

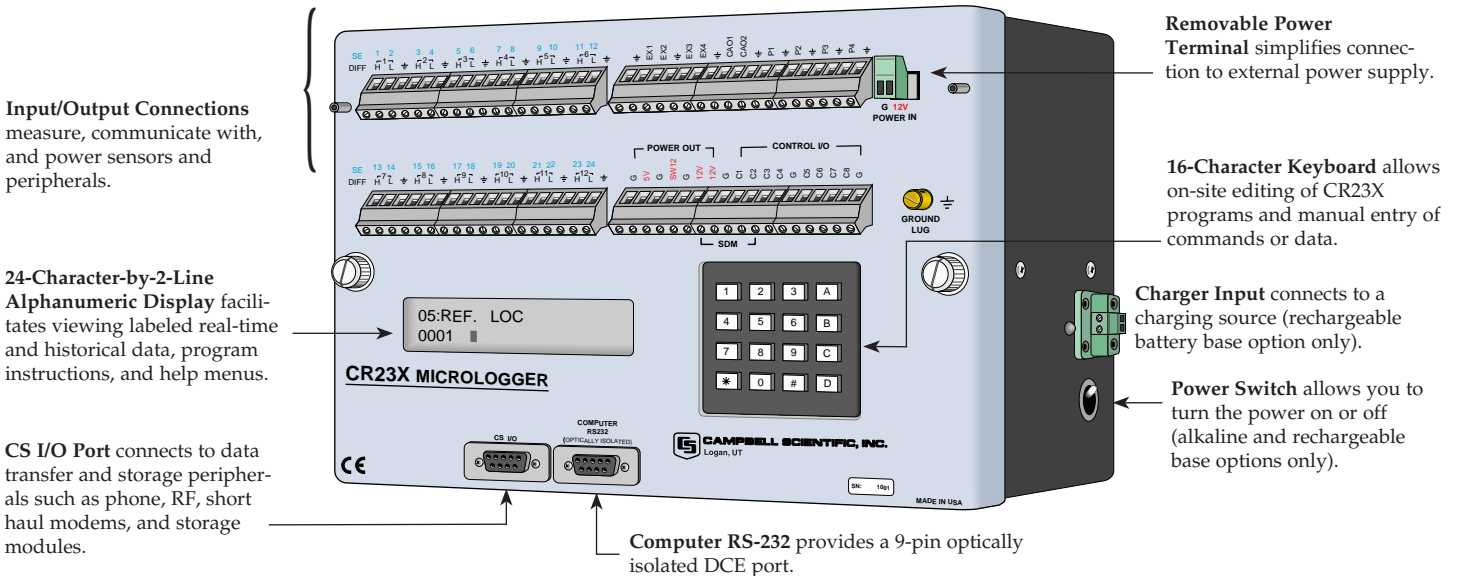
# CR23X Micrologger®

A Portable, Rugged, Powerful Data Acquisition System



# System Description

The CR23X Micrologger® is a compact, rugged, powerful datalogger. Housed in a portable, self-contained package, the Micrologger consists of measurement and control electronics, communication ports, keyboard, display, power supply, and carrying handle. Minimum power requirements allow extended field use from a dc voltage source.



## Design Features

The CR23X measures most sensor types directly, communicates via modems, reduces data, controls external devices, and stores both data and programs in either non-volatile Flash memory or battery-backed SRAM. The standard 2 Mbyte memory stores 1,000,000 data points in two final storage areas. With the 4 Mbyte option, the CR23X can store over 2 million data points.

Two operating system options are available. The array-based operating system stores arrays of data at specified intervals or when some other set condition has been met. The table-based operating system allows you to group and store like data in separate tables.

The CR23X contains a comprehensive set of measurement, processing, and output instructions for programming the datalogger. Measurement instructions specific to bridge configurations, voltage outputs, vibrating wire sensors, SDI-12 sensors, thermocouples, Synchronous Devices for Measurement (SDMs), and multiplexers are standard. Processing instructions support algebraic, statistical, and transcendental functions for on-site processing. Output instructions control external devices and process data over time. These instructions include averages, maximums, minimums, standard deviations, histograms, and FFTs.

The maximum rate the CR23X can execute its program is 100 times per second. The maximum rate a single input can be measured is 1,500 samples per second. A battery-backed clock assures accurate timekeeping.

*Cover photos (CR23X applications): From top, Eddy covariance systems, Automotive performance testing, Weather station installation, Geotechnical monitoring.*

## Input/Output Connections

### Analog Inputs

Twenty-four single-ended (12 differential) channels measure voltage levels with 15-bit resolution on five software selectable voltage ranges.

### Pulse Counting Channels

The CR23X has four 8-bit (two 16-bit) pulse channels for measuring switch closures, low-level ac pulses, and high frequency pulses.

### Digital Input/Output Ports

The CR23X has eight digital input/output control ports. All of the ports can be used for output control and to sense the status of external devices. Three of these ports can read SDM peripherals and four of them can be configured as pulse counters or interrupt inputs.

### Continuous Analog Outputs

Two continuous analog outputs with 15-bit resolution provide voltage levels to strip chart recorders or proportional controllers.

### Switched Excitation Outputs

Four outputs provide precision excitation voltages for resistive bridge measurements. The excitation is programmable over a  $\pm 5000$  mV range.

### Power Connections

The continuous 5 V and 12 V terminals are for connecting sensors and non-CSI peripherals. The switched 12 V terminal is program controlled.

## Battery Base Options

The alkaline base option includes 10 D-cell batteries with a 10 Ahr rating at 20°C. The rechargeable base option provides an internal 7 Ahr sealed rechargeable battery that can be trickle-charged via vehicle power, solar panels, or ac power. For charging the battery via ac power, a 110 Vac wall charger is offered for US customers or other countries with 110 Vac outlets. A 100 to 240 Vac wall charger is also available. When using vehicle power, our DCDC18R Boost Regulator is used to increase the vehicle's supply voltage to charging levels required by the CR23X. The low-profile (no battery) option requires a user-supplied dc source. It is preferred when the system's power consumption, (e.g. satellite transmitters) needs a user-supplied deep-cycle battery or when it's advantageous to have a thinner datalogger.

## Peripherals and Software

**CR23X-based systems typically include a data retrieval option and may include measurement and control peripherals. Our software supports datalogger programming, communications between the CR23X and PC, and data display.**

### Data Storage and Retrieval Options

**Storage Modules** reliably store data and datalogger programs. The data and programs can be downloaded later to a PC.

**Direct Links** use the CR23X's RS-232 port to connect the datalogger to a computer. The CR23X can be connected to the computer over distances up to 50 feet.

**Short Haul Modems** provide local communications between the CR23X and a PC with an RS-232 serial port.

**Multidrop Interface** permits a PC to address and communicate with one or more dataloggers over a single two-twisted-pair cable.

**PDA's** can communicate with the CR23X. Palm OS-based PDA's require PConnect software and Pocket PC and Windows® Mobile 2003 devices require PConnectCE software.

**Ethernet Communication Peripherals** allow the CR23X to communicate over a local network or the Internet.

*A GOES satellite system provides data retrieved from a weather station on Nevado Sajama, Bolivia, to climate researchers in the United States.*



## Transient Protection

Rugged gas tubes protect the analog inputs from electrical transients. The CR23X is **CE** Compliant under the European Union's EMC Directive.

## Operation in Harsh Environments

Standard operating range is -25° to +50°C; an extended range of -40° to +80°C is available. A CR23X housed in a weather-resistant enclosure with desiccant is protected from humidity and most contaminants.

**Radio Frequency (RF) Communications** are supported via UHF, VHF, or spread spectrum radios.

**Telephone Networks** use landlines or cellular transceivers for communications between the datalogger and PC. Our voice-synthesized modem transmits the CR23X's data by voice.

**Satellite Transmitters** transmit data via the GOES system.

## Channel Expandability

SDMs and multiplexers expand the already formidable measurement and control capabilities of the CR23X. SDMs are addressable peripherals that expand digital control ports, analog output ports, and measurement capabilities. Multiplexers allow sharing of switched excitation channels and analog inputs, thereby increasing the number of sensors that can be measured. Several SDMs or multiplexers can be connected to one datalogger.

## Software Packages

**PC200W Starter Software** allows you to transfer the datalogger's program and collect data via a direct communications link. PC200W is available at no charge from: [www.campbellsci.com/downloads](http://www.campbellsci.com/downloads)

**LoggerNet and PC400** provides more capabilities than PC200W. They support:

- Direct and telecommunications links
- Datalogger programming for most commercially available sensors, SDMs, multiplexers, and relays
- Real-time data display
- Report generation

**Real-Time Data Monitor (RTDM)** allows experienced users to create custom graphic screens. RTDM supports automatic generation of JPEG output for Internet display. A similar software package, RTDMRT, was developed for customers who require display-only capability. RTDMRT allows you to display screens that were created using RTDM.

# Industrial Applications

## Vehicle Testing

This versatile, rugged datalogger is ideally suited for testing cold and hot temperature, high altitude, off-highway, and cross-country performance. The CR23X is compatible with our SDM-CAN interface, GPS16-HVS receiver, and DSP4 Heads Up Display.

The CR23X can measure:

- **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, ac on and off, refrigerant pressures, time-to-comfort, blower current
- **Brakes**—line pressure, pedal pressure and travel, ABS, line and pad temperature
- **Engine**—pressure, temperature, crank position, RPM, time-to-start, oil pump cavitation
- **General vehicle**—chassis monitoring, road noise, vehicle position and speed, steering, air bag, hot/cold soaks, wind tunnels, traction, CANbus, wiper speed and current, vehicle electrical loads



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

## Process Control

The CR23X can monitor production allowing operators to discard items that don't meet specifications. Real-time measurements can be displayed for operators and stored for review by quality control personnel. Product and assembly line status can be monitored simultaneously, providing on-line quality control while minimizing production down time.



*The CR23X monitors and controls the pumps, fans, and starter motors in an HVAC system.*

Process and control applications:

- Maintain oven/dryer temperature
- Monitor conveyor/belt speed
- Sound alarms for out-of-specification conditions or equipment malfunction
- Maintain liquid or gas levels

## HVAC Systems

A CR23X-based system can monitor inside and outside temperatures, flow rates, differential pressures, motor temperatures, and relative humidity. This information can be used by the datalogger to:

- Increase air exchange when conditions are favorable
- Maintain different temperatures in specific areas of the facility
- Reduce HVAC functions when the facility is unoccupied
- Initiate shutdowns, sound alarms, and notify personnel
- Record facility events and conditions

## Other Applications

- Laboratory applications
- Mining, mineral extraction, and earth science
- Aerospace/aviation
- Energy management and conservation
- Structural or fatigue analysis
- Machinery testing

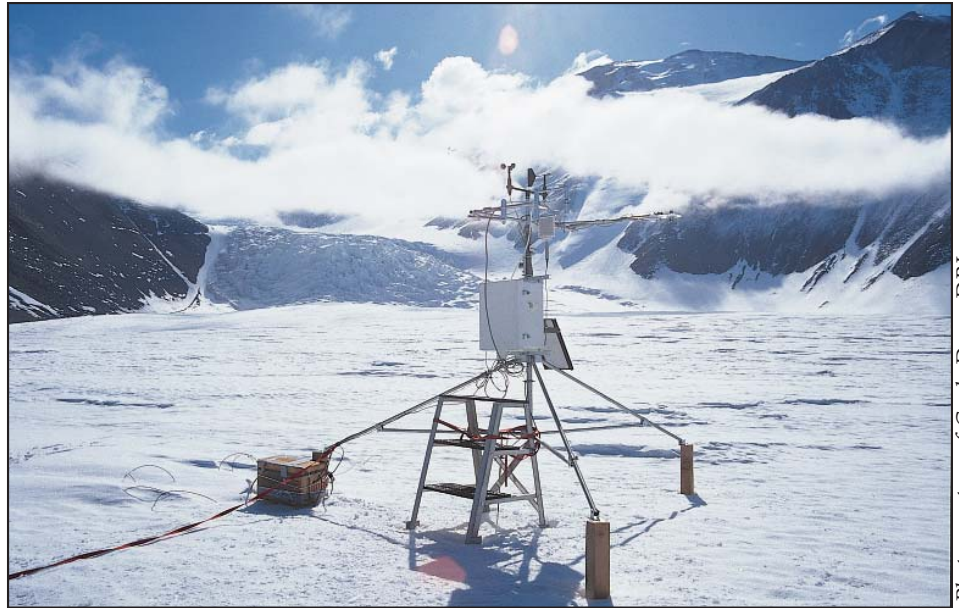


Photo courtesy of Gayle Dana, DRI

*Eddy covariance station provides data for energy balance studies in the McMurdo Dry Valleys of Antarctica.*

## Eddy Covariance System

These systems use Eddy Covariance techniques to calculate water vapor, carbon dioxide, and heat flux. Below are the sensors and their measurements.

- CSAT3 Sonic Anemometer—absolute wind and sonic temperature fluctuations
- KH20 Hygrometer—fluctuations of atmospheric water vapor
- LI7500 Infrared Gas Analyzer—both absolute CO<sub>2</sub> and water vapor
- FW05 Fine Wire Thermocouple—temperature

The CR23X measures the above sensors and computes fluxes.

## Bowen Ratio Systems

The CR23X is integral to our Bowen Ratio Systems. These systems calculate evapotranspiration (ET) by measuring air temperature, net radiation, soil heat flux, and dew point. The Bowen Ratio Systems measure air temperature at two heights with type E fine-wire thermocouples. To measure dew point, air samples from two heights are forced through mixing volumes and routed to a cooled mirror dew point hygrometer. Every two minutes the air drawn through the cooled mirror is switched from one height to the other. The CR23X also is used in another Bowen Ratio System that measures water vapor and CO<sub>2</sub> concentrations.



*Bowen Ratio Systems calculate evapotranspiration and CO<sub>2</sub> fluxes over a sorghum field near Lincoln, Nebraska.*

## Meteorology

The CR23X is ideal for weather stations that require a large number of inputs.

Typical measurements include:

- wind speed
- wind direction
- precipitation
- barometric pressure
- snow depth
- solar radiation
- air and soil temperature
- relative humidity
- soil moisture

The CR23X can calculate:

- standard deviations for wind direction
- vapor pressure from wet/dry bulb temperature
- saturation vapor pressure from air temperature

It can also automatically control calibration sequences and compute conditional averages that exclude invalid data (e.g., data recorded during power failures or calibration intervals).

## Other Applications

- Water level/stage
- Avalanche control
- Snow science
- Arctic research
- Soil moisture
- Water quality
- Agriculture
- Air Quality
- SCADA/Modbus

# CR23X Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; non-condensing environment required. To maintain electrical specifications, Campbell Scientific recommends recalibrating dataloggers every two years.

## PROGRAM EXECUTION RATE

Program is synchronized with real-time up to 100 Hz. Two fast (250  $\mu$ s) single-ended measurements can write to final storage at 100 Hz. Burst measurements to 1.5 kHz are possible over short intervals.

## ANALOG INPUTS

DESCRIPTION: 12 differential or 24 single-ended, individually configured. Channel expansion provided through AM16/32 or AM416 Relay Multiplexers and AM25T Thermocouple Multiplexers.

ACCURACY:  $\pm 0.025\%$  of FSR, 0° to 40°C  
 $\pm 0.05\%$  of FSR, -25° to 50°C  
 $\pm 0.075\%$  of FSR, -40° to 80°C; (-XT only)

Note:  $\pm 5 \mu$ V offset voltage error is possible with single-ended (SE) measurements.

### RANGES AND RESOLUTION:

Input Range (mV)	Resolution ( $\mu$ V)		Accuracy (mV) (-25° to 50°C)
	Diff.	SE	
$\pm 5000$	166	333	$\pm 5.00$
$\pm 1000$	33.3	66.6	$\pm 1.00$
$\pm 200$	6.66	13.3	$\pm 0.20$
$\pm 50$	1.67	3.33	$\pm 0.05$
$\pm 10$	0.33	0.66	$\pm 0.01$

INPUT SAMPLE RATES: Includes the measurement time and conversion to engineering units. Differential measurements incorporate two integrations with reversed input polarities to reduce thermal offset and common mode errors. Fast measurement integrates the signal for 250  $\mu$ s; slow measurement integrates for one power line cycle (50 or 60 Hz).

Fast single-ended voltage:	2.1 ms
Fast differential voltage:	3.1 ms
Slow single-ended voltage (60 Hz):	18.3 ms
Slow differential voltage (60 Hz):	35.9 ms
Fast differential thermocouple:	6.9 ms

INPUT NOISE VOLTAGE: Typical for  $\pm 10$  mV Input Range; digital resolution dominates for higher ranges.

Fast differential:	0.60 $\mu$ V rms
Slow differential (60 Hz):	0.15 $\mu$ V rms
Fast single-ended:	1.20 $\mu$ V rms
Slow single-ended (60 Hz):	0.30 $\mu$ V rms

COMMON MODE RANGE:  $\pm 5$  V

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE WITHOUT DAMAGE:  $\pm 16$  Vdc max.

INPUT CURRENT:  $\pm 2.5$  nA typ.,  $\pm 10$  nA max. @ 50°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):

$\pm 0.25^\circ\text{C}$ , 0° to 40°C
$\pm 0.5^\circ\text{C}$ , -25° to 50°C
$\pm 0.7^\circ\text{C}$ , -40° to 80°C (-XT only)

## ANALOG OUTPUTS

DESCRIPTION: 4 switched, active only during measurement, one at a time; 2 continuous.

RANGE: Programmable between  $\pm 5$  V

RESOLUTION: 333  $\mu$ V

ACCURACY:  $\pm 5$  mV;  $\pm 2.5$  mV (0° to 40°C)

CURRENT SOURCING: 50 mA for switched; 15 mA for continuous

CURRENT SINKING: 50 mA for switched, 5 mA for continuous (15 mA for continuous with Boost selected in P133).

FREQUENCY SWEEP FUNCTION: The switched outputs provide a programmable swept frequency, 0 to 5 V square wave for exciting vibrating wire transducers.

## RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: The CR23X provides ratio-metric measurements of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Precise, dual polarity excitation using any of the 4 switched outputs eliminates dc errors. Conductivity measurements use a dual polarity 0.75 ms excitation to minimize polarization errors.

ACCURACY:  $\pm 0.02\%$  of FSR ( $\pm 0.015\%$ , 0° to 40°C) plus bridge resistor error.

## PERIOD AVERAGING MEASUREMENTS

DESCRIPTION: The average period for a single cycle is determined by measuring the duration of a specified number of cycles. Any of the 24 SE analog inputs can be used. Signal attenuation and ac coupling are typically required.

### INPUT FREQUENCY RANGE:

Signal	peak-to-peak <sup>1</sup>		Min. Pulse w.	Max Freq. <sup>2</sup>
	Min.	Max.		
500 mV	10.0 V	2.5 $\mu$ s	200 kHz	
40 mV	2.0 V	10 $\mu$ s	50 kHz	
5 mV	2.0 V	62 $\mu$ s	8 kHz	
2 mV	2.0 V	100 $\mu$ s	5 kHz	

<sup>1</sup>Signals centered around datalogger ground  
<sup>2</sup>Assuming 50% duty cycle

RESOLUTION: 12 ns divided by the number of cycles measured

ACCURACY:  $\pm 0.01\%$  of reading

## PULSE COUNTERS

DESCRIPTION: Four 8-bit or two 16-bit inputs selectable for switch closure, high frequency pulse, or low-level AC. Counters read at 10 or 100 Hz.

MAXIMUM COUNT RATE: 2.5 kHz and 25 kHz, 8-bit counter read at 10 Hz and 100 Hz, respectively; 400 kHz, 16-bit counter.

### SWITCH CLOSURE MODE:

Minimum Switch Closed Time: 5 ms  
Minimum Switch Open Time: 6 ms  
Maximum Bounce Time: 1 ms open without being counted

### HIGH FREQUENCY PULSE MODE:

Minimum Pulse Width: 1.2  $\mu$ s  
Maximum Input Frequency: 400 kHz  
Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V at low frequencies. Larger input transitions are required at high frequencies because of input filter with 1.2  $\mu$ s time constant. Signals up to 400 kHz will be counted if centered around +2.5 V with deviations  $\geq \pm 2.5$  V for  $\geq 1.2 \mu$ s.  
Maximum Input Voltage:  $\pm 20$  V

### LOW LEVEL AC MODE:

Internal ac coupling removes dc offsets up to  $\pm 0.5$  V.  
Input Hysteresis: 15 mV  
Maximum ac Input Voltage:  $\pm 20$  V

Minimum ac Input Voltage:

(Sine wave mV RMS)	Range (Hz)
20	1.0 to 1000
200	0.5 to 10,000
1000	0.3 to 16,000

## DIGITAL I/O PORTS

DESCRIPTION: 8 ports selectable as binary inputs or control outputs. Ports C5-C8 capable of counting switch closures and high frequency pulses.

HIGH FREQUENCY MAX: 2.5 kHz

OUTPUT VOLTAGES (no load): high 5.0 V  $\pm 0.1$  V; low < 0.1

OUTPUT RESISTANCE: 500 ohms

INPUT STATE: high 3.0 to 5.5 V; low -0.5 to +0.8 V

INPUT RESISTANCE: 100 kohms

## SDI-12 INTERFACE SUPPORT

DESCRIPTION: Digital I/O Ports C5-C8 support SDI-12 asynchronous communication; up to ten SDI-12 sensors can be connected to each port. Meets SDI-12 Standard version 1.2 for datalogger and sensors mode.

## CE COMPLIANCE (as of 03/02)

STANDARD(S) TO WHICH CONFORMITY IS DECLARED:

EN55022: 1995 and EN61326: 1998

## EMI and ESD PROTECTION

IMMUNITY: Meets or exceeds following standards:  
ESD: per IEC 1000-4-2;  $\pm 8$  kV air,  $\pm 4$  kV contact discharge  
RF: per IEC 1000-4-3; 3 V/m, 80-1000 MHz  
EFT: per IEC 1000-4-4; 1 kV power, 500 V I/O  
Surge: per IEC 1000-4-5; 1 kV power and I/O  
Conducted: per IEC 1000-4-6; 3 V 150 kHz-80 MHz  
Emissions and immunity performance criteria available on request.

## CPU AND INTERFACE

PROCESSORS: Hitachi 6303; Motorola 68HC708 supports communications.

PROGRAM STORAGE: Up to 16 kbytes for active program; additional 16 kbytes for alternate programs. Operating system stored in 512 kbytes Flash memory.

DATA STORAGE: 1 Mbyte Flash standard.

Additional 4 Mbytes Flash available as an option.

DISPLAY: 24-character-by-2-line LCD

SERIAL INTERFACES: Optically isolated RS-232 9-pin interface for computer or modem. CS 9-pin I/O interface for peripherals such as storage modules or CSI modems.

BAUD RATES: Selectable at 300, 1200, 2400, 4800, 9600, 19.2K, 38.4K, and 76.8K. ASCII protocol is one start bit, eight data bits, no parity, one stop bit.

CLOCK ACCURACY:  $\pm 1$  minute per month, -25° to +50°C;  $\pm 2$  minutes per month, -40° to +85°C

## SYSTEM POWER REQUIREMENTS

VOLTAGE: 11 to 16 Vdc

TYPICAL CURRENT DRAIN: 2 mA quiescent with display off (2.5 mA max), 7 mA quiescent with display on, 45 mA during processing, and 70 mA during analog measurement.

INTERNAL BATTERIES: 10 Ahr alkaline or 7 Ahr rechargeable base. 1800 mAhr lithium battery for clock and SRAM backup typically provides 10 years of service.

EXTERNAL BATTERIES: Any 11 to 16 Vdc battery may be connected; reverse polarity protected.

## PHYSICAL SPECIFICATIONS

SIZE: 9.5" x 7.0" x 3.8" (24.1 cm x 17.8 cm x 9.6 cm). Terminal strips extend 0.4" (1.0 cm) and terminal strip cover extends 1.3" (3.3 cm) above the panel.

WEIGHT: 3.6 lbs (1.6 kg) with low-profile base  
8.3 lbs (3.8 kg) with alkaline base  
10.7 lbs (4.8 kg) with rechargeable base

## WARRANTY

Three years against defects in materials and workmanship.

We recommend that you confirm system configuration and critical specifications with Campbell Scientific before purchase.



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