



CR9000X-Series

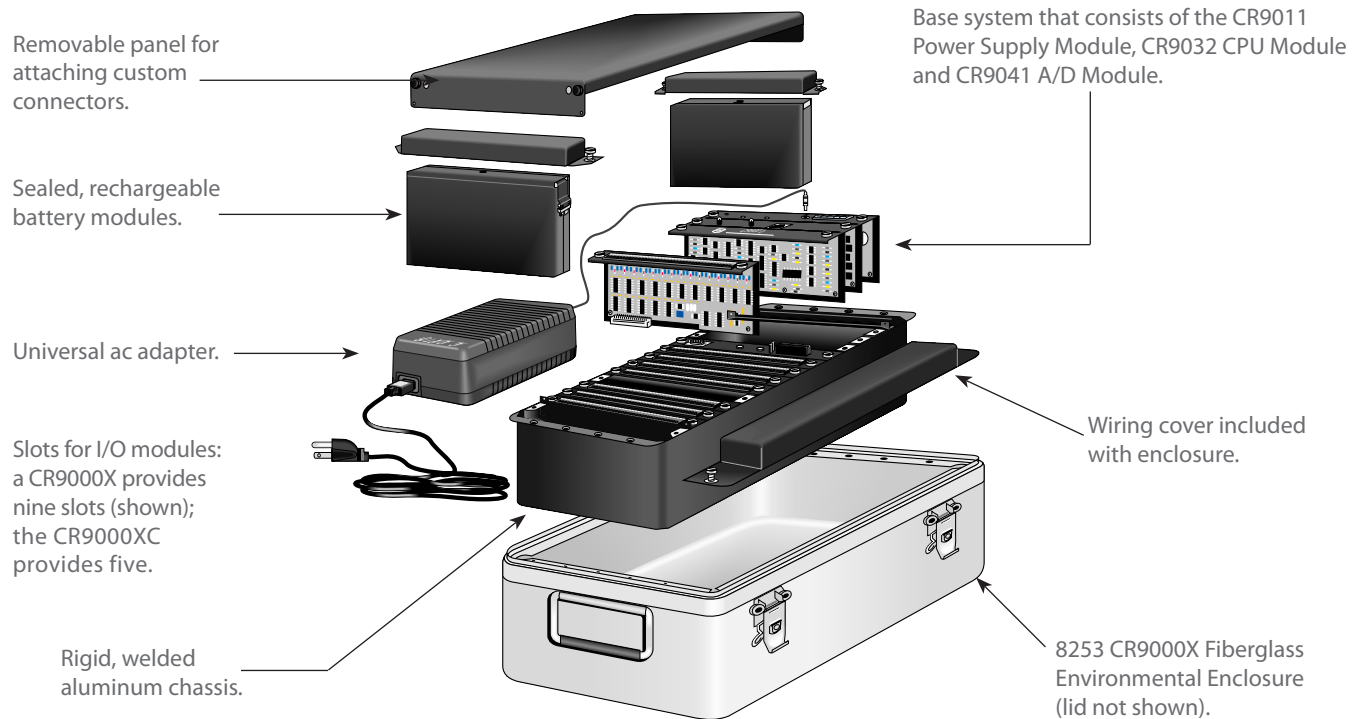
Measurement and Control Dataloggers



Precision measurement system in a rugged, battery-powered package



CR9000X & CR9000XC Measurement and Control Datalogger



Design Features

- Modular system that consists of a base system and a chassis with I/O module slots. Up to nine user-selected modules insert in the CR9000X or five user-selected modules in the CR9000XC
- Measurement rate of up to 100k samples/second
- 16-bit resolution with programmable gain
- Powerful instruction set that supports measurement of most sensor types, on-board processing, data reduction, and intelligent control
- 128 MB of internal SDRAM for data and program storage
- Expandable memory using a PCMCIA card or a CompactFlash® card through the use of an adapter
- Robust ESD protection
- CE compliant
- Low power, 12 Vdc operation
- Data values stored in tables with a time stamp and record number
- Operating temperature range of -25° to +50°C; extended range of -40° to +70°C available
- 180 MHz clock speed

Base System

CR9032 CPU Module

The CR9032 is a 32-bit CPU module that provides system control, data processing, and communications. It features a clock speed of 180 MHz and 128 MB of internal SDRAM for data and program storage.

The CR9032 includes an RS-232 DCE port, 10baseT/100baseT port, CS I/O port, and a PC-card slot. The CS I/O port supports communications with our SDM device at rates up to 115,200 bps. The PC-card slot accepts one Type I, Type II, or Type III PCMCIA card. CompactFlash cards are supported with an adapter. Industrial grade CompactFlash cards offered by Campbell Scientific store 256 MB or 2 GB of data.

Power Supply

The power supply consists of the sealed rechargeable battery module, universal ac adapter, and CR9011 Power Supply Module. The battery module has a 14 Ah rating for the CR9000X and a 7 Ah rating for the CR9000XC. The batteries are recharged using the universal ac adapter, a dc input, or another external source. The CR9011 module controls the current flowing to the charging source. A relay included in the CR9011 allows the datalogger to turn the power on and off. This conserves power and increases the battery's life.

CR9041 A/D and Amplifier Module

The CR9041 module provides signal conditioning and 16-bit, 100 kHz A/D conversions.

CR9000XC

The CR9000XC is a compact version of the CR9000X. The CR9011 Power Supply Module, CR9032 CPU Module, CR9041 A/D and Amplifier Module, five I/O module slots, one 7 Ah sealed rechargeable battery, and an environmental enclosure are included with the purchase of the CR9000XC.

Transient Protection

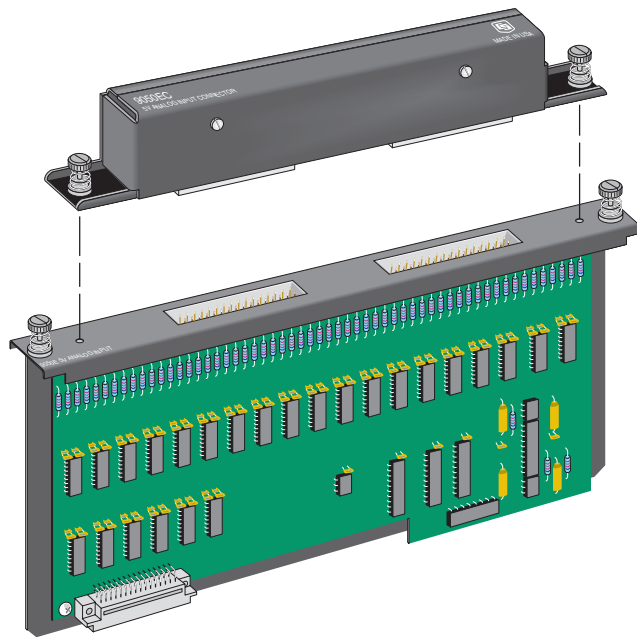
Rugged gas tubes protect all terminal block inputs and outputs from electrical transients. The CR9000X series is CE compliant under the European Union's EMC Directive, meeting ESD, EMC, Fast Transient standards.

I/O Modules

A mix of I/O modules is selected based on the measurements required for the application. Individual I/O modules can be "swapped out", allowing the system to be reconfigured if requirements change. I/O modules whose model numbers end in an E (e.g., CR9051E, CR9055E) and the CR9052DC include an easy connector module.

CR9051E Analog Input Module

The CR9051E provides 14 differential (28 single-ended) input channels for measuring voltages up to ± 5 V. Resolution is $1.6 \mu\text{V}$ on the most sensitive range. This module has an on-board reference PRT and connectors for precise thermocouple measurements. The CR9051E channels are fault protected to $+50 \text{ V}/-40 \text{ V}$. This prevents overvoltage on one channel from corrupting measurements on other channels. The CR9051E channels become open circuits when the datalogger is powered down so sensors are not loaded.



Easy Connector module allows sensor wiring to remain connected while the input module's measurement electronics and the rest of the datalogger system are used elsewhere.



CR9052DC and CR9052IEPE Anti-Alias Filter and Spectrum Analyzer Modules

The CR9052DC is a high-performance anti-alias filter and Fast Fourier Transform (FFT) spectrum analyzer with dc excitation. The CR9052IEPE module provides excitation and signal conditioning for IEPE-type (Integral Electronic Piezo Electric) accelerometers, microphones, and pressure transducers. Detailed information and specifications are available in the CR9052DC and CR9052IEPE brochure.

CR9055 or CR9055E 50-Volt Analog Input Module

The CR9055(E) has 14 differential (28 single-ended) programmable input channels for measuring voltages up to ± 50 V. Resolution to $16 \mu\text{V}$ is available.

CR9058E Isolation Module

The CR9058E provides 10 isolated differential channels for measuring thermocouples or other low level voltage measurements that are at an elevated voltage plane. Each channel has its own isolated ground for shielded cable connection, and its own 24-bit A/D converter that supplies input isolation for up to $\pm 60 \text{ Vdc}$. An on-board digital signal processor provides digital noise filtering that is automatically maximized for the specified integration time. For precise thermocouple measurements, the CR9058E includes an on-board reference PRT.

CR9060 Excitation Module

The CR9060 provides six continuous analog outputs (CAOs), 10 switched excitation channels, and eight digital control outputs. The CAOs have individual digital-to-analog converters for proportional control, waveform generation, and excitation. Each CAO sources up to 50 mA between $\pm 5 \text{ V}$. The excitation channels provide precision voltages for bridge measurements. The digital outputs control external devices.

CR9071E Timer/Pulse Input Module

The CR9071E provides 16 digital I/O and 12 pulse counting channels. Four pulse channels count switch closures; the other eight channels count low-level ac signals. All of the pulse channels can measure high-level frequencies up to 1 MHz. The digital I/O channels are used for digital control, communications, output triggering, and pulse counting. The CR9071E supports interval timing and pulse width duration.

Operating System/Logic Control

The on-board operating system includes measurement, processing, and output instructions for programming the datalogger. The programming language, CRBASIC, uses a BASIC-like syntax. Measurement instructions specific to bridge configurations, voltage outputs, thermocouples, and pulse/frequency signals are included. Processing

instructions support algebraic, statistical, and transcendental functions for on-site processing. Output instructions process data over time and control external devices. These instructions include averages, maximums, minimums, standard deviation, histograms, rainflow histograms, level crossings, and FFTs.

Enclosure Options

8253 Fiberglass Environmental Enclosure

The environmental enclosure is designed for field applications where the enclosure will be exposed to the elements. A CR9000X housed in this enclosure is protected from water, dust, and most environmental pollutants.

8255 Lab Enclosure

The Lab Enclosure is for applications where the CR9000X will reside inside a building.

At right shows the 8253 environmental enclosure.



Data Storage and Retrieval

Data storage and retrieval options commonly used with the CR9000X series include:

- **PCMCIA Cards or CompactFlash® (CF) Cards** can be used to augment the datalogger's storage capacity or to transport data or programs from the datalogger to a PC.
- **Ethernet Cables** connected to the on-board 10baseT/100baseT port transmit data to a PC with an Ethernet port via a local network or the Internet.

- **PC or laptop** can be connected directly to the datalogger's RS-232 port (no interface required). This port provides electrical isolation. Alternatively, the PC or laptop can be connected to the CR9000X's CS I/O port via an SC32B or SC-USB interface.

Although the following peripherals do not support the maximum measurement rate, the CR9000X series is also compatible with:

- Telephone modems (landline and cellular)
- Spread spectrum radio

Measurement and Control Peripherals

The following peripherals expand the capabilities of the CR9000X series:

- **AM25T Multiplexer** increases the number of thermocouples/voltages that can be measured. Combinations of both can be made on each AM25T.
- **SDM-CAN Interface** allows the datalogger to sample data directly from a CANbus network..

Although the following peripherals do not support the maximum measurement rate, the CR9000X series is also compatible with:

- SDM-CD16AC 16-Channel AC/DC Relay Controller
- SDM-CVO4 4-Channel Current/Voltage Output Module
- AM16/32B Multiplexer



Above are measurement and control devices that are typically used with the CR9000X.

Software

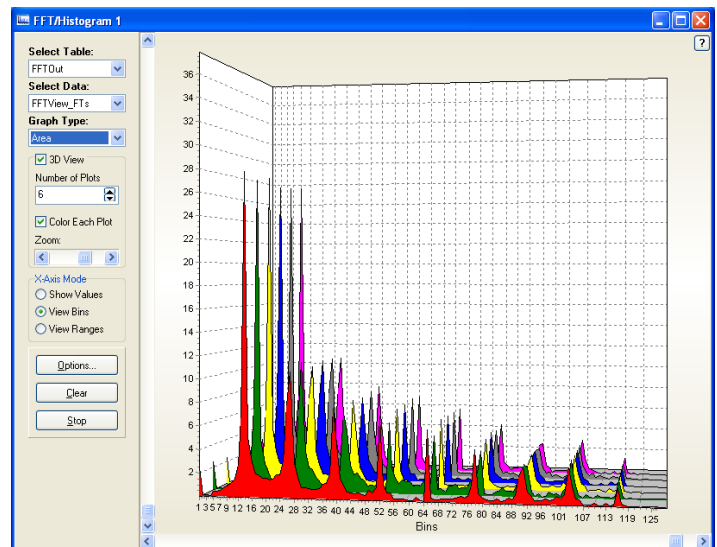
RTDAQ Real-Time Data Acquisition Software

RTDAQ is an ideal solution for industrial and real-time users desiring to use reliable data collection software over a single telecommunications medium, and who do not rely on scheduled data collection. RTDAQ's strength lies in its ability to handle the display of high speed data.

Tools bundled with RTDAQ include Short Cut, ProgGen, and CRBasic for creating datalogger programs; RTMC for graphically displaying data; View Pro and Split for working with data files; and LogTool and PakBus Graph for troubleshooting communications.

Features/Benefits:

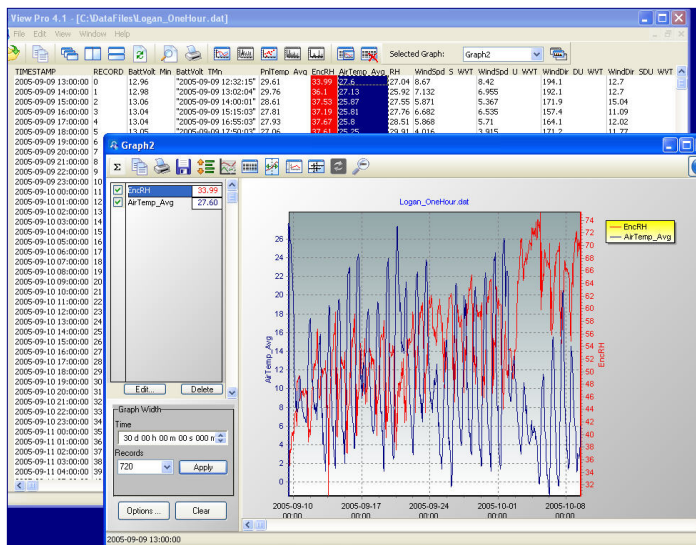
- Provides non-invasive field calibration of sensors—incorporating the appropriate multipliers and off sets into the datalogger program
- Monitors real-time data using the Graph, Fast Graph (similar to PC9000's virtual oscilloscope), Histogram Viewer, Fast Fourier Transform (FFT) Viewer, Rainflow Viewer, Table Monitor (similar to the PC9000 Field Monitor), and XY Plot Viewer
- Displays historical data files including specialized engineering data such as FFTs and histograms



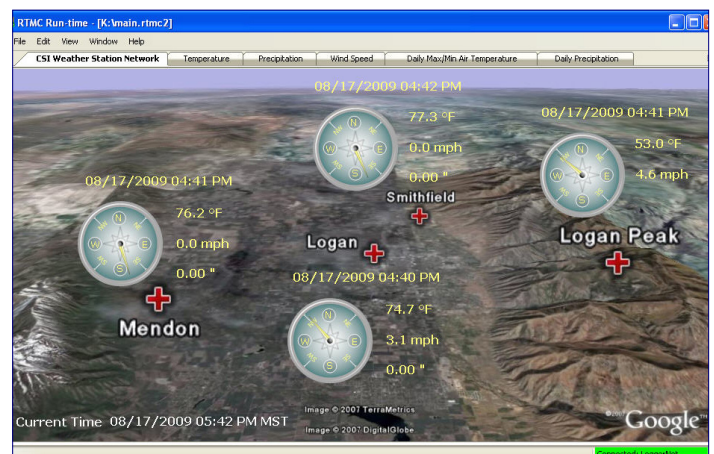
The FFT is an example of the many real-time data displays offered by RTDAQ that allow you to view the measurements instantly.

Other Compatible Software

- **Short Cut (SCWin)**—generates straight-forward CR9000X programs in four easy steps. Short Cut can be downloaded, at no charge, from our website at: www.campbellsci.com/downloads
- **PC200W**—intended for first-time users or users with simple data collection needs. PC200W can be downloaded, at no charge, from our website at: www.campbellsci.com/downloads
- **PC400**—supports a variety of telecommunication options, manual data collection, and data display. It does not support combined communication options (e.g., phone-to-RF), PakBus routing, or scheduled data collection
- **LoggerNet**—allows you to write datalogger programs, transfer those programs to the datalogger, collect the data, and analyze the data. Combined communication options (e.g., phone-to-RF), PakBus routing, and scheduled data collection are supported.



Both RTDAQ and LoggerNet use View Pro to display historical data in a tabular or graphical format.



RTMC is bundled with RTDAQ and LoggerNet. Users who want additional capabilities and more flexibility can purchase RTMC Pro—an enhanced version of RTMC.

Applications

Photography by Boily



Our dataloggers have been used over the years to monitor many prominent bridges. Whether bridges are large or small, Campbell Scientific is committed to providing quality instrumentation and support to help maintain their safety.

Structural and Seismic Monitoring

The rapid sampling rate and large number of high resolution channels provided by the CR9000X-series dataloggers make them ideal for structural and seismic monitoring. These dataloggers can be used in applications ranging from simple beam fatigue analysis, to structural mechanics research, to continuous monitoring of large, complex structures.

The onboard instruction set supports many algorithms and math functions that are useful for structural and seismic monitoring. The datalogger can store data as rainflow or level crossing histograms. The rainflow and level crossing algorithms can be processed for extended periods of time, not just a finite number of cycles. The instruction set also supports triggered output with pre-trigger data capture capability. Triggers can be based on sensor output, time, and/or user control.



The CR9000X supports remote, unattended monitoring of highway overpasses, amusement park rides, roads, buildings, and retaining walls.

For example, if an overpass or bridge is being monitored, data collection can be triggered:

- (1) by a sensor detecting the approach of a car or an earthquake,
- (2) at pre-programmed times, or
- (3) by pushing a button.

The datalogger's control functions allow it to activate alarms, actuate electrical devices, or shut down equipment based on time or measured conditions.

Typical sensors used for structural and seismic monitoring include:

- Carlson strain meters
- Foil strain gages (set up in quarter, half, or full bridge strain configurations)
- Inclinometers
- Crack and joint sensors
- Tilt sensors:
- Piezoresistive accelerometers
- Piezoelectric accelerometers
- Capacitive accelerometers
- Borehole accelerometers
- Servo force balance accelerometers

Vehicle Monitoring and Testing



Vehicle monitoring includes not only passenger cars but locomotives, airplanes, helicopters, tractors, buses, heavy trucks, drilling rigs, race cars, ATVs, and motorcycles.

The versatile, rugged design and low power requirements of the CR9000X-series dataloggers make them well suited for vehicle monitoring. They excel in cold and hot temperature, high altitude, off-highway, and cross-country performance testing. The CR9000X series is compatible with our SDM-CAN interface.

Compatible sensors often used for vehicle monitoring and testing include thermocouples, pressure transducers, GPS receivers, pulse pick-ups, flow transducers, potentiometers, strain gages, load cells, digital switches, accelerometers, LVDTs, and tilt sensors. Most sensors connect directly to the datalogger, eliminating costly external signal conditioning.

Common measurements include:

- › **Suspension**—strut pressure, spring force, travel, mounting point stress, deflection, ride.
- › **Fuel system**—line and tank pressure, flow, temperature, injection timing
- › **Comfort control**—ambient and supply air temperature, solar radiation, fan speed, blower currents, ac on/off, refrigerant pressures, time-to-comfort
- › **Brakes**—line pressure, pedal pressure and travel, ABS, fluid and pad temperature
- › **Engine**—pressure, temperature, crank position, RPM, time-to-start, oil pump cavitation
- › **General vehicle**—chassis monitoring, road noise, NVH, traction, payload, vehicle position/ speed, steering, air bag, hot/cold soaks, wind tunnels, CANbus, wiper speed/current, vehicle electrical loads

Other Applications

- › **Aerospace/aviation**—can endure the rigors of space travel and provided acceleration, structural, and equipment performance measurements.
- › **Geotechnical**—measures tilt, convergence, displacement, geographic position, strain, load, vibration, overburden, level, flow, creep, and force for slope stability, subsidence, seismicity studies, structural restoration, or site assessment applications.
- › **Mining**—monitors mine ventilation, slope stability, convergence, and equipment performance
- › **Machinery testing**—provides temperature, pressure, RPM, velocity, power, acceleration, position, torque, and strain measurements.
- › **Laboratory**—can serve as a monitoring device to record parameters over time and can also be used to regulate and control test conditions.



Photo courtesy NASA

Our dataloggers measured the effects of gravity on a test structure aboard a NASA low-gravity flight.

Compatibility with Retired Products

Customers can add CR9000X-series dataloggers to networks containing the older CR9000-series dataloggers. I/O modules other than the CR9080 can be used with either the CR9000-series or CR9000X-series dataloggers. CR9000 communication interfaces (i.e., NL105, BLC100, TL925, PLA100)

are not compatible with the CR9000X series, and therefore have been retired. RTDAQ software is not compatible with the older CR9000-series dataloggers. Customers can upgrade a CR9000 or CR9000C to a CR9000X or CR9000XC by replacing their CR9031 CPU module with a CR9032 CPU module.

CR9000X & CR9000XC Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; extended testing over -40° to +70°C range available as an option, excluding batteries. Non-condensing environment is required. To maintain specifications, Campbell Scientific recommends recalibrating dataloggers every two years. We recommend that you confirm system configuration and critical specifications with Campbell Scientific before purchase.

CR9032 CPU MODULE

PROCESSORS: 180 MHz Hitachi SH-4

MEMORY: 128 Mbytes of internal SDRAM for program and data storage. Expanded data storage with PCMCIA type I, type II or type III cards or CompactFlash® cards with an adapter

SERIAL INTERFACES: RS-232 9-pin RS-232 DCE port for computer or modem. CS I/O 9-pin port for CSI peripherals and SDM devices.

ETHERNET INTERFACE: 10baseT/100baseT port for communications over a local network or the Internet.

CR9011 POWER SUPPLY MODULE

VOLTAGE: 9.6 to 18 Vdc

TYPICAL CURRENT DRAIN: Base system with no modules is 500 mA active; 300 mA standby. Current drain of individual I/O modules varies. Refer to specifications for each I/O module for specific values. Power supply module can place the system in standby mode by shutting off power to the rest of the modules.

DC CHARGING: 9.6 to 18 Vdc input charges internal batteries at up to 2 A rate. Charging circuit includes temperature compensation.

INTERNAL BATTERIES: Sealed rechargeable with 14 Ah (7 Ah for the CR9000XC) capacity per charge.

EXTERNAL BATTERIES: External 12 V batteries can be connected.

CR9041 A/D and AMPLIFIER MODULE

A/D Conversions: 16-bit, 100 kHz

CR9050 & CR9051E ANALOG INPUT MODULES

INPUT CHANNELS PER MODULE: 14 Differential (diff) or 28 single-ended (SE)

RANGE, RESOLUTION, AND INPUT NOISE:

Input Range (mV)	Resolution (1 A/D count) (μV)	Input Noise CR9050 (μV RMS)	Input Noise CR9051E (μV RMS)	Max Sample Rates (kHz)
±5000	158.0	105	130	100
±1000	32.0	35	35	100
±200	6.3	7	7	50
±50	1.6	4	4	50

Note: Measurement averaging provides lower noise and better resolution.

ACCURACY OF VOLTAGE MEASUREMENTS:

Single-ended & Differential:
±(0.07% of reading + 4 A/D counts) -25° to +50°C
±(0.14% of reading + 4 A/D counts) -40° to +70°C

Dual Differential (two measurements with input polarity reversed):
±(0.07% of reading + 1 A/D count) -25° to +50°C
±(0.14% of reading + 1 A/D count) -40° to +70°C

COMMON MODE RANGE: ±5 V

DC COMMON MODE REJECTION: >120 dB

INPUT RESISTANCE: 2.5 gigaohms typical

MAXIMUM INPUT VOLTAGE WITHOUT DAMAGE:
±20 V CR9050, -40 to +50 V CR9051E

TYPICAL CURRENT DRAIN: 25 mA active

Resistance & Conductivity Measurements (also requires CR9060 Excitation Module)

ACCURACY: ± (0.04% of reading + 2 A/D counts) limited by accuracy of external bridge resistors.

MEASUREMENT TYPES: 6-wire and 4-wire full bridge, 4-wire, 3-wire, and 2-wire half bridge. Uses excitation reversal to remove thermal EMF errors.

CR9055(E) 50 V-ANALOG INPUT MODULE

INPUT CHANNELS PER MODULE: 14 diff or 28 SE.

RANGE AND RESOLUTION:

Input Range (V)	Resolution (1 A/D count) (μV)	Input Noise (μV RMS)	Max Sample Rates (kHz)
±50	1580	1050	100
±10	320	350	100
±2	63	85	50
±0.5	16	60	50

Note: Measurement averaging provides lower noise and better resolution.

ACCURACY OF VOLTAGE MEASUREMENTS:

Single-Ended & Differential:
±(0.1% of reading + 4 A/D counts) -25° to +50°C
±(0.2% of reading + 4 A/D counts) -40° to +70°C

Dual Differential:
(two measurements with input polarity reversed)
±(0.1% of reading + 1 A/D count) -25° to +50°C
±(0.2% of reading + 1 A/D counts) -40° to +70°C

COMMON MODE RANGE: ±50 V

DC COMMON MODE REJECTION: >62 dB

INPUT RESISTANCE: 100 kohms typical

MAXIMUM INPUT VOLTAGE WITHOUT DAMAGE: ±150 V

TYPICAL CURRENT DRAIN: 15 mA active

CR9058E ISOLATION MODULE

INPUT CHANNELS PER MODULE: 10 isolated, differential; each channel has its own isolation ground for shielded cable connection.

RANGE, RESOLUTION, AND INPUT RESISTANCE:

Input Range (Vdc)	Resolution w/o Averaging (μV)	Resolution w/ Averaging (μV)	Input Resistance (kohms)
±2	±10	±2	10,000
±20	±100	±20	88.9
±60	±300	±60	269

ACCURACY:

Gain Error: ±0.02% of reading (-40° to +50°C), ±0.07% of reading (-40° to +70°C)

Offset Error: ±0.01% of FSR (-40° to +50°C), ±0.01% of FSR (-40° to +70°C)

INPUT TO SYSTEM GROUND CMRR db:

Input Range (Vdc)	DC	60 Hz	300 Hz	2 kHz
±2	>160	93.3	81.0	70.7
±20	>160	99.1	88.8	71.6
±60	>160	94.6	85.3	66.7

INPUT TO INPUT CROSSTALK db:

Input Range (Vdc)	DC	60 Hz	300 Hz	2 kHz
±2	< -160	-121.3	-108.8	-94.3
±20	< -160	-120.8	-98.6	-96.1
±60	< -160	-108.7	-87.9	-82.5

MINIMUM SCAN TIME PER MODULE (for VoltDiff or TCDiff):
1460 μs with no input reversal and no open circuit detection; selecting input reversal (Rev parameter = 1) adds 2300 μs to the minimum scan time and selecting open circuit detection (voltage range = V2C) adds 1460 μs to the minimum scan time. If the scan time is insufficient, the CR9000X will report an error at compile time.

MAXIMUM CONTINUOUS VOLTAGE W/O DAMAGE:

Input Range (Vdc)	H to L ISO Ground (Vdc)	H or L to Systm Ground (Vdc)	ISO Ground to Systm Ground (Vdc)	H or L to Systm Ground (Vdc)
±2	±208	±109	±360	±469
±20	±223	±121	±360	±481
±60	±448	±233	±360	±593

MAXIMUM ESD VOLTAGE ON INPUTS: ±5000V

TYPICAL CURRENT DRAIN: 360 mA operating, 5 mA standby

CR9052DC/CR9052IEPE ANTI-ALIAS MODULES

Refer to the CR9052DC and CR9052IEPE Brochure.

CR9060 EXCITATION MODULE

TYPICAL CURRENT DRAIN: 108 mA quiescent, 125 mA active

Analog Outputs

ANALOG OUTPUTS PER MODULE: 10 switched, 6 continuous

SWITCHED: Provides excitation for resistance measurements. Only one output can be active at a time.

CONTINUOUS: All outputs can be active simultaneously.

RANGE: ±5 V

ACCURACY: ± (0.2% of output ±4 mV)

RESOLUTION: 12-bit A/D (2.4 mV)

OUTPUT CURRENT: ±50 mA

Digital Control Outputs

CONTROL CHANNELS PER MODULE: 8

OUTPUT VOLTAGES (no load):

High: 5.0 V ±0.2 V
Low: < 0.2 V

OUTPUT RESISTANCE: 100 ohms

CR9071E COUNTER & DIGITAL I/O MODULE

Counter Channels

COUNTER CHANNELS PER MODULE: 12

MAXIMUM COUNTS PER INTERVAL: 2³² Max. counts per interval will never be reached because with a maximum input frequency of 1 MHz, the 32-bit counter will go 71.58 minutes before it rolls over. The maximum CR9000X scan rate is 1 minute.

SWITCH CLOSURE MODE (4 channels)

Minimum switch closed time: 5 ms
Minimum switch open time: 6 ms
Maximum bounce time: 1 ms open without being counted

HIGH FREQUENCY MODE (all channels)

Minimum pulse width: 500 ns
Maximum input frequency: 1 MHz
Thresholds: Pulse counted on transition from below 1.5 V to above 3.5 V
Maximum input voltage: ±20 V

Note: Because of the pulse channels' input filter with a 200 ns time constant, higher frequencies will require larger input transitions.

LOW LEVEL AC MODE (8 channels)

Input hysteresis: 10 mV
Minimum ac voltage: 25 mV RMS
Maximum input voltage: ±20 V
Frequency range:

(mV RMS)	RANGE (Hz)
25	1 to 10,000
≥50	0.5 to 20,000

TYPICAL CURRENT DRAIN: 35 mA

Digital Inputs/Outputs

I/O CHANNELS PER MODULE: 16

OUTPUT VOLTAGES (no load)

High: 5.0 V ±0.2 V
Low: < 0.2 V

OUTPUT RESISTANCE: 320 ohms

INPUT STATE:

High: 3.5 to 5 V
Low: -0.5 to 1.2 V

INPUT RESISTANCE: 100 kOhms

Interval Measurement

I/O CHANNELS: Resolution is the scan rate

PULSE CHANNELS

Maximum interval: 1 minute
Resolution: 40 ns

TRANSIENT PROTECTION

All analog and digital inputs and outputs use gas discharge tubes and transient filters to protect against high-voltage transients. Digital I/Os also have over-voltage protection clamping.

PHYSICAL

Size

LAB ENCLOSURE: 15.75"L x 9.75"W x 8"D (40 x 24.8 x 20.3 cm)

FIBERGLASS ENVIRONMENTAL ENCLOSURE:
18"L x 13.5"W x 9"D (45.7 x 34.3 x 22.9 cm)

CR9000XC: 10"L x 11"W x 9"D (25.4 x 27.9 x 22.9 cm)

Weight

LAB ENCLOSURE: 30 lbs including modules (13.6 kg)

FIBERGLASS ENVIRONMENTAL ENCLOSURE:
42 lbs including modules (19.1 kg)

CR9000XC: 27 lbs including modules (12.3 kg)

REPLACEMENT BATTERIES: 6.4 lbs (2.9 kg)

ADDITIONAL MODULES: 1 lb each (0.5 kg)

WARRANTY

Three years against defects in materials and workmanship.

