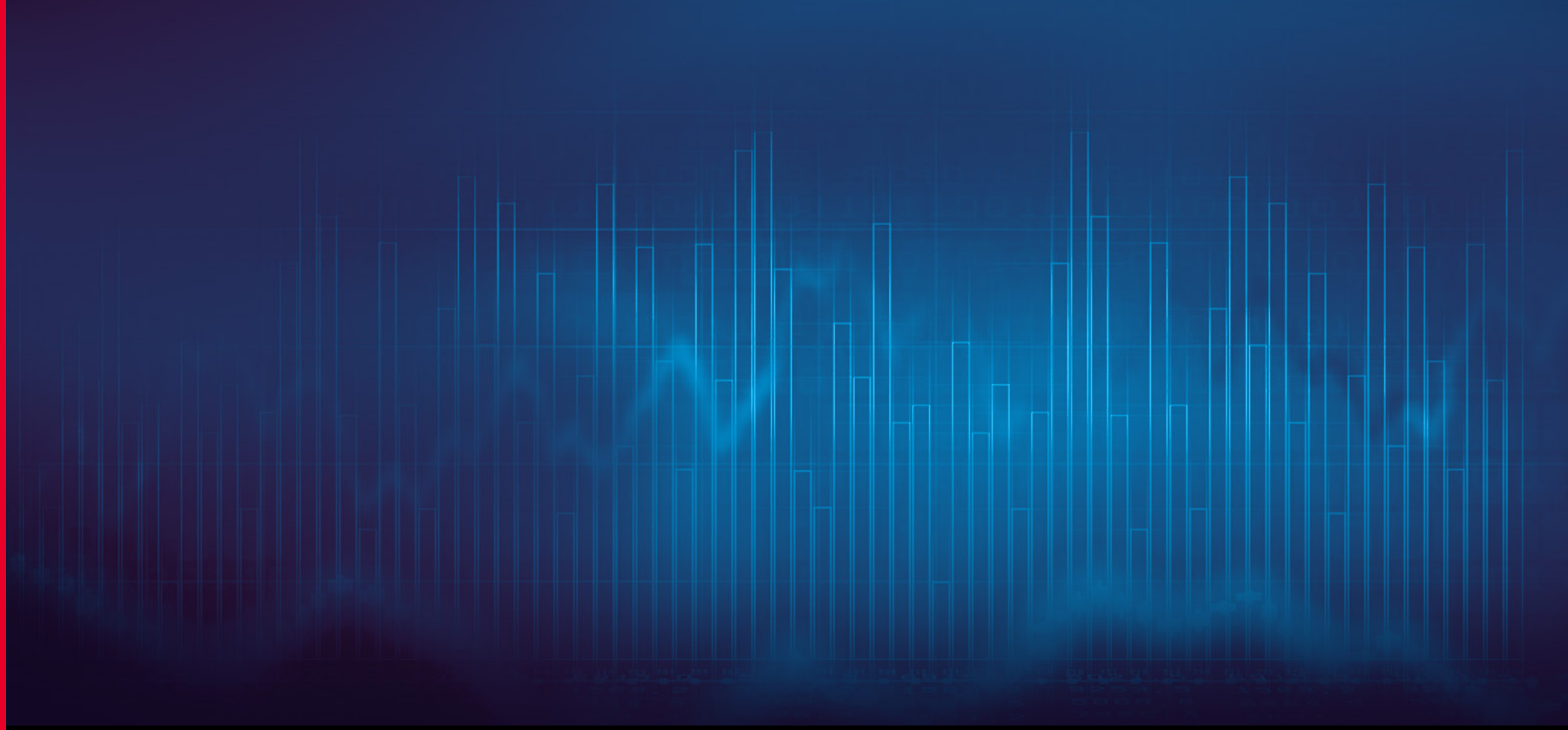


Making Dynamic Data Acquisition Measurements Using a DAQ

eBook

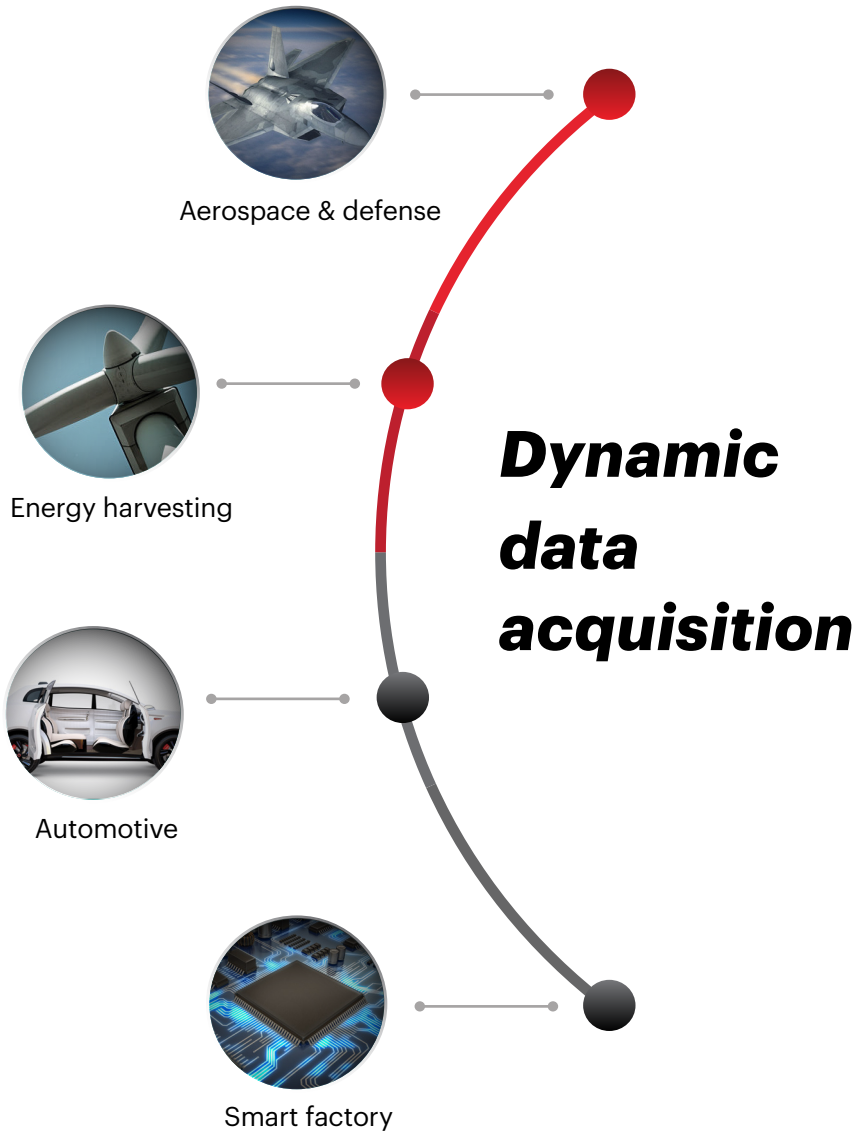
KEYSIGHT

Making Dynamic Data Acquisition Measurements Using a DAQ

Dynamic data acquisition is ubiquitous in industries such as aerospace and defense, telecommunications, automobiles, Internet of Things (IoT), and renewable energy industries.

Exponential growth in product feature sets and performance means increased complexity in product design, integration, and test characterization. To stay ahead of the product development curve, engineers need fast and accurate test systems with precision measurements across the widest range of signal types.

On top of accuracy, speed, and resolution, your test system needs to capture dynamic signals that are transient, signals with external noise, complex mixed signals, and more.



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CHAPTER 1

What is Dynamic Data Acquisition?

CHAPTER 1

What is Dynamic Data Acquisition?

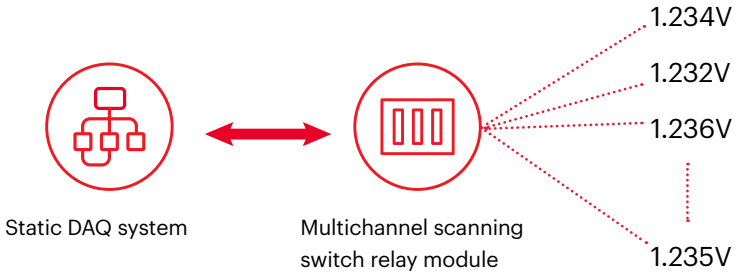
Static versus dynamic data acquisition

A traditional Data Acquisition (DAQ) system scans its input channels and logs the measured data as it reads through each channel. Most DAQ systems in the marketplace today are static systems. The system generally takes a single measurement as it scans through each channel.

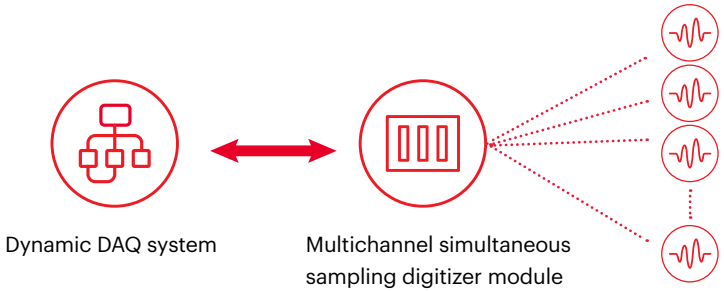
A modern DAQ system has dynamic data acquisition capabilities. As it scans through each channel, the system takes multiple samples of measurements instead of just a single measurement.

Read more about static versus dynamic DAQ in this white paper: Dynamic Data Acquisition System.

> A traditional DAQ provides one sample of static data. Dynamic data is more complex because it represents a data set.

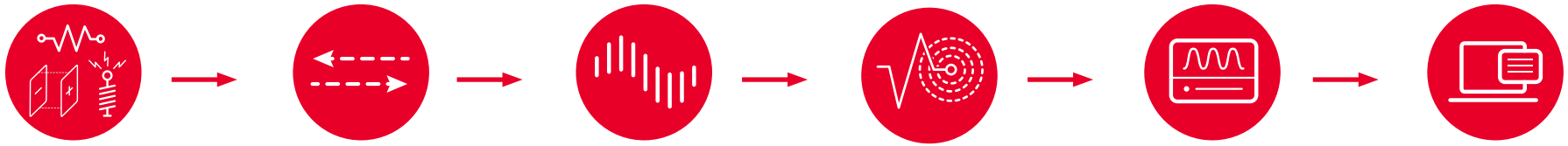


Data scanned by the switch relay module are single point measurements.



Data scanned by the simultaneous sampling digitizer module are multiple point measurements or captured waveforms signals (for example, with high sample rates such as 800 kSa / seconds).

Architecture of a dynamic data acquisition system



Sensors

DAQ systems' input channels are incredibly versatile because their design measures many types of signals and sensors such as voltage, current, resistance, temperature, capacitance, stress, strain, vibration, and shock.

Cable & Connections

Connection to the sensors is via twisted or shielded cables in the form of two-wire single-ended or two-wire differential inputs.

Some sensors connect using the four-wire Kelvin contact method. This approach reduces measurement errors due to voltage drops across long cable lengths.

Signal Conditioning

Signal conditioning amplifies, attenuates, linearizes, filters, or isolates signals from transducers before they advance to the hardware for processing.

Signal conditioning converts signals from their raw form into a measurable condition that is quantifiable and accurate.

Signal Digitizer

A signal digitizer has multiple input channels synchronized to sample simultaneously. The signal becomes digitized based on the configured sampling rate.

The digitizer captures dynamic signals for further processing such as digitally filtered, mathematically converted, and formatted.

DAQ System

The DAQ system receives and reads the digitized signal, whether they are in voltage, current, or resistance, with a timestamp for each reading.

The system also configures the digital input / output channels. For example, switch control, analog output signal sourcing, triggering controls, data logging, storage setups, and more.

PC Data Acquisition Software

The software has capabilities to remotely control multiple DAQ hardware systems, store data, and display data in various formats such as trend charts, bar charts, tables, statistical data, and more.

It can configure, synchronize, capture, monitor, and process signals from multiple DAQ systems.

CHAPTER 2

Sensors, Cables, and Connections

CHAPTER 2

Sensors, Cables, and Connections

Types of sensors and dynamic data applications

> Learn more about the physical parameters in this white paper: Mechanical Test Characterization for Validation Reliability

Dynamic data acquisition application	Type of sensors	Sensor characteristics and usage
Vibration and shock analysis	Piezoelectric	Common usage for the piezoelectric sensor is in industrial applications because of its ruggedness and rigidity.
	Capacitive	The capacitive sensor is typically micro-fabricated using MEMS fabrication technology. This sensor is applicable in electronic devices such as mobile phones and IoT devices.
	Piezoresistive	Use the piezoresistive sensor for shock testing because it can manage a gravitational force equivalent of > 200 g.
Audio and acoustic analysis	Pressure-field microphone	The pressure-field microphone has a flat frequency response using a diaphragm to capture the sound pressure and is useful for measuring surface pressures.
	Free-field microphone	The field-free microphone has a flat frequency response when measuring acoustics at zero degrees incidence, or when directly pointing to the sound source. Its frequency response compensates for the higher pressures at high frequencies. It measures sound pressure as if it existed before the introduction of the microphone into the sound field. Use these sensors for outdoor measurements or in an anechoic chamber.
	Random incidence microphone	The random incidence microphone is applicable when measuring the sound field coming from multiple directions.
Stress and strain analysis	Resistive strain gauge	Resistive strain gauge applications are commonly used with the Wheatstone bridge circuit to accurately measure strains of structures under tensile, torsional, or compression stress.
	Piezoelectric	Piezoelectric sensors can measure strain and are less susceptible to temperature fluctuations as compared to the resistive strain gauge.

Sensors, Cables, and Connections

Types of cables and connections

Once you have converted the physical parameter into an electrical signal using a sensor, it is now ready to send to the measuring instrument. Issues can occur by using improper cables, or if the connections are not correct. The main problem you may encounter is noise.

Figure 4 is an example of twisted pair shielded cables to reduce noise from the system. Each pair of wires in the bundle is twisted together to further reduce crosstalk interference from other wire pairs. Shielding the wires reduces electromagnetic and radio frequency interference.

Figure 5 shows a one-wire (single-ended) multiplexer used in an application where common ground is practical. Two-wire (differential) multiplexers are standard for applications that have a differential with high and low input.

> Improper cables and connections introduce unwanted noise signals into your measurements

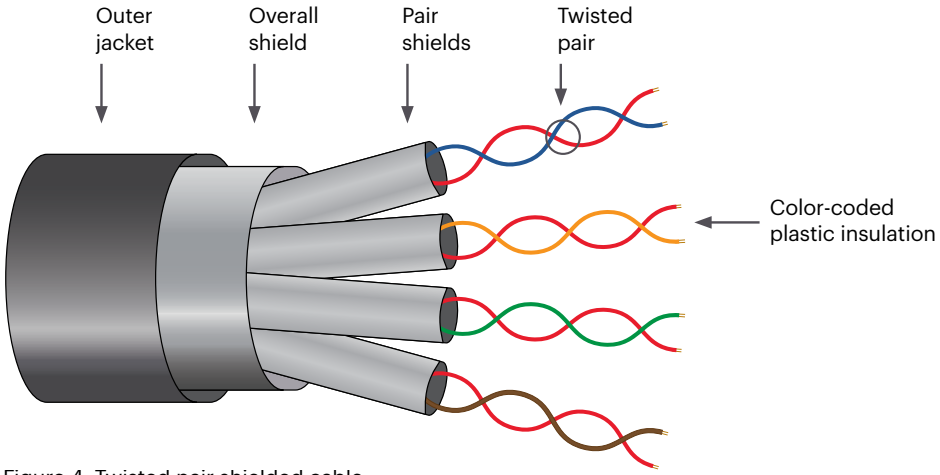


Figure 4. Twisted pair shielded cable

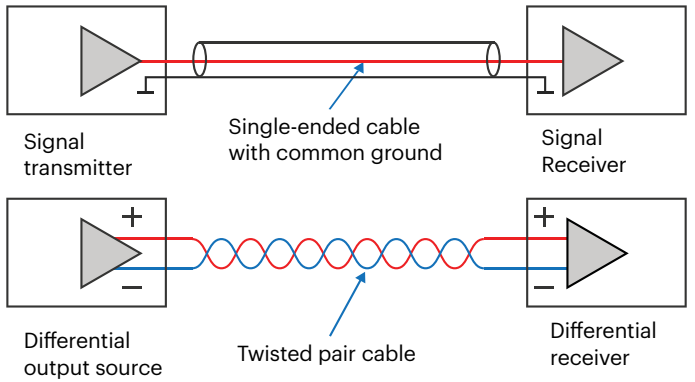
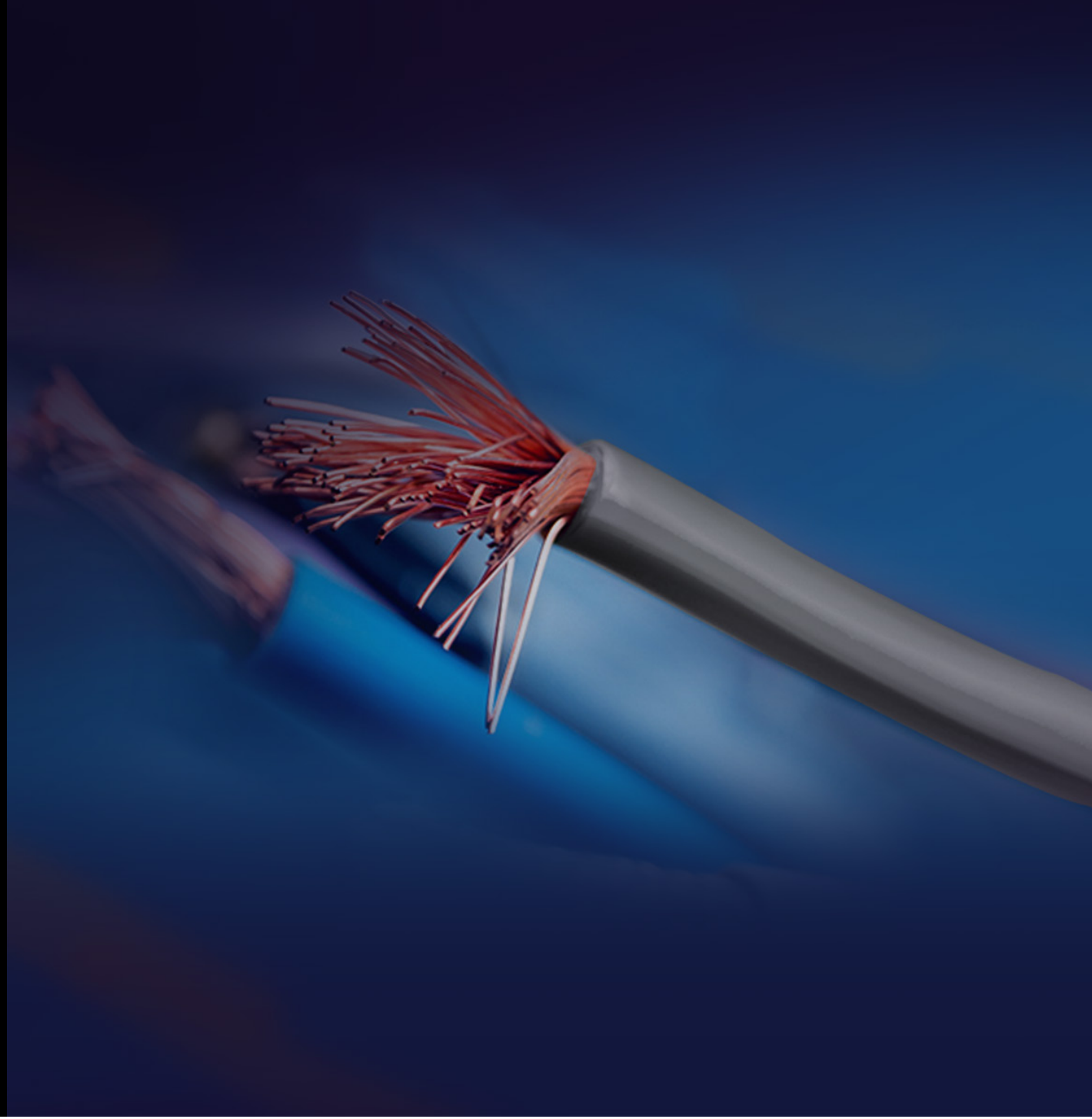


Figure 5. Single-ended versus differential cable wiring

CHAPTER 3

Data Aquisition System



CHAPTER 3

Data Acquisition System

Signal conditioning

Signal conditioning amplifies, attenuates, shapes, or isolates signals from transducers before transferring to the measurement hardware. Signal conditioning converts the signal to a form that is easily measurable by the system.

Examples of signal conditioning includes

- Amplification of small signals
- Attenuation of large signals
- Thermocouple compensation for temperature measurements
- Current sourcing for 2-wire and 4-wire resistance measurements
- Filtering to remove system noise
- Shunt resistors for current measurements

In some DAQ systems, the signal conditioning components are incorporated internally within the system. These systems can measure DC and AC voltage, resistance, frequency, current, and temperature on any input channel without the need for external signal-conditioning components.

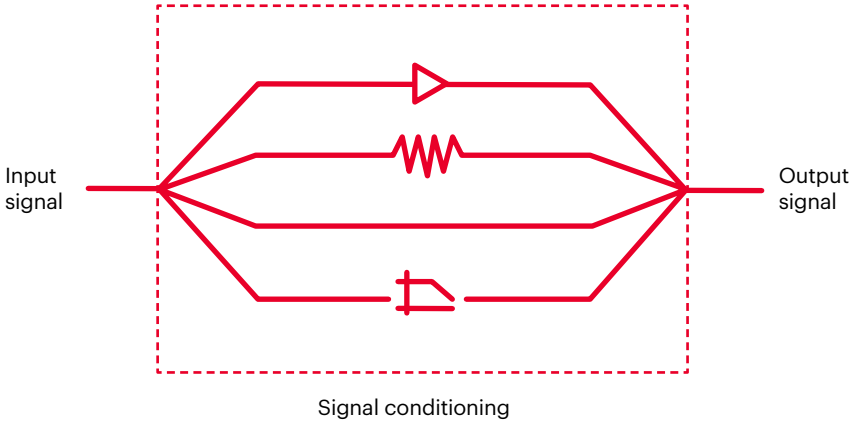


Figure 6. Examples of the various types of signal conditioning

> Signal conditioning converts the signal to a form that is easily measurable by the system.

Data Acquisition System

Signal conditioning

Figure 7 shows a basic single-channel analog-to-digital DAQ digitizer that supports Integrated Electronics Piezoelectric (IEPE) sensors. The DAQ digitizer provides a constant current source to excite the sensor using the same cable path. The DAQ digitizer module then reads the voltage measured from the IEPE sensor. There is a clock reference that can synchronize the multiple DAQ digitizer modules.

The measured voltage is converted using a built-in analog to digital converter. The information transfers into the DAQ mainframe for further processing, storage, and display.

A DAQ digitizer module will have many channels with a DAQ clock reference to synchronize the channels giving you a multichannel simultaneous analog-to-digital sampling.

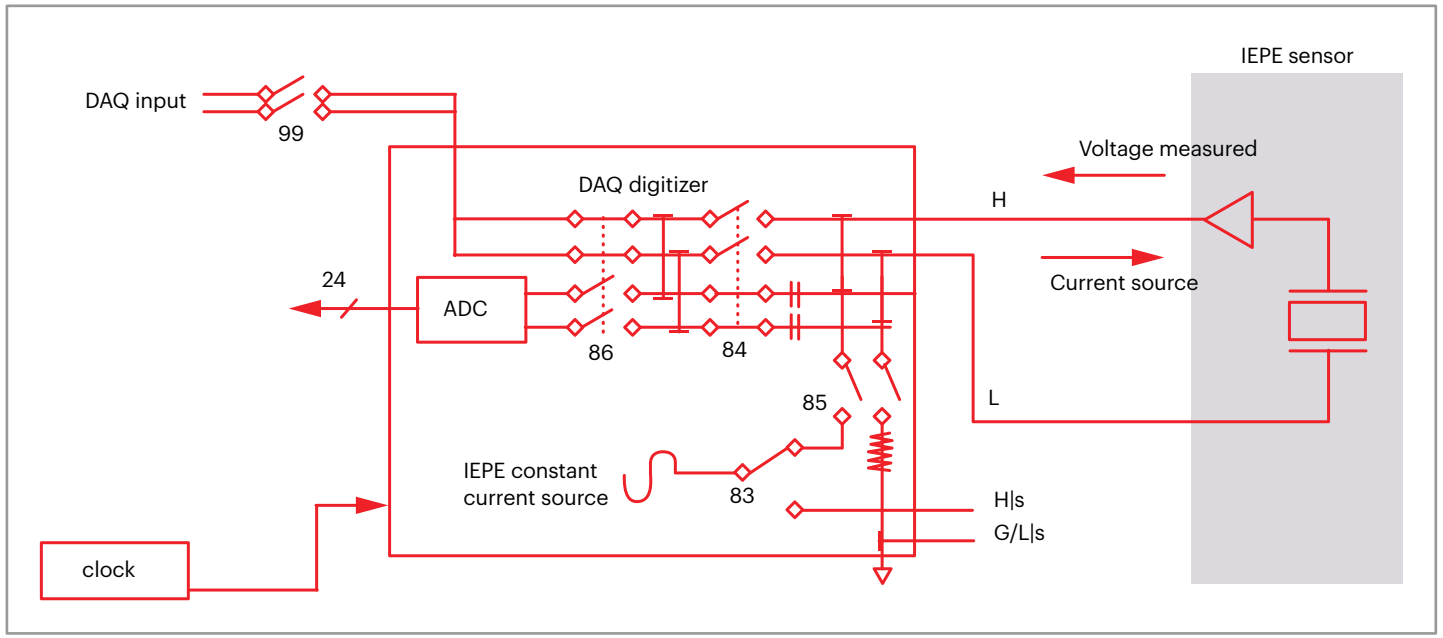


Figure 7. Example of a single-channel DAQ digitizer

> Learn more about the benefits of a DAQ in this white paper: Dynamic Aquisition Data System

Data Acquisition System

Simultaneous virtual computation

A dynamic DAQ system can have many channels for measurements. You can also configure a computed channel or a virtual digitizer channel. Figure13 shows a PC DAQ application software interface that enables you to configure a computed channel using mathematical operations such as multiply, divide, add, or subtract between two real measurement channels.

You can even perform a math operation between a real measurement channel and a constant value. The DAQ can perform a math function between two computed channels to form a new computed channel.

This process gives you the necessary flexibility to display the final measurement units rather than performing the calculation offline.

These measurements are exportable using file formats that are readable by MATLAB, Microsoft Excel / Word for further post-analysis reporting.

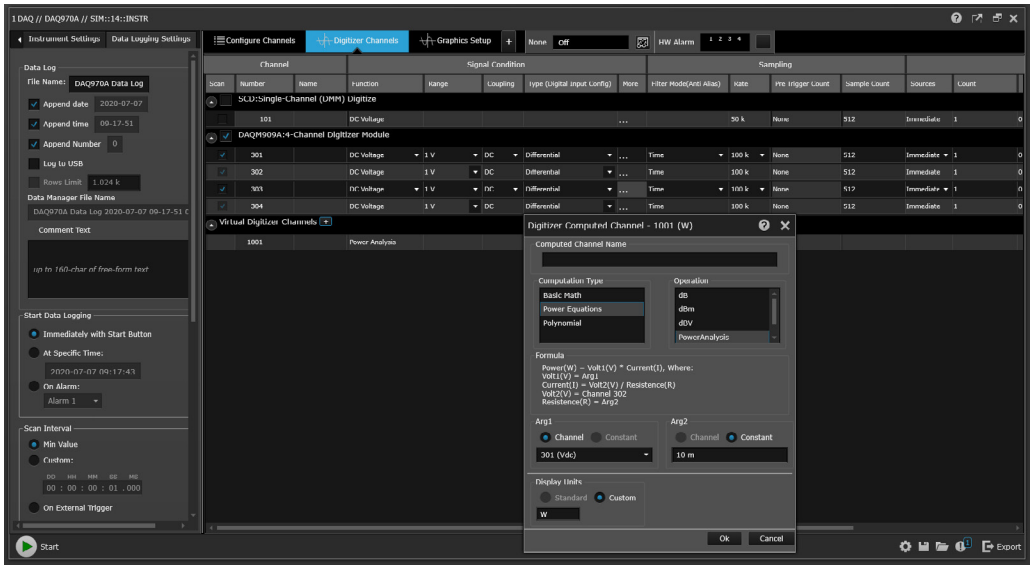


Figure 8. PC computed channel configuration setup in a DAQ application software

CHAPTER 4

Control Data Analysis Software

CHAPTER 4

Control Data Analysis Software

Remote control and configuration

Keysight PathWave BenchVue software will demonstrate the features and how the control data analysis software complements the DAQ hardware system.

An important function is the capability to remotely control a DAQ or multiple DAQ systems by using Keysight PathWave BenchVue software. Using the software with the DAQ hardware is an effective tool for monitoring operations because of its versatility in measuring multiple signal types, data logging capability over lengthy periods, and multichannel measurement input scalability.

There are two types of remote control configurations:

- Centralized DAQ system
- Distributed DAQ system

> Find out more about remote control and configurations in this white paper: Effective Monitoring and Streamline Testing Using a DAQ

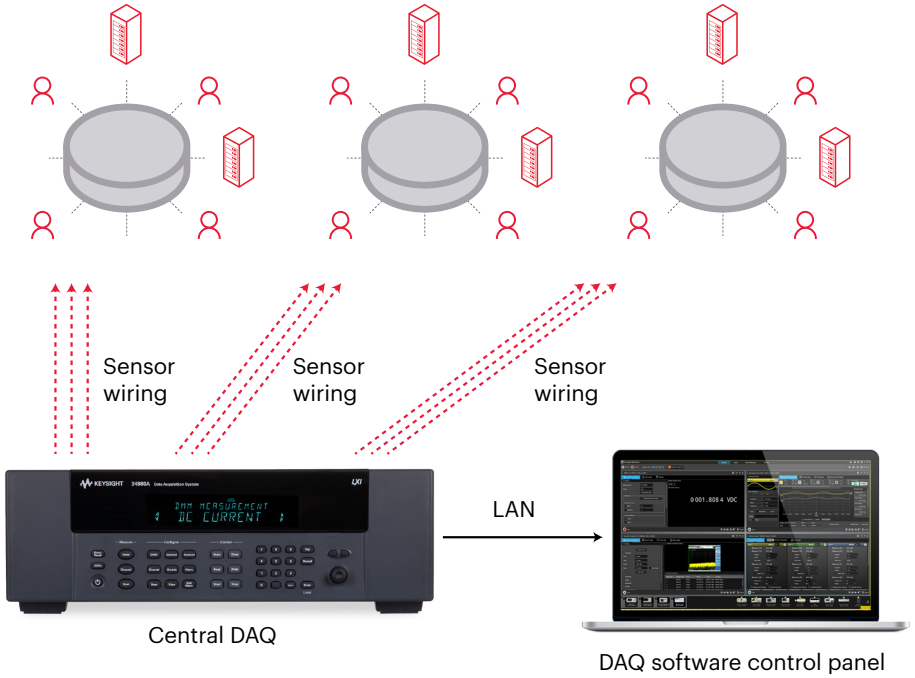


Figure 9. Centralized DAQ system

This setup is ideal for R&D product designers who are working on standalone projects or gathering data points from a single point physical location within a small footprint. Data synchronization is achievable when using a single DAQ system.

However, if the sensor wirings are too long, they can potentially decrease measurement accuracy. Control data analysis software helps to configure the sensors on a single remote control panel.

Control Data Analysis Software

Remote control and configuration

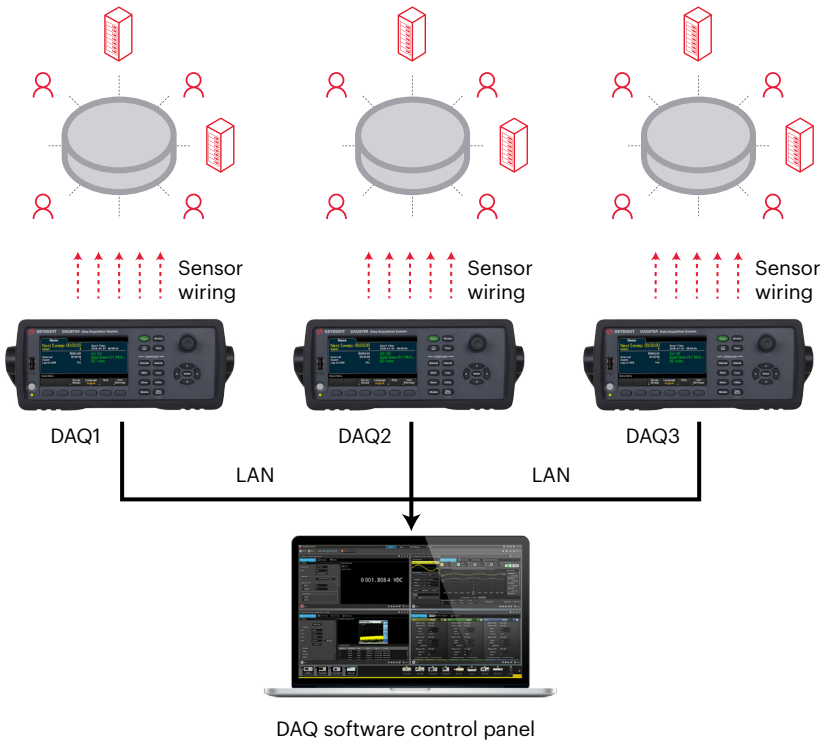


Figure 10. Distributed DAQ system

Each work cell has a dedicated DAQ system with a small DAQ mainframe. Each cell connects via the Ethernet or LAN to the DAQ software running in a central control location.

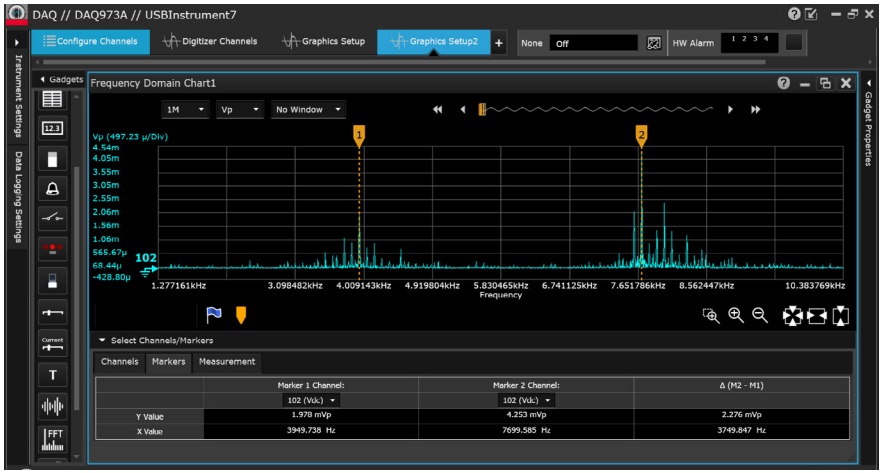
Since each DAQ's location is close to the work cell, sensor wirings are very short ensuring optimal measurement accuracy. The biggest challenge for a distributed DAQ system setup is the time synchronization for the data collected. Control data analysis software helps you to synchronize the data collection of a distributed system.

Control Data Analysis Software

Graphical displays in time and frequency domain

PathWave BenchVue DAQ software enables you to graph and perform time domain analysis. The PC DAQ application software displays data in a time domain chart. The easy access buttons quickly measure minimum or maximum amplitude, magnitude, rise or fall time, duty cycle, period, phase, negative or positive width, and a host of other statistical measurements.

When the PathWave BenchVue DAQ software is in frequency domain chart mode, it can quickly help you derive Total Harmonic Distortion (THD), Total Harmonic Distortion with Noise (THD+N), or Signal to Noise and Distortion Ratio (SINAD) measurement with a click of a button. Frequency domain analysis helps you identify the telltale signature profile of non-stationary machinery operation, unwanted AC power harmonic distortions, or identify the type of environmental noise.

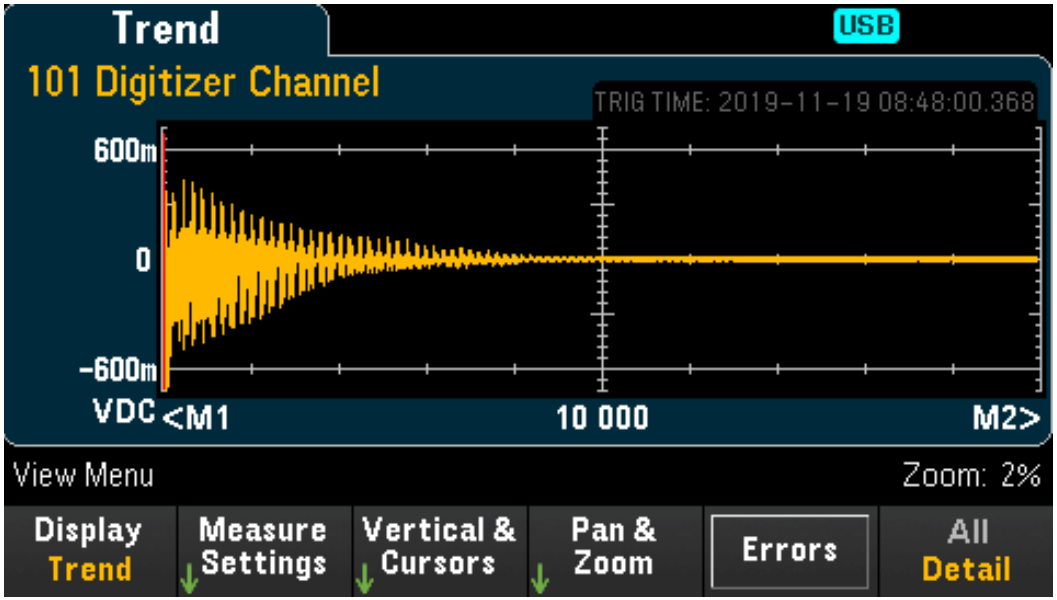


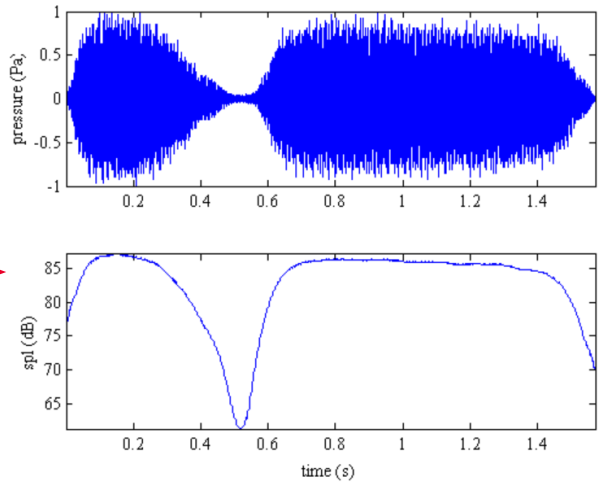
Control Data Analysis Software

Export data for further engineering evaluation

PathWave BenchVue DAQ software has graphing tools to view your dynamic signals in time-domain and frequency-domain. You can zoom, pan, and use markers for your analysis work.

You can choose to export your data from the DAQ software to formats readable by PC software such as Microsoft Excel / Word and MATLAB for further detailed post-analysis work.

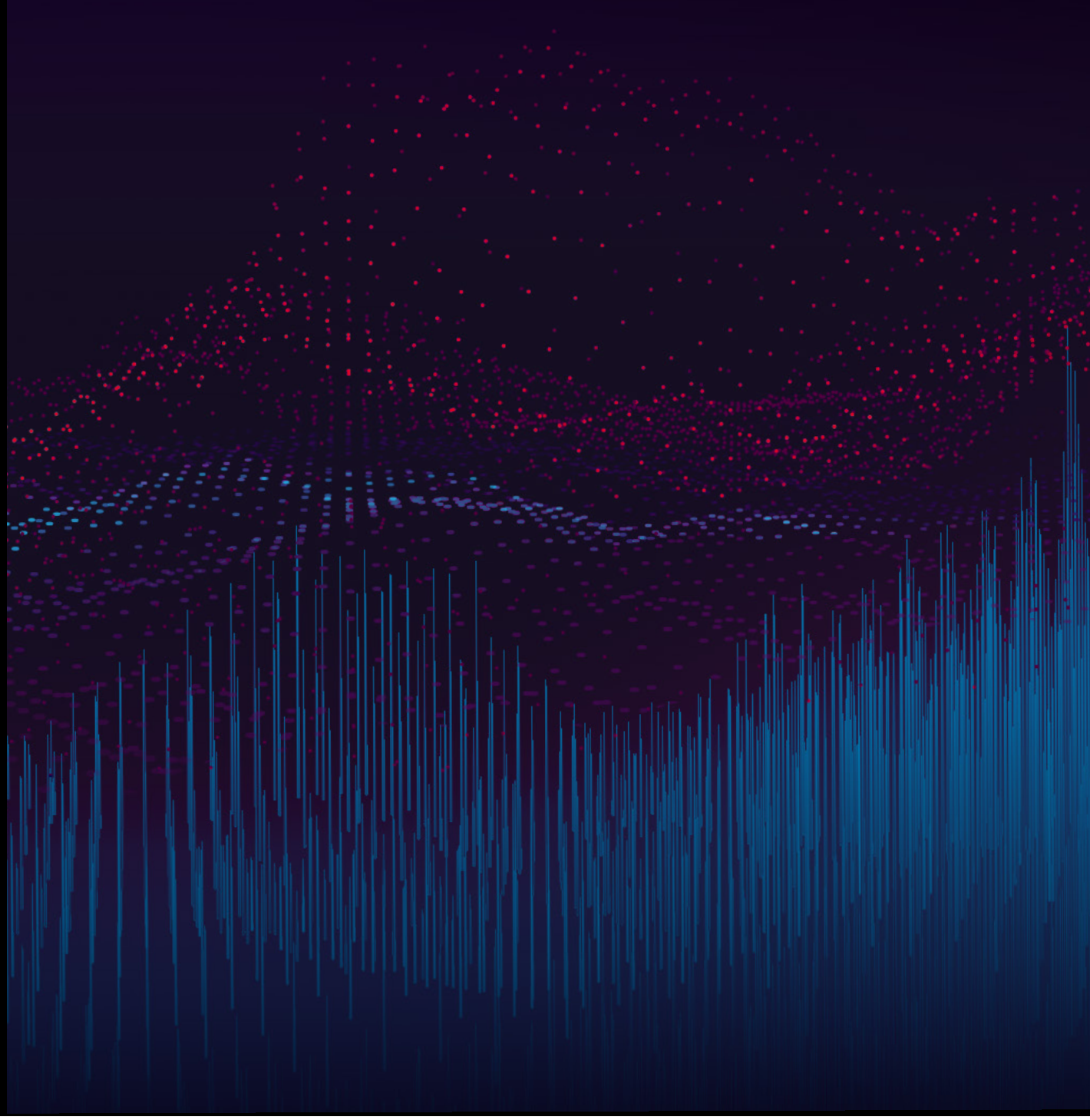




Post-analysis work using a PC with MATLAB displaying the dynamic sound pressure level signal. Image source

CHAPTER 5

Summary



SUMMARY

The DAQ system is not new in the field of measurement science. However, it is becoming increasingly important because today's products are more complex in terms of design, integration, and test characterization. The system ensures accuracy and reduces the errors and variability often associated with the acquisition and analysis of dynamic data.

This eBook has walked through the architecture of a dynamic DAQ system. You can now confidently choose the sensors, types of cables to use, hardware requirements, and the PC DAQ software for controlling your DAQ hardware, and how to perform data analysis.

Keysight Technologies has DAQ solutions for electrical, physical, mechanical, acoustic, and signal routing applications up to 50 GHz. Our extensive range of DAQ platforms will help you meet your project's objectives and goals.

Keysight's DAQ970A / DAQ973A next-generation compact systems give you the high quality and performance to test your product's design. The Keysight 34980A larger capacity standalone mainframe is for higher capacity production testing, while the standard high-performance Keysight PXI DAQ solution can help you with your demanding applications. Keysight's USB DAQ solution provides quality testing in a compact form factor that is cost-effective.

Summary

Keysight DAQ hardware solutions

DAQ970A/DAQ973A

- Mid-size standalone mainframe with three module slots for benchtop R&D and manufacturing environments
- Built-in 6.5-digit digital multimeter and signal conditioning circuitry; fast reading measurements up to 50,000 readings / second and scan rate of up to 450 channels / second
- Available with nine types of modules: multiplexer, matrix, RF and general purpose, SPDT / Form C switches, multifunction, and simultaneous sampling digitizer

34980A

- Large capacity standalone mainframe with up to eight module slots
- Built-in 6.5-digit digital multimeter, signal conditioning circuitry; high performance switching with a scan rate of up to 1000 channels / second
- Choose from 21 plug-in modules: multiplexer, matrix, RF and general purpose, Form A and C switches, system control, and breadboard modules

M9000 PXI DAQ

- Provides flexibility, compatibility, and performance required for demanding applications
- Designed for large systems with monitoring functions
- Choose from a variety of plug-in modules: simultaneous sampling digitizer, multiplexer, matrix, RF, microwave and general purpose switches, system control, and signal conditioning modules

U2000 USB DAQ

- Provides flexibility as a standalone product or can be plugged into a chassis to make synchronized measurements
- Comes with six module slots — requires external controller or PC
- Choose from 18 plug-in modules: matrix, multifunction DAQ, simultaneous DAQ, digital input / output, digital-to-analog converter, and signal conditioning

Summary

DAQ PC software solution

PathWave BenchVue software for the PC eliminates many bench test challenges. With just a few clicks, you can connect, control instruments, and automate test sequences. You can quickly move past the test development phase and access results faster than ever before.

Dedicated instrument applications enable you to quickly configure the most commonly used measurements and setups for each instrument family. Rapidly build custom test sequences with the integrated Test Flow application to automate and visualize test results without the need for instrument programming.

BenchVue supports hundreds of Keysight instrument types and models — all from one easy-to-use application.

Summary

References

White papers

- Dynamic Data Acquisition System
- Mechanical test characterization for validation and reliability
- Effective Monitoring and Streamline Testing Using a DAQ

Webinar

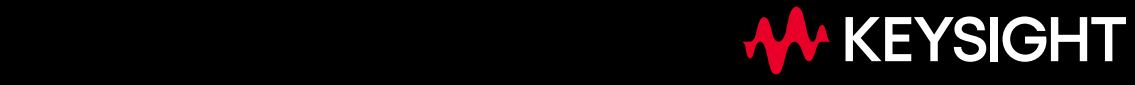
- Simultaneously Monitoring Dynamic Data Using a DAQ Solution

Keysight solutions

- DAQ970 series standalone systems
- 34980A large standalone system
- M9000 series PXI DAQ
- U2000 series USB DAQ

Keysight PathWave BenchVue DAQ software

- PathWave BenchVue DAQ software application
- PathWave BenchVue complete bundle software solution



Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.