Hunter River Salinity Trading Scheme

Discharge Point Telemetry Specification

Implementation officer	Hunter River Salinity Trading Scheme (HRSTS) Participant Environmental Officer
Relevant to	HRSTS Participants
Relevant documents	Applicable NSW EPA scheme participant EPLs
Relevant legislation	Protection of the Environment Operations **Act** (1997) Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002

Monitoring, Evaluation and Review, Revision History

Outcome: How does this Manual deliver against the purpose and scope?	
Monitoring	This document details the equipment used by participants to transfer conductivity and flow data collected under their Environment Protection Licence to WaterNSW.
Evaluation and Review	To determine review frequency of controlled documents, risk rank the document using the WaterNSW Risk Management Process to establish: *How likely is there to be a change in legislation or process and what is the consequence of that change?* **Risk Rating** / **Recommended Review Period** Extreme / Annually Major / Annually Medium / 2 years **Minor** / **3 years or as required**
Revision history Rev V0.5 – Ben Mulhearn	Ben Mulhearn – Draft - Initial total rewrite of legacy document to align site technical specifications of participants hardware to that required under the Gen2 project upgrade and align to requested EPA HRSTS licensing requirements
Rev V0.9 – Mitchell Bennett (NSW EPA)	Adjusting the document so that it can be included as a condition within an Environment Protection Licence (EPL)
Rev V1.0 – Released 2018-10-04	Approved Sri Sritharan. Endorsed Lee Garnham ARK Container STW105064 D2018/109124

Approval **Sri Sritharan - Water System Operations Adviser**

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Title: Supervising Instrumentation Officer
(HRSTS Participant Technical Liaison)

Contents

1. Introduction

The Hunter River Salinity Trading Scheme (HRSTS) ensures that discharges of saline water from mines and power stations in the Hunter River Valley are managed to meet predetermined targets. It is a requirement of each Environment Protection Licence (EPL) issued by the Environment Protection Authority (EPA) that the licensee monitors the conductivity and flow during each discharge. This data must be transferred to the Service Coordinator, currently WaterNSW.

2. Purpose and Scope of this Document

This document provides technical information to licensees in the Hunter River Salinity Trading Scheme for establishment of remote site telemetry equipment for timely communication of discharge point monitoring to the WaterNSW telemetry system.

Individual licensees are responsible for the capture and storage of all monitoring data required under their EPL. Specifications for the equipment used to monitor flow and water quality are documented in each EPL and are outside the scope of this document.

3. Telemetry System

The telemetry system requirements are a Cellular IP Modem / Data-Logger / Telemetry system platform consisting of:

- a HyQuest ICE3 IP data Modem on the Telstra Next G Network;
- a Campbells CR850 or CR1000 data-loggers with displays and onsite networking where required; and
- communicating to the WaterNSW HyQuest HydroTel Telemetry data acquisition system

4. Remote Site Telemetry Equipment

The benchmark for remote field equipment is listed in **Appendix A.** If the licensee proposes to use alternative equipment, it **must ensure that**:

- It logs the required site data every five minutes;
- The data is telemetered in a conforming protocol format at least hourly into the WaterNSW Hydrotel Telemetry Platform to ensure seamless telemetry monitoring under the scheme and the participants EPL;
- All required sensor parameters are as per the EPA EPL requirements; and
- Site communication is available continuously for the discharge point monitoring equipment

If other hardware is used from the recommended suite, the discharge licence holder accepts all costs and responsibility for integration / non-integration into the WaterNSW Hydrotel Telemetry Platform.

Appendix B provides the Technical Specifications of the recommended equipment.

5. Remote Discharge Point Site Programming

A base program is available without charge from WaterNSW to allow licensees to record, view, change and transfer data via telemetry in a format that is acceptable to WaterNSW.

6. Remote Discharge Point Data Transfer

The logger at each discharge point logs data every 5 minutes.

The discharge points' Cellular IP modems must be configured to transfer data into the WaterNSW Hydrotel system hourly. Data transfer from each site must be staggered so that not all sites are reporting into HydroTel at the same time. This is to evenly distribute system resources.

Participants and WaterNSW can prompt a manual transfer of data outside these windows as required. Increased polled telemetry regimes may be instituted by WaterNSW during flow events.

All remote sites' time base must be set to Eastern Standard Time for the entire year (not Daylight Savings Time).

Logged data must be transferred in the format shown below:

```
DataTable(Table1,StoreNow,-1)
  Sample (1,SiteNo,Long)                          - DP HRSTS assigned site Number
  Sample (1,LogVoltRaw,IEEE4)                     - DP DC Voltage supply value
  FieldNames("LogVolt Vdc")
  Sample (1,WaterFLOWRaw,IEEE4)                   - DP Flow value in ML/Day
  FieldNames("WaterFLOW M/Day")
  Sample (1,WaterECRaw,IEEE4)                     - DP Compensated Conductivity value
  FieldNames("WaterEC uS/Cm")
  Sample (1,WaterTMPRaw,IEEE4)                    - DP Water Temperature value
  FieldNames("WaterTEMP DegC")
  Sample (1,LoggedDisSaltTonnage,IEEE4)           - DP Salt Tonnage value
  FieldNames("DischargeTonnes")
  Sample (1,DischargeStatus,Long)                 - DP Site Status
  FieldNames("DischargeStatus")
  Sample (1,WaterTrbRaw,IEEE4)                    - DP Water Turbidity value
  FieldNames("WaterTRB")
  Sample (1,WaterpHRaw,IEEE4)                     - DP Water pH value
  FieldNames("WaterPH")
  Sample (1,WaterLVLRaw,IEEE4)                    - DP Water Level – where required
  FieldNames("WaterLVL")
```

Logged data must meet the following specifications:

Site Variables	Description	Output Units	Accuracy	Range
Site Battery Volts	Data logger supply voltage	Vdc	+/- 5 %	9-16 Vdc – nominally 12.6Vdc
DP Flow Value (core)	Flow value from site. Either produced from a site flow meter or meters, or less preferred a height to flow algorithm onboard the data logger	ML/Day	+/- 10%	As required or licensed
EC25 Conductivity Value (TC 2%) (core)	The compensated conductivity value of the released water, referenced to 25'C, Temperature Coefficient of 2% / Deg'C	uS/Cm	+/- 5 %	10,000uS/cm or as required
Water Temperature (core)	The water temperature of the discharge point release water, usually integrated into the conductivity sensor or sonde	Deg'C	+/- 0.1 %	0-50'C or 0-100'C
Salt Tonnage (core)	The incremental tonnes of salt value during a release	Tonnes		
DP Status (core)	Indicates the status of the site: 1 = IDLE 2 = DISCHARGING or 3 = SIMULATION / TESTING	NA	NA	NA
Water Turbidity (optional)	The water turbidity of the discharge point release water	NTU	+/- 5 %	0 to 500
Water pH (optional)	The water pH of the discharge point release water	pH	+/- 0.1 %	0-14
Water Level (where required)	The water level of the weir or monitoring point to at some sites feed into a custom Height to Flow algorithm	Meters	+/- 0.1 %	~0-1.5m

7. Cellular Telemetry Signal Strength

Telemetry equipment must have access to adequate coverage by the Telstra Next-G cellular network to reliability operate.

SMS and Hydrotel Web portal data access allows the participants to remotely monitor their sites telemetered signal strength to track or review if site communication becomes problematic. The licensee must perform this signal analysis to ensure that their site equipment is communicating robustly. For example, it will be necessary for the licensee to install a higher gain antenna or mast or radio relay on higher ground if the signal is blocked by an overburden dump.

8. Site Power Supplies

The licensee must ensure that the power supply to the telemetry equipment is reliable under adverse weather conditions including storms and floods. A five-day minimum back up battery supply is recommended.

The telemetry hardware is solar capable and will operate between 10-16 Vdc, nominally around 12.6-13.3 Vdc. Additionally a 240 Vac to 12 Vdc battery charger backup power supply can be utilised and are readily available.

The current draw of the equipment in a quiescent state is in the mA range and minimal. Please refer to Appendix B for specific power current draw in various states.

9. Testing

All telemetry equipment testing is the responsibility of the licensee. WaterNSW will participate in confirmation of the telemetry link upon at least 14 working days prior notice. The following information must be provided to WaterNSW:

- Site name and EPA EPL number and a copy of said EPL
- sensor configuration (ranges, offsets, algorithms) and physical and instrumentation arrangements of the discharge point site
- if localised Modbus comms will be required and if so, supply the IP address, gateway and subnet mask to participant requires for their network. Further the preferred Modbus address as well.
- date and time that telemetry testing will be performed

Equipment must be tested for correct operation. Loop sources can be simulated in this testing phase. Statements of performance / accuracy must be obtained from equipment suppliers and retained onsite and presented on request.

WaterNSW will confirm to the participant that the testing of communications in its HydroTel system has occurred.

Appendix A – Hardware Listing

Discharge points use either of the following hardware arrangement dependent on the site and plant needs:

1. A CR850 Data Logger and ICE3 Modem OR
2. A CR1000 Data Logger, with additional Keyboard Display and ICE3 Modem
    a. Further an ethernet module if required for localised plant comms interface

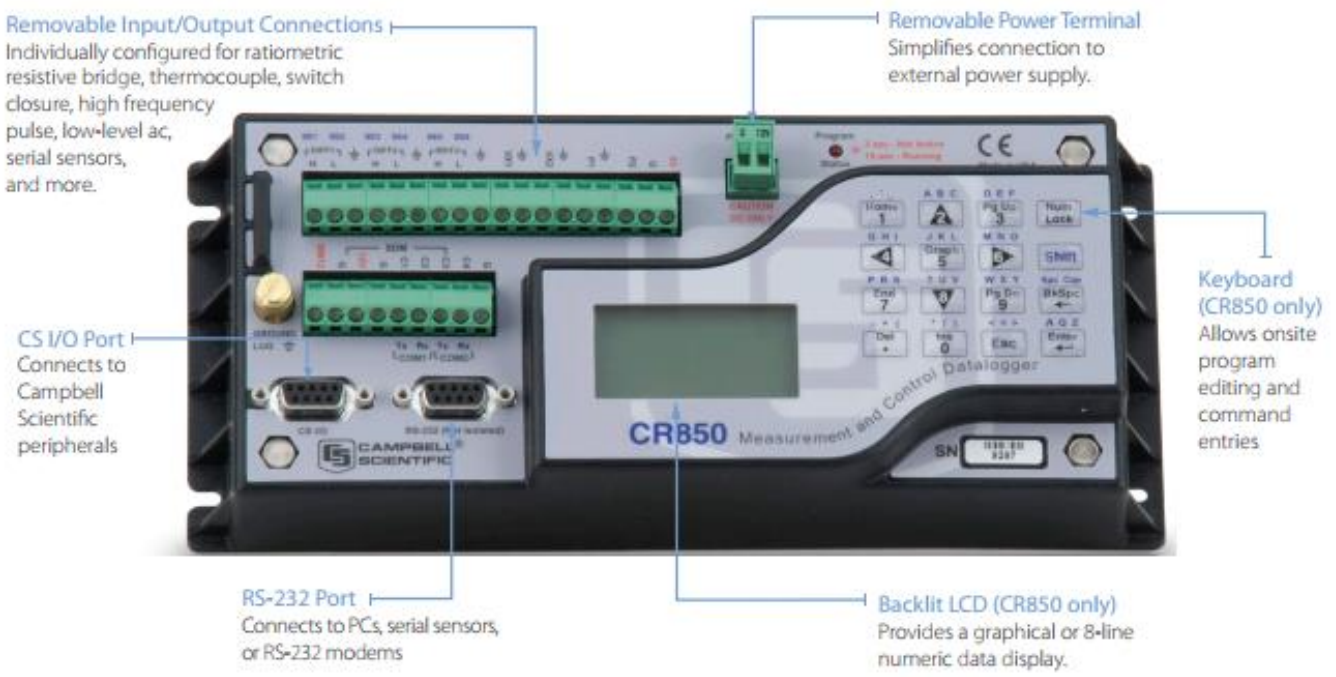
Model No Device Type	Supplier	Description	Use
CR850 Data Logger	Campbell Scientific	Data Logger with Integrated LCD Screen – No ethernet port – suited to 3x 4-20mA IO channels and supports SDI comms	For smaller DP site with less IO and no ethernet local plant comms
CR1000 Data Logger	Campbell Scientific	Data Logger without LCD Screen – double IO to above of 6x 4-20mA IO channels and supports SDI comms	For larger sites with more IO and a requirement to access the data loggers values via Modbus ethernet comms
CR1000KD Keyboard Display	Campbell Scientific	Combination LCD Display & Keyboard supportive to CR1000 unit above	Used by staff to review and configure the logger without laptop connectivity
NL121 Ethernet Interface	Campbell Scientific	Ethernet comms module supportive to CR1000 unit above	Provides participants Modbus supply of the loggers data to their local plant PLC / DCS / SCADA platforms
ICE3 Data Modem	HyQuest Solutions	Cellular IP Data Modem operating in the 850MHz Telstra Next-G Band	Facilitates telemetry connectivity from data logger to the WaterNSW HydroTel system

Appendix B – Equipment Technical Specifications

CR850 From: https://s.campbellsci.com/documents/au/product-brochures/b_cr800.pdf

CR800 and CR850 Measurement and Control Systems

The CR800 and CR850 dataloggers provide precision measurement capabilities in a rugged, battery-operated package. Both models consist of measurement electronics encased in a plastic shell and an integrated wiring panel. The standard operating range is -25° to +50°C. An extended range of -55° to +85°C for the CR800 or -30° to +80°C for the CR850 is also available.



Benefits and Features

- 4 MB* of battery-backed SRAM
- Program execution rate of up to 100 Hz
- CS I/O and RS-232 serial ports
- 13-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
- Single DAC used for excitation and measurements to give ratiometric measurements
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- Battery-backed SRAM and clock that ensure data, programs, and accurate time are maintained while datalogger is disconnected from the main power source
- One program-status LED
- Serial communications with serial sensors and devices supported via I/O port pairs
- PakBus, Modbus, and DNP3 protocols supported

Model Descriptions

The models differ in their keyboard display. The CR800 uses an external keyboard display, the CR1000KD, which connects to the CR800 via its CS I/O port. The CR850 includes an on-board keyboard display as part of its integrated package.

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.

Storage Capacity*

The CR800 series has 2 MB of flash memory for the Operating System, and 4 MB of battery-backed SRAM for CPU usage, program storage, and data storage. Data is stored in a table format.

**Campbell Scientific is increasing the data storage memory from 2 MB to 4 MB. Dataloggers with a serial number greater than or equal to 3605 will have a 4 MB memory. The 4 MB dataloggers will also have a sticker on the canister stating "4M Memory".*

CR800-Series Specifications

Electrical specifications are valid over a -25° 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-SE6 or DIFF1-DIFF3)

3 differential (DIFF) or 6 single-ended (SE) individually configured input channels. Channel expansion provided by optional analog multiplexers.

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

Range (mV)[1]	DIFF Res (µV)[2]	Basic Res (µV)
±5000	667	1333
±2500	333	667
±250	33.3	66.7
±25	3.33	6.7
±7.5	1.0	2.0
±2.5	0.33	0.67

[1]Range overhead of ~9% on all ranges guarantees that full-scale values will not cause over range.
[2]Resolution of DIFF measurements with input reversal.

ACCURACY[3]:
±(0.06% of reading + offset), 0° to 40°C
±(0.12% of reading + offset), -25° to 50°C
±(0.18% of reading + offset), -55° to 85°C (-XT only)

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

Offset for DIFF w/input reversal = 1.5-Basic Res + 1.0 µV
Offset for DIFF w/o input reversal = 3-Basic Res + 2.0 µV
Offset for SE = 3-Basic Res + 3.0 µV

ANALOG MEASUREMENT SPEED:

Integration Type/ Code	Integration Time	Settling Time	Total Time[4] SE w/ No Rev	Total Time[4] DIFF w/ Input Rev
250	250 µs	3 ms	~1 ms	~12 ms
60 Hz[5]	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz[5]	20.00 ms	3 ms	~25 ms	~50 ms

[4]Includes 250 µs for conversion to engineering units.
[5]AC line noise filter.

INPUT NOISE VOLTAGE: For DIFF measurements with input reversal on ±2.5 mV input range; digital resolution dominates for higher ranges.
250 µs Integration: 0.34 µV RMS
50/60 Hz Integration: 0.19 µV RMS

INPUT LIMITS: ±5 V

DC COMMON MODE REJECTION: >100 dB

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

INPUT VOLTAGE RANGE W/O MEASUREMENT CORRUPTION: ±8.6 Vdc max.

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.

INPUT CURRENT: ±1 nA typical, ±6 nA max. @ 50°C; ±90 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
±0.8°C, -55° to 85°C (-XT only)

ANALOG OUTPUTS (VX1-VX2)

2 switched voltage outputs sequentially active only during measurement.

RANGE AND RESOLUTION:

Channel	Range	Resolution	Current Source/Sink
(VX 1–2)	±2.5 Vdc	0.67 mV	±25 mA

Voltage outputs programmable between ±2.5 V with 0.67 mV resolution.

ANALOG OUTPUT ACCURACY (VX):
±(0.06% of setting + 0.8 mV), 0° to 40°C
±(0.12% of setting + 0.8 mV), -25° to 50°C
±(0.18% of setting + 0.8 mV), -55° to 85°C (-XT only)

Vx FREQUENCY SWEEP FUNCTION: Switched outputs provide a programmable swept frequency, 0 to 2500 mv square waves for exciting vibrating wire transducers.

PERIOD AVERAGE

Any of the 6 SE analog inputs can be used for period averaging. Accuracy is ±(0.01% of reading + resolution), where resolution is 136 ns divided by the specified number of cycles to be measured.

INPUT AMPLITUDE AND FREQUENCY:

Voltage Gain	Input Range (±mV)	Input Signal (peak to peak) Min (mV)[6]	Input Signal (peak to peak) Max (V)[7]	Min Pulse Width (µV)	Max[8] Freq (kHz)
1	250	500	10	2.5	200
10	25	10	2	10	50
33	7.5	5	2	62	8
100	2.5	2	2	100	5

[6]Signal centered around *Threshold* (see PeriodAvg() instruction).
[7]Signal centered around datalogger ground.
[8]Maximum frequency = 1/(twice minimum pulse width) for 50% of duty cycle signals.

RATIOMETRIC MEASUREMENTS

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

RATIOMETRIC MEASUREMENT ACCURACY:[9,10, 11]
±(0.04% of voltage measurement + offset)

[9]Accuracy specification assumes excitation reversal for excitation voltages < 1000 mV. Assumption does not include bridge resistor errors and sensor and measurement noise.

[10]Estimated accuracy, ΔX (where X is value returned from the measurement with Multiplier =1, Offset = 0):
BrHalf() instruction: $\Delta X = \Delta V_x/V_x$
BrFull() instruction $\Delta X = 1000 \cdot \Delta V_x/V_x$, expressed as mV·V^{-1}.
ΔV^{-1} is calculated from the ratiometric measurement accuracy. See Resistance Measurements Section in the manual for more information.

[11]Offsets are defined as:
Offset for DIFF w/input reversal = 1.5-Basic Res + 1.0 µV
Offset for DIFF w/o input reversal = 3-Basic Res + 2.0 µV
Offset for SE = 3-Basic Res + 3.0 µV
Excitation reversal reduces offsets by a factor of two.

PULSE COUNTERS (P1-P2)

2 inputs individually selectable for switch closure, high frequency pulse, or low-level ac. Independent 24-bit counters for each input.

MAXIMUM COUNTS PER SCAN: 16.7 x 10^6

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

HIGH FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 µs time constant.

LOW LEVEL AC MODE: Internal ac coupling removes dc offsets up to ±0.5 V.
Input Hysteresis: 12 mV @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

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 I/O PORTS (C1-C4)

4 ports software selectable, as binary inputs or control outputs. Provide on/off, pulse width modulation, edge timing, subroutine interrupts/wake up, switch closure pulse counting, high-frequency pulse counting, asynchronous communications (UARTs), SDI-12 communications, and SDM communications.

LOW FREQUENCY MODE MAX: <1 kHz

HIGH FREQUENCY MAX: 400 kHz

SWITCH CLOSURE FREQUENCY MAX: 150 Hz

EDGE TIMING RESOLUTION: 540 ns

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

OUTPUT RESISTANCE: 330 Ω

INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V

INPUT HYSTERISIS: 1.4 V

INPUT RESISTANCE:
100 kΩ with inputs <6.2 Vdc
220 Ω with inputs ≥6.2 Vdc

SERIAL DEVICE / RS-232 SUPPORT: 0 to 5 Vdc UART

SWITCHED 12 V (SW12)

One independent 12 Vdc unregulated source is switched on and off under program control. Thermal fuse hold current = 900 mA @ 20°C, 650 mA @ 50°C, 360 mA @ 85°C.

EU DECLARATION OF CONFORMITY

VIEW AT: www.campbellsci.com/cr800 or www.campbellsci.com/cr850

COMMUNICATIONS

RS-232 PORTS:
DCE 9-pin: (not electrically isolated) for computer connection or connection of modems not manufactured by Campbell Scientific.
COM1 to COM2: Two independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 Vdc UART
Baud Rate: selectable from 300 bps to 115.2 kbps.
Default Format: 8 data bits; 1 stop bits; no parity
Optional Formats: 7 data bits; 2 stop bits; odd, even parity

CS I/O PORT: Interface with telecommunication peripherals manufactured by Campbell Scientific

SDI-12: Digital control ports C1 or C3 are individually configurable and meet SDI-12 Standard version 1.3 for datalogger mode. Up to 10 SDI-12 sensors are supported per port.

PROTOCOLS SUPPORTED: PakBus, AES-128 Encrypted PakBus, Modbus, DNP3, FTP, HTTP, XML, HTML, POP3, SMTP, Telnet, NTCIP, NTP, Web API, SDI-12, SDM

SYSTEM

PROCESSOR: Renesas H8S 2322 (16-bit CPU with 32-bit internal core running at 7.4 MHz)

MEMORY: 2 MB of flash for operating system; 4 MB of battery-backed SRAM for CPU usage, program storage and final data storage

RTC CLOCK ACCURACY: ±3 min. per year. Correction via GPS optional.

RTC CLOCK RESOLUTION: 10 ms

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 Vdc

INTERNAL BATTERIES: 1200 mA h lithium battery for clock and SRAM backup, typically provides 3 years of backup

EXTERNAL BATTERIES: Optional 12 Vdc nominal alkaline and rechargeable available. Power connection is reverse polarity protected.

TYPICAL CURRENT DRAIN @ 12 Vdc:
Sleep Mode: 0.7 mA typical; 0.9 mA max.
1 Hz Sample Rate (1 fast SE measurement): 1 mA
100 Hz Sample Rate (1 fast SE measurement): 16.2 mA
100 Hz Sample Rate (1 fast SE meas w/RS-232 communication): 28 mA
Active external keyboard display adds 7 mA (100 mA with backlight on).

PHYSICAL

DIMENSIONS: 24.1 x 10.4 x 5.1 cm (9.5 x 4.1 x 2 in); additional clearance required for cables and leads.

WEIGHT: 0.7 kg (1.5 lb)

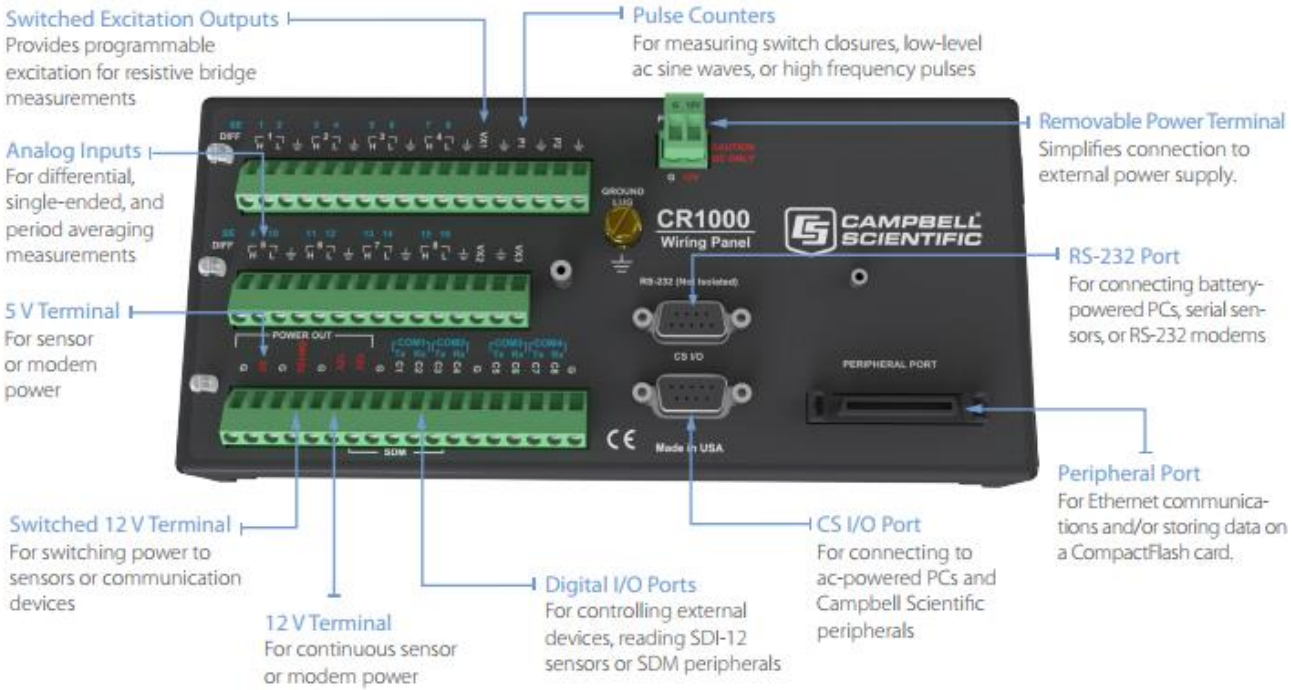
WARRANTY

3-years against defects in materials and workmanship.

CR1000 From: https://s.campbellsci.com/documents/au/product-brochures/b_cr1000.pdf

CR1000 Measurement and Control Datalogger

The CR1000 provides precision measurement capabilities in a rugged, battery-operated package. It consists of a measurement and control module and a wiring panel. Standard operating range is -25° to +50°C; an optional extended range of -55° to +85°C is available.



Benefits and Features

- 4 MB memory*
- Program execution rate of up to 100 Hz
- CS I/O and RS-232 serial ports
- 13-bit analog to digital conversions
- 16-bit H8S Renesas Microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Single DAC used for excitation and measurements to give ratio metric measurements
- Gas Discharge Tube (GDT) protected inputs
- Battery-backed SRAM memory and clock ensuring data, programs, and accurate time are maintained while the CR1000 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

Measurement and Control Module

The module measures sensors, drives direct communications and telecommunications, reduces data, controls external devices, and stores data and programs in on-board, non-volatile storage. The electronics are RF shielded and glitch protected by the sealed, stainless steel canister. A battery-backed clock assures accurate timekeeping. The module can simultaneously provide measurement and communication functions. The on-board, BASIC-like programming language supports data processing and analysis routines.

Wiring Panel

The CR1000WP is a black, anodized aluminum wiring panel that is compatible with all CR1000 modules. The wiring panel includes switchable 12 V, redistributed analog grounds (dispersed among analog channels rather than grouped), unpluggable terminal block for 12 V connections, gas-tube spark gaps, and 12 V supply on pin 8 to power our COM-series phone modems and other peripherals. The control module easily disconnects from the wiring panel allowing field replacement without rewiring the sensors. A description of the wiring panel's input/output channels follows.

CR1000 Specifications

Electrical specifications are valid over a -25° 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-SE16 or DIFF1-DIFF8)
8 differential (DF) or 16 single-ended (SE) individually configuredinput channels. Channel expansion provided by optional analog multiplexers.

RANGES and RESOLUTION: Basic resolution (Basic Res) is the A/D resolution of a single A/D conversion. A DF measurement with input reversal has better (finer) resolution than Basic Res.

Range (mV)[1]	DF Res (µV)[2]	Basic Res (µV)
±5000	667	1333
±2500	333	667
±250	33.3	66.7
±25	3.33	6.7
±7.5	1.0	2.0
±2.5	0.33	0.67

[1]Range overhead of ~9% on all ranges guarantees that full-scale values will not cause over range.
[2]Resolution of DF measurements with input reversal.

ACCURACY[3]:
±(0.06% of reading + offset), 0° to 40°C
±(0.12% of reading + offset), -25° to 50°C
±(0.18% of reading + offset), -55° to 85°C (-XT option only)

[3]Accuracy does not include the sensor and measurement noise. Offsets are defined as:
Offset for DF w/input reversal = 1.5-Basic Res + 1.0 µV
Offset for DF w/o input reversal = 3-Basic Res + 2.0 µV
Offset for SE = 3-Basic Res + 3.0 µV

ANALOG MEASUREMENT SPEED:

Integration Type/Code	Integration Time	Settling Time	Total Time[4] SE w/ No Rev	Total Time[4] DF w/ Input Rev
250	250 µs	3 ms	~1 ms	~12 ms
60 Hz[5]	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz[5]	20.00 ms	3 ms	~25 ms	~50 ms

[4]Includes 250 µs for conversion to engineering units.
[5]AC line noise filter.

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±2.5 mV input range (digital resolution dominates for higher ranges).
250 µs Integration: 0.34 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 W/O MEASUREMENT CORRUPTION: ±8.6 Vdc max.

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.

INPUT CURRENT: ±1 nA typical, ±6 nA max. @ 50°C; ±90 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
±0.8°C, -55° to 85°C (-XT option only)

ANALOG OUTPUTS (VX1-VX3)
3 switched voltage, sequentially active only during measurement.

RANGE AND RESOLUTION:

Channel	Range	Resolution	Current Source/Sink
(VX 1–3)	±2.5 Vdc	0.67 mV	±25 mA

ANALOG OUTPUT ACCURACY (VX):
±(0.06% of setting + 0.8 mV), 0° to 40°C
±(0.12% of setting + 0.8 mV), -25° to 50°C
±(0.18% of setting + 0.8 mV), -55° to 85°C (-XT only)

VX FREQUENCY SWEEP FUNCTION: Switched outputs provide a programmable swept frequency, 0 to 2500 mv square waves for exciting vibrating wire transducers.

PERIOD AVERAGE
Any of the 16 SE analog inputs can be used for period averaging. Accuracy is ±(0.01% of reading + resolution), where resolution is 136 ns divided by the specified number of cycles to be measured.

INPUT AMPLITUDE AND FREQUENCY:

Voltage Gain	Input Range (±mV)	Signal (peak to peak) Min. (mV)[6]	Signal (peak to peak) Max (V)[7]	Min Pulse Width (µV)	Max[8] Freq (kHz)
1	250	500	10	2.5	200
10	25	10	2	10	50
33	7.5	5	2	62	8
100	2.5	2	2	100	5

[6]Signal centered around Threshold (see PeriodAvg() instruction).
[7]With signal centered at the datalogger ground.
[8]The maximum frequency = 1/(twice minimum pulse width) for 50% of duty cycle signals.

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

RATIOMETRIC MEASUREMENT ACCURACY:[9,10, 11]
±(0.04% of Voltage Measurement + Offset)

[9]Accuracy specification assumes excitation reversal for excitation voltages < 1000 mV. Assumption does not include bridge resistor errors and sensor and measurement noise.

[10]Estimated accuracy, ΔX (where X is value returned from the measurement with Multiplier = 1, Offset = 0):
BrHalf() instruction: $\Delta X = \Delta V_r/V_x$
BrFull() instruction $\Delta X = 1000 \cdot \Delta V_r/V_x$, expressed as mV·V^{-1}.
ΔV_r is calculated from the ratiometric measurement accuracy. See Resistance Measurements Section in the manual for more information.

[11]Offsets are defined as:
Offset for DIFF w/input reversal = 1.5-Basic Res + 1.0 µV
Offset for DIFF w/o input reversal = 3-Basic Res + 2.0 µV
Offset for SE = 3-Basic Res + 3.0 µV
Excitation reversal reduces offsets by a factor of two.

PULSE COUNTERS (P1-P2)
2 inputs individually selectable for switch closure, high frequency pulse, or low-level ac. Independent 24-bit counters for each input.

MAXIMUM COUNTS PER SCAN: 16.7×10^6

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

HIGH-FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 µs time constant.

LOW-LEVEL AC MODE: Internal ac coupling removes ac offsets up to ±0.5 Vdc.
Input Hysteresis: 12 mV RMS @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

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 I/O PORTS (C1-C8)
8 ports software selectable, as binary inputs or control outputs. Provide on/off, pulse width modulation, edge timing, subroutine interrupts / wake up, switch closure pulse counting, high frequency pulse counting, asynchronous communications (UARTs), and SDI-12 communications. SDM communications are also supported.

LOW FREQUENCY MODE MAX: <1 kHz
HIGH-FREQUENCY MODE MAX: 400 kHz
SWITCH-CLOSURE FREQUENCY MAX: 150 Hz
EDGE TIMING RESOLUTION: 540 ns
OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1
OUTPUT RESISTANCE: 330 Ω
INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V
INPUT HYSTERESIS: 1.4 V
INPUT RESISTANCE: 100 kΩ with inputs <6.2 Vdc
0.220 kΩ with inputs ≥6.2 Vdc
SERIAL DEVICE/RS-232 SUPPORT: 0 TO 5 Vdc UART

SWITCHED 12 VDC (SW-12)
1 independent 12 Vdc unregulated source is switched on and off under program control. Thermal fuse hold current = 900 mA at 20°C, 650 mA at 50°C, 360 mA at 85°C.

EU DECLARATION OF CONFORMITY
https://s.campbellsci.com/documents/us/compliance/eudoc_cr1000series.pdf
https://s.campbellsci.com/documents/us/compliance/eudoc_cr1000kd.pdf

COMMUNICATIONS
RS-232 PORTS:
DCE 9-pin: (not electrically isolated) for computer connection or connection of modems not manufactured by Campbell Scientific.
COM1 to COM4: 4 independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 Vdc UART
Baud Rates: selectable from 300 bps to 115.2 kbps.
Default Format: 8 data bits; 1 stop bits; no parity
Optional Formats: 7 data bits; 2 stop bits; odd, even parity

CS I/O PORT: Interface with telecommunications peripherals manufactured by Campbell Scientific.

SDI-12: Digital control ports C1, C3, C5, and C7 are individually configured and meet SDI-12 Standard v 1.3 for datalogger mode. Up to 10 SDI-12 sensors are supported per port.

PERIPHERAL PORT: 40-pin interface for attaching CompactFlash or Ethernet peripherals

PROTOCOLS SUPPORTED: PakBus, AES-128 Encrypted PakBus, Modbus, DNP3, FTP, HTTP, HTML, POP3, PPP, SMTP, Telnet, NTCIP, NTP, SDI-12, SDM, TLS.

SYSTEM
PROCESSOR: Renesas H8S 2322 (16-bit CPU with 32-bit internal core running at 7.3 MHz)

MEMORY: 2 MB of flash for operating system; 4 MB of battery-backed SRAM for CPU usage and final data storage; 512 kB flash disk (CPU) for program files.

REAL-TIME CLOCK ACCURACY: ±3 min. per year. Correction via GPS optional.

REAL-TIME CLOCK RESOLUTION: 10 ms

SYSTEM POWER REQUIREMENTS
VOLTAGE: 9.6 to 16 Vdc

INTERNAL BATTERIES: 1200 mAh lithium battery for clock and SRAM backup that typically provides three years of backup

EXTERNAL BATTERIES: Optional 12 Vdc nominal alkaline and rechargeable available. Power connection is reverse polarity protected.

TYPICAL CURRENT DRAIN at 12 Vdc:
Sleep Mode: < 1 mA
1 Hz Sample Rate (1 fast SE measurement): 1 mA
100 Hz Sample Rate (1 fast SE measurement): 6 mA
100 Hz Sample Rate (1 fast SE measurement w/RS-232 communication): 20 mA
Active external keyboard display adds 7 mA (100 mA with backlight on).

PHYSICAL
DIMENSIONS: 23.9 x 10.2 x 6.1 cm (9.4 x 4 x 2.4 in); additional clearance required for cables and leads.

MASS/WEIGHT: 1 kg / 2.1 lb

WARRANTY
3 years against defects in materials and workmanship.

CR1000KD From: https://www.campbellsci.com.au/cr1000kd

Detailed Description

The CR1000KD displays 8 lines x 21 characters (64 x 128 pixels) and has a 16-character keyboard. The CR1000KD is powered by the data logger's power supply. An SC12 connects the CR1000KD to the CR1000WP or CR800; the two connectors on the SC12 allow attachment of additional peripherals.

The CR1000KD supports custom menus. With custom menus, you can set up choices within the data logger program that are initiated by a simple toggle or pick from a list in the menu displayed on the CR1000KD (for example, ***Initiate Sensor Calibration Sequence*** versus ***Bypass Sensor Calibration Sequence***.)

There is not a CR1000KD Operator's Manual. Operation of the CR1000KD is described in the CR800 and CR1000 data logger manual.

Specifications

Operating Temperature Range	-25° to +50°C
Dimensions	10.2 x 15.2 x 1.5 cm (4.0 x 6.0 x 0.6 in.)
Weight	272 g (10 oz)
Current Drain	
Quiescent	Negligible
Active	7 mA (without backlight) 100 mA (with backlight)

NL121 From: https://www.campbellsci.com.au/nl121

Overview

The NL121 is the easiest and lowest-cost way to add an Ethernet interface connection to a CR1000 or CR3000. This small device, about the size of a deck of cards, simply plugs onto the datalogger's peripheral port. Through the NL121, the Internet capabilities of the datalogger can be accessed, such as PakBus, Modbus, and DNP3 over TCP, as well as Web, email, file transfer, and cloud-based application clients. Using any standard IP network—within an office or across the Internet—data can be collected from the datalogger, and the datalogger can be controlled.

Benefits and Features

- The easiest way to add Ethernet to a CR1000 or CR3000
- Provides a native Ethernet connection, allowing the datalogger to communicate directly using a variety of Internet protocols
- Integrated protection for surge and ESD
- Datalogger-controlled power-management schemes for low-power operation
- Three year extended warranty available on this product

Specifications

Datalogger Interface	40-pin peripheral port on CR1000 or CR3000
Ethernet	10/100 Mbps, auto-detect 10BaseT/100Base-TX, full/half duplex, IEEE 802.3, auto MDI/MDI-X
Power Source	12 V from datalogger 40-pin peripheral port
Power Consumption	55 mA typical
Operating Temperature Range	-40° to +70°C
Dimensions	10.2 x 6.4 x 2.8 cm (4.0 x 2.5 x 1.1 in.)
Weight	66.62 g (2.35 oz)
Compliance	
Application of Council Directive(s)	2004/108/EC Electromagnetic Compatibility Directive (EMC)
Product Standard	EN 61326-1:2013 – Electrical Equipment for measurement, control and laboratory use (EMC requirements – for use in industrial locations)
2011/65/EU	The Restriction of Hazardous Substances Directive (RoHS2)

ICE3 From:
https://www.hyquestsolutions.com/fileadmin/HYQUEST/Products/Data_Acquisition_2015/PDF/iCE3FX_Datalogger.pdf

IP Capable: iCE³ FX Intelligent Communications

iCE³ FX
TELEMETRY

HYDROLOGY | GROUNDWATER | FLOOD | WATER QUALITY | CLIMATIC

iCE³ FX
Datalogging Capable modem

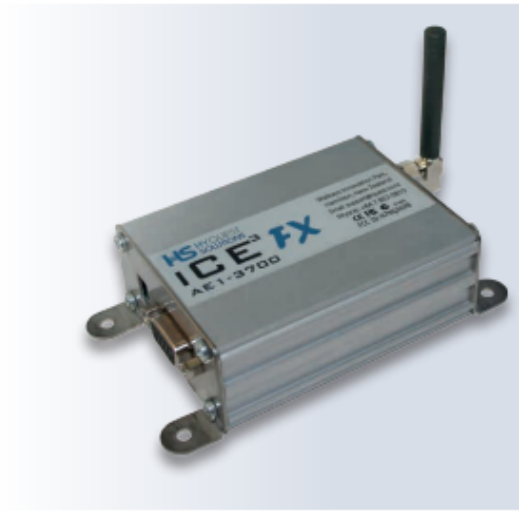
The iCE³ FX has been designed and constructed as a compact, intelligent unit to provide IP connectivity to a wide range of equipment fitted with an RS232 port. It can manage on-demand or scheduled connections on both public/dynamic or private/static IP networks.

The iCE³ FX differs from a standard type wireless modem as it offers additional intelligent features. It has the ability to autonomously manage the tasks to give IP communications capability to almost any RS232 equipped device that is not equipped with its own IP functionality.

For dynamic IP scenarios, the iCE³ FX initiates a TCP or UDP socket connection and sends an identification call-in to a suitably equipped base station such as HydroTel™ or the iQuest Global Data Network. The base system captures the iCE³ FX's dynamic IP address, switches to the native protocol for the target device and the iCE³ FX becomes transparent allowing native communication through the TCP socket or via UDP.

- **Intelligent communications:** scheduling and link management.
- **Local IP connection** request via an AT command from host device.
- **Remote IP connection** request via SMS command.
- Digital input and analogue input with integral standalone **datalogging** function. Equipped with 8MB flash memory.
- **FTP transfer** of logged data in CSV format to up to two separate FTP hosts (in standalone mode).
- Optional **GPS Logging** and Clock Sync.
- **Gateway** (store and forward) communications for use with iQuest devices. E.g. to link a wireless IP network to a radio network.
- **SMS** text back (current sensor value).
- Over the Air software and firmware **upgrades**.

Wireless 3G Modem
The iCE³ FX includes a high performance wireless modem. This is a multi-band device that will operate on most 3G and also legacy 2G (GSM) or 2.5G (Edge) networks around the world. This modem enables high-speed data transfer virtually on



demand. Configuration options have been included to make the connection scenarios very flexible and also to minimise data traffic.

RS232 Port
One DCE configured RS232 communication port is provided for interfacing with the host device. Specialised cables are available that cater for devices requiring customised handshaking control.

GPS
As an optional add-on (hardware and software) the modem can be configured to log GPS position (longitude, latitude and altitude) and synchronise the device clock from GPS time.

Power Supply
The normal power supply for the iCE³ FX is an external dc supply, 12V supply rechargeable SLA battery. A high efficiency switch mode regulator supplies all on board requirements.

LED Indicators
A blue LED indicates the iCE³ FX general status. A range of conditions may be determined through this LED. Different flash sequences show the unit and communication status. A red LED shows when the digital input is active.

Connectors
A high-density DB15F connector is used for the RS232 communications port. The power supply connects via a polarised four pin latched connector. The two hardware inputs are also accessed on the connector. The antenna connects via an industry standard SMA type connector.

Antenna
A small "stubby" type antenna may be attached directly to the unit or alternatively, an external higher gain antenna can be connected via a coaxial cable and SMA connector.

Enclosure
The case is constructed from extruded aluminium alloy with stainless steel end plates with mounting feet. The SIM card is contained in a small slide-in holder on the front of the unit.

Real Time Clock / Calendar.
An internal real-time clock is provided to control the call-in schedule (if used). This can be set via a computer through the RS232 port, or via the IP network from a HydroTel™ base station. This is automatically synchronised to the wireless network's time reference if this is available.

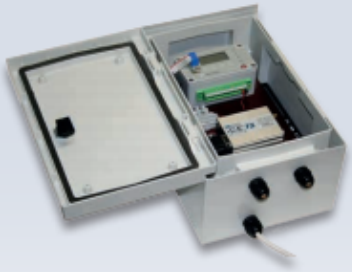
Physical I/O Specification

Digital Input
One digital input operating with either clean contact activation to 0V or a 5 to 30V DC signal. Maximum input frequency is 5 kHz in frequency mode. External debounce components may be required for applications with long cables and/or in electrically noisy environments.

Analogue Input
One 12-bit uni-polar analogue input is included. Range 0-5V. Input impedance 103kΩ. Referenced to 0V common. For current mode, an external current sink resistor (typically 250ohms) is required.

Basic Specification

- **Size:** 82mm x 63mm x 30mm (3.2in x 2.48in x 1.18in) (LxWxH)
- **Mass:** 184g (6.49oz)
- **Power Supply:** External 5V – 32V dc supply. Over-voltage and reverse polarity protected with self-resetting fuse.
- **Power Consumption:** Average 12mA @ 13.8V in idle mode, 4.5mA in full power save mode. Average 50mA @ 13.8V when on-line. Actual current consumption is dependent on the modem state and relative signal strength (transmit power required). The modem power mode may be scheduled to optimise the power budget.
- **Communications:**
  - Non-isolated DCE RS232 at 1200 – 38400 bps (default 38400 bps)
  - Wireless modem. IP support includes TCP Client, TCP Server, UDP, FTP.
- **Data Storage:** 8 MB flash memory. A typical site 2 parameters logged every 15 minutes plus battery voltage logged hourly will give 10 years of data storage before overwrite occurs.
- **Environmental:**
  Operating:
  -10ºC to +70ºC (14 ºF to +158 ºF).
  Storage:
  -10ºC to +85ºC (14 ºF to +185 ºF)



iCE³ FX providing a communication solution for the iBox custom enclosure

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