



phantom[®]
HAPTIC DEVICES

Premium 1.56DOF/1.5HF6DOF Device Guide

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Hardware usage guidelines are provided to assist the user in protecting the effectiveness and life of the device. They are not intended as recommendations for the prevention of repetitive stress injury, carpal tunnel syndrome or any other conditions, injuries or disorders; users should consult their own physicians. By using the Phantom device, the user acknowledges and agrees that Sensable shall have no liability for any disorder, condition or injury arising from any use of the device.

Warning Do NOT open the Phantom device. Attempting to open or repair the device by anyone other than a certified authorized service center voids the manufacturer warranty and hardware maintenance contract.

Questions or Comments

If you have any questions for our technical support staff, please contact us at support@sensable.com. You can also phone 1-888-SENSABL (U.S.A. only) or 1-781-939-7444 (International).

If you have any questions or comments about the documentation, please contact us at documentation@sensable.com.



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Preface

About this Guide

The Phantom Premium® Device Guide describes the process of installing the required device drivers for your new Phantom Premium haptic device and connecting the hardware device to your computer. You will also find information on how to use the device and other information about the device.

For the most current device information please visit the Sensable website at www.sensable.com.

We've worked extensively to ensure that the Phantom Premium device and device drivers install and work smoothly. If you experience any problems in the installation or use of your device, please contact Sensable support (see inside cover for contact information).

Please note, if you are installing your device on a supported non-Microsoft® Windows OS, you will find additional information in a separate document that shipped with your software product.

Typographical Conventions

This guide uses the following typographical conventions:

Convention	Description	Example
<i>Italics</i>	First use of a new term; reference to another document or file.	A <i>Voxel</i> is...; see the <i>User Manual</i> .
Bold	Keywords, actual user input, or examples.	Click Ok .
Greater Than (>)	Indicates a menu pick, as in “select Options from the Tools menu”.	Tools>Options

1

Getting Started

This guide covers the currently shipping Phantom Premium haptic device. The information contained in this manual was current at the time of publication. Visit www.sensable.com for the latest information.

This chapter describes the following:

- The contents of the shipping box
- The Phantom Premium haptic device
- System Requirements
- The proper handling of the Phantom Premium haptic device

Contents of the Shipping Box

If you are purchasing a Phantom device for the first time, in your shipping box you should find the following:

- **The Phantom Premium haptic device:** The Phantom device uses high-fidelity force feedback to make it possible to touch and manipulate virtual objects.
- **The Phantom Premium Device Guide:** Describes the process of connecting the haptic device as well as how to work with the device including proper handling, troubleshooting, and device specifications.
- **The Phantom Device Driver Installation Guide:** Describes the process of installing the device drivers.
- **Parallel Port Cable:** This cable is used to attach the computer's parallel port to the Phantom Premium or, one unit to another. The cable is an IEEE 1284 EPP cable with a ferrite bead that provides an impedance at 100mhz of 199 ohms or greater.
- **Universal Power Supply:** The power supply can be used on any standard circuit, using the supplied power cord.
- **Power Cord:** The power cord connects the Universal Power Supply to the wall outlet.
- **(Optional) Accessory Bag:** Contains thimble gimbal and stylus. May contain the encoder gimbal if ordered. The encoder gimbal must be installed before connecting the device to your PC. See "Appendix F: Installing/Removing the Encoder Gimbal" for information. The accessory bag may also contain the Pinch end effector(s) (thumb-pad and/or scissors) if they were ordered (6 DOF only). Note that these attachments must be installed before connecting to the PC. For more information, see "Appendix G: Working with Pinch End Effectors."

If any items are missing, please call Sensable at 1-888-SENSABL.

The Phantom Premium Haptic Device

The Phantom Premium device enhances productivity and efficiency by enabling the most intuitive human/computer interaction possible, the ability to solve problems by touch.

The Phantom Premium 1.5 6DOF and 1.5HF 6DOF devices sense motion in 6 degrees of freedom.

The Phantom Premium system's high fidelity force feedback senses motion providing the best, most realistic 3D Touch sensation for any application. You can feel the point of the stylus in all axes, and track its orientation. The Phantom Premium's design, compact footprint, and simple parallel port interface ensure quick installation and ease of use.

Features

- FCC and CE Certified
- Six degree-of-freedom positional sensing
- Comfortable stylus with textured paint for long term use and secure grip
- Removable stylus for end-user customization
- Integrated momentary switch on the stylus for ease of use and end-user customization
- Constructed of metal components and injection-molded plastics

System Requirements

The Phantom Premium haptic device requires certain hardware and software components to be able to function properly. This sections describes the requirements for operating the Phantom Premium haptic device.

Note Visit www.sensable.com to get the latest and most complete system requirements information.

- An Intel® processor based personal computer (A minimum of Pentium® II class processor is recommended) or select personal computer.
- IEEE 1284 EPP compliant parallel port interface; a Phantom Communication Converter (PCC - sold separately) and FireWire Card (requires IEEE-1394a-2000 compliant FireWire Port).
- The most current version of the Phantom Device Driver (PDD). See the *Phantom Device Driver Installation Guide* for specific PDD requirements.

Proper Handling and Positioning of the Phantom Premium Device

Warning Gripping and lifting the Phantom Premium device improperly may damage it. To reduce the risk of damage, please follow the instructions below.

Handling the Phantom Premium Device

Calibrating the device: The Phantom Premium device may need to be recalibrated from time to time, particularly if it has lost power. You can use the Phantom Test application (**Start>All Programs>Sensible**) to recalibrate the device.

Lifting the device: The Phantom Premium is a sensitive piece of electronic equipment. Lift by placing your hands under the bottom of the base, and support the base when moving it. Lifting by any of the moving parts may affect the unit's performance and risks damaging the device.

Stylus with Switch: The stylus is the “handle” or “pen” you use to interact with virtual objects. Your forefinger or thumb should rest above the raised switch when using the device. Like a mouse button, the switch is used differently in each application. After the device is calibrated, the stylus may be left resting on the desk.

Protecting the device from damage It is best to place the unit firmly on the tabletop and away from edges to reduce the risk of damage to the device from a direct, unintentional elbow hit. Remember Do NOT attempt to lift the unit or relocate it on the desk by pulling on the stylus. This may result in severe damage to the device.

Positioning the Phantom Premium Device

The correct placement of the device will vary from one user to another. You may want to experiment to find a placement that feels right for you.

- The device should be positioned so that you are comfortable when working with it.
- You should not feel any strain on your wrist or forearm when working with the device.
- If you are left-handed, you may find it easier to work with the mouse placed to the left of the keyboard.
- Remember to take breaks often to stretch your hands, wrists, and elbows.

Caring for the Phantom Premium Device.

- DO start the device at the neutral position without fail.
- DO grip the handle firmly in an application that applies torque.
- DO use small hand motions near the neutral position.
- DON'T drop the device.
- DON'T apply sharp impact forces to any part of the device.
- DON'T ram any movable member into a hard stop with great force.
- DON'T let go of the device in the middle of an application.
- DON'T twist the handle past its physical limitations.
- Try to minimize unnecessary vibration to the device.

Turn off the switches in the back to debug without forces and torque.

1 GETTING STARTED

Proper Handling and Positioning of the Phantom Premium Device

1

Installing the Phantom Premium Device

This chapter will describe, step by step, how to install the Phantom Premium haptic device. The installation is done in two steps.

- Install the software, the Phantom Device Driver, that allows your computer to communicate with the Phantom Premium device.
- Connect the hardware, the Phantom Premium device, to your computer and power source.

Installing the Phantom Device Drivers

The Phantom Premium device communicates with the computer through the Parallel Port Cable. To enable this, you must install a software driver, called the Phantom Device Drivers (PDD), to control the communication.

Specific instructions for installing the PDD on Windows XP, Vista and Windows 7 operating systems can be found in the *Phantom Device Driver Installation Guide*. For installation instructions for other operating systems, see the additional documentation shipped with your device or software product or contact customer support

Note As with most other software packages, you must have administrator privileges on the machine in order to install software. If you are unfamiliar with installing software or do not have administrator privileges, please have your System Administrator execute the installation steps for you.

Connecting the Phantom Premium Device

In this section you will setup the Phantom Premium device and plug in all of the cables.

Note If you ordered an Encoder Gimbal, you must install that component before proceeding with connecting the Phantom Premium device. See "Appendix F: Installing/Removing the Encoder Gimbal."

2 INSTALLING THE PHANTOM PREMIUM DEVICE

Connecting the Phantom Premium Device

The high demands of the Phantom Premium device on the parallel port require the device to have a dedicated parallel port for its use. If you are currently using your parallel port for a printer, dongle or other peripheral, you will need to install an additional parallel port card in your system. You can choose whether to connect the Phantom Premium device or the other peripherals to the additional card.

- 1 Restart your computer after installing the PDD if you have not already done so.
- 2 Connect the cables as follows:
 - a With the computer still turned off, attach the male end of the supplied IEEE-1284 rated cable to your computer's parallel port.

FIGURE 1.



Connect the power cables to the back of the Premium device.

- b Plug the female end of the cable to the parallel connector of the Phantom Premium.
- c Plug the power cord into the AC power socket of the Phantom Premium.
- d Plug the power cord into an available outlet (for 110V the outlet must be rated for at least 2 Amps, for 220V: 1 Amp).

- e Leave the Gimbal and base motor switches in the "On" position for normal operation. These switches can be used to cut off motor power for debugging purposes.
- 3 Position the Phantom Premium device.

IMPORTANT

Sensable Technologies uses only Parallel Port components that exceed the IEEE 1284 EPP implementation recommendations. Sensable is not responsible for any damage that may result from using 3rd party cables.

Run Phantom Test to Verify Setup

In this section you will run the Phantom Test application to confirm that the device is properly connected and installed.

- 1 Select **Start>All Programs>Sensable>Phantom Test**.
- 2 Put the Phantom in neutral position. Neutral position is described as when the 4 rotary joints are lined up. See "Appendix D: Maximizing Positioning Accuracy" for more information about position accuracy.
- 3 You can press the space bar on your keyboard to reset.

2 INSTALLING THE PHANTOM PREMIUM DEVICE

Run Phantom Test to Verify Setup

1

Using the Phantom Premium Device

This chapter will introduce you to working with the Phantom Premium haptic device and the physical limits of the device's range of motion. It is important to understand these physical limitations so that you do not inadvertently damage the device by forcing it past its designed limits.

Working in 3D Space

We have become so accustomed to using a mouse to move around a computer monitor that we don't think twice as we move our hand around a desk to move the cursor on the computer screen. But there was a time not long ago when this seemingly simple task was not second nature; some even found it challenging and were often frustrated as they learned. If you are new to working in 3D digital space and haptics, working with the Phantom Premium device may take a little getting used to. Understanding where objects are in 3D space may take some practice before you are able to move and manipulate objects with ease and certainty. Be patient with yourself.

Use Caution when Using the Phantom Premium Device

It is important to exercise care when working with force feedback devices:

- Read the manual thoroughly prior to using your Phantom Premium
- DO NOT place your fingers inside the mechanism. At the installation site, access to motors and pulleys should be prevented.
- DO NOT put your face in the workspace of the Phantom Premium. Safety glasses are recommended.
- As a user of this product and software, you accept full responsibility for assuring that the device is used in a safe and responsible manner.

Physical Limits of the Device

The Phantom Premium device has six degrees of motion provided by six axis points. All the degrees of motion have physical limits. When you reach one of these limits you will feel a sudden stop; this is the mechanical stop designed into the device. Forcing the device past any of these stops risks damaging the device.

Take some time to become more familiar with the physical limits of the Phantom Premium before using the device by moving the device through its full range of motion at each axis point.

- 1 Grasp the stylus as you would a pen, with the free end of the stylus (the eraser end of a pencil) pointing toward you and the point of the stylus (the end connected to the arm) pointing toward the unit. Gently move the stylus in all directions to feel the physical limits, mechanical stops.
- 2 Next, move the device at the "body", "shoulder", and "elbow" of the Phantom Premium device.
 - a Start with large-but gentle-movements. Beginning at the top, move the arm of the device left/right. The body, sometimes referred to as the turret, of the Phantom Premium device will pivot until it reaches a physical limit. Again, do not try to force the device past any of the mechanical stops.
 - b Next, move the stylus up/down. The primary movement will happen in the shoulder of the Phantom Premium device.
 - c Next move it in/out with the primary movement happening in the elbow. When you reach a physical limit, you'll feel one of the device's mechanical stops. Don't force the device past any of these stops.
- 3 Next you perform micro movements further down the haptic device, moving the device at the stylus.
 - a Holding the stylus with one hand rotate left/right at the top of the yoke.
 - b Next pivot it up/down at the bottom of the yoke where it joins the stylus.
 - c Finally gently twist the stylus back/forth.

Now you should have an understanding of the range of motion of the Phantom Premium device at each axis point and where its limits are.

Warning ALWAYS work with the connected end of the stylus pointing away from you. NEVER rotate the stylus with the point facing you.

Using the Motors

Motor power switch for base motors The first motor power switch is used to cut off the power to these three base motors which are responsible for translational force feedback. When the switch is in the "ON" position, the motors and encoders are both connected. When the switch is in the "OFF" position, the encoders are still powered but the motors are not.

The second motor power switch is used to cut off the power to the three gimbal motors which are responsible for rotational torque feedback. When the switch is in the "ON" position, the motors and encoders are both connected. When the switch is in the "OFF" position, the encoders are still powered but the motors are not.

These are handy features for debugging new haptics code.

3 USING THE PHANTOM PREMIUM DEVICE

Using the Motors

Appendix: Troubleshooting

This section provides tips for correcting some common problems encountered with the Phantom Premium device. If after following these steps, you cannot resolve the problem, please contact customer support (see Appendix B: "Customer Support").

#1 The device is not calibrated, what do I do?

Place the Phantom Premium device in neutral optimal startup position and press the Space bar on the keyboard. For information about this optimal position see Appendix D: "Maximizing Positioning Accuracy".

#2 Unable to Communicate with the Phantom - Configure BIOS Parallel Port Mode.

Depending on your computer, you may have to configure your system's BIOS for communicating to the on-board parallel port via the EPP or EPP+ECP communication protocols. If you encounter communication problems, please see your system administrator or contact your reseller.

#3 The Phantom Premium suddenly does not operate as expected.

If your Phantom was previously working properly but you are now encountering trouble, contact Sensable Technologies immediately for further assistance. Do not proceed further until you call our toll-free number (1-888-SENSABL) or email Sensable at support@sensable.com.

When contacting Support, you may be asked to run the "Phantom Test" application to help with diagnosis. This application can be found in the directory where you installed the Phantom Device Drivers or via the **Start>All Programs>Sensable** menu.

The following describes the basic features of this test application which you should be prepared to run.

- Select the Phantom device which you want to test. Usually this will be "Default Phantom".
- Read Encoders - The values being sensed for the positions and rotations of the device are dynamically displayed in the window. The stylus switch is ON when the user presses the front, blue button. The presence switch is ON when the user presses the second, white button. The picture of the Phantom Premium should change dynamically as you move the stylus around.
- Cycle Amps - This will simply turn the amplifiers off then on again repeatedly to test their functioning. You should hear the device clicking on and off.
- Test Forces - IMPORTANT: Hold onto the stylus when executing this test. Move the sliders with your mouse to generate forces which push against your hand. X controls force parallel to the table. Y controls force up and down. Z controls force in and out.
- Box Test - Provides a box which you can feel with your Phantom Premium device. The sides of the box should feel flat and the corners sharp.
- Quit - Quits the test application.

Appendix: Customer Support

Warning DO NOT OPEN THE DEVICE. Attempting to open or repair the device by anyone other than a certified authorized service center voids the manufacturer warranty and hardware maintenance contract. There are no serviceable components in the Phantom Premium device or power supply. Return to Sensable for servicing.

If you encounter any difficulties within your warranty period, you can obtain Technical Support through the three channels listed below. If you are out of warranty and do not have active maintenance, Technical Support is limited.

- If you purchased your Phantom Premium device from a distributor, please contact them first.
- Sensable Technologies Customer Support can be reached via e-mail at support@sensable.com.
- Sensable Technologies Customer Support can also be reached via telephone:
 - In the United States: 1-888-SENSABL (1-888-736-7225)
 - Outside the United States: +1-781-939-7444

Appendix: Regulatory Notices

FCC Notice (U.S. Only)

The Phantom® Premium model haptic devices are classified by the Federal Communications Commission (FCC) as Class B digital devices.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC rules. The following information is provided on the device covered in this document in compliance with FCC regulations:

Product Name: Phantom Premium

Model Numbers: Model version(s) of Premium 1.5 6DOF, 1.5 HF 6DOF

Company Name: Sensable Technologies, Inc.

NOTES

Any changes or modifications to the hardware not expressly approved by Sensable Technologies could void the user's authority to operate this equipment. This device is to be used with the Sensable-supplied power supply only. Replacement power supplies are available directly from Sensable Technologies.

Canadian Requirements:

Canadian Department of Communications Radio Interference Regulations

These digital apparatus, the Phantom Premium haptic devices, do not exceed the Class B limits for radio-noise emissions from digital apparatus as set out in the Radio Interference Regulations of the Canadian Department of Communications.

Règlement sur le brouillage radioélectrique du ministère des Communications Cet appareil numérique, the Phantom Premium haptic device, respecte les limites de bruits radioélectriques visant les appareils numériques de classe B prescrites dans le Règlement sur le brouillage radioélectrique du ministère des Communications du Canada.

European Requirements:

EN 55022 Statement

This is to certify that the Sensable Technologies Phantom Premium haptic devices are shielded against the generation of radio interference in accordance with the application of Council Directive 89/336/EEC, Article 4a. Conformity is declared by the application of EN 55022 Class B (CISPR 22).

Warning: These are Class B products. In a domestic environment, this product may cause radio interference, in which case, the user may be required to take appropriate measures.

Achtung: Dieses ist ein Gerät der Funkstörgrenzwertklasse B. In Wohnbereichen können bei Betrieb dieses Gerätes Rundfunkstörungen auftreten, in welchen Fällen der Benutzer für entsprechende Gegenmaßnahmen verantwortlich ist.

Attention: Ceci est un produit de Classe B. Dans un environnement domestique, ce produit risque de créer des interférences radioélectriques, il appartiendra alors à l'utilisateur de prendre les mesures spécifiques appropriées.

Appendix: Maximizing Positioning Accuracy

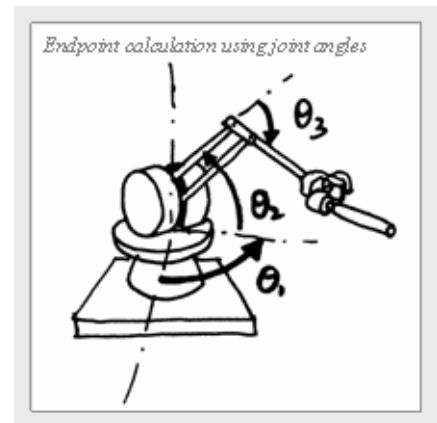
The objective of this technical note is to help you achieve a high level of positioning accuracy in the Phantom devices as specified in our product literature.

Phantom devices have excellent inherent repeatability under no-load conditions. However, they can only be accurate if they have been initialized properly. The proper procedure for initialization is outlined in this note.

Why initialization matters

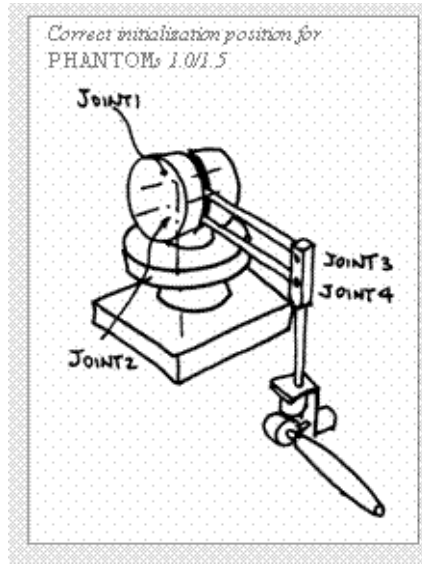
All Phantom devices are equipped with incremental rotary encoders, which measure the joint angles of the Phantom mechanism. These measurements are then used to calculate the endpoint position in Cartesian space, based on the linkage structure, link lengths and other such parameters.

This method of arriving at the endpoint position implies an absolute knowledge of the joint angles. However, incremental encoders can only provide angular measurements relative to the joint angles at which the system “woke up” at initialization time. To obtain absolute angular measurements, the system must initialize at a known position and orientation, often referred to as neutral position.



Initialization position for Phantom Devices

To keep the initialization procedure simple, we have chosen an easily recognized point in the center of the workspace of the Phantom as neutral position. Roughly speaking, the optimal startup position involves keeping the first link horizontal and perpendicular to the front face of the base, and the second link vertical and pointing down from the first. If there is an encoder gimbal, the face of the gimbal with a label indicating “This side faces the Phantom” should be vertical and it should face the base of the Phantom. The thimble or stylus should be horizontal in the plane of the first and second linkages.



The goal of this procedure is to line up the four rotary joints of the Phantom 4-bar linkage to form a rectangle. If the two joints on the short linkage closest to the base are called Joints 1 and 2, and the joints on the second linkage are called Joints 3 and 4, the lines between Joints 1 and 3 and Joints 2 and 4 must be horizontal, and the lines between Joints 1 and 2 and Joints 3 and 4 must be vertical.

To eyeball or not to eyeball

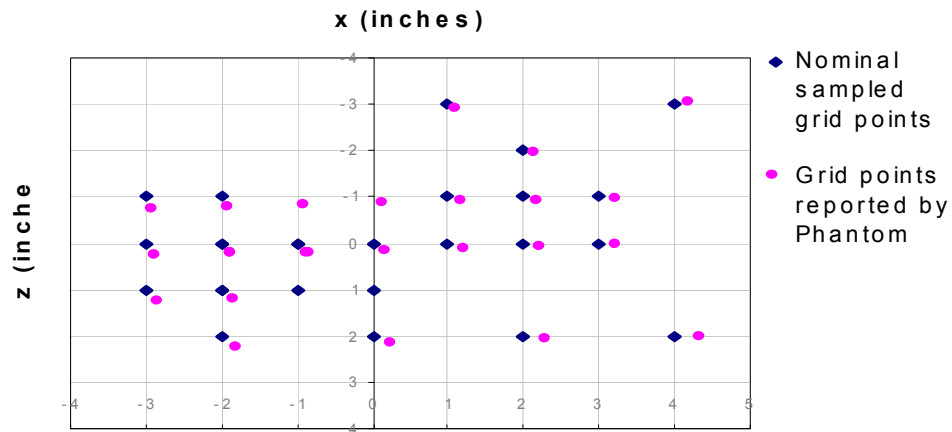
Given that the initialization position dictates future positioning accuracy of the Phantom, is it sufficient to eyeball the startup position or is it necessary to create a fixture to ensure accurate and repeatable system initialization?

The answer to that question depends greatly on the application. The following figure shows typical positioning errors when the initialization position is translated from the optimal startup position by an “eyeballing” error of 0.2" in the -x and -z directions. The best-case error is around the initialization point with the errors growing larger near the edges of the workspace. Furthermore, there is some skewing of the coordinate system. Due to the error in reported position, the forces presented to the user will also be similarly skewed.

However, the human is an imprecise position and force measurement device and such differences are generally not perceivable. For applications in which a single Phantom is used to present forces in a virtual reality simulation, eyeballing is generally adequate.

On the other hand, for applications in which position is critical, such as teleoperation, 3D digitization or operation of two Phantom's in the same virtual space, it is generally advisable to create a jig for accurate initialization.

**Phantom 1.5 positioning errors
with a typical $(-0.2, 0, -0.2)$ "eyeballing"
error**



Appendix: Configuring Multiple Devices

If you want to use more than one Phantom haptic device with your computer, you can create as many as 20 uniquely named Phantom configurations. Each named Phantom configuration can refer to a particular system configuration that you use frequently. Which device to use is defined by the software application which uses it.

To create a new Phantom configuration use the Phantom Configuration Utility.

- 1 From the **Start** menu, open the **Control Panel**. Select **Phantom Configuration**. The Phantom Configuration window opens.
- 2 On the hardware tab, click **Add**.
- 3 Enter a name to call that device, click **OK**.
- 4 From the Phantom model menu, select the **correct model**.
- 5 Click **OK**.

Dual Configurations

The Dual Configuration settings only apply if you want to set up a pair of Phantom devices to work in tandem with each other. You must have created at least two Phantom devices as described above before the Dual Configuration tab can be used. Once you have created at least two devices, go to the Dual Configuration area and select the Phantom devices you would like to use in a paired configuration. Then, enable the check box to turn the dual configuration on.

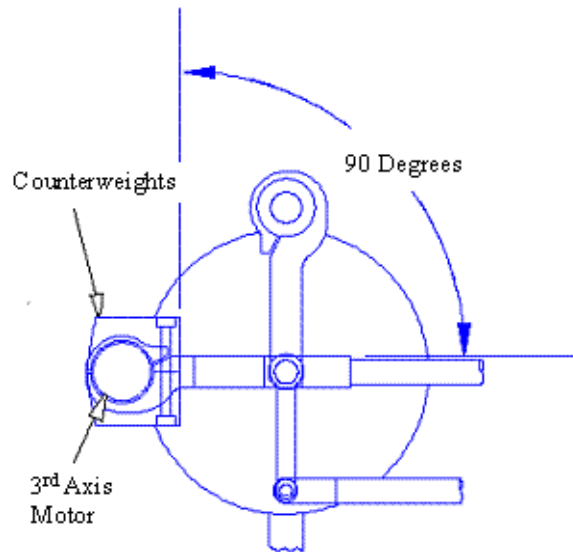
Appendix: Installing/Removing the Encoder Gimbal

Adding the Encoder Gimbal and counterweights to a Phantom Premium

- 1 If you previously connected the Phantom device, unplug the power and parallel cables.
- 2 Loosen the #4-40 set-screw in the last link using the hex key provided (.050") (Sensable part number 01641).
- 3 Remove the thimble-gimbal from the last link by pulling it out with a slight force.
- 4 Insert the bare shaft of the encoder gimbal assembly into the end of the last link of the Phantom Premium.
- 5 Lightly tighten the set-screw. Be careful not to tighten it too much; it could strip the threads and/or mar the shaft.
- 6 Pass the 26-pin connector between the upper and lower arms in the arm assembly.
- 7 Plug the 26-pin connector into the socket located on top of the Phantom Premium.
- 8 Using the small cable ties included, fasten the cable to the mechanical arm so that the cable will not interfere with the movement of the Phantom Premium in any way. Be sure to leave enough slack near the encoder gimbal so that it can rotate 360. A dressed Phantom Premium 1.5 should only have three ties: #1 on the gimbal arm, #2 on the upper bar, and #3 on the front of the left support facing towards the back of the unit.
- 9 Cut the excess material from the ends of the cable ties.
- 10 Plug in the power and parallel cables.

For a Phantom Premium 1.5 6DOF/1.5HF 6DOF

- 1 Position the counterweights on the 3rd axis motor as shown at right, being careful to avoid the motor driver wires. The counterweights should be perpendicular to the Phantom Premium's arms. The counterweights should be approximately 1mm away from the motor mount in the motor axis direction. You may have to bend the motor driver terminals to 60 away from the motor to make room for the counterweights; do this carefully. Insert and tighten two 8-32 screws to secure them.



Removing the Encoder Gimbal and counterweights from a Phantom Premium

- 2 Unplug both the power and parallel cable from the Phantom.
- 3 Unplug the 26 pin connector on the Phantom Premium base.
- 4 Cut the cable ties that route the cable with the 26 pin connector. Be careful not to cut any part of the cable. Note the routing of the cable as you take it off.
- 5 Using the Hex key provided (0.050") (Sensable part number 01641), loosen the #4-40 set-screw (Sensable part number 01509) located near the end of the last link.
- 6 Pull the encoder gimbal assembly out of the last link. The gimbal should slide out with a minimal amount of force.
- 7 Hold both counterweight pieces in one hand to avoid dropping them. Using a 9/64" hex key (Sensable part number 01629), remove the two screws in the counterweights and remove the counterweights.
- 8 Insert the bare shaft of the thimble-gimbal into the end of the last link. Be sure that the shaft is inserted as far into the last link as possible, to preload the bearings and prevent any play in the device.
- 9 Lightly tighten the set-screw. Be careful not to tighten it too much: it could strip the threads and/or mar the shaft.
- 10 Plug in the power and parallel cables.

Appendix: Power Specifications

	With Internal Auto-Switching Power Supply
Output Current Rating	8.3 A
AC Input	100 ~120 VAC 200 ~ 240 VAC (auto-switching power supply)
Input Frequency	50/60 Hz
AC Current	5A / 115V, 2.5A / 230 V
Inrush Current	15A / 115V, 30A / 230 V

Appendix: Working with Pinch End Effectors

The Phantom 6 DOF family of haptic devices enables attaching interchangeable end effectors that provide pinch functionality. There are two pinch-capable grips: thumb-pad and scissors (examples available in the following pages).

Requirements

- A Pinch-capable Phantom Premium device (1.5 6DOF, 1.5HF 6DOF)
- The most recent version of the Phantom Device Driver (PDD).
- OpenHaptics v2.x BETA. **Pinch end effectors will not work with OpenHaptics v2.0.**
- Windows XP, Vista or Windows 7 (32 or 64-bit)

Specifications

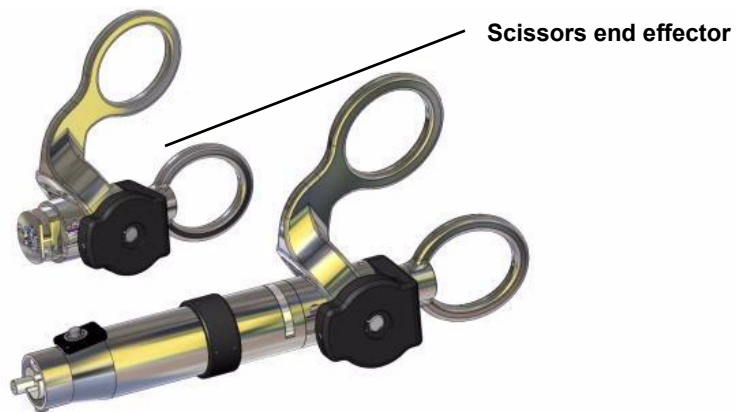
- Range of Motion: 0 to 30 degrees
- Digital Encoder: +/- 2% linearity potentiometer
- Force Feedback: None

Installing or Removing the End Effectors

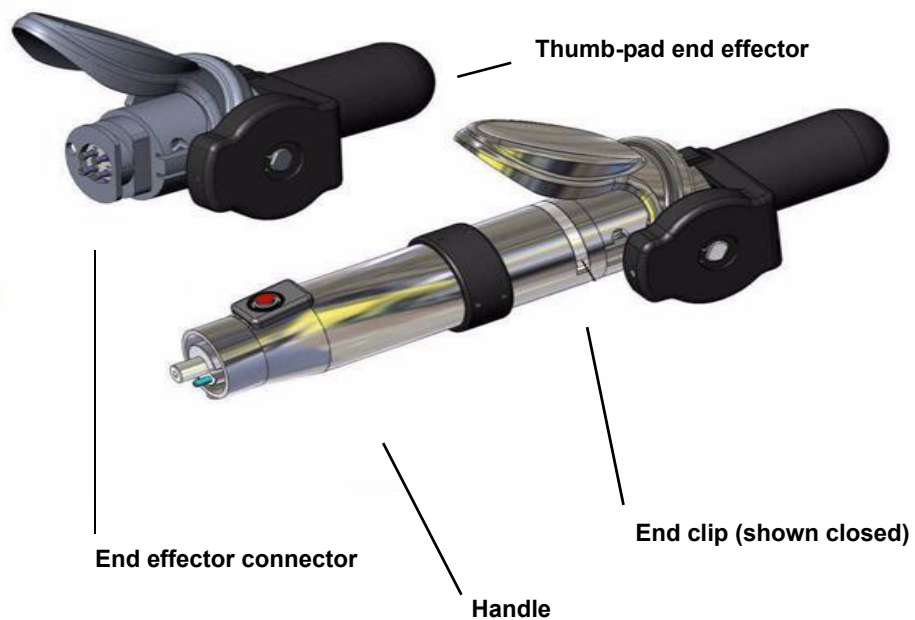
Follow the instructions below to install or remove the Pinch end effectors (thumb-pad and scissors).

Installing the End Effector

- 1 Remove the end cap by opening the end clip and carefully sliding out the cap.
- 2 Align the male connector of the end effector with the female end of the 6 DOF handle and push to insert it. Make sure that the vertical edge of the end effector connector aligns with the vertical edge of the 6 DOF handle connector.
- 3 Close the end clip tightly to keep the end effector in place.



The diagrams on the following page show the thumb-pad and scissors attachments before and after assembly.



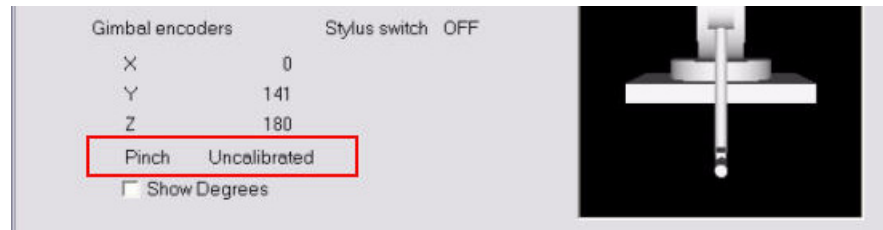
Removing the End Effectors

- 1 Open the end clip.
- 2 Carefully disconnect the end effector from the 6 DOF handle. Make sure to apply the end cap to the 6 DOF handle whenever an end effector is not connected.

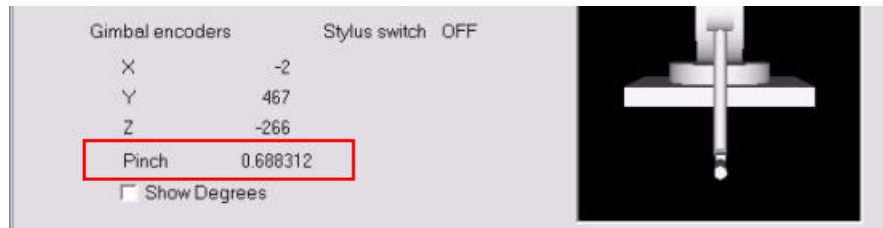
Calibrating the End Effectors

After you have installed the Phantom Device Driver (PDD) and have connected the Phantom device to your computer, you will need to calibrate the device and the thumb-pad or scissors end effectors. End effectors are calibrated through the *Read encoders* tab of the Phantom Test dialog. To do this, follow the steps below.

- 3 From **Start>All Programs>Sensable**, open **Phantom Test**.
- 4 Hold the Phantom device in the neutral position (with the 4 rotary joints lined up) and press the **Space bar** on the keyboard.
- 5 The Pinch option in the dialog will report a status of *Uncalibrated*.



- 6 Close (press) the end effector completely, and press the **Space bar** on the keyboard.
- 7 Open (release) the end effector completely, and the press the **Space bar** again.
- 8 The Pinch option in the dialog should now show continuous readings from the end effector encoder (as shown). This indicates that the end effector is calibrated and ready to use.



Note When the thumb-pad end effector is completely open (released), the Pinch reading corresponds to **zero**. (If using scissors, it corresponds to **one**.) When the thumb-pad end effector is completely closed (pressed completely), the Pinch reading corresponds to **one** in normalized encoder values. (If using scissors, it corresponds to **zero**.) The intermediate positions are distributed between zero and one (or vice versa, if using scissors).

Appendix: Device Specifications

Product specifications are subject to change without notice. Device specifications continue onto the following page.

	Premium 1.5 6DOF	Premium 1.5 High Force 6DOF
Workspace	Translational= 15 W x 10.5 H x 7.5 D inches 381 W x 267 H x 191 D mm Rotational= Yaw: 297 degrees/ 5.18 radians Pitch: 260 degrees/ 4.54 radians Roll: 335 degrees/ 5.85 radians	
Footprint	13 W x 10 D inches 330 W x 254 D mm	
Range of Motion	Lower arm movement pivoting at elbow	
Nominal Position Resolution	860 dpi 0.03 mm Rotational= Yaw & Pitch: 0.0023 degrees/ 0.00004 radians Roll: 0.0080 degrees/ 0.00014 radians	3784 dpi 0.007mm Rotational= Yaw & Pitch: 0.0023 degrees/ 0.00004 radians Roll: 0.0080 degrees/ 0.00014 radians
Backdrive friction	0.15 oz 0.04 N	0.75 oz 0.2 N
Maximum exertable force (nominal position)	1.9 lbf 8.5 N Rotational= Yaw & Pitch: 73 oz-in/ 515 mNm Roll: 24 oz-in/ 170 mNm	8.4 lbf 37.5 N Rotational= Yaw & Pitch: 73 oz-in/ 515 mNm Roll: 24 oz-in/ 170 mNm
Continuous exertable force (nominal position)	0.3 lbf 1.4 N Rotational= Yaw & Pitch: 27 oz-in/ 188 mNm Roll: 7 oz-in/ 48 mNm	1.4 lbf 6.2 N Rotational= Yaw & Pitch: 27 oz-in/ 188 mNm Roll: 7 oz-in/ 48 mNm
Stiffness	20 lbf in ⁻¹ 3.5 N mm ⁻¹	
Inertia (apparent mass at tip) -without encoder gimbal	< 0.17 lbm < 75 g	< 0.33 lbm < 150 g
Force Feedback	x, y, z, Tx, Ty, Tz	
Position Sensing	x, y, z, roll, pitch, yaw	x, y, z, roll, pitch, yaw
Interface	Parallel Port	
Supported Platforms	Intel-based PCs	
GHOST® SDK Compatibility	Yes	Upon special request
OpenHaptics™ Toolkit Compatibility	Yes	

