

# OT-2 Integration Kit

Operating Manual



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## 1. SAFETY / DISCLAIMER

The device is designed with safety in mind and no danger is known if the device is intact, installed and operated as described in the manual. Only use the device in the way as it is described in the intended use.

The most important prerequisites for use, operation, and safety are explained to ensure smooth operation. No warranty or liability claims will be covered if the instrument is used in ways other than those described or if the necessary prerequisites and safety measures are not observed.



The instrument may only be operated by persons who read the manual and following the safety instructions.



Please be aware that, as the Opentrons platform is highly flexible it is the customers responsibility to ensure the process is compatible with the installed setup/devices. The responsibility includes for example testing if the required mixing frequency is supported and, especially when using devices which generate heat, a good airflow is provided.

Always read the Operating Manual of the device that is used before starting the implementation process.

**QINSTRUMENTS does not give any warranty for using our devices in the Opentrons system. The use is at your sole risk.**

## 2. PRODUCT DESCRIPTION

### 2.1 INTENDED USE

The OT-2 Integration Kit is designed to integrate QINSTRUMENT devices into the OT-2 Robot. Therefore it comprises a hardware and software interface. The OT-2 Integration Kit does not include a device. Devices need to be bought separately.



Not all devices are supported. Ask our support team if unsure if the desired device is compatible.

### 2.2 FEATURES

At QINSTRUMENTS we are always interested in the latest developments in Lab Automation. That is why we were excited when we got the chance to use one of the Opentrons 2 System in one of our projects and get first-hand experience with it.

The simple yet robust design combined with the opportunity to easily create custom scripts and the open access philosophy is a set of intriguing features as we found out. It offers countless ways of optimizing and digging into the system and the scripts to get a deeper understanding of the mechanisms at work. It is however a time-consuming process that can be daunting, the resources and the focus of a team on getting things done might make the System unattractive. Therefore, we created the OT-2 Integration Kit for our devices. The combination of hard and software offers a smooth integration with the clear goal to make it as simple as possible to get the device up and running shortly and minimizing the related risk of running into errors.

That said we are however aware that the combination of labware, additional devices and the customization of the Opentrons hard and software in the field is endless. Therefore, we cannot take any liability for using the OT-2 Integration kit.

This document describes all steps necessary to integrate a QINSTRUMENTS device into the OT-2 System. The document will start with the list of prerequisites followed by an overview of the components and the installation process and then going into detail of how to install each component and using the python module in your script. Finally, some integration examples are given. Be aware that the Kit itself does not include a device.

As the result of the integration the commands to control a QINSTRUMENTS device can be used directly in your scripts and you have the power of high-end mixing, heating and cooling abilities available in your Opentrons System to implement your desired workflow.

All required information and downloads are available at:

<https://www.qinstruments.com/knowledge/qinstruments-supports-opentrons-applications/>

## 2.3 PREREQUISITES

To use the OT-2 Integration Kit the following requirements need to be fulfilled. Please check if the requirements are met before continuing.

User	It is assumed that the user is familiar with the general operation of the Open- trons System and knows for example how to use the Opentrons App, how to load protocols and conduct calibrations. Opentrons provides lots of learning material on their support page: <a href="https://support.opentrons.com/en/">https://sup- port.opentrons.com/en/</a>
OT-2 Robot	The OT-2 adapter plate and the software components are only compatible with the second edition of the Opentrons Liquid Handler. OT-2 product page: <a href="https://opentrons.com/ot-2">https://opentrons.com/ot-2</a>
OT-2 App version	See homepage for up-to-date compatibility information: <a href="https://www.qin-&lt;br/&gt;struments.com/knowledge/qinstruments-supports-opentrons-applications/">https://www.qin- struments.com/knowledge/qinstruments-supports-opentrons-applications/</a>
OT-2 API V2	Usage of the second version of the OT-2 API is mandatory. API documentation: <a href="https://docs.opentrons.com/v2/index.html">https://docs.opentrons.com/v2/index.html</a>

## 2.4 TECHNICAL SPECIFICATION

### Properties

Material	Aluminum anodized
Dimension	142 x 99 x 10 [mm]   5.59 x 3.9 x 0.39 [inch]
Weight	0.3 kg   0.66 lbs

### Drawing

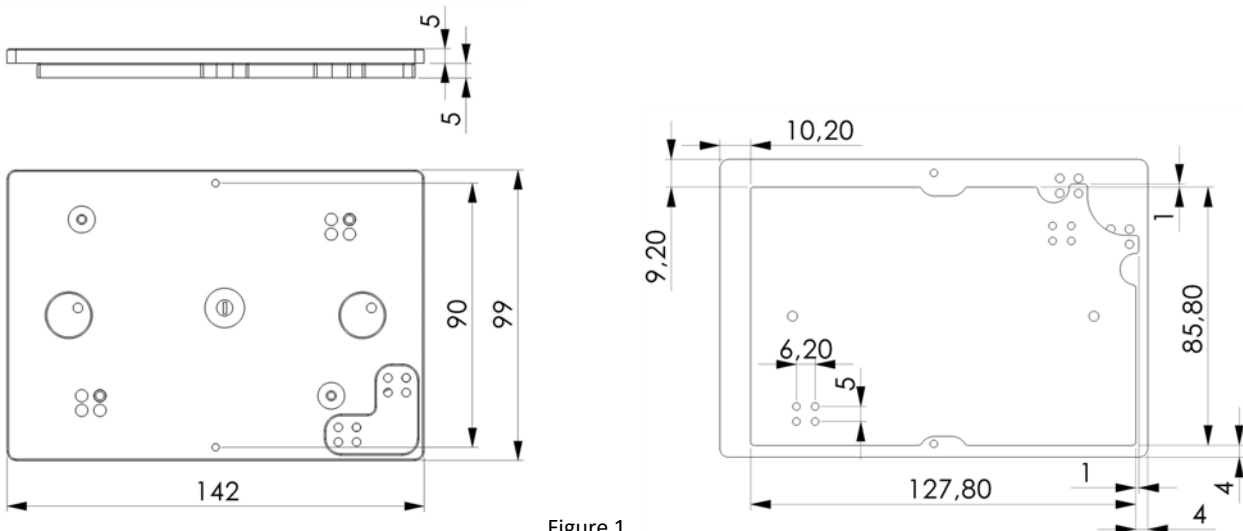
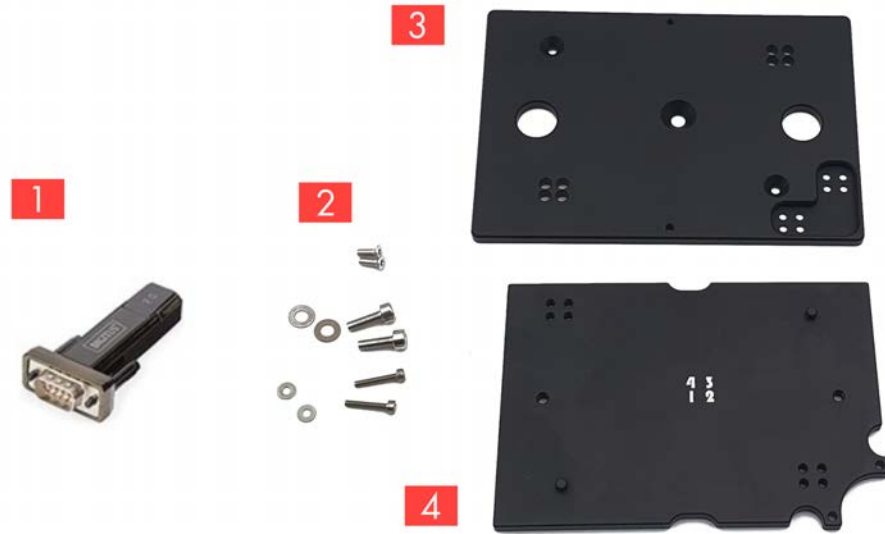


Figure 1  
Technical drawing of device



Technical specification are subject to change.

## 2.5 DELIVERY PARTS



Part 1	<p><b>QOT USB/RS232 converter</b>  <i>To identify QINSTRUMENTS devices and use them in parallel with other instruments a programmed converter is required.</i></p>
Part 2	<p><b>Set of screws for mounting</b>          2x ISO 14581 M3 x 8          2x DIN 912 M2.5 x 14          2x DIN 912 M4 x 16          2x DIN125 A2.7 - A2          2x DIN125 A4.3 - A2</p>
Part 3	<p><b>QI plate</b>  <i>Plate to mount QINSTRUMENTS device to</i></p>
Part 4	<p><b>OT plate</b>  <i>Plate that is connected to the OT-2 deck</i></p>
Part 5	<p><b>QOT python module (software - not displayed)</b>  <i>A set of Python modules that extends the Opentrons API to use QINSTRUMENTS devices. The latest release is available for download on the homepage.</i>  <a href="https://www.qinstruments.com/fileadmin/Application/08-Opentrons/QOT_python_module.zip">https://www.qinstruments.com/fileadmin/Application/08-Opentrons/QOT_python_module.zip</a></p>

## 2.6 QOT PLATE DESCRIPTION

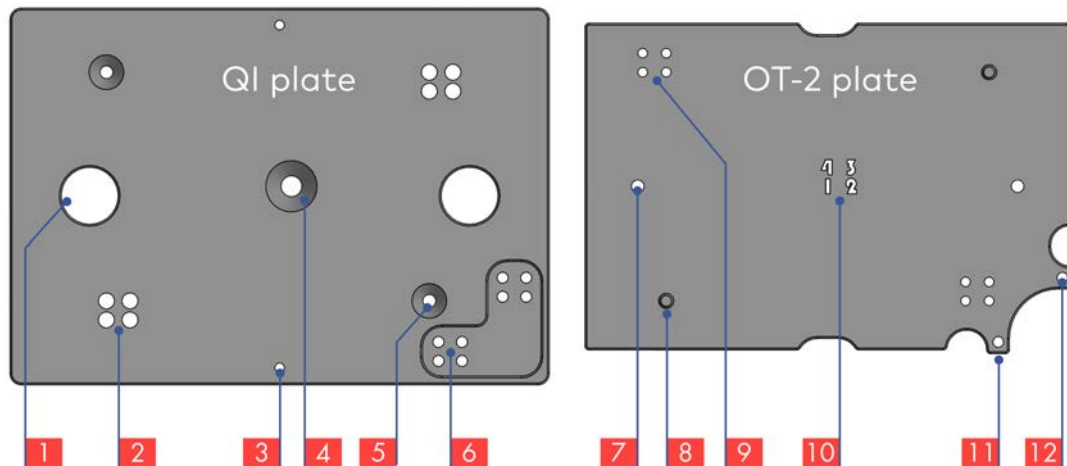


Figure 2 Device image which highlights important device elements

- 1 Screw cavity for mounting option C (2x)  
If mounting option C is used to mount the QOT adapter plat to the OT-2 deck the screw tail needs this space
- 2 QOT plate aligning holes (2x 4)  
Holes to align the two QOT plates to each other in 4 defined positions. The holes are related to the QOT plate aligning pins [8]. Each position can be described with the set-up number.
- 3 QI Device mounting threads (2x)  
M3 threads to mount a QINSTRUMENTS device on the QOT plate.
- 4 Set-up number view hole  
Hole to view engraved set-up number on OT-2 plate after the plates are joined.
- 5 QOT plate mounting holes (2x)  
Holes for screws to mount the QI plate to the OT-2 plate to form the QOT plate. The holes are related to the QOT plate mounting threads [9].
- 6 QI plate mounting holes for mounting option B (2x 4)  
Holes for screws to mount the QOT plate to the OT-2 deck, if mounting option B is used.
- 7 OT-2 mounting threads for mounting option C (2x)  
M4 threads to mount the QOT plate to the OT-2 deck, if mounting option C is used.
- 8 QOT plate aligning pins (2x)  
Pins to align the two QOT plates to each other in 4 defined positions. The pins are related to the QOT plate aligning holes [2]. Each position can be described with the set-up number.
- 9 QOT plate mounting threads (2x 4)  
Threads to mount the QOT plates to each other. The threads are related to the QOT plate mounting holes [5].
- 10 Set-up numbers  
Engraved numbers (1 - 4). After mounting the plates . The set-up number of the mounting position can be seen through the Set-up number view hole [4].
- 11 OT-2 plate protrusion for mounting option A (2x)  
The protrusion of the OT-2 plate at this area is in direct contact with the leaf spring of the OT-2 deck to realize an optimal mounting.
- 12 OT-2 plate mounting holes for mounting option B (2x 4)  
Holes for screws to mount the QOT plate to the OT-2 deck, if mounting option B is used.

## 2.7 SOFTWARE DESCRIPTION

The software comprises two elements, a customized labware definition file and the QOT python module.

### QOT python module

The QOT python module provides the software interface to easily integrate QINSTRUMENTS devices into Opentrons scripts. Loading this module will be part of all scripts, that are operating QINSTRUMENTS devices. The python module provides the QIDevice class, which is used to operate the instrument. Due to the USB/RS232 Converter a QINSTRUMENTS device can simply be initialized using the serial number of the device as a parameter. After that, all commands of the device that are described in the related Integration manual can be send to the QI device in the script.

Further Information can be found in the following chapters: [3.5 Install QOT python module](#)  
[4.4 Execute command](#)  
[5.1 Class reference](#)

### Labware definition file - customization

The labware definition file describes the properties (width, length, height, ...) and further parameters (order of wells, ...) of any labware that is placed onto the Opentrons deck to make it accessible to the software and realize a save and defined interaction with the object. The format for this information is json (JavaScript Object Notation). The json file describing the used labware is loaded in the script to use the labware.

In order to use any labware together with a QINSTRUMENT device, the labware definition file **must** be adapted. Besides installing the python module the adaption of the labware definition file is a required step for integration.

How this is done is described in the following chapter: [4.2 Adapt labware definition file](#)



Customization of **all** labware definition files of labware that is used on a QINSTRUMENTS device is mandatory.

**Not adjusting labware definition files will probably damage your device.**

Labware definition files for adapters that are provided from QINSTRUMENTS can easily be created with the Opentrons online labware creator and the information on the adapter data sheets available on our homepage.

Sources of labware definition files are:

OT standard labware library	<a href="https://labware.opentrons.com/">https://labware.opentrons.com/</a>
OT online labware creator	<a href="https://labware.opentrons.com/create/">https://labware.opentrons.com/create/</a>
OT service	<a href="https://opentrons-ux.typeform.com/to/xi8h0W">https://opentrons-ux.typeform.com/to/xi8h0W</a>
QINSTRUMENTS adapter data sheets	<a href="https://www.qinstruments.com/automation/adapter/">https://www.qinstruments.com/automation/adapter/</a> (If the data sheet of one of the adapters you plan to use is missing please get in touch)



## 2.8 MAINTENANCE AND CLEANING

The QOT plate is maintenance-free for standard use purposes.

Cleaning should be done with a wet but not soaked cloth using a mild soap solution and water or an alcohol-based disinfectant.



Be aware that mounted devices have their own maintenance and cleaning instructions. Assure to read these instructions thoroughly.

If you have any questions about cleaning please contact your distributor or directly QINSTRUMENTS. Should it become necessary to repair the equipment, it should be returned to an authorized servicing agent. The equipment must be clean and free from harmful substances. Always ship the shaker well-packed, preferably in the original shipping container in order to avoid damages.

## 3. INSTALLATION

### 3.1 INTRODUCTION AND OVERVIEW

Although the installation process was streamlined to make it as smooth as possible, several steps are required to enable the operation of a QINSTRUMENTS device via the OT-2 robot. All steps will be described in detail and should be easy to follow. If you are uncertain about how to proceed, please get in contact. (see [8. Support](#))

The installation process can be divided into a hardware and a software related part and comprises the following steps. Use the check-boxes to keep track of your installation progress.

Chapter	Step	
<a href="#">3.2</a>	Assemble the QOT plate depending on the desired deck position.	<input type="checkbox"/>
<a href="#">3.3</a>	Mount the QOT plate depending on the chosen mount option on the OT-2 deck.	<input type="checkbox"/>
<a href="#">3.4</a>	Mount the QINSTRUMENTS device to the QOT plate and connect it to the OT-2 robot via the QOT USB/RS232 Converter	<input type="checkbox"/>
<a href="#">3.5</a>	Install QOT python module	<input type="checkbox"/>

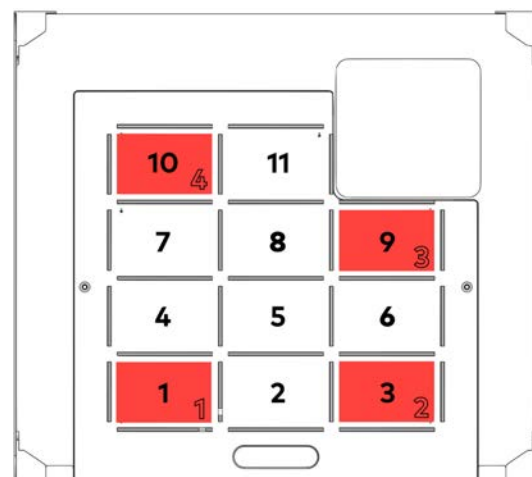
### 3.2 ASSEMBLE QOT PLATE

The QOT adapter can be placed on each of the eleven deck positions. However, regarding the cable management, it is recommended to place the device on the left (position 1, 4, 7, 10) or right (position 3, 6, 9) column of the deck. The QI device can be mounted on the QOT adapter in both orientations so that the cables will come out to the left or right of the device and can be easily be placed in the Opentrons housing.

If you do not want or cannot afford to lose any deck position there are 4 deck positions (1, 3, 9, 10) where the QOT adapter can be placed without losing an adjacent position if the QOT adapter is assembled with the fitting set-up number.

Figure 3 Top view of Opentrons deck with four red highlighted deck positions. If the QOT plate is placed on one of this highlighted deck positions (1, 3, 9, 10) no neighboring position gets lost.

The bottom right number at the red areas is the set-up number of this position. The QOT plate needs to be assembled with that set-up number to have the beneficial effect of not losing a neighboring position.





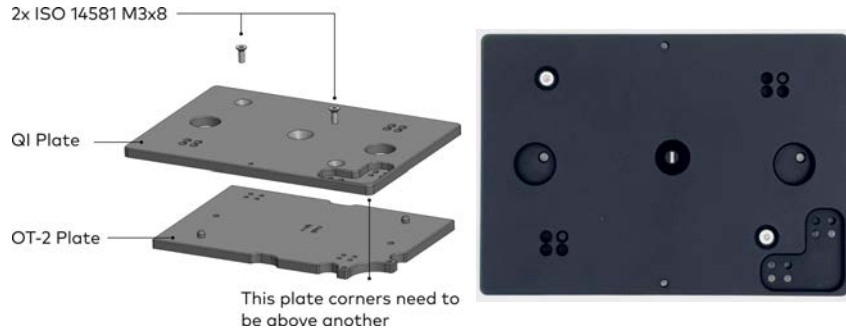
Combination of Opentrons deck position and QOT adapter plate set-up number for not losing a neighboring deck position.

Deck position	1	3	9	10
QOT plate set-up number	1	2	3	4

Via the aligning pins on the OT-2 plate and the corresponding aligning holes in the QI plate the plates can be assembled in 4 different defined set-ups. The set-up numbers are: 1, 2, 3, 4. The plates are fixed in the chosen position using the delivered M3 x 8 screws. The set-up number of the current configuration can be viewed through a hole in the middle of the QI Plate.

Figure 4 Isometric view and description of QOT plate assembling parts. (left)

Top view of the QOT adapter plate, where you can see the set-up number. The QOT plate is assembled in the way that the set-up number is 1 (right)



### 3.3 MOUNT QOT PLATE

The Adapter plate establishes the connection between the Opentrons Deck and the QINSTRUMENTS device. It offers a simple way to mount QINSTRUMENTS devices onto several different deck positions. Depending on the deck position the two plates of the adapter need to be fastened different (see [3.2](#)).

There are 3 options (A, B, C) to mount the QOT plate on the OT-2 deck. The difference between the options is the tightness of the connection. Depending on your assay the requirements for the tightness can vary greatly. The influencing factors are described in depth in the Operation manual of your device. In general the demand for a stronger connection will rise with mixing speed and adapter and probe weight. Starting from a 96 well plate up to using a custom aluminum adapter to work with special deep-well plates or vials the need for a tighter connection will rise.

Having a stable connection is a key factor for reproducible mixing results and a save operation, therefore this is an important decision. If unsure you can always start with option A and upgrade the mount type if required. A simple sign to use a stronger mount option is that the QINSTRUMENTS device does not sit still while shaking.



If there are any signs of movement of the QINSTRUMENTS device while shaking it is advised to use a stronger mount option.



The QOT plate must always be placed with the cavity in the QI plate in the same corner as the spring leaves on the OT-2 deck.

### Mount option A

This is the easiest way of mounting the QOT adapter plate. It works like mounting any other normal lab-ware on the OT-2 robot. It is done by inserting the QOT adapter plate onto one of the Opentrons deck positions. The cavity in the adapter plate needs to be in the front, right orientation to place the plate on the deck. The adapter is hold in position via the spring steel sheets of the deck.



Figure 5 The image on the left only shows the OT-2 plate for visualization and understanding reasons. The OT-2 plate is hold in position by the two leaf springs in the right lower corner of the OT-2 deck (red circle). The image on the right shows the complete QOT plate placed at deck position 3, with set-up number 2

### Mount option B

Mount option B uses the given threads of the spring leaves available at each OT-2 deck position to screw tight the QOT plate. Depending on how the following steps are conducted it might be necessary to remove the whole OT-2 deck plate, which might require to recalibrate all used labware.

This connection is much stronger and reliable than option A. It has however the weakness that the QOT plate is mounted at the corner position of the plate. At heavy loads the QOT plate can start to vibrate and influence other labware or devices on the OT-2 deck.

Step	Instruction
------	-------------

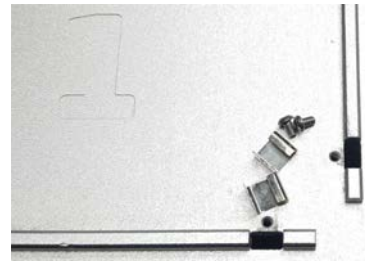
- 1 Get access to the leaf spring screws. Depending on the environment the OT-2 robot is placed this might be achieved by lifting or "crawling" under the robot or by screwing loose the complete OT-2 deck plate.



Figure 6 Image on the left shows of the OT-2 deck with red circles around the screws holding the deck plate. Image on the right shows the bottom-side of the OT-2 deck plate, with removed (left) and not removed (right) leaf springs.

- 2 Remove the leaf springs at the desired deck position.


Figure 7 Image of top-side of OT-2 deck with removed leaf springs, showing the now usable threads.



- 3 Place and screw tight the QOT plate using the delivered M2.5 x 14 screws and A2.7 washers.


Figure 8 Image of QOT plate mounted to the OT-2 deck via option B at deck position 1 with set-up number 1



 Recalibration of all used labware might be necessary after displacing and placing the OT-2 deck plate.

## Mounting option C

This option needs more crafting and might therefore not be doable for every customer. This is however the strongest connection and will prevent possible vibration and provide a more quiet operation of the device than mount option A and B.

Step	Instruction
1	<p>Remove the OT-2 deck plate by loosening the two fastening screws.</p> <p>Figure 9 Image showing the OT-2 deck with red circles around the screws holding the deck plate.</p> 
2	<p>Positioning the QOT plate at the desired OT-2 deck position. And mark the position of the QOT mounting threads for mounting option C on the OT-2 plate</p> <p>Figure 10 Image of QOT plate at OT-2 deck position 1 using a marker pencil to mark the position of the mount threads for option C (red circle) on the OT-2 deck.</p> 
3	<p>Drill two 7 mm holes at the marked position into the OT-2 deck</p> <p>Figure 11 Image of the OT-2 deck with two 7 mm holes at the marked position at deck position 1</p> 
4	<p>Mount the QOT plate from the bottom side of the OT-2 plate through the drilled holes with the delivered M4 x 16 screws and the A4.3 washers.</p> <p>Figure 12 Side view of the OT-2 plate, where the QOT plate is mounted at deck position 1 with 2 screws and washers coming from the bottom side of the OT-2 plate</p> 

5 Mount the OT-2 deck plate along with the mounted QOT plate, back in place.

Figure 13 View of the OT-2 deck with the QOT plate mounted at deck position 1 with set-up number 1 using the mount option C



Recalibration of all used labware might be necessary after displacing and placing the OT-2 deck plate.

### 3.4 MOUNT AND CONNECT QINSTRUMENTS DEVICE

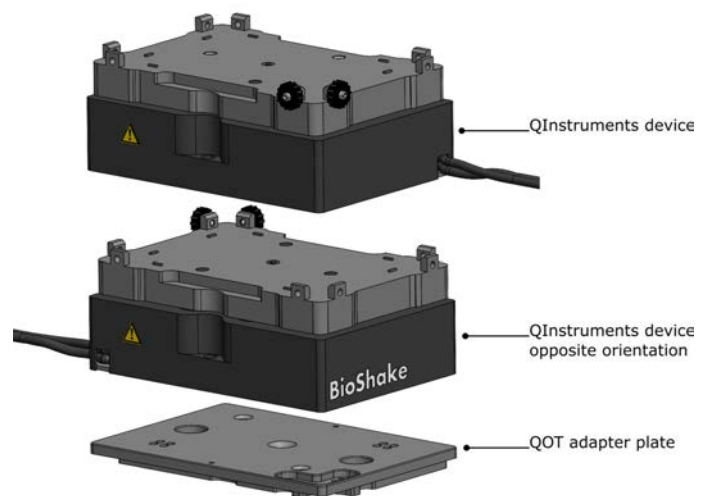
In the last two steps the QOT plate was assembled to fit to a certain OT-2 deck position (keyword: set-up number) and mounted via one of the three mounting options (A, B, C) to this position. The next step is to mount the QINSTRUMENTS device on the QOT plate.

Via the M3 QI Device mounting threads in the QI Plate a QI device can be mounted to the QOT Plate using the DIN 912 M3 x 18 screws, delivered with the QINSTRUMENTS device. The device can be mounted in both orientation on the plate. This can be useful for the cable management in the Opentrons System. Remove the rubber base elements at the bottom of the device before mounting, to get the correct thread length.



Remove the rubber base elements at the bottom of the device before mounting the QINSTRUMENTS device.

Figure 14 Illustration showing the possibility to mount a QINSTRUMENTS device in two different orientations onto the QOT plate.



To connect a QINSTRUMENTS device to the Opentrons robot, the QOT USB/RS232 Converter is required. It converts the connector type from RS232 to USB, and via the integrated chip it provides identification information for the software. The converter also works if it is connected via an USB hub to the Opentrons robot.

If you are using your own USB/RS232 converter with a FTDI chip, it is required to set the value of the [USB String Descriptors | Manufacturer] property to: QInstruments

The value is case sensitive! Big Q and I in the beginning and s at the end.



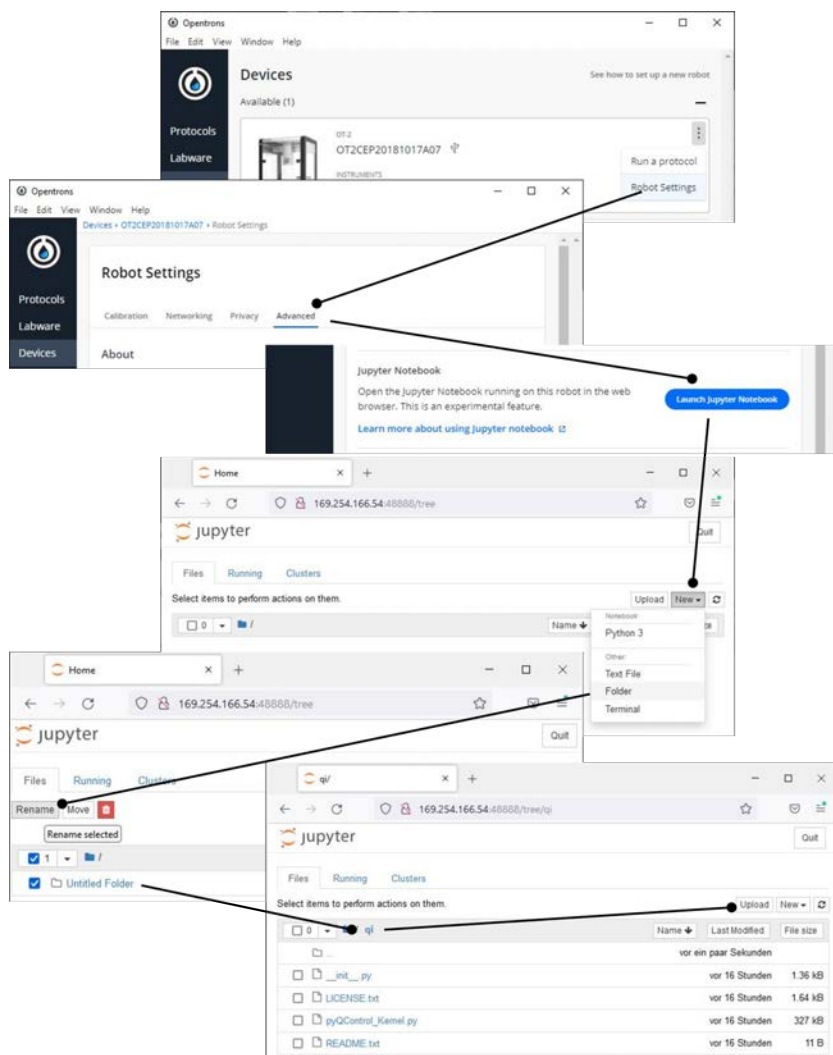
For reliable recognition of a connected QI device, it is beneficial to connect the devices before powering on the Opentrons robot.



### 3.5 INSTALL QOT PYTHON MODULE

- | Step | Instruction   |
|------|---|
| 1    | Download and unzip the QOT python module files to a temporary folder on the computer the OT-2 robot is connected to and where the Opentrons App is installed<br><a href="https://www.qinstruments.com/fileadmin/Application/08-Opentrons/QOT_python_module.zip">https://www.qinstruments.com/fileadmin/Application/08-Opentrons/QOT_python_module.zip</a>   |
| 2    | Install QOT python module files on the Opentrons Robot. <ul style="list-style-type: none"> <li>2.1 Open the jupyter notebook folder via the Opentrons App. In the Tab named Advanced in the Robot settings the button [Launch Jupyter Notebook] is provided to directly open the jupyter notebook.</li> <li>2.2 Create directory <code>qi</code> in two steps. First create new directory and second rename the directory to <code>qi</code></li> <li>2.3 Upload all unpacked QOT python module files to directory <code>qi</code></li> </ul> |

Figure 15 Screenshots showing the workflow of installing the QOT module files on the Opentrons Robot

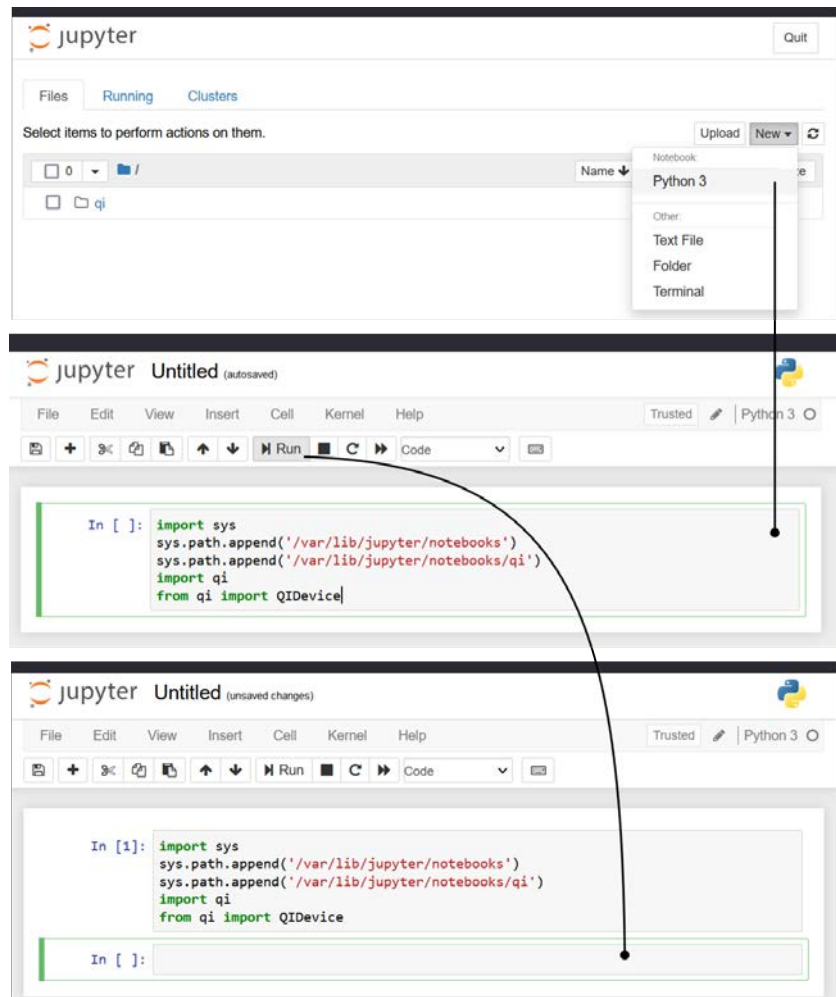


**i** Do not change the upload directory. The files must be in the folder `qi` in the jupyter base path. The `pytransform.so` file will not show up in the list after upload.

- 3 Test if installation was successful. It is not required that a QI device is connected to the Open-  
trons robot for this test.
  - 3.1 Launch Jupyter Notebook (see Step 2)
  - 3.2 Create New Python 3 Notebook
  - 3.3 Insert the following text into the first Cell and run it. No error message should occur

```
import sys
sys.path.append('/var/lib/jupyter/notebooks')
sys.path.append('/var/lib/jupyter/notebooks/qi')
import qi
from qi import QIDevice
```

Figure 16 Screenshots showing the workflow of testing the installation of the QOT module files on the Opentrons Robot



## 4. OPERATION

### 4.1 INTRODUCTION

This chapter gives step-by-step instructions on how to implement the operation of a QINSTRUMENTS device in an Opentrons script. It is assumed that all installation steps have been completed successfully. The general concept is that the QINSTRUMENTS device operates independently from the labware that is mounted on top of it. That means, for the interaction with the labware the normal commands and the workflow from the Opentrons API (`load_labware`, `aspirate`, `dispense`, ...) are used. The QI device is controlled separately via the API provided from QINSTRUMENTS. To realize this, the main task that needs to be done is to add an offset to the labware that is used. How this is achieved is described in the following sections.

If it is the first time a QI device is used in a script it is advised, to initially remove the QI device from the OT-2 deck to lower the risk of damaging the robot due to mistakes that may happen when writing the script.



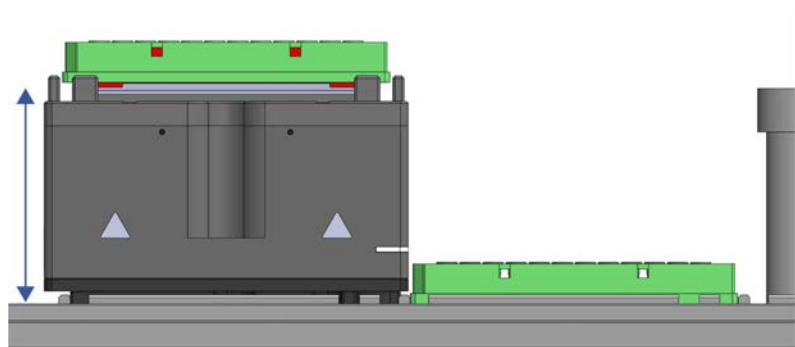
It is advised to remove the QINSTRUMENTS devices for initial script testing to reduce the risk of damaging the robot due to mistakes in implementation details.

### 4.2 ADAPT LABWARE DEFINITION FILE

Before starting to write the script it is required to identify the labware that is mounted on the QINSTRUMENTS device, because the definition file of that labware needs to be adapted initially. The adaption is due to the raise of the labware which is caused by mounting it on the device and optionally on an adapter.

The value of this raise needs to be determined and the value needs to be written into the labware definition file at a certain position. To not change the original labware files a copy must be created, which is then adapted.

Figure 17 Illustration showing the raise of the labware (z-offset) due to using it with a QINSTRUMENTS device



- Labware on top of
  - Microplate adapter (red)
  - QINSTRUMENTS device (grey)
  - QOT adapter plate (black)
- Z-offset depends on
  - Microplate adapter type
  - QINSTRUMENTS device type
  - (QOT adapter plate adds fixed value)
- > Adapt z-offset of labware definition file
- Standard labware usage
  - Microplate direct on Opentrons deck
  - (z-offset = 0)
- > Standard labware definition file

The procedure has the following steps

4.2.1 Determine z-offset value

4.2.2 Find the labware definition file of the labware

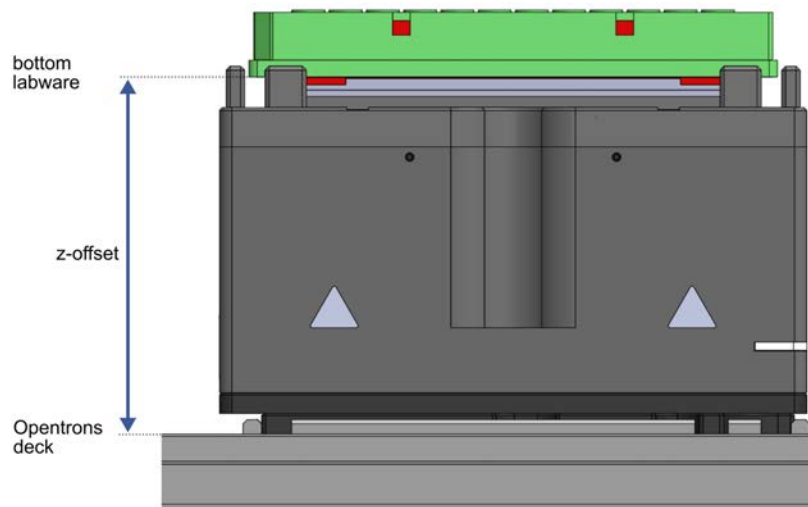
4.2.3 Copy labware definition file to the labware source folder and rename file

4.2.4 Adapt and save copied labware definition file

### 4.2.1 Determine z-offset value

The easiest way to determine the z-offset value is to measure the offset right at the final setup in the Opentrons robot. It must be measured from the Opentrons deck to the bottom of labware. It is advised to add a few millimeters to ensure a save height. The precise height and x, y position will be set as part of the calibration process that is happening in the Opentrons App when running a script.

Figure 18 Illustration showing the distance that needs to be measured and which corresponds to the z-offset value.



If measuring is not an option, the z-offset can be determined by adding up the values of the three parts (QOT adapter plate, QINSTRUMENTS device, Adapter) that contribute to the z-offset value.

1. QOT adapter plate [mandatory]

QOT adapter plate	10 mm
-------------------	-------

2. QINSTRUMENTS device height [mandatory]

BioShake 3000	51.75 mm
---------------	----------

BioShake 3000-T	52,50 mm
-----------------	----------

BioShake 3000-T elm	
---------------------	--

BioShake D30-T elm	
--------------------	--

HeatPlate	
-----------	--

BioShake 3000 elm	48,20 mm
-------------------	----------

BioShake 3000 elm DWP	
-----------------------	--

BioShake 5000 elm	
-------------------	--

BioShake D30 elm	
------------------	--

ColdPlate	74,50 mm
-----------	----------

Q1	87,20 mm
----	----------

### 3. Labware Adapter [optional]

When an adapter is used it is important to understand that the offset generated from the adapter most of the time does not equal the height of the adapter. The offset is only the value the labware is lifted from the bottom in regard to the mounting. This raise value, is not part of any specification document and can only be measured or determined by an educated guess.

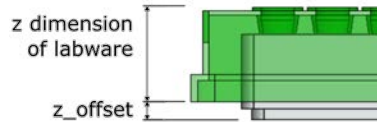


Figure 19 Illustration showing the raise (z\_offset) of the labware (green) by mounting it on an adapter (grey)

The z-offset value can either be measured or calculated.



It is strongly recommended to always add a few millimeters to ensure the pipetting tip will not collide with the labware during the calibration process.

The exact position (x, y, z) of the labware will be determined during the calibration process.

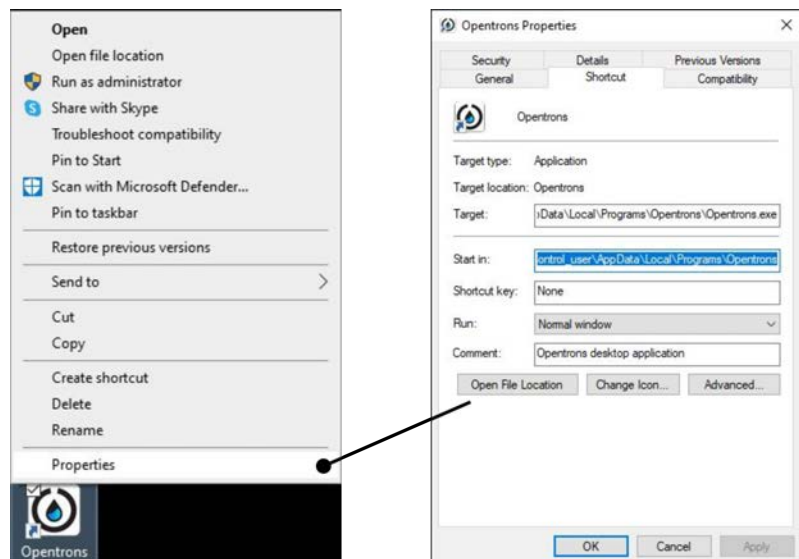
#### 4.2.2 Find the labware definition file of the labware

Normally there are two possibilities in regard to the labware definition file location.

1. The labware was created via the online Opentrons Custom Labware Creator. Then you should know where you have saved the labware definition file
2. A default labware from Opentrons is used, then the definition file is located in the following directory  
`[Opentrons App Install folder]\resources\python\Lib\site-packages\opentrons_shared_data\data\labware\definitions\2`

The [Opentrons App Install folder] can be reached via the Opentrons App icon properties. See image below for explanation.

Figure 20 Right click on Opentrons App icon to get to the property window. Use the [Open File Location] button to open the Opentrons App install folder in a file browser.



At this location each labware has a separate folder. In this labware folder are files named 1.json, 2.json, ... The number in the file name represents the version of the labware. So in general the file with the highest number should be used.

### 4.2.3 Copy labware definition file to the labware source folder and rename file

The default custom labware location is defined in the Opentrons App Settings in the Advanced Tab. The location can be reached via the provided button in the App.

If the labware is not already in the labware source folder, copy the definition file (for example: 2.json), of the labware that should be used with the QI device, to the labware source folder location.

Independent from which labware file (Opentrons or Custom definition) is used, it is strongly recommended to rename the file. It is suggested to name the file in regard to the device and an optional adapter that is used.

For example if you want to use the Opentrons `nest_96_wellplate_200ul_flat` labware on a QINSTRUMENT BioShake 3000 device.

```
Copy the file      2.json
from              [Opentrons App Install folder]\resources\python\Lib\site-pack-
                  ages\opentrons_shared_data\data\labware\definitions\2\nest_96_
                  wellplate_200ul_flat
to               [Opentrons Custom Labware Source Folder]
Rename           2.json
to              nest_96_wellplate_200ul_flat_**bs3000**.json
```

The labware file will automatically show up in the labware entry of the Opentrons App, **after** making the adaptations presented in the next step, and can then be used in your script.

### 4.2.4 Adapt and save copied labware definition file

Open the new labware definition file with a Text-Editor, for example notepad and make changes to the attributes, like described below and save the file afterwards.



Do not change other attributes if you do not know the implications. Wrong values can lead to a device damage.

"namespace"	You can be creative, for example the name of your company. <b>Important:</b> only lowercase letters "qinstruments"
"displayName"	Insert the name of the labware file. In the example it could be: "nest_96_wellplate_200ul_flat_bs3000"
"loadName"	Insert the name of the labware file. In the example it could be: "nest_96_wellplate_200ul_flat_bs3000"
"cornerOffsetFromSlot": { "x": 0, "y": 0, "z": 64 }	This is the most important change in the labware definition file that we make. We will just change the "z" attribute value. The new z value is the offset we determined in chapter <a href="#">4.2.1</a> Consider adding a few millimeters to the determined z-offset value. The exact position of the labware will be determined during the labware calibration process. In the example it could be: 64

### 4.3 IMPORT QOT PYTHON MODULE AND CONNECT TO DEVICE

The class provided to work with a QINSTRUMENTS device is called **QIDevice**. The system path needs to be extended to make the QOT python module, that is defining the class, available.

```
import sys
sys.path.append('/var/lib/jupyter/notebooks')
sys.path.append('/var/lib/jupyter/notebooks/qi')
import qi
from qi import QIDevice
```

At first the **QIDevice** class is initiated and after that a connection to the device is established. This is done with the following commands. It is important to put all QIDevice related commands in an if-statement as shown below. The only required parameter is the serial number of the device.

```
if not protocol.is_simulating():
    bs_3000_t = QIDevice(serial_number='8902')
    bs_3000_t.connect()
```

Errors occurring during initialization will be displayed to the user. With the **QIDevice** object that is returned after connection, the QINSTRUMENTS device can now be controlled.

### 4.4 EXECUTE COMMAND

Executing a command is done by using the **exec\_cmd()** function of the QIDevice object. See an example below. Don't forget to put the QIDevice commands into an if-statement. This if-statement can occur as often as required in the script.

```
if not protocol.is_simulating():
    bs_3000_t.exec_cmd('setShakeTargetSpeed500')
    bs_3000_t.exec_cmd('sonwr50', blocking=True)
```

In the integration manual a list of all available commands can be found. The integration manual is available online: <https://www.qinstruments.com/?id=276#c2666>

To plan a proper assay workflow, it is important to understand the behavior of certain commands after they have been called. Regards their behavior, commands can be divided into blocking and non-blocking commands.

- |              |   |
|--------------|---|
| Blocking     | hereby means that after the command has been called to be executed, it will return to the protocol, to the next line of code in your protocol, after the command has been completed.                          |
| Non-blocking | hereby means that after the command has been called to be executed it will immediately return after the command has been successfully send to the device, without waiting for the realization of the command. |

For the script flow it is important to know if the execution of a command of the QINSTRUMENTS device is blocking or not. Both behaviors might be desired. Blocking does mean that no delay needs to be set in the script to wait for the command to finish, the command will be finished after execution. This makes it easy to create a reliable script execution. On the other hand, non-blocking execution allows to execute further script commands in parallel to an activity of the QINSTRUMENTS device. A description of all commands can be found in the integration manual. If no parameter that can change the behavior is given in the following list, the command behavior cannot be changed.



The characters <, > are not part of the command string and must be removed.

Example: shakeOnWithRuntime<val> --> shakeOnWithRuntime500

## List of Blocking and Non-blocking commands

### resetDevice

blocking	('resetDevice')	Returns after device reset is complete
----------	-----------------	--

### shakeOn

blocking	('shakeOn')	Returns after device reached defined mixing speed
----------	-------------	---

### shakeOnWithRuntime

non-blocking	('shakeOnWithRuntime<val>')	Returns after device reached defined mixing speed but will NOT wait until runtime has elapsed
--------------	-----------------------------	---

blocking	('shakeOnWithRuntime<val>', blocking=True)	Returns after given runtime elapsed
----------	--	-------------------------------------

### setShakeTargetSpeed

non-blocking	('setShakeTargetSpeed<val>')	If called while device is already shaking, returns immediately
--------------	------------------------------	--

blocking	('setShakeTargetSpeed<val>', polling=True)	Returns after target speed reached
----------	--	------------------------------------

### shakeOff

blocking	('shakeOff')	Return after device stopped and reached the home position
----------	--------------	---

### shakeGoHome

blocking	('shakeGoHome')	Returns after device reached home position
----------	-----------------	--

### tempOn

non-blocking	('tempOn')	Returns immediately
--------------	------------	---------------------

blocking	('tempOn', polling=True)	Returns after temperature reached
----------	--------------------------	-----------------------------------

### setTempTarget

non-blocking	('setTempTarget<val>')	If called while temperature control is already on, returns immediately
--------------	------------------------	--

blocking	('setTempTarget<val>', polling=True)	Returns after target temperature reached
----------	--------------------------------------	--



## 5. APPENDIX

### 5.1 CLASS REFERENCE

**class** QIDevice(serial\_number: *str*)

Main class of the QOT python module. It is derived from the serial.Serial class of the pyserial module. For each QINSTRUMENTS device that is connected and used in the script an object of this class must be created. Initialization/connection and executing commands is realized with this object.

PARAM serial\_number: *str* The serial number of the device that should be used. The serial number is written on the device.



A device is only recognized if a QINSTRUMENTS USB/RS232 Converter is used or the adapter is configured as described in chapter [3.4 Mount and connect QINSTRUMENTS Device](#)

FUNCTIONS **connect**(self) -> *None*

Tries to connect to the QIDevice with the given serial number. Connecting to the device is required before any command can be executed.

RAISES QIDeviceCommunicationError QIDevice with given serial number could not be found.

**exec\_cmd**(self, cmdString: *str*, **\*\*kwargs**) -> *str*

Transmit a command to the QI device and get the response. The list of commands and return values can be found in the integration manual on the QINSTRUMENTS homepage (<https://www.qinstruments.com>).



The command termination character (<CR>) must not be set at the end of the command when using the exec\_cmd() function.

PARAM cmdString: *str* Command that should be executed.  
**\*\*kwargs** Additional parameter(s) that depends on the command that is executed. See List of blocking and non-blocking commands.  
 RAISES QIDeviceError Error while executing command.

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**WO2008135565, US8323588, EP2144716:** Sample handling device for and methods of handling a sample

**WO2011113858, US9126162, EP2547431:** Positioning unit for a functional unit

**WO2013113847, US10052598, EP2809436:** Cog-based mechanism for generating an orbital shaking motion

**WO2013113849, US9371889, EP2809435:** Mechanism for generating an orbital motion or a rotation motion by inverting a drive direction of a drive unit

**WO2014207243, US20160368003, EP3013480:** Application-specific sample processing by modules surrounding a rotor mechanism for sample mixing and sample separation

**WO002022128814A1:** Laboratory apparatus comprising a fixing mechanism for fixing a slide

**WO002022128809A2:** Laboratory apparatus comprising a mixing mechanism for mixing a medium of a slide

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