

Sarnicola Simulation Systems, Inc.

BACKGROUND INFORMATION

for the

HexadUSB Six-Channel Motion Controller

Sarnicola Simulation Systems, Inc.
PO Box 480
970 Conklin Rd.
Conklin, NY 13748 USA
(607)724-4021

Rev Draft.1 29 Oct 2002

1.0 INTRODUCTION

The Sarnicola Simulation Systems product line includes a variety of three and six degree-of-freedom motion platforms suitable for a wide range of equipment test and simulation applications. Each of these platforms is based on a particular type of extensible leg. For example, the Hexad series uses six hydraulic cylinders while the Triad series uses three folding Sarnicola legs. The state of the platform--its centroid position and deck orientation--are determined entirely by the extensions of the platform legs. Consequently, most applications require smooth, rapid, and precise control of leg extension under realtime computer control.

The Sarnicola approach to this challenge has been to provide an analog servo controller for each leg with the controller interfaced to the host computer. A position sensor (usually a potentiometer) integrated into each leg provides a position feedback signal, while the computer provides a position command signal. A second-order position servo uses these signals to command a power amplifier that in turn controls the hydraulic valve or motor amplifier on its associated leg. The computer software commands the required leg extension, and the controller sees to it that the leg goes there smoothly and accurately.

The original controller configuration--developed in the early nineties-- included a third-party digital-to-analog (DAC) card that plugged into the computer's ISA bus, together with a proprietary companion card that included six analog servo controllers and drive amplifiers. Although this design has worked very well, the ISA bus has become obsolete, modern computers often do not provide enough space for two full-length cards, and customers have requested a more flexible solution. Consequently, SSS now offers two standard controller designs, both fully external to the computer.

- The *TriadPPI Controller* is a low-cost, three-channel controller that interfaces to the host computer by way of its parallel printer port. It is intended primarily for entertainment three-degree-of-freedom applications.
- The *HexadUSB Controller* is a more advanced design that includes six channels of position control, an emergency stop feature, sixteen bits of digital input, sixteen bits of digital output, and six channels of digital leg position data. It interfaces to the host computer by way of the Universal Serial Bus (USB), thus making it compatible with essentially all modern computers and operating systems.

This document describes the HexadUSB Motion Controller and its applications.

2.0 GENERAL DESCRIPTION AND FEATURES

Packaging. ABS plastic case. 3.2 x 10.1 x 7.5 (HxWxD). Custom packaging (eg, rackmount) is available.

Power. 100-120 V, 50-60 Hz, 0.3 A

Controls. None. (All control is handled by the host computer.)

Indicators. E-Stop/Ready LED.

Connectors. USB-B Jack for host computer interface.

DB-25S for interface to platform.

DB-25S for Digital Output (16 bits TTL, +5VDC power out)

DB-25S for Digital Input (16 bits TTL, +5VDC, ± 12 VDC power out.) and E-Stop

AC power cord

3.0 CONTROL SOFTWARE

The HexadUSB Motion Controller uses a USB interface to the host computer so it is compatible with any operating system that supports USB. A driver is provided for Windows 98, NT, or 2000. Since the controller uses a hardware servo system, no computer resources or software need to be devoted to the actual control algorithm. The user software simply commands the desired leg extension for each leg in the form of an integer value that is proportional to the position feedback voltage corresponding to the desired leg extension.

User software must compute the desired leg extension. SSS provides application software for all its motion control products, and can prepare custom software for other HexadUSB applications. For customers who prefer to prepare their own software, SSS provides an Application Programming Interface (API) in the form of a dynamic linked library (.dll) file that includes a function which accepts the desired leg extension as an argument. [Currently in development.] The API also provides utility functions for

- Reading the sixteen digital input lines
- Writing to the sixteen digital output lines
- Logging leg extension data from the six leg extension sensors
- Simplifying the control of standard motion platform configurations (the “hexapod” or “Stewart” configurations, for example.)

Each SSS motion platform is shipped with a test program called HexTest, described in section 3.1 below.

3.1 The HexTest Software Package

Each SSS HexUSB controller package includes HexTest, a general-purpose control software package suitable for general system setup and test, as well as for a variety of demonstration and test applications. The software allows straightforward system setup and performance evaluation, and provides a sophisticated sum-of-sines profile generator that is useful in system demonstrations and in many equipment testing applications. Specific features include

- Convenient, mouse-oriented user interface.

- Real-time graphical depiction of platform state.
- HPU interface control
- Manual control of each axis independently.
- Full control of the position and orientation of the center-of-rotation coordinate system.
- Automatic logging of both commanded and actual leg extensions.
- Standard test profile generation.
- Custom test profile generation using a 30-term sum-of-sines with full control of amplitude, frequency and phase of each term in all six degrees of freedom.

3.2 Programming

SSS provides a Windows-compatible dynamic linked library (.dll) to assist users in developing specialized applications programs. Details will be provided with the product. [This product is currently in development.]

3.3 Custom Software Applications

SSS provides complete support for customer software requirements from providing consulting on customer software development efforts to providing turnkey applications prepared to customer requirements. Previous applications have involved

- Automated system qualification testing feature.
- Sea-state motion profiles for seaborne equipment testing.
- Interface to military flight simulators.
- Complete entertainment simulation systems.
- Automated test data logging, data reduction and display features.
- Custom host interfaces including RS-232, RS-422, and parallel data bus, and using various protocols and conventions.

4.0 CONTROL HARDWARE

The HexUSB control system produces the required attitude of the motion platform by individually controlling the lengths of its six legs. The software computes the required leg lengths and transmits them as commands to the controller via USB. The controller, in its turn, implements a second-order control system which commands the servo valve on each leg to open until the leg reaches its commanded extension. Each leg is equipped with a linear potentiometer which measures leg extension and completes the servo loop by transmitting the leg length signal back to the controller.

4.1 System Configuration

The overall hardware system configuration of a Hexad application depends strongly on customer requirements. In a typical large-scale simulator implementation, the HexUSB controller would connect via USB to a ‘Motion Control Computer’ supplied by SSS. The Motion Control Computer would provide all the immediate software support for standalone operation and system testing, but

during actual simulator operation it would interface to the simulation Host Computer to receive realtime motion state data. In addition, the Motion Control Computer would also interpret digital data from the HexUSB controller DIO lines and pass that information to the Host system. For example, the controller may be monitoring and controlling HPU performance and operational status, or an array of safety sensors and interlocks. (In this configuration, the HexUSB Controller and the Motion Computer completely replaces the “Motion Control Cabinet” found on many older flight simulator motion systems.)

In a simple entertainment simulator, or an engineering test installation, the motion control computer hosts all the system software.

4.2 Features

The SSS HexUSB controller provides maximum flexibility in a simple package.

- The controller interfaces to its control computer by way of a standard USB interface.
- The controller uses a second-order electronic analog servo system to control leg position based on potentiometer feedback. This approach provides reliability, simple adjustment, and high performance without using computer system resources.
- Standard packaging is extremely simple: a single small ABS cabinet with no external controls, a single LED indicator, and commonly available connectors.
- Single 6.2 x 8.8 x 1.0 inch PC board includes all components including power supply, thus simplifying custom packaging. Possible custom packaging features include
 - Rack mounting (fits into 1U) (Rack-mounted control computers also available)
 - Front-panel tuning controls
 - Integration into existing customer packaging
 - Alternate power sources
- Simple, stable, three-parameter tuning. Standard packaging uses “set and forget” trim pots.
 - Zero sets the position of the leg when retracted (span is stable and software settable).
 - Gain sets the stiffness of the response and system bandwidth.
 - Damping sets the overshoot.
- Emergency stop system constantly monitors an opto-isolated TTL-level signal indicating system readiness. When this signal is removed by the opening of an E-Stop switch or other emergency condition sensor, the controller disengages from computer control and gracefully settles the platform.
- Sixteen digital (TTL-level) input lines and sixteen output lines, for monitoring and controlling various system functions.
- On-board digital data acquisition system. The controller monitors the leg position feedback signals and transmits them back to the control computer with eight-bit precision.