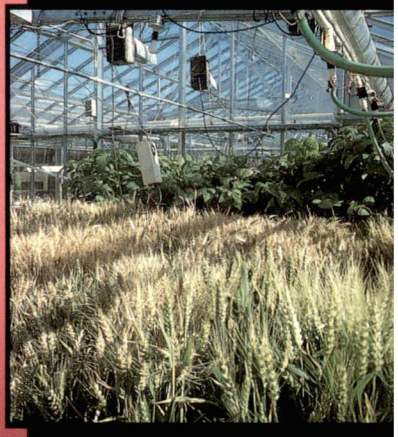
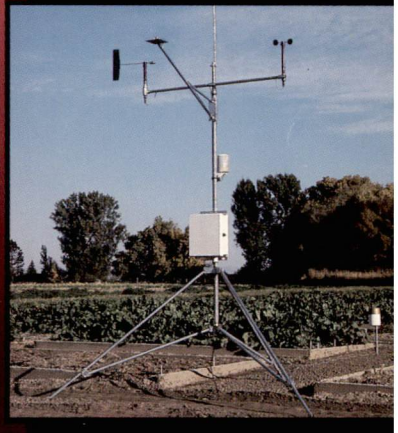
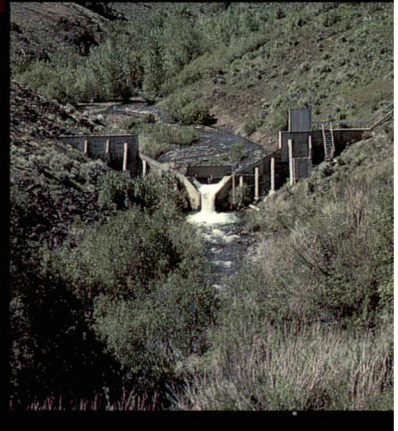
CR10 *Measurement and Control System*





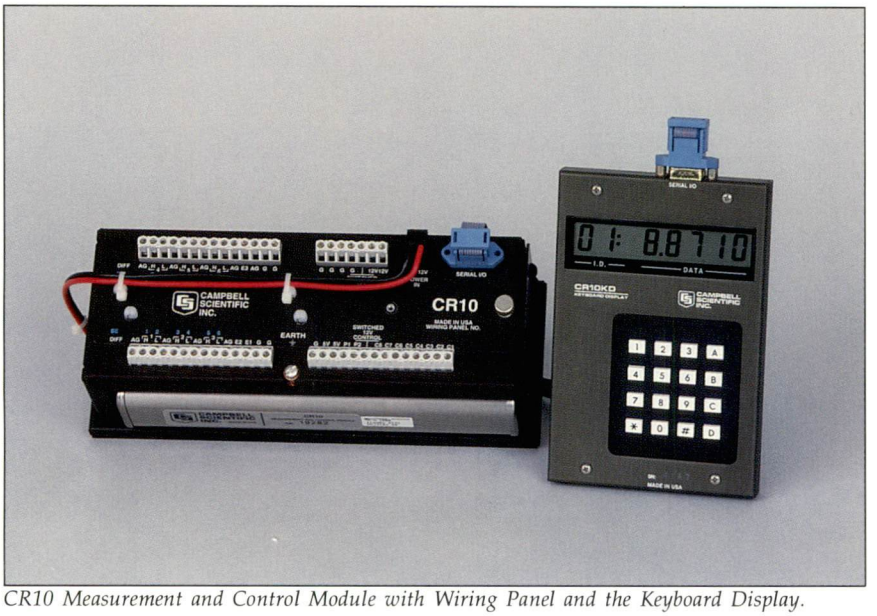


CAMPBELL SCIENTIFIC, INC.
815 W. 1800 N. • Logan, Utah 84321-1784 • (801) 753-2342 • FAX (801) 752-3268

CR10 Measurement and Control System

A Rugged, Operational Instrument with Research Grade Performance

The CR10 combines a micro-computer, clock, multimeter, calibrator, scanner, timer, frequency counter, and controller in a compact, sealed, stainless steel package.



CR10 Measurement and Control Module with Wiring Panel and the Keyboard Display.

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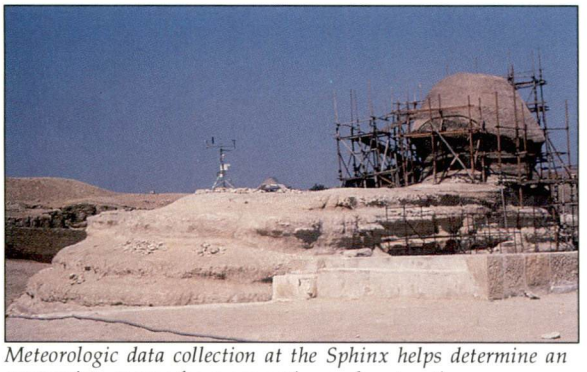
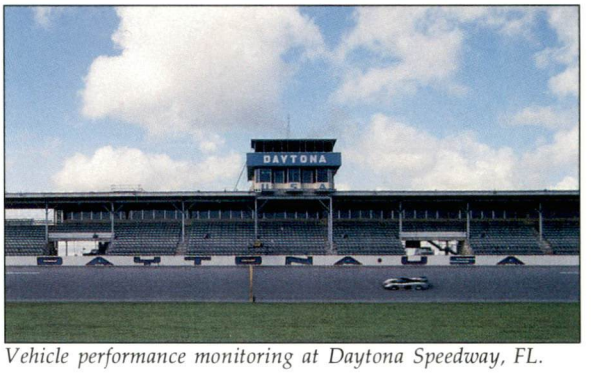
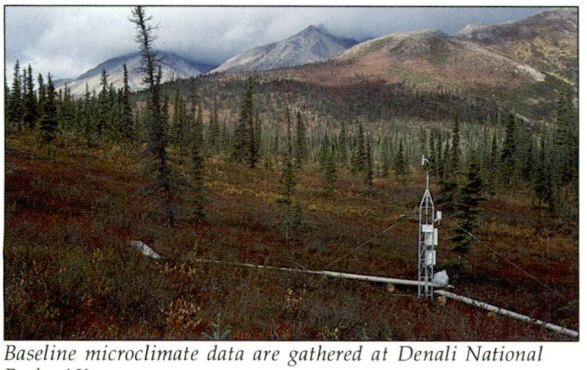
Campbell Scientific data acquisition systems deliver accurate, reliable measurement and control capability, even in extreme environments. Our systems have collected data on every continent, at sea, and in space.



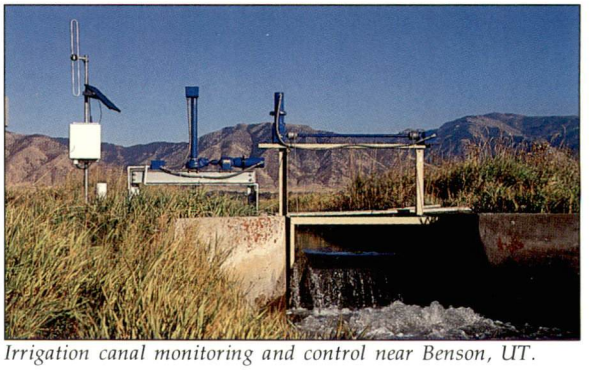
Meteorologic data collection at the Sphinx helps determine an appropriate course for preservation and restoration.



Vehicle performance monitoring at Daytona Speedway, FL.



Baseline microclimate data are gathered at Denali National Park, AK.



Irrigation canal monitoring and control near Benson, UT.

Cover Photos At left: CR10 Measurement and Control Module. From top right: *Industry* Turbine performance and hook load testing, photo courtesy Aerospatiale Helicopters, Inc.; *Research* NASA CELSS Research Lab, Utah State University, Logan, UT; *Agriculture* Agricultural Research Plots, Logan, UT; *Hydrology* Weir in Reynolds Creek drainage, southeast of Boise, ID

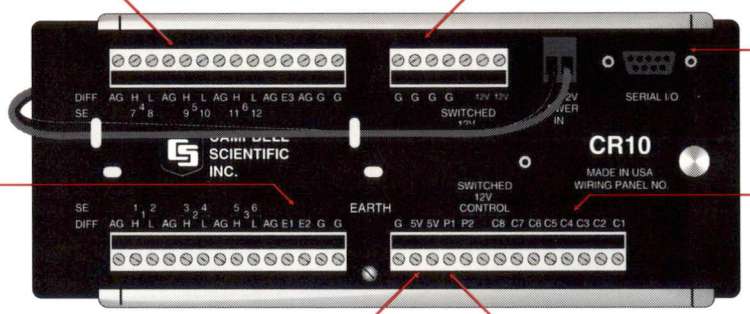
System Description

The CR10 consists of a Measurement and Control Module and a detachable Wiring Panel. The Keyboard Display is recommended for on-site communication, station setup, and troubleshooting, but may be replaced by a computer where environmental conditions allow.

12 Analog Inputs - (single-ended channels, each pair differential*) Five software selectable input voltage ranges. Resolution is 0.33 µV on the 2.5 mV range (0.006°C on type E thermocouple). Multiplexers provide additional inputs. AG terminals are for analog ground connections.

3 Switched Excitation Channels for precision excitation of sensors or short-term actuation of external devices. Excitation is programmable over a ±2500 mV range.

5 V terminals provide power to some peripherals.



Power and Ground Connections for 12 V external batteries or peripherals. Switched 12 V terminal is controlled by any digital output.

9-Pin Serial I/O Port for connection of data storage, retrieval, and telecommunications peripherals.

8 Digital Inputs/Outputs for output control, sensing status, and reading SDM peripherals or SDI-12 sensors.

2 Pulse Counting Channels are software selectable for switch closures, high frequency pulses, or low level AC measurement.

MEASUREMENT AND CONTROL MODULE

Protected in a sealed, rugged, stainless steel cannister, the programmable module provides sensor measurement, timekeeping, communication, data reduction, data/program storage and control functions. A multi-tasking operating system allows simultaneous communication and measurement functions. Operating temperature range is -25° to +50°C, standard; -55° to +85°C, on request.

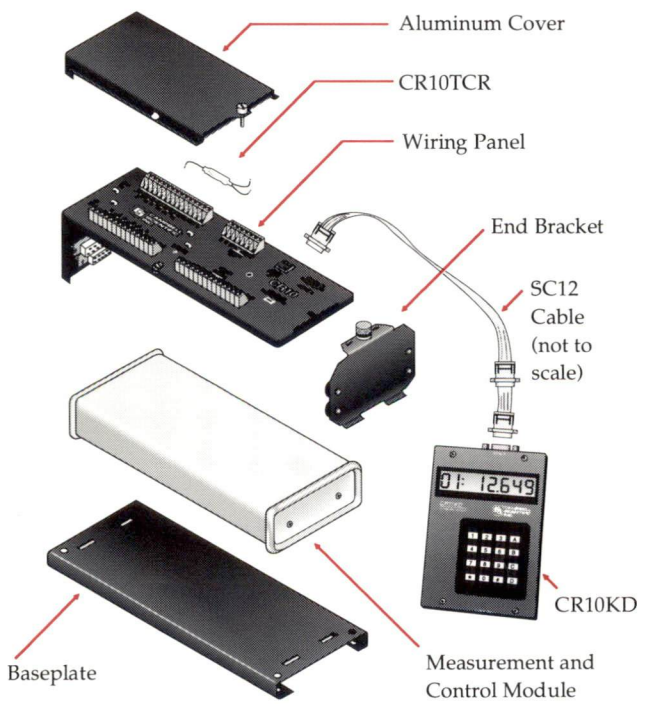
The standard instruction set includes 30 measurement, 43 processing/math, and 15 program control instructions. Optional instructions are available for specialized measurement or processing capabilities.

The standard memory stores 29,900 data points in two Final Storage areas. Solid-state or SRAM card storage modules provide additional on-site data storage.

The Measurement and Control Module interfaces with the Wiring Panel via two D-style connectors. The CR10's electronics are RF shielded and glitch protected by the sealed, stainless steel packaging. A "watchdog" hardware reset function restores normal microprocessor function if lost due to an input transient or intermittent component failure.

WIRING PANEL

The Wiring Panel consists of a top panel, end bracket, and baseplate. The top panel includes screw terminals for sensor connections and a 9-pin serial I/O port; the end bracket attaches the Wiring Panel to the Control Module and to an enclosure-mounted or free-standing baseplate. The Control Module easily disconnects from the Wiring Panel allowing field replacement without rewiring the sensors. All wiring panel connections are protected with spark gaps or transzorbs.



CR10KD KEYBOARD/DISPLAY

The portable CR10KD programs the CR10, manually initiates data transfer, and displays sensor readings, stored values, or flag/port status. One CR10KD may be carried from station to station in a CR10 network. The CR10KD features an 8-character LCD and a 16-character keyboard. Operating temperature range is -25° to +50°C. The CR10KD is powered by the CR10's power supply.

SC12 AND SC12R CABLES

The SC12 ribbon cable (included) or the SC12R, a rugged temperature-resistant cable that is purchased separately, connect peripherals or interfaces to the CR10's serial port.

CR10TCR THERMOCOUPLE REFERENCE

The CR10TCR thermistor provides a temperature reference for thermocouple measurements. It requires one single-ended analog input. An aluminum cover to reduce temperature gradients along the input terminals is included.

PERIPHERALS

The CR10 is powered by a 9.6 to 16 VDC supply and housed in a weather-resistant enclosure (page 8). Measurement, control, and data storage/transfer peripherals are optional depending on the application (pages 4 and 5).

*Differential measurements measure the voltage difference between two inputs. Single-ended measurements measure the inputs with respect to ground. All inputs must be within the ±2.5 V common mode range.

Applications

The CR10's measurement precision, flexibility, long-term reliability, and economical price has resulted in its widespread use in scientific, commercial, and industrial applications. Popular applications are discussed below.

METEOROLOGY

The CR10 is used in long-term climatological monitoring, meteorological research, and routine weather measurement applications. Standard CR10 outputs include wind vector averaging, sigma theta, histograms, saturation vapor pressure, and vapor pressure from wet/dry bulb temperatures.

A CR10 mounted on a 10m tower monitors conditions at a regional winter sports park (Summit County, UT).

Typical meteorologic measurements:

- WIND SPEED is measured with voltage, photo-chopped, switch closure, or magnetic pulse type anemometers. Expansion peripherals allow wind profile studies.
- WIND DIRECTION is measured by a precision potentiometer wind vane.
- SOLAR RADIATION is measured with a silicon cell or thermopile pyranometer.
- TEMPERATURE sensors include thermistors, thermocouples, RTD's, or silicon types.
- RELATIVE HUMIDITY is measured with wet/dry bulb psychrometers, AC resistive sensors, strain gage or capacitive sensors. Capacitive probes include signal conditioning.
- DEW POINT is calculated from temperature and relative humidity data or measured by cooled mirror or lithium chloride sensors. Dew point sensors require external power.
- PRECIPITATION data is provided by a tipping bucket switch closure rain gage or a weighing gage.
- EVAPORATION is measured with standard pans or lysimeters fitted with a potentiometer or strain gage.
- BAROMETRIC PRESSURE is sensed by capacitance or strain gage pressure transducers.
- SOIL WATER POTENTIAL is obtained using AC conductivity moisture blocks or analog output tensiometers.
- LEAF WETNESS is detected by a resistance grid.

Applications include:

WEATHER STATION NETWORKS provide regional and local real-time meteorological data for weather monitoring, forecasting, and local warnings. Other applications include climatic modeling, agricultural meteorology, and "ground truth" for satellite imagery.

AIR QUALITY applications use the CR10's automatic control of calibration sequences and conditional averaging where invalid data taken during power failures, calibration intervals, or other conditions are excluded.

AGRICULTURE

In addition to meteorological monitoring, the CR10's versatility allows measurement of agricultural processes and equipment in applications such as:

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

Weather Watch 2000 monitors routine climatological conditions and calculates evapotranspiration (ET). Features include a modular design, pre-wired sensors, and easy-to-use menu-driven support software.

HYDROLOGY

The CR10 is well-suited to remote, unattended monitoring of hydrologic conditions. Many hydrologic sensors, including the SDI-12 compatibles, interface directly to the CR10.

Gaging station equipped with CR10-controlled sampler takes samples based on flow (Little Platte River, WI).

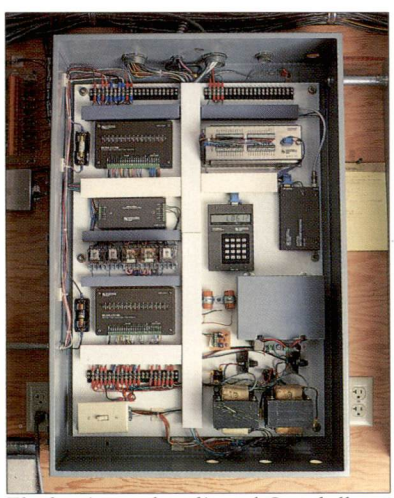
Typical hydrologic measurements:

- WATER LEVEL is read directly with an incremental shaft encoder, a DB1 double bubbler, or a strain gage or vibrating wire pressure transducer. Some shaft encoders require a QD1 Interface. Vibrating wire transducers require an AVW1 or AVW4 Interface.
- WELL DRAW-DOWN TESTS use a pressure transducer measured either logarithmically or at a rate based on incremental changes in water level.
- IONIC CONDUCTIVITY measurements use the AC excitation from one of the CR10's three switched excitation ports.
- WATER QUALITY samplers are controlled by the datalogger as a function of time, water level thresholds, or rate of change.
- ALARM AND PUMP ACTUATION is controlled through any digital I/O port which operates external relay drivers.

INDUSTRY

The growing number of applications where the CR10 can inexpensively automate data collection and improve productivity and quality include:

- HVAC systems
- Vehicle/machinery testing
- Transportation
- Process control
- Water and sewage treatment
- Regulatory compliance
- Routine operations and maintenance
- Structural or fatigue analysis
- Energy management/ conservation
- Environmental testing



The heating and cooling of Campbell Scientific's factory is controlled by a CR10 and peripherals (Logan, UT).

More specifically, the CR10 can:

MEASURE input from:

- load cells
- strain gages
- flow sensors
- speed sensors
- humidity sensors
- v/mV transducers
- temperature probes
- pressure transducers
- 4-20 mA transducers*

MONITOR conditions of:

- valves
- filters
- boilers
- generators
- engines
- refrigerators
- appliances
- vehicles
- compressors
- turbines
- chillers
- pumps
- batteries
- transformers
- weighing scales

CONTROL based on time or measured parameters:

- pumps
- solenoids
- motors
- resistive loads
- relays
- alarms

VEHICLE TESTING

The CR10 is ideal for applications requiring compact packaging such as:

- engine test cell monitoring
- durability testing
- fleet monitoring
- solar vehicle "C-studies"
- vehicle performance verification

Datalogger monitors and records pressure on hydraulic rams of haulage trucks (Oquirrh Mtns., UT).

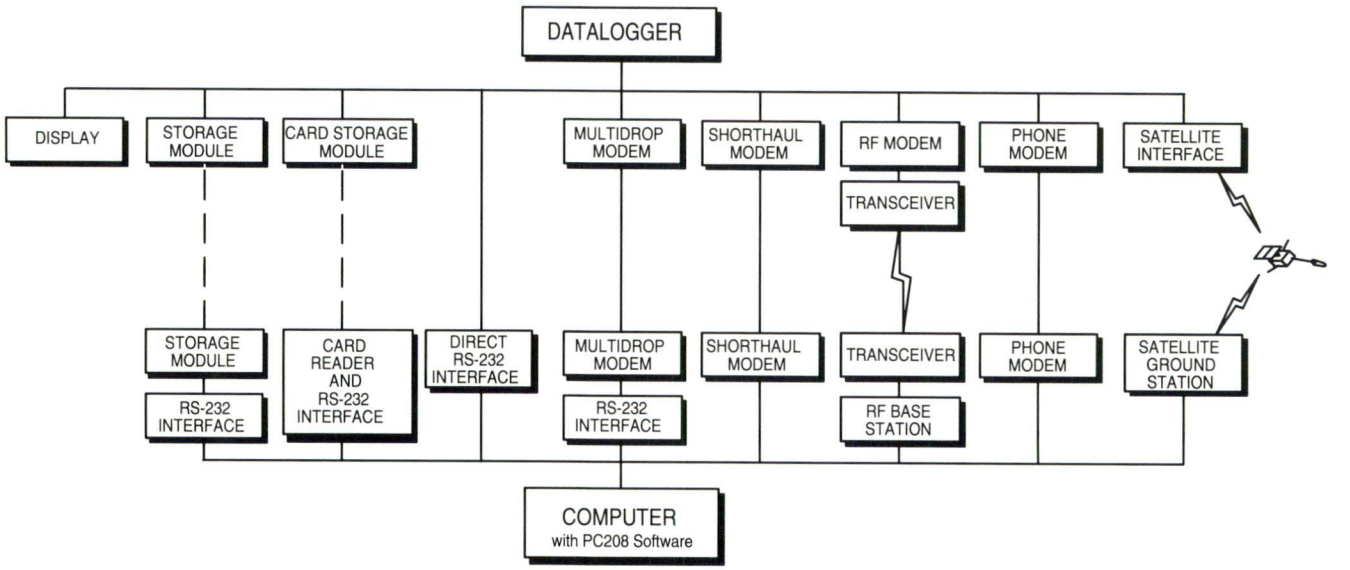
Common parameters for vehicle monitoring and durability testing are listed below:

- TEMPERATURE sensors include thermocouples and infrared (IR) detectors. The linearization for K-type thermocouples extends from -50° to 1370°C, allowing measurements from ambient to extreme exhaust temperatures.
- PRESSURE, FORCE, TORQUE, AND ACCELERATION are measured with strain gage transducers.
- FUEL FLOW, ENGINE RPM, AND VEHICLE SPEED usually require magnetic pulse transducers or incremental encoders; both connect directly to the pulse counter inputs.
- THROTTLE POSITION is measured with potentiometers.
- TIMING EVENTS are output to the datalogger in period, pulse width, frequency, counts, or time intervals with the SDM-INT8 Interval Timer (see page 5).
- FREQUENCY DISTRIBUTION HISTOGRAMS allow data compression over extended performance tests.
- RAIN FLOW HISTOGRAMS allow fatigue analysis tests.

*Contact Campbell Scientific for proper wiring configuration.

Data Storage and Transfer

Up to 29,900 raw or processed data points can be stored in the CR10's memory. Data are transferred to a computer via one or more communication options including multidrop or short-haul modems, radios, phone lines, or satellite. On-site data retrieval options include direct line, storage module, RAM cards, display, or printer.



SOFTWARE

PC208 Datalogger Support Software supports telecommunications, programming, and data processing functions. With an appropriate communication link, PC208 provides two-way communication between Campbell dataloggers and IBM-PC or compatible computers. A Monitor mode allows real-time graphical display of datalogger measurements.

DISPLAY

The CR10KD Keyboard/Display provides on-site review of data values and program instructions. On-site connection to a terminal or computer is also possible (Direct Line Options).

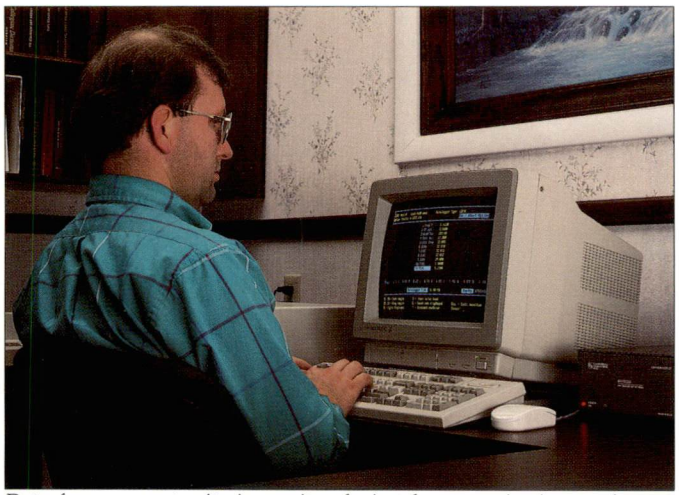
STORAGE MODULES

Rugged, battery-backed RAM storage modules reliably store data over a -35° to +65°C (extended range on request) temperature range. The SM192 or SM716 Storage Module (96K or 358K low resolution data points, respectively) can remain connected to the CR10 or be carried to the field to retrieve data from the CR10's memory. Eight storage modules can be connected to one CR10. The SC532 Interface is used to transfer data or programs between the storage module and an MS-DOS computer. Consult Campbell Scientific if data playback to a non-MS-DOS computer is required.

CARD STORAGE MODULES

The CSM1 Card Storage Module and the MCR1 Memory Card Reader are microprocessor-based read/write modules. The CSM1 can either remain with the CR10 or be transported to the datalogger site. The MCR1 remains at the computer base station for module/computer communication. Battery-backed RAM memory cards are inserted into the CSM1 and MCR1 for data and/or program transfer. Currently available "credit-card-sized" RAM cards store 256k bytes to 2M bytes (130k and 1M low resolution data points, respectively). The system operates over a -40 to +50°C range and was developed for use with the CR10 by Campbell Scientific Limited, U.K.

Record temperature of -69°F was monitored via radio telemetry (Peter Sinks, UT).



Data from a remote site is monitored via telecommunications and PC208 Software.

DIRECT LINE OPTIONS

Direct Datalogger-to-Computer Interface

The SC32A RS-232 Interface supplies an optically isolated connection between the CR10 and a computer over distances up to 50 feet.

Short Haul Modems

Short haul modems provide local communication between the CR10 and a computer with an RS-232 serial port. The modem transmits data up to 5 miles over four-wire unconditioned line (two twisted pairs).

Coax Network

The MD9 Multidrop Interface links a central computer to over 200 dataloggers on a single coaxial cable. Total coax cable length can be up to three miles.

RADIO FREQUENCY (RF) COMMUNICATION

Campbell Scientific's RF communication system uses the RF95 modem and a low-powered transceiver at the remote station(s), and a transceiver connected to an RF232 Base Station at the computer site. Up to 255 stations can be interrogated over a single UHF or VHF frequency. Any station can serve as a repeater to extend the line-of-sight transmission of the base station.

TELEPHONE NETWORKS

Telephone communication links require a DC112 modem at the CR10 site and a Hayes-compatible 300 or 1200 baud modem at the calling end. Remote RF or MD9 networks are also accessible by telephone. Communication via cellular telephone is also possible; consult the factory for details.

Channel Expandability

The following peripherals expand CR10 measurement or control capability. Contact Campbell Scientific regarding the suitability of these peripherals for your application.

SYNCHRONOUS DEVICES FOR MEASUREMENT (SDM's)

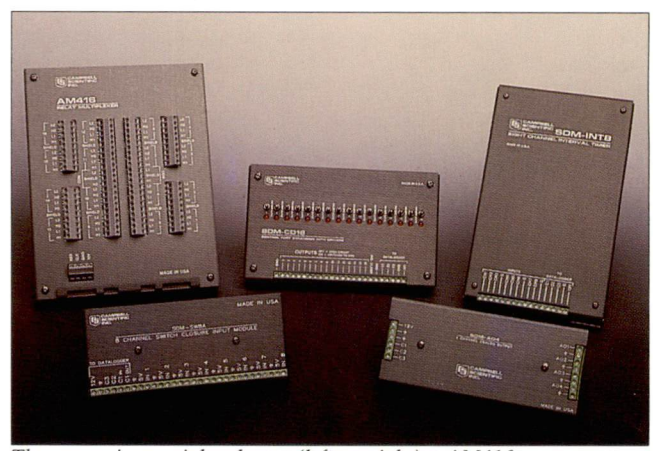
SDM's are addressable peripherals that expand digital control ports, analog output ports, and datalogger measurement capabilities. Up to 16 SDM's may be connected to three control ports on one CR10. SDM operation is controlled by datalogger instructions 101-104.

SDM-A04 Four Channel Continuous Analog Output Module provides four independent continuous analog outputs for proportional control or strip chart recording.

SDM-CD16 Control Port Module has 16 digital control ports with drivers to activate external relays, solenoids, or resistive loads. A manual override toggle switch is provided for each port.

SDM-INT8 Eight Channel Interval Timer expands the number of pulse count channels in the system and outputs processed timing data to the datalogger. Timing events are captured with ±1 microsecond resolution over a maximum range of 16.77 seconds. Output options include period, pulse width, frequency, counts, and interval time.

SDM-SW8A Pulse Counter is an 8-channel pulse count expansion for switch closure measurements. Channels can be individually configured for single-pole double-throw (SPDT), single-pole single-throw (SPST), or voltage pulse measurements. Output options include signal state, duty cycle, or counts.



The expansion peripherals are (left to right): AM416, SDM-SW8A, SDM-CD16, SDM-A04, and SDM-INT8.

MULTIPLEXERS

Multiplexers increase the number of sensors that can be measured by a CR10. The AM416 sequentially multiplexes sixteen groups of four lines at a time (a total of sixty-four lines). Compatible sensors include thermistors, thermocouples, potentiometers, load cells, strain gages, vibrating wires, and soil moisture blocks. The AM25T multiplexes 25 sets of two lines at a time. Compatible sensors include thermocouples and other low-level voltage output sensors. Several multiplexers can be controlled by a single CR10.

The Datalogger Program

The CR10's ability to make measurements, calculations, logical decisions, and phone calls stems from its internal program. The CR10's program can be extremely powerful, yet is composed of simple instructions. Knowledge of a high level programming language, such as FORTRAN or BASIC, is not required.

PROGRAM DEVELOPMENT

A CR10 program consists of a series of instructions designed to perform measurement, data processing, data storage, and logical control functions. To construct a program, the user selects application-specific instructions from a library of PROM-based instructions. These instructions, developed for data acquisition and control, allow the CR10 to measure most sensors without external signal conditioning.

Program development can be accomplished with a prompt sheet and a CR10KD keyboard. In addition, a prompt-driven, computer-based datalogger program editor (EDLOG) is available in Campbell Scientific's PC208 Datalogger Support Software.

INSTRUCTION FORMAT

Programs can be entered or edited and system performance verified on-site with a CR10KD keyboard/display.

Each CR10 program instruction is identified by a number. For example: Instruction 1 controls single-ended voltage measurements; Instruction 55 applies a 5th order polynomial to incoming data; Instruction 83 sets up an if/then statement, and Instruction 101 controls operation of an SDM device (SDM-INT8). The variety of instructions allows users to select measurement, processing, data storage and control sequences that precisely fit their applications.

The instructions are grouped into four functional categories. A list of the standard CR10 instruction set follows; more detailed information is available in the CR10 manual and prompt sheet.

INPUT/OUTPUT INSTRUCTIONS are primarily for sensor measurement, but also control and communicate with external devices. Some internal functions, such as control of the CR10's timer, are also I/O instructions. Specific examples include:

- Single-Ended (SE) Volts
- Differential (DIFF) Volts
- Pulse Count
- Excite, Delay, SE Volts
- AC Half Bridge
- Full Bridge
- Three-Wire Half Bridge
- Excite, Delay, DIFF Volts
- Full Bridge with Measured Excitation
- Battery Voltage
- 107 Temperature Probe
- 207 RH Probe
- Thermocouple Temperature (SE)
- Thermocouple Temperature (DIFF)
- Platinum RTD Temperature
- Internal Temperature
- Time
- Signature
- Set Digital Ports
- Read Digital Ports
- Burst
- Excitation With Delay
- Timer
- Period Interval Measurement
- Vibrating Wire Measurement
- Set/Control External Device (e.g. SDMs)

PROCESSING INSTRUCTIONS allow data reduction, entry of simple algorithms, or conversion of raw data into engineering units. In the following instructions, X, Y, and Z are Input Locations where incoming data values or processed results are temporarily stored; F refers to a fixed value (constant).

- Z = F
- Z = X
- Z = Z+1
- Z = X+Y
- Z = X+F
- Z = X-Y
- Z = X*Y
- Z = X*F
- Z = X/Y
- Z = SQRT(X)
- Z = LN(X)
- Z = EXP(X)
- Z = 1/X
- Z = ABS(X)
- Z = FRAC(X)
- Z = INT(X)
- Z = X MOD F
- $Z = X^Y$
- Z = SIN(X)
- Z = ARCTAN (X/Y)
- Spatial Maximum
- Spatial Minimum
- Spatial Average
- Scaling Array
- 5th Order Polynomial
- Saturation Vapor Pressure
- Wet/Dry Bulb Temp to Vapor Pressure
- Low Pass Filter
- Resistance from Bridge Output

OUTPUT PROCESSING INSTRUCTIONS process measured values, collected over time.

- Sample
- Average
- Totalize
- Maximize
- Minimize
- Histogram
- Wind Vector
- Real Time
- High/low Resolution
- Sample on Max or Min
- Redirect Output to Input Storage
- Standard Deviation

PROGRAM CONTROL INSTRUCTIONS allow logic based on time or data. They also control serial data output and CR10-initiated telecommunications.

- Subroutine
- Loop
- If X Compared to Y
- If X Compared to F
- If Flag/Port
- If Time
- If Case/Begin Case
- Else
- End
- Control Serial Data Output
- Initiate Telecommunications
- Send Serial Character

Once an instruction is selected, a set of associated parameters is queued in the datalogger's program memory. Each parameter controls a specific aspect of the instruction's operation. Depending on the versatility of the instruction, from 1 to 12 parameters are required. For example, the parameters associated with Instruction 2 (DIFFerential voltage measurement) are:

1 - REPS - Defines the number of times an instruction executes (allows one instruction to measure several identical sensors).

2 - RANGE - Defines the full scale range of the voltage to be measured. Ranges are ± 2.5, 7.5, 25, 250, and 2500 mV. Fast (272 µs), slow (2.72 ms), 60 Hz rejection, and 50 Hz rejection integration times are also selected with this parameter.

3 - INPUT CHANNEL - Defines the analog input channel that will make the first measurement.

4 - LOCATION - Defines the first Input Storage location.

5 - MULTIPLIER - Allows multiplication of data; for example, 1.8 is entered to convert a temperature measurement from °C to °F.

6 - OFFSET - Allows addition or subtraction of an offset value; for example, 32 is entered to complete the above temperature conversion.

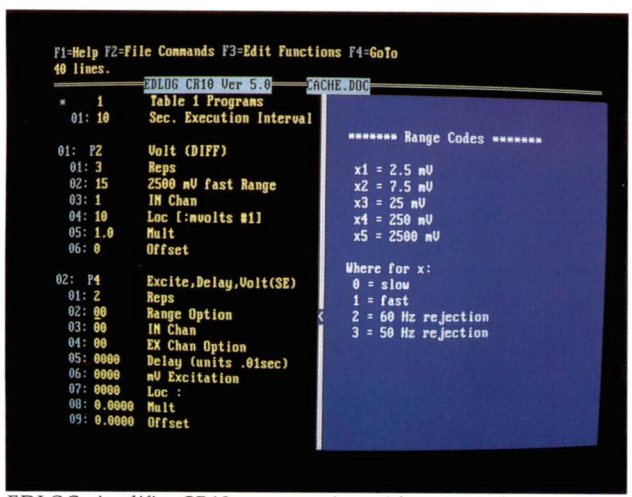
Once the parameters have been entered, the next instruction is selected. This procedure is followed until a specific program has been created. Following program entry, the datalogger checks for errors, then begins executing the program and acquiring data.

SCAN RATE, DATA STORAGE

The maximum rate the datalogger can execute its program is 64 times per second. (The maximum rate a single input can be measured is 750 samples per second.) After measurement and analog-to-digital conversion, data are directed to Input Storage locations which hold the measurement value for viewing, subsequent processing, or until transfer to Final Storage. Data can be selectively stored based on user-defined events or intervals and need not be tied to scan rate. Each data point remains in Input Storage until written over by subsequent measured or processed values.

EDLOG

Datalogger program development is supported by PC208 software (EDLOG). Help screens are available to define all instructions and parameter options. Input locations can be annotated with alphanumeric labels so that computer-monitored data are labelled. Once the program has been created, it can be downloaded to the CR10 directly, through telecommunications, or to a storage module for later transfer.



EDLOG simplifies CR10 programming with annotated instructions, parameters, and labels.

SAMPLE PROGRAM

Every five minutes, the following program measures air temperature (°C) at six locations within a greenhouse. Critical maximum temperature is 30°C (86°F); if any temperature exceeds that threshold, a control port trips a relay that activates an exhaust fan. The average temperature value measured by each thermistor is recorded hourly.

SENSOR CONNECTIONS
In this example, sensor signal leads are connected to CR10 single-ended input channels 1 through 6; excitation leads are connected to excitation channel 1; and sensor grounds are connected to any analog ground terminal. Port 1 controls the exhaust fan.

	Program	Comments
	* 1 Table 1 Programs	*Executes the following program every 5 minutes.*
	01: 300 Sec. Execution Interval	
Measurement & Processing	01: P11 Temp 107 Probe	*Measures six Model 107 Thermistors and places the results in Input Locations 1-6.*
	01: 6 Reps	
	02: 1 IN Chan	
	03: 1 Excite all reps w/EX chan 1	
	04: 1 Loc [:TEMP #1]	
	05: 1 Mult	
	06: 0 Offset	
	02: P49 Spatial Maximum	*Analyzes the incoming data and places the highest temperature in Input Location 7.*
	01: 6 Swath	
	02: 1 First Loc TEMP #1	
	03: 7 Max Value Loc [:MAX TEMP]	
Exhaust Fan Control	03: P89 If X <=> F	*Compares that temp. against 30°C. If the measured temp. is higher, the exhaust fan is activated (or remains active),*
	01: 7 X Loc MAX TEMP	
	02: 3 >=	
	03: 30 F	
	04: 30 Then Do	
	04: P86 Do	
	01: 41 Set high Port 1	
	05: P94 Else	*else, if lower*
	06: P86 Do	*the exhaust fan is turned off (or remains off.)*
	01: 51 Set low Port 1	
	07: P95 End	
Data Output	08: P92 If time is	*The following data is ouput to Final Storage every hour:*
	01: 0 minutes into a	
	02: 60 minute interval	
	03: 10 Set high Flag 0 (output)	
	09: P77 Real Time	*date, hour, minute;*
	01: 110 Day,Hour-Minute	
	10: P71 Average	*average temp. measured by <u>each</u> sensor. (Each average is based on 12 measurements.)*
	01: 6 Reps	
	02: 1 Loc TEMP #1	
	11: P End Table 1	

With PC208 software and an appropriate telecommunications link, a researcher can monitor real-time data or control the exhaust fan remotely. Data transfer to a computer can be selected as binary, comma-delineated or printable ASCII.

Enclosures, Power Supplies, and Towers

A CR10 housed in a weather-resistant enclosure can collect data under extremely harsh conditions. A low power design allows the CR10 to operate one year on a 7.0 Ahr, unregulated 12 volt source, depending on scan rate, number of sensors scanned, and external temperature. For field installations, Campbell Scientific can provide towers and mounting accessories.

ENCLOSURES

A protective enclosure for the CR10 is required where dust, water, sunlight, or environmental pollutants are present.

Our NEMA 4X enclosures are modified for cable entry and attach to a flat surface, a vertical mast (1.00" to 1.25" IPS pipe), or a tripod or tower. The white fiberglass-reinforced polyester enclosures are UV-stabilized and reflect solar radiation, reducing temperature gradients inside the housing. An internal mounting plate is prepunched for easy system configuration and exchange of equipment in the field. A lockable hasp provides additional security.

Two standard enclosures are available for the CR10, its power supply, and peripherals.

ENC 12/14 houses the CR10, power supply, and one or more peripherals. It is shipped with a bracket for attachment to the CM6/CM10 tripod, a bracket for attachment to the UT3 tower (option code -DN), or a bracket for attachment to the UT930 tower (option code -TN). Internal dimensions are 12" x 14" x 5.5"; weight is 12 lbs.

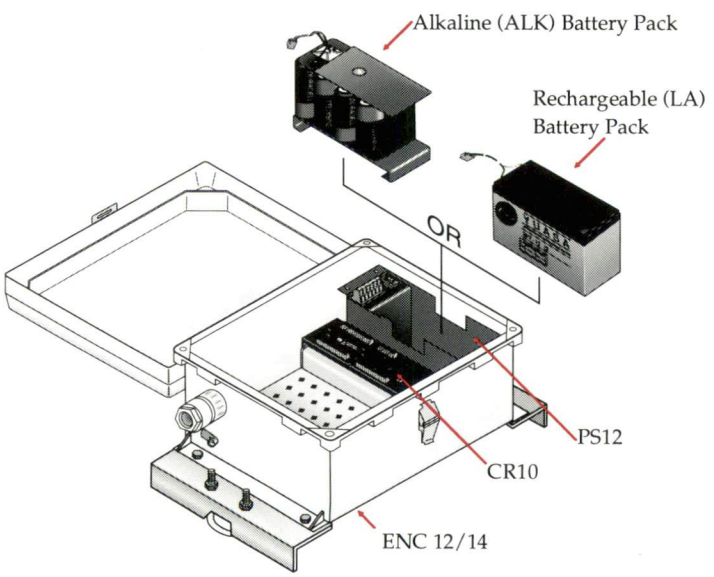
ENC 16/18 houses the CR10, power supply, and one or more peripherals. It is shipped with a bracket for attachment to a CM6/CM10 tripod, a UT3 tower, or a UT930 tower. Internal dimensions are 16" x 18" x 9"; weight is 17 lbs.

While these enclosures satisfy most application requirements, other sizes can be specially ordered.

POWER SUPPLIES

The **PS12 Power Supply with Charging Regulator** accepts 16 to 26 VDC or AC input and provides a charging voltage to the 12 volt rechargeable battery option or to an external 12 volt battery. The battery options are shown below:

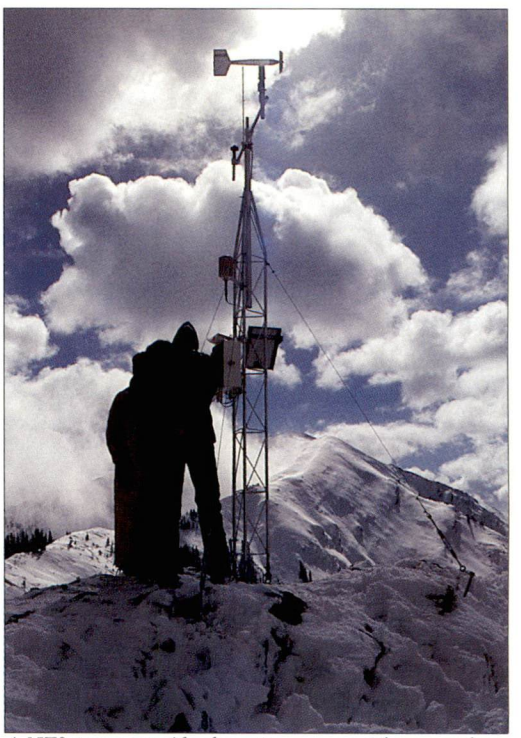
PS12ALK contains eight non-rechargeable 'D'-cell alkaline batteries with a 7.5 Ahr rating at 20°C.



PS12LA rechargeable battery option includes one 12 volt, 7 Ahr rechargeable battery, a 16V, 350 mA or an 18V, 880 mA wall charger, and an AC transformer. The rechargeable battery is float-charged with AC power or a solar panel.

SOLAR PANELS

MSX10 unregulated solar panel is used to float-charge the PS12LA rechargeable battery. Based on an illumination of 1 kW/m^2 and ambient temperature of 20°C, a peak voltage of 17 volts is supplied. Call Campbell Scientific if regulated solar panels for recharging customer-supplied 12 volt batteries are required.



A UT3 tower provides long-term support for an enclosure, solar panel, and meteorological sensors. The tower is further stabilized with guy wires (Aspen, CO).

TOWERS & MOUNTS

For field installations, Campbell Scientific manufactures durable tripods and towers designed for easy installation and adjustable placement of sensor mounts.

CM6 and CM10 are portable, sturdy tripods that support 6 and 10 foot wind sensor measurement heights, respectively. They can be staked down or secured to concrete pads.

UT3 is an aluminum instrument tower that provides a 3m (10 foot) wind sensor measurement height for long-term applications. The UT3's hinged-base anchors to a user-supplied concrete pad.

UT930 is an aluminum 10 m (30 foot) instrument tower for fixed applications. Its triangular sections are bolted together with zigzag bracing. Models are available for cementing into the ground or securing to a flat surface. The UT930 can be further stabilized by guy wires.

Specifications

CR10 = 29,908 data pts

The following electrical specifications are valid for an ambient temperature range of -25° to +50°C unless otherwise specified.

PROGRAM EXECUTION RATE

System tasks initiated in sync with real-time up to 64 Hz. One measurement with data transfer is possible at this rate without interruption. A single input may be measured over short intervals at rates up to 750 Hz using Burst Measurement.

ANALOG INPUTS

NUMBER OF CHANNELS: 6 differential or up to 12 single-ended. Each differential channel can be configured as two single-ended channels.

CHANNEL EXPANSION: The AM416 Relay Multiplexer allows an additional 64 single-ended channels to multiplex into four CR10 single-ended channels. The AM25T allows an additional 25 differential channels to multiplex into a single CR10 differential channel. Up to three multiplexers can be connected to one CR10.

ACCURACY OF VOLTAGE MEASUREMENTS AND ANALOG OUTPUT VOLTAGES: ±0.1% of FSR, ±0.05% of FSR (0 to 40°C) (e.g., ±0.1% FSR = ±5.0 mV for ±2500 mV range)

RANGE AND RESOLUTION: Ranges are software selectable for any channel. Resolution for a single-ended measurement is twice the value shown.

Full Scale Range (mV)	*Resolution (µV)*
± 2500	333
± 250	33.3
± 25	3.33
± 7.5	1.00
± 2.5	0.33

INPUT SAMPLE RATES: The fast A/D conversion uses a 0.25 ms signal integration time and the slow conversion uses a 2.72 ms signal integration. Two integrations, separated in time by 1/2 of an AC line cycle, are used with the 60 Hz or 50 Hz noise rejection option. Differential measurements include a second sampling with reversed input polarity to reduce thermal offset and common mode errors. Input sample rates are the time required to measure and convert the result to engineering units.

Fast single-ended voltage:	2.6 ms
Fast differential voltage:	4.2 ms
Slow single-ended voltage:	5.1 ms
Slow differential voltage:	9.2 ms
Differential with 60 Hz rejection:	25.9 ms
Fast differential thermocouple:	8.6 ms

INPUT NOISE VOLTAGE:

Fast differential	--- 0.82 microvolts RMS
Slow differential	--- 0.25 microvolts RMS
Differential with 60 Hz rejection	--- 0.18 microvolts RMS

COMMON MODE RANGE: ± 2.5 volts.

DC COMMON MODE REJECTION: > 140 dB.

NORMAL MODE REJECTION: 70 dB (60 Hz with slow differential measurement).

INPUT CURRENT: 3 nanoamps maximum.

INPUT RESISTANCE: 200 gigohms.

EXCITATION OUTPUTS

DESCRIPTION: The CR10 has 3 switched excitations, active only during measurement, with only one output active at a time. The off state is high impedance.

RANGE: ± 2.5 volts.

RESOLUTION: 0.67 millivolts.

ACCURACY: Same as voltage input.

OUTPUT CURRENT: 20 mA @ ± 2.5 V; 35 mA @ ± 2.0 V; 50 mA @ ± 1.5 V.

FREQUENCY SWEEP FUNCTION: A swept frequency, square wave output between 0 and 2.5 volts is provided for vibrating wire transducers. Timing and frequency range are specified by the instruction.

RESISTANCE AND CONDUCTIVITY MEASUREMENTS

ACCURACY: 0.015% of full scale bridge output, limited by the matching bridge resistors. The excitation voltage should be programmed so the bridge output matches the full scale input voltage range.

MEASUREMENT TYPES: 6-wire and 4-wire full bridge, 4-wire, 3-wire, and 2-wire half bridge. Bridge measurements are ratiometric and dual polarity to eliminate thermal emf. AC resistance measurements use a dual polarity 0.75 ms excitation pulse for ionic depolarization, with the signal integration occurring over the last 0.25 ms.

PERIOD AVERAGING MEASUREMENTS

DEFINITION: The time period for a specified number of cycles of an input frequency is measured, then divided by the number of cycles to obtain the average period of a single cycle.

INPUTS: Any single-ended analog channel; signal dividing or AC coupling is normally required.

INPUT FREQUENCY RANGE:

Range Code	*Peak to Peak Volts Required @ Max. Freq.**	*Maximum Frequency*
1	2 mV	8 kHz
2	3 mV	20 kHz
3	12 mV	50 kHz
4	2000 mV	200 kHz

*AC voltage must be centered around CR10 ground.

REFERENCE ACCURACY: (-25° to 0°C) ± 80 ppm (0° to +50°C) ± 30 ppm

RESOLUTION: ± 100 nanoseconds divided by the number of cycles measured. Resolution is reduced by signal noise and for signals with a slow transition through the zero voltage threshold.

TIME REQUIRED FOR MEASUREMENT: Signal period times the number of cycles measured plus 1.5 cycles.

PULSE COUNTERS

NUMBER OF PULSE COUNTER CHANNELS: 2 eight bit or 1 sixteen bit; software selectable.

MAXIMUM COUNT RATE: 2000 Hz, eight bit counter; 250 kHz, sixteen bit counter. Pulse counter channels are scanned at 8 Hz.

MODES: Switch closure, high frequency pulse, and low level AC.

SWITCH CLOSURE MODE
- Minimum Switch Closed Time: 5 milliseconds.
- Minimum Switch Open Time: 6 milliseconds.
- Maximum Bounce Time: 1 millisecond open without being counted.

HIGH FREQUENCY PULSE MODE
- Minimum Pulse Width: 0.002 milliseconds.
- Maximum Input Frequency: 250 kHz.
- Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V.
- Maximum Input Voltage: ± 20 V.

LOW LEVEL AC MODE
(Typical of magnetic pulse flow transducers or other low voltage, sine wave outputs).
- Minimum AC Input Voltage: 6 mV RMS.
- Input Hysteresis: 11 mV.
- Maximum AC Input Voltage: 20 V RMS.

Frequency Range:

AC Input (RMS)	*Range*
20 mV	1 Hz to 100 Hz
50 mV	0.5 Hz to 400 Hz
150 mV to 20 V	0.3 Hz to 1000 Hz

(Consult factory if higher frequencies are desired.)

DIGITAL I/O PORTS

1.5 mA @ 5 V

8 ports, software selectable as binary inputs or control outputs.

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

OUTPUT RESISTANCE: 500 Ω.

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

INPUT RESISTANCE: 100 kΩ.

SDI-12 INTERFACE STANDARD

This communication protocol, developed for microprocessor-based hydrologic and environmental sensors, is available as a software option in the CR10.

SENSOR CONNECTIONS: Digital I/O Port #8 (for asynchronous communication), 12V power, and ground. Up to ten SDI-12 sensors can be connected to a CR10.

CR10TCR THERMOCOUPLE REFERENCE

POLYNOMIAL LINEARIZATION ERROR: Typically <±0.5°C over -35 to +50°C range and <±0.1°C over -24 to +45°C range.

INTERCHANGEABILITY ERROR: Typically <±0.2°C over 0 to +50°C range increasing to ±0.5°C at -40°C.

TRANSIENT PROTECTION

All input and output connections to the CR10 module are protected using RC filters or transzorbs connected to a heavy copper bar between the circuit card and the case. The Wiring Panel includes additional spark gap and transzorb protection.

CPU AND INTERFACE

PROCESSOR: Hitachi 6303.

MEMORY: 32K ROM, 64K RAM.

DISPLAY: 8 digit LCD (0.5" digits).

PERIPHERAL INTERFACE: 9 pin D-type connector for keyboard display, storage module, modem, printer, card storage module, and RS-232 adapter. Baud rates selectable at 300, 1200, 9600 and 76,800. ASCII communication protocol is one start bit, one stop bit, eight data bits (no parity).

CLOCK ACCURACY: ± 1 minute per month.

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 volts.

TYPICAL CURRENT DRAIN: 0.7 mA quiescent, 13 mA during processing, and 46 mA during analog measurement.

BATTERIES: Any 12 volt battery can be connected as a primary power source. Several power supply options are available from Campbell Scientific.

PHYSICAL SPECIFICATIONS

SIZE: 7.8" x 3.5" x 1.5" - Measurement & Control Module; 9" x 3.5" x 2.9" - with CR10WP Wiring Panel. Additional room required for connectors.

WEIGHT: 2 lbs.

WARRANTY

Three years against defects in materials and workmanship.

Additional Information

ASSURANCE OF QUALITY

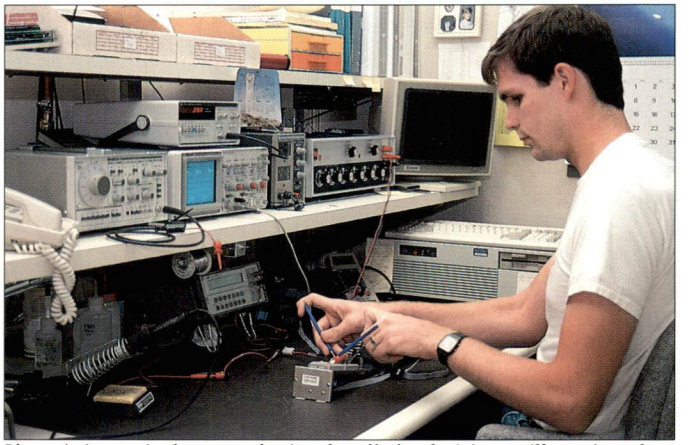
Campbell Scientific has produced portable research-grade dataloggers for more than nineteen years. Our commitment to quality is evidenced in the design and workmanship of the CR10 Measurement and Control System. Tailored for demanding field use, the CR10 features durable components, compact size, low power consumption, wide temperature tolerance, an internal "watchdog" timer, and glitch protection.

After bench testing, all CR10 Modules are cycled and tested between -35° and +65°C in an environmental chamber.

Every CR10 is calibrated and thoroughly tested to ensure consistent, dependable performance. The CPU, system components, and all I/O connections are tested. The datalogger's results are calibrated against the National Institute of Standards and Technology (NIST). A test report and calibration certificate including NIST traceable numbers are shipped with each CR10.

WARRANTY AND REPAIR

The CR10 has a three-year warranty covering parts and labor. Our experienced Mean Time Between Failure (MTBF) is over 80 years.

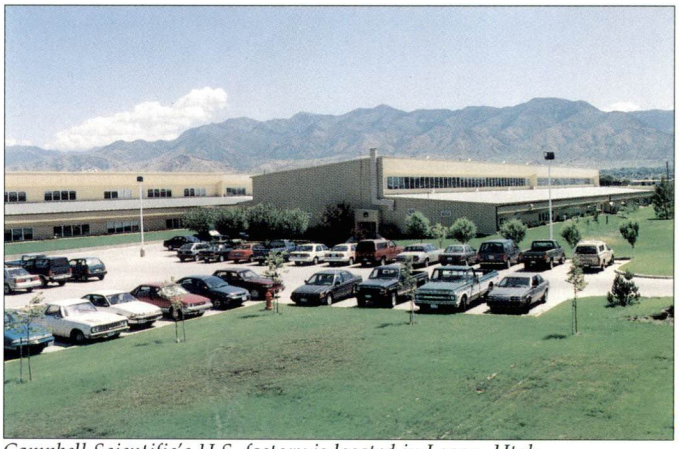


If repair is required, our professional staff of technicians will repair and recalibrate the CR10 to original specifications.

FOR MORE INFORMATION

For more information on the products mentioned in this brochure, please contact a Campbell Scientific applications engineer. Customers supported by our U.S. factory should contact our environmental, water resources, or industrial groups.

Pricing and ordering information is available from our price list, our Product Configuration Guide, or our order entry staff. Contact our Customer Service and Marketing Department for information on customized training sessions or authorized representatives in your area.



Campbell Scientific's U.S. factory is located in Logan, Utah.

Please call us today. We would like to discuss your application needs with you.

CAMPBELL SCIENTIFIC, INC.

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