Selecting the Right Data Acquisition System
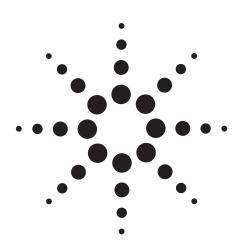
Introduction

Engineers often must monitor a handful of signals over extended periods of time, and then graph and analyze the resulting data. The need to monitor, record and analyze data arises in a wide range of applications, including the design-verification stage of product development, environmental chamber monitoring, component inspection, benchtop testing and process trouble-shooting.

This application note describes the various methods and devices you can use to acquire, record and analyze data, from the simple pen-and-paper method to using today's sophisticated data acquisition systems. It discusses the advantages and disadvantages of each method and provides a list of questions that will guide you in selecting the approach that best suits your needs.

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Data acquisition options

Data acquisition technology has taken giant leaps forward over the last 30 to 40 years. For example, 40 years ago, in a typical college lab, apparatus for tracking the temperature rise in a crucible of sodium-tungsten-bronze consisted of a thermocouple, a bridge, a lookup table, a pad of paper and a pencil. Today's college students are much more likely to use an automated process and analyze the data on a PC

Today, numerous options are available for gathering data. The optimal choice depends on several factors, including the complexity of the task, the speed and accuracy you require, and the documentation you want. Data acquisition systems range from the simple to the complex, with a range of performance and functionality.

Pencil and paper

The old pencil and paper approach is still viable for some situations, and it is inexpensive, readily available, quick and easy to get started. All you need to do is hook up a digital multimeter (DMM) and begin recording data by hand. Unfortunately, this method is error-prone, tends to be slow and requires extensive manual analysis. In addition, it works only for a single channel of data; while you can use multiple DMMs, the system will quickly becomes bulky and awkward. Accuracy is dependent on the transcriber's level of fastidiousness and you may need to scale input manually. For example, if the DMM is not set up to handle temperature sensors, manual scaling will be required. Taking these limitations into account, this is often an acceptable method when you need to perform a quick experiment.

Strip chart recorder

Modern versions of the venerable strip chart recorder allow you to capture data from several inputs. They provide a permanent paper record of the data, and because this data is in graphical format, they allow you to easily spot trends. Once set up, most recorders have sufficient internal intelligence to run unattended — without the aid of either an operator or a computer.

Drawbacks include a lack of flexibility and relatively low accuracy, which is often constrained to a few percentage points. You can typically perceive only small changes in the pen plots. While recorders perform well when monitoring a few channels over a long period of time, their value can be limited. For example, they are unable to turn another device on or off. Other concerns include pen and paper maintenance, paper supply and data storage, all of which translate into paper overuse and waste. Still, recorders are fairly easy to set up and operate, and offer a permanent record of the data for quick and simple analysis.

Scanning digital multimeter

Some benchtop DMMs offer an optional scanning capability. A slot in the rear of the instrument accepts a scanner card that can multiplex between multiple inputs, with 8 to 10 channels of mux being fairly common. DMM accuracy and the functionality inherent in the instrument's front panel are retained. Flexibility is limited in that it is not possible to expand beyond the number of channels available in the expansion slot. An external PC usually handles data acquisition and analysis.

PC plug-in cards

PC plug-in cards are single-board measurement systems that take advantage of the ISA or PCI-bus expansion slots in a PC. They often have reading rates as high as 100,000 readings per second. Counts of 8 to 16 channels are common, and acquired data is stored directly into the computer, where it can then be analyzed. Because the card is essentially part of the computer, it is easy to set up tests. PC cards also are relatively inexpensive, in part, because they rely on the host PC to provide power, the mechanical enclosure and the user interface.

On the downside, PC plug-in cards often have only 12 bits of resolution, so you can't perceive small variations with the input signal. Furthermore, the electrical environment inside a PC tends to be noisy, with high-speed clocks and bus noise radiated throughout. Often, this electrical interference limits the accuracy of the PC plug-in card to that of a handheld DMM.

These cards also measure a fairly limited range of dc voltage. To measure other input signals, such as ac voltage, temperature or resistance, you may need some sort of external signal conditioning. Additional concerns include problematic calibration and overall system cost, especially if you need to purchase additional signal conditioning accessories or a PC to accommodate the cards. Taking that into consideration, PC plug-in cards offer an attractive approach to data acquisition if your requirements fall within the capabilities and limitations of the card.

Data loggers

Data loggers are typically stand-alone instruments that, once they are setup, can measure, record and display data without operator or computer intervention. They can handle multiple inputs, in some instances up to 120 channels. Accuracy rivals that found in standalone bench DMMs, with performance in the 22-bit, 0.004-percent accuracy range. Some data loggers have the ability to scale measurements, check results against user-defined limits, and output signals for control.

One advantage of using data loggers is their built-in signal conditioning. Most are able to directly measure a number of different inputs without the need for additional signal conditioning accessories. One channel could be monitoring a thermocouple, another a resistive temperature device (RTD) and still another could be looking at voltage. Thermocouple reference compensation for accurate temperature measurement is typically built into the multiplexer cards.

A data logger's built-in intelligence helps you set up the test routine and specify the parameters of each channel. Once you have completed the setup, data loggers can run as standalone devices, much like a recorder. They store data locally in internal memory, which can accommodate 50,000 readings or more. PC connectivity makes it easy to transfer data to your computer for in-depth analysis. Most data loggers are designed for flexibility and simple configuration and operation, and many provide the option of remote site operation via battery packs or other methods.

Depending on the A/D converter technique used, certain data loggers take readings at a relatively slow rate, especially compared to many PC plug-in cards. Still, reading speeds of 250 readings/second are not uncommon. Keep in mind that many of the phenomena being monitored are physical in nature — such as temperature, pressure and flow — and change at a fairly slow rate. Additionally, because of a data logger's superior measurement accuracy, multiple readings and averaging are not necessary, as they often are in PC plug-in solutions.

Data acquisition front ends

Data acquisition front ends are often modular and are typically connected to a PC or controller. They are used in automated test applications for gathering data and for controlling and routing signals in other parts of the test setup. Front end performance can be very high, with speed and accuracy rivaling the best standalone instruments.

Data acquisition front ends are implemented in a number of formats, including VXI versions, such as the Agilent E1419A multifunction measurement and control VXI module, and proprietary card cages.. Although front-end cost has been decreasing, these systems can be fairly expensive, and unless you require the high performance they provide, you may find their price to be prohibitive. On the plus side, they do offer considerable flexibility and measurement capability.

Data Logger Applications

A good, low-cost data logger with moderate channel count (20 - 60 channels) and a relatively slow scan rate is more than sufficient for many of the applications engineers commonly face. Some key applications include:

- Product characterization
- Thermal profiling of electronic products
- Environmental testing; environmental monitoring
- Component characterization
- Battery testing
- White-goods testing
- Building and computer room monitoring
- Process monitoring, evaluation and troubleshooting

Data logger application:
Automated test station to evaluate prototype ICs

- Quick installation socket on test PC board
- PC board mounted on heater/cooler to test IC under varying temperature conditions
- Fully automated using Visual Basic, GPIB instruments

Results:

- Cuts evaluation time by half
- Accurate, consistent results
- Easy documentation

Data logger application:
Characterize new power supply design

- Check output voltages and noise levels
- Simulate load (with power resistor) and check heat rise, efficiency
- Measure key components for absolute temperature

Results:

- Shortened development time
- Increased reliability by limiting internal temperatures
- Verified power supply input specifications

Which data acquisition system is right for you?

No single data acquisition system works for all applications. Answering the following questions may help you decide which will best meet your needs:

1. Does the system match my application?

What is the measurement resolution, accuracy and noise performance?

How fast does it scan?

What transducers and measurement functions are supported?

Is it upgradeable or expandable to meet future needs?

How portable is it?

Can it operate as a standalone instrument?

2. How much does it cost?

Is software included, or is it extra?

Does it require signal conditioning add-ons?

What is the warranty period?

How easy and inexpensive is it to calibrate?

3. How easy is it to use?

Can the specifications be understood?

What is the user interface like?

How difficult is it to reconfigure for new applications?

Can data be transferred easily to new applications?

Which application packages are supported?

Conclusion

Data acquisition can range from pencil, paper and a measuring device, to a highly sophisticated system of hardware instrumentation and software analysis tools. The first step for users contemplating the purchase of a data acquisition device or system is to determine the tasks at hand and the desired output, and then select the type and scope of equipment that meets their criteria. All of the sophisticated equipment and analysis tools that are available are designed to help users understand the phenomena they are monitoring. The tools are merely a means to an end.

Glossary

Data acquisition — the collection of data from sensors, electrical signals and instruments. Data acquistion is usually automated, and it can be performed in a factory, on a lab bench or in the field.

Data logger — a data acquisition system designed for acquiring and archiving physical measurement data. Typically a standalone system with moderate channel count (20 - 60 channels) that acquires data over time.

Digital multimeter — a digital instrument for measuring ac and dc volts, dc current and resistance

DMM — digital multimeter

Multiplexing — a scheme for switching multiple channels to a single channel

PC plug-in cards — PC plug-in cards are measurement systems that plug into the ISA or PCI-bus expansion slots in a PC.

Signal conditioning — makes a signal suitable for input to an analog-to-digital (A-D) converter. A signal may be filtered to remove noise, or attenuated or amplified to meet the range of the A-D converter.

Related Agilent Literature

Product overview — 34970A Data Acquisition/Switch Unit, pub. no. 5965-5290EN

Application note 290 — Practical Temperature Measurements, pub. no. 5965-7822EN

Application note 1386 — Essential Components of Data Acquisition Systems, pub. no. 5988-5386EN

Application note 1387 — Types of Data Acquisition Architectures, pub. no. 5988-5387EN

Application note 1389-1 — Digital Multimeter Measurement Errors Series: System Cabling Errors and DC Voltage Measurement Errors in Digital Multimeters, pub. no. 5988-5511EN

Application note 1389-2 — Digital Multimeter Measurement Errors Series: Resistance; DC Current; AC Current; and Frequency and Period Measurement Errors in Digital Multimeters, pub. no. 5988-5512EN

Application note 1389-3 — Digital Multimeter Measurement Errors Series: AC Voltage Measurement Errors in Digital Multimeters, pub. no. 5988-5513EN

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