force dimension

Summary

The purpose of this document is:
> to describe the setup of the lambda.7 haptic device,
> to describe the installation of the software drivers and the Force Dimension SDK,
> to describe the basic operation modes of the lambda.7 haptic device.

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1. System overview

Figure 1 – Overview of the lambda.7 haptic device

1. device stand rear leg
2. device stand front legs
3. device stand pole
4. haptic device controller
5. arms of translational base
6. rotational wrist
7. end-effector (force gripper handle)
8. pole interface
9. power switch
10. power connector
11. USB connector

2. Important safety instructions

IMPORTANT

WHEN USING THIS HAPTIC DEVICE, BASIC SAFETY PRECAUTIONS
SHOULD ALWAYS BE FOLLOWED TO REDUCE THE RISK
OF FIRE, ELECTRICAL SHOCK, OR PERSONAL INJURY.

1. Read and understand all instructions.

2. Follow all warnings and instructions marked on your haptic device.

3. Do not use or place your haptic device near water.

4. Place your haptic device securely on a stable surface.

5. Make sure that the workspace of your haptic device is free of objects.

6. Do not overload wall outlets and extension cords as this can result in a risk of fire or electrical shock.

7. Switch off your haptic device when it is not in use.

8. To reduce the risk of electrical shock, do not disassemble your haptic device.

3. Setting up the lambda.7 haptic device

This section describes the different steps to follow to safely setup your lambda.7 device before use.

IMPORTANT

PLEASE KEEP THE ORIGINAL PACKAGING
ONLY USE THE ORIGINAL PACKAGING DURING STORAGE OR SHIPMENT

3.1 Haptic device installation

The lambda.7 haptic device is shipped in three cardboard boxes. Please start by opening the larger of the three boxes which contains the lambda.7 haptic device controller and accessories, as illustrated in figure 2.
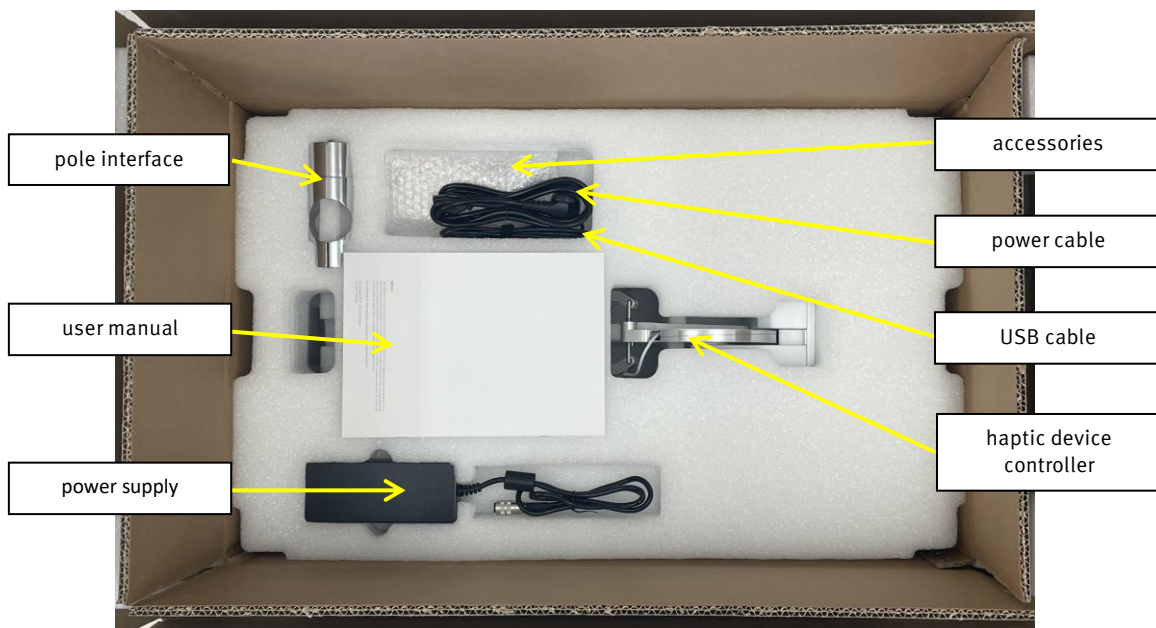
Figure 2 – Transportation box which contains the lambda.7 device controller and accessories.

Among the accessories included with the haptic device are nine screws and an orange hex key that are required to assemble the device stand contained in the two smaller cardboard boxes. The haptic device controller is mounted at the end of the setup procedure and is therefore best kept in its protective box until then.

The operations described in the following steps are best performed by a team of two people.

The **lambda.7 support stand** is composed of **three legs** and **one mast** which are illustrated in figures 3 and 4. These parts can be found in the two cardboard boxes that come with the unit.
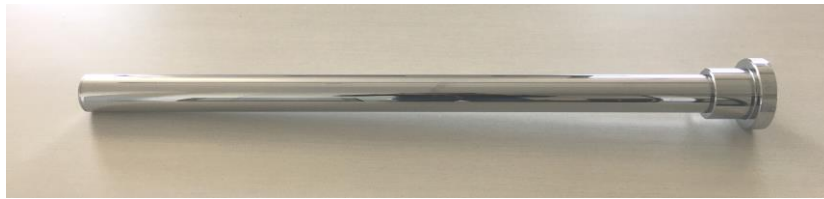

Figure 3 –stand pole (1x)

Figure 4 – stand leg (3x)

The three legs are mounted to the pole by securely fastening the nine **stand screws** (three screws per leg) using the **orange hex key,** as shown in figure 5. The screws and orange hex key can be found in the plastic case that contains the haptic device controller.
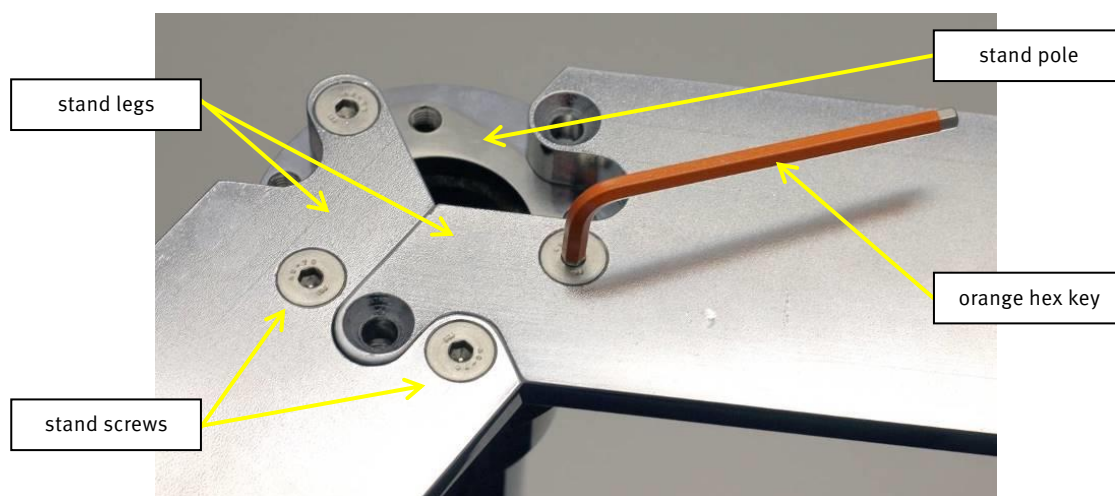

Figure 5 – Mounting the device stand legs onto the pole.

Once the device stand is mounted, the upper foam layer with the accessories may be lifted out of the box, thereby revealing the lambda.7 haptic device controller, as shown in figure 6.
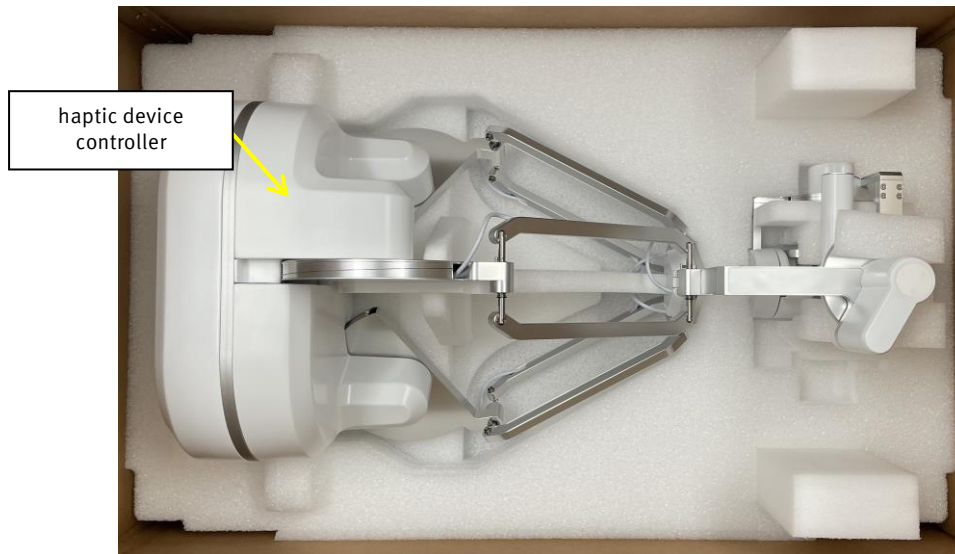
Figure 6 – Shipping box containing the lambda.7 device after removal of the upper foam layer.

Place the upper foam layer upside down on a flat surface.

Carefully extract the haptic device from the carboard box and place the system on its upper foam layer as shown in figure 8. This will protect the haptic device during preparation.

Finally, remove the protective foam which secures the wrist and gripper handle.

Figure 7 – Lifting the haptic device out of its shipping box.
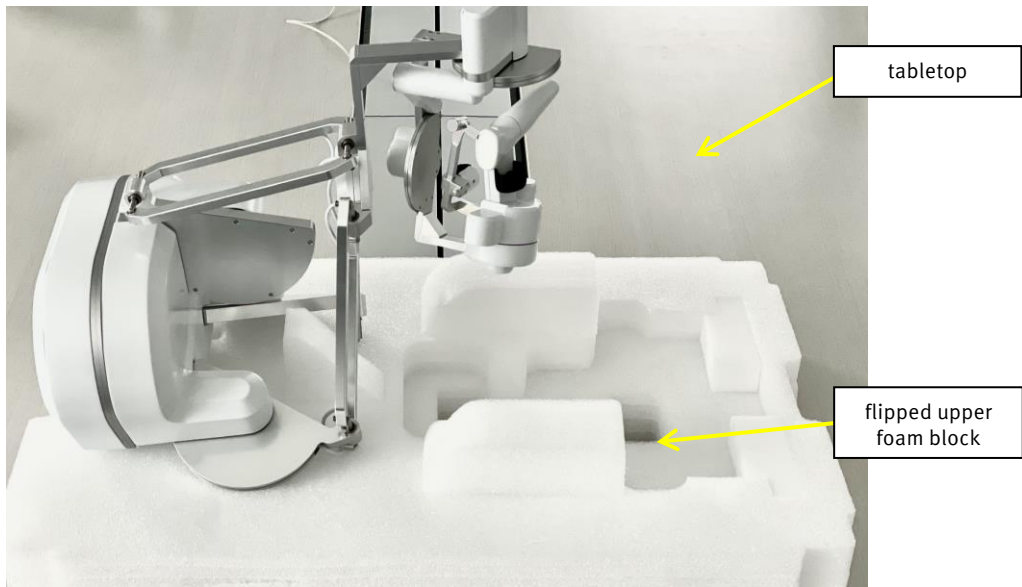
Figure 8 – The haptic device shall be placed on its flipped upper foam layer on a flat surface for preparation.

Insert the **pole interface** at the rear of haptic device controller by **making sure that the groves of the pole interface align with the spherical contact points** on the device.

*Figure 9 – Aligning the **pole interface** with the **contact points** of the lambda.7 haptic device.*

Securely fasten the **tightening screw** by using the **red hex key,** as illustrated in figure 10.

Figure 10 – Mounting the pole interface to the haptic device controller with the help of the tightening screw.

By using the same **red hex key**, loosen the **clamping screw** as illustrated on the left image of figure 11.

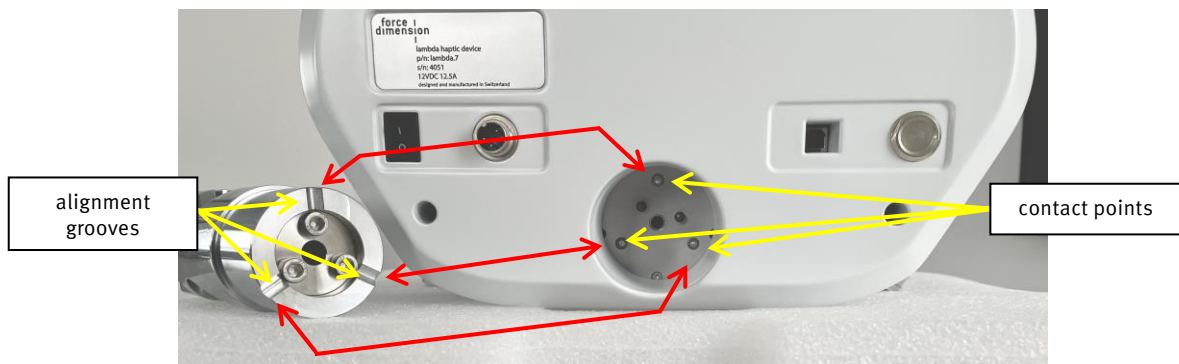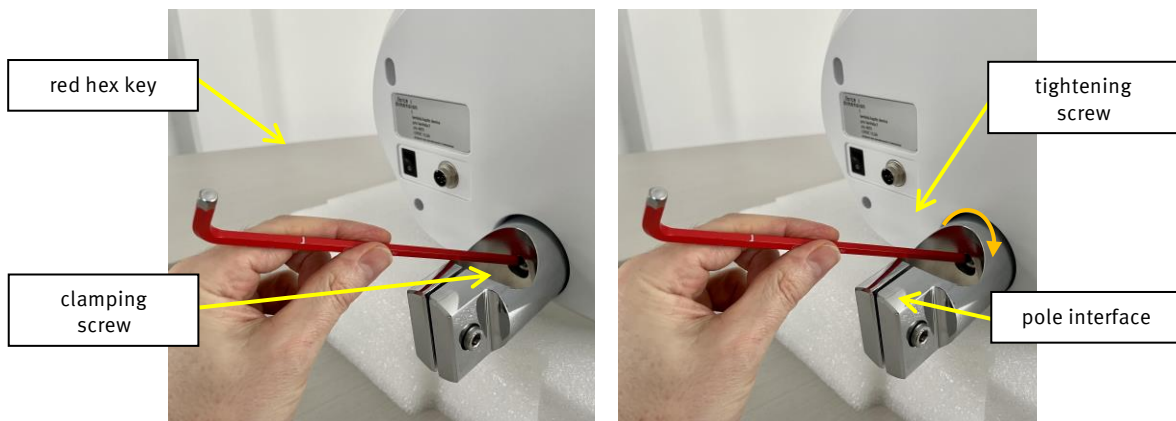Finally, mount the lambda.7 device base on its stand pole by sliding it from the top, as shown on the right image of figure 11. Place the haptic device controller at the desired height and lock the mechanism by fastening the clamping screw.

Verify that the device is correctly secured by making sure that the device base cannot rotate around its vertical stand pole. If any slippage occurs, further tightening of the clamping screw may be required.

Figure 11 – After loosening the clamping screw, the haptic device controller can be mounted on the stand pole.
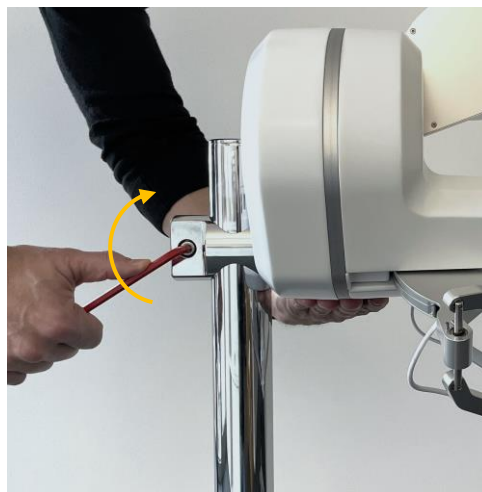
Figure 12 – Fastening the clamping screw while holding the device with the opposite hand.

Your lambda.7 haptic device is now fully assembled. You may place the haptic device at your console desk where you will be operating the system.

3.2 Installing the power supply

Plug and tighten the power supply into the power connector. For safety purposes you should only operate your lambda.7 haptic device using the original power supply that came with your haptic device controller. Replacement power supplies can be ordered directly from Force Dimension.

Figure 13 – Connection and tightening of the power connector.

3.3 Connecting the lambda.7 haptic device to your computer

Connect the lambda.7 haptic device to your computer using the USB cable which is included in the box.

3.4 Software installation

A USB flash drive, located with the accessories, includes the drivers and SDK installation media for the different operating systems.

4. Configuring the lambda.7 under Windows

4.1 Installing the software

The USB driver must be first installed onto your system **prior to connecting the lambda.7 to the computer**. To do this, perform the following steps:

1. Plug the Force Dimension USB flash drive into your Windows computer.

2. Open the `\Windows` folder on the USB flash drive and select the appropriate `\32-bit` or `\64-bit` subfolder according to the operating system version on your computer.

3. Run the installation program and follow its instructions.

4.2 Installation description

The installation program creates the following subfolders in:

`C:\Program Files\Force Dimension\sdk-<version>`

`\bin` subfolder

This directory contains the demonstration executables and the DLL files required to run the lambda.7 software. The required DLL files are also copied to the Windows system folder during the installation.

`\drivers` subfolder

This directory contains the USB drivers required to operate your haptic device.

`\examples` subfolder

This directory contains the demonstration programs. Example applications described in section 7.4 and come with their full source code.

`\doc` subfolder

All documentation files and notices are located in that directory.

`\manuals` subfolder

All hardware user manuals are located in that directory.

`\lib,\include` subfolders

These directories contain the files required to compile your application with the Force Dimension SDK. Please refer to the on-line programming manual for more information (see subfolder `\doc`).

4.3 Installing the drivers

USB drivers

The lambda.7 requires the Force Dimension USB driver. These drivers are installed automatically, and no additional step is required.

5. Configuring the lambda.7 under Linux

5.1 Installing the software

The Force Dimension development folder must be installed onto your system before the lambda.7 can be used. To do this, perform the following steps:

1. Plug the Force Dimension USB flash drive into your Linux computer.

2. Extract the `sdk-<version>.tar.gz` archive for your system architecture from the `\Linux` subfolder to the desired location (typically your home folder) by running the following command within the target folder:

   ```
   tar -zxvf sdk-<version>.tar.gz
   ```

   This will create a `sdk-<version>` development folder in the target location.

5.2 Installation description

The development folder contains the following directories:

`\bin` subfolder

This directory contains the demonstration executables and the binary files required to run the lambda.7 software.

`\examples` subfolder

This directory contains the demonstration programs. Example applications described in section 7.4 and come with their full source code.

`\doc` subfolder

All documentation files and notices are located in this subfolder.

`\manuals` subfolder

All hardware user manuals are located in that directory.

`\lib,\include` subfolders

These directories contain the files required to compile your application with the Force Dimension SDK. Please refer to the on-line programming manual for more information (see subfolder `\doc`).

5.3 Installing the drivers

The Linux version of the Force Dimension SDK requires the development packages for the `libusb-1.0` to be installed on your Linux distribution.

IMPORTANT

PLEASE NOTE THAT USB ACCESS TO THE HAPTIC DEVICE REQUIRES SUPERUSER PRIVILEDGES ON MOST LINUX DISTRIBUTIONS

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6. Configuring the lambda.7 under macOS

6.1 Installing the software

The Force Dimension development folder must be installed onto your system before the lambda.7 can be used. To do this, perform the following steps:

1. Plug the Force Dimension USB flash drive into your Apple computer.

2. Open the `sdk-<version>.dmg` file for your version of macOS from the `\macOS` folder and extract the `sdk-<version>` folder to the desired location (typically your home folder).

   This will create a `sdk-<version>` development folder in the target location.

6.2 Installation description

The development folder contains the following directories:

`\bin` subfolder

This directory contains the demonstration executables and the binary files required to run the lambda.7 software.

`\examples` subfolder

This directory contains the demonstration programs. Example applications described in section 7.4 and come with their full source code.

`\doc` subfolder

All documentation files and notices are located in this subfolder.

`\manuals` subfolder

All hardware user manuals are located in that directory.

`\lib,\include` subfolders

These directories contain the files required to compile your application with the Force Dimension SDK. Please refer to the online programming manual for more information (see subfolder `\doc`).

6.3 Installing the drivers

The macOS version of the Force Dimension SDK uses Apple's native USB drivers. No further installation is required.

7. Operating the lambda.7

7.1 Coordinate system

base translation

The position of the center of the end-effector (handle) is expressed in Cartesian coordinates and in IUS (metric) units. Figure 14 illustrates the coordinate system. You will notice that the Z-axis of the coordinate system is parallel to the first revolute axis of the wrist.

The actual origin of the coordinate system (0,0,0) is located on a virtual point situated at the center of the physical workspace of the haptic device.
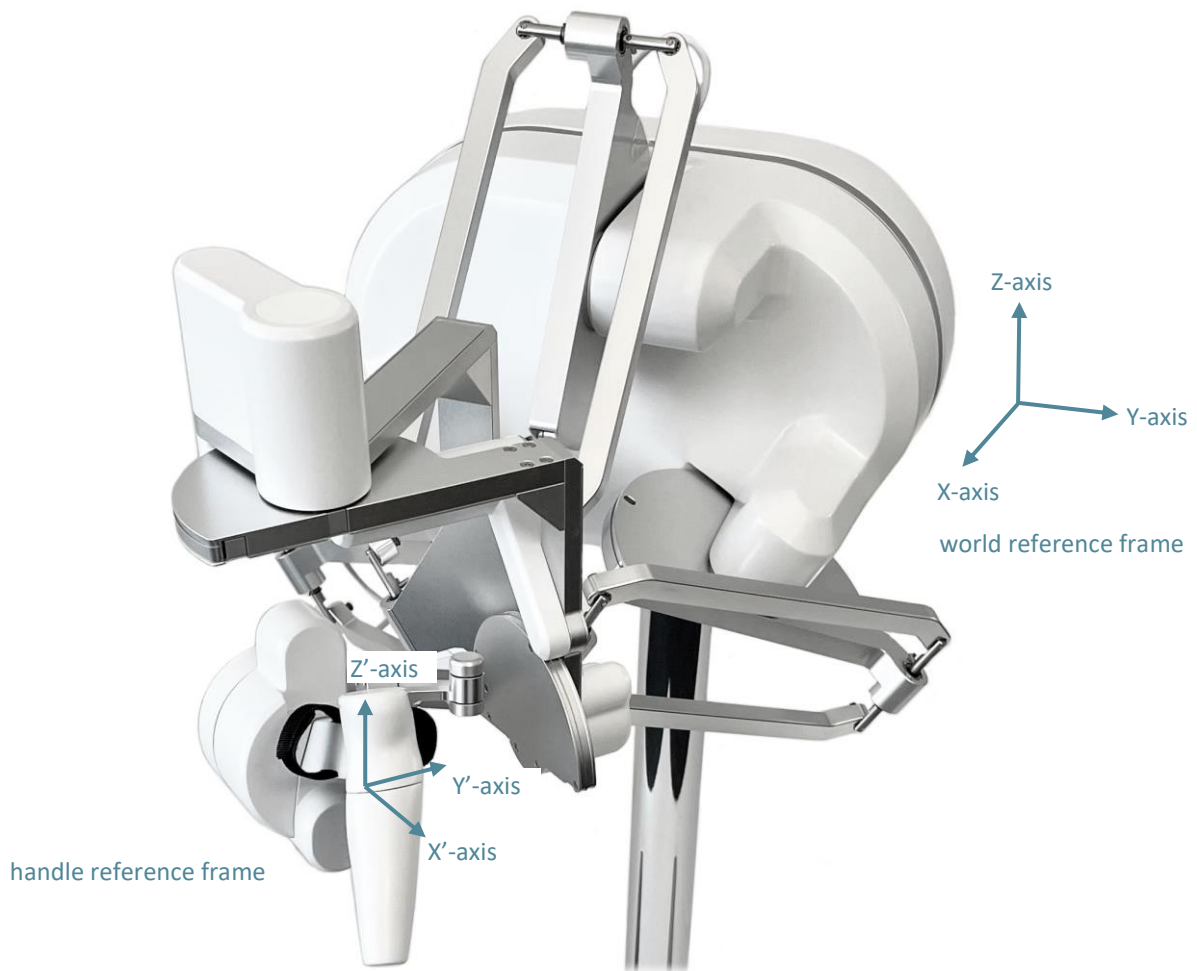

Figure 14 – World and handle reference frames of the lambda.7 haptic device

wrist orientation

The orientation of the lambda.7 haptic device handle is expressed by a reference frame which is numerically represented in the SDK using a 3x3 rotation matrix. This reference frame is expressed in relation to the world coordinate system described in figure 14.

The reference frame of the handle is computed from the angle values returned by the joint sensors mounted of each revolute axis of the wrist as illustrated in figure 15. When all joint angles are equal to zero, an identity rotation matrix is returned.
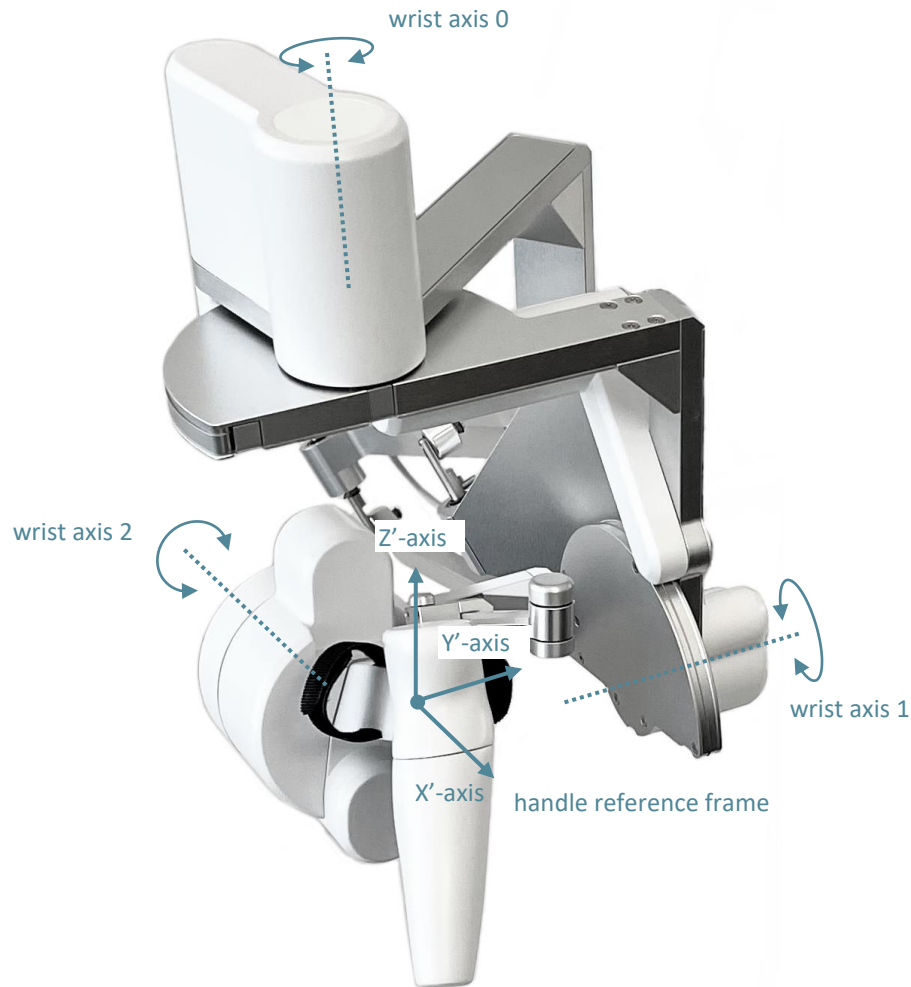

Figure 15 – Reference frame of the handle of the lambda.7 haptic device

gripper angle

The angular position of the force gripper is returned in either degrees or radian.

A **positive angle value** is returned for **right-hand** lambda.7 haptic devices. A **negative angle value** is returned for **left-hand** haptic devices.

Angular values closer to zero correspond to configurations where the force gripper is in a closed configuration. Opening of the force gripper increases the magnitude of the angle.

7.2 Operating modes

calibration

Calibration of the haptic device controller is necessary to obtain accurate, reproducible localization of the end-effector within the workspace of the haptic device. The lambda.7 is designed in such a way that there can be no drift of the calibration over time, so the procedure only needs to be performed once each time the device is powered ON.

The automatic calibration procedure is performed by software using the Force Dimension SDK, for example by launching the application "**HapticInit**" which automatically drives the device throughout its workspace. Please do not touch the device during this automatic calibration procedure. After calibration, the device is ready for normal operation.

gravity compensation

To prevent user fatigue and to improve dexterity during manipulation, the lambda.7 features gravity compensation. When gravity compensation is enabled, the weights of the arms and of the end-effector are taken into account and a vertical force is dynamically applied to the end-effector in addition to the desired user force command. Please note that gravity compensation is computed on the host computer, and therefore only gets updated every time a new force command is sent to the haptic device by the application. Gravity compensation is enabled by default and can be disabled through the Force Dimension SDK.

forces

By default, and when an application opens a connection to the haptic device controller, all forces are initially disabled. Forces can be enabled or disabled through the Force Dimension SDK.

brakes

The device features electromagnetic brakes that can be enabled through the Force Dimension SDK. These brakes are enabled by default every time the forces are disabled. When the brakes are engaged, a viscous force is created that prevents rapid movement of the end-effector.

7.3 Running the Haptic Desk program

The Haptic Desk application is available as a test and diagnostic program and offers the following capabilities:

> list all Force Dimension haptic devices connected to the system,
> test the position reading of the haptic device in Cartesian coordinates,
> test all force and torque capabilities of the haptic device,
> test the active locks,
> run the auto-calibration procedure,
> read the haptic device status,
> read the haptic device encoder sensors individually,
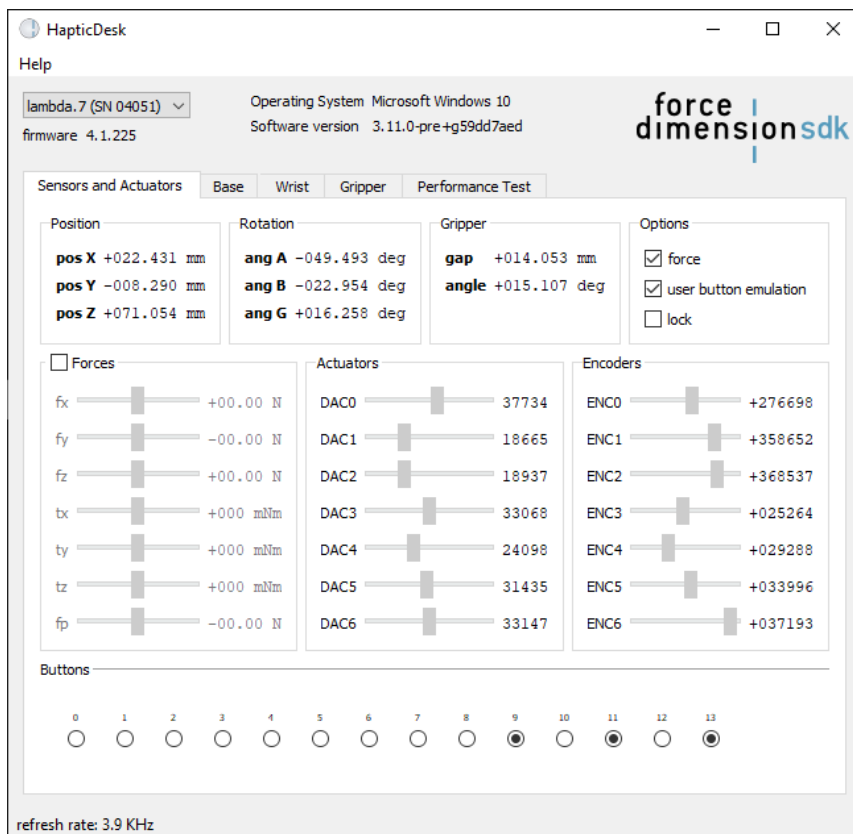> read the simulated user button.

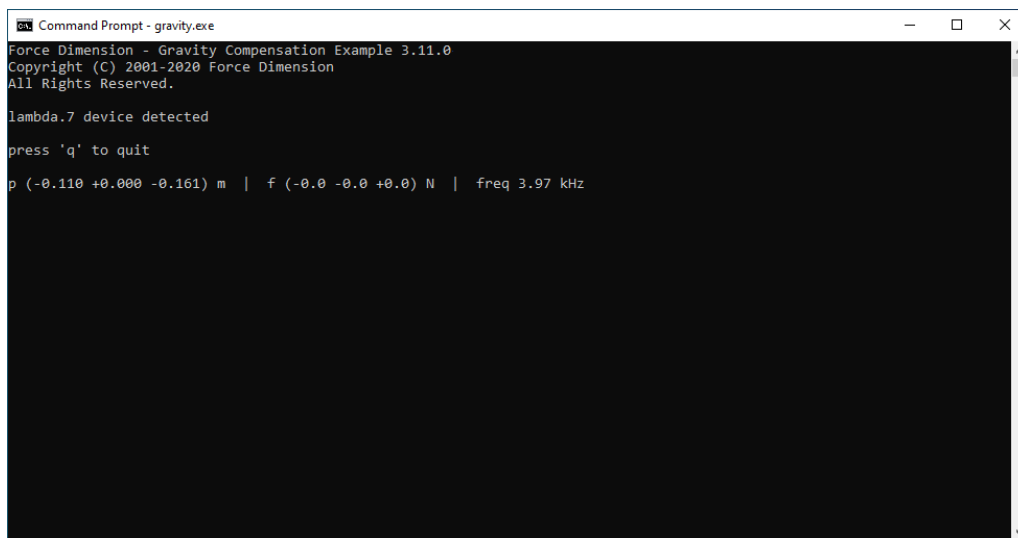*Figure 16 – Haptic Desk test and diagnostic program*

7.4 Running the demonstrations programs

Two demonstration programs can also be used to diagnose the device. The source code and an executable file for each of these demonstration programs are provided in two separate directories named `\gravity` and `\torus`.

Once the system is setup, we suggest running application **`gravity`** to check that everything is working properly and to evaluate your system's performance independently of the graphics rendering performance. Application **`torus`** will allow you to test the combined performance of haptics and graphics rendering.

gravity example

This example program runs a best effort haptic loop to compensate for gravity. The appropriate forces are applied at any point in space to balance the device end-effector so that it is safe to let go of it. The refresh rate of the haptic loop is displayed in the console every second.

Figure 17 – Gravity example

torus example

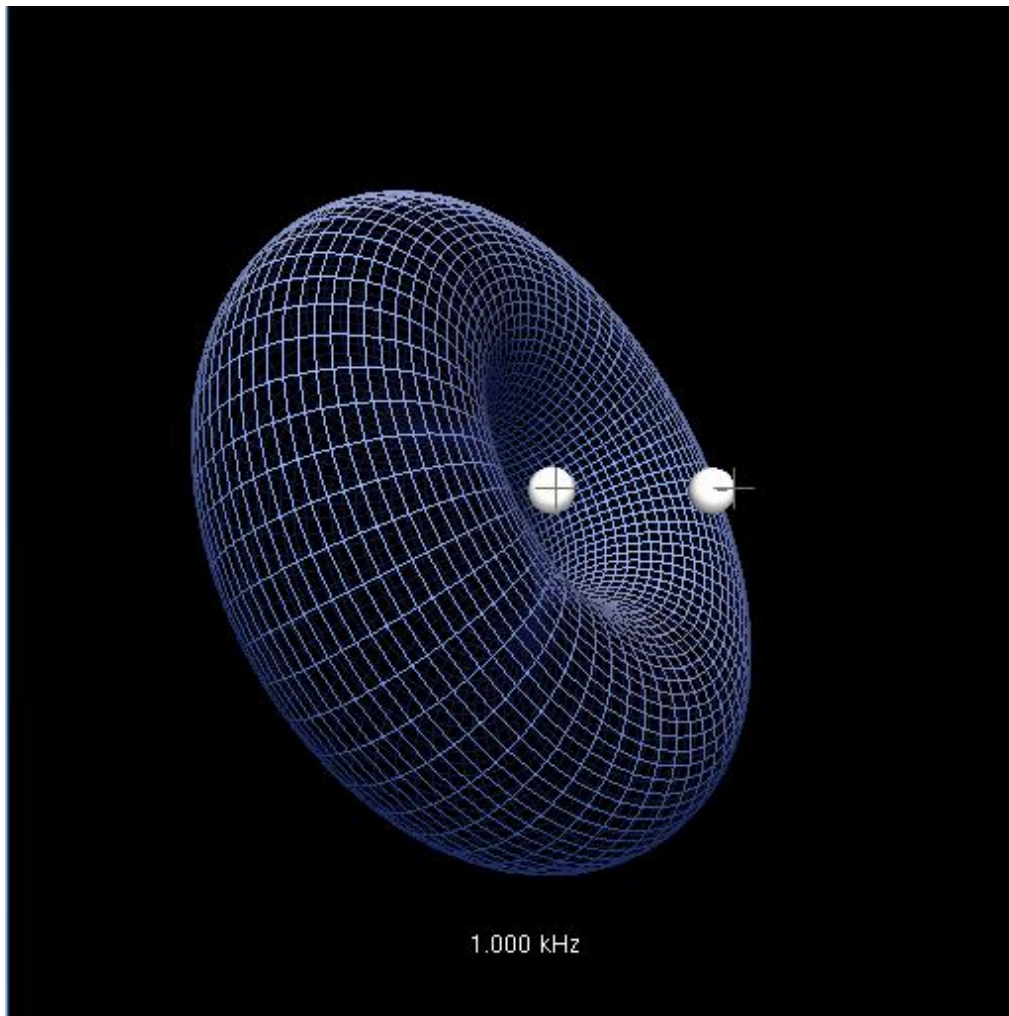The `torus` example displays an OpenGL scene with haptic feedback.

Figure 18 – Torus example

note – OpenGL must be installed for your compiler and development environment to compile this example. Please refer to your compiler documentation for more information, or consult http://www.opengl.org

8. Technical information

lambda.7

workspace	translation	∅ 240 mm x L 170 mm
	rotation	180 (yaw) x 140 (pitch) x 290 (roll) deg
	gripper	15 deg
forces	translation	20.0 N
	rotation	200 (yaw), 400 (pitch), 100 (roll) mNm
	gripper	± 8.0 N
resolution	translation	0.0015 mm
	rotation	0.0067 (yaw) x 0.0067 (pitch) x 0.0135 (roll) deg
	gripper	0.015 deg
active locks	translation	parking position

electronics

interface	standard	USB 2.0
	refresh rate	up to 4 KHz
power	universal	100V - 240V

software

platforms	Microsoft	Windows
	Linux	all distributions
	Apple	macOS
	Blackberry	QNX
	WindRiver	VxWorks
libraries	Haptics SDK	
	Robotics SDK	

features

ergonomics	available in left- and right-hand configuration
structure	delta-based parallel kinematics
	hand-centered rotation movements
	decoupling between translation and rotation movements
	active gravity compensation
calibration	automatic
	driftless
safety	communication watchdog
	electromagnetic damping

notice