force
dimension

USER MANUAL
omega.x haptic device
version 1.8
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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 drivers and haptic software SDK
- to describe the operation of the omega.x haptic device

glossary

FD-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.

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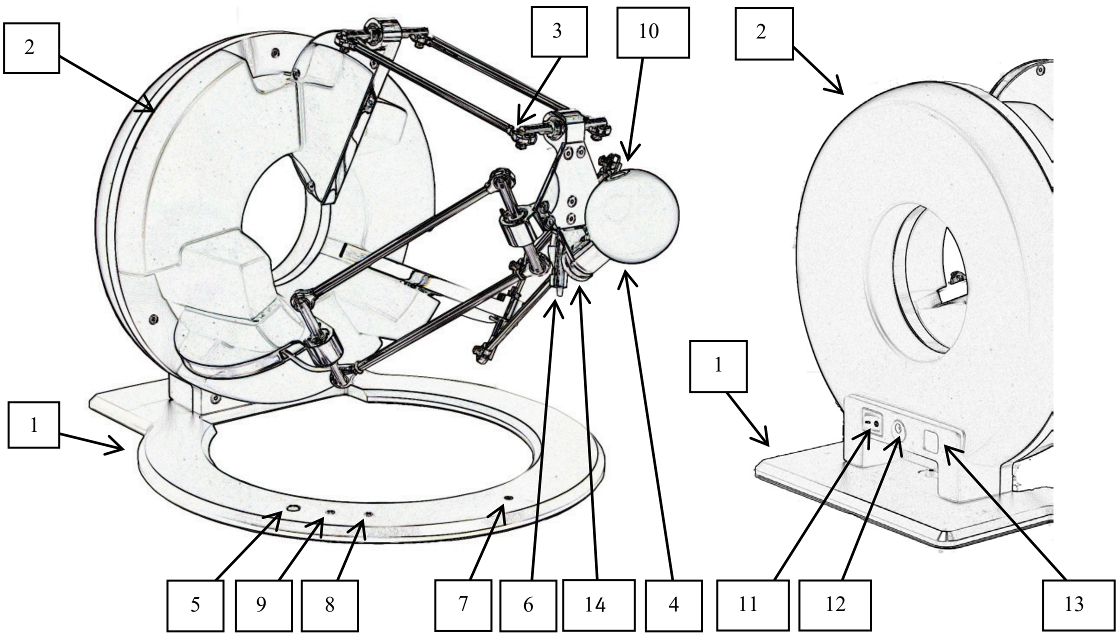
1. device description



1. base plate
2. control unit
3. arms
4. end-effector
5. force button
6. calibration pole
7. calibration pit
8. status LED
9. force LED
10. programmable button
11. power switch
12. power connector
13. USB connector
14. tightening knob

2. 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
4. place the unit securely on a stable surface
5. make sure that the workspace of the omega.x 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 omega.x when it is not in use
8. to reduce the risk of electrical shock, do not disassemble the omega.x

3. setting up the omega.x

IMPORTANT

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

3.1 unpacking the device

Before unpacking the device, remove the device stabilizer and the accessories box from within the box. Carefully remove the device and the end-effector stabilizer from the box, then remove the end-effector stabilizer.

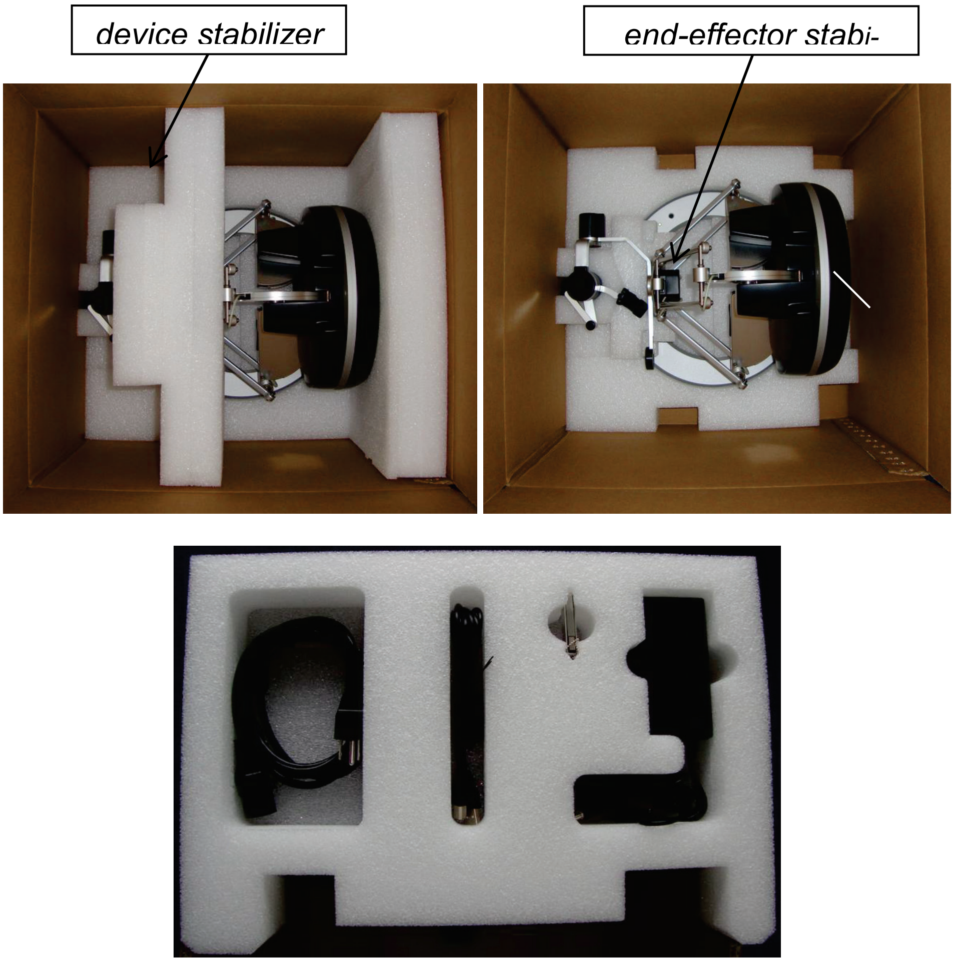


figure 1 – omega.x shipping box and accessories box

The accessories box contains the power and data cables, as well as the driver and SDK installation media.

3.2 installing the power supply

Plug the power supply into the power connector. The system supports either 110/120 Volts or 220/230 Volts. Only use the Force Dimension power supply that came with your device. Replacement power supplies can be ordered from Force Dimension.

4. configuring the omega.x under Windows

4.1 installing the software

The installation USB drive must be installed onto your system **before connecting the omega.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 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 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 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 drive into your system
2. 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
   ```

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 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 omega.x under Mac OS X

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 drive into your system
2. 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)
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 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 omega.x

7.1 device geometry

omega.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 2 shows the coordinate system. The actual origin of the coordinates system (0,0,0) is located on a virtual point at the center of the workspace. The calibration pit places the device at the (0.019, 0.0, - 0.074) location.

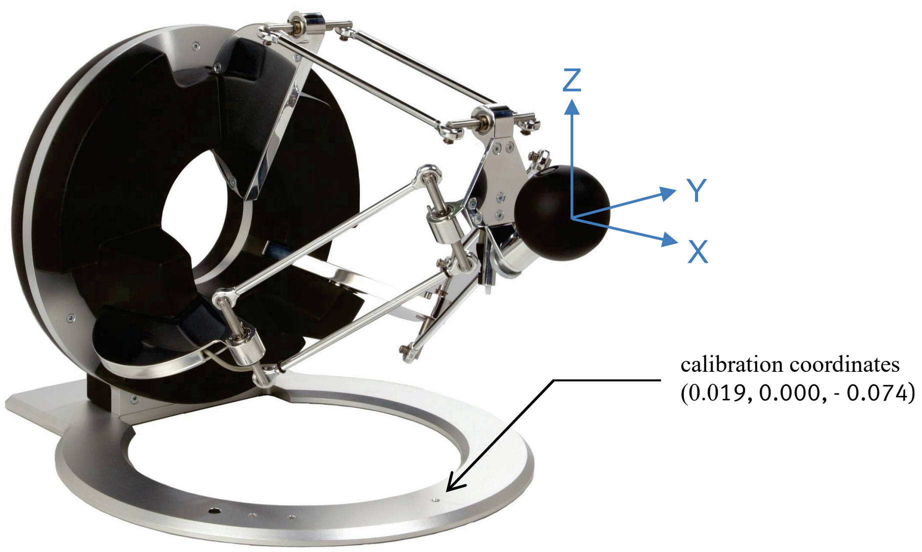


figure 2 – coordinate system

omega.6 and omega.7 extensions (optional)

The omega.6 and omega.7 provide a rotational structure. Rotation information can be retrieved as a reference frame expressed by a 3x3 rotation matrix:

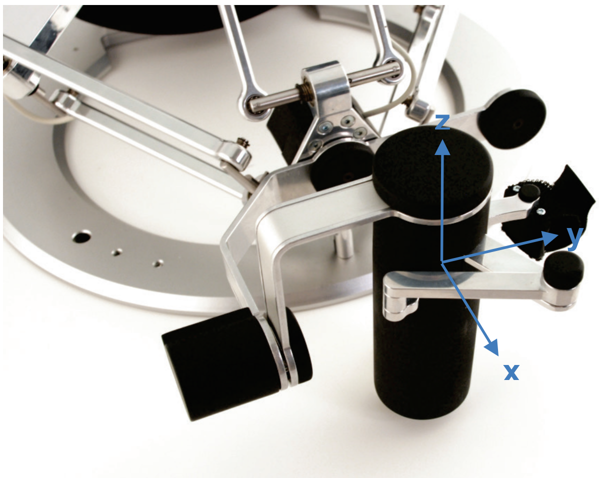


figure 3 – reference frame of the omega.6 and omega.7:

7.2 operating the omega.x

status indicators

The status LED displays the status of the system.

- LED OFF — the system is off
- LED ON — the system is ready
- LED BLINKING (fast) — the system requires calibration
- LED BLINKING (slow) — the omega.6 extension requires calibration

While the status LED is ON, it is possible to read the position 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 the 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 the calibration pole in the dedicated calibration pit. The device detects when the calibration position is reached and the status LED stops blinking. Figure 4 illustrates the calibration procedure. After the initial calibration described above, the LED will stop blinking (omega.3).

figure 4 – calibration procedure

On the omega.6 and omega.7 (optional), the LED will blink at a slower frequency, indicating that the rotational structure is usable but not fully calibrated. To fully calibrate the omega.6 and omega.7 extensions, each of the three rotation axis and the grasping axis of the omega.7 must be moved by hand to their respective end-stops once. When the device has reached all end stops, the LED stops blinking and the device is fully calibrated.

gravity compensation – to prevent user fatigue and to increase accuracy 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 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 at any time by pressing the force button.

brakes – the device feature electromagnetic brakes that can be enabled via software. 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. Also, enabling the brakes via the Force Dimension SDK simultaneously disables the forces.

end-effector tightening knob (omega.3) – the orientation of the end-effector can be adjusted by means of the tightening knob.

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 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 cannot be disabled.

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 HapticDesk program

Under Windows, the HapticDesk is available as a test and diagnostic program.

HapticDesk 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

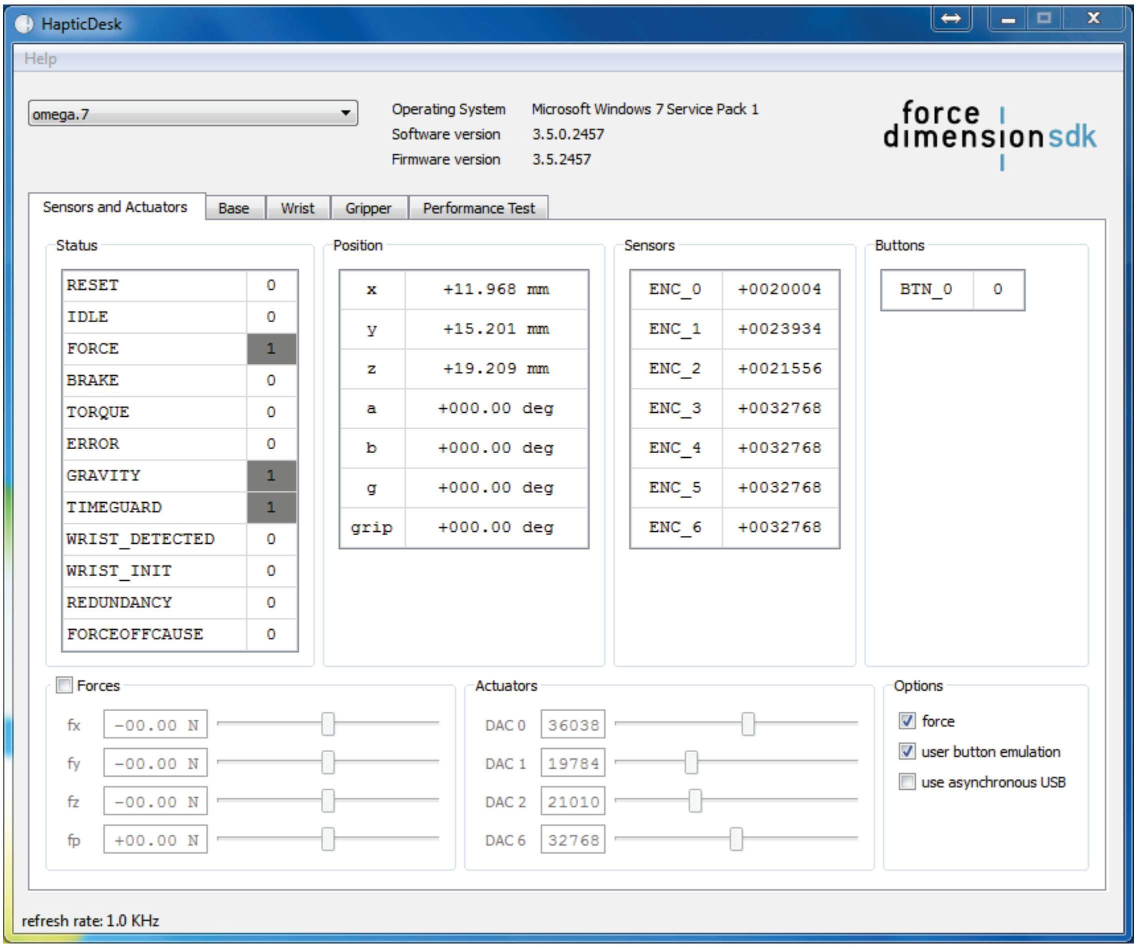


figure 5 – HapticDesk test and diagnostic program

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 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.

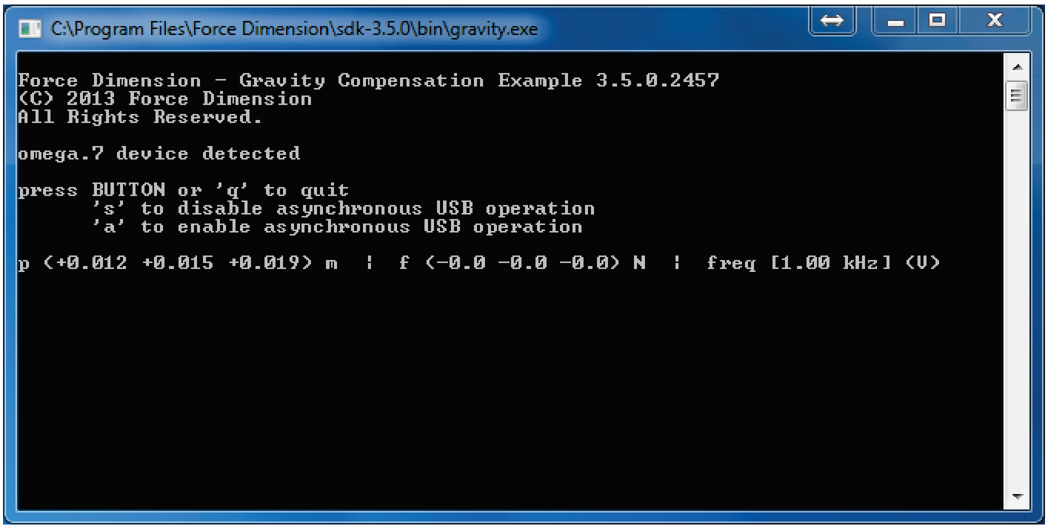


figure 6 – gravity example

torus example

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

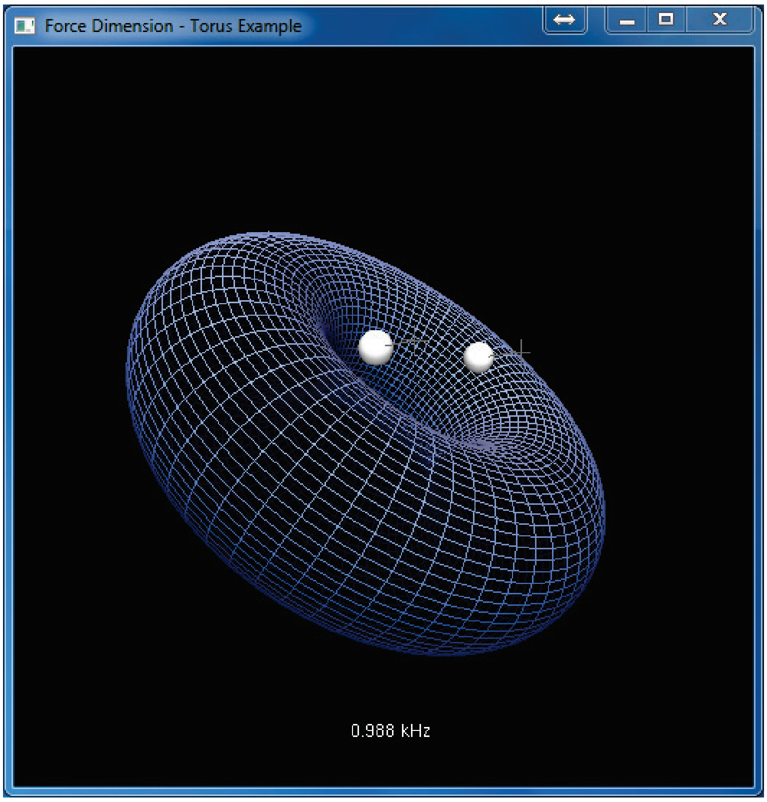


figure 7 – torus example

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

omega.3

workspace	translation	∅ 160 mm x L 110mm
forces	continuous	12.0 N
resolution	linear	‹ 0.01 mm
stiffness	closed loop	14.5 N/mm
dimensions	height	270 mm
	width	300 mm
	depth	350 mm
interface	standard	USB 2.0
	rate	up to 4 KHz
power	universal	100V - 240V
calibration	automatic	
	driftless	
structure	delta-based parallel kinematics	
	active gravity compensation	
user input	1 programmable button	
safety	velocity monitoring	
	electromagnetic damping	

omega.6 extension

workspace	rotation	240 x 140 x 320 deg
resolution	angular	0.09 deg
option	available for right or left hand	
user input	1 programmable button	

omega.7 extension

workspace	rotation	240 x 140 x 180 deg
	gripper	25 mm
force	continuous	± 8 N
resolution	angular	0.09 deg
	linear	0.006 mm
option	available for right or left hand	

software

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

notice