Application of a Real Time Structural Health Monitoring (SHM) System for Tall Buildings

Powerful benefits of real time SHM:

- Enhances understanding of a building's health through continuous monitoring and analysis
- Provides a basis for rapid decision making regarding building safety and the possible need for evacuation following an extreme event
- Improves emergency response by identifying potential failure locations
- Allows more rapid identification of hidden structural damage
- Supplies building performance information needed to more rapidly return a facility to operation

Millikan Library: Pasadena, CA

The Millikan Library building, a ten-story, reinforced concrete frame structure built in 1967, is the tallest building on the Caltech campus. Because of its close proximity to active earthquake fault lines and ready access to some of the leading seismic and engineering minds in the world, Millikan Library was proposed as an ideal location for design and installation of the first real time structural health monitoring system in the world.

> "I am extremely satisfied with the work that Digitexx has done on the Caltech campus."
> *– Prof. W. D. Iwan*

In 2002, Digitexx, in close cooperation with Prof. Bill Iwan, developed a patented earthquake detection and location algorithm based on drift displacement and inter-story shear force. Using this knowledge, the team connected 36 accelerometers to a 16-bit data acquisition/controller (RTMS-2001) installed on the roof of the building. Then, connected to the Caltech LAN, the system can provide simultaneous real time data to up to 5 users—anywhere in the world.

Using data from past seismic events including the 2003 Big Bear Earthquake and the 2008 Chino Hills Earthquake, the Digitexx/Caltech system has contributed significantly to the expansion of knowledge about building performance and the application of real time monitoring.

For research purposes, the Digitexx system may be used with an eccentric mass excitation system installed on the roof of the building to investigate the natural frequencies and mode shapes of the building and observe how these building properties change after an earthquake event.

Photos Courtesy of Caltech

DIGITEXX DATA SYSTEMS, INC

California Office:
201 South Lake Ave., Suite 702
Pasadena, CA 91101

Arizona Office:
13880 N. Northsight Blvd., Suite 109
Scottsdale, AZ 85260

(T) 626.956.1356
(F) 626.956.1357
www.digitexx.com

Real Time Monitoring System Architecture

The Digitexx monitoring system is based on a highly efficient, multithreaded software design that allows the system to acquire data from a large number of channels, monitor and condition this data, and distribute it, in real time, over the Internet to multiple remote locations.

Thirty-six accelerometers deployed throughout the building continuously send out data computing actual drift ratios. If an event such as an earthquake occurs, pre-assigned thresholds of drift (based on FEMA recommendations for levels of displacement and inter-story drift) are exceeded in one or multiple locations, thus triggering the recording and analyzing of data (including pre-event memory). Once an event is recorded, the system notifies a list of users (via e-mail) and uploads the event via FTP to another site. The system is also capable of identifying and graphing inter-story hysteresis loops (See figure 1).

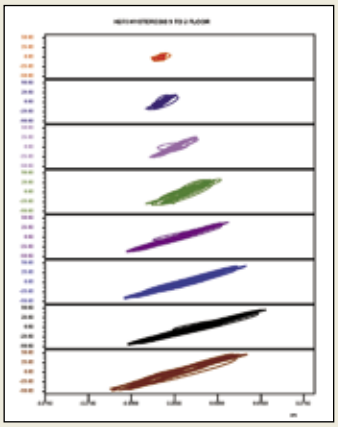
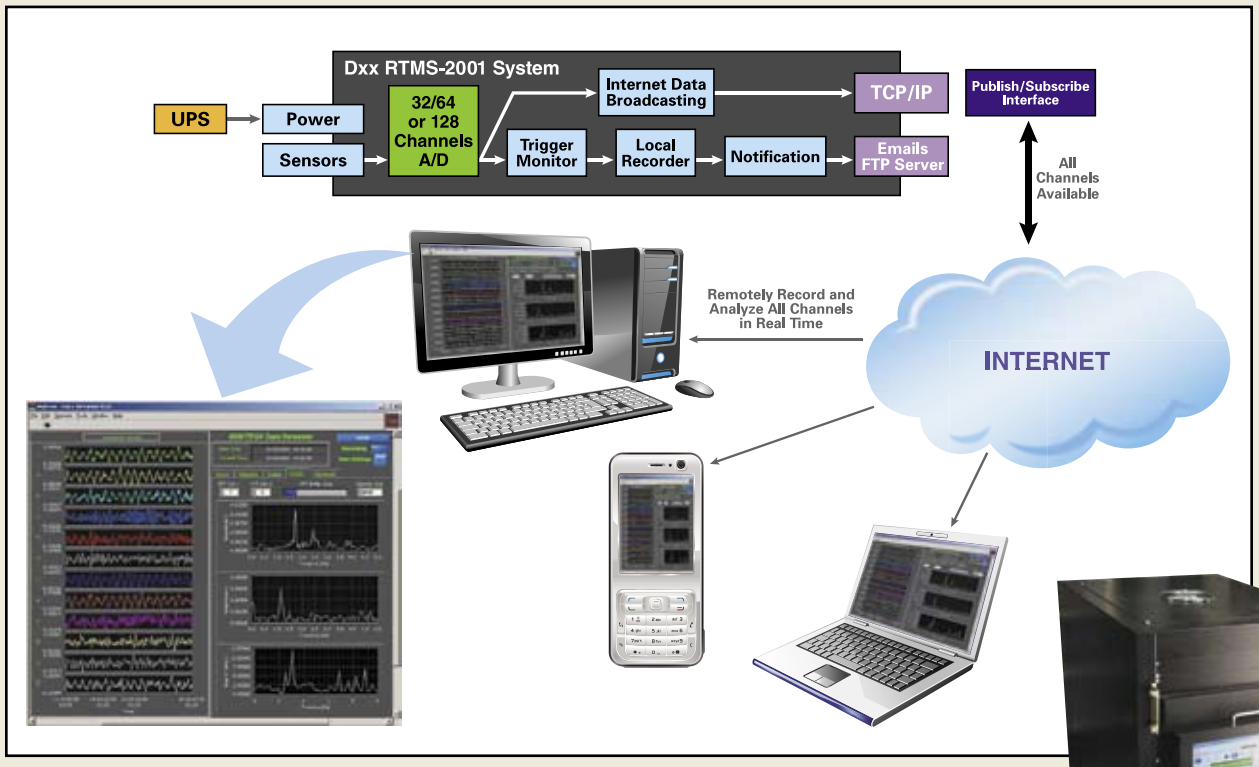


Figure 1: Hysteresis Loops plotted in real time during the Big Bear Earthquake, Feb. 22, 2003



About Digitexx

Founded in 2000, Digitexx was the first company in the industry to develop real time structural health monitoring systems for a variety of industries and applications including: bridges, tall buildings, campuses, windmills, oil rigs and more. Digitexx's innovative earthquake damage detection and locational algorithm system for tall buildings is jointly patented with Caltech. When properly configured, the Digitexx system is capable of measuring and responding to both natural and man-made events such as: earthquakes, wind, explosions and accidental heavy impacts.

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