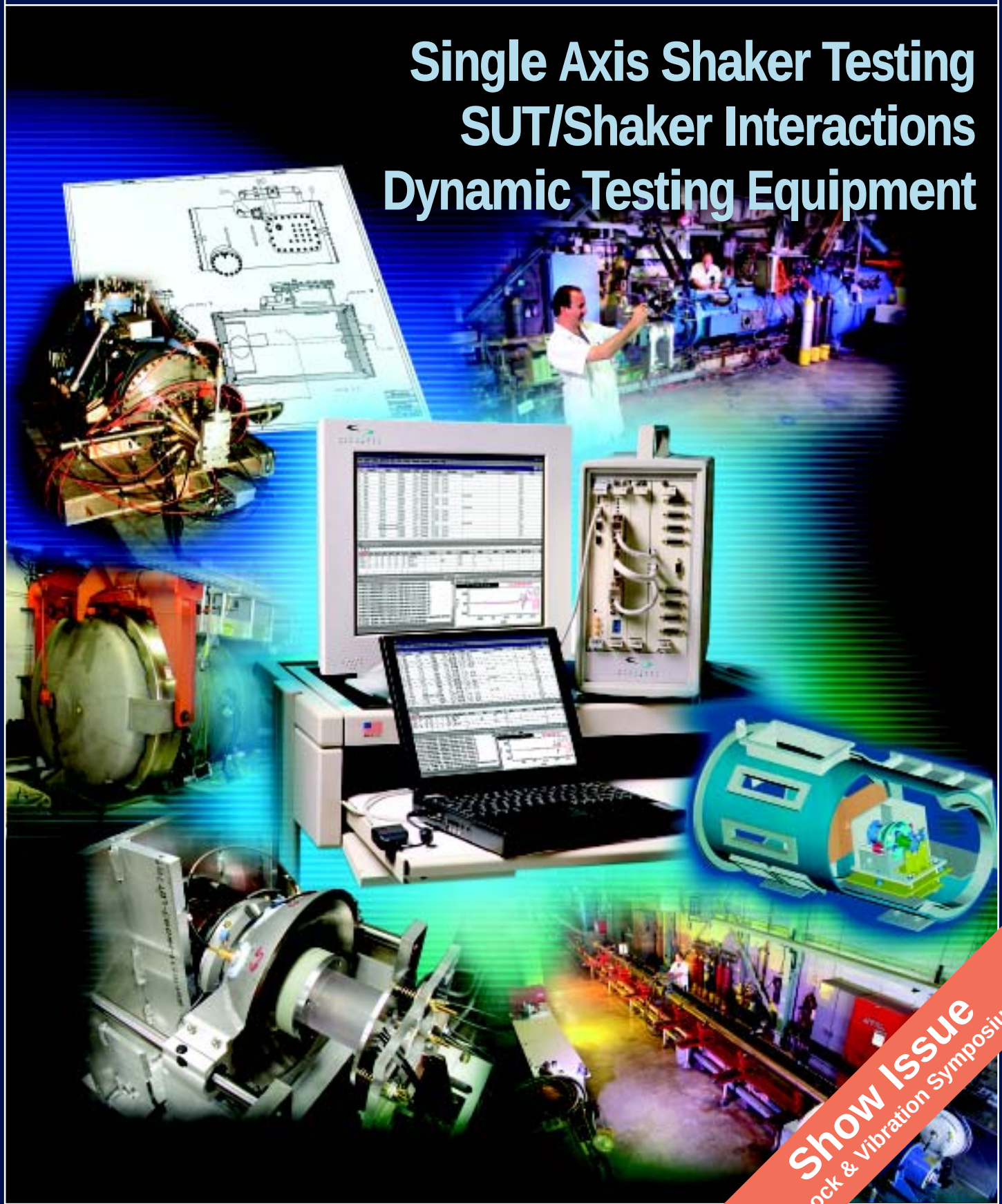
SOUND&VIBRATION

DYNAMIC TESTING REFERENCE ISSUE OCTOBER 2002

Single Axis Shaker Testing
SUT/Shaker Interactions
Dynamic Testing Equipment



Show Issue
Shock & Vibration Symposium

High Bandwidth Measurement Systems Push Limits of Transducers and Techniques

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In July of this year the Advanced Research Products Group within Spectral Dynamics (SD) participated in a critical testing series at Lawrence Livermore National Laboratories. A problem facing LLNL was the previous Primary Target Chamber (PTC) testing had not succeeded in characterizing the failure modes of the PTC pressure seals. Breeches in the PTC pressure seals were observed from previous PTC tests. These breeches were in response to the insult of the enormous pressures on the interior of the PTC, pressures equivalent to those generated by a 28 gram projectile colliding with a target at a velocity greater than 7 km/sec (15,659 mph or Mach 21).

This was intended to be a series of four tests total, to be performed over a three-week period at the LLNL HEAF (High Explosives Application Facility) and Gas Gun Facilities. Due to failures of legacy components within the primary data acquisition system (DAS) during the first test cycle, the SD engineers provided the support necessary to make their system the primary DAS for the remaining tests. They agreed to verify that their system would be sufficiently robust enough for the rigors of two-stage gas gun experiments at the Nevada Test Site, JASPER (Joint Actinide Shock Physics Experimental Research) Facility.

Spectral Dynamics worked along side the in-house instrumentation people at the LLNL HEAF and Gas Gun facilities in Livermore, CA. The SD VIDAS (VXI Data Acquisition System) offered a desirable methodology combined with advanced data acquisition capabilities while allowing enough flexibility in implementation to meet the requirements of the test series.

There were a number of PTC questions to be answered based on earlier experiments conducted at JASPER associated with trying to profile the gas gun performance. An important question was: what effects on the data and acquisition system would the electromagnetic pulse (EM-Pulse) discharge have? The gun releases approximately 700 kJoules of energy. Using existing LLNL high energy discharge instrumentation methodology, all of the instrumentation was rack mounted and powered from an isolated power system. An artificial ground plane was created under the 19 in. steel rack using an aluminum plate sandwiched between two sheets of plywood. Both the primary and secondary data systems were controlled through an Ethernet fiber link. This total isolation technique mitigated the effects of large ground bounce, or electrical discharge, which can create anomalies that later must be corrected in the data.

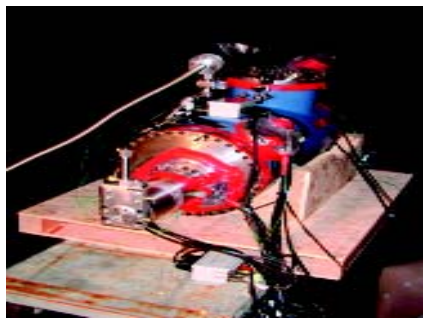
The tests at the HEAF facility showed that the large EM-Pulse generated by the CDUs (capacitive discharge units) used to drive the detonators were seen via inductive coupling but had no impact on the data. In fact, the instrumentation used to-date did not have the bandwidth/sensitivity to see this event. This actually encouraged the staff, since there was no doubt as to which of the sequence of the experiment's events were being seen while reviewing the test event data. The HEAF tests subjected the PTC assembly to 30 and 45 grams of HE (High Explosives). The 120 Ω strain gauges were mounted axially and radially on the PTC and on instrumented load bolts.

After completing a successful series of tests at the HEAF facility, the SD and LLNL instrumentation systems were moved to the LLNL Gas Gun facility for a hemispherical impact test. The hemispherical test setup included pressure and strain gauges.

The strain gauge response data were analyzed using the built in post-processing capabilities of the IMPAX-SD application. The SHOCK (Shock Response Spectra) algorithm[1] yielded significant shock response spectra to well over 200 kHz.

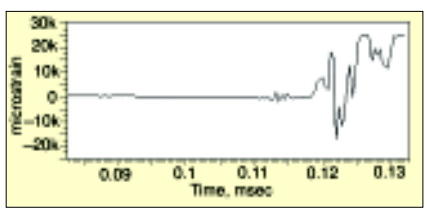
During the post-test analysis phase, Randal Thomas of LLNL determined that some absolute time zero correlation questions existed between the different data systems used in this test. Performing further data analysis at the SD Facility in Fremont, CA, using the data analysis tools in the IMPAX-SD application, he quickly isolated the fiducial trigger data and the CW X-ray pulse used to generate the time zero trigger reference. These signals were both clearly evident in the data due to the Spectral Dynamics VXI data system's deep memory capability. Because all of the needed data were available, the timing issues were quickly resolved.

Through this battery of tests, experimenters were able to see for the first time extended bandwidth strain gauge data from the explosive events. This turnkey system incorporated sufficient features and memory storage capacity to record the prevailing high-speed transients. Preliminary analysis of the event was possible immediately after completion along with automatic storage of the event to a PC for later analysis.



PTC/UVSV asembly being leak tested using CO gas detector after 30 gram shot.

PTC test article inside 1 kgram test tank at LLNL HEAF.



Raw strain gage data zoomed to identify time.

Acknowledgements. This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48. (UCRL-MI-150155)

1. Smallwood, David O., "An Improved Recursive Formula for Calculating Shock Response Spectra," Shock and Vibration Bulletins 51 & 56, The Shock and Vibration Information Center, Naval Research Laboratory, Washington, D.C., August 1986.

Comments from Mark Remelman – "I thoroughly enjoyed working in such a strong team environment. I would like to thank the LLNL instrumentation specialists, facilities control staff, explosives specialists, project engineers, and management for making me feel like a part of the team. These tests were performed on a very tight schedule, yet the determination to not only get the job done but to get it done right was gratifying. In these post 911 times national defense is on everybody's mind and I am grateful for the opportunity to help."

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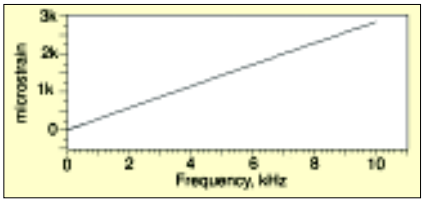
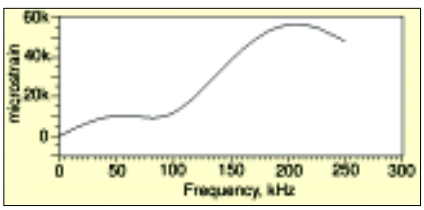


10 Hz to 10 kHz SRS (traditional spectrum of interest).



10 Hz to 250 kHz end frequency limit raised to 10× over sample point. The value of the extended flat bandwidth response of the Spectral Dynamics data acquisition system graphically shows what traditional approaches have missed. All data were 16 bits, acquired at an effective sample rate of 2.5M samples/sec with automatic finite impulse response filtering to the Nyquist limit. the Sigma Delta ADC was actually running at 20 MHz.