

# LabVIEW Aids Production Testing of Actuators for Home Theater Systems

by Bruno Paillard, Faculte de genie, Universite de Sherbrooke, and Philippe Roy, D-Box Audio Inc

**The Challenge:** Developing and implementing an extensive home theater system actuator test procedure for use during development and production, without the need for specialized and costly test equipment.

**The Solution:** Using LabVIEW to create the extensive test procedure needed for the home theater actuator.

## Home Theater Motion System

Developed by D-Box Technologies, Odyssee is a motion simulation system for the home theater. We built it with four actuators, each capable of a 1/2 in. travel. We place those actuators under the legs of a sofa or a row of theater seats. A motion profile generator coordinates the

*Given the high-power nature of the system and the fact that nontechnical users most often operate it, we needed to build a reliable, robust fault-protection sub-system that is as transparent to the user as possible.*

actuators, which synthesizes motion in three degrees of freedom (up-down, forward-backward, and left-right), according to the action in the movie. The actuators are also self-instrumented, which means that they can measure their operating parameters in real time and provide diagnostics information on-demand.

A very high dynamic brushless motor, controlled by a TMS320F240 digital signal processor (DSP), comprises each actuator. The processor drives a low friction, proprietary transmission drive. Each actuator can perform a wide range of motion profiles, from very slow, very smooth (imperceptible) movements, to very dynamic ones (vibrations up to 100 Hz). The total travel is small, which is a necessary condition of home use. However, the impact on the perception of the movie is impressive because it enhances and completes the auditory and visual senses.

## Self-Instrumentation and Fault Protection

Given the high-power nature of the system and the fact that nontechnical users most often operate it, we needed to build a reliable, robust fault-protection sub-system that is as transparent to the user as possible. We set up the DSP software to process most faults, giving the motion system the advantage of reacting to fault conditions in an “intelligent” manner. For instance, a temperature fault does not trigger an instantaneous drive shut down, but instead shuts off motion, or parks, in a controlled manner.

A group of sensors and estimators feeds information to the fault-protection software. We measure temperatures of motor and power transistors by using thermistors placed inside the transistor bridge and motor. We also measure position using an incremental encoder and commutation tracks placed on the shaft of the motor. In addition, we measure supply voltages for the high-voltage rail (power section), and the low-voltage supply (logic). A real-time model of the motor estimates motor current.

## KineLink Communication Channel

The four actuators connect to a motion profile generator that controls them through a dedicated opto-isolated communication link called KineLink. KineLink is a specialized protocol that serves four purposes. KineLink transports motion profiles, sent as four continuous streams of position samples, from the motion profile generator to the actuators. KineLink also transports possible fault information from the actuators back to the motion profile generator. The motion profile generator displays this information to the user. Eventually, if one actuator experiences trouble and

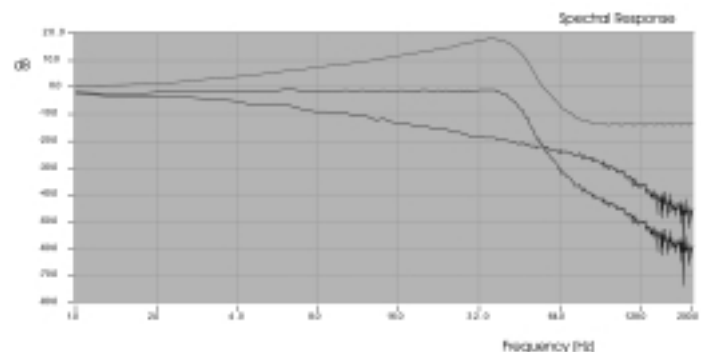


*One Actuator of the Odyssee System*

goes into “park,” the motion profile generator also parks the three remaining actuators to avoid a situation in which only three actuators hold the platform. In addition, KineLink ensures the timing and regularity of the input sampling rate, which is important to avoid audible and vibration artifacts from a sampling frequency exhibiting jitter and variability. Finally, KineLink transports information about the operation of the actuators (vital signs) back to the motion profile generator for testing purposes.

## LabVIEW Monitors Actuator Behavior

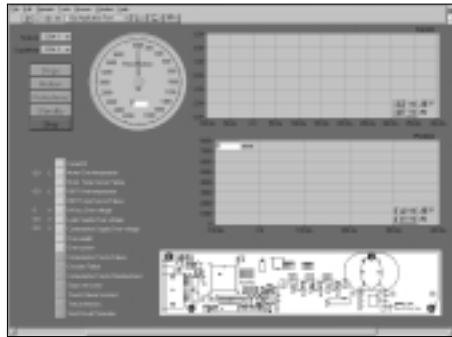
With the self-instrumented architecture of the actuators, we can easily perform testing during development and in production. It is a simple matter to connect an Odyssee actuator to a PC through its KineLink connector and use a test application written in LabVIEW to check all hardware sections, as well as the mechanical and electronic behavior of the actuator. No specialized test equipment is required to perform these tests; all that is needed is the tested actuator and a PC running the custom LabVIEW test application.



*Natural Frequency Response of the Actuator and Correction Filter*

Such test applications rely on test functions that are designed-in the embedded DSP code. These functions return, on demand, variables such as the temperatures of motor and power transistors, position and speed of the motor, estimated current and weight, supply voltages (power and logic), etc. These variables are read synchronously, at the motion profile sampling rate, while sending motion profile samples to the actuator.

During development, using these functions, we can perform on-line fine-tuning of the actuator's parameters. For instance, one such test application sends a uniform white random signal to the actuator and reads its position response, synchronously to the excitation. With input and output vectors in PC memory, we use a recursive least squares procedure to estimate



*Production Test Application*

does not need specialized test equipment other than a PC running the test application.

We primarily see the cost of self-instrumentation during the development of the product. It adds some complexity (development time) to the embedded software driving the device.

Although we must pay some consideration to the hardware design to handle self-instrumentation, in most cases it does not add much complexity to the hardware, because the functions needed for self-instrumentation are also needed for the core functionality of the device.

The benefits of self-instrumentation, however, are well worth the extra development time. We see them during development and at production time. Self-instrumentation facilitates the design of extensive test procedures. The fact that the tests are conducted "in-operation" means that we can test very high-level functionality and

behavior, involving many interactions between sub-systems, as easily as low-level sub-system functionality. Most importantly, we implement the tests as a simple application running on a PC and do not require specialized and costly test equipment.

The use of LabVIEW greatly facilitates the development of the test applications. For instance, we built the communication functions on the LabVIEW VISA libraries. The presence of extensive signal processing libraries in LabVIEW accelerates the integration of high-level signal processing features to the test applications. Finally, the ease with which a user can design a graphical user-friendly interface is one of the best features of LabVIEW.

For more information, contact Bruno Paillard, Genie électrique et informatique, Faculté de génie, Université de Sherbrooke, Sherbrooke, PC, Canada J1K 2R1, Tel (819) 821-8000 x2138, E-mail [bruno.paillard@gel.usherb.ca](mailto:bruno.paillard@gel.usherb.ca) or Philippe Roy, D-Box Audio Inc, 2180 De La Province, Longueuil, PC, Canada, J4G 1R7.

## *The use of LabVIEW greatly facilitates the development of the test applications.*

the natural impulse and frequency response of the actuator. From this response, we optimize a correction filter, which we then integrate into the embedded software of the actuator to equalize its response.

During production testing, we use one such application to provide an extensive automated test of the actuators. Functions tested include communication, supply voltages, motion and temperature sensor integrity, motor static and dynamic behavior, etc. For each function tested, this LabVIEW application gives a diagnostic and also points the test technician to a possible location of the problem on a virtual map of the motor drive system. Again, the user



[ni.com/labview](http://ni.com/labview)

(512) 683-0100 • Fax (512) 683-9300 • [info@ni.com](mailto:info@ni.com)

Worldwide Offices: Australia 03 9879 5166 • Austria 0662 45 79 90 0 • Belgium 02 757 00 20 • Brazil 55 11 284 5011 • Canada 514 694 8521  
China 021 6555 7838 • Czech Republic 420 2 2423 5774 • Denmark 45 76 26 00 • Finland 09 725 725 11 • France (0)1 48 14 24 24 • Germany 089 741 31 30  
Greece (0)1 42 96 427 • Hong Kong 2645 3186 • India 91 80 535 5406 • Israel 03 6393737 • Italy 02/413091 • Japan 03 5472 2970 • Korea 02 596 7456  
Malaysia 603 9596711 • Mexico 001 800 010 0793 • Netherlands (0348) 433466 • New Zealand 09 914 0488 • Norway 32 27 73 00 • Poland 48 22 528 94 06  
Portugal 210 311 210 • Russia 095 238 7139 • Singapore 65 2265886 • Slovenia 386 3 425 4200 • South Africa 11 805 8197 • Spain 91 640 0085  
Sweden 08 587 895 00 • Switzerland 056 200 51 51 • Taiwan 02 2528 7227 • U.K. 01635 523545 • Venezuela 80014466