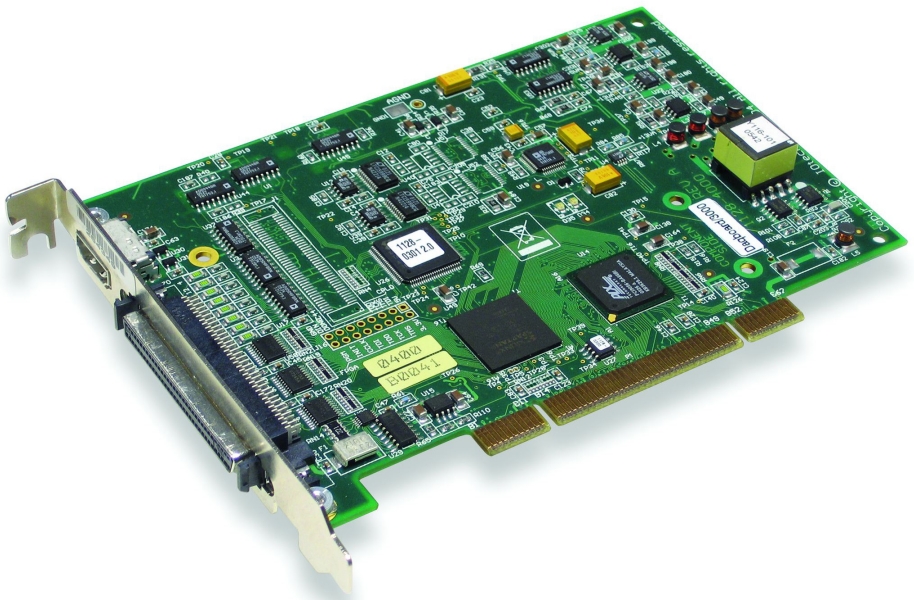
PCI-2500 Series

PCI 16-Bit, 1 MHz Multifunction Boards



The PCI-2500 Series provides 1 MHz sampling, synchronous multifunction I/O, analog input expansion capability, and extensive software support

Overview

The PCI-2500 Series offers high-speed, multifunction data acquisition in a low-cost, board-only design.

Each board offers synchronous and concurrent voltage input, temperature input, waveform output, counter input, quadrature encoder input, timer output, and digital I/O.

Everything necessary to begin acquiring, viewing, and storing data is included with the PCI-2500 Series, including comprehensive software support.

The PCI-2500 Series feature a 16-bit, 1 MHz A/D converter, 16 analog input channels (user-expandable to 64), up to four 16-bit, 1 MHz analog outputs, 24 high-speed digital I/O, 2 timer outputs, and four 32-bit counters. All analog I/O, digital I/O, and counter/timer I/O can operate synchronously and simultaneously, guaranteeing deterministic I/O timing amongst all signal types.

A high-speed, low-latency, highly deterministic control output mode operates independent of the PC. In this mode, both digital and analog outputs can respond to analog, digital, and counter inputs as fast as 2 µs; at least 1,000 times faster than most other boards that rely on the PC for decision making.

Features

- Four low-cost, 16-bit, 1 MHz multifunction PCI boards
- 8 differential or 16 single-ended analog inputs (software selectable per channel)
- Four 16-bit, 1 MHz analog outputs with continuous waveform capability
- 24 high speed digital I/O lines
- Four 32-bit counter input channels with quadrature encoder capability
- Ultra low-latency control output capability (as low as 2 µs latency)
- Multiple DMA channels

Supported Operating Systems

– Windows 10/8/7/Vista®/XP 32/64-bit

Analog Input

The PCI-2500 Series has a 16-bit/1 MHz A/D coupled with 16 single-ended, or 8 differential analog inputs. Seven software programmable ranges provide inputs from ±10 V to ±100 mV full scale*. Each channel can be software-configured for a different range, as well as for single-ended or differential bipolar input**.

* Single-ended ±10 V range on PCI-2511

** API programming can mix single-ended and differential channels

PCI-2500 Series Selection Chart

	Analog Inputs	Input Ranges	Analog Outputs	Digital I/O	Counters/Timers
PCI-2511	16 SE	1	0	24	4/2
PCI-2513	16 SE/8 DIFF	7	0	24	4/2
PCI-2515	16 SE/8 DIFF	7	2	24	4/2
PCI-2517	16 SE/8 DIFF	7	4	24	4/2

PCI-2500 Series

Overview

Analog Output (PCI-2515/PCI-2517)

Two or four 16-bit, 1 MHz analog outputs are provided with an output range of -10 V to +10 V.

With Bus Mastering DMA, each D/A output can continuously output a waveform at up to 1 MHz and read from PC RAM or a file on the hard disk. In addition, a program can asynchronously output a value to any D/A channels for non-waveform applications. Each analog output can also be used in a control mode, where their output level is dependent on whether an associated analog, digital or counter input is above or below a user-specified condition.

When generating waveforms, the following clock sources can pace each output:

- **Asynchronous internal clock:** The on-board programmable clock can generate updates ranging from once every 19 hours to 1 MHz, independent of any acquisition rate.
- **Synchronous internal clock: t**he rate of analog output update can be synchronized to the acquisition rate derived from 1 MHz to once every 19 hours.
- **Asynchronous external clock**: a user-supplied external input clock can be used to pace the D/A, entirely independent of analog inputs.
- **Synchronous external clock**: a user-supplied external input clock can pace both the D/A and the analog input.

Digital I/O

Twenty four TTL-level digital I/O lines are included. Digital I/O can be programmed in 8-bit groups as either inputs or outputs.

Digital inputs and outputs can be scanned synchronously with other inputs and outputs, and can be controlled by other inputs; see "Scanning Modes" for more information.

Digital Input

Digital inputs can be read asynchronously before, during, or after an analog input scan.

Ports programmed as inputs can be part of the scan group and scanned along with analog input channels, or can be asynchronously accessed via the PC at any time, including when a scanned acquisition is occurring.

Digital Output and Pattern Generation

Digital outputs can be updated asynchronously at any time before, during or after an acquisition. Each output bit can be used in a control mode, where the output state is dependent on whether an associated analog, digital or counter input is above or below a user-specified condition.

Two of the 8-bit ports can be used to generate a 16-bit digital pattern at up to 1 MHz. The digital pattern can be read from PC RAM or a file on the hard disk. Digital pattern generation can be clocked using the internal clock (PCI-2511/PCI-2513) or with the same sources described with analog output (PCI-2515/PCI-2517).

Counter Input

Four 32-bit counters accept frequency inputs up to 20 MHz, and can be configured in a variety of modes including counter, period, pulse width, time between edges, or multi-axis quadrature encoder.

Counter inputs can be read asynchronously under program control, or synchronously as part of an analog and digital scan group based either on an internal programmable timer or external clock source.

Counter channels can be combined to implement Z-channel encoding functions and gating functions. When configured together in this way the channels must be read synchronously.

Quadrature Encoders

Quadrature encoders generating pulse rates up to 20 MHz and x1, x2, x4 count modes are supported. Two encoder channels are supported with only A phase and B phase signals. One channel is supported with A phase, B phase, and Z index signals.

Timer Output

Two 16-bit timer outputs can generate different square waves with a programmable frequency range from 16 Hz to 1 MHz.

Synchronous I/O

The PCI-2500 Series can synchronously read analog, digital, and counter inputs while generating analog outputs and digital pattern outputs.

Digital and counter inputs do not affect the overall A/D rate because they use no time slot in the scanning sequencer.

Scanning Modes

Input Scanning

Several scanning modes are available. The user can load the scan buffer with any combination of analog input channels. Each channel in the scan buffer is measured sequentially at 1 µs per channel. The user can specify that the sequence repeat immediately or after a programmable delay. For example, in the fastest mode with a 0 delay, a single analog channel can be scanned continuously at 1 MS/s; two analog channels can be scanned at 500 kS/s each; 16 analog input channels can be scanned at 62.5 kS/s.

The digital and counter inputs can be read synchronously with software as part of a scan group, or asynchronously at any time before, during, or after an analog input scan sequence. Asynchronous mode is not deterministic as to exactly when the digital or counter input is read relative to an analog input channel.

Output Scanning

The digital and analog outputs can be updated asynchronously at any time before, during, or subsequent to an analog input sequence, or updated continuously from the PC, or as the direct result of input from an analog, digital, or counter channel.

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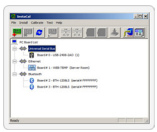
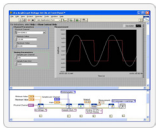
Software

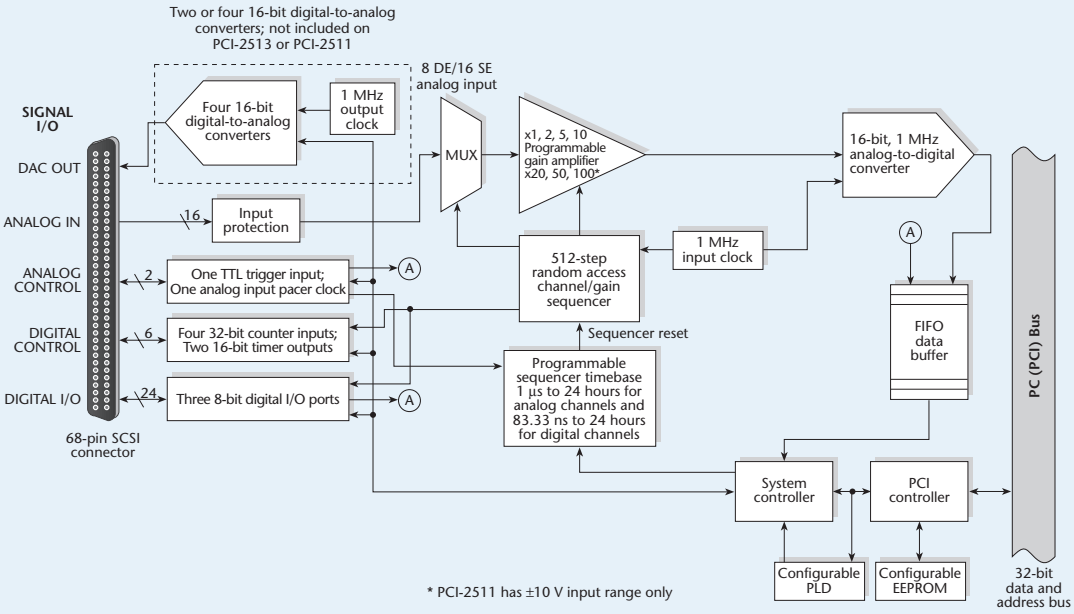
Software Support

The PCI-2500 Series is supported by the software in the table below.

Ready-to-Run Applications		
InstaCal		An interactive installation, configuration, and test utility for MCC hardware. Windows OS InstaCal is included with the free MCC DAQ Software bundle.
TracerDAQ™ and TracerDAQ Pro		Virtual strip chart, oscilloscope, function generator, and rate generator applications used to generate, acquire, analyze, display, and export data. Supported features may vary by hardware. The Pro version provides enhanced features. Windows OS TracerDAQ is included with the free MCC DAQ Software bundle. TracerDAQ Pro is available as a purchased software download.
General-Purpose Programming Support		
Universal Library™ (UL) for Windows		Library for developing applications in C, C++, VB, C# .Net, VB .Net, and Python on Windows. The UL for Windows is included with the free MCC DAQ Software bundle.
Application-Specific Programming Support		
ULx for NI LabVIEW™		A comprehensive library of VIs and example programs for NI LabVIEW that is used to develop custom applications that interact with most MCC devices. Windows OS ULx for NI LabVIEW is included with the free MCC DAQ Software bundle.
DASYLab®		Icon-based data acquisition, graphics, control, and analysis software that allows users to create complex applications in minimal time without text-based programming. Windows OS DASYLab is available as a purchased software download. An evaluation version is available for 28 days.
MATLAB® driver		High-level language and interactive environment for numerical computation, visualization, and programming. The Mathworks Data Acquisition Toolbox™ allows users to acquire data from most MCC PCI and USB devices. Visit www.MathWorks.com for more information about the Data Acquisition Toolbox.

PCI-2500 Series

Specifications



Specifications

General

Power Consumption (per board): 3 W
Operating Temperature: 0 ˚C to +60 ˚C
PCI Bus: PCI r2.2 compliant, universal 3.3 V/5 V signaling support, compatible with PCI-X
Storage Temperature: -40 ˚C to +80 ˚C
Relative Humidity**: 0 to 95% non-condensing**
Vibration: MIL STD 810E cat 1 and 10
Signal I/O Connector: 68-pin standard "SCSI Type III" female connector
Dimensions: 165 mm W x 15 mm x 108 mm H (6.5" x 0.6" x 4.2")
Weight: 160 g (0.35 lbs)

Accuracy

Voltage Range*	Accuracy ±(% of reading + % Range) 23 °C, ± °10 ±C, 1 year	Temperature Coefficient ±(ppm of reading + ppm Range)/ °C –30 °C to 13 °C and 33 °C to 70 °C	Noise** (cts RMS)
–10 V to 10 V	0.031% + 0.008%	14 + 8	1.5
–5 V to 5 V	0.031% + 0.009%	14 + 9	2.0
–2 V to 2 V	0.031% + 0.010%	14 + 10	2.0
–1 V to 1 V	0.031% + 0.02%	14 + 12	2.5
–500 mV to 500 mV	0.031% + 0.04%	14 + 18	4.0
–200 mV to 200 mV	0.036% + 0.075%	14 + 12	5.0
–100 mV to 100 mV	0.0442% + 0.15%	14 + 18	9.0

* Assumes diff input single channel scan, 1 MHz scan rate, unfiltered, CMV=0.0 V, 30 min warm-up, exclusive of noise
** Noise reflects 10,000 samples at 1 MHz, typical, differential short, using , CA-68-3S cable.
Note: PCI-2511 is single-ended only, 0.040% + 0.010% accuracy, 14 + 8 temperature coefficient, 2.0 noise.

Maximum Usable Input Voltage + Common Mode Voltage	
Ranges	**Maximum (CMV + Vin)**
5, 10 V	10,5 V
0.1, 0.2, 0.5, 1, 2 V	6.0 V

Analog Inputs

Channels: 16 single-ended or 8 differential, programmable on a per channel basis as single-ended or differential, except for PCI-2511 which is limited to 16 single-ended analog inputs
Over-Voltage Protection: ±30 V without damage
Ranges: Software or sequencer selectable on a per channel basis, ±10 V, ±5 V, ±2 V, ±1 V, ±0.5 V, ±0.2 V, ±0.1 V, except for PCI-2511 which has a fixed range of ±10 V
Input Impedance: 10 MΩ single-ended; 20 MΩ differential
Total Harmonic Distortion: -80 dB typ for ±10 V range, 1 kHz fundamental
Signal to Noise and Distortion: 72 dB typ for ±10 V range, 1 kHz fundamental
Bias Current: 40 pA typ (0 ˚C to 35 ˚C)
Crosstalk: -67 dB typ DC to 10 kHz
Common Mode Rejection: -70 dB typ DC to 1 kHz

Type: Successive approximation
Resolution: 16 bit
Maximum Sample Rate: 1 MHz
Nonlinearity (Integral): ±2 LSB max
Nonlinearity (Differential): ±1 LSB max

Input Sequencer

Analog, digital, and frequency inputs can be scanned synchronously, based on either an internal programmable timer, or an external clock source. Analog and digital outputs can be synchronized to either of these clocks.

Input Scan Clock Sources: The maximum scan clock rate is the inverse of the minimum scan period. The minimum scan period is equal to 1 µs times the number of analog channels. If a scan contains only digital channels, the minimum scan period is 250 ns. Some platforms can sustain scan rates of up to 83.33 ns for digital-only scans.

Internal
- Analog channels from 1 µs to 1 sec in 20.83 ns steps
- Digital channels and counters from 250 ns to 1 sec in 20.83 ns steps

External, TTL level input
- Analog channels down to 1 µs min
- Digital channels and counters down to 250 ns min

Programmable Parameters per Scan: Channel (random order), gain
Depth: 512 locations
On-Board Channel-to-Channel Scan Rate:
Analog: 1 MHz max
Digital: 4 MHz if no analog channels are enabled, 1 MHz with analog channels enabled
External Input Scan Clock Maximum Rate:
Analog: 1 MHz max
Digital: 4 MHz if no analog channels are enabled, 1 MHz with analog channels enabled
Clock Signal Range:
Logical zero: 0 V to 0.8 V
Logical one: 2.4 V to 5.0 V
Minimum Pulse Width: 50 ns high, 50 ns low

Trigger Sources and Modes

Input Scan Trigger Sources
Single channel analog hardware trigger, single channel analog software trigger, external single channel digital trigger (TTL TRG input), digital pattern trigger, counter/totalizer trigger

Input Scan Triggering Modes

Single-Channel Analog Hardware Trigger: the first analog input channel in the scan is the analog trigger channel.
- **Input Signal Range**: -10 to +10 V max
- **Trigger Level**: Programmable (12-bit resolution)
- **Latency**: 350 ns typ, 1.3 µs max
- **Accuracy**: ±0.5% of reading, ±2 mV offset max
- **Noise**: 2 mV RMS typ

Single-Channel Analog Software Trigger: The first analog input channel in the scan is the analog trigger channel.
- **Input Signal Range**: Anywhere within range of the selected trigger channel
- **Trigger Level**: Programmable 16-bit resolution
- **Latency**: One scan period max

External Single Channel Digital Trigger (TTL trigger input)
- **Input Signal Range**: -15 V to +15 V max
- **Trigger Level**: TTL-level sensitive
- **Minimum Pulse Width**: 50 ns high, 50 ns low
- **Latency**: one scan period max

Digital Pattern Triggering: 8- or 16-bit pattern triggering on any of the digital input ports. Programmable for trigger on equal, not equal, above or below a value. Individual bits can be masked for "don't care" condition.
- **Latency**: One scan period max

Counter/Totalizer Triggering: Counter/totalizer inputs can trigger an acquisition. User can select to trigger on a frequency or on total counts that are equal, not equal, above or below a value, or within or outside of a window rising or falling edge.
- **Latency**: One scan period max

Analog Outputs (PCI-2515 and PCI-2517 only)

Analog output channels are updated synchronously relative to scanned inputs, and clocked from either an internal on-board clock, or an external clock source. Analog outputs can also be updated asynchronously, independent of any other scanning in the system. Bus mastering DMA provides CPU and system-independent data transfers, ensuring accurate outputs that are irrespective of other system activities. Streaming from disk or memory is supported, allowing continuous waveform outputs (limited only by available PC system resources).

Channels: 2 (PCI-2515); 4 (PCI-2517)
Resolution: 16 bits
Data Buffer: PC-based memory
Output Voltage Range: ±10 V
Output Current: ±10 mA
Offset Error: ±0.0045 V max
Digital Feedthrough: <10 mV when updated
DAC Analog Glitch: <12 mV typical at major carry
Gain Error: ±0.01%
Update Rate: 1 MHz max, 19 hours min (no minimum with external clock), resolution 20.83 ns
Settling Time: 2 µs to rated accuracy
Clock Sources: 4, programmable
On-board D/A clock (independent of scanning input clock), Onboard scanning input clock, External D/A input clock (independent of external scanning input clock), External scanning input clock

Digital I/O

Channels: 24
Ports: 3 x 8-bit, each port is programmable as input or output
Input Scanning Modes: two; programmable
1. Asynchronous, under program control at any time relative to input scanning
2. Synchronous with input scanning

Input Characteristics: 10 kΩ pull up to +5 V, 20 pF to common
Input Protection: ±15 kV ESD clamp diodes
Input Levels:
Low: 0 to 0.8 V
High: +2.0 V to +5.0 V
Output Levels:
Low: <0.8 V
High: >2.0 V
Output Characteristics: Output 12 mA per pin, 200 mA total continuous
Sampling/Update Rate: 4 MHz max; rates up to 12 MHz are sustainable on some platforms.
Pattern Generation Output: Two of the 8-bit ports can be configured for 16-bit pattern generation. The pattern can also be updated synchronously with an acquisition at up to 4 MHz.

Counter

Each of the four high speed, 32-bit counter channels can be configured for counter, period, pulse width, time between edges, or multi-axis quadrature encoder modes. Counter inputs can be scanned synchronously along with analog and digital scanned inputs, based on an internal programmable timer, or an external clock source.

Channels: 4 x 32-bit
Input Frequency: 20 MHz max
Input Signal Range: -5 V to +10 V
Input Characteristics: 10 kΩ pull-up, ±15 kV ESD protection
Trigger Level: TTL
Minimum Pulse Width: 25 ns high, 25 ns low
Debounce Times: 16 selections from 500 ns to 25.5 ms; positive or negative edge sensitive; glitch detect mode or debounce mode
Time Base Accuracy: 30 ppm (0 ˚C to 50 ˚C)
Programmable mode: Counter. , Period, Pulse width, Timing, Encoder
Counter mode options: Totalize, Clear on Read, Rollover, Stop at all Fs, 16- or 32-bit, Gating On, Decrement On
Period mode options: Measure x1, 10, 100, or 1000 periods, 16- or 32-bit, time bases to choose from: 20.83 ns, 208.3 ns, 2.083 µs, 20.83 µs, any other channel can gate the period measurement
Pulse width mode options: 16- or 32-bit values, 4 time bases to choose from: 20.83 ns, 208.3 ns, 2.083 µs, 20.83 µs, any other channel can gate the pulse width measurement
Timing mode options: 16- or 32-bit values, time base is selectable for 20.83 ns, 208.3 ns, 2.083 µs, 20.83 µs
Encoder mode options: x1, 2, 4 options, 16- or 32-bit values, Z-channel clearing of counter, any other channel can gate the counter
Power Available for Encoders: 5 V @ 500 mA max
Multi-axis Quadrature Encoder Inputs:
1 channel with A (phase), B (phase), and Z (index)
2 channels with A (phase) and B (phase)
x1, x2, and x4 count modes
Single-ended TTL

Frequency/Pulse Generators

Channels: 2 x 16-bit
Output Waveform: Square wave
Output Rate: 1 MHz base rate divided by 1 to 65,535 (programmable)
High-Level Output Voltage: 2.0 V min @ -1.0 mA; 2.9 V min @ -400 µA
Low-Level Output Voltage: 0.4 V max @ 400 µA

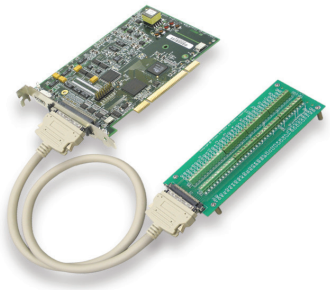
PCI-2500 Series

Ordering

Order Information

Hardware

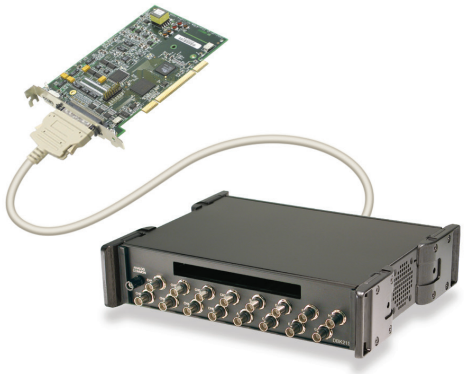
Part No.	Description
PCI-2511	Multifunction DAQ board with 16 single-ended analog inputs, 1 MS/s sample rate, 24 digital I/O, and four counters
PCI-2513	Multifunction DAQ board with 16 SE/DIFF analog inputs, 1 MS/s sample rate, 24 digital I/O, and four counters
PCI-2515	Multifunction DAQ board with 16 SE/DIFF analog inputs, 1 MS/s sample rate, two 16-bit analog outputs, 24 digital I/O, and four counters
PCI-2517	Multifunction DAQ board with 16 SE/DIFF analog inputs, 1 MS/s sample rate, four 16-bit analog outputs, 24 digital I/O, and four counters



PCI-2500 Series board attached to a TB-100 terminal board. The TB-100 provides access to all signal I/O. The TB-100 can be panel or rack mounted using the optional RM-TB-100 rack mount.

Accessories and Cables

Part No.	Description
TB-100	Termination board with screw-terminals; connects via a CA-68-3R, CA-68-3S, or CA-68-6S cable.
RM-TB-100	Rack-mount kit, 19 in., for TB-100
DBK215	BNC termination module with 16 BNC connectors and internal screw terminal connections
CA-68-3R	68-conductor ribbon expansion cable for connection to the TB-100.
CA-68-3S, CA-68-6S	68-conductor shielded cable for connection to the TB-100.



PCI-2500 Series board attached to a DBK215 BNC and screw-terminal module. The DBK215 provides 16 BNC connectors plus internal screw-terminal connections.

Software also Available from MCC

Part No.	Description
TracerDAQ Pro	Out-of-the-box virtual instrument suite with strip chart, oscilloscope, function generator, and rate generator – professional version
DASYLab	Icon-based data acquisition, graphics, control, and analysis software