Pushing the Limits of Data Acquisition

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Traditionally, vibration data acquisition and analysis systems have been limited to low channel count applications as stand-alone instruments have reached their technological limits. However, today computer-based instrumentation has progressed, leveraging technological advances such as increased processor power, and enabling data acquisition systems to evolve. Demanding applications that require high channel count synchronization, online processing, and data storage are now feasible. For example, B&B Technologies, a system integrator, recently designed a re-entry vehicle vibration test system that acquires, processes, and stores vibration test data at unprecedented rates and thus complete more accurate tests.

Engineers and scientists have traditionally relied on lower channel count or unsynchronized data acquisition and analysis systems for measuring sound, vibration, position, strain, and other physical quantities characterizing mechanical systems. Today, computer-based instrumentation enables engineers and scientists to perform detailed analysis using high-channel-count, synchronized data acquisition systems; in fact, with new advances in synchronization technology, it is now possible to simultaneously acquire data from up to 5,000 channels.

Leveraging modern data acquisition systems that acquire faster, more accurate, and more tightly synchronized data, engineers today create more accurate system tests that enable faster development and safer, more reliable products. Such is the case for B&B Technologies (BBT), who recently designed a test system that acquires, processes, and stores data at unprecedented rates. Utilizing the immense power, speed and storage capabilities of modern PC architecture, National Instruments' LabVIEW graphical programming environment and data acquisition boards in conjunction with prototype and readily available NI instrumentation, BBT was able to design a system capable of handling the demanding bandwidth and processor intensive requirements for this country's intercontinental ballistic missile re-entry test system.

The Challenge

The challenge proposed by Sandia National Laboratories (SNL) required a system that would acquire and store up to 160 channels of vibration test data at speeds of 102.4 kSamples/sec for up to 120 minutes. Each channel had to be simultaneously triggered with less than 0.1 degree phase mismatch between any channel on the system which inferred synchronization of the low-level clock across multiple devices to provide data suitable for high resolution phase analysis. In addition, four channels were to be graphed run-time along with having a Fast Fourier Transformation (FFT) performed and displayed for each of the four selected channels. The enormous amount of data required for 160 channels at high speed acquisition and real-time calculations combined with very tight synchronization would be cost prohibitive without the advent of computer-based measurements or virtual instrumentation.

The NTS Solution

The Vibration Test System (VTS) was designed to address the vibration testing needs of SNL for testing and verifying re-entry vehicles. Prior to this system, SNL had been unable to synchronize, acquire and digitally store the data from systems with such high channel counts and fast scan rates. However, BBT used the PXI platform with 24 NI 4472 boards (NI 4472 is a 24-bit, simultaneous acquisition board with 8 analog input channels) to meet system requirements. In addition, a NI 6653 (timing and synchronization controller that enable synchronization of up to 5,000 channels) provides the scan clock and simultaneously triggers all channels. With extensive testing, it was found that the test requirements exceeded even the fastest computers' bus and bandwidth limitations of one computer. The flexibility of PXI, though, allowed the use of two PCs to handle the high channel count and high scan rate scenarios. With a data throughput of 25MB/s or 1.5GB/minute per chassis, this dictated the use of standard Ultra 160 SCSI storage drives instead of low-cost Ultra ATA IDE hard disk drives. In the end, three options were provided to accommodate the wide variety of channel counts and scan rates, each of which providing LAN connectivity.

Test Breakdown

1) The first option uses a single PC-based workstation connected to a single PXI chassis, thus allowing the scanning and storage of up to 80 channels at 102.4 kHz for up to 120 minutes. With two identical computers and chassis provided, SNL was given two complete, independent test systems for channel counts under eighty.

2) The second option uses one workstation connected to two PXI chassis piggy-backed together allowing the scanning and storage of 160 channels at scan rates of up to 40 kHz for almost 4 hours. The maximum throughput of this system was reduced to 19.2 MB/s as a result of the increased bus activity associated with the additional cards. Both chassis were connected by the NI 6653 with one chassis as the master responsible for setting up the triggering and clock synchronization.

3) The third option uses both workstations, each connected to a PXI chassis with both chassis connected by the NI 6653 with one of the systems as the master. The LabVIEW software requires no slave system input as all acquisition and trigger setup is performed on the master system and then transferred to the slave over Ethernet. Upon test completion, the user is prompted to transfer any or all of the slave's acquired data to the master computer for further analysis. Figures 1 and 2 show the block diagram and photograph respectively of the system described above.

Using LabVIEW, an easy-to-use graphical user interface was created to configure, monitor, and retrieve results. The user specifies configuration as well as acquisition parameters such as scan rate, test duration, etc. During acquisition, data is processed and streamed to disk using LabVIEW's extensive analysis library. At test completion, the program returns to the main panel where another test can be run or channels can be extracted. When extracting a channel, the user chooses the test to extract data from and in doing so, retrieves all test parameters from the text file and is then able to specify the device, channel, start offset and number of scans to extract.

As an added benefit of the modular nature of the system, the system can be expanded upon with many additional 80 channel modules creating much higher channel count systems. Finally, with the incorporation of Ultra SCSI hot-swappable hard disk drives, the modularity of this system allows its use as a high performance, high channel count infinite recorder.

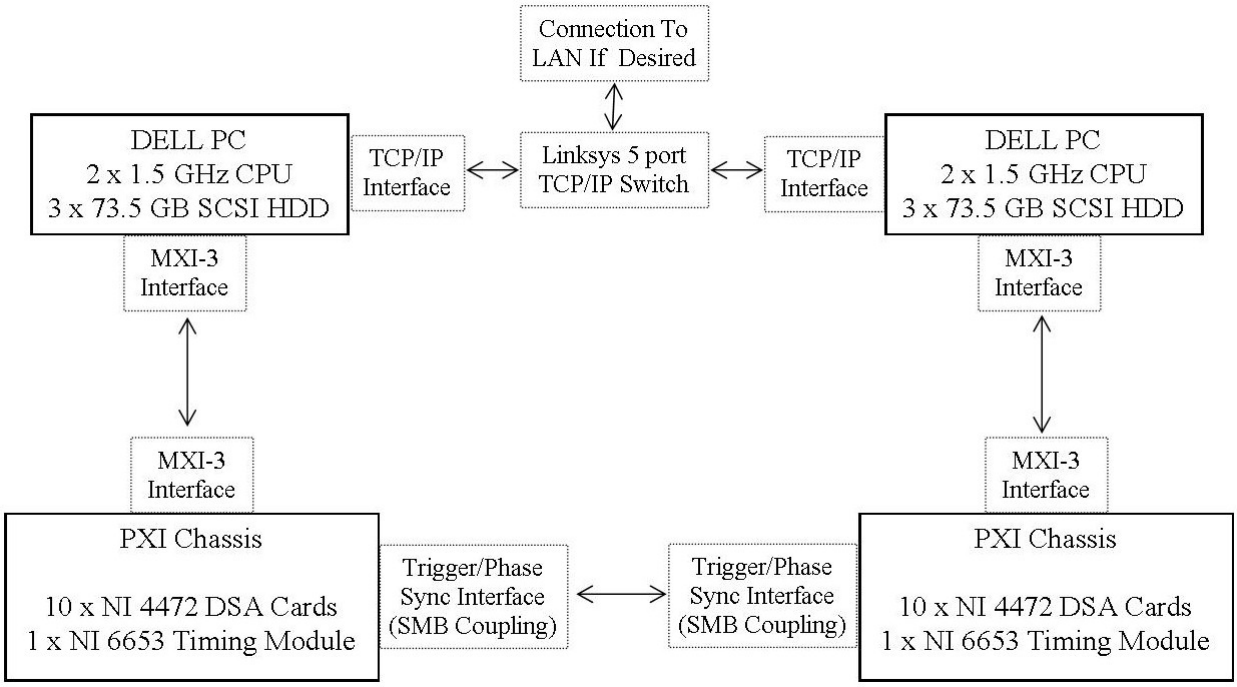

Figure 1. Two Workstation, Two PXI Chassis Configuration Block Diagram

Conclusions

With the implementation of the VTS, Sandia National Laboratories now has an easy-to-use, robust solution that allows them to confidently acquire, monitor and digitally store accurate, synchronized vibration data from up to 160 channels at 102.4kHz taken from a re-entry vehicle. Furthermore, SNL is now able to maintain and archive digital test results which can be called upon at any time for further analysis or review.

New technologies in computer-based measurement now enable such modern data acquisition systems that demand speed, accuracy, and tight synchronization. Engineers and scientists can create complete solutions that require acquisition, online processing, and data storage by utilizing the easy software development and lower system cost of computer-based measurements. Test and measurement engineers continue to push the limits for data acquisition, thus giving design engineers more accurate data and better results now than ever before.

Figure 2. VTS Hardware Setup for a Two Workstation, Two PXI Test Configuration

About NTS Test Systems Engineering

NTS TSE, located in Albuquerque, NM, designs and integrates test, measurement, automation, data acquisition and control systems utilizing diverse hardware platforms, operating systems, and instrumentation standards. Our expertise involves projects ranging from LabVIEW instrument drivers to full-blown automated turnkey systems. The dedicated staff of electrical and mechanical engineers, project managers and technicians of NTS are well versed in designing, integrating and programming real world solutions for industrial applications for a diverse set of operating systems and standards.

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