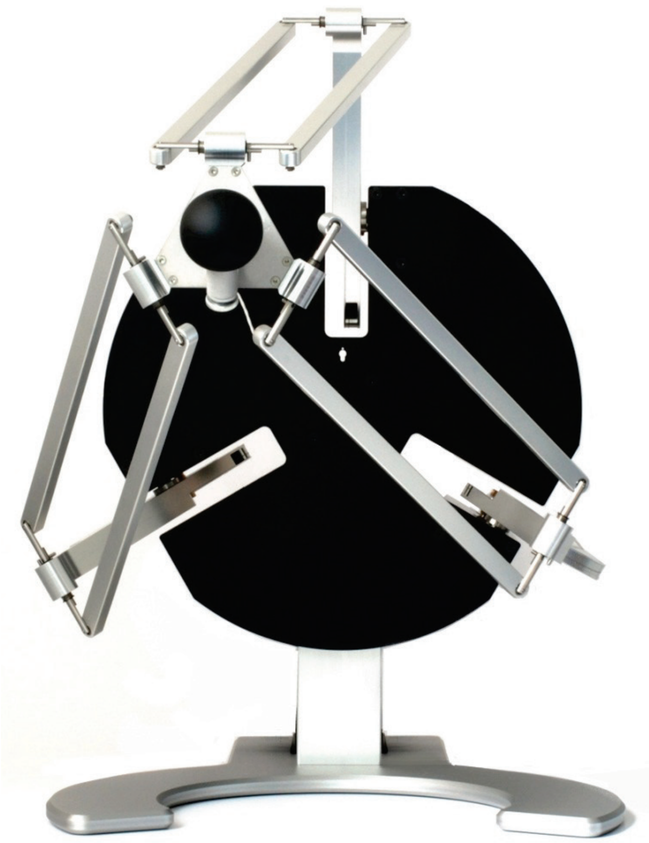
USER MANUAL
delta.x haptic device
version 1.11
03.2020



Force Dimension
Switzerland

www.forcedimension.com

summary

The purpose of this document is

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

glossary

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

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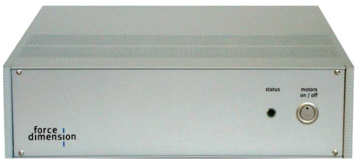
1. important safety instructions

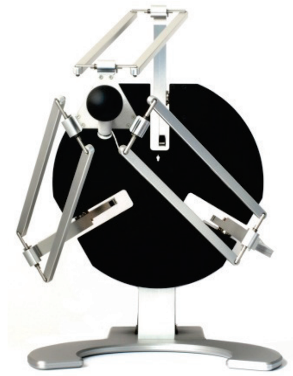
IMPORTANT

WHEN USING THIS UNIT, 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 this unit.
3. do not use or place this system near water.



Control Unit (DHC)



delta.x unit (DHD)

4. place the two units securely on a stable surface.
5. make sure that the working space of the DHD is free of objects..
6. do not overload wall outlets and extension cords. This can result in the risk of fire or electrical shock.
7. switch off the DHC (control unit) when the system is not in use.
   make sure the forces are disabled on the control unit before turning the power off
8. to reduce the risk of electrical shock, do not disassemble the DHC (control unit).

2. connecting the delta.x

A black connector box mounted of the foot base of the device centralizes all the connections between the motor encoders and the DHC. This section is provided for reference only.

1. on the device back plate (figure 1), connect the data cable and motor cable to their respective connectors (figure 2).

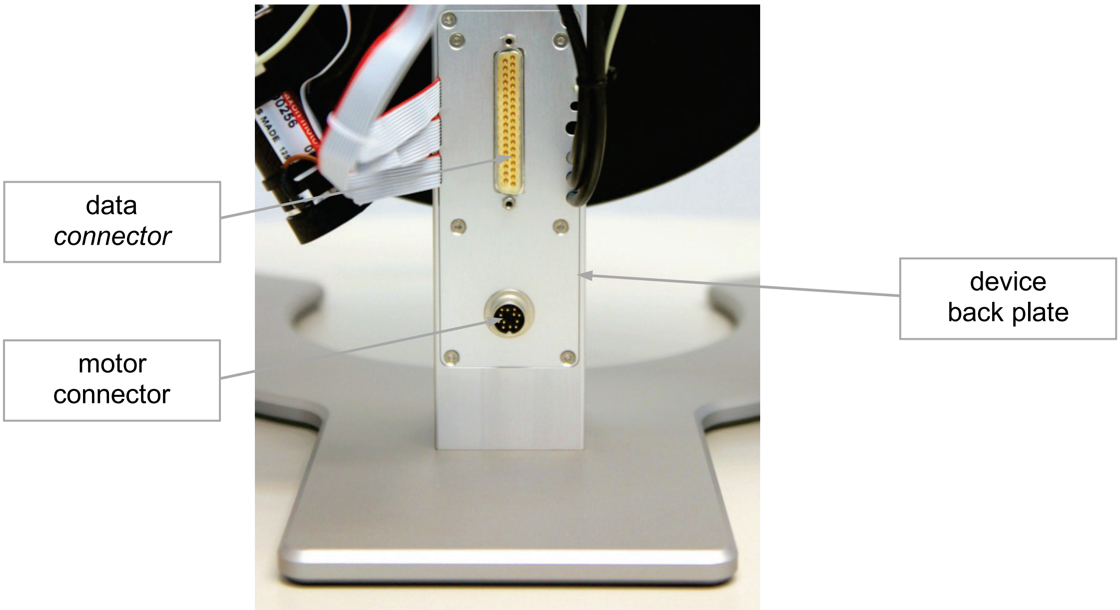


figure 1 – identifying the back plate connectors

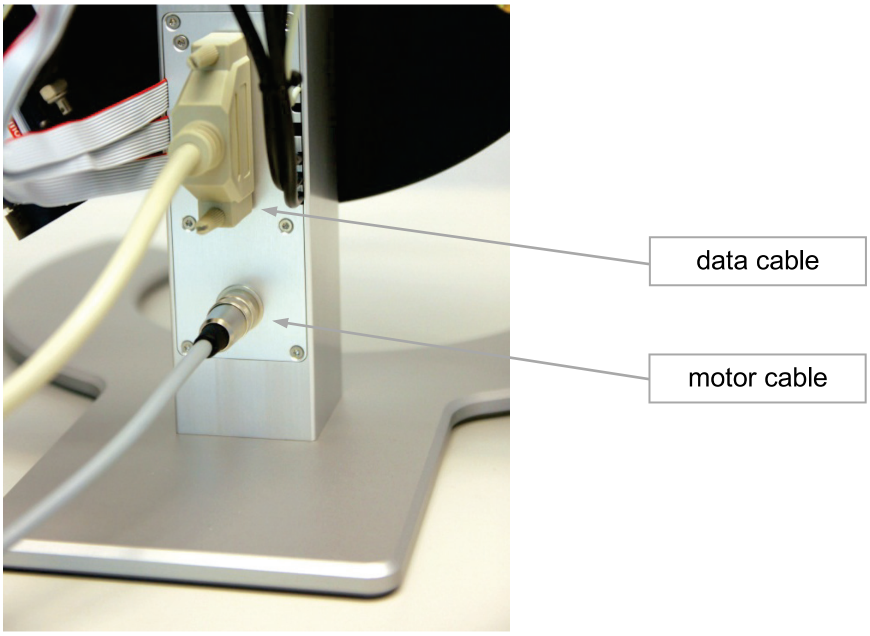


figure 2 – connecting the data and motor cables

2. on the controller back plate, connect the data cable and motor cable to their respective connectors (figure 3).

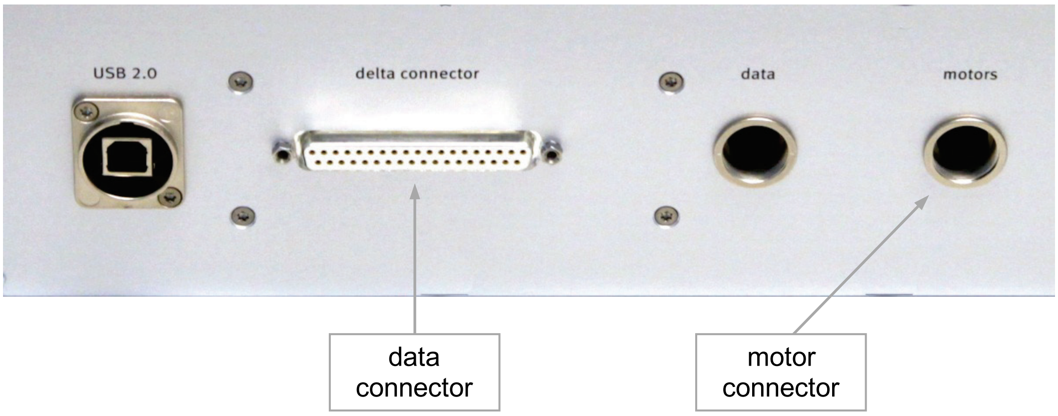


figure 3 – connecting the data and motor cables to the controller back plate

3. connect the control unit power socket (visible on figure 4, under the main power switch) to a power point using a three prong grounded plug.

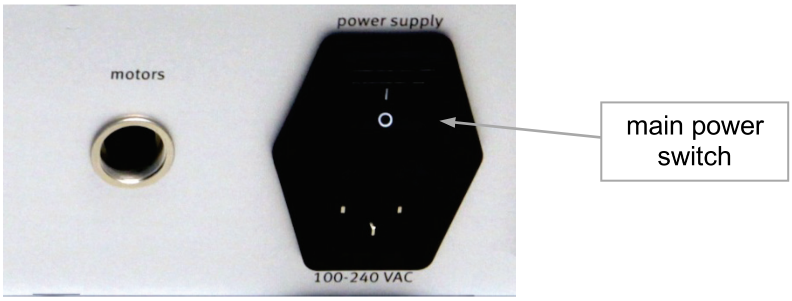


figure 4 – controller main power switch and socket

3. configuring the delta.x base

The delta base can be rotated using the orientation handle located on the foot base (figure 5). Make sure you securely tighten the handle after adjusting the delta base angle. The angle can be adjusted by increments of 11.25 deg.

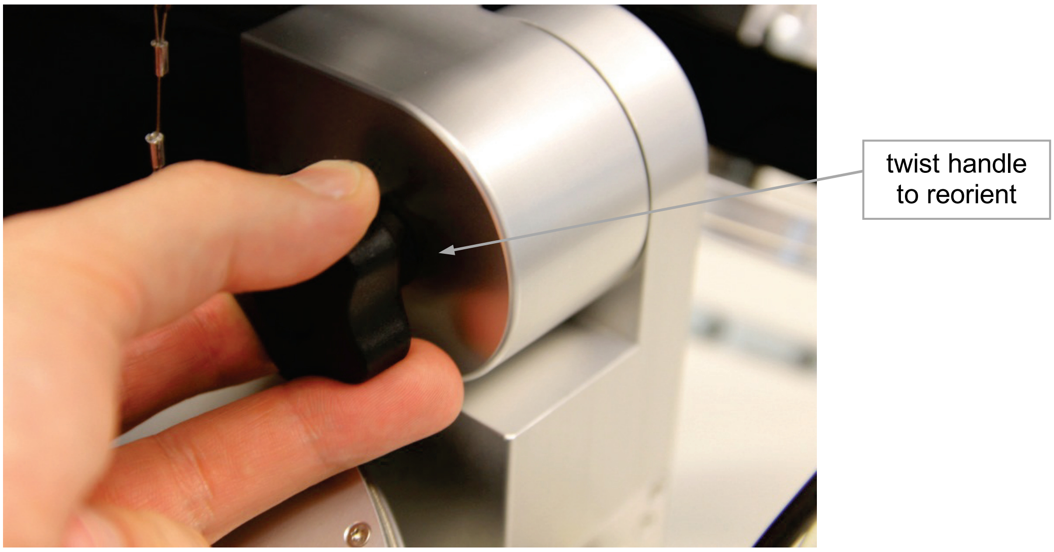


figure 5 – device base orientation handle

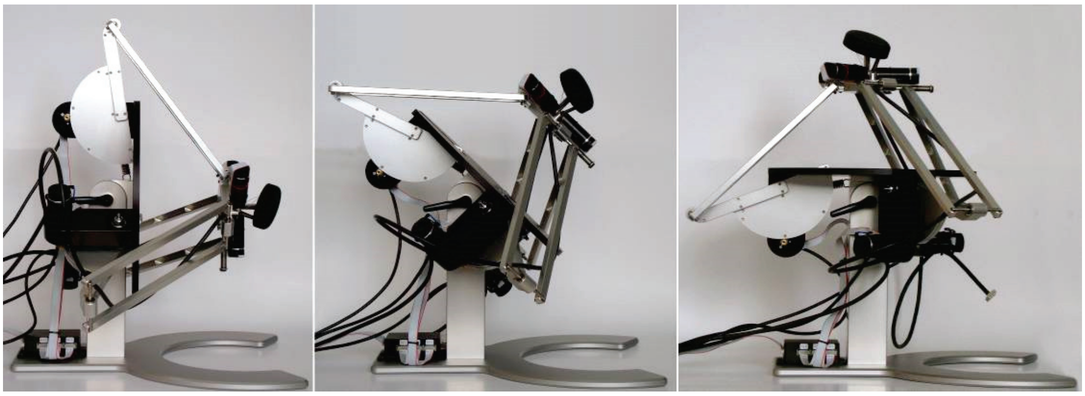


figure 6 – rotating the device (horizontal - vertical)

The FD-SDK provides a dedicated function, `dhdSetDeviceAngle()`, which adapts the reference frame and gravity compensation to the physical base angle of the delta.x base. See the programmer's manual for more details.

4. configuring the delta.x under Windows

4.1. installing the software

The installation USB drive must be installed onto your system **before connecting the delta.x to the system**. To do this, perform the following steps.

1. plug the Force Dimension USB drive into your system
2. open the `\Windows` subfolder on the USB drive
3. run `setup.exe` icon to launch the installation program
4. follow the instructions given by the installation program

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 delta.x software. The required DLL files are also copied to the Windows system folder during the installation.

`\drivers` subfolder

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

`\examples` subfolder

This directory contains the demonstration programs. Example applications described in section 7.5 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 you application with the Force Dimension SDK. Please refer to the on-line programming manual for more information.

4.3. installing the drivers

USB drivers

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

5. configuring the delta.x under Linux

5.1. installing the software

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

5. plug the Force Dimension USB drive into your system
6. decompress the `sdk-<version>.tar.gz` file from the drive `\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
   ```

7. 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 delta.x software.

\examples subfolder

This directory contains the demonstration programs. Example applications described in section 7.5 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 you 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` and `freeglut` to be installed on your Linux distribution.

6. configuring the delta.x under macOS

6.1. installing the software

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

8. plug the Force Dimension USB drive into your system
9. open the `sdk-<version>.dmg` file from the drive `\Mac OS` subfolder and extract the `sdk-<version>` folder to the desired location (typically your home folder)
10. 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 delta.x software.

`\examples` subfolder

This directory contains the demonstration programs. Example applications described in section 7.5 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 you application with the Force Dimension SDK. Please refer to the on-line programming manual for more information.

6.3. installing the drivers

The Apple version of the Force Dimension SDK uses Apple's native USB drivers, which are included in Mac OS X 10.4 and higher. No further installation is required.

7. using the delta.x

7.1. device geometry

delta.x translation axis

The position of the end-effector can be read from the controller. The system converts the encoder values into (X, Y, Z) coordinate, expressed in IUS (metric) unit. Figure 7 shows the coordinate system.

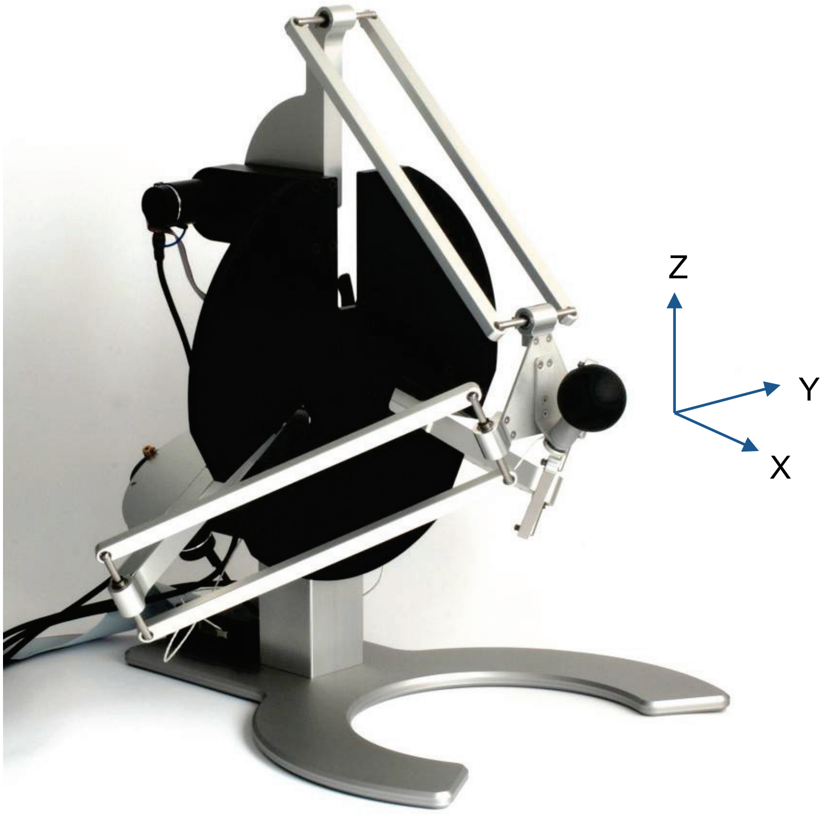


figure 7 – coordinate system

delta.6 extension (optional)

The delta.6 provides a rotational structure. Rotation information can be retrieved as a reference frame expressed by a 3x3 rotation matrix:

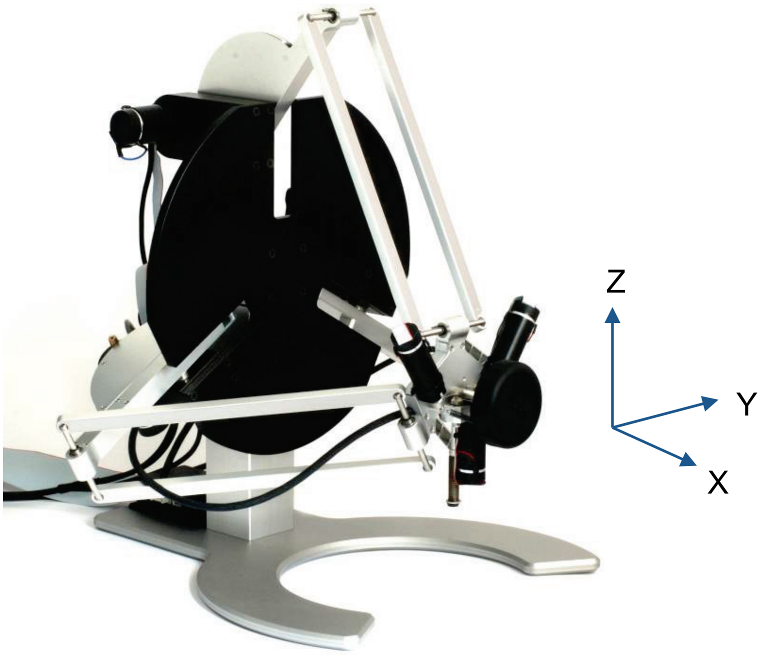


figure 8 – reference frame of the delta.6

7.2. operating the control unit

On the front panel of the delta controller unit are the following user interface functions (figure 9).

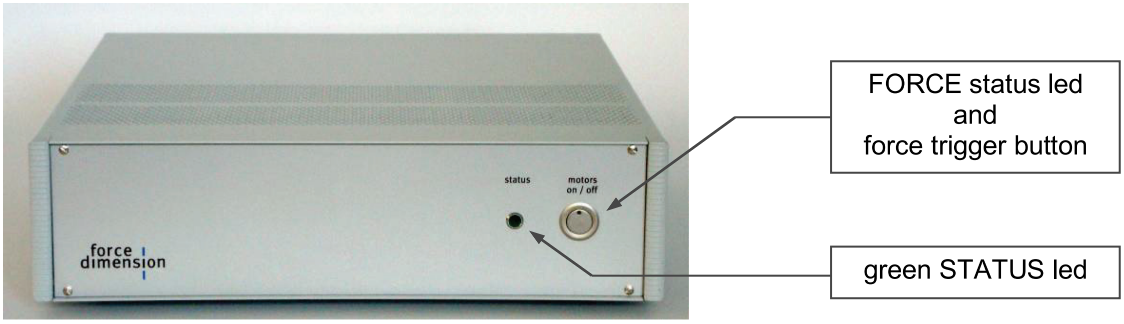


figure 9 – controller panel functions

STATUS Indicator

A **green led** indicator displays the status of the system.

Led OFF	The system is off
Led ON	The system is ready
Led BLINKLING	The system is waiting for the user to set the force gripper to its initial rest position. This is required to calibrate the position of the delta.

force feedback button

While the green led status indicator in ON, it is possible to read the position of the force gripper and to send forces. Forces can be switched ON or OFF by pressing the button located at the far right of the front panel. When the forces are ON, a red light is activated. By pressing the same button, the forces are switched OFF as well as the red indicator.

When the system is initialized, the forces are automatically set to OFF mode. The user has to press the Force Feedback Button to activate the forces ON.

If the Controller detects that the speed of the force gripper exceeds the programmed security limit, the forces are automatically cut off and the brakes are released.

A viscous force is created when trying to move the force gripper. Brakes can be switched ON or OFF using a software function provided in the software library (see the programming manual for more information).

7.3. calibration

Calibration is necessary to obtain accurate, reproducible localization of the end-effector within the workspace of the device. The delta.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 delta.x can be calibrated in 2 different ways:

1. by slowly sweeping each axis from end-stop to end-stop. This is the **recommended** calibration method.
2. by holding the force button on the control unit for 2 seconds while maintaining the end-effector at the calibration position (axis 0 retracted, axis 1 and 2 extended, see figure 10). **Make sure all axes are resting on their respective mechanical end-stop** prior to holding the force button down, or the calibration might be incorrect.

When the calibration is achieved, the status LED stops blinking.

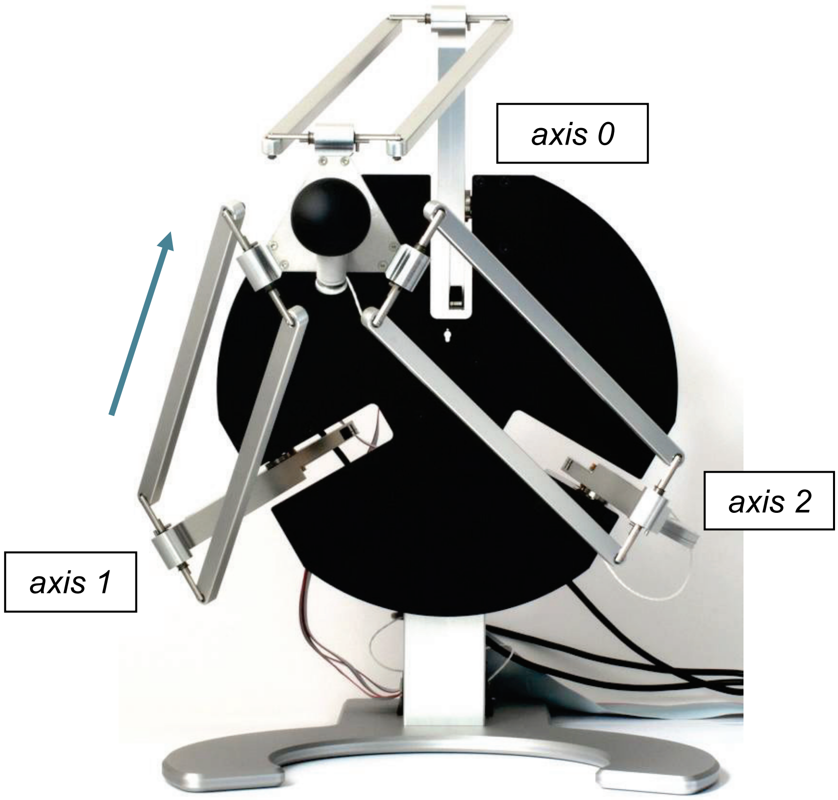


figure 10 – moving the end-effector toward the calibration position

7.4. running the HapticDesk program

Under Windows, the Haptic Desk is available as a test and diagnostic program. Haptic Desk allows the programmer to:

- list all Force Dimension haptic devices connected to the system
- test each device position reading
- test each device force/torque capability
- test each device auto-calibration procedure
- read each device status
- read any device encoder individually

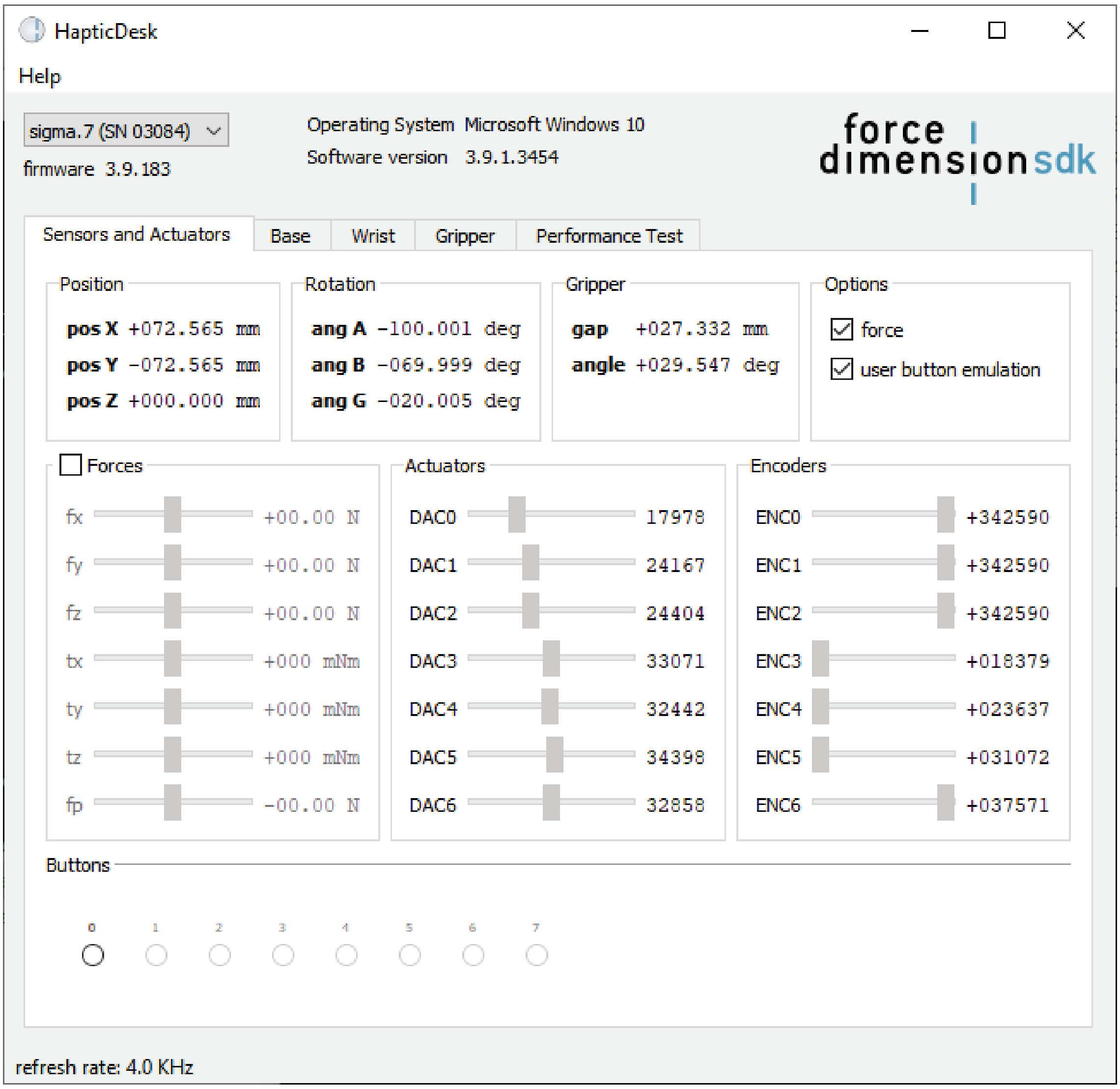


figure 11 – Haptic Desk test and diagnostic program

7.5. 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 the demonstration programs are provided in two separate directories named `\gravity` and `\torus`.

Once the system is setup, we suggest running gravity to check that everything is working properly and to evaluate your system's performance independently of the graphics rendering performance. `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.

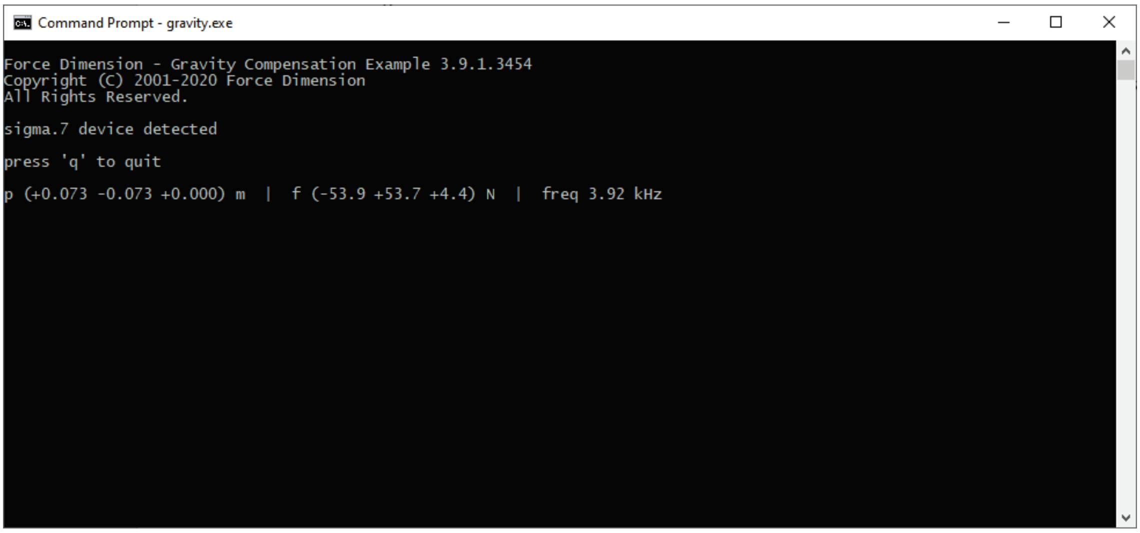


figure 12 – gravity example

torus example

The `torus` example displays an OpenGL scene that can be haptically explored.

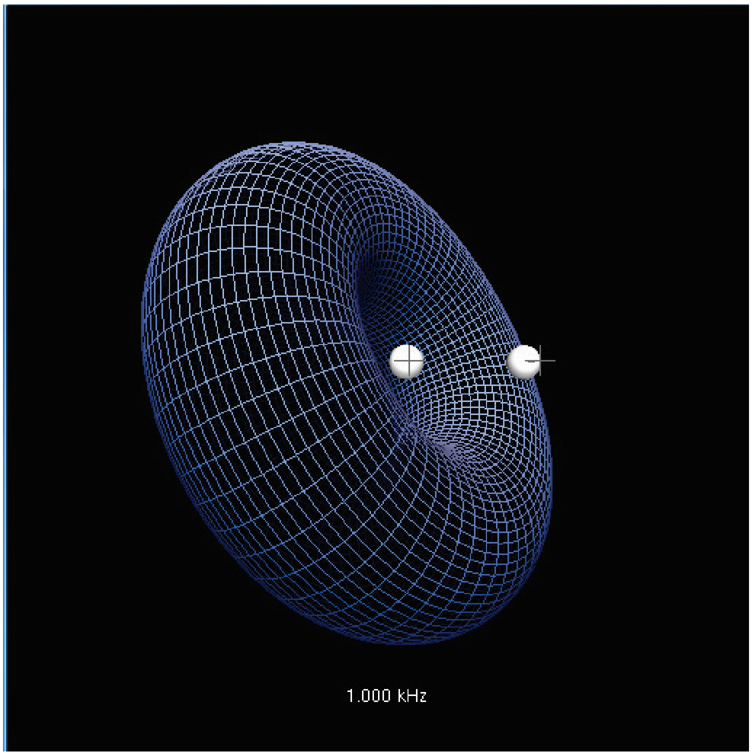


figure 13 – torus example

note – OpenGL and the OpenGL Utility Toolkit (GLUT) 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/resources/libraries/glut.html

8. technical information

delta.3

workspace	translation	∅ 400 x L 260 mm
forces	continuous	20.0 N
resolution	linear	0.02 mm
stiffness	closed loop	14.5 N/mm
dimensions	height	550 mm
	width	550 mm
	depth	440 - 630 mm

features

structure	delta-based parallel kinematics
	hand-centered, decoupled rotations (delta.6)
	gravity compensated
	orientable device base
controller	external unit
calibration	automatic, driftless
comfort	enhanced sensitivity for reduced user fatigue
user input	1 programmable button
safety	velocity monitoring
	electromagnetic damping

delta.6 extension

workspace	rotation	± 22 deg
torques	continuous	0.150 Nm
resolution	angular	‹ 0.04 deg

controller

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

software

SDK	Force Dimension haptic SDK
	Force Dimension robotic SDK
	chai3d (www.chai3d.org)

notice