensor signal period, ironless 3-phase linear motor



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Subject to change. This manual is superseded by any new release. The latest respective release is available for download (p. 2) on our website.

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## 1 About this Document

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## 1.1 Objective and Target Audience of this User Manual

This manual contains information on the intended use of the V-551.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

The latest versions of the user manuals are available for download (p. 2) on our website.

## 1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

**CAUTION**



## Dangerous situation

Failure to comply could lead to minor injury.

- Precautionary measures for avoiding.

**NOTICE**




## Dangerous situation

Failure to comply could cause damage to equipment.

- Precautionary measures for avoiding.

## INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1.	Action consisting of several steps whose sequential order must be observed
2.	
➤	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning sign on the product which refers to detailed information in this manual.

## 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.

## 1.4 Other Applicable Documents

The devices and software tools from PI mentioned in this documentation are described in their own manuals.

Product	Document
C-891 PIMag® Motion controller for magnetic direct drives	MS251E User Manual
PIMikroMove	SM148E Software Manual

## 1.5 Downloading Manuals

### INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 45).

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., V-551).
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 "Get download link by email" for the desired manual and fill out the enquiry form.

The download link will then be sent to the email address entered.





## 2 Safety

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### 2.1 Intended Use

The V-551 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, and lubricants.

The V-551 has a magnetic direct drive and an incremental-measuring position sensor. In accordance with its design, the V-551 is intended for positioning, adjusting and shifting loads in one axis at various velocities.

The V-551 is intended for operation with a horizontally aligned motion axis. With a vertically aligned motion axis, the V-551 may only be operated with suitable gravity compensation (**not** in the scope of delivery).

The V-551 is not intended for applications in areas in which a failure would present severe risks to human beings or the environment.

The intended use of the V-551 is only possible when completely installed and in conjunction with a suitable controller (p. 10). The controller is not included in the scope of delivery of the V-551.

### 2.2 General Safety Instructions

The V-551 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the V-551.

- Use the V-551 for its intended purpose only, and only when it is in perfect technical condition.
- Read the user manual.
- Eliminate any faults and malfunctions likely to affect safety immediately.

The operator is responsible for the correct installation and operation of the V-551.

## 2.3 Organizational Measures

### User manual

- Always keep this user manual available with the V-551.  
The latest versions of the user manuals are available for download (p. 2) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the V-551 to a third party, also include this user manual as well as other relevant information provided by the manufacturer.
- Use the device only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the V-551 only after you have read and understood this user manual.

### Personnel qualification

The V-551 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

## 3 Product Description

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### 3.1 Model Overview

Three standard versions of the V-551.xD are available. They differ with regard to the travel range and therefore the dimensions.

Model	Travel range	Dimension
V-551.2D	60 mm	220 mm × 160 mm × 50.5 mm
V-551.4D	130 mm	290 mm × 160 mm × 50.5 mm
V-551.7D	230 mm	450 mm × 160 mm × 50.5 mm

- For further technical data, see the specifications (p. 47).

## 3.2 Product View



Figure 1: V-551.4D

- 1 Base body
- 2 Connection for motor cable (panel plug, HD Sub-D 26)
- 3 Connection for sensor cable (socket, Sub-D 15)
- 4 Motion platform
- x Positive direction of motion

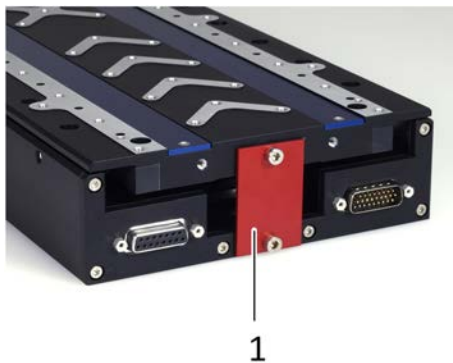






Figure 2: V-551 with transport safeguard, identical for all models

- 1 Transport safeguard (plate with 2 M4x12 screws)

### 3.3 Product Labeling

There is a type plate on the base body of the V-551 that contains the following information:

Labeling	Description
V-551.4D	Product name (example), the characters following the period refer to the model
115003601	Serial number (example), individual for each V-551 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 65)
	CE conformity mark
Country of origin: Germany	Country of origin
WWW.PI.WS	Manufacturer's address (website)
	Manufacturer's logo

### 3.4 Scope of Delivery

Item number	Component
V-551	Linear stage according to the order (p. 7)
-	Transport safeguard, consisting of: <ul style="list-style-type: none"> <li>1 plate, 30 mm × 45 mm, red anodized</li> <li>2 socket head screws, A2 M4x12 ISO 4762</li> </ul>
1890	Screw set for mounting the V-551, consisting of: <ul style="list-style-type: none"> <li>4 socket head screws, A2 M6x30 ISO 4762</li> </ul>
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> <li>1 flat-head screw with cross recess, M4x8, ISO 7045</li> <li>2 safety washers</li> <li>2 flat washers</li> </ul>
MP163EK	Short instructions for V-408, V-508, V-52x, and V-551 stages with magnetic direct drive, in printed form

### 3.5 Accessories

Order number	Description			
V-551.AP1	Adapter for setting up an XY system when the upper stage is a V-551.7D. Material: Aluminum alloy, anodized, mass: 580 g; including the following socket head screws:			
	Item number	Quantity	Description	Comment
	#1295	4 pcs.	M4x10, DIN EN ISO 4762, A2	Mounting the V-551.AP1 onto the X axis
	#1890	4 pcs.	M6x30, DIN EN ISO 4762, A2	Mounting the V-551.7D onto the V-551.AP1
	#1421	4 pcs.	M6x10, DIN EN ISO 4762, A2	Mounting the V-551.7D onto the V-551.AP1

➤ To order, contact our customer service department (p. 45).

### 3.6 Suitable Controllers

The V-551 must be connected to a suitable controller. The following controller from PI is suitable for operating the V-551:

Controller	Description
C-891.130300	PIMag® motion controller for magnetic direct drives, 1 axis, 24/48 V, 5 A, USB and RS-232 interface

PC software is included in the scope of delivery of the controllers from PI. The operation of the controllers is described in the corresponding user manuals.

Please note that the cables for connecting the V-551 to the electronics must also be ordered separately.

➤ To order, contact our customer service department (p. 45).

### 3.7 Technical Features

#### 3.7.1 Linear Encoder

The V-551 is equipped with an optical linear encoder. For the resolution, refer to the table in the "Specifications" section (p. 47).

Optical linear encoders measure the actual position directly (direct metrology). Therefore, errors occurring in the drivetrain such as nonlinearity, backlash or elastic deformation, cannot influence the measurement of the position.

### 3.7.2 Reference Switch

The V-551 has an optical reference switch (see "Reference Specifications" (p. 49)).

See the controller user manual and/or associated software manuals for the commands that make use of the reference signal.

### 3.7.3 Limit Switches

The V-551 is equipped with noncontact, Hall-effect limit switches.

Each limit switch sends an overrun signal on a dedicated line to the controller. The controller then stops the motion. If the controller does not stop the motion in time, the stage runs into the hard stop.

See "Limit Switch Specifications" (p. 49) for more information.

### 3.7.4 Magnetic Direct Drive

The V-551 is equipped with an ironless magnetic direct drive for high velocity and acceleration. The drive allows a high position resolution with long travel ranges due to its sine-commutated drive.

Magnetic direct drives have advantages when compared to classical spindle-based solutions, especially with respect to wear and dynamics. Because they use as few mechanical components as possible, there is less friction and backlash and therefore more precision and a longer lifetime.





## 4 Unpacking

### NOTICE

**Mechanical overload from incorrect handling!**

An impermissible mechanical load on the V-551 due to transportation without a transport safeguard can damage the motion platform of the V-551 as well as cause loss of accuracy.

- Only ship the V-551 in the original packaging and with the transport safeguard installed.

The V-551 is delivered with a transport safeguard installed.

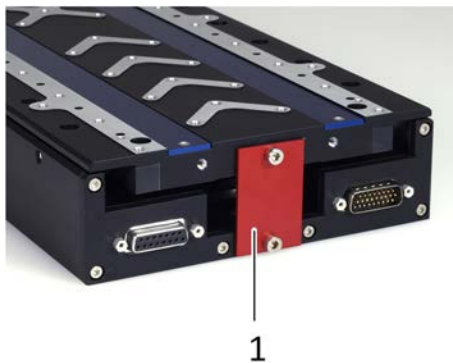


Figure 3: V-551 with transport safeguard, identical for all models

- 1 Transport safeguard (plate with 2 M4x12 screws)

### Tools and accessories

- Hex key AF 3

### Unpacking the V-551

1. Unpack the V-551 with care.
2. Compare the contents with the items listed in the contract and the packing list. If parts are incorrectly supplied or missing, contact PI immediately.
3. Inspect the contents for signs of damage. If you notice signs of damage, contact PI immediately.
4. Remove the transport safeguard:
  - a) Loosen and remove both M4 screws.
  - b) Remove the plate.
5. Keep all packaging materials and the transport safeguard in case the product needs to be transported later.



## 5 Installation

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### 5.1 General Notes on Installation

#### NOTICE



##### Attraction of magnetizable objects!

The magnets on the bottom side of the motion platform of the V-551 can attract magnetizable objects such as loose screws. Objects attracted can damage the V-551.

- Make sure that there are no movable, magnetizable objects within a radius of at least 10 cm around the motion range of the platform of the V-551.

#### NOTICE



##### Damage to magnetically sensitive objects!

The magnets on the bottom side of the motion platform of the V-551 can damage magnetically sensitive objects such as magnetic data carriers and electronic devices.

- Make sure that there are no magnetically sensitive objects within a radius of at least 10 cm around the motion range of the platform of the V-551.

#### NOTICE



##### Heating up of the V-551 during operation!

The heat produced during operation of the V-551 can affect your application.

- Install the V-551 so that the application is not affected by the dissipated heat.
- Ensure sufficient ventilation at the place of installation.
- Make sure that the complete bottom side of the V-551 is in contact with the surface on which the V-551 is mounted.

**NOTICE****Lubricants, dirt, condensation!**

Dirt, oil, lubricants and condensation will render the motor/drive inoperable.

- Keep the V-551 free from lubricants.
- Keep the V-551 free from dirt and condensation.

**INFORMATION**

The V-551 is intended for operation with a horizontally aligned motion axis. With a vertically aligned motion axis, the V-551 may only be operated with suitable gravity compensation (**not** in the scope of delivery).

- Contact our customer service department (p. 45) for details on gravity compensation.


**INFORMATION**

For the positive direction of motion of the motion platform, see "Product View" (p. 8).

## 5.2 Connecting the V-551 to the Protective Earth Conductor

**INFORMATION**

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

The V-551 has an M4 threaded hole for attaching the protective earth conductor. This hole is marked with the symbol for the protective earth conductor  (see "Dimensions" (p. 50)).

**Requirements**

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ The stage is **not** connected to the controller.

**Tools and accessories**

- Suitable protective earth conductor: Cross-sectional area of the cable  $\geq 0.75 \text{ mm}^2$
- Supplied M4 protective earth screw set (p. 9) for connecting the protective earth conductor
- Suitable screwdriver

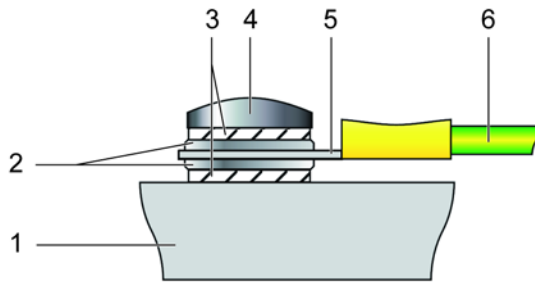


Figure 4: Connecting the protective earth conductor (profile view)

- |   |                            |
|---|----------------------------|
| 1 | Base body of the V-551     |
| 2 | Flat washer                |
| 3 | Safety washer              |
| 4 | Screw                      |
| 5 | Cable lug                  |
| 6 | Protective earth conductor |

### Connecting the V-551 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the V-551 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for connecting the protective earth conductor is  $<0.1 \Omega$  at 25 A.

## 5.3 Mounting the V-551 onto a Surface

### NOTICE



#### Protruding screw heads!

Protruding screw heads can damage the V-551.

- Ensure that the screw heads do not protrude from countersunk holes so that they do not interfere with the motion.

### NOTICE



#### Warping of the V-551 when mounted on uneven surfaces!

Mounting the V-551 onto an uneven surface can warp the V-551. Warping reduces the accuracy.

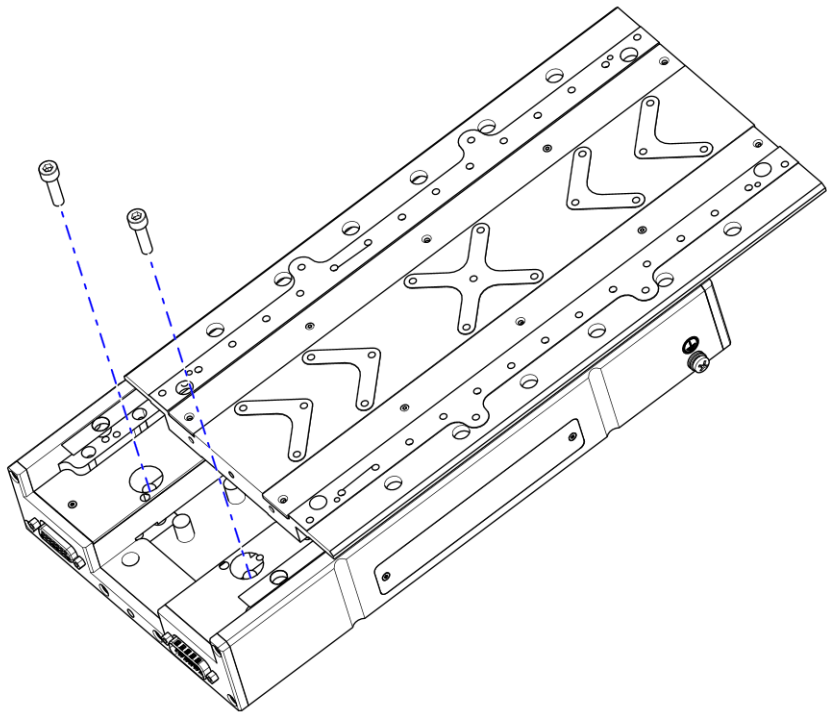
- Mount the V-551 onto an even surface. The recommended evenness of the surface is  $\leq 20 \mu\text{m}$ .
- For applications with large temperature changes:  
Only mount the V-551 onto surfaces that have the same or similar thermal expansion properties as the V-551 (e.g., surfaces made of aluminum).

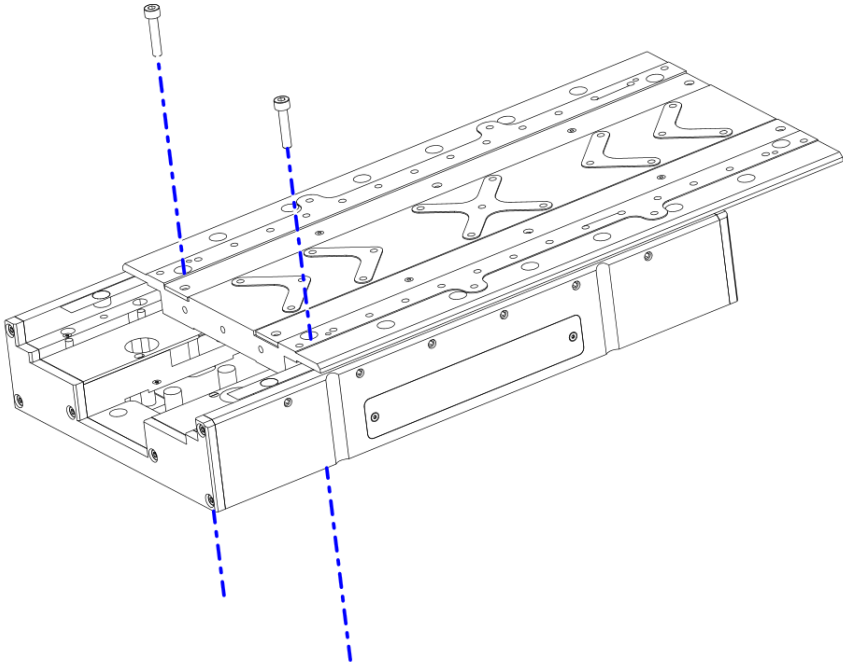
**INFORMATION**

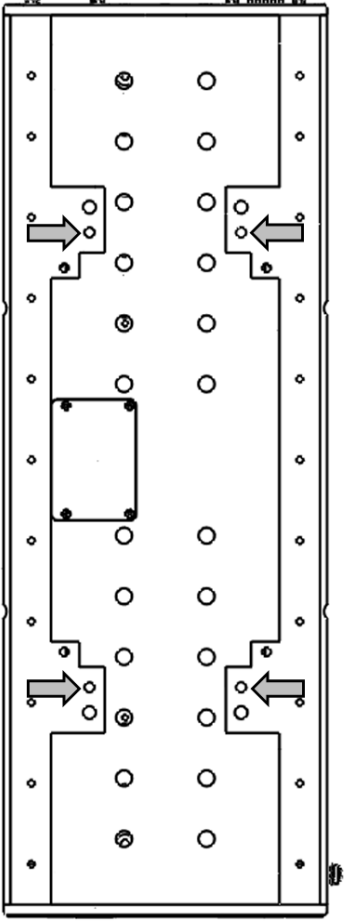
The mounting holes that are needed for mounting from above are only accessible when the motion platform is displaced to the end of the factory-set **travel range**. If you want to modify the travel range of the V-551 by displacing the hard stops (p. 27):

- Mount the V-551 on the surface **before** modifying the travel range.

The mounting holes of the V-551 are intended for the following mounting options:

Mounting option	Mounting holes, details see "Dimensions" (p. 50)
<p>Mounting from above using four M6x30 screws</p> <p>The motion platform must be pushed to the end of the travel range each time to make the mounting holes accessible.</p>	 <p>Figure 5: Mounting of the V-551 from above with four M6x30 screws, two of four screws shown here</p>

Mounting option	Mounting holes, details see "Dimensions" (p. 50)
<p data-bbox="151 389 470 454">Mounting from above using four M4x30 screws</p> <p data-bbox="151 499 470 656">The motion platform must be pushed to the end of the travel range each time to make the mounting holes accessible.</p> <p data-bbox="151 701 470 902">This mounting option is used for example, when setting up an XY system consisting of two V-551.2D or V-551.4D stages (p. 22).</p>	 <p data-bbox="512 1093 1243 1122">Figure 6: Mounting the V-551 from above using four M4x30 screws</p>

Mounting option	Mounting holes, details see "Dimensions" (p. 50)
<p>Mounting from below using four M6 screws</p> <p>This mounting option is used for example, when setting up an XY system and the upper stage is a V-551.7D (p. 24).</p>	 <p>Figure 7: Mounting the V-551 from below with four M6 screws; here: V-551.7D. The position of the M6 holes with a depth of 8 mm is different for the V-551 models</p>

### Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ The V-551 is **not** connected to the controller.
- ✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws, see "Dimensions" (p. 50)):
  - For mounting from above: Four M6 or M4 threaded holes are provided.
  - For mounting from below: Four  $\varnothing 6.4$  mm through holes are provided.
  - For applications with large temperature changes: The surface should have the same thermal expansion properties as the V-551 (e.g., surface made of aluminum).
  - The flatness of the surface is  $\leq 20 \mu\text{m}$ .



- ✓ You have accounted for the space required to route cables without bending and according to regulations.

### Tools and accessories

- Mounting accessories:
  - For mounting from above: 4 M6x30 screws (in the scope of delivery (p. 9)) or 4 M4 screws of suitable length
  - For mounting from below: 4 M6 screws of suitable length
- Suitable tools for tightening the screws

### Mounting the V-551 on a surface

1. Align the stage on the surface so that the corresponding mounting holes in the stage and the surface overlap.
2. Completely screw in the screws into all mounting holes.

For mounting from above:

- Move the motion platform to the factory-set end of the travel range each time to make the mounting holes accessible.

Maximum permissible torque:

- M6: 8.8 Nm
- M4: 2.6 Nm

3. Check that the stage is affixed firmly to the surface.

## 5.4 Setting Up a Multi-Axis System

The V-551 can be used in XY systems.

Designations in these instructions:

- **Lower stage:** Forms the basis of the multi-axis system (X axis); is mounted on a surface
- **Upper stage:** Forms the Y axis of the multi-axis system; is mounted on the lower stage rotated by 90°

### 5.4.1 General Notes on Setting Up a Multi-Axis System

#### NOTICE



#### Impermissibly high load on the stages!

In an XY system, the stage for the Y-axis must be moved as well. Impermissibly high loads interfere with the motion and can damage the stages.

- Include the mass of the moved stage in the calculation of the load to be moved.
- For all stages in a multi-axis system: Do **not** exceed the maximum permissible load.

**NOTICE****Protruding screw heads!**

Protruding screw heads can damage the V-551.

- Ensure that the screw heads do not protrude from countersunk holes so that they do not interfere with the motion.

**NOTICE****Screws that are too long!**

Screws that are inserted too deeply can damage the lower stage.

- Observe the depth of the mounting holes in the motion platform (p. 50) of the lower stage.
- Only use screws of the correct length for the respective mounting holes.

**INFORMATION**

Any model of the V-551 can be used as lower or upper stage.

If a V-551.7D is to be used as the upper stage, an adapter is required, see "Accessories" (p. 10).

**INFORMATION**

The mounting holes that are needed for mounting the upper stage are only accessible when the motion platform is moved to the **factory-set** end of the travel range (exception: Mounting a V-551.7D from below). If you want to change the travel range of the upper stage by displacing the hard stops (p. 27):

- Mount the upper stage on the lower stage **before** modifying the travel range.

### 5.4.2 Setting up the XY System without an Adapter

The XY system is set up without an adapter when a V-551.2D or a V-551.4D is used as upper stage.

**Requirements**

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 21).
- ✓ The used stages are disconnected from the controller.
- ✓ You have properly mounted the lower stage onto a surface (p. 17).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

**Tools and accessories**

- 4 M4x30 screws
- Suitable screwdriver

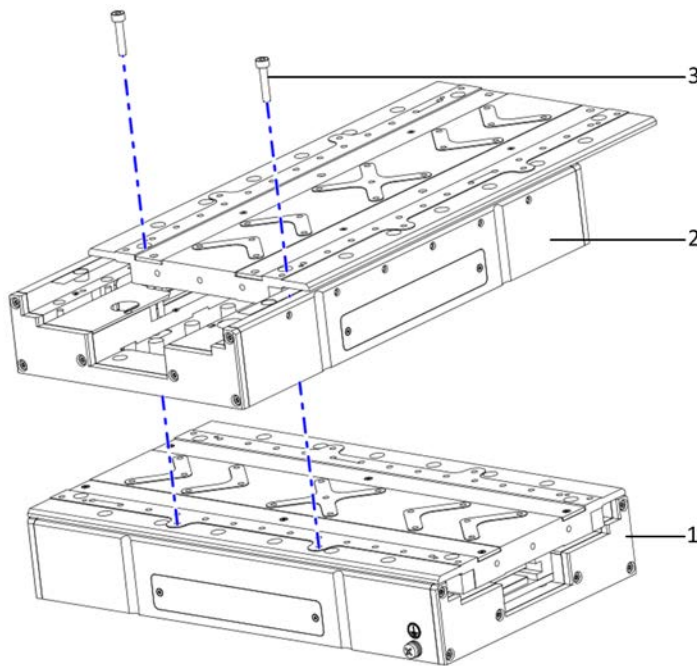
**Setting up the XY system without an adapter**

Figure 8: Example V-551.4D on V-551.4D: Setting up an XY system without an adapter

- 1 Lower stage
  - 2 Upper stage
  - 3 2 of 4 M4x30 screws
1. Align the upper stage on the lower stage so that the corresponding mounting holes overlap.
  2. Tighten the screws in all mounting holes completely.
    - Move the motion platform to the factory-set end of the travel range each time to make the mounting holes accessible.
    - Maximum permissible torque: 2.6 Nm
  3. Check that the upper stage is affixed firmly.

### 5.4.3 Setting up the XY System with an Adapter

The XY system is set up with an adapter when a V-551.7D is used as upper stage.

#### CAUTION



##### Risk of crushing by falling parts!

During setup of an XY system, a risk of minor injury from crushing is possible when parts fall off in the following situations:

- When mounting from below: When the XY system is tilted by 180°
- When mounting from above: When you move the platform of the upper stage (change in center of gravity)
- Observe the total weight of the XY system.
- Wear safety shoes.
- Prevent the upper stage from falling when its platform is moved.

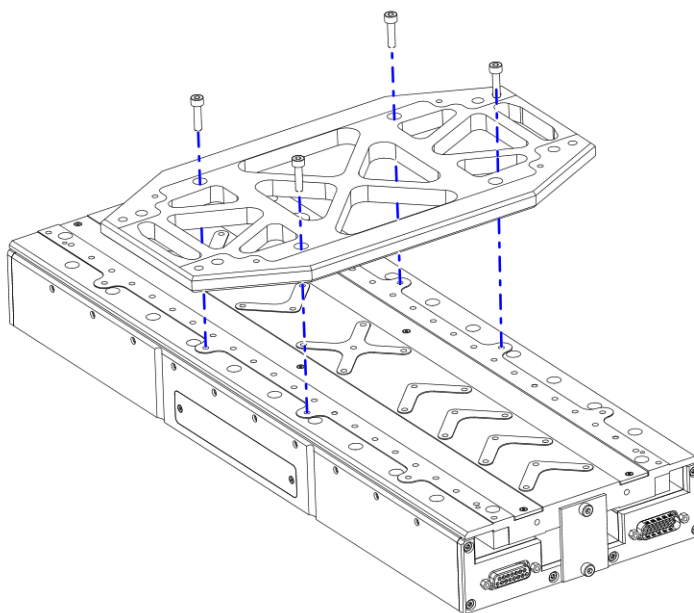
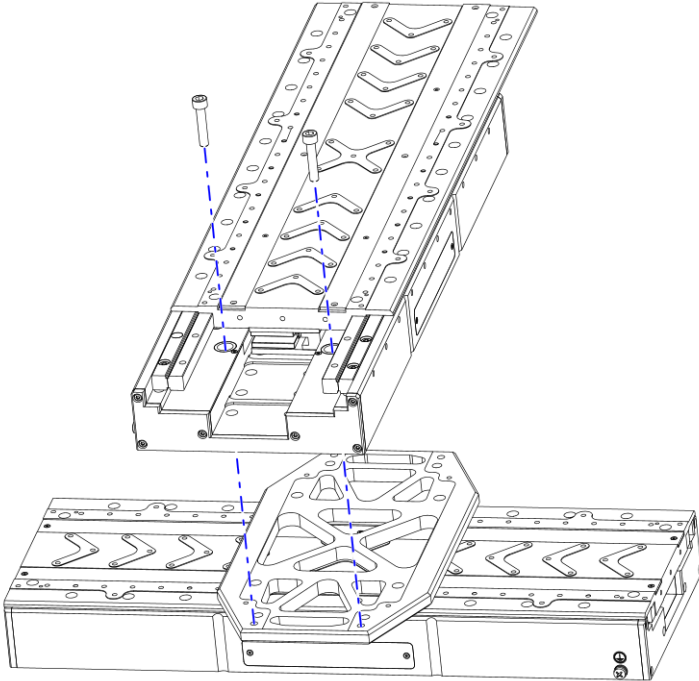


Figure 9: Mounting the V-551.AP1 adapter to the lower stage (here V-551.7D) using four M4x10 screws

The following options are provided for mounting the upper stage on the adapter:

Options for mounting on adapter	Mounting holes, details see "Dimensions" (p. 50)
<p>Mounting from above with four M6x30 screws</p> <p>The motion platform of the upper stage must be pushed to the end of the travel range each time to make the mounting holes accessible.</p>	 <p>Figure 10: Mounting the V-551.7D from above with four M6x30 screws, shown here with two of four screws</p>

Mounting from below with four M6x10 screws

If necessary for mounting the upper stage, the XY system can be tilted temporarily by 180° so that it is vertical. The upper stage is then at the bottom, and the bottom sides of the stage and the adapter are facing up.

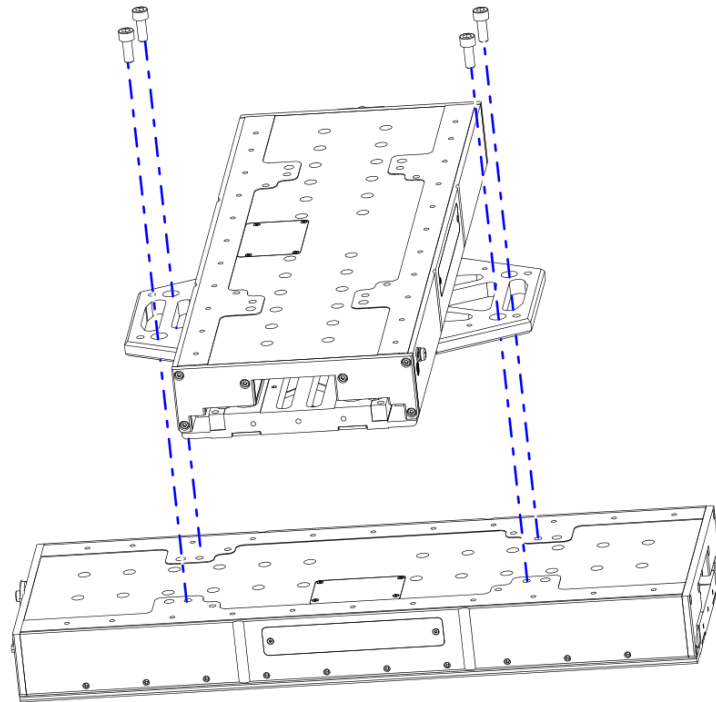


Figure 11: Mounting the V-551.7D from below with four M6x10 screws; XY system tilted by 180° so that it is vertical

### Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 21).
- ✓ The used stages are disconnected from the controller.
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

### Tools and accessories

- V-551.AP1 adapter, available as optional accessory (p. 10)
- Screws in the scope of delivery of the adapter:
  - 4 M4x10 screws
  - Depending on the option selected for mounting the V-551.7D onto the adapter: 4 M6x30 or 4 M6x10 screws
- When the lower stage has not been mounted onto a surface yet: 4 suitable screws; see "Mounting the V-551 on a Surface" (p. 17)
- When you tilt the XY system vertically by 180°: Safety shoes

### Setting up an XY system with an adapter

1. Mount the adapter on the lower stage:
  - a) Make sure that the counterbores on the four holes with  $\varnothing$  4.5 mm in the adapter are facing upwards.
  - b) Align the adapter on the lower stage as in the above figure.
  - c) Mount the adapter with four M4x10 screws, maximum permissible torque: 2.6 Nm.
  - d) Check that the adapter is affixed firmly.
2. Mount the upper stage on the adapter:
  - a) When mounting from below: If necessary, tilt the upper stage and the lower stage, on which the adapter is mounted, vertically by 180°.
  - b) Align the upper stage and the adapter to each other so that the corresponding mounting holes overlap.
  - c) Tighten in the four M6 screws; options see above. When mounting from above: Move the motion platform to the factory-set end of the travel range each time to make the mounting holes accessible. Maximum permissible torque: 8.8 Nm.
  - d) Check that the upper stage is affixed firmly.
3. When the stage has not been mounted onto a surface yet:
 

When you have tilted the XY system by 180° so that it is vertical:

  - a) Observe the total weight of the XY system and wear safety shoes.
  - b) Attach the transport safeguards to both stages (p. 41).
  - c) Tilt the XY system vertically by 180° again so that the motion platform of the upper stage is facing upwards again.
  - d) Remove the transport safeguards from both stages (p. 13).
    - Follow the instructions in "Mounting the V-551 on a Surface" (p. 17).

## 5.5 Option: Modifying the Travel Range

The travel range of the V-551 can be changed by displacing the integrated hard stops.

### NOTICE



#### Improper displacement of the hard stops!

Improper displacement of the hard stops damages the V-551.

- Do not let any screws or other foreign bodies fall inside the V-551.
- After displacement of the hard stops, make sure that the two adjustable parts are present and properly mounted.
- Attach the cover again after displacing the hard stops.

**INFORMATION**

The hard stops are set for the travel range at the factory according to the specifications (p. 47). Displacing the hard stops reduces the factory-set travel range.

The mounting holes for mounting the V-551 from above are only accessible with the default setting for the travel range.

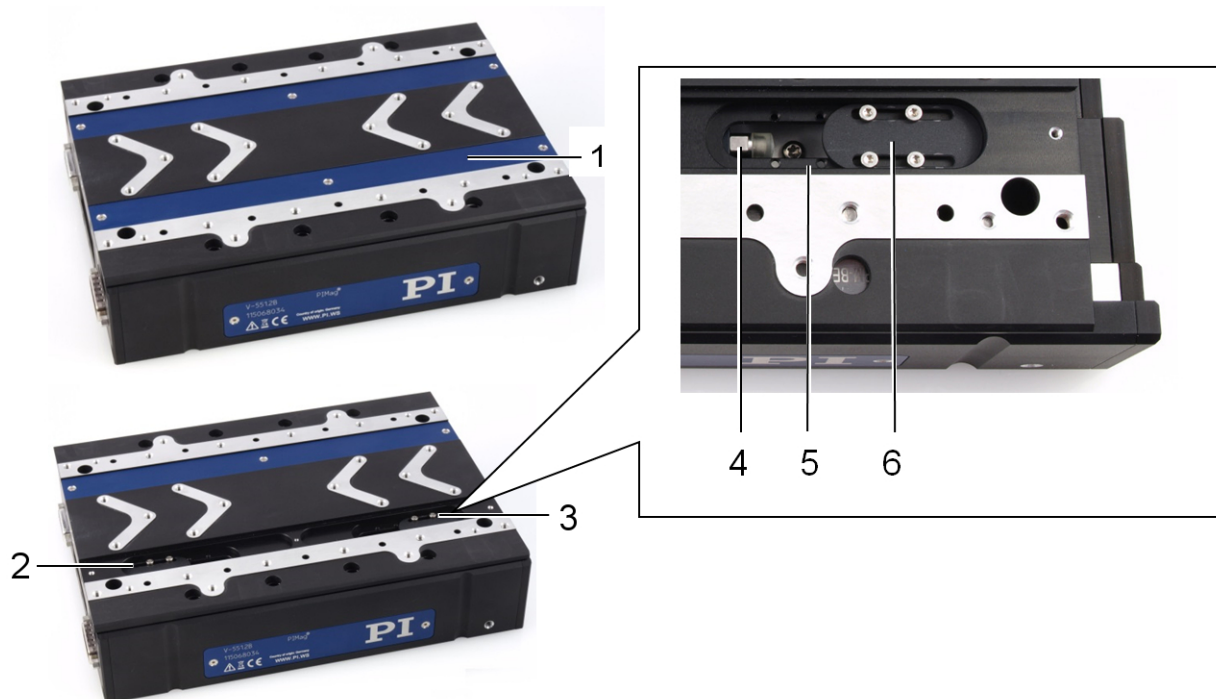


Figure 12: Hard stops of the V-551, overview and detailed view of a hard stop

- 1 Cover for the hard stops (on the side that faces the type plate)

Accessible after removal of the cover:

- 2 Hard stop for limiting the travel range in the positive direction of motion  
 3 Hard stop for limiting the travel range in the negative direction of motion  
 4 Detail: Fixed buffer of the hard stop  
 5 Detail: Recess with eight M2 holes  
 6 Detail: Adjustable part of the hard stop, with two longitudinal holes for fine alignment



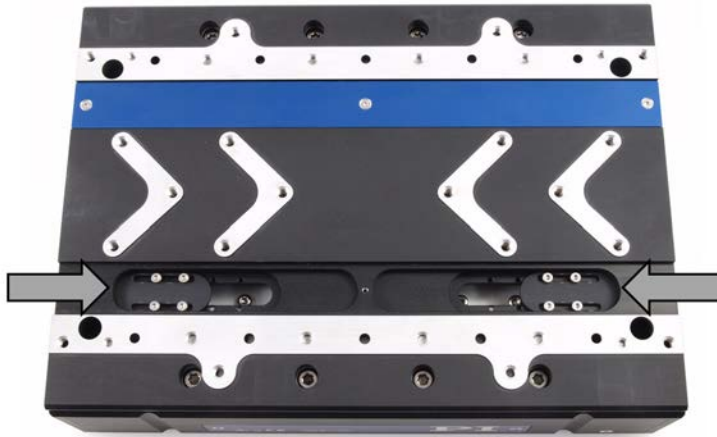


Figure 13: Factory setting of the hard stops of the V-551: The outer edge of each adjustable part touches the edge of the recess in the motion platform; see arrows.

### INFORMATION

If you want to check the setting of the hard stops while changing the travel range:

1. Connect the V-551 to the controller via the sensor cable (p. 33).
2. Start up the controller and establish communication between the controller and PC; see documentation of the controller.
3. Read the current position of the axis of the V-551 in the used PC software; see the documentation of the controller and/or the PC software.

### Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have properly mounted the stage onto a surface or on a V-551 (p. 17).
- ✓ The drive of the V-551 is deactivated. Options:
  - The motor cable is **not** connected to the V-551.
  - When operated with the C-891 controller: The drive is switched off with the **EAX** command.
- ✓ You know the travel range required for a collision-free application.

### Tools and accessories

- TX6 Torx screwdriver

### Modifying the travel range

1. Remove the cover of the hard stops:
  - a) Loosen the three M2 screws.

- b) Carefully remove the screws and place them sufficiently far away (minimum distance to the bottom side of the motion platform: 10 cm).
- c) Pull the cover up and away from the motion platform.

2. Displace one hard stop:

- a) Loosen the four M2 screws on the adjustable part of the stop.



Example:

- b) Carefully remove the screws and place them sufficiently far away (minimum distance to the bottom side of the motion platform: 10 cm).



Example:

- c) Coarse alignment: Move the adjustable part of the hard stop so that it can be mounted with four of the eight M2 holes.
- d) Insert the four M2 screws into the corresponding holes, but do not completely tighten them yet.



Example:

- e) Fine alignment: Move the adjustable part of the hard stop along the longitudinal holes until the desired travel range is achieved.



Example:

- f) Tighten the four screws with a maximum torque of 0.3 Nm each.
  - g) Check that the adjustable part is affixed firmly.
3. If necessary, move the second hard stop according to the instructions in step 2.
4. Adjust the parameters for the soft limits of the axis to the changed travel range on the controller; see documentation of the controller.

## 5.6 Fixing the Load to the V-551

### NOTICE

**Impermissibly high forces and torques!**

Impermissibly high forces and torques that are applied to the motion platform can damage the V-551.

- For affixing type and mass of the load, pay attention to the maximum permissible forces according to the specifications (p. 47).
- Avoid tilting torques at the motion platform.

### NOTICE

**Screws that are too long!**

Screws inserted too deeply damage the V-551.

- Pay attention to the maximum screw-in depth for the mounting holes (p. 50).
- Only use screws of the correct length for the respective mounting holes.

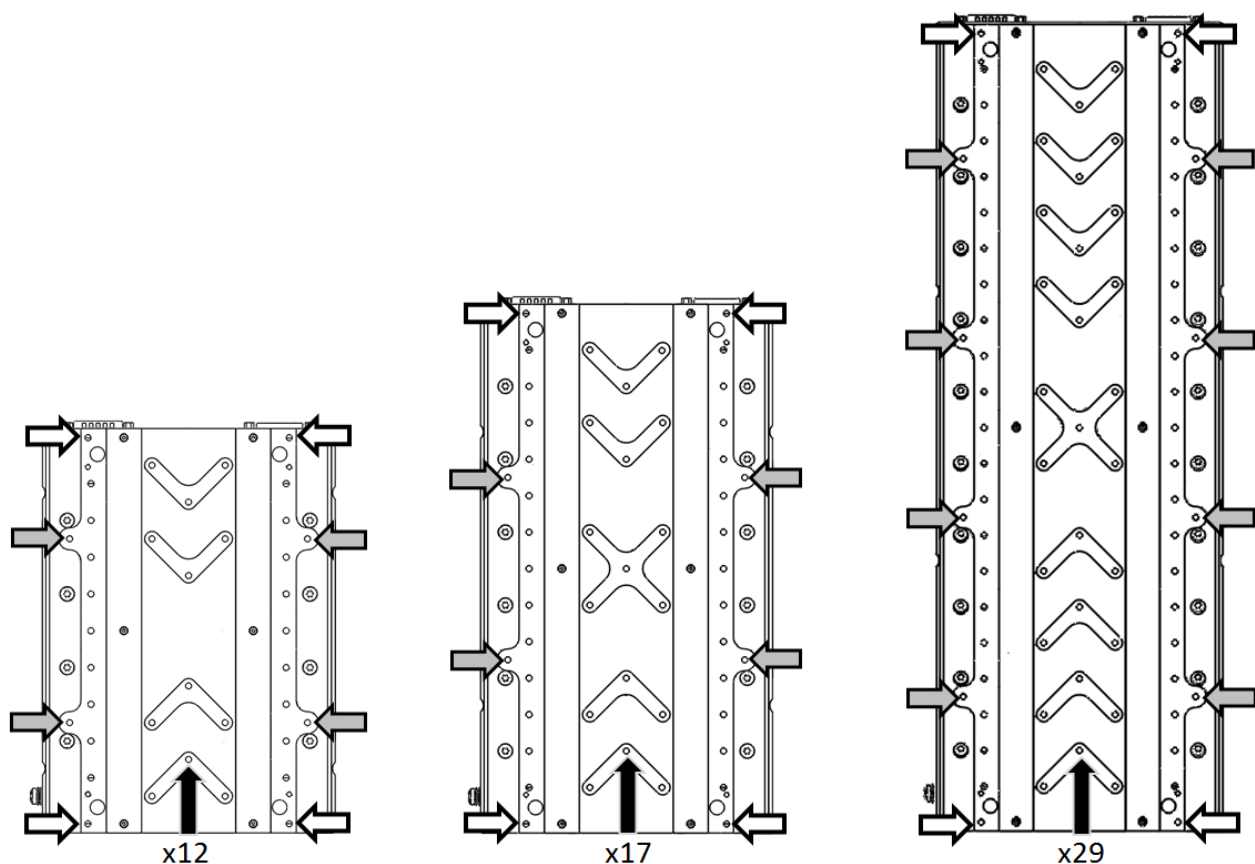


Figure 14: Mounting holes for affixing the load; from the left: V-551.2D, V-551.4D, V-551.7D

The arrows identify the following mounting holes in the motion platform of the V-551:

- White arrows: M4 threaded holes, depth 5.5 mm
- Gray arrows: M4 threaded holes, depth 4.5 mm
- Black arrows: M4 threaded holes, depth 8 mm

### Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have properly mounted the stage onto a surface (p. 16) or on a V-551 (p. 21).
- ✓ The V-551 is **not** connected to the controller.
- ✓ You have prepared the load so that it can be affixed to the motion platform (for the required position and depth of the holes for accommodating the screws, see "Dimensions" (p. 50)):
  - The distance 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 affixing the load on the motion platform.

**Tools and accessories**

- Four M4 screws of suitable length (p. 50)
- Suitable tool for tightening the screws

**Affixing the load to the V-551**

1. Align the load on the V-551 so that the mounting holes in the load and the holes in the motion platform overlap.
2. Affix the load to the mounting holes with the screws:
  - Maximum permissible torque for M4 screws: 2.6 Ncm
3. Check that load is affixed firmly.

## 5.7 Connecting the Motor Cable and Sensor Cable to the V-551

**Requirements**

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ Motor cable and sensor cable are **not** connected to the controller.

**Tools and accessories**

- Motor cable, HD Sub-D 26 (m/f)
- Sensor cable, Sub-D 15 (m/f)
- Suitable controller

**Connecting the motor cable and sensor cable to the V-551**

1. Connect the cable:
  - Connect the connector (f) of the motor cable to the 26-pin HD Sub-D panel plug (m) of the V-551.
  - Connect the connector (m) of the sensor cable to the 15-pin Sub-D socket (f) of the V-551.
2. Use the integrated screws to secure the connector (f) and the connector (m) against accidental disconnection from the V-551.



## 6 Startup and Operation

### In this Chapter

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Starting Up the V-551 with the C-891 Controller .....	38

### 6.1 General Notes on Startup and Operation

The startup of the V-551 is done with the PIMag® C-891 motion controller from PI.

#### CAUTION



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

There is a risk of minor injuries from crushing between the moving parts of the stage or the load and a fixed part or obstacle.

- Use protective structures to keep limbs away from areas in which they could be caught by moving parts.
- Observe the safety distances in accordance with DIN EN ISO 13857 when installing protective structures.

#### NOTICE



##### **Damage due to collisions!**

Collisions can damage the stage, the load to be moved, and the surroundings.

- Make sure that no collisions are possible between the stage, the load to be moved, and the surroundings in the motion range of the stage.
- Do not place any objects in areas where they can be caught by moving parts.
- Stop the motion immediately if a controller malfunction occurs.
- If possible, adapt the travel range limits of your mechanical system in the software that you use for commanding the motion.

#### NOTICE



##### **Damage from transport safeguard that has not been removed!**

Damage can occur to the stage if the transport safeguard (p. 13) of the stage has not been removed and a motion is commanded.

- Remove the transport safeguard before you start up the system consisting of the stage and the controller.

**NOTICE****Damage from improper or incomplete installation!**

The V-551 can develop high forces and accelerations. If the V-551 has been improperly or incompletely installed, the V-551, the load, and the surroundings can be damaged during operation.

- Only start up the system when the V-551 and the load have been correctly mounted; see "Installation" (p. 15).

**NOTICE****Attraction of magnetizable objects!**

The magnets on the bottom side of the motion platform of the V-551 can attract magnetizable objects such as loose screws. Objects attracted can damage the V-551.

- Make sure that there are no movable, magnetizable objects within a radius of at least 10 cm around the motion range of the platform of the V-551.

**NOTICE****Damage to magnetically sensitive objects!**

The magnets on the bottom side of the motion platform of the V-551 can damage magnetically sensitive objects such as magnetic data carriers and electronic devices.

- Make sure that there are no magnetically sensitive objects within a radius of at least 10 cm around the motion range of the platform of the V-551.

**NOTICE****Heating up of the V-551 during operation!**

The heat produced during operation of the V-551 can affect your application.

- Ensure sufficient ventilation at the place of installation.
- Ensure that the effective nominal current and the peak current do **not** exceed the permissible values (p. 47).



**NOTICE****Undesired displacement due to lack of self-locking!**

The drive of the V-551 does not have self-locking. The V-551 can therefore unintentionally move in the following cases:

- Switching off the controller
- Rebooting the controller
- Switching off the servo mode for the axis
- Switching off the drive for the axis
- Safety switch-off by the controller due to overtemperature or overcurrent

Unintentional displacement can damage the stage, the load to be moved, and the surroundings.

- Only operate the V-551 with a horizontally aligned motion axis.
- If you want to operate the V-551 with a vertically aligned motion axis: Attach suitable gravity compensation (**not** in the scope of delivery). Contact our customer service department (p. 45) for details on gravity compensation.
- Before switching off or rebooting the controller, take suitable measures to ensure that no unintentional displacement of the motion platform are possible.

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

Operating voltages that are too high or incorrectly connected can cause damage to the V-551.

- Do **not** exceed the operating voltage range (p. 49) for which the V-551 is specified.
- Only operate the V-551 when the operating voltage is properly connected; see "Pin Assignment" (p. 62).

**NOTICE****Unintentional motion!**

Unintentional motion of the stage is possible when connecting the V-551 to the controller. Defective software or wrong operation of the software can also result in unintentional motion.

- Do not place any objects in areas where they can be caught by moving parts.
- Before connecting the V-551, check whether a macro is defined as the startup macro in the controller and cancel the selection of the startup macro if necessary.

**NOTICE****Damage due to high velocity and traveling to the hard stop with maximum force!**

High velocities and traveling to the hard stop with maximum force can cause damage, strong heat development, or considerable wear on the mechanical system.

- Stop the motion immediately if a controller malfunction occurs.
- Ensure that the end of the travel range is approached at low velocity.
- Set the control signal so that the moving part does not stop abruptly or try to continue motion at the end of the travel range.
- Determine the maximum velocity for your application.
- Set suitable soft limits for closed-loop operation on the controller.

**NOTICE****Damage to the V-551 and the load due to oscillation**

The optimum values of the servo control parameters of the controller depend on the application and the moved mass. Unsuitable servo control parameter settings of the controller can cause the V-551 to oscillate. Oscillation can damage the V-551 and/or the load affixed to it.

- If the V-551 is oscillating (unusual operating noise), immediately switch off the servo mode for the axis on the controller or switch off the controller.
- Only switch on the servo mode for the axis on the controller after you have modified the servo control parameter settings; see the manual of the controller.

**INFORMATION**

The C-891 controller and the V-551 are delivered as a preconfigured system.

- If a connection assignment is given on the labels of the controller and/or V-551, observe this assignment when connecting the V-551.

## 6.2 Starting Up the V-551 with the C-891 Controller

**INFORMATION**

After switching the motor on, a reference move must be performed by sending the **FRF** command.

For this purpose, PIMikroMove provides the **Start up axes** step (opened in the PIMikroMove main window via the **C-891 > Start up axes...** menu item)

The servo mode for the axis can only be activated when the reference move has been successfully performed.

**Requirements**

- ✓ You have read and understood the general notes on startup and operation (p. 35).
- ✓ You have properly installed (p. 15) the stage.
- ✓ You have read and understood the user manual of the controller.

- ✓ You have read and understood the manual of the PC software.
- ✓ The controller and the required PC software have been installed. All connections on the controller have been set up (see user manual of the controller; the V-551 is connected via the motor cable and sensor cable).

### **Starting up the V-551 with the C-891 controller**

- Start up the stage (see user manual of the controller).



## 7 Maintenance

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### 7.1 General Notes on Maintenance

The V-551 is maintenance-free.

### 7.2 Preparing the V-551 for Transport

#### NOTICE



#### **Mechanical overload from incorrect handling!**

An impermissible mechanical load on the V-551 due to transportation without a transport safeguard can damage the motion platform of the V-551 as well as cause loss of accuracy.

- Only ship the V-551 in the original packaging and with the transport safeguard installed.

#### **Tools and accessories**

- Transport safeguard (p. 8)
- Hex key AF 3

#### **Preparing the V-551 for transport**

- Attach the transport safeguard to the base body and the motion platform (p. 8) using two M4 screws.

### 7.3 Cleaning the V-551

#### **Requirements**

- ✓ You have disconnected the stage from the controller.

#### **Cleaning the stage**

- When necessary, clean the surface of the stage with a cloth dampened lightly with a mild cleanser or disinfectant.



## 8 Troubleshooting

Problem	Possible causes	Solution
Target position is approached too slowly or with overshoot	<ul style="list-style-type: none"> <li>▪ Servo control parameters are not optimally set</li> <li>▪ Large changes to the load or the alignment of the V-551</li> <li>▪ Velocity / acceleration set improperly</li> </ul>	<ul style="list-style-type: none"> <li>➤ Switch off the servo control system or the controller immediately.</li> <li>➤ Check whether the servo control parameter settings correspond to the selected closed-loop control mode; see user manual of the controller.</li> <li>➤ If necessary, correct the settings of the servo control parameters.</li> </ul>
Target position is not kept stable		
Uncontrolled oscillation of the V-551		
Increased wear	<ul style="list-style-type: none"> <li>▪ Warped base body</li> <li>▪ Lateral forces on motion platform too high</li> <li>▪ Velocity too high</li> <li>▪ Traveling to the hard stop with maximum force</li> </ul>	<ul style="list-style-type: none"> <li>➤ Mount the V-551 on an even surface. The recommended flatness of the surface is <math>\leq 20 \mu\text{m}</math>.</li> <li>➤ Avoid lateral forces on the motion platform of the V-551.</li> <li>➤ Ensure that the end of the travel range is approached at low velocity and with low force.</li> </ul>
Reduced accuracy		
No or limited motion	<ul style="list-style-type: none"> <li>▪ Excessive load</li> <li>▪ Excessive counterforces in the direction of motion</li> </ul>	<ul style="list-style-type: none"> <li>➤ Reduce the load and/or counterforces in the direction of motion.</li> </ul>
	<ul style="list-style-type: none"> <li>▪ Transport safeguard has not been removed</li> </ul>	<ul style="list-style-type: none"> <li>➤ Remove the transport safeguard (p. 13).</li> </ul>
	<ul style="list-style-type: none"> <li>▪ Improper displacement of the hard stops</li> </ul>	<ul style="list-style-type: none"> <li>➤ Check whether the adjustable parts of the hard stops are correctly mounted (p. 27).</li> <li>➤ Contact our customer service department (p. 45).</li> </ul>
	<ul style="list-style-type: none"> <li>▪ When operated with C-891 controller: Overheating protection has been activated.</li> </ul>	<ul style="list-style-type: none"> <li>➤ Wait a few minutes until the stage has cooled off.</li> <li>➤ Re-establish the readiness of the system for operation; see documentation of the controller.</li> </ul>

Problem	Possible causes	Solution
	<ul style="list-style-type: none"><li>▪ When operated with C-891 controller: Overcurrent protection has been activated.</li></ul>	<ul style="list-style-type: none"><li>➤ Re-establish the readiness of the system for operation; see documentation of the controller.</li><li>➤ Reduce the acceleration and/or velocity in the application; see documentation of the controller.</li></ul>

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 45).



## 9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email ([service@pi.de](mailto:service@pi.de)).

- 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.

The latest versions of the user manuals are available for download (p. 2) on our website.



## 10 Technical Data

### In this Chapter

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### 10.1 Specifications

#### 10.1.1 Data Table

Motion and positioning	V-551.2x	V-551.4x	V-551.7x	Unit	Tolerance
Active axes	X	X	X		
Travel range	60	130	230	mm	
Pitch	±50	±100	±100	μrad	typ.
Yaw	±50	±50	±50	μrad	typ.
Straightness	±1	±1	±2	μm	typ.
Flatness	±2	±2	±2	μm	typ.
Velocity	0.2 <sup>(1)</sup>	0.2 <sup>(1)</sup>	0.2 <sup>(1)</sup>	m/s	max.

Mechanical properties	V-551.2x	V-551.4x	V-551.7x	Unit	Tolerance
Load capacity in Z	150	150	150	N	max.
Load capacity in Y	50	50	50	N	max.
Moved mass	2.2	2.7	4.9	kg	
Overall mass	4.2	5.5	9.7	kg	
Linear guide	Crossed roller bearing with anti-creep system				

Drive properties	V-551	Unit	Tolerance
Drive type	Linear motor, ironless, 3-phase		
Intermediate circuit voltage	48 <sup>(2)</sup>	VDC	max.
Peak force	180	N	typ.
Nominal force	27	N	typ.
Peak current, effective	10	A	typ.

Drive properties	V-551	Unit	Tolerance
Nominal current, effective	1.5	A	typ.
Force constant, effective	18	N/A	typ.
Resistance per phase	3.15	$\Omega$	typ.
Inductance per phase	0.9	mH	typ.
Back EMF phase-phase	16	V·s/m	max.
Pole pitch N-N	30	mm	

Encoder options	V-551.xD	Unit
Integrated sensor	PIOne incremental linear encoder	
Sensor signal	Sin/cos, 1 V peak-peak, 2 $\mu$ m signal period	
Sensor resolution	0.2 <sup>(3)</sup>	nm
Min. incremental motion	0.5 <sup>(4)</sup>	nm
Unidirectional repeatability	0.02	$\mu$ m
Bidirectional repeatability	$\pm 0.05$	$\mu$ m
Travel range limit	Hall effect limit switches, N/O contacts, 5 V, TTL	
Reference switch	Optical, direction sensing (reference edge track), 5 V, TTL	
Reference switch repeatability	<1	$\mu$ m

Miscellaneous	V-551
Operating temperature range	10 °C to 50 °C
Humidity	20 – 90% rel., not condensing
Material	Aluminum, black anodizedschwarz eloxiert
Motor connection	HD D-Sub 26 (m)
Sensor connection	D-Sub 15 (f)

<sup>(1)</sup> With C-891




<sup>(2)</sup> 24 VDC with C-891 and 24 V power supply

<sup>(3)</sup> interpolated

<sup>(4)</sup> With ACS NanoPWM

### 10.1.2 Maximum Ratings

The V-551 is designed for the following maximum ratings:

Maximum operating voltage	Maximum operating frequency	Maximum power consumption
		
48 V	—	650 W

### 10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the V-551 must be observed:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 795 hPa (corresponds to roughly 825 Torr to 596 Torr)
Relative humidity	Highest relative humidity 80% for temperatures up to 31 °C Decreasing linearly to 50% relative humidity at 40 °C
Storage temperature	-20 °C to 60 °C
Transport temperature	-20 °C to 60 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

### 10.1.4 Reference Switch Specifications

Type	Optical sensor
Supply voltage	+5 V/GND
Signal output	TTL level

### 10.1.5 Limit Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V / ground
Signal output	TTL level
Signal logic	The signal level changes when passing the limit switch. The signal logic is active low. That means: <ul style="list-style-type: none"> <li>Normal motor operation: high (+5 V)</li> <li>Limit switch reached: low (0 V)</li> </ul>

## 10.2 Dimensions

### 10.2.1 V-551.2D

Dimensions in mm. Note that the decimal points are separated by a comma in the drawings.  
Motion platform in reference position.

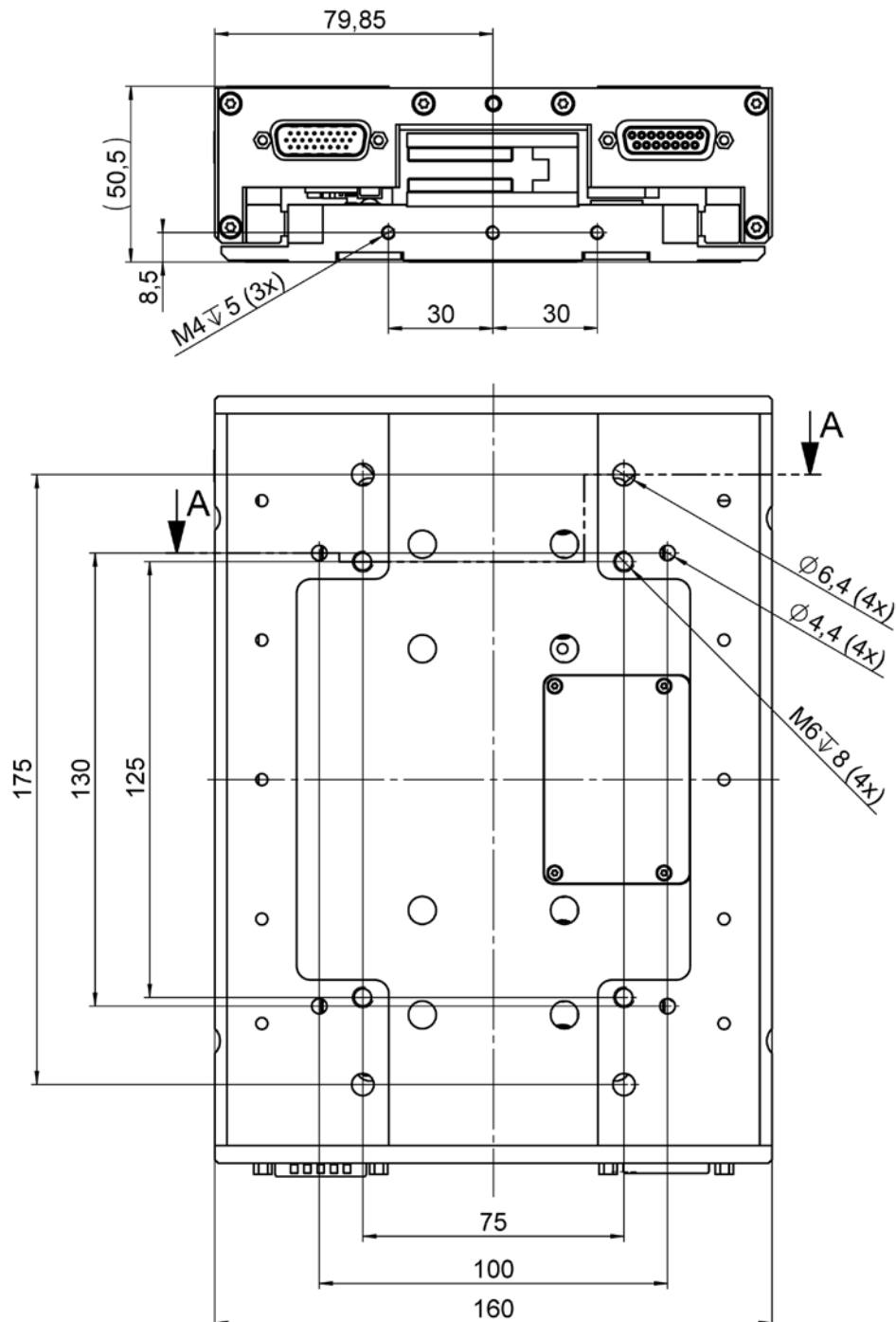


Figure 15: Dimensions of the V-551.2D: Side view and bottom

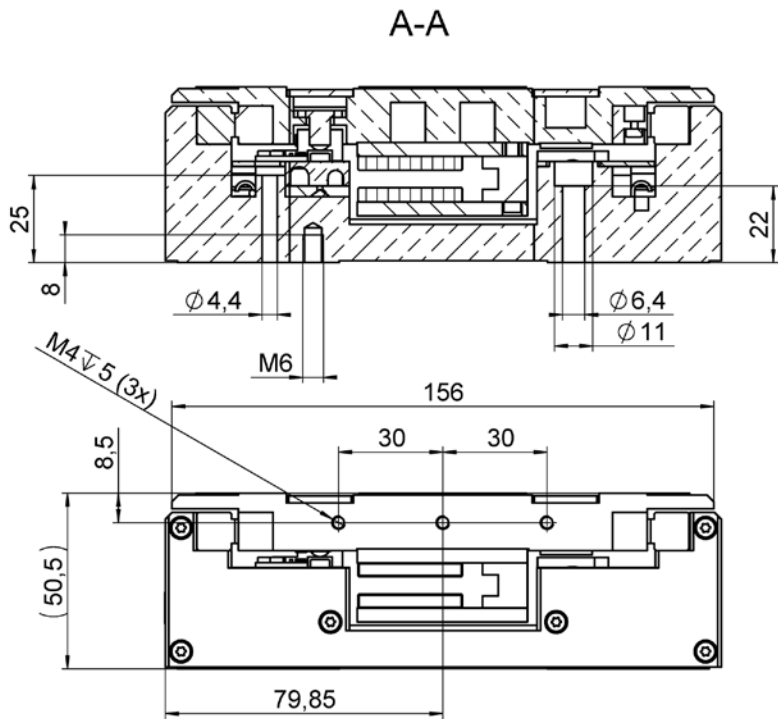


Figure 16: Dimensions of the V-551.2D: Section A and side view

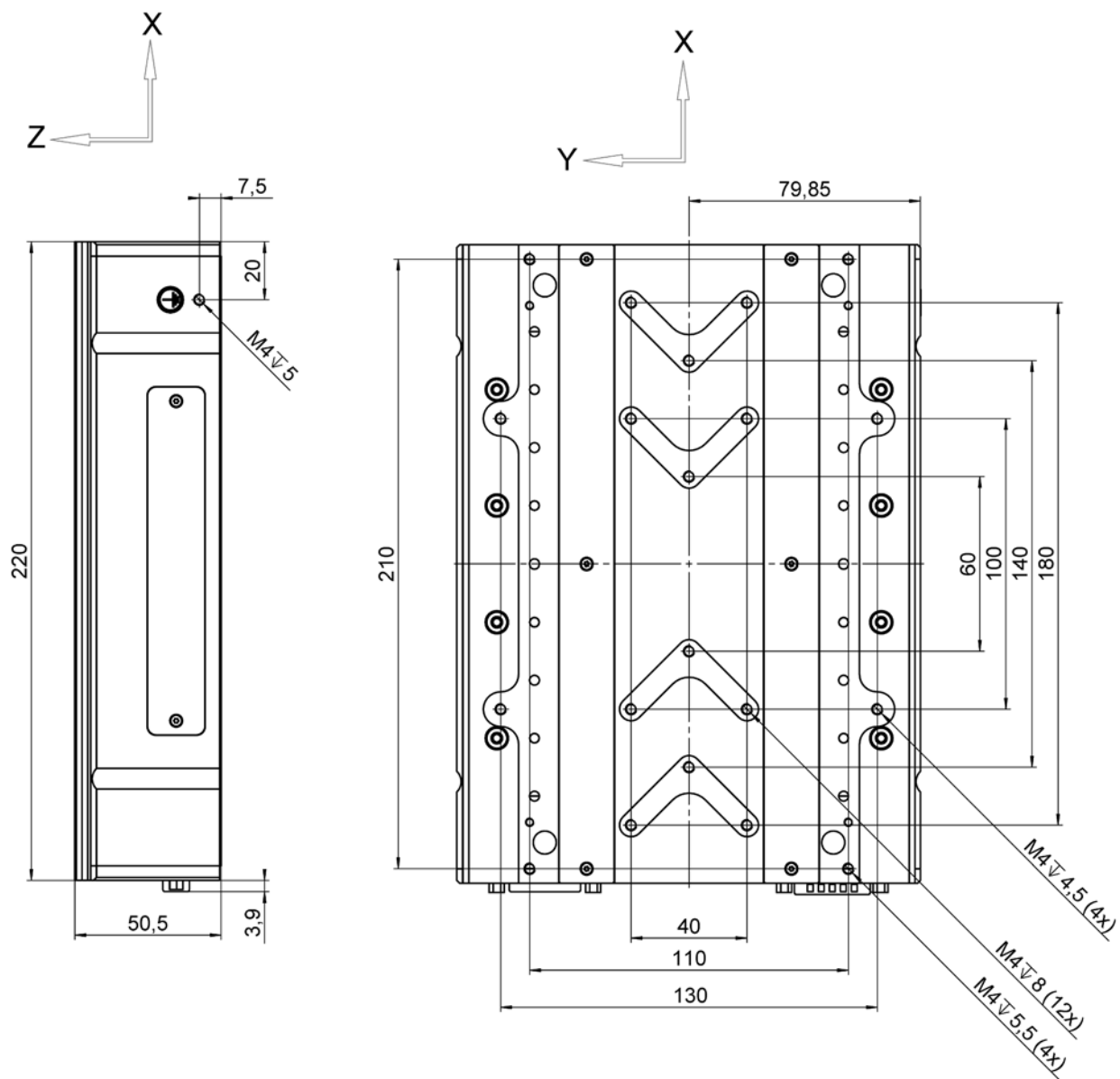


Figure 17: Dimensions of the V-551.2D: Side view and top view



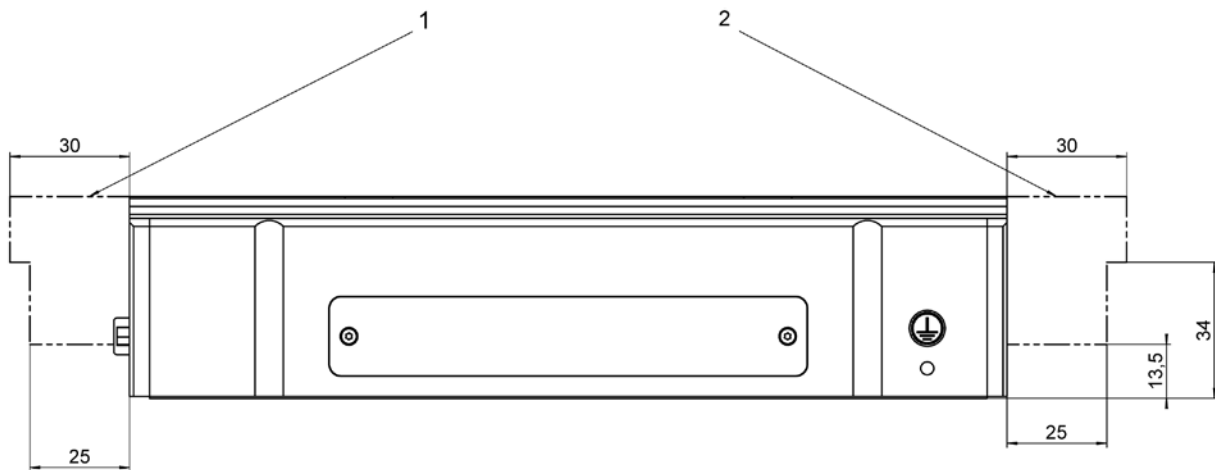


Figure 18: Stage in reference position (shown with solid line)

The dotted-dashed line shows the maximally extended motion platform

- 1 Maximum displacement of the platform at the negative end of the travel range
- 2 Maximum displacement of the platform at the positive end of the travel range

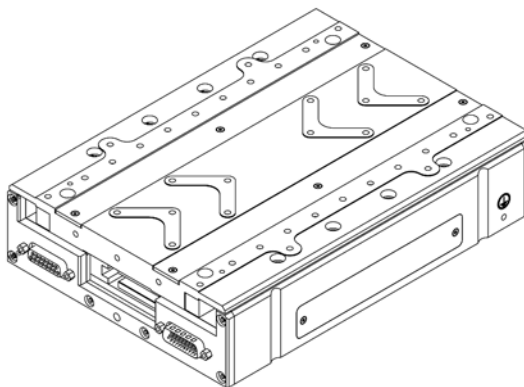


Figure 19: V-551.2D

### 10.2.2 V-551.4D

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

Motion platform in reference position.

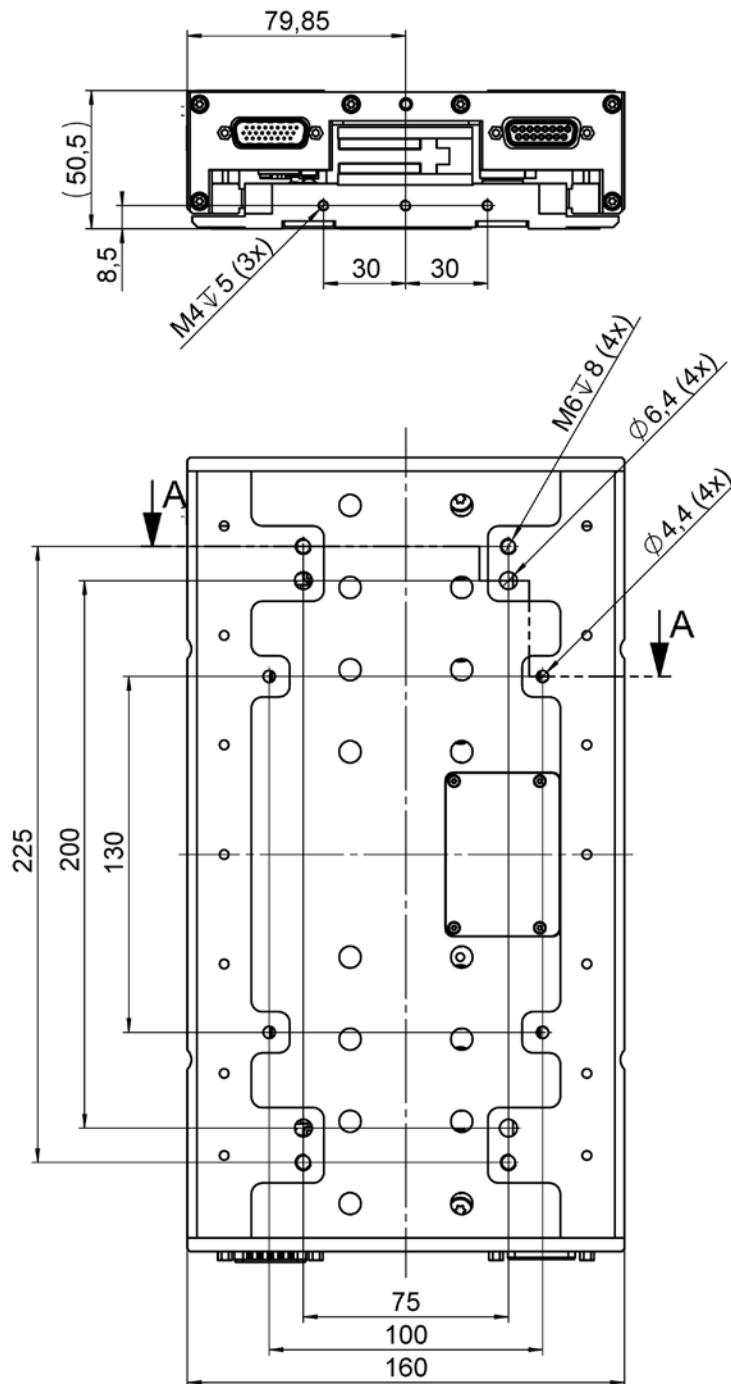


Figure 20: Dimensions of the V-551.4D: Side view and bottom side

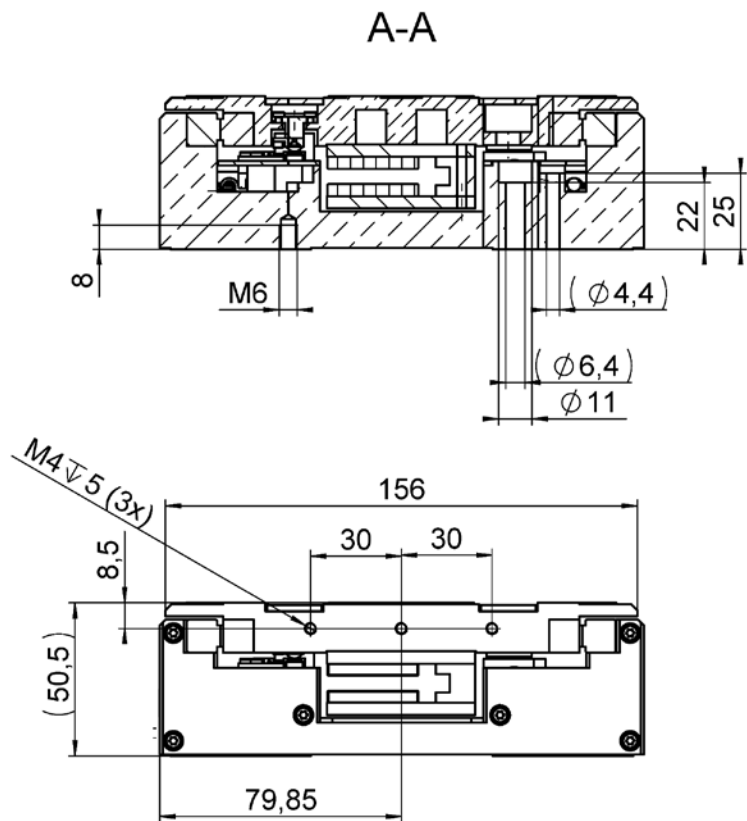


Figure 21: Dimensions of the V-551.4D: Section view A and side view

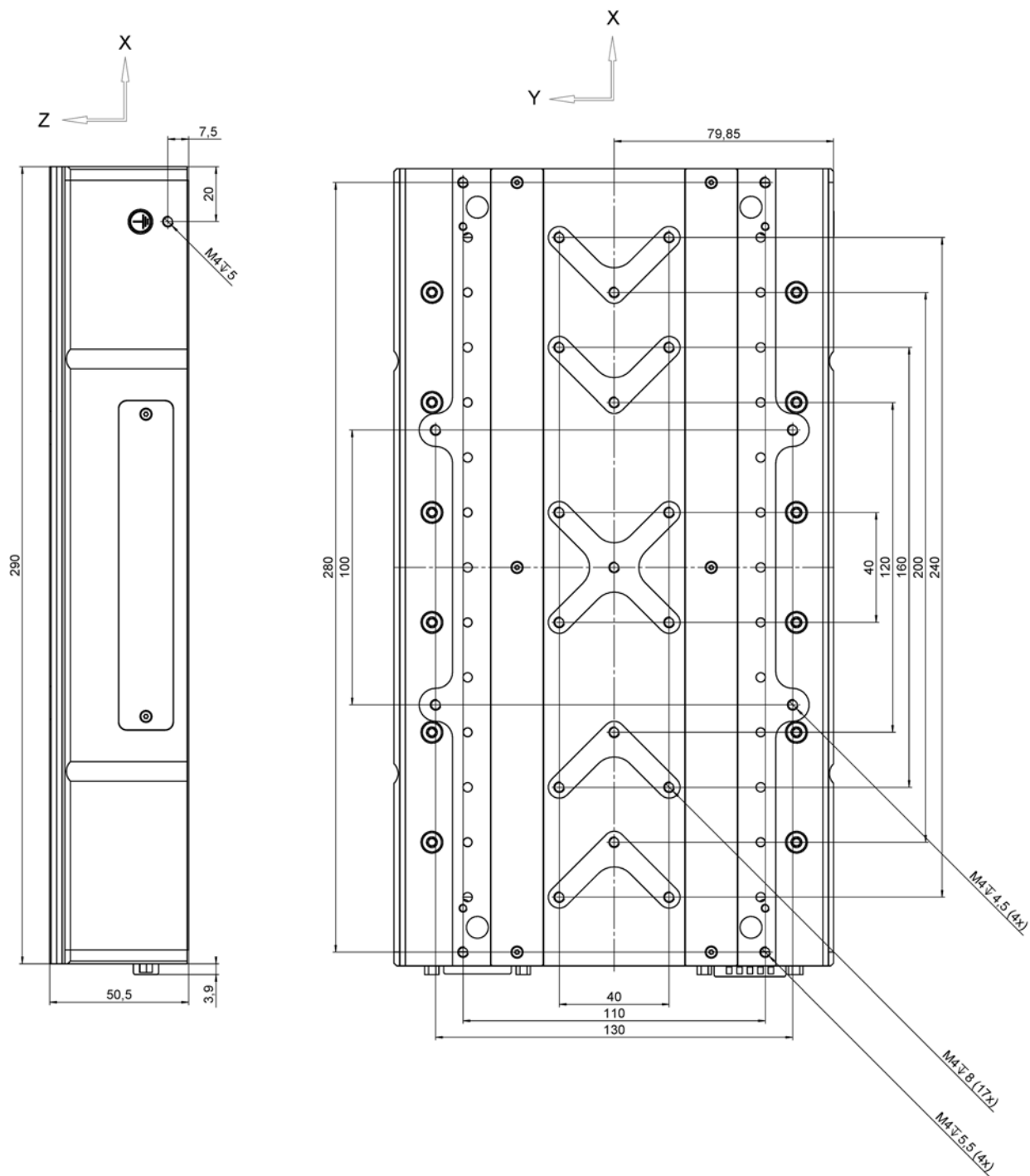


Figure 22: Dimensions of the V-551.4D: Side view and top view

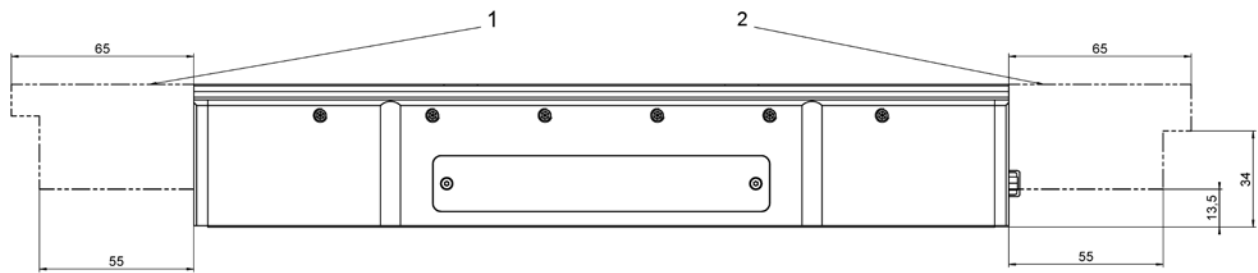


Figure 23: Stage in reference position (shown by solid line)

The dotted-dashed line shows the maximally extended motion platform

- 1 Maximum displacement of the platform at the positive end of the travel range
- 2 Maximum displacement of the platform at the negative end of the travel range

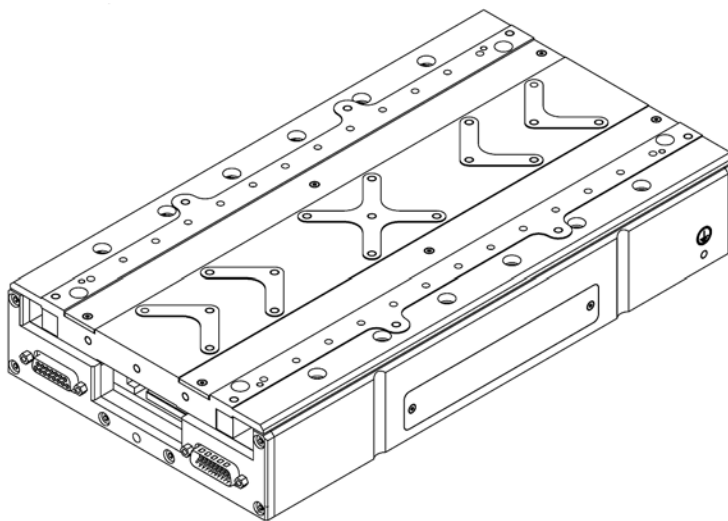


Figure 24: V-551.4D

### 10.2.3 V-551.7D

Dimensions in mm. Note that the decimal points are separated by a comma in the drawings.  
Motion platform in reference position.

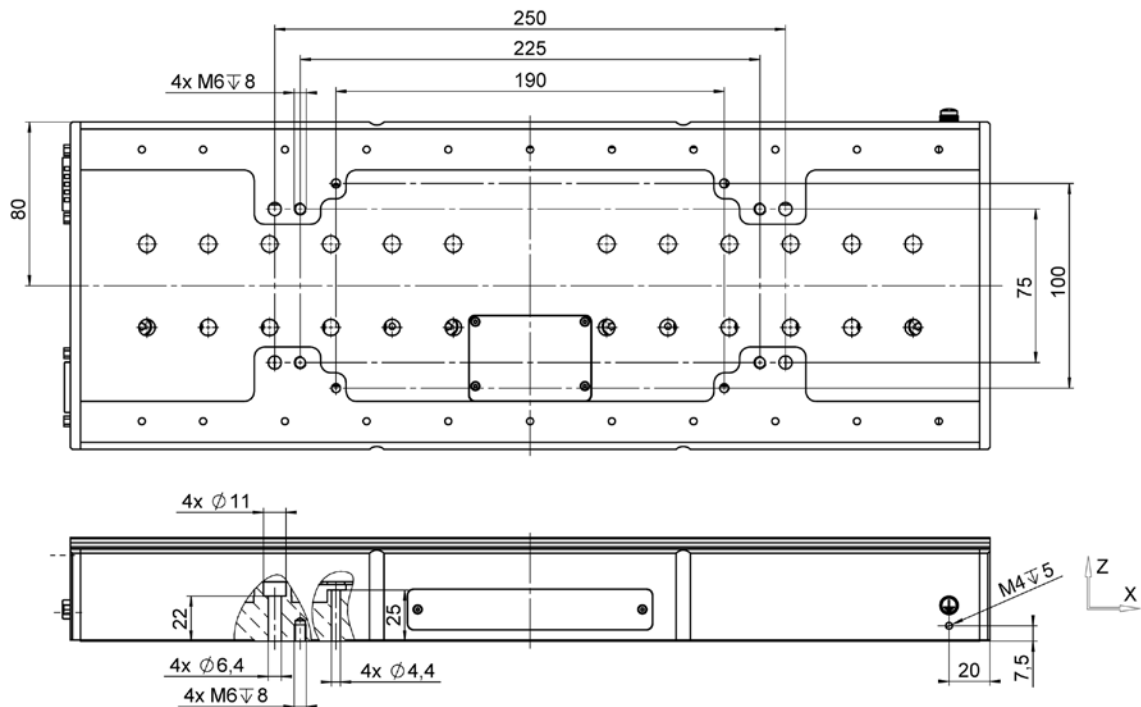


Figure 25: Dimensions of the V-551.7D: Bottom view and side view

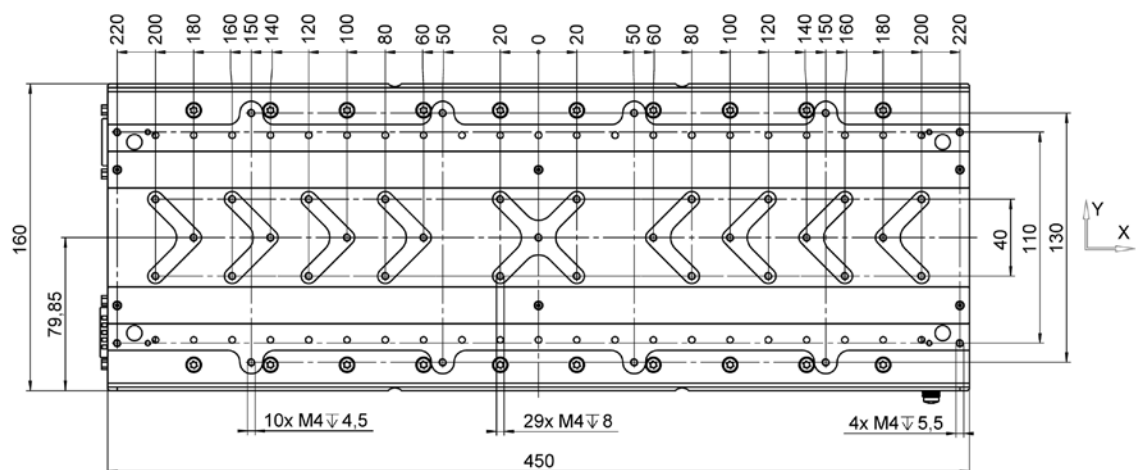


Figure 26: Dimensions of the V-551.7D: Top view

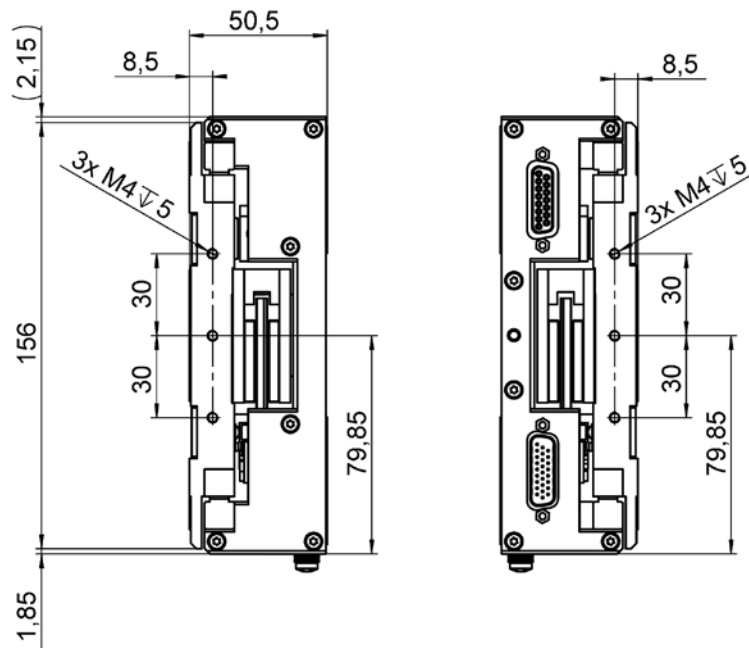


Figure 27: Dimensions of the V-551.7D: Side views

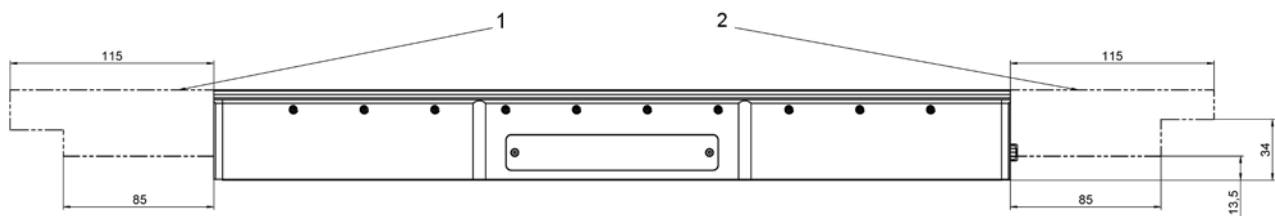


Figure 28: Stage in reference position (shown with solid line)

The dotted-dashed line shows the maximally extended motion platform

- 1 Maximum displacement of the platform at the positive end of the travel range
- 2 Maximum displacement of the platform at the negative end of the travel range

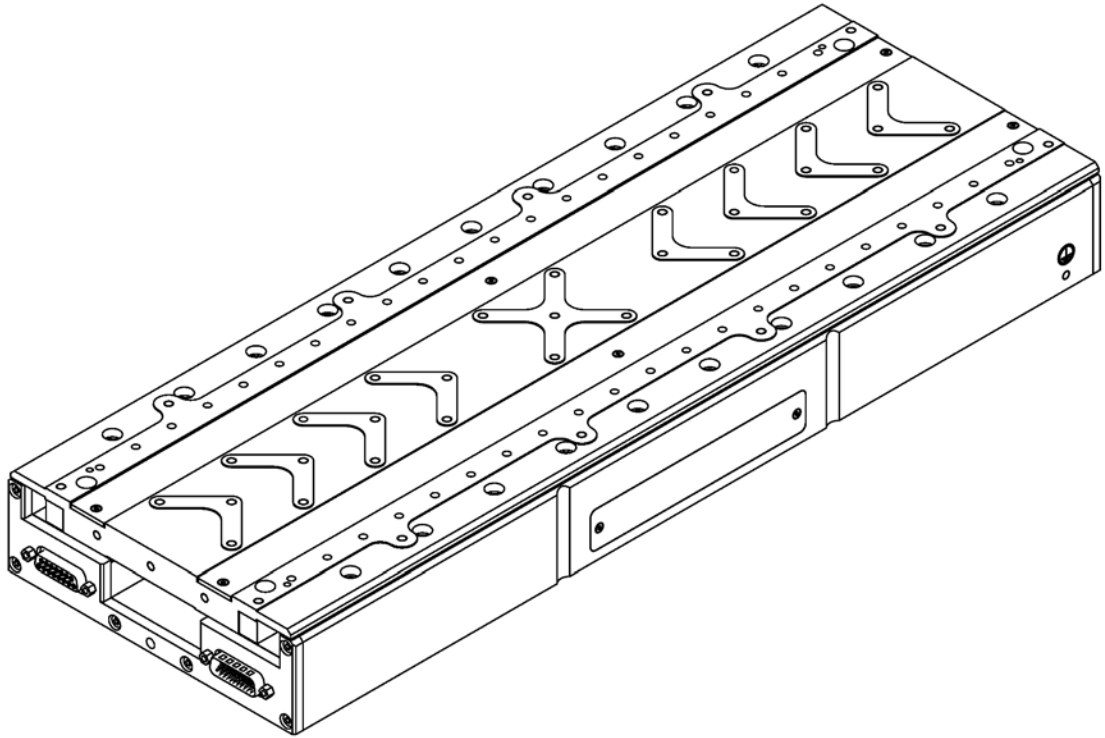


Figure 29: V-551.7D



### 10.2.4 V-551.AP1 Adapter

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

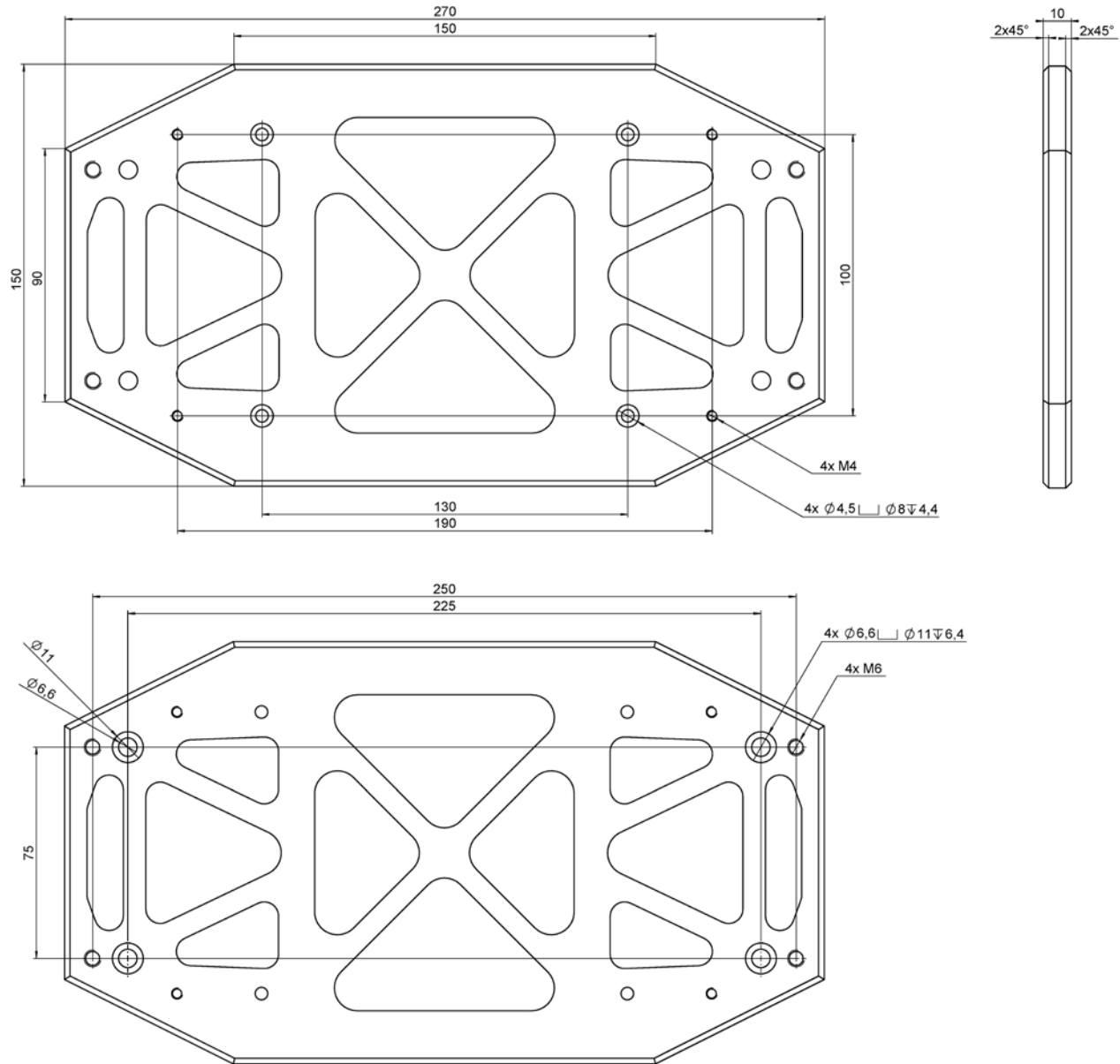


Figure 30: V-551.AP1 Adapter

## 10.3 Pin Assignment

### 10.3.1 Sensor

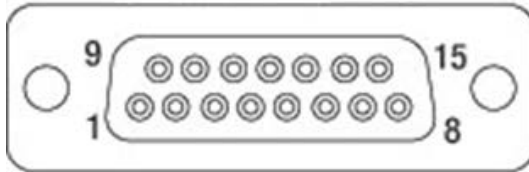


Figure 31: Sub-D 15 socket (f)

Pin	Function	Description
1	Vcc 5 V	Supply voltage for encoder
2	AGND	Encoder ground
3	SIN+	Encoder sine+
4	SIN-	Encoder sine-
5	GND	Temperature sensor ground
6	COS+	Encoder cosine+
7	COS-	Encoder cosine-
8	N-Limit	Negative limit switch
9	PT100	PT100 temperature sensor
10	REF+	Reference+
11	Thermistor	Protection against overheating
12	REF-	Reference-
13	Reserved	
14	GND	Ground
15	P-Limit	Positive limit switch

### 10.3.2 Motor

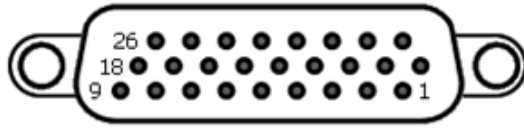


Figure 32: HD Sub-D 26 connector (m)

Pin	Function*	Description
1	Ph1	Phase 1
2	Ph1	Phase 1
3	Ph2	Phase 2
4	Ph2	Phase 2
5	Ph3	Phase 3
6	Ph3	Phase 3
7 - 24	-	-
25	GND	Ground
26	-	-

\* The "-" sign indicates that the corresponding pin has not been assigned.



## 11 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 its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

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

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Roemerstr. 1  
D-76228 Karlsruhe, Germany





## 12 EU Declaration of Conformity

For the V-551, an EU Declaration of Conformity has been issued in accordance with the following European directives:

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN 50581 or EN IEC 63000

