VTI Instruments

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The Living Lab – Structural Monitoring with PXI Instruments & Virginia Tech

Intro

The development of Virginia Tech's Goodwin Hall provided the Virginia Tech College of Engineering with a unique opportunity to conduct some of the most advanced research in topics such as structural health monitoring, building occupancy, patterns for improving sustainable development, and studies on floor vibrations on human health.

Goodwin Hall is the most instrumented building for vibrations in the world with over 240 accelerometers distributed throughout the building. What makes it truly unique however is that the instrumentation was mounted during the construction phase, with the accelerometers placed on structural steel on all levels. This system will become a focal point for research in a variety of fields, including:

- Structural Health Monitoring
- Building Dynamics
- Digital Signal Processing
- Sensor network Design
- Big Data Analysis

In the development of a test bed of this magnitude, Virginia Tech searched for a partner with a proven track record of developing reliable, distributable data acquisition solutions. VTI Instruments' reputation and history as a flexible, precision DAQ provider allowed for a partnership in the development of this system to be forged.

Solution Details

Dynamic signal analysis of structures requires high speed, high bandwidth instruments for data acquisition. By incorporating the VTI CMX09 PXIe chassis, the EMX-4250 PXIe DSA, and the EMX-2500 PXIe LXI Ethernet controller, Virginia Tech was able to create a 288 channel modular, scalable, DAQ solution distributed throughout the building on multiple floors.

The CMX09's rugged and light-weight design and the optional bolt-down kit made the incorporation of the units within the design of the building simple. Multiple one meter breakout-box cables were used to make connecting transducers within the chassis quick and easy, as well as providing LED channel health indicators for monitoring.

The solution included 18 EMX-4250 16 Channel PXI Express Dynamic Signal Analyzers. With its unique "smart" analog design, the EMX-4250 is able to deliver 204.8 kSa/s/channel. The differential inputs of this digitizer also deliver superior common mode performance, making it ideal for noise vibration and harshness testing, machine condition monitoring, rotational analysis, acoustic test, modal test, and other general purpose high speed digitization and signal analysis solutions.

The EMX-2500 Gigabit Ethernet LXI Controller for the PXI Express chassis played an essential role in the creation of this DAQ solution. The distribution between sensors meant that Virginia Tech would require lots of cabling, and could face high latencies in data transfer. The EMX-2500 incorporates LAN IEEE-1588 time-stamping, allowing Virginia Tech to use CAT5 cables, drastically reducing cabling costs as well as achieving synchronous data acquisition with accuracies within 100ns.

Using the EMX-4250's, the CMX09 chassis are able to automatically synchronize using LAN events specified by the LXI specification. This is equivalent to synchronizing a chassis using a trigger signal, except a LAN message is used over Ethernet. Just like trigger line synchronization, the entire system can be triggered by an external trigger signal connected to one instrument, by sending a trigger command, by sending a LAN event trigger, or by an analog signal at one of the ADC channels crossing trigger threshold level. In this configuration, sampling and timestamp clocks are synchronized to the IEEE 1588 PTP master chosen by the best master clock (BMC) algorithm.

The development of the continuous data collection system on open IVI driver standards, as well as the incorporation of COTS equipment protect Virginia Tech's capital investment and mitigates obsolescence, ensuring longevity of the DAQ system for the lifetime of the building.

Project Conclusions

The Goodwin Hall living lab will be invaluable in the education of future engineers. This structure will provide several hundreds of students with real life exposure and experience to techniques, equipment, and methodologies of real-world engineering practices.

The data gathered from this test bed will also play a tremendous role in the advancement of many industries. The data will provide insight into topics such as building occupancy, creating more environmentally friendly structures, security and threat detection, emergency management, human/structure interaction, and much more.