USER MANUAL
omega.x haptic device
version 1.9

Force Dimension
Switzerland

www.forcedimension.com

summary

The purpose of this document is

- to describe the setup of the omega.x haptic device
- to describe the installation of the software drivers and the Force Dimension SDK
- to describe the operation modes of the omega.x haptic device

glossary

SDK	refers to the Software Development Kit (SDK) for all Force Dimension products.
omega.x	refers to the base haptic device shared by the omega.3, omega.6 and omega.7 haptic devices. Unless specified, all instructions in this manual apply to all three device types.

table of contents

1. system overview

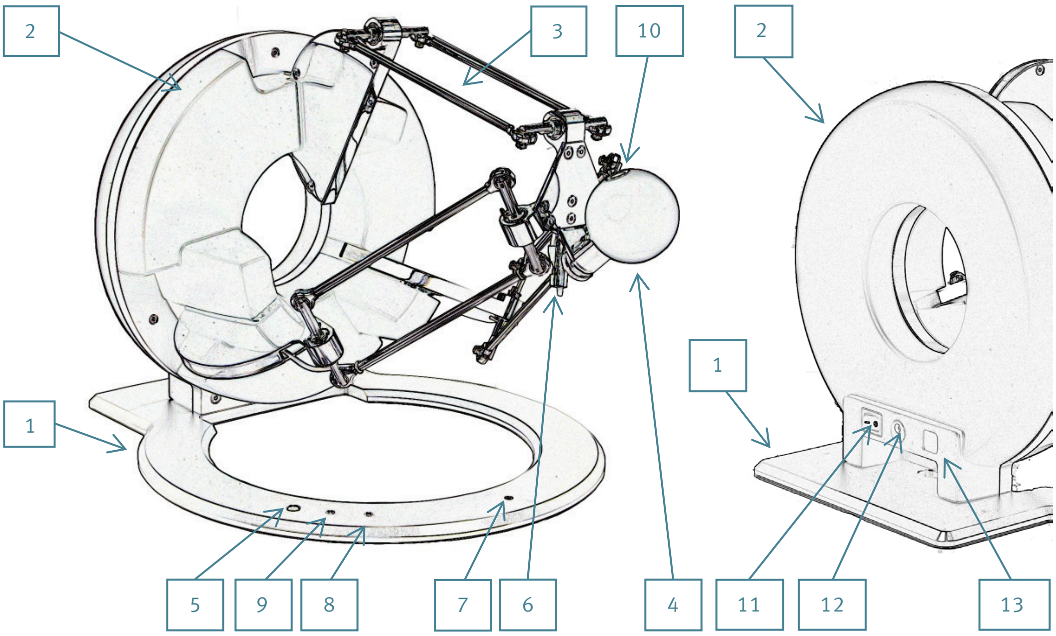


figure 1 – overview of the omega.3 haptic device

1. base plate
2. control unit
3. front arms
4. end-effector
5. force button
6. calibration pole
7. calibration pit
8. status LED
9. force LED
10. user button
11. power switch
12. power connector
13. 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 omega.x haptic device

This section describes the different steps to follow to safely setup your omega.x haptic device before use.

IMPORTANT

PLEASE KEEP THE ORIGINAL PACKAGING
ONLY USE THE ORIGINAL PACKAGING DURING STORING OR SHIPPING

3.1 unpacking the device

Before unpacking the omega.x haptic device, remove the haptic device foam stabilizer and the accessories foam section located inside the shipping box.

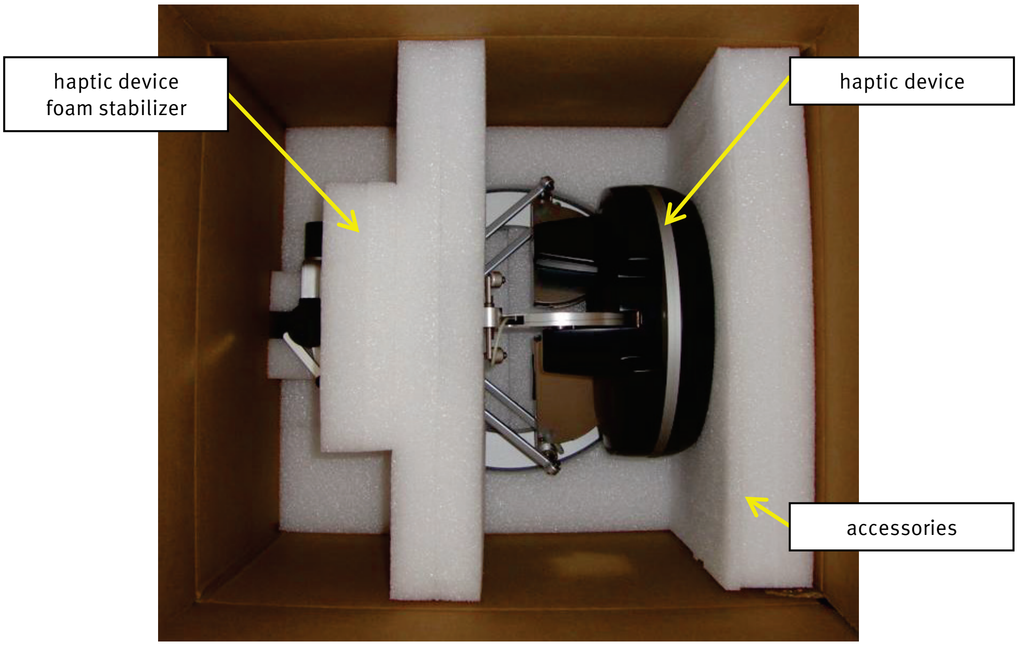


figure 2 – view when opening the shipping box

Carefully remove the haptic device and the foam stabilizer from the box, then remove the foam stabilizer from the haptic device.

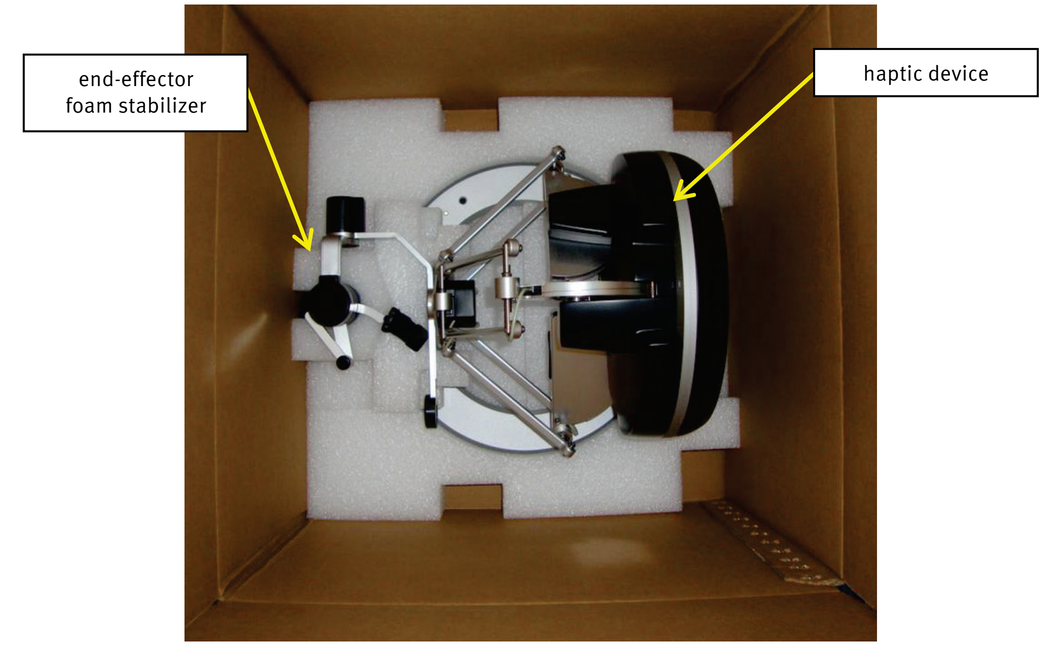


figure 3 – view of the shipping box after removal of the foam stabilizer and accessories

The accessories compartment contains the power supply, power and USB cables, as well as the USB flash drive.

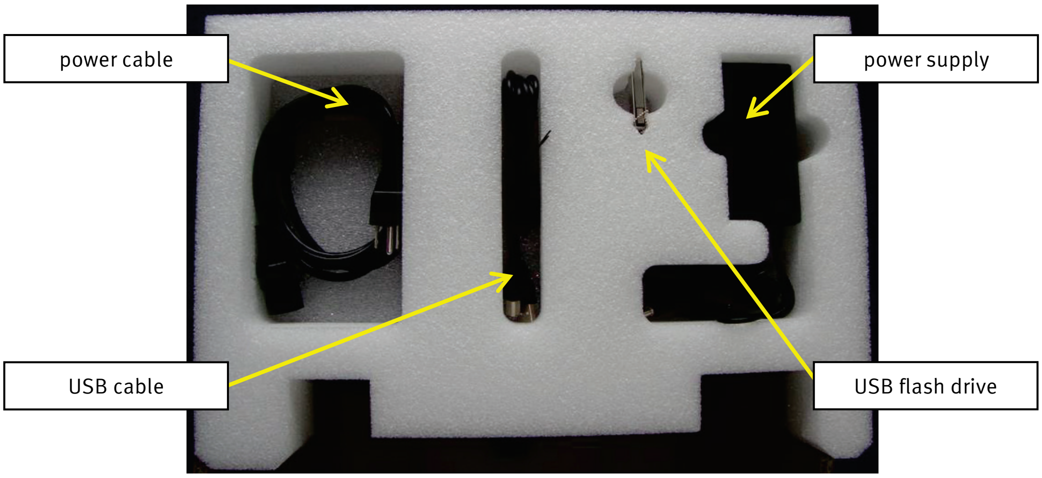


figure 4 – omega.x accessories

3.2 installing the power supply

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

4. configuring the omega.x under Windows

The USB driver must be first installed onto your system **prior to connecting the omega.x 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

4.1 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 omega.x 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.

4.2 installing the drivers

USB drivers

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

5. configuring the omega.x under Linux

5.1 installing the software

The Force Dimension development folder must be installed onto your system before the omega.x 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
   ```

3. 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 omega.x 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.

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

6. configuring the omega.x under macOS

6.1 installing the software

The Force Dimension development folder must be installed onto your system before the omega.x 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)
3. 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 omega.x 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.

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 omega.x

7.1 coordinate system

base translation

The position of the center of the end-effector (handle) is expressed in Cartesian coordinate and in IUS (metric) unit. Figure 5 illustrates the coordinate system.

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.

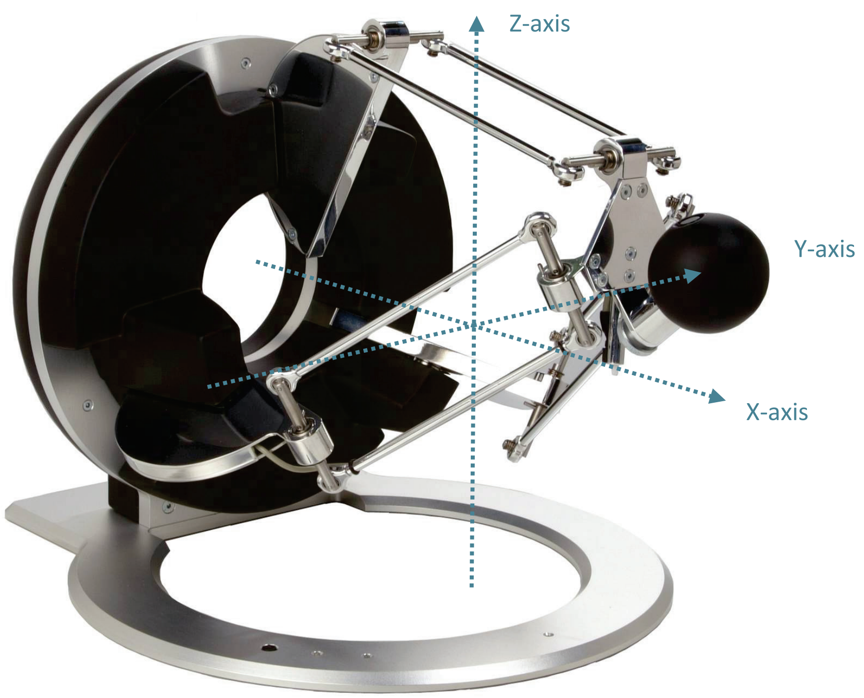
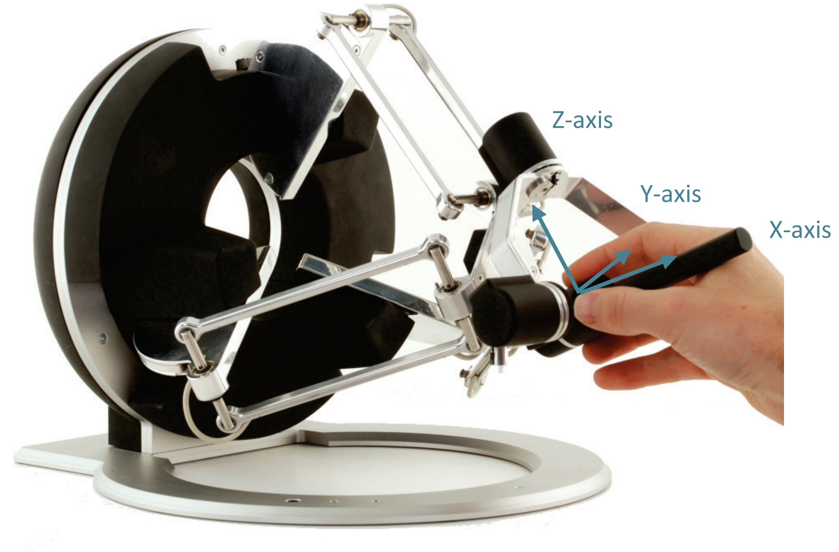


figure 5 – Cartesian coordinate system of the omega.x haptic device

wrist orientation

The omega.6 and omega.7 haptic devices incorporate a rotational wrist. The orientation of the wrist is expressed by a reference frame R_{wrist} which is numerically represented using a 3x3 rotation matrix. This reference frame is expressed in relation to the world coordinate system described in figure 5 and is computed from the angle values returned by the joint sensors mounted of each revolute axis of the wrist.



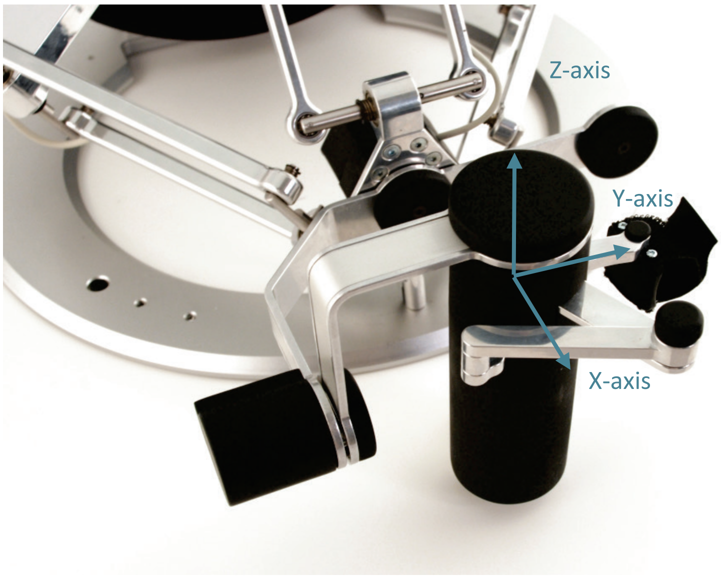


figure 6 – reference frame of the wrist (omega.6 and omega.7 haptic devices)

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** omega.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

status indicators

The displays the status of the system:

- LED OFF — the system is off
- LED ON — the system is ready
- LED FLASHING (fast) — the system requires calibration
- LED FLASHING (slow) — the wrist requires manual calibration (omega.6 or omega.7)

While the status LED is ON, it is possible to read the position of the of the end-effector, but no forces can be applied. Forces must be enabled by pressing the force button. When the forces are enabled, the force LED is turned ON. Forces can be disabled by pressing force button again.

features

calibration

Calibration is necessary to obtain accurate, reproducible localization of the end-effector within the workspace of the device. The omega.x 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 when the device is powered ON.

The calibration procedure consists in placing calibration pole in the dedicated calibration pit. The device detects when the calibration position is reached and the status LED stops flashing.

Figure 7 illustrates the calibration procedure. After the initial calibration described above, the LED will stop flashing (omega.3).

figure 7 – calibration procedure

On the omega.6 and omega.7, the status LED will blink at a slower frequency, indicating that the wrist is usable but not fully calibrated. To fully calibrate the omega.6 and omega.7 wrists, each of the three rotation axes of the wrist and the grasping axis of the omega.7 must be moved by hand to their respective end-stops positions. When the device has reached all end-stops, the LED stops flashing, and the device is now fully calibrated.

Alternatively, an automatic calibration procedure of the omega.x active axes can be 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 omega.x 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 device, the forces are disabled. Forces can be enabled or disabled at any time by pressing the force button.

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.

safety features

The omega.x features several safety features designed to prevent uncontrolled application of forces and possible damage to the device. These safety features can be adjusted or disabled via a protected command in the Force Dimension SDK.

IMPORTANT

PLEASE NOTE THAT THE WARRANTY MAY NOT APPLY
IF THE SAFETY FEATURES HAVE BEEN OVERRIDEN.

When a connection to the omega.x haptic device is made from the computer, the forces are automatically disabled to avoid unexpected behaviors. The user must press the force button to enable the forces. This feature can be bypassed through the Force Dimension SDK.

If the control unit detects that the velocity of the end-effector is higher than the programmed security limit, the forces are automatically disabled, and the device brakes are engaged to prevent a possibly dangerous acceleration from the device. This velocity threshold can be adjusted or removed through the Force Dimension SDK.

Please refer to the on-line programming manual for more information.

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
- run the auto-calibration procedure
- read the haptic device status
- read the haptic device encoder sensors individually
- read the haptic device user button (if available)

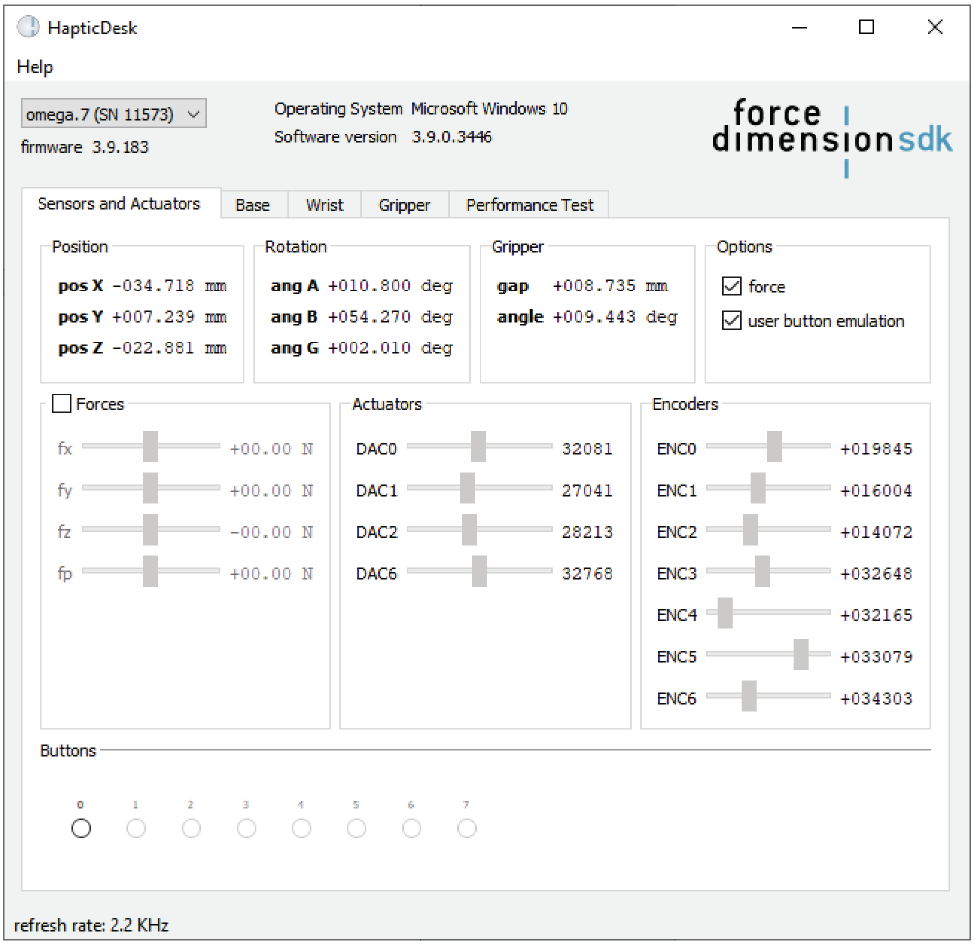


figure 8 – Haptic Desk test and diagnostic program

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.

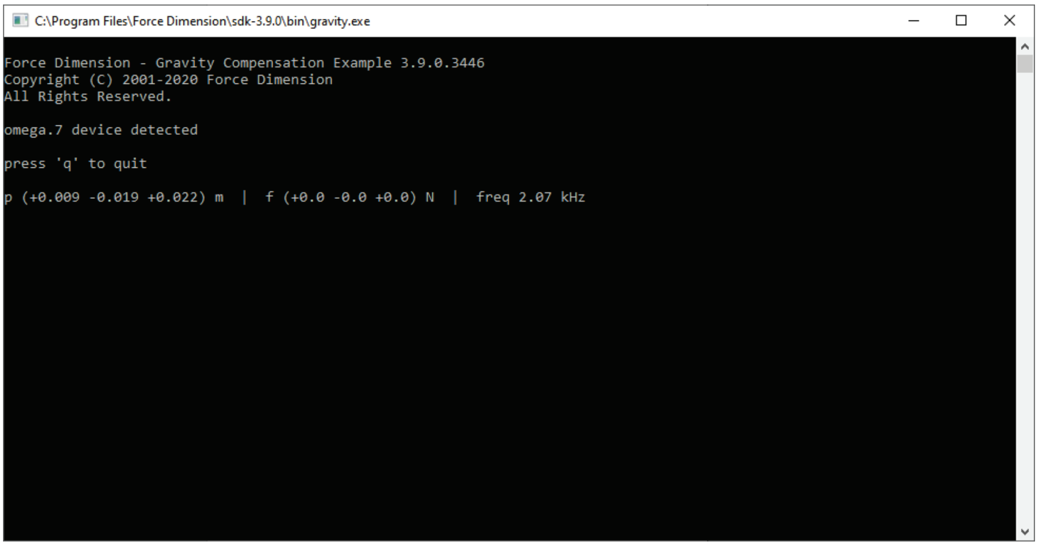


figure 9 – gravity example

torus example

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

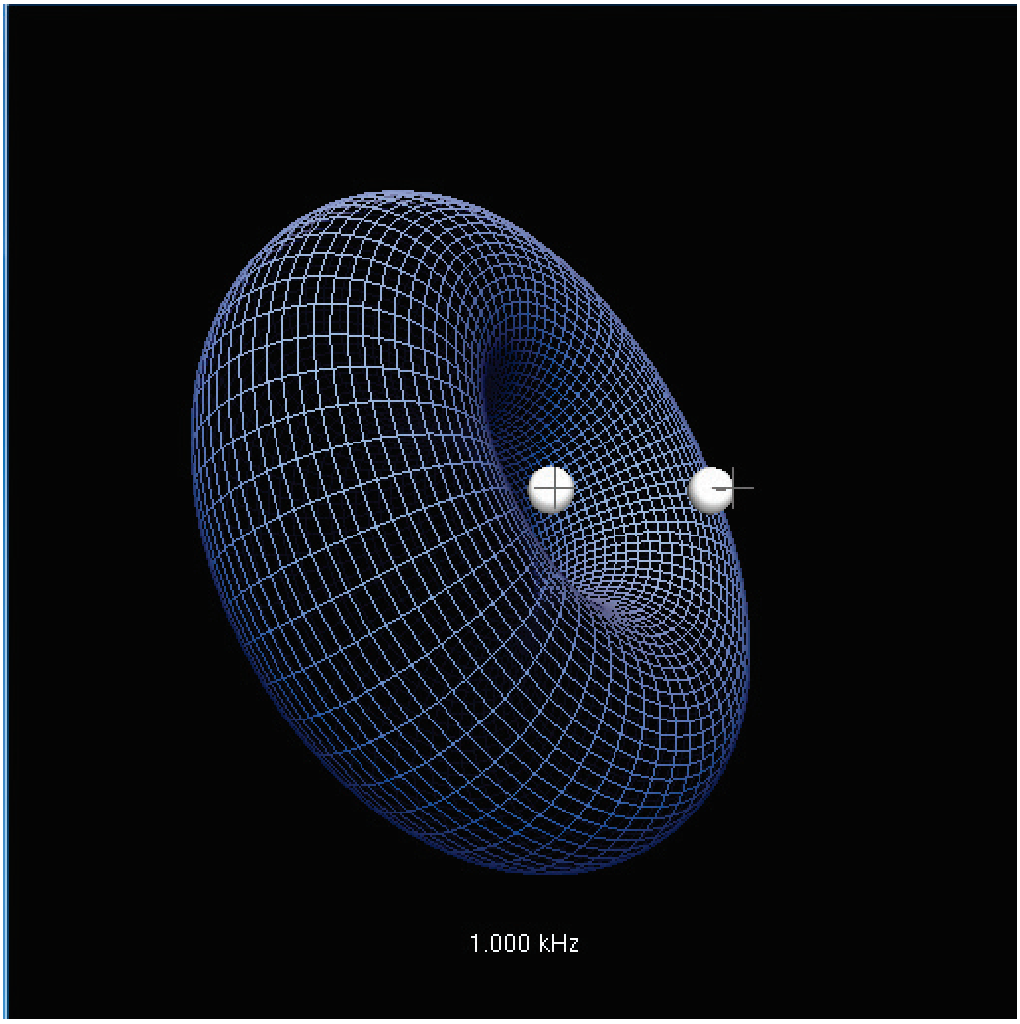


figure 10 – torus example

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 - omega.3

omega.3

workspace	translation	∅ 160 mm x L 110mm
forces	continuous	12.0 N
resolution	linear	‹ 0.01 mm
dimensions	height width depth	270 mm 300 mm 350 mm

electronics

interface	standard rate	USB 2.0 up to 4.0 KHz
power	universal	100V - 240V

software

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

features

ergonomics	the device can be used with both left and right hands
structure	delta-based parallel kinematics active gravity compensation
calibration	automatic driftless
user input	1 user button
safety	velocity monitoring electromagnetic damping

9. technical information - omega.6

omega.6

workspace	translation	∅ 160 mm x L 110mm
	rotation	240 x 140 x 320 deg
forces	continuous	12.0 N
resolution	linear	< 0.01 mm
	angular	0.09 deg
dimensions	height	270 mm
	width	300 mm
	depth	350 mm

electronics

interface	standard	USB 2.0
	rate	up to 4.0 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
user input	1 user button
safety	velocity monitoring
	electromagnetic damping

10. technical information - omega.7

omega.7

workspace	translation	∅ 160 mm x L 110mm
	rotation	240 x 140 x 180 deg
	gripper	25 mm
forces	continuous	12.0 N
	grasping	± 8 N
resolution	linear	< 0.01 mm
	angular	0.09 deg
	linear	0.006 mm
dimensions	height	270 mm
	width	300 mm
	depth	350 mm

electronics

interface	standard	USB 2.0
	rate	up to 4.0 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
user input	1 simulated button using the force gripper
safety	velocity monitoring
	electromagnetic damping

notice