ADLINK TECHNOLOGY INC.



White Paper

High Precision Multi-channel PXIe Systems Realize More Efficient Wind Tunnel Testing

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High Precision Multi-channel PXIe Systems Realize More Efficient Wind Tunnel Testing

Simulation tests of aerodynamics are conducted to improve the physical designs of a variety of products so as to enhance overall safety, comfort and performance. Study results of aerodynamics have significant impact on many areas of our lives, from bicycle helmets and clothing to automotive exterior designs, bridge and building structures, and aircraft configurations. The larger the object being tested, the more complicated the test will be.

One such test of aerodynamics is the wind tunnel. In the initial stage of a wind tunnel test, a scale model in miniature is often used for simulation in a small laboratory, with design improvements continually made based on data acquired from the tests. However, the airflow volume measured in a small wind tunnel laboratory is not enough to determine more subtle changes in airflow behaviors, so that true scale tests, or real world tests, in a large wind tunnel laboratory will still be required at the final stage.

For instance, testing a true scale model of an aircraft requires a large amount of sensors mounted across the length of the tested object in order to acquire data related to critical components such as airfoils and engine, or to determine the disturbance of high-speed airflow caused by various airfoil shapes. The increased number of sensors and extended test scale add to the difficulty in accurate test and measurement.



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In the past, traditional test and measurement solutions used data loggers to acquire data from sensors. However, different kinds of sensors require different data loggers; this increases the difficulty in achieving integrated data analysis and developing a sensing network. PXI modular instrumentation platforms based on industry-standard computer buses have become an alternate option for customers looking for more flexibility and efficiency in their testing scenarios without incurring additional cost. A highly efficient, precision test and measurement solution based on PXI Express (PXIe) architecture -- with multiple channels and fully integrated synchronization -- can connect with sensors for measuring different physical quantities and can help to simplify and speed up system installation.



Challenges in Wind Tunnel Testing

Complicated relationship between sensors and data loggers

Testing a large object to actual scale requires different types of sensors for measuring correlations among surface pressure, airflow velocity, and vibration acceleration. It's difficult to integrate sensors of different types and brands, and various data loggers are used to continually acquire and record data from the sensors according to the system time set separately set in each data logger. Users are required to install electrical wiring for each data logger and additional signal wiring for drivers of each sensor, adding steps that can be complex and time-consuming.

Difficult data integration due to non-synchronized trigger among loggers

Simultaneously triggering these data loggers in the field is also challenging. A traditional solution is to connect the data loggers via their bus interface designated for synchronization and provide an external clock reference. However, this complicates signal wiring; in addition, loggers can be safely retrieved only when the testing is over and data can only be gathered and analyzed in a data center during periods when the system is operating and loggers are scheduled to log data.

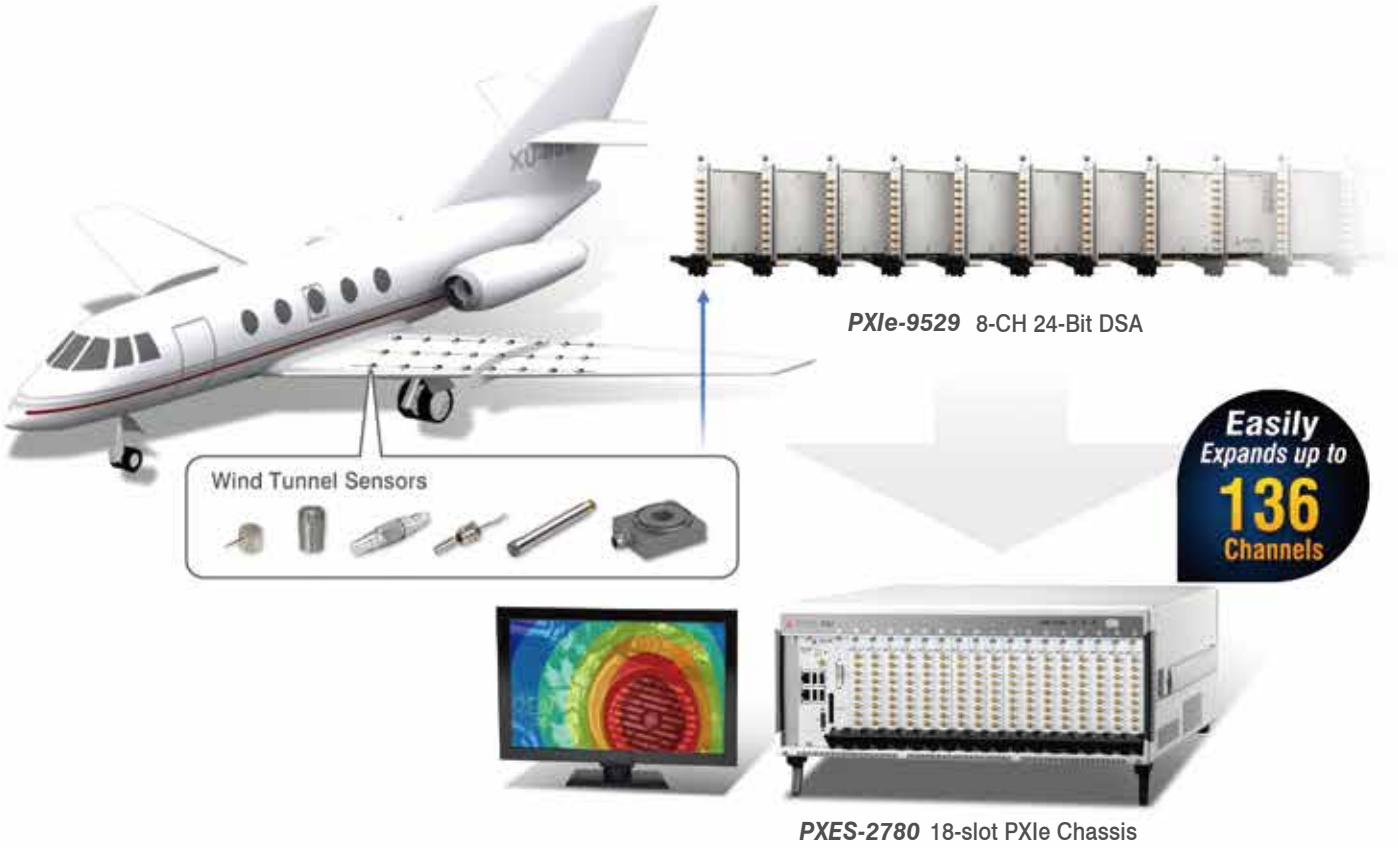
Lack of unified system clock causes drifts in data precision

Another problem is maintaining accuracy and precision in measurement. In a conventional test and measurement system, each data logger works on its own system clock and acquires data regularly. However, the clock settings of an individual data logger has nuances, which result in minor drifts in data precision and accumulate into greater inaccuracy over a longer measurement time. Theoretically, aerodynamic experiments require data capture of material changes under surface pressure, airflow velocity, and vibration acceleration during exactly the same period of time; non-synchronized data recording would forfeit their reference value for analysis.

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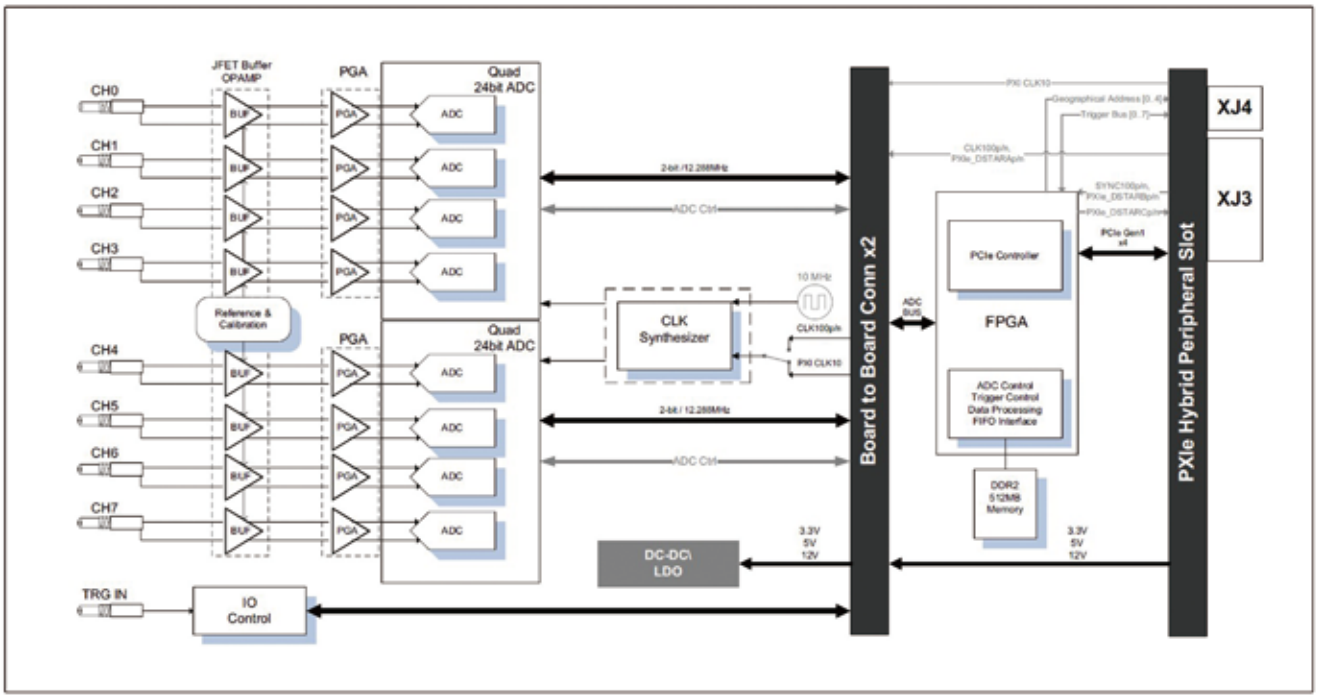
High efficiency, multi-channel PXIe systems meet requirements for accurate wind tunnel testing

Innovative and flexible, PXI Express is a modular electronic instrumentation platform designed to meet all the aforementioned challenges and provide a more efficient solution for building test and measurement equipment. The following section will highlight the features of a PXIe solution provided by ADLINK as an example of modular instrumentation; the solution includes a high slot-count chassis carrying a number of high-speed digitizers to meet requirements in massive wind tunnel aerodynamic testing. Note that ADLINK is just one of several vendors to provide high quality PXIe equipment for test and measurement, and the following configuration can be replicated as a multi-vendor solution, which is yet another benefit of using PXI Express technology.



- PXIe-9529 dynamic signal acquisition (DSA) module x17: provide flexible expansion up to 136 channels for data acquisition in a single chassis
- PXES-2780 18-slot 3U chassis x 1:installs 17 units of PXIe-9529 module
- PXIe-3975 controller x 1: runs programs for data acquisition and real time analysis

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Supports cross-sensor data acquisition

The PXIe DSA module provides up to eight 24-bit analog input channels of tight synchronization in a single module, with all the channels having the same front-end design, independent signal amplifier and analog/digital converter to allow for simultaneous data transfers between channels, so that the module can support data acquisition from various sensors. The module also features high resolution and high dynamic range, suitable for recording physical signals that require quantified measurement from low frequency to high frequency, such as vibration, pressure, and fluid volume.

Simplifies electrical wiring

All of the analog input (AI) channels of the DSA module support sensing devices compliant with IEPE standards. The module's front-end circuit was designed to provide power to activate connected IEPE sensors; therefore, the users can use the interfaces at the front panel to directly connect sensing devices without the need for additional wiring. This helps to greatly reduce wiring complexity in test/measurement instrumentation.

Reduce measurement inaccuracy with AC/DC coupling

Each of the eight AI channels in the DSA module is equipped with AC/DC coupling. Because sensors provided by different manufacturers vary in their lengths of wiring, which may produce input/output impedance mismatch with the connected module and cause drifts in signal leveling, the use of AC coupling can help to reject DC signals resulting from impedance mismatches and eliminate measurement inaccuracy.

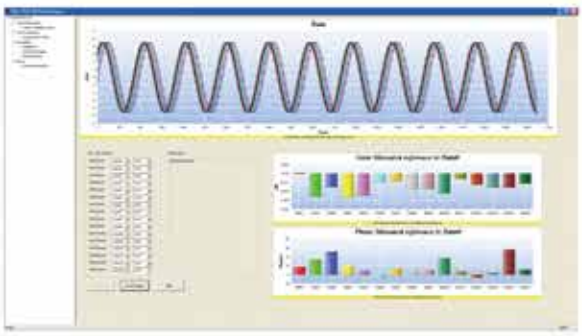
Synchronization enabled by PXI Trigger structure

The 18-slot 3U chassis provides a PXI Trigger bus on the backplane to allow users to program the deployment of master/slave modules. When the master module receives a trigger signal for data acquisition, it will immediately pass the signal to all the slave modules in the chassis via the built-in trigger lines. All wires for synchronization are already built into the system, so users do not have to deploy additional wiring or prepare for external trigger signal source.

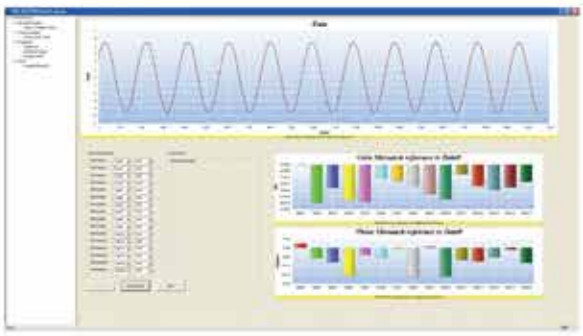
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Unified system clocking

The PXIe chassis includes a system clock to provide reference timing for PXIe modules with phase-locked loop (PLL). This system timing signal is precisely transferred to all PXIe module slot pins to serve as an external reference clock for certain data acquisition (DAQ) boards or high-speed digitizers designed with PLL. The PLL built into this configuration's DSA module can switch its time reference from an internal clock to the system clock provided by the chassis, which allows test and measurement system designers to lock the timing of all the boards and modules to the 10MHz reference clock provided by the chassis. In this way, all boards and modules in the system can acquire synchronized data in unified periods without inconsistency and inaccuracy.



Synchronization Operation Mode without PLL



Synchronization Operation Mode with PLL

Real-time data processing

This PC-based test and measurement system inherits the high-speed and high-efficiency data transfer performance of PCI Express architecture, which allows for real-time data transmission to the control center during the course of data acquisition and simultaneous data storage to storage media, or even data transfers and updates among databases of different testing stations.

Conclusion

To implement precision test and measurement on a true scale, large objects require the deployment of high-density measurement points and a variety of sensors for measuring different physical quantities. More simplified wiring, more computing power provided by high performance architecture – in this example, x86 architecture -- and excellent network connectivity are key factors to reduce the time needed for system installation and data analysis. The discussed PXI Express system is aimed at fulfilling these requirements, so as to ensure the accuracy of data acquired from different sensors and precise test and measurement results over an extended length of time.

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About ADLINK Technology

ADLINK Technology is enabling the Internet of Things (IoT) with innovative embedded computing solutions for edge devices, intelligent gateways and cloud services. ADLINK's products are application-ready for industrial automation, communications, medical, defense, transportation, and infotainment industries. Our product range includes motherboards, blades, chassis, modules, and systems based on industry standard form factors, as well as an extensive line of test & measurement products and smart touch computers, displays and handhelds that support the global transition to always connected systems. Many products are Extreme Rugged™, supporting extended temperature ranges, shock and vibration.

ADLINK is a Premier Member of the Intel® Internet of Things Solutions Alliance and is active in several standards organizations, including PCI Industrial Computer Manufacturers Group (PICMG), PXI Systems Alliance (PXISA), and Standardization Group for Embedded Technologies (SGeT).

ADLINK is a global company with headquarters in Taiwan and manufacturing in Taiwan and China; R&D and integration in Taiwan, China, the US, and Germany; and an extensive network of worldwide sales and support offices. ADLINK is ISO-9001, ISO-14001, ISO-13485 and TL9000 certified and is publicly traded on the TAIEX Taiwan Stock Exchange (stock code: 6166).

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