Sarnicola Simulation Systems, Inc.

BACKGROUND INFORMATION

for the

Hexad Six-Channel Universal Motion Controller

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1.0 INTRODUCTION

The Sarnicola Simulation Systems *Hexad* product line includes a variety of six degree-of-freedom motion platforms suitable for a wide range of equipment test and simulation applications. The *Hexad Universal Motion Controller* (UMC) was developed to provide a single, comprehensive motion control solution for these motion platforms. The UMC is an advanced design that includes six channels of position control, an emergency stop feature, sixteen bits of digital input, sixteen bits of digital output, two channels of analog output, two channels of analog input, and six channels of digital leg position data. It interfaces to the motion control computer by way of the Universal Serial Bus (USB 2), thus making it compatible with essentially all modern computers and operating systems.
The standard product includes *HexTest*, a comprehensive software application that allows complete control of a motion platform from a standard Windows PC.

The versatile UMC design lends itself easily to custom applications. Sarnicola Simulation Systems can provide complete custom systems based on its own platforms or on many other systems including legacy military and commercial flight simulation motion platforms.

2.0 GENERAL DESCRIPTION AND FEATURES

Packaging. Compact, portable, metal case. 2.25 x 13 x 11 (HxWxD). Custom packaging (eg, rackmount) is available.

Power. 100-230 VAC/DC, 50-60 Hz, 0.5 A

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

Indicators. Green Power Pilot LED
Green System OK LED
Red E-Stop LED
Green Online LED
Red Offline LED

Connectors. USB-B Jack for host computer interface.
DB-25S for interface to platform.
CPC-17 (16 pin standard sex) for Digital Output (16 bits TTL, +5VDC power out)
CPC-17 (16 pin standard sex) for Digital Input (16 bits TTL, +5VDC, $\pm$12VDC power out.) and E-Stop
IEC Power Entry module (switched and fused)

3.0 CONTROL SOFTWARE

The Hexad Universal Motion Controller uses a USB interface to the motion control computer so it

is compatible with any operating system that supports USB 2. The standard product includes *HexTest*, a control program designed for Windows 98, NT, 2000, or XP. 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 UMC applications.

3.1 The *HexTest* Software Package

Each SSS *Hexad* UMC 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. The system also provides file playback and basic host connectivity via RS-232. Specific features include

- Convenient, intuitive, mouse-oriented user interface.
- Real-time graphical depiction of platform state.
- HPU interface control (if HPU control hardware is included)
- Manual control of each axis independently.
- Full control of the position and orientation of the center-of-rotation coordinate system.
- Automatic data 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.
- Playback of prerecorded motion files.
- Automated system test (“morning readiness check”).
- Basic host computer interface (RS-232) for realtime operation.
- User-defined update rates from 20 to 60 Hz.
- Interface monitoring.

3.2 Custom Software Applications

SSS provides complete support for customer software requirements from consulting on customer software development efforts to complete 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 *Hexad* UMC system produces the required attitude of the motion platform by individually controlling the lengths of its six legs. The motion control 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 *Hexad* UMC 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 UMC 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 UMC 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 *Hexad* Universal Motion Controller provides maximum flexibility in a simple package.

- The UMC 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 metal cabinet with no external controls,

a few LED indicators, and commonly available connectors.

- Single 8 x 8 inch PC board simplifies 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
  - Opto-isolated DIO.

- Simple, stable, four-parameter tuning. Standard packaging uses "set and forget" trimpots.
  - Zero sets the position of the leg when retracted.
  - Span sets the leg stroke length.
  - 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.

- The system monitors the USB interface and enters E-Stop if the motion controller goes off line.

- Sixteen auxiliary digital (TTL-level) input lines and sixteen output lines, for monitoring and controlling various system functions.

- Two auxiliary analog inputs (10-bit resolution) and two analog outputs (12-bit resolution) 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 ten-bit precision.