force dimension

summary

The purpose of this document is
> to describe the setup of the sigma.7 haptic device
> to describe the installation of the drivers and haptic software API
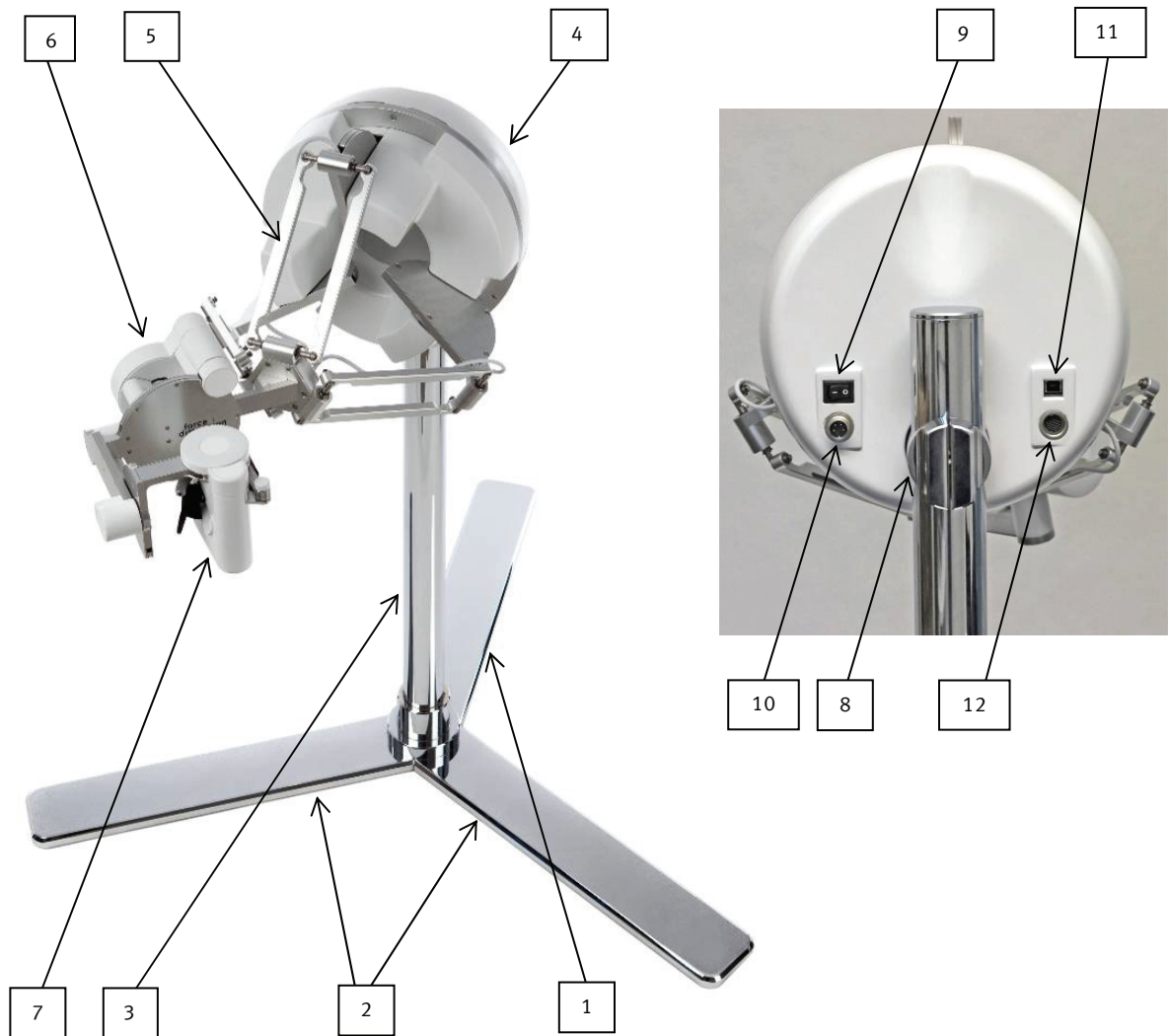> to describe the operation of the sigma.7 haptic device

glossary

FD-SDK   refers to the Software Development Kit (SDK) for all Force Dimension products.
sigma.x   refers to the base haptic device shared by sigma.7 haptic devices. Unless speci-
              fied, all instructions in this manual apply to all sigma device types.

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10. power connector
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2. important safety instructions

<div style="border:1px solid black">

IMPORTANT

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

</div>

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

4. place the unit securely on a stable surface

5. make sure that the workspace of the sigma.7 is free of objects

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

7. switch off the sigma.7 when it is not in use

8. to reduce the risk of electrical shock, do not disassemble the sigma.7

3. setting up the sigma.7

This section describes the steps to follow to setup your sigma.7 device before use.


IMPORTANT

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

3.1   device installation

The sigma.7 haptic device is shipped in 3 boxes. Please start by opening the 2 smaller boxes which contain the device stand. The operations described below are best performed by a team of 2 people.

9 screws and a corresponding orange hex-driver tool are provided in the packaging.

Each one of the 3 legs is mounted on the pole by securely fastening 3 screws, as shown in figure 2. Make sure that the legs are laid out as shown in figure 3, so that the rubber feet of the lower 2 legs on this figure are located near the lower leg borders. The rear leg of the stand is recognized with the rubber foot being located at its centered position.
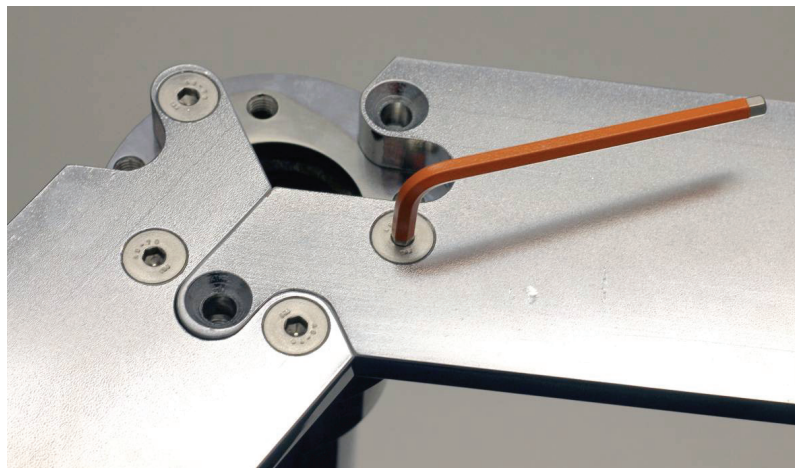
figure 2 – mounting of the device stand legs onto the pole
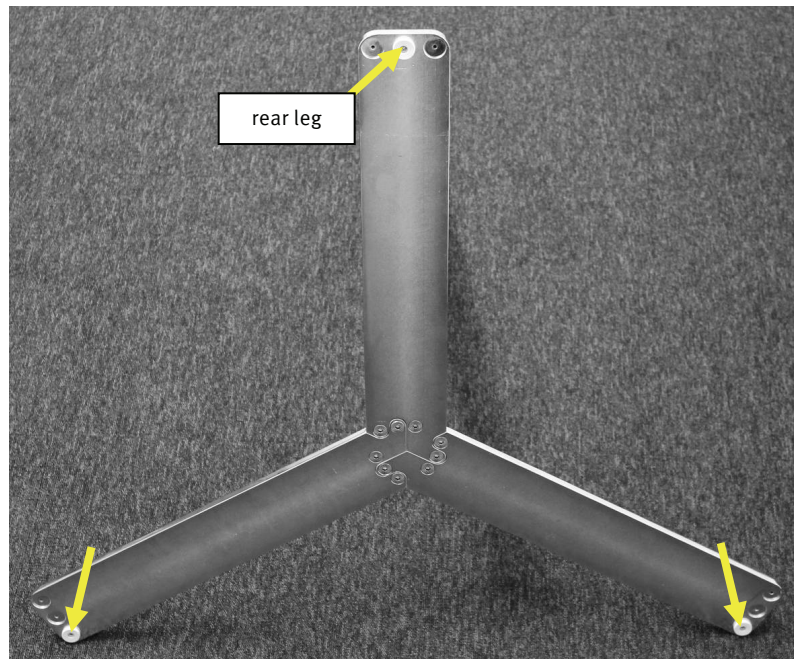
figure 3 – mounted stand legs showing correct layout of the 3 rubber feet (yellow arrows)

Once the device stand mounted, you may open the larger hard plastic container housing the sigma.7 haptic device base.

First release the cables from the front packaging foam block before removing the system from the box, as shown in figure 4.
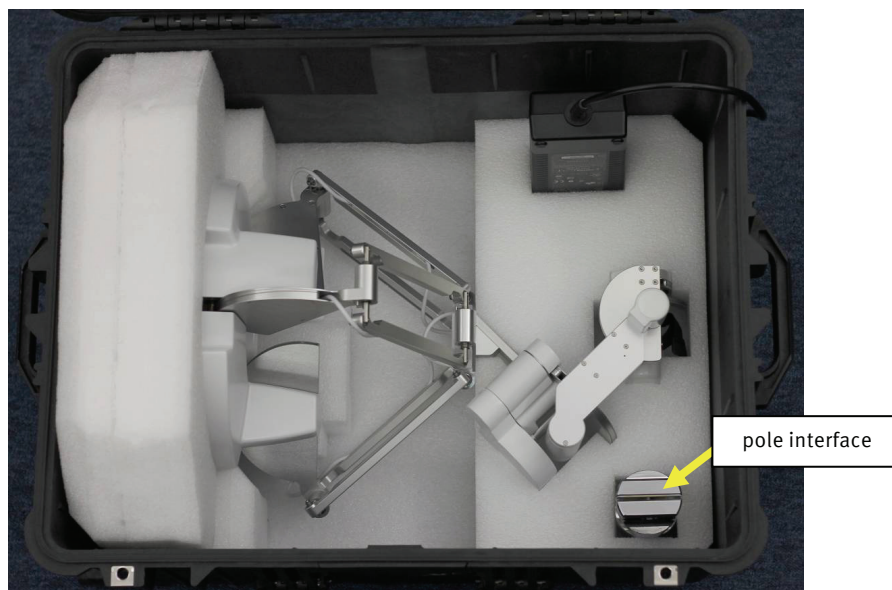
figure 4 – box containing sigma.7 device, after removal of front foam part

Remove the pole attachment interface and power supply before lifting out device from its lower foam block as illustrated in figure 5. While a first person may hold the device, a second person may remove the lower foam block and place it on a table top or any other stable flat surface. The device can then be installed back on this lower foam block, in its initial position, as shown in figure 6.

figure 5 – the device is lifted out of the plastic container
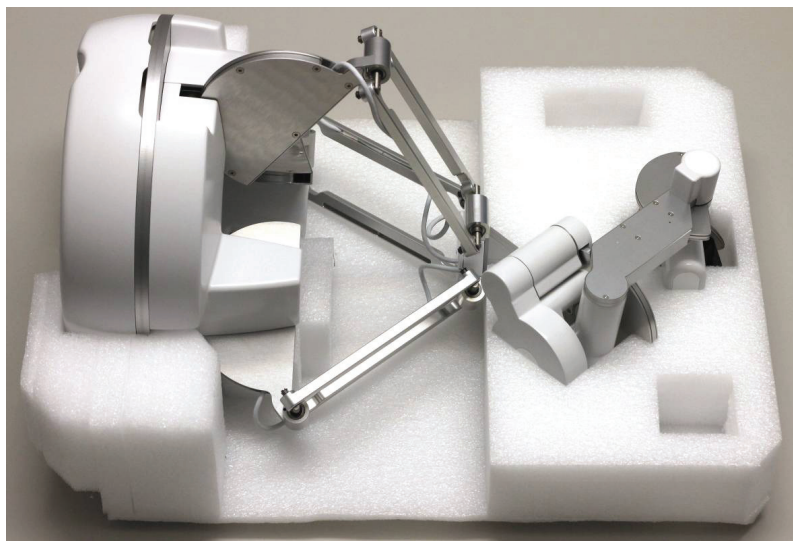
figure 6 – the device is placed back on its lower foam block

Insert the pole attachment interface at the back of device body shroud and securely fasten the screw by using the provided red hex-driver tool, as illustrated in figure 7. Please make sure that the pole attachment interface is correctly oriented as shown in figure 8. By using the same hex-driver you may now loosen the clamping screw.

*figure 7 – mounting of the pole attachment interface*

Finally the sigma.7 device base can be mounted on its stand pole by sliding it from the top, as illustrated in figure 8. Place the base at the desired height and lock the mechanism by fastening the clamping screw as shown in figure 9.

Please verify that the device is correctly secured by making sure that the device base cannot rotate around its vertical pole. If any slippage occurs, further tightening may be necessary.

figure 8 – after loosening clamping screw, device body is mounted on stand pole
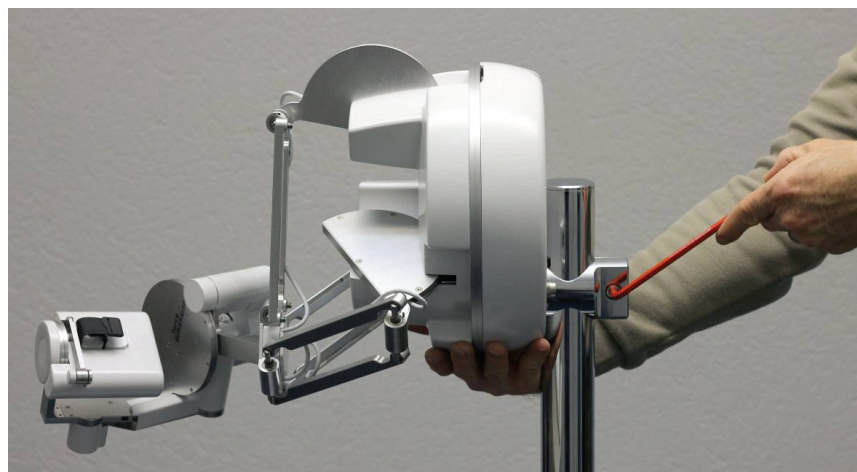
figure 9 –fastening of clamp screw while holding the device with the other hand

Your sigma.7 haptic device is now fully assembled. You may now place the haptic device at your console desk where you will be operating the system. Please note that optimal wrist dexterity is achieved when the forearm of the operator is aligned with the first rotational motion axis of the wrist mechanism, as shown in figure 10 (yellow dashed lines). This optimal configuration can be obtained by correctly positioning and orientating the device with respect to the operator.

For optimal stability, the rear stand leg (see figure 3) should be aligned with the pole attachment interface protruding from the back of device body, as shown in figure 10 (blue dashed lines).

figure 10 – relative forearm alignment for optimal wrist dexterity (yellow dashed lines) and rear leg orientation of stand (blue dashed lines)

You will also find in the plastic container the power and USB cables, as well as the driver and SDK installation media (memory stick).

3.2 installing the power supply

Plug the power supply into the power connector. The system may support either high-input voltage (200-240 volt) or low-input voltage (100-120 volt). For safety purposes you should only operate your sigma.7 haptic device using the original Force Dimension power supply that came with your device. Replacement power supplies can be ordered directly from Force Dimension.

4. configuring the sigma.7 under Windows

4.1 installing the software

The installation USB drive must be installed onto your system **before connecting the sigma.7 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 sigma.7 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 7.4 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 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 sigma.7 requires the Force Dimension USB driver. These drivers are installed automatically and no additional step is required.

5. configuring the sigma.7 under Linux

5.1   installing the software

The Force Dimension development folder must be installed onto your system before the sigma.7 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 sigma.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 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 sigma.7 under Mac OS X

6.1   installing the software

The Force Dimension development folder must be installed onto your system before the sigma.7 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 sigma.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 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 sigma.7

7.1   device geometry

sigma.7 translation axis

The position of the center of the end-effector (handle) can be read from the controller. The system converts the encoder values into (X, Y, Z) coordinates, expressed in IUS (metric) unit. Figure 11 shows the coordinate system. The actual origin of the coordinate system (0,0,0) is located on a virtual point at the center of the workspace.
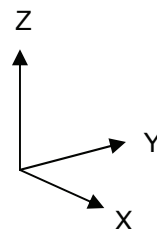
figure 11 – coordinate system

7.2   operating the sigma.7

features

calibration – calibration is necessary to obtain accurate, reproducible localization of the end-effector within the workspace of the device. The sigma.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 when the device is powered on.

The automatic calibration procedure is performed by software using the DHD-API, for example by launching the application "autoinit.exe" 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 increase accuracy during manipulation, the sigma.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 on top of the user command. Please note that gravity compensation is computed on the host computer, and therefore it only gets updated whenever a force command is sent to the device by the application. Gravity compensation is enabled by default and can be disabled via the Force Dimension SDK.

forces - by default, when an application opens a connection to the device, the forces are disabled. Forces can be enabled or disabled via software.

brakes – the device features electromagnetic brakes that can be enabled via the DHD-API. The brakes are on by default when the forces are disabled, and can be enabled automatically by the control unit in some cases. When the brakes are on, a viscous force is created that prevents rapid movement of the end-effector.

safety features

The sigma.7 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 device is made from the computer, the forces are automatically disabled to avoid unexpected behaviors.

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 via the Force Dimension SDK. Please refer to the on-line programming manual for more information.

7.3   running the Haptic Desk 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
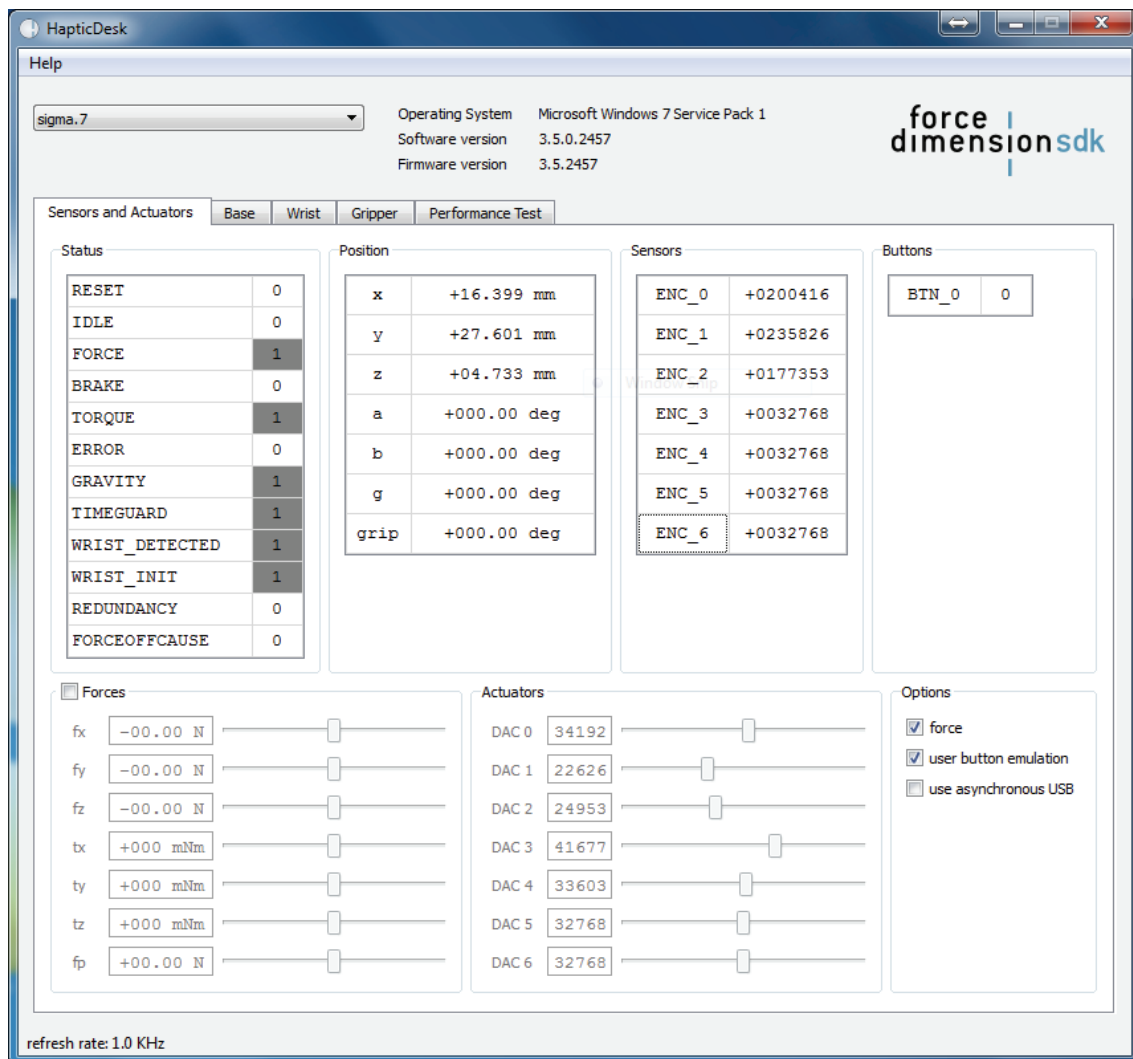> read each device status
> read any device encoder individually

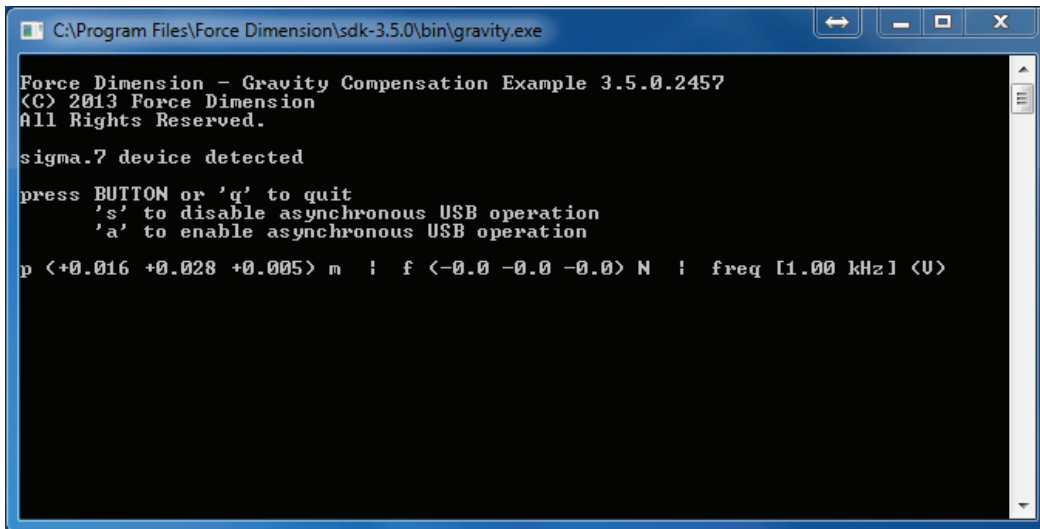figure 5 – Haptic Desk test and diagnostic program

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 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 every thing 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 6 – gravity example

torus example

The `torus` example displays an OpenGL scene that can be haptically explored.
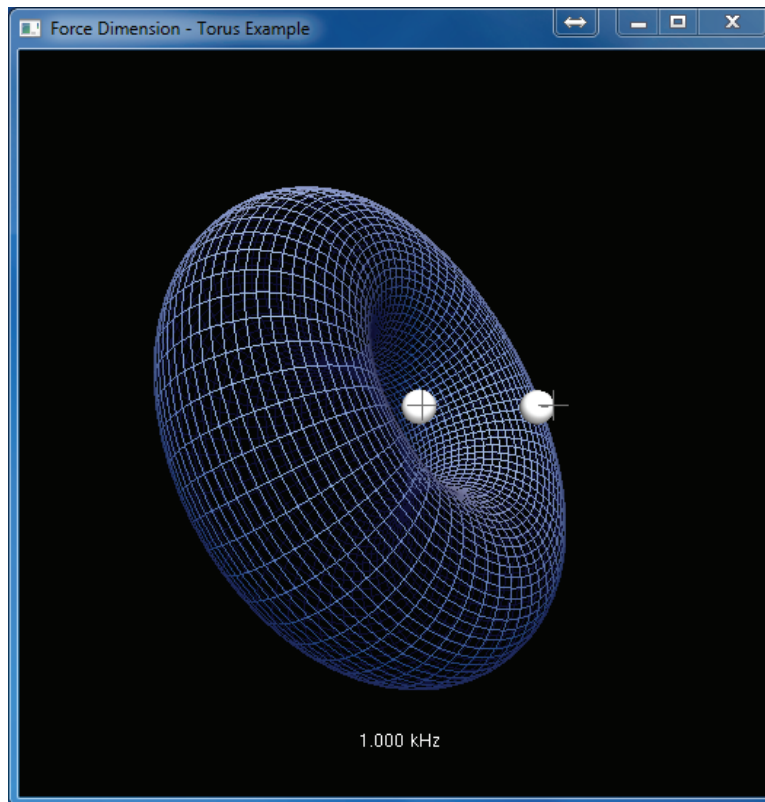
figure 7 – reflections example

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

sigma.7

workspace	translation	⌀ 190 mm x L 130 mm
	rotation	235 x 140 x 200 deg
forces	translation	20.0 N
	rotation	400 mNm
	grasping	± 8.0 N
resolution	linear	0.0015 mm
	rotation	0.013 deg
	grasping	0.006 mm
option	available for right or left hand	
interface	standard	USB 2.0
	refresh rate	up to 4 KHz
power	universal	110V - 240V
OS	Microsoft	Windows XP / Vista / 7 / 8
		Windows CE 7
	Linux	kernel 2.6 / 3.x
	Apple	OS X 10.7 / 10.8
	QNX	Neutrino 6.5
	WindRiver	VxWorks 6.3 / 6.9
software	haptic SDK	
	robotic SDK	
calibration	automatic	
	driftless	
structure	delta-based parallel kinematics	
	hand-centered rotations	
	rotations decoupled from translations	
	active gravity compensation	
user I/O	6 external switch input channels	
	6 external digital output channels	
safety	velocity monitoring	
	electromagnetic damping	

notice