CR3000 Micrologger

Rugged, Reliable, and Ready for any Application

campbellsci.com/cr3000

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campbellsci.com/cr3000
The CR3000 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. The CR3000’s low power requirements allow extended field use from a dc voltage source.

**Benefits and Features**
- Program execution rate of up to 100 Hz
- 16-bit analog to digital conversions
- 16-bit microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- 4 MB data storage memory
- Battery-backed SRAM and clock that ensure data, programs, and accurate time are maintained while the CR3000 is disconnected from its main power source
- Serial communications with serial sensors and devices supported via I/O port pairs
- PakBus®, Modbus, DNP3, TCP/IP, FTP, and SMTP protocols supported

**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.

**Data Storage Capacity**
The CR3000 Micrologger provides 2 MB of flash memory for the operating system (OS) and 4 MB of battery-backed SRAM for CPU usage, program storage, and data storage. Data is stored in a table format. The storage capacity of the CR3000 can be increased by using a CompactFlash® card.
**Transient Protection**
Gas Discharge Tube (GDT) protects the inputs from electrical transients. The CR3000 is CE compliant under the European Union’s EMC Directive, meeting ESD, EMC, Fast Transient standards.

**Input Output Terminals**

**Analog Inputs**
Twenty-eight single-ended (14 differential) channels measure voltage levels with 16-bit resolution on five software selectable voltage ranges.

**Pulse Counters**
Four 24-bit pulse channels measure switch closures, high frequency pulses, or low-level ac.

**Switched Excitation Outputs**
Four switched voltage and three switched current outputs provide precision excitation for ratiometric sensor/bridge measurements.

**Digital I/O Ports**
Eight ports have multiple functions including digital control output, interrupt, pulse counting, switch closure, frequency/period measurements, edge timing, or SDI-12 communication. Three additional ports are dedicated for measuring SDM devices.

The I/O ports can be paired as transmit and receive. Each pair has 0 to 5 V UART hardware that allows serial communications with serial sensors and devices. An RS-232-to-logic-level converter may be required in some cases.

**Continuous Analog Outputs**
Two continuous analog outputs provide voltage levels to displays or proportional controllers.

**Peripheral Port**
Campbell Scientific offers Ethernet and CompactFlash devices that directly connect to this peripheral port.

**RS-232 Port**
The RS-232 port is for connecting a PC, serial sensor, or RS-232 modem. The PC attaches to the CR3000 via an RS-232 cable—no interface required. This port isolates the PC’s electrical system from the datalogger, thereby protecting against ground loops, normal static discharge, and noise.

**CS I/O Port**
Many communication peripherals connect with the CR3000 via this port. A PC may connect with this port via an SC32B, SC-USB, or SC115 interface.

**Power Connections**
The continuous 5 V and 12 V terminals are for connecting sensors and non-Campbell Scientific peripherals. Two switched 12 V terminals are program controlled.

**Enclosures**
A CR3000 housed in a weather-resistant enclosure (ENC12/14 or larger) can collect data under extremely harsh conditions.

**Communication Protocols**
The CR3000 supports the PakBus, Modbus, DNP3, TCP/IP, FTP, and SMTP communication protocols. With the PakBus protocol, networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in the case of delivery failure, allows automatic switch over to a configured backup route.

The Modbus RTU protocol supports both floating point and long formats. The datalogger can act as a slave and/or master.

The DNP3 protocol supports only long data formats. The dataloggers are level 2 slave compliant, with some of the operations found in a level 3 implementation.

The TCP/IP, FTP, and SMTP protocols provide TCP/IP functionality when the CR3000 is used in conjunction with an IP network device such as the NL121, NL116, or NL240.

**Operating Temperature Ranges**
Standard operating range is -25° to +50°C; an extended range of -40° to +85°C is available. Battery bases have different temperature ranges (see Battery Base Options).

**Battery Base Options**

**Alkaline Base**
The alkaline base includes 10 D-cell batteries that provide a 10 Ah rating at 20°C. Operating temperature range is -25° to +50°C.

**Rechargeable Base**
This base includes an internal 7 Ah sealed rechargeable battery that can be charged via a vehicle, solar panel, or ac wall charger. Operating temperature range is -40° to +60°C.

When using vehicle power, our DCDC18R is used to increase the vehicle’s supply voltage to charging levels required by the CR3000.

**Low-Profile Base (no battery)**
The low-profile base requires a user-supplied dc source. It is preferred when the system’s power consumption needs a larger capacity battery or when it’s advantageous for the Micrologger to be thinner and lighter.
Communication Options

To determine the best option for an application, consider the accessibility of the site, availability of services (e.g., cellular phone or satellite coverage), quantity of data to collect, and desired time between data-collection sessions. Some communication options can be combined—increasing the flexibility, convenience, and reliability of the communications.

External Data Storage Devices
Campbell Scientific offers CompactFlash modules that store the CR3000’s data on an industrial-grade CompactFlash (CF) card. The CR3000 can also store data on an SC115 2 GB Flash Memory Drive.

iOS Devices and Android Devices
An iOS device or Android device can be used to view and collect data, set the clock, and download programs. To use an iOS or Android device, go to the Apple Store or Google Play and get the LoggerLink Mobile Apps.

Direct Links
A 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 CR3000’s CS I/O port via an SC32B, SC-USB, or SC115 interface.

Keyboard Display
The CR3000’s integrated keyboard display is used to program the datalogger, manually initiate data transfer, and display data. It displays 8-lines by 21-characters (64 x 128 pixels) and has a 16-character keyboard. Custom menus are supported allowing customers to set up choices within the datalogger program that can be initiated by a simple toggle or pick list.

Mountable Display
The CD100 or CD295 can be mounted in an enclosure lid, which allows customers to view the CR3000’s data on-site without opening the enclosure.

Internet and IP Networks
Campbell Scientific offers a variety of interfaces that enable the CR3000 Micrologger to communicate with a PC via TCP/IP.

Telephone Networks
The CR3000 can communicate with a PC using landlines, cellular CDMA, or cellular GPRS transceivers. A voice synthesized modem enables anyone to call the CR3000 via phone and receive a verbal report of real-time site conditions.

Multidrop Interface
The MD485 intelligent RS-485 interface permits a PC to address and communicate with one or more dataloggers over a single cable. Distances up to 4000 feet are supported.

Short Haul Modems
The SRM-SA RAD Short Haul Modem supports communications between the CR3000 and a PC via a four-wire unconditioned line (two twisted pairs).

Radios
Radio frequency (RF) communications are supported via narrow-band UHF, narrowband VHF, spread spectrum, or meteor burst radios. Line-of-sight is required for all of our RF options.

Satellite Transmitters
Satellite transmitters offered by Campbell Scientific include a NESDIS-certified GOES transmitter, an Argos transmitter, an Iridium transmitter, and an Inmarsat BGAN satellite IP terminal. Satellite telemetry offers an alternative for remote locations where phone lines or RF systems are impractical.
Channel Expansion

4-Channel Low Level AC Module
The LLAC4 is a small peripheral device that allows customers to increase the number of available low-level ac inputs by using control ports. This module is often used to measure up to four anemometers, and is especially useful for wind profiling applications.

Multiplexers
Multiplexers increase the number of sensors that can be measured by a datalogger by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single datalogger. The CR3000 is compatible with the AM16/32B and AM25T multiplexers.

Synchronous Devices for Measurement (SDMs)
SDMs are addressable peripherals that expand the datalogger’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 the system. Multiple SDMs, in any combination, can be connected to one datalogger.

Software

Starter Software
Our easy-to-use starter software is intended for first time users or applications that don’t require sophisticated communications or datalogger program editing. SCWin Short Cut generates straight-forward datalogger programs in four easy steps. PC200W allows customers to transfer a program to, or retrieve data from a CR3000 via a direct communications link.

At www.campbellsci.com/downloads, the starter software can be downloaded at no charge. Our Resource DVD also provides this software as well as PDF versions of our brochures and manuals.

Datalogger Support Software
Our datalogger support software packages provide more capabilities than our starter software. These software packages contains program editing, communications, and display tools that can support an entire datalogger network.

PC400, our mid-level software, supports a variety of telemetry options, manual data collection, and data display. For programming, it includes both Short Cut and the CRBasic program editor. PC400 does not support combined communication options (e.g., phone-to-RF), PakBus® routing, and scheduled data collection.

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.

LoggerNet is Campbell Scientific’s full-featured datalogger support software. It is referred to as “full-featured” because it provides a way to accomplish almost all the tasks you’ll need to complete when using a datalogger. LoggerNet supports combined communication options (e.g., phone-to-RF) and scheduled data collection.

RTMC, a program for displaying the datalogger’s data, is bundled with LoggerNet and RTDAQ. RTMCR and RTMC Web Server clients also use forms created in the developer mode of RTMC.

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

Measurement precision, flexibility, and long-term reliability of the CR3000 make it ideal for scientific, commercial, and industrial applications.

Open Path Eddy Covariance Systems

For eddy covariance applications, the CR3000 can measure the EC150 Open-Path CO₂ Analyzer, CSAT3A Sonic Anemometer, and KH20 Krypton Hygrometer then compute fluxes on-line.

The open path eddy covariance systems measure sonic sensible heat flux, momentum flux, and the flux of other scalars between the atmosphere and earth’s surface.

The system consists of a CR3000 datalogger, fast response three-dimensional sonic anemometer, and fast response scalar sensors. An independent measurement of temperature and humidity from a slow response sensor is also used to calculate background meteorological variables. Horizontal wind speed and direction are computed by the datalogger from the three-dimensional measurements of wind made by the sonic anemometer.

Meteorology

The CR3000 is used in long-term climatological monitoring, meteorological research, and routine weather measurement applications.

Sensors the CR3000 can measure include:

- cup, propeller, and sonic anemometers
- tipping bucket rain gages
- wind vanes
- pyranometers
- ultrasonic ranging sensor
- thermistors, RTDs, and thermocouples
- barometers
- RH probes
- Cooled mirror hygrometers

Wind Profiling

Our data acquisition systems can monitor conditions at wind assessment sites, at producing wind farms, and along transmission lines. The reliability of these systems ensures data collection, even under adverse conditions. Wide operating temperature ranges and weatherproof enclosures allow our systems to operate reliably in harsh environments.

The CR3000 makes and records measurements, controls electrical devices, and can function as PLCs or RTUs. Because the datalogger has its own power supply (batteries, solar panels), it can continue to measure and store data and perform control during power outages.

Typical sensors for wind assessment applications include, but are not limited to:

- cup, propeller, and sonic anemometers (up to 10 anemometers can be measured by using two LLAC4 peripherals)
- wind vanes
- thermistors, RTDs, and thermocouples
- barometers
- pyranometers

For turbine performance applications, the CR3000 monitors electrical current, voltage, wattage, stress, and torque.

Photo courtesy RADTech Ltd. UK

A Campbell Scientific datalogging system monitors this offshore wind farm located between Rhyl and Prestatyn in North Wales at about 7 to 8 km out to sea.
**Agriculture and Agricultural Research**
The versatility of the CR3000 allows measurement of agricultural processes and equipment in applications such as:

- plant water research
- canopy energy balance
- plant pathology
- machinery performance
- frost prediction
- crop management decisions
- food processing/storage
- integrated pest management
- irrigation scheduling

**Air Quality**
The CR3000 can monitor and control gas analyzers, particle samplers, and visibility sensors. The datalogger can also automatically control calibration sequences and compute conditional averages that exclude invalid data (e.g., data recorded during power failures or calibration intervals).

**Road Weather/RWIS**
Our fully NTCIP-compliant Environmental Sensor Stations (ESS) are robust, reliable weather stations used for road weather/RWIS applications. A typical ESS includes a tower, CR3000, two road sensors, remote communication hardware, and sensors that measure wind speed and direction, air temperature, humidity, barometric pressure, solar radiation, and precipitation.

**Soil Water**
The CR3000 is compatible with soil water blocks, matric water potential sensors, Time-Domain Reflectometry (TDR) systems, self-contained water content reflectometers, and tensiometers. These soil water instruments are used extensively to monitor water content and matric potential in applications requiring knowledge of soil water inventory or movement.

**Vehicle Testing**
This versatile, rugged datalogger is ideally suited for testing cold and hot temperature, high altitude, off-highway, and cross-country performance. The CR3000 is compatible with our SDM-CAN interface and GPS16X-HVS receiver.

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

The CR3000 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.

**Other Applications**

- Structural or fatigue analysis
- Wireless sensor/datalogger networks
- Water quality
- Water level/flow
- Mesonet systems
- Avalanche forecasting, snow science, polar, high altitude
- HVAC Systems
- Aerospace/aviation

The CR3000 can monitor and control pumps, fans, and starter motors in an HVAC system.
CR3000 Specifications

**Electrical specifications are valid over a -25°C to +50°C, non-condensing environment, unless otherwise specified. Recalibration recommended every three years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.**

**PROGRAM EXECUTION RATE**
10 ms to one day @ 10 ms increments

**ANALOG INPUTS** (SE1-5GE or DFI1-DFI14)
14 channels (DFF) or 25 single-ended (SS) individually configured input channels. Channel expansion provided by optional analog multiplexers.

**RANGES, RESOLUTION**:
Basic resolution (Basic Res.) is the resolution of a single A/D conversion. A DFF measurement with input reversal has better (finer) resolution by twice Basic Res.

<table>
<thead>
<tr>
<th>Range (mV)</th>
<th>DF Res (µV)</th>
<th>Basic Res (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±5000</td>
<td>±33.3</td>
<td>16.7</td>
</tr>
<tr>
<td>±2500</td>
<td>±16.7</td>
<td>8.33</td>
</tr>
<tr>
<td>±200</td>
<td>±3.33</td>
<td>1.67</td>
</tr>
<tr>
<td>±50</td>
<td>±0.83</td>
<td>0.417</td>
</tr>
<tr>
<td>±25</td>
<td>±0.25</td>
<td>0.125</td>
</tr>
</tbody>
</table>

**ANALOG INPUT ACCURACY**

1. ±0.04% of reading + offset, 0° to 40°C
2. ±0.07% of reading + offset, -25° to 50°C
3. ±0.09% of reading + offset, -40° to 85°C (XT only)

Accuracy does not include sensor and measurement noise. Offsets are defined as:

- Offset for DFF w/ input reversal = 1.5 Basic Res + 10 µV
- Offset for DFF w/o input reversal = 3 Basic Res + 20 µV

**ANALOG MEASUREMENT SPEED**

<table>
<thead>
<tr>
<th>Integration Type</th>
<th>Integration Time</th>
<th>SE w/ No Rev</th>
<th>DF w/ Input Rev</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 µs</td>
<td>250 µs</td>
<td>200 µs</td>
<td>±0.7 ms</td>
</tr>
<tr>
<td>10 ms</td>
<td>10 ms</td>
<td>8 ms</td>
<td>±1.4 ms</td>
</tr>
</tbody>
</table>

**INPUT NOISE VOLTAGE**
For DFF measurements with input reversal on ±20 mV input range, digital resolution dominates for higher ranges.

- 250 µs Integration: 0.4 µV RMS
- 50/60 Hz Integration: 0.19 µV RMS

**INPUT LIMITS**
±5 Vdc

**DC COMMON MODE REJECTION**
>100 dB

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

**INPUT VOLTAGE RANGE AND MEASUREMENT CORRUPTION**
±8.6 Vdc max.

**SUSTAINED INPUT VOLTAGE AND DAMAGE**
±16 Vdc max.

**INPUT CURRENT**
- ±1 nA typical, ±6 nA max. @ 50°C
- ±120 nA @ 85°C

**INPUT RESISTANCE**
20 GΩ typical

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

- ±0.3°C, -25° to 50°C
- ±0.6°C, -40° to 85°C (XT only)

**ANALOG OUTPUTS** (Vx1-Vx4, Ix1-Ix3, CA01, CA02)
4 switched voltage and 3 switched current outputs sequentially active during measurement. Two continuous outputs.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Range</th>
<th>Source</th>
<th>Sink</th>
<th>Compliance Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vx 1-4</td>
<td>±5 V</td>
<td>0.17 mV</td>
<td>0.5 V</td>
<td>N/A</td>
</tr>
<tr>
<td>Ix 1-3</td>
<td>±25 mA</td>
<td>0.08 µA</td>
<td>N/A</td>
<td>±5 V</td>
</tr>
<tr>
<td>CA01</td>
<td>±0.17 mV</td>
<td>0.15 mA</td>
<td>N/A</td>
<td>±5 V</td>
</tr>
</tbody>
</table>

**ANALOG OUTPUT ACCURACY (Vx and CA0):**

1. ±0.04% of setting + 0.5 mV, 0° to 40°C
2. ±0.07% of setting + 0.5 mV, -25° to 50°C
3. ±0.09% of setting + 0.5 mV, -40° to 85°C (XT only)

**ANALOG OUTPUT ACCURACY (Ix):**

1. ±0.1% of setting + 0.5 mA, 0° to 40°C
2. ±0.13% of setting + 0.5 mA, -25° to 50°C
3. ±0.15% of setting + 0.5 mA, -40° to 85°C (XT only)

**VX FREQUENCY SWEEP FUNCTION**
Switched outputs provide a programmable sweep frequency, 0 to 3000 mV square wave for exciting vibration wire transducers.

**RATIOMETRIC MEASUREMENTS**

**MEASUREMENT TYPES**
Provides ratiometric resistance measurements using voltage or current excitation. 4 switched voltage excitation outputs are available for measurement of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. 3 switched current excitation outputs are available for direct resistance measurements. Optional excitation polarity reversal minimizes dc errors.

**RATIOMETRIC MEASUREMENT ACCURACY**

1. ±0.02% of voltage reading + offset, 0° to 40°C
2. ±0.05% of voltage reading + offset, -25° to 50°C
3. ±0.03% of voltage reading + offset, -40° to 85°C

Accuracy specification assumes excitation reversal for excitation voltages < 500 mV and excitation currents < 500 µA. Assumption does not include bridge resistor errors and measurement noise.

**RATIOMETRIC MEASUREMENT ACCURACY**

1. For Resistance measurement, the sensor resistance is determined from Vx1/ix1, where excitation current Vx1 is measured across a 1000 Ω, ±0.05% of 25°C, 2 ppm/°C. TCR internal resistor
2. For resistance measurement, the sensor resistance is determined from Vx1/ix1, where Vx1 is value returned from measurement with multiplier = 1, Offset = 0.

**Ratiometric ε (εX) = A/V × Vx1/ix1, εX expressed as mV/mV**

εX is calculated from the ratiometric measurement accuracy. See Resistance Measurements Section in the manual for more information.

**PULSE COUNTERS (P1-P4)**
4 inputs individually selectable for switch closure, high frequency pulse, or low-level AC. Independent 24-bit counters for each input.

**MAXIMUM COUNTS PER SCAN**
16.8 x 10^9

**SWITCH CLOSURE MODE**
Minimum Switch Closed Time: 5 ms
Maximum Switch Open Time: 6 ms
Maximum Bounce Time: 1 ms open w/o being counted

**SWITCH CLOSURE FREQUENCY MAX**
150 Hz

**HIGH FREQUENCY MAX**
400 kHz

**SWITCH COUNTS PER SCAN**
46 ms

**NEW PORTS**
8 ports software selectable as binary inputs or control outputs.

**COMMUNICATION**

- **TCP/IP**
- **SMTP**
- **Telnet**
- **NTP**
- **Web API**
- **PakBus**
- **Modbus**
- **DNP3**
- **FTP**
- **HTTP**
- **XML**
- **HTML**
- **POP3**
- **SDI-12**
- **SDM**

**SYSTEM**

- **PROCESSOR**
- **MEMORY**
- **POWER REQUIREMENTS**
- **SYSTEM POWER REQUIREMENTS**
- **VOLTAGE**
- **10 to 16 Vdc**

**RECHARGEABLE BASE INPUT**
17 to 24 Vdc or 18 V RMS ac

**INTERNAL BATTERIES**
1200 mAh lithium battery for clock and SDM battery backup. Typically provides 3 years of backup. Optional 10 A alkaline or 7 A rechargeable battery plus bare available as primary power supply.

**EXTERNAL BATTERIES**
Optional 12 V alkaline and rechargeable available. Power connection is reverse polarity protected.

**TYPICAL CURRENT DRAW**

1. 2 mA

**PHYSICAL SPECIFICATIONS**

- **DIMENSIONS**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Power Consumption</th>
<th>Additional Features</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 years against defects in materials and workmanship.</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>