

MP145E
Q-521 Miniature Stage
User Manual

Version: 1.0.0

Date: 17.03.2016



This document describes the following products:

- **Q-521**
Q-Motion miniature linear positioning stage, piezoelectric inertia drive

This document applies to various model versions of the Q-521. The model version of the Q-521 is coded in the order number by means of three characters after a period. Meaning of the characters and valid values:

First character after the period:

Travel range

- 1 = 12 mm
- 2 = 22 mm
- 3 = 32 mm

Second character after the period:

Sensor equipment

- 0 = without sensor
- 3 = with sensor, sensor resolution 4 nm
- 4 = with sensor, sensor resolution 1 nm

Third character after the period:

Vacuum suitability

- 0 = suitable to 10^{-6} hPa
- U = suitable to 10^{-9} hPa



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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) 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 the necessary information on the intended use of the Q-521.

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. 3) on our website.

1.2 Symbols and Typographic Conventions

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

CAUTION



Dangerous situation

If not avoided, the dangerous situation will result in minor injuries or damage to the equipment.



- Actions to take to avoid the situation.

NOTICE





Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➤	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 affixed to the product that refers to detailed information in this manual.

1.3 Definition

Term	Explanation
Load capacity	Maximum load capacity in the vertical direction when the stage is mounted horizontally. The contact point of the load is in the center of the platform.
Linear encoder	The linear encoder is an incremental sensor for capturing changes in position. Signals from the sensor are used for axis position feedback. After switching on the controller a reference point definition must be performed before absolute target positions can be commanded and reached.

1.4 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.

1.5 Other Applicable Documents

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

Description	Document
E-870.10, E-870.11, E-870.21, E-870.41 Piezomotor / PiezoMike Drive Electronics, OEM Board, 1 to 4 Channels	E870T0001 Technical Note
E-870.1G, E-870.2G, E-870.4G Piezomotor / PiezoMike Drive Electronics, Bench-Top, 1 to 4 Channels	E870T0002 Technical Note
E-871.1A1 Q-Motion® Controller, 1 Channel, USB Interface	PZ241E User Manual
E-873.1A1, E-873.1AR, E-873.1AT Q-Motion® Controller, 1 Channel, USB Interface	E873T0001 Technical Note
PIMikroMove	SM148E Software Manual

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 59).

INFORMATION

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected manuals are only displayed on the website after entering the password.

The password is included on the CD of the product.

For products with CD: Identify the password

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including *releasenews* in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.

Downloading Manuals

1. Open the website <http://www.pi.ws>.
2. Click **Info**.
3. If you have a user name and password:
 - a) Click **Login**.
 - b) Log in with the user name and password.
4. Click >> **Product Downloads**.
5. In the **Product Files** area, click the corresponding product category.
6. On the right-hand side of the page, select the corresponding subcategory.
7. Navigate to the product code on the page.

The following manuals are displayed:

 - Freely accessible manuals
 - Manuals that are protected by a password
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

2 Safety

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2.1 Intended Use

The Q-521 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

In accordance with its design and realization, the Q-521 is intended for single-axis positioning, adjusting and shifting of loads at different velocities in interval operation. The Q-521 uses a PIShift piezomotor as a drive. When at rest, the drive is self-locking, requires no current, generates no heat, and maintains its position.

The Q-521 can be mounted in any orientation. The specifications of the Q-521 apply to horizontal mounting (p. 61).

The Q-521 is **not** intended for applications in areas in which a failure would present severe risks to human beings or the environment. For further information on the operating conditions of the Q-521, see "Technical Data" (p. 61).

Some models of the Q-521 are equipped with a linear encoder for direct position measurement.

The intended use of the Q-521 is only possible when completely mounted and connected. The Q-521 must be operated with suitable electronics (p. 15). The electronics are not included in the scope of delivery of the Q-521.

2.2 General Safety Instructions

The Q-521 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 Q-521.

- Only use the Q-521 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the Q-521.

2.3 Organizational Measures

User manual

- Always keep this user manual available with the Q-521. The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or Technical Notes.
- If you give the Q-521 to other users, 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 result in minor injury and damage to equipment.
- Only install and operate the Q-521 after you have read and understood this user manual.

Personnel qualification

The Q-521 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

2.4 Measures for Handling Vacuum-Compatible Products

When handling the vacuum version of the stage, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. In addition, the Q-521.xxU models are wipe cleaned afterwards and then shrink-wrapped twice in vacuum-compatible film.

- Only touch the stage with powder-free gloves.
- If necessary, wipe the stage clean after unpacking.

3 Product Description

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3.1 Model Overview

Classification of the Q-521 models

The model version of the Q-521 is coded in the order number by means of three characters after a period; see also "Detailed model names". Each character codes a feature of the model version:

	First character	Second character	Third character
Feature	Travel range	Sensor (linear encoder)	Vacuum suitability
Feature value	1 = 12 mm 2 = 22 mm 3 = 32 mm	0 = without sensor 3 = with sensor, sensor resolution 4 nm 4 = with sensor, sensor resolution 1 nm	0 = suitable to 10 ⁻⁶ hPa U = suitable to 10 ⁻⁹ hPa

If the value "x" is used in this manual for a character after the period, the corresponding description or instruction applies to all feature values of the corresponding feature.

Detailed model names

Order number	Product name
Q-521.100	Q-Motion® Miniature Linear Positioning Stage, 12 mm Travel Range, Without Position Sensor for Open-Loop Operation, 1 N Push/Pull Force, Dimensions 21 × 30 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa

Order number	Product name
Q-521.10U	Q-Motion® Miniature Linear Positioning Stage, 12 mm Travel Range, Without Position Sensor for Open-Loop Operation, 1 N Push/Pull Force, Dimensions 21 × 30 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁹ hPa
Q-521.130	Q-Motion® Miniature Linear Positioning Stage, 12 mm Travel Range, Linear Encoder, 4 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 30 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.140	Q-Motion® Miniature Linear Positioning Stage, 12 mm Travel Range, Linear Encoder, 1 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 30 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.14U	Q-Motion® Miniature Linear Positioning Stage, 12 mm Travel Range, Linear Encoder, 1 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 30 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁹ hPa
Q-521.200	Q-Motion® Miniature Linear Positioning Stage, 22 mm Travel Range, Without Position Sensor for Open-Loop Operation, 1 N Push/Pull Force, Dimensions 21 × 32 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.20U	Q-Motion® Miniature Linear Positioning Stage, 22 mm Travel Range, Without Position Sensor for Open-Loop Operation, 1 N Push/Pull Force, Dimensions 21 × 32 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁹ hPa
Q-521.230	Q-Motion® Miniature Linear Positioning Stage, 22 mm Travel Range, Linear Encoder, 4 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 32 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.240	Q-Motion® Miniature Linear Positioning Stage, 22 mm Travel Range, Linear Encoder, 1 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 32 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.24U	Q-Motion® Miniature Linear Positioning Stage, 22 mm Travel Range, Linear Encoder, 1 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 32 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁹ hPa
Q-521.300	Q-Motion® Miniature Linear Positioning Stage, 32 mm Travel Range, Without Position Sensor for Open-Loop Operation, 1 N Push/Pull Force, Dimensions 21 × 42 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa

Order number	Product name
Q-521.30U	Q-Motion® Miniature Linear Positioning Stage, 32 mm Travel Range, Without Position Sensor for Open-Loop Operation, 1 N Push/Pull Force, Dimensions 21 × 42 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁹ hPa
Q-521.330	Q-Motion® Miniature Linear Positioning Stage, 32 mm Travel Range, Linear Encoder, 4 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 42 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.340	Q-Motion® Miniature Linear Positioning Stage, 32 mm Travel Range, Linear Encoder, 4 nm Resolution, 1 N Push/Pull Force, Dimensions 21 × 42 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁶ hPa
Q-521.34U	Q-Motion® Miniature Linear Positioning Stage, 32 mm Travel Range, Linear Encoder, 4 nm Position Resolution, 1 N Push/Pull Force, Dimensions 21 × 42 × 10 mm (W × L × H), Piezoelectric Inertia Drive, Vacuum-Compatible to 10 ⁻⁹ hPa

3.2 Product View

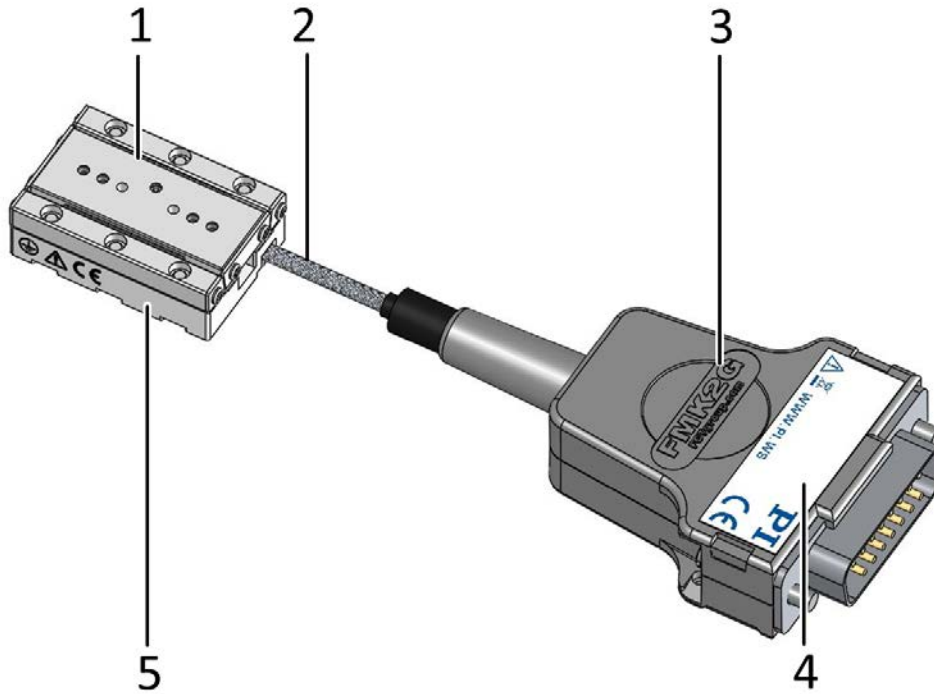


Figure 1: Example for models without sensor: Q-521.200 stage

- 1 Moving platform
- 2 Cable exit for drive connection
- 3 Connection for drive; with Q-521.x00 models: Sub-D 15 (m) connector,
with Q-521.x0U models: Sub-D 15 (f) connector
- 4 Type plate p. 12
- 5 Base body

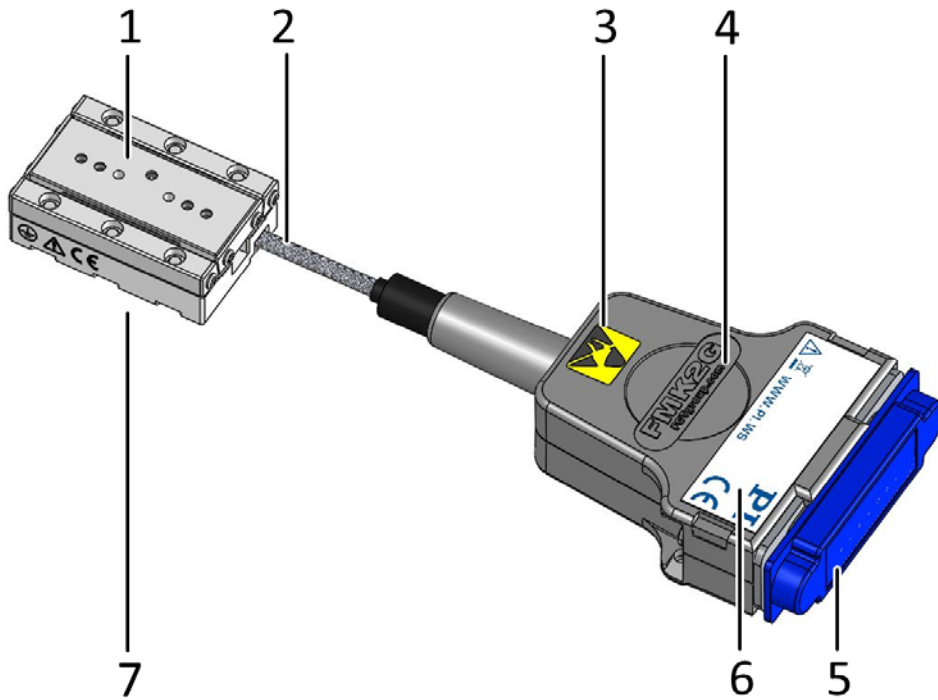


Figure 2: Example for models with sensor: Q-521.240 stage

- 1 Moving platform
- 2 Cable exit for connection of drive and sensor
- 3 Warning sign "Electrostatic sensitive devices"
- 4 Connection for drive and sensor; with Q-521.xx0 models:
Sub-D 15 (m) connector, with Q-521.xxU models: Sub-D 15 (f) connector
- 5 ESD protection: ESD protective cap with Q-521.xx0; nonconductive foil with Q-521.xxU
- 6 Type plate p. 12
- 7 Base body

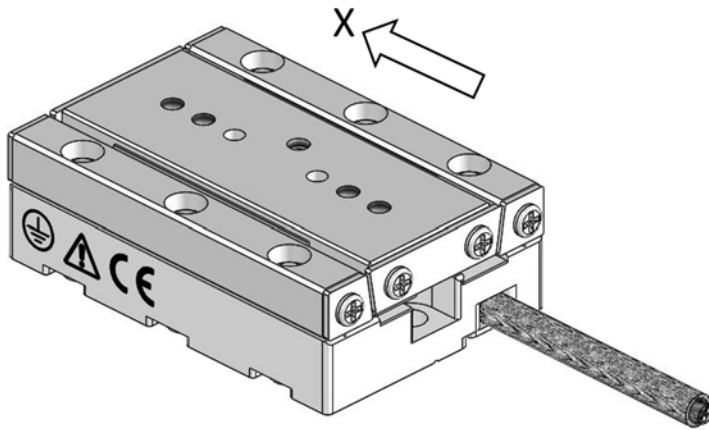


Figure 3: Direction of motion of the platform of the Q-521, Q-521.240 used as an example

The arrow in the figure above shows the direction of motion on positive commanding.

3.3 Product Labeling

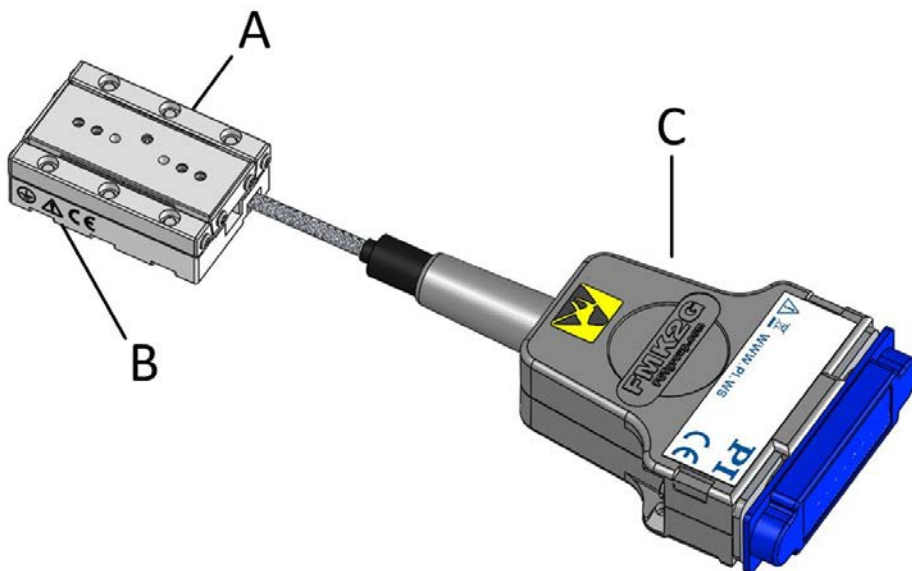








Figure 4: Example for models with sensor: Product labeling and type plate of the Q-521.240 stage

Position	Labeling	Description
A, C		Manufacturer's logo
B		Symbol for the protective earth conductor, marks the protective earth connection of the Q-521 (p. 23)
B, C		Warning sign "Observe manual!"
B, C		CE conformity mark
C	113064246	Serial number (example), individual for each Q-521 Meaning of the places (counting from left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive numbers
C	Q-521.240	Product name (example), the characters following the period refer to the model
C		Old equipment disposal
C	WWW.PI.WS	Manufacturer's address (website)
C		Warning sign "Electrostatic sensitive devices"

3.4 Scope of Delivery

The Q-521 is delivered with the following components:

Item ID	Components
Q-521	Linear positioning stage as specified in the order (p. 7)
Q521B0003	Screw set for mounting the Q-521, consisting of: <ul style="list-style-type: none"> ▪ 2 dowel pins, A2 1.5 m6 x 4 ISO 2338 ▪ 2 socket head cap screws, A2 M2x6 ISO 4762
MP139EK	Short instructions for Q-5xx / Q-6xx PIShift stages
Only for models without sensor:	
7202500042-0015	Air-side adapter cable for connection to the E-870 drive electronics, Sub-D 15 (f) to Mini-DIN 4 (m), 0.3 m

Item ID	Components
Only for models with sensor:	
7202500043-0015	Air-side adapter cable for connection to the E-871 controller, Sub-D 15 (f) to HD Sub-D 15 (m) and HD Sub-D 15 (f), 0.3 m
Only for models suitable for operation to 10^{-9} hPa:	
5604500041	Adapter for operation outside of a vacuum chamber, Sub-D 15 (m/m)

3.5 Accessories

Order number	Description
E-873.UHV1	Air-side extension cable from vacuum feedthrough or Q-521.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 1 m
E-873.UHV2	Air-side extension cable from vacuum feedthrough or Q-521.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 2 m
E-873.UHV3	Air-side extension cable from vacuum feedthrough or Q-521.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 3 m
Q-121.80U	Adapter plate for setting up an XY system consisting of two Q-521, for use in a vacuum to 10^{-9} hPa. Material: Aluminum alloy, uncoated; mass: 4.5 g; including: <ul style="list-style-type: none"> ▪ 2 dowel pins, A2 1.5 m6 x 4 ISO 2338 ▪ 3 machine screws, 1.4567 M2x4
Q-121.10U	Adapter bracket for vertical mounting of a Q-521; for recommended Z combinations, see p. 30.
Q-121.20U	For use in a vacuum to 10^{-9} hPa. Material: Aluminum alloy, uncoated; mass: 13.5 g / 16.8 g / 26.6 g; each including:
Q-121.30U	<ul style="list-style-type: none"> ▪ 4 dowel pins A2 1.5 m6 x 5 ISO 2338 ▪ 6 machine screws, 1.4567 M2x8

For Q-521.xx0 models only (suitable for use in a vacuum to 10⁻⁶ hPa):

Order number	Description
C-815.VF	Vacuum feedthrough (drive and sensor signals), Sub-D 15 (m/f), including C815T0003 Technical Note

For Q-521.xxU models only (suitable for use in a vacuum to 10⁻⁹ hPa):

Order number	Description
C-815.VFU1	Vacuum feedthrough (drive and sensor signals), Sub-D 15 (m/m), DN40CF
C-815.VFU3	Vacuum feedthrough (drive and sensor signals), 3 x Sub-D 15 (m/m), DN63CF
C-815.VFU6	Vacuum feedthrough (drive and sensor signals), 6 x Sub-D 15 (m/m), DN100CF
C-815.VFU15	Vacuum feedthrough (drive and sensor signals), 15 x Sub-D 15 (m/m), DN160CF

➤ To order, contact our customer service department (p. 59).

3.6 Suitable Electronics

Electronics		Suitable for	
Order number	Description	Stage without sensor Q-521.x0x	Stage with sensor Q-521.x3x Q-521.x4x
E-870.10	PIShift Piezomotor / PiezoMike Drive Electronics, 1 Channel, OEM Board	<input checked="" type="checkbox"/>	
E-870.11	PIShift Piezomotor / PiezoMike Drive Electronics, 1 Channel, OEM Board with Connector Strip	<input checked="" type="checkbox"/>	
E-870.1G	PIShift Piezomotor / PiezoMike Drive Electronics, 1 Channel, Bench-Top Device	<input checked="" type="checkbox"/>	

Electronics		Suitable for	
Order number	Description	Stage without sensor Q-521.x0x	Stage with sensor Q-521.x3x Q-521.x4x
E-870.21	PIShift Piezomotor / PiezoMike Drive Electronics, 2 Channels, OEM Board with Connector Strip	<input checked="" type="checkbox"/>	
E-870.2G	PIShift Piezomotor / PiezoMike Drive Electronics, 2 Channels, Bench-Top Device	<input checked="" type="checkbox"/>	
E-870.41	PIShift Piezomotor / PiezoMike Drive Electronics , 4 Channels, OEM Board with Connector Strip	<input checked="" type="checkbox"/>	
E-870.4G	PIShift Piezomotor / PiezoMike Drive Electronics, 4 Channels, Bench-Top Device	<input checked="" type="checkbox"/>	
E-871.1A1	Q-Motion® Controller, 1 Channel, USB Interface		<input checked="" type="checkbox"/>
E-873.1A1	Q-Motion® Controller, 1 Channel, TCP/IP, USB and RS-232 Interface, Bench-Top Device		<input checked="" type="checkbox"/>
E-873.1AR	Q-Motion® Controller, 1 Channel, USB Interface, Bench-Top Device (Industry)		<input checked="" type="checkbox"/>
E-873.1AT	Q-Motion® Controller, 1 Channel, TCP/IP-, USB and RS-232 Interface, Bench-Top Device (Industry)		<input checked="" type="checkbox"/>

➤ To order, contact our customer service department (p. 59).

3.7 Technical Features

3.7.1 Linear Encoder (Sensor)

Some of the Q-521 models are equipped with an optical linear encoder. For the encoder resolution, refer to the table in the "Specifications" section (p. 61).

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 Point Switch

The Q-521 models equipped with a sensor have an optical reference point switch.

The commands that use the reference signal are described in the user manual of the controller and/or in the corresponding software manuals.

3.7.3 ID Chip

Q-521 models with sensor contain an ID chip in the connector.

The following data is stored as parameters on the ID chip:

- Information on the stage: Type, serial number, date of manufacture, version of the hardware
- Settings for the sensor: Interpolation rate, corrections of hysteresis as well as of phase and offset, gain values

When switched on or rebooted, controllers from PI read the data from the ID chip.

For more information on the ID chip recognition, see the manual of the controller used.

4 Unpacking

NOTICE



Electrostatic hazard

Touching the pins in the Sub-D 15 connection of models equipped with sensor can damage electrostatic (also: ESD-) sensitive components of the Q-521. For this reason, these models are supplied with ESD protection.

- Remove the ESD protection from the connection only when you connect the Q-521 to the controller.

INFORMATION

When handling the vacuum version of the stage, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. In addition, the Q-521.xxU models are wipe cleaned afterwards and then shrink-wrapped twice in vacuum-compatible film.

- Only touch the stage with powder-free gloves.
- If necessary, wipe the stage clean after unpacking.

1. Unpack the Q-521 with care.
2. If present, do **not** remove the ESD protection from the connection of the Q-521.
3. Compare the contents with the items listed in the contract and the packing list.
4. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
5. Keep all packaging materials and the ESD protection in case the product needs to be returned.

5 Installation

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5.1 General Notes on Installation

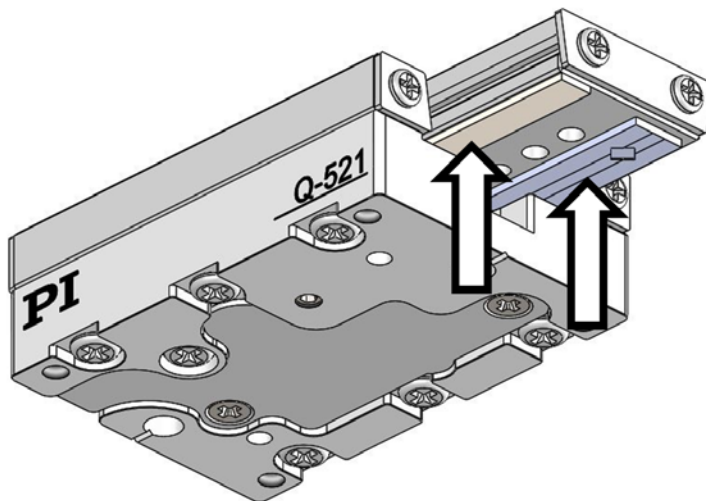


Figure 5: Accessible when the moving platform is driven out: Ceramic rail of the PIShift drive and, for models with sensor, ruler of the linear encoder, example Q-521.240

NOTICE



Damage from mechanical actions!

The ruler of the linear encoder is scratch-sensitive and can be damaged by mechanical actions, e.g. from pointed objects.

- Treat the ruler with extreme care.

NOTICE**Malfunction due to soiling!**

Any type of soiling, e.g. dust, oil, lubricant or condensation, will render the Q-521 inoperable.

- Keep the Q-521 free from dirt and condensation.
- Avoid touching the ceramic rail and the ruler.

NOTICE**Electrostatic hazard**

Touching the pins in the Sub-D 15 connection of models equipped with sensor can damage electrostatic (also: ESD-) sensitive components of the Q-521. For this reason, these models are supplied with ESD protection.

- Remove the ESD protection from the connection only when you connect the Q-521 to the controller.

NOTICE**Heating up of the Q-521 during operation!**

The heat produced during operation of the Q-521 can affect your application.

- Install the Q-521 so that the application is not impaired by the dissipated heat.
- Ensure sufficient ventilation at the place of installation.
- Make sure that the complete bottom side of the Q-521 is in contact with the surface on which the Q-521 is mounted.

NOTICE**Unintentional changes in position with vertical mounting!**

If the load exceeds the self-locking of the drive when the stage is mounted vertically, unintentional changes in the position of the moving platform occur. Unintentional changes in position of the moving platform can damage the drive, the load or the environment.

- When the stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive (p. 61).

NOTICE**Damage from unsuitable cables!**

Unsuitable cables can damage the electronics.

- Only use cables provided by PI for connecting the Q-521 to the electronics.

INFORMATION

For optimum repeatability, all components must be firmly affixed to each other.

INFORMATION

When handling the vacuum version of the stage, appropriate cleanliness must be ensured.

- Only touch the stage with powder-free gloves.
- If necessary, wipe the stage clean.

INFORMATION

The positive direction of motion of the axis is given in the product view (p. 10).

5.2 Mounting the Q-521 on a Surface and Connecting It to a Protective Earth Conductor

NOTICE**Protruding screw heads!**

Protruding screw heads can damage the Q-521.

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

NOTICE**Warping of the Q-521 due to mounting on uneven surfaces!**

Mounting the Q-521 on an uneven surface can warp the Q-521. Warping reduces the accuracy.

- Mount the Q-521 on an even surface. The recommended evenness of the surface is $\leq 2 \mu\text{m}$.
- For applications with large temperature changes:
Only mount the Q-521 on surfaces that have the same or similar thermal expansion properties as the Q-521.

INFORMATION

The electrical contact of the Q-521 to the protective earth conductor is established via the surface, on which the Q-521 is mounted.

- The corresponding contact surfaces must be sufficiently conductive.
- The protective earth conductor is connected to the surface on which the Q-521 is mounted.
- The screws are secured against unintentional loosening; e.g., with thread-locking adhesive.

INFORMATION

- Observe the applicable standards for mounting the protective earth conductor.

You have the following options for fastening the Q-521:

- From above with 2 M2x6 screws
- From below with 4 M2 screws of suitable length

Requirements

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ The Q-521 is disconnected from the electronics.
- ✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws and locating pins, see "Dimensions" (p. 65)):
 - The surface must be connected to the protective earth conductor.
 - The contact surfaces to the bottom side of the stage have to be sufficiently conductive to ensure the proper functioning of the protective earth conductor.
 - The contact resistance at all connection points relevant for mounting the protective earth conductor is $<0.1 \Omega$ at 25 A.
 - For applications with large temperature changes: The surface should have the same thermal expansion properties as the Q-521 (e.g., surface made of steel).
 - The evenness of the surface is $\leq 2 \mu\text{m}$.
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

Tools and accessories

- Screws:
 - For mounting from above: 2 M2x6 socket head cap screws in the scope of delivery (p. 13)
 - For mounting from below: 4 M2 screws of suitable length

- Option: 2 1.5 m6 x 4 locating pins, in the scope of delivery
- Suitable tools for tightening the screws
- Thread-locking adhesive

Mounting the Q-521 on a surface and connecting it to a protective earth conductor

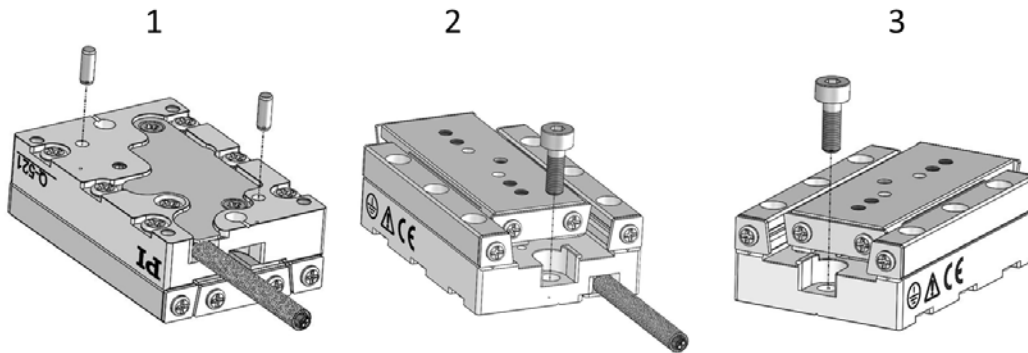


Figure 6: Mounting from above, using a Q-521.2xx as an example

- 1 Option: Aligning the stage (view from below) on the surface with 1.5 m6 x 4 locating pins.
 2, 3 Mounting the stage on the surface with two M2x6 screws.

1. Option: Align the Q-521 on the surface with the locating pins.
2. Mount the Q-521 on the surface.
 Maximum torque: 35 Ncm
 For mounting from above:
 - If necessary, manually displace the moving platform of the Q-521 to access the countersunk holes in the base body.
 For mounting from below:
 - Maximum screw-in depth in the Q-521: 4 mm
3. Secure the screws against unintentional loosening, e.g., with thread-locking adhesive.
4. Check that the Q-521 is affixed firmly.

5.3 Setting Up a Multi-Axis System

The Q-521 can be used in multi-axis systems.

Typical combinations:

- XY system (p. 27)
- Z system (p. 30) (XZ or XYZ combination)

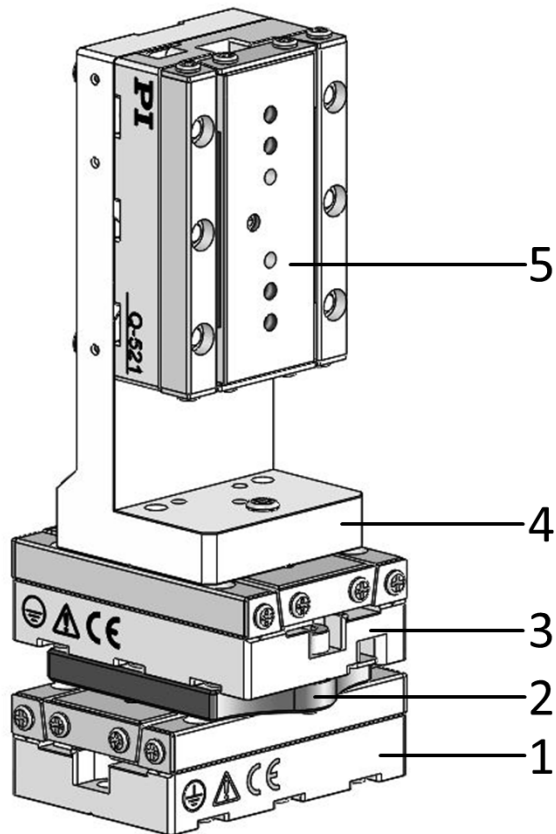


Figure 7: Example of an XYZ system: Three Q-521.240 mounted using an adapter plate and an adapter bracket

- 1 Lower stage
- 2 Q-121.80U adapter plate (for use in a vacuum to 10^{-9} hPa)
- 3 Middle stage
- 4 Q-121.x0U adapter bracket (for use in a vacuum to 10^{-6} hPa)
- 5 Upper stage

5.3.1 General Information on Setting Up a Multi-Axis System

NOTICE



Impermissibly high load on the stages!

In a multi-axis system, the stage used for the Y and/or Z axis must also be moved. Impermissibly high loads impair the motion and can damage the stages.

- Include the masses of the moved stages and the mounting adapters (p. 14) in the calculation of the load to be moved.
- For all stages in a multi-axis system: Do **not** exceed the maximum permissible load.
- When a stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.

- Only install and operate the multi-axis system after you have read and understood the user manuals of all components of the multi-axis system.
- If you require special mounting adapters, contact our customer service department (p. 59).

5.3.2 Setting Up an XY System

NOTICE



Screws and locating pins that are too long!

Screws and locating pins that are inserted too deeply damage the Q-521.

- Observe the depth of the mounting holes (p. 65) in the moving platform.
- Observe the maximum depth for the insertion of locating pins (p. 65) into the moving platform.
- Only use screws and locating pins of the correct length for the respective holes.

INFORMATION

Any model of the Q-521 can be used as lower or upper stage.

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°

Requirements

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 27).
- ✓ The stages are disconnected from the electronics.
- ✓ You have properly mounted the lower stage on a surface and connected it to a protective earth conductor (p. 23).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

Tools and accessories

- Mounting accessories from the scope of delivery of the upper stage (p. 13):
 - 2 locating pins, 1.5 m6 x 4
 - 2 socket head cap screws, M2x6
- Q-121.80U adapter plate, available as an optional accessory (p. 14), including mounting accessories:
 - 2 locating pins, 1.5 m6 x 4
 - 2 machine screws, M2x4
- Suitable tools for tightening the screws

Setting up an XY system

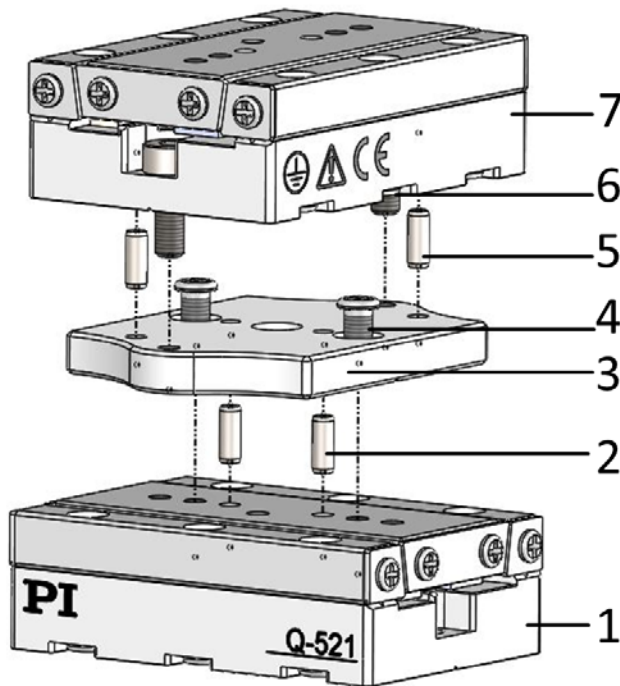


Figure 8: Example: Mounting a Q-521.240 on a Q-521.240

- 1 Lower stage
- 2 2 locating pins, 1.5 m6 x 4
- 3 Q-121.80U adapter plate
- 4 2 machine screws, M2x4
- 5 2 locating pins, 1.5 m6 x 4
- 6 2 socket head cap screws, M2x6
- 7 Upper stage

1. Mount the adapter plate on the lower stage with locating pins and M2x4 machine screws:
 - The counterbores of the three holes in the middle of the adapter plate point upwards.
 - Maximum torque: 35 Ncm
 - Check that adapter plate is affixed firmly.
2. Mount the upper stage on the adapter plate with locating pins and M2x6 socket head cap screws:
 - If necessary, manually displace the moving platform of the upper stage to access the countersunk holes in the base body.

- Maximum torque: 35 Ncm
- 3. Check that the upper stage is affixed firmly.

5.3.3 Setting Up a Z System with an Adapter Bracket

NOTICE



Screws and locating pins that are too long!

Screws and locating pins that are inserted too deeply damage the Q-521.

- Observe the depth of the mounting holes (p. 65) in the moving platform.
- Observe the maximum depth for the insertion of locating pins (p. 65) into the moving platform.
- Only use screws and locating pins of the correct length for the respective holes.

NOTICE



Warping of the Z system with large temperature changes!

Large temperature changes can cause warping of the Z system, because the Q-521 and the adapter bracket for the vertical mounting (p. 14) have different thermal expansion properties. Warping reduces the accuracy.

- Avoid large temperature changes for the Z system.
- If it is not possible to avoid large temperature changes: Do not use the locating pins for mounting.

Designations in these instructions:

- **Lower stage:** X axis in an XZ combination; Y axis in an XYZ combination. The stage to which the upper stage is mounted with an adapter bracket.
- **Upper stage:** Forms the Z axis of the multi-axis system; is mounted on the lower stage in a vertical alignment using an adapter bracket.

Recommended Z Systems

The following tables show recommended combinations of adapter brackets and stages.

Each upper stage is shown with the moving platform in the middle position and with a maximally extended platform.

Systems with Q-121.10U adapter bracket

		Orientation of adapter bracket and upper stage to the lower stage:			
Combination of stages and adapter bracket:	0°	90°	180°	270°	
<p>Q-521.1xx + Q-121.10U</p>					
<p>Q-521.2xx + Q-121.10U</p>	<p>Not possible. The moving platforms of the stages collide with each other.</p>		<p>Not possible. The moving platforms of the stages collide with each other.</p>		

Systems with Q-121.20U adapter bracket

		Orientation of adapter bracket and upper stage to the lower stage:			
Combination of stages and adapter bracket:	0°	90°	180°	270°	
<p>Q-521.2xx + Q-121.20U</p>					
<p>Q-521.3xx + Q-121.20U</p>	<p>Not possible. The moving platforms of the stages collide with each other.</p>		<p>Not possible. The moving platforms of the stages collide with each other.</p>		

Systems with Q-121.30U adapter bracket

Orientation of adapter bracket and upper stage to the lower stage:				
Combination of stages and adapter bracket:	0°	90°	180°	270°
<p>Q-521.3xx +</p> <p>Q-121.30U</p>				

Requirements

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 27).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.
- ✓ If you set up an XZ combination: You have properly mounted the lower stage on a surface.
- ✓ If you set up an XYZ combination: You have properly mounted the stages for the X and Y axis. (p. 27)

Tools and accessories

- Suitable adapter bracket; for combination options, see "Recommended Z Systems" p. 30. Available as optional accessories (p. 14):

- Q-121.10U adapter bracket
- Q-121.20U adapter bracket
- Q-121.30U adapter bracket

For the diameter and position of the holes in the adapter bracket, see "Dimensions" (p. 65)

- Mounting accessories from the scope of delivery of the adapter bracket:
 - 4 locating pins, 1.5 m6 x 5
 - 6 machine screws, M2x8
- Suitable tools for tightening the screws

Setting up a Z system with an adapter bracket

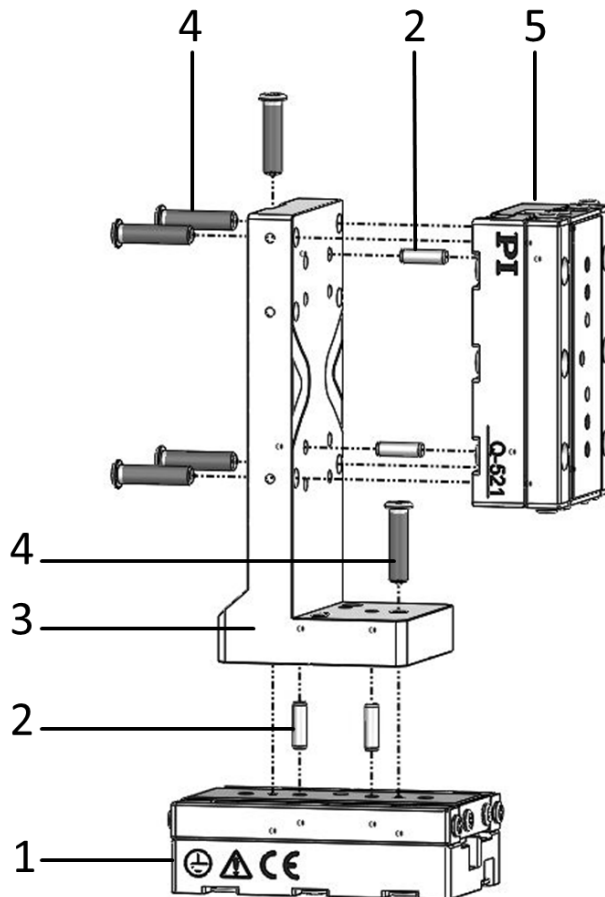


Figure 9: Example: Setting up an XZ system consisting of two Q-521.240 and a Q-121.20U adapter bracket

- 1 Lower stage
- 2 4 locating pins, 1.5 m6 x 5
- 3 Q-121.20U adapter bracket
- 4 6 machine screws, M2x8
- 5 Upper stage

1. Mount the upper stage to the long side of the adapter bracket:
 - Align the upper stage so that the cable exit points away from the origin of the sides of the adapter bracket; i.e., upwards in the Z system.
 - Maximum torque: 35 Ncm.
2. Mount the short side of the adapter bracket to the moving platform of the lower stage:
 - Permissible alignments, see "Recommended Z systems"
 - Maximum torque: 35 Ncm

3. Check that the adapter bracket and the upper stage are affixed firmly.

5.4 Affixing the Load to the Q-521

NOTICE



Impermissibly high forces and torques!

Impermissibly high forces and torques that are applied to the moving platform can damage the Q-521.

- For affixing type and mass of the load, observe the maximum permissible forces according to the specifications (p. 61).
- Avoid tilting torques at the moving platform.

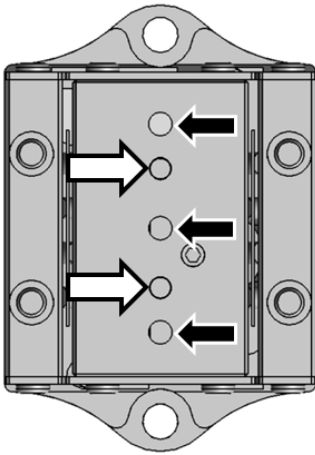
NOTICE



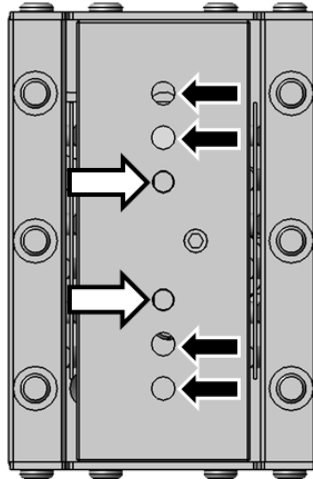
Screws and locating pins that are too long!

Screws and locating pins that are inserted too deeply damage the Q-521.

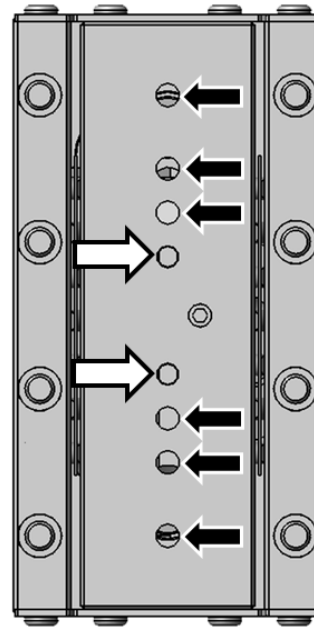
- Observe the depth of the mounting holes (p. 65) in the moving platform.
- Observe the maximum depth for the insertion of locating pins (p. 65) into the moving platform.
- Only use screws and locating pins of the correct length for the respective holes.



Q-521.1xx



Q-521.2xx



Q-521.3xx

The arrows mark the mounting holes in the moving platform of the Q-521:

For aligning the load:

White arrows: Locating holes \varnothing 1.5 mm H7, depth 3 mm

For affixing the load:

Black arrows: M2 threaded holes, depth 3 mm

Requirements

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have properly mounted the stage on a surface (p. 23) or on a Q-521 (p. 25).
- ✓ The stage is disconnected from the electronics.
- ✓ You have prepared the load so that it can be affixed to the moving platform:
 - The distance between the center of gravity of the load and the center of the moving platform is as small as possible in all directions.
 - At least three points are provided for affixing the load on the moving platform.

Tools and accessories

- At least three M2 screws of suitable length (p. 65)
- Suitable tools for tightening the screws
- 2 locating pins of suitable length, for locating holes with \varnothing 1.5 mm H7

Affixing the load to the Q-521

1. Option: Align the load on the Q-521 with the locating pins.
2. Affix the load using the screws.
 - Maximum torque: 35 Ncm
3. Check that load is affixed firmly.

5.5 Connecting the Q-521 to the Electronics

The electronics to be used for operating the Q-521 depends on the presence of a sensor (see also "Suitable Electronics" (p. 15)):

- Models without sensor (Q-521.x0x): E-870 drive electronics (p. 38)
- Models with sensor (Q-521.x3x, Q-521.x4x): E-871 or E-873 controller (p. 41)

INFORMATION

The Q-521 and the electronics can be delivered as a pre-configured system.

- If a connection assignment is given on the labels of the Q-521 and/or electronics, observe this assignment when connecting the Q-521.

5.5.1 Connecting the Q-521 to the Drive Electronics

Requirements

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have installed the E-870 drive electronics (p. 15).
- ✓ You have read and understood the user manual of the drive electronics.
- ✓ The drive electronics are switched off; i.e., **not** connected to the power source.

Tools and accessories

- If the drive electronics have a Mini-DIN 4 socket (models: E-870.x1, E-870.xG): 7202500042-0015 adapter cable, in the scope of delivery (p. 13)
- If the drive electronics have a connector strip (model E-870.10): Suitable adapter from Sub-D 15 (f) to the connector strip:
 - The pin assignment of the J10 connector strip (2x4 pin) can be found in the E870T0001 Technical Note.
 - If you need a suitable adapter, contact our customer service department (p. 59).

- If a Q-521.x0U is to be operated at atmospheric pressure: 5604500041 adapter, in the scope of delivery (p. 13)
- If the Q-521 is to be operated in a vacuum:
 - E-873.UHVx extension cable, available as optional accessory (p. 14)
 - Suitable vacuum feedthrough, available as an optional accessory (p. 14):
For Q-521.x00: C-815.VF (suitable for use in a vacuum to 10^{-6} hPa)
For Q-521.x0U: C-815.VFUx (suitable for use in a vacuum to 10^{-9} hPa)
 - Suitable tools for installing the vacuum feedthrough

Connecting the Q-521.x0x to E-870 drive electronics with Mini-DIN 4 socket for operation at atmospheric pressure

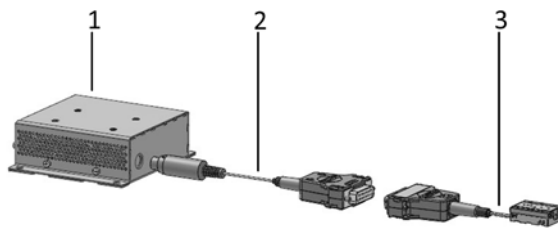


Figure 10: Connection diagram for Q-521.x00 and drive electronics with Mini-DIN 4 socket, for operation at atmospheric pressure

- 1 Drive electronics with Mini-DIN 4 socket (here E-870.xG)
- 2 7202500042-0015 adapter cable
- 3 Q-521.x00

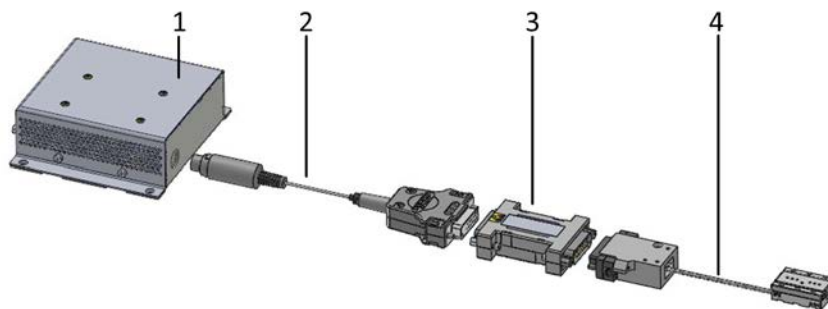


Figure 11: Connection diagram for Q-521.x0U and drive electronics with Mini-DIN 4 socket, for operation at atmospheric pressure

- 1 Drive electronics with Mini-DIN 4 socket (here E-870.xG)
- 2 7202500042-0015 adapter cable
- 3 5604500041 adapter
- 4 Q-521.x0U

1. Connect the stage and drive electronics to each other as shown in the connection diagram above.
2. Take suitable measures to secure the connections against accidental disconnection.

Connecting the Q-521.x0x to E-870 drive electronics with Mini-DIN 4 socket for operation in a vacuum

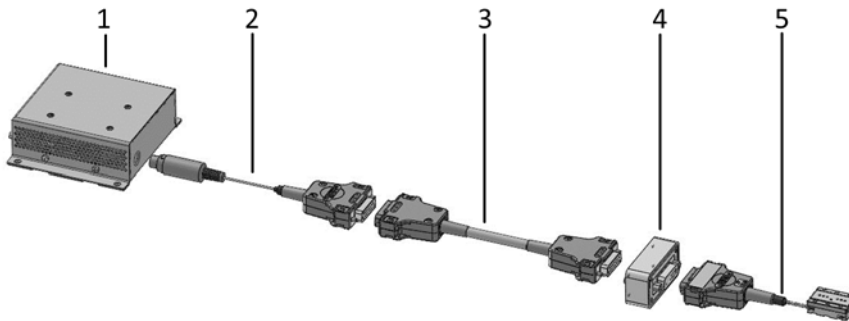


Figure 12: Connection diagram for Q-521.x00 and drive electronics with Mini-DIN 4 socket, for operation in a vacuum to 10^{-6} hPa

- 1 Drive electronics with Mini-DIN socket (here E-870.xG)
- 2 7202500042-0015 adapter cable
- 3 E-873.UHVx extension cable
- 4 C-815.VF vacuum feedthrough
- 5 Q-521.x00

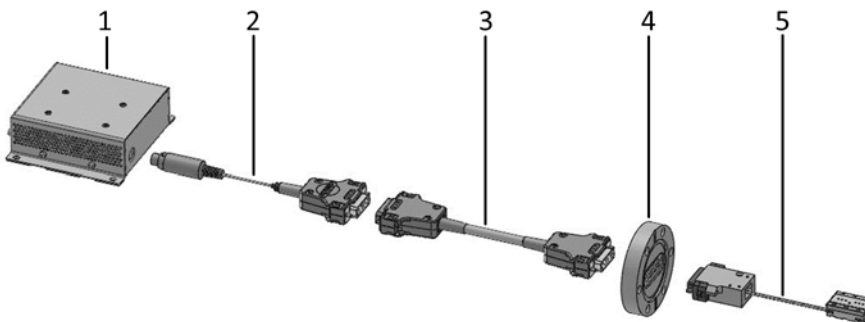


Figure 13: Connection diagram for Q-521.x0U and drive electronics with Mini-DIN 4 socket, for operation in a vacuum to 10^{-9} hPa

- 1 Drive electronics with Mini-DIN socket (here E-870.xG)
- 2 7202500042-0015 adapter cable
- 3 E-873.UHVx extension cable
- 4 C-815.VFUx vacuum feedthrough (here C-815.VFU1)
- 5 Q-521.x0U

1. Before connecting for the first time: Install the vacuum feedthrough:

- a) Obtain the dimensions from the corresponding dimensional drawing (p. 72).
 - b) Make sure that the vacuum feedthrough is oriented correctly:
C-815.VF: Vacuum side = Sub-D 15 (f) socket
C-815.VFUx: See dimensional drawing (p. 72)
 - c) Make a suitable opening in the vacuum chamber.
 - d) Install the vacuum feedthrough.
2. Connect the stage and drive electronics to each other as shown in the connection diagram above.
 3. Take suitable measures to secure the connections against accidental disconnection.

Connecting the Q-521.x0x to E-870 drive electronics with connector strip

If a Q-521.x0x is to be operated at atmospheric pressure:

- Connect the Q-521.x0x to the connector strip of the drive electronics using a suitable adapter.

If a Q-521.x0x is to be operated in a vacuum:

1. Follow the instructions in "Connecting the Q-521.x0x to E-870 drive electronics with Mini-DIN 4 socket for operation in a vacuum" to install the vacuum feedthrough and to connect the stage, vacuum feedthrough, and cables.
2. Connect the 7202500042-0015 adapter cable to the connector strip of the drive electronics using a suitable adapter.

5.5.2 Connecting the Q-521 to the Controller

Requirements

- ✓ You have read and understood the general notes on installation (p. 21).
- ✓ You have installed the controller (p. 15).
- ✓ You have read and understood the user manual of the controller.
- ✓ The controller is switched off.

Tools and accessories

- For connection to E-871: 7202500043-0015 Y adapter cable, in the scope of delivery (p. 13)
- If a Q-521.x4U is to be operated at atmospheric pressure: 5604500041 adapter, in the scope of delivery (p. 13)
- If the Q-521 is to be operated in a vacuum:
 - E-873.UHVx extension cable, available as optional accessory (p. 14)
 - Suitable vacuum feedthrough, available as an optional accessory (p. 14):
For Q-521.xx0: C-815.VF
For Q-521.xxU: C-815.VFUx

- Suitable tools for installing the vacuum feedthrough

Connecting the Q-521.x3x or Q-521.x4x to the E-871 controller for operation at atmospheric pressure

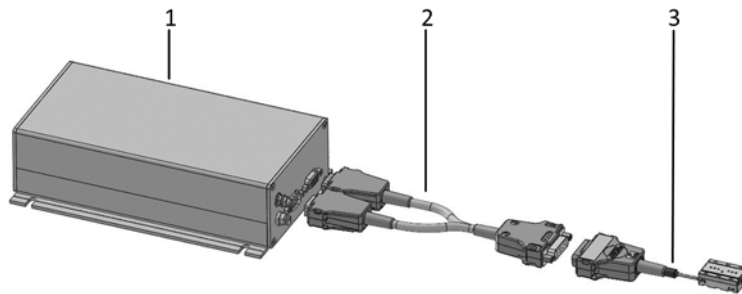


Figure 14: Connection diagram for Q-521.x30 or Q-521.x40 and E-871 controller, for operation at atmospheric pressure

- 1 E-871.1A1 controller
- 2 7202500043-0015 Y adapter cable
- 3 Q-521.x30 or Q-521.x40

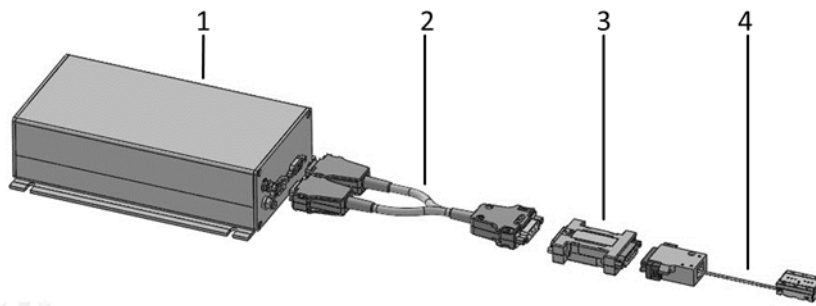


Figure 15: Connection diagram for Q-521.x4U and E-871 controller, for operation at atmospheric pressure

- 1 E-871.1A1 controller
- 2 7202500043-0015 Y adapter cable
- 3 5604500041 adapter
- 4 Q-521.x4U

1. Remove the ESD protection from the connection of the Q-521.
2. Connect the stage and controller to each other as shown in the connection diagram above.
3. Secure the connections with the integrated screws against accidental disconnection.

Connecting the Q-521.x3x or Q-521.x4x to the E-873 controller for operation at atmospheric pressure

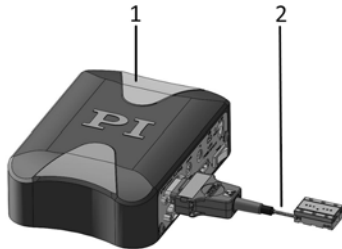


Figure 16: Connection diagram for Q-521.x30 or Q-521.x40 and E-873 controller, for operation at atmospheric pressure

- 1 E-873 controller (here E-873.1A1)
- 2 Q-521.x30 or Q-521.x40

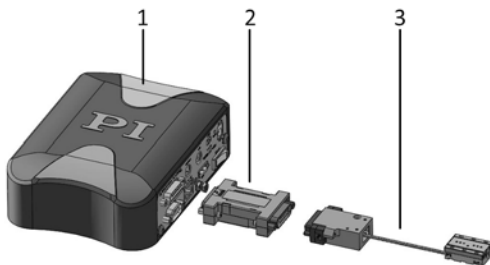


Figure 17: Connection diagram for Q-521.x4U and E-873 controller, for operation at atmospheric pressure

- 1 E-873 controller (here E-873.1A1)
- 2 5604500041 adapter
- 3 Q-521.x4U

1. Remove the ESD protection from the connection of the Q-521.
2. Connect the stage and controller to each other as shown in the connection diagram above.
3. Secure the connections with the integrated screws against accidental disconnection.

Connecting the Q-521.x3x or Q-521.x4x to the E-871 controller for operation in a vacuum

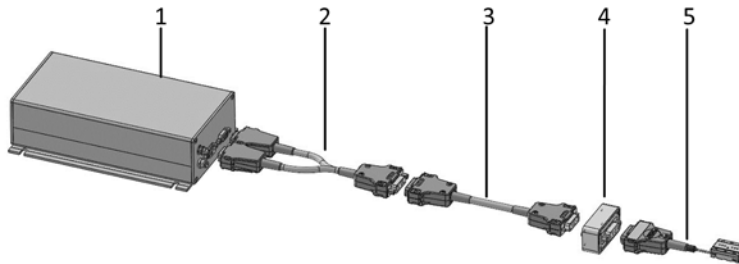


Figure 18: Connection diagram for Q-521.x30 or Q-521.x40 and E-871 controller, for operation in a vacuum to 10^{-6} hPa

- 1 E-871.1A1 controller
- 2 7202500043-0015 Y adapter cable
- 3 E-873.UHVx extension cable
- 4 C-815.VF vacuum feedthrough
- 5 Q-521.x30 or Q-521.x40

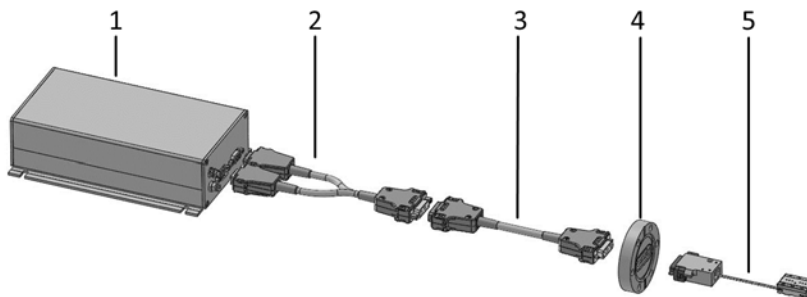


Figure 19: Connection diagram for Q-521.x4U and E-871 controller, for operation in a vacuum to 10^{-9} hPa

- 1 E-871.1A1 controller
- 2 7202500043-0015 Y adapter cable
- 3 E-873.UHVx extension cable
- 4 C-815.VFUx vacuum feedthrough (here C-815.VFU1)
- 5 Q-521.x4U

1. Before connecting for the first time: Install the vacuum feedthrough:
 - a) Obtain the dimensions from the corresponding dimensional drawing (p. 72).
 - b) Make sure the vacuum feedthrough is oriented correctly:
C-815.VF: Vacuum side = Sub-D 15 (f) socket
C-815.VFUx: See dimensional drawing (p. 72).
 - c) Make a suitable opening in the vacuum chamber.

- d) Install the vacuum feedthrough.
2. Remove the ESD protection from the connection of the Q-521.
3. Connect the stage and controller to each other as shown in the connection diagram above.
4. Secure the connections with the integrated screws against accidental disconnection.

Connecting the Q-521.x3x or Q-521.x4x to the E-873 controller for operation in a vacuum

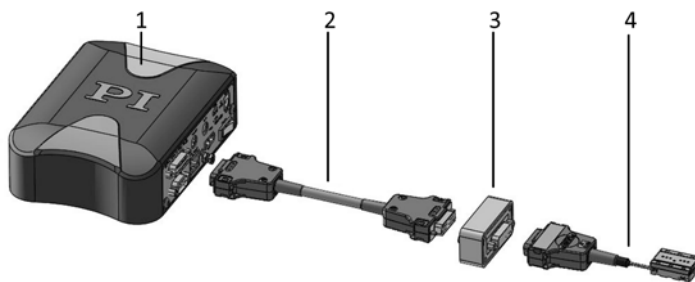


Figure 20: Connection diagram for Q-521.x30 or Q-521.x40 and E-873 controller, for operation in a vacuum to 10^{-6} hPa

- 1 E-873 controller (here E-873.1A1)
- 2 E-873.UHVx extension cable
- 3 C-815.VF vacuum feedthrough
- 4 Q-521.x30 or Q-521.x40

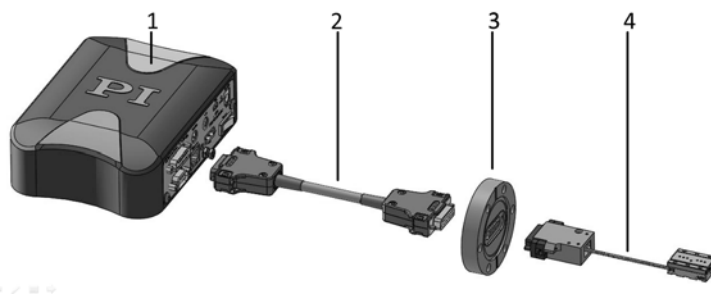


Figure 21: Connection diagram for Q-521.x4U and E-873 controller, for operation in a vacuum to 10^{-9} hPa

- 1 E-873 controller (here E-873.1A1)
- 2 E-873.UHVx extension cable
- 3 C-815.VFUx vacuum feedthrough (here C-815.VFU1)
- 4 Q-521.x4U

1. Before connecting for the first time: Install the vacuum feedthrough:
 - a) Obtain the dimensions from the corresponding dimensional drawing (p. 72).
 - b) Make sure the vacuum feedthrough is oriented correctly:
C-815.VF: Vacuum side = Sub-D 15 (f) socket
C-815.VFUx: See dimensional drawing (p. 72).
 - c) Make a suitable opening in the vacuum chamber.
 - d) Install the vacuum feedthrough.
2. Remove the ESD protection from the connection of the Q-521:
3. Connect the stage and controller to each other as shown in the connection diagram above.
4. Secure the connections with the integrated screws against accidental disconnection.

6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation	47
Starting Up the stage	50

6.1 General Notes on Start-Up and Operation

CAUTION



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

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the Q-521 in the case of malfunction or failure of the system. If touch voltages exist, touching the Q-521 can result in minor injuries from electric shock.

- Connect the Q-521 to a protective earth conductor (p. 23) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the Q-521 to the protective earth conductor before starting it up again.

CAUTION



Burning from hot surface!

The surface of the Q-521 and its vicinity can heat up during operation. Touching the Q-521 and surrounding parts can result in minor injuries from burning.

- Cool the Q-521 so that the temperature of its surface and surrounding parts does **not** exceed 65 °C.
- If sufficient cooling is not possible: Make sure that the hot Q-521 and its surrounding parts **cannot** be touched.
- If sufficient cooling and protection against contact are not possible: Mark the danger zone in accordance with the legal regulations.

NOTICE**Overheating during continuous operation!**

The highest velocity is achieved at maximum operating frequency; however, the Q-521 can overheat during continuous operation as a result.

- Observe the recommended operating time according to the operating frequency in step mode (p. 64).
- Ensure sufficient ventilation at the place of installation.

NOTICE**Damage from collisions!**

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

- Make sure that no collisions are possible between the stage, the load to be moved and the environment 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 an electronics malfunction occurs.

NOTICE**Operating frequency too high!**

An operating frequency that is too high can cause damage to the Q-521.

- Only operate the Q-521 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating frequency range (p. 63) for which the Q-521 is specified.

NOTICE**Considerable wear due to high operating frequency!**

A high operating frequency in step mode can cause considerable wear on the mechanical system.

- When the E-870 drive electronics are used:
 - If necessary, reduce the values of the parameters **PIShift Steps per Second** (ID 0x1F000600) and **PIShift Frequency** (ID 0x1F000400) on the drive electronics, see documentation of the drive electronics.
- When the E-871 controller is used:
 - When the **PIShift Open-Loop Driving Mode** (ID 0x1F000702) parameter has a value of 0 (step mode) and motions in open-loop operation are initiated with the SMO command: The step frequency depends directly from the control value commanded with SMO and is limited by the value of the **Maximum Motor Output** (ID 0x9) parameter. If necessary, reduce the commanded control value and the value of the **Maximum Motor Output** parameter.
- Reduce the operating time with a high operating frequency (p. 64).
- Stop the motion immediately if an electronics malfunction occurs.

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

Operating voltages that are too high or incorrectly connected can cause damage to the Q-521.

- Only operate the Q-521 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 63) for which the Q-521 is specified.
- Only operate the Q-521 when the operating voltage is properly connected; see "Pin Assignment" (p. 78).

NOTICE**Reduced lifetime of the piezo actuator due to permanently high voltage!**

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic of the Q-521.

- When the Q-521 is not used, switch off the electronics.

NOTICE**Destruction of the piezo actuators by electric flashovers!**

Using the Q-521 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuators of the drive by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids and conductive materials (e.g. metal dust). In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- Avoid operating the Q-521 in environments that can increase the electrical conductivity.
- Only operate the Q-521 within the permissible ambient conditions and classifications (p. 63).
- For operation in vacuum below 0.1 hPa:
Do **not** operate the Q-521 during evacuation.

NOTICE**Increased wear due to small working range!**

Using a small working range permanently increases the wear in this area.

- If possible: Select another part of the travel range for the working range in regular intervals.

6.2 Starting Up the stage

The electronics to be used for operating the Q-521 depends on the presence of a sensor (see also "Suitable Electronics" (p. 15)):

- Models without sensor (Q-521.x0x): E-870 drive electronics (p. 51)
- Models with sensor (Q-521.x3x, Q-521.x4x): E-871 or E-873 controller (p. 52)

INFORMATION

If the parameters of the electronics are not adapted to the Q-521 and the application (load, orientation of the Q-521), the Q-521 will either not move or not move satisfactorily.

- Only operate the Q-521 when the parameters of the electronics have been correctly set.
- Pay particular attention to the parameter settings for operating voltage and operating frequency.

INFORMATION

The PIShift drive generates noise in step mode. The noise generation depends on the current step frequency.

6.2.1 Starting Up the Q-521.x0x with Drive Electronics

INFORMATION

The values for the parameters of the E-870 drive electronics are listed in a table in this section. For optimum drive performance, the values of the following parameters should be identical:

- **PIShift Steps per Second** (ID 0x1F000600)
- **PIShift Frequency** (ID 0x1F000400)

Requirements

- ✓ You have read and understood the general notes on start-up and operation (p. 47).
- ✓ You have read and understood the documentation of the E-870 drive electronics (E870T0001 Technical Note or E870T0002 Technical Note).
- ✓ You have properly installed (p. 21) the stage.
- ✓ The E-870 drive electronics have been properly installed and all connections on the E-870 have been set up (see E870T0001 Technical Note or E870T0002 Technical Note).

Starting up the Q-521.x0x with drive electronics

1. Make sure that the parameters of the E-870 drive electronics have been set correctly; for values, see table below.
2. Provide the control signal required for operating the system. Details can be found in the E870T0001 or E870T0002 Technical Note.
3. If necessary: Adapt the **PIShift Steps per Second** parameter (ID 0x1F000600) and the **PIShift Frequency** parameter (ID 0x1F000400) to your application (see also "Operating Time" (p. 64)).

The following table lists the settings for the parameters of the E-870 drive electronics. Further information on the parameter settings is found in the "Operating Time" section (p. 64).

Parameter	Parameter in E-870 Drive Electronics	Value	Unit
Operating voltage, upper limit	PIShift Upper Supply Voltage ID 0x1F000000	48	V
Operating voltage, lower limit	PIShift Lower Supply Voltage ID 0x1F000100	0	V
Charging current during forward motion	PIShift Forward Current ID 0x1F000200	0.2	A

Parameter	Parameter in E-870 Drive Electronics	Value	Unit
Charging current during backward motion	<i>PIShift Backward Current</i> ID 0x1F000300	-0.2	A
Operating frequency in step mode	<i>PIShift Frequency</i> ID 0x1F000400	20000	Hz
Duty cycle of the current source during the output of one period of the modified sawtooth signal in step mode	<i>PIShift Charge Cycle</i> ID 0x1F000500	1	-
Number of steps that the stage moves per second with the set operating frequency.	<i>PIShift Steps per Second</i> ID 0x1F000600	20000	

6.2.2 Starting Up the Q-521.x3x or Q-521.x4x with a Controller

INFORMATION

If you use the software included in the scope of delivery of the E-871 or E-873 controller, the operating parameters can be loaded from the *PIMicosStages2.dat* stage database. The entries in the stage database are updated regularly.

- Download the PI Update Finder from the PI website (<http://www.update.pi-portal.ws>) and use it to update the *PIMicosStages2.dat* stage database on your PC.

For further information, see the user manual of the E-871 controller.

INFORMATION

For optimum drive performance in step mode, the ***Maximum Motor Output*** (ID 0x9) parameter in the *PIMicosStages2.dat* stage database takes a value of 15 kHz.

For further information, see "Operating Time" (p. 64) and user manual of the E-871 controller.

Requirements

- ✓ You have read and understood the general notes on start-up and operation (p. 47).
- ✓ You have properly installed (p. 21) 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).

Starting up the Q-521.x3x or Q-521.x4x with the E-871 or E-873 controller

1. Start up the stage (see user manual of the controller).
The start-up comprises the following steps:
 - Selecting the stage type
 - Defining the reference point of the axis
 - Commanding of first motions for testing
2. If necessary: Adapt the **Maximum Motor Output** (ID 0x9) parameter to your application (also refer to "General Notes on Start-Up and Operation" (p. 47) and "Operating Time" (p. 64)).

In the user manual of the controller, the start-up is described using the PIMikroMove program.

7 Maintenance

In this Chapter

General Notes on Maintenance.....	55
Performing a Maintenance Run.....	55
Cleaning the Q-521	55

7.1 General Notes on Maintenance

NOTICE



Damage due to improper maintenance!

Improper maintenance can lead to misalignment and failure of the Q-521.

- Only loosen screws according to the instructions in this manual.

7.2 Performing a Maintenance Run

The maintenance run must cover the entire travel range.

- Perform the maintenance run after every 10 million steps.

7.3 Cleaning the Q-521

Prerequisites

- ✓ You have disconnected the stage from the electronics.

Cleaning the stage

Only when the stage is **not** used in vacuum:

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

Only when the stage is used in vacuum:

- Only touch the stage with powder-free gloves.
- If necessary, wipe the stage clean.

8 Troubleshooting

Problem	Possible causes	Solution
Functional impairment after system modification	<ul style="list-style-type: none"> ▪ Drive electronics or controller has been replaced ▪ The stage has been replaced 	<p>E-870 drive electronics from PI:</p> <ul style="list-style-type: none"> ➤ Adapt the parameters of the drive electronics in the E-870 Control PC program to the Q-521 (see "Starting up the Q-521.x0x with the E-870 Drive Electronics" (p. 51) and Technical Note E870T0001 and/or E870T0002). <p>E-871 or E-873 controller from PI:</p> <ul style="list-style-type: none"> ➤ Load the parameter set from the stage database that corresponds to the Q-521 model. ➤ If necessary: Set the parameters on the controller in the PIMikroMove PC program so that they correspond to the application (load, orientation) of the Q-521 model (see user manual of the controller).
No or limited motion	Cable not connected correctly or defective	<ul style="list-style-type: none"> ➤ Check the connecting cable(s)
	Excessive load	<ul style="list-style-type: none"> ➤ Reduce the load. Observe the information in the "Technical Data" section (p. 61). ➤ If the stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.
	Parameters of the drive electronics incorrectly set	<ul style="list-style-type: none"> ➤ See the "Functional impairment after system modification" problem in this table.
	Operating voltage too low	<ul style="list-style-type: none"> ➤ Provide an operating voltage of 48 V.
	Unfavorable operating frequency for step mode	<ul style="list-style-type: none"> ➤ Adapt the operating frequency for the step mode (for details, see "Starting up the stage" (p. 50) and manual of the electronics used).
	Warped base body	<ul style="list-style-type: none"> ➤ Mount the Q-521 on an even surface. The recommended evenness of the surface is $\leq 2 \mu\text{m}$.

Problem	Possible causes	Solution
	Unfavorable load mounting	<ul style="list-style-type: none"> ➤ Observe the maximum torque when affixing the load (p. 36). ➤ Keep the distance between the center of gravity of the load and the center of the moving platform as small as possible in all directions.
	Unsuitable ambient conditions	<ul style="list-style-type: none"> ➤ Only operate the Q-521 in a clean environment and within the permissible ambient conditions (p. 63).
	Wear of the drive	<ul style="list-style-type: none"> ➤ Replace the Q-521 and make sure that the operating parameters of the electronics are adapted to the stage.
	Drive is blocked	<ul style="list-style-type: none"> ➤ Carefully release the blockage by manually moving the moving platform back and forth. ➤ Contact our customer service department (p. 59).

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. 59).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (info@pi.ws).

- If you have questions concerning your system, have the following information ready:
 - Product codes and serial numbers of all products in the system
 - Firmware version of the controller (if present)
 - Version of the driver or the software (if present)
 - Operating system on the PC (if present)
- 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. 3) on our website.

10 Technical Data

In this Chapter

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10.1 Specifications

10.1.1 Data Table

Preliminary Data	Q-521.130	Q-521.140 Q-521.14U	Q-521.230	Q-521.240 Q-521.24U	Q-521.330	Q-521.340 Q-521.34U	Q-521.x00 Q-521.x0U	Unit
Motion and positioning	12 mm travel range, resolution 4 nm	12 mm travel range, resolution 1 nm, UHV version Q-521.14U	22 mm travel range, resolution 4 nm	22 mm travel range, resolution 1 nm, UHV version Q-521.24U	32 mm travel range, resolution 4 nm	32 mm travel range, resolution 1 nm, UHV version Q-521.34U	12 mm to 32 mm travel range, open-loop, UHV versions Q-521.x0U	
Active axis	X	X	X	X	X	X	X	
Travel range	12	12	22	22	32	32	12 to 32	mm
Integrated sensor	Linear encoder	Linear encoder	Linear encoder	Linear encoder	Linear encoder	Linear encoder	-	
Sensor resolution	4	1	4	1	4	1	-	nm
Min. incremental motion	8	2	8	2	8	2	-	nm
Unidirectional repeatability over entire travel range	25	25	25	25	30	30	-	nm

Preliminary Data	Q-521.130	Q-521.140 Q-521.14U	Q-521.230	Q-521.240 Q-521.24U	Q-521.330	Q-521.340 Q-521.34U	Q-521.x00 Q-521.x0U	Unit
Bidirectional repeatability over entire travel range	40	40	40	40	50	50	-	nm
Unidirectional repeatability over 100 μm travel range	12	12	12	12	12	12	-	
Bidirectional repeatability over 100 μm travel range	24	24	24	24	24	24	-	nm
Pitch / yaw over entire travel range	100	100	100	100	100	100	100	μrad
Pitch / yaw over 100 μm travel range	1	1	1	1	1	1	1	μrad
Maximum velocity*	10	10	10	10	10	10	10	mm/s
Mechanical properties								
Load capacity	10	10	10	10	10	10	10	N
Push / pull force	1	1	1	1	1	1	1	N
Length	30	30	32.2	32.2	42.2	42.2	30 to 42.2	mm
Width	21	21	21	21	21	21	21	mm
Height	10	10	10	10	10	10	10	mm
Drive properties								
Motor type	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	
Miscellaneous								
Operating temperature range	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	$^{\circ}\text{C}$
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	

Preliminary Data	Q-521.130	Q-521.140 Q-521.14U	Q-521.230	Q-521.240 Q-521.24U	Q-521.330	Q-521.340 Q-521.34U	Q-521.x00 Q-521.x0U	Unit
Cable length	1	1	1	1	1	1	1	m
Connector	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	
Recommended controller	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-870	

* Typical velocity at a control frequency of 20 kHz

The specifications were determined on a surface with an evenness of 2 µm.

10.1.2 Maximum Ratings

The Q-521 stage is designed for the following operating data:

Maximum Operating Voltage	Maximum Operating Frequency	Maximum Power Consumption
48 V	20 kHz	10 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the Q-521:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	Q-521.xx0: 1100 hPa to 10 ⁻⁶ hPa Q-521.xxU: 1100 hPa to 10 ⁻⁹ hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C, non-condensing Decreasing linearly to 50 % relative humidity at 40 °C, non-condensing
Operating temperature	0 °C to 40 °C

Storage temperature	-20 °C to 70 °C
Transport temperature	-20 °C to 70 °C
Maximum bakeout temperature for Q-521.xxU:	120 °C, for 12 hours, only in switched-off state
Maximum bakeout temperature for Q-521.xx0:	80 °C, for 2 hours, only in switched-off state
Overvoltage category (acc. to EN 60664-1:2007 / VDE 0110-1)	II
Protection class (acc. to EN 61140 / VDE 0140-1)	I
Degree of pollution (acc. to EN 60664-1:2007 / VDE 0110-1)	1
Degree of protection (acc. to IEC 60529)	IP20

10.2 Operating Time

The operating time and the operating frequency in step mode affect the lifetime of the stage. In order to prevent overheating and high wear, the operating time with the given operating frequency and 100 % duty cycle must not exceed the values given in the following table.

Operating Frequency in Hz ¹	Operating Time ² / 48 V, ±0.2 A
20000	10 s (max.)
10000	20 s (max.)
5000	60 s (max.)
≤ 1000	120 s (max.)

¹ For the relevant parameters see "Starting Up the stage" (p. 50) and the user manual of the electronics used.

² With 100 % duty cycle without heat dissipation

10.3 Dimensions

10.3.1 Q-521.1xx

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

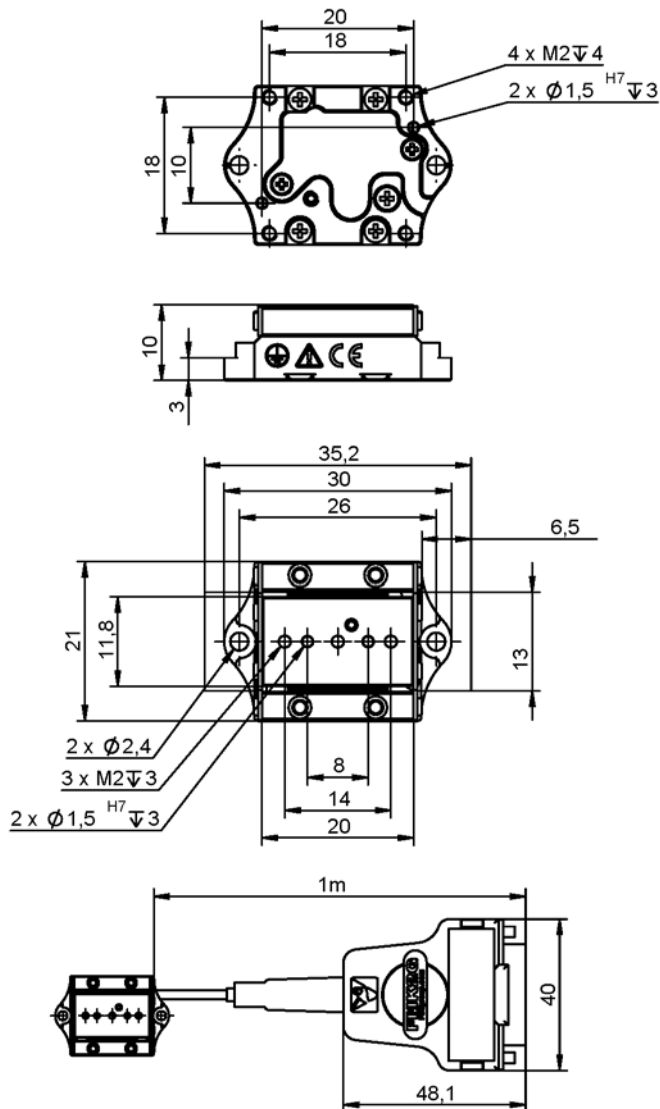


Figure 22: Q-521.1xx

10.3.2 Q-521.2xx

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

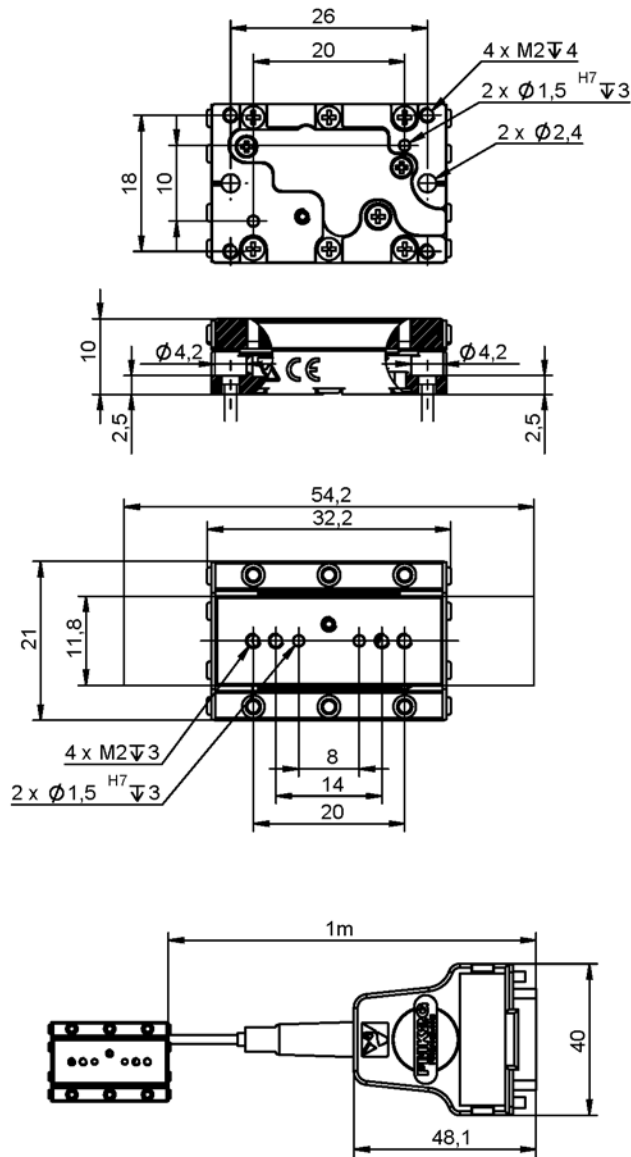


Figure 23: Q-521.2xx

10.3.3 Q-521.3xx

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

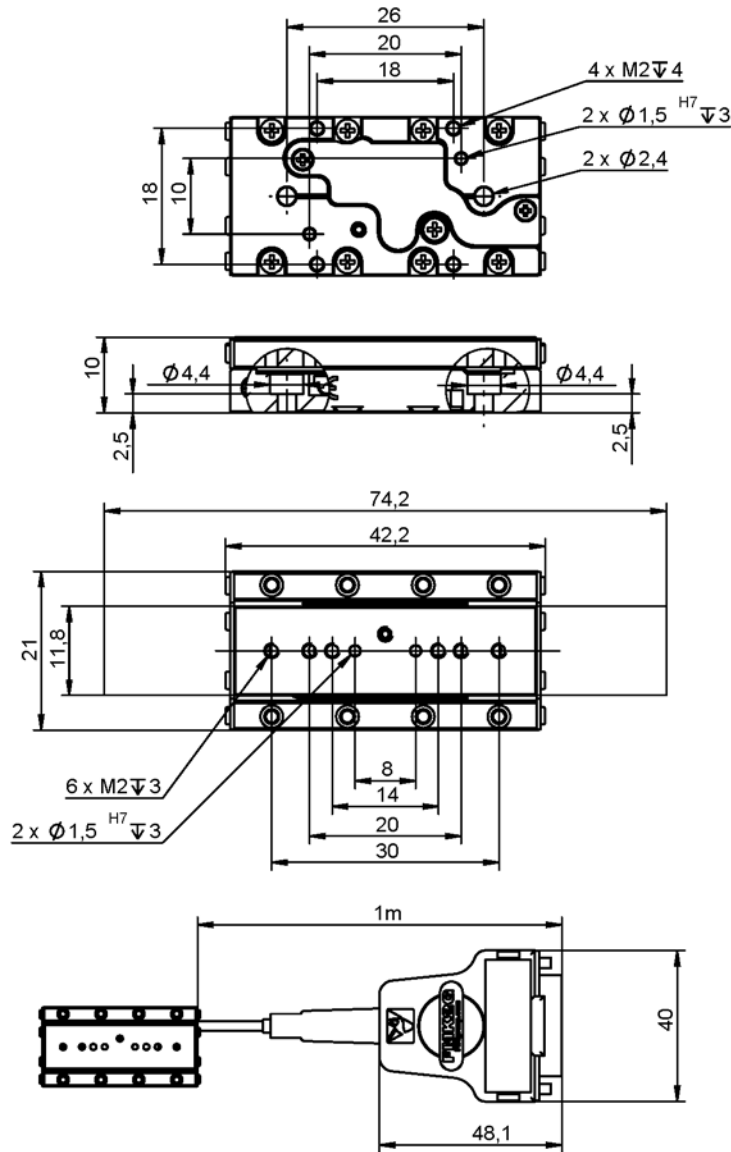


Figure 24: Q-521.3xx

10.3.4 Q-121.80U Adapter Plate

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

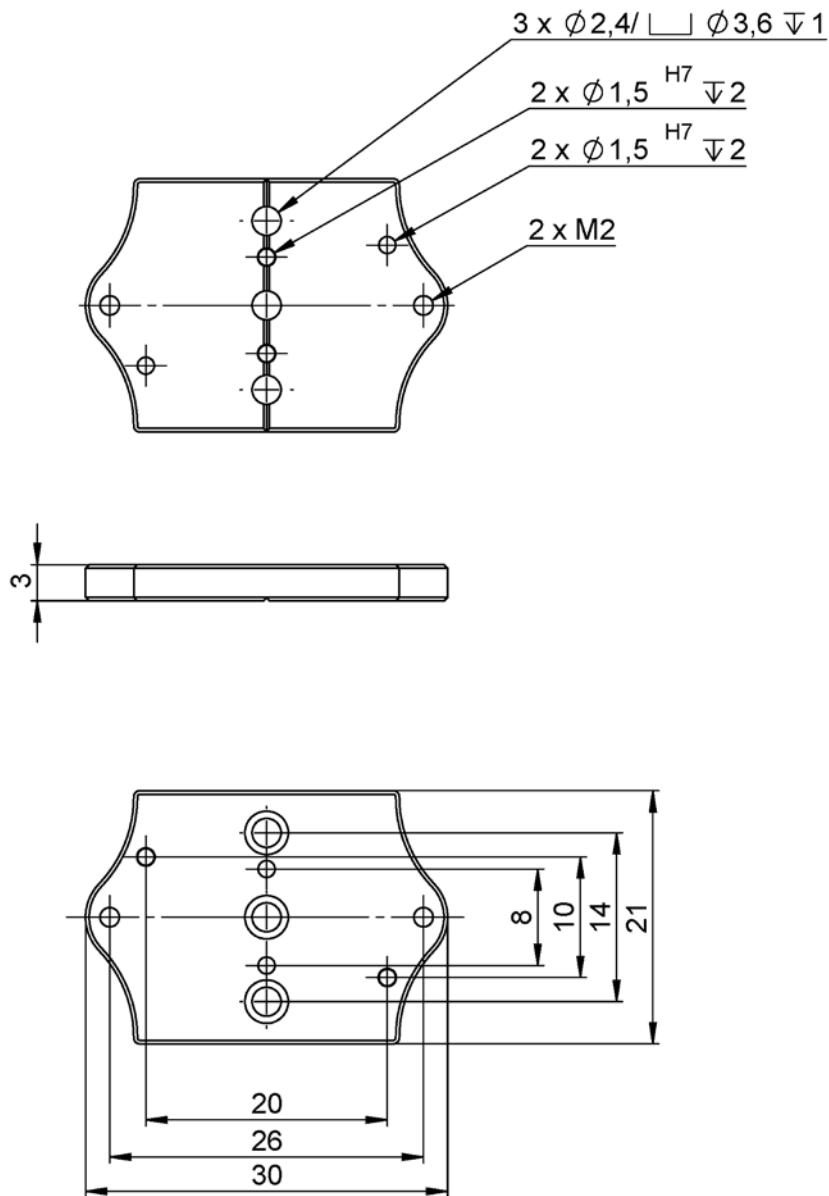


Figure 25: Q-121.80U adapter plate

10.3.5 Q-121.10U Adapter Bracket

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

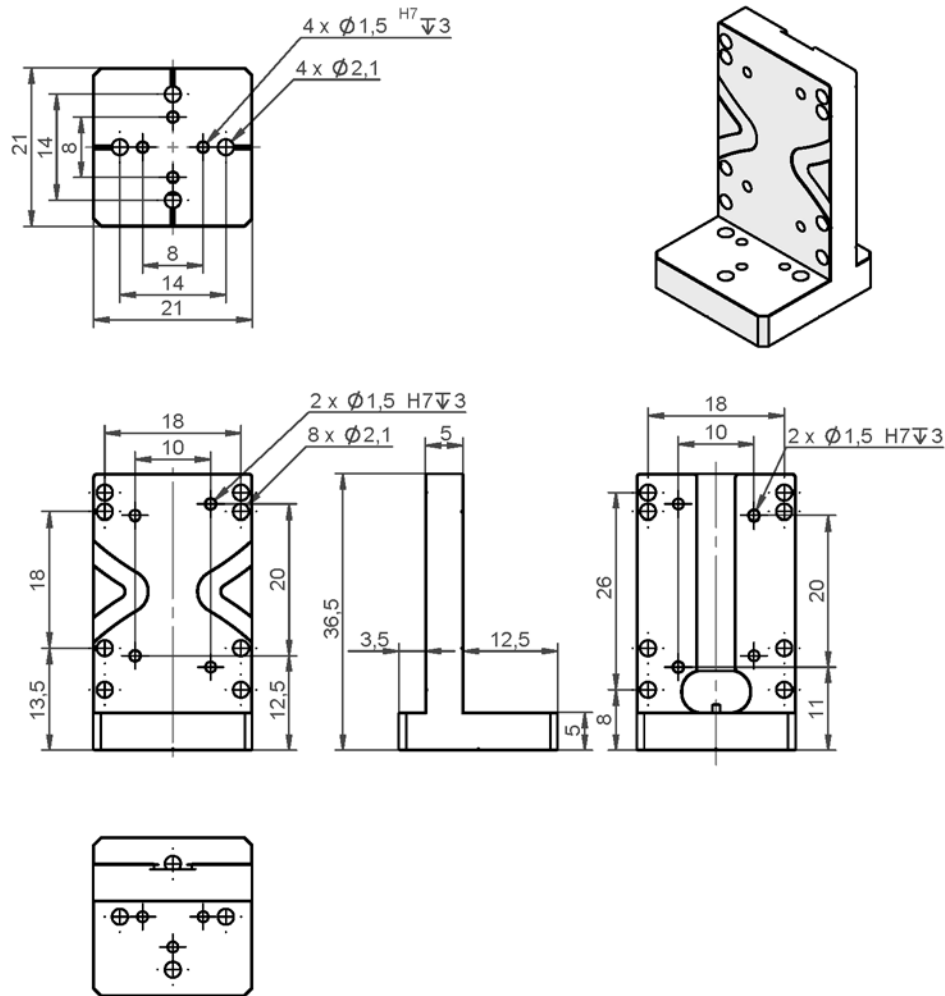


Figure 26: Q-121.10U adapter bracket

10.3.6 Q-121.20U Adapter Bracket

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

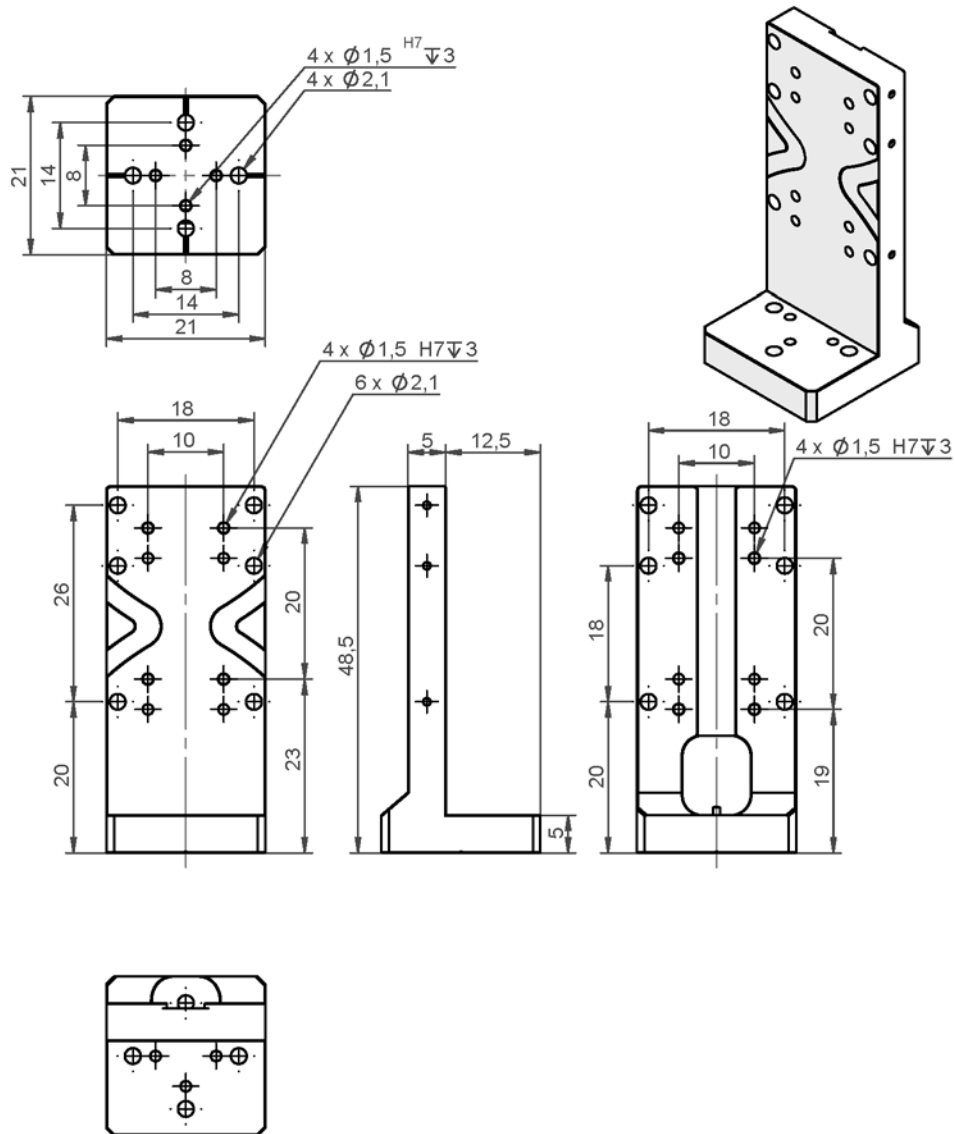


Figure 27: Q-121.20U adapter bracket

10.3.7 Q-121.30U Adapter Bracket

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

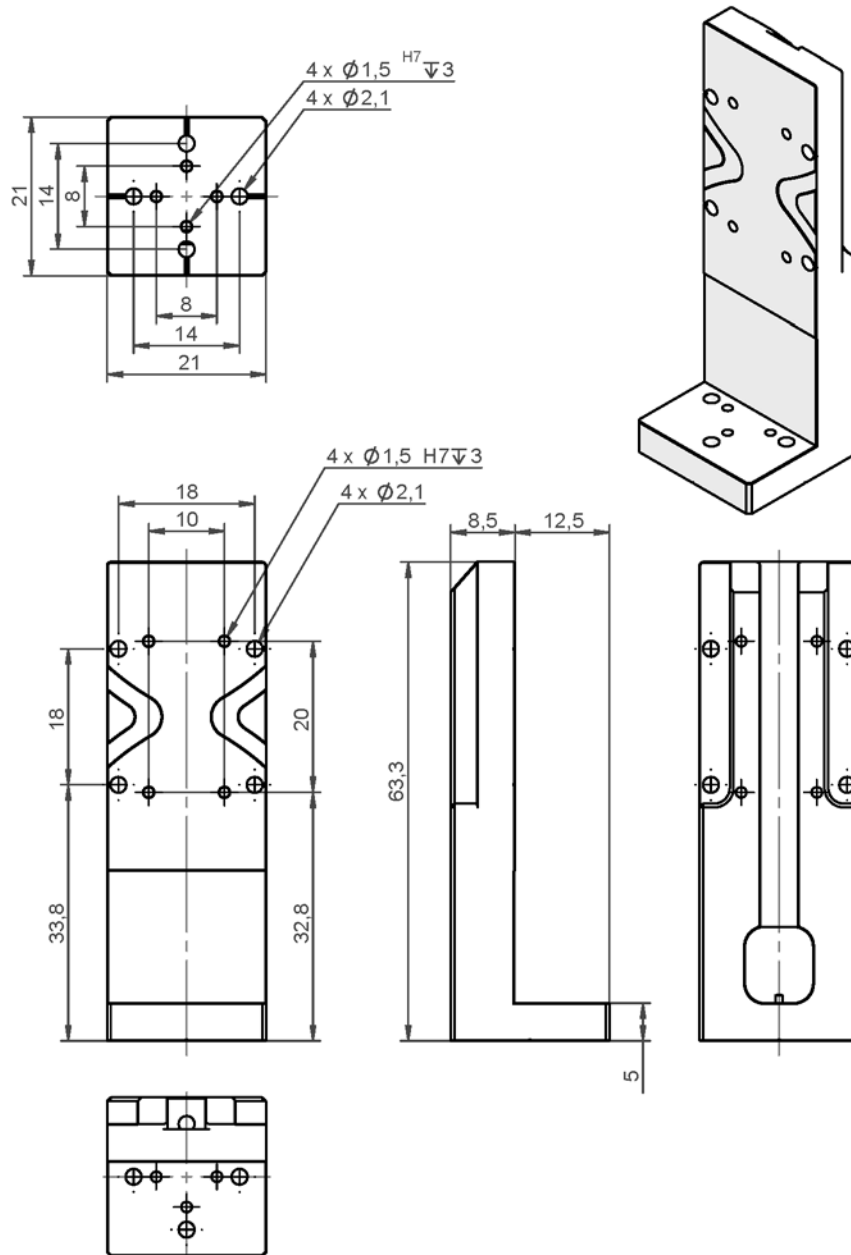


Figure 28: Q-121.30U adapter bracket

10.3.8 Vacuum Feedthroughs

Available vacuum feedthroughs:

- C-815.VF (p. 73)
- C-815.VFU1 (p. 74)
- C-815.VFU3 (p. 75)
- C-815.VFU6 (p. 76)
- C-815.VFU15 (p. 77)

C-815.VF vacuum feedthrough for 10⁻⁶ hPa

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

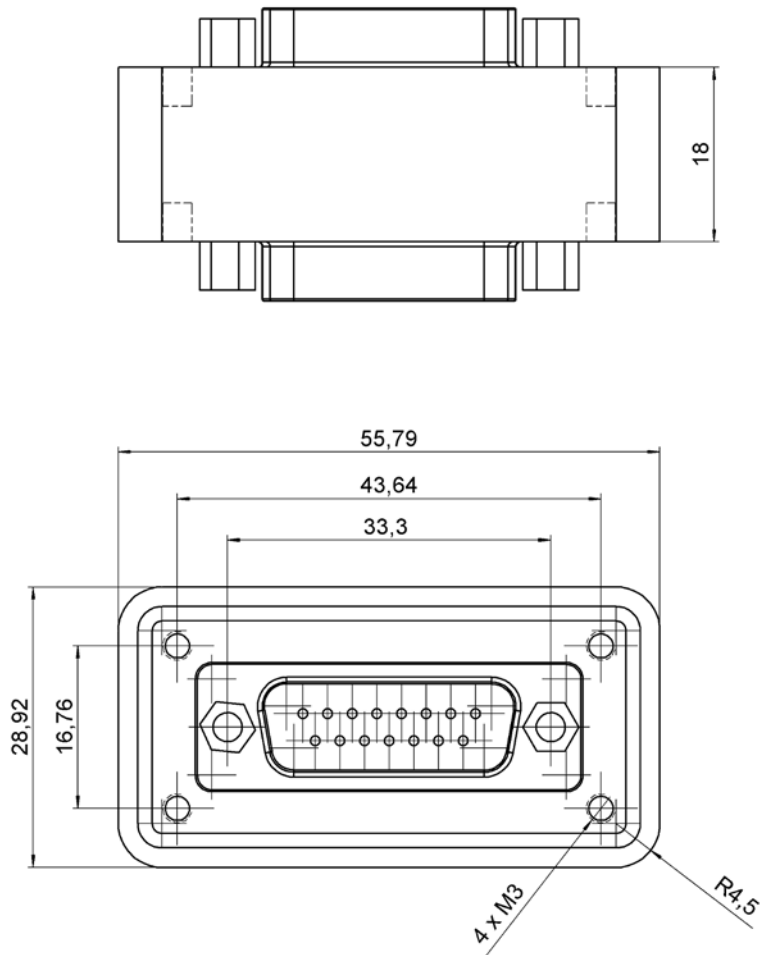


Figure 29: C-815.VF vacuum feedthrough Sub-D 15 (m/f)

C-815.VFU1 vacuum feedthrough for 10⁻⁹ hPa

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

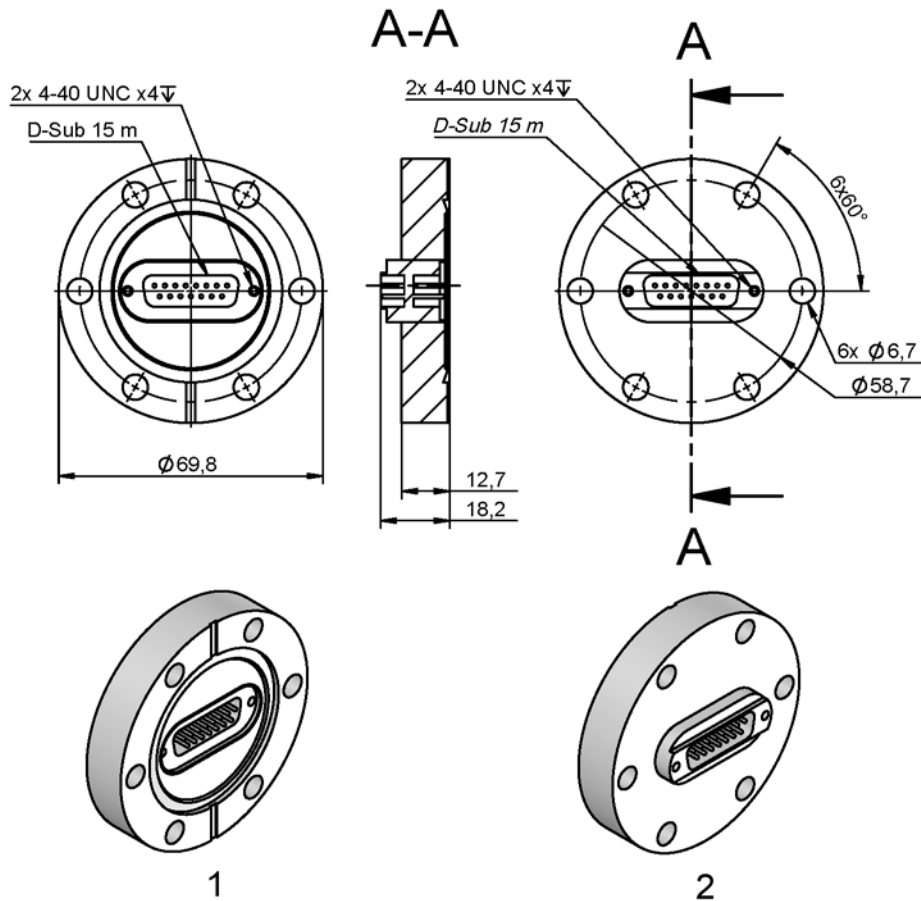


Figure 30: C-815.VFU1 vacuum feedthrough, Sub-D 15 (m/m)

- 1 Vacuum side
- 2 Air side

C-815.VFU3 vacuum feedthrough for 10⁻⁹ hPa

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

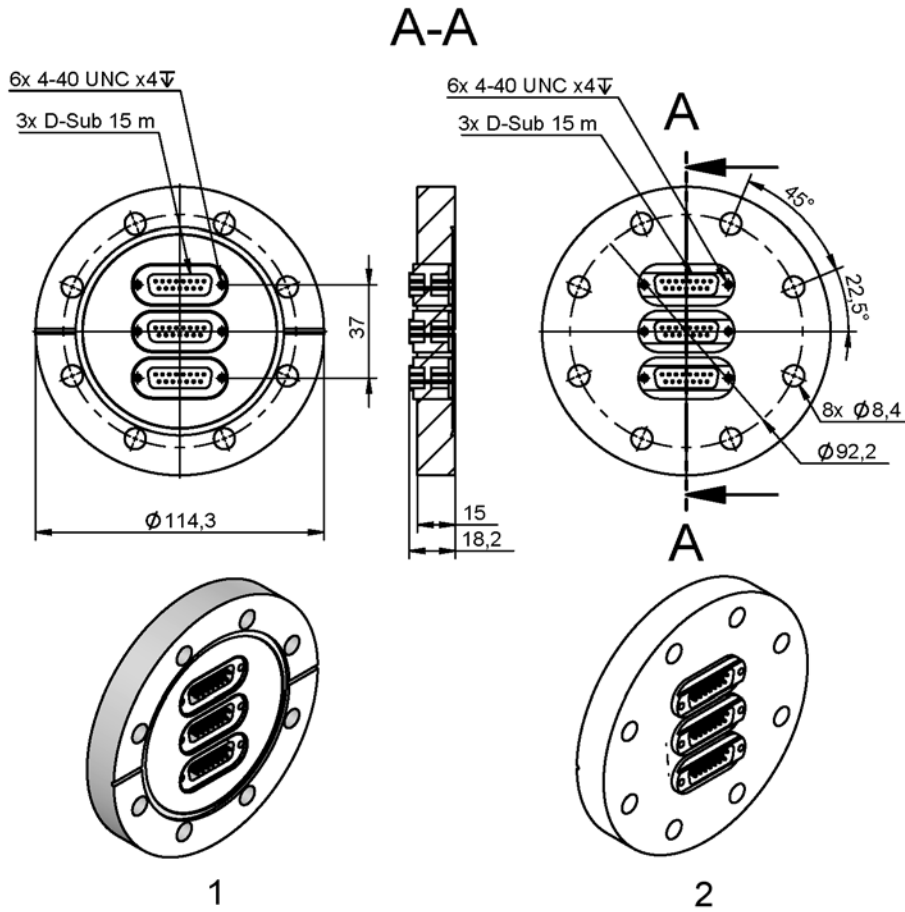


Figure 31: C-815.VFU3 vacuum feedthrough, Sub-D 15 (m/m)

- 1 Vacuum side
- 2 Air side

C-815.VFU6 vacuum feedthrough for 10⁻⁹ hPa

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

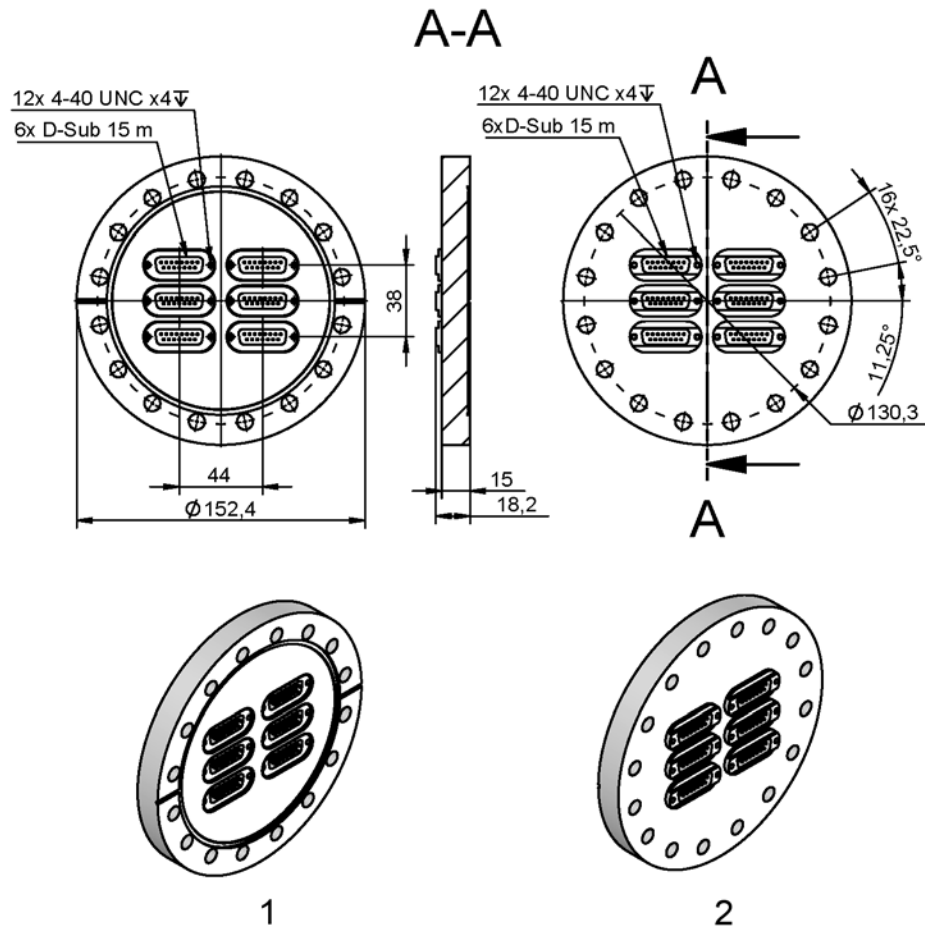


Figure 32: C-815.VFU6 vacuum feedthrough, Sub-D 15 (m/m)

- 1 Vacuum side
- 2 Air side

C-815.VFU15 vacuum feedthrough for 10⁻⁹ hPa

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

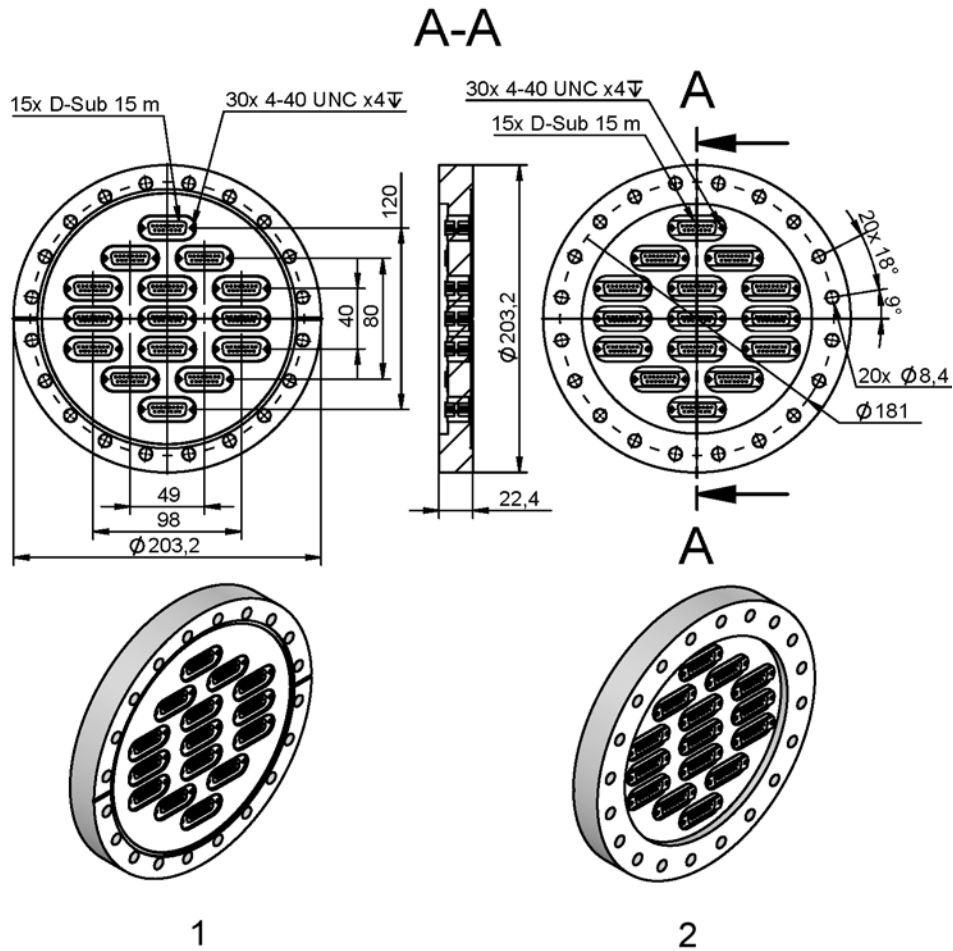


Figure 33: C-815.VFU15 vacuum feedthrough, Sub-D 15 (m/m)

- 1 Vacuum side
- 2 Air side

10.4 Pin Assignment

10.4.1 Q-521.xx0

Connector: Sub-D 15 (m)

The Sub-D 15 (m) connector transmits the signals of the drive and, for the models with sensor, in addition the signals of the sensor and of the ID chip.

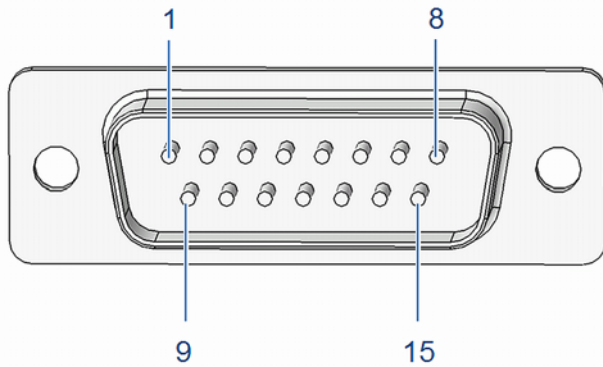


Figure 34: Sub-D 15 (m) connector

Pin	Signal ¹	Function	Direction
1	REF - ²	Reference signal differential (-)	Output
2	Motor (-)	Motor signal differential (-)	Input
3	Motor (+)	Motor signal differential (+)	Input
4	V _{DD} ²	Supply voltage (+5 V)	Input
5	-	-	-
6	ID Chip Daten ²	ID chip data	Output
7	SIN - ²	Encoder A (-)	Output
8	COS - ²	Encoder B (-)	Output
9	Motor (-)	Motor signal differential (-)	Input
10	GND	GND	GND
11	Motor (+)	Motor signal differential (+)	Input
12	-	-	-
13	REF +	Reference signal differential (+)	Output
14	SIN + ²	Encoder A (+)	Output
15	COS + ²	Encoder B (+)	Output

¹ The "-" sign indicates that the corresponding pin has not been assigned.

² Only for models with sensor. Not assigned for models without sensor.

The cable shield is connected to the connector shell.

10.4.2 Q-521.xxU

Connector: Sub-D 15 (f)

The Sub-D 15 (f) connector transmits the signals of the drive and, for the models with sensor, in addition the signals of the sensor and of the ID chip.

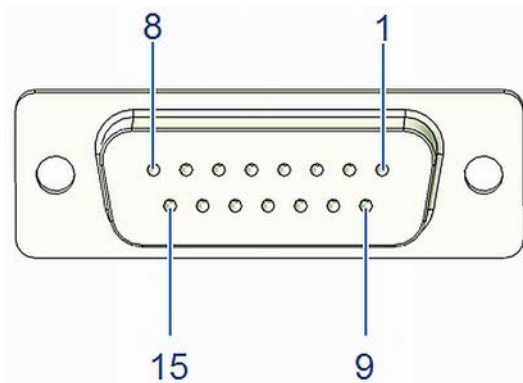


Figure 35: Sub-D 15 (f) connector

Pin	Signal ¹	Function	Direction
1	COS - ²	Encoder B (-)	Output
2	SIN - ²	Encoder A (-)	Output
3	ID Chip Daten ²	ID Chip Daten ²	Output
4	-	-	-
5	V _{DD} ²	Supply voltage (+5 V)	Input
6	Motor (+)	Motor signal differential (+)	Input
7	Motor (-)	Motor signal differential (-)	Input
8	REF - ²	Reference signal differential (-)	Output
9	COS + ²	Encoder B (+)	Output
10	SIN + ²	Encoder A (+)	Output
11	REF + ²	Reference signal differential (+)	Output
12	-	-	-

Pin	Signal ¹	Function	Direction
13	Motor (+)	Motor signal differential (+)	Input
14	GND	GND	GND
15	Motor (-)	Motor signal differential (-)	Input

¹ The "-" sign indicates that the corresponding pin has not been assigned.

² Only for models with sensor. Not assigned for models without sensor.

The cable shield is connected to the connector shell.

10.4.3 C-815.VF Vacuum Feedthrough

Sub-D 15 (m/f)

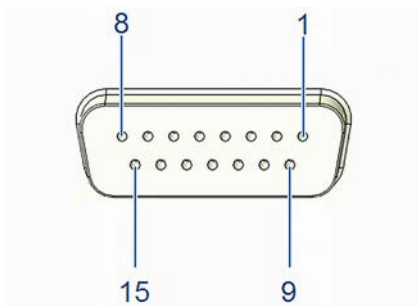


Figure 36: Vacuum side: Sub-D 15 (f) socket

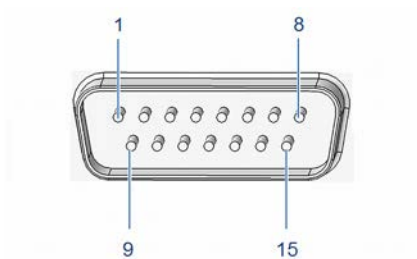


Figure 37: Air side: Sub-D 15 (m) panel plug

Vacuum side (f)			Air side (m)
Pin	Signal	Function	Pin
1	REF -	Reference signal differential (-)	1
2	Motor (-)	Motor signal differential (-)	2
3	Motor (+)	Motor signal differential (+)	3
4	V _{DD}	Supply voltage (+5 V)	4
5	-	-	5
6	ID chip data	ID chip data	6
7	SIN -	Encoder A (-)	7
8	COS -	Encoder B (-)	8
9	Motor (-)	Motor signal differential (-)	9
10	GND	GND	10
11	Motor (+)	Motor signal differential (+)	11
12	-	-	12
13	REF +	Reference signal differential (+)	13
14	SIN +	Encoder A (+)	14
15	COS +	Encoder B (+)	15

10.4.4 C-815.VFUx Vacuum Feedthrough

Sub-D 15 (m/m)

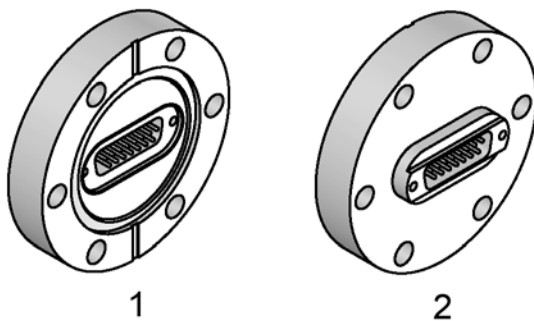


Figure 38: C-815.VFUx vacuum feedthrough

- 1 Vacuum side
- 2 Air side

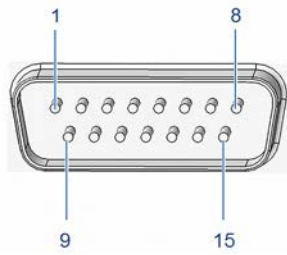


Figure 39: Sub-D 15 (m) panel plug

Vacuum side			Air side
Pin	Signal	Function	Pin
1	COS -	Encoder B (-)	8
2	SIN -	Encoder A (-)	7
3	ID chip data	ID chip data	6
4	-	-	5
5	V _{DD}	Supply voltage (+5 V)	4
6	Motor (+)	Motor signal differential (+)	3
7	Motor (-)	Motor signal differential (-)	2
8	REF -	Reference signal differential (-)	1
9	COS +	Encoder B (+)	15
10	SIN +	Encoder A (+)	14
11	REF +	Reference signal differential (+)	13
12	-	-	12
13	Motor (+)	Motor signal differential (+)	11
14	GND	GND	10
15	Motor (-)	Motor signal differential (-)	9

10.4.5 5604500041 Adapter

Sub-D 15 (m/m)

The adapter is only required if a Q-521.xxU model is to be operated at atmospheric pressure (i.e., without a vacuum feedthrough).

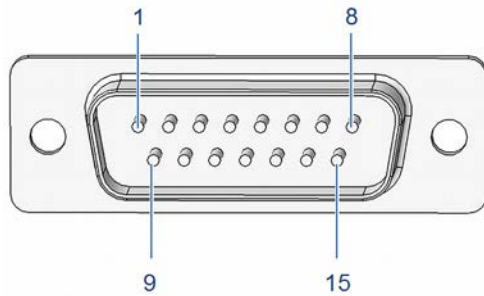


Figure 40: Sub-D 15 (m) connector

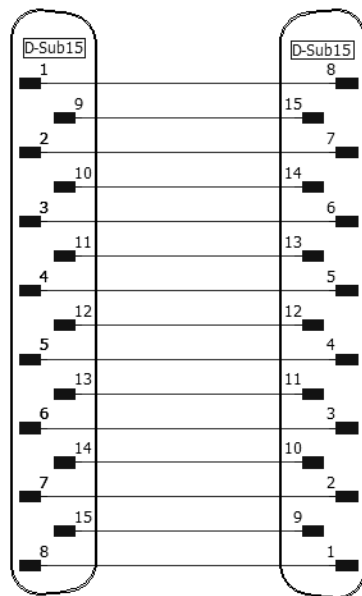


Figure 41: Pin assignment of the 5604500041 adapter

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 the responsibility as the product manufacturer, PI miCos GmbH undertakes environmentally correct disposal of all old PI miCos equipment made available on the market after 13 August 2005 without charge.

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

PI miCos GmbH
Freiburger Strasse 30
79427 Eschbach, Germany



12 EC Declaration of Conformity

For the Q-521, an EC Declaration of Conformity has been issued in accordance with the following European directives:

Low Voltage Directive

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN 50581

