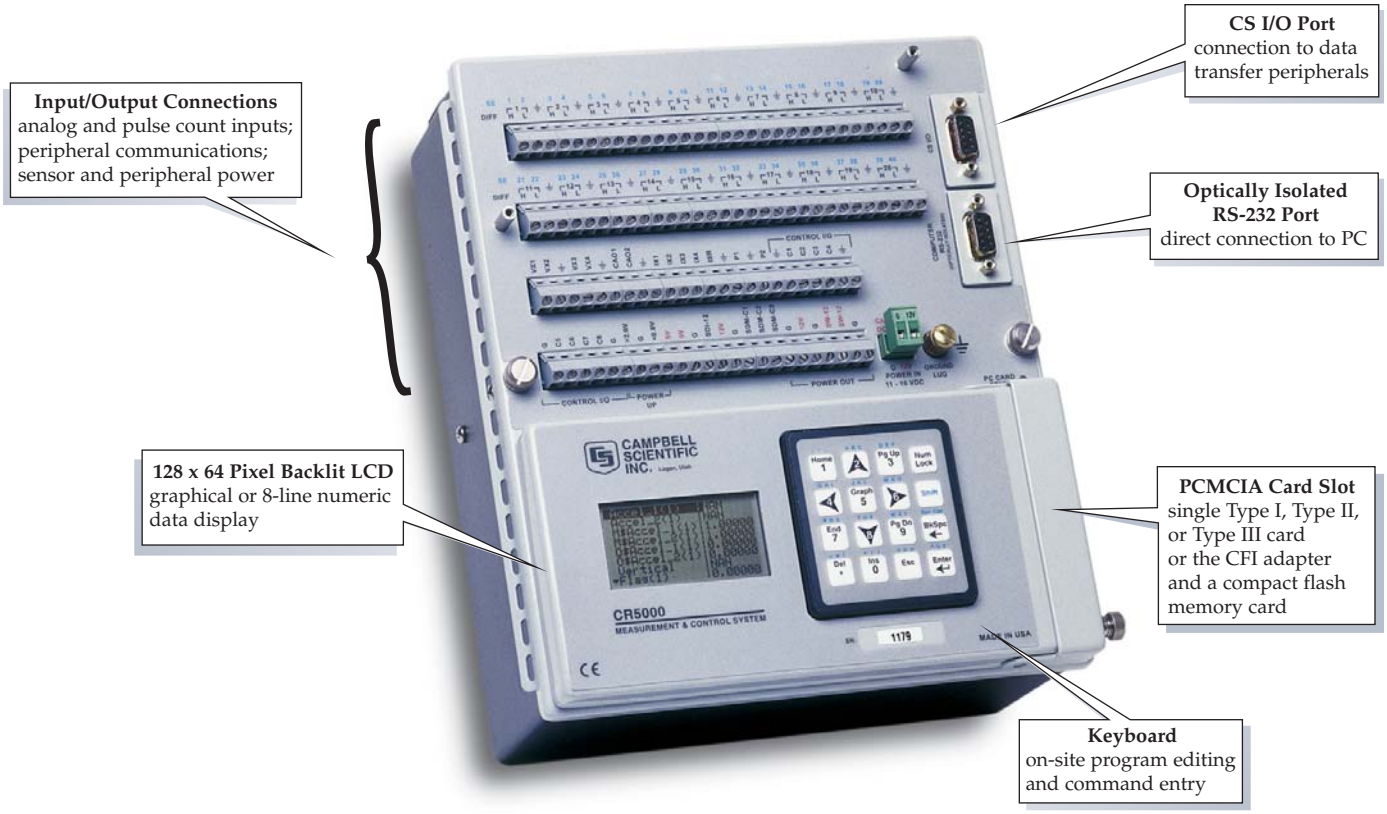
CR5000 Measurement and Control System

A rugged, high-performance data acquisition system



System Description

Design Features

- Stand-alone unit offering high performance and an environmentally rugged design
- Maximum throughput of 2k to 5k measurements per second (configuration dependent)
- Powerful instruction set that supports measurement of most sensor types, on-board processing, data reduction, and intelligent control
- Backlit display allowing numerical or graphical display of stored data
- PC-card slot for extended data storage and transporting data to a PC
- Battery-backed SRAM memory and clock ensuring data, programs, and accurate time are maintained while the CR5000 is disconnected from its main power source
- Robust ESD protection
- Low power, 12 Vdc operation
- Data values stored in tables with a time stamp and record number

Data Storage Capacity

Data and multiple programs are stored on-board in battery-backed SRAM. Up to 900,000 low-resolution data points can be stored in CPU memory. Storage capacity can be increased using a PC-card.

Operating System

The on-board operating system includes measurement, processing, and output instructions for programming the datalogger. Measurement instructions specific to bridge configurations, voltage outputs, thermocouples, pulse/frequency signals, vibrating wires, Synchronous Devices for Measurement (SDMs), and multiplexers are standard. 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 deviations, histograms, rainflow histograms, level crossings, and FFTs. Multiple datalogger programs can be stored in the CR5000 allowing easy program changes in the field.

Cover photo applications: Greenhouse monitoring and control; heavy equipment monitoring; eddy covariance flux measurements; passenger vehicle/light truck performance testing.

Connections and Measurement Types

Analog Inputs

Twenty differential (40 single-ended) input channels support five full-scale ranges (±20 mV to ±5000 mV) at 16-bit measurement resolution. Larger signal voltages are accommodated with precision 2:1 and 10:1 input voltage divider modules.

Period Averaging

Any of the 40 single-ended input channels can be used for period averaging measurements. Period averaging measurements can be used to monitor pulse width and pulse counts.

Pulse Counting Channels

Two 16-bit pulse channels count switch closures, low-level ac pulses, and high frequency square waves.

Control Ports

Eight digital input/output ports provide pulse counting, edge timing, status sensing, and on/off control. Three ports read SDM peripherals (see Channel Expansion) and sensors, such as the CSAT3 and CS7500.

Analog Outputs

Four switched precision voltage outputs provide excitation for resistive bridge measurements, programmable over a ±5000 mV range. Four switched current outputs are available for resistance measurements, programmable over a ±2.5 mA range. Two continuous analog outputs are provided for strip chart recording or driving proportional controllers.

Power Outputs

Two 5 V and two 12 V terminals are provided for powering sensors and peripherals continuously. Two switched 12 V outputs provide an unregulated 12 volts that can be switched on and off under program control.

PCMCIA Card Slot

The PCMCIA card slot supports one Type I, Type II, or Type III PC Card or the CFI adapter and one compact flash card. The card can be used to expand the CR5000's storage capacity or transport data or programs to a PC. The storage capacity of Type II cards exceeds 1 Gbyte. Type III cards provide data storage capacities exceeding 1 Gbyte but may not be suitable for all environments. Campbell Scientific offers compact flash cards that store 64 Mbytes, 256 Mbytes, or 1 Gbyte of data.

Transient Protection

Rugged gas tubes protect all terminal block inputs and outputs from electrical transients. The CR5000 is CE compliant under the European Union's EMC Directive.

Channel Expansion

Synchronous Devices for Measurement

SDMs are addressable peripherals that expand the CR5000's measurement and control capabilities. For example, SDMs are available to add control ports, analog outputs, pulse count channels, interval timers, or even a CANbus interface to your system. Multiple SDMs in any combination can be connected to one CR5000 datalogger.

The SDM-CAN (left of CR5000) allows a vehicle's on-board diagnostic system to output standardized data streams that are synchronized with other measurements and stored in the CR5000.

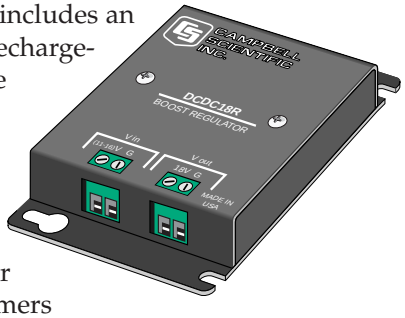
Multiplexers

Multiplexers increase the number of sensors that can be measured by a CR5000 by sequentially connecting each sensor to the datalogger. The CR5000 is compatible with the AM16/32 and AM25T. Several multiplexers can be controlled by a single CR5000.

Base Options

Rechargeable Base

The rechargeable base includes an internal 7 Ahr sealed rechargeable battery that can be charged from vehicle power, solar panels, or ac power. For charging the battery via ac power, a 110 to 120 Vac, 60 Hz wall charger is offered for US customers or other countries with 110 Vac outlets.



When using vehicle power, our DCDC18R Boost Regulator is used to increase the vehicle's supply voltage to charging levels required by the CR5000.

Low-Profile Base (no battery)

The low-profile option requires a user-supplied dc source. It is preferred when the system's power consumption needs a user-supplied deep cycle battery or when it's advantageous to have a thinner datalogger.

Communications

Remote stations can be accessed via Ethernet, phone modems, CDMA digital cellular modems, spread spectrum radios, short haul modems, and satellite transmitters. The CR5000's optically isolated RS-232 port allows the CR5000 to be connected directly to a PC. Real-time and historical data can be displayed on-site using a PC or the integrated keyboard/display.

Operation in Harsh Environments

Standard operating range is -25° to +50°C; an extended range of -40° to +85°C is available. A weather-proof enclosure and the use of desiccant is recommended for protection from humidity and most contaminants.

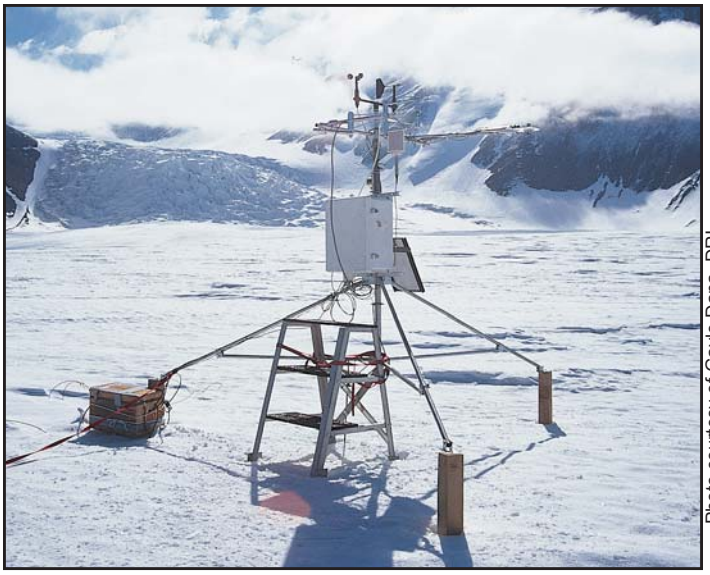


Photo courtesy of Gayle Dana, DRI

The wide temperature range of Campbell Scientific equipment allowed this eddy covariance station to provide data for energy balance studies in the McMurdo Dry Valleys of Antarctica.

Software

Software tools for the CR5000 include PC9000, LoggerNet, and ViewDAQ. Detailed information is contained in the PC9000, LoggerNet, and ViewDAQ product literature.

PC9000 Application Software

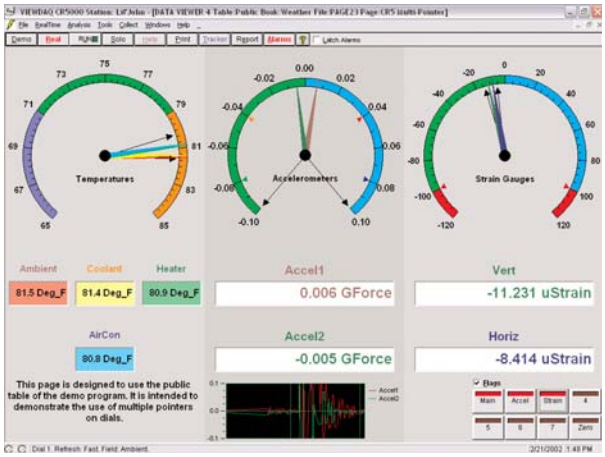
PC9000 supports programming, data collection, data display, data storage, and report generation.

Program Generator/Editor

- Supports pick-and-click programming for most commercially available sensors
- Creates a CRBasic program, wiring diagram, and data table information file

Communication/Data Collection

- Supports Ethernet and serial communications
- Transfers programs to or from the datalogger
- Collects data on command



ViewDAQ provides a variety of virtual instruments for displaying real-time data. Virtual dials, numeric displays and strip chart shown.

Data Display

- Monitors real-time data using tabular displays, virtual meters, virtual oscilloscopes, X-Y plotters, FFTs, level crossing, rainflow histograms, and histograms
- Provides historical time series data

LoggerNet Datalogger Support Software

LoggerNet allows you to set up and manage a network of dataloggers. It supports programming, communications, and data retrieval between the dataloggers and a computer. Data can be retrieved via Ethernet, telephone modems, spread spectrum radios, and direct links. LoggerNet is especially useful for networks that contain both CR5000s and other Campbell Scientific dataloggers, such as the CR10X or CR23X, that are not compatible with PC9000 software.

ViewDAQ Real-Time Display Software

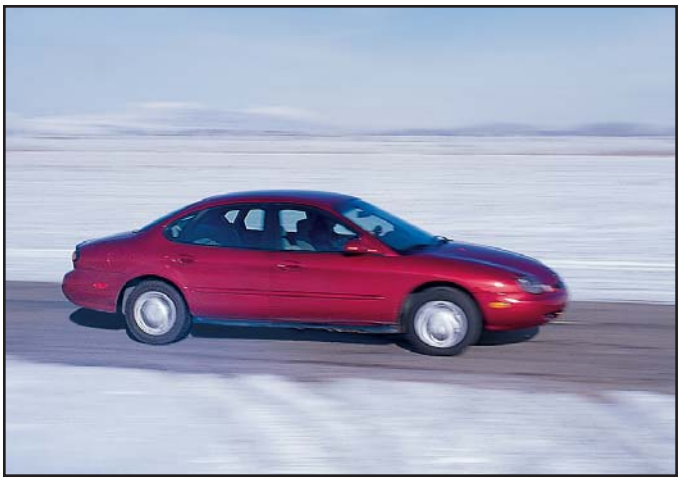
ViewDAQ is object-oriented software that allows you to create customized pages for displaying real-time data. ViewDAQ provides a variety of virtual instruments such as virtual dial, virtual thermometer, virtual gauge, compass, and dual compass that can be dragged and dropped anywhere on the page. It allows user control of position, size, colors, orientation, and scales. Besides virtual instruments, you can enter text and labels, set flags and alarms, and control background colors and page borders. Switches and potentiometers are provided for control functions. Multiple pages can be bound into a book.

Applications

Vehicle Monitoring and Testing

The versatile, rugged design and low power requirements of the CR5000 make it well suited for vehicle monitoring. Vehicle monitoring includes not only passenger cars but locomotives, airplanes, helicopters, tractors, buses, heavy trucks, drilling rigs, race cars, ATVs, and motorcycles. The CR5000 can provide cold and hot temperature, high altitude, off-highway, and cross-country performance testing. It is compatible with our GPS16-HVS GPS receiver, SDM-CAN interface, and DSP4 Heads Up Display.

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 CR5000, eliminating costly external signal conditioning.



The CR5000 is ideal for cross-country performance testing. For example, a system could monitor geographic position and velocity then transmit performance and position data to the home office via cellular phone.

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, air conditioning 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, traction, payload, vehicle position/speed, steering, air bag, hot/cold soaks, wind tunnels, CANbus, wiper speed/current, vehicle electrical loads

Eddy Covariance Systems

These systems use eddy covariance techniques to calculate water vapor, carbon dioxide, and heat flux. Below are the sensors used and their measurements:

- **CSAT3 Sonic Anemometer**—absolute wind and sonic temperature fluctuations
- **KH20 Hygrometer**—fluctuations of atmospheric water vapor
- **CS7500 Infrared Gas Analyzer**—both absolute CO_2 and water vapor
- **FW05 Fine Wire Thermocouple**—absolute temperature

The CR5000 measures the above sensors and computes fluxes on-line. The raw time-series data can be saved to a PC-card, along with processed data for later analysis. A PC at the site is not required. The CR5000's storage capacity can be increased using PC cards.

For eddy covariance applications, the CR5000 can measure the CS7500 Open-Path CO_2 Analyzer, CSAT3 Sonic Anemometer, and KH20 Krypton Hygrometer then compute fluxes on-line.

Other Applications

- Laboratory applications
- Greenhouse monitoring
- Mining
- HVAC systems
- Aerospace/aviation
- Energy management and conservation
- Structural or fatigue analysis
- Machinery testing
- Process monitoring and control

CR5000 Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; testing over -40° to +85°C is available as an option excluding batteries. Non-condensing environment is required. To maintain electrical specifications, Campbell Scientific recommends recalibrating dataloggers every two years.

PROGRAM EXECUTION RATE

The CR5000 can measure one channel and store the result in 500 µs; all 40 SE* channels can be measured in 8 ms (5 kHz aggregate rate).

ANALOG INPUTS

DESCRIPTION: 20 DF* or 40 SE, individually configured. Channel expansion provided through AM16/32, AM416, and AM25T Multiplexers.

RANGES, RESOLUTION, AND TYPICAL INPUT NOISE: Basic Resolution (Basic Res) is the A/D resolution of a single conversion. **Resolution of DFM* with input reversal is half the Basic Res**. Noise values are for DFM with input reversal; noise is greater with SEM.*

Input Rng (mV)	Basic Res (µV)	0 Int. (µV RMS)	250 µs Int. (µV RMS)	20/16.7 ms Int. (µV RMS)
±5000	167	70	60	30
±1000	33.3	30	12	6
±200	6.67	8	2.4	1.2
±50	1.67	3.0	0.8	0.3
±20	0.67	1.8	0.5	0.2

ACCURACY†:

±(0.05% of Reading + Offset) 0° to 40°C

±(0.075% of Reading + Offset) -25° to 50°C

±(0.10% of Reading + Offset) -40° to 85°C

Offset for DFM w/input reversal = Basic Res +1 µV

Offset for DFM w/o input reversal = 2Basic Res + 2 µV

Offset for SEM = 2Basic Res + 10 µV

MINIMUM TIME BETWEEN MEASUREMENTS:

Zero Integration:	125 µs
250 µs Integration:	475 µs
16.7 ms Integration:	19.9 ms
20 ms Integration:	23.2 ms

COMMON MODE RANGE: ±5 V

DC COMMON MODE REJECTION: >100 dB with input reversal (>80 dB without input reversal)

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

SUSTAINED INPUT VOLTAGE WITHOUT DAMAGE: ±16 Vdc

INPUT CURRENT: ±2 nA typ., ±10 nA max. @ 50°C

INPUT RESISTANCE: 20 GΩ typical

ACCURACY OF INTERNAL THERMOCOUPLE REFERENCE JUNCTION:

±0.25°C, 0° to 40°C
±0.5°C, -25° to 50°C
±0.7°C, -40° to 85°C

ANALOG OUTPUTS

DESCRIPTION: 4 switched voltage; 4 switched current; 2 continuous voltage; switched outputs active only during measurements, one at a time.

RANGE: Voltage (current) outputs programmable between ±5 V (±2.5 mA)

RESOLUTION: 1.2 mV (0.6 µA) for voltage (current) outputs

ACCURACY: ±10 mV (±10 µA) for voltage (current) outputs

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

CURRENT SINKING: 50 mA for switched voltage; 5 mA for continuous (15 mA w/selectable option)

COMPLIANCE VOLTAGE: ±5 V for switched current excitation

RESISTANCE MEASUREMENTS

Provides voltage ratio measurements of 4- and 6-wire full bridges, and 2-, 3-, 4-wire half bridges. Direct resistance measurements available with current excitation. Dual-polarity excitation is recommended.

VOLTAGE RATIO ACCURACY†: Assumes input and excitation reversal and an excitation voltage of at least 2000 mV.

±(0.04% Reading + Basic Res/4) 0° to 40°C

±(0.05% Reading + Basic Res/4) -25° to 50°C

±(0.06% Reading + Basic Res/4) -40° to 85°C

ACCURACY† WITH CURRENT EXCITATION: Assumes input and excitation reversal, and an excitation current, I_x, of at least 1 mA.

±(0.075% Reading + Basic Res/2I_x) 0° to 40°C

±(0.10% Reading + Basic Res/2I_x) -25° to 50°C

±(0.12% Reading + Basic Res/2I_x) -40° to 85°C

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 40 SE analog inputs can be used; signal attenuation and ac coupling may be required.

INPUT FREQUENCY RANGE:

Input Rng (mV)	Signal (peak to peak) Min.	Max.[1]	Min. Pulse W.	Max. Freq
±5000	600 mV	10 V	2.5 µs	200 kHz
±1000	100 mV	2.0 V	5.0 µs	100 kHz
±200	4 mV	2.0 V	25 µs	20 kHz

[1]Maximum signals must be centered around datalogger ground.

RESOLUTION: 70 ns/number of cycles measured

ACCURACY: ±(0.03% of Reading + Resolution)

PULSE COUNTERS

DESCRIPTION: Two 16-bit inputs selectable for switch closure, high frequency pulse, or low-level ac.

MAXIMUM COUNT: 4 x 10^9 counts per scan

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:
Maximum Input Frequency: 400 kHz
Maximum Input Voltage: ±20 V
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 1.2 µs time constant filter.

LOW LEVEL AC MODE:
Internal ac coupling removes dc offsets up to ±0.5 V.

Input Hysteresis: 15 mV
Maximum ac Input Voltage: ±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.

OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low < 0.1 V

OUTPUT RESISTANCE: 330 Ω

INPUT STATE: high 3.0 to 5.3 V; low -0.3 to 0.8 V

INPUT RESISTANCE: 100 kΩ

EMI and ESD PROTECTION

The CR5000 is encased in metal and incorporates EMI filtering on all inputs and outputs. Gas discharge tubes provide robust ESD protection on all terminal block inputs and outputs. The following European CE standards apply.

EMC tested and conforms to BS EN61326:1998.

Details of performance criteria applied are available upon request.

Warning: This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to correct the interference at the user's own expense.

CPU AND INTERFACE

PROCESSOR: Hitachi SH7034

MEMORY: Battery-backed SRAM provides 2 Mbytes for data and operating system use with 128 kbytes reserved for program storage. Expanded data storage with PCMCIA type I, type II, or type III card.

DISPLAY: 8-line-by-21 character alphanumeric or 128 x 64 pixel graphic LCD display w/backlight.

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

BAUD RATES: Selectable from 1,200 to 115,200 bps. ASCII protocol is eight data bits, one start bit, one stop bit, no parity.

CLOCK ACCURACY: ±1 minute per month, -25° to +50°C; ±2 minute per month, -40° to +85°C

SYSTEM POWER REQUIREMENTS

VOLTAGE: 11 to 16 Vdc

TYPICAL CURRENT DRAIN: 400 µA software power off; 1.5 mA sleep mode; 4.5 mA at 1 Hz (200 mA at 5 kHz) sample rate.

INTERNAL BATTERIES: 7 Ahr rechargeable base (optional); 1650 mAhr lithium battery for clock and SRAM backup, 10 years of service typical, less at high temperatures.

EXTERNAL BATTERIES: 11 to 16 Vdc; reverse polarity protected.

PHYSICAL SPECIFICATIONS

SIZE: 9.8" x 8.3" x 4.5" (24.7 cm x 21.0 cm x 11.4 cm) Terminal strips extend 0.4" (1.0 cm).

WEIGHT: 4.5 lbs (2.0 kg) with low-profile base; 12.2 lbs (5.5 kg) with rechargeable base

WARRANTY

Three years against defects in materials and workmanship.

*SE(M): Single-Ended (Measurement)

*DF(M): Differential (Measurement)

† Sensor and measurement noise not included.

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

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