# CR1000X Specifications

Datalogger

Electrical specifications are valid over a -40 to +70 °C, non-condensing environment, unless otherwise specified. Extended electrical specifications (noted as XT in specifications) are valid over a -55 to +85 °C non-condensing environment. Recalibration is recommended every three years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.


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## System specifications

**Processor**: Renesas RX63N (32-bit with hardware FPU, running at 100 MHz)

**Memory**:

- Total onboard: 128 MB of flash + 4 MB battery-backed SRAM
  - Data storage: 4 MB SRAM + 72 MB flash (extended data storage automatically used for auto-allocated Data Tables not being written to a card)
  - CPU drive: 30 MB flash
  - OS load: 8 MB flash
  - Settings: 1 MB flash
  - Reserved (not accessible): 10 MB flash
- Data storage expansion: Removable microSD flash memory, up to 16 GB

**Program Execution Period**: 1 ms to 1 day

**Real-Time Clock**:

- Battery backed while external power is disconnected
- **Resolution**: 1 ms
- **Accuracy**: ±3 min. per year, optional GPS correction to ±10 µs

**Wiring Panel Temperature**: Measured using a 10K3A1A BetaTHERM thermistor, located between the two rows of analogue input terminals.

## Physical specifications

**Dimensions**: 23.8 x 10.1 x 6.2 cm (9.4 x 4.0 x 2.4 in); additional clearance required for cables and wires.

**Weight/Mass**: 0.86 kg (1.9 lb)

**Case Material**: Powder-coated aluminium

## Power requirements

**Protection**: Power inputs are protected against surge, over-voltage, over-current, and reverse power. IEC 61000-4 Class 4 level.

**Power In Terminal**:

- **Voltage Input**: 10 to 18 VDC
- **Input Current Limit at 12 VDC**:
  - 4.35 A at -40 °C
  - 3 A at 20 °C
  - 1.56 A at 85 °C
- 30 VDC sustained voltage limit without damage.

**USB Power:** Functions that will be active with USB 5 VDC include sending programs, adjusting data logger settings, and making some measurements. If USB is the only power source, then the CS I/O port and the 5V, 12V, and SW12 terminals will not be operational.

**Internal Lithium Battery**: AA, 2.4 Ah, 3.6 VDC (Tadiran TL 5903/S) for battery-backed SRAM and clock. 3-year life with no external power source.

**Average Current Drain**:

Assumes 12 VDC on POWER IN terminals.

- **Idle**: <1 mA
- **Active 1 Hz Scan**: 1 mA
- **Active 20 Hz Scan**: 55 mA
- **Serial** (RS-232/RS-485): Active + 25 mA
- **Ethernet Power Requirements**:
  - **Ethernet 1 Minute**: Active + 1 mA
  - **Ethernet Idle**: Active + 4 mA
  - **Ethernet Link**: Active + 47 mA

**Vehicle Power Connection**: When primary power is pulled from the vehicle power system, a second power supply OR charge regulator may be required to overcome the voltage drop at vehicle start-up.

# Power output specifications

## System power out limits (when powered with 12 VDC)

| Temperature (°C) | Current Limit[1] (A) |
|---|---|
| –40° | 4.53 |
| 20° | 3.00 |
| 70° | 1.83 |
| 85° | 1.56 |
| [1] Limited by self-resetting thermal fuse | |

## 12 V and SW12 V power output terminals

12V, SW12-1, and SW12-2: Provide unregulated 12 VDC power with voltage equal to the Power Input supply voltage. These are disabled when operating on USB power only.

| SW12 current limits | |
|---|---|
| **Temperature (°C)** | **Current Limit [1] (mA)** |
| –40° | 1310 |
| 0° | 1004 |
| 20° | 900 |
| 50° | 690 |
| 70° | 550 |
| 80° | 470 |
| [1] Thermal fuse hold current. | |

## 5 V and 3.3 V

5V: One regulated 5 V output. Supply is shared between the 5V terminal and CS I/O DB9 5 V output.

- **Voltage Output**: Regulated 5 V output (±5%)
- **Current Limit**: 230 mA

## C as power output

- C Terminals:
  - **Output Resistance ($R_o$)**: 150 Ω
  - **5 V Logic Level Drive Capacity**: 10 mA @ 3.5 VDC
  - **3.3 V Logic Level Drive Capacity**: 10 mA @ 1.8 VDC

## CS I/O pin 1

**5 V Logic Level Max Current**: 200 mA

## Voltage excitation

**VX**: Four independently configurable voltage terminals (VX1-VX4). When providing voltage excitation, a single 16-bit DAC shared by all VX outputs produces a user-specified voltage during measurement only.VX terminals can also be used to supply a selectable, switched, regulated 3.3 or 5 VDC power source to power digital sensors and toggle control lines.

| | Range | Resolution | Accuracy | Maximum Source/Sink Current[1] |
|---|---|---|---|---|
| Voltage Excitation | ±4 V | 0.06 mV | ±(0.1% of setting + 2 mV) | ±40 mA |
| Switched, Regulated | +3.3 or 5 V | 3.3 or 5 V | ±5% | 50 mA |
| [1] Exceeding current limits causes voltage output to become unstable. Voltage should stabilize when current is reduced to within stated limits. | | | | |

# Analogue measurement specifications

16 single-ended (SE) or 8 differential (DIFF) terminals individually configurable for voltage, thermocouple, current loop, ratiometric, and period average measurements, using a 24-bit ADC. One channel at a time is measured.

## Voltage measurements

**Terminals**:

- **Differential Configuration**: DIFF 1H/1L – 8H/8L
- **Single-Ended Configuration**: SE1 – SE16

**Input Resistance**: 20 GΩ typical

**Input Voltage Limits**: ±5 V

**Sustained Input Voltage without Damage**: ±20 VDC

**DC Common Mode Rejection**:

- > 120 dB with input reversal
- ≥ 86 dB without input reversal

**Normal Mode Rejection**: > 70 dB @ 60 Hz

**Input Current @ 25 °C**: ±1 nA typical

**Filter First Notch Frequency ($f_{N1}$) Range**: 0.5 Hz to 31.25 kHz (user specified)

Analogue Range and Resolution:

| | | Differential with Input Reversal | | Single-Ended and Differential without Input Reversal | |
|---|---|---|---|---|---|
| Notch Frequency ($f_{N1}$) (Hz) | Range[1] (mV) | RMS (µV) | Bits[2] | RMS (µV) | Bits[2] |
| 15000 | ±5000<br>±1000<br>±200 | 8.2<br>1.9<br>0.75 | 20<br>20<br>19 | 11.8<br>2.6<br>1.0 | 19<br>19<br>18 |
| 50/60[3] | ±5000<br>±1000<br>±200 | 0.6<br>0.14<br>0.05 | 24<br>23<br>22 | 0.88<br>0.2<br>0.08 | 23<br>23<br>22 |
| 5 | ±5000<br>±1000<br>±200 | 0.18<br>0.04<br>0.02 | 25<br>25<br>24 | 0.28<br>0.07<br>0.03 | 25<br>24<br>23 |

[1] Range overhead of ~5% on all ranges guarantees that full-scale values will not cause over range

[2] Typical effective resolution (ER) in bits; computed from ratio of full-scale range to RMS resolution.

[3] 50/60 corresponds to rejection of 50 and 60 Hz ac power mains noise.

Accuracy (does not include sensor or measurement noise):

- 0 to 40 °C: ±(0.04% of measurement + offset)
- –40 to 70 °C: ±(0.06% of measurement + offset)

Voltage Measurement Accuracy Offsets:

| | Typical Offset (µV RMS) | |
|---|---|---|
| Range (mV) | Differential with Input Reversal | Single-Ended or Differential without Input Reversal |
| ±5000 | ±0.5 | ±2 |
| ±1000 | ±0.25 | ±1 |
| ±200 | ±0.15 | ±0.5 |

Measurement Settling Time: 20 µs to 600 ms; 500 µs default

Multiplexed Measurement Time:

Measurement time = INT(multiplexed measurement time • (reps+1) + 2ms

| | Differential with Input Reversal | Single-Ended or Differential without Input Reversal |
|---|---|---|
| Example fN1[1] (Hz) | Time[2] (ms) | Time[2] (ms) |
| 15000 | 2.04 | 1.02 |
| 60 | 35.24 | 17.62 |
| 50 | 41.9 | 20.95 |
| 5 | 401.9 | 200.95 |

[1] Notch frequency (1/integration time).

[2] Default settling time of 500 µs used.

## Resistance measurement specifications

The data logger makes ratiometric-resistance measurements for four- and six-wire full-bridge circuits and two-, three-, and four-wire half-bridge circuits using voltage excitation. Excitation polarity reversal is available to minimize dc error.

Accuracy:

Assumes input reversal for differential measurements `RevDiff` and excitation reversal `RevEx` for excitation voltage <1000 mV. Does not include bridge resistor errors or sensor and measurement noise.

- 0 to 40 °C: ±(0.01% of voltage measurement + offset)
- –40 to 70 °C: ±(0.015% of voltage measurement + offset)
- –55 to 85 °C (XT): ±(0.02% of voltage measurement + offset)

## Period-averaging measurement specifications

Terminals: SE1-SE16

Accuracy: ±(0.01% of measurement + resolution), where resolution is 0.13 µs divided by the number of cycles to be measured

Ranges:

- Minimum signal centred around specified period average threshold.
- Maximum signal centred around data logger ground.
- Maximum frequency = 1/(2 * (minimum pulse width)) for 50% duty cycle signals

| Gain Code Option | Voltage Gain | Minimum Peak to Peak Signal (mV) | Maximum Peak to Peak Signal (V) | Minimum Pulse Width (µs) | Maximum Frequency (kHz) |
|---|---|---|---|---|---|
| 0 | 1 | 500 | 10 | 2.5 | 200 |
| 1 | 2.5 | 50 | 2 | 10 | 50 |
| 2 | 12.5 | 10 | 2 | 62 | 8 |
| 3 | 64 | 2 | 2 | 100 | 5 |

## Current-loop measurement specifications

The data logger makes current-loop measurements by measuring across a current-sense resistor associated with the RS-485 resistive ground terminal.

**Terminals**: RG1 and RG2

**Maximum Input Voltage**: ±16 V

**Resistance to Ground**: 101 Ω

**Current Measurement Shunt Resistance**: 10 Ω

**Maximum Current Measurement Range**: ±80 mA

**Absolute Maximum Current**: ±160 mA

**Resolution**: ≤ 20 nA

**Accuracy**: ±(0.1% of reading + 100 nA) @ -40 to 70 °C

## Pulse measurement specifications

Two inputs (P1-P2) individually configurable for switch closure, high-frequency pulse, or low-level AC measurements. See also Digital input/output specifications (p. 4). Each terminal has its own independent 32-bit counter.

> **NOTE:**
> Conflicts can occur when a control port pair is used for different instructions (`TimerInput()`, `PulseCount()`, `SDI12Recorder()`, `WaitDigTrig()`). For example, if C1 is used for `SDI12Recorder()`, C2 cannot be used for `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`.

**Maximum Input Voltage**: ±20 VDC

**Maximum Counts Per Channel**: $2^{32}$

**Maximum Counts Per Scan**: $2^{32}$

**Input Resistance**: 5 kΩ

**Accuracy**: ±(0.02% of reading + 1/scan)

### Switch closure input

**Terminals**: C1-C8

**Pull-Up Resistance**: 100 kΩ to 5 V

**Event**: Low (<0.8 V) to High (>2.5 V)

**Maximum Input Frequency**: 150 Hz

**Minimum Switch Closed Time**: 5 ms

**Minimum Switch Open Time**: 6 ms

**Maximum Bounce Time**: 1 ms open without being counted

### High-frequency input

**Terminals**: C1-C8

**Pull-Up Resistance**: 100 kΩ to 5 V

**Event**: Low (<0.8 V) to High (>2.5 V)

**Maximum Input Frequency**: 250 kHz

### Low-level AC input

**Minimum Pull-Down Resistance**: 10 kΩ to ground

**DC-offset rejection**: Internal AC coupling eliminates DC-offset voltages up to ±0.05 VDC

**Input Hysteresis**: 12 mV at 1 Hz

**Low-Level AC Pulse Input Ranges**:

| Sine wave (mV RMS) | Range (Hz) |
|---|---|
| 20 | 1.0 to 20 |
| 200 | 0.5 to 200 |
| 2000 | 0.3 to 10,000 |
| 5000 | 0.3 to 20,000 |

## Digital input/output specifications

Terminals configurable for digital input and output (I/O) including status high/low, pulse width modulation, external interrupt, edge timing, switch closure pulse counting, high-frequency pulse counting, UART[1], RS-232[2], RS-422[3], RS-485[4], SDM[5], SDI-12[6], I2C[7], and SPI[8] function. Terminals are configurable in pairs for 5 V or 3.3 V logic for some functions.

> **NOTE:**
> Conflicts can occur when a control port pair is used for different instructions (`TimerInput()`, `PulseCount()`, `SDI12Recorder()`, `WaitDigTrig()`). For example, if C1 is used for `SDI12Recorder()`, C2 cannot be used for `TimerInput()`, `PulseCount()`, or `WaitDigTrig()`.

**Terminals**: C1-C8

**Maximum Input Voltage**: ±20 V

**Logic Levels and Drive Current**:

| Terminal Pair Configuration | 5 V Source | 3.3 V Source |
|---|---|---|
| Logic low | ≤ 1.5 V | ≤ 0.8 V |
| Logic high | ≥ 3.5 V | ≥ 2.5 V |

### Edge timing

**Terminals**: C1-C8

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[1]Universal Asynchronous Receiver/Transmitter for asynchronous serial communications.

[2]Recommended Standard 232. A loose standard defining how two computing devices can communicate with each other. The implementation of RS-232 in Campbell Scientific data loggers to computer communications is quite rigid, but transparent to most users. Features in the data logger that implement RS-232 communication with smart sensors are flexible.

[3]Communications protocol similar to RS-485. Most RS-422 sensors will work with RS-485 protocol.

[4]Recommended Standard 485. A standard defining how two computing devices can communicate with each other.

[5]Synchronous Device for Measurement. A processor-based peripheral device or sensor that communicates with the data logger via hardwire over a short distance using a protocol proprietary to Campbell Scientific.

[6]Serial Data Interface at 1200 baud. Communication protocol for transferring data between the data logger and SDI-12 compatible smart sensors.

[7]Inter-Integrated Circuit is a multi-controller, multi-peripheral, packet switched, single-ended, serial computer bus.

[8]Serial Peripheral Interface - a clocked synchronous interface, used for short distance communications, generally between embedded devices.

**Maximum Input Frequency**: ≤ 1 kHz

**Resolution**: 500 ns

### Edge counting

**Terminals**: C1-C8

**Maximum Input Frequency**: ≤ 2.3 kHz

### Quadrature input

**Terminals**: C1-C8 can be configured as digital pairs to monitor the two sensing channels of an encoder.

**Maximum Frequency**: 2.5 kHz

**Resolution**: 31.25 µs or 32 kHz

### Pulse-width modulation

**Maximum Period**: 36.4 seconds

**Resolution**:

- **0 – 5 ms**: 83.33 ns
- **5 – 325 ms**: 5.33 µs
- **> 325 ms**: 31.25 µs

## Communications specifications

**Ethernet Port**: RJ45 jack, 10/100Base Mbps, full and half duplex, Auto-MDIX, magnetic isolation, and TVS surge protection.

**Internet Protocols**: Ethernet, PPP, RNDIS, ICMP/Ping, Auto-IP (APIPA), IPv4, IPv6, UDP, TCP, TLS (v1.2), DNS, DHCP, SLAAC, Telnet, HTTP(S), SFTP, FTP(S), POP3/TLS, NTP, SMTP/TLS, SNMPv3, CS I/O IP, MQTT[1]

**Additional Protocols**: CPI, PakBus, PakBus Encryption, SDM, SDI-12, Modbus RTU / ASCII / TCP, DNP3, custom user definable over serial, UDP, NTCIP, NMEA 0183, I2C, SPI

**USB Device**: Micro-B device for computer connectivity

**CS I/O**: 9-pin D-sub connector to interface with Campbell Scientific CS I/O peripherals.

**SDI-12** (C1, C3, C5, C7): Four independent SDI-12 compliant terminals are individually configured and meet SDI-12 Standard v 1.4.

**RS-485** (C5 to C8): One full duplex or two half duplex

**RS-422** (C5 to C8): One full duplex or two half duplex

**RS-232/CPI**: Single RJ45 module port that can operate in one of two modes: CPI or RS-232. CPI interfaces with Campbell Scientific CDM measurement peripherals and sensors. RS-232 connects, with an adapter cable, to computer, sensor, or communications devices serially.

**CPI**: One CPI bus. Up to 1 Mbps data rate. Synchronization of devices to 5 µS. Total cable length up to 610 m (2000 ft). Up to 20 devices. CPI is a proprietary interface for communications between Campbell Scientific data loggers and Campbell Scientific CDM peripheral devices. It consists of a physical layer definition and a data protocol.

**Hardwired**: Multi-drop, short haul, RS-232, fibre optic

**Satellite**: GOES, Argos, Inmarsat Hughes, Irridium

## Standards compliance specifications

View EU Declarations of Conformity at www.campbellsci.eu/cr1000x.

**Shock and Vibration**: MIL-STD 810G methods 516.6 and 514.6

**Protection**:

- Wiring panel: IP40
- Measurement module when connected to the wiring panel: IP65

**EMI and ESD protection**:

- **Immunity**: Meets or exceeds following standards:
  - **ESD**: per IEC 61000-4-2; ±15 kV air, ±8 kV contact discharge
  - **Radiated RF**: per IEC 61000-4-3; 10 V/m, 80-1000 MHz
  - **EFT**: per IEC 61000-4-4; 4 kV power, 4 kV I/O
  - **Surge**: per IEC 61000-4-5; 4 kV power, 4kV I/O
  - **Conducted RF**: per IEC 61000-4-6; 10 V power, 10 V I/O
- Emissions and immunity performance criteria available on request.

## Warranty

**Standard**: Three years against defects in materials and workmanship.

**Extended** (optional): An additional four years, bringing the total to seven years.

[1]Message Queuing Telemetry Transport - a messaging protocol for the Internet of Things (IoT)

## Terminal functions

| Analogue input terminal functions | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE DIFF | 1 2 ⌐1¬ H L | | 3 4 ⌐2¬ H L | | 5 6 ⌐3¬ H L | | 7 8 ⌐4¬ H L | | 9 10 ⌐5¬ H L | | 11 12 ⌐6¬ H L | | 13 14 ⌐7¬ H L | | 15 16 ⌐8¬ H L | | RG1 | RG2 |
| Single-Ended Voltage | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Differential Voltage | H | L | H | L | H | L | H | L | H | L | H | L | H | L | H | L | | |
| Ratiometric/Bridge | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Thermocouple | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| Current Loop | | | | | | | | | | | | | | | | | ✓ | ✓ |
| Period Average | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |

| Pulse counting terminal functions | | | |
|---|---|---|---|
| | P1 | P2 | C1-C8 |
| Switch-Closure | ✓ | ✓ | ✓ |
| High Frequency | ✓ | ✓ | ✓ |
| Low-level Ac | ✓ | ✓ | |

| Analogue output terminal functions | |
|---|---|
| | VX1-VX4 |
| Switched Voltage Excitation | ✓ |

| Voltage Output | | | | | | |
|---|---|---|---|---|---|---|
| | C1-C8[1] | VX1-VX4 | 5V | 12V | SW12-1 | SW12-2 |
| 5 VDC | ✓ | ✓ | ✓ | | | |
| 3.3 VDC | ✓ | ✓ | | | | |
| 12 VDC | | | | ✓ | ✓ | ✓ |

[1] C terminals have limited drive capacity. Voltage levels are configured in pairs.

| Communications terminal functions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | RS-232/CPI |
| SDI-12 | ✓ | | ✓ | | ✓ | | ✓ | | |
| GPS | PPS | Rx | Tx | Rx | Tx | Rx | Tx | Rx | |
| TTL 0-5 V | Tx | Rx | Tx | Rx | Tx | Rx | Tx | Rx | |
| LVTTL 0-3.3 V | Tx | Rx | Tx | Rx | Tx | Rx | Tx | Rx | |
| RS-232 | | | | | Tx | Rx | Tx | Rx | ✓ |
| RS-485 (Half Duplex) | | | | | A- | B+ | A- | B+ | |

| Communications terminal functions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | RS-232/CPI |
| RS-485 (Full Duplex) | | | | | Tx- | Tx+ | Rx- | Rx+ | |
| I2C | SDA | SCL | SDA | SCL | SDA | SCL | SDA | SCL | |
| SPI | MOSI | SCLK | MISO | | MOSI | SCLK | MISO | | |
| SDM[1] | Data | Clk | Enabl | | Data | Clk | Enabl | | |
| CPI/CDM | | | | | | | | | ✓ |

[1] SDM can be on either C1-C3 or C5-C7, but not both at the same time.

Communications functions also include Ethernet and USB.

| Digital I/O terminal functions | |
|---|---|
| | C1-C8 |
| General I/O | ✓ |
| Pulse-Width Modulation Output | ✓ |
| Timer Input | ✓ |
| Interrupt | ✓ |
| Quadrature | ✓ |

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