Tactiq
&
Ling Dynamic Systems

DVC48 Vibration Controller Product Development

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1 Introduction

Vibration and shock testing is now a pre-requisite for testing the durability of many products. Applications range from testing a space vehicle's resistance to vibration on entry into a planet's atmosphere to ensuring that a mobile phone can withstand the rigor of daily use. Testing is typically undertaken using electro-dynamic "shakers". The shakers vary in size from a couple of kilos to 50 tonnes. Each shaker is driven by a power amplifier matched to its size. A Vibration Controller drives the power amplifier in accordance with a test schedule defined by the operator. The degree of acceleration applied to the unit under test is measured by the Vibration Controller using one or more sensitive accelerometers. This data is used by the controller to continually adjust the amplifier drive to maintain the acceleration test profile specified by the operator. If acceleration limits are exceeded the controller will abort the test.

LDS (Ling Dynamic Systems Ltd) designs and builds innovative vibration test systems, vibration controllers, and signal analysers. The company provide solutions for quality testing and design improvement for a diverse range of manufacturers and independent test laboratories.

http://www.lds-group.com/

A Tactiq Senior Engineer / Team Leader played a key role in the development of LDS' **DVC48 Vibration Controller**. This document describes key aspects of the development process and the role played by the Tactiq engineer.

DVC48 Vibration Controller

The DVC48 is a digital closed loop controller. It's employs adaptive DSP algorithms to control a range of shaker systems from the size of a coffee mug up to the V994 giant pictured below.

V994 Combo Shaker

This V994-HBT2500 combo weighing in at 50 metric tonnes comprises a two-piece design to make manufacturing and transport practical. This is the largest combo produced by LDS.

2 DVC48 Vibration Controller

The DVC48 was introduced by LDS in 1999 following a three year development program. The 19" rack mounted controller hardware utilises a Motorola 68EN360 SoC microprocessor with 1 or 2 Analog Devices SHARC™ 48 bit DSPs. The unit has a single differential amplifier drive output and a second output for connection to additional measurement equipment. Up to 8 accelerometers are supported allowing the controller to measure acceleration from multiple points on the unit under test. The user interface is provided by custom application running under Windows 98, ME or NT. Connection to the DVC48 unit is via a 10MB Ethernet connection. The DVC48 is capable of executing swept sine, random and shock tests using shakers ranging in weight from 2 kilos to 50 tonnes.

3 Tactiq's Role in DVC48 Development

LDS had not previously developed a complex digital electronics product with high software content. Tactiq's contribution to good software development practice, project planning, source version control and design documentation greatly improved LDS' software development process.

The development team for the DVC48 was located at LDS' headquarters in the UK. An engineer from Tactiq designed implemented and tested all of the DVC48's digital electronics including DSP, microprocessor, static and dynamic memory, programmable logic bus arbiter and digital I/O. The sensitive analogue accelerometer input circuits were designed by an LDS engineer. Layout and route of two printed circuit boards was outsourced to a sub-contractor under management of the Tactiq engineer.

System boot and initialisation firmware was written and debugged by Tactiq. This incorporates a command line debug monitor that is operated via terminal emulator running on a host PC. Built in self test and diagnostic routines facilitate test and debug of the DVC48 hardware. Test and debug was entirely undertaken by the Tactiq engineer. Within two days of the assembled pre-production CPU / DSP printed circuit board arriving, it had been sufficiently debugged for the 68EN360 processor to execute boot code from FLASH memory, configure the processors I/O and successfully test 4MB of DRAM. Basic functions of the command line monitor were also operational. Within 3 weeks the hardware was debugged to the limit of diagnostics capability.

The first prototype DVC48 was shipped to TUV's facility at Bearley in the UK for Electro Magnetic Compatibility (EMC) testing. Tactiq provided on site support throughout the 4 day test schedule, making modifications to correct EM emission problems. At the close of the test session the DVC48 passed EMC class B (office environment) emissions and class A (industrial environment) immunity.

Development of the DSP algorithms for closed loop vibration testing was taking longer than expected, primarily due to the unexpected complexity of closed loop adaptive control. It was at this point that the experience and flexibility of the Tactiq engineer provided additional benefit to LDS through the provision of support and guidance to LDS' DSP engineers. This included re-writing some of the DSP software and bringing in a third party specialist to assist with the identification and correction of issues with the DSP adaptive algorithms. The result of this effort combined with further hardware debug and testing resulted in the first fully functional DVC48 controller entering full system test on time.

4 Development Process

4.1 Understanding Requirements

Clearly documented product requirements are essential to ensure that all interested parties have a common understanding of the performance, features and cost targets. This stage of the product life cycle offers a low cost opportunity to make changes that effect product specification.

LDS sales and marketing had identified key market requirements for the DVC48. LDS Engineering had worked with marketing but initial requirements and design documentation was fragmented. Tactiq identified this issue and guided the LDS engineering team to collate the requirements and design data into fewer, well structured documents. This documentation proved invaluable during the DVC48 design and implementation phases.

4.2 Design

A good design will clearly show how a product is architected to meet requirements and ensure maintainability and extensibility. The DVC48 is designed to meet tough industrial EMC standards and to facilitate future enhancements. At the beginning of the hardware design process DSP processor performance requirements could not be accurately estimated. Tactiq designed the embedded electronics to function with either 1 or 2 SHARC DSPs. Early examples of the DVC48 were fitted with 2 DSPs. Production systems required only a single DSP, saving over £200 per unit in manufacturing cost.

4.3 Implementation

The DVC48 hardware was designed using LDS' Mentor Graphics V8 CAD/CAE tools, AMD "Mach" logic design tools and Timing Designer to analyse timing of the digital electronics. The 68EN360 was chosen for its performance and high level of integration. The SHARC DSPs were chosen for their FFT performance.

The embedded boot, built in self test (BIST), diagnostics and command line monitor firmware were written in C using a cross compiler running on a host x86 PC. The DSP software was written in C with a small portion in assembler for performance optimisation.

4.4 Testing and Validation

Product integration testing and validation was carried out as a collaborative effort between the Tactiq engineer and the LDS team. Tactiq took a lead role in the development of the DVC48 integration and validation testing plans.

The BIST, diagnostics and command line monitor firmware developed by Tactiq provided a comprehensive suite of test and debug tools. Some of these tools are self contained test tools whereas others are used in conjunction with test equipment such as oscilloscopes and logic analysers, the later being used primarily for the purposes of debug.

Following the launch of the DVC48, the BIST software proved very valuable for manufacturing test and quality assurance.