



## DATALOGGER PROGRAMMING AND SENSORS CONNECTION ADVANCED COURSE

### Module

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Mission 4 "Education and Research" - Component 2: "From research to business" - Investment  
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



# Section 1 - Datalogger

## 1.1 General description

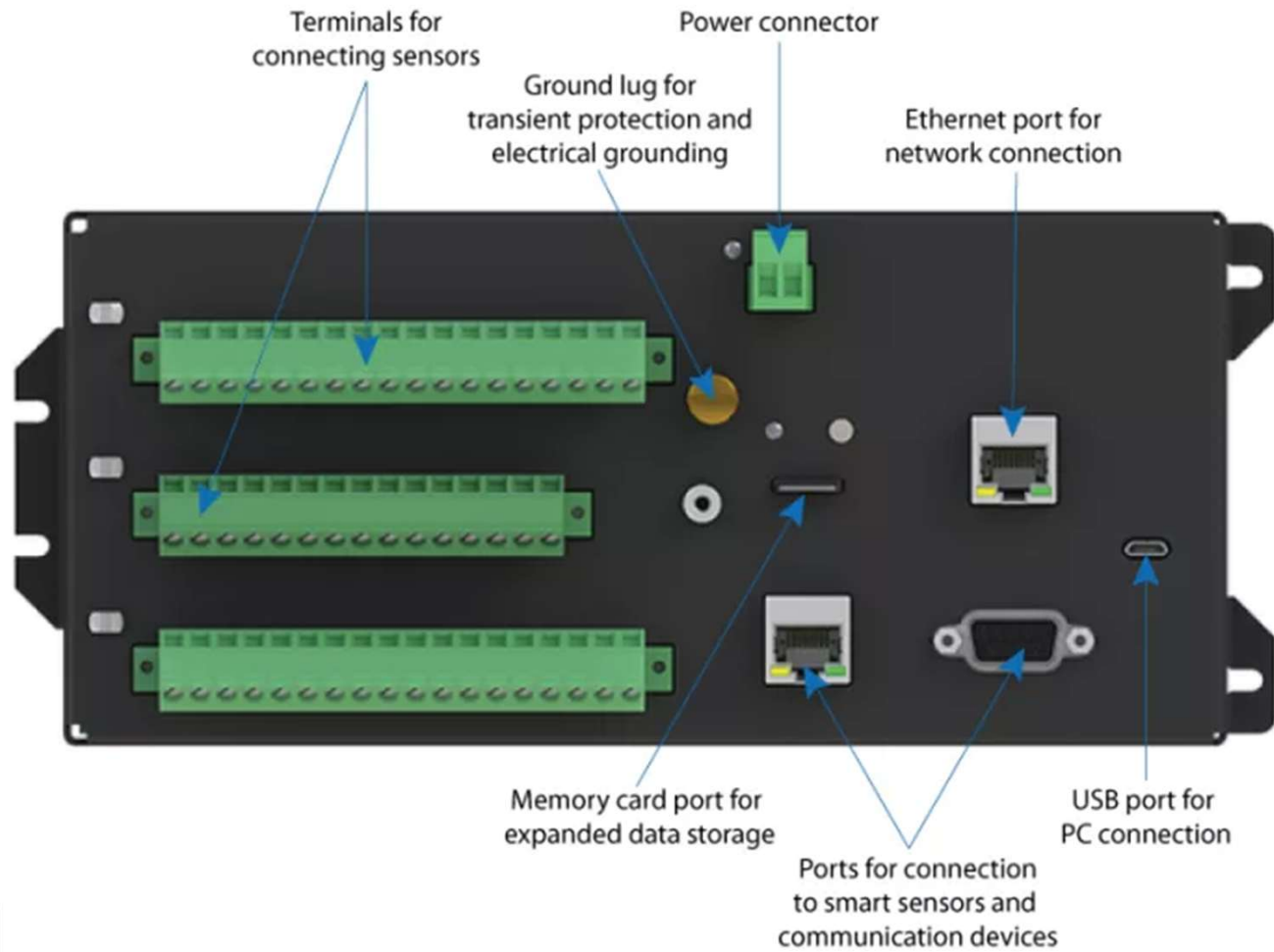
## What is a datalogger

- 🌐 **Electronic device to record data from sensors**
- 🌐 **Programmable** to convert signals into physical units
- 🌐 **Data storage** (flash memory, PC, clouds, etc.)
- 🌐 **General purpose**

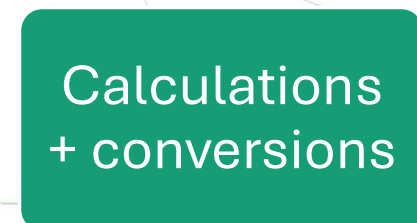
<https://www.campbellsci.com/data-loggers>

<https://www.youtube.com/@CampbellScientific>

# Datalogger parts




*Section 2*







*Section 3*





# Datalogger models

	Operating Temperature Range	Maximum Scan Rate	Analog Inputs	Communication Protocols
<p><b>CR3000</b> Measurement and Control Datalogger</p> 	<ul style="list-style-type: none"> <li>-40° to +85°C (extended)</li> <li>-25° to +50°C (standard)</li> <li>Non-condensing environment</li> <li>Battery bases have different temperature ranges. The rechargeable base option has an operating temperature range of -40° to +60°C. The alkaline base option has a temperature range of -25° to +50°C.</li> </ul>	100 Hz	28 single-ended or 14 differential (individually configured)	PakBus, Modbus, DNP3, SDI-12, SDM

	Operating Temperature Range	Maximum Scan Rate	Analog Inputs	Communication Protocols
<p><b>CR1000X</b> Measurement and Control Datalogger</p> <p>Popular</p> 	<ul style="list-style-type: none"> <li>Non-condensing environment</li> <li>-55° to +85°C (extended)</li> <li>-40° to +70°C (standard)</li> </ul>	1000 Hz	16 single-ended or 8 differential (individually configured) Two analog inputs can measure 4 to 20 mA or 0 to 20 mA natively. Four analog inputs can provide pulse/digital I/O functions.	CPI, PakBus, SDM, SDI-12, Modbus, TCP, DNP3, UDP, NTCIP, NMEA 0183, I2C, SPI, and others
<p><b>CR6</b> Measurement and Control Datalogger</p> <p>Popular</p> 	<ul style="list-style-type: none"> <li>Non-condensing environment</li> <li>-55° to +85°C (extended)</li> <li>-40° to +70°C (standard)</li> </ul>	1000 Hz	Up to 12 single-ended or 6 differential (The CR6 has 12 universal [U] and 4 control [C] terminals that can be programmed for a variety of functions. The number of analog inputs, switched excitations, and digital ports assume all the ports are configured the same.)	CPI, PakBus, SDM, SDI-12, Modbus, TCP, DNP3, UDP, NTCIP, NMEA 0183, I2C, SPI, and others
<p><b>CR300</b> Measurement and Control Datalogger</p> <p>Popular</p> 	<ul style="list-style-type: none"> <li>Non-condensing environment</li> <li>-40° to +70°C (standard)</li> </ul>	10 Hz	6 single-ended or 3 differential (individually configured)	PakBus, Modbus, DNP3, SDI-12, TCP, UDP, and others
<p><b>CR310</b> Measurement and Control Datalogger</p> 	<ul style="list-style-type: none"> <li>Non-condensing environment</li> <li>-40° to +70°C (standard)</li> </ul>	10 Hz	6 single-ended or 3 differential (individually configured)	PakBus, Modbus, DNP3, SDI-12, TCP, UDP, and others

# Datalogger models

## Two new models

	<i>Operating Temperature Range</i>	<i>Maximum Scan Rate</i>	<i>Analog Inputs</i>	<i>Communications Protocols</i>
<p><b>CR1000Xe</b> Measurement and Control Datalogger</p> 	<ul style="list-style-type: none"> <li>&gt; -40° to +70°C (standard)</li> <li>&gt; -55° to +85°C (extended)</li> <li>&gt; Non-condensing environment</li> </ul>	1000 Hz	16 single-ended or 8 differential (individually configured). Two analog inputs can measure 4 to 20 mA or 0 to 20 mA natively.	CPI, PakBus, SDM, SDI-12, Modbus, TCP, DNP3 outstation, UDP, NTCIP, NMEA 0183, I2C, SPI, CampbellCloud HTTPS/MQTTs, and others
<p><b>CR350</b> Measurement and Control Datalogger</p> 	<ul style="list-style-type: none"> <li>&gt; -40° to +70°C</li> <li>&gt; Non-condensing environment</li> </ul>	10 Hz	4 single-ended or 2 differential (individually configured)	PakBus, PakBus Encryption, Modbus RTU/ASCII/TCP, DNP3, SDI-12, and others

## Terminal types

🌐 **Analog** inputs

🌐 **Pulse** counters

🌐 Switched voltage **excitation** outputs

🌐 **Digital** I/O ports

🌐 RS-232, RS-422, or RS-485 ports

🌐 5 V, 12 V and switched 12 V terminals



# Section 1 - Datalogger

## 1.2 Specifications

Specs




[https://s.campbellsci.com/documents/us/product-brochures/s\\_cr1000xe.pdf](https://s.campbellsci.com/documents/us/product-brochures/s_cr1000xe.pdf)





# Section 1 - Datalogger

## 1.3 Models comparison

# Datalogger models



🌐 Different per **size**, number of **channels**, communication, accuracy, etc.

	Operating Temperature Range	Maximum Scan Rate	Analog Inputs	Communication Protocols
<p><b>CR3000</b> Measurement and Control Datalogger</p> 	<ul style="list-style-type: none"> <li>▶ -40° to +85°C (extended)</li> <li>▶ -25° to +50°C (standard)</li> <li>▶ Non-condensing environment</li> <li>▶ Battery bases have different temperature ranges. The rechargeable base option has an operating temperature range of -40° to +60°C. The alkaline base option has a temperature range of -25° to +50°C.</li> </ul>	100 Hz	28 single-ended or 14 differential (individually configured)	PakBus, Modbus, DNP3, SDI-12, SDM

	Operating Temperature Range	Maximum Scan Rate	Analog Inputs	Communication Protocols
<p><b>CR1000X</b> Measurement and Control Datalogger</p> <p>Popular</p> 	<ul style="list-style-type: none"> <li>▶ Non-condensing environment</li> <li>▶ -55° to +85°C (extended)</li> <li>▶ -40° to +70°C (standard)</li> </ul>	1000 Hz	16 single-ended or 8 differential (individually configured) Two analog inputs can measure 4 to 20 mA or 0 to 20 mA natively. Four analog inputs can provide pulse/digital I/O functions.	CPI, PakBus, SDM, SDI-12, Modbus, TCP, DNP3, UDP, NTCIP, NMEA 0183, I2C, SPI, and others
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<p><b>CR300</b> Measurement and Control Datalogger</p> <p>Popular</p> 	<ul style="list-style-type: none"> <li>▶ Non-condensing environment</li> <li>▶ -40° to +70°C (standard)</li> </ul>	10 Hz	6 single-ended or 3 differential (individually configured)	PakBus, Modbus, DNP3, SDI-12, TCP, UDP, and others
<p><b>CR310</b> Measurement and Control Datalogger</p> 	<ul style="list-style-type: none"> <li>▶ Non-condensing environment</li> <li>▶ -40° to +70°C (standard)</li> </ul>	10 Hz	6 single-ended or 3 differential (individually configured)	PakBus, Modbus, DNP3, SDI-12, TCP, UDP, and others

# Datalogger models

## Two new models

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<b>CR1000Xe</b> Measurement and Control Datalogger 	<ul style="list-style-type: none"> <li>&gt; -40° to +70°C (standard)</li> <li>&gt; -55° to +85°C (extended)</li> <li>&gt; Non-condensing environment</li> </ul>	1000 Hz	16 single-ended or 8 differential (individually configured). Two analog inputs can measure 4 to 20 mA or 0 to 20 mA natively.	CPI, PakBus, SDM, SDI-12, Modbus, TCP, DNP3 outstation, UDP, NTCIP, NMEA 0183, I2C, SPI, CampbellCloud HTTPS/MQTTs, and others
<b>CR350</b> Measurement and Control Datalogger 	<ul style="list-style-type: none"> <li>&gt; -40° to +70°C</li> <li>&gt; Non-condensing environment</li> </ul>	10 Hz	4 single-ended or 2 differential (individually configured)	PakBus, PakBus Encryption, Modbus RTU/ASCII/TCP, DNP3, SDI-12, and others

# Section 3 - Software di configurazione, gestione e controllo

3.1 – Device Configuration Utility

# DCU - summary



Connect to a datalogger (cable or Ethernet)

*If USB -> 5 V!!!*



Date and time settings

*with PC time*



Send a programme



Verify OS installed  
Verify update/upgrade OS

*Suggested when connected if outdated*



Status table

*See next slide*



File control and security

*Programme management*



Terminal

*Sensors settings, e.g. SDI-12*

# Status



Record No	1,595
Time Stamp	5/21/2025 11:52:39 AM
OSVersion	CR1000X.Std.08.01
OSDate	09/23/2024
OSSignature	41,327
SerialNumber	70184
RevBoard	020.001.p.e
StationName	70184
RecipeStatus	
ProgName	CPU:temp_test_mod_v5.CR1X
StartTime	5/21/2025 11:12:55 AM
RunSignature	49,159
ProgSignature	36,336
WatchdogErrors	0
PanelTemp	24.47958
Battery	0
LithiumBattery	3.677859
Low12VCount	0
CompileResults	CPU:temp_test_mod_v5.CR1X -- Compiled in PipelineMode.
StartUpCode	65
ProgErrors	0
VarOutOfBound	0
SkippedScan	0
SkippedSystemScan	0
ErrorCalib	0
MemorySize	4,194,304
MemoryFree	57,628

Record No	1,595
Time Stamp	5/21/2025 11:52:39 AM
OSVersion	CR1000X.Std.08.01

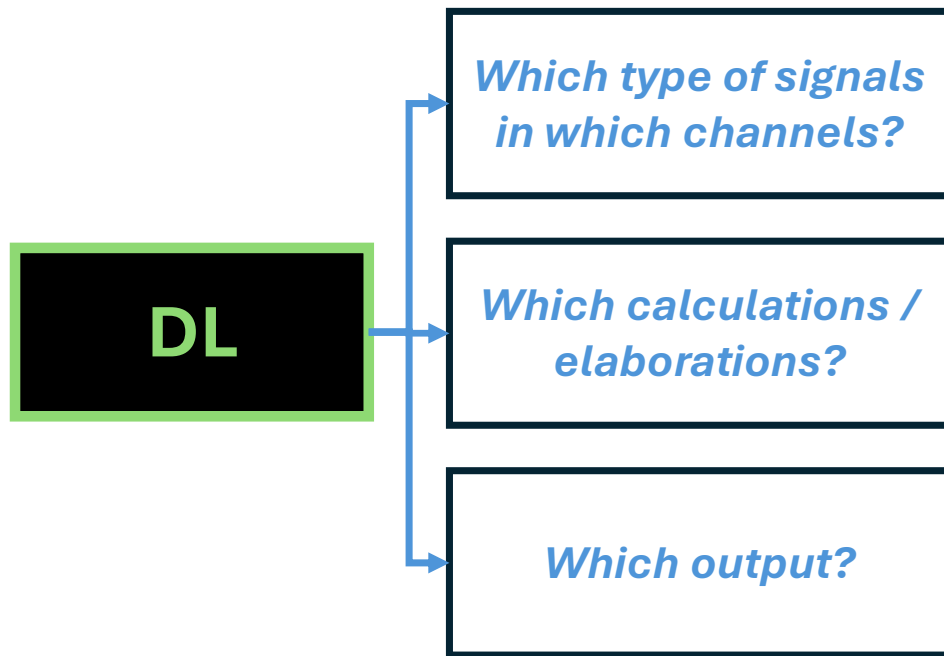
MemoryFree	57,628
CommsMemFree	305 100(99),92(91),199(198),100(96),15(14),25(23),14(12),1(1),0(0),0(0)
FullMemReset	0
CardStatus	No Card Present.
MeasureOps	194
MeasureTime	142,600
ProcessTime	787,784
MaxProcTime	789,854
BuffDepth	0
MaxBuffDepth	0
LastSystemScan	5/21/2025 11:53:00 AM
SystemProcTime	356
MaxSystemProcTime	360
PortStatus(1)	0
PortStatus(2)	0
PortStatus(3)	0
PortStatus(4)	0
PortStatus(5)	0
PortStatus(6)	0
PortStatus(7)	0
PortStatus(8)	0
PortConfig(1)	SDI-12
PortConfig(2)	Input
PortConfig(3)	RS485 A-
PortConfig(4)	RS485 B+
PortConfig(5)	Input

PortConfig(5)	Input
PortConfig(6)	Input
PortConfig(7)	Input
PortConfig(8)	Input
SW12Volts(1)	0
SW12Volts(2)	0
SW12CSIO	-1
PakBusRoutes	13,4089,4089,5000
Messages	
CalVolts(1)	8,000.158
CalVolts(2)	1,599.909
CalVolts(3)	319.7759
CalRefSlope(1)	-0.04259603
CalRefSlope(2)	-0.009371054
CalRefSlope(3)	-0.002777082
CalRefOffset(1)	2.554944
CalRefOffset(2)	0.5674039
CalRefOffset(3)	0.1750101
CalGain(1)	0.0006422554
CalGain(2)	0.0001267055
CalGain(3)	2.527439e-05
CalOffset(1)	-145
CalOffset(2)	-144
CalOffset(3)	-135
CalCurrent(1)	0.09999441
CalCurrent(2)	0.09999672

# Section 3 - Software di configurazione, gestione e controllo

3.2. PC400

## How to instruct the logger



Communication: PC400 (core, free) or LoggerNet (complete, at a cost)



# PC400



PC400 4.8 Datalogger Support Software - CR1000XSeries ( CR1000XSeries )

File View Datalogger Network Tools Help

Connect

Clock/Program Monitor Data Collect Data

**Datalogger Information**  
Datalogger Name: CR1000XSeries  
Datalogger Type: CR1000XSeries

**Direct Connect Connection**  
COM Port: COM5

**Datalogger Settings**  
Baud Rate: 115200  
PakBus Address: 1  
Security Code: 0  
Extra Response Time: 0s  
Max Time Online: 0h 0m 0s

**Data File Paths**  
Table2: C:\Users\simos\Documents\Working\_stuff\CMCC\tempo\_inde\Projects&co\ITINERIS\Temp\_sensors\_test\CR1000XSeries\_Table2\_v5.dat  
Table1: C:\Users\simos\Documents\Working\_stuff\CMCC\tempo\_inde\Projects&co\ITINERIS\Temp\_sensors\_test\CR1000XSeries\_Table1\_v5.dat  
Status: C:\Users\simos\Documents\Working\_stuff\CMCC\tempo\_inde\Projects&co\ITINERIS\Temp\_sensors\_test\CR1000XSeries\_Status\_v5.dat  
Public: C:\Users\simos\Documents\Working\_stuff\CMCC\tempo\_inde\Projects&co\ITINERIS\Temp\_sensors\_test\CR1000XSeries\_Public\_v5.dat  
DataTableInfo: C:\Users\simos\Documents\Working\_stuff\CMCC\tempo\_inde\Projects&co\ITINERIS\Temp\_sensors\_test\CR1000XSeries\_DataTableInfo\_v5.dat

**Clocks**  
Datalogger  
PC  
 Pause Clock Update  
Time Zone Offset  
Set Clock 00 h 00 m




**Datalogger Program**  
temp\_test\_mod\_v5.CR1X  
Send Program...  
Retrieve Program...

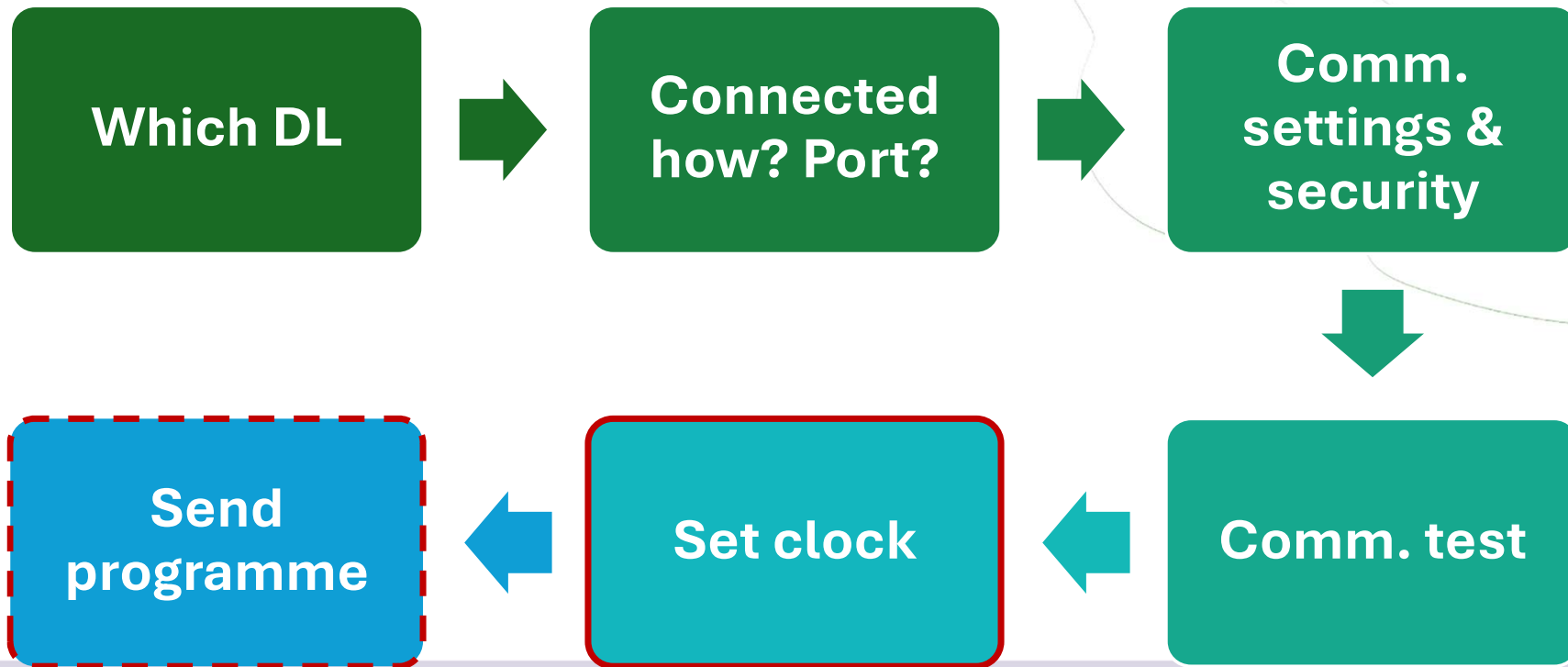
Disconnected

# PC400 – Datalogger setup

Wizard



-  - Can be done also in DCU, LoggerNet
-  - Can be done also afterwards
-  - Can be done also in Short Cut




# Data tables

🌐 Output are organized in **tables**











- **Public** → at scan rate, real time
- **Status**
- **Custom** → usually one for battery and logger temp., one with measurements. Samples, averages, or simple aggregations at the desired interval

🌐 Data monitor also in Dev. Config. and LoggerNet

**PUBLIC** 

PC400 4.8 Datalogger Support Software - CR1000XSeries ( CR1000XSeries )

File View Datalogger Network Tools Help

Disconnect          

Clock/Program Monitor Data Collect Data

Add Delete Port/Flag Options

51127	RecNum	53	
51132	TimeStamp	2025 09:30:42	
CR1000XSeries	BattV	0.00	
	PTemp_C	22.54	
	TA_002	-30.13	
	RH_002	-0.12	
	TA_001	-30.09	
	RH_001	-0.10	
	TA_HC2A	-40.00	
	RH_HC2A	0.00	
	TA_HygroVue	NAN	
	RH_HygroVue	NAN	

## Data download

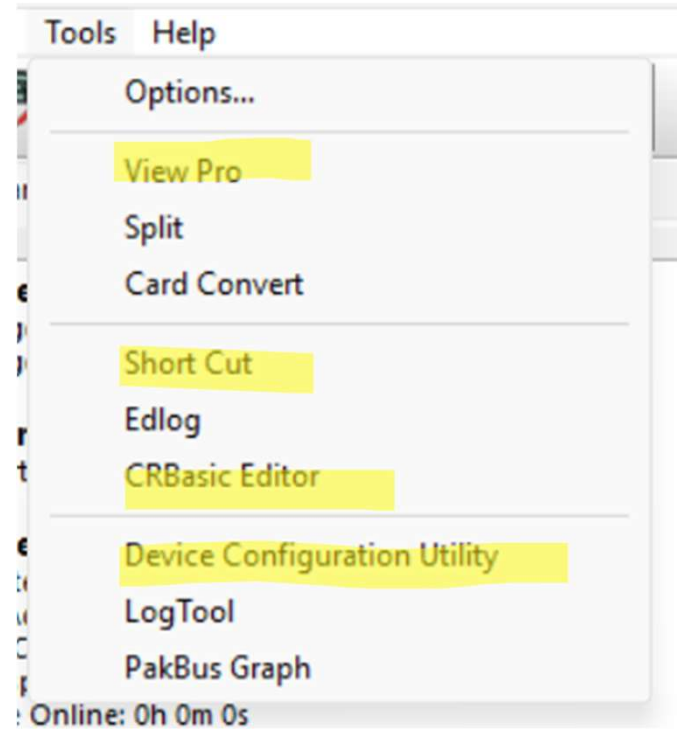
- 🌐 Select **which data** you need
- 🌐 Select the table and specify **destination** and **filename**
- 🌐 **Save** to text files
- 🌐 Files can be visualized
- 🌐 No visualization of data (plots)

### **WARNING! Risk of data loss!**

*Same filename+all data → overwrites!  
Check the filenames of all the tables  
you need!*



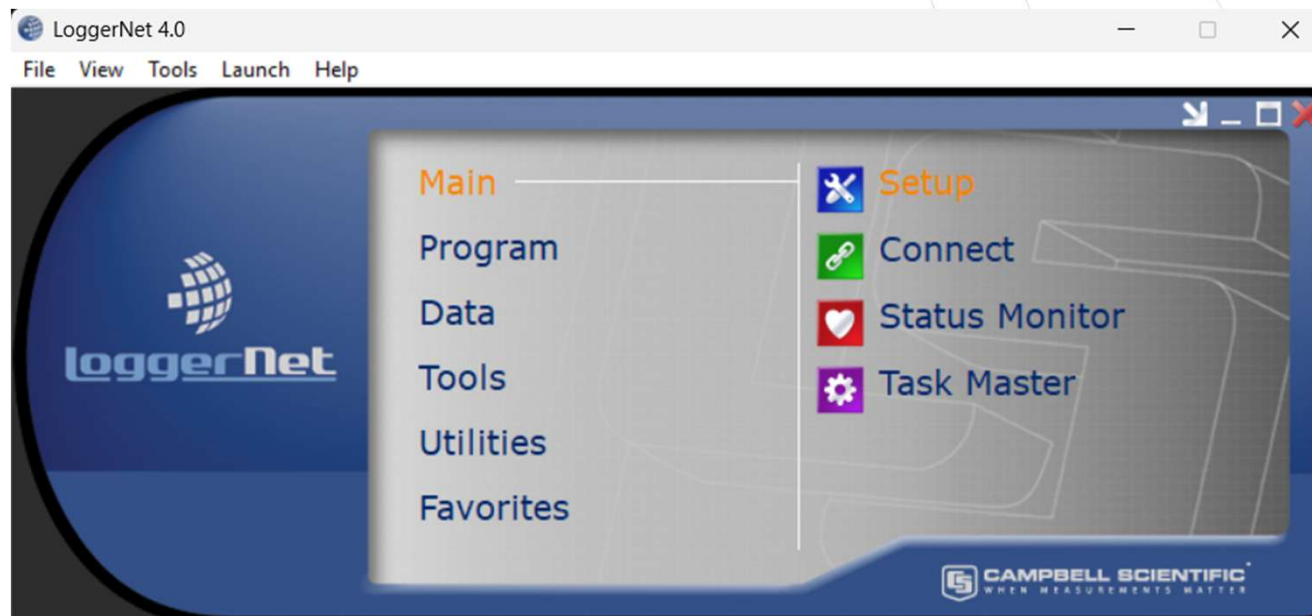
## Other functionalities



# Section 3 - Software di configurazione, gestione e controllo

## 3.3. LoggerNet

# LoggerNet: a complete CS software



## LoggerNet software

🌐 Same functionalities as PC400 +  
dedicated utilities and more options

- **Datalogger setup**
- **Connect**
- **Device configuration**
- **Access to ViewPro and programming tools**

🌐 Example of additional functionalities:

- **Status Monitor**
- **Plots**
- **More options for data collection and more formats**
- **Download scheduling**
- **Remote connection**

# Section 3 - Software di configurazione, gestione e controllo

## 3.4. ViewPro

# Simple visualisation tool



PC400 4.8 Datalogger Support Software - CR1000XSeries ( CR1000XSeries )

File View Datalogger Network Tools Help

Disconnect [Icons]

Clock/Program Monitor Data Collect Data

**What to Collect**

New data from datalogger (Append to data files) Change Table's Output File...

All data from datalogger (Overwrite data files) Start Data Collection

Table	File Name
<input checked="" type="checkbox"/> DataTableInfo	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet\Projects&co\ITINERIS\Temp_sensors_test\CR1000XSeries_DataTableInfo_v5.dat
<input checked="" type="checkbox"/> Public	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet\Projects&co\ITINERIS\Temp_sensors_test\CR1000XSeries_Public_v5.dat
<input checked="" type="checkbox"/> Status	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet\Projects&co\ITINERIS\Temp_sensors_test\CR1000XSeries_Status_v5.dat
<input checked="" type="checkbox"/> Table1	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet\Projects&co\ITINERIS\Corso_avanzato_logger\CR1000XSeries_Table1_v5.dat
<input checked="" type="checkbox"/> Table2	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet\Projects&co\ITINERIS\Temp_sensors_test\CR1000XSeries_Table2_v5.dat

**Data Collection Results**

Summary

Table	Output File Name	File Output Mode	Output Format
DataTableInfo	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet...	Overwrite Existing File	ASCII Table Data, Long Header (TOA5)
Public	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet...	Overwrite Existing File	ASCII Table Data, Long Header (TOA5)
Status	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet...	Overwrite Existing File	ASCII Table Data, Long Header (TOA5)
Table1	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet...	Overwrite Existing File	ASCII Table Data, Long Header (TOA5)
Table2	C:\Users\simos\Documents\Working_stuff\CMCC\tempo_indet...	Overwrite Existing File	ASCII Table Data, Long Header (TOA5)

Total number of values collected:  OK View File Help

Connection Time 1:19:25

20°C Soleggiato [Taskbar Icons] 10:50 AM 5/27/2025

Text files downloaded

# Section 3 - Software di configurazione, gestione e controllo

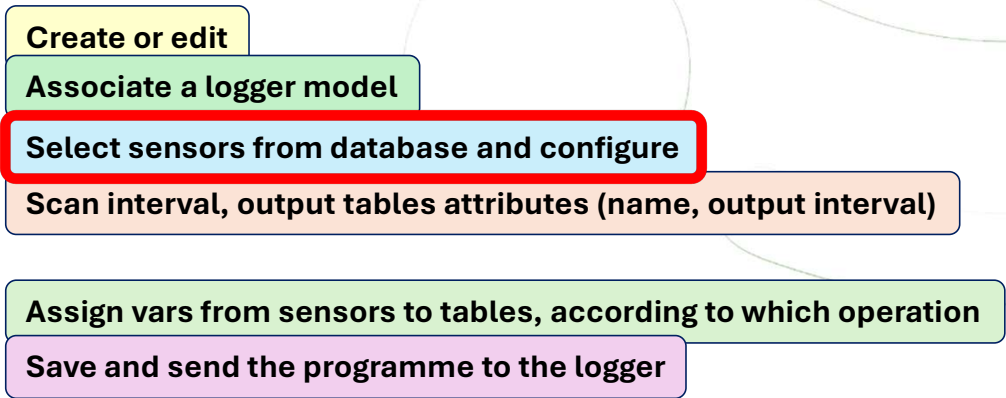
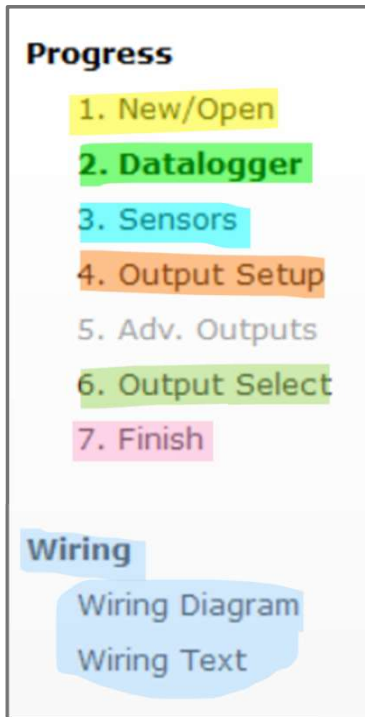
3.5. Short Cut

# Short Cut

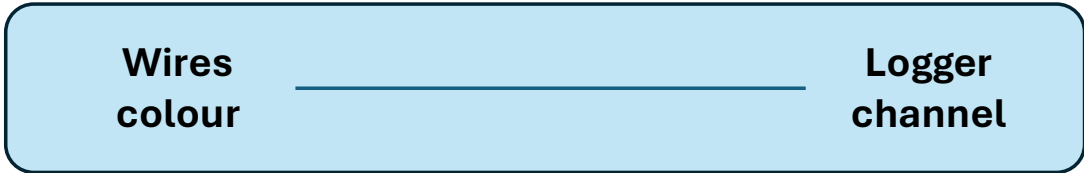
🌐 The easiest and fastest way to **create** a programme

🌐 Accessible via PC400, LoggerNet or directly (Windows)

🌐 Few steps:




**WARNING!**  
Colours may change!



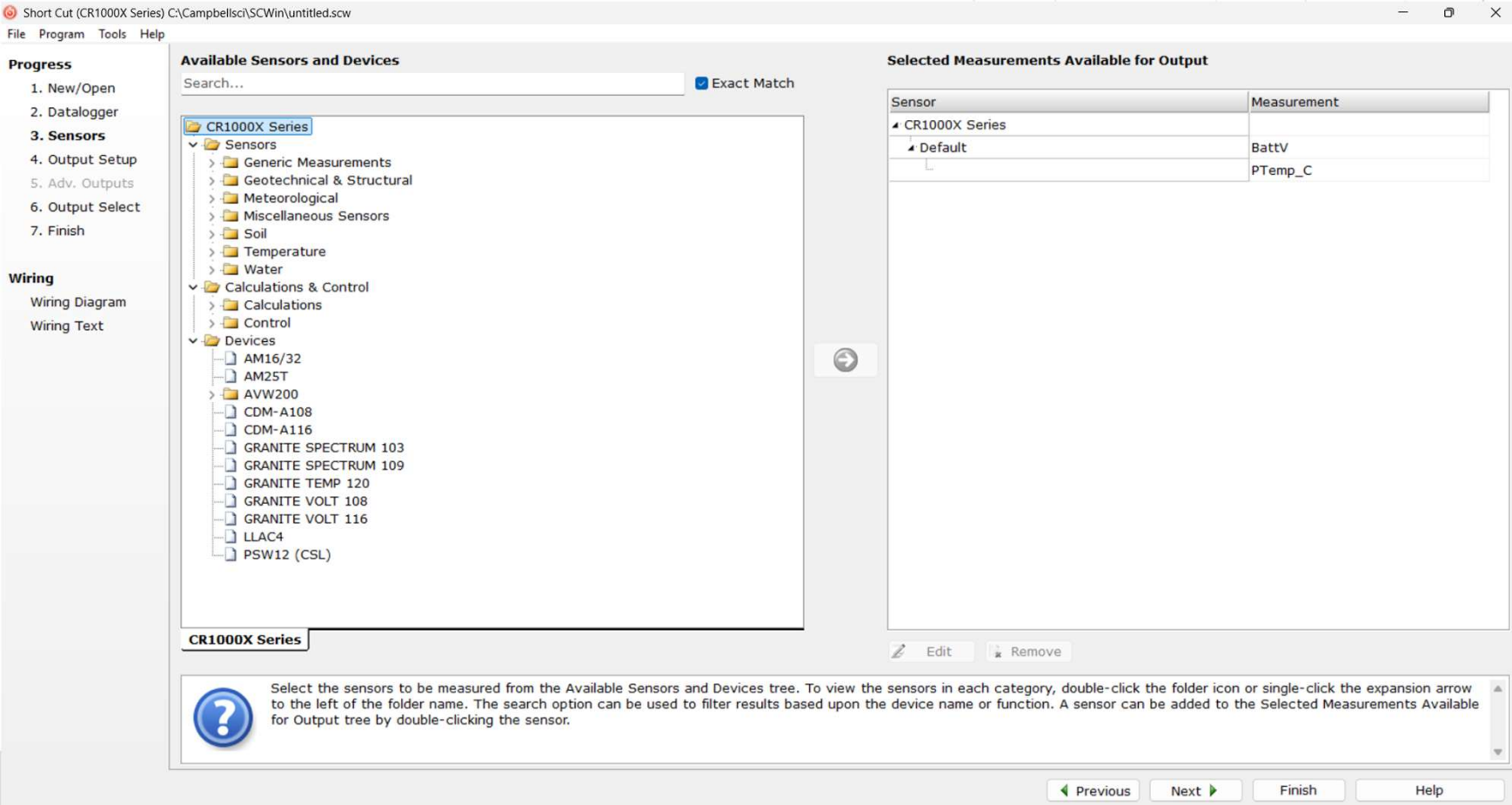
# Select sensors from database and configure

## Two databases



The screenshot shows the Short Cut software interface. The main window title is "Short Cut (CR1000X Series) C:\Campbellsci\SCWin\untitled.scw". The menu bar includes "File", "Program", "Tools", and "Help". The "Program" menu is open, showing options like "Program Security", "Datalogger ID", "Power-Up Settings", "Select CR200 Compiler", "First notch frequency", and "Sensor Support". The "Sensor Support" sub-menu is open, showing two options: "Campbell Scientific, Inc. (US)" and "Campbell Scientific, Ltd. (UK)". The "Campbell Scientific, Ltd. (UK)" option is selected and circled in red. Below the menu, there are two buttons: "Create New Program" and "Open Existing Program". The main area of the window displays a code editor with various configuration commands such as "Units BattV=Volts", "Units PTemp\_C=Deg C", "Units AirTC=Deg C", "Units RH=%", "Define Data Tables", "DataTable(DataTable60Minutes, True, -1)", "DataInterval(0, 60, Min, 10)", "Average(1, AirTC, FP2, False)", "Maximum(1, AirTC, FP2, False, False)", "Minimum(1, AirTC, FP2, False, False)", "EndTable", "DataTable(DataTable1440Minutes, True, -1)", "DataInterval(0, 1440, Min, 10)", and "Average(1, BattV, FP2, False, False)". The Campbell Scientific logo is visible in the bottom right corner. A help icon and a text box at the bottom of the window provide information about the "Sensor Support" option: "Sensor Support - Determines which group of sensor files will be displayed when creating a program: Campbell Scientific, Inc. (U.S.) or Campbell Scientific, Ltd (U.K.). When one option is selected, the sensor files developed for the other are filtered out of the list of sensors." Navigation buttons for "Previous", "Next", "Finish", and "Help" are located at the bottom right of the window.

# Select sensors from database and configure



The screenshot displays the software interface for configuring a CR1000X Series datalogger. The window title is "Short Cut (CR1000X Series) C:\Campbellsci\SCWin\untitled.scw". The interface is divided into several sections:

- Progress:** A vertical list of steps: 1. New/Open, 2. Datalogger, 3. Sensors (highlighted), 4. Output Setup, 5. Adv. Outputs, 6. Output Select, 7. Finish.
- Wiring:** Options for "Wiring Diagram" and "Wiring Text".
- Available Sensors and Devices:** A tree view showing the "CR1000X Series" folder expanded to show various sensor categories like "Sensors", "Calculations & Control", and "Devices". A search bar and "Exact Match" checkbox are at the top.
- Selected Measurements Available for Output:** A table showing the selected sensors and their measurements.

Sensor	Measurement
CR1000X Series	
Default	BattV
	PTemp_C

At the bottom of the window, there is a help icon and a text box: "Select the sensors to be measured from the Available Sensors and Devices tree. To view the sensors in each category, double-click the folder icon or single-click the expansion arrow to the left of the folder name. The search option can be used to filter results based upon the device name or function. A sensor can be added to the Selected Measurements Available for Output tree by double-clicking the sensor." Below this are navigation buttons: "Previous", "Next", "Finish", and "Help".

What if my sensor is not on the lists?

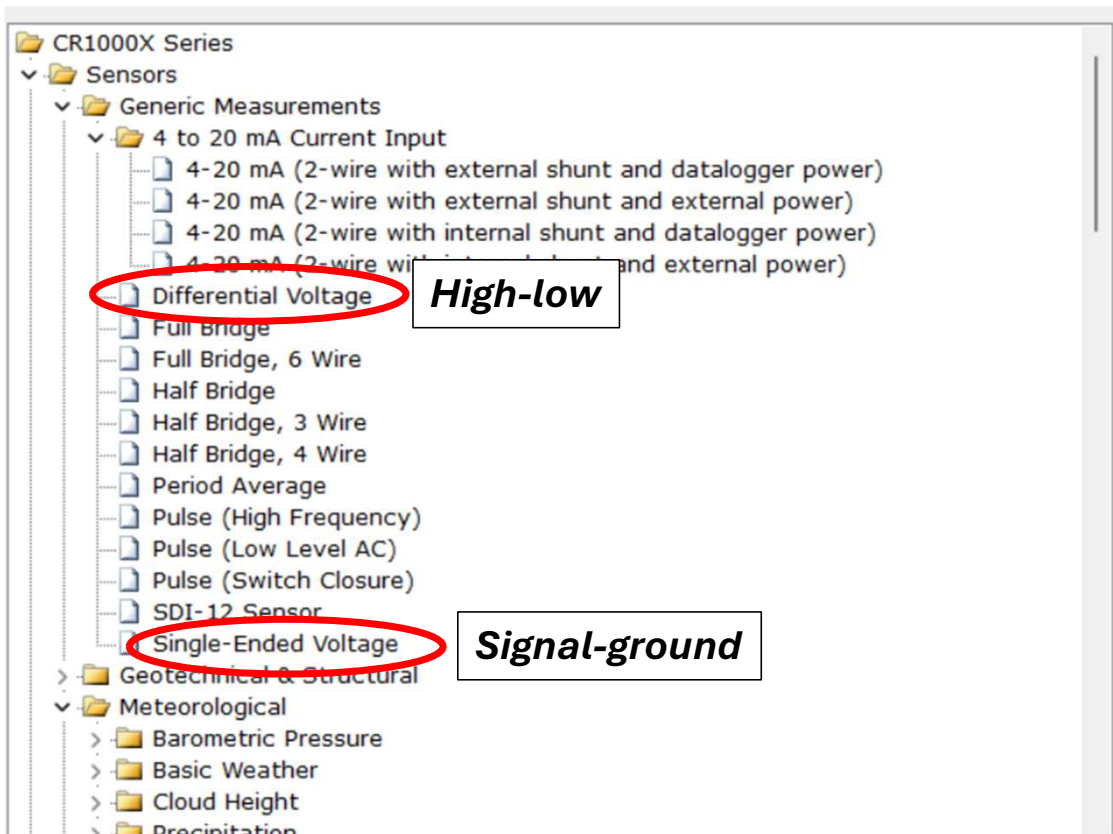
🌐 First check under “**miscellaneous**”

🌐 Still possible to use the Short Cut if standard measure (single ended, differential – see sec. 2): **Generic Measurements**

🌐 **Custom** sensors can be saved

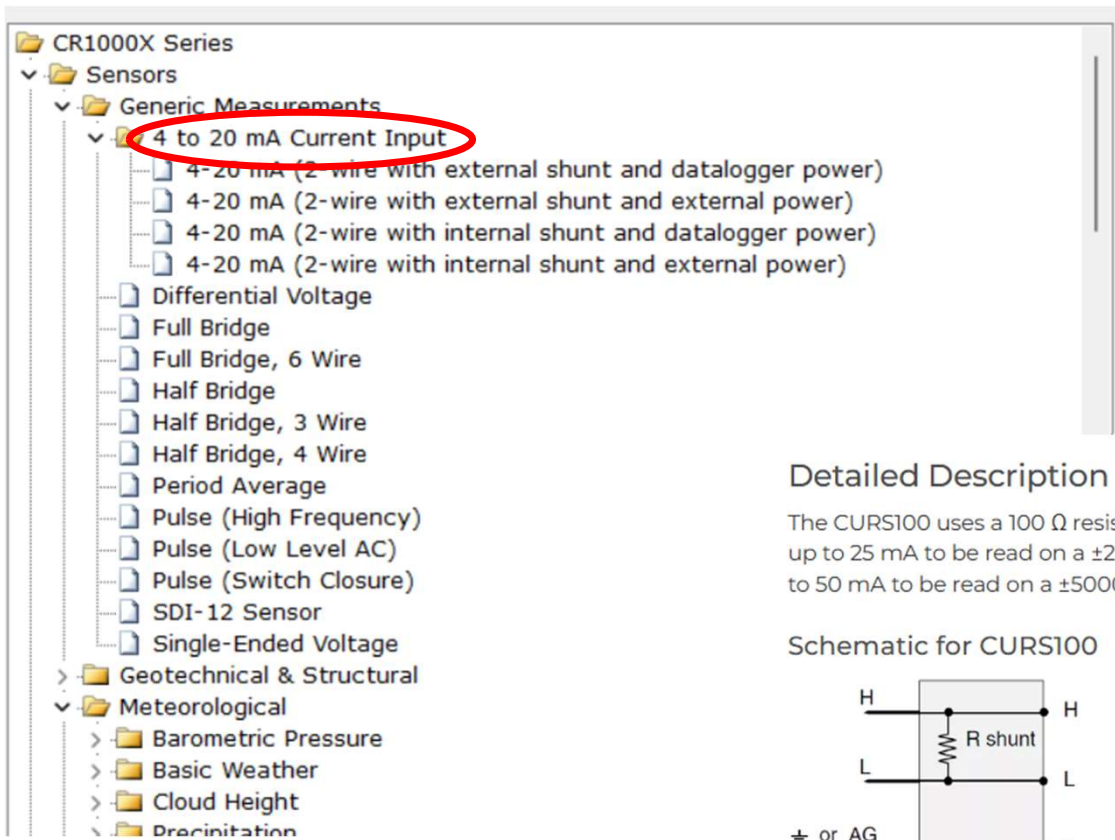
🌐 Some examples and special cases in the next slides

# Analogue measurements



Linear relation with physical units → multiplier, offset

# Analogue measurements

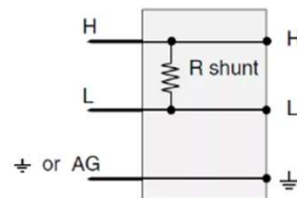


- Linear relation with physical units → multiplier, offset
- Convert to mV using a known precision (shunt) resistance (Ohm law  $V=R*I$ )
- Dedicated **module** from CS (CURS100)

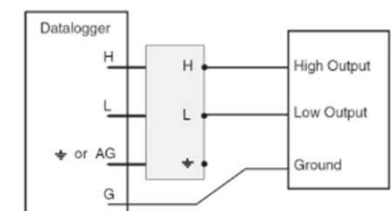
## Detailed Description

The CURS100 uses a 100 Ω resistor for the current shunt that allows currents up to 25 mA to be read on a ±2500 mV range (CR10X, CR510) and currents up to 50 mA to be read on a ±5000 mV range.

## Schematic for CURS100



## CURS100-to-Sensor Hookup



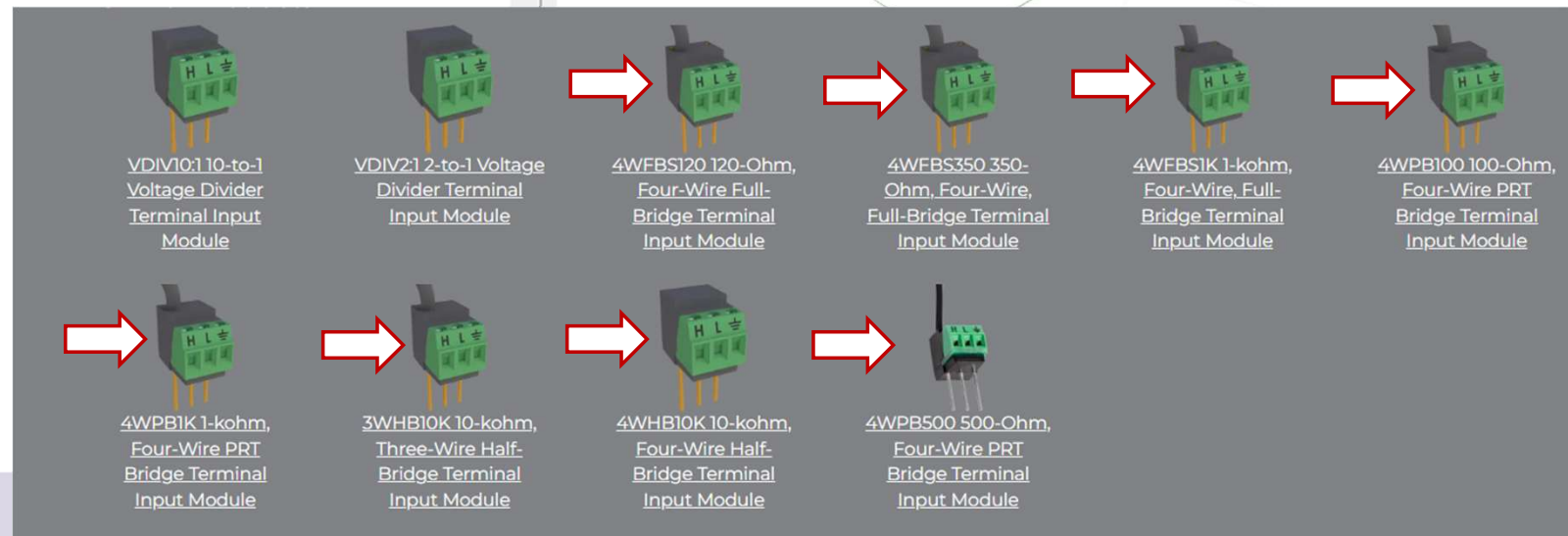
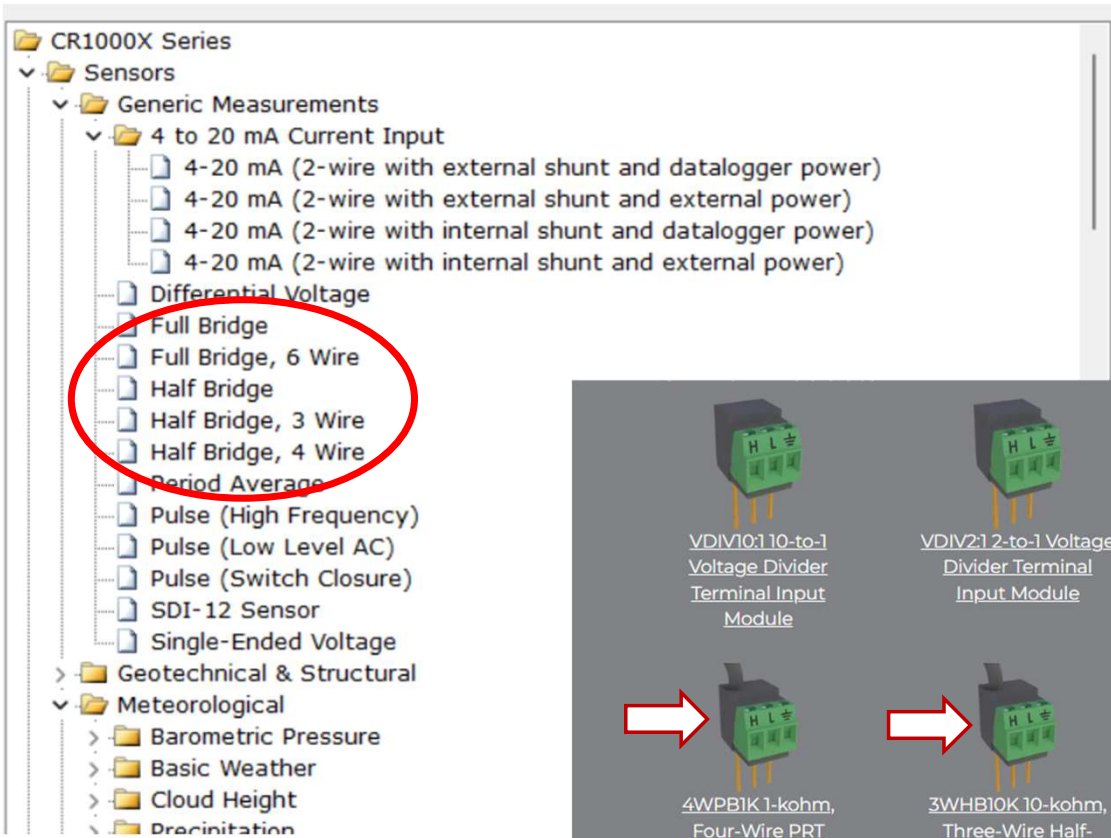
# Bridge measurements

🌐 **Resistance** measurements with Voltage excitation

🌐 V drop across R of the sensor and one or more known resistors.

🌐 **Typical for PRT**

🌐 CS selling dedicated terminal input **modules**



# Bridge measurements

## Half bridges

Rs=sensing resistor

Rf=fixed, known resistance

Vx = excitation voltage

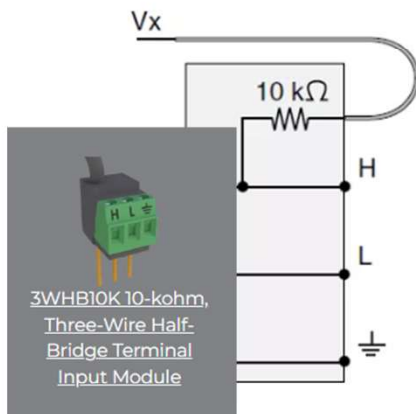
V1, V2 = sensor return voltages

From the V drop we can retrieve Rs, that scales with temperature

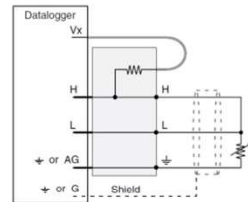
Resistive-bridge type and circuit diagram	CRBasic instruction and fundamental relationship	Relational formulas
<p>Half Bridge<sup>1</sup></p>	<p>CRBasic Instruction: <code>BrHalf()</code></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = \frac{V_1}{V_x} = \frac{R_s}{R_s + R_f}</math></p>	$R_s = R_f \frac{X}{1 - X}$ $R_f = \frac{R_s(1 - X)}{X}$
<p>Three Wire Half Bridge<sup>1,2</sup></p>	<p>CRBasic Instruction: <code>BrHalf3W()</code></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = \frac{2V_2 - V_1}{V_x - V_1} = \frac{R_s}{R_f}</math></p>	$R_s = R_f X$ $R_f = \frac{R_s}{X}$
<p>Four Wire Half Bridge<sup>1,2</sup></p>	<p>CRBasic Instruction: <code>BrHalf4W()</code></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = \frac{V_2}{V_1} = \frac{R_s}{R_f}</math></p>	$R_f = \frac{R_s}{X}$ $R_s = R_f X$

# Bridge measurements

## Detailed Description 3WHB10K Schematic



3WHB10K-to-Sensor Hookup



Resistive-bridge type and circuit diagram	CRBasic instruction and fundamental relationship	Relational formulas
<p>Half Bridge<sup>1</sup></p>	<p>CRBasic Instruction: <b>BrHalf()</b></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = \frac{V_1}{V_x} = \frac{R_s}{R_s + R_f}</math></p>	$R_s = R_f \frac{X}{1 - X}$ $R_f = \frac{R_s(1 - X)}{X}$
<p>Three Wire Half Bridge<sup>1,2</sup></p>	<p>CRBasic Instruction: <b>BrHalf3W()</b></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = \frac{2V_2 - V_1}{V_x - V_1} = \frac{R_s}{R_f}</math></p>	$R_s = R_f X$ $R_f = \frac{R_s}{X}$
<p>Four Wire Half Bridge<sup>1,2</sup></p>	<p>CRBasic Instruction: <b>BrHalf4W()</b></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = \frac{V_2}{V_1} = \frac{R_s}{R_f}</math></p>	$R_f = \frac{R_s}{X}$ $R_s = R_f X$

# Bridge measurements

## Full bridges

More complex circuits, V drops across different combinations

<p>Full Bridge<sup>1,2</sup></p>	<p>CRBasic Instruction: <b>BrFull()</b></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = 1000 \frac{V_1}{V_x} = 1000 \left( \frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2} \right)</math></p>	<p>These relationships apply to <b>BrFull()</b> and <b>BrFull6W()</b></p> $R_1 = \frac{R_2(1 - X_1)}{X_1}$ $R_2 = \frac{R_1 X_1}{1 - X_1}$ <p>where <math>X_1 = \frac{-X}{1000} + \frac{R_3}{R_3+R_4}</math></p> $R_3 = \frac{R_4 X_2}{1 - X_2}$ $R_4 = \frac{R_3(1 - X_2)}{X_2}$ <p>where <math>X_2 = \frac{X}{1000} + \frac{R_2}{R_1+R_2}</math></p>
<p>Six Wire Full Bridge<sup>1</sup></p>	<p>CRBasic Instruction: <b>BrFull6W()</b></p> <p>Fundamental Relationship: X = result w/mult = 1, offset = 0 <math>X = 1000 \frac{V_2}{V_1} = 1000 \left( \frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2} \right)</math></p>	

# Pulse and Frequencies

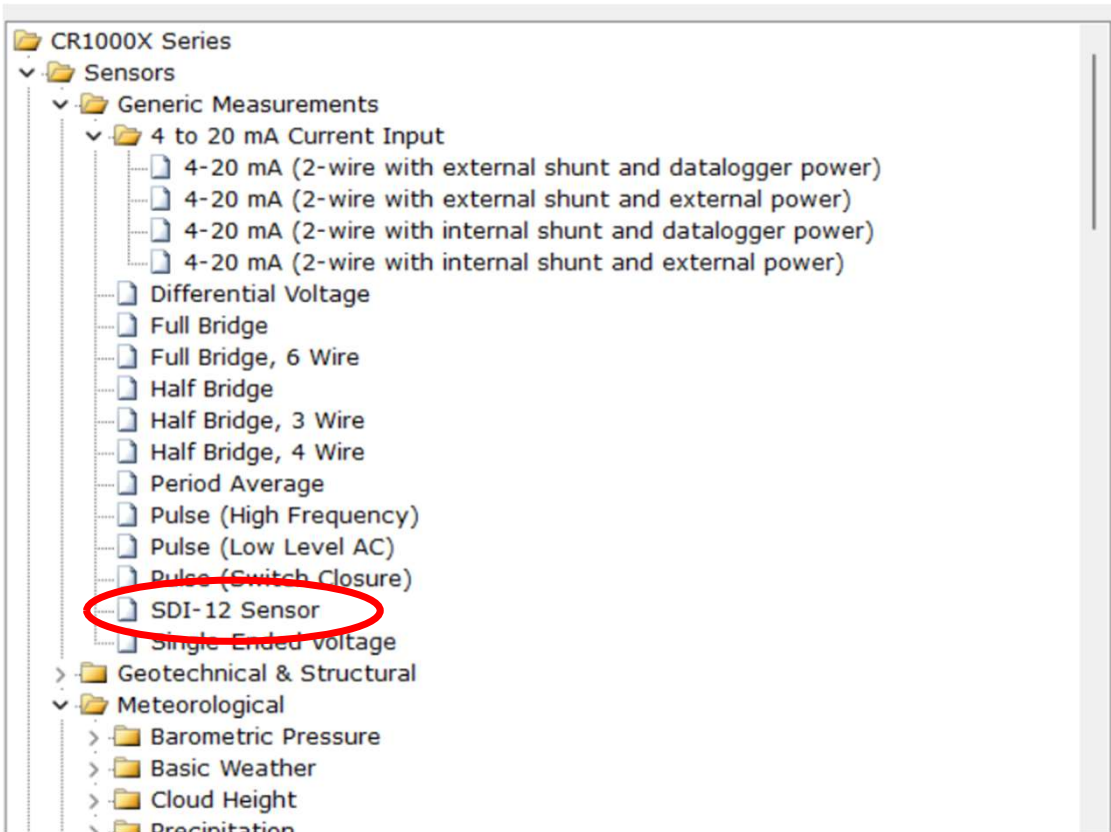
The data logger includes terminals that are configurable for pulse input as shown in the following image.

Input Type	Pulse Input Terminal
High-frequency	P1 P2 C (all)
Low-level AC	P1 P2
Switch-closure	P1 P2 C (all)

🌐 Output signal = series of **voltage waves**.  
 “The sensor couples its output signal to the measured phenomenon by modulating wave frequency. The data logger detects the state transition as each wave varies between voltage extremes (high-to-low or low-to-high). Measurements are processed and presented as counts, frequency, or timing data”

*(from manual)*

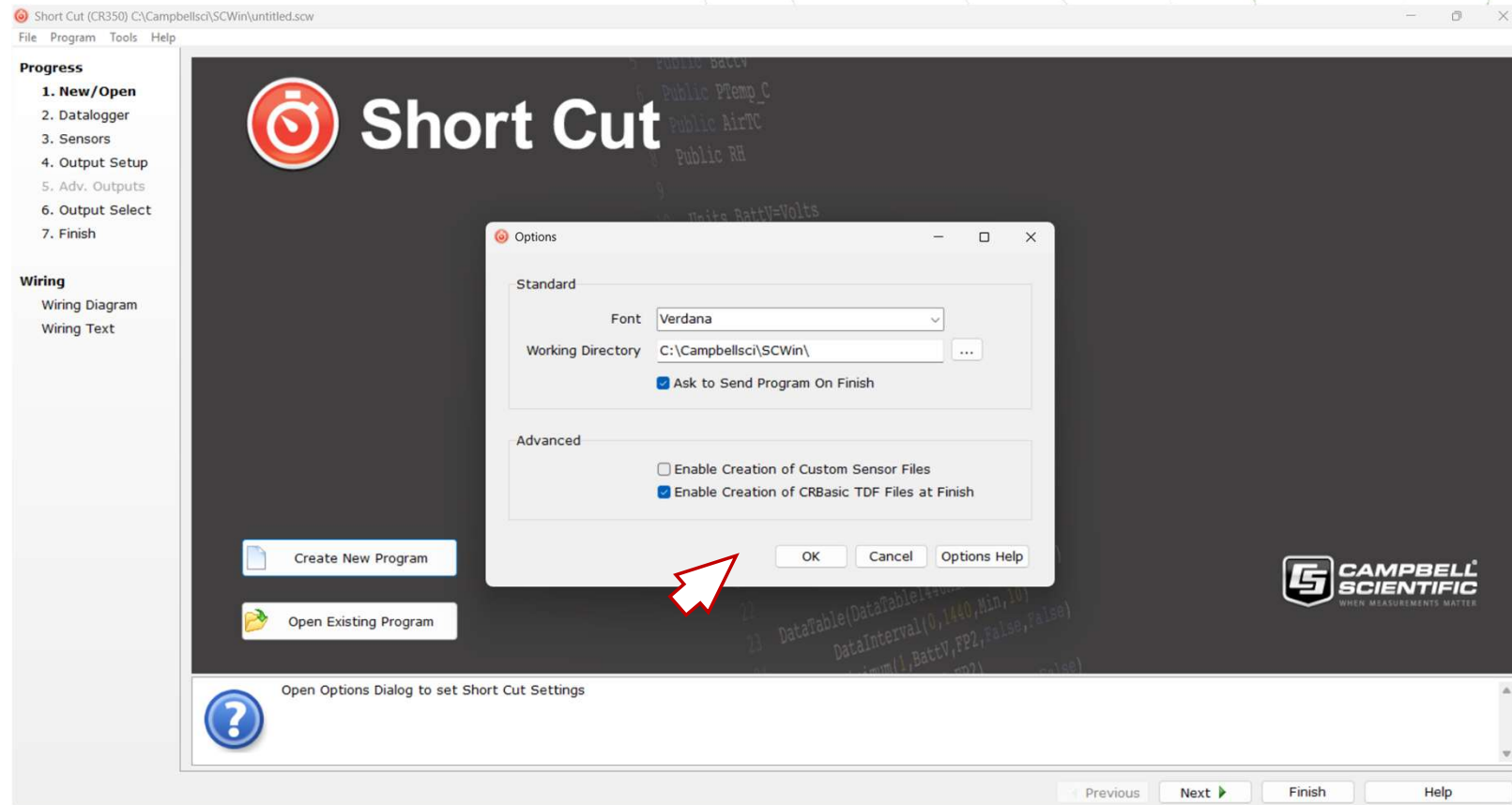
# SDI-12



- Standard comm. protocol to transfer measurements taken by an intelligent sensor. Takes a measurement, computations, outputs **in engineering units**. (SDI-12 SG)
- Relatively slow communication (1200 BR)
- Battery powered data recorders with micro-processor-based sensors for environ. data
- Ports C1, C3, C5, and C7. All sensors in the same port → different addresses
- Transparent mode from terminal (DCU, PC400) → config
  - Programmed mode (see Sect. 3.6)

# Custom sensors

Can be enabled from Tools → Options...



# Custom sensors

Right-click on one “close” sensor

The screenshot shows the CR350 software interface. On the left, a 'Progress' sidebar lists steps from 'New/Open' to 'Finish'. The main window is divided into three panes: 'Available Sensors and Devices', 'Selected Measurements Available for Output', and a 'CR350' status bar. The 'Available Sensors and Devices' pane shows a tree structure under 'CR350' with 'Sensors' expanded to 'Generic Measurements' and '4 to 20 mA Current Input'. The 'Differential Vol' sensor is selected, and a 'Create Custom Sensor' button is visible. A green arrow points to this button. The 'Selected Measurements Available for Output' pane is currently empty. The 'CR350' status bar at the bottom contains a help icon and a text box explaining how to select sensors.

The screenshot shows the 'Differential Voltage (Version: 1.2)' dialog box. It has two tabs: 'Properties' and 'Wiring'. The 'Properties' tab is active, showing various configuration options. The 'Long Name' is 'Generic Measurements\Differential Voltage' and the 'ShortName' is 'VoltsDiff'. An 'Image' is selected from a file path. There are several checkboxes, including 'Allow Reps' and 'Reverse inputs to cancel offsets'. Numerical fields for 'Measurement Result' (DiffVolt), 'Range of sensor voltage' (2500 mV), 'First notch frequency' (Reject 60 Hz Noise (50 ms)), 'Settling time (us)' (500), 'Multiplier' (1), and 'Offset' (0) are present, each with an 'Edit...' button. There are also options for 'Optional Field Calibration' and 'Zeroing Calibration'. A 'Select Zeroing Calibration Group' dropdown is set to 'Do Not Group'. At the bottom, there is a 'Save As...' button, a 'Cancel' button, and a 'Help' button. A diagram at the bottom left shows two channels, 'DiffChan H' and 'DiffChan L', connected to a 'Sensor'.

# Sensors for practice

# LICOR LI-190R

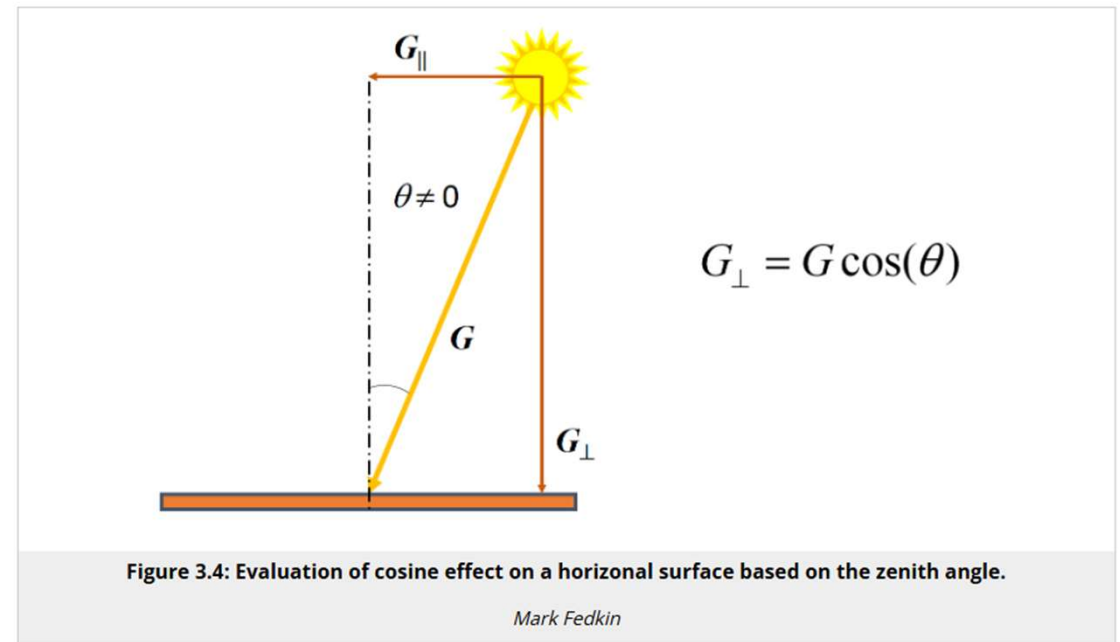
- 🌐 Type of measurement: **analogue**
- 🌐 What it measures: photosynthetic active radiation (**PAR** or **PPFD**)
- 🌐 Technology: enhanced silicon **photodiode** mounted under a cosine-corrected acrylic diffuser, with a spectral filter (spectral response)

🌐 Output:  $\mu\text{A}$ , directly proportional to hemispherical PAR.

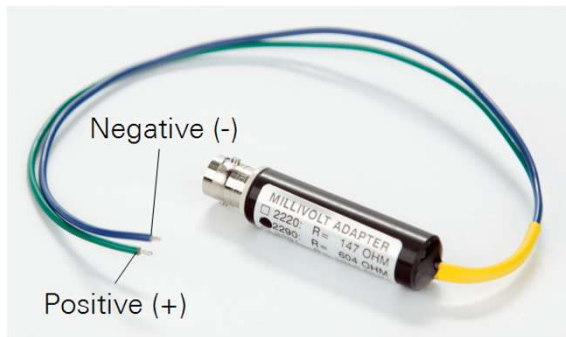
Multiplier M to radiation ( $\mu\text{mol s}^{-1} \text{m}^{-2}$ ).

🌐 2290 millivolt adapter: known resistance  $\rightarrow$  mV  $\rightarrow$

$\mu\text{mol m}^{-2} \text{s}^{-1}$



# LICOR LI-190R

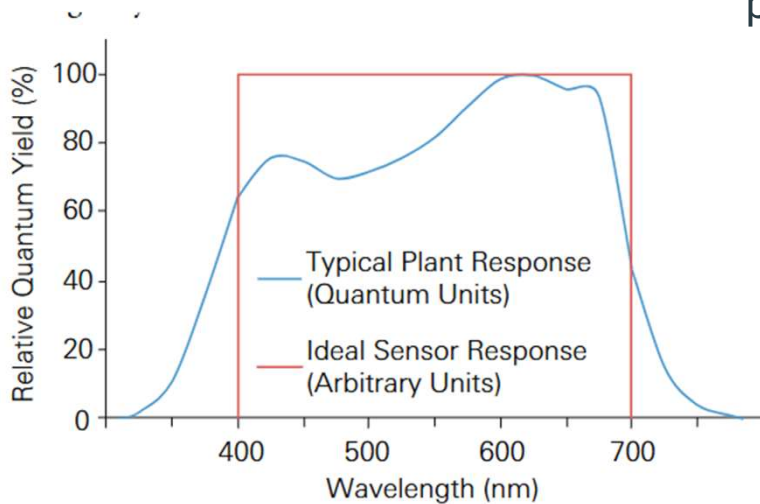


$$M = -1 / (G * C)$$

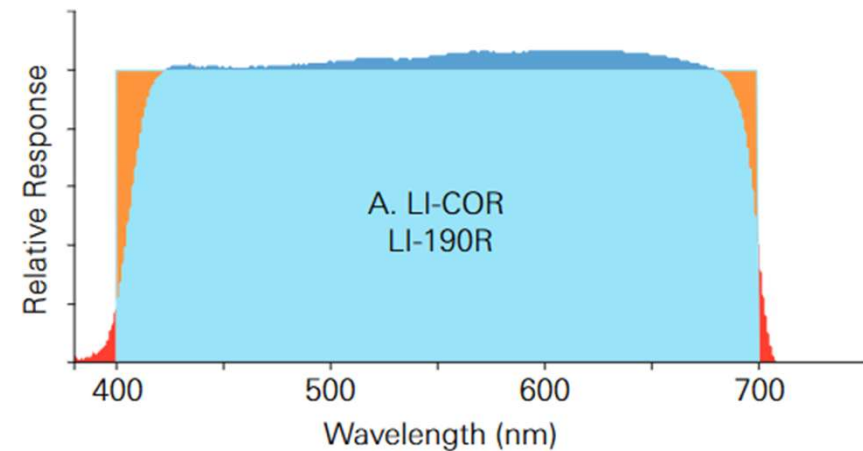
Multiplier in  $\mu\text{mol s}^{-1} \text{m}^{-2}$  per mV

Resistance =  $0.604 \text{ mV } \mu\text{A}^{-1}$

Calibration constant in  $\mu\text{A}$  per  $1000 \mu\text{mol s}^{-1} \text{m}^{-2}$



Photosynthetic rates normalized by light intensity in units of absorbed quanta (photons; relative quantum yield) at each wavelength.

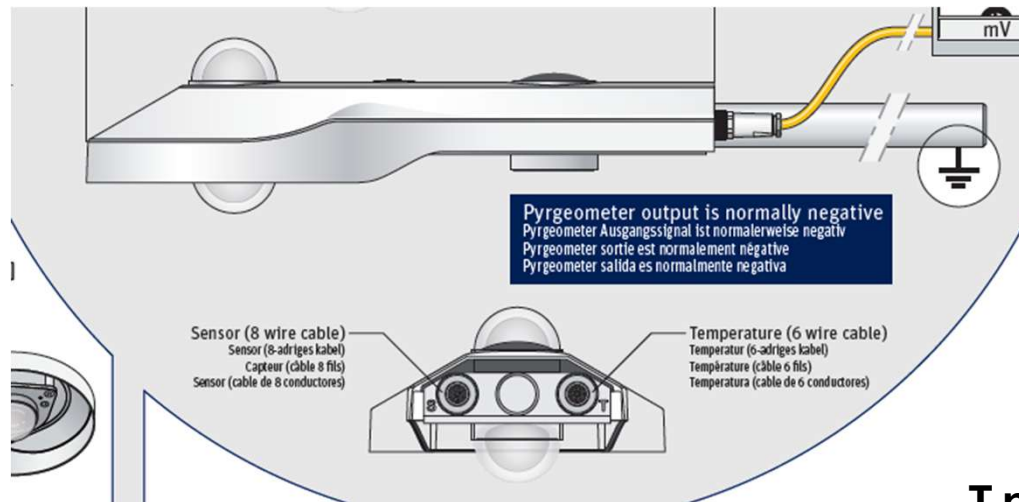


**Figure 2.** Ideal sensor response and response of a typical plant.

## Kipp&Zonen CNR4

- 🌐 Type of measurement: **analogue** (6 sensors – 4 radiometers, 2 temperature sensors)
- 🌐 What it measures: short-wave and long-wave radiations + Temp.
- 🌐 Technology: **thermopile** - irradiation is proportional to the difference between the temperature of the sun exposed area and the temperature of the shadow area.
- 🌐 Output:  $\mu\text{V}$ . Sensitivity  $\rightarrow \text{W m}^{-2}$

# Kipp&Zonen CNR4



$$E_{SW} = \frac{U_{emf}}{S}$$

$$E_{LW} = \frac{U_{emf}}{S} + 5.67 \cdot 10^{-8} \cdot T_b^4$$

$U_{emf} [\mu V]$  = Output Voltage  
 Ausgangsspannung • Sortie tension • Voltaje de salida

$S \left[ \frac{\mu V}{W/m^2} \right]$  = Sensitivity  
 Empfindlichkeit • Sensibilité • Sensibilidad

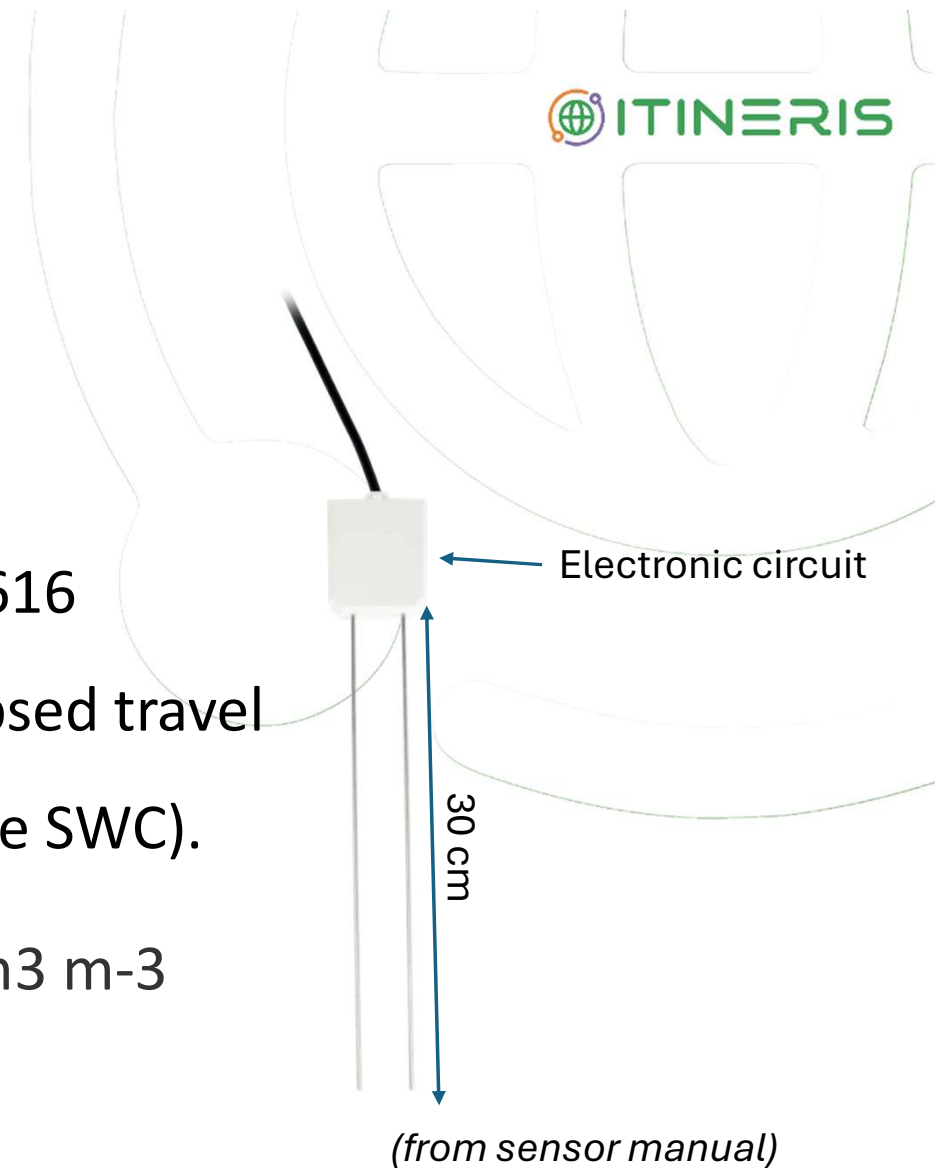
$T_b [K]$  = Temperature  
 Temperatur • Température • Temperatura

**T proportional to Resistance (PT100 or Thermistor)**

*(from sensor manual)*

## Campbell Scientific CS616

- 🌐 Type of measurement: **digital** (frequency)
- 🌐 What it measures: Soil water content (**SWC**)
- 🌐 Technology: **time-domain** measurement (CS616 generates an electromagnetic pulse. The elapsed travel time and pulse reflection are used to calculate SWC).
- 🌐 Output: megahertz oscillation frequency ->  $m^3 m^{-3}$



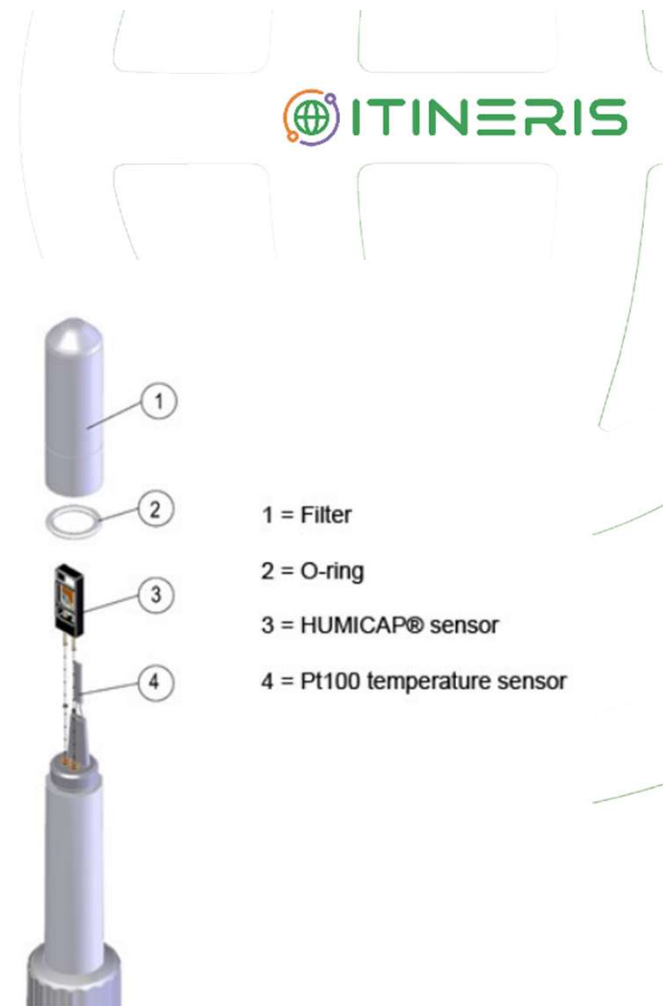
## VAISALA HMP155A

🌐 Type of measurement: **digital** (RS-485)

🌐 What it measures: **Air temperature and RH**

🌐 Technology: **capacitive** thin film polymer sensor (RH)  
– effect of humidity on the dielectric constant of a polymer. **PRT** (Temp) - platinum wire whose resistance is proportional to temperature

🌐 Output: % and K or °C



*(from sensor manual)*

# Campbell Scientific HygroVUE

🌐 Type of measurement: **digital** (SDI-12)

🌐 What it measures: **Air temperature and RH**

🌐 Technology: single **chip** element

🌐 Output: % and K or °C

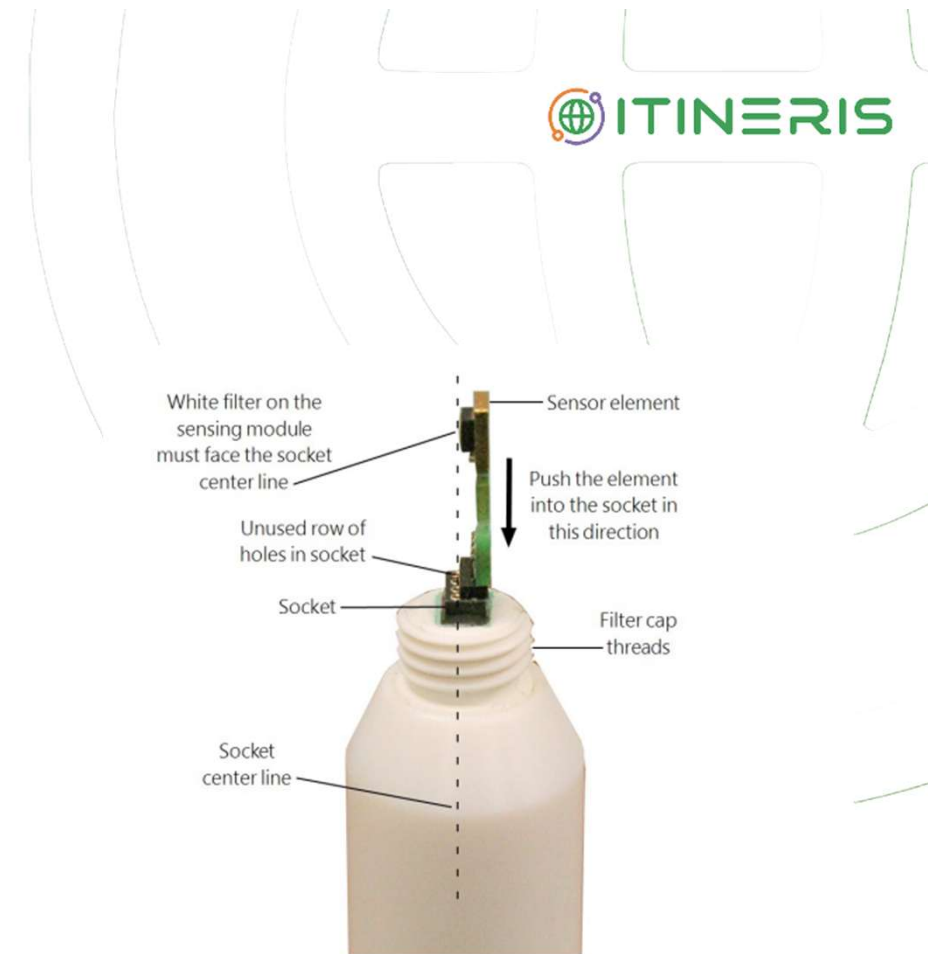


Figure 9-1. Correct fit of the 4-pin sensor element (side view)

*(from sensor manual)*



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**THANKS!**

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Mission 4 "Education and Research" - Component 2: "From research to business" - Investment  
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"

