

DESTRUCTIVE TEST FACILITY RELIES ON VXI FIBER OPTIC NETWORK FOR SYNCHRONOUS DATA ACQUISITION

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Abstract - VXIbus is an ideal standard for instrumentation associated with developmental test systems used by industrial applications due to its adaptability, accuracy, and responsiveness. This application note is one such example of a VXI solution for a worldwide leader in commercial property and risk management that operates a destructive test facility to analyze the results of disasters predominantly caused by fire.

The company implemented a re-configurable 2,400 channel test system based on KineticSystems' VXI modules that used a fiber optic ring to synchronize multiple chassis and multiple channels. Technical details of the VXI implementation and results will be discussed.

DISASTER ANALYSIS USING KINETICSYSTEMS VXI SOLUTIONS

"World Trade Centre NYC is on fire - Terrorist Action"

"Post-Katrina Fire at Oakwood Mall Damaged One-Third of Stores"

"Building Collapses After Explosion, Fire"

"Detroit Warehouse Fire Claims 3 Firefighters"

The headlines are all too familiar. Whether fires are ignited by terrorism, natural disasters or circumstance, the results are often the loss of human life as well as millions of dollars worth of products. To advance loss prevention practices and establish new industry safety standards, a major insurance company built its own state-of-the-art research and testing facilities, including a destructive test facility.

While computer modeling is often used to conduct structural tests, such as collapsing steel beams in large fires or predicting the extent of property damage from earthquake hazards, the cornerstone of the destructive test facility is a fire technology laboratory that conducts full-scale, real-life destructive test research, rather than rely on computer modeling.

The lab is capable of generating fires that produce greater than 20MWs of energy and collecting data to advance the understanding of how materials and fire behave, measure and learn from the rate of heat release from different configurations of materials, and determine combustibility and protection requirements for different commodities produced and used by the company's clients.

It is credited with engineering new and innovative ways to protect facilities from fire, in industries ranging from semiconductor plants to chemical manufacturers.

Fire Technology Lab Characteristics

Over 100,000 square feet in size, the fire technology lab is larger than the size of two American football fields, capable of replicating warehouse-size fires of up to 2,000 degrees Fahrenheit while collecting synchronized test data from over 2,000 channels.

The major burn lab area consists of three sections – one features an eight-story-high moveable "ceiling platform" for simulating practically any size facility. Another section has a fixed "ceiling platform." Between the two is a Calorimeter Hood

area to collect discharges, soot and ash. It is capable of measuring the energy from a 20 megawatt (MW) fire.

Above the entire burn lab and its “ceiling platforms” is a permanent ceiling with an attic area housing an instrumentation room.

Adjacent to the huge burn lab area are a dozen smaller labs for intermediate- and small-scale burn testing, enabling researchers to study a broad range of commodities and storage arrangements.

The company also runs tests on a forensic basis on fires that have occurred to try to analyze what happened during the fire, such as understanding the damage path and other characteristics.

Data Acquisition Requirements

Nearly a decade ago, the insurance company deployed VXI (VME eXtension for Instrumentation) equipment in their lab and their research scientists were comfortable with the accuracy, durability and open standard testing platform design (IEEE 1155). However, the VXI system that collected data was limited to the performance of loop controllers and often used only by the handful of scientists that were familiar with the system they had fashioned internally.

Research scientists now desired greater flexibility, larger channel count and real-time synchronization. Management also insisted that a standard testing platform be used by all researchers, in order to permit quantifiable data comparisons.

Because the host materials are destroyed when conducting the burn tests, scientists at the company required that the data acquisition system be able to capture large amounts of data and record it in real time.

It was an assignment taken on by Invensys ENE, Inc., a systems integrator specializing in building automation systems, automatic temperature controls and environmental control systems, industrial process control systems and HVAC equipment service and retrofit. They were engaged to design an integrated Data Acquisition and Building Control System for the destructive test facility.

“It was very important to the company’s research scientists that all the data would be synchronized,” says Doug Kirk, Business Development Director of Invensys ENE. “If they were looking at a temperature in one quadrant and a temperature in another quadrant, they wanted to be certain they were looking at temperature at the same moment or they could relate to what moment it was.”

Data Acquisition Components

According to Kirk, the customer’s insistence on data synchronization quickly narrowed the vendor field to KineticSystems. KineticSystems offers a FOXI™ fiber optic network (the Fiber Optic VXI Interface for PCI bus) which was the only system Invensys ENE discovered that would provide a high-throughput (10 Mbyte/s) interface between a host computer and VXI mainframes, provide for large I/O channel counts and allow up to a 2 kilometer (6,560 ft.) distance between fiber optic nodes.

Other advantages of the FOXI interface include:

- Providing full VXI Slot-0 functionality
- Eliminating bulky parallel cables with the fiber optic highway
- Supporting up to 126 mainframes on a single highway
- Supporting Windows 2000/XP

The V122 PCI Host Adapter, a fiber-optic highway and one or more V120 VXI Slot-0 controllers form a FOXI™ VXI interface system. The KineticSystems V120 module is a single- width, C-size, VXIbus controller that interfaces the FOXI highway to a VXI mainframe. It is a slave device on the highway and receives its commands from the host adapter.

For most I/O, the lab uses V213 Scanning ADCs (Analog-Digital Converters) with 64 channels of analog input. Features of the V213 include:

- 16-bit resolution
- 10Hz to 1kHz low-pass filter options
- Differential inputs and programmable gain per channel
- Programmable limit checking and triggering with an ADC sampling rate to 50 ksamples/s
- Precision on-board reference for end-to-end calibration
- Optional 4Mbyte multibuffer memory

A 32-channel V200 Sigma-Delta ADC was also installed by the company to handle the extraordinary sampling rates needed to capture data from fires ignited by explosions. The Sigma-Delta ADC features:

- One Sigma-Delta ADC per channel
- 16-bit resolution at 200,000 samples per channel
- Programmable gain per channel
- On-board DSP for limit checking
- Internal/external clock selection with programmable clock rate
- AC/DC coupling
- 8 or 32Mbyte multibuffer memory
- Simultaneous sampling and multi-board synchronization
- Continuous/transient capture modes with pre- and post-trigger data collection

The sigma-delta architecture of the V200 provides inherent filtering and synchronous sampling without the need for sample/hold amplifiers or sophisticated analog filters. A simple, 3-pole pre-filter assures no frequency aliasing. Each channel has independently programmable input gain. Channel calibration and self-test are performed automatically on command by the embedded DSP. This DSP also allows programmable level and slope limit checking. An optional add-on DSP card will perform E.U. conversion and other real-time analysis functions.

Instrumentation Alignment

In the major burn area, there are three primary test locations: the floor, the “ceiling platforms” and the duct work that draws the smoke out of the room. And each of these three areas has instrumentation.

The groups of instrumentation are tied to different KineticSystems card cages and boards that are all brought back to one computer that records all of the data from the test.

Each of the three test sections in the main burn lab has permanent VXI hardware that is sealed in cabinets and permanently cooled in the instrumentation room in the attic. Another reason to isolate the electronics is that the harsher part of fires is not heat, but the soot from the fires, especially when burning petroleum-based, plastics material.

Each set of permanent instrumentation is also physically tied to a different RMU (Remote Measurement Unit). The RMUs consist of a KineticSystems V198 4-slot C-size VXI mainframe chassis and two or three V213s to handle the sensing of temperature, pressure and on/off activity. The RMUs eliminate disconnecting and reconnecting instrumentation, since scientists merely use the particular 4-slot backplane that they want to use, depending on where a test is going to be run.

For example, the moveable and fixed “ceiling platforms” are equipped with an array of temperature sensors (thermocouples) and an array of sensors to monitor and record when a sprinkler head has activated. The lab also places an array of pressures sensors, water supplies and peripheral sensors around the outside area in the vertical plane around where the fire is occurring.

Since equipment on the “ceiling platforms” can be subjected to short durations of high temperatures reaching 300 degrees F and as well as to combustion materials, both of the RMUs used with these tests also reside in the cooled attic instrumentation room.

Because of the channel count needed when conducting tests in the “ceiling platform areas,” each has its RMU tied to its own KineticSystems V196 13-slot C-size VXI mainframe chassis – a full-size mainframe featuring a 1000-watt power supply and a high-performance jumperless backplane.

RMUs for Flexible Data Collection

While three RMUs are installed in the attic to facilitate the array of sensors collecting data from the two “ceiling platforms” and the Calorimeter, a fleet of portable RMUs are used for testing on the floor.

The portable RMUs consist of roll-around cabinets outfitted with the 4-Slot VXI chassis enclosed in a NEMA 12 stainless steel box, about the size of a dishwasher, which is up off the ground with a PC sitting out front. They are deemed “fire proof” because the electronics are above the 36-inch barrier where heavy, flammable gases tend to collect.

The RMUs allow researchers at the burn lab to add channel count when and where needed as

they investigate specific aspects of the fire and collect data from sensors placed close to the fire.

“What we did is create a fiber network,” says Kirk, “where lab personnel could pull up to a column on the floor of the facility, plug-in to the fiber loop using a patch panel to become part of the network and collect data. This gives them flexibility to choose from where they would collect data.”

“We added a 25 foot wire harness and created a sacrificial termination panel where they could land the thermocouple wiring and different types of field sensors to the terminal panel. Each RMU comes equipped with a 25-foot whip with quick-disconnects that are run from that panel to the RMU so they could actually run the terminations closer to the fire and keep the electronic equipment further away.”

Ducts through which gases and combustion materials escape are also monitored by gas analyzers, with data collected by strategically placed RMUs.

Unlike the initial VXI system in the previous test building that had three different remote nodes that communicated together, the new destructive test facility has 20 nodes that can either function as 20 separate systems or one system comprised of up to 20 nodes.

Prepackaged Software Simplifies Application

While the fiber optic FOXI hardware network was critical in order to achieve real-time test synchronization for the company, another advantage to utilizing the FOXI hardware network was KineticSystems’ prepackaged test software and development tools designed to simplify, manage and accelerate VXI-based testing.

As is often the case, Invensys ENE directed KineticSystems to work with a third party software developer to quickly and easily produce an interface that would provide the final application solution desired by the company.

Before written approval for the fire technology lab was received, initial acceptance tests were run using 1,600 active channels to verify that all channels could operate simultaneously and be time-stamped through seven chassis which would

be networked and brought back to a central system using KineticSystems’ test software and the front-end interface.

Building Scope

Building the Destructive Test Facility was a multi-million dollar project that encompassed the building controls system, the data acquisition system and a great deal of system integration. Indeed, the issue with the new building was to reach a complete, highly efficient solution.

When the building was being designed, scientists came up with a fairly generic proposal of what they expected the data acquisition system to do and put it out for bid.

A competitor to Invensys ENE offered more of a building control, generic PLC-type solution. It didn’t have the hardware capability, the accuracy, the resolution, the timing or other characteristics the scientists desired.

The KineticSystems VXI A/D technology brought by Invensys ENE to the company, provides more than 2,500 channels of data acquisition hardware across 12 laboratory areas to collect data gleaned from simulating unique industry facilities that require customized property loss prevention solutions caused by fire.

The resulting data acquisition solution provides the company’s researchers the flexibility, synchronization and real-time data collection they desired.

Web sites of companies mentioned in article:
Invensys ENE, Inc.: www.enesystems.com
KineticSystems: www.kscorp.com

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