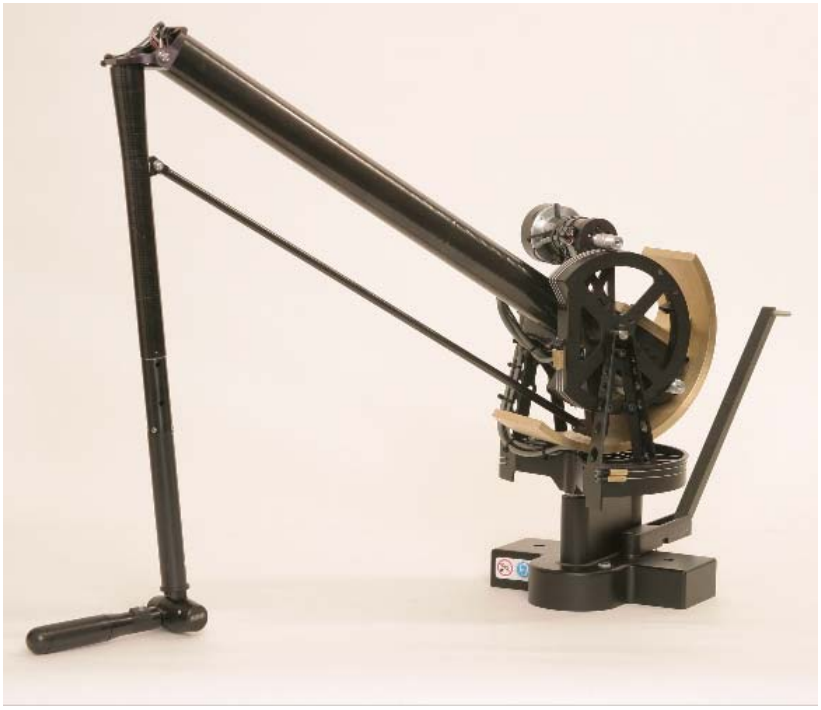
PHANTOM® Premium

3.0/6DOF User Guide



Bringing 3D Touch™ to Your Desktop

2/11/08TR | P/N 02598 REV4

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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 anyoneother than a certified authorized service center voids the manufacturer warranty and hardwaremaintenance 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 1-781-937-8315 (International).

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

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Preface

Congratulations on your purchase of a PHANTOM PREMIUM 3.0L 6DOF, the largest member of the award-winning PHANTOM line of 3D Touch systems. PHANTOM PREMIUM 3.0L 6DOF combines the precision and quality of its predecessors with the ease-of-use and the ergonomics required for everyday use in the professional, desktop environment. It will enable you to interact with 3D computer data and models in an entirely new, dramatically more intuitive and productive way – using your sense of touch.

You are joining the community of owners of the PHANTOM® device, the 3D Touch components that have been widely recognized as the finest force-feedback device available. It is unlike any other device in that it offers **realistic** 3D Touch technology, the ability to feel the properties of virtual 3D objects, with higher fidelity and lower cost than other 6DOF force feedback devices.

The PHANTOM community is a vibrant one made up of researchers, distributors, engineers, physicians and other professionals from all over the world. We invite you to be an active participant by visiting our WEB Site (www.sensable.com), joining our User Group, and stopping by to visit us at trade shows and our home in Woburn. Call our sales and support team at 888-SENSABL (888-736-7225), or email us at "support@sensable.com" or "sales@sensable.com" if you have any questions. Our team at SensAble Technologies is committed to providing you with the best interface technology and customer support available. Now you can power up your PHANTOM device and "feel the difference"!

This manual will guide you through the installation and setup of your PHANTOM PREMIUM 3.0L 6DOF. If you encounter any difficulties, please contact Customer Support (support@sensable.com).

We also invite you to visit our Web site at www.sensable.com to learn more about:

- SensAble's 3D Touch technology
- 3D Touch-enabled applications and software products from SensAble and other vendors
- Artists, engineers, medical professionals, data analysts and other 3D professionals who are revolutionizing the quality, productivity and satisfaction of their work through 3D Touch
- Haptics resources for researchers and developers

Caution

The PHANTOM PREMIUM 3.0L 6DOF components have been tested to comply with the European low voltage and EMC directives and related standards. This device must be installed in accordance with the applicable requirements.

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

- Read the manual thoroughly prior to using you PHANTOM PREMIUM 3.0L 6DOF.
- DO NOT put your face in the workspace of the PHANTOM PREMIUM 3.0L 6DOF. Safety glasses are recommended.
- DO NOT place your fingers inside the mechanism. At the installation site, access to motors and pulleys should be prevented.
- DO NOT run a haptics application unless the base is properly anchored to the desk or other surface as outlined in this manual.
- As a user of this product and software you accept full responsibility for assuring that the device is used in a safe and reasonable manner.

Table of Contents

Introduction

About This Guide

The PHANTOM Premium 3.0L 6DOF User's Guide describes the process of installing the hardware and required device drivers for your new PHANTOM Premium system.

We've worked extensively to ensure that the PHANTOM Premium device and PHANTOM Device Drivers install and work smoothly on your computers. If you experience any problems in the installation or use of your system or hardware, please contact technical support (contact information can be found on the inside cover of this document). Your feedback and input are essential! Please don't hesitate to contact us with technical questions and suggestions for improvement.

How This Guide Is Organized

The PHANTOM Premium 3.0L 6DOF User's Guide is divided as follows:

- **Getting** describes the PHANTOM Premium and many of the items that came with the system.
- **Installing the PHANTOM Device Drivers** describes how to install the software necessary to run this product on Intel processor PCs under Windows 2000 and Windows XP.
- **Connecting and Using the PHANTOM Premium 3.0L System** describes how to connect the hardware.

Typographical Conventions

The PHANTOM Premium User's Guide uses the following conventions:

Italics	Indicates terms or concepts, and shows emphasis. It also indicates cross-references to related publications or chapters in this guide.
Bold	Used to indicate directory paths or program group names.
NOTE*:*	Used to highlight important additional information.

Getting Started

Shipping Crate Contents

You should find the following items in the PHANTOM Premium 3.0L 6DOF shipping crate:

- **The PHANTOM Premium haptic device**
- **This PHANTOM Premium User's Guide**
- **PHANTOM Device Driver (PDD) CD:** This CD includes all of the drivers needed to set up and run the PHANTOM Premium as described in the next sections. (If you also purchased OpenHaptics®, the PHANTOM Device Drivers will be found on that Product CD.)
- **Amplifier Box** (see *Understanding the Amplifier Box* later in this guide)
- **Cables** (see *Connecting Cables* later in this guide)
- **Counterweight**
- **Accessory Box:**
    - Safety glasses
    - Feet (4x)
    - Mounting screws
    - Allen wrench
    - Pinch end-effectors (thumb-pad and/or scissors, depending on your order)

See *Understanding the System Components* for more information.

Note Your box may also include other SensAble™ software purchased with your order.

If any items are missing, please call SensAble Technologies at +1-888-SENSABL (US only) or +1781-937-8315 (US and outside the US).

Important Do NOT throw away the packaging materials. If for any reason you need to ship the device in the future, you will want to reuse these materials to reduce the risk of damage to the device.

System Requirements

The following system requirements apply to the use of the PHANTOM Premium and driver software:

- The PHANTOM Premium 3.0L 6DOF, via an IEEE 1284 Parallel Port Interface, can operate on either Microsoft® Windows® 2000 or XP.
- When PCs are used, it is recommended that you use a 300 MHz Pentium processor at minimum. A dual-processor machine is highly recommended.
- The PHANTOM Device Drivers (PDD) version 4.2.105 or later. Distribution of these drivers requires approximately 30 MB of disk space. The PHANTOM Device Drivers *do not* specify memory requirements; however, a minimum of 32 MB is recommended.
- The PHANTOM Device Drivers (PDDs) are distributed on CD-ROM and are downloadable from www.sensable.com.
- An Intel® processor based personal computer (A minimum of Pentium® II class processor is recommended) or select AMD® processor personal computer.

Removing the Haptic Device from its Box

The haptic device in its entirety (excluding cables), as shown in Figure 1, is bolted to the shipping pallet with four #1/4-20 Socket Head Screws (SensAble Part # 02460). These screws may be removed with a Hex Key (SensAble Part # 01986) supplied with the unit (inside the accessories box).

The haptic device in its entirety weighs about 60 pounds (27 Kilos). Exercise care when lifting the device by the handles, to place it on a desk or the intended workbench. Do not attempt to lift the device by using any other part as lifting means. Severe bodily injury and damage to the device may result.

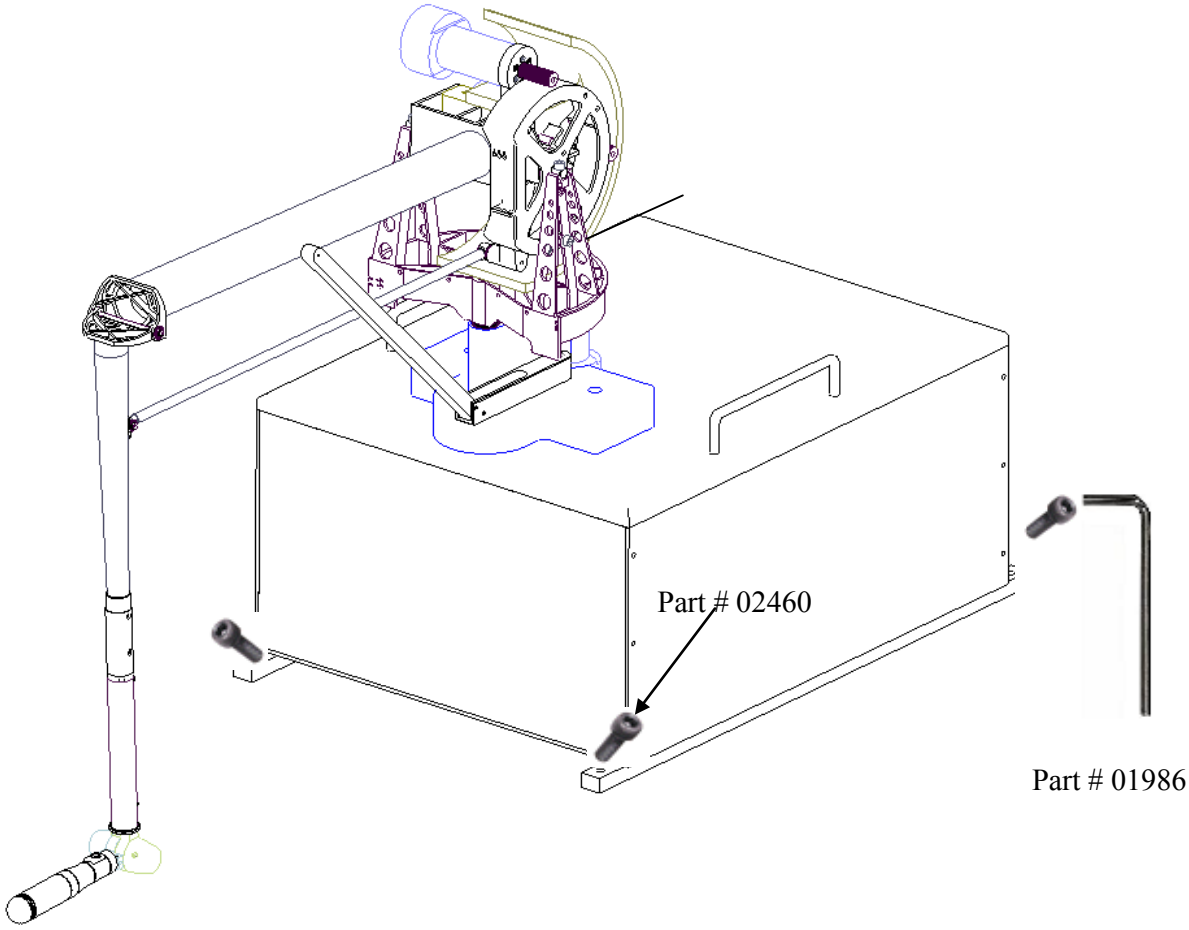

Figure 1:PHANTOM PREMIUM 3.0L 6 DOF SYSTEM

Understanding the System Components

These are the components that make up the PHANTOM Premium 3.0L 6DOF System:

- The PHANTOM Premium 3.0L 6DOF Arm (Haptic Device)
- The Amplifier Box
- Connecting Cables
    - Parallel Port Cable
    - Power Cord
    - Encoder Signal Cable (15 Pin-Dsub)
    - Base Motor Power Cable (8-Pin Din)
    - Gimbal Motor Power Cable (6-Pin Din)

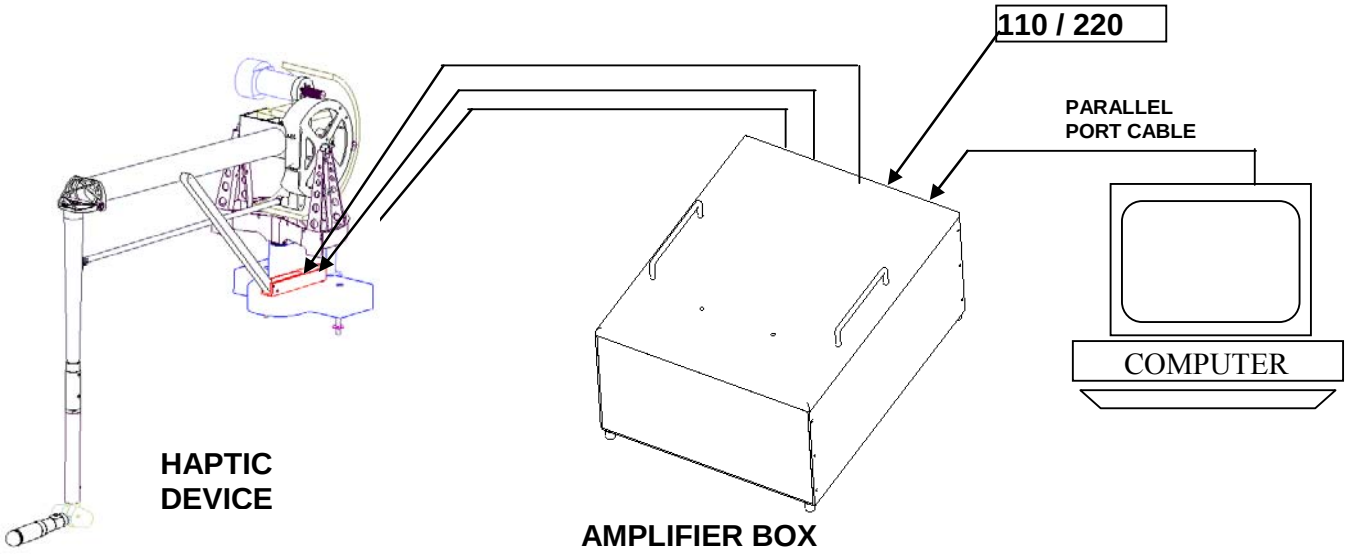

Figure 2 Diagram of the PHANTOM PREMIUM 3.0L setup

Figure 2 illustrates the components. Read through the rest of this manual for detailed information on setting up of the PHANTOM Premium 3.0L 6 DOF Arm, the Amplifier Box and the Cables.

***Notes:**

1. The AC receptacle on the electronics console (Amp Box) is connected to the wall outlet with a country/region specific power cord. The integral switching power supply in the Amp Box works for both 110V and 220V AC inputs.

2. Parallel Port to Computer: The 25-Pin male connector is connected to the computer's parallel port using the supplied IEEE-1284 rated cable. This cable has a ferrite bead that provides an impedance at 100mhz of 199 ohms or greater.

The PHANTOM Premium 3.0L 6 DOF Arm

The PHANTOM Premium 3.0L Arm (Haptic Device) consists of the following components as illustrated in Figure 3 below:

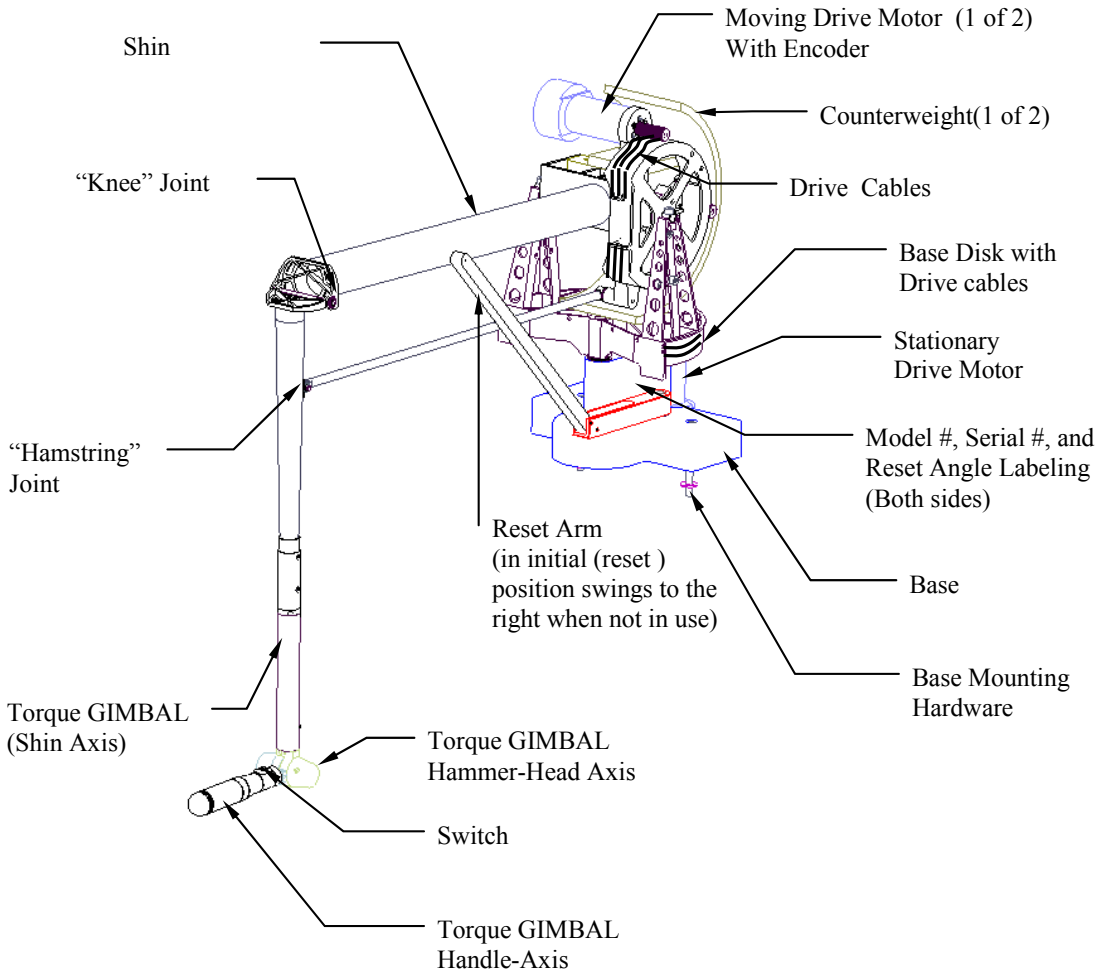

Figure 3:PHANTOM PREMIUM 3.0L 6 DOF HAPTIC Arm Components

The End Effector (Gimbal)

The PHANTOM Premium 3.0L 6DOF is available in two end-effector configurations. Either end-effector (Gimbal) has 3 degrees of Torque feedback. These configurations are installed at the factory and must be ordered as desired (cannot be modified by the user).

A) Forward Handle Gimbal (PHANTOM 3.0L-6DOF Part # 02605)
B) Reverse Handle Gimbal (PHANTOM 3.0L-6DOF Part # 02604)

A momentary tactile switch is located on the Stylus as shown in Figure 4. The stylus also has an auto-detect feature for safety (two shiny contact surfaces separated by an insulating ring). PHANTOM forces will operate only when the user properly grasps the stylus, thus allowing the stylus to detect user-presence (hand must make contact with both shiny surfaces).

The gimbal is also marked "LEFT" and "RIGHT." Shown below is the "Forward Handle" configuration. When the handle is facing the user, as in this case, the "RIGHT" marking on the Hammer-Head Axis should be to the right of the user.

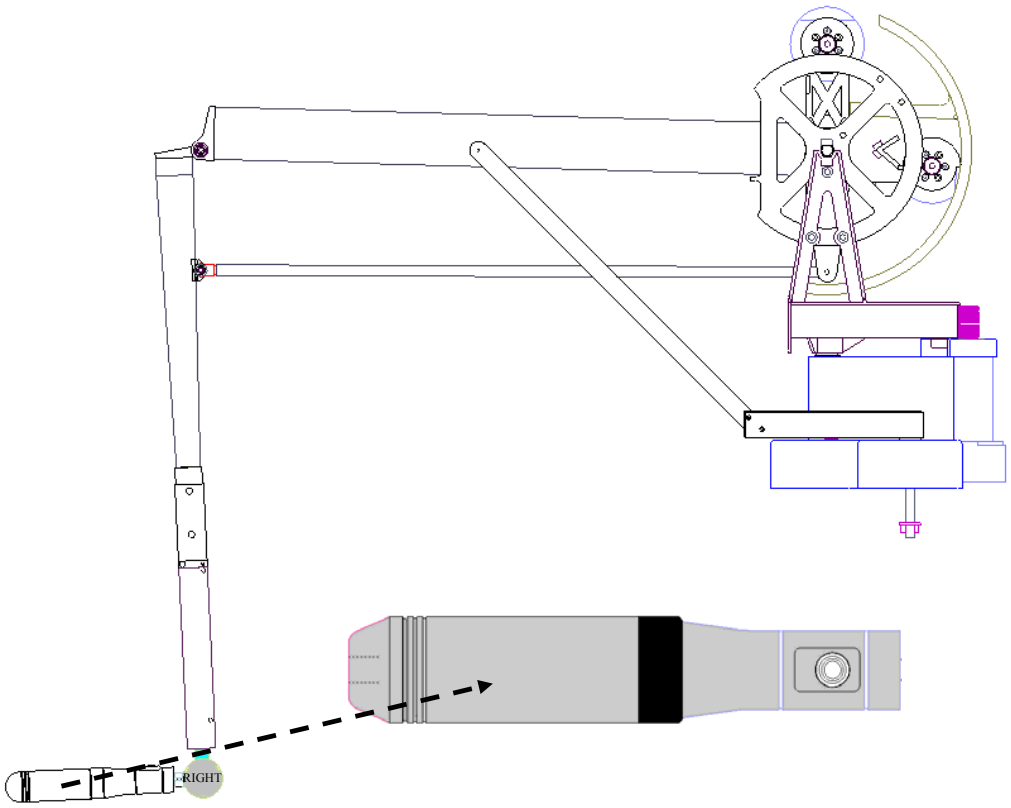

Figure 4: PHANTOM PREMIUM 3.0L 6DOF HAPTIC Arm Forward Handle Gimbal

Shown below in Figure 5is the “Reverse Handle” configuration. When the handle faces the user in this case, the “RIGHT” marking on the Hammer-Head Axis is to the right of the user.

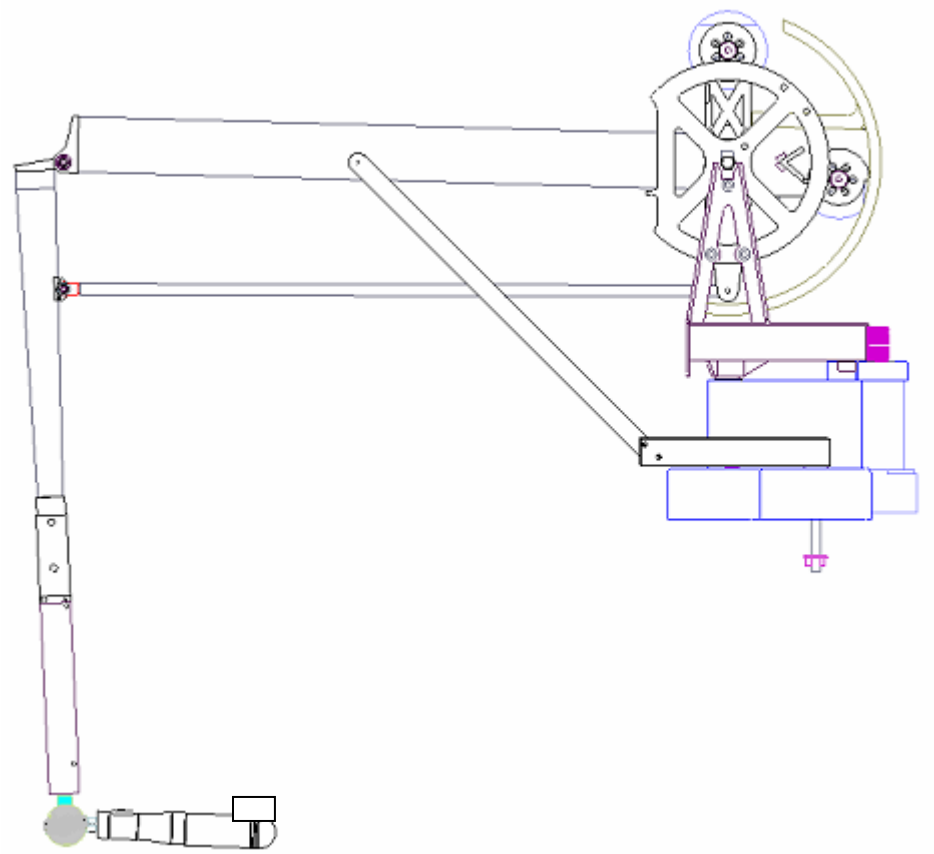

Figure 5: *PHANTOM PREMIUM 3.0L 6DOF HAPTIC Arm Reverse Handle Gimbal*

The PHANTOM Premium 3.0L 6DOF System Mounting Configurations

The PHANTOM Premium 3.0 L 6 DOF Haptic Device, as removed from the box, may be directly bolted onto a workbench by using the four #1/4-20 Socket Head Cap Screws that were securing it to the pallet, or with four shorter #1/4-20 Socket Head Cap Screws (3/4” long) provided in the accessories box.

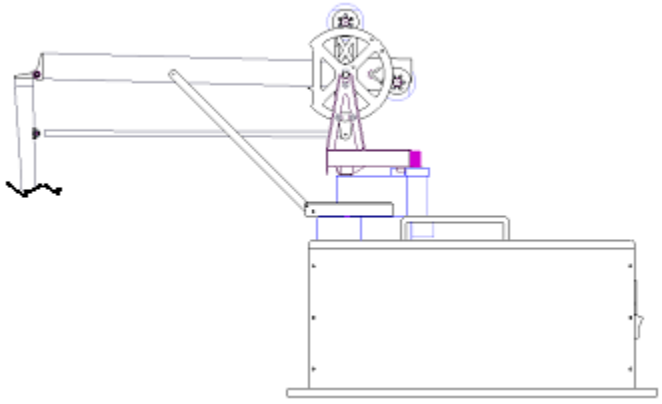

Figure 6: *As Shipped Configuration*

If desired, the PHANTOM Premium 3.0 L 6 DOF Haptic Arm may be disassembled from the Amp Box by using the Hex Key provided to remove two #1/4-20 Socket Head Cap Screws that are securing it (Part # 01971). These two screws may be reused to bolt the Haptic Arm directly to a workbench(Figure 6). Nuts and washers are provided with the device. The Amp Box may then be placed under the bench or as desired by the user. The supplied cables are about 7 feet long.

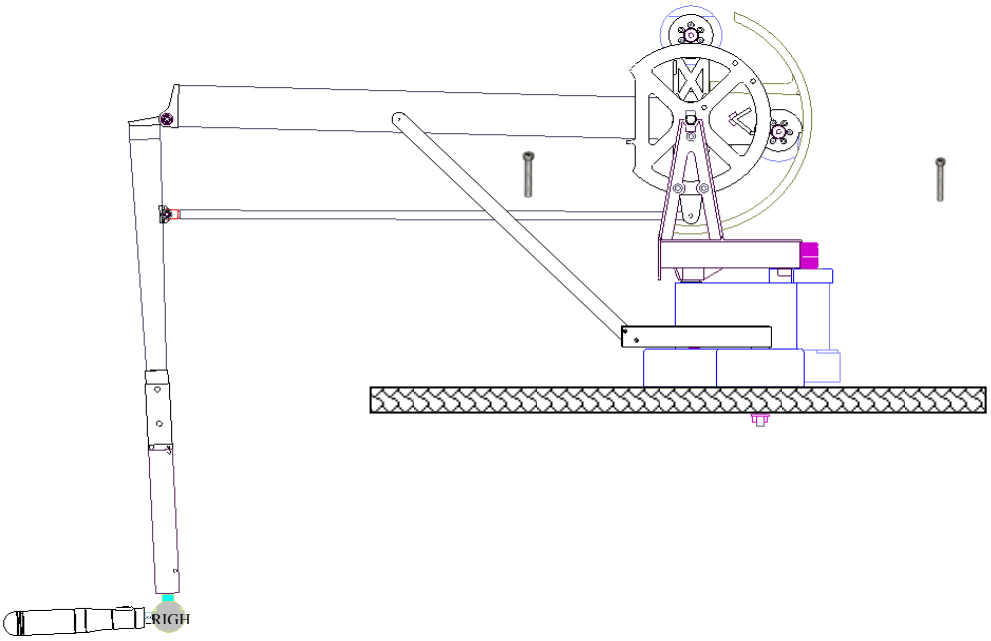

Figure 6: Mounting the Haptic Arm Only Configuration

Two mounting holes in the base are sized to accommodate ¼-20 Socket Head Cap Screws and are positioned 5” (12.7 cm) apart as shown in Figure 7. The system comes with two 1.5” long, ¼-20 Socket Head Cap Screws (Part # 01971) and two 3” long, ¼-20 Socket Head Cap Screws (Part # 01988) with the necessary nuts (Part # 01972) and washers (Part # 01973).

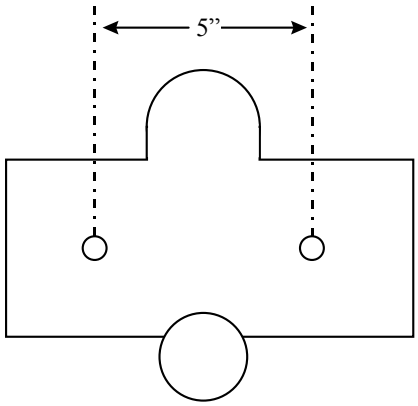

Figure 7: Mounting Hole Locations in the Base

The optimal mounting height in this Configuration is 10” (25 cm) above the plane of the workbench. This allows a seated user to reach into the entire possible workspace.
Device Shown in Figure 8 (following page) as placed on the Workbench with Non-Skid Rubber Feet Installed.

The PHANTOM Premium 3.0 L 6DOF Haptic Device, as removed from the box, may be also be placed on a workbench by installing hard-rubber feet, provided in the accessory box directly to the securing metal bars. If desired the metal bars may be removed using the Hex Key provided and the feet installed directly on the Electronics Console.

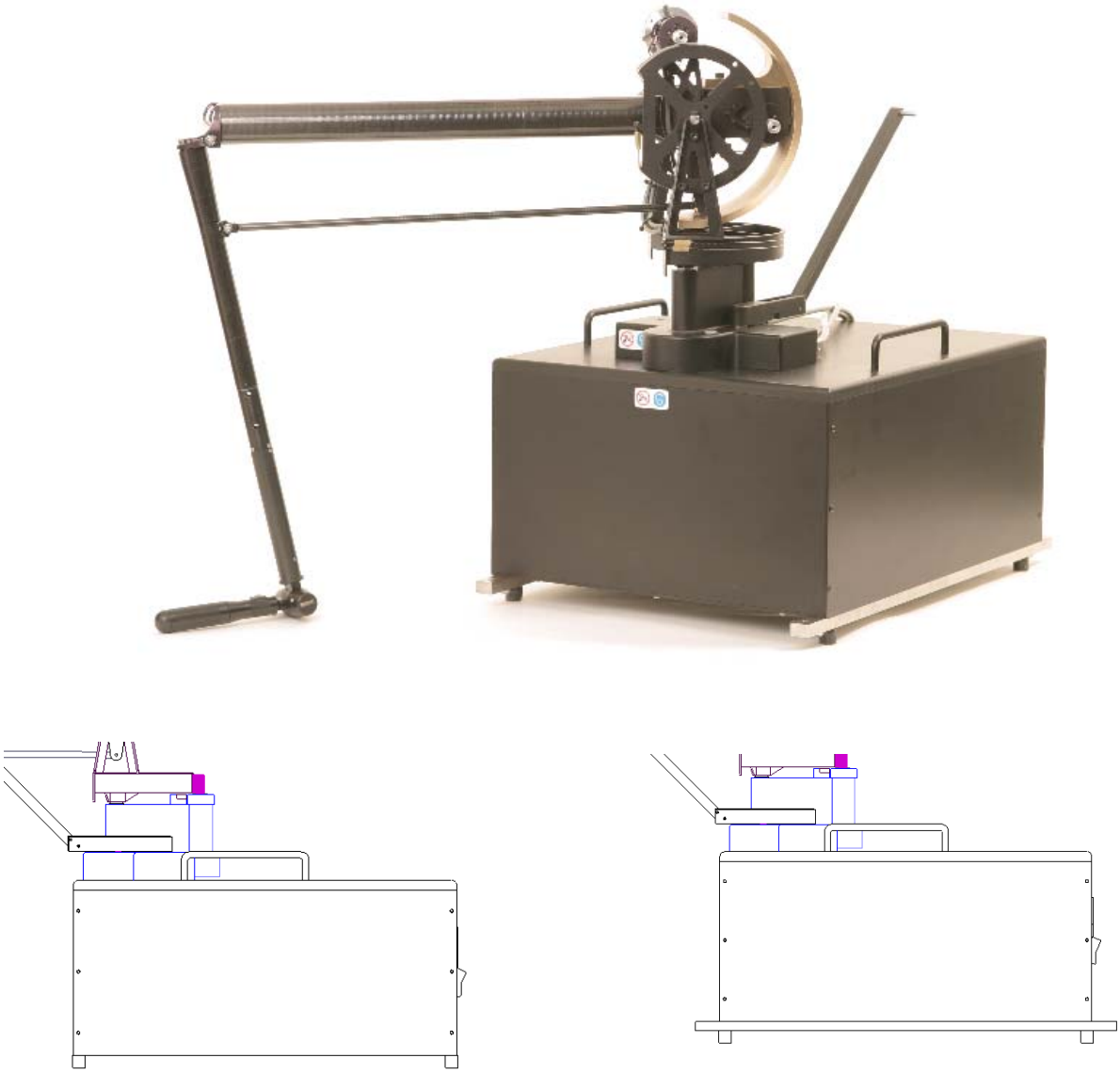

Figure 8:Feet Installed (with Securing Bar either Present or Removed)

Neutral and Reset Positions

The PHANTOM Premium 3.0L 6DOF sensors must be reset at the beginning of every program that uses the device. The position and orientation of the PHANTOM Premium 3.0L, when read from software, is always relative to the position in which the sensors were reset. The device can be reset in either the neutral or reset positions.

Neutral Position

The PHANTOM Premium 3.0L 6DOF is in the neutral position when the lines joining the four joints in the four bar linkage system are at their right angle positions as shown in Figure 12. Specifically, the line joining Joints 1 and 3 as well as the line joining Joints 2 and 4 should be horizontal, and the line joining Joints 3, 4 and 5 should be vertical. When the device is in this position, the "shin" linkage would be slightly off vertical and the "thigh" linkage would appear to be cocked upward (see Figure 9). If you have an encoder gimbal with stylus, the stylus should be positioned as indicted in Figure 9 with the switch on top.

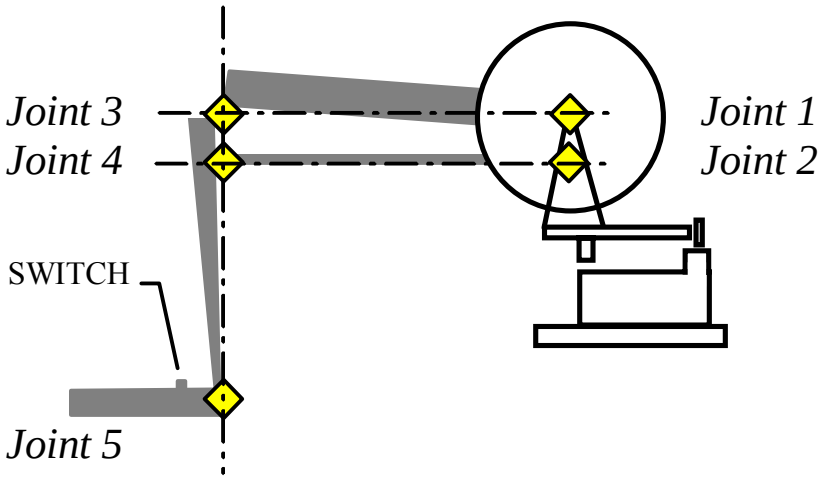

Figure 9: The PHANTOM PREMIUM 3.0L 6 DOF in Neutral Position

This is the default reset position that the PHANTOM Premium 3.0L 6 DOF should be in when starting up any of the demo programs that come with the system. This position also considered the (0,0,0) location for the device. If the PHANTOM Premium 3.0L 6 DOF is correctly reset, all software library functions assume that in this position the joint at the end of the handle is at the origin of its coordinate system.

Reset Position

The PHANTOM Premium 3.0L 6DOF features a reset arm that can be used to reset the sensors in the same position (see Figure 3). The reset arm swings forward and snaps into position under the head of the screw.

To set your Haptic Device into the calibration arm, locate the small hole at the base of the shin washer, just above the Hammer-Shaped Head. This small hole (see Figure 10) is located on the Flat portion of the clamp, next to the Socket Head Cap Screw. Insert the small post at the end of the reset arm into the hole. Hold handle/stylus in position shown.

For reverse-handle configuration, turn the handle/stylus all the way against its dead-stop such that the phillips-head screw is visible. See digital picture in Figure 10. Also read the following file "README - 3.0 6DOF reverse handle configuration.txt" on your device driver CD.

Your PHANTOM Premium 3.0L 6DOF has been factory calibrated to its neutral position (0,0,0), and the corresponding reset position has been determined. This reset position is represented by three angles: ResetAngle0, ResetAngle1, and ResetAngle2, which are stored in the system registry (RegEdit).

These reset position values for your unit can be found on the calibration label located on the base of the PHANTOM Premium 3.0L 6 DOF Arm, as well as in Table 1.

When finished resetting your PHANTOM Premium 3.0L 6 DOF, swing the reset arm out of the way. This reset position is not the neutral position. The PHANTOM Premium 3.0L 6 DOF should not be in this position when running the demonstration programs that come with it until the changes are made as described in this section.

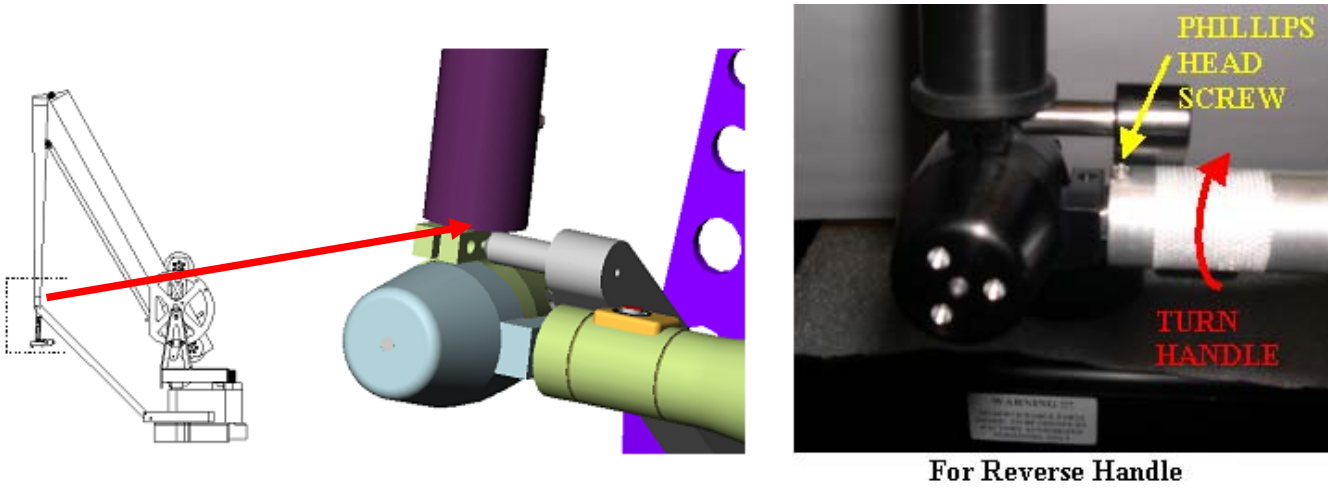

Figure 10: PHANTOM PREMIUM 3.0L 6 DOF in Reset Position *(Normal and Reverse Handle)*

If you wish to use this position as the reset position in your own software you will need to change the <reset angles> entry in the configuration file or you will not be able to accurately read the position and orientation of the PHANTOM Premium 3.0L 6 DOF. If your version of PDD is 4.2.32 and above, Reset Angles tab in the PHANTOM configuration control panel as shown in Figure 11, then you can enter the reset angles[1] in radians as provided in Table 1. Otherwise, you can edit these reset angle values directly in the registry, as shown in the instructions after Figure 11.

[1] The value of the reset angles should between 0 and 2π

Through the Reset Angles tab:

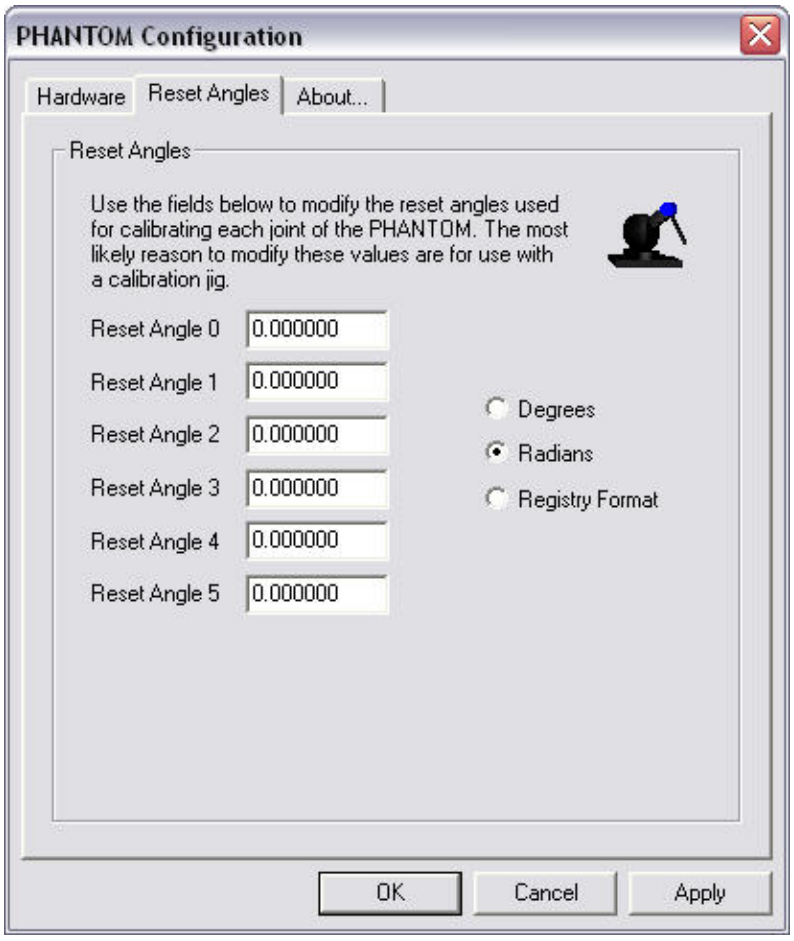

Figure 11:PHANTOM Configuration, Reset Angles Tab

Through the Windows registry:

(You must have administrative privileges to perform this action; you will need to edit three fields in the registry)

1. Choose Start >Run regedit32
2. Select Edit > Find ResetAngle
3. Left mouse click ResetAngle0
4. Edit > Modify
5. (Make sure base is selected as hexadecimal)
6. Enter the value from the table below for ResetAngle0
7. Select OK
8. Left mouse click ResetAngle1
9. Edit > Modify
10. (Make sure base is selected as hexadecimal)
11. Enter the value from the table below for ResetAngle1
12. Select OK
13. Left mouse click ResetAngle2
14. (Make sure base is selected as hexadecimal)
15. Enter the value from the table below for ResetAngle2

16. Select OK
17. Close the registry

Variable Name	Hex Value	Radians
ResetAngle0	PLACE ResetAngle0 VALUES HERE	
ResetAngle1	PLACE ResetAngle1 VALUES HERE	
ResetAngle2	PLACE ResetAngle2 VALUES HERE	
ResetAngle3	0x01921FB5	1.570796327
ResetAngle4	0x04B65F1F	4.71238898

Table 1:Reset Angle

The reset arm should be swung out of the way after the initialization process.

For a more in-depth discussion on correct initialization procedures for systems based on the PHANTOM 3D Touch systems, see the section “Initializing the PHANTOM Premium SE” in the enclosed Technical Memo, “Maximizing positioning accuracy on PHANTOM® Premium Systems”.

Understanding the Amplifier Box

Rear Panel

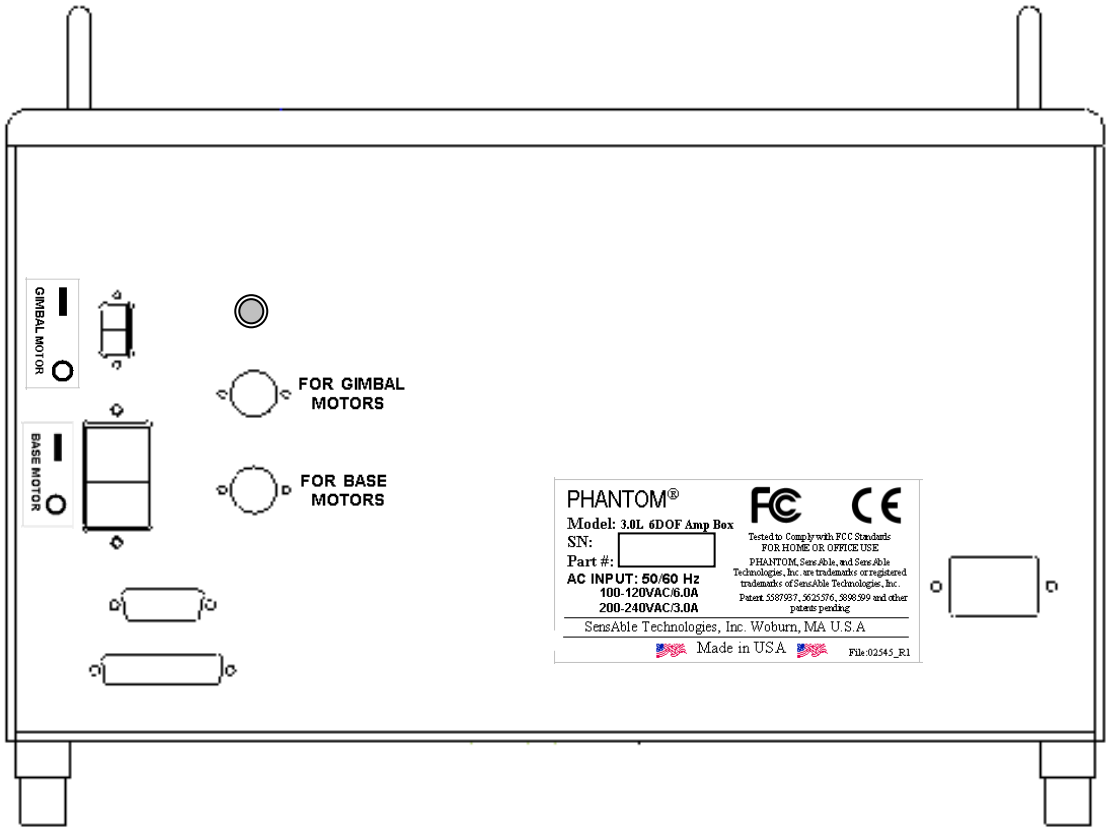

Figure 12 :Rear Panel of Amplifier Box

The Amplifier box has 6 pluggable connectors/outlets, refer to Figure 12.

NOTE:

There is no AC On/Off switch. The Electronics Console gets power as soon as it is plugged in. There are no serviceable components inside. Do not open this console. Risk of electrical shock exists. The switch on the unit shuts off the gimbal motors during software debugging.

The AC input rating is listed on the Serial Number label affixed next to the AC receptacle.

Connecting Cables

- Parallel Port Cable **(Part #: 01724)**: Parallel Port To Computer: The 25-Pin male connector is connected to the computer's parallel port using the supplied IEEE-1284 rated cable.

- Power Cord: A country specific power cord is shipped with (included in) each unit.

- Encoder Signal Cable **(Part #: 01092)**: This cable with 15-Pin Dsub connectors on both ends connects the PHANTOM Device encoders to the Amp Box.

- Base Motor Power Cable 8-Pin **(Part #: 02550)**: This cable has two 8-Pin Din connectors. One of the 8-Pin connectors is threaded. This threaded connector connects to the 8-Pin connector on the base of the Haptic Arm (Figure 13). The non-threaded 8-Pin connector connects to the 8-Pin connector on the Amp Box.

- Gimbal Motor Power Cable 6-Pin **(Part #: 02539)**: This cable has two 6-Pin Din connectors. One of the 6-Pin connectors is threaded. This threaded connector connects to the 6-Pin connector on the base of the Haptic Arm. The non-threaded 6-Pin connector connects to the 6-Pin connector on the Amp Box.

- Audio Jack Cable **(Part #: 02448)**: Without this user touch presence detecting cable the Amp Box will not provide forces to the Haptic Arm.

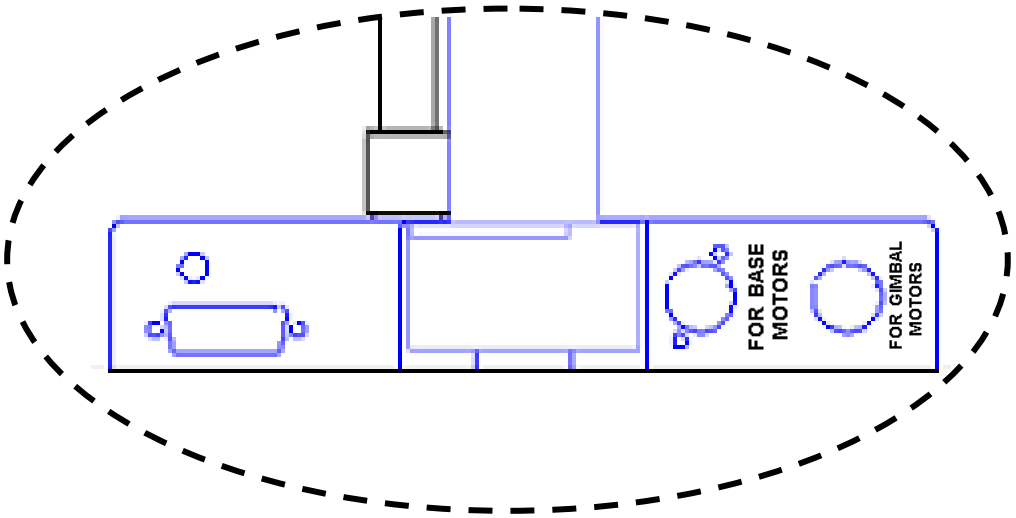

Figure 13:Rear view, PHANTOM Base Haptic arm

Installing the PHANTOM Device Drivers

This and the following section will show you, step by step, how to install the PHANTOM Premium device. First you will install the device driver software on your computer. Then**, while the computer is off**, you will setup the PHANTOM Premium device and plug in all of the cables.

To install the PHANTOM Device Drivers on a Windows 2000/XP platform:

1. Log in to your computer as administrator (or as a user with administrative privileges).
2. Insert the CD into the CD-ROM drive. Then run **SETUP.EXE** from the PHANTOM Device Drivers folder. Follow the instructions on the screen during the installation to specify the installation directory and custom installation instructions.

   If you have previously installed an older version of the PHANTOM Device Drivers on the computer, you will be prompted to remove it before proceeding with the installation. If you get this message, exit the setup program. Then go to the Start menu in Windows and select Settings > Control Panel > Add/Remove Programs. Find PHANTOM Device Drivers in the list and select it. Then hit the Add/Remove button and follow the on screen directions.

   NOTE: If you are prompted during the uninstall to delete shared files that appear to no longer be needed, DO NOT DELETE these files unless you are absolutely sure of their use.

   When you have finished uninstalling, resume the installation of the new PHANTOM Device Drivers.

   The default directory for installing the PHANTOM Device Drivers is **C:\Program Files\SensAble\PHANTOM Device Drivers**.

   At the end of the Setup process you will be presented with a dialog box to allow you to configure the software for your PHANTOM Premium device.

3. Configure the PHANTOM Premium using the dialog box on the following page. Note that you can access the PHANTOM Configuration application any time after installation through **Start > Settings > Control Panel > PHANTOM Configuration**.

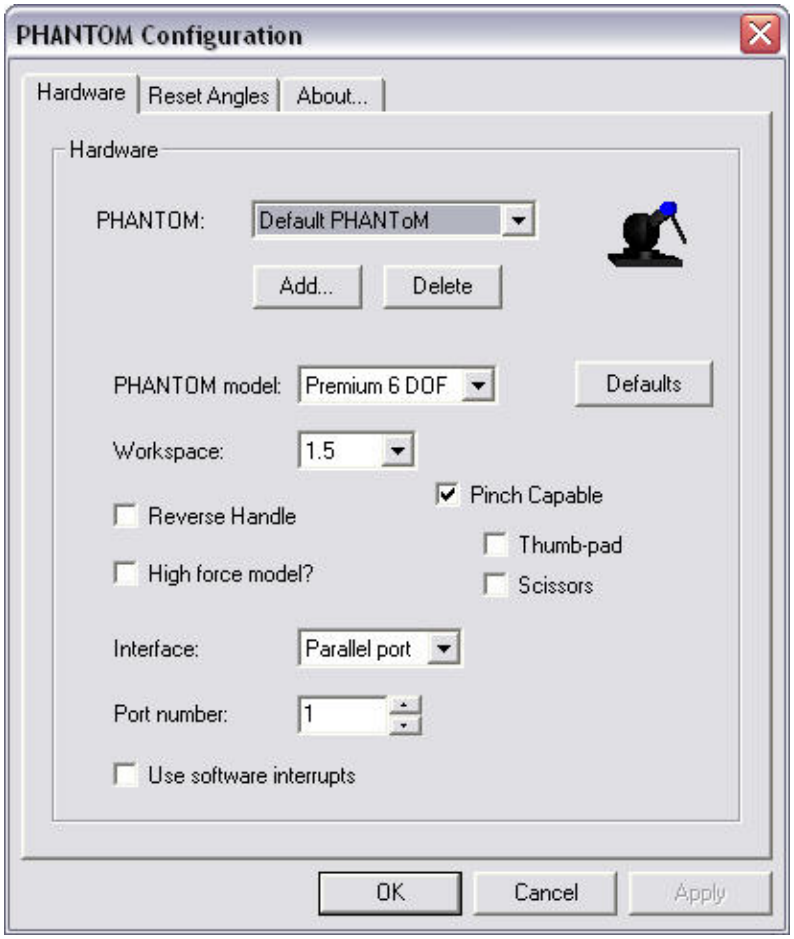

Figure 14: Selecting the Configuration

- **PHANTOM:** Select Default PHANToM from the pull-down list.
- **PHANTOM model:** Select Premium 6 DOF from the pull-down list.
- **Workspace:** Select 3.0 from the pull-down list.
- **Reverse Handle:** Click to select this check box if your device uses a reverse handle.
- **Pinch Capable:** Click to select this check box if your 6 DOF device uses a handle with a pinch-capable adapter. This checkbox must be checked before a Pinch end effector can be used.
  - **Thumb-pad:** Click to select this check box if you will be using the Pinch thumb-pad end effector (see *Appendix A: Working with Pinch End Effectors*).
  - **Scissors:** Click to select this check box if you will be using the Pinch scissors end effector (see *Appendix A: Working with Pinch End Effectors*).

The "**Use software interrupts**" should only be used when using a PCI-based add-in parallel port card. It should be selected only if normal interrupts are not working.

3. After the installation completes you will be prompted to restart the computer**.** You do not need to restart it now, as you will be shutting down your system before you connect your PHANTOM device.

4. If you are planning to install one of the SensAble SDKs you should install it now. For instructions on installing the SDK, see the SDK documentation.

Connecting and Using the PHANTOM Premium 3.0L System

1. Shut down your computer.
2. Connect all cables except the AC Power Cable between the computer, Haptic Arm and The Amp Box (Figure 15).
3. Secure all connectors, where means are provided, to prevent them from falling off.
4. Plug in the AC Power Cable.
5. In the Control Panel, Under Phantom Configuration, select Premium Model 3.0L 6DOF as the device.

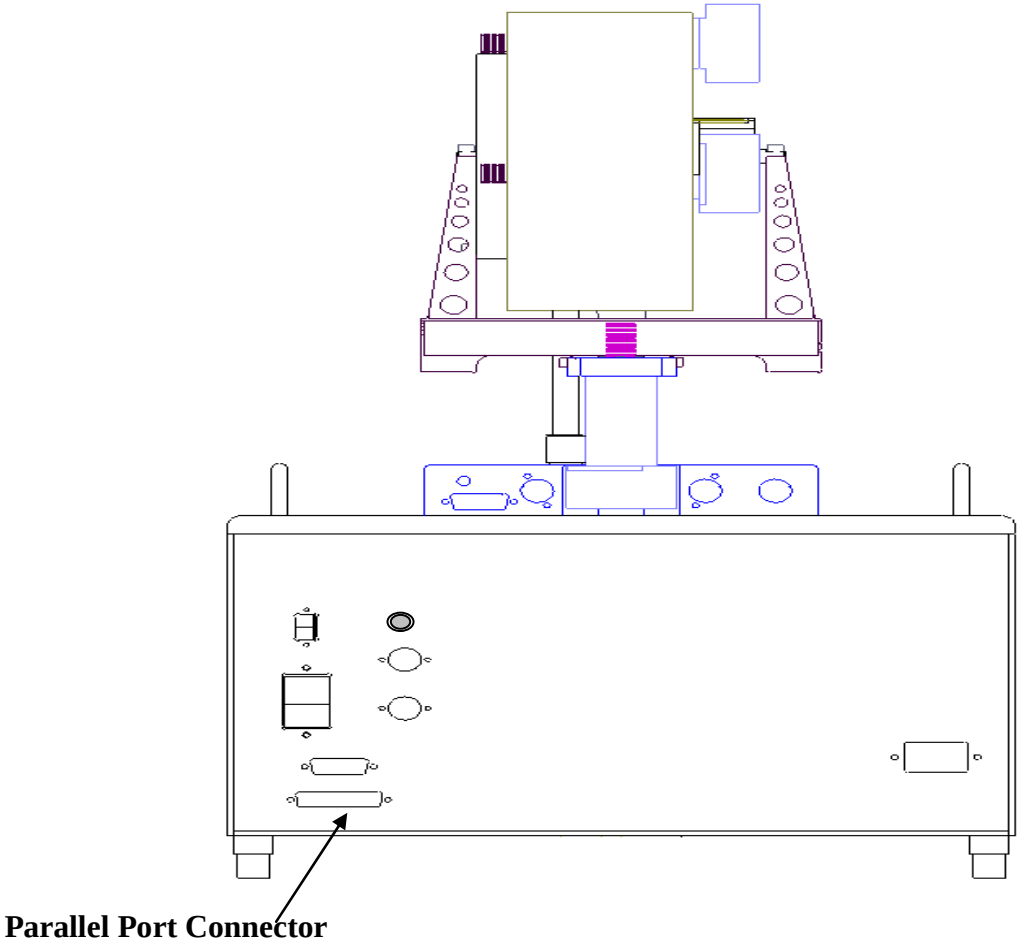

Figure 15:PHANTOM Premium, rear view

Appendix A: 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, or 3.0/6DOF).
- PHANTOM Device Driver (PDD) version 4.2.105 or later.
- OpenHaptics v2.x BETA. Please contact SensAble for this Beta version. **Pinch end effectors will not work with OpenHaptics v2.0.**
- Windows XP (32 or 64-bit)

Specifications

- Range of Motion: 0 to 45 degrees
- Encoder Resolution: <0.1 degrees
- Force Feedback: None

Installing or Removing Pinch 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.

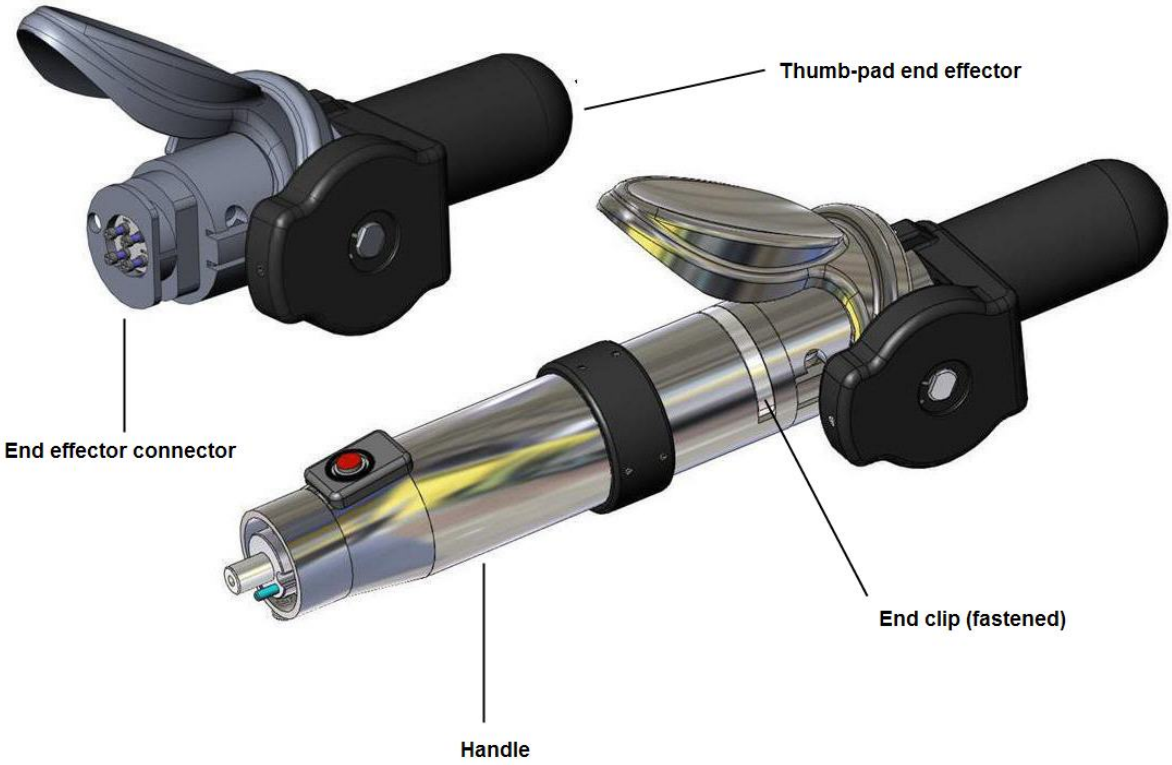

Figure 16: The thumb-pad end effector before and after assembly

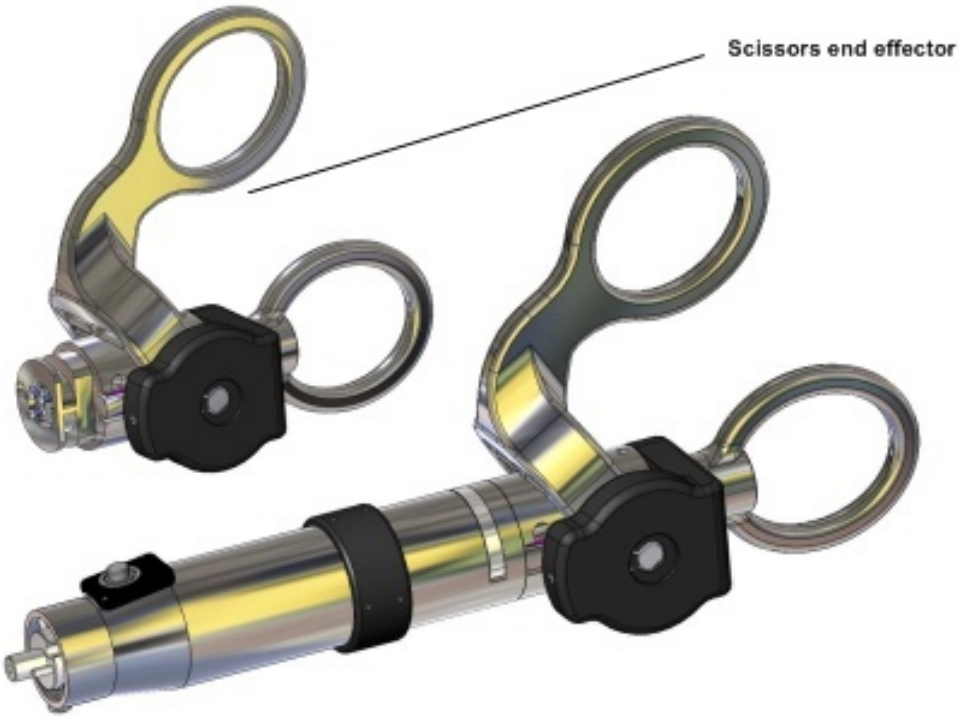

Figure 17: The scissors end effector before and after assembly

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.

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

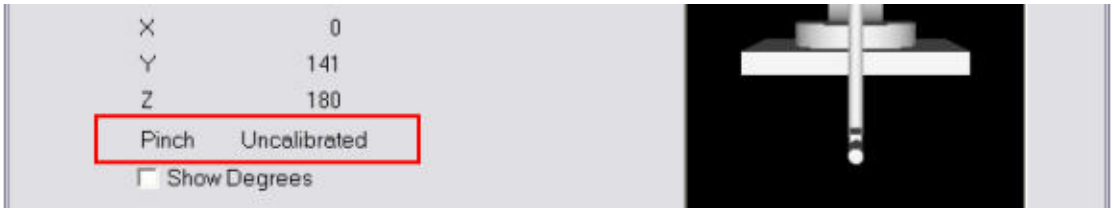

Figure 18: The PHANTOM Test screen when Pinch/Scissor is uncalibrated

4. Close (press) the end effector completely, and press the **Space bar** on the keyboard.
5. Open (release) the end effector completely, and the press the **Space bar** again.
6. 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.

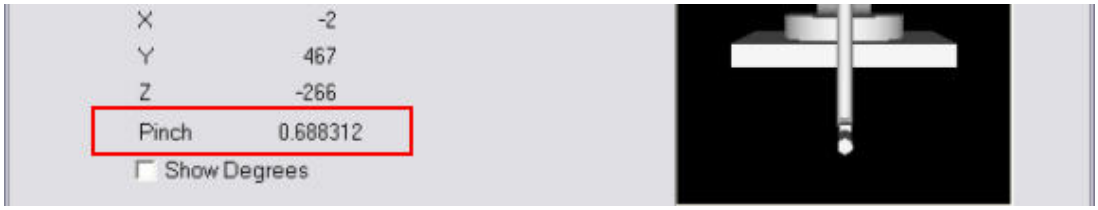

Figure 19: The PHANTOM Test screen when Pinch/Scissor is calibrated

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 B: Device Specifications

Below are the product specifications for the PHANTOM Premium devices. Please note that product specifications are subject to change without notice.

	Premium 1.0	Premium 1.5	Premium 1.5 High Force	Premium 3.0	
Workspace	10 W x 7 H x 5 D inches 254 W x 178 H x 127 D mm	15 W x 10.5 H x 7.5 D inches 381 W x 267 H x 191 D mm		33 W x 23 H x 16 D 838 W x 584 H x 406 D mm	
Footprint	13 W x 10 D inches 330 W x 254 D mm	13 W x 10 D inches 330 W x 254 D mm		Detachable portion	8 W x 8 D inches 203 W x 203 D mm
				Electronics console (AMP box)	15 W x 20 D inches 381 W x 508 D mm
Range of Motion	Hand movement pivoting at wrist	Lower arm movement pivoting at elbow		Full arm movement pivoting at shoulder	
Nominal Position Resolution	860 dpi 0.03 mm	860 dpi 0.03 mm	3784 dpi 0.007mm	> 1000 dpi ~ 0.02 mm	
Backdrive friction	0.15 oz 0.04 N	0.15 oz 0.04 N	0.75 oz 0.2 N	0.75 oz 0.2 N	
Maximum exertable force (nominal position)	1.9 lbf 8.5 N	1.9 lbf 8.5 N	8.4 lbf 37.5 N	4.9 lbf 22 N	
Continuous exertable force (nominal position)	0.3 lbf 1.4 N	0.3 lbf 1.4 N	1.4 lbf 6.2 N	0.7 lbf 3 N	
Stiffness	20 lbf in^{-1} 3.5 N mm^{-1}	20 lbf in^{-1} 3.5 N mm^{-1}		5.7 lbf in^{-1} 1 N mm^{-1}	
Inertia (apparent mass at tip) -without encoder gimbal	< 0.17 lbm < 75 g	< 0.17 lbm < 75 g	< 0.33 lbm < 150 g	< 0.35 lbm < 159 g	

Continued on following page

	Premium 1.0	Premium 1.5	Premium 1.5 High Force	Premium 3.0
Force Feedback	x, y, z	x, y, z		x, y, z
Position Sensing	x, y, z (roll, pitch, yaw optional)	x, y, z (roll, pitch, yaw optional)	x, y, z (roll, pitch, yaw upon special request)	x, y, z (roll, pitch, yaw optional)
Interface	Parallel Port	Parallel Port		Parallel Port
Supported Platforms	Intel-based PCs	Intel-based PCs		Intel-based PCs
GHOST® SDK Compatibility	Yes	Yes	Upon special request	Yes
OpenHaptics™ Toolkit Compatibility	Yes	Yes		Yes