ZooCADA™ - Met

Weather Station System

Version R01

Reference Manual

Copyright Notice

ZooCADA-Met Version R01 Reference Manual

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System Overview

The ZooCADA-Met Weather Station System is a software program and hardware system designed to monitor the local climate at zoological facilities. The general design concept is to eliminate any need for staff to use manual instruments to collect data for routine climate monitoring; instead ZooCADA-Met does it automatically, allowing staff to focus on more productive activities. The weather station is designed to operate standalone or as part of a network of ZooCADA stations. It is equally suitable for standalone deployment in many other situations where reliable climate data needs to be recorded.

Each ZooCADA-Met system comprises of a datalogger, it's peripherals, an all-in-one weather sensor or selection of sensors, and is designed to monitor and record the local climate while serving climate data via the network to other network connected ZooCADA stations. On the network, each datalogger is referred to as a station.

The system is designed to monitor air temperature, relative humidity, dew point temperature, vapour pressure deficit, barometric pressure, solar radiation, wind speed and direction, precipitation (rainfall) and lightning strikes. It can optionally monitor and record soil volumetric water content and soil temperature. The climate instrument measurements are logged each hour on the hour and each day at midnight. Soil instrument measurements are also logged hourly with a daily summary.

The air temperature, relative humidity, dew point temperature, vapour pressure deficit and barometric pressure are logged as the average value over the preceding minute. Solar radiation, rainfall and lightning strikes are totalised, while wind speed and direction are logged as wind vector direction and speed. Soil moisture, averaged over the top 300 mm of soil depth, and soil surface temperature are recorded hourly, with daily summaries containing the minimum, maximum, and average measurements logged at midnight. This data can be used by staff to assist with research and animal welfare management.

Alarms are provided for severe weather events of high rainfall, high wind speed, high air temperature and low air temperature to alert staff and enable appropriate hazard mitigation actions to be taken in a timely manner. A table of high and low temperature setpoints for each month of the year, along with setpoints for high wind speed and high rainfall, are set to meet site specific requirements. Alarms are also provided for power failure, communications failure, and weather sensor failure as these failures may affect the station's ability to operate correctly.

All alarms are delivered via email messages which are sent to a list of email addresses of key staff. The alarm email messages are designed to be conspicuous in busy email inboxes, and self explanatory to the recipients. Each message states the current alarm, or list of current alarms if multiple alarms are active, and gives the current measurements for temperature, relative humidity, barometric pressure and its tendency, rainfall and wind speed, so staff can make informed decisions in respect of how quickly they need to attend to the problem(s). The system also sends a reminder email message each morning to remind staff of any outstanding alarms that have not yet been cleared.

As with all of our datalogger based systems, staff can connect to the datalogger across the local area network to view the current conditions at each station and all of the operating parameters active in the datalogger. If the site's local area network is set up to allow remote access, dataloggers can also be configured to allow remote monitoring and support with password controlled access that can be unique to each datalogger in a zoo-wide system.

Program Features

Data Logging

- Weather parameters logged hourly and daily:
- - Air temperature and relative humidity average of previous minute.
- - Air dew point temperature and vapour pressure deficit average of last minute.
- - Barometric pressure calibrated to mean sea level average of last minute.
- - Solar radiation, either in kilowatt hours or megajoules, total.
- - Wind vector direction and speed.
- - Wind maximum gust and gust direction.
- - Air temperature maximum and time of maximum.
- - Air temperature minimum and time of minimum.
- - Air relative humidity maximum and time of maximum.
- - Air relative humidity minimum and time of minimum.
- - Lightning strikes total count, average and minimum distance.
- Soil volumetric water content and temperature logged hourly. (Optional)
- Soil volumetric water content and temperature average, maximum and minimum logged daily. (Optional)
- Datalogging memory in excess of 1 year between downloads before memory overwrite.
- Data logged to ring memory so oldest data is overwritten first when memory full.
- Data files downloadable to Windows based PC using Campbell Scientific LoggerNet software.
- Data graphing from Windows based PC using Campbell Scientific LoggerNet software.

Alarms

- Power failure. (The electricity supply to the station has failed)
- Communications failure. (The station can't obtain data from another station)
- Weather sensor failure. (Alerts operators of problems with any of the weather sensors)
- Air temperature too high or too low. (With high and low setpoints for each month)
- High rainfall. (With per hour and per day set points)
- High wind. (With average speed and maximum gust setpoints)

General

- Battery backup of datalogger 12V power so system keeps logging data during power failure.
- Alarm messages sent via email to staff.
- Communications to stations via LAN enables staff to monitor system operation.
- Communications to stations via LAN enables automated or manual collection of logged data.
- System maintenance from Windows based PC using Campbell Scientific LoggerNet software.

ZooCADA-Met is a station of our modular control and data acquisition system. Each station can operate standalone or as an integral part of a fully networked, zoo-wide, system with various stations performing different tasks. Using our modular approach, up to 4000 stations, distributed over any geographic area, can be networked provided that network connectivity (typically the site's IP computer network) is available at each station.

Adena Scientific believes that accuracy and reliability are paramount requirements of any system used in animal welfare roles so we purpose designed our ZooCADA system to meet zoological needs and built it to run on dataloggers manufactured by Campbell Scientific in the USA and available worldwide.

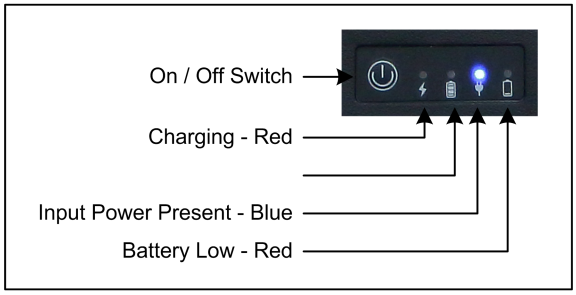
Uninterruptible Power Supply

An uninterruptible power supply (UPS) ensures the datalogger continues to record data and transmit alarms during power failure events. The UPS is a DC-DC type, with an integral lithium-ion rechargeable battery. Its input is 12 Vdc, which comes from a mains powered power supply, and its output is 12 Vdc, which is used to power the datalogger and control system.

When the UPS input is receiving 12 Vdc from the mains power supply, the 12 Vdc is routed through the UPS to the UPS output to power the datalogger and control system. Up to approximately 0.6 Amp is simultaneously supplied to the battery charging circuit to keep the internal battery charged. If the input 12 Vdc power to the UPS is interrupted, the UPS battery automatically takes over supplying 12 Vdc to the UPS output to power the datalogger and its peripherals, and continues to do so until either the 12 Vdc input power is restored or the battery becomes fully discharged.

UPS Power Switch and LED Indicators

The UPS is fitted with an On/Off switch and four LED indicators as shown in the diagram below.



On / Off Switch

The On/Off switch only operates when there is no input power available to the UPS. As long as the UPS battery is charged and input power is available, the UPS output will automatically switch ON to provide output power.

When input power is not available the On/Off switch can be used to shutdown the UPS. One press switches ON the UPS and two presses switches OFF the UPS. This function is provided to allow the system to be powered down for maintenance without discharging the UPS battery.

Charging Indicator

The charging indicator is a Red LED next to the lightning bolt symbol.

The indicator is lit while the battery being charged.

The indicator is off when the battery is fully charged.

Battery Power Only Indicator

The battery power only indicator is a Blue LED next to the battery symbol.

The indicator is lit while the UPS output power is being supplied only from the battery.

The indicator is off when input power is available.

Input Power Present Indicator

The input power present indicator is a Blue LED next to the power plug symbol.

The indicator is lit while the UPS output power is being supplied from the input power.

The indicator is off when input power is not available.

Battery Low Indicator

The battery low indicator is a Red LED next to the low battery symbol.

The indicator is lit when the UPS battery is almost flat.

The indicator is off when the battery is charged.

UPS Run Time

The length of time the UPS will operate to power the datalogger depends on several variables including the number of sensors that are connected, the amount of data communications activity, the age and condition of the battery, and how charged the battery is when the UPS starts operating.

Testing with a new and fully charged UPS has shown that the UPS can power the datalogger, and several sensors for about 20-24 hours.

Storing the UPS

To shutdown the UPS for an extended period of time, such as when being placed into storage, first disconnect the input power so the UPS begins operating from its internal battery power, then immediately press the On/Off switch two times to switch the UPS OFF. All the LEDs will switch OFF. The UPS can now be safely stored.

When stored, the UPS battery will self-discharge at a rate that is greatly affected by the ambient temperature. The UPS should therefore be fully charged before being placed into storage and, if it is to be kept stored for an

extended period of time, the UPS should be periodically recharged to prevent the battery deteriorating and loosing its original capacity.

As a guide the UPS should not be stored for longer than the periods of time below without being recharged...

6 months at 20^{O} C

3 months at 30^{O} C

2 months at 35^{O} C

UPS Specifications

Input: 12 Vdc, 3 Amps

Output: 12 Vdc, 2.5 Amps (Rated), 3 Amps (Max)

Input Connector: 2.1 mm DC Socket

Output Connector: 2.5 mm DC Plug

Over Current Protection: 3.5 Amps +/- 0.5 Amp

Battery Capacity: 7.4 V, 4000 mAh (29.6 Wh)

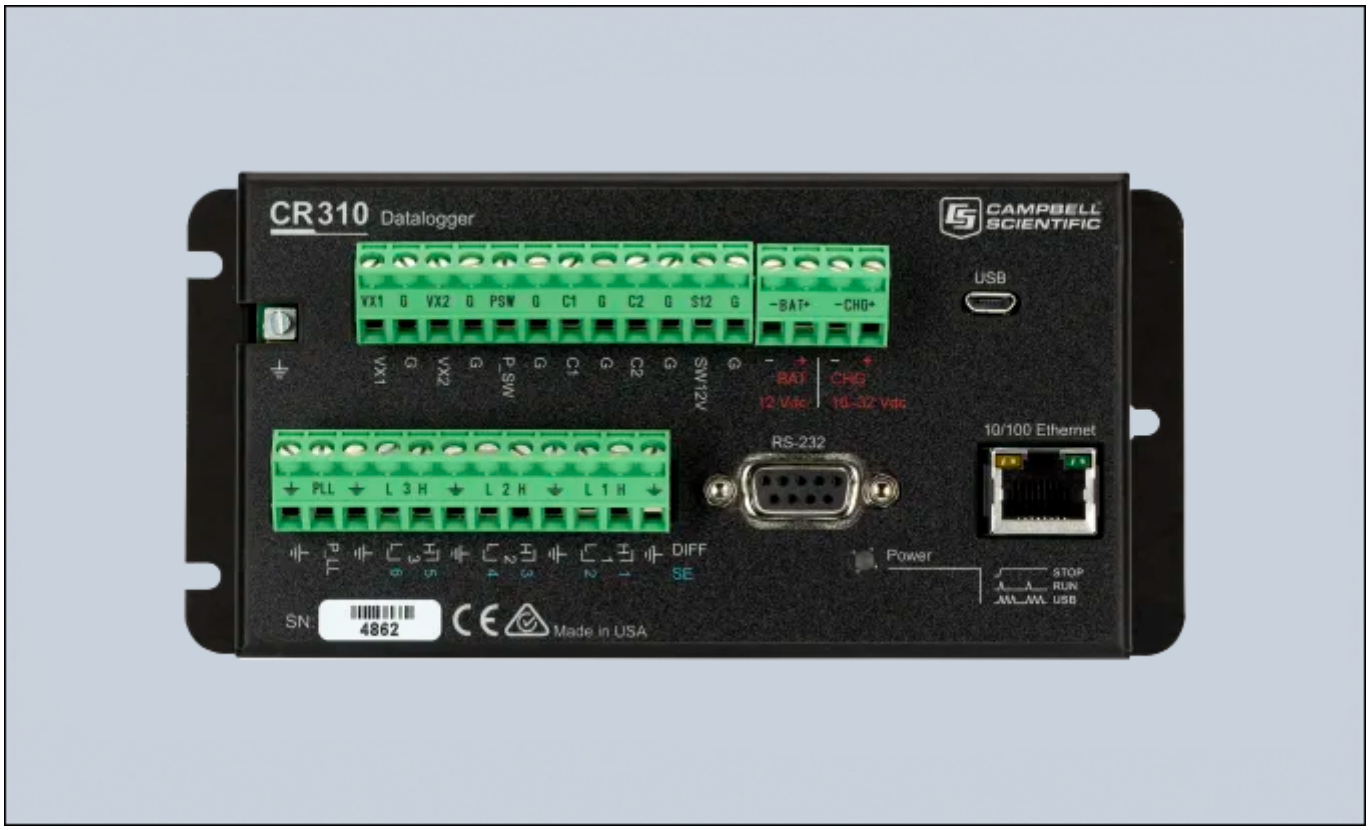
Alternative Sealed Lead Acid Battery UPS

The CR310 datalogger has a built-in charging system for Sealed Lead Acid batteries. A mains power supply with 24 Vdc output is connected to the CHG terminals on the datalogger and a 1.3 AH Sealed Lead Acid battery is connected to the BAT terminals. The datalogger draws it's power from the battery and, while mains power is available, the datalogger's charging system maintains the battery in a fully charged state. During a power failure the datalogger continues to draw its power from the battery until the battery becomes fully discharged.

WARNING: A fuse must always be installed, as close to the battery as possible, in the positive wire that runs from the datalogger to the battery to prevent risk of fire if a short circuit occurs. Do not bypass a blown fuse. Always replace fuses with the correct type.

The Sealed Lead Acid battery option offers a cost advantage over the lithium iron battery DC-DC UPS system but a Sealed Lead Acid battery is likely to need more frequent replacement, typically about once every three years. Lithium iron batteries can be discharged to about 85% of their capacity, whereas Sealed Lead Acid batteries can only be discharged to about 50% of their capacity, without causing damage to the battery. This may become a consideration in areas where mains power failures tend to be of a long duration, but in areas where mains power failures seldom extend over a prolonged period of time, Sealed Lead Acid batteries will provide a perfectly good UPS solution.

Datalogger CR310



This section is intended for maintenance and support purposes. There are no controls or adjustments on the datalogger, it's simply wired into the station and runs the software that is loaded into it.

The CR310 datalogger is the programmable heart of a ZooCADA-Met station. It has a range of inputs and outputs that send and receive sensor data and other control signals, and provides network connectivity so users can interrogate the control system from a computer via the network. It also records the measurements obtained from the sensors and retains that data in memory from where it can be downloaded to a computer at a later date.

The datalogger can be powered down, if necessary, by withdrawing the combined battery and charger connector. Always download the data from the datalogger before powering it down. The datalogger has an internal battery to maintain it's memory if power is removed but, if that battery has become weak due to age, data loss may occur.

Computer and Network Connections

The 10/100 Ethernet connector is used to connect the datalogger to the local area network (LAN) so it can be accessed via other computers, either using the Campbell LoggerNet software or by using a web browser, and is able to transmit alarm email messages to recipients via the Internet.

Please refer to section "7. Setting up Communications with the Datalogger" in the CR310 Product Manual, which can be downloaded from the Campbell Scientific web site, for full information on set up procedures.

After being connected to a LAN for about one minute, the LEDs on the connector will indicate the status of the network connection as follows...

Orange LED - Off for no link, Solid for valid Ethernet link, Flashing for Ethernet activity.

Green LED - Off for 10 Mbps link, Solid for 100 Mbps link.

The datalogger can obtain a dynamic IP address from the DHCP server on the LAN, but we strongly recommend that it be configured with a static IP address. When multiple stations are installed on a site, a static address makes it easier to set up stations to communicate with one another across the LAN and simplifies routing to the Internet for off-site access. These network settings are configured using the "Device Configuration Utility" in the LoggerNet software.

The USB connector allows direct connection, using a ordinary USB cable, to any Windows computer that has the Campbell LoggerNet software installed on it. This is used when carrying out the initial configuration of the datalogger, and for maintenance or data collection as an alternative to a LAN connection when desired.

Inputs and Outputs

Users need not be concerned with the datalogger inputs and outputs for the usual operation of the system. This information is provided to assist with diagnostic tests in case it is needed.

Analog Inputs

The datalogger has six single ended (SE) analog inputs, labelled 1 to 6 with blue numbers on the datalogger panel. The voltages measured on single ended inputs are measured with respect to datalogger ground. The datalogger measures the analog inputs once each time the program scans, which is every two seconds.

SE1 - Power Good Indication.

When the mains power is available and the power supply is producing 12 Vdc, this input will be steady at approximately 2000 mVdc. During a power failure it will return to 0 Vdc. The power failure alarm is triggered if this voltage falls below 1000 mVdc.

SE2 - Not Used.

SE3 - Not Used.

SE4 - Not Used.

SE5 - Not Used.

SE6 - Not Used.

Pulse Inputs

The datalogger has two pulse counter inputs labelled P_SW and P_LL.

P_SW - Not Used.

The pulse input P_SW operates on pull-to-ground switch closure.

This port is not currently used.

P_LL - Not Used.

The pulse input P_LL accepts low voltage (20 V max) AC signal.

This port is not currently used.

Excitation Outputs

The datalogger has two excitation outputs, labelled VX1 and VX2 on the datalogger panel. These excitation outputs are designed to be used to provide excitation voltage for various analog sensors that are typically used on the datalogger's analog measurement inputs.

VX1 - Provides 2400 mV pulse for optional scan indicator LED.

VX2 - Not Used.

Control Ports

The datalogger has two control ports labelled C1 and C2 on the datalogger panel. These are programmable ports that can be software configured for use as logic inputs, logic outputs, pulse counters, and data ports.

C1 - SDI-12 Sensor Data Bus.

SDI-12 is an asynchronous serial data communications protocol designed for intelligent environmental monitoring sensors. It is possible to use up to sixty two SDI-12 sensors on a single SDI-12 bus using the addresses 0-9, A-Z, and a-z but using this many sensors on a single bus is not recommended. Each sensor must be set to its own unique address.

NOTE: New sensors are set to a default address of "0" and, unless that is the required address, must be changed to the required address before use.

The SDI-12 bus on control port C1 is used for the sensors that are permanently fixed in position for the enclosure air temperature and relative humidity and, if installed, the external (outside) air temperature and relative humidity. The address allocations normally used by the ZooCADA system are:

Address 0 - Outside air temperature and relative humidity, or All-In-One weather sensor.

Address 1 - Enclosure 1 air temperature and relative humidity sensor.

Address 2 - Enclosure 2 air temperature and relative humidity sensor.

Address 3 - Barometric pressure sensor. (Optional)

Address a - Enclosure 1 soil moisture sensor. (Optional)

Address b - Enclosure 2 soil moisture sensor. (Optional)

C2 - This port is not currently in use.

RS232 Port

The datalogger includes an 9-pin D-sub connector labelled RS-232. This is a standard RS-232 interface for communications between Campbell Scientific dataloggers and various external devices. This port is not currently used.

Data Storage Memory

Measurement data is normally stored in data tables within SRAM (Static Random Access Memory). During data table initialisation, memory is allocated to each data table according to parameters defined in the program.

An internal lithium battery retains the SRAM memory when primary power is removed.

WARNING: Always download data from the datalogger before making any program changes. Depending upon settings, data may be erased from this memory area when a program is sent to the datalogger.

To preserve the existing data when sending a program update to the datalogger that does not affect the data tables, such as when changing temperature setpoints, simply select the Preserve data if no table changed radio button in the dialog box before clicking the [Send] button .

The data memory is organised as ring memory so that when the memory is full, oldest data is overwritten by newest data. To see the total number of records that can be stored in memory before data overwriting begins, or to reset the data tables, select Station Status > Table Fill Times from the Connect Screen in the LoggerNet software. The datalogger program sets the memory so that an equal number of days will be stored in the various data tables.

A CR310 datalogger can store several months of data before memory overwrite occurs. To prevent risk of data loss due to overwriting of the ring memory, or any other cause, download the data manually on a regular basis or set up LoggerNet to download it automatically on a regular time schedule.

Power Circuits

Users need not be concerned with the datalogger power circuits for the usual operation of the system. This information is provided to assist with diagnostic tests in case it is needed.

Datalogger 12 Vdc Power Input

The datalogger is powered by 12 Vdc, from the UPS, which is applied via the battery and charger connector which is the main power to the system. Unplugging this connector will power down the datalogger and its sensors. The battery/charger connector provides pins for + and - 12 Vdc . In this system all +12 Vdc power circuits into and out of the datalogger are RED wires.

Datalogger 12 Vdc Switched Power Output

The datalogger switched power output SW12V terminal is not used in this system.

Power Ground

The terminals on the datalogger panel marked G are the power ground terminals. Each device that is connected to the +12 Vdc power terminal must have its ground (-ve or common) wire connected to one of the G terminals. In this system all power ground circuits are BLACK wires.

Analog Ground

The terminals on the datalogger panel marked ⏚ are analog ground for single ended analog inputs, excitation returns, and a ground for sensor shield wires. Do not connect power ground wires to the analog ground.

Station Setpoints File

```
'*****************************************************************************************************************
'* ZooCADA-Met Weather Station System                                                                            *
'* Station Setpoints File For:                                                                                   *
'* Copyright 2015-2023 Adena Scientific Limited                                                                  *
'* Datalogger: Campbell Scientific CR300 Series                                                                  *
'* File name: STATION_SETPOINTS_ZMET_R01.CR300                                                                   *
'* Revision Date: 2025-01-22                                                                                     *
'*****************************************************************************************************************

'Temperature Setpoints.
'WARNING: Must be at least 4 degrees C difference between HI and LO setpoints.
'Setpoints are used for temperature alarms.
'
ConstTable(Setpoints)                          'Beginning of editable constants table
  '
  'Monthly Temperature Setpoints.
  Const SET_JAN_HI = 35.0                      'January Day Hi Temperature deg C
  Const SET_JAN_LO = -5.0                      'January Night Lo Temperature deg C
  '
  Const SET_FEB_HI = 35.0                      'February Day Hi Temperature deg C
  Const SET_FEB_LO = -5.0                      'February Night Lo Temperature deg C
  '
  Const SET_MAR_HI = 35.0                      'March Day Hi Temperature deg C
  Const SET_MAR_LO = -5.0                      'March Night Lo Temperature deg C
  '
  Const SET_APR_HI = 35.0                      'April Day Hi Temperature deg C
  Const SET_APR_LO = -5.0                      'April Night Lo Temperature deg C
  '
  Const SET_MAY_HI = 35.0                      'May Day Hi Temperature deg C
  Const SET_MAY_LO = -5.0                      'May Night Lo Temperature deg C
  '
  Const SET_JUN_HI = 35.0                      'June Day Hi Temperature deg C
  Const SET_JUN_LO = -5.0                      'June Night Lo Temperature deg C
  '
  Const SET_JUL_HI = 35.0                      'July Day Hi Temperature deg C
  Const SET_JUL_LO = -5.0                      'July Night Lo Temperature deg C
  '
  Const SET_AUG_HI = 35.0                      'August Day Hi Temperature deg C
  Const SET_AUG_LO = -5.0                      'August Night Lo Temperature deg C
  '
  Const SET_SEP_HI = 35.5                      'September Day Hi Temperature deg C
  Const SET_SEP_LO = -5.0                      'September Night Lo Temperature deg C
  '
  Const SET_OCT_HI = 35.0                      'October Day Hi Temperature deg C
  Const SET_OCT_LO = -5.0                      'October Night Lo Temperature deg C
  '
  Const SET_NOV_HI = 35.0                      'November Day Hi Temperature deg C
  Const SET_NOV_LO = -5.0                      'November Night Lo Temperature deg C
  '
  Const SET_DEC_HI = 35.0                      'December Day Hi Temperature deg C
  Const SET_DEC_LO = -5.0                      'December Night Lo Temperature deg C
  '
  'Heavy rain setpoints.
  Const SET_RAIN_HOUR_HI = 10                  'Rain hourly total high setpoint in mm
  Const SET_RAIN_DAY_HI = 100                  'Rain daily total high in mm (NIWA 100mm within 24 hours)
  '
  'Strong wind setpoints.
  Const SET_WIND_SPEED_HI = 23                 'Wind speed high setpoint in m/s (NIWA 90 km/h = 25 m/s)
  Const SET_WIND_GUST_HI = 28.5                'Wind gust speed high in m/s (NIWA 110mm km/h = 30.5 m/s)
  '
EndConstTable                                  'End of editable constants table

'*****************************************************************************************************************
'*                                          END OF INCLUDE FILE                                                  *
'*****************************************************************************************************************
```

Station Setpoints File

The station setpoints are constants that determine the high and low air temperatures, the high rainfall, and the high wind speed settings for the weather station alarms. When the current measurement for one or more of those settings exceeds the setpoint, the appropriate alarms are triggered. There is a separate pair of temperature setpoints for each month of the year to enable different temperatures to be used for the seasons if desired.

The station setpoints constants are programmed into a structure called a constants table which can be edited using the CRBasic Editor, or by using the datalogger's built-in web site while logged in with administrator level privileges, the later being the easier and recommended method. The setpoints table is stored in a separate program file named STATION_SETPOINTS_ZLOG_R01, hereinafter simply referred to as the STATION_SETPOINTS file, so they are not overwritten whenever an updated program is uploaded to the datalogger.

To change the station setpoints constants by editing the STATION_SETPOINTS file it is necessary to use the CRBasic editor, then load the updated file into the datalogger. To do so, users need to have access to the program code on a Windows computer that has the Campbell Scientific LoggerNet program suite installed on it.

For full information on using the LoggerNet software please refer to the LoggerNet Manual which is downloadable from the Campbell Scientific web site.

IMPORTANT: When editing setpoints ensure that only the numeric value is changed. Do not change anything else, especially the constant name or the = sign otherwise compile errors will be the likely result.

To change the setpoint constants using the datalogger's built-in web site, first login to the web site as an administrator, then select the Setpoints data table from the list of available tables. Edit the desired value(s) by double clicking on the current value, typing in the new value, and pressing the [Enter] key.

Once the change(s) are complete move down to the ApplyAndRestart value, the last value in the table, and change it from false to true then press the [Enter] key. This will cause the datalogger to restart and put the newly entered values into effect.

If the STATION_SETPOINTS file is edited using the CRBasic editor, it is essential to manually stop the program running and then restart it so the datalogger will recompile the program and make the new setpoints operational.

Do not change the name of the STATION_SETPOINTS file. The datalogger expects this file to be present and cannot run the program without it.

Air Temperature Setpoints

The high and low temperature alarm setpoints, in degrees Celsius, for each month.

```
Const SET_JAN_HI = 30.0
Const SET_JAN_LO = -5.0
```

The constant pair for each month is identified with three characters JAN, FEB, MAR, and so on, representing the calendar month that the setpoints correspond to.

Decimal values. The high and low air temperatures at which a temperature alarm is triggered. The default values are 30 degrees for the high setpoint and -5 degrees for the low setpoint.

There MUST be a minimum of four degrees Celsius between the high and low value in each pair and the high setpoint must always be higher than the low setpoint. If a setpoints error is detected an error is displayed in the Public data table Month variable. If an air temperature setpoints error is detected, the setpoints will default to 30 degrees Celsius for the high setpoint and 2 degrees Celsius for the low setpoint until the error is corrected.

Staff receiving this alarm can take action to mitigate the effects of the extreme temperature.

Rainfall Setpoints

The high rainfall alarm setpoints, in millimetres.

```
Const SET_RAIN_HOUR_HI = 10
Const SET_RAIN_DAY_HI = 100
```

Decimal values. The amount of rainfall at which the high rainfall alarm is triggered. The defaults are 10 mm for the hourly setpoint and 100 mm for the daily setpoint.

If the RainHour total displayed in the Public data table exceeds the SET_RAIN_HOUR_HI setpoint, the high rainfall alarm is triggered. This setpoint should be set to the amount of rain, from a sudden torrential downpour, that's likely to result in flooding within the zoo park. Note that the RainHour measurement is a sixty minute rolling total that updates every minute.

If the RainDay total displayed in the Public data table exceeds the SET_RAIN_DAY_HI setpoint, the high rainfall alarm is triggered. This setpoint should be set to the amount of rain, from persistent heavy rain throughout a day, that's likely to result in flooding within the zoo park. The RainDay total is reset to zero each day at midnight.

Wind Setpoints

The high wind alarm setpoints, in metres per second.

```
Const SET_WIND_SPEED_HI = 23.5
Const SET_WIND_GUST_HI = 28.5
```

Decimal values. The wind speed at which the high wind speed alarm is triggered. The defaults are 23.5 m/s for ongoing high wind speed and 28.5 m/s for the wind gust.

If the WindVectSpd displayed in the Public data table exceeds the SET_WIND_SPEED_HI setpoint, the high wind alarm is triggered. This setpoint should be set to the wind speed at which damage within the zoo park, such as tree limbs breaking off, may result. Note that the WindVectSpd measurement is a ten minute rolling average that updates every minute.

If the GustSpdHour displayed in the Public data table exceeds the SET_WIND_GUST_HI setpoint, the high wind alarm is triggered. This setpoint should be set to the wind gust speed at which damage within the zoo park, such as tree limbs breaking off, may result. Note that the GustSpdHour measurement is the maximum wind gust speed for the hour. The GustSpdHour value is reset to zero hourly on the hour.

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Station Constants File

```
'*************************************************************************************************************
'* ZooCADA-Met Weather Station System                                                                        *
'* Station Constants File For:                                                                               *
'* Copyright 2015-2023 Adena Scientific Limited                                                              *
'* Datalogger: Campbell Scientific CR300 Series                                                              *
'* File name: STATION_CONSTANTS_ZMET_R01.CR300                                                               *
'* Revision Date: 2025-02-13                                                                                 *
'*************************************************************************************************************

'Declare General Station Constants.
Const ENCLOSURE As String = "WEATHER STATION"    'Enclosure name
Const CUSTOM_FILE = False                        'Customisation file enabled True/False

'Declare Alarms Module Constants.
Const ALARM_ENABLE = True                        'Alarm enable = true, disable = false
Const ALARM_DEGREES = 0                          'Alarm temperature triger over setpoint (Normally 0)
Const ALARM_RESET = 2                            'Alarm temperature reset under setpoint (Normally 2)

'Declare Email Module Constants.
Const EMAIL_ENABLE = True                        'Enable sending of alarm email messages (True/False)
Const EMAIL_TEST = True                          'Divert alarm email messages to test file (True/False)
Const EMAIL_RESEND = 300                         'Resend time for alarm emails time in seconds (min 10 seconds)
Const EMAIL_TRIES = 3                            'Number of times to resend new alarm states (Typically 3)
Const EMAIL_NAG = True                           'Resend email outstanding alarms daily at NAG_HOUR True, False
Const EMAIL_NAG_HOUR = 8                         'Hour of the day to resend outstanding alarms.
Const EMAIL_ATTACH = ""                          'Email attachment file name (if desired)

'Declare Email Module Email Recipient Email Addresses.
'(Separate multiple addresses with commas).
Const TO_ADDR = "my.name@mycompany.co.nz, manager@mycompany.co.nz"

'Declare Comms Module Station Address Constants.
Const EXT_TRH1_ENABLE = False                    'Ext T/RH primary remote station enable true/false
Const EXT_TRH1_PK = 91                           'Ext T/RH primary remote station pakbus address
Const EXT_TRH1_IP As String = "192.168.10.91"    'Ext T/RH primary remote station IP address
Const EXT_TRH2_ENABLE = False                    'Ext T/RH secondary remote station enable true/false
Const EXT_TRH2_PK = 92                           'Ext T/RH secondary remote station pakbus address
Const EXT_TRH2_IP As String = "192.168.10.92"    'Ext T/RH secondary remote station IP address
Const MAX_COMMS_FAILS = 6                        'Maximum Number of comms failures before alarm
Const COMMS_PRIORITY = 2                         'Comms priority. REFER TO MANUAL!

'Declare Installed Sensor Options.
Const GUST_INSTALLED = True                      'AIO produces wind gust speed data (True/False)
Const TILT_INSTALLED = True                      'AIO produces sensor tilt N-S and W-E data (True/False)
Const LTNG_INSTALLED = True                      'AIO produces lightning data (True/False)
Const GRASS_INSTALLED = False                    'Separate grass temperature sensor installed (True/False)
Const PYRO_INSTALLED = False                     'Separate pyranometer sensor installed (True/False)
Const TBRG_INSTALLED = False                     'Separate tipping bucket rain gauge installed (True/False)
Const SOIL_INSTALLED = False                     'Separate soil moisture sensor installed (True/False)

'Declare External Temp/RH Local Sensor Constant.
Const EXT_SDI_ADDR As String = "0"               'Ext all-in-one weather sensor SDI-12 address (Normally "0")
Const EXT_TRH_PRIMARY = True                     'Ext T/RH local sensor (True = primary, False = secondary)

'Declare Soil Moisture Sensor Constants.
Const EXTSOIL_SDI_ADDR As String = "c"           'External Soil sensor SDI-12 address (Normally "c")

'Declare Barometric Pressure Sensor Constants.
Const BARO_STN_ELEV = 47                         'Barometer pressure sensor elevation in metres above MSL

'Declare Solar Radiation Sensor Constants.
Const SOLAR_SDI_ADDR As String = "d"             'Pyranometer SDI-12 address if separately installed (Normally "d")
Const SOLAR_KWH = False                          'Record solar radiation totals as kWh. (True kWh / False MJ)

'*************************************************************************************************************
'*                                          END OF INCLUDE FILE                                              *
'*************************************************************************************************************
```

Station Constants File

The station constants determine various operating parameters for the station. They are intended to be configured during system commissioning and usually don't need changing later.

The station constants are stored in a separate program file named STATION_CONSTANTS_ZLOG_R01, hereinafter simply referred to as the STATION_CONSTANTS file, so they are not overwritten whenever an updated program is uploaded to the datalogger.

To change the station constants it is necessary to edit the STATION_CONSTANTS file, then load the updated file into the datalogger. To do so, users need to have access to the program code on a Windows computer that has the Campbell Scientific LoggerNet program suite installed on it.

For full information on using the LoggerNet software please refer to the LoggerNet Manual which is downloadable from the Campbell Scientific web site.

If the STATION_CONSTANTS file is edited using the CRBasic editor, it is essential to manually stop the program running and then restart it so the datalogger will recompile the program and make the new setpoints operational.

Do not change the name of the STATION_CONSTANTS file. The datalogger expects this file to be present and cannot run the program without it.

IMPORTANT: When editing constants ensure that only the numeric value is changed. Do not change anything else, especially the constant name or the = sign otherwise compile errors will be the likely result.

Enclosure Name

The name that is used to identify the station for the web interface and in alarm email messages.

```
Const ENCLOSURE As String = "WEATHER STATION"
```

Set the text between the "" marks to a suitable name. The maximum length is 25 characters including spaces.

Customisation File

Flag determines whether or not the station has a customisation file.

```
Const CUSTOM_FILE = False
```

Logical True or False. Normally set to False unless a customisation file has been created for the station.

Customisation files enable code for additional sensors and/or special processing to be added to the station program without changing the standard station program file.

Alarm Enable

Flag determines whether or not the alarm system should be operational.

```
Const ALARM_ENABLE = True
```

Logical True or False. Normally set to True unless an ongoing maintenance problem is causing excessive nuisance alarms, in which case it can be set to False until the problem can be resolved. The alarms must be enabled in order for alarm events to be written to the Event Log data table.

Temperature Alarm Trigger Level

The number of degrees beyond the temperature setpoint at which an alarm is triggered.

```
Const ALARM_DEGREES = 0
```

A decimal value. Normally kept at 0 degrees. If the enclosure temperature either rises above the high setpoint or falls below the low setpoint by ALARM_DEGREES, it will trigger a temperature alarm. For example, if the enclosure high setpoint is 16 degrees and ALARM_DEGREES is set to 4, the high temperature alarm will be triggered at 20 degrees.

Temperature Alarm Reset Level

The number of degrees beyond the temperature setpoint at which to reset the alarm.

```
Const ALARM_RESET = 2
```

A decimal value. Typically about 2 degrees. A temperature alarm is reset when the enclosure temperature returns to less than ALARM_RESET past the high or low temperature setpoint. For example, if the enclosure low setpoint is 10 degrees and ALARM_RESET is set to 2, the low temperature alarm will reset at 8 degrees Celsius.

Email Enable

Flag determines whether or not the email system should be operational.

```
Const EMAIL_ENABLE = True
```

Logical True or False. Normally set to True unless there is no internet connectivity available, or an ongoing maintenance problem is causing excessive nuisance emails, in which case it can be set to False until the problem can be resolved.

NOTE: The Campbell Scientific Email Relay server has a limit of 100 emails per day (USA time) from any given datalogger which, if exceeded, results in the Email Relay server rejecting further emails from that datalogger until the next day.

Email Test

Flag determines whether or not the email system is to operate in test mode and divert email messages to a file.

```
Const EMAIL_TEST = False
```

Logical True or False. Normally set to False unless email messages are to be diverted to a file for test purposes. The file name is EmailTest.txt and is stored in the datalogger. This function allows extensive testing of the alarms and email messaging systems without actually sending the email messages via the Email Relay server.

Email Resend

The number of seconds between retry attempts when an email message fails to send.

```
Const EMAIL_RESEND = 300
```

An integer value. Normally set in the range of 60 seconds to 300 seconds (1 to 5 minutes). This value MUST be a multiple of the program scan rate (normally 2 seconds) or the timer will malfunction.

Email Tries

The number of times the email system attempts to send an email message.

```
Const EMAIL_TRIES = 3
```

An integer value. Normally set in the range of 1 to 4. A value of 1 means the system will only attempt to send an email message once, if it fails to send there are no retries. A value greater than 1 enables the email system to retry sending an email message that failed to send on the first attempt. Retries are at the interval determined by the constant EMAIL_RESEND, see above.

Email Daily Resend Enable

Flag indicates if an alarm email reminder message should be sent once each day for outstanding alarms.

```
Const EMAIL_NAG = True
```

Logical True or False. Normally set to True unless users prefer to not have an alarms email message sent to them daily as a reminder of any alarms that have not yet been cleared.

Email Daily Resend Time

The hour of the day at which the daily alarm resend is to occur.

```
Const EMAIL_NAG_HOUR = 8
```

Set to a number between 0 and 23, zero being midnight and 1 to 23 being the hour of the current day. Normally set to 8 for 08:00am so emails arrive among the first inbox deliveries for the day so staff have the opportunity to schedule whatever response they consider appropriate into their day. These email messages will be sent an hour earlier during Daylight Savings time as the datalogger is always operating on Standard Time.

Email Attachment File Name

The filename of a file to be sent as an attachment with each alarm email message.

```
Const ATTACH = ""
```

Not currently used. The filename is entered between the quotes and must be present in the datalogger's file storage space. If no attachment is desired, empty quotes must be defined.

Email Message Recipients

The email addresses of the staff who are to receive alarm email messages.

```
Const TO_ADDR = staff1.name@domain, staff2.name@domain, staff3.name@domain
```

A comma separated list of the email addresses for all the staff who are to receive the alarm messages from this station. Each station can have a different email recipient list so alarms can be sent to the staff member(s) usually responsible for each specific animal enclosure.

Primary Remote Station Communications

Flag enables or disables network communications to the primary remote station.

```
Const EXT_TRH1_ENABLE = False
```

Logical True or False. Normally set to True unless this station has the only external temperature and RH sensor on the network. If this station has an external temperature and RH sensor installed, a remote station can provide a second pair of external sensor values. If this station has no external sensor installed, the primary remote station provides the external temperature and RH sensor values for use by this station.

Primary Remote Station PakBus Address

The PakBus address of the primary remote station.

```
Const EXT_TRH1_PK = 91
```

An integer value. Each station on the network has a unique PakBus address in the range from 1 to 3999. PakBus addresses from 4000 to 4094 are reserved for software such as LoggerNet. By convention we use the same number for the PakBus address as the last octet of the dataloggers IPv4 network address when IPv4 network addressing is in use.

Primary Remote Station IP Address

The static IP address of the primary remote station.

```
Const EXT_TRH1_IP = 192.168.10.91
```

An integer value. Each station on the network has a unique IPv4 or IPv6 address. If possible, use the number of the last octet of the station IPv4 network address for the PakBus address when IPv4 addressing is in use.

Secondary Remote Station Communications

Flag enables or disables network communications to the secondary remote station.

```
Const EXT_TRH2_ENABLE = False
```

Logical True or False. Set to True if a secondary remote station is available on the network that can provide the external sensor values. This is a fall back in case the communications to the primary remote station fails or if the primary remote station constant EXT_TRH1_ENABLE is set to False.

Secondary Remote Station PakBus Address

The PakBus address of the secondary remote station.

```
Const EXT_TRH2_PK = 82
```

An integer value. Each station on the network has a unique PakBus address in the range from 1 to 3999. PakBus addresses from 4000 to 4094 are reserved for software such as LoggerNet. By convention we use the same number for the PakBus address as the last octet of the dataloggers IPv4 network address when IPv4 network addressing is in use.

Secondary Remote Station IP Address

The static IP address of the secondary remote station.

```
Const EXT_TRH2_IP = 192.168.10.82
```

An integer value. Each station on the network has a unique IPv4 or IPv6 address. If possible, we use the number of the last octet of the station IPv4 network address for the PakBus address when IPv4 addressing is in use.

Maximum Communications Failures Before Alarm

The number of times communications to the remote station(s) can fail before an alarm is triggered.

```
Const MAX_COMMS_FAILS = 6
```

An integer value normally set between 3 and 9. The communications module will attempt to obtain the comms array from the designated remote station(s) every three minutes. If a remote station cannot be reached within the set number of tries an alarm is triggered.

NOTE: The alarm is always logged but depending upon the cause of the comms failure it may not be possible to send the alarms email message.

Communications Priority

The communications priority for communications by this station.

```
Const COMMS_PRIORITY = 2
```

An integer value set between 0 and 2. All stations MUST be set to 2 except for stations serving the external data to the network. On stations configured as primary and Secondary external data providers the priority should be set to zero, COMMS_PRIORITY = 0. On stations configured to obtain external data from Primary or Secondary data providers and then provide that data to a number of other dataloggers on the same network switch the priority should be set to one, COMMS_PRIORITY = 1.

AIO Sensor Wind Gust Installed (Optional)

Flag signals whether or not the all-in-one weather sensor includes wind gust data.

```
Const GUST_INSTALLED = True
```

Logical True or False. Normally to True as AIO sensors normally produce wind gust data. If the AIO sensor does not produce gust data, set this to False so the maximum 1 minute wind speed samples can be stored as a pseudo wind gust speed measurement that is maximum 1 minute gust instead of maximum 10 second gust.

AIO Sensor Tilt Installed (Optional)

Flag signals whether or not the all-in-one weather sensor includes sensor tilt detection.

```
Const TILT_INSTALLED = True
```

Logical True or False. Set to True when the AIO sensor provides N-S and W-E axis tilt measurement to indicate how level the sensor is mounted. AIO sensors need to be level within about +/- 2 degrees in either N-S axis or W-E axis. Set to False if the AIO sensor does not have this feature. If the AIO sensors doesn't have tilt detection the N-S tilt and W-E tilt values are omitted from the logged data tables.

AIO Lightning Sensor Installed (Optional)

Flag signals whether or not the all-in-one weather sensor includes lightning detection.

```
Const LTNG_INSTALLED = True
```

Logical True or False. Normally set to False unless the all-in-one weather sensor has lightning detection. Setting this constant to True enables processing and logging of lightning strikes and the approximate distance to the lightning strikes. If there is no lightning detector in the AIO sensor, the lightning strike count and lightning distance values are omitted from the logged data tables.

Grass Temperature Sensor Installed (Optional)

Flag signals whether or not the optional grass temperature sensor is installed at the station.

```
Const GRASS_INSTALLED = True
```

Logical True or False. Normally set to False unless the optional grass temperature sensor is installed. This sensor is displayed as the current grass temperature with the minimum grass temperature, typically reached in the early morning hours, logged hourly and each day at midnight. If there is no grass temperature sensor at the station, the grass minimum is omitted from the data tables.

Solar Pyranometer Sensor Installed (Optional)

Flag signals whether or not the optional SDI-12 solar pyranometer sensor is installed at the station.

```
Const PYRO_INSTALLED = True
```

Logical True or False. Set to True to use an optional SDI-12 solar pyranometer, such as the Campbell Scientific CS320, at the station. Set to False if the AIO weather sensor includes a pyranometer function or no pyranometer is installed. If no pyranometer is installed at the station, the hourly and daily solar insolation values are logged as "NAN" as a place holder in the daily and hourly data tables.

Tipping Bucket Rain Gauge Installed (Optional)

Flag signals whether or not the optional tipping bucket rain gauge is installed at the station.

```
Const TBRG_INSTALLED = True
```

Logical True or False. Set to False if the AIO weather sensor includes a precipitation measuring function. Set to True to enable the use of an optional tipping bucket rain gauge at the station. The optional tipping bucket rain gauge input is suitable for any standard switch closure pulse rain gauge. The bucket size calibration is set in the STATION SENSORS file. If there is no rain gauge installed at the station the hourly and daily precipitation values are logged as "NAN" as a place holder in the hourly and daily data tables.

Soil Moisture Sensor Installed (Optional)

Flag signals whether or not the optional SDI-12 soil moisture sensor is installed at the station.

```
Const SOIL_INSTALLED = True
```

Logical True or False. Set to True if an SDI-12 soil moisture sensor is installed at the station, otherwise set to False. If there is no soil moisture sensor installed at the station the hourly and daily soil moisture data tables are disabled to prevent them being logged.

All-In-One Weather Sensor SDI-12 Address

The SDI-12 address for the all-in-one weather sensor.

```
Const EXT_SDI_ADDR = "0"
```

An integer value. Normally set to "0" with sensor wired to port C1. May be any other valid SDI-12 address value provided that it is unique for all sensors wired to the same port. This constant and the default address value are the same as for the external temperature and relative humidity sensors on all other ZooCADA stations because the all-in-one weather sensor normally provides either the primary or secondary external temperature and relative humidity values to the ZooCADA network for use by HVAC controlling stations. The SDI-12 address must be unique for each sensor installed on the same port.

External Temperature and Relative Humidity Installed Is Primary Sensor

Flag indicates if the external air Temperature and RH measurements from the all-in-one weather sensor is the primary external temperature and relative humidity measurement provider for the ZooCADA network.

```
Const EXT_TRH_PRIMARY = True
```

Logical True or False. Always set to True unless another station on the network is intended to be the primary external Temperature and RH measurement provider. When set to False the external temperature and RH sensor installed at this station becomes the secondary external sensor for the network. When set True it is the primary external sensor for the network.

The primary sensor provides the values CommsEx1TC and CommsEx1RH while the secondary sensor provides the values CommsEx2TC and CommsEx2RH into the communication array for sharing across the network.

Soil Moisture and Temperature Sensor SDI-12 Address

The SDI-12 address for the enclosure soil moisture & soil temperature sensor.

```
Const E01SOIL_SDI_ADDR = "c"
```

Character value. Normally set to "c" for the external soil moisture sensor with all sensors wired to port C1. An address must be set if this sensor is installed. The SDI-12 address must be unique for each sensor installed on the same port.

Barometric Pressure Station Elevation

The elevation, above Mean Sea Level, of the station with the barometric pressure sensor installed.

```
Const BARO_STN_ELEV = 47
```

An integer value. The elevation above Mean Sea Level, in metres, of the station with the barometric pressure sensor installed. This value is used to calculate the correction of the station pressure to Mean Sea Level pressure for display and logging.

Solar Pyranometer Sensor SDI-12 Address

The SDI-12 address for the solar pyranometer sensor.

```
Const SOLAR_SDI_ADDR = "d"
```

A character value. Normally set to "d" with sensor wired to port C1. May be any other valid SDI-12 address value provided that it is unique for all sensors wired to the same port. An address must be set if a pyranometer sensor is installed on stations where the all-in-one weather sensor does not include a pyranometer function.

Solar Radiation Use kWh Instead of MJ

Change solar radiation totals calibration from the standard MJ to kWh.

```
Const SOLAR_KWH = True
```

Logical value. Normally set to False so the system uses MJ as the solar energy total. If kWh is the preferred unit for the site change to Const SOLAR_KWH to False.

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Station Sensors File

```
'*****************************************************************************************************************
'* ZooCADA-Met Weather Station Sensors Configuration                                                              *
'* Station Sensors Configuration File For:                                                                       *
'* Copyright 2015-2025 Adena Scientific Limited                                                                  *
'* Datalogger: Campbell Scientific CR300 Series                                                                  *
'* File name: STATION_SENSORS_ZMET_R01.CR300                                                                     *
'* Revision Date: 2025-02-07                                                                                     *
'*****************************************************************************************************************
'
'NOTE: Leave sections unchanged for Optional Sensors if not installed.
'      Temperatures must be calibrated to degrees Celsius (deg C).
'      Relative Humidity must be calibrated to percent (%)
'      Barometric pressure must be calibrated to hectopascals (hPa).
'      Solar radiation must be calibrated to Watts per square metre (W/m^2).
'      Precipitation must be calibrated to millimetres (mm).
'      Wind Speed and gust speed must be calibrated to metres per second (m/s).
'      Wind direction and gust direction must be calibrated to degrees (degrees).
'      Lightning strikes is the numeric count as an integer.
'      Lightning distance must be calibrated to kilometres (km).
'      Sensor tile N-S must be calibrated to +/- degrees from horizontal (degrees).
'      Sensor tile N-S must be calibrated to +/- degrees from horizontal (degrees).


'DECLARE SENSOR VARIABLES AND ARRAYS
'-----------------------------------
'
'Leave this section empty if no sensor variables are needed.
#If Section = "SensorVars" Then
  '
  'Declare AIO Weather Sensor Array.
  Dim AIOWeatherData(14)
  '
  'Compiler Directive - If pyranometer sensor installed.
  #If PYRO_INSTALLED = True Then
    'Declare Pyranometer Array.
    Dim Pyranometer(4)
  #EndIf    'End complier directive
  '
  'Compiler Directive - If soil moisture sensor installed.
  #If SOIL_INSTALLED = True Then
    'Declare Soil Moisture Sensor Array.
    Dim ExtSoilData(6)
  #EndIf    'End complier directive
  '
#EndIf


'MEASURE MAIN WEATHER SENSORS
'----------------------------
'
#If Section = "SlowScanAIO" Then
  '
  'Measure ATMOS 41 (Campbell Scientific ClimaVue 50) AIO Weather Sensor.
  'Air temp & RH, Barometer, Solar Rad, Rain, Wind speed & Direction, Lightning, Tilt.
  SDI12Recorder(AIOWeatherData(),C1,EXT_SDI_ADDR,"M!",1,0,-1)
  '
  'Link the ATMOS 41 sensor array channels to program inputs.
  'Set to NAN where AIO sensor doesn't output that value.
  RawAirTC = AIOWeatherData(8)                  'AIO air temperature (deg C)
  RawAirRH = AIOWeatherData(11) * 100           'AIO air relative humidity fraction calibrated (%)
  RawBaroPres = AIOWeatherData(10) * 10         'AIO barometric pressure kilopascals calibrated (hPa)
  '
```

```
  #If PYRO_INSTALLED = False Then              'Compiler Directive - If separate pyranometer installed
    RawSolarRad = AIOWeatherData(1)            'AIO Solar Radiation (W/m2)
  #EndIf                                       'End complier directive
  '
  #If TBRG_INSTALLED = False Then              'Compiler Directive - If separate rain gauge installed
    RawPrecip = AIOWeatherData(2)              'AIO Precipitation (mm)
  #EndIf                                       'End complier directive
  '
  RawWindSpd = AIOWeatherData(5)               'AIO Wind Speed (m/s)
  RawWindDir = AIOWeatherData(6)               'AIO Wind Direction (deg)
  RawGustSpd = AIOWeatherData(7)               'AIO Wind Max 10 Sec gust speed (m/s)
  RawGustDir = NAN                             'AIO Wind gust direction (degrees)
  '
  #If LTNG_INSTALLED = True Then               'Compiler Directive - If AIO produces lightning data.
    RawStrikes = AIOWeatherData(3)             'AIO Lightning Strike Count
    RawDistance = AIOWeatherData(4)            'AIO Lightning Distance (km)
  #EndIf                                       'End complier directive
  '
  RawTiltNS = AIOWeatherData(13)               'AIO Sensor Tilt North-South (deg)
  RawTiltWE = AIOWeatherData(14)               'AIO Sensor Tilt West-East (deg)
  '
#EndIf


'MEASURE GRASS TEMPERATURE SENSOR (OPTIONAL)
'-------------------------------------------
'
#If Section = "SlowScanGrass" Then
  '
  'Measure grass minimum Campbell Scientific 107 probe.
  Therm107(RawGrassTC,1,2,Vx2,0,50,1.0,0)
  '
#EndIf


'MEASURE SEPARATE PYRANOMETER SENSOR (OPTIONAL)
'----------------------------------------------
'
#If Section = "SlowScanPyro" Then
  'Example for Campbell Scientific CS320.
   SDI12Recorder(Pyranometer(),C1,SOLAR_SDI_ADDR,"M!",1,0,-1)
   '
   RawSolarRad = Pyranometer(1)
  '
#EndIf


'MEASURE SEPARATE TIPPING BUCKET RAIN GAUGE (OPTIONAL)
'-----------------------------------------------------
'
#If Section = "MainScanTBRG" Then
  'NOTE: Pulse counters must be in program main scan.
  'Example for Pronamic 300.023.20 with 0.2mm Bucket.
  'P_SW Input, 0.2mm bucket.
  PulseCount(RawPrecip,1,P_SW,2,0,0.2,0)
  '
#EndIf
```

```
'MEASURE SOIL MOISTURE SENSOR (OPTIONAL)
'--------------------------------------
'
#If Section = "SlowScanExSoil" Then
  '
  'Measure External Water Content Reflectometer Sensor on Port C1/A3.
  'Measurements 'VWC', 'EC', 'T', 'Pm', 'Pd' & 'Vr'
  'Optionally use "M4!" instruction for probes with OS2 - see CS650 Users Manual.
  SDI12Recorder(ExtSoilData(),C1,EXTSOIL_SDI_ADDR,"M3!",1,0)
  '
#EndIf

'*************************************************************************************************************
'*                                          END OF INCLUDE FILE                                              *
'*************************************************************************************************************
```

The CRBasic code required to obtain the measurements from the station's sensors, and calibrate them into the standard units used within the ZooCADA system, is contained in a file named STATION_SENSORS_ZMET_R01, hereinafter simply referred to as the STATION_SENSORS file.

Keeping the sensors configuration in its own file enables different sensor types to be installed at different stations, as needed, without necessitating changes to the main station program. This enables stations to be installed with the optimum sensors types for the site during initial installation and, if necessary, a sensor can be replaced with a different sensor type in the future if it fails and has been superseded by a new type.

The CRBasic code for optional sensors must be retained in the STATION_SENSORS file even if the optional sensors are not installed at the station. Optional sensors are enabled or disabled by settings in the STATION_CONSTANTS file and the necessary code changes are automatically made by the compiler when the system is installed.

IMPORTANT: The STATION_SENSORS file is determined during installation of the station sensors and is critical to the correct operation of the station.

Users should NOT change this file unless requested by Technical Support.

To change the station sensor configuration it is necessary to edit the STATION_SENSORS file, then load the updated file into the datalogger. To do so, users need to have access to the program code on a Windows computer that has the Campbell Scientific LoggerNet program suite installed on it.

For full information on using the LoggerNet software please refer to the LoggerNet Manual which is downloadable from the Campbell Scientific web site.

If the STATION_SENSORS file is edited using the CRBasic editor, it is essential to manually stop the station program running and then restart it so the datalogger will recompile the program and make the new sensor configuration operational.

Do not change the name of the STATION_SENSORS file. The datalogger expects this file to be present and cannot run the program without it.

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Data Tables

TOA5, OKH_NH2_DL01, CR300, 4206, CR310.Std.09.02, CPU:OKH_NH2_DL01_R14.CR300, 1367, E01_T_RH_10M							
TIMESTAMP	RECORD	EnAirTC	EnAirRH	EnAirVpd	ExAirTC	ExAirRH	ExAirVpd
TS	RN	Deg C	%	kPa	Deg C	%	kPa
		Avg	Avg	Avg	Avg	Avg	Avg
2023-01-01 00:00:00	4387	18.24	81.5	0.388	16.4	67.7	0.602
2023-01-01 00:10:00	4388	18.14	81.3	0.389	16.25	68.19	0.587
2023-01-01 00:20:00	4389	18.07	81.5	0.383	16.18	68.79	0.574
2023-01-01 00:30:00	4390	17.99	81.5	0.381	15.99	67.64	0.588
2023-01-01 00:40:00	4391	17.91	81.4	0.381	15.84	69.2	0.554
2023-01-01 00:50:00	4392	17.82	81.6	0.374	15.76	69.82	0.54
2023-01-01 01:00:00	4393	17.75	81.9	0.368	15.62	69.06	0.549
2023-01-01 01:10:00	4394	17.66	82	0.363	15.43	70.63	0.515
2023-01-01 01:20:00	4395	17.57	82.4	0.354	15.17	70.81	0.503
2023-01-01 01:30:00	4396	17.49	82.7	0.345	14.89	72.21	0.47
2023-01-01 01:40:00	4397	17.39	82.7	0.343	14.73	72.15	0.466
2023-01-01 01:50:00	4398	17.31	82.7	0.341	14.6	73.1	0.447
2023-01-01 02:00:00	4399	17.21	82.9	0.337	14.57	73.53	0.439
2023-01-01 02:10:00	4400	17.13	83.3	0.326	14.37	74.25	0.421
2023-01-01 02:20:00	4401	17.04	83.5	0.32	14.12	74.27	0.414
2023-01-01 02:30:00	4402	16.95	83.6	0.316	13.87	75.1	0.394
2023-01-01 02:40:00	4403	16.85	84	0.308	13.77	76.18	0.375

The datalogger stores all data in files called data tables. Data tables are made up of records and fields. Each row in a table represents a record and each column represents a field. The datalogger program determines the number of tables and the number of fields in each record. The image above shows a typical data table's contents and this is explained below; all other tables follow the same general format but will contain different information. Data files are typically stored as CSV text files with a .dat extension which can be imported and formatted into a spreadsheet, as has been done in the above example, or directly accessed by tools in Campbell Scientific LoggerNet software.

Data Table Header Rows

The data table contains four header rows providing information about the datalogger, the table, and its fields, with each field surrounded by double quotes which we have not shown in the diagram above for clarity.

First Row

The first header row of the data table is the environment line consisting of eight fields. The example image shown above contains the following:

TOA5 - Table output format. Can be changed using LoggerNet.

OKH_NH2_DL01 - The datalogger station name in LoggerNet. Can be changed using LoggerNet.

CR300 - The datalogger model range.

4206 - The datalogger serial number.

CR310.Std.09.02 - The datalogger operating system version.

CPU:OKH_NH2_DL01_R14.CR300 - Datalogger program name. Can change by sending new program.

1367 - Datalogger program signature. Changed by revising program or sending a new program.

E01_T_RH_10M - The data table name as defined in the datalogger program.

Second Row

The second header row of the data table contains the field names. The default field names are either a combination of the variable names (or aliases) from which the data is derived with an underscore and a three letter suffix, or a specified field name. The suffix is an abbreviation of the data process that outputs the data to final storage. The example image shown above contains the following field names:

TIMESTAMP - The date and time field showing when the record was created.

RECORD - A numerical record number field. Resets to zero when data tables are reset.

EnAirTC - Enclosure air temperature field.

EnAirRH - Enclosure air relative humidity field.

EnAirVpd - Enclosure air vapour pressure deficit field.

ExAirTC - External air temperature field.

ExAirRH - External air relative humidity field.

ExAirVpd - External air vapour pressure deficit field.

Third Row

The third header row of the data table contains the engineering units for the fields. These units are defined at the beginning of the datalogger program. The example image shown above contains the following units information:

TS - Time stamp for the time stamp field.

RN - Record Number for the record number field.

deg C - Degrees C for the enclosure temperature field.

% - Percentage for the enclosure relative humidity field.

kPa - Kilopascals for the enclosure vapour pressure deficit field.

deg C - Degrees C for the external temperature field.

% - Percentage for the external relative humidity field.

kPa - Kilopascals for the external vapour pressure deficit field.

Fourth Row

The fourth header row of the data table contains the abbreviations for the data process used to produce the field data. The example image shown above contains the following units information:

Blank - No special data processing is used for the time stamp field.

Blank - No special data processing is used for the record number field.

Avg - Average used for the enclosure temperature field.

Avg - Average used for the enclosure relative humidity field.

Avg - Average used for the enclosure vapour pressure deficit field.

Avg - Average used for the external temperature field.

Avg - Average used for the external relative humidity field.

Avg - Average used for the external vapour pressure deficit field.

Data Processing Abbreviations

Data processing instructions, such as average, maximum, minimum, or instantaneous sample, are used in the datalogger program to determine the type of data that is stored in the data tables. The following list contains all the abbreviations that can be used in the fourth row of the data tables and conditionally as field name suffixes on the first row. Not all of these are used in the ZooCADA system programs but are shown here for completeness.

Data Processing Abbreviations	
Data Processing Name	Abbreviation
Totalize	Tot
Average	Avg
Maximum	Max
Minimum	Min
Sample at Max or Min	SMM
Standard Deviation	Std
Moment	MMT
Sample	No abbreviation
Histogram1	Hst
Histogram4D	H4D
FFT	FFT
Covariance	Cov
Level Crossing	LCr
WindVector	WVc
Median	Med
ET	ETsz
Solar Radiation (from ET)	RSo
Time of Max	TMx
Time of Min	TMn

It is important to understand how the output data processing operates. All fields, except for instantaneous samples, are processed to produce the logged value. The example table shown in the image at the beginning of this section shows records that are logged at a ten minute interval, and at 02:40:00 the enclosure temperature average (EnAirTC) for record 4403 was logged as 16.85 degrees Celsius. Therefore 16.85 degrees Celsius is the average of all the measurements made by the datalogger over the ten minute interval from 02:30:01 to 02:40:00. The enclosure temperature sensors are measured every minute so this logged average is therefore the average of ten sensor measurements.

Data Table Data Record Rows

All rows after the fourth header row are called data records.

Data records are normally created at programmed regular intervals such as every ten minutes, hourly, or daily as shown by their time stamps. Event records are created whenever specified events occur, such as alarms or system errors, so the time stamp will show irregular record times.

The time stamp always indicates the time at the beginning of the datalogger program scan in which the record was written to the table. In the example table, shown in the image above, record number 4403 was written at 02:40:00 (2:40 am) on January 1, 2023.

Default Data Table Definitions

The datalogger includes three default data tables which are always present. Each of these data tables only contains the most recent measurements and information.

The default data tables are not downloaded when the logged data is downloaded from the datalogger as doing so is unnecessary, however they are available for viewing on a computer while it is connected to the datalogger with the LoggerNet software, or via a web browser.

DataTableInfo

The DataTableInfo data table is automatically created when a datalogger program produces other data tables. It reports statistics related to the data tables and is only updated when viewed.

Viewing this data table enables staff to determine the amount of data record storage used and available.

Table Name - DataTableInfo

TIMESTAMP - Record Date and Time (DateTime).

RECORD - Record Number (Integer).

DataTableName(1) - Name of the first data table created by the program (Text).

DataTableName(2) - Name of the second data table created by the program (Text).

SkippedRecord(1) - Number of skipped records in the first data table (Integer).

SkippedRecord(2) - Number of skipped records in the second data table (Integer).

DataRecordSize(1) - Number of records allocated to the first data table (Integer).

DataRecordSize(1) - Number of records allocated to the first data table (Integer).

DataRecordSize(2) - Number of records allocated to the second data table (Integer).

DataRecordSize(2) - Number of records allocated to the second data table (Integer).

SecsPerRecord(1) - Data output interval for the first data table (Integer).

SecsPerRecord(2) - Data output interval for the second data table (Integer).

DataFillDays(1) - Number of days required to fill the first data table (Decimal).

DataFillDays(1) - Number of days required to fill the first data table (Decimal).

DataFillDays(2) - Number of days required to fill the second data table (Decimal).

DataFillDays(2) - Number of days required to fill the second data table (Decimal).

DataFilled(1) - Percent of first data table filled (Decimal + Text).

DataFilled(1) - Percent of first data table filled (Decimal + Text).

DataFilled(2) - Percent of second data table filled (Decimal + Text).

DataFilled(2) - Percent of second data table filled (Decimal + Text).

NOTE: The example above is for a datalogger program that produces two data tables. The first or only number in brackets is the table number and increments for each new data table that is produced. A second number in the brackets, if present, indicates 1 for storage in on board memory or 2 for storage in an SD card and is only present for datalogger models such as the CR1000X that support multiple storage options.

Status

The Status data table includes information about the health of the datalogger and is updated only when viewed. The information in this data table is primarily intended to assist technical staff to verify that the datalogger and its program are functioning correctly and can be helpful if diagnosing problems.

Users do not normally need to view this table. For full details of the fields in this data table, please refer to section "23.2 Status Table System Information" in the CR310 Product Manual.

Public

The Public data table is configured by the datalogger program and updated at the scan interval set within the datalogger program. It shows measurement and calculation results as they are made. This data table is for the ZooCADA-Met program and is an extremely useful tool for monitoring the station.

We recommend that users view this table as a daily check that everything is operating as expected.

Table Name - Public

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

Platform - The software platform, in this case ZooCADA-Log.

Station - The name of the station (Text).

BattV - Battery voltage in Volts (Decimal).

ExtAirTC - External air current temperature in degrees C (Decimal).

ExtAirRH - External air current relative humidity in percent (Decimal).

ExtAirDP - External air dew point in degrees C (Decimal).

ExtAirVpd - External air current vapour pressure deficit in kilopascals (Decimal).

Optional soil moisture section if soil moisture sensor installed.

ExtSoilTC - External soil current temperature in degrees C (Decimal).

ExtSoilVWC - External soil volumetric water content in cubic metres per cubic metre (Decimal).

End of optional soil moisture section.

Optional grass temperature section if grass temperature sensor installed.

GrassTC - External grass temperature in degrees C (Decimal).

End of optional grass (minimum) temperature section.

BaroStn - Barometric pressure, at the station, in hectopascals.

BaroMSL - Barometric pressure, calibrated to Mean Sea Level, in hectopascals.

BaroTend - Barometric pressure tendency and amount of change in hectopascals.

SolarRad - Solar radiation in W/m^2 (Decimal).

SolarHour - Solar energy total for current hour in MJ or kWh per square metre (Decimal).

SolarDay - Solar energy total for current day in MJ or kWh per square metre (Decimal).

RainHour - Precipitation total for current hour in mm (Decimal).

RainDay - Precipitation total for current day in mm (Decimal).

WindVectSpd - Wind vector speed ten minute rolling average in m/s (Decimal).

WindVectDir - Wind vector direction ten minute rolling average in degrees (Decimal).

GustSpdHour - Wind gust speed maximum for current hour in m/s (Decimal).

GustDirHour - Wind gust direction for current hour in degrees (Decimal).

LtngStrikes - Lightning strikes total detected for last minute (Integer).

LtngDistance - Lightning distance average for last minute degrees (Decimal).

SensorTiltNS - Weather sensor tilt North-South axis for last minute in degrees (Decimal).

SensorTiltWE - Weather sensor tilt West-East axis for last minute in degrees (Decimal).

CurMonth - The current month of the year for which the setpoints are selected (Text).

Set_ExtAirTC_HI - The high temperature alarm setpoint for the current month in degrees Celsius (Decimal).

Set_ExtAirTC_LO - The low temperature alarm setpoint for the current month in degrees Celsius (Decimal).

Set_RainHour_HI - The high rainfall current hour alarm setpoint in millimetres (Decimal).

Set_RainDay_HI - The high rainfall current day alarm setpoint in millimetres (Decimal).

Set_WindSpd_HI - The high wind speed, 10 minute average, alarm setpoint in millimetres (Decimal).

Set_GustSpd_HI - The high wind gust speed, current hour, alarm setpoint in millimetres (Decimal).

TCState - The current state of the external air temperature (Text).

- OK - The external air temperature is within the range determined by the alarm setpoints.
- HIGH - The external air temperature is higher than the high temperature alarm setpoint.
- LOW - The external air temperature is lower than the low temperature alarm setpoint.
- ERROR - The external air temperature is in an indeterminate state.

RainState - The current state of the rainfall total (Text).

- OK - The rainfall total is below the high rainfall alarm setpoints.
- HIGH - The rainfall total is higher than the high rainfall alarm setpoint.

WindState - The current state of the wind speed (Text).

- OK - The wind speed is below the high wind speed alarm setpoints.
- HIGH - The wind speed is higher than the high wind speed alarm setpoint.

SensorState - The current state of the all-in-one weather sensor (Text).

- OK - The weather sensor is operating within normal specifications.
- TC - The temperature value is outside of the expected range.
- RH - The relative humidity value is outside of the expected range.
- BP - The barometric pressure value is outside of the expected range.
- SR - The solar radiation value is outside of the expected range.
- RG - The precipitation value (rain gauge) is outside of the expected range.
- WS - The wind speed value is outside of the expected range.
- WD - The direction value is outside of the expected range.
- WG - The wind gust value is outside of the expected range.
- LS - The lightning strikes value is outside of the expected range.

LD - The lightning distance value is outside of the expected range.

ST - The sensor tilt value is outside of the allowable range for the sensor.

The SensorState will either be OK, or a string of one or more two letter fault ID codes, separated by commas, with FAIL appended to the end of the string to indicate a failed sensor.

BaroQMState - The current quality metric (QM) state, if available, of the barometric pressure sensor (Text).

OK - The barometric pressure sensor is working normally, the sensor does not provide QM data.

OK (QM n.nn) - The barometric pressure sensor is working normally.

RECALIB SOON (QM n.nn) - The sensor will need recalibrating in two to three months.

FAIL (QM n.nn) - The barometric pressure sensor needs recalibrating or has failed.

FAIL - The barometric pressure sensor has failed, the sensor does not provide QM data.

PowerState - The current state of mains electricity supply (Text).

OK - Mains power supply s OK.

POWER FAIL - Mains power supply has failed.

AlarmState - The current state of the alarm system (Text).

DISABLED - The alarm system has been disabled, no alarms will be detected.

INITIALISING - The alarm system is starting up and determining if any alarms are active.

NO ALARMS - All alarms are cleared.

>> ALARMS << - One or more alarms have been triggered.

EmailState - The current state of the email system (Text).

DISABLED - The email messaging system is set to disabled, email messages will not be sent.

TEST MODE - The email messages are diverted to a file for test purposes.

SYSTEM READY - The email system is ready to begin sending email messages.

SEND ATTEMPT - The email system is attempting to send a message.

SENT OK - The Email Relay server has received the message and relayed it to the recipients.

COMMS FAIL- Connection to the Email Relay server failed, the message was not sent.

DATA ERROR - The EmailRelay() function was called but not executed, the message was not sent.

COMMS ERROR - Error in communication to the Email Relay server, the message was not sent.

CommsState - The current state of the remote station (datalogger) communications (Text).

DISABLED - Remote station communications is not in use and has been disabled.

INITIALISING - The communications system is starting up.

COMMS ATTEMPT - The communications system is attempting to contact a remote station.

COMMS RETRY - The last attempt to contact a remote station failed and is now being tried again.

COMMS OK - Communications with the primary remote station succeeded.

COMMS SEC OK - Communications with the secondary remote station succeeded.

COMMS FAIL - All attempts to contact a remote station have failed.

CommsEx1TC - The communications array primary external temperature in degrees C (Decimal).

CommsEx1RH - The communications array primary external relative humidity in % (Decimal).

CommsEx2TC - The communications array secondary external temperature in degrees C (Decimal).

CommsEx2RH - The communications array secondary external relative humidity in % (Decimal).

CommsExBaro - The communications array barometric (station) pressure in hPa (Decimal).

CommsExSolar - The communications array solar radiation in W/m2 (Decimal).

CommsExRainHr - The communications array rainfall rolling 60 minute total in mm (Decimal).

CommsExRainDay - The communications array rainfall daily total in mm (Decimal).

CommsExWindSpd - The communications array wind vector speed in m/s (Decimal).

CommsExWindDir - The communications array wind vector direction in degrees (Int).

CommsExGustSpd - The communications array wind gust speed current hour in m/s (Decimal).

CommsExGustDir - The communications array wind gust direction current hour in degrees (Int).

Customisation Variables section.

CustomVar1 - Variable defined in customisation file, can be whatever variable name is appropriate.

CustomVar2 - Variable defined in customisation file, can be whatever variable name is appropriate.

NOTE: Customisation variables may or may not be present for any given station and are always placed at the bottom of the Public data table.

ZooCADA-Log Data Table Definitions

The format of the data tables for each type of dataset are identical across all ZooCADA systems.

All records in data tables, except for the Event Log, are generated at predetermined time intervals, 10 Minutes, Hourly, or Daily and provide what is called time-series data. Time series data can be easily plotted on a graph. The Event Log is event driven so its records are generated at whatever time the event occurs.

Enclosure number E00 is for functions common to all areas of the building whilst EXT is for external (outside) measurements common to all buildings.

Event Log

The EVENT_LOG data table contains a descriptive indication of each event that occurs. Events are logged at the time they occur. This table is limited to 1000 events before its ring memory overwrites.

Table Name - E00_EVENT_LOG

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

EventDetected - Event description (Text).

Hourly Weather Summary

This data table provides an hourly summary of the external weather parameters. All averages and totals are for the entire hour except for wind speed and direction which use a ten minute short average.

Table Name - EXT_MET_HOUR

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

ExAirTC_Avg - Air temperature average in degrees Celsius (Decimal).

ExAirRH_Avg - Air relative humidity average in percent (Decimal).

ExAirDP_Avg - Air dew point average in degrees Celsius (Decimal).

ExAirVpd_Avg - Air vapour pressure deficit average in kilopascals (Decimal).

ExBaroStn_Avg - Barometric pressure at the station average in hectopascals (Decimal).

ExBaroMSL_Avg - Barometric pressure at Mean Sea Level average in hectopascals (Decimal).

ExSolarHour_Tot - Solar energy total in kilowatt hours or megajoules (Decimal).

ExRainHour_Tot - Precipitation (rainfall) total, in millimetres (Decimal).

ExWindSpeed_WVc - Wind vector speed in metres per second (Decimal).

ExWindDir_WVc - Wind vector direction in degrees (Decimal).

ExWindGust_Max - Wind gust maximum in metres per second (Decimal).

ExWindGust_TMx - Wind gust time of maximum. (DateTime).

ExWindGustDir - Wind gust direction of maximum, in degrees (Decimal).

ExAirTC_Max - Air temperature maximum in degrees Celsius (Decimal).

ExAirTC_TMx - Air temperature time of maximum. (DateTime).

ExAirTC_Min - Air temperature minimum in degrees Celsius (Decimal).

ExAirTC_TMn - Air temperature time of minimum. (DateTime).

ExAirRH_Max - Air relative humidity maximum, in percent (Decimal).

ExAirRH_TMx - Air relative humidity time of maximum. (DateTime).

ExAirRH_Min - Air relative humidity minimum, in percent (Decimal).

ExAirRH_TMn - Air relative humidity time of minimum. (DateTime).

ExGrassTC_Min - Grass temperature minimum in degrees Celsius (Decimal).

ExGrassTC_TMn - Grass temperature time of minimum. (DateTime).

Optional lightning strikes section.

ExLtngStrikes_Tot - Lightning strikes total (Integer).

ExLtngDist_Avg - Lightning strikes distance average in kilometres (Decimal).

ExLtngDist_Min - Lightning strikes distance minimum in kilometres (Decimal).

End of optional lightning strikes section.

SensorTiltNS - Sensor tilt angle, North-South axis, in degrees. (Decimal)

SensorTiltWE - Sensor tilt angle, West-East axis, in degrees. (Decimal)

Daily Weather Summary

This data table provides a daily summary, logged at midnight (00:00), of the external weather parameters. All averages and totals are for the entire day.

Table Name - EXT_MET_DAY

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

ExAirTC_Avg - Air temperature average in degrees Celsius (Decimal).

ExAirRH_Avg - Air relative humidity average in percent (Decimal).

ExAirDP_Avg - Air dew point average in degrees Celsius (Decimal).

ExAirVpd_Avg - Air vapour pressure deficit average in kilopascals (Decimal).

ExBaroStn_Avg - Barometric pressure at the station average in hectopascals (Decimal).

ExBaroMSL_Avg - Barometric pressure at Mean Sea Level average in hectopascals (Decimal).

ExSolarDay_Tot - Solar energy total in kilowatt hours or megajoules (Decimal).

ExRainDay_Tot - Precipitation (rainfall) total in millimetres (Decimal).

ExWindSpeed_WVc - Wind speed vector in metres per second (Decimal).

ExWindDir_WVc - Wind direction vector in degrees (Decimal).

ExWindGust_Max - Wind gust speed maximum in metres per second (Decimal).

ExWindGust_TMx - Wind gust time of maximum. (DateTime).

ExWindGustDir - Wind gust direction of maximum in degrees (Decimal).

ExAirTC_Max - Air temperature maximum in degrees Celsius (Decimal).

ExAirTC_TMx - Air temperature time of maximum. (DateTime).

ExAirTC_Min - Air temperature minimum in degrees Celsius (Decimal).

ExAirTC_TMn - Air temperature time of minimum. (DateTime).

ExAirRH_Max - Air relative humidity maximum in percent (Decimal).

ExAirRH_TMx - Air relative humidity time of maximum. (DateTime).

ExAirRH_Min - Air relative humidity minimum in percent (Decimal).

ExAirRH_TMn - Air relative humidity time of minimum. (DateTime).

ExGrassTC_Min - Grass temperature minimum in degrees Celsius (Decimal).

ExGrassTC_TMn - Grass temperature time of minimum. (DateTime).

Optional lightning strikes section.

ExLtngStrikes_Tot - Lightning strikes total (Integer).

ExLtngDist_Avg - Lightning strikes distance average in kilometres (Decimal).

ExLtgDist_Min - Lightning strikes distance minimum in kilometres (Decimal).

End of optional lightning strikes section.

SensorTiltNS - Sensor tilt angle, North-South axis, in degrees. (Decimal)

SensorTiltWE - Sensor tilt angle, West-East axis, in degrees. (Decimal)

Hourly Soil Moisture and Temperature (Optional)

This data table provides hourly soil moisture measurements for the exterior soil.

Table Name - EXT_SOIL_60M

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

ExSoilTC - Enclosure soil temperature in degrees Celsius (Decimal).

ExSoilVWC - Enclosure soil volumetric water content in cubic metres per cubic metre (Decimal).

ExSoilEC - Enclosure soil electrical conductivity in decisiemens per meter (Decimal).

Daily Soil Moisture and Temperature Summary (Optional)

This data table provides a daily summary, logged at midnight (00:00), of the soil conditions in the enclosure over the previous day. If two soil moisture sensors are used, additional fields are added to the data table.

Table Name - EXT_SOIL_DAY

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

ExSoilTC_Avg - Average soil temperature in degrees Celsius (Decimal).

ExSoilTC_Max - Maximum soil temperature in degrees Celsius (Decimal).

ExSoilTC_TMx - Time of maximum soil temperature (DateTime).

ExSoilTC_Min - Minimum soil temperature in degrees Celsius (Decimal).

ExSoilTC_TMn - Time of minimum soil temperature (DateTime).

ExSoilVWC_Avg - Average soil volumetric water content in cubic metres per cubic metre (Decimal).

ExSoilVWC_Max - Maximum soil volumetric water content in cubic metres per cubic metre (Decimal).

ExSoilVWC_TMx - Time of maximum soil volumetric water content (DateTime).

ExSoilVWC_Min - Minimum soil volumetric water content in cubic metres per cubic metre (Decimal).

ExSoilVWC_TMn - Time of minimum soil volumetric water content (DateTime).

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Using The Web Interface

The datalogger has a built-in web interface which enables easy viewing of the station status and data using a web browser from any network connected computer. No additional software is needed.

The web interface allows users to view the data without being logged on and offers several administrative functions that can be accessed by logging on to the datalogger with an administrator level logon.

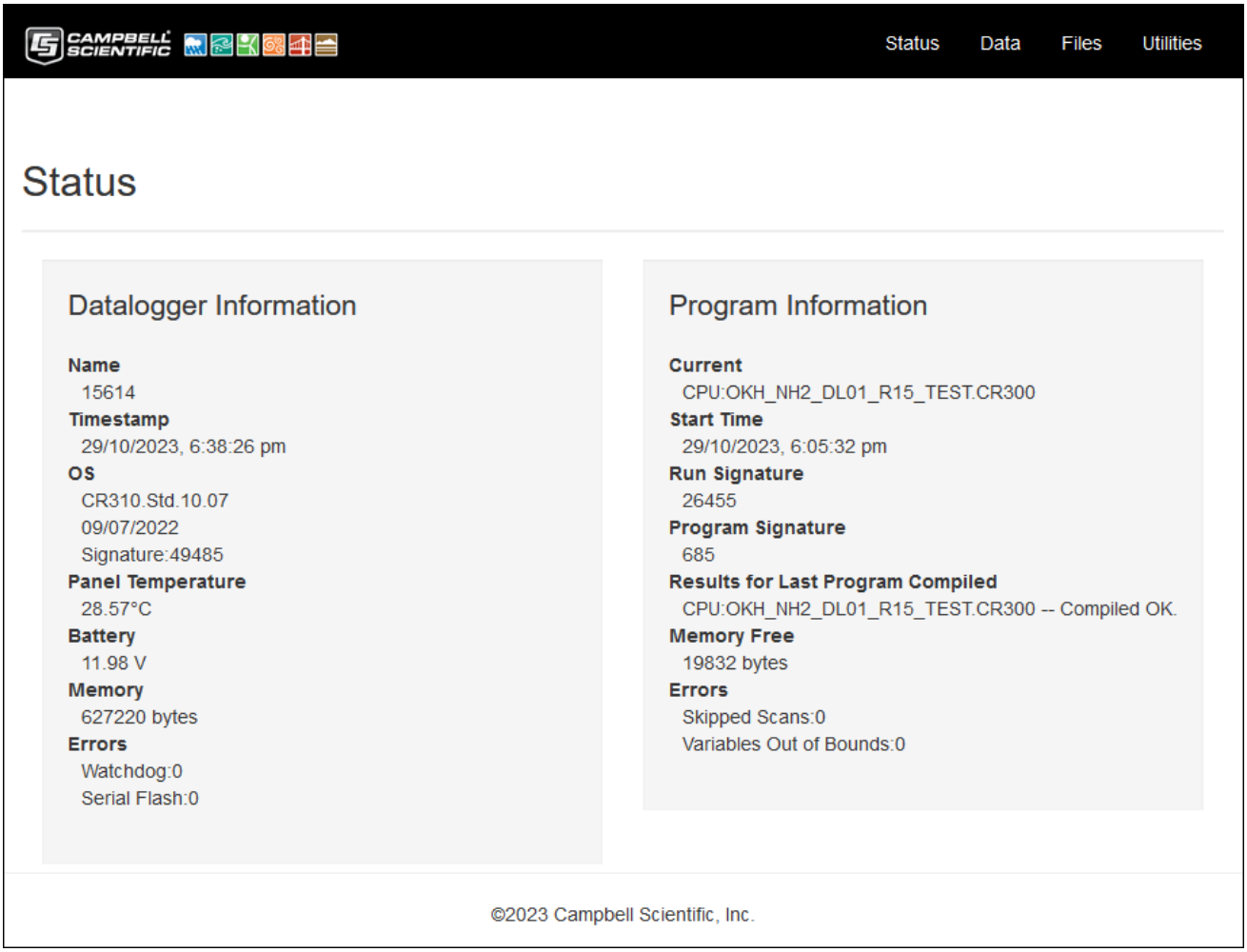
We recommend using the web interface for viewing data, and LoggerNet software for administrative tasks.

The web interface makes day to day station checks quick and easy for users, whereas LoggerNet enables all the functionality of the entire datalogger network to be efficiently configured, utilised and maintained.

Connecting To A Station

1. Open the web browser on the computer
2. Enter the IP address of the station, in the format 192.168.5.92, into the browser's address and press [Enter].
3. The Status page will be displayed.

Status Page



The Status page gives key information about the datalogger and the program that is running in the datalogger. It can be selected by clicking on Status on the header/menu bar at the top of the page.

Click the [Refresh] button anytime it is desired to refresh the information on the page.

The web interface Status page displays a subset of the information in the dataloggers Status data table, which is an automatically generated default table. The complete Status data table can be viewed using the LoggerNet software. Most fields in the Status table are read only, and of a numeric data type unless otherwise noted.

Full details of all the fields in the Status table can be found in section "23.2 Status Table System Information" in the CR310 Product Manual.

The fields displayed on the web interface Status page are described below in the order they are displayed.

Datalogger Information

Name - Datalogger station name stored in flash memory. Defaults to serial number. This is not the same name as that is entered into the LoggerNet software for the stations network name. This station name can be sampled into a data table, but it is not the name that appears in data file headers. Updated at startup or when the name is changed using the Device Configuration Utility in LoggerNet.

Timestamp - Datalogger date and time.

OS - Datalogger operating system version, release date and signature. Updates at startup.

Panel Temperature - Datalogger wiring panel temperature in degrees Celsius. Updates once per minute, when viewing the Status table, or programmatically.

Battery - Voltage of the 12V battery powering the system. Updates once per minute, when viewing the Status table, or programmatically.

Memory - Total final-data memory size (bytes) in the datalogger. Updated at startup.

Errors - Datalogger watchdog errors that have occurred while running this program, the count increments each time datalogger restarts due to error and resets automatically when a new program is compiled. Can be reset by entering 0. Updated at startup and on each error occurrence.

Program Information

Current - Program file that is currently running in the datalogger. Updates at startup.

Start Time - Date and time the CRBasic program was started. Updates at beginning of program compile.

Run Signature - Signature of the running binary (compiled) program. Value is independent of comments or non-functional changes. Often changes with operating system changes. Updates after compiling and before running the program.

Program Signature - Signature of the CRBasic program file including comments. Does not change with operating system changes. Updates after compiling the program.

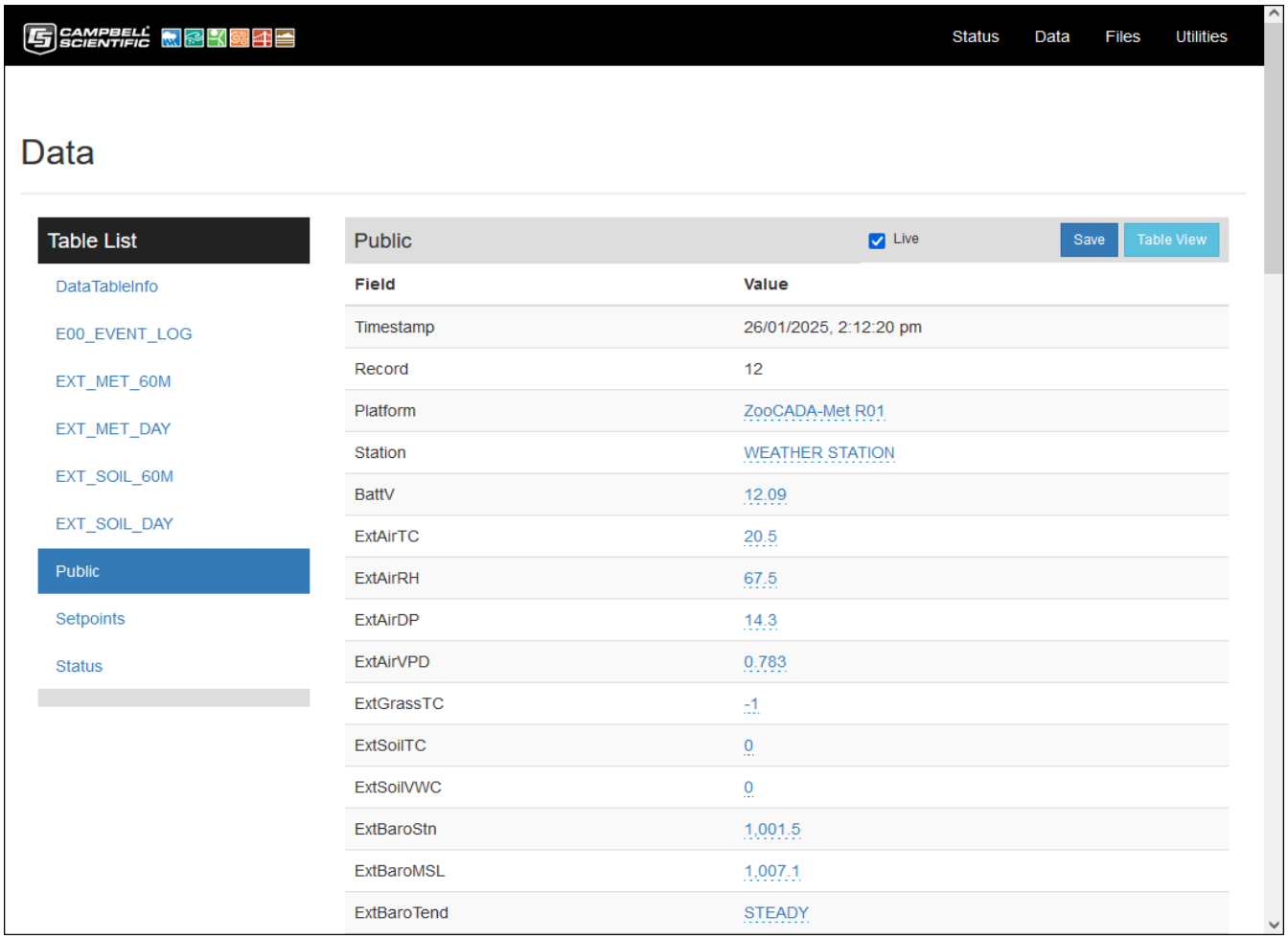
Results for Last Program Compiled - Contains messages generated at compilation or during runtime. Updated after compile and for runtime errors such as variable out of bounds.

Memory Free - Unallocated final-data memory in the datalogger (bytes). Free memory is not necessarily available for data tables. As memory is allocated and freed, small sections of unallocated memory, which are unusable for data tables, may be created. Updated after compile completes.

Errors - Skipped Scans is the number of program scans that have been skipped while the CRBasic program is running. Does not include scans intentionally skipped as a result of program instructions Do/Loop and ExitScan instructions. Updated as skipped scans occur. Can be reset by entering 0.

Variables Out of Bounds is the number of attempts to write to an array outside of the declared size. The write does not occur. Indicates a CRBasic program error. Updated at runtime when the error occurs. Can be reset by entering 0.

Data Page



The Data page enables data tables stored in the datalogger to be viewed and downloaded. On some datalogger models this page also allows selected Public variables to be graphed in realtime. It can be selected by clicking on Data on the header/menu bar at the top of the page.

When selecting this page, if you are not logged on, the logon dialog box is displayed. Click the [Cancel] button to continue as an anonymous user without a logon, if this option is allowed by datalogger security settings, or enter your logon credentials to continue. You must logon to be able to make administrative changes.

The Table List on the left hand side of the page shows the available data tables. The Public data table is selected by default when the page is opened. Choose the desired table by clicking on the table name in the Table List.

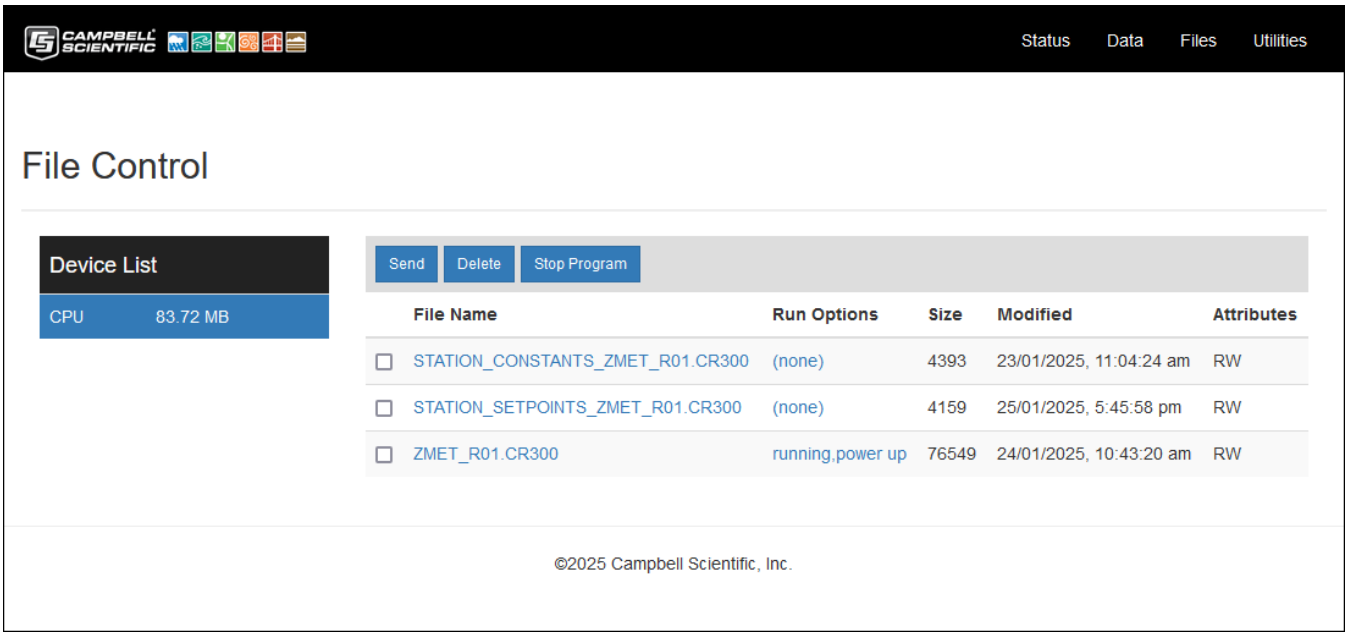
The grey header displays the name of the selected data table. Check the Live checkbox to allow the display to update automatically as new data arrives. Click the [Save] button to save the data table to the computer.

The button on the right of the [Save] button toggles between [Table View] and [Record View] display modes.

[Table View] - Selects the table view mode when the page is currently in record view mode.

[Record View] - Selects the record view mode when the page is currently in table view mode.

File Control Page



The File Control page enables management of the datalogger files. Files can be sent, deleted, activated, and deactivated. The files page can be selected by clicking on Files on the header/menu bar at the top of the page.

When selecting this page, if you are not logged on, the logon dialog box is displayed. Click the [Cancel] button to continue as an anonymous user without a logon, if this option is allowed by datalogger security settings, or enter your logon credentials to continue. You must logon to be able to make administrative changes.

IMPORTANT: Changes using this page should not be made unless requested by technical support.

The available devices are listed in the Device List on the left hand side of the page. Normally there will only be the one device, the datalogger CPU, and it will be automatically selected.

The files loaded onto the selected device are displayed below the grey header/toolbar which provides the buttons for each task. A checkbox beside each file allows the files to be selected.

Send - Click to send a file to the datalogger. A dialog box opens to allow selection of the desired file. Double click the desired file to send it to the datalogger.

Delete - Click to delete the selected file. A confirmation dialog box appears. Click [Yes] to delete the file [No] to keep the file and cancel the delete operation.

Stop Program - Click to stop the program running in the datalogger. A confirmation dialog box appears. Click [Yes] to stop the program [No] to cancel the operation. The information shown under Run Options will change to indicate the program has stopped.

There should always be at least one program file in the list, this being the program currently running in the datalogger. Under the Run Options heading it will show running, power up next to the file name.

When a program is upgraded to a new version, the datalogger will automatically set the new program to run on datalogger startup and retain the previous version. This is useful if an unexpected problem occurs with the new program version as it's easy to set the new program version to stop and then set the previous version to run.

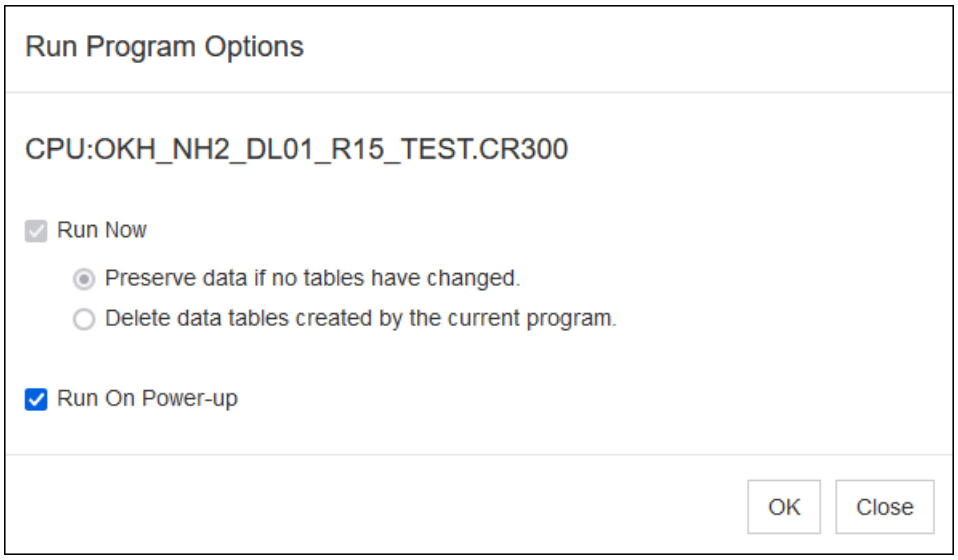
File Name Click

Clicking on the file name opens a Windows dialog box that allows the file to be saved to the computer or opened with a program on the computer. The save option is selected by default. Save the file as desired.

IMPORTANT: LoggerNet is required on the computer if the program file is to be edited.

Run Options Click

The Run Options shown next to the file name indicate if the datalogger program is running and whether or not it is set to start on power up. Clicking the Run Options opens the Run Options Dialog Box.



If the datalogger program is running the dialog box will look like the example above with the Run Now options greyed out as they are not available.

If the program is stopped the Run Now options will be available.

Run Now Checkbox - Select to start the datalogger program, then choose the desired data table option.

Preserve data if no tables have changed - Datalogger will attempt to preserve the data tables.

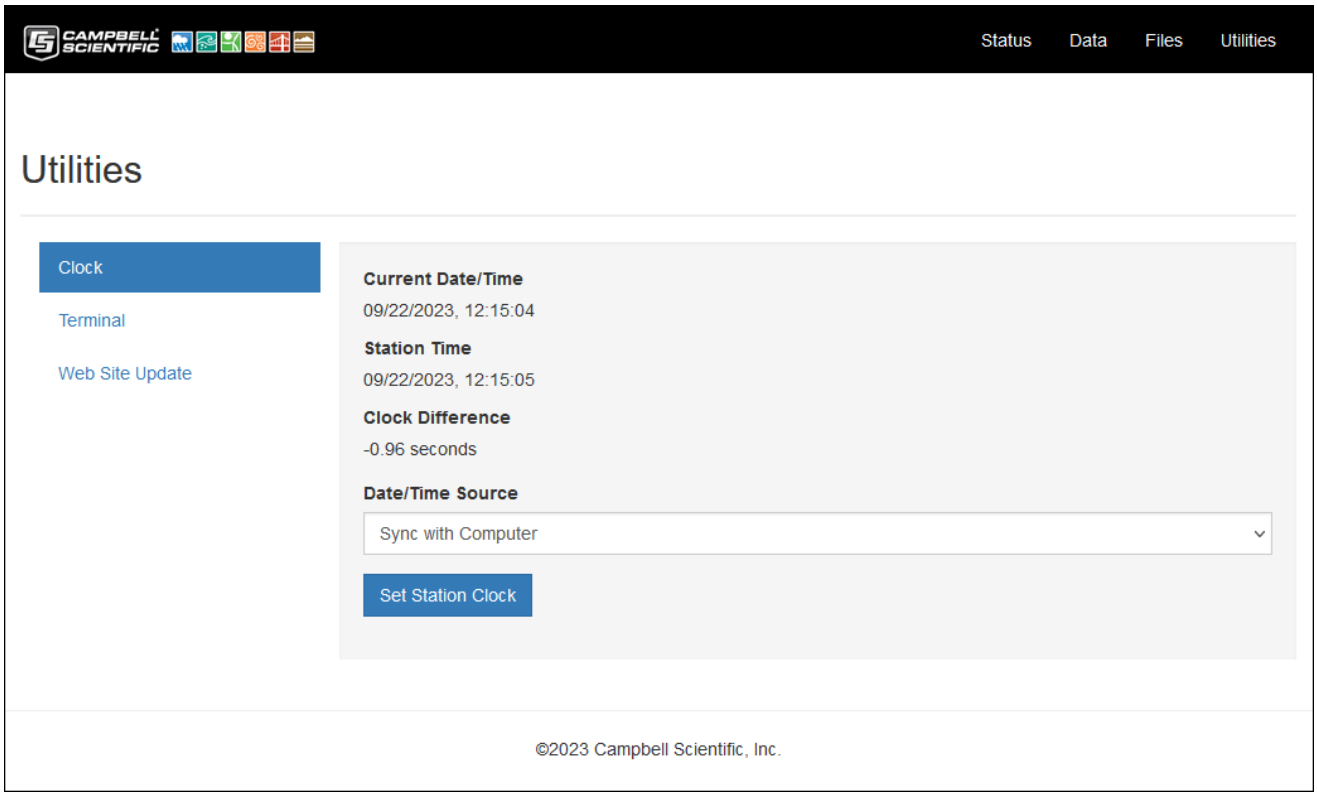
Delete data tables created by the current program - The data tables will be deleted.

Run On Power-up - Select to enable the program to start automatically when the datalogger is powered up.

WARNING: Failure to select Run On Power-up will cause the system to remain stopped after a power failure. It will then have to be manually started using the Run Options Dialog box every time there is a power failure to the datalogger until this setting is corrected.

Once the correct Run Options have been selected, click the [OK] button to start the datalogger program. The Run Options shown next to the file name will update to indicate the current status.

Utilities Page



The Utilities page enables setting the datalogger realtime clock and it provides a terminal function. It can be selected by clicking on Utilities on the header/menu bar at the top of the page.

The available utilities are listed on the left hand side of the page. Click to select the desired utility.

Clock Setting

When the page opens the Clock Setting utility is immediately available. It shows the current date and time from the computer, the station (datalogger) date and time, and the difference between the two.

The Date/Time Source drop down pick list offers two options for setting the time...

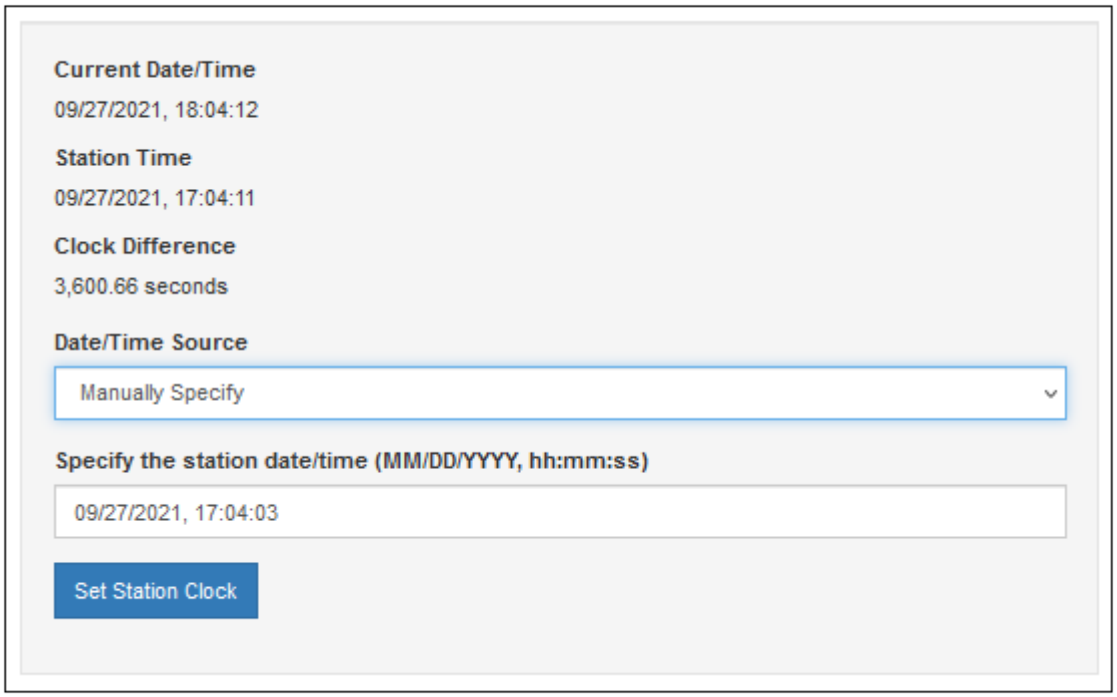
Sync With Computer - Click to set the station to the computer's time. Beware of daylight savings!

Manually Specify - Manually enter the correct time and date. This is the safest option.

IMPORTANT: Always use the Manually Specify option when setting the station (datalogger) clock to avoid inadvertently setting the station to the computer's Daylight Savings Time, which may cause data loss.

To reset the datalogger date and time to the correct date and time...

1. Choose the Manually Specify option from the Date/Time Source drop down pick list. The page will update and a text box Specify the station date/time (MM/DD/YYYY,hh:mm:ss) will be displayed as shown below.



2. Edit the displayed date and/or time as necessary so the correct date and time is displayed.

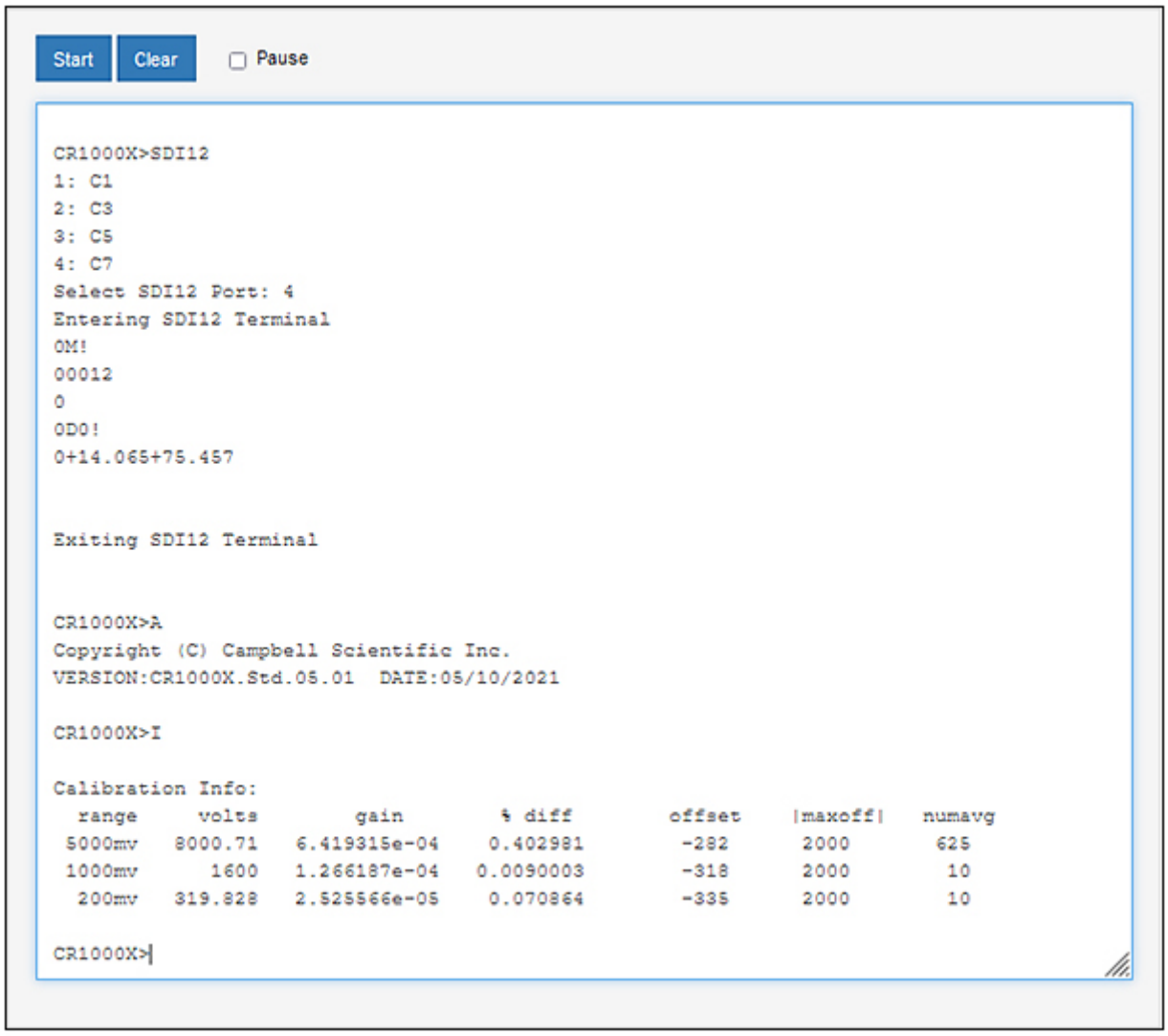
3. Click the [Set Station Clock] button. A confirmation dialog box appears.

4. Click the [Yes] button to immediately update the station clock, or [No] to cancel the operation.

Tip: When editing the station time, enter a new time that is about thirty seconds ahead of the current time of day, then click the [Set Station Clock] button. Hover the mouse pointer over the [Yes] button on the confirmation dialog box and watch the Current Date/Time display approach the new time you entered for the station, then click the [Yes] button when the current time is one second before the time you have set.

IMPORTANT: DO NOT adjust the station (datalogger) clock for daylight savings time as doing so creates data anomalies that cannot be easily corrected and may result in loss of data.

Terminal



The terminal function is primarily an engineering tool. It is not necessary to use it for routine datalogger operations other than configuring SDI-12 sensors. A sample Terminal session is shown above.

In this example the datalogger was placed into SDI-12 Transparent mode using the SDI12 command, then selecting SDI-12 port C7 by entering the selection 4 from the choices given.

NOTE: Only one sensor can be connected to the datalogger SDI-12 port when Transparent mode is used.

The SDI-12 command 0M! was issued to request the sensor initiate measurement. The 0 is the sensor SDI-12 address, M is the measurement instruction, and ! is the command terminator.

The SDI-12 command 0D0! was then issued to retrieve the measurement values from the sensor. The 0 is the sensor SDI-12 address, D0 is the measurement instruction, and ! is the command terminator.

The sensor responded with the values +14.065 and +75.457 which for the sensor used is the air temperature in degrees Celsius and the relative humidity in percent.

The SDI-12 Transparent mode was then exited and two commands issued to the datalogger.

Command A requested the datalogger operating system information, and command I requested the datalogger calibration information.

Sensor Measurements

This section provides information about how the datalogger program obtains the various climate measurements used to monitor the external (outdoor) climate. The measurements provide information that can assist users with research, and management of the zoo park. All sensors are read and processed automatically by the datalogger.

All-In-One 50 Weather Sensor Checks

A SDI-12 all-in-one weather sensor is installed at at suitable location in the zoo park and is wired back to the datalogger which measures the sensor once every minute to collect all the individual measurements, these being air temperature, relative humidity, barometric pressure, solar radiation, precipitation, wind speed, wind direction, wind gust speed, and on some models, wind gust direction, lightning strikes, and lightning distance.

Each time a measurement is completed, the program carries out a series of tests to ensure the measurement values obtained are within the manufacturers specified operating range. If a measurement fails, it typically returns a value that is out of range such as -9999 or NAN (Not A Number) so detecting such values enables the program to automatically manage sensor errors.

The test criteria for the air temperature (TC) measurement value is:

TC between -40 and 60 degrees C and TC is not NAN

The test criteria for the air relative humidity (RH) measurement value is:

RH between 0 and 100 % and RH is not NAN

The test criteria for the barometric pressure (BP) measurement value is:

BP between 500 and 1100 hPa and BP is not NAN

The test criteria for the solar radiation (SR) measurement value is:

SR between 0 and 1750 W/m^2 and SR is not NAN

The test criteria for the precipitation (RG) measurement value is:

RG between 0 and 50 mm and RG is not NAN

The test criteria for the wind speed (WS) measurement value is:

WS between 0 and 30 m/s and WS is not NAN

The test criteria for the wind direction (WD) measurement value is:

WD between 0 and 359 degrees and WD is not NAN

The test criteria for the wind gust speed (WG) measurement value is:

WG between 0 and 30 m/s and WG is not NAN

The test criteria for the lightning strikes (LS) measurement value is:

LS between 0 and 65535 and LS is not NAN

NOTE: These checks verify that the measurement values returned by the sensor fall within the expected measurement range. They cannot verify that functioning sensors are also accurately calibrated, periodic calibration tests are recommended for this purpose.

Temperature Average, Minimum and Maximum Measurements

The all-in-one weather sensor reports the air temperature, as an average over the preceding minute, once each minute. The current temperature measurement is displayed in the Public variable ExtAirTC. The program processes this measurement to derive the average, minimum, time of minimum, maximum, and time of maximum, temperatures hourly and daily which are then logged in the hourly EXT_MET_HOUR data table and in the daily EXT_MET_DAY data table. All temperatures are displayed and logged in degrees Celsius.

Relative Humidity Average, Minimum and Maximum Measurements

The all-in-one weather sensor reports the air relative humidity (RH), as an average over the preceding minute, once each minute. The current relative humidity measurement is displayed in the Public variable ExtAirRH. The program processes this measurement to derive the average, minimum, time of minimum, maximum, and time of maximum, RH hourly and daily which are then logged in the hourly EXT_MET_HOUR data table and in the daily EXT_MET_DAY data table. The RH is displayed and logged as a percentage.

Grass Minimum Temperature Measurements

The grass minimum temperature is the lowest temperature reached overnight by a temperature sensor supported horizontally, just above short grass, and freely exposed to the sky. The recommended sensor type is a Campbell Scientific 107 sensor for this measurement. The program measures the sensor once every minute and displays the current grass temperature in the Public variable ExtGrassTC. The grass minimum temperature and the time it occurred is then logged in the hourly EXT_MET_HOUR data table and in the daily EXT_MET_DAY data table. The temperature is displayed and logged in degrees Celsius.

Dew Point Temperature Measurements

The dew point temperature is calculated from the vapour pressure, relative humidity, and the saturation vapour pressure. The saturation vapour pressure is derived from the dry bulb temperature, and the vapour pressure from saturation vapour pressure and relative humidity.

The dew point is calculated using Tetens' equation solved for dew point with coefficients optimized for the temperature range of -35 to +50 degrees C as follows...

$$Td = \frac{a3 \times Ln\left(\frac{Vp}{a1}\right)}{a2 - Ln\left(\frac{Vp}{a1}\right)}$$

$$\begin{aligned}
&Where:\\
&Td = Dew\ Point\ Temperature\\
&Vp = Vapour\ Pressure\\
&a1 = 0.61078\\
&a2 = 17.558\\
&a3 = 241.88
\end{aligned}$$

The current dew point temperature measurement, in degrees Celsius, is displayed in the Public variable ExtAirDP and logged in the hourly EXT_MET_HOUR data table and the daily EXT_MET_DAY data table.

Vapour Pressure Measurements

The vapour pressure, saturation vapour pressure, and vapour pressure deficit values are all calculated by the program from the temperature and relative humidity values measured by the sensors.

It is important to understand that relative humidity (RH), is actually a ratio between the amount of water vapour currently in an air sample, called the vapour pressure, and the maximum amount of water vapour that air sample can "hold" at its current temperature, called the saturation vapour pressure.

The RH is determined using the following equation:

$$RH\ \% = \left(\frac{Vapour\ Pressue}{Saturation\ Vapour\ Pressure} \right) \times 100$$

The saturation vapour pressure value increases with increasing temperature, so if the air in an enclosure has a RH of 60 % at 15 degrees Celsius, and that same air is then warmed to 20 degrees Celsius it will have a RH of about 44 %, or if cooled to 10 degrees Celsius it will have a RH of about 83 %.

The saturation vapour pressure for air at a given temperature can be derived using the following polynomial (reference Lowe, Paul R.: 1977, "An approximating polynomial for computation of saturation vapour pressure," Journal of Applied Meteorology, 16, 100-103), adjusted from units of millibars to kilopascals:

$$SatVP = (A0 + A1 \times T + A2 \times T^2 + A3 \times T^3 + A4 \times T^4 + A5 \times T^5 + A6 \times T^6) \times 0.1$$

$Where:$
$T = Temperature$
$A0 = 6.107799961$
$A1 = 4.436518521E-01$
$A2 = 1.428945805E-02$
$A3 = 2.650648471E-04$
$A4 = 3.031240396E-06$
$A5 = 2.034080948E-08$
$A6 = 6.136820929E-11$

When the relative humidity and the saturation vapour pressure are known, the vapour pressure can be determined using the following equation:

$$VP = RH \times SatVP \div 100$$

The vapour pressure deficit is then determined by the following equation:

$$VPD = SatVP - VP$$

The vapour pressure deficit determines how much plants can transpire so it's useful for horticultural purposes, such as managing plants in a nocturnal house. The current vapour pressure deficit ExtAirVpd value is displayed in the Public data table with the hourly and daily averages logged in the respective data tables.

Barometric Pressure Measurements

The all-in-one weather sensor reports the barometric pressure, as an average over the preceding minute, once each minute. This measurement is referred to as the station pressure (the pressure at that station's elevation) and is placed into the communications array where it can be accessed by all stations on the network.

In order for other stations on the network to display and log the barometric pressure measurement, the station constant BARO_ENAB must be set to True and the station's elevation above Mean Sea Level, (MSL) in metres, must be entered into the BARO_STN_ELEV station constant in each station where the display and logging of the barometric pressures is desired.

The station pressure is displayed in the BaroStn variable in the Public data table and the pressure calibrated to Mean Sea Level is displayed in the BaroMSL variable, also in the Public data table. Both pressures are displayed in hectopascals (hPa). The station pressure is useful in situations where a measure of the actual pressure is required, whilst the barometric pressure at Mean Sea Level is consistent with pressures shown on meteorological charts intended to indicate the prevailing atmospheric conditions.

The barometric pressure measurement, at Mean Sea Level, is derived from the station pressure measurement by calculating the difference pressure *dP* using the station elevation *E* above Mean Sea Level, in metres, then adding that difference pressure to the station pressure.

The difference pressure is determined using the following equation:

$$dP = 1013.25\left\{1 - \left(1 - \frac{E}{44307.69231}\right)^{5.25328}\right\}$$

This equation assumes U. S. Standard Atmosphere and dry air (Atmospheric Science, Wallace and Hobbs 1977), and is as given in the Campbell Scientific BaroVue 10 Product Manual.

The average barometric pressure is logged in the hourly EXT_MET_HOUR data table and the daily EXT_MET_DAY data table.

Barometric Pressure Tendency Indication

If the barometric pressure is available on the network and the station is configured to display it, the barometric pressure tendency, measured over the previous three hours, is also displayed in the Public data table variable BaroTend. The variable will display one of the following indications:

RISING x hPa	-	The pressure has increased by x HectoPascals
FALLING x hPa	-	The pressure has decreased by x HectoPascals
STEADY	-	The pressure has not changed
ERROR	-	An error was detected in the pressure measurement.

In order to be considered as RISING or FALLING the current barometric pressure must be at least 3.0 hPa different from the barometric pressure stored three hours ago. A pressure change of less than 3.0 hPa over three hours is considered to be STEADY barometric pressure. The three hourly stored pressure is updated once every minute as is the tendency indication.

Solar Radiation Measurements

The solar radiation is measured using a pyranometer which may be integrated into the all-in-one weather sensor, or it can be a separate SDI-12 instrument. In either case the pyranometer returns the solar radiation as a power measurement calibrated in Watts per square metre (W/m^2). This measurement is normally converted to a solar insolation measurement in megajoules per square metre (MJ/m^2) totalised on an hourly and daily basis.

ZooCADA-Met can optionally display and record solar insolation in kWh/m^2 to suit the preferences of any site. Setting the Station Constant SOLAR_KWH to True changes the default calibration of MJ/m^2 to kWh/m^2 sitewide. Given that 1 Joule = 1 Watt for 1 second, the following formulas are used to calculate the solar insolation in MJ and kWh.

The conversion from Watts to megajoules is:

$$MJ = W \times T \times 1E^{-6}$$

$$Where:$$
$$MJ = megajoules$$
$$W = Watts$$
$$T = seconds$$

The conversion from Watts to kilowatt hours is:

$$kWh = W \times T \times 2.7777777777778E^{-7}$$

$$Where:$$
$$kWh = killowatt\ hours$$
$$W = Watts$$
$$T = seconds$$

The hourly solar insolation total is logged in the EXT_MET_HOUR data table each hour and the daily solar insolation total is logged in the EXT_MET_DAY data table each day at midnight.

Wind Vector Direction And Speed Measurement

The all-in-one weather sensor uses an ultrasonic anemometer and returns the wind speed in metres per second and wind direction in degrees, with 0 degrees representing a northerly wind blowing from north to south. The ultrasonic anemometer measures the wind speed and direction every 10 seconds and stores the instantaneous wind vector components.

Each minute, the ZooCADA-Met program queries the all-in-one weather sensor which then outputs the average of the instantaneous measurements for wind speed and direction over the previous minute. The ZooCADA program stores ten, one minute, samples and calculates 10 minute rolling averages for display and telemetry purposes. The hourly and daily averages are also calculated for data logging.

Calculating averages for wind speed and direction requires special consideration. Whilst it can be acceptable to calculate a simple arithmetic mean for wind speed, this cannot be done for wind direction. A problem arises because wind direction is usually reported as an angle in degrees, typically 0-359 degrees, where 0 degrees represents North. If the wind is blowing from a northerly direction and samples traverse the discontinuity at the

0 and 359 degrees points of that circular scale, calculating an arithmetic average will result in an average wind direction that is somewhere in the southern quadrant, which is clearly incorrect.

To correctly calculate an average from a circular scale, trigonometric functions must be used to handle the angles. The calculations return the resultant wind vector direction and the wind vector speed.

The first step is to calculate the orthogonal components of each wind direction and speed sample, these being the West-East component and the North-South component. These are calculated using the following formula:

$$Cwe = -Ws \times \sin\left[\frac{\pi}{180} \times Wd\right]$$

$$Cns = -Ws \times \sin\left[\frac{\pi}{180} \times Wd\right]$$

$Where:$
$Cwe = West-East\ component$
$Cns = North-South\ component$
$Ws = Wind\ speed$
$Wd = Wind\ direction\ in\ degrees$

The next step is to calculate the arithmetic average of the *Cwe* components and the *Cns* components for all of the samples to obtain *AvgCwe* and *AvgCns* values as follows:

$$AvgCwe = \frac{Cwe_1 + Cwe_2 + Cwe_3 \ldots Cwe_n}{n}$$

$$AvgCns = \frac{Cns_1 + Cns_2 + Cns_3 \ldots Cns_n}{n}$$

$Where:$
$Cwe = West-East\ component$
$AvgCwe = Average\ of\ West-East\ components$
$Cns = North-South\ component$
$AvgCns = Average\ of\ North-South\ components$
$n = Number\ of\ samples\ being\ averaged$

The wind vector direction is calculated from the average West-East component and the average North-South component as follows:

$$Wvd = \left(360 + \left(\frac{180}{\pi} \times atan2(-AvgCns, -AvgCwe)\right)\right) mod\ 360$$

$Where:$
$AvgCwe = Average\ of\ West-East\ direction\ components$
$AvgCns = Average\ of\ North-South\ direction\ components$
$Wvd = Wind\ vector\ direction\ in\ degrees$

The wind vector speed is calculated from the average West-East component and the average North-South component as follows:

$$Wvs = \sqrt{AvgCwe^2 + AvgCns^2}$$

$Where:$
$AvgCwe = Average\ of\ West-East\ direction\ components$
$AvgCns = Average\ of\ North-South\ direction\ components$
$Wvs = Wind\ vector\ speed\ in\ m/s$

Precipitation (Rain) Measurements

The amount of precipitation is measured using a rain gauge that may be integrated into the all-in-one weather sensor, or a standard tipping bucket with a switch closure pulse output can be used. In either case the precipitation is collected by a funnel and flows down into the measuring instrument. The measurement is made either by counting drops of a known size determined by the instrument which responds to a query once a minute from ZooCADA-Met by reporting the amount of precipitation collected over the last minute calibrated in millimetres, or by gradually filling a tiny bucket until it tips and empties itself operating an electronic switch in the process to produce a single pulse which ZooCADA-Met counts and calibrates to millimetres each minute. Tipping bucket rain gauges are the preferred sensor type where frequent falls of heavy rain occur as they tend to be more accurate, however the precipitation measurements achieved by all-in-one weather sensors are plenty accurate for most purposes and can sometimes be more accurate measuring heavy dew and very intermittent light rainfall.

IMPORTANT: The accuracy of all-in-one weather sensors rain measurements decreases during high-intensity rain storms greater than 50 mm/hr. A standard tipping bucket rain gauge is recommended for applications with high-intensity rainfall that require accurate long-term accumulation measurements.

Irrespective of the method of measuring rainfall, the ZooCADA-Met program accumulates an hourly and a daily precipitation total in millimetres. The hourly total is a rolling sixty minute total, sixty one-minute samples, which are totalised and displayed the Public variable RainHour and logged to the EXT_MET_HOUR data table each hour on the hour.

Using a rolling sixty minute total provides users with the opportunity of using an alternative interpretation, the sixty minute rainfall intensity. This is updated every minute enabling rapidly increasing or decreasing rain

intensity to be monitored and compared against setpoints for the high rainfall alarm. This rolling total is also placed into the communications array so it can be utilised by other stations on the network.

In addition, a separate daily total RainDay, accumulated during the day, is displayed in the Public data table and logged to the EXT_MET_DAY data table each day at midnight, then reset after logging ready for the next day. The daily total is also constantly compared against the high rain alarm setpoints. Using the rolling sixty minute total and the daily accumulated total enables either a sudden brief heavy downpour event, of a slower persistent rain event, to trigger the high rain alarm when sufficient rainfall has occurred.

Soil Moisture and Temperature Measurements (Optional)

A Range of instruments are available with SDI-12 output for measuring soil moisture. The recommended sensor type is a Campbell Scientific CS650 soil moisture reflectometer which produces a measurement of the soil volumetric water content, the bulk electrical conductivity, and the soil temperature. This sensor comprises of an epoxy block that contains the electronics and holds two parallel, 300 mm long, stainless steel rods that are inserted into the soil. A thermistor in the bottom of the epoxy block senses the soil temperature. Using a technique known as time domain reflectometry, the CS650 sends a signal along the stainless steel rods and measures the propagation time, signal attenuation, and temperature. Dielectric permittivity, volumetric water content, and bulk electrical conductivity are then derived from these values by the sensor's microprocessor and sent to the datalogger each time the instrument is queried.

SDI-12 Sensor Address Settings

The SDI addresses should be set on the external and enclosure sensors as follows…

External All-In-One Weather Sensor	-	Port C1 - Address "0"
External Solar Pyranometer	-	Port C1 - Address "c"
External Soil Moisture & Temperature	-	Port C1 - Address "d"

Communications to Remote Stations

All stations (dataloggers) in the ZooCADA system are designed to operate either as a single standalone station, or as one station in a network of stations where one or more of the external sensors may be located at remote stations with communications between stations achieved across a conventional IP computer network. The values required to be retrieved via network communications must be present in the Public data table and are placed into an array. The datalogger program uses a designated communications array for this purpose. The measurement values stored in the communications array of any given station are available, via network communications, to all other stations across the network.

The station that a user can currently "touch" is referred to as the local station, all other stations are remote stations.

Up to two remote stations with can be configured as sources for remote sensor measurement values, one is designated as the primary remote station and the other is the secondary remote station. The primary remote station is normally the first that the communications attempts to retrieve the desired values from. If communications to the primary remote station fails, the communications will automatically try to retrieve the values from the secondary remote station.

Normally in a wired IP network the communications are very reliable and the secondary remote station is unlikely to be called, but in a wireless network where the link quality may vary the secondary remote station can provide an alternative path by which the desired values can be obtained when necessary.

External Temperature and Humidity Sensor Configuration Options

Correct configuration of external temperature and humidity sensors is critical to the proper functioning of the ZooCADA system. Only one external temperature and humidity sensor can be installed on any one datalogger and is referred to as the local external sensor. When two external sensors are available on the network one of them must be assigned as the primary external sensor, the other becomes the secondary external sensor.

All ZooCADA stations that provide climate control functions require at least one external air temperature and RH sensor, installed as either a local sensor or a remote sensor, to provide the external air reference used by the control system. ZooCADA monitoring only stations do not need an external air reference but can be configured to log data from a remote external sensor, or to provide a local external sensor to the network.

Single Primary Local Sensor Only

In this configuration the primary external sensor is connected to the local station and there are no remote sensors available. The local external sensor should be configured as the primary sensor when it is the only external sensor on the network. This is also the configuration for a single standalone datalogger installation.

The station constants settings are:

EXT_TRH_LOCAL = True

EXT_TRH_PRIMARY = True

Primary Local Sensor with a Remote Sensor

In this configuration the primary external sensor is connected to the local station and a secondary remote sensor is available. The local sensor is configured as the primary external sensor and the local station obtains the secondary external sensor measurement values from another station on the network.

The station constants settings are:

EXT_TRH_LOCAL = True

EXT_TRH_PRIMARY = True

Secondary Local Sensor with a Remote Sensor

In this configuration the secondary external sensor is connected to the local station and a primary remote sensor is available. The local sensor is configured as the secondary sensor and the local station obtains the primary external sensor measurement values from another station on the network.

The station constants settings are:

EXT_TRH_LOCAL = True

EXT_TRH_PRIMARY = False

Single Remote Sensor Only

In this configuration there is no external sensor connected to the local station. The local station obtains the external sensor values from another station on the network.

The station constants settings are:

EXT_TRH_LOCAL = False

EXT_TRH_PRIMARY = False

Two Remote Sensors

In this configuration there is no external sensor connected to the local station. The local station obtains the external sensor values for both external sensors from another station on the network.

The station constants settings are:

EXT_TRH_LOCAL = False

EXT_TRH_PRIMARY = False

The Communications Array

A communications array is maintained by the datalogger program in the Public data table of the datalogger. This array contains the temperature and relative humidity values from the primary and, if installed, secondary external sensors, and may contain additional sensor values as well. Any station on the network can retrieve the array with all its values from any other station on the network. All values in the communications array are in the format "CommsValue" where the "Comms" prefix indicates it is a communications array value.

Communications array values are:

CommsEx1TC - Primary external temperature in degrees C (Decimal).

CommsEx1RH - Primary external relative humidity in % (Decimal).

CommsEx2TC - Secondary external temperature in degrees C (Decimal).

CommsEx2RH - Secondary external relative humidity in % (Decimal).

CommsExBaro - Barometric (station) pressure in hPa (Decimal).

CommsExSolar - Solar radiation in W/m2 (Decimal).

CommsExRainHr - Rainfall rolling 60 minute total in mm (Decimal).

CommsExRainDay - Rainfall daily total in mm (Decimal).

CommsExWindSpd - Wind vector speed in m/s (Decimal).

CommsExWindDir - Wind vector direction in degrees (Int).

CommsExGustSpd - Wind gust speed current hour in m/s (Decimal).

CommsExGustDir - Wind gust direction current hour in degrees (Int).

If a sensor is not present, or the sensor measurement returns an error, the corresponding communications array variables are loaded with "NAN" which means Not A Number. The program in each datalogger interprets that NAN as a sensor error and responds accordingly.

For the primary and secondary external air temperature and relative humidity measurements, the datalogger program reads the measurement values from the communications array, checks for obvious errors, averages the values if the values from two sensors are available, then uses the resultant external temperature and relative humidity values for HVAC control purposes as well as logging those values.

Remote Station Communication Configuration Options

Each station must be allocated its own static IP address and its own PakBus address, both of which must be unique on the network. These addresses are used to communicate with the station over the network and are set using the Device Configuration Utility in the LoggerNet software.

The datalogger program for each station must also be configured with the IP address and PakBus address of each remote station it is to communicate with, and the communications to each designated address must be enabled. These settings are made in the STATION_CONSTANTS file.

The examples below assume a private IP network (192.168.x.x) with the subnet 192.168.1.x). These IP address numbers may be different depending upon your specific network. Please consult your network administrator for IP address allocation information. The PakBus addresses are specific to the dataloggers on the network and will have been defined during datalogger installation.

A page is provided at the back of this manual that can be used to record the station names, IP addresses and PakBus addresses during installation for future reference.

Primary Remote Station

This is the remote station from which the local station will normally retrieve the desired values.

The station constants settings are:

EXT_TRH1_ENABLE = True

EXT_TRH1_PK = 82

EXT_TRH1_IP = 192.168.1.82

To disable the primary remote station, set:

EXT_TRH1_ENABLE = False

Secondary Remote Station

This is the remote station from which the local station will attempt to retrieve the desired values if the communications to the primary remote station fails or is disabled.

The station constants settings are:

EXT_TRH2_ENABLE = True

EXT_TRH2_PK = 92

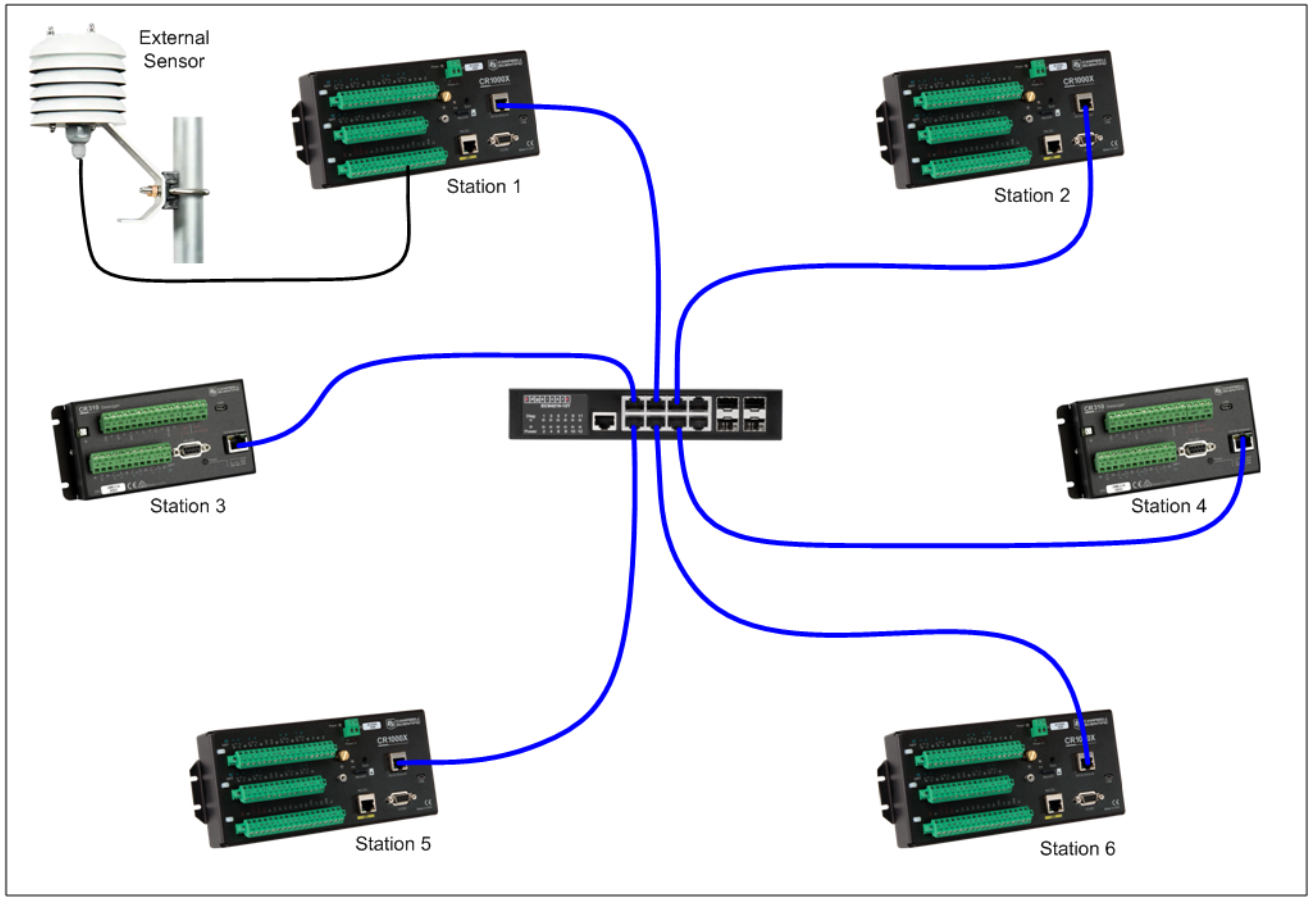
EXT_TRH2_IP = 192.168.1.92

To disable the secondary remote station, set:

EXT_TRH2_ENABLE = False

Small Network Example

The diagram below is an example of a small network. Station 1 has the primary external sensor and there is no secondary external sensor. All other stations retrieve the primary external sensor measurement values from Station 1. This solution doesn't offer failsafe redundancy for the external sensor but is perfectly adequate for a small network.



In this example, assuming the PakBus address and the IP address for each station is the station number in the diagram above, the configuration settings would be:

Station 1

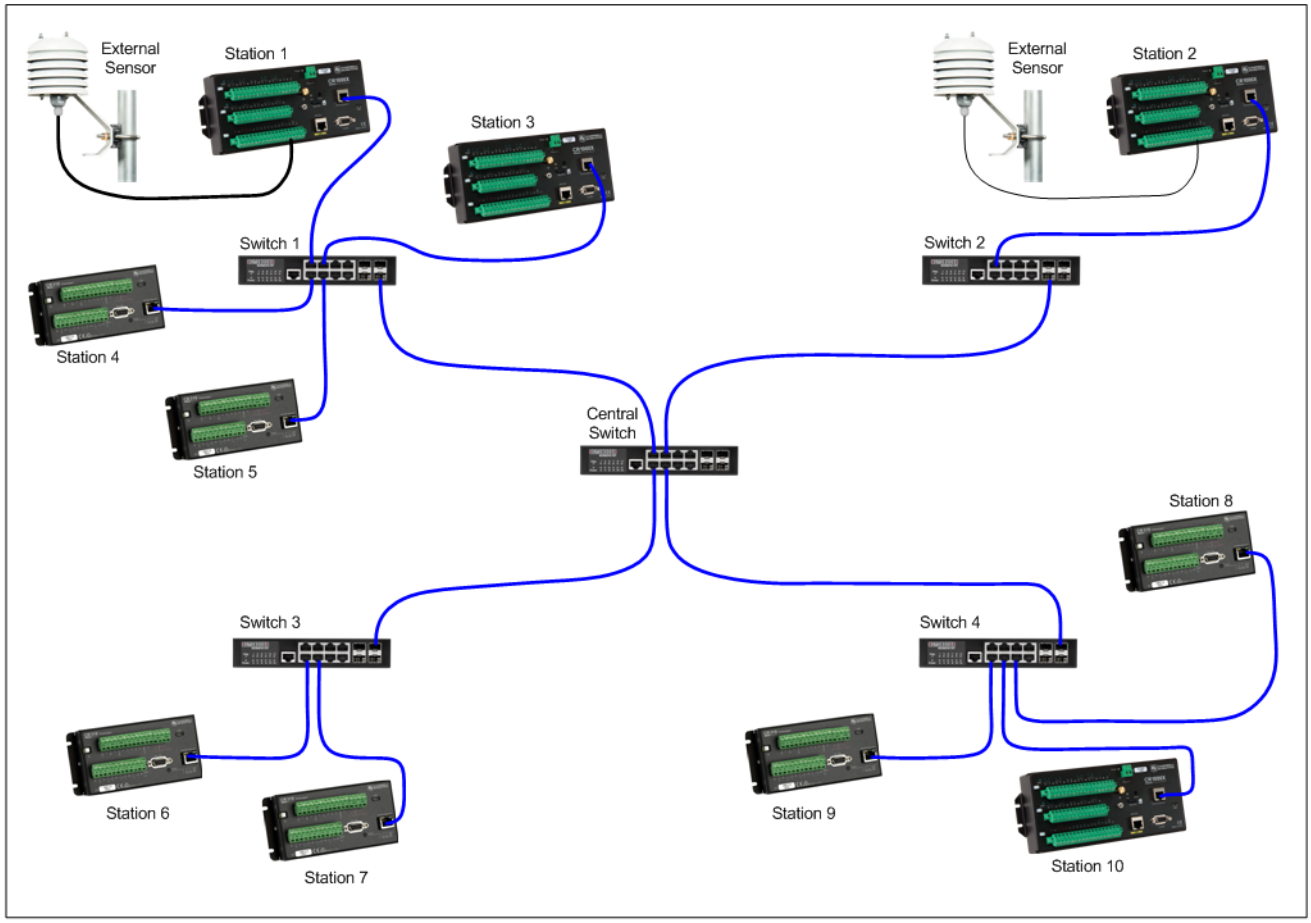
EXT_TRH_LOCAL = True
EXT_TRH_PRIMARY = True
EXT_TRH1_ENABLE = False
EXT_TRH1_PK = 1 (ignored)
EXT_TRH1_IP = 192.168.1.1 (ignored)
EXT_TRH2_ENABLE = False
EXT_TRH2_PK = 2 (ignored)
EXT_TRH2_IP = 192.168.1.2 (ignored)

All Other Stations

EXT_TRH_LOCAL = False
EXT_TRH_PRIMARY = False
EXT_TRH1_ENABLE =True
EXT_TRH1_PK = 1
EXT_TRH1_IP = 192.168.1.1
EXT_TRH2_ENABLE = False
EXT_TRH2_PK = 2 (ignored)
EXT_TRH2_IP = 192.168.1.2 (ignored)

Large Network Example

The diagram below is an example of a large network that includes failsafe redundancy for the external sensors. In this example, the stations are also configured so the communications that retrieves the external sensor measurement values is distributed across the network to improve network traffic management.



A good design technique is to keep communications between stations localised, as much as possible, to the network switches they are directly connected to.

Station 1 has the primary external sensor and retrieves the secondary external sensor measurement values from Station 2, while Station 2 has the secondary external sensor and retrieves the primary external sensor measurement values from Station 1. These two stations traverse the Central Switch to exchange the two values.

The other stations on Switch 1 all retrieve both external sensor measurement values from Station 1. Stations 6 and 8 traverse the central switch to retrieve both external sensor measurement values from Station 2. All other stations on Switch 2 (in this case none) would retrieve both external sensor measurement values from Station 2. All other stations on Switch 3 (in this case just Station 7) would retrieve both external sensor measurement values from Station 6. All other stations on Switch 4 (in this case Stations 9 and 10) would retrieve both external sensor measurement values from Station 8. This distributes the network traffic to avoid potential bottlenecks.

If a communications failure to the designated primary remote occurs for any station, except Stations 1 and 2 with local sensors installed, the station is able to retrieve the array of external sensor measurement values from a secondary remote station. All stations normally have the measurement values from both external sensors in its communications array so if the communications fails to a station with an external sensor installed on it, all stations can continue to operate using just the values from the remaining good external sensor station. This provides a high level of reliability of the shared external sensor values.

In this example, assuming the PakBus address and the IP address for each station is the station number in the diagram above, the configuration settings would be:

Station 1

EXT_TRH_LOCAL = True
EXT_TRH_PRIMARY = True
EXT_TRH1_ENABLE = True
EXT_TRH1_PK = 2
EXT_TRH1_IP = 192.168.1.2
EXT_TRH2_ENABLE = False
EXT_TRH2_PK = 10 (ignored)
EXT_TRH2_IP = 192.168.1.10 (ignored)

Station 2

EXT_TRH_LOCAL = True
EXT_TRH_PRIMARY = False
EXT_TRH1_ENABLE =True
EXT_TRH1_PK = 1
EXT_TRH1_IP = 192.168.1.1
EXT_TRH2_ENABLE = False
EXT_TRH2_PK = 8 (ignored)
EXT_TRH2_IP = 192.168.1.8 (ignored)

Stations 3, 4 and 5

EXT_TRH_LOCAL = False
EXT_TRH_PRIMARY = False
EXT_TRH1_ENABLE = True
EXT_TRH1_PK = 1
EXT_TRH1_IP = 192.168.1.1
EXT_TRH2_ENABLE = True
EXT_TRH2_PK = 2
EXT_TRH2_IP = 192.168.1.2

Stations 6 and 8

EXT_TRH_LOCAL = False
EXT_TRH_PRIMARY = False
EXT_TRH1_ENABLE =True
EXT_TRH1_PK = 2
EXT_TRH1_IP = 192.168.1.2
EXT_TRH2_ENABLE = True
EXT_TRH2_PK = 1
EXT_TRH2_IP = 192.168.1.1

Station 7

EXT_TRH_LOCAL = False
EXT_TRH_PRIMARY = False
EXT_TRH1_ENABLE = True
EXT_TRH1_PK = 6
EXT_TRH1_IP = 192.168.1.6
EXT_TRH2_ENABLE =True
EXT_TRH2_PK = 2
EXT_TRH2_IP = 192.168.1.2

Stations 9 and 10

EXT_TRH_LOCAL = False
EXT_TRH_PRIMARY = False
EXT_TRH1_ENABLE = True
EXT_TRH1_PK = 8
EXT_TRH1_IP = 192.168.1.8
EXT_TRH2_ENABLE =True
EXT_TRH2_PK = 2
EXT_TRH2_IP = 192.168.1.2

Communications States

The datalogger program displays the current communications state CommsState in the Public data table so users can easily check on the communications operation.

The possible communication states are:

COMMS ATTEMPT X - Attempting to contact a remote station.

This state is displayed while the local station is attempting to communicate with a remote station. The number "X" is the attempt number which increments for each successive attempt if communications is not established on the first attempt.

COMMS OK - Primary remote station contacted successfully.

This state is displayed after the local station has successfully completed communications with the primary remote station and collected the data in its communications array. This is the normal state.

COMMS SEC OK - Secondary remote station contacted successfully.

This state is displayed after the local station has successfully completed communications with the secondary remote station and collected the data from its communications array. This is the normal state that is expected when the primary remote station is either disabled or communications to it fails.

COMMS RETRY X - Communications retry needed after initial attempt failed.

This state is displayed after the local station failed an attempt to communicate with a remote station. The number "X" is the number of the pending retry and increments for each successive retry until either the maximum number of retries is reached or the communications succeeds.

COMMS FAIL - Communications failure, remote stations cannot be contacted.

This state is displayed when communications has been been successful and the maximum number of retries has been reached. This state triggers a Comms Failure alarm and is written to the Event Log.

DISABLED - Communications to remote stations is switched off and isn't used.

This state is displayed when communications is set to disabled because there are no remote stations to communicate with, or there is an unresolved communications problem and it was desirable to prevent a recurring communications alarm until repair work can be carried out.

INITIALISING - Communications state is undetermined while control system program is starting up.

This state is displayed when the datalogger program is starting up and the communications system has not yet made an attempt to communicate with a remote station. It represents a temporary indeterminate state that will resolve itself to one of the above states.

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Functional States

The datalogger program uses state switches to keep track of the operation of all functions. The current setting of each state switch is displayed in the Public data table variables so system users can see what state each program function is in. Each of the state switches is detailed below.

Air Temperature State

The air temperature state is displayed in the Public data table TcState variable. This gives a visual indication of whether or not the air temperature is currently within the setpoint range.

The possible air temperature states are:

HIGH - The air temperature is above the high temperature alarm setpoint.

OK - The air temperature is in the normal range.

LOW - The air temperature is below the low temperature alarm setpoint.

ERROR - The air temperature is in an indeterminate state.

Rainfall State

The rainfall state is displayed in the Public data table RainState variable. This gives a visual indication of whether or not the rainfall is currently within the setpoint range.

The possible rainfall states are:

HIGH - The rainfall is above the high rainfall alarm setpoint.

OK - The rainfall is in the normal range.

Wind Speed State

The wind speed state is displayed in the Public data table WindState variable. This gives a visual indication of whether or not the wind speed is currently within the setpoint range.

The possible wind speed states are:

HIGH - The wind speed is above the high wind alarm setpoint.

OK - The wind speed is in the normal range.

All-In-One Weather Sensor State

The all-in-one weather sensor state is displayed in the Public data table SensorState variable. This gives a visual indication of whether or not the sensor is operating correctly.

The possible weather sensor states are:

OK - The sensor is operating normally.

TC FAIL - The temperature sensor is malfunctioning.

RH FAIL - The relative humidity sensor is malfunctioning.

BP FAIL - The barometric pressure sensor is malfunctioning.

SR FAIL - The solar radiation sensor is malfunctioning.

RG FAIL - The precipitation (rain gauge) sensor is malfunctioning.

WS FAIL - The wind speed sensor is malfunctioning.

WD FAIL - The wind direction sensor is malfunctioning.

WG FAIL - The wind gust sensor is malfunctioning.

LS FAIL - The lightning strike sensor is malfunctioning.

LD FAIL - The lightning distance sensor is malfunctioning.

ST FAIL - The weather sensor tilt is excessive and will result in inaccurate measurements.

The all-in-one weather sensor state may indicate multiple failures. For example if the state indicated WD, WS, WG FAIL it could suggest a complete failure of the wind measuring instrument in the weather sensor. Another possible multiple failure state indication is TC, RH, BP, SR, RG, WS, WD, WG, LS, LS, ST FAIL which, although it suggests every instrument in the weather sensor has failed, could be the result of a failure of the power supply to the weather sensor rather than a failure of the weather sensor itself.

Barometric Pressure Sensor Quality Metric State

The ZooCADA-Met weather station supports the quality metric value output by some barometric pressure sensors, whether the barometric pressure sensor is part of an all-in-one weather sensor or is a standalone barometric pressure sensor. The barometric pressure sensor quality metric state is displayed in the Public data table BaroQMState variable. A barometric pressure sensor failure alarm is triggered if the sensor state indicates that the sensor has failed.

The current QM (Quality Metric) value, if available, is reported in the BaroQMState variable to provide a visible indication of the current calibration accuracy of the barometric pressure sensor. A QM value of 6 or higher indicates a freshly calibrated sensor, 5 or higher indicates the calibration is OK, 4 to 4.99 indicates that recalibration is needed most likely in the next two to three months, and less than 4 indicates the sensor needs recalibration.

If the sensor state indicates FAIL with a QM value of 4 or higher, the fault may be in the instrument electronics or elsewhere, not necessarily in the pressure sensor itself.

The possible barometric pressure sensor states (systems with QM value) are:

OK (QM n.nn) - The barometric pressure sensor is working normally.

RECALIB SOON - The sensor will need recalibrating in two to three months.

FAIL (QM n.nn) - The barometric pressure sensor needs recalibrating or has failed.

The possible barometric pressure sensor states (systems without QM value) are:

OK - The barometric pressure sensor is working normally.

FAIL - The barometric pressure sensor needs recalibrating or has failed.

Power State

The mains power state is displayed in the Public data table PowerState variable. A prolonged power outage may result in the enclosure temperature reaching unacceptably high or low levels so any power outage triggers an alarm to alert staff. The datalogger is battery backed and is able to send alarm email messages while the UPS systems on the LAN are operating (typically 5-10 minutes after a power outage).

The possible power states are:

OK - Mains power is available, either from the electricity supply company or an on site generator set.

POWER FAIL - The mains power supply has failed, no mains power is available. Alarm triggered.

Alarm State

The alarm state is displayed in the Public data table AlarmState variable. The alarm system is designed record all alarm events into an Event Log data table so users can check on the recent system events, including any alarms. In addition to recording alarms in the Event Log, the alarms state is used to trigger the sending of alarms email messages via the email messaging system.

The possible alarms states are:

DISABLED - The alarm system has been disabled, no alarms will be detected.

INITIALISING - The alarm system is starting up and determining if any alarms are active.

NO ALARMS - All alarms are cleared.

>> ALARMS << - One or more alarms have been triggered.

NOTE: The alarms state displays >> ALARMS << with the chevrons when alarms are active to make this item more conspicuous in the displayed list of Public data table variables. The alarms state is not intended to provide details on the various alarms, this information is available via the other state switch indications, the Event Log, and the email messages.

Other State Switches

For information on the communications state CommsState and the email message send state EmailState please see the “Communications to Remote Stations” and “Email Messaging System” sections respectively.

Event Log

TOA5, OKH_NH2_DL01, CR300, 15614, CR310.Std.10.07, CPU:OKH_NH2_DL01_R15.CR300.685.E00_EVENT_LOG		
TIMESTAMP	RECORD	EventDetected
TS	RN	
		Smp
2024-01-1118:28:18	0	Datalogger Program Started
2024-01-1118:29:48	1	Alarm Power Failure
2024-01-1118:29:48	2	Email Alarms
2024-01-1118:29:48	3	EMAIL TEST MODE
2024-01-1118:31:20	4	Power Failure Cleared
2024-01-1118:31:20	5	Email Alarms Cleared
2024-01-1118:31:20	6	EMAIL TEST MODE

The EVENT_LOG data table contains a descriptive indication of each event that occurs. This data table holds the most recent 1000 events, normally sufficient for several weeks of routine events, before its ring memory overwrites the oldest records with the newest records. The event log records all alarms and various other system events.

NOTE: Many of the event messages are also used to build the content of alarm email messages or appear in the various state variables displayed in the datalogger Public data table. Logging these events in the EVENT_LOG data table provides significant insights into the system operation and assists with problem resolution.

Viewing The Event Log

The Event log can be viewed two ways:

1. By collecting the data from the datalogger using LoggerNet, then opening the EVENT_LOG file with the View Pro utility which is part of LoggerNet. The data table is displayed in an easily readable format.

2. By viewing the data table in the dataloggers built-in web site.

Please see the Using The Web Interface chapter in this document for details on using the dataloggers built-in web site or the LoggerNet Product Manual, which can be downloaded from the Campbell Scientific web site, for details on using the various LoggerNet tools.

Event Messages

This section lists all the events that may be logged in the EVENT_LOG data table, for the ZooCADA-Met program, and provides an explanation of their meaning.

All-In-One Weather Sensor

AIO Sensor XX, YY, ZZ Fail - An instrument in the weather sensor has failed and triggered an alarm.

These events occur when the all-in-one weather sensor malfunctions. A weather sensor alarm will be raised. The XX, YY, ZZ abbreviations refer to the instrument(s) in the weather sensor from which an error was detected.

The weather sensor instrument codes are:

TC - Temperature sensor.

RH - Relative humidity sensor.

BP - Barometric pressure sensor.

SR - Solar radiation sensor.

RG - Precipitation (rain gauge) sensor.

WS - Wind speed sensor.

WD - Wind direction sensor.

WG - Wind gust sensor.

LS - Lightning strike sensor.

LD - Lightning distance sensor.

ST - Weather sensor tilt sensor.

Alarm Weather Sensor Failure - The all-in-one weather sensor is malfunctioning.

Weather Sensor Failure Cleared - The all-in-one weather sensor alarm was cleared.

These events occur when the all-in-one weather sensor malfunctions, raising an alarm. The alarm automatically clears when the malfunction is repaired.

Barometric Pressure Sensor

Systems with QM reporting:

Barometric Sensor OK (QM n.nn) - The barometric pressure sensor is working normally.

Barometric Sensor RECALIB SOON - The sensor will require recalibration in two to three months.

Barometric Sensor FAIL (QM n.nn) - The barometric pressure sensor needs recalibrating or has failed.

Systems without QM reporting:

Barometric Sensor OK - The barometric pressure sensor is working normally. (systems without QM value)

Barometric Sensor FAIL (QM n.nn) - The barometric pressure sensor needs recalibrating or has failed.

These events indicate a change of the barometric pressure sensor's state switch BaroQMState and are based on the sensor's QM (Quality Metric) output. A QM of 5 or higher indicates the OK state, 4 to 4.99 indicates recalibration is needed soon, less than 4 indicates the sensor needs recalibration or has failed.

Severe Weather Alarms

Alarm High temperature - The high air temperature alarm was triggered.

High Temperature Cleared - The high air temperature alarm was cleared.

Alarm Low temperature - The low air temperature alarm was triggered.

Low Temperature Cleared - The low air temperature alarm was cleared.

These events occur when the air temperature exceeds the high temperature or low temperature setpoints. The alarm automatically clears when the temperature returns to within the normal range.

Alarm High Rainfall - The high rainfall alarm was triggered.

High Rainfall Cleared - The rainfall alarm was cleared.

These events occur when the high rainfall rolling hourly total or daily accumulated total setpoints are exceeded triggering an alarm. The alarm automatically clears when the rolling hourly total and daily total have both reduced to 10% below their respective high rainfall setpoints.

Alarm High Wind Speed - The wind speed or wind gust speed alarm was triggered.

High Wind Speed Cleared - The wind speed or wind gust alarm was cleared.

These events occur when the wind speed or wind gust speed exceed the high wind setpoints. The alarm automatically clears when the wind speed and wind gust speed have both reduced to 10% below their respective high wind speed setpoints.

Datalogger Program Restarts

Datalogger Program Started - The datalogger program was (re)started.

ZooCADA-Met R01 - Follows the program restarted message to identify the program and its version.

These events occur when the datalogger is powered on after a power failure and whenever a change to the program causes the program to restart. Program restarts will also occur when a new program is uploaded to the data logger or if the user adjustable Setpoints are edited. This is usually normal functioning of the datalogger but an excessive number of random restarts, not caused by power failure or program changes may indicate an problem with the datalogger.

Power Failure

Alarm Power Failure - The mains power failure alarm was triggered.

Power Failure Cleared - The mains power failure alarm was cleared.

These events occur when a mains power failure occurs and when the power is subsequently restored.

Remote Station Communications

COMMS FAIL - The communications to the remote stations has failed.

This event occurs when the local station cannot communicate with the remote station(s) to retrieve the external sensor data. It may correct itself before becoming an alarm event. Successful communications attempts are not logged. Excessive or continuous communications failures are usually the result of network problems, datalogger configuration errors, or hardware failures.

Alarm Comms Failure - The data network communications failure alarm was triggered.

Comms Failure Cleared - The data network communications alarm has been cleared.

These events occur when a network failure occurs and when the network is subsequently restored to normal operation. Communications failures generally point to network problems, a configuration or hardware problem with a remote station, or a configuration or hardware problem with the local station. On sites where radio communications form part of the network the radio links may cause random intermittent communications failures that come right on their own.

Email System

Email Alarms - An email message advising of the alarms for this station has been sent.

This event occurs when the datalogger sends an email message advising staff of the station's alarms and is a normal function of the system. The event is generated every time the alarms system for the station changes state (either a new alarm occurs or an existing alarm is cleared).

Email Alarms Re-Send - The daily outstanding alarms email message for this station has been sent.

This event occurs when the datalogger sends the outstanding alarms reminder email message. This is a normal function of the system that is intended to remind staff each day of all outstanding alarms that have not yet been resolved. This message is not sent unless it is enabled in the system settings and unresolved alarms are present.

Email Alarms Cleared - An email message advising all the alarms for this station have been cleared.

This event occurs when the datalogger sends an email message advising staff that all the station's alarms have been cleared. It is a normal function of the system.

EMAIL SENT OK - The Email Relay server has received the message and relayed it to the recipients.

This event occurs when the datalogger successfully sends an email message. It is a normal function and the event is logged simply to enable confirmation that the email system is working.

EMAIL COMMS FAIL - The connection to the Email Relay server failed.

This event occurs when an email message cannot be sent because the datalogger is unable to connect to the Email Relay server. The error could be due to the Email Relay server being down in which case the system will return to normal operation when the Email Relay server administrator restores their server to operation. Other causes could be a network communications problem, a hardware fault, or a datalogger configuration error.

EMAIL DATA ERROR - The EmailRelay() function was called but not executed, the message was not sent.

This event occurs when an email message cannot be sent because execution of the EmailRelay() function did not occur due to lack of data records or not enough time. Possible causes include a network problem, a hardware fault, or a datalogger program error.

EMAIL COMMS ERROR - Error in communication to the Email Relay server, the message was not sent.

This event occurs when a connection to the Email Relay server was made but there was an error in communication, or the Email Relay server dropped the connection. Possible causes include a network problem, a datalogger program error, or a hardware fault.

This error also occurs if the datalogger has exceeded the maximum of 100 email messages sent via the Campbell Scientific Email Relay server in one day. If this limit is reached the Email Relay server terminates all further email send attempts by that datalogger until the next day (USA Time). A potential cause is an intermittent sensor fault that causes its measurement value to flip-flop between normal and an alarm state hundreds of time a day. This error will be obvious to staff as their email inbox will have been flooded with alarm email messages from the affected station.

EMAIL DISABLED - The email messaging system is set to disabled, email messages will not be sent.

This event occurs when an email message would have been sent but the email system was set to disabled as it is not required. This is an informative diagnostic message, not a fault in the system.

EMAIL TEST MODE - The email messages are diverted to a file for test purposes.

This event occurs when an email message would have been sent but the email system was set to Test Mode which diverts the messages to a file for test purposes. and is an advisory message only.

Alarms Module

The datalogger program monitors the temperature, rainfall wind speed, the functioning of the all-in-one weather sensor, and various other parameters to determine the alarms. An alarm is triggered whenever an abnormal event is detected. An alarm reset occurs when the trigger event has returned to normal. No user intervention is required to reset the alarms, this process is fully automated, although staff may well need to take action to either remedy the cause of the alarm, or arrange for a service technician to repair the fault that caused the alarm.

The alarms control module must be enabled in the STATION_CONSTANTS file for the alarms detection to operate.

Enabling The Alarms

The alarms module is enabled, or disabled, by setting the ALARM_ENABLE station constant in the datalogger program as follows:

ALARM_ENABLE = True (The alarms are enabled), or

ALARM_ENABLE = False (The alarms are disabled).

NOTE: Enabling the alarms module enables alarms and alarm resets to be detected and then recorded in the EVENT_LOG data table. The email module must also be enabled in order for the datalogger program to send alarms email messages to staff. Please see the Email Messaging System chapter for further information.

Alarms Delay

The alarm delay time AL_DELAY (typically 10 seconds) is set in the program constants and is applied to all alarms to prevent nuisance alarms that would otherwise occur if an alarm condition is triggered and then immediately returns to normal. This delay time can be changed if necessary but is not intended to be user adjustable.

Alarms Event Logging

When the alarms module is enabled, each change of state of the alarms (alarms triggered and/or reset) will result in the alarm event being written to the event log. Please refer to the event log chapter for detailed information on all event messages and their meaning. Once an alarm is reset it is logged as being cleared as it no longer appears in the list of active alarms.

Alarms Module States

The datalogger program displays the current alarms state variable AlarmState in the Public data table so users can easily check on the overall state of the alarm system.

The possible alarm states displayed in the Public data table variable are:

DISABLED - The alarm system is not in use and has been disabled.

INITIALISING - The alarm system is starting up and determining if any alarms are active.

NO ALARMS - All alarms are cleared.

>> ALARMS << - One or more alarms have been triggered.

The alarm state only indicates the state of the alarm system, not the state of each individual alarm. The state of the individual alarms is indicated via the state variables displayed in the Public data table, the event log, and the alarm email messages.

Temperature Alarms Operation

The temperature alarms process is entirely automatic, once the temperature returns to normal, the alarms will automatically reset.

The normal air temperature range is determined by the high temperature and low temperature alarm setpoints, Set_ExtAirTC_HI and Set_ExtAirTC_LO respectively. When the air temperature moves too far beyond one of these setpoints an air temperature alarm is triggered.

The air temperature setpoints are contained in the Setpoints data table in the datalogger and can be changed by users. There are air temperature setpoints for each month of the year to enable the alarms to be configured differently for the different seasons if desired. The default is the same air temperature setpoints all year round.

The operation of the air temperature setpoints is intentionally the same as the setpoints in ZooCADA enclosure HVAC control systems to provide consistency for staff on sites with multiple ZooCADA stations.

The air temperature is measured once every minute and a temperature alarm is triggered if the air temperature ExtAirTC becomes higher than the high setpoint Set_ExtAirTC_HI, or lower than the low setpoint Set_ExtAirTC_LO, by the station constant ALARM_DEGREES.

Once an alarm is triggered it remains in that state until the reset conditions are met. The air temperature alarm automatically resets when the enclosure temperature becomes lower than the station constant ALARM_RESET amount below the high temperature setpoint Set_ExtAirTC_HI and higher than the ALARM_RESET amount above the low temperature setpoint Set_ExtAirTC_LO.

The alarm trigger station constant ALARM_DEGREES is normally set to 0 on the weather station so the alarm is triggered when the setpoint is reached, and the alarm reset station constant ALARM_RESET is normally set to about 2 degrees. The difference between these two values becomes the temperature alarm hysteresis value and must be at least one degree.

The following logic is applied to determine the state of the temperature alarm for each enclosure:

If Temperature >= Set_ExtAirTC_HI + ALARM_DEGREES

Set AlarmState to HighAlarm

Otherwise if Temperature <= Set_ExtAirTC_LO - ALARM_DEGREES

Set AlarmState to LowAlarm

Otherwise if Temperature > Set_ExtAirTC_LO - ALARM_RESET and Temperature < Set_ExtAirTC_HI + ALARM_RESET

Set AlarmState to OK

The nature of the alarm is logged in the EVENT_LOG data table and sent to staff in the alarms email messages.

Rainfall Alarms Operation

The rainfall alarm has two setpoints, SET_RAIN_HOUR_HI and SET_RAIN_DAY_HI in the Station Setpoints table and are displayed in the Public data table variables Set_RainHour_HI and Set_RainDay_HI respectively.

The high rainfall alarm is triggered whenever the the rolling sixty minute rainfall total RainHour exceeds the Set_RainHour_HI setpoint. The RainHour total changes up or down in value every minute depending upon the amount of rain so that it displays the total rainfall over the previous sixty minutes. This means the displayed value can also be interpreted as rainfall intensity in millimetres per hour on a minute by minute basis.

The high rainfall alarm is also triggered whenever the total rainfall accumulated during the day RainDay exceeds the Set_RainDay_HI setpoint. The rainfall amount, measured over the previous minute, is added to RainDay each minute. This value is reset at midnight after the total is logged.

A brief period of heavy rain can trigger the high rainfall alarm and the alarm will probably reset later in the day when the rain stops. This ensures that brief heavy downpours, that may cause localised flash flooding, will trigger an alarm and that alarm clears when the threat has passed as long as the accumulated RainDay total remains below the Set_RainDay_HI setpoint.

In a longer period of persistent rain, the accumulated daily total will trigger the high rainfall alarm and even if the rain stops the alarm will not reset until midnight. This alarm ensures that longer persistent rainfall that can cause a gradual build up of surface water resulting localised flooding is also detected. This alarm condition is always automatically reset at midnight.

After a high rainfall alarm is triggered, it automatically resets only when the RainHour total has reduced to at least 10% below the Set_RainHour_HI setpoint and the RainDay total is at least 10% below the Set_RainDay_HI setpoint. If the RainDay total was exceeded during the day, it will not be reset until after it is logged at midnight, which will cause the high rainfall alarm to persist until then.

The high rainfall alarm is logged in the EVENT_LOG data table and sent to staff by alarm email message.

Wind Speed Alarms Operation

The wind speed alarm has two setpoints, SET_WIND_SPEED_HI and SET_WIND_GUST_HI in the Station Setpoints table and are displayed in the Public data table variables Set_WindSpd_HI and Set_GustSpd_HI respectively.

The high wind speed alarm is triggered whenever the rolling ten minute average wind speed WindVectSpd exceeds the Set_WindSpd_HI setpoint. The WindVectSpd value changes up or down every minute so it displays the average wind speed over the previous ten minutes. This alarm indicates that the wind speed is sufficiently high that it may begin to cause damage, such as tree limbs breaking off.

The high wind speed alarm is also triggered whenever the maximum wind gust speed GustSpdHour exceeds the Set_GustSpd_HI setpoint. The GustSpdHour value stores the maximum wind gust speed recorded during the hour. This alarm indicates when a strong gusty wind speed may become damaging even though the underlying average wind speed has not reached a damaging level.

After a high wind speed alarm is triggered, it automatically resets only when the WindVectSpd has reduced to at least 10% below the Set_WindSpd_HI setpoint and the GustSpdHour is at least 10% below the Set_GustSpd_HI setpoint.

The high wind speed alarm is logged in the EVENT_LOG data table and sent to staff by alarm email message.

All-In-One Weather Sensor Failure Alarms Operation

In the event that an instrument within the all-in-one weather sensor fails, it is likely to produce a value that is outside of its specified operating range, such as -9999, or perhaps NAN which means Not A Number.

Each time the weather sensor is queried by the datalogger program, the program tests each of the returned measurement values for any out of range value(s). The program sets out of range values to NAN and uses the NAN value, where possible, to prevent erroneous measurements from cancelling existing period summary totals, averages, maximums, and minimums that originate from a sensor that fails. It does this by preventing NAN values from being used in the period summary calculations. The rationale being that it's better to preserve whatever data has been collected in the period than to loose it all, even though the period data may then be incomplete. Data users can determine from the E00_EVENT_LOG data table if any errors occurred within the time span of any given data set that could cause inaccuracies need to be considered during data analysis.

If an out of range value or NAN is detected the program sets the weather sensor's state variable, SensorState, to indicate the nature of the failure, then logs it to the E00_EVENT_LOG data table for reference.

The possible weather sensor states are:

OK - The sensor is operating normally.

TC FAIL - The temperature sensor is malfunctioning.

RH FAIL - The relative humidity sensor is malfunctioning.

BP FAIL - The barometric pressure sensor is malfunctioning.

SR FAIL - The solar radiation sensor is malfunctioning.

RG FAIL - The precipitation (rain gauge) sensor is malfunctioning.

WS FAIL - The wind speed sensor is malfunctioning.

WD FAIL - The wind direction sensor is malfunctioning.

WG FAIL - The wind gust sensor is malfunctioning.

LS FAIL - The lightning strike sensor is malfunctioning.

LD FAIL - The lightning distance sensor is malfunctioning.

ST FAIL - The weather sensor tilt is excessive and will result in inaccurate measurements.

The all-in-one weather sensor state may indicate multiple failures. For example if the state indicated WD, WS, WG FAIL it could suggest a complete failure of the wind measuring instrument in the weather sensor. Another possible multiple failure state indication is TC, RH, BP, SR, RG, WS, WD, WG, LS, LS, ST FAIL which, although it suggests every instrument in the weather sensor has failed, could be the result of a failure of the power supply to the weather sensor rather than a failure of the weather sensor itself.

Barometric Pressure Sensor Failure Alarms Operation

The barometric pressure sensor failure alarm process is entirely automatic and integrated with the all-in-one weather sensor alarms in the Public table SensorState variable. When a faulty sensor has been repaired, the alarms will automatically reset. A sensor failure alarm can also occur if the sensor quality metric (QM) state, if available, indicates that the sensor requires recalibration. The sensor QM state is displayed in the Public table BaroQMState variable.

When the QM value is available, the possible states displayed in the BaroQMState variable are:

OK (QM n.nn) - The barometric pressure sensor is working normally.

RECALIB SOON - The sensor will need recalibrating in two to three months.

FAIL (QM n.nn) - The barometric pressure sensor needs recalibrating or has failed.

When no QM value is available the possible states displayed in the BaroQMState variable are:

OK - The barometric pressure sensor is working normally.

FAIL - The barometric pressure sensor needs recalibrating or has failed.

NOTE: Barometric pressure sensors require periodic recalibration, typically every few years. Please see the manufacturers Product Manual for more information on recalibration procedures.

A newly calibrated sensor has a QM typically greater than 6 and its state is set to OK. As the sensor ages it's QM value diminishes. When the QM value drops below 4, the sensor needs recalibration and its state is set to FAIL. A warning that sensor recalibration will be needed in the next two to three months is produced while the QM value is in the range 4 to 4.99 during which time the state is set to RECALIB SOON.

If a sensor failure is displayed, check the QM value first, if it's available. If the QM value is greater than 3.99 the failure may not be due to the sensor card, it could be a fault in the instrument electronics or elsewhere.

Power Failure Alarm Operation

The power failure alarm is automatic. It triggers when the power fails and resets when power is restored.

Mains electric power failures are usually the result of a failure somewhere in the power distribution system off site, rather than a problem with the electrical system in the building that is monitored by the datalogger, and power will be restored as soon as the electricity supply company is able to remedy the fault. The alarm is provided so that staff are informed and have the opportunity to take action should it be required.

A "power good" signal of about 2.6 Vdc from the datalogger's power supply is applied to the datalogger analog input port SE1. The PowerState variable in the Public data table indicates the presence or absence of that signal with two possible states as follows:

OK - Mains power is available, either from the electricity supply company or an on site generator set.

POWER FAIL - The mains power supply has failed, no mains power is available. Alarm triggered.

The nature of the alarm is logged in the EVENT_LOG data table and sent to staff in the alarms email messages.

WARNING: ALWAYS TREAT POWER LINES AS LIVE. Failures on the electricity supply network are normally restored without warning when the lines company has repaired the fault. **ELECTRIC SHOCK CAN BE FATAL!**

Communications Failure Alarm Operation

Although the ZooCADA-Log system itself does not require external temperature and relative humidity measurement values, it can fully participate in the sharing of external sensor measurement data across the network. Any station can be installed and configured to provide external sensor measurements to the network. Typically there is one or two stations installed with external sensors on a site and all the stations then communicate with one another to share that, and other data.

Occasionally, particularly in wireless links, communications errors result in a loss of a communication link between stations. The datalogger handles communications failures with multiple retries and use of a secondary station if the communications to the primary station fails, so normally the required data values are retrieved. If communications cannot be achieved within the MAX_COMMS_FAILS station constant number of retries, a communications failure alarm is triggered. The alarm automatically resets when communications is restored.

If the cause of the failure is due to a fault in the local station or its network connection, emailed alarm messages cannot be sent, but all communications failure are logged in the EVENT_LOG and the current state of the communications is displayed in the CommsState variable in the Public data table.

The possible communications states are:

COMMS ATTEMPT X - Attempting to contact a remote station.

COMMS OK - Primary remote station contacted successfully.

COMMS SEC OK - Secondary remote station contacted successfully.

COMMS RETRY X - Communications retry needed after initial attempt failed.

COMMS FAIL - Communications failure, remote stations cannot be contacted.

DISABLED - Communications to remote stations is switched off and isn't used.

INITIALISING - Communications state is undetermined while control system program is starting up.

The nature of the alarm is logged in the EVENT_LOG data table and sent to staff in the alarms email messages.

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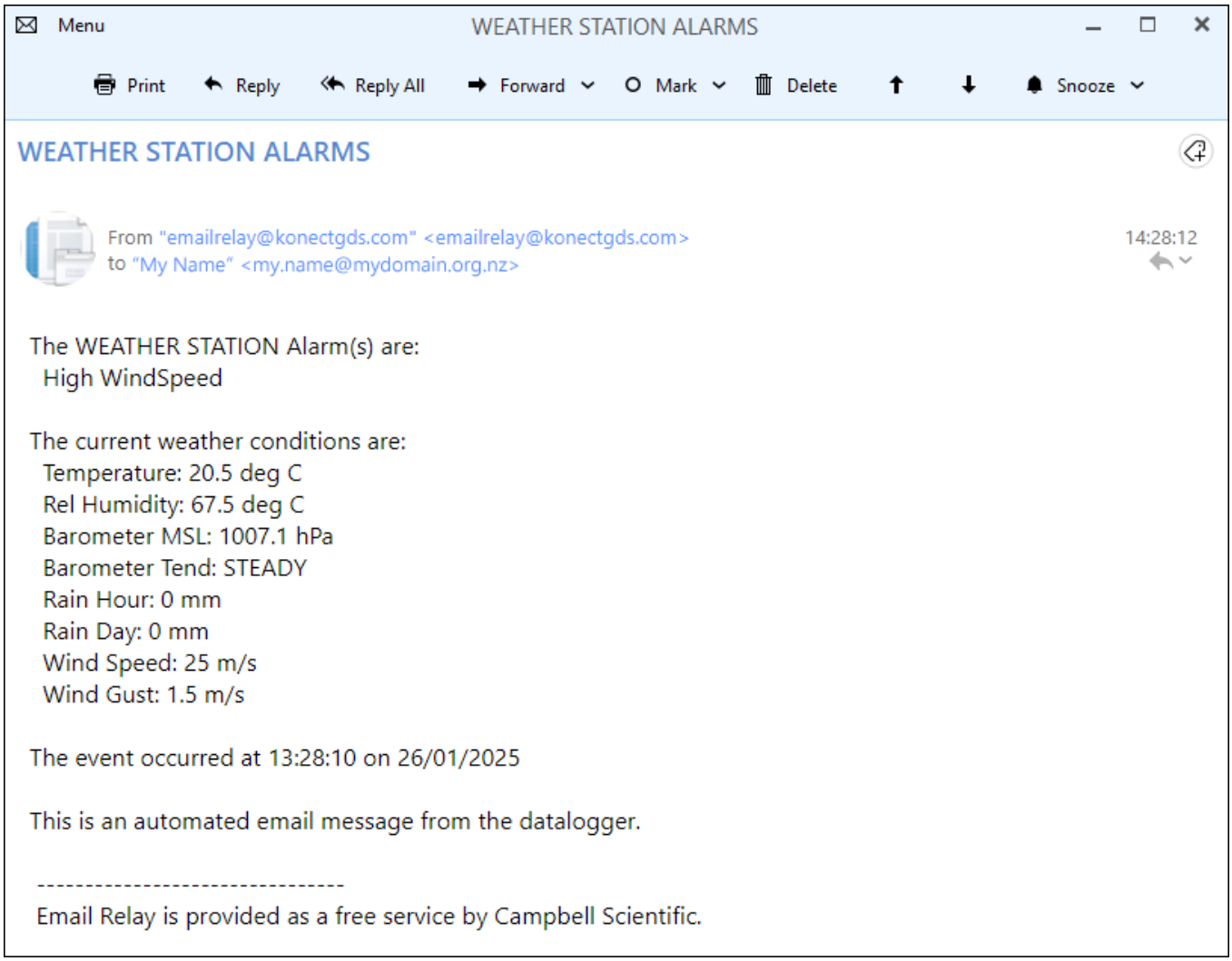
Email Messaging System



The datalogger can send alarm email messages advising users of events occurring at the station that need prompt attention. All messages are in the same format which is designed to alert users by the subject line alone, with more information contained in the message body. The format is designed to ensure messages are readily identified in a users email In-Box even on the smaller screens of mobile phones. A sample email message is shown above.

Alarms State Changed Email Messages

The operation of the email messaging system is completely automated.

The current state (active or inactive) of each alarm is stored in an array as a simple True or False, alarm active or alarm inactive respectively. Every two seconds the datalogger program checks the array to determine if the array contents have changed. If nothing has changed the alarms system does nothing further. If the array contents have changed, the datalogger program creates a list of the alarms that are active and uses that list to build the body of a new email message. If no alarms are active (all previous alarms have been cleared) the list of alarms simply becomes a single "All Alarms Cleared" line instead of a list of current alarms.

In this way, each alarm email message contains an up to date list of all the currently active alarms for the station. If there were two alarms listed on the previous email message and one of those has subsequently been cleared, the new email will simply list the remaining active alarm. This keeps the email message as concise as possible.

The email message is then sent via Campbell Scientific's Email Relay server to all the email recipients in the recipients list which is stored in the STATION_CONSTANTS file.

If the email message is not successfully sent to the Email Relay server, the datalogger program will try to send it again. The number of tries and the time between each try is set in the STATION_CONSTANTS file, typically three tries five minutes apart. Usually email messages are sent successfully on the first try but this technique helps ensure email messages will be sent successfully if the first try fails.

Alarms Daily Reminder Email Messages

Once each day the datalogger program can check the alarms array to determine if there are any outstanding alarms for the station that might have been overlooked. If outstanding alarms are present, it can then send a reminder email message to advise staff of the current situation.

The daily reminder email message function is enabled by default. If necessary, it can be disabled by setting the station constant ALARM_NAG = False in the datalogger program.

The reminder email message is normally sent at the beginning of the day so staff can schedule whatever remedial actions they consider appropriate into their day. The time at which the reminder email is sent is determined by the EMAIL_NAG_HOUR station constant. This setting, as with all ZooCADA system times, always operates in Standard Time. The default daily reminder email message send time setting is 8 for 08:00 hours.

If there are no outstanding alarms for the station, the reminder email message is not sent. This is to prevent cluttering up staff email inboxes with "All Alarms Cleared" messages on large sites with a number of stations.

Email Messaging System States

The datalogger program displays the current alarm email state EmailState in the Public data table so users can easily check on the messaging system operation.

The possible email message states are:

SENT OK - The Email Relay server has received the message and relayed it to the recipients.

This state is displayed after the datalogger successfully sends an email message. It indicates that the email message was sent normally.

COMMS FAIL - The connection to the Email Relay server failed.

This state is displayed when an email message cannot be sent because the datalogger is unable to connect to the Email Relay server. The error could be due to the Email Relay server being down in which case the system will return to normal operation when the Email Relay server comes back online. Other causes could be a network problem, a hardware fault, or a datalogger configuration error.

COMMS ERROR - Error in communication to the Email Relay server, the message was not sent.

This state is displayed when a connection to the Email Relay server was made but there was an error in communication, or the Email Relay server dropped the connection. Possible causes include a network problem, a datalogger program error, or a hardware fault.

This error also occurs if the datalogger has exceeded the maximum of 100 email messages sent via the Campbell Scientific Email Relay server in one day. If this limit is reached the Email Relay server terminates all further email send attempts by that datalogger until the next day (USA Time).

DISABLED - The email messaging system is set to disabled, email messages will not be sent.

This state is displayed when the email messaging system is set to disabled because it is not required. This is an informative indication, not a fault in the system.

DATA ERROR - The EmailRelay() function was called but not executed, the message was not sent.

This state is displayed when an email message cannot be sent because execution of the EmailRelay() function did not occur due to lack of data records or not enough time. Possible causes include a network problem, a hardware fault, or a datalogger program error.

TEST MODE - The email messages are diverted to a file for test purposes.

This state is displayed when an email message would normally have been sent but the email system is set to Test Mode so the message was diverted to a file for test purposes. This is an informative diagnostic message, not a fault in the system.

Email Message Format

The email message subject is set as follows:

New Alarms - The WEATHER STATION plus the word "ALARMS".

Daily Re-sent Alarms - The WEATHER STATION plus the words "ALARMS (RE-SENT)".

Alarms Cleared - The WEATHER STATION plus the words "ALARMS CLEARED".

The first line in the message body "The WEATHER STATION Alarm(s) are:" identifies the station and provides a heading for the list of alarms.

Under the first line, the message body lists all of the current active alarms for the weather station. To avoid clutter any cleared alarms are not listed. If there were multiple alarms listed on the previous email and one of those alarms has subsequently been cleared, the newly cleared alarm is simply removed from the list.

When all alarms are cleared, an email message is sent stating "All Alarms Cleared" in place of the previous list of active alarms. This confirms to staff that there are no alarms outstanding.

A blank line follows the alarms list to separate it from the second list.

The second list has the heading "The current weather conditions are:"

Following the second list heading, the current air temperature, relative humidity, barometric pressure, barometric tendency, rain hour total, rain day total, wind speed, and wind gust speed are listed. These weather conditions are listed on every weather station alarms email message, and the weather station alarms cleared message, to give staff an immediate indication of the current weather conditions and assist them with making decisions on their alarm response. The weather conditions values are updated before each email message send retry if the message is not successfully sent on the first try.

A blank line follows the temperatures list to separate it from the remainder of the message body.

The subsequent lines in the message body indicate the time the event occurred and identify the message as being an automated message from the datalogger.

NOTE: The time the event occurred is retained for subsequent email message send retries if the initial email message fails to send. This helps provides staff with an indication of how much time has elapsed since the alarm actually occurred.

Each email message ends with a footer stating "Email Relay is provided as a free service by Campbell Scientific" which is automatically applied by Campbell Scientific's Email Relay server.

Alarms Email Messages

The following information details the various alarms that can be sent by the datalogger as email messages to the recipients listed in the TO_ADDR station constant. All email messages are designed to provide a consistent format and concise content.

All-In-One Weather Sensor Alarm Messages

Alarm Weather Sensor Failure - The all-in-one weather sensor is malfunctioning.

This alarm is triggered when the all-in-one weather sensor malfunctions. Further details about the nature of this alarm are logged in the ERROR_LOG data table.

WARNING: Failure of the weather sensor with either a TC FAIL or RH FAIL state is a critical failure when it is the only external temperature and relative humidity sensor on site as the HVAC operation in every enclosure controlled by the ZooCADA system will be compromised.

Severe Weather Alarm Messages

Alarm High temperature - The high air temperature alarm was triggered.

This alarm is triggered when the air temperature rises above the Set_ExtAirTC_HI setpoint by the station constant ALARM_DEGREES amount. It may be necessary for staff to take action to mitigate any adverse effect the unusually high temperature may have on the animals on exhibit, or the park visitors.

Alarm Low temperature - The low air temperature alarm was triggered.

This alarm is triggered when the air temperature falls to below the Set_ExtAirTC_LO setpoint by the station constant ALARM_DEGREES amount. It may be necessary for staff to take action to mitigate any adverse effect the unusually low temperature may have on the animals on exhibit, or the park visitors.

Alarm High Rainfall - The high rainfall alarm was triggered.

This alarm is triggered when the rainfall rolling sixty minute total exceeds the Set_RainHour_HI setpoint and/or when the daily accumulated rainfall total exceeds the Set_RainDay_HI setpoint. It may be necessary for staff to take action to mitigate any localised flooding that may occur within the park.

Alarm High Wind Speed - The wind speed or wind gust speed alarm was triggered.

This alarm is triggered when the wind speed rolling ten minute average exceeds the Set_WindSpd_HI setpoint and/or when the maximum daily wind gust speed exceeds the Set_GustSpd_HI setpoint. It may be necessary for staff to take action to mitigate wind damage and/or to manage potential hazards to the animals on exhibit, or staff and visitors, that may arise from such things as falling tree limbs.

General Fault Alarms Messages

Comms Failure - The data network communications failure alarm was triggered.

This alarm is triggered when a network failure occurs. Communications failures usually point to network problems or a configuration or hardware problem at either a remote station or the local station. On sites where radio communications form part of the network the radio links may cause random intermittent communications failures that come right on their own.

Power Failure - The mains power failure alarm was triggered.

This alarm is triggered when a mains power failure occurs. Staff may need to respond to outages of extended duration to prevent spoilage of refrigerated food, such as by installing a temporary generator to supply the building.

Email Messages Daily Limit

The maximum number of email messages that can be sent by a datalogger in any one day is 100. This is a function of the Email Relay server provided by Campbell Scientific and is designed to ensure the system is not open to abuse. It is highly unlikely this will be exceeded by a station operating with ZooCADA system software.

If a station does exceed the limit, the email server will respond with an error which is displayed in the Public data table EmailState variable as "EMAIL COMMS ERROR". The Email Relay server will automatically reset at the end of the day, the time of which is determined by the server time (USA time).

Enabling The Email Messaging

The email messaging system is enabled, or disabled, by setting the EMAIL_ENABLE station constant in the STATION_CONSTANTS file as follows:

EMAIL_ENABLE = True - Sending email is enabled.

EMAIL_ENABLE = False - Sending of email is disabled, messages sent to test file instead.

Ensure there is at least one email address defined in the TO_ADDR station constant before enabling the email messaging system.

IMPORTANT: The alarms must also be enabled for email messaging to operate. If the alarms are set to disabled the email messaging is also automatically disabled.

Recipient Email Addresses

The automated alarm email messages are sent to the list of recipients whose email addresses are set in the TO_ADDR station constant. There must be at least one email recipient address if the alarms are enabled.

The format is:

TO_ADDR = keeper1@myisp.co.nz, keeper2@myisp.co.nz, manager@myisp.co.nz

Each address in the list must be separated from the next address with a comma.

It is best to send the email messages to at least two staff members to ensure the alarms have the best chance of being received by someone who can respond in a timely manner.

Email Test Function

The email module has a test function that enables the alarms and email system to be tested, without actually sending email messages, by diverting the messages to a file in the datalogger memory. This test function is enabled, or disabled, by setting the EMAIL_TEST station constant in the STATION_CONSTANTS file as follows:

EMAIL_TEST = True - Email messages are diverted to a file.

EMAIL_TEST = False - Email messages are sent to the email recipients.

The EMAIL_ENABLE constant must also be set to True.

When in the email test mode each email message is sent to a text file named EmailTest.txt in the datalogger. This file stores the exact text of every email message that is "sent" while the test mode is operating, including the email send retries because there is no confirmation from an Email Relay server. The file can be accessed using the Campbell Scientific LoggerNet software and a text editor or by using the File Control Page from the datalogger's built-in web interface.

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Installation Notes

Use these pages to record any important notes specific to the site installation or operation.

Templates for Record Keeping

The following pages are intended to assist users with record keeping.

Good records are essential for audit, research and maintenance purposes. We recommend that users keep an ongoing file of all system settings in a manner that is appropriate to their business operations.

Each time settings are changed, a new record of the settings should be created and added to the file. Previous records should be retained when new records are added. This will provide an auditable trail of all setting changes that can assist research with site specific records of what works well for the animal species on display at that site.

These records also assist with maintenance. In the event that system settings have to be reinstated after maintenance work, the correct set of documented settings can be used to complete the reinstatement.

Please photocopy the following pages as needed and use them to create your own record keeping system.

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ZooCADA-Met Station Configuration Record (Page 1 of 2)

Station Name: ..... Site ID: ..... Date: ...../...../.....

Datalogger Settings

Datalogger Model:	Serial Number:
PakBus Address:	IP Address:
Subnet mask:	Gateway:
Program name:	

Station Setpoints

SET_JAN_HI =	SET_SEP_HI =
SET_JAN_LO =	SET_SEP_LO =
SET_FEB_HI =	SET_OCT_HI =
SET_FEB_LO =	SET_OCT_LO =
SET_MAR_HI =	SET_NOV_HI =
SET_MAR_LO =	SET_NOV_LO =
SET_APR_HI =	SET_DEC_HI =
SET_APR_LO =	SET_DEC_LO =
SET_MAY_HI =	SET_RAIN_HOUR_HI =
SET_MAY_LO =	SET_RAIN_DAY_HI =
SET_JUN_HI =	SET_WIND_SPEED_HI =
SET_JUN_LO =	SET_WIND_GUST_HI =
SET_JUL_HI =	
SET_JUL_LO =	
SET_AUG_HI =	
SET_AUG_LO	

Complete a new page each time the configuration is changed so an auditable record of changes is created.

ZooCADA-Met Station Configuration Record (Page 2 of 2)

Station Constants - General

ENCLOSURE =	TILT_INSTALLED =
CUSTOM_FILE =	LTNG_INSTALLED =
ALARM_ENABLE =	GRASS_INSTALLED =
ALARM_DEGREES =	PYRO_INSTALLED =
ALARM_RESET =	TBRG_INSTALLED =
EMAIL_ENABLE =	SOIL_INSTALLED =
EMAIL_TEST =	EXT_SDI_ADDR =
EMAIL_RESEND =	EXT_TRH_PRIMARY =
EMAIL_TRIES =	EXTSOIL_SDI_ADDR =
EMAIL_NAG =	BARO_STN_ELEV =
EMAIL_NAG_HOUR =	SOLAR_SDI_ADDR =
EMAIL_ATTACH =	SOLAR_KWH =
GUST_INSTALLED =	

Station Constants - Email Addresses

TO_ADDR =

Station Constants - Comms Module

EXT_TRH1_ENABLE =	EXT_TRH2_ENABLE =
EXT_TRH1_PK =	EXT_TRH2_PK =
EXT_TRH1_IP =	EXT_TRH2_IP =
MAX_COMMS_FAILS =	COMMS_PRIORITY =

Complete a new page each time the configuration is changed so an auditable record of changes is created.

Station Change Log

Station Name: ..... Site ID: .....

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Station Change Log

Station Name: ..... Site ID: .....

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	

Date of Change:	Change(s) made:
Changed By:	