VIPER®

USER MANUAL

FOR MODELS

VIPER 4

VIPER 8

VIPER 16

URM18PH392
May 2020 Rev. A

Medical Device Use

The VIPER™ products are certified to meet the EN60601 conformance standards as noted in the following sections. If VIPER™ products are used in a medical setting it is intended that they are used as medical device *components*. Medical device components are products integrated into other medical devices or medical device systems.

The VIPER™ system does not have a specific indication for use and there are no stand-alone regulatory clearances or approvals for the VIPER™ itself.

As defined by FDA (21 CFR 820.3(c)), a component is any raw material, substance, piece, part, software, firmware, labeling, or assembly that is intended to be included as part of the finished, packaged, and labeled device.

The end user/OEM/VAR/Distributor must determine how the VIPER™ products will be used and comply with all FDA/CE regulations pertaining to the development and sale of finished medical devices and all other regulatory requirements.

FCC Statement

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.

EMC/EMI:

IEC 60601-1-2 Medical Electrical Equipment, Edition 4.0

Immunity Requirements:

EN61000-4-2:2009	Electrostatic Discharge
EN61000-4-3:2005/A1:2008/A2:2010	Radiated Immunity
EN61000-4-4:2004/A1:2010	EFT/Burst Power Leads
EN61004-5:2006	Surge Immunity
EN61000-4-6:2009	Conducted Immunity, Power Leads
EN61000-4-8:2010	Power Frequency Magnetic Fields
EN61000-4-11: 2004	Voltage Dips and Interrupts

Note: The conducted emission herein only applies if a Polhemus-supplied power supply is used with the VIPER™ unit.

Electrical Safety Approvals

IEC 60601-1 Medical Electrical Equipment, Edition 3.1

Classifications

Electric Shock Protection	Class I - protectively earthed with power from supply mains
Shock Protection Degree	Sensors and TX-1 Source = BF / TX2 and TX4 Sources = B
Ingress Protection	Sensors and TX-1 Source = IP67 TX2 and TX4 Sources = IPX0 (see Section 7)
Sterilization	Sensors and TX1 = ethylene oxide gas
Flammability	Not intended for use in a flammable or oxygen rich atmosphere
Mode of Operation	Continuous

How To Use This Manual

This user manual serves as a reference guide for the setup and operation of the Polhemus VIPER™ tracker.

To quickly set up and run a new VIPER™ system, refer to **Section 3. GETTING STARTED**. This section offers a step-by-step approach to guide you in installing, configuring and running your device in a simplified scenario of one Source and one Sensor.

The manual is divided into several parts:

Section 1. VIPER™ SYSTEM OVERVIEW provides detailed descriptions and physical information about the hardware and software components and accessories that make up the VIPER™ system.

Section 2. OPERATION provides general description of how the tracker can be deployed and some advice on physical installation.

Section 3. GETTING STARTED is a detailed step-by-step guide to installation, setup and simple operation of a minimal system. This section is designed to familiarize you with the basic process of setting up a system without delving into details of larger or more complex installations.

Section 4. VIPER™ COMMAND INTERFACE lists the different commands for controlling VIPER™ and describes their functions.

Section 5. PRECAUTIONS Outlines precautions to observe when using VIPER™.

Section 6. BIT ERRORS provides a list of the system errors and their meanings.

Section 7. EXPLANATION OF SYMBOLS provides an explanation of symbols used in this manual.

Appendix A. Terms & Acronyms is a good resource for terms used commonly throughout the manual. Follow red definition hyperlinks placed in each section to read the term definition in Appendix A. If reading with a PDF reader: After following a definition link, hold down the Alt key plus the left arrow on your keyboard to return to your place in the manual.

Throughout the manual, look for the following symbols for background information, helpful tips and cautionary notes:


More Information.


Helpful tip.


Caution, Warning, or Safety Note.

SAFETY NOTICES

This apparatus has been designed and tested in accordance with EN60601-1, 3rd edition.

- **Before powering up the instrument, be aware that the main plug shall only be inserted in a socket outlet provided with a protective ground contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.**
- **The VIPER™ sensors and sensor ports use standard USB-C style connectors. These ports are NOT a USB connection. Only plug a VIPER™ sensor/stylus into these sensor ports.**
- **When connecting a host device to the VIPER™ USB or RS-422 output port, ensure that the host device is compliant to the relevant safety standard for that device (EN60950/EN61010).**
- **Only connect a Polhemus magnetic source into the source ports.**
- **Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.**
- **Only use the sync port with a Polhemus provided sync cable and in accordance with the instructions in this manual.**
- **Do not connect two magnetic sources of the same frequency. The SEU will cease operation.**
- **Be sure to read and understand the concept of Hemisphere of Operation in this manual and operate the product using the correct Hemisphere of Operation setting.**
- **Be sure to read and understand the setup and operation of this product to ensure accurate measurements.**
- **Read the Precautions section of this manual.**

WARNINGS

- This instrument contains no user serviceable parts. Do not attempt to service the unit. Return it to Polhemus for repair.
- Do not perform any unauthorized modification to the instrument.
- Do not use the instrument in a manner not specified by the manufacturer.
- Only use the DC power supply provided by Polhemus: part number 1C0614.
- Ensure the VIPER™ power supply or power cord to the power supply is accessible so mains power can be removed quickly.

CONTRAINDICATIONS

There are no contraindications with the VIPER™ system as provided by Polhemus. The final medical product that the VIPER™ system is incorporated into needs to be evaluated for contraindications.

CLEANING

The only required maintenance is cleaning the System Electronics Unit (SEU), Sources, Sensors and Cables. If the instrument requires cleaning:

1. Remove power from the SEU.
2. Clean the external surfaces of the SEU, Cables and external shells of the Sources and Sensors with a soft cloth dampened with a mixture of mild detergent and water.

Make sure that the SEU is completely dry before reconnecting it to a power source.

STERILIZATION

No component of VIPER™ is provided sterilized. Only the sensors and TX1 Source can be sterilized and only with ETO Gas. There is no known limit on the number of cycles.

STORAGE AND TRANSPORT

Temperature	-10C to +50C
Relative Humidity	10% to 90% non-condensing
Atmospheric Pressure	50kPa to 106kPa

DISPOSAL

VIPER™ components are considered electronic waste and should be disposed of in accordance with local ordinances.

SPECIFICATION

Update Rate (per Sensor, simultaneous samples)

VIPER™ 4 - 240Hz, VIPER™ 8 and VIPER™ up to 960Hz. (30, 60, 120, 240, 480 or 960Hz).

Latency

960Hz – 1 millisecond. 480Hz – 2 milliseconds. 240Hz – 3.5 milliseconds.

Number of Sensor Inputs

VIPER™ 4: 1 to 4; VIPER™ 8: 1 to 8; VIPER™ 16: 1 to 16.

Number of Source Inputs

VIPER™ 4: 1; VIPER™ 8: 2; VIPER™ 16: 4.

I/O Ports

USB 2.0; RS422 tested to 921,600. (Possible to program baud rate to 7,372,800).

Static Accuracy

0.015 in. RMS for X, Y or Z position; 0.10° RMS for Sensor orientation (magnetically clean environment, FTT® turned off).

Resolution

0.00004 in. (0.0010 mm) at 12 in. (30 cm) range; 0.0003° orientation.

Range

30 in. (76 cm) radius from Source at above specifications with TX2. Useful operation in excess of 72 in. (182 cm) in radius with one Source. Using multiple Sources extends tracking range further.

Multiple Systems

Provisions available to operate multiple systems in same environment.

Angular Coverage

All-attitude.

Data Format

IEEE 754 binary.

External Sync

Configurable port for either input or output. (See Section 2.3.)

Physical Characteristics

See Appendix C.

Power Requirements

5 Volt 8 amps max; 100-240VAC and 50-60Hz.

Operating Temperature

10°C-40°C at a relative humidity of 10% to 90% non-condensing.

Operating Environment

SEU/TX2/TX4: Rated IPX0. Not protected against the ingress of water or dust. Operate, store and transport in a dry environment.

TX1/Sensors: Rated IP67. May be submerged in freshwater up to 1 meter for up to 30 minutes. Dust-tight.

Atmospheric Pressure 50kPa to 106kPa.

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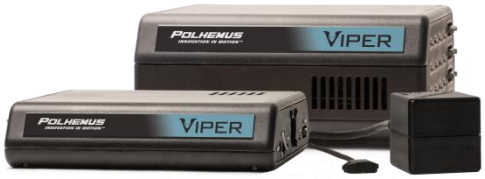
1. VIPER™ SYSTEM OVERVIEW

Congratulations on your purchase of VIPER™, the latest generation of Polhemus Tracking Systems. The VIPER™ design has several new innovations. These innovations include FTT® (Fly True Technology) – a new technology that adds real-time eddy current distortion mitigation, up to four magnetic sources in a single System Electronics Unit (SEU), and faster update rates as high as 960Hz.

VIPER™ is available in three different models: VIPER™ 4, VIPER™ 8, and VIPER™ 16.



1.1 INTRODUCTION

The Polhemus VIPER™ is an electromagnetic tracking system based on a scalable architecture that supports up to 16 Sensors and 4 Sources in a single chassis.

The flexible VIPER™ design offers unprecedented versatility and scalability for the Polhemus motion tracking user.

1.1.1 HOW VIPER™ MOTION TRACKING WORKS

An electromagnetic (EM) field is emitted from one or more Sources. Sensors detect the emitted field(s) and the System Electronics Unit (SEU) calculates Position and Orientation (P&O) of each of the Sensors. The P&O data is streamed from the SEU via USB or RS-422 to a connected host computer.

On a Windows® host PC the VIPER™ Command Manager app (VPcmdMgr) may be used to visualize the motion of the Sensors. Open-source programming libraries and sample programs are available for developing custom applications that use the Sensor P&O data on Windows® or other computer operating system platforms.

The VIPER™ system operation is configured and controlled by an open source command interface. VIPER™ commands are applied to the system via the VPcmdMgr or via custom end-user software. The VIPER™ command set is explained in detail in Section 4. of this user manual. VPcmdMgr users and software developers will find explanations of the available commands in online help and useful tips and information displayed on the VPcmdMgr display.

VIPER™ system hardware components are precisely calibrated at the factory using NIST (National Institute of Standards and Technology) traceable fixturing. Recalibration of the system is never required.

1.2 VIPER™ SYSTEM COMPONENTS

The VIPER™ System consists of a System Electronic Unit (SEU), one to sixteen Sensors and one to four electromagnetic (EM) Sources. Communication with the system is via USB 2.0 or RS-422. The system only requires 5 volt power. Host computer apps, programming libraries, and documentation are installed via web download or thumb drive.

1.2.1 VIPER™ SEU

The VIPER™ SEU comes in three variations:

- The **VIPER™ 4** system supports one EM Source and up to four Sensors.
- The **VIPER™ 8** system supports up to two EM Sources and up to eight Sensors.
- The **VIPER™ 16** system supports up to four EM Sources and up to sixteen Sensors.

FIGURE 1. VIPER™ SEU FRONT VIEW: VIPER™ 4, VIPER™ 8, VIPER™ 16

FIGURE 2. VIPER™ SEU REAR VIEW: VIPER™ 4/8, VIPER™ 16

Figure 3 below identifies controls and ports on a VIPER™ 8 chassis.

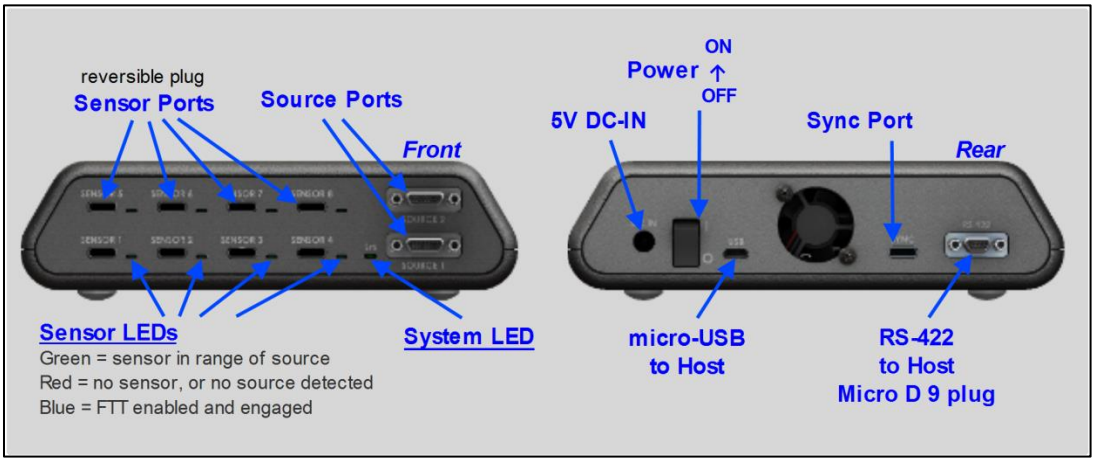


FIGURE 3. VIPER™ 8 SEU PANEL LEGEND

Figure 4 below details approximate VIPER™ SEU dimensions. Note that all SEUs have the same footprint. Rubber feet add approximately 0.2 inches (0.51 cm) to the height.

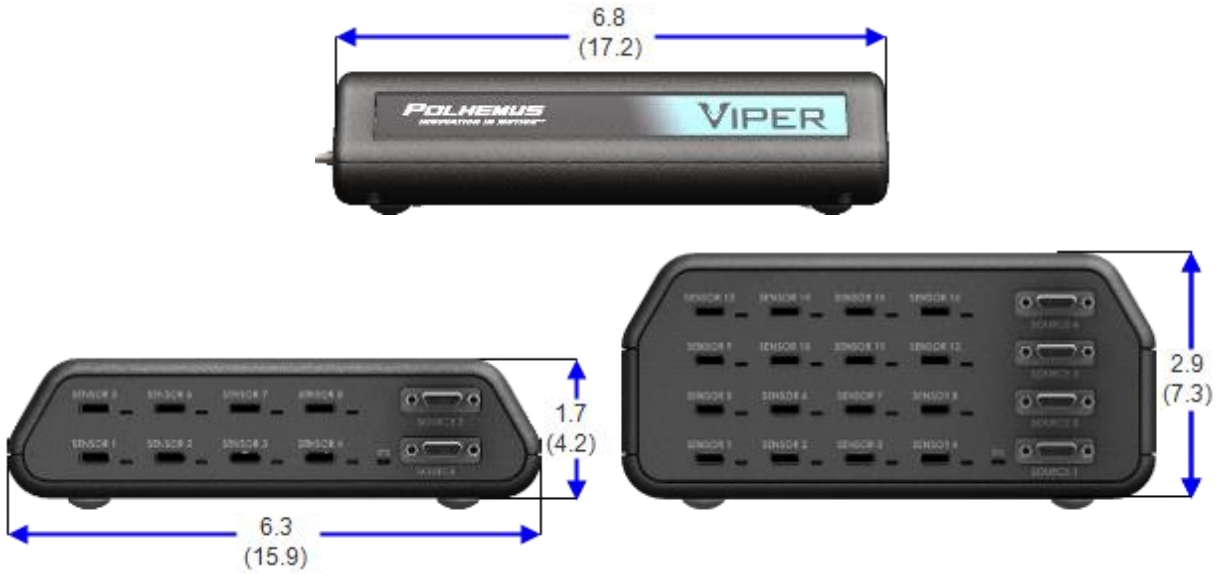


FIGURE 4. VIPER™ SEU DIMENSIONS (APPROXIMATE), INCHES (CM)

1.2.1.1 LED PATTERNS

Startup sequence:

1. All SEU LEDs turn red for approximately 2 seconds, and then flash green once.
2. Each sensor board will flash a blue LED pattern corresponding to detected Source frequency:
    a. Sensor Ports 1, 2, 3, or 4 will flash blue:
        - ONCE for corresponding Source frequency 1-4.
          For example, Source Frequency 1 will cause sensor port 1 LED to flash blue ONCE during startup sequence, Source Frequency 2 will cause port 2 to flash blue ONCE, etc.
        - TWICE for Source frequencies 5-8, and so on.
          For example, Source Frequency 5 will cause sensor port 1 LED to flash blue TWICE during startup sequence, Source Frequency 6 will cause port 2 to flash blue TWICE, etc.

    b. All four LEDs on the board will flash red if no source is detected.
3. Sequentially, each sensor port LED will flash once:
    - Green if a sensor is detected, or
    - Red if no sensor is detected.
4. All LEDs turn OFF (dark) as the boot process completes.

Runtime Sensor port LEDs:

Green:	Sensor Active
Red:	Sensor Inactive or out of range.
Blue:	Sensor FTT® is engaged. (Requires FTT® mode to be enabled. See Section 2.1.)
Alternating Green/Blue:	Sensor FTT® is on but not engaged until sensor is "*Homed*." (See Section 2.1.)
Sensor board LEDs blink red:	Duplicate source frequencies detected on blinking sensor boards; tracker cannot start.

1.2.2 SENSOR

Position and Orientation (P&O) is calculated at the EM center of the Sensor device, relative to a Cartesian origin location in the motion tracking area. By default, this reference location is at the EM center of a VIPER™ Source, so all calculated Sensor P&O is relative to that Source. Alternatively, the reference location may be defined by the user, selected for the specific needs of the application. Refer to Sections 3.5 "Configuring VIPER™ multi-source modes of operation" and 4.2.14 "SOURCE CONFIGURATIONS AND MODES OF OPERATION" for details about this.

The VIPER™ Sensor is available in multiple styles, including:

- **FT-Standard**: with mounting holes
- **FT-Flatsided**: without mounting holes
- **FT-Clip**: with tapered edges that fit into a mounting clip

The Sensors connect easily to the SEU via reversible plugs so the orientation of the connector does not matter when plugging in.

See Appendix C for Sensor dimensions.

FIGURE 5. VIPER™ SENSORS. FROM TOP: FT-STANDARD, FT-FLATSIDED, AND FT-CLIP (WITH CLIP SHOWN)

1.2.3 STYLUS

The Stylus is a pen-shaped device that is tracked positionally in three dimensions as well as angularly. A push button switch is integrated to give the user control of the data output. Stylus position measurements are calculated at the tip of the Stylus, using precise factory calibration. The tip is removable/replaceable and available with a sharp point (standard) tip or a rounded tip. The Stylus is available in two sizes: 3 inches long (FT3-Stylus) and 8 inches long (FT8-Stylus).

FIGURE 6. VIPER™ FT3-STYLUS AND FT8-STYLUS

1.2.4 SOURCE

The VIPER™ Source emits the electromagnetic field (EM field) necessary to track the P&O of Sensors within range. The three-dimensional space in which the EM field is detectable by the Sensors is known as the *motion tracking area*. Multiple Sources may be used to define and expand this area. When more than one Source is used, each Source must operate at a different frequency so that it can be distinguished from the others by the Sensors. (Source frequency is not a configurable feature; Sources are manufactured to operate at specific frequencies and may be purchased accordingly.)

In a standard installation, the Source is usually the reference for Sensor P&O measurements. The Source is powered by the SEU and is connected at the dedicated Source connection port(s). Up to four sources can be used in a single VIPER™ system.

The Source is usually mounted in a fixed position to a non-metallic surface or stand located in close proximity to the Sensors.

VIPER™ Sources are available in a variety of form factors and EM frequencies. The standard TX2 Source is a 2-inch cube. Other sizes available include TX4 (a 4-inch cube) and several smaller sizes, including the HR-Source. The larger sized Sources emit a stronger field that can be detected from farther away by the standard Sensors. The smaller sized Sources have a proportionally weaker field and are useful where close proximity and smaller form factor are needed. Specifications in this manual are based on the standard 2-inch Source.

See Appendix C for approximate Source dimensions.

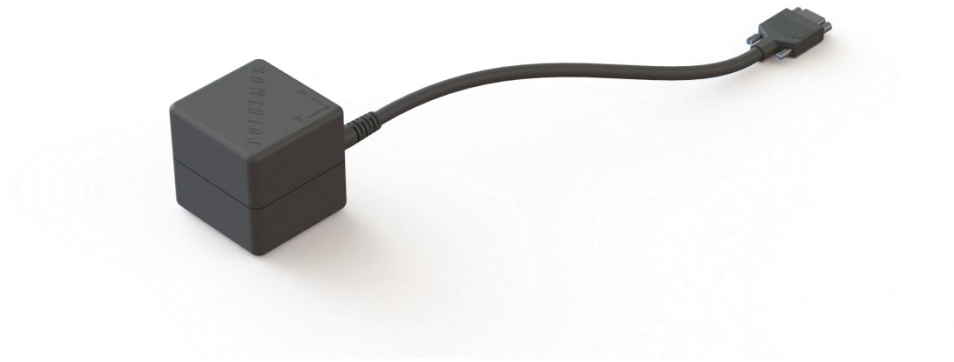


FIGURE 7. VIPER™ TX2 SOURCE

2. OPERATION

With the ability to drive multiple Sources and sixteen Sensors, VIPER™ can be operated in many configurations. Modes of operation can be configured on a per-Sensor basis. Typical modes of operation are described below.

Standard Single-Source operation: A single Source is used. All Sensor position and orientation (P&O) is referenced to that one Source. On a VIPER™ 8 or VIPER™ 16 system, the one Source must be connected to Source port 1. This is the traditional way that most legacy Polhemus trackers operate.

Standard Multi-Source modes of operation: Two, three, or four Sources of differing frequencies are used on a VIPER™ 8 or VIPER™ 16 system. Each Sensor P&O is referenced to the nearest connected Source. In this mode, one VIPER™ system can effectively behave as the equivalent of up to four individual and independent conventional tracking systems. This is a new and unique capability of VIPER™ over earlier tracking systems. These modes of operation are discussed in detail in Section 3.5.

Expanded Multi-Source operation: Multiple Sources are configured together to define an expanded tracking area. By default, each Sensor operates with all Sources. If desired, each Sensor may be configured to operate with any combination of Sources.

VIPER™ Sensor and Source configuration commands allow the user to configure and modify these basic modes of operation. These commands and modes of operation are discussed in detail in Sections 3.5 and 4.2.13 below.

2.1 FTT® MODE

FTT® (Fly True Technology) is a revolutionary real-time magnetic distortion mitigation method exclusive to Polhemus. The benefits are most noticeable in a tracking environment with electromagnetic distorting conditions, namely the presence of certain conductive metals that support magnetic eddy currents. These conditions, when in proximity to the Sensor or Source can cause errors in the position and orientation outputs from the VIPER™ tracking system until removed.

HOW IT WORKS:

FTT® Mode is an iterative filter that uses measured magnetic fields emitted from the VIPER™ Source, known environmental conditions, and electromagnetic hemispheric frequencies detected by the FT Sensor to recognize the negative influence of magnetic distortion and apply a real-time filtered correction. The resulting tracking performance can be stunningly good in environmental conditions that might otherwise limit the utility of the tracker (examples include tracking near large metal objects like desks, filing cabinets, steel walls, and rebar concrete floors).

To use FTT®, the VIPER™ tracker must have FTT® Mode enabled and the FT Sensor in a "*Home*" location near a Source. When FTT® is enabled in this way, the LED light for the FT Sensor port in use on the VIPER™ SEU (System Electronics Unit) will be green in color. The LED will blink in a green and blue pattern until "*Homing*" has occurred.

As the FT Sensor is moved away from the Source or a distortion-inducing object is brought close to the FT Sensor or Source, FTT® will engage and the LED light for the FT Sensor port in use will turn blue. FTT® is now actively working to sense the electromagnetic distortion and apply a correction filter in real-time to the Position and Orientation tracking output. FTT® corrects for both position and orientation data output.

FTT® should start with the Sensor in "Home" location and with the FT-Sensor's SEU Sensor port in a **GREEN** LED state. The Sensor port LED will alternate **GREEN** and **BLUE** until Sensor is "Homed" this way.

At introduction, VIPER™ FTT® has two modes of operation: **Stationary Source Mode** for conventional tracking applications where VIPER™ Sources are mounted in a fixed position and **Moving Source Mode** where VIPER™ Sources may be used in innovative dynamic and diverse scenarios. Be sure to understand the difference between the modes and select the best one for your tracking applications. Refer to Section 4.2.12 FTT MODE command for details about the available FTT® modes.

Both FTT® modes will "carry" the high-quality tracking performance of the VIPER™ tracker in difficult conditions for a period of time but due to the iterative nature of the filter, it is necessary to periodically return the FT Sensor to *Home* in order to effectively reset the tracker's measurement quality factors.

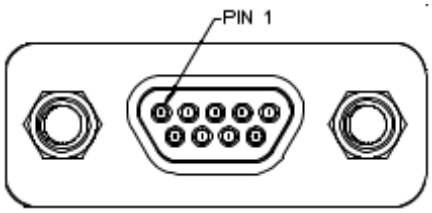
FTT® is a real-time distortion mitigation correction.
Due to the iterative nature of this feature, FTT® can cause tracking output to be less precise in magnetically benign tracking environments than without it.
FTT® is a solution to a problem, but **if no problem is present, it may be best not to engage** at all so that tracking solution variables are minimized. Users may decide to leave FTT® Mode OFF in many situations depending upon tracking quality needs.

2.2 I/O CONSIDERATIONS

VIPER™ has two communication I/O ports: USB and RS-422. The USB port uses a micro USB connector. The RS-422 port uses a Micro D 9-pin plug connector (male, Molex part number 836119006). The pinout is shown in Figure 8 below.

Either I/O port can be used for command input and data output. When the VIPER™ is powered ON, either port will respond to commands when used as a single output port.

VIPER™ also supports a *dual-output mode* where the tracker data stream is output to *both ports*. In this mode, it is recommended that the USB port be used for command input (as well as data output) and the RS-422 port be monitored only for output data.



1	TX+	**6**	TX-
2		**7**	Reset
3		**8**	
4	RX+	**9**	RX-
5	GND		

Micro D 9-pin Plug, Molex part 83611-9006

FIGURE 8. PINOUT VIPER™ RS-422 MALE CONNECTOR

2.3 EXTERNAL SYNC

The VIPER™ External Sync port accepts a standard USB Type C connector. Pins A7 and B7 are the active sync pins as illustrated in Figure 9 below.

Functionally, VIPER™ External Sync hardware can operate in two modes. These modes are configured using the SYNC MODE command, detailed in Section 4.2.3.

Internal Sync Mode: A 3.3V sync pulse is output simultaneously with each P&O frame output. The pulse has duration of 10µs and occurs at the beginning of the data collection cycle. This is the default mode.

External Sync Mode: When the external device applies a ground pulse (minimum duration of 10µs), P&O computation is initiated using sensor data immediately preceding the ground pulse.

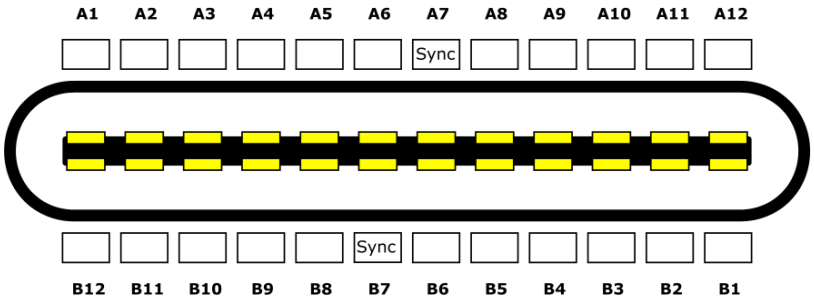


FIGURE 9. VIPER™ EXTERNAL SYNC PINOUT

2.4 SOFT RESET

Pin 7 on the RS-422 connector port can be used to soft-reset the SEU. Apply GND to this pin for duration of 10ms to force a soft reset.

3. GETTING STARTED

3.1 SETTING UP VIPER™ HARDWARE FOR THE FIRST TIME

When setting up VIPER™ for the first time, it is highly recommended that you start by experimenting with one Source and a couple of Sensors in a standard configuration before moving on to more complex installations with multiple Sensors and Sources.

3.1.1 MAKE CONNECTIONS

Refer to the figure below for connecting your VIPER™ components together.

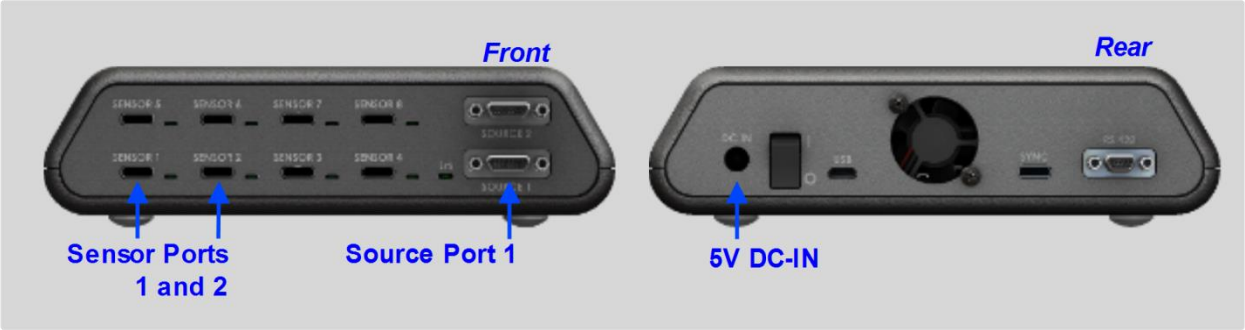


FIGURE 10. GETTING STARTED: CONNECTIONS

1. Place the SEU near the host computer.
2. Attach one or two Sensors in Sensor ports 1 and 2.
3. Attach a Source to Source port 1.
4. Connect the VIPER™ power supply to the 5V DC IN port on the rear panel.

3.1.2 PLACE SOURCE AND SENSOR(S)

When placing Source and Sensors for the first time (when VIPER™ is configured with factory default settings), it is important to place the Sensors on the +X side of the source. This places the Sensor in the **+X hemisphere** of the Source. The +X and +Y axes are identified on the surface of the standard Source cube to help you identify where the +X side of the Source is. This is illustrated in Figure 11 below.

> If your sensor is not in the default +X hemisphere, use the HEMISPHERE command (Section 4.2.9) to tell VIPER™ which hemisphere the Sensor inhabits or to turn on Auto-Hemisphere.

See Appendix B SOURCE HEMISPHERES for a detailed discussion of the concept of hemispheres.

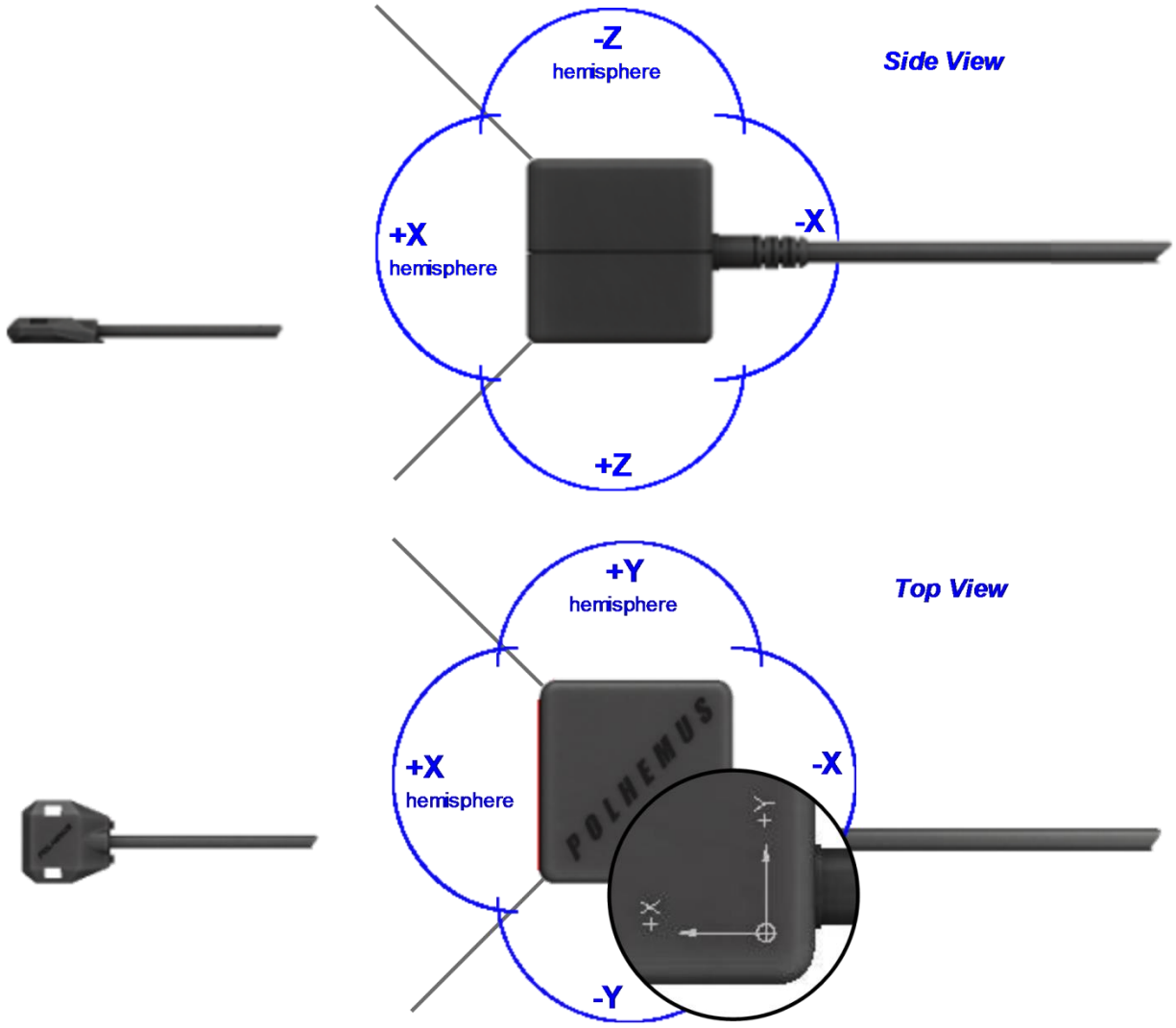


FIGURE 11. SENSOR PLACED IN +X HEMISPHERE

3.2 INSTALL HOST SOFTWARE (WINDOWS®)

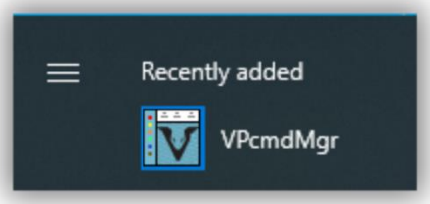
VIPER™ Host Software is provided on a USB thumb drive or is downloaded from the Polhemus website. Run **VIPER_Installer.exe** to install all of the necessary drivers and software. Review **VIPER_RELEASE_NOTES.htm** for information about what is contained in the Host Software distribution.

> To access non-Windows® and developer content, follow instructions displayed in the VIPER™ Host Software Release Notes.

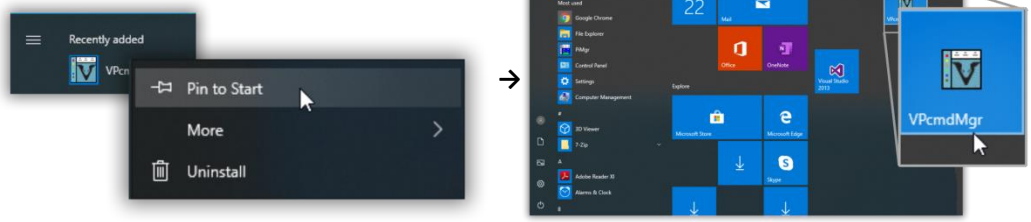
3.3 RUN VIPER™ COMMAND MANAGER

Start the VIPER™ Command Manager (VPcmdMgr) application by clicking the icon that was installed with the Host Software.

On Windows® 10, this icon will appear in the Start Menu under "***Recently Added***:"

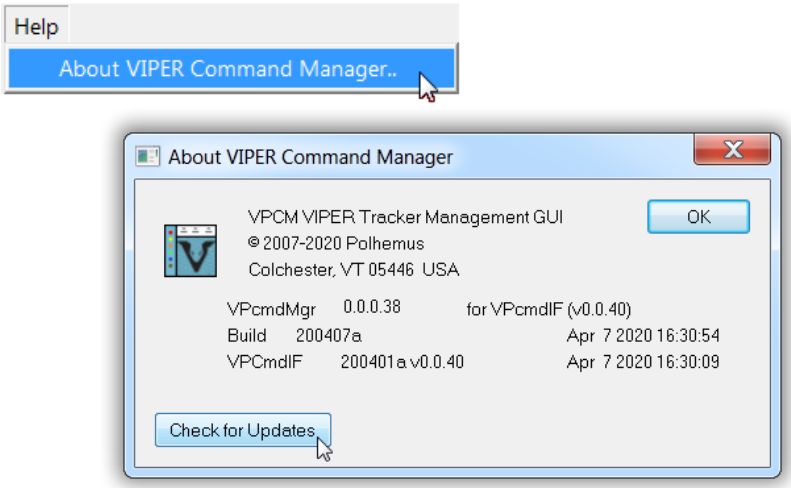


For easy access to the VPcmdMgr icon directly under the Windows® 10 Start Menu, right-click and select **Pin to Start**.



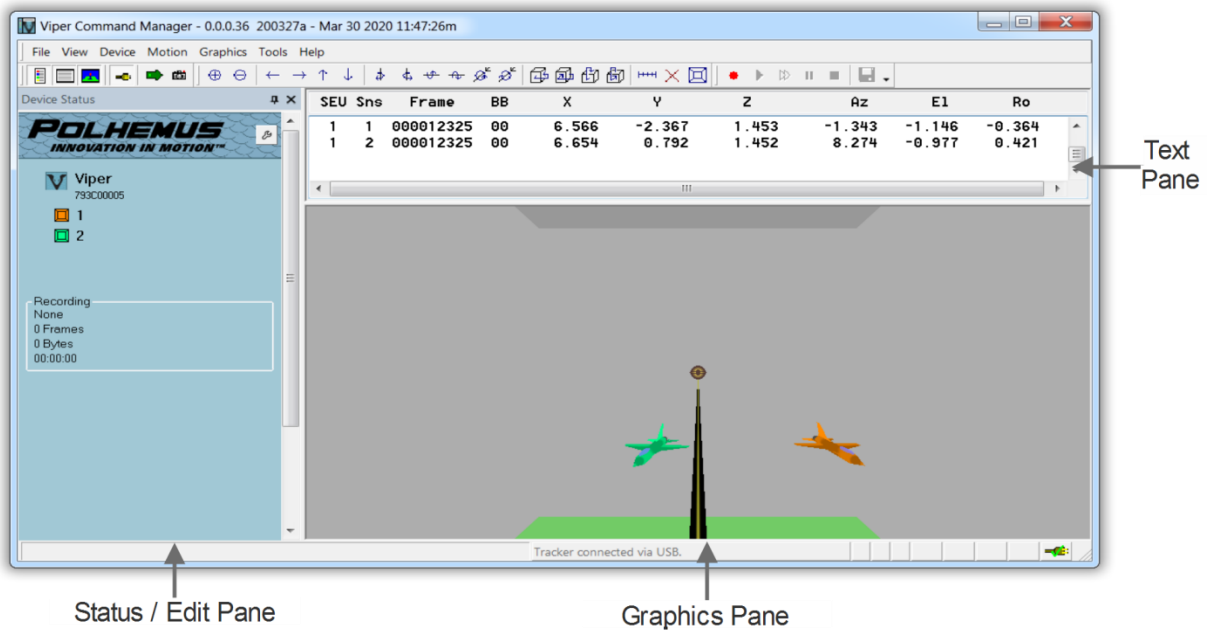
3.3.1 UPDATE VIPER™ COMMAND MANAGER

After installing VIPER™ Command Manager for the first time, check for available updates to the program.



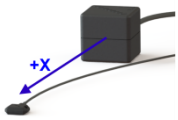
3.4 VIPER™ COMMAND MANAGER USER INTERFACE OVERVIEW

On startup, the VIPER™ Command Manager app (VPcmdMgr) connects automatically to VIPER™ and collects a single frame of P&O data.

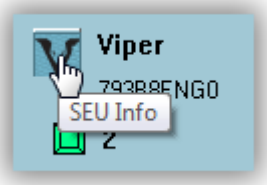


On the Status Pane at the left, icons for the VIPER™ SEU and connected Sensors and/or Stylus' are displayed. Different colored Sensor/Stylus icons correspond to animated avatars in the Graphics Pane to the right.

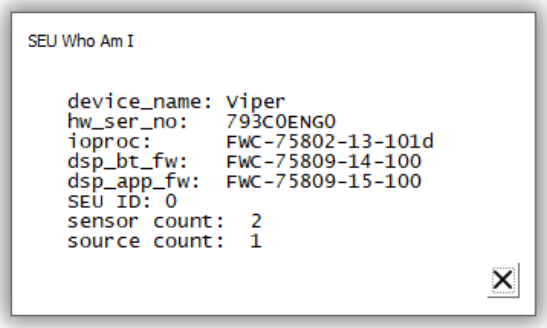
In the Graphics pane, the sensor avatars are displayed with +X pointing out of the screen toward the viewer's eye. This corresponds to looking at the sensor(s) and source from the direction of the +X axis.



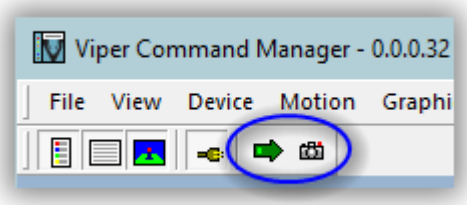
When the mouse pointer is hovered over active controls in the app, the mouse pointer will change and a descriptive tool tip will appear. Use this feature to discover active controls in VPcmdMgr:



For example, to view "Who Am I" information about the VIPER™ device, click on the VIPER® icon in the Status Pane.



3.4.1 DISPLAYING VIPER™ P&O DATA

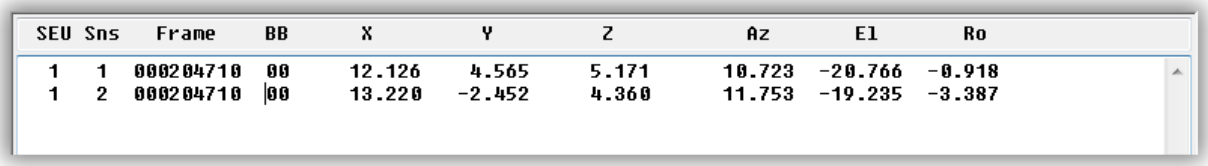


To collect and display a single frame of data, click on in the toolbar or type **p**.

To collect and display continuous streaming data, click on in the toolbar or type **c**.

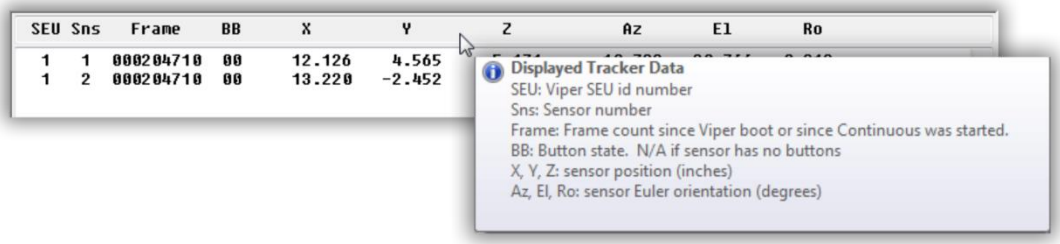
P&O data is displayed in text format in the Text Pane and graphically by animated avatars in the Graphics Pane.

By default, VIPER™ outputs SEU number and Sensor number, Frame Number, Position in inches and Orientation in Euler Degrees.

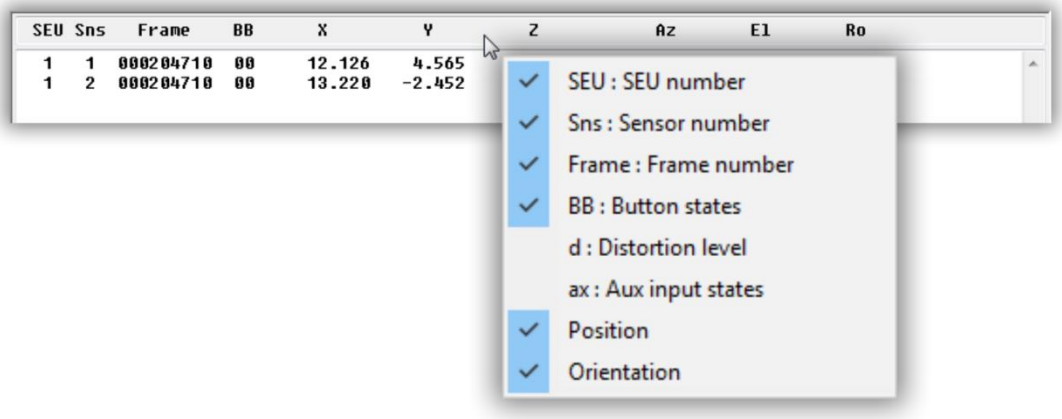


SEU	Sns	Frame	BB	X	Y	Z	Az	El	Ro
1	1	000204710	00	12.126	4.565	5.171	10.723	-20.766	-0.918
1	2	000204710	00	13.220	-2.452	4.360	11.753	-19.235	-3.387

Hover the mouse pointer over the title bar in the text pane to see what data is currently displayed.



Right-click the mouse over the title bar in the text pane to select data to be displayed.



3.4.2 CONFIGURING VIPER™

To configure VIPER™ settings, click on the icon in the Status Pane.

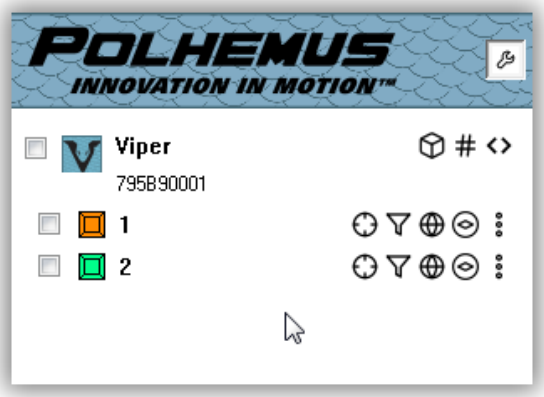
The Status Pane changes color and enters Edit Mode.

3.4.2.1 COMMONLY USED SETTINGS

In Edit Mode, the Status Pane displays checkboxes next to the VIPER™ SEU icon and next to icons for each connected Sensor. A series of control icons for configuring VIPER™ are displayed next to these.

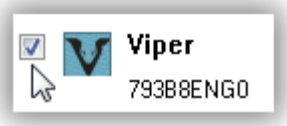
The most commonly used settings are accessible directly from these controls. Hover the mouse pointer over these controls to discover which settings are available here.

The controls are defined below.



SEU-Level Settings:

SEU settings apply to the selected SEU in the Edit-mode Status Pane.



Sensor Level Settings:

When applied, Sensor-level settings will be applied to all selected Sensors in the Edit-Mode Status Pane.

If the SEU is checked, Sensor-level settings are applied to all sensor ports: all sensors on the SEU, connected or not.

Source Rotation

Units of Measure

All SEU Settings (Advanced; See Section 3.4.2.2 “Advanced settings” below.)

Sensor Boresight. Right-click to RESET.

Sensor Filter Settings

Sensor Hemisphere

Sensor FTT® Mode

All Sensor Settings (Advanced; See Section 3.4.2.2 “Advanced settings” below.)

3.4.2.2 ADVANCED SETTINGS

The Advanced Settings controls provide access to all available VIPER™ settings in a single "block" display. Each time the Advanced Settings control is clicked, the tracker is queried to display all of the current settings.

Hover the mouse pointer over buttons in the toolbar at the top of the panel to identify the function of each button, also described in the table below:

	**Refresh from device**. Re-queries VIPER™ for current settings; overwrites any un-applied changes displayed in the panel.
	**Apply changes**. Sends commands to VIPER™ to change settings. This button is disabled until a change has been made in the settings below.
	**Reset**. Sends RESET commands to VIPER™ to restore all displayed settings to factory defaults. The panel is refreshed to display the factory defaults.

Inside the Block Config panels, click on the listed properties to display information about each setting and default values in the bottom portion of the display as illustrated in Figure 12 below.

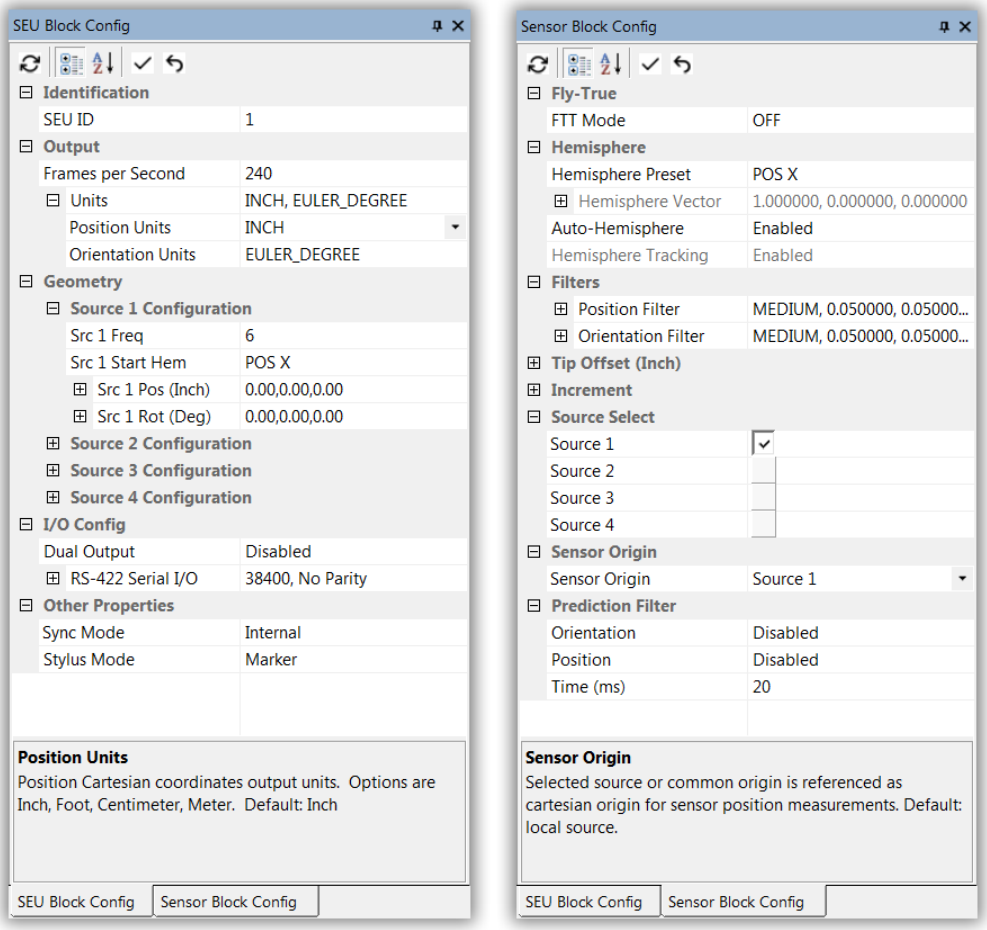


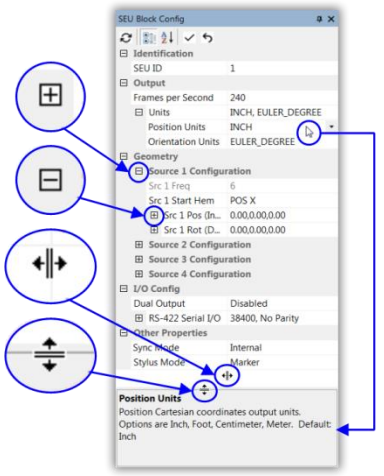
FIGURE 12. SEU AND SENSOR BLOCK CONFIGURATION PANELS

The Block Configuration Panels have several controls to manipulate the display.

1. Click in any field to see reference information about the VIPER™ setting it controls in the description pane at the bottom.

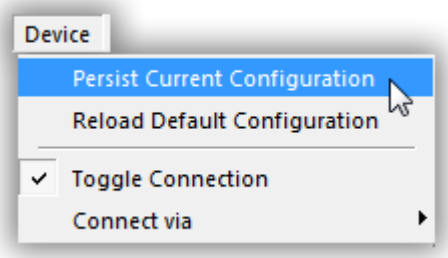
2. Click on the + and – buttons to expand and collapse groups of settings.

3. Columns and rows are resizable vertically and horizontally. Click on boundaries between panes to activate resizing handles.



3.4.2.3 PERSISTENCE

With few exceptions, the settings accessed through the Advanced Block Config panels are *persistent* settings.



This means that these settings can be stored in VIPER™ flash memory. Stored persistent settings are activated each time VIPER™ is powered ON. To store the currently active settings to flash, select **Device Menu→Persist Current Configuration**.

To revert to factory default configuration, select **Reload Default Configuration**. Then, to restore factory settings to flash memory, select **Persist Current Configuration** again.

3.4.3 KEYBOARD SHORTCUTS

VIPER™ Command Manager keyboard shortcuts are not case-sensitive.

TABLE A. VIPER™ COMMAND MANAGER KEYBOARD SHORTCUTS

B	Apply Boresight command to all Sensors
Control-B	Un-boresight all Sensors
C	Toggle Continuous data streaming
Control-E	Display Event Log Pane
Delete key	Clear Text Pane
Shift-Delete	Clear Event Log Pane
P	Collect a Single frame of P&O data
Q	Toggle FTT® Mode ON/OFF for all Sensors
F2	Zoom IN
F3	Zoom OUT
←	Rotate scene clockwise about the vertical screen axis
→	Rotate scene counter-clockwise about the vertical screen axis
↓	Rotate scene toward the eye about the horizontal screen axis
↑	Rotate scene away from the eye about the horizontal screen axis

3.5 CONFIGURING VIPER™ MULTI-SOURCE MODES OF OPERATION

As described previously in Section 2. , VIPER™ is able to drive up to four Source components.

> ***Note***: When multiple Sources are used, each Source must operate at a different electromagnetic (EM) frequency.
>
> If multiple Sources of the same frequency are connected, VIPER™ will not operate.
>
> Polhemus offers Sources in a variety of EM frequencies.

When VIPER™ powers up, it detects plugged in Sensor and Source components. (*Hot swapped* Sensors are also detected when plugged in while VIPER™ is running.)

Depending on the pattern of connected Sources, VIPER™ defaults to one of several standard modes of operation. These modes are detailed in the following Sections 3.5.1, 3.5.2, and 3.5.3.
Each mode is characterized by:

- Which Source(s) the Sensor detects for determining position and orientation (P&O)

and

- Which Source is the referenced Cartesian origin (0, 0, 0) and null orientation.

3.5.1 SINGLE-SOURCE MODE

- Applies to **VIPER™ 8** and **VIPER™ 16** systems.
- **One Source is plugged into Source port 1.**
- All Sensors report P&O relative to Source 1.
- No Source is plugged into any other Source port.

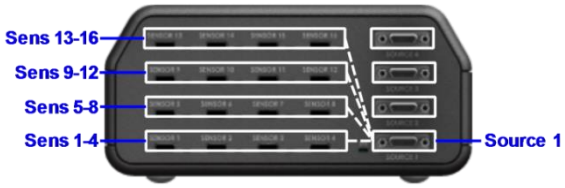


FIGURE 13. VIPER™ 16 SINGLE-SOURCE MODE

3.5.2 DUAL-SOURCE MODE

Each group of 8 Sensors report P&O with respect to Sources 1 and 3. In this mode, VIPER™ behaves as two independent 8-Sensor tracking systems.

- Applies to **VIPER™ 16** systems only.
- Two Sources are plugged into Source ports 1 and 3.
- Sensors 1-8 report P&O relative to Source 1.
- Sensors 9-16 report P&O relative to Source 3.
- **Sources 1 and 3 must operate at different EM frequencies***.
- No Source is plugged into Source ports 2 and 4.

***See warning note above.**

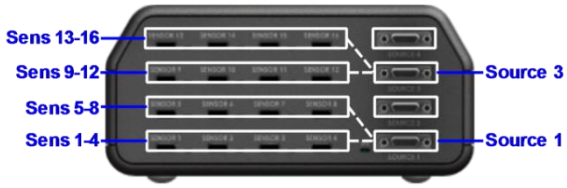


FIGURE 14. VIPER™ 16 DUAL-SOURCE MODE

3.5.3 LOCAL-SOURCE MODE

Each group of 4 Sensors report P&O with respect to the Local Source. Refer to Figure 15 and Figure 16 below to see the location of Local Sources.

Applies to all VIPER™ systems; this is the standard operating mode for **VIPER™ 4**.

On a **VIPER™ 8** system:

- Behaves as two independent 4-Sensor systems.
- Two Sources are plugged in to Source ports 1 and 2.
- **Sources 1 and 2 must operate at different EM frequencies*.**
- Sensors 1-4 report P&O with respect to their Local Source: Source 1.
- Sensors 5-8 report P&O with respect to their Local Source: Source 2.

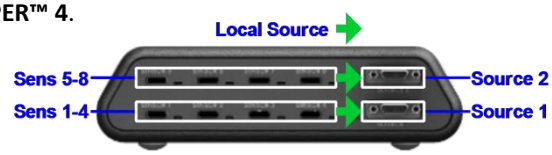


FIGURE 15. VIPER™ 8 LOCAL SOURCE LOCATIONS

On a **VIPER™ 16** system:

- Behaves as up to four independent 4-Sensor systems.
- Two–four Sources are plugged into Source ports 1-4.
- **Sources must each operate at a different EM frequency*.**
- **One Source must be plugged into Source port 1.**
- Sensors 1-4 report P&O with respect to their Local Source: Source 1.
- Sensors 5-8 report P&O with respect to their Local Source: Source 2.
- Sensors 9-12 report P&O with respect to their Local Source: Source 3.
- Sensors 13-16 report P&O with respect to their Local Source: Source 4.

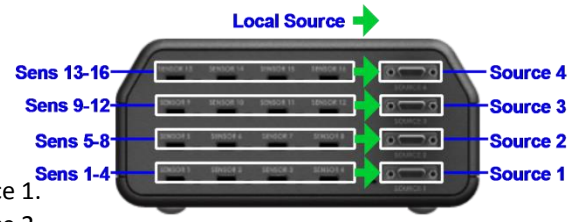


FIGURE 16. VIPER™ 16 LOCAL SOURCE LOCATIONS

*See warning note above.

3.5.3.1 NEAREST SOURCE

Viper 16™ flexibility allows variations on the Local- and Single-Source modes. Groups of 4 Sensors report P&O with respect to the Nearest Source: The Local Source, or if no Local Source is detected, then the first Source detected on a lower numbered Source Port.

- Applies to **VIPER™ 16** systems only.
- Two or three Sources are plugged into any Source ports 1-4.
- **One Source must be plugged into Source port 1.**
- **All Sources must operate at different EM frequencies***.

Examples A, B, and C below illustrate three of many possible combinations.

Example A:

- **VIPER™ 16** behaves as independent 4- and 12-Sensor systems.
- Different freq. Sources are plugged into Source Ports 1 and 2.
- Sensors 1-4 report P&O with respect to their Local Source: Source 1.
- Sensors 5-16 report P&O with respect to their Nearest Source: Source 2.

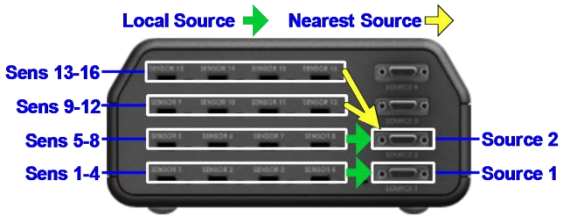


FIGURE 17. VIPER™ 16 NEAREST SOURCE, EXAMPLE A

Example B:

- **VIPER™ 16** behaves as independent 12- and 4-Sensor systems.
- Different freq. Sources are plugged into Source Ports 1 and 4.
- Sensors 1-12 report P&O with respect to their Nearest Source: Source 1.
- Sensors 13-16 report P&O with respect to their Local Source: Source 4.

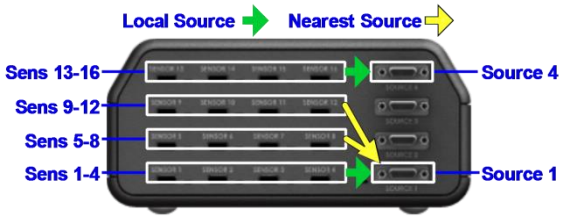


FIGURE 18. VIPER™ 16 NEAREST SOURCE, EXAMPLE B

Example C:

- **VIPER™ 16** behaves as three independent 4-, 8- and 4-Sensor systems.
- Different freq. Sources are plugged into Source Ports 1, 2, and 4.
- Sensors 1-4 report P&O with respect to their Local Source: Source 1.
- Sensors 5-16 report P&O with respect to their Nearest Source: Source 2.
- Sensors 13-15 report P&O with respect to their Local Source: Source 4.

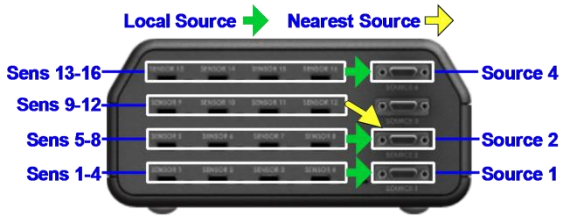


FIGURE 19. VIPER™ 16 NEAREST SOURCE, EXAMPLE C

*See warning note above.

3.5.4 CUSTOM MULTI-SOURCE MODE CONFIGURATION

For applications in which the standard Single- Dual- and Local-Source mode are not quite right, VIPER™ can be configured to operate in a custom user-selected Multi-Source mode.

Multi-Source behavior is defined on a per-Sensor basis by two settings that may be manually configured:

SOURCE SELECT defines which Source(s) a Sensor detects for determining P&O.
SENSOR ORIGIN defines which Source serves as the Sensor's referenced Cartesian position origin (0, 0, 0) and null orientation.

Both of these settings are configured using VIPER™ configuration commands SOURCE SELECT and SENSOR ORIGIN. These commands and settings are detailed in Section 4.2.14.

3.5.5 EXPANDED TRACKING AREA MULTI-SOURCE MODE

In the previous three modes of operation, connected VIPER™ Sources are used as individual units, each one defining a separate frame of reference for Sensor P&O. As such, each "Source tracking volume" is limited in size and shape by the strength of the EM field emitted by that Source.

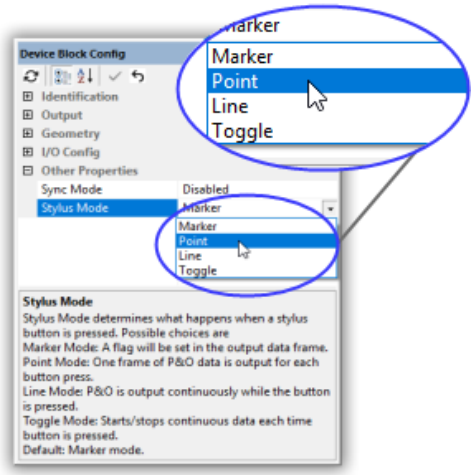
For applications that require an expanded tracking area, the connected VIPER™ Sources can be configured together to define a single expanded tracking volume and frame of reference for all Sensors.

The SOURCE CONFIGURATION command allows the user to specify the position and orientation of each connected Source relative to a user-defined virtual frame of reference. The reference frame may correspond to one of the Sources or it may be a virtual point implied by the position configurations for the Sources in the system. The SOURCE CONFIGURATION command is detailed in Section 4.2.7.

> ***Note***: VIPER™ operates in Expanded Tracking Area Mode whenever SOURCE CONFIGURATION is applied to the system, regardless of the pattern of connected Sources.

3.6 USING A STYLUS WITH VIPER™

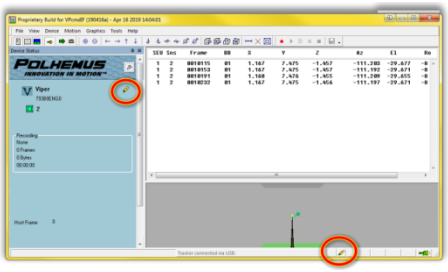
To use the VIPER™ Stylus as a point digitizer:



1. Set the SEU Stylus Mode setting to Point Mode.
   a. Enter Edit Mode by clicking .
   b. Display Advanced SEU configuration settings by clicking .
   c. Select Stylus Mode→Point.

Click on the Apply Changes button at the top of the SEU Block Config Pane.

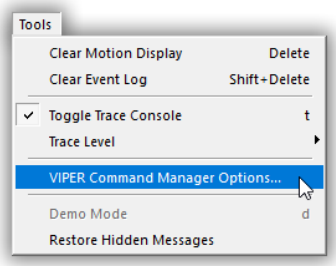
The Digitizer Mode icon will display in the Status Bar at the bottom of the screen and on the Status Pane next to the SEU glyph.

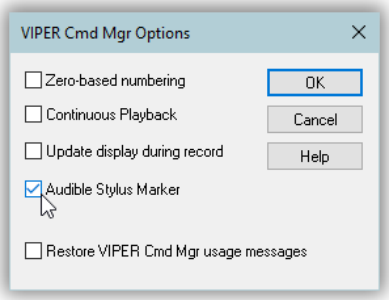


2. Now start VIPER™ Continuous Mode by clicking or typing **c**.

Now in Continuous Mode with Stylus Point Mode enabled, each press of the Stylus button will produce one frame of data in the VIPER™ Command Manager display.

To make VIPER Command Manager emit an audible tone when the stylus button is pressed, enable **Audible Stylus Marker** in VIPER Command Manager Options from the Tools Menu.





4. VIPER™ COMMAND INTERFACE

The purpose of this section is to describe VIPER™ configuration settings and other commands. These settings are applied to the system via the VIPER™ command interface, which defines the commands, actions, and configuration data used to interact with the tracker device.

VIPER™ commands can be applied to the device with the VIPER™ Command Manager or directly via the USB or RS422 I/O channel with a user-developed custom application.

For application development, Polhemus offers an open-source Standard C++ SDK conforming to C++14 core language features. Refer to online developer resources for details on the use of the VIPER™ command interface directly or with these VIPER™ SDK libraries. Links to online developer resources are provided in the Release Notes of the VIPER™ Host Software installation media.

4.1 COMMAND SUMMARY

VIPER™ commands fall into a variety of categories:

- Command is applied per-SEU or per-Sensor.
- Some commands are Executive in nature in that they perform executive actions on the running SEU.
- Some are Get-only, reporting the current state of the system or version and/or serial numbers.
- Configuration commands may pertain to persistent or not-persistent configuration settings.

The tables below list the main user commands and summarize their scope and function.

TABLE B. CONFIGURATION COMMANDS - PERSISTENT

Command	Actions	Scope	Section
FRAME RATE	Get/Set/Reset	SEU	4.2.1
UNITS	Get/Set/Reset	SEU	4.2.2
SYNC MODE	Get/Set/Reset	SEU	4.2.3
STYLUS MODE	Get/Set/Reset	SEU	4.2.4
SEU ID	Get/Set/Reset	SEU	4.2.5
SOURCE ROTATION	Get/Set/Reset	SEU	4.2.6
SOURCE CONFIG	Get/Set/Reset	SEU	4.2.7
PREDICTION FILTER	Get/Set/Reset	sensor	4.2.8
HEMISPHERE	Get/Set/Reset	sensor	4.2.9
FILTER	Get/Set/Reset	sensor	4.2.10
INCREMENT	Get/Set/Reset	sensor	4.2.11
FTT MODE	Get/Set/Reset	sensor	4.2.12
VIRTUAL SENSOR	Get/Set/Reset	sensor	4.2.13
SOURCE SELECT	Get/Set/Reset	sensor	4.2.14.1
SENSOR ORIGIN	Get/Set/Reset	sensor	4.2.14.2

TABLE C. CONFIGURATION COMMANDS -- NOT PERSISTENT (RUN-TIME ONLY)

Command	Actions	Scope	Section
RS-422 SERIAL CONFIG	Get/Set/Reset	SEU	4.3.1
DUAL OUTPUT MODE	Get/Set/Reset	SEU	4.3.2
TIP OFFSET	Get/Set/Reset	sensor	4.3.3

Command	Actions	Scope	Section
BORESIGHT	Get/Set/Reset	sensor	4.3.4

TABLE D. P&O COMMANDS

Command	Actions	Scope	Section
SINGLE PNO	Get Only	SEU	4.4.3
CONTINUOUS PNO	Set/Reset	SEU	4.4.4

TABLE E. READ-ONLY COMMANDS

Command	Actions	Scope	Section
BIT RESULTS	Get Only	SEU	4.5.1
STATION MAP	Get Only	SEU	4.5.2
MAP STATUS	Get Only	SEU	4.5.3
WHO AM I	Get Only	SEU	4.5.4
SENSOR WHO AM I	Get Only	sensor	4.5.5
SOURCE WHO AM I	Get Only	source	4.5.6

TABLE F. EXECUTIVE COMMANDS

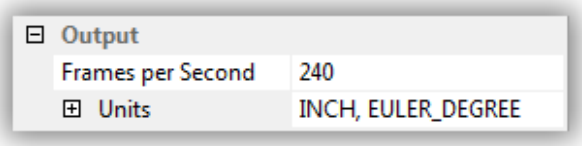
Command	Actions	Scope	Section
PERSIST	Set Only	SEU	4.6.1
BLOCK CONFIG	Reset Only	SEU	4.6.2
ENABLE MAP	Set/Reset	SEU	4.6.3

4.2 CONFIGURATION COMMANDS, PERSISTENT

4.2.1 FRAME RATE COMMAND

This command sets the update rate of frames per second. The frame rate can be set to 30Hz, 60Hz, 120Hz, or 240Hz for all VIPER™ SEUs. VIPER™ 8 and VIPER™ 16 systems may also be set to output data at 480Hz or 960Hz.

In VIPER™ Command Manager, Frame Rate is configured in the SEU Block Config panel in the **Output** group.
Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.



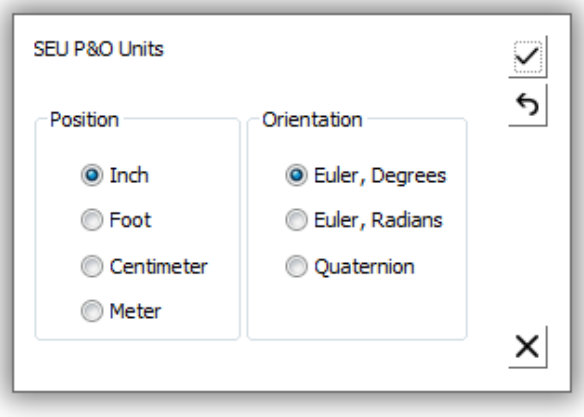
Default: 240Hz
Scope: SEU
Persistent: YES

4.2.2 UNITS COMMAND

This command sets the Position and Orientation output units.

- Position Cartesian coordinates output units options are Inch, Foot, Centimeter, and Meter.
- Orientation output units options are Euler Angle Degrees, Euler Angle Radians, and Quaternion.

In VIPER™ Command Manager, Units are configured by selecting # in the Edit Mode Status Pane.



Default: Inches, Euler Degrees.
Scope: SEU
Persistent: YES

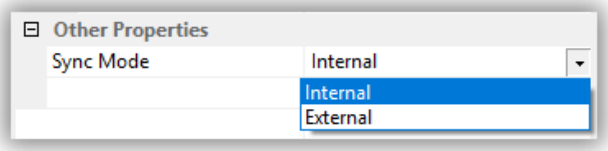
4.2.3 SYNC MODE COMMAND

The Sync Mode setting determines how the VIPER™ External Sync hardware works.

Internal Sync: A 3.3V sync pulse is output simultaneously with each P&O frame output. The pulse has duration of 10µs and occurs at the beginning of the data collection cycle.

External Sync: When the external device applies a ground pulse (minimum duration of 10µs), P&O computation is initiated using sensor data immediately preceding the ground pulse.

In VIPER™ Command Manager, Sync Mode is configured in the SEU Block Config panel in the **Other Properties** group.
Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.



Default: Internal
Scope: SEU
Persistent: YES

4.2.4 STYLUS MODE COMMAND

The Stylus Mode setting determines what happens when a Stylus push button switch is pressed.

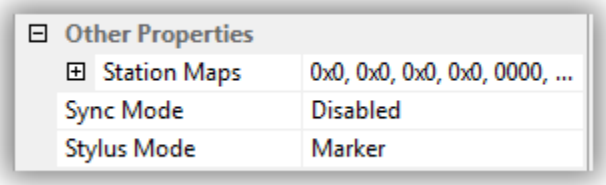
Marker Mode: Pushing the switch causes a flag (or "mark") to be set in the output P&O frame for that Stylus.

Point Mode: Pushing the switch causes VIPER™ to emit one frame of P&O data. The data frame includes P&O of *all connected Sensors* (not just the Stylus).

Line Mode: VIPER™ outputs continuous P&O data while the switch is pressed. The continuous stream stops when the switch is released. P&O of *all connected Sensors* is output.

Toggle Mode: Pushing the switch causes VIPER™ to start or stop continuous data streaming. (This is equivalent to using the CONTINOUS PNO command.)

In VIPER™ Command Manager, Stylus Mode is configured in the SEU Block Config panel in the **Other Properties** group.
Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.

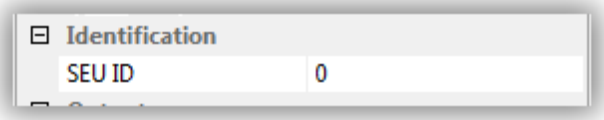


Default: Marker Mode
Scope: SEU
Persistent: YES

4.2.5 SEU ID COMMAND

This command allows you to program a numeric ID into the SEU. The SEU ID will appear in the SEU ID field of output P&O frames.

In VIPER™ Command Manager, SEU ID is configured in the SEU Block Config panel in the **Identification** group.
Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.



Default: SEU ID is zero
Scope: SEU
Persistent: YES

4.2.6 SOURCE ROTATION COMMAND

Note: Do not use the SOURCE ROTATION command when the SOURCE CONFIGURATION command is in use (for Expanded Tracking Area Mode).

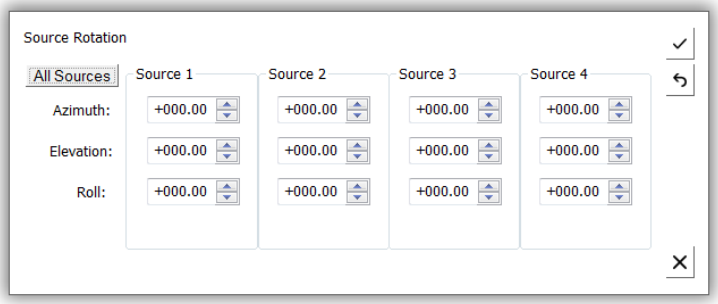
Source Rotation allows the user to modify the reference frame rotation of the Source(s). It is essentially a non-physical rotation of the Source and becomes the new orientation reference for each Sensor's measurements.

Source Rotation is not a Sensor-specific setting and affects the global reference frame of the tracking system.

Source Rotation allows the user to specify the Azimuth, Elevation and Roll of each Source in the system, or all Sources in the system.

Note: When used in conjunction with the SOURCE SELECT command (Section 4.2.14.1), Source rotation affects the reference frame of only the Sensors that select that Source.

In VIPER™ Command Manager, Source Rotation is configured by selecting in the Edit Mode Status Pane.



Default: (0,0,0) Azimuth, Elevation, Roll for all Sources
Scope: SEU
Persistent: YES

4.2.7 SOURCE CONFIGURATION COMMAND

Source configuration allows the user to configure Position and Orientation for all Sources in the Expanded Tracking Area Mode of operation, detailed in Section 3.5.5. Setting the P&O of each source in this way effectively defines the frame of reference for Sensor P&O that is output by the tracker.

Source Position and Orientation configured by this command is expressed in current tracker units of measure as configured by the UNITS command.

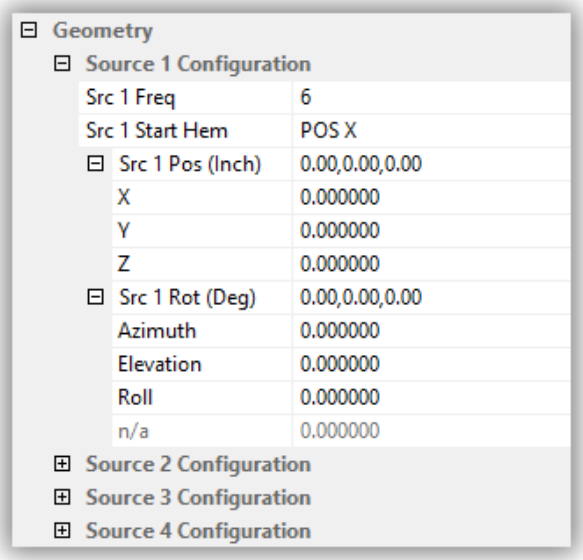
The Startup Hemisphere configured by this command describes the direction with respect to that Source from which Sensors enter the tracking area or approach the Source. At runtime, Sensors begin tracking by detecting the EM fields emitted by the sources in the tracking area. Correct computation of P&O depends upon prior knowledge about which side of the Source the Sensor is expected to be on when the Source is initially detected. (This moment of initial detection occurs when the SEU is powered ON.)

Possible Startup Hemisphere values are *±X*, *±Y*, *±Z* or *Auto*:

±X, Y, Z values correspond to the source hemispheres depicted previously in Figure 11.
Auto engages Auto-Hemisphere, discussed below in Section 4.2.9

In VIPER™ Command Manager, Source Configuration is configured in the SEU Block Config panel in the **Geometry** group.

Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.



Default: None (Position (0,0,0) and Orientation (0,0,0) Azimuth, Elevation, Roll for all Sources)

Scope: SEU

Persistent: YES

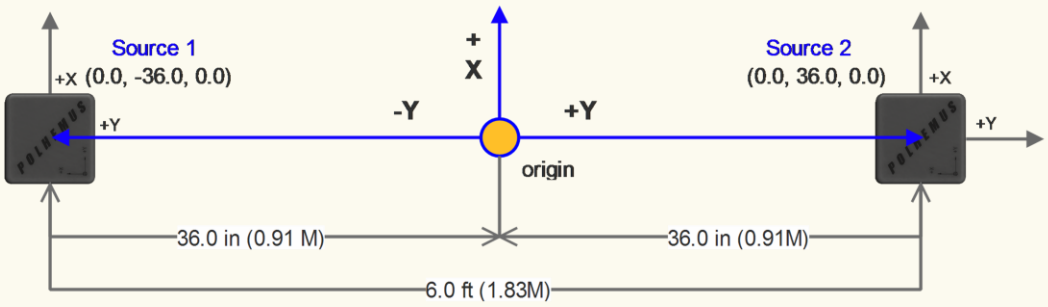
Note: Do not use the SOURCE ROTATION command when the SOURCE CONFIGURATION command is in use.

Note: **Auto** Startup Hemisphere requires FT Sensors to function.

Non-FT Sensors will assume POS X Startup Hemisphere for Source(s) with Auto Startup Hemisphere configured.

Example Scenario: SOURCE CONFIGURATION

Your project uses two TX4 Sources placed 6 feet apart. You are tracking a human subject wearing 6 sensors on arms and shoulders. The subject is moving freely between the two sources, which are mounted on tripods 4 feet above the floor. Sources 1 and 2 are facing in the same direction.



You want the Sensors' P&O reference (origin) to be at the point halfway between the Sources.

You will use the SOURCE CONFIGURATION command to tell VIPER™ the position and orientation of each of the two Sources**, also referenced to the origin**.

Therefore, in our example Source 1 is positioned at (0.0, -36.0, 0.0) inches: It is 3 feet in the –Y direction from the origin, and it is equal to the origin in X and Z. (Note, the +Z axis extends downward toward the floor.)

Source 2 is likewise positioned at (0.0, +36.0, 0.0) inches.

Since both Sources' positive X, Y, and Z axes are parallel to the reference axes, the orientation of both is (0,0,0) degrees Azimuth, Elevation, Roll.

For Startup Hemisphere for each Source, you will choose AUTO. When the VIPER™ Sensors initially detect the Sources, VIPER™ will automatically detect and track the Sensors' hemisphere of operation. (See Section 4.2.9 HEMISPHERE command for an explanation of the Auto-Hemisphere feature.)

Source 1 Configuration	
Src 1 Freq	6
Src 1 Start Hem	**Auto**
⊟ Src 1 Pos (Inch)	**0.00,-36.00,0.00**
X	0.000000
Y	**-36.000000**
Z	0.000000
⊞ Src 1 Rot (Deg)	0.00,0.00,0.00

Source 2 Configuration	
Src 2 Freq	1
Src 2 Start Hem	**Auto**
⊟ Src 2 Pos (Inch)	**0.00,36.00,0.00**
X	0.000000
Y	**36.000000**
Z	0.000000
⊞ Src 2 Rot (Deg)	0.00,0.00,0.00

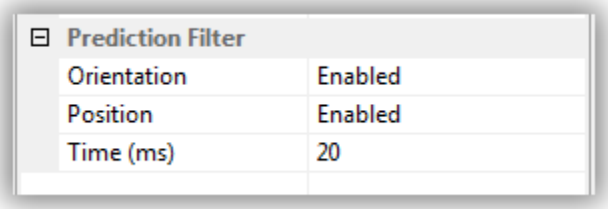
Finally, you will want to execute the PERSIST command to save these settings to VIPER™ FLASH memory so that when VIPER™ reboots, the settings will persist.

4.2.8 PREDICTION FILTER COMMAND

The PREDICTION FILTER command enables and disables the VIPER™ Prediction Filter for Position and/or Orientation tracker data.

When enabled, VIPER™ predicts current and future Sensor P&O based on previous P&O data. Prediction time is configurable from 1ms.

In VIPER™ Command Manager, Prediction Filter is configured in the Sensor Block Config panel in the **Prediction Filter** group.
Access the Sensor Block Config panel by selecting ⋮ to the right of a Sensor icon ▣ in the Edit Mode Status Pane.



Default: Disabled for both Position and Orientation. Default time is 20ms

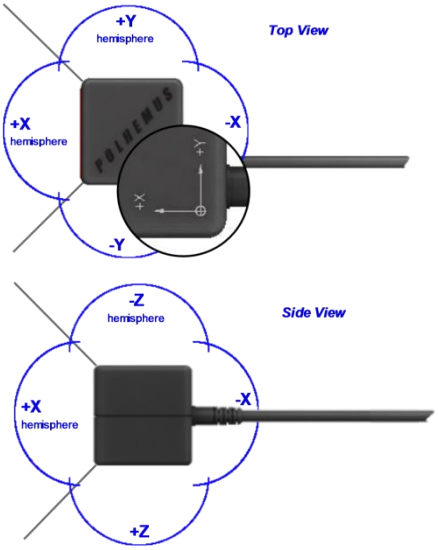
Scope: Sensor

Persistent: YES

⚠ ***Note***: Operating the tracker with maximum capacity Sensors and Sources at the highest FRAME RATE (960Hz) and Prediction Filter enabled on multiple Sensors may cause a slight reduction in actual frames-per-second output.

4.2.9 HEMISPHERE COMMAND

This command allows the user to configure the VIPER™ Auto-Hemisphere feature or to manually configure Sensor *hemisphere of operation*.



Hemisphere of operation is the half of the sphere surrounding the Source that can be used at any one time without ambiguity in the sign of a Sensor's reported X, Y, Z measurements. This is due to the symmetry of magnetic fields emitted by the Source. For more information about this phenomenon, see Appendix B. SOURCE Hemispheres.

Automatic Hemisphere Detection

With **FT-Sensors**, VIPER™ automatically detects and tracks Sensor hemisphere of operation when Auto-Hemisphere is enabled.

ⓘ ***Note***: The FT-Sensor **must move initially** for Auto-Hemisphere detection to engage.

Manual Hemisphere Configuration

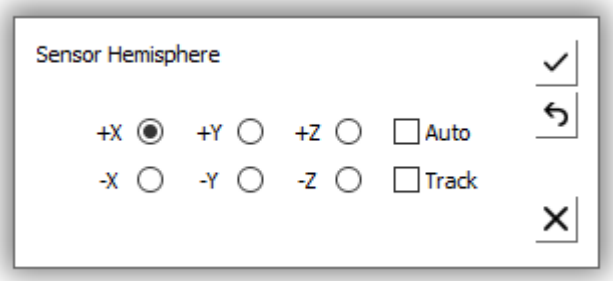
Without Auto-Hemisphere, X, Y, Z sign ambiguity can occur if correct hemisphere of operation is not manually configured.

Further, each Sensor can operate correctly on only one side of a Source, unless Hemisphere Tracking is used. With Hemisphere Tracking enabled, VIPER™ continuously modifies the operating hemisphere, allowing full tracking coverage around all sides of the Source.

> ***Note***: To start Hemisphere Tracking, VIPER™ must be operating in a known, valid hemisphere. That is, the Sensor must be located in the currently configured hemisphere of operation.
>
> ***Note***: Hemisphere Tracking is automatically enabled with Auto-Hemisphere detection.

For Expanded Tracking Area Multi-Source configurations (Section 3.5.5), **Startup Hemisphere** is configured with the SOURCE CONFIGURATION setting (Section 4.2.7).

In VIPER™ Command Manager, Hemisphere is configured by selecting in the Edit Mode Status Pane.



Default: +X for all Sensors

Scope: Sensor

Persistent: YES, except Hemisphere Tracking, unless Auto-Hemisphere is enabled.

> ***Note***: If Auto-Hemisphere is applied to a non-FT Sensor, VIPER™ responds to the HEMISPHERE command with a warning, and Auto-Hemisphere is not engaged on that sensor. Instead, Hemisphere Tracking is enabled on that Sensor and the +X Hemisphere is assumed.
>
> If the Auto-Hemisphere was previously enabled and the detected Sensor is not an FT Sensor, the default Hemisphere Tracking will be enabled and +X starting Hemisphere will be assumed.

4.2.10 FILTER COMMAND

VIPER™ employs optional filtering that is designed to control noise (jitter) in the P&O data output. Filters can be applied to position or orientation or both. The FILTER command is applied on a per-Sensor basis.

Traditional Polhemus Adaptive Filter

The FILTER command establishes the sensitivity, boundary, and transition control parameters for the Traditional adaptive filter that operates on the position and orientation outputs of the VIPER™ system. The user can adjust the parameters of this filter to fine-tune the overall dynamic response of VIPER™ or select pre-configured presets. The definitions of these parameters and presets are detailed in Table G. and Table H. below.

TABLE G. ADAPTIVE FILTER PARAMETERS

F	The sensitivity of the filter to dynamic input conditions. **Sensitivity** is the proportion of new input data to recent average data that is used to update the floating filter parameter. The smaller the value here, the less sensitive the output becomes to changes in new input data, or the heavier the filter becomes. Range: **0 < *F* < 1.0**
F-Low	The maximum allowable filtering to be applied to the outputs during periods of low (static) input dynamics. A smaller value here allows the output to be less sensitive to changes in new input data when input data is relatively static. That is, MORE filtering occurs on static data. Range: **0 < *F-Low* < *F-High*.**
F-High	The minimum allowable filtering to be applied to the outputs during periods of highly dynamic input conditions. A larger value here allows the output to be more sensitive to changes in new input data when input data is changing rapidly. That is, LESS filtering occurs on highly dynamic data." Range: ***F-Low*** < ***F-High*** < 1.0
F-Max Trans	The maximum allowable transition rate from minimum filtering (for highly dynamic input conditions) to maximum filtering (for relatively static input conditions) by proportionately limiting the decay to the low filter limit whenever the input conditions effect a transition to a narrower bandwidth. A lower value here slows down the transition from light filtering to heavy filtering when data dynamics change. Range: 0 < ***F-MaxTrans*** < 1.0

TABLE H. VIPER™ ADAPTIVE FILTER PRESETS

FILTER PRESET	SENSITIVITY (F)	BOUNDARY (F-LOW)	BOUNDARY (F-HIGH)	MAX TRANSITION RATE (F-MAX TRANS)
None	n/a	n/a	n/a	n/a
Light	0.2	0.2	0.8	0.95
Medium	0.05	0.05	0.05	0.95
Heavy	0.02	0.02	0.02	0.95
Custom	User-specified	User-specified	User-specified	User-specified

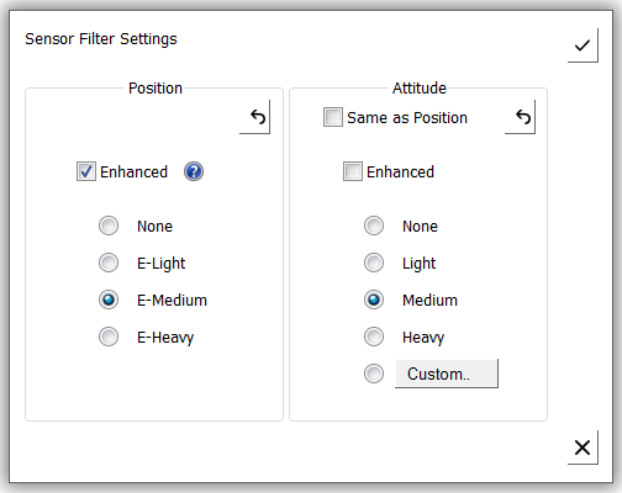
About Polhemus Traditional Adaptive Filters

The Traditional filter used by VIPER™ is a single-pole, low-pass filter with an adaptive pole location. The pole location is constrained within user-specified boundary values ***F-Low*** and ***F-High*** but is continuously self-adaptive between these limits as a function of a user-specified sensitivity parameter ***F*** and the sensed input conditions (ambient noise plus rotational rate). For input "rate" conditions that fall within the adaptive range, the adaptive feature varies the pole location between the ***F-Low*** and ***F-High*** limits to maximize the output resolution for static inputs while minimizing the output lag for dynamic inputs. Whenever the input conditions cause the filter to make a transition to a narrower bandwidth (i.e., increased filtering), the transition rate of the pole location is constrained to a user-specified maximum allowable rate (***F-Max Trans***).

Enhanced Filter

VIPER™ Enhanced Filter mode is now available with **FT Sensors**. The added capabilities of FT Sensors lead to a powerful new filtering mode that has excellent characteristics with respect to low noise and low latency. Enhanced Filters have pre-configured Light, Medium and Heavy presets available. These are identified as ***E-Light***, ***E-Medium*** and ***E-Heavy*** in the Filter Settings controls.

In VIPER™ Command Manager, Filters are configured by selecting ▽ in the Edit Mode Status Pane.



Default: Traditional Medium for Position and Attitude, all Sensors
Scope: Sensor
Persistent: YES

> ***Note***: If the FILTER command is used to set the Enhanced Filter on a non-FT Sensor, VIPER™ responds to the command with a warning and the Traditional Medium Filter is enabled for that Sensor.
>
> If the Enhanced Filter was previously enabled and the detected Sensor is not an FT Sensor, the default Traditional Medium filter will be engaged.

4.2.11 INCREMENT COMMAND

When enabled, INCREMENT operates in one of two modes:

Fixed-Threshold: New P&O data is reported when changes in position and/or orientation have satisfied the user-defined movement threshold. (Unchanged P&O data is output until movement threshold is satisfied.)

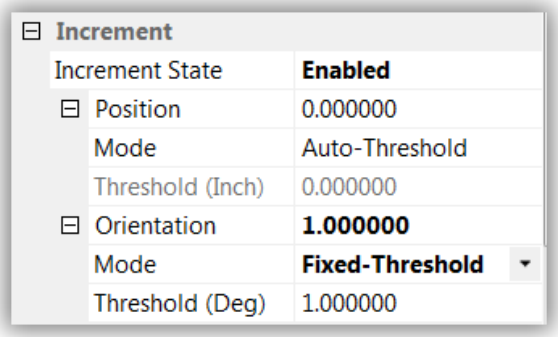
Auto-Threshold: VIPER™ continuously evaluates electromagnetic (EM) signal strength and noise in the environment and dynamically and automatically establishes increment thresholds based on those conditions.

Refer to the Example Scenario below for a more detailed description of the difference between Fixed- and Auto-Threshold.

Fixed Increment thresholds are expressed in current tracker units of measure as configured by the UNITS command.

In VIPER™ Command Manager, Increment is configured in the Sensor Block Config panel in the **Increment** group.

Access the Sensor Block Config panel by selecting ⋮ to the right of a Sensor icon ▣ in the Edit Mode Status Pane.



Default: Disabled for both Position and Orientation
Scope: Sensor
Persistent: YES

4.2.12 FTT MODE COMMAND

This command configures the VIPER™ FTT® Mode on FT Sensors. At initial release, FTT® has two modes of operation. Be sure to understand the difference between the modes and select the best one for your tracking applications.

Stationary Source Mode: This mode is for configurations that involve VIPER™ Sources that *do not move* in 3D space during tracking (for example, a Source mounted in a fixed location on a wall in a building or on a table; suspended from a ceiling; or embedded in a static position inside a manikin).

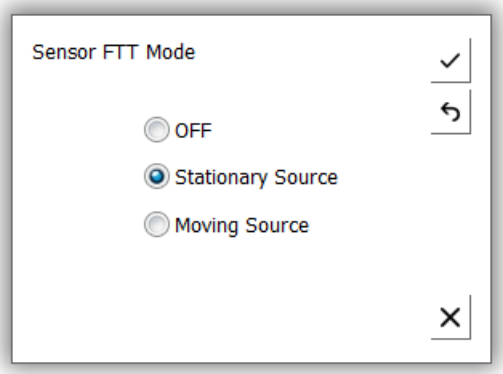
Moving Source Mode: This mode is for dynamic configurations that involve VIPER™ Sources that *do move* in 3D space during tracking. Moving Source Mode is useful in diverse applications such as:

- a small size TX1 Source embedded in an ultrasound wand that moves while in use, or
- a Source installed within a motion platform simulator, or
- a Source installed in a moving vehicle.

> ***Note***: Moving Source Mode is only applicable to systems operating in Local Source Mode, where Sensors report P&O relative to their Local Source. To learn more about Local Source Mode, see Section 3.5.3.

In VIPER™ Command Manager, FTT® mode is configured by selecting in the Edit Mode Status Pane.

FTT® Stationary Source Mode can be enabled and disabled for all Sensors by typing **q**.



Default: OFF for all Sensors

Scope: Sensor

Persistent: YES

> ***Note***: If FTT® Mode is applied to a non-FT Sensor, VIPER™ responds to the FTT MODE command with a warning, and FTT® Mode is OFF on that sensor.
>
> If the FTT® Mode was previously enabled and the detected Sensor is not an FT Sensor, FTT® Mode will be OFF on that detected Sensor.

4.2.13 VIRTUAL SENSOR COMMAND

This command is used to create or destroy a **Virtual Sensor** with an unused Sensor number. VIPER™ outputs P&O for a Virtual Sensor from a configured Input, which is selected from available connected live (*active)* Sensors. Once created, a Virtual Sensor may be configured just like an active Sensor—this is useful for testing, comparing and troubleshooting behavior produced by Sensor configuration settings.

When creating a Virtual Sensor, the Virtual Sensor's number is chosen from unused sensor numbers *local* to the active Sensor Input. Local sensor numbers are in groups of 4 on the VIPER™ panel as depicted in Figure 20.

FIGURE 20. LOCAL SENSOR GROUPS

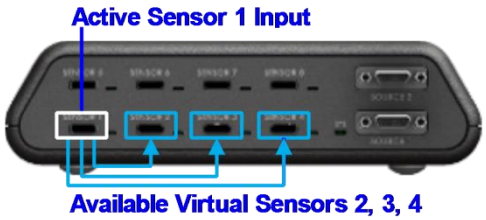
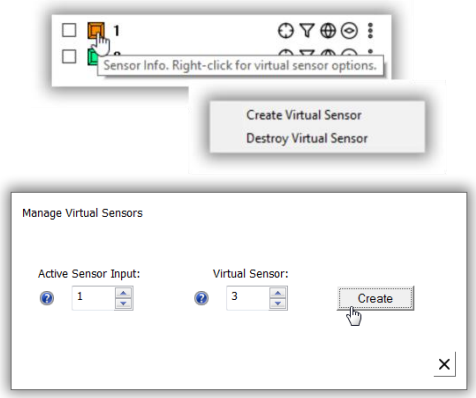


FIGURE 21. VIRTUAL SENSOR EXAMPLE

For example, if a live Sensor 1 is connected, Virtual Sensors 2, 3, and 4 could be created using Sensor 1 as the Active Sensor Input. (Figure 21)

Note that a live Sensor may be used as Input to "feed" multiple Virtual Sensors at the same time.

In VIPER™ Command Manager, to create or destroy a virtual Sensor, right-click on a Sensor icon in the Edit Mode Status Pane.



Default: n/a

Scope: Sensor

Persistent: YES

4.2.14 SOURCE CONFIGURATIONS AND MODES OF OPERATION

For more information about these commands, please refer to Section 3.5 "Configuring VIPER™ multi-source modes of operation."

4.2.14.1 SOURCE SELECT COMMAND

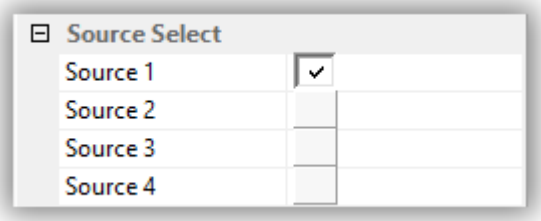
> ***Note***: SOURCE SELECT is an advanced feature that is applicable only in rare and very specific circumstances**.**

Each Sensor uses one or more detected Sources for determining P&O. These are the Sensor's **Source Selection**. The default Source Selection in various Multi-Source modes as described in Section 3.5 are determined by which Sources are plugged into VIPER™.

The SOURCE SELECT command is used to override the default Source Selection when multiple Sources are used.

In VIPER™ Command Manager, Source Select is configured in the Sensor Block Config panel in the **Source Select** group.

Access the Sensor Block Config panel by selecting ⋮ to the right of a Sensor icon ▣ in the Edit Mode Status Pane.



Default: Selected according to detected Sources

Scope: Sensor

Persistent: YES

> ***Note***: Sensors should not come closer than approximately 4 inches from Source(s) that are not in the Sensor's Selected Source list. Degraded tracking performance may result temporarily in this case, but the condition will be resolved when the Sensor is moved away.
>
> ***For example***, a system has connected Sensors 1-12 and Sources 1-3. If Sensor 2 has Source Selection 1 and 2, that means Sensor 2 is using only Sources 1 and 2 for P&O calculation. Sensor 2 should stay at least 4 inches away from Source 3.

Example Scenario: SOURCE SELECT

Your project design uses different types of Sensors and Sources simultaneously:

- 10 Micro Sensors in ports 1-10 and 2 TX1 Sources in source ports 1 and 2 for close-range "micro" tracking
- 6 FT-Standard sensors in port 11-16 and 2 TX4 Sources in source port 3 and 4 for Expanded Area "macro" tracking.

You want the Micro Sensors to track using *only* the EM fields emitted by the TX1 Sources.

You want the FT-Standard Sensors to track using *only* the EM fields emitted by the TX4 Sources.

Because you are using the two TX4 Sources for Expanded Area Tracking you must first apply Source Configuration settings for Sources 3 and 4. See Section 4.2.7 "SOURCE CONFIGURATION command."

Then, use the SOURCE SELECT command to configure:

- Micro Sensors 1-10 to track using the TX1 Sources 1 and 2.
- FT-Standard Sensors 11-16 to track using the TX4 Sources 3 and 4.

Finally, you will want to execute the PERSIST command to save these settings to VIPER™ FLASH memory so that when VIPER™ reboots, the settings will persist.

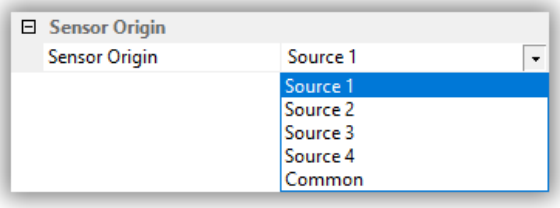
4.2.14.2 SENSOR ORIGIN COMMAND

Note: SENSOR ORIGIN is an advanced feature that is applicable only in rare and very specific circumstances**.**

The SENSOR ORIGIN command is used to configure the Sensor's P&O reference.

In VIPER™ Command Manager, Sensor Origin is configured in the Sensor Block Config panel in the **Sensor Origin** group.

Access the Sensor Block Config panel by selecting ⋮ to the right of a Sensor icon ▣ in the Edit Mode Status Pane.



Default: The Source local to the Sensor, or Common Origin if SOURCE CONFIGURATION command is applied.

Scope: Sensor

Persistent: YES

Example Scenario: SENSOR ORIGIN

Your project is a multi-player game that uses 16 FT-Sensors and 4 VIPER™ Sources over an expanded tracking area.

The SOURCE CONFIGURATION command is applied to establish the position and rotation of each source relative to a Common Origin.

You want each Sensor to use the expanded tracking area afforded by detecting the EM fields of all the Sources, BUT you do *not* want the P&O to be relative to the Common Origin.

Instead, you want to configure each player-group of 4 Sensors to use a different Source as the P&O reference, with one Sensor in the group using the Common Origin.

Use the SENSOR ORIGIN command to configure the P&O reference of each sensor in each group of four.

4.3 CONFIGURATION COMMANDS, NOT-PERSISTENT

4.3.1 RS-422 SERIAL PORT CONFIGURATION COMMAND

This command programs the baud rate and parity settings in the VIPER™ UART for the RS-422 I/O port.

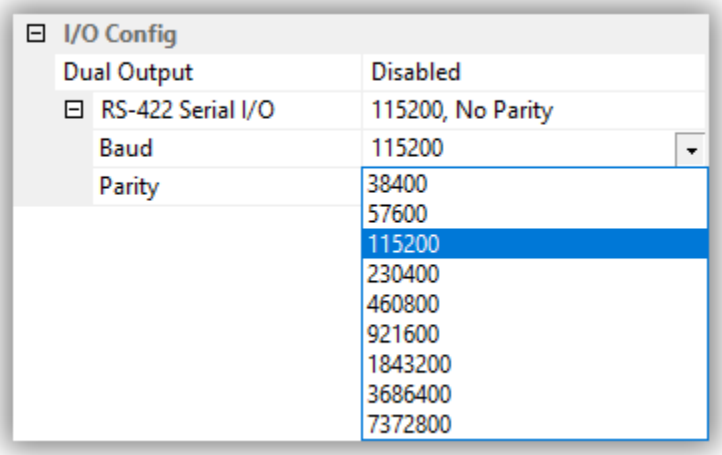
Available baud rates:	Available Parity settings
38,400 baud	None
57,600 baud	Even
115,200 baud	Odd
230,400 baud	
460,800 baud	
921,600 baud	
1,843,200 baud*	
3,686,400 baud*	
7,372,800 baud*	

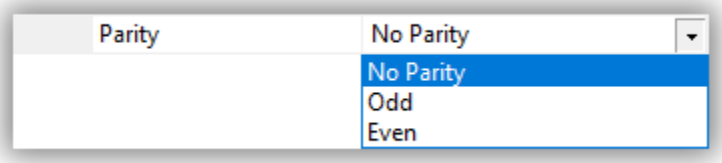
***Note**: RS-422 Serial port output has been tested up to 921.6K baud.

The RS-422 Serial Configuration settings are not persistent. If it is necessary to use the RS-422 channel for command I/O, the host program must first connect at the default setting and then change the setting to the desired configuration.

In VIPER™ Command Manager, Serial I/O Port settings are configured in the SEU Block Config panel in the **I/O Config** group.

Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.





Default: 115200 baud, No Parity

Scope: SEU

Persistent: NO

Host-side RS-422 settings usually also include Data Bits, Stop Bits and Handshaking/Flow Control parameters. When setting up the Host RS-422 port, use the following additional settings:

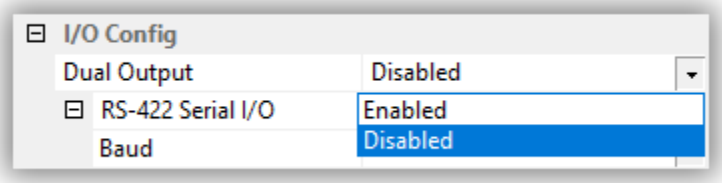
- 8 Data Bits
- 1 Stop Bit
- No Handshake/Flow Control

4.3.2 DUAL OUTPUT MODE COMMAND

This command enables and disables Dual Output Mode described in Section 2.2. By default, VIPER™ emits command responses and data to the I/O port from which the command was received. This includes streaming P&O data. When Dual Output Mode is enabled, P&O data is output to both USB and RS-422 ports. Command responses are also output to both ports.

In VIPER™ Command Manager, Dual Output Mode is configured in the SEU Block Config panel in the **I/O Config** group.

Access the SEU Block Config panel by selecting <> to the right of the VIPER™ SEU icon in the Edit Mode Status Pane.



Default: Disabled
Scope: SEU
Persistent: NO

4.3.3 TIP OFFSET COMMAND

The TIP OFFSET of a VIPER™ Stylus is the positional offset of the Stylus tip from the electromagnetic (EM) center of the Sensor coil inside the Stylus handle. Each VIPER™ Stylus is factory calibrated with a tip offset. This allows the **tip** of the Stylus pen to act as the measurement reference.

For all other VIPER™ Sensor components, there is no factory calibrated tip offset.

For Stylus and Sensor components, the TIP OFFSET values cause VIPER™ to produce P&O for a point other than the electromagnetic (EM) center of the Sensor coil.

Applying the TIP OFFSET command to a Stylus overrides the factory calibrated offset that is read by VIPER™ when the SEU is started. In most circumstances it is not recommended to apply this command to a Stylus.

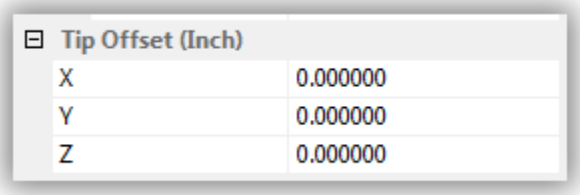
> ***Note***: Applying the TIP OFFSET command to a Stylus overrides the factory calibrated offset that is read by VIPER™ when the SEU is started. In most circumstances it is not recommended to apply this command to a Stylus.

TIP OFFSET may be useful for a Sensor when the Sensor is mounted on a custom instrument, where the Position of the tip of the instrument is of interest rather than the Sensor itself.

TIP OFFSET is expressed in current tracker position units as configured by the UNITS command.

In VIPER™ Command Manager, Tip Offset is configured in the Sensor Block Config panel in the **Tip Offset** group.

Access the Sensor Block Config panel by selecting ⋮ to the right of a Sensor icon ▣ in the Edit Mode Status Pane.



Default: Factory Calibrated

Scope: Sensor

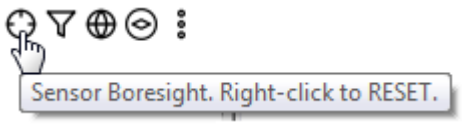
Persistent: No

4.3.4 BORESIGHT COMMAND

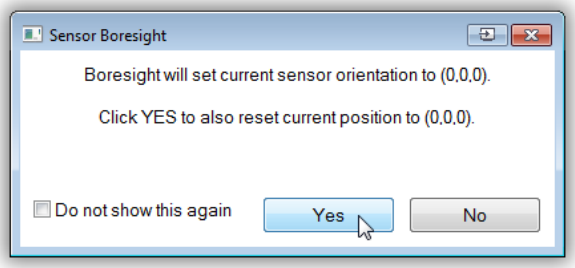
This command causes the Sensor to be electronically aligned in orientation (and optionally, position) at the current coordinates and establishes the boresight reference angles for the Sensor. If a "Reset Origin" command argument is applied, X, Y and Z outputs will equal 0,0,0 at the boresight position. VIPER™ then produces P&O outputs relative to the reference(s). Any Sensor orientation can be designated as the zero orientation point.

A Sensor may be un-boresighted by RESETTING the command.

In VIPER™ Command Manager:
BORESIGHT is SET for all checked Sensors by selecting ⌖ in the Edit Mode Status Pane with the **LEFT Mouse Button.**



BORESIGHT SET will also reset the current Sensor position to (0,0,0) by clicking YES in the Sensor Boresight popup window



BORESIGHT is RESET by clicking ⌖ with the right mouse button

Default: no boresight

Scope: Sensor

Persistent: NO

4.4 P&O COMMANDS

Position and Orientation (P&O) commands cause VIPER™ to output P&O data either one frame at a time or in a continuous stream.

A VIPER™ P&O frame is output via the USB and/or RS-422 connection. Both channels are used if DUAL OUTPUT MODE is enabled (see Section 4.3.2).

A VIPER™ P&O frame is a binary structure that varies in size, depending on how many Sensors are connected to the SEU.

4.4.1 STANDARD P&O FRAME

A standard VIPER™ P&O frame contains the information below. VIPER™ Command Manager displays the fields identified with * by default. The other fields are available for display by configuring the P&O display parameters.

* **SEU ID**.....32-bit SEU identifier configured by SEU ID command.

* **SEU Frame number**.....32-bit number of frames tracked since the SEU was powered on, or since frame count was reset. See Frame Count Reset below.

Sensor count.....32-bit number of Sensors' P&O data that is contained in the frame

For each reporting Sensor:

* **Sensor number**.....7-bit numeric reflecting the SEU sensor port that the Sensor is plugged into.

* **Sensor button states**.....2-bit states of any button switches integrated into the Sensor. A VIPER™ Stylus uses one of these bits.

Distortion level.....8-bit numeric distortion level detected by the Sensor in levels 0-255.

Auxiliary digital input value...10-bits of available data input for custom integrated hardware.

* **Sensor Position (X, Y, Z)**.....32-bit floating point Cartesian coordinates in position units configured by the UNITS command.

* **Sensor Orientation**.....Expressed as (3) or (4) 32-bit floating point values for Euler Angles (Azimuth, Elevation, Roll) or a 4-term Orientation Quaternion **Q(*w, x, y, z*)***, as configured by the UNITS command.

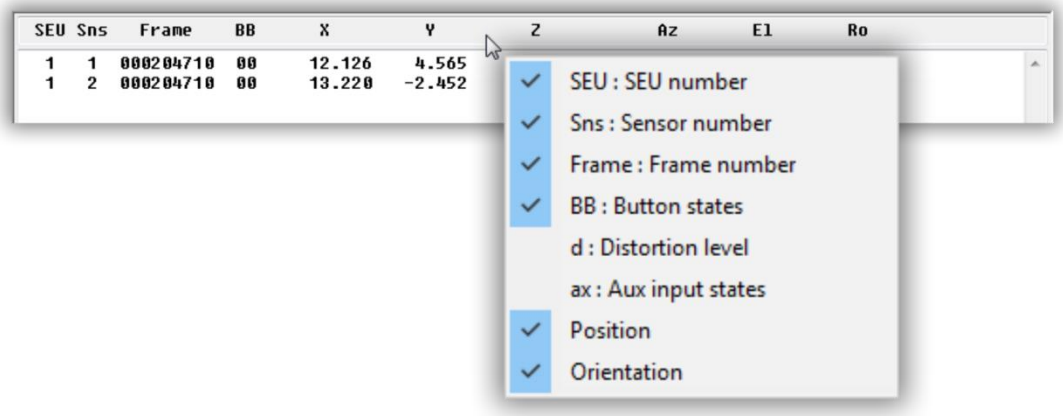
[***Note** the order of Quaternion components: Scalar value ***w*** is output first.]

The output summary above is not an exact representation of the byte structure of the P&O frame. Developers will require exact frame specification provided in developer resources. Links to online developer resources are provided in the Release Notes of the VIPER™ Host Software installation media.

Frame Count Reset

Frame Count may be reset in the CONTINUOUS PNO command by providing an argument to the command. In the VIPER™ Command Manager, this is performed automatically each time Continuous Data is started.

Right-click the mouse over the title bar in the text pane to select data to be displayed.



4.4.2 ALTERNATIVE P&O FRAME WITH ACCELERATION

VIPER™ has the ability to output P&O in an alternative data mode that includes Sensor acceleration in X, Y, Z axes and magnitude.

A VIPER™ P&O frame with acceleration data contains the fields below. VIPER™ Command Manager displays the fields identified with * by default. The other fields are available for display by configuring the P&O display parameters.

* **SEU ID**.....32-bit SEU identifier configured by SEU ID command.

* **SEU Frame number**.....32-bit number of frames tracked since the SEU was powered on, or since frame count was reset. See Frame Count Reset above.

Sensor count.....32-bit number of Sensors' P&O data that is contained in the frame.

For each reporting Sensor:

* **Sensor number**.....7-bit numeric reflecting the SEU Sensor port that the Sensor is plugged into.

* **Sensor button** states.....2-bit states of any button switches integrated into the Sensor. A VIPER™ Stylus uses one of these bits.

Distortion level.....8-bit numeric distortion level detected by the Sensor in levels 0-255.

Auxiliary digital input value...10-bits of available data input for custom integrated hardware.

* **Sensor Position (X, Y, Z)**.....32-bit floating point Cartesian coordinates in position units configured by the UNITS command.

* **Sensor Orientation**.....Expressed as (3) or (4) 16-bit compressed values for Euler Angles (Azimuth, Elevation, Roll) or a 4-term Orientation Quaternion **Q(*w, x, y, z*)***, as configured by the UNITS command.

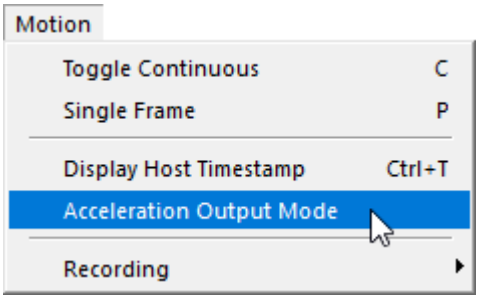
[***Note** order of Quaternion components: Scalar value ***w*** is output first.]

* **Sensor Acceleration**.....Expressed as (4) 16-bit compressed values for acceleration in X, Y, Z and magnitude.

Acceleration-mode P&O output is specified as an argument to the SINGLE_PNO and CONTINUOUS_PNO commands.

In VIPER™ Command Manager, to specify Acceleration-mode, select **Motion Menu→Acceleration Output Mode**.

Subsequent Single- or Continous-P&O output will reflect this selection.



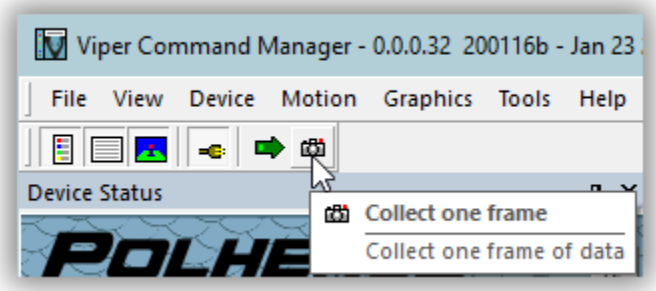
4.4.3 SINGLE PNO COMMAND

This command polls VIPER™ for a single frame of P&O data. VIPER™ emits a frame that includes P&O data from all connected Sensors, as summarized above in Section 4.4.1 or an Acceleration-Mode P&O frame as summarized in Section 4.4.2., depending on the P&O mode specified in the command arguments.

In VIPER™ Command Manager:
To collect a single frame of P&O data:
Click on in the toolbar,
or
Type the **p** keyboard shortcut anywhere on the app window.

VIPER Command Manager displays a Standard- or Acceleration-Mode P&O frame based on the Motion menu selection described above.

Scope: SEU



4.4.4 CONTINUOUS PNO COMMAND

This command starts or stops Continuous P&O data stream from VIPER™. When the system is in continuous mode, P&O frames are streamed continuously at the frame update rate specified by the FRAME RATE command.

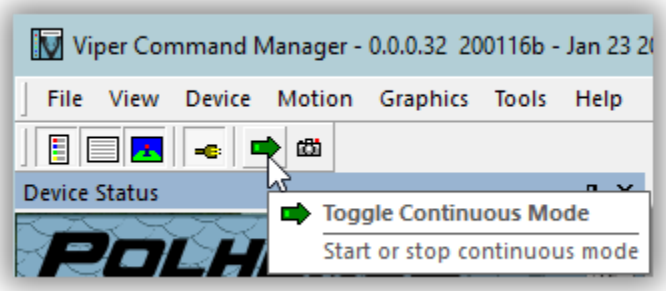
P&O data from all connected Sensors is output, as summarized in Section 4.4.1 or an Acceleration-Mode P&O frame as summarized in Section 4.4.2, depending on the P&O mode specified in the command arguments.

P&O frame count is reset to zero, left unchanged, or set to a custom value, depending on frame count specification in the command arguments. (When continuous data is started via VIPER Command Manager, frame count is always reset to zero.)

In VIPER™ Command Manager:
To start and stop continuous P&O data:
Click on in the toolbar,
or
Type the **c** keyboard shortcut anywhere on the app window.

VIPER Command Manager displays continuous Standard- or Acceleration-Mode P&O frames based on the Motion menu selection described above.

Scope: SEU



4.5 READ-ONLY COMMANDS

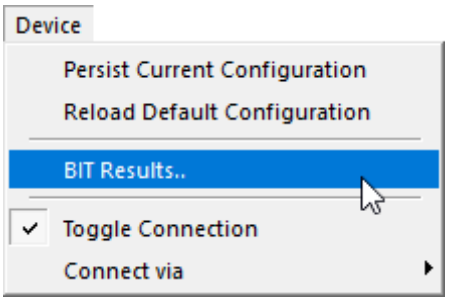
4.5.1 BIT RESULTS COMMAND

This command allows the user to read Built-In Test (BIT) results

This is a diagnostic command that allows the user to detect and determine the cause of VIPER™ internal system errors. If errors are detected a flag is placed in P&O output frame header. The BIT RESULTS command can be used to gather more information if this flag is output.

Details of BIT errors are described in Section 6.

In VIPER™ Command Manager, to display VIPER™ BIT RESULTS, select
Device Menu→BIT Results



Scope: SEU, Get Only

4.5.2 STATION MAP COMMAND

The purpose of this command is to report the detected Sensors and Sources connected to the system.

In VIPER™ Command Manager detected Sensor and Source counts are included in the SEU Who Am I display. See Section 4.5.4 below

4.5.3 DISTORTION MAP STATUS COMMAND

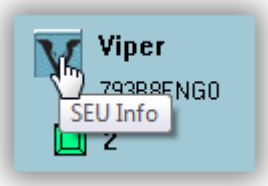
This command will return the name of the installed distortion map and can be used to erase it from VIPER™ memory.

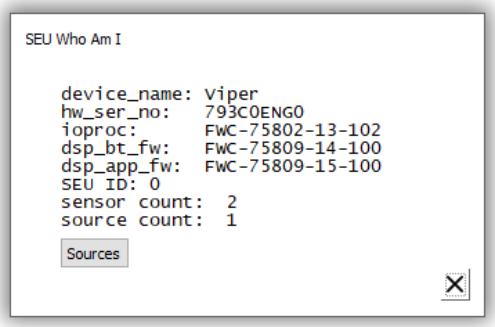
Note: As of initial release, user-installed maps are not yet functional.

4.5.4 WHO AM I COMMAND

This command returns basic identification and firmware version of VIPER™ system.

In VIPER™ Command Manager, to display VIPER™ Who Am I information, click on the VIPER™ SEU icon in the Status Pane.



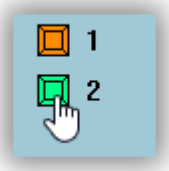


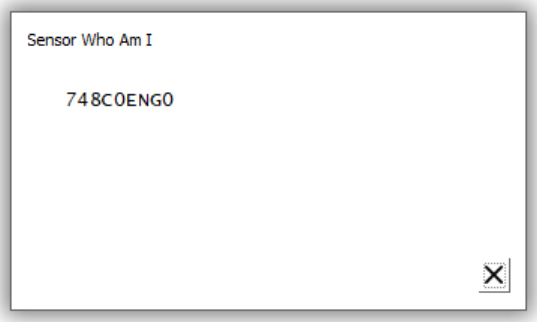
Scope: SEU, Get Only

4.5.5 SENSOR WHO AM I COMMAND

This command retrieves the Sensor serial number.

In VIPER™ Command Manager, to display Sensor Who Am I information, click a sensor icon in the Status Pane.



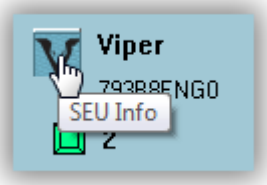


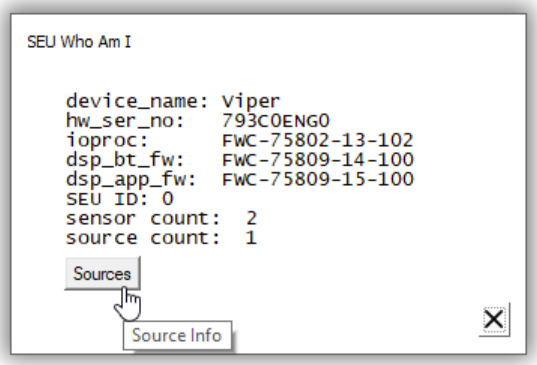
Scope: Sensor, Get Only

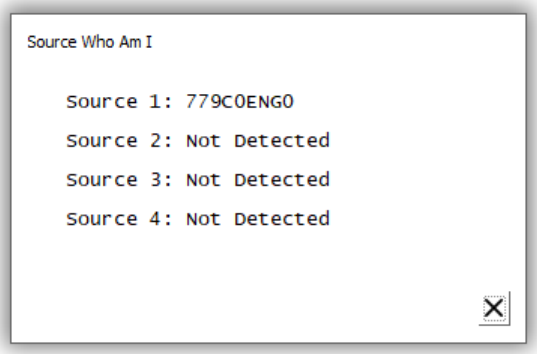
4.5.6 SOURCE WHO AM I COMMAND

This command retrieves a Source serial number.

In VIPER™ Command Manager, to display VIPER™ Who Am I information, click on the VIPER™ SEU icon in the Status Pane.
Then click on the Sources button.







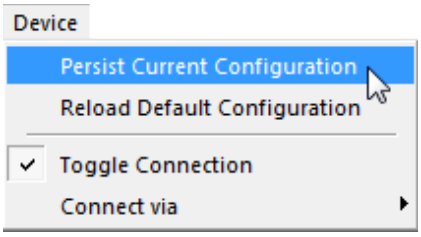
Scope: Source, Get Only

4.6 EXECUTIVE COMMANDS

4.6.1 PERSIST COMMAND

This command saves the current configuration settings to non-volatile FLASH. When VIPER™ reboots, the current settings persist. Only configuration settings marked "Persistent" can be saved. To restore VIPER™ to Factory Default Configuration, apply the BLOCK CONFIG RESET command prior to PERSIST.

In VIPER™ Command Manager, to persist current VIPER™ settings, select
Device Menu→Persist Current Configuration

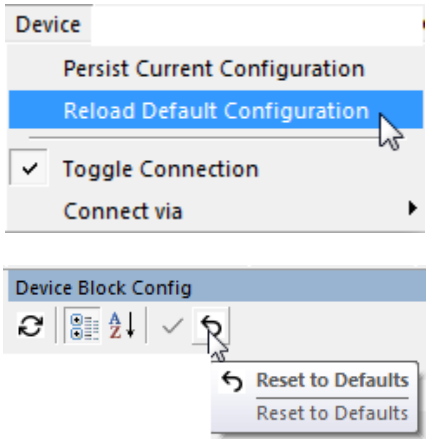


Scope: SEU

4.6.2 BLOCK CONFIG RESET COMMAND

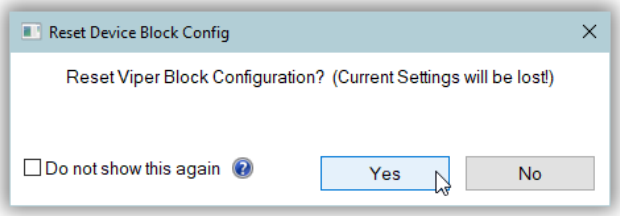
This command is used to RESET all VIPER™ configuration settings to Factory Defaults. To restore the VIPER™ to Factory Configuration, follow the BLOCK CONFIG RESET command with PERSIST.

In VIPER™ Command Manager, to reset VIPER™ to factory default configuration, select
Device Menu→Reload Default Configuration
or
Select ↩ in SEU Block Configuration panel toolbar.



Scope: SEU

When executing BLOCK CONFIG RESET and PERSIST commands in VIPER™ Command Manager, a challenge window will appear, as these operations may not be recoverable.



4.6.3 ENABLE DISTORTION MAP COMMAND

This command will enable or disable a Distortion map if one is installed.

Note: As of initial release, user-installed maps are not yet functional.

5. PRECAUTIONS

1. Using the VIPER™ Tracker in the vicinity of conductive metals may lead to errors in the accuracy of this product. The errors are caused by eddy current distortion. VIPER™ contains eddy current mitigation but there will still be some accuracy degradation in heavily distorted environments.
2. VIPER™ magnetic signals operate in a range of 10 kHz to 40 kHz. Operating in an environment of similar magnetic signals will cause interference. If interference does exist, VIPER™ can operate in multiple frequency bands to enable a user to attempt to operate in a band where there is no interference.
3. Do not operate another VIPER™ Source within 7 meters of a same frequency Source as this could cause interference.
4. Do not place Sensors in close range of un-configured Source(s) to avoid transient tracking degradation. See warning note in Section 4.2.14.1 "SOURCE SELECT command."
5. See BIT ERRORS in Section 6.

6. BIT ERRORS

This section explains the Built-In Test (BIT) error codes that the VIPER™ may return in response to the BIT RESULTS command or in response to any other command if the tracker cannot operate with the reported error condition.

> ***Note***: These error codes indicate a malfunction in VIPER™ system hardware or firmware, or in a system component that may result in inaccurate measurements.

Code	Displayed Message	Definition	Actions to Take
00	**No Error**	System startup and self-test success.	
01	**SENSOR Error**	A problem with a Sensor has been detected.	• Try a different Sensor to see if the error is cleared. • Contact Polhemus Technical Support.
02	**SENSOR PORT Error**	A problem with an SEU Sensor PORT has been detected.	• Move Sensor to a different port to see if the error clears. • Contact Polhemus Technical Support.
03	**SOURCE Error**	A problem with a Source and/or SEU Source PORT has been detected.	• Try a different Source. • Try a different Source Port. • Contact Polhemus Technical Support.
04	**SEU Error**	A problem with SEU hardware or firmware has been detected.	• Contact Polhemus Technical Support.
05	**Duplicate Source Frequencies**	Two or more Sources operating at the same EM frequency are plugged into the SEU.	• Unplug the duplicate frequency Source(s). • Replace with a Source of a different frequency. • Power-cycle VIPER™ or Soft Reset.

7. EXPLANATION OF SYMBOLS

Lot/Batch Number

Serial Number

Part Number

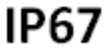

Manufacturer


Conforms with the Medical Device Directive (93/42/EEC)


Type BF Applied Part


Consult Instructions for Use


Caution



Dust Tight/water immersion 1 meter 30 min

Not protected against harmful effects of water


More Information


Helpful tip

APPENDIX A. TERMS & ACRONYMS

Alignment Obtaining congruence between the axes of the VIPER™ system and the axes of the application. The process whereby the VIPER™ system coordinate reference is brought into coincidence, either physically or mathematically, with other coordinates of the environment.

Alignment Frame The reference frame in which the position and orientation of the Sensor is measured. The default alignment frame is the Source frame.

API Application Programming Interface. Programming library used to develop custom host software for driving the instrument. Sometimes used interchangeably with "SDK."

ASCII American national Standard Code for Information Interchange defines a certain 8-bit code for display and control characters.

Attitude See Orientation.

Attitude Matrix A three-by-three matrix containing the direction cosines of the sensor's X axis in column one, the direction cosines of the sensor's Y axis in column two, and the direction cosines of the sensor's Z axis in column three. The order of the Euler angle rotation sequence is azimuth, elevation, and roll.

X Direction Cosines	Y Direction Cosines	Z Direction Cosines
CA*CE	CA*SE*SR - SA*CR	CA*SE*CR + SA*SR
SA*CE	CA*CR + SA*SE*SR	SA*SE*CR – CA*SR
-SE	CE*SR	CE*CR

Where:

CA = Cos (azimuth)
CE = Cos (elevation)
CR = Cos (roll)
SA = Sin (azimuth)
SE = Sin (elevation)
SR = Sin (roll)

Auto-Hemisphere Tracking With FT Sensor technology, VIPER™ is able to automatically detect and track the operating Hemisphere of an FT Sensor.

Azimuth The coordinate of orientation tracking in the horizontal plane. Azimuth is a rotation around the Z (vertical) axis, where an increase in the angle is clockwise when viewed in the positive direction along this axis. Note, in Polhemus' default frame of reference, the +Z axis points down, with +X pointing forward and +Y pointing to the right. The term "yaw" is often substituted for azimuth, especially in the context of flight.

Baud Rate The signaling rate on a serial line. For example, to convey an 8-bit byte normally requires at least two additional bit times, a start bit and a stop bit so that synchronization is possible without a separate clocking line. For example, such an arrangement implies for a 115200 baud rate conveyance of data at a 115200*8/10 = 92,160 bit rate.

Benign Environment A tracking environment free of the need for special calibration or compensation brought on by the unique features of a particular installation and its environment (e.g. high light levels for optical tracking, high sound levels for sonic tracking, or high metallic distortion for magnetic tracking). If not otherwise noted, all measurements and statements pertaining to VIPER™ performance shall be regarded as occurring in such a benign environment.

BIT Built-In Test features in the VIPER™ system firmware monitor the status and health of the VIPER™ system and flag certain preset conditions; not to be confused with "bit," a contraction of "binary digit."

Boresight Any procedure that rotates the Sensor frame so as to precisely align the Sensor to the designated reference frame.

In a VIPER™ system context, the term usually refers to the system software routine that, on command, performs a coordinate rotation, which effectively aligns the Sensor frame to a predefined boresight reference orientation, e.g. the Source reference frame.

Cartesian Coordinates In three dimensions, three numbers that indicate the location of a point relative to a fixed reference point (the origin), being the shortest (perpendicular) distances from three fixed and orthogonal axes which intersect at the origin.

Degree A measurement of a plane angle, defined so that a full rotation is 360 degrees. A full rotation equals 2π radians; therefore, one degree is equivalent to π/180 radians. See also Radians and Orientation Angles.

Digitizer A special Sensor, shaped like a pen or Stylus, used for recording the X, Y, Z coordinates of an object; easily captures data points in hard to reach places; requires no mechanical arm or optical markers.

Direction Cosines The cosines of the angles between the Sensor's x, y, z axes and the X, Y, Z axes of the measurement reference (alignment) frame.

Elevation Coordinate of orientation tracking in the vertical plane where an increase in the angle is upward from the horizontal. Elevation is a rotation around the Y (horizontal) axis, where an increase in the angle is clockwise when viewed in the positive direction along this axis. Note, in Polhemus' default frame of reference, the +Y axis points to the right, with +X pointing forward and +Z pointing down. The term "pitch" is often substituted for azimuth, especially in the context of flight.

EM Field Electromagnetic Field**.** An EM field is a combination of an electric field (created by changes in voltage) and a magnetic field (created by flow of electric current).

Euler Angles See Orientation Angles.

Factory Defaults The values assigned to certain system variables by the factory. Stored in non-volatile memory, they are used to reinitialize the variables if configuration information is lost.

Firmware Term used to describe the software programmed into VIPER™ non-volatile memory.

Frame of Reference Also called a reference frame. In 3 dimensions, 3+1 reference points are sufficient to fully define a reference frame. Using Cartesian coordinates, a reference frame may be defined with a reference point at the origin and a reference point at one unit distance along each of the 3 coordinate axes. When a standard Polhemus Source serves as the reference, the origin is at the EM center of the Source and the positive X, Y, and Z axes extend forward, right, and down from the EM center.

Hemisphere The symmetry of the magnetic fields generated by the Source creates two mathematical solutions to each set of Sensor data processed. Therefore, only half of the total spatial sphere surrounding the Source is practically used at any one time without ambiguity in the X, Y, Z measurements (usually sign flips). This half sphere is referred to as the "current hemisphere."

When configuring Hemisphere, the selected hemisphere is defined by a LOS (line-of-sight) vector from the source through a point at the zenith of the hemisphere, and is specified by the direction cosines of the chosen LOS vector. See also Hemisphere Tracking and Auto-Hemisphere Tracking definitions. See Appendix B.

Hemisphere Tracking A feature in which the Polhemus tracker continuously modifies the operating Hemisphere, allowing full tracking coverage around all sides of the Source. Note that the Sensor must be in a known, valid Hemisphere before engaging Hemisphere Tracking.

Host Any modern computer device capable of supporting an RS-422 interface or the high speed USB 2.0 interface and capable of bi-directional data transmission.

I/O latency The interval of time needed by the host computer to transfer data from the VIPER™ system into the host application.

Lag

The interval of time between requesting a VIPER™ system data point and receiving it into the host computer.

Latency

The interval of time between when measurement data were collected and when the P&O result is ready for transfer to the host computer.

Local Source

The Source that is local to a given Sensor is determined by where the Source connector is plugged into the SEU. The Local Source is the Source that is detected in the Source Port at the same board level as the Sensor. The green arrows in the diagram at right show the location of the local Source Port for each group of 4 sensors. By default, Sensors report P&O with respect to the Local Source or the Nearest Source detected on a lower numbered Source Port if none is detected in the local Source port. See also Nearest Source definition.

Motion Tracking Area

Also called the *Motion Box* or *Tracking Volume*. The volume in which motion tracking is specified to perform as prescribed. Although this 3D volume usually is cubical in nature, many of the tracking technologies known as 'active' are dependent on a source of stimulation (e.g., magnetic field, light source) which actually performs equally well at a constant radius from the Source so that the "box" actually might be better described as spherical or hemispherical.

Nearest Source

The Local Source, or if no Local Source is detected, then the first Source detected on a lower numbered Source Port**.** The yellow arrows in the diagram at right show the location of the Nearest Source for the top two groups of 4 sensors. By default, Sensors report P&O with respect to the Local Source or the Nearest Source detected on a lower numbered Source Port if none is detected in the local Source port. See also Local Source definition.

NIST-traceable

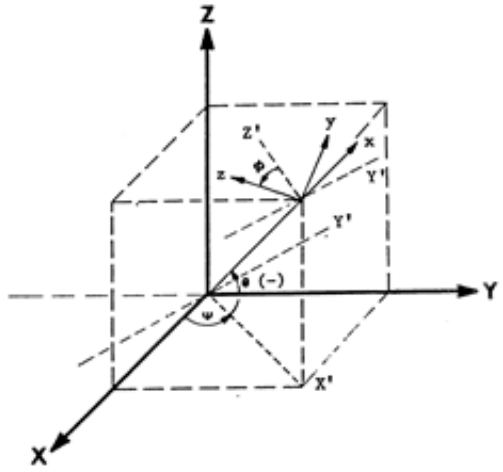
NIST traceable calibration is an assurance program that certifies that a manufacturer is fully equipped to calibrate equipment to National Institute of Standards and Technology (NIST) standards and that any products offered by that manufacturer will match those NIST-maintained measurement standards. With NIST traceable calibration, Polhemus' calibration fixturing has an unbroken chain of measurements that leads back to NIST maintained standards.

Orientation

The imaginary rotation that is needed to move an object from a reference placement to its current placement. Orientation is given relative to a frame of reference specified by a Cartesian coordinate system. Also known as Attitude.

Orientation Angles

The azimuth, elevation, and roll angles that define the current orientation of the Sensor coordinate frame with respect to the designated tracking system reference frame. Euler angles may be specified in degrees or radians.



Legend

X, Y, Z	= Alignment (Reference) Frame
x, y, z	= Rotated Stylus or Sensor Coordinate
Ψ	= Azimuth
θ	= Elevation
ϕ	= Roll

The Euler angle coordinates that are output by VIPER™ as one measure of Sensor orientation are graphically defined in the figure below. Here, the x, y, z and X, Y, Z tri-axis arrays represent independent, three-dimensional orthogonal coordinate frames. The x, y, z triad represents the Sensor frame in its current orientation state. The X, Y, Z triad represents the reference frame against which the relative orientation of the Sensor frame is measured. By definition, the X, Y, Z frame also represents the zero-orientation reference state of the Sensor frame.

The Euler angles azimuth, elevation and roll, are designated ψ, θ, and ϕ. These angles represent an azimuth-primary sequence of frame rotations that define the current orientation of the Sensor with respect to its zero-orientation state. The defining rotation sequence is an azimuth rotation followed by an elevation rotation followed by a roll rotation.

The azimuth angle ψ is defined in the figure as a rotation of the X and Y reference axes about the Z reference axis. The transition axes labeled X' and Y' represent the orientation of the X and Y axes after the azimuth rotation.

The elevation angle θ is defined as a rotation of the Z reference axis and the X' transition axis about the Y' transition axis. The transition axis labeled Z' represents the orientation of the Z reference axis after the elevation rotation. The current x-axis of the current Sensor frame represents the orientation of the X' transition axis after the elevation rotation.

Last, the roll angle ϕ is defined as a rotation of the Y' and Z' transition axes about the x-axis of the Sensor frame. The y and z-axes of the current Sensor frame represent the orientation of the Y' and Z' transition axes after the roll rotation.

In the diagram above, the azimuth, elevation and roll rotations are positive, negative and positive respectively.

Output List A list of the data items included in a data record.

Parity In serial communication, a parity bit may be added to each transmitted byte to check whether corruption has occurred. Serial port configuration may set parity to None, Even, or Odd. During transmission, the sender calculates the parity bit and sends it. The receiver calculates parity and compares the result to the parity bit received.

Persistent Setting Tracker settings that may be stored in VIPER™ flash memory so that they will *persist* through power-cycle or soft reset. (These settings are not automatically persisted, however. A PERSIST operation must be performed to store the settings to flash.)

P&O Acronym for position and orientation, the six pieces of data needed to fully describe tracking of an object in 3D space. Some tracking devices, by virtue of their principle of

operation, can produce only position or only orientation whereas others can produce both P&O (although the user usually can opt for only those parameters desired).

PNO — See P&O.

Position — The (X, Y, Z) Cartesian coordinates of position tracking where normally +X is in the forward direction; +Y is in the right hand direction; and +Z is downward.

Pitch — See Elevation.

Quaternion — Also called Orientation Quaternion or Attitude Quaternion. A four-parameter mathematical notation for representing orientations and rotations of objects in three dimensions. Compared to Euler angles they are simpler to compose and avoid the problem of gimbal lock. Compared to rotation matrices they are more compact, more numerically stable, and more efficient. Typically represented in the form $q = q_0 + iq_1 + jq_2 + kq_3$, a quaternion contains a vector and a scalar. In this form, q_0 is the scalar part and $(iq_1 + jq_2 + kq_3)$ is the vector part. In Polhemus' notation, quaternion parameters ($q_{0\text{-}3}$) are sometimes referred to as (*w, x, y, z*). The quaternion can be used to represent the Sensor's orientation without the need for trigonometric functions. Note that Polhemus trackers output quaternion with the scaler value *w* first, followed by the vector coords *x, y, z*.

The attitude matrix output from VIPER™ can be equivalently represented by the following matrix using quaternions:

X Directional Cosines	Y Directional Cosines	Z Directional Cosines
$q_0^2 + q_1^2 - q_2^2 - q_3^2$	$2(q_1q_2 - q_0q_3)$	$2(q_1q_3 + q_0q_2)$
$2(q_3q_0 + q_1q_2)$	$q_0^2 - q_1^2 + q_2^2 - q_3^2$	$2(q_2q_3 - q_0q_1)$
$2(q_1q_3 - q_0q_2)$	$2(q_1q_0 + q_3q_2)$	$q_0^2 - q_1^2 - q_2^2 + q_3^2$

Radian — The SI (Système international) unit for measuring angles. An arc of a circle with the same length as the radius of that circle subtends an angle of 1 radian. The circumference subtends an angle of 2π radians. More generally, the magnitude in radians of the subtended angle is expressed as $\vartheta = s/r$, where s is the arc length and r is the radius. See also Degree and Orientation Angles.

Reset Button — System reset switch; does not cycle power but does a soft-reboot of VIPER™ SEU.

Response — The interval of time between a request to the VIPER™ system to collect a data point and when that data is available for input from the VIPER™ system.

Roll — Coordinate of orientation tracking. Roll is a rotation around the X (horizontal forward/aft) axis, where an increase in the angle is clockwise when viewed in the positive direction along this axis. Note, in Polhemus' default frame of reference, the +X axis points forward, with +Y pointing to the right and +Z pointing down.

SDK	Software Development Kit; software development toolset available for VIPER™-based trackers, consisting of programming libraries, help files, and sample code. SDK is sometimes referred to as "API," although API refers specifically to the programming libraries used to interface with the instrument.
SEU	System Electronics Unit. The main electronics unit of the tracking system to which Sensors and Source may be connected.
Sensor	The Sensor measures the magnetic field generated by the Source. The Sensor is used to track both the position and orientation of the object to which it is attached, relative to the measurement reference frame.
Source	The Source generates the magnetic field measured by the Sensor. The Source's X, Y, and Z-axes are the default measurement reference frame.
Stylus	A pencil-shaped housing for the Sensor with an integral switch used by the operator to indicate and/or select points to be digitized.
Sync	Shorthand for synchronization. For example, "sync signal."
Units	The unit of assumed Position and Orientation. VIPER™ outputs Position data in inches, feet, centimeters or meters. Orientation is output as Euler angles in degrees or radians, or Quaternion.
Update Rate	The rate at which P&O data is output from the VIPER™ system. Usually expressed as frames per second (fps) or Hertz (Hz).
Useful Range	The operating distance (Sensor to Source) at which the resolution and noise performance of the VIPER™ system can be realized.
User Defaults	The values assigned to certain system variables by the user. Stored in non-volatile memory, the system receives these variable values at power-up.
VPcmdMgr	VIPER™ Command Manager application.
XYZ or X, Y, Z	The Cartesian coordinates of position tracking where normally +X is in the forward direction; +Y is in the right hand direction; and +Z is downward.
XYZAER	The output string of data reporting the position, XYZ, and orientation, AER – azimuth, elevation and roll – of the tracking Sensor.

Yaw	Same as azimuth.

APPENDIX B. SOURCE HEMISPHERES

> If the application requires the Sensor(s) to move back and forth to different sides of the Source, Hemisphere Tracking or Auto-Hemisphere must be enabled with the HEMISPHERE command.

When the VIPER™ system is started, Sensors track by detecting the presence of the electromagnetic (EM) field produced by one or more Sources in the tracking area.

The field emitted by the Source is a symmetrical dipole field. That means that when it is detected from any direction, the detected field is identical to the field emitted in the opposite direction. For that reason, the VIPER™ Sensor cannot initially distinguish the direction from which it initially detects the Source; it needs to be told at startup, using the HEMISPHERE command or via Auto-Hemisphere.

Source hemispheres are described by the Cartesian axes with origin at the center of the Source. Figure 22 below depicts the location of the +/- X, Y, Z sides of the standard Source.

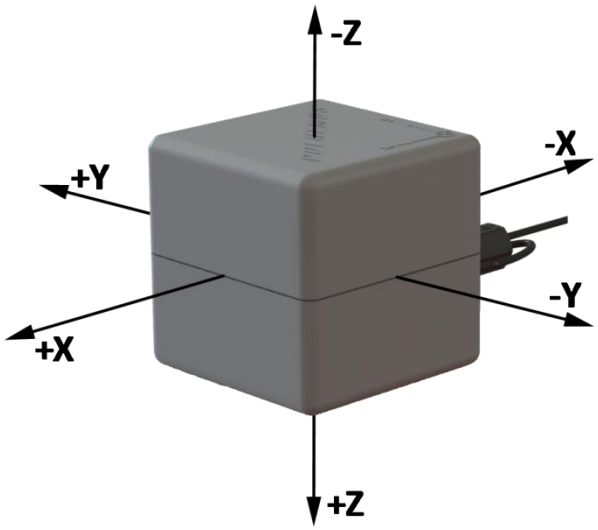


FIGURE 22. SOURCE HEMISPHERES

Unless configured otherwise, VIPER™ assumes that all Sensors will detect the Source(s) from the +X direction. That is, the Sensors are assumed to operate in the "plus X" hemisphere. **The default hemisphere setting is +X for all Sensors.** It is for this reason that the Getting Started section advises the novice user to position the Sensor on the +X side of the Source.

When the correct hemisphere is not established, the Sensors' position coordinates output will frequently have the wrong sign.

> Incorrect hemisphere setting or operation is the number one cause of sign errors in the position data.

Once correct hemisphere is established, it is usually a good idea to enable Hemisphere Tracking. When Hemisphere Tracking is enabled, VIPER™ automatically maintains correct hemisphere even if the Sensor is passed to the opposite side of the Source.

APPENDIX C. SENSOR AND SOURCE DIMENSIONS

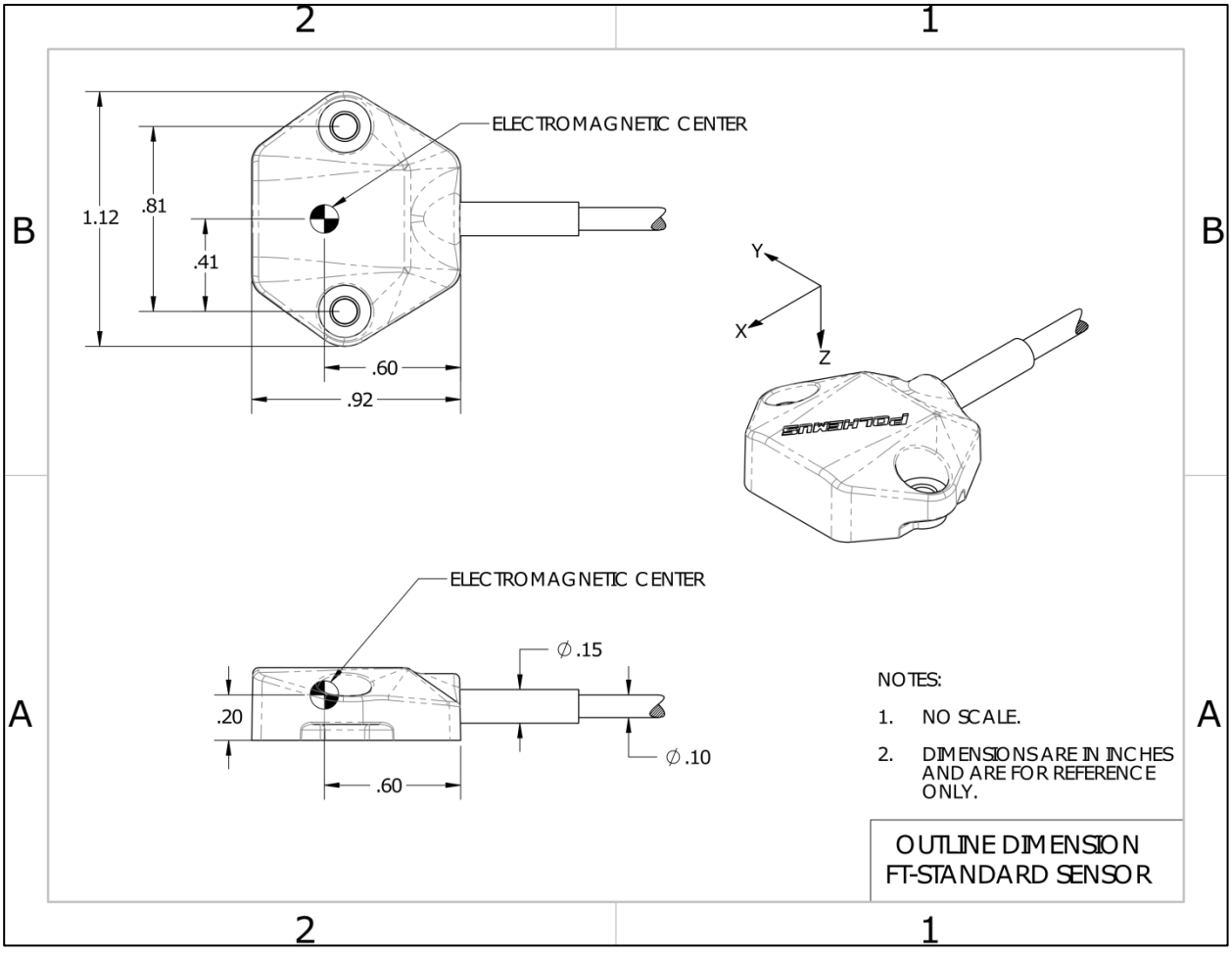


FIGURE 23. OUTLINE DIMENSIONS (APPROX.), VIPER™ FT-STANDARD SENSOR

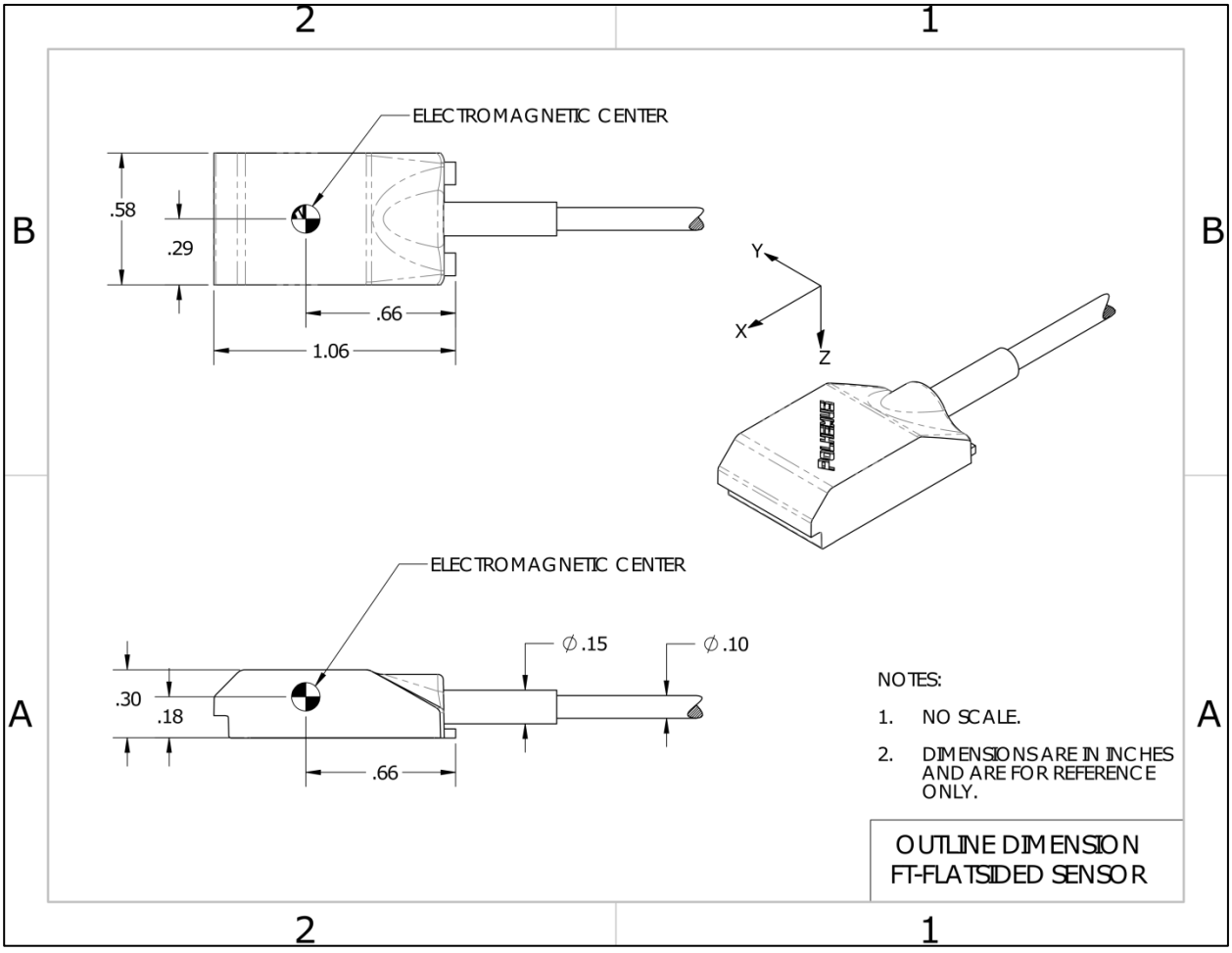


FIGURE 24. OUTLINE DIMENSIONS (APPROX.), VIPER™ FT-FLATSIDED SENSOR

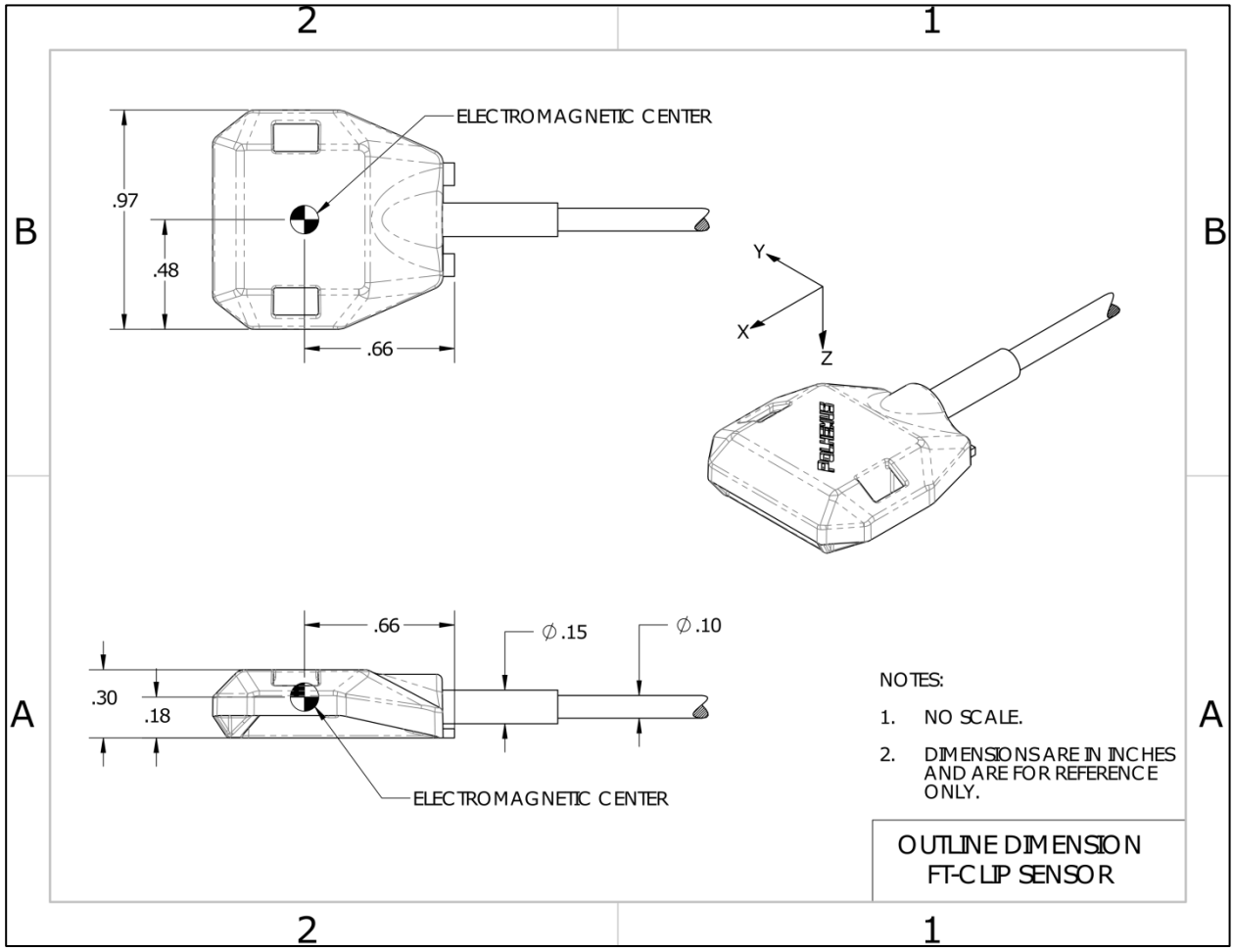


FIGURE 25. OUTLINE DIMENSIONS (APPROX.), VIPER™ FT-CLIP SENSOR

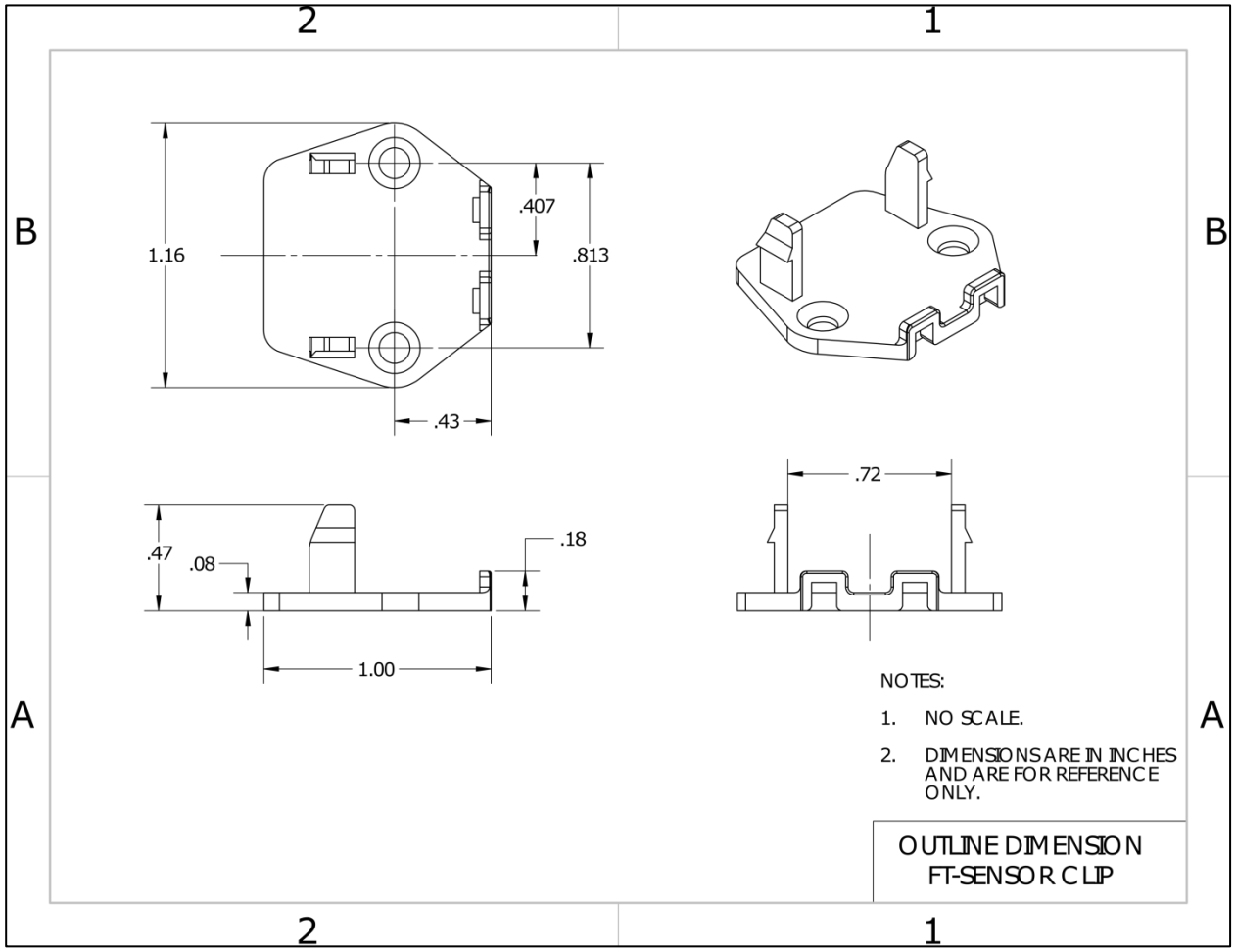


FIGURE 26. OUTLINE DIMENSIONS (APPROX.), VIPER™ FT SENSOR CLIP

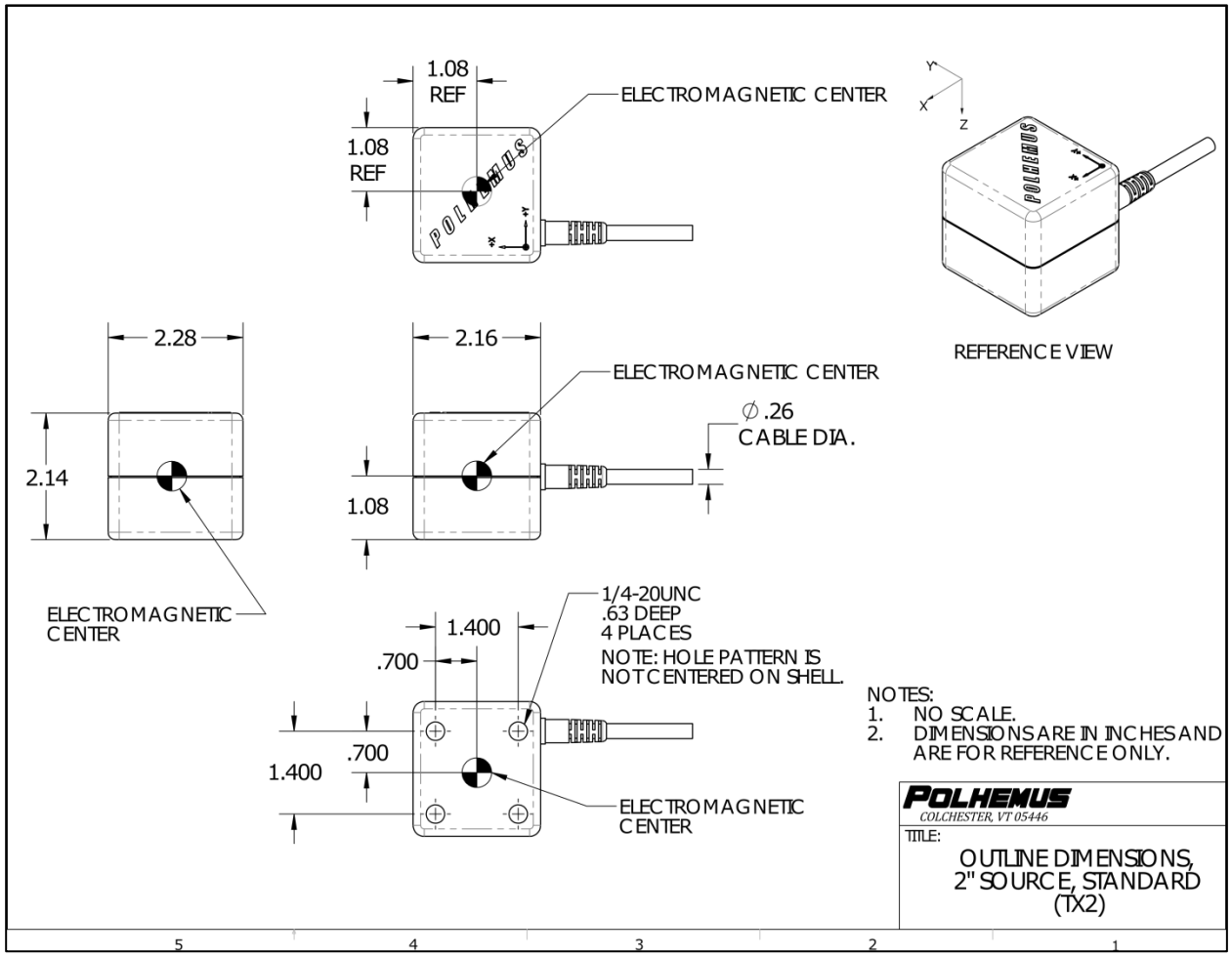


FIGURE 27. OUTLINE DIMENSIONS (APPROX.), TX2 STANDARD SOURCE

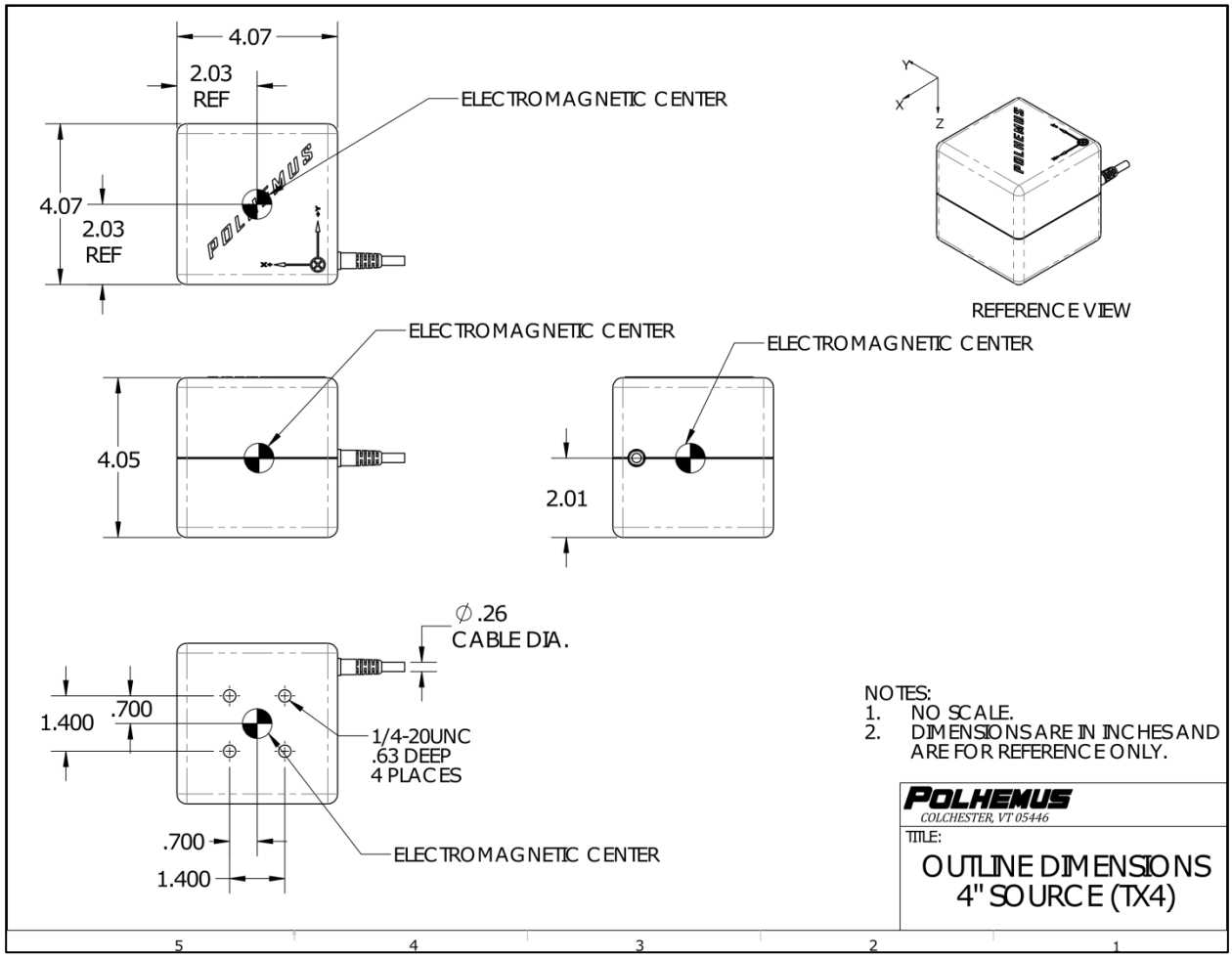


FIGURE 28. OUTLINE DIMENSIONS (APPROX.), TX4 SOURCE

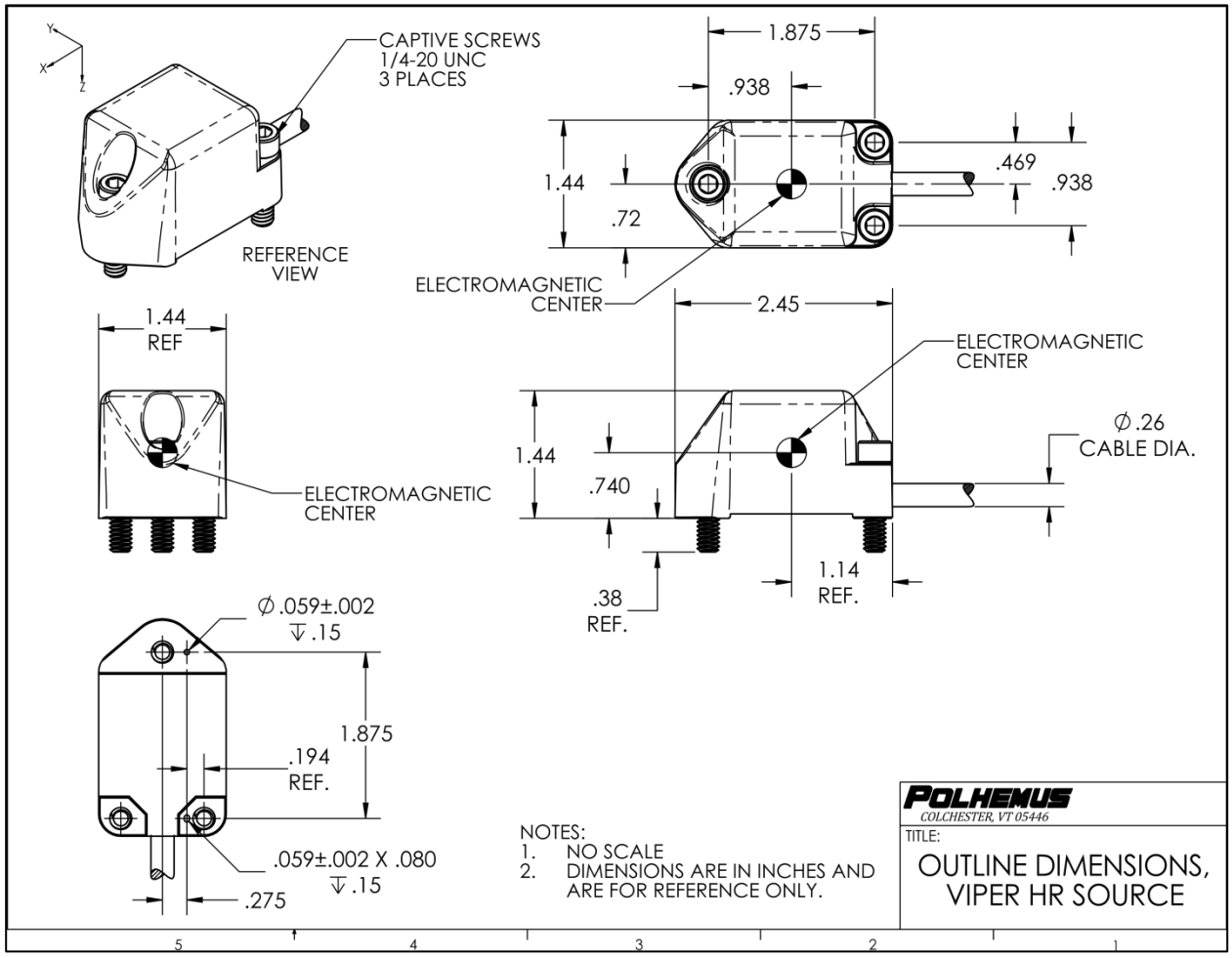


FIGURE 29. OUTLINE DIMENSIONS (APPROX.), VIPER™ HR SOURCE

APPENDIX D. LIMITED WARRANTY AND LIMITATION OF LIABILITY

Polhemus warrants that the Product shall be free from defects in material and workmanship for a period of two years from the date of Polhemus' delivery to the Buyer, or two years and 30 days from the date Polhemus shipped Product to an authorized reseller, whichever occurs first, with the exception of all Sensors which have a warranty period of one year against material defects. Polhemus shall, upon notification within the warranty period, correct such defects by repair or replacement with a like serviceable item at Polhemus' option. This warranty shall be considered void if the Product is operated other than in accordance with the instructions in Polhemus' User Manual or is damaged by accident or mishandling. Parts or material which are disposable or expendable or subject to normal wear beyond usefulness within the warranty period such as lamps, fuses, etc., are not covered by this warranty.

In the event any Product or portion thereof is defective, Buyer shall promptly, and within the warranty period, notify Polhemus in writing of the nature of the defect and return the defective parts to Polhemus at the direction of Polhemus' Customer Service representative. Upon determination by Polhemus that the parts or Products are defective and covered by the warranty set forth above, Polhemus, at its option shall repair or replace the same without cost to Buyer. Buyer shall be responsible for any import/export duties/tariffs and pay all charges for transportation and delivery costs to Polhemus' factory for defective parts where directed to be sent to Polhemus, and Polhemus shall pay for transportation costs to Buyer's facility only for warranty replacement parts and Products. Removed parts covered by claims under this warranty shall become the property of Polhemus.

In the event that allegedly defective parts are found not to be defective, or not covered by warranty, Buyer agrees that Polhemus may invoice Buyer for all reasonable expenses incurred in inspecting, testing, repairing and returning the Products and that Buyer will pay such costs on being invoiced therefor. Buyer shall bear the risk of loss or damage during transit in all cases.

Any repaired or replaced part or Product shall be warranted for the remaining period of the original warranty or thirty (30) days, whichever is longer.

Warranties shall not apply to any Products which have been:

- repaired or altered other than by Polhemus, except when so authorized in writing by Polhemus; or
- used in an unauthorized or improper manner, or without following normal operating procedures; or
- improperly maintained and where such activities, in Polhemus' sole judgment, have adversely affected the Products. Neither shall warranties apply in the case of damage through accidents or acts of nature such as flood, earthquake, lightning, tornado, typhoon, power surge(s) or failure(s), environmental extremes or other external causes. Warranties shall not apply to any Products if the Products are defective because of normal wear and tear; or
- used for any purpose without obtaining any applicable regulatory approvals.

POLHEMUS DOES NOT WARRANT AND SPECIFICALLY DISCLAIMS THE WARRANTY OF MERCHANTABILITY OF THE PRODUCTS OR THE WARRANTY OF FITNESS OF THE PRODUCTS FOR ANY PARTICULAR PURPOSE. POLHEMUS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, EXCEPT OF TITLE AND AGAINST PATENT INFRINGEMENT, OTHER THAN THOSE SPECIFICALLY SET FORTH HEREIN.

IN NO EVENT SHALL POLHEMUS BE LIABLE UNDER ANY CIRCUMSTANCES FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO LOSS OF PROFITS OR REVENUE. WITHOUT LIMITING THE FOREGOING POLHEMUS'S MAXIMUM LIABILITY FOR DAMAGES FOR ANY CAUSE WHATSOEVER, EXCLUSIVE OF CLAIMS FOR PATENT INFRINGEMENT AND REGARDLESS OF THE FORM OF THE ACTION (INCLUDING BUT NOT LIMITED TO CONTRACT NEGLIGENCE OR STRICT LIABILITY) SHALL BE LIMITED TO BUYER'S ACTUAL DIRECT DAMAGES, NOT TO EXCEED THE PRICE OF THE GOODS UPON WHICH SUCH LIABILITY IS BASED.

APPENDIX E. CUSTOMER SERVICE

If problems are encountered with the VIPER™ or if you are having difficulty understanding how the commands work, help is just a telephone call away.

Call Polhemus at the numbers listed below and select "2" for Customer Service and then "1" for Technical Support. Polhemus is open Monday through Friday, 8:00 AM to 5:00 PM, Eastern Standard Time (US). For the most part, our customer service representatives are usually able to solve problems over the telephone and get you back into the fast lane right away.

Help is also available on our web page at https://polhemus.com/support/technical-support/. Select techsupport@polhemus.com to send us an email describing the problem or question.

If a problem requires repair of your system, the customer service representative will issue a Return Merchandise Authorization (RMA) number and you may then return the system to the factory. ***Do not return any equipment without first obtaining an RMA number.*** Please retain and use the original shipping container, if possible, to avoid transportation damages (for which you or your shipper would be liable). If your system is still under warranty, Polhemus will repair it free of charge according to the provisions of the warranty as stated in Appendix D of this document. The proper return address is:

Polhemus RRL : RMA #_____
40 Hercules Drive
PO Box 560
Colchester, VT 05446-0560
USA

From within the U.S. and Canada: (800) 357-4777
From outside the U.S. or Canada: (802) 655-3159