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*ZooCADA - Lab*

**Laboratory Environment Control & Monitoring System**

Version R01

# Reference Manual





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### ZooCADA-Lab Version R01 Reference Manual

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# Limited Warranty



A Typical ZooCADA-Lab Installation



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# System Overview

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## System Overview

The ZooCADA-Lab Environmental Control and Monitoring System is a software program and hardware system designed to control the temperature, relative humidity, and lighting within special purpose rooms such as animal rehabilitation rooms and endangered species breeding labs for zoological or conservation purposes. The general design concept is to eliminate any need for staff to control HVAC and lighting manually every day, and regularly adjust seasonal timings to maintain the environment; instead ZooCADA-Lab does it automatically, allowing staff to focus on more productive activities.

Each ZooCADA-Lab system comprises of a datalogger, it's peripherals and sensors, and is designed to control a single room, hereinafter referred to as the enclosure. On the network, each datalogger is referred to as a station. The system is designed to maintain the enclosure temperature as close as possible to the natural environment, complete with diurnal and seasonal variation, but without the undesirable extremes sometimes delivered by nature.

A table of high and low temperature setpoints for each month of the year, determined by the keepers based on the specific needs of the animal species housed in the enclosure, is entered into the ZooCADA-Lab program which then automatically controls the enclosure's ventilation and air conditioning to keep the temperature within the setpoint range while allowing natural diurnal variation. The enclosure diurnal temperature range can also be deliberately narrowed to optimise the temperature band to support breeding programs or to meet any particular animal health needs that staff consider appropriate for the animals in their care.

Throughout the daily cycle ZooCADA-Lab monitors the enclosure air temperature and relative humidity as well as the external (outside) air temperature and relative humidity. These measurements, along with the setpoints, are used to determine when to start and stop fan forced ventilation of the enclosure. The ventilation system uses filtered external air, as much as possible, to maintain the enclosure air temperature within the setpoint range, with the enclosure air temperature varying in accord with the natural external air throughout the diurnal cycle. During times when the outside air temperature makes it impossible for ventilation alone to maintain the enclosure air temperature within the setpoint range, the air conditioning is automatically started to provide additional heating or cooling. Utilising external air exchange to control the enclosure climate as much as possible reduces the amount of time the air conditioning system needs to run, which in turn reduces maintenance and energy costs.

The combination of ventilation and air conditioning helps to maintain the relative humidity in the enclosure within natural levels much of the time, however there will be times when high natural relative humidity in the outside air, or when water vapour is introduced into the enclosure from cleaning activities, that make additional humidity control necessary. This is achieved by automatically starting a dehumidifier inside the enclosure whenever the enclosure relative humidity exceeds a programmed setpoint.

The enclosure lighting cycle is controlled by one of four user selectable modes with seasonal variation operating in all modes. These modes enable the enclosure lighting to be tailored to suit a wide variety of diurnal and nocturnal animals with lighting changes that reasonably represent natural conditions in the best interests of the welfare of the animals housed in the enclosure. ZooCADA-Lab users can easily set up their selected lighting equipment to best meet the needs of the animals currently housed in the enclosure. This may be low level moonlight lighting and high level plant grow lighting for a setup to suit nocturnal animals, or bright sunlight lighting with supplemental "basking" heat lamps for a setup to suit reptiles. A wide range of variations is possible.

ZooCADA-Lab records the enclosure and external temperature and relative humidity measurements every ten minutes. Daily summaries containing the minimum, maximum, and average temperature and relative humidity are also recorded, along with the HVAC run times. This data can be used by staff to assist with research and animal welfare management. The run time of the HVAC equipment and the electricity used are also recorded as this data can assist staff with energy management.

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.

# System Overview

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## Program Features

### Data Logging

- Enclosure and external temperature and RH values logged every 10 minutes.
- Enclosure and external max, min and average temperature and RH values logged daily.
- Ventilation, air conditioning and dehumidifier run time each logged as hourly and daily totals.
- Portable temperature & RH sensors with ten minute logging for micro-climate monitoring. (Optional)
- Barometric pressure sensor with hourly logging. (Optional)
- Lighting cycle times logged daily.
- Electricity use in kWh logged as hourly and daily totals.
- Event log of last 1000 alarm and system control events.
- 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.

### HVAC Control System

- Automatically controls ventilation, air conditioning and dehumidifier.
- High and low temperature set-points for each month to provide seasonal variation.
- High relative humidity (RH) set-point to control dehumidifier.
- External temperature and RH sensor values from local and/or networked remote stations.
- External temperature and RH averaging when two sensors available via stations on site.
- Enclosure temperature and RH averaging when two sensors installed in enclosure.
- When sensor averaging is used the system continues to run normally if one sensor fails.
- Alarm messages sent by email to staff if temperature is too high, too low, or if sensors fail.
- Manual override controls for ventilation fan, air conditioner, and dehumidifier.

### Lighting Control System

- Automatically controls two lighting circuits for non-dimmable, pluggable loads.
- Automatically adjusts lighting timing each day for natural seasonal variation.
- Customer selectable operating modes for easy reconfiguration of enclosure to suit different species.
- Selectable for Diurnal or Nocturnal lighting on a day/night cycle.
- Selectable for Stepped or Build lighting on a day only cycle.

### General

- Battery backup of datalogger 12V power so system keeps logging data during power failure.
- Alarms sent via email to staff if power fails, or if communications to a remote station fails.
- 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-Lab 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 applications that support animal welfare, 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.

# Manual Control Panel

## Manual Control Panel



The Manual Control Panel enables users to select each part of the system to either automatic or manual operation. This enables equipment to be manually switched ON to test that it is operating correctly, or manually switched OFF when required. Setting the switch to AUTO resumes automated control of the equipment.

### Ventilation Fan Switch

The Ventilation Fan switch has three positions, AUTO, OFF and ON which operate as follows.

#### AUTO

Select the AUTO position to enable automated operation of the ventilation fan.

When operating automatically, the software determines the best times to start and stop the ventilation fan based on the the enclosure air temperature and the difference between the the enclosure air temperature and the external (outside) air temperature.

During periods of time when the enclosure air temperature cannot be maintained within the programmed setpoints by the ventilation system alone, the air conditioning system will be automatically started.

The ventilation fan is automatically stopped while the air conditioning is running to prevent air that is warmed or cooled by the air conditioning being wastefully exhausted from the enclosure.

A timer monitors the length of time the ventilation fan is stopped. If the ventilation fan has been stopped for longer than the preset time, typically three hours, it is automatically forced to run for thirty minutes, regardless of the air conditioning running, to ensure that stale air cannot build up in the enclosure.

# Manual Control Panel

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## OFF

Select the OFF position to stop the ventilation fan from operating.

When switched OFF the ventilation fan will not run under any circumstances and there will be no controlled ventilation of the enclosure. This function is primarily intended to allow maintenance of the fan and filters to be carried out safely, or to shut down the system when the enclosure is not in use.

The air conditioning system operates independently of the ventilation fan so during periods of time when the ventilation fan is switched OFF the air conditioning will still maintain the enclosure air temperature within the range determined by the programmed setpoints. Controlling the enclosure air temperature using the air conditioning alone will consume more energy than the combined ventilation and air conditioning method.

## ON

Select the ON position to force the ventilation fan to operate continuously.

When switched ON the ventilation fan runs continuously regardless of the air temperature in the enclosure or the external (outside) air temperature. This function is primarily intended to allow the fan to be tested for maintenance purposes or, in an emergency situation, allows the ventilation fan to be manually switched ON.

The air conditioning system operates independently of the ventilation fan so during periods of time when the ventilation fan is switched ON the air conditioning will still attempt to maintain the enclosure air temperature within the range determined by the programmed setpoints. Controlling the enclosure air temperature using the air conditioning while the ventilation fan is running will result in longer run times for the air conditioning system and a corresponding increase in energy consumption as the newly warmed or cooled air will be quickly exhausted from the enclosure and replaced with external (outside) air, rather like operating the air conditioning in a room with its windows and doors open.

## A/C Switch

The A/C (Air conditioning) switch has four positions, AUTO, OFF, COOL and HEAT which operate as follows.

### AUTO

Select the AUTO position to enable automated operation of the air conditioning system.

When operating automatically, the software determines the best times to start and stop the air conditioning based on the the programmed high and low enclosure air temperature setpoints for the current season, and the hysteresis value which is typically 0.5 degrees C. The air conditioning provides additional heating or cooling when the external air temperature is higher or lower than the desired enclosure temperature range.

<p><b>IMPORTANT:</b> The temperature setting on the air conditioner's remote control <b>MUST</b> be set to a value that is within the enclosure high and low setpoints for the current month.</p>
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If the enclosure air temperature is higher than the high temperature setpoint plus the hysteresis value the air conditioning system will start and run in cooling mode. The air conditioning stops when the enclosure air temperature reduces to the high temperature setpoint minus the hysteresis value.

If the enclosure air temperature is lower than the low temperature setpoint minus the hysteresis value the air conditioning system will start and run in heating mode. The air conditioning stops when the enclosure air temperature increases to the low temperature setpoint plus the hysteresis value.

The hysteresis value, above and below the setpoints, is exactly the same as a conventional thermostat and prevents rapid on/off cycling of the air conditioning system.

# Manual Control Panel

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The ventilation fan is automatically stopped while the air conditioning is running to prevent air that is warmed or cooled by the air conditioning being wastefully exhausted from the enclosure.

A timer monitors the length of time the ventilation fan is stopped. If the ventilation fan has been stopped for longer than the preset time, typically three hours, it is automatically forced to run for thirty minutes, regardless of the air conditioning running, to ensure that stale air cannot build up in the enclosure.

**NOTE:** The high and low setpoints represent the maximum and minimum enclosure air temperatures in the desired operating range for the enclosure. The air conditioning starts when that range is exceeded, and stops when the enclosure air temperature has returned to a value that is within the desired range.

**IMPORTANT:** The air conditioner will not be started in cooling mode if the enclosure temperature is lower than the air conditioner's lowest cooling capability, set by the station constant **LOWEST\_AC** during installation, even if the enclosure temperature is higher than the high setpoint temperature.

## OFF

Select the OFF position to stop the air conditioning system from operating.

When switched OFF the air conditioning system will not run under any circumstances and there is no supplementary heating or cooling of the enclosure. This could result in the enclosure air temperature becoming hotter or colder than the desired range. This function is intended to allow maintenance of the air conditioning to be carried out safely, or to shut down the system when the enclosure is not in use.

The ventilation fan operates independently of the air conditioning system so during periods of time when the air conditioning system is switched OFF the ventilation fan will maintain the enclosure air temperature within the range determined by the programmed high and low setpoints, providing the the external (outside) air temperature does not become substantially hotter or colder than the high and low temperature setpoints.

## COOL

Select the COOL position to force the air conditioning to run continuously in cooling mode.

When switched to COOL the air conditioning runs continuously in cooling mode, using its internal thermostat for temperature control. This function is primarily intended to allow the air conditioning to be tested for maintenance purposes or, in an emergency situation, to allow a reasonable level of control of the enclosure air temperature to be maintained by air conditioning alone.

Users need to select COOL or HEAT appropriately depending upon the season, typically COOL in Summer and HEAT in Winter, or as required to cause the desired change in temperature in the enclosure.

## HEAT

Select the HEAT position to force the air conditioning to run continuously in heating mode.

When switched to HEAT the air conditioning runs continuously in heating mode, using its internal thermostat for temperature control. This function is primarily intended to allow the air conditioning to be tested for maintenance purposes or, in an emergency situation, to allow a reasonable level of control of the enclosure air temperature to be maintained by air conditioning alone.

Users need to select COOL or HEAT appropriately depending upon the season, typically COOL in Summer and HEAT in Winter, or as required to cause the desired change in temperature in the enclosure.

**IMPORTANT:** Selecting the air conditioning to manual heat or cool changes the ventilation fan automatic cycle to run on timer only. This prevents wasteful exhaust of conditioned air by the ventilation system.

# Manual Control Panel

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## Dehumidifier Switch

**IMPORTANT:** Only dehumidifier models that “remember” their settings when power is switched OFF and restart with those same settings active can be used with this control system.

The Dehumidifier switch has three positions, AUTO, OFF and ON which operate as follows.

### **AUTO**

Select the AUTO position to enable automated operation of the dehumidifier.

When operating automatically, the software determines the best times to start and stop the dehumidifier based on the the programmed relative humidity setpoints for the enclosure air. The dehumidifier has a high setpoint for daytime and a higher setpoint for nighttime running to maintain natural diurnal variation.

Control of the dehumidifier is a simple power ON/OFF function.

Once switched ON by the system, the dehumidifier uses its own controls to operate as it normally would to reduce the humidity of the air according to the setting of those controls which must be set to the maximum moisture removal setting.

The system will switch the dehumidifier OFF when the relative humidity in the enclosure is reduced to below the high relative humidity setpoint.

### **OFF**

Select the OFF position to stop the dehumidifier from operating.

When switched OFF the dehumidifier will not run under any circumstances. The relative humidity in the enclosure could increase to undesirable levels. This function is intended to allow maintenance of the dehumidifier to be carried out safely, or to shut down the system when the enclosure is not in use.

### **ON**

Select the ON position to force the dehumidifier to operate continuously.

When switched ON the dehumidifier will run continuously regardless of the relative humidity of the enclosure air. This function is primarily intended to allow the dehumidifier to be tested for maintenance purposes or, in an emergency situation, to allow the dehumidifier to be manually switched ON.

## Lighting Switch

The Lighting switch has four positions, AUTO, OFF, LX1, and LX2 which operate as follows.

### **AUTO**

Select the AUTO position to enable automated operation of the lighting equipment.

When operating automatically, the software determines the correct times to switch the two lighting circuits, LX1 and LX2, ON and OFF based on the time of day and the selected lighting mode. The software also calculates automatic adjustments for seasonal variation.

For further information on lighting modes see “Lighting Mode Switches” below.

The lighting cycle timing for the enclosure is calculated based on the day of the year and the site latitude so that it incorporates natural seasonal variation that closely emulates the natural diurnal cycle.

# Manual Control Panel

## OFF

Select the OFF position to stop the lighting from operating.

When switched OFF the lighting will not run under any circumstances. There will be no controlled lighting in the enclosure which may be detrimental to animals and plants housed within the enclosure. This function is primarily intended to allow maintenance of the lighting equipment to be carried out safely, or to shut down the system when the enclosure is not in use.

## LX1

Select the LX1 position to force the LX1 circuit to operate continuously.

LX1 is the lighting circuit that is used to power the lighting equipment that runs either in the early morning and late afternoon (Diurnal Stepped mode), all day (Diurnal Build and Diurnal modes), or all night (Nocturnal mode). In Diurnal and Nocturnal modes, think of LX1 as being the enclosure sunlight scene lighting.

This function is primarily intended to allow the lighting equipment to be tested for maintenance purposes or, in an emergency situation, to allow the lighting to be manually switched ON.

## LX2

Select the LX2 position to force the LX2 circuit to operate continuously.

When the mode switches are set for Build mode operation, LX1 and LX2 will both operate continuously.

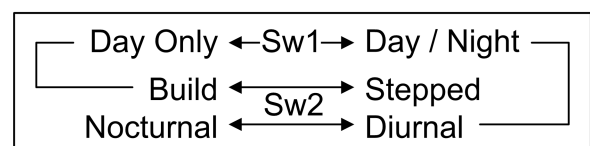
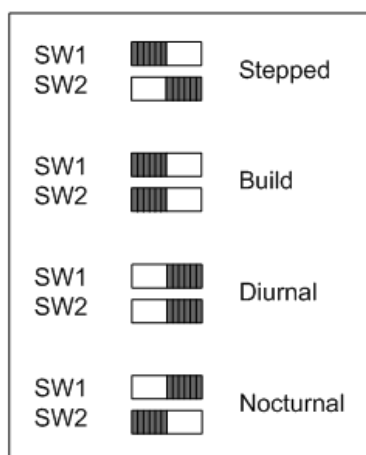
LX2 is the lighting circuit that is used to power the lighting equipment that runs either in middle of the day (Diurnal Stepped mode and Diurnal Build mode), all night (Diurnal mode), or all day (Nocturnal mode). In Diurnal and Nocturnal modes, think of LX2 as being the enclosure moonlight scene lighting.

This function is primarily intended to allow the lighting equipment to be tested for maintenance purposes or, in an emergency situation, to allow the lighting to be manually switched ON.

## Lighting Mode Switches

There are four lighting modes selected by a pair of option switches (SW1 and SW2) located on the underside of the Manual Control Panel housing.

The switches can be moved at any time and the change of setting will become effective within 2 seconds at which time the selected mode will be displayed in the [Public](#) data table [LxMode](#) field.



Option Switch label

Option Switch Settings

# Manual Control Panel

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## Diurnal Stepped Mode

To operate the system in Diurnal Stepped mode, set SW1 to Day Only and set SW2 to Stepped.

In Diurnal Stepped mode the lighting circuit LX1 is switched ON at sunrise for the early morning part of the day, after which time LX1 is switched OFF and LX2 is switched ON. LX2 is then switched OFF for the late afternoon part of the day and LX1 is switched ON until sunset. The effect is to start the lighting cycle at a low level with only LX1 operating, then step it to a higher level with only LX2 operating, and then finish the cycle at a low level with only LX1 operating.

Both lighting circuits LX1 and LX2 are switched OFF during the night.

The duration of the middle portion of the day when LX2 is operating on its own can be changed by altering the station setpoint [SET\\_SUP\\_PERCENT](#) if this is found to be necessary.

Diurnal Stepped mode is typically used for animal enclosures where the lighting is required to provide low level light with a specific colour temperature for the morning and afternoon lighting, and a higher level light with a different colour temperature during the main portion of the day. The enclosure is left dark overnight.

## Diurnal Build Mode

To operate the system in Diurnal Build mode, set SW1 to Day Only and set SW2 to Build.

In Diurnal Build mode the lighting circuit LX1 is switched ON all day from sunrise to sunset. The lighting circuit LX2 is switched ON during the middle portion of the day only. The effect is to start the lighting cycle at a low level with only LX1 operating, then build it to a higher level with LX1 and LX2 both operating, and then finish the cycle at a low level with only LX1 operating.

Both lighting circuits LX1 and LX2 are turned OFF during the night.

The duration of the middle portion of the day when LX2 is operating in addition to LX1 can be changed by altering the station setpoint [SET\\_SUP\\_PERCENT](#) if this is found to be necessary.

Diurnal Build mode is typically used for reptile enclosures where the lighting is required to provide the sunlight scene all day with a supplemental "basking" heat lamp turned on during the middle portion of the day for what would normally be the warmest portion of the day. The enclosure is left dark overnight.

## Diurnal Mode

To operate the system in Diurnal mode, set SW1 to Day/Night and set SW2 to Diurnal.

In Diurnal mode the lighting circuit LX1 is switched ON all day from sunrise to sunset and the lighting circuit LX2 is switched ON all night. The enclosure lighting cycle follows the natural daily cycle.

Diurnal mode is typically used for animal enclosures where the lighting is required to provide the sunlight scene during the natural daytime and the moonlight scene during the natural nighttime.

## Nocturnal Mode

To operate the system in Nocturnal mode, set SW1 to Day/Night and set SW2 to Nocturnal.

In Nocturnal mode the lighting circuit LX1 is switched ON all day and the lighting circuit LX2 is switched ON all night but the sunrise and sunset timing is inverted so that moonlight occurs during the natural day and sunlight occurs during the natural night while retaining the natural daytime to nighttime ratio.

Nocturnal mode is typically used for nocturnal animal enclosures where the lighting is required to provide the moonlight scene during the natural daytime so the animals can be on exhibit and the sunlight scene to grow the plants in the exhibit during the natural nighttime.



# Uninterruptible Power Supply

## Uninterruptible Power Supply

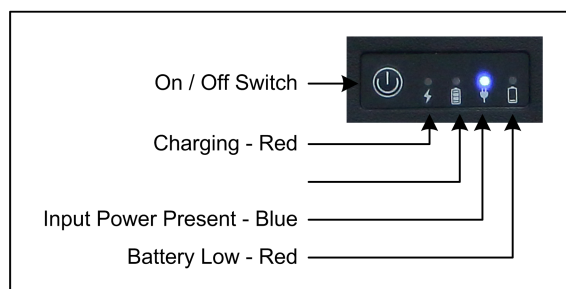


An uninterruptible power supply (UPS) ensures the datalogger continues to record data and transmit alarms during power failure events. The UPS is a DC-DC type, with an integral lithium-ion rechargeable battery. Its input is 12 Vdc, which comes from a mains powered power supply, and its output is 12 Vdc,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



# Uninterruptible Power Supply

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## **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

# Uninterruptible Power Supply

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extended period of time, the UPS should be periodically recharged to prevent the battery deteriorating and losing 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° C

3 months at 30° C

2 months at 35° C

## UPS Specifications

Input: 12 V dc, 3 Amps

Output: 12 V dc, 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)

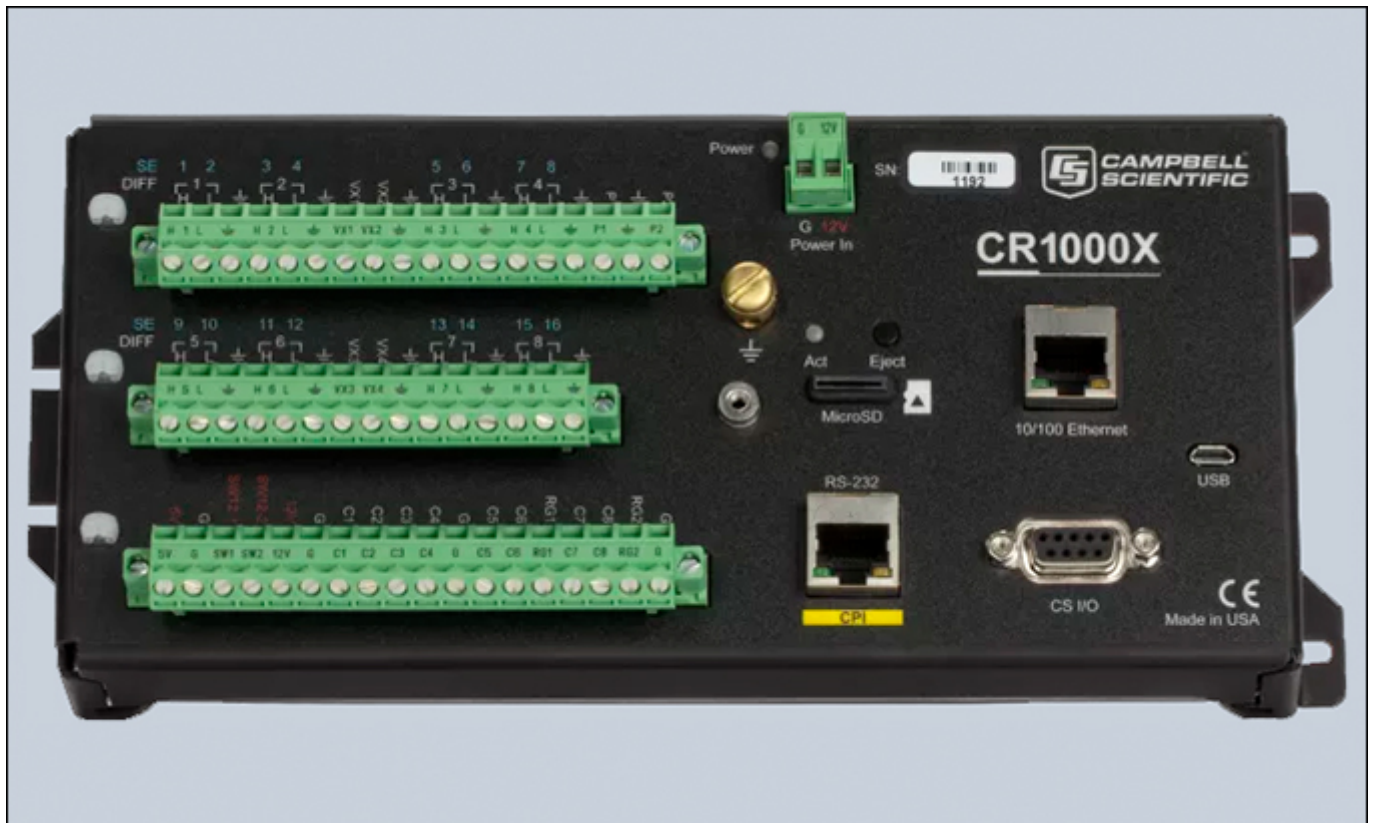
# Uninterruptible Power Supply

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# Datalogger CR1000X

## Datalogger CR1000X



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 CR1000X datalogger is the programmable heart of a ZooCADA-Lab 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 [Power In](#) connector. Always download the data from the datalogger before powering it down. The datalogger has an internal battery so the internal storage is retained 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 "3.1 Setting up Communications with the Datalogger" in the CR1000X 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.

# Datalogger CR1000X

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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 as this makes it much easier to set up stations to communicate with one another across the LAN when multiple stations are installed on site, and it simplifies routing to the Internet for off-site access if this is used. 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 10 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 sixteen single ended (SE) analog inputs, labelled 1 to 16 with blue numbers on the datalogger panel, thirteen of which are used. 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.

When a switch input is selected to be active by its switch it will receive a 2400 mV pulse every two seconds which is recognised by the software as logic high. Each of the switch inputs has a 10k Ohm pull-down resistor between the input and ground to hold the input at 0 Vdc when it is not selected which is recognised by the software as logic low.

#### SE1 - Power Good Signal.

When the mains power is available and the power supply is producing 12 Vdc, this input will be steady at approximately 2.6 Vdc. During a power failure it will return to 0 Vdc. The power failure alarm is triggered if this voltage falls below 1.0 Vdc.

#### SE2 - Ventilation Fan Switch Auto.

When the ventilation fan switch is in the AUTO position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

#### SE3 - Ventilation Fan Switch On.

When the ventilation fan switch is in the ON position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

#### SE4 - A/C Switch Auto.

When the A/C switch is in the AUTO position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

#### SE5 - A/C Switch Cool.

When the A/C switch is in the COOL position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

# Datalogger CR1000X

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## SE6 - A/C Switch Heat.

When the A/C switch is in the HEAT position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

## SE7 - Dehumidifier Auto.

When the dehumidifier switch is in the AUTO position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

## SE8 - Dehumidifier On.

When the dehumidifier switch is in the ON position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

## SE9 - Lighting Auto.

When the lighting switch is in the AUTO position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

## SE10 - Lighting LX1.

When the lighting switch is in the LX1 position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

## SE11 - Lighting LX2.

When the lighting switch is in the LX2 position this input will receive 2400 mV pulses.

When the switch is in any other position this input will remain at 0 Vdc.

## SE12 - Option Switch 1.

When option switch 1 is set to the Day Only position this input will receive 2400 mV pulses.

When the switch is in the Day/Night position this input will remain at 0 Vdc.

## SE13 - Option Switch 2.

When option switch 2 is set to the Nocturnal/Build position this input will receive 2400 mV pulses.

When the switch is in the Stepped/Diurnal position this input will remain at 0 Vdc.

## SE14 - Circuit Breaker Tipped - HVAC.

When one of the HVAC circuit breakers is tripped this input will be at 0 Vdc.

When all the HVAC circuit breakers are reset this input will receive 2400 mV pulses.

## SE15 - Circuit Breaker Tipped - Lighting (LX).

When one of the lighting circuit breakers is tripped this input will be at 0 Vdc.

When all the lighting circuit breakers are reset this input will receive 2400 mV pulses.

# Datalogger CR1000X

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## Pulse Inputs

The datalogger has two pulse counter inputs labelled P1 and P2. In this application only P1 is used.

### P1 - kWh Meter Input.

The kWh meter produces one pulse for every 0.01 kWh of electricity that's consumed. These pulses are counted by the datalogger P1 pulse input. Each time the datalogger program scans, the P1 counter is read and reset. The datalogger program then accumulates the pulse count in kWh and logs an hourly total each hour and a daily total each day.

## Excitation Outputs

The datalogger has four excitation outputs, labelled VX1 to VX4 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. In this application only VX1 is being used.

### VX1 - Switch Excitation.

The switch excitation is 2400 mV. The datalogger switches ON the excitation voltage at the beginning of each program scan, carries out the input measurements, then switches OFF the excitation voltage at the end of the program scan. The program normally scans once every ten seconds so VX1 will produce one brief excitation pulse every ten seconds.

## Control Ports

The datalogger has eight control ports labelled C1 to C8 on the datalogger panel. These are programmable ports that can be software configured for use as logic inputs, logic outputs, pulse counters, data buses, and other special functions. In this application ports C1 to C3, C5 and C7 are used to provide separate data buses for the SDM-CD8S output module and the SDI-12 sensors.

### C1 - SDM Data Bus (Data).

### C2 - SDM Data Bus (Clock).

### C3 - SDM Data Bus (Enable).

These three control ports work together to form the data bus to the SDM-CD8S module. The cables connecting the datalogger to the SDM module must be kept as short as possible to prevent risk of data errors being caused by interference or damage to equipment from induced surges.

This data bus is designed to allow up to sixteen SDM modules to be connected to the datalogger so each SDM module must be set to its own unique address. In this application only one SDM module is used and its address must be set to "0".

### C5 - SDI-12 Data Bus (Fixed Sensors).

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.



# Datalogger CR1000X

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The SDI-12 bus on control port **C5** 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 as standard by the ZooCADA system are:

Address 0 - Outside air temperature and relative humidity.

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

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

Address 3 - Outside barometric pressure. (Optional sensor)

The datalogger program normally measures and averages the two enclosure sensors to provide an optimum measurement of the enclosure air temperature and relative humidity.

In the event that one of the two sensors fails the system will continue to operate normally using the remaining good sensor. If both sensors fail an automatic email alarm message is created.

## **C7** - SDI-12 Data Bus (Portable Sensors).

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 **C7** is used for the portable sensors that staff can place within the enclosure, as they wish, to monitor the air temperature and relative humidity of various microclimates for research purposes. The portable sensor address allocations used by ZooCADA-Lab are:

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

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

Address 3 - Enclosure air temperature and relative humidity sensor 3.

Address 4 - Enclosure air temperature and relative humidity sensor 4.

Address 5 - Enclosure air temperature and relative humidity sensor 5.

Address 6 - Enclosure air temperature and relative humidity sensor 6.

Address 7 - Enclosure air temperature and relative humidity sensor 7.

Address 8 - Enclosure air temperature and relative humidity sensor 8.

Address 9 - Enclosure air temperature and relative humidity sensor 9.

The datalogger attempts to communicate with each of these sensors in turn every ten minutes and, if a sensor responds with the expected measurement values, the program logs those values into a sensor specific data table. If no response is received from a sensor nothing is logged for that sensor. There are no alarms linked to these sensors as they are purely for data collection, not control system purposes.

## **RS232/CPI and CS I/O Ports**

The datalogger includes an RJ45 jack labelled **RS-232/CPI** and a 9-pin D-sub connector labelled **CS I/O**. These ports are for connecting Campbell Scientific peripheral devices and are not currently used.

# Datalogger CR1000X

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## MicroSD Card Storage

The datalogger has a slot labelled [MicroSD](#) for a removable, supplemental memory card that can be configured for use as an extension of the datalogger data table storage memory, or for storage of discrete data files.

The control system does not use the microSD card extra storage option.

## 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 existing data when sending a program update to the datalogger that doesn't affect the data tables, 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 full, the oldest data is overwritten by the new 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.

A CR1000X 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 +12V Power Input

The datalogger is powered by 12 Vdc, from the UPS, which is applied via the [Power In](#) connector which is the main power to the system. Unplugging this connector will power down the datalogger, the SDM-CD8S module and the SDI-12 sensors. The [Power In](#) connector provides a pin for +12 Vdc and Ground. In this system all +12 Vdc power circuits into and out of the datalogger are RED wires.

### Datalogger +12V Power Output

The SDM-CD8S module and the SDI-12 sensors are all powered from the unswitched [12V](#) power output terminal which is on the datalogger panel next to the control ports.

### Power Ground

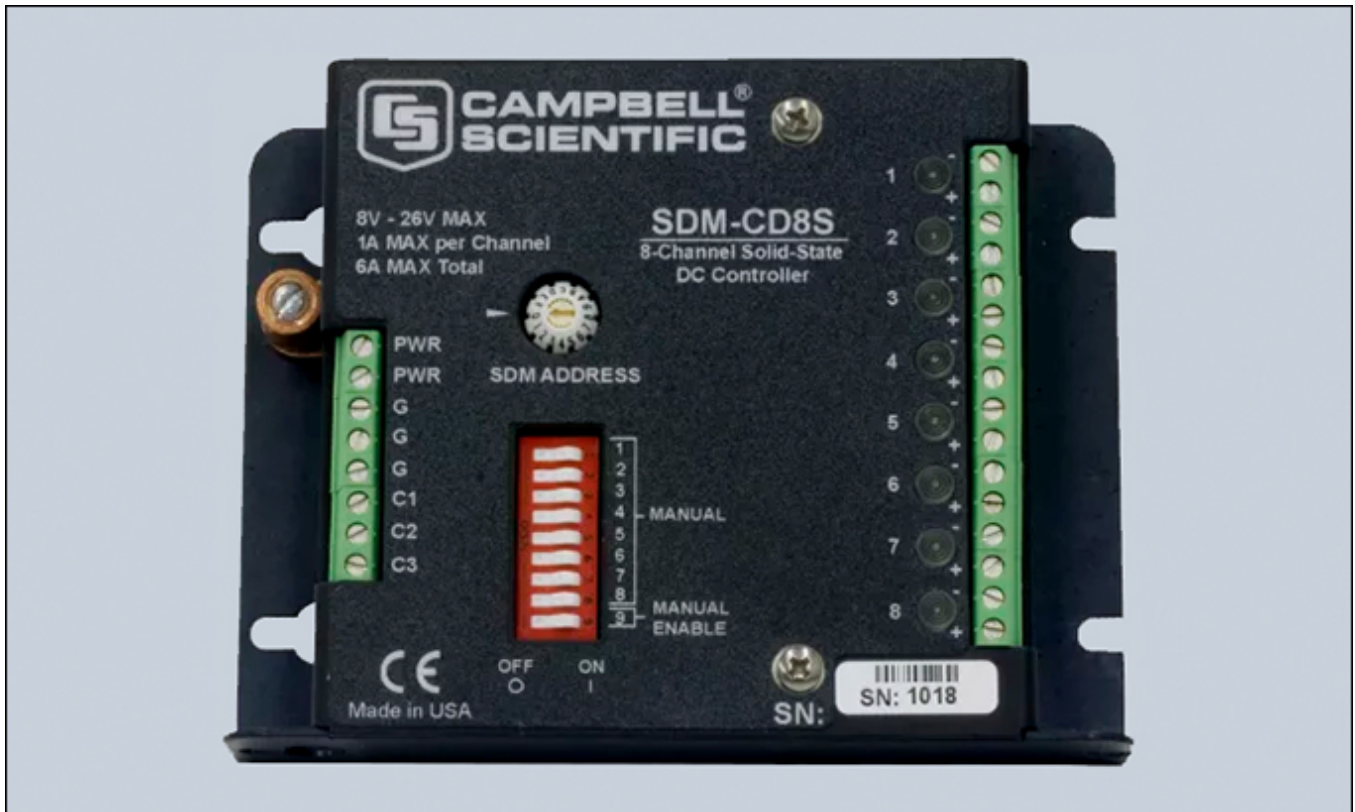
The terminals on the datalogger panel marked [G](#) are the power ground terminals. Each device that is connected to the [12V](#) power terminal must have its ground (-ve or common) wire connected to one of the [G](#) terminals. In this system all power ground circuits are BLACK wires.

### Analog Ground

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

## Output Module SDM-CD8S

### Output Module SDM-CD8S



This section is intended for maintenance and support purposes, users should not change any settings on the module unless requested by technical support.

The output module links the datalogger to the electrical relays in the switchboard. It provides an indicator LED for each output channel, a set of test switches, and an address selector switch.

The datalogger uses a data bus to send the control states from the datalogger program to the output module. First, the datalogger sends an 8 bit address to select the output module, then it sends sixteen control bits with each bit corresponding to one output port on the module. The SDM-CD8S is an 8 port module so it uses only the first 8 bits to switch its output ports ON or OFF as determined by the setting of control bit for each port.

The output ports operate in the return circuit of the controlled device in a “pull to ground” type configuration. Each output port controls a relay in the switchboard, which in turn controls the connected electrical equipment. One side of each relay coil is supplied with +12 Vdc from the mains powered +12 Vdc power supply and the other side of each relay coil is connected to its respective SDM-CD8S output port. When the SDM-CD8S output port is switched ON, either by the datalogger program or by the test switches on the SDM-CD8S panel, the relay is energised to switch ON the associated electrical equipment. The relays provide an electrical interface, and isolation, between the 12 Vdc powered circuits of the datalogger electronics and the 230 Vac mains power that operates the lighting and HVAC equipment in the enclosure.

### Connections to Datalogger

The output module receives power from the datalogger 12V supply on the **PWR** terminal and power ground on the **G** terminal, so the SDM-CD8S output module is powered on whenever the datalogger is powered on.

Terminals **C1** to **C3** are the data bus through which the datalogger communicates with the SDM-CD8S module and are wired to control ports **C1** to **C3** on the datalogger.

# Output Module SDM-CD8S

---

## Connections to Relays

The six control relays in the switchboard are connected to their respective output channels on the SDM-CD8S module. The switching in the SDM-CD8S for each relay is in the relay's power return circuit.

The relays receive +12 Vdc directly from the mains powered 12 Vdc power supply, not from the UPS. This is done so that the relays are not energised during a power failure thus maximising the time the datalogger can run on the UPS before the battery becomes discharged. There is no point in energising the relays during a mains power failure as none of the lighting and HVAC equipment can operate without mains power.

## LED Indicators

The output module has eight RED LED indicators, one for each output channel, that are lit when the output channel is switched ON.

The output channels are allocated as follows:

Channel 1 - Ventilation Fan.

ON when the ventilation fan is running. OFF when the ventilation fan is stopped.

Channel 2 - A/C Run.

ON when the air conditioning system is running. OFF when the air conditioning system is stopped.

Channel 3 - A/C Heat.

ON when the air conditioning system is selected to heating mode. OFF for cooling mode.

Channel 4 - Dehumidifier.

On when the dehumidifier is running. OFF when the dehumidifier is stopped.

Channel 5 - Lighting Circuit LX1.

ON when the lighting circuit LX1 is switched on. OFF when the lighting circuit LX1 is switched off.

Channel 6 - Lighting Circuit LX2.

ON when the lighting circuit LX2 is switched on. OFF when the lighting circuit LX2 is switched off.

Channel 7 - Not Used.

Channel 8 - Not Used.

## Test Switches

A block of nine switches enables each output to be tested independently of datalogger program commands.

The **Manual** switches 1 to 8 correspond to the eight output channels. The **Manual Enable** switch (switch 9) enables the manual test mode.

For correct operation of the control system, ensure all switches are set to OFF unless a test is in progress.

To perform manual tests, first set switch 9 to ON (**Manual Enable**), then set the desired channel number switch to ON. The corresponding channel LED will be lit and the relay for that circuit should be energised.

Ensure all switches are returned to the OFF position upon completion of tests.

## Output Module SDM-CD8S

---

### Address Selector Switch

The [SDM Address](#) switch is a small rotary switch for setting the address of the module on the data bus. The address range of 0-9, A-F is available. The default address for the SDM-CD8S on ZooCADA-Lab systems is "0".

Do not change this setting, it must be set to address "0" at all times.

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# Station Setpoints

## Station Setpoints

```
*****
* ZooCADA-Lab Laboratory Environment Control and Monitoring System *
* Station Setpoints File For: *
* Copyright 2015-2023 Adena Scientific Limited *
* Datalogger: Campbell Scientific CR1000X *
* File name: STATION_SETPOINTS_ZLAB_R01.CR1X *
* Revision Date: 2024-12-05 *
*****

*WARNING: Must be at least 4 degrees C difference between HI and LO setpoints.
*WARNING: HI must be less than SET_TOO_HOT, LO must be higher than SET_TOO_COLD.
*

ConstTable(Setpoints)                                'Beginning of editable constants table
*
'Enclosure Monthly Temperature Setpoints.
Const SET_JAN_HI = 23.3                               'January Day Hi Temperature deg C
Const SET_JAN_LO = 17.3                               'January Night Lo Temperature deg C
*
Const SET_FEB_HI = 23.7                               'February Day Hi Temperature deg C
Const SET_FEB_LO = 17.7                               'February Night Lo Temperature deg C
*
Const SET_MAR_HI = 21.0                               'March Day Hi Temperature deg C
Const SET_MAR_LO = 15.0                               'March Night Lo Temperature deg C
*
Const SET_APR_HI = 17.9                               'April Day Hi Temperature deg C
Const SET_APR_LO = 11.9                               'April Night Lo Temperature deg C
*
Const SET_MAY_HI = 14.6                               'May Day Hi Temperature deg C
Const SET_MAY_LO = 8.6                                'May Night Lo Temperature deg C
*
Const SET_JUN_HI = 13.7                               'June Day Hi Temperature deg C
Const SET_JUN_LO = 7.7                               'June Night Lo Temperature deg C
*
Const SET_JUL_HI = 13.3                               'July Day Hi Temperature deg C
Const SET_JUL_LO = 7.3                               'July Night Lo Temperature deg C
*
Const SET_AUG_HI = 13.7                               'August Day Hi Temperature deg C
Const SET_AUG_LO = 7.7                               'August Night Lo Temperature deg C
*
Const SET_SEP_HI = 14.2                               'September Day Hi Temperature deg C
Const SET_SEP_LO = 8.2                               'September Night Lo Temperature deg C
*
Const SET_OCT_HI = 16.6                               'October Day Hi Temperature deg C
Const SET_OCT_LO = 10.6                              'October Night Lo Temperature deg C
*
Const SET_NOV_HI = 19.5                               'November Day Hi Temperature deg C
Const SET_NOV_LO = 13.5                              'November Night Lo Temperature deg C
*
Const SET_DEC_HI = 21.6                               'December Day Hi Temperature deg C
Const SET_DEC_LO = 15.6                              'December Night Lo Temperature deg C
*
'Outside Temperature Fan Cutoff Setpoints.
Const SET_TOO_HOT = 28.0                             'Setpoint External Temperature Too Hot deg C
Const SET_TOO_COLD = 6.0                             'Setpoint External Temperature Too Cold deg C
*
'Enclosure RH Setpoints, Used To Control Dehumidifier.
Const SET_RH_HI = 95.0                               'Setpoint RH Hi % during night (Highest RH Value)
Const SET_RH_HI_DAY = 80.0                           'Setpoint RH Hi % during day (Intermediate RH value)
Const SET_RH_LO = 60.0                               'Setpoint RH Lo % (Lowest RH Value)
*
'Enclosure Lighting Constants.
Const SET_REF_TIME_MINS = 480                        'LX reference time minutes after midnight (480 = 8:00am)
Const SET_REF_VARIATION = 25                         'Percentage of seasonal variation placed before ref time
Const SET_SUP_PERCENT = 60                           'Percentage of day length to run supplementary lighting
*
EndConstTable                                        'End of editable constants table

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

## Station Setpoints

---

The station setpoints are constants that specify the operational setpoints for the system. Monthly setpoints determine the upper and lower air temperatures that define the temperature range within which the enclosure is required to operate. When the enclosure temperature moves outside of the setpoints range a temperature alarm is triggered. There is a separate pair of setpoints for each month of the year to enable the system to be set to accommodate seasonal variation across the year. Additional constants determine the limits of external (outside) air temperature and humidity beyond which the ventilation system should not operate, along with timing settings for the enclosure lighting.

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\\_ZLAB\\_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.

**IMPORTANT:** When setpoints are changed the datalogger must restart its program to make the new setpoints effective. During this restart, the enclosure lighting will go OFF for a few seconds then carry out a 30 seconds fade up to resume the correct lighting scene with the new settings.

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.



# Station Setpoints

---

## Enclosure Temperature Setpoints

The upper and lower temperature setpoints, in degrees Celsius, for the enclosure for each month.

Const SET\_JAN\_HI = 18.5

Const SET\_JAN\_LO = 13.5

Decimal values. 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.

These temperatures are the highest and lowest temperatures that are desired inside the enclosure and will be maintained as much as possible by the ventilation system. If the setpoint is exceeded by more than the station constant [TC\\_HYST](#), the air conditioning will operate to return the temperature to within the desired range. There MUST be a minimum of four degrees Celsius between the high and low value in each pair. If a setpoints error is detected an error is displayed in the [Public](#) data table [Month](#) field.

The enclosure temperature setpoints must be set within the range determined by the [SET\\_TOO\\_HOT](#) and [SET\\_TOO\\_COLD](#) setpoints, see "Outside Temperature Limits" below.

## Outside Temperature Limits

The high and low outside air temperature limits, in degrees Celsius, for the ventilation system.

Const SET\_TOO\_HOT = 28.0

Const SET\_TOO\_COLD = 6.0

Decimal Values. When either of these setpoints is exceeded the ventilation fan will not run its usual cycle. This prevents air being brought into the enclosure that will cause the air conditioning to run excessively. If the ventilation system has not been run for an extended period of time determined by the station constant [FAN\\_IDLE\\_LIMIT](#) it is forced to run for 30 minutes to prevent stale air build up in the enclosure, regardless of these limit temperatures.

## Enclosure Relative Humidity Setpoints

The high and low Relative Humidity setpoints, in percent, for the dehumidifier control.

Const SET\_RH\_HI = 85.0

Const SET\_RH\_DAY = 70.0

Const SET\_RH\_LO = 50.0

Decimal Values. The constant [SET\\_RH\\_HI](#) determines the highest humidity level that is desired in the enclosure during the night and is also used to stop the ventilation fan if the enclosure relative humidity is already high and continuing to ventilate the enclosure with humid external air will only make the enclosure humidity worse.

The constant [SET\\_RH\\_DAY](#) determines the highest humidity level that is desired in the enclosure during the day.

The constant [SET\\_RH\\_LO](#) is the low RH setpoint and is used for humidity state display purposes only.

The program selects the day [SET\\_RH\\_DAY](#) setpoint or the night [SET\\_RH\\_HI](#) setpoint at a time based on the datalogger's realtime clock and whether the datalogger program is set to operate in nocturnal or diurnal mode. The selected setpoints are used to control the dehumidifier, and to determine the enclosure relative humidity state which is displayed in the [Public](#) data table [E00RhState](#) field.

The dehumidifier is switched ON when the currently selected high RH setpoint is exceeded and switched OFF when the RH returns to a level 2% RH below the currently selected high RH setpoint.

# Station Setpoints

---

## Reference Time

The time, in minutes, after midnight at which a nocturnal enclosure lighting cycle is linked to the actual time.

`Const SET_REF_TIME_MINS = 480`

An integer value. Normally between 420 to 540 minutes (7:00 am to 9:00 am). This should normally be set to a time that is at least 10 minutes before the enclosure opens for public viewing to ensure the enclosure lighting is in the moonlight scene ready for the arrival of the first visitors. The default is 480 minutes (8:00 am).

## Reference Variation

The portion of lighting seasonal variation to add before the reference time.

`Const SET_REF_VARIATION = 25`

A decimal value. Normally in the range 0 to 50. This sets the percentage of the calculated seasonal variation for the current day that is placed before the reference time `SET_REF_TIME_MINS`, with the remainder of the seasonal variation placed after the reference time. This keeps the lighting state change closer to the start of visitor hours effectively shifting middle of the day/night further away from the reference time.

For example, if the system is operating in `NOCTURNAL` mode, the calculated seasonal variation amount for the current night is 90 minutes, and `REF_VARIATION` is set to 25, then the seasonal variation is apportioned with 22 minutes being added to the start of the moonlight scene and 68 minutes being added to the end of the moonlight scene. If `REF_VARIATION` is set to 0 then the change from the sunlight scene to the moonlight scene will always occur at the reference time, minus the dimmer fade time `FADE_TIME_MINS`, and all the seasonal variation will be added to the end of the moonlight scene.

## Supplementary Lighting Ratio

The ratio of supplementary lighting cycle to full day lighting cycle.

`Const SET_SUP_PERCENT = 60`

Decimal values. This constant is the percentage of the day that supplementary lighting, such as basking lights, will run when the system is running in `DIURNAL STEPPED` or `DIURNAL BUILD` mode. The value entered must be in the range 10 to 100 with 60 being the default. The supplementary lighting always runs in the middle portion of the day to approximate the hottest or brightest portion of a typical day. The `TimeSupOn` and `TimeSupOff` fields in the Public data table display the times at which the supplementary lighting switches on and off.

# Station Setpoints

---

## Temperature Setpoints Manual Override

Keepers can temporarily override the temperature setpoints whenever they need to.

**IMPORTANT:** Temporary setpoints overrides are automatically removed if the datalogger is restarted.

The temperature setpoints [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) normally get their values from the [Setpoints](#) data table for each month of the year based on the dataloggers realtime clock/calendar, but sometimes keepers will need to set different setpoints on a temporary basis. At the bottom of the [Public](#) data table there are two fields [ManualTC\\_HI](#) and [ManualTC\\_LO](#) which can be used to override the automatic monthly setpoints.

Normally [ManualTC\\_HI](#) and [ManualTC\\_LO](#) are both set to zero, the default, which allows the automatic monthly setpoints to be active. When one or both of these is set to a non-zero value the manual override becomes active. If the manual setpoint [ManualTC\\_HI](#) is non-zero its value replaces [SetPointTC\\_HI](#) and if [ManualTC\\_LO](#) is non-zero its value replaces [SetPointTC\\_LO](#). The [Month](#) field changes to display [MANUAL OVERRIDE](#) and the fields [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) display the values that have been made active by the override.

If only one of the manual override setpoints is set to a non-zero value, the other setpoint continues operating with the existing monthly setpoint value. For example if [SetPointTC\\_HI](#) is set to 17 degrees and [SetPointTC\\_LO](#) is set to 10 degrees, and then [ManualTC\\_HI](#) is set to 19 degrees, the result will be [SetPointTC\\_HI](#) will change to 19 degrees while [SetPointTC\\_LO](#) will remain set to 10 degrees.

To set a manual setpoint, logon to the datalogger web interface and select the [Public](#) data table. Scroll down to the manual setpoints at the bottom of the fields list. Use the mouse to select the field to be edited by clicking on the value field beside the field name. This highlights the field. Click on the field again. This will highlight just the digits in the field. Edit the digits to the desired new value then press the [Enter] key. The newly edited values are effective immediately and the [Month](#) field will display [MANUAL OVERRIDE](#) if the setpoint(s) are overridden or the month of the year if the manual setpoints were reset to zero to remove the override.

If incorrect manual setpoints are entered the [Month](#) field will display [SETPOINTS ERROR](#) and the datalogger program defaults to operating over the range determined by the [SET\\_TOO\\_COLD](#) and [SET\\_TOO\\_HOT](#) constants, typically about 6 degrees and 28 degrees respectively. Defaulting to these constants ensures that the HVAC will continue to function relatively normally, albeit with a wider temperature range, if the system is left with erroneous setpoints entered.

To avoid an error, ensure the manual setpoints meet the following criteria:

The [ManualTC\\_HI](#) setpoint must be lower than the [SET\\_TOO\\_HOT](#) station constant, and it must be at least four degrees higher than the displayed [SetPointTC\\_LO](#) value.

The [ManualTC\\_LO](#) setpoint must be higher than the [SET\\_TOO\\_COLD](#) station constant, and it must be at least 4 degrees lower than the displayed [SetPointTC\\_HI](#) value.

## Station Setpoints

---

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# Station Constants

## Station Constants

```
*****
* ZooCADA-Lab Laboratory Environment Control and Monitoring System *
* Station Constants File For: *
* Copyright 2015-2023 Adena Scientific Limited *
* Datalogger: Campbell Scientific CR1000X *
* File name: STATION_CONSTANTS_ZLAB_R01.CR1X *
* Revision Date: 2024-12-05 *
*****

'Declare General Station Constants.
Const ENCLOSURE As String = "NEW STATION" 'Enclosure name
Const CUSTOM_FILE = False 'Customisation file enabled True/False
Const FAN_IDLE_LIMIT = -10800 'Fan idle time limit in seconds (-10800 seconds = 3 hours)
Const FAN_RUN_TIME = 1800 'Fan run cycle time in seconds (1800 seconds = 30 mins)
Const FAN_TIMER_ONLY = False 'Fan preset to use idle time limit based ventilation only
Const LOWEST_AC = 16 'Lowest temperature degrees C A/C can cool down to
Const LATITUDE = -37.7 'Site Latitude
Const ADJ_REF_DST = True 'Adjust reference time for daylight savings time
Const FADE_TIME_MINS = 0 'Fade time in minutes for day-night crossfade (dimming systems)
Const MIN_EXHIBIT_MINS = 600 'Limit length shortest days/nights in minutes (600 = 10 Hours)

'Declare Alarms Module Constants.
Const ALARM_ENABLE = True 'Alarm enable = true, disable = false
Const ALARM_DEGREES = 3.0 'Alarm temperature trigger +/- From enclosure setpoints
Const ALARM_RESET = 1.0 'Alarm temperature reset +/- From alarm setpoints

'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 = 60 '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 = 82 'Ext T/RH primary remote station pakbus address (KNZ=82)
Const EXT_TRH1_IP As String = "192.168.10.82" '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 = 81 'Ext T/RH secondary remote station pakbus address
Const EXT_TRH2_IP As String = "192.168.10.81" 'Ext T/RH secondary remote station IP address
Const MAX_COMMS_FAILS = 6 'Maximum Number of comms failures before alarm
```

## Station Constants

```
'Declare External Temp/RH Local Sensor Constants.
Const EXT_TRH_LOCAL = True             'Ext T/RH Local sensor installed True, False
Const EXT_TRH_PRIMARY = True          'Ext T/RH Local sensor True = primary, False = secondary
Const EXT_SDI_ADDR As String = "0"    'Ext T/RH Local sensor, Port C5 SDI-12 address (Normally "0")

'Declare Enclosure Temp/RH Sensor Constants.
Const E01TRH_SDI_ADDR As String = "1" 'Enclosure 1 T/RH sensor, Port C5 SDI-12 address (Normally "1")
Const E02TRH_SDI_ADDR As String = "2" 'Enclosure 2 T/RH sensor, Port C5 SDI-12 address (Normally "2")

'Declare Barometric Pressure Sensor Constants.
Const BARO_ENAB = True                'Barometric pressure display and logging enable (True/False)
Const BARO_STN_ELEV = 47              'Barometer sensor station elevation in metres above MSL
Const BARO_LOCAL = True               'Barometric pressure local sensor installed True, False
Const BARO_SDI_ADDR = "3"            'Barometric sensor, Port C5 SDI-12 address (Normally "3")

'Declare Portable Temp/RH Sensor Constants.
Const PORT_SENS_ENAB = True           'Portable sensors enabled (True/False)
Const PS1TRH_SDI_ADDR As String = "1" 'Portable T/RH sensor 1, Port C7 SDI-12 address (Normally "1")
Const PS2TRH_SDI_ADDR As String = "2" 'Portable T/RH sensor 2, Port C7 SDI-12 address (Normally "2")
Const PS3TRH_SDI_ADDR As String = "3" 'Portable T/RH sensor 3, Port C7 SDI-12 address (Normally "3")
Const PS4TRH_SDI_ADDR As String = "4" 'Portable T/RH sensor 4, Port C7 SDI-12 address (Normally "4")
Const PS5TRH_SDI_ADDR As String = "5" 'Portable T/RH sensor 5, Port C7 SDI-12 address (Normally "5")
Const PS6TRH_SDI_ADDR As String = "6" 'Portable T/RH sensor 6, Port C7 SDI-12 address (Normally "6")
Const PS7TRH_SDI_ADDR As String = "7" 'Portable T/RH sensor 7, Port C7 SDI-12 address (Normally "7")
Const PS8TRH_SDI_ADDR As String = "8" 'Portable T/RH sensor 8, Port C7 SDI-12 address (Normally "8")
Const PS9TRH_SDI_ADDR As String = "9" 'Portable T/RH sensor 9, Port C7 SDI-12 address (Normally "9")

'Declare Daylight Savings Function Constants (New Zealand).
Const DST_N_START = 5                 'Start number 5 = Last
Const DST_D_START = 1                 'Start day 1 = Sunday
Const DST_M_START = 9                 'Start month 9 = September
Const DST_N_END = 1                   'End number 1 = First
Const DST_D_END = 1                   'End day 1 = Sunday
Const DST_M_END = 4                   'End month 4 = April
Const DST_HOUR = 2                    'Hour 2 = 2am
|
'*****
' *                                     END OF INCLUDE 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\\_ZLAB\\_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.

## Station Constants

---

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

After uploading a changes `STATION_CONSTANTS` file 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 enclosure for the web interface and in alarm email messages.

```
Const ENCLOSURE As String = "WETA LAB"
```

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.

### Ventilation Fan Idle Time Limit

The maximum number of seconds that the fan can remain idle before ventilation is enforced.

```
Const FAN_IDLE_LIMIT = -10800
```

A negative integer value. Normally set to -10800 seconds (3 hours). When this time has elapsed the ventilation fan is forced to run for the time defined by the `FAN_RUN_TIME` setting. This function ensures that ventilation cannot fall below the minimum acceptable level for the welfare of the animals in the enclosure.

### Ventilation Fan Run Time

The number of seconds the ventilation fan runs when running on the timer.

```
Const FAN_RUN_TIME = 1800
```

An integer value. Normally set to 1800 seconds (30 minutes). This value MUST be a multiple of the program scan rate (normally 2 seconds) or the timer will malfunction. When running on the timer, the ventilation fan will stop after the `FAN_RUN_TIME` has elapsed. When the ventilation fan is running as a result of one of the normal automatic start criteria being met, the start conditions are retested each time the `FAN_RUN_TIME` elapses and the ventilation fan will only continue running if one of the normal start conditions is still met. This prevents the ventilation fan running for unreasonably long periods of time when none of the normal stop conditions are being met.

## Station Constants

---

### Ventilation Fan Fixed Cycle Time

Flag determines if the ventilation fan will run on a variable cycle or always run on a fixed time cycle.

`Const FAN_TIMER_ONLY = False`

A logical value. Normally set to False so the ventilation fan runs as and when it needs to in order to maintain the enclosure temperatures within the setpoints range. Set this to True to force the ventilation fan to always run on a regular timed cycle irrespective of the enclosure temperature. This function allows the enclosure to be ventilated adequately while the air conditioning is set to manually maintain a fixed temperate in the enclosure.

### Air Conditioning System Lowest Cool Temperature

The lowest temperature the air conditioning system can cool down the enclosure to.

`Const LOWEST_AC = 16`

A decimal value. Typically about 16 degrees Celsius. This prevents the air conditioner being started in cooling mode when the enclosure temperature is lower then the coolest temperature that the air conditioner can produce, to prevent unpredictable results.

### Site Latitude

The geographic latitude for the enclosure, in degrees, used in the lighting cycle timing calculations.

`Const LATITUDE = -37.7`

A decimal value,. Negative for the Southern Hemisphere and positive for the Northern Hemisphere. It should be set to the actual latitude of the site where the enclosure is located, or to the latitude where the animals held in the enclosure normally live if it is desired to more closely represent their natural living conditions.

### Daylight Savings Lighting Reference Adjustment Enable

Flag determines whether or not the LX reference time will be automatically adjusted for daylight savings time.

`Const ADD_REF_DST = True`

Logical True or False. Normally set to True. The reference time `SET_REF_TIME_MINS` is always set to standard time but the lighting cycle calculations can be automatically adjusted one hour during daylight savings so the lighting in "on-display" enclosures remains in step with the daylight savings time. Setting this to False prevents the daylight savings adjustment being applied with the effect that lighting cycle changes will appear to be one hour late during daylight savings time which may be a better choice for "off-display" enclosures.

### Fade Time for Dimmers

The amount of time to allow for cross fade to occur on dimmer based lighting systems.

`Const FADE_TIME_MINS = 0`

An integer value in the range 0 to 30. This should be set to zero for switched lighting in ZooCADA-Lab installations. If ZooCADA-Lab is triggering dimmers that control the lighting this should be set to the same time that the dimmers crossfade is set to in order to allow the lighting dimmers to complete the crossfade between the moonlight and sunlight scenes before the exhibit opens for visitors. The default is 0 minutes.



# Station Constants

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## Minimum Exhibit Lighting Time

The minimum time, in minutes, that the exhibit, visitor viewing, lighting state must operate.

`Const MIN_EXHIBIT_MINS = 600`

An integer value. Normally set in the range of 540 to 720 minutes (9 to 12 hours). The default is 600 minutes (10 hours). This is the minimum desired duration for the exhibit visitor viewing portion of the lighting cycle in the `DIURNAL` or `NOCTURNAL` modes. In `DIURNAL` mode the duration of the sunlight scene on short winter days may become too short, similarly, in `NOCTURNAL` mode, the duration of the moonlight scene on long summer days may become too short, and end before the exhibit closes to visitors. To prevent this set the constant `MIN_EXHIBIT_MINS` to match the duration of visitor hours.

## 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.

## Alarm Trigger Level

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

`Const ALARM_DEGREES = 4`

A decimal value. Typically about 4 degrees. This value **MUST** not be less than 2.0 degrees Celsius. The air conditioner normally cycles on and off about 1 degree either side of the the high or low setpoint. 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.

## Alarm Reset Level

The number of degrees beyond the enclosure 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.

## Station Constants

---

**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.

# Station Constants

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## 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, assuming it's a simple network with small number of dataloggers.

## Primary Remote Station IP Address

The static IP address of the primary remote station.

```
Const EXT_TRH1_IP = 192.168.10.91
```

Each station on the network has a unique IPv4 or IPv6 address. By convention we use the same number for the last octet of the station IPv4 network address for the PakBus address when IPv4 addressing is in use, assuming it's a simple network with small number of dataloggers.

# Station Constants

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## 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, assuming it's a simple network with small number of dataloggers.

## Secondary Remote Station IP Address

The static IP address of the secondary remote station.

`Const EXT_TRH2_IP = 192.168.10.82`

Each station on the network has a unique IPv4 or IPv6 address. By convention we use the same number for the last octet of the station IPv4 network address for the PakBus address when IPv4 addressing is in use, assuming it's a simple network with small number of dataloggers.

## 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 five minutes. If a remote station cannot be reached within the set number of tries an alarm is triggered.

**NOTE:** Alarms are always logged but the station may not be able to send emails during a comms failure.

## External Temperature and Relative Humidity Sensor Installed

Flag indicates if an external air SDI-12 Temperature and RH sensor is installed on this datalogger.

`Const EXT_TRH_LOCAL = False`

Logical True or False. Normally set to False unless the installation has an external temperature and relative humidity sensor installed. Setting this flag to True instructs the program compiler to include the necessary program code for the external sensor.

## Station Constants

---

### External Temperature and Relative Humidity Installed Is Primary Sensor

Flag indicates if the external air Temperature and RH sensor is installed on this datalogger is the primary sensor.

```
Const EXT_TRH_PRIMARY = False
```

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

### External Temperature and Relative Humidity Sensor SDI-12 Address

The SDI-12 address for the local external temperature & relative humidity sensor, if Installed.

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

An integer value. Normally set to "0" with the sensor wired to port [C5](#). May be any other valid SDI-12 address value provided the sensor is wired to port [C5](#) and the address is unique for all sensors wired to that port. If an external temperature and RH sensor is installed on this station an address must be entered for this constant.

### Enclosure Temperature and Relative Humidity Sensors SDI-12 Addresses

The SDI-12 address for each of the two enclosure temperature & relative humidity sensors.

```
Const E01TRH_SDI_ADDR = "1"
```

```
Const E02TRH_SDI_ADDR = "2"
```

Integer values. Must be set to "1" for sensor 1 in the enclosure, and "2" for sensor 2 in the enclosure, with both sensors wired to port [C5](#). May be any other valid SDI-12 address value provided the sensor is wired to port [C5](#) and the address is unique for all sensors wired to that port.

### Barometric Pressure Enable

Flag determines whether or not the Barometric Pressure is displayed and logged.

```
Const BARO_ENAB = True
```

Logical True or False. Normally set to False unless a Barometric Pressure sensor is installed. The sensor may be installed on the local station or on a remote station. The station barometric pressure is retrieved from the communications array and corrected to Mean Sea Level for display.

### Barometric Pressure Station Elevation

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

```
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 barometric pressure for display and logging. This value is ignored if [BARO\\_ENAB](#) is set to False.

# Station Constants

---

## Barometric Pressure Sensor Installed

Flag indicates if an external SDI-12 Barometric Pressure sensor is installed on this datalogger.

```
Const BARO_LOCAL = True
```

Logical True or False. Normally set to False unless a Barometric Pressure sensor is installed on this station. This optional sensor measures the atmospheric pressure at the station which is referred to as the station pressure. The measurement value is placed into the communications array so it is available to all stations on the network. Barometric pressure sensors can only be installed on stations with external temperature and RH sensors.

## Barometric Pressure Sensor SDI-12 Address

The SDI-12 address for the local Barometric Pressure sensor, if Installed.

```
Const BARO_SDI_ADDR = "3"
```

An integer value. Normally set to "3" with the sensor wired to port C5. May be any other valid SDI-12 address value provided the sensor is wired to port C5 and the address is unique for all sensors wired to that port. If a barometric pressure sensor is installed on the local datalogger an address must be set.

## Portable Temperature and Relative Humidity Sensors Enable

Flag determines whether or not the optional portable Temperature and Relative Humidity sensors are enabled.

```
Const PORT_SENS_ENAB = True
```

Logical True or False. Normally set to True unless the portable sensors option is not installed. The portable sensors installation comprises of 5-pin XLR connectors around the enclosure where the portable sensors can be plugged in. If these connectors are installed the constant `PORT_SENS_ENAB` should be kept set to enabled. It is not necessary to change this setting to if the connectors are installed but no portable sensors are currently plugged in, as the datalogger program automatically detects the presence of absence of the sensors as they are plugged in and unplugged.

## Portable Temperature and Relative Humidity Sensors SDI-12 Addresses

The SDI-12 addresses for the portable temperature & relative humidity sensors.

```
Const PS1TRH_SDI_ADDR = "1"
```

```
Const PS2TRH_SDI_ADDR = "2"
```

```
Const PS3TRH_SDI_ADDR = "3"
```

```
Const PS4TRH_SDI_ADDR = "4"
```

```
Const PS5TRH_SDI_ADDR = "5"
```

```
Const PS6TRH_SDI_ADDR = "6"
```

```
Const PS7TRH_SDI_ADDR = "7"
```

```
Const PS8TRH_SDI_ADDR = "8"
```

```
Const PS9TRH_SDI_ADDR = "9"
```

Integer values. Must be set to "1" for portable sensor sensor 1, "2" for portable sensor 2, and so on up to "9" for portable sensor 9, with all portable sensors wired to port C7. If no portable sensors are currently in use these

## Station Constants

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constants must still be set as the datalogger program checks each address to determine if the sensor is present and if it is present logging of the sensor measurement values is automatically enabled.

**NOTE:** The data files for portable sensors are programmed to correspond with the portable sensor addresses so these sensors should be labelled with their addresses so users know which data file belongs to which sensor.

### Daylight Savings Configuration

The following set of constants defines the beginning and end of Daylight Savings Time and must be correctly configured to suit the specific requirements of the country where the ZooCADA system is deployed if the daylight savings function is to be used. The default settings are for New Zealand.

**IMPORTANT:** The quote marks shown are required in these settings.

The occurrence of the day within the month on which DST begins.

`Const DST_N_START = "5"`

Integer value. To specify the first occurrence of the day in the month set the value to 1, the second is 2, the third is 3, the fourth is 4, and to specify the last occurrence of the day set the value to 5.

The day of the week in which DST begins.

`Const DST_D_START = "1"`

Integer value. To specify Sunday set the value to 1, Monday is 2, Tuesday is 3, Wednesday is 4, Thursday is 5, Friday is 6, and Saturday is 7.

The month in which DST begins.

`Const DST_M_START = "9"`

Integer value. To specify January set the value to 1, February is 2, through to December which is 12.

The occurrence of the day within the month on which DST ends.

`Const DST_N_END = "1"`

Integer value. To specify the first occurrence of the day in the month set the value to 1, the second is 2, the third is 3, the fourth is 4, and to specify the last occurrence of the day set the value to 5.

The day of the week on which DST ends.

`Const DST_D_END = "1"`

Integer value. To specify Sunday set the value to 1, Monday is 2, Tuesday is 3, Wednesday is 4, Thursday is 5, Friday is 6, and Saturday is 7.

The month on which DST ends.

`Const DST_M_END = "4"`

Integer value. To specify January set the value to 1, February is 2, through to December which is 12.

## Station Constants

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The hour at which the DST change occurs.

`Const DST_HOUR = "2"`

Integer value. Specifies the hour of the day that the Daylight Savings change takes place. The hour is specified as for a 24 hour clock so midnight at the beginning of the day is 0, 1:00am is 1, 2:00 am is 2, through to 11:00am which is 11, 12:00 midday is 12, 1:00 pm is 13, 2:00pm is 14, through to 11:00pm which is 23:00, and finally midnight at the end of the day is 24.



## Data Tables

### Data Tables

TOA5, OKH_WL1_DL01, CR1000X, 21182, CR1000X.Std.05.01, CPU:OKH_WL1_DL01_R05.CR1X, 60338, 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
2021-07-1816:00:00	0	20.18	68.54	0.744	19.34	72.15	0.625
2021-07-1816:10:00	1	20.02	68.39	0.74	19.27	72.25	0.62
2021-07-1816:20:00	2	19.89	68.08	0.741	19.22	71.9	0.626
2021-07-1816:30:00	3	19.78	68.42	0.728	19.17	71.86	0.625
2021-07-1816:40:00	4	19.64	68.51	0.72	19.04	72.02	0.616
2021-07-1816:50:00	5	19.63	68.59	0.717	18.94	72.12	0.61
2021-07-1817:00:00	6	19.75	68.79	0.718	18.94	72.15	0.609
2021-07-1817:10:00	7	19.75	68.55	0.723	18.87	72.39	0.601
2021-07-1817:20:00	8	19.53	69.06	0.702	18.72	72.85	0.586
2021-07-1817:30:00	9	19.4	69.3	0.691	18.52	73.37	0.568
2021-07-1817:40:00	10	19.3	69.21	0.689	18.38	73.54	0.559
2021-07-1817:50:00	11	19.22	69.08	0.688	18.25	73.57	0.554
2021-07-1818:00:00	12	19.14	68.94	0.688	18.16	73.49	0.552
2021-07-1818:10:00	13	19.09	68.88	0.687	18.07	73.47	0.549
2021-07-1818:20:00	14	19.05	68.84	0.686	18.01	73.48	0.547
2021-07-1818:30:00	15	18.97	69.1	0.677	17.93	73.82	0.538
2021-07-1818:40:00	16	18.89	69.11	0.674	17.83	74.02	0.53
2021-07-1818:50:00	17	18.83	68.98	0.674	17.76	73.96	0.529

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. Please note that each field in the header lines is 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\_WL1\_DL01 - The datalogger station name in LoggerNet. Can be changed using LoggerNet.

CR1000X - The datalogger model.

21182 - The datalogger serial number.

CR1000X.Std.05.01 - The datalogger operating system version.

CPU:OKH\_WL1\_DL01\_R02.CR1X - Datalogger program name. Can change by sending new program.

60338 - 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.

# Data Tables

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## Second Row

The second header row of the data table contains the field names. The default field names are a combination of the variable names (or aliases) from which the data is derived and a three letter suffix. 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 field.

**ExAirTC** - External (Outside) air temperature field.

**ExAirRH** - External (Outside) air relative humidity field.

**ExAirVPD** - External (Outside) air vapour pressure 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.

**%** - Percent for the enclosure relative humidity field.

**kPa** - Kilopascals for the enclosure vapour pressure deficit field.

**Deg C** - Degrees C for the external (outside) temperature field.

**%** - Percent for the external (outside) relative humidity field.

**kPa** - Kilopascals for the external (outside) 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 (outside) temperature field.

**Avg** - Average used for the external (outside) relative humidity field.

**Avg** - Average used for the external (outside) vapour pressure deficit field.

# Data Tables

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## 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 of the average temperature are logged at a ten minute interval, and at 18:50:00 the enclosure temperature average (**EnAirTC**) for record 17 was logged as 18.83 degrees Celsius. Therefore 18.83 degrees Celsius is the average of all the measurements made by the datalogger over the ten minute interval from 18:40:01 to 18:50:00. The enclosure 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 17 was written at 18:50:00 (6:50pm) on July 18<sup>th</sup> 2021.

# Data Tables

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## 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\(1,1\)](#) - Number of records allocated to the first data table (Integer).

[DataRecordSize\(1,2\)](#) - Number of records allocated to the first data table (Integer).

[DataRecordSize\(2,1\)](#) - Number of records allocated to the second data table (Integer).

[DataRecordSize\(2,2\)](#) - 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\(1,1\)](#) - Number of days required to fill the first data table (Decimal).

[DataFillDays\(1,2\)](#) - Number of days required to fill the first data table (Decimal).

[DataFillDays\(2,1\)](#) - Number of days required to fill the second data table (Decimal).

[DataFillDays\(2,2\)](#) - Number of days required to fill the second data table (Decimal).

[DataFilled\(1,1\)](#) - Percent of first data table filled (Decimal + Text).

[DataFilled\(1,2\)](#) - Percent of first data table filled (Decimal + Text).

[DataFilled\(2,1\)](#) - Percent of second data table filled (Decimal + Text).

[DataFilled\(2,2\)](#) - 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.

# Data Tables

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## Status

The Status table includes information about the health of the data logger 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 "10.2 Status Table System Information" in the CR1000X 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-Lab 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-Lab.

**Station** - The name of the station (Text).

**BattV** - Battery Voltage in Volts (Decimal).

**E01AirTC** - Enclosure 1 air current temperature in degrees C (Decimal).

**E01AirRH** - Enclosure 1 air current relative humidity in percent (Decimal).

**E01AirVpd** - Enclosure 1 air current vapour pressure deficit in kilopascals (Decimal).

**ExtAirTC** - External (Outside) air current temperature in degrees Celsius (Decimal).

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

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

### Optional Barometric Pressure Sensor Display

**ExtBaroMsl** - External (Outside) barometric pressure in hectopascals.)

### End of Optional Barometric Pressure Sensor Display

**PowerCurHr** - Energy used during the current hour in kWh (Decimal).

**PowerCurDay** - Energy used during the current day in kWh (Decimal).

### Optional Portable Temperature and RH Sensors

(Up to 9 if installed - Ps1... to Ps9 all in the format below.)

**Ps1TC** - Portable Sensor 1 Temperature in Degrees Celsius (Decimal).

**Ps1RH** - Portable Sensor 1 Relative Humidity in Percent (Decimal).

### End of Optional Portable Sensors Section

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

**SetPointTC\_HI** - The high temperature setpoint for the current month in degrees Celsius (Decimal).

**SetPointTC\_LO** - The low temperature setpoint for the current month in degrees Celsius (Decimal).

## Data Tables

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**TimeSunrise** - Time HH:MM when Diurnal Day lighting or Nocturnal Grow Light starts (Text).

**TimeSupOn** - Time HH:MM when supplementary lighting eg. reptile basking light starts (Text).

**TimeSupOff** - Time HH:MM when supplementary lighting eg. reptile basking light ends (Text).

**TimeSunset** - Time HH:MM when Diurnal Night lighting or Nocturnal Moonlight starts (Text).

<b>IMPORTANT:</b> These times are appended with DST when daylight savings time is active.
---

**E00TcState** - The current state of the enclosure(s) air temperature (Text).

**HIGH** - The enclosure air temperature is above the high temperature A/C run setpoint.

**OK** - The enclosure air temperature is in the normal range.

**LOW** - The enclosure air temperature is below the low temperature A/C run setpoint.

**ERROR** - The enclosure air temperature is in an indeterminate state.

**E00RhState** - The current state of the enclosure(s) air relative humidity (Text).

**HIGH** - The enclosure air relative humidity is above the high humidity setpoint.

**OK** - The enclosure air relative humidity is in the normal range.

**LOW** - The enclosure air relative humidity is below the low humidity setpoint.

**ERROR** - The enclosure air relative humidity is in an indeterminate state.

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

**TOO\_HOT** - The external air temperature is above the too high setpoint (Ventilation not possible).

**OK** - The external air temperature is in the normal range.

**TOO\_COLD** - The external air temperature is below the too low setpoint (Ventilation not possible).

**ERROR** - The external air temperature is in an indeterminate state.

**ExtRhState** - The current state of the external air relative humidity (Text).

**WORSE** - The external air relative humidity is worse (higher) than the enclosure air relative humidity.

**OK** - The external air relative humidity is in the normal range.

**BETTER** - The external air relative humidity is better (lower) than the enclosure air relative humidity.

**ERROR** - The external air relative humidity is in an indeterminate state.

**FanSwitch** - The current position of the ventilation fan control switch (Text).

**MANUAL** - The ventilation fan is manually switched ON and will run continually.

**AUTO** - The ventilation fan is set to automatic control.

**OFF** - The ventilation fan is manually switched OFF and will not run.

## Data Tables

---

**FanState** - The current state of the ventilation fan control (Text).

**RUN MANUAL** - The fan was started manually by staff and will run continually.

**RUN (Timer)** - The fan was started automatically by the timer.

**RUN WARMING** - The fan was started automatically to increase the enclosure temperature.

**RUN COOLING** - The fan was started automatically to decrease the enclosure temperature.

**IDLE** - The fan was stopped automatically.

**OFF** - The fan was stopped manually by staff and will not run.

**AcSwitch** - The current position of the air conditioning control switch (Text).

**MANUAL HEAT** - The air conditioning is manually switched ON heating and will run continually.

**MANUAL COOL** - The air conditioning is manually switched ON cooling and will run continually.

**AUTO** - The air conditioning is set to automatic control.

**OFF** - The air conditioning is manually switched OFF and will not run.

**AcState** - The current state of the air conditioning control (Text).

**RUN MANUAL HEAT** - The air conditioning was started manually by staff and will heat continually.

**RUN MANUAL COOL** - The air conditioning was started manually by staff and will cool continually.

**RUN WARMING** - The fan was started automatically to increase the enclosure temperature.

**RUN COOLING** - The fan was started automatically to decrease the enclosure temperature.

**IDLE** - The air conditioning was stopped automatically.

**OFF** - The air conditioning was stopped manually by staff and will not run.

**DhuSwitch** - The current position of the dehumidifier control switch (Text).

**MANUAL** - The dehumidifier is manually switched ON and will run continually.

**AUTO** - The dehumidifier is set to automatic control.

**OFF** - The dehumidifier is manually switched OFF and will not run.

**DhuState** - The current state of the dehumidifier control (Text).

**RUN MANUAL** - The dehumidifier was started manually by staff and will run continually.

**IDLE** - The dehumidifier was stopped automatically.

**OFF** - The dehumidifier was stopped manually by staff and will not run.

**LxSwitch** - The current position of the lighting control switch (Text).

**MANUAL LX2** - The lighting is manually switched to LX2 ON and will run continually.

**MANUAL LX1** - The lighting is manually switched to LX1 ON and will run continually.

**AUTO** - The lighting is set to automatic control.

**OFF** - The lighting is manually switched OFF and will not run.

## Data Tables

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**LxMode** - Lighting Operating Mode (Text).

**DIURNAL STEPPED** - Lighting option switches set to Stepped mode.

**DIURNAL BUILD** - Lighting option switches set to Build mode.

**DIURNAL** - Lighting option switches set to Diurnal mode.

**NOCTURNAL** - Lighting option switches set to Nocturnal mode.

**LxState** - Lighting State (Text).

**DAY** - LX switched to AUTO, in Day state, Diurnal, Diurnal Build or Stepped mode, LX1 is ON.

**DAY (Step Sup)** - LX switched to AUTO, in Day Stepped state, Diurnal Stepped mode, LX2 is ON.

**DAY (Build Sup)** - LX switched to AUTO, in Day Build state, Diurnal Build mode, LX1 and LX2 ON.

**NIGHT** - LX switched to AUTO, in Night state, Diurnal mode, LX2 is ON.

**NIGHT (Off)** - LX switched to AUTO, in Night state, Diurnal Build or Stepped, LX1 and LX2 OFF.

**GROW LIGHTS** - LX switched to AUTO, in Day (grow lights) state, Nocturnal mode, LX1 is ON.

**MOONLIGHT** - LX switched to AUTO, in Moonlight state, Nocturnal mode, LX2 is ON.

**MANUAL LX1** - LX switched to LX1, LX1 is ON continuously.

**MANUAL LX2** - LX switched to LX2, LX2 is ON continuously.

**MANUAL LX1 (Sup)** - LX switched to LX1, in Diurnal Build mode, LX1+ LX2 are ON continuously.

**E01SenState** - Enclosure sensors operational state (Text).

**TC OK, RH OK** - Both temperature and RH sensors are OK.

**TC OK, RH1 FAIL** - Temperature sensors Ok, RH sensor failed at SDI-12 address 1.

**TC OK, RH2 FAIL** - Temperature sensors Ok, RH sensor failed at SDI-12 address 2.

**TC OK, RH FAIL** - Temperature sensors both OK, RH sensors both failed.

**TC1 FAIL, RH OK** - Temperature sensor failed at SDI-12 address 1, RH sensors OK.

**TC2 FAIL, RH OK** - Temperature sensor failed at SDI-12 address 2, RH sensors OK.

**TC FAIL, RH OK** - Temperature sensors both failed, RH sensors both OK.

**TC1 FAIL, RH1 FAIL** - Temperature sensor and RH sensor both failed at SDI-12 address 1.

**TC2 FAIL, RH2 FAIL** - Temperature sensor and RH sensor both failed at SDI-12 address 2.

**TC FAIL, RH FAIL** - Both temperature and RH sensors have failed.

### **Optional External Sensor Sensor Display**

**ExtSensState** - The current state of the external temperature and relative humidity sensors (Text).

**TC OK, RH OK** - The temperature and relative humidity sensors are both ok.

**TC OK, RH FAIL** - The temperature sensor is ok and the relative humidity sensor has failed.

**TC FAIL, RH OK** - The temperature sensor has failed and the relative humidity sensor is ok.

**TC FAIL, RH FAIL** - The temperature sensor and the relative humidity sensor have both failed.

### **End of Optional External Sensor Sensor Display**



## Data Tables

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### Optional Local Barometric Pressure Sensor

**BaroSensState** - The current state of the local external barometric pressure sensor (Text).

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

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

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

### End of Optional Local Barometric Pressure Sensor

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

**OK** - Mains power supply is 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.

## Data Tables

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### Communications Array

[CommsEx1TC](#) - The primary external temperature in degrees C (Decimal).

[CommsEx1RH](#) - The primary external relative humidity in % (Decimal).

[CommsEx2TC](#) - The secondary external temperature in degrees C (Decimal).

[CommsEx2RH](#) - The secondary external relative humidity in % (Decimal).

[CommsExBaro](#) - The barometric pressure sensor measurement in hectopascals (Decimal).

[CommsExSolar](#) - Reserved for solar radiation sensor measurement.

[CommsExRain](#) - Reserved for rainfall sensor measurement.

[CommsExWspd](#) - Reserved for wind speed sensor measurement.

[CommsExWdir](#) - Reserved for wind direction sensor measurement.

### End of Communications Array

[Sens1TC](#) - Enclosure sensor number 1 temperature in Deg C (Decimal).

[Sens1RH](#) - Enclosure sensor number 1 relative humidity in % (Decimal).

[Sens2TC](#) - Enclosure sensor number 2 temperature in Deg C (Decimal).

[Sens2RH](#) - Enclosure sensor number 2 relative humidity in % (Decimal).

[ManualTC\\_HI](#) - User entry of manual override for the SetPointTC\_HI month setting (Decimal).

[ManualTC\\_LO](#) - User entry of manual override for the SetPointTC\_LO month setting (Decimal).

### 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-Lab 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).

## Data Tables

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### **HVAC Hourly Accumulated Run Times**

This data table provides hourly accumulated totals of the run time for each part of the HVAC system.

Table Name - [E00\\_HVAC\\_60M](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[FanHrRunMins](#) - Ventilation fan accumulated run time for the past hour in minutes (Decimal).

[AcHrRunMins](#) - Air conditioning system accumulated run time for the past hour in minutes (Decimal).

### **HVAC Daily Accumulated Run Times**

This data table provides daily accumulated totals of the run time for each part of the HVAC system.

Table Name - [E00\\_HVAC\\_DAY](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[FanDayRunMins](#) - Ventilation fan accumulated run time for the past day in minutes (Decimal).

[AcDayRunMins](#) - Air conditioning system accumulated run time for the past day in minutes (Decimal).

### **Enclosure Hourly Energy Use**

This data table provides an hourly accumulated total of the energy used within the enclosure. It enables a profile of the energy consumption across any given day to be analysed for energy management purposes. This can help identify daily peaks and troughs in energy use.

Table Name - [E00\\_KWH\\_60M](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[PowerCurHr](#) - Energy consumption for the past hour in kilowatt hours (Decimal).

### **Enclosure Daily Energy Use**

This data table provides a daily accumulated total of the energy used within the enclosure. It enables a profile of the energy consumption across any number of days or months to be analysed for energy management purposes. This can help identify seasonal peaks and troughs in energy use.

Table Name - [E00\\_KWH\\_DAY](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[PowerCurDay](#) - Energy consumption for the past day in kilowatt hours (Decimal).

## Data Tables

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### Enclosure Daily Lighting Cycle Summary

This data table provides a daily summary of the lighting cycle settings in operation for the day. It enables a profile of the lighting cycle across any number of days or months to be analysed for research purposes.

Table Name - [E00\\_LIGHT\\_DAY](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[SunsetTime](#) - The time the sunset transition, from sunlight (grow lights) to moonlight, began (HH:MM).

[SunriseTime](#) - The time the sunrise transition, from moonlight to sunlight (grow lights), began (HH:MM).

[LengthNight](#) - The duration of the moonlight scene of the lighting cycle in hours (Decimal).

[LengthDay](#) - The duration of the sunlight (grow lights) phase of the lighting cycle in hours (Decimal).

[SupTime](#) - The time the supplementary lighting phase of the lighting cycle began (HH:MM).

[LengthSup](#) - The duration of the supplementary lighting phase of the lighting cycle in hours (Decimal).

### Enclosure Ten Minute Temperature and Relative Humidity

This data table provides high resolution monitoring of the climate in the enclosure and is ideal for graphing to ensure the enclosure climate is being maintained within the desired range. This data table also records the external (outside) temperature and relative humidity data which, when plotted on a graph against the enclosure data, helps with analysis of the HVAC performance.

Table Name - [E01\\_T\\_RH\\_10M](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[EnAirTC\\_Avg](#) - Average enclosure temperature in degrees Celsius (Decimal).

[EnAirRH\\_Avg](#) - Average enclosure relative humidity in percent (Decimal).

[EnAirVPD\\_Avg](#) - Average enclosure vapour pressure deficit in kilopascals (Decimal).

[ExAirTC\\_Avg](#) - Average external (outside) temperature in degrees Celsius (Decimal).

[ExAirRH\\_Avg](#) - Average external (outside) relative humidity in percent (Decimal).

[ExAirVPD\\_Avg](#) - Average external (outside) vapour pressure deficit in kilopascals (Decimal).

## Data Tables

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### Enclosure Daily Temperature and Relative Humidity Summary

This data table provides a daily summary, logged at midnight (00:00), of the enclosure temperature and relative humidity over the previous day. The table records the average temperature along with the minimum and maximum temperatures and relative humidities, and the times they occurred.

Table Name - [E01\\_T\\_RH\\_DAY](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[EnAirTC\\_Avg](#) - Average enclosure temperature in degrees Celsius (Decimal).

[EnAirTC\\_Max](#) - Maximum enclosure temperature in degrees Celsius (Decimal).

[EnAirTC\\_TMx](#) - Time of maximum temperature (DateTime).

[EnAirTC\\_Min](#) - Minimum enclosure temperature in degrees Celsius (Decimal).

[EnAirTC\\_TMn](#) - Time of minimum temperature (DateTime).

[EnAirRH\\_Max](#) - Maximum enclosure relative humidity in percent (Decimal).

[EnAirRH\\_TMx](#) - Time of maximum relative humidity (DateTime).

[EnAirRH\\_Min](#) - Minimum enclosure relative humidity in percent (Decimal).

[EnAirRH\\_TMn](#) - Time of minimum relative humidity (DateTime).

### External Daily Temperature and Relative Humidity Summary

This data table provides a daily summary, logged at midnight (00:00), of the external (outside) temperature and relative humidity over the previous day. The table records the average temperature along with the minimum and maximum temperatures and relative humidities, the times they occurred.

Table Name - [EXT\\_T\\_RH\\_Day](#)

[TIMESTAMP](#) - Record Date and Time (DateTime).

[RECORD](#) - Record Number (Integer).

[ExAir TC\\_Avg](#) - Average External (Outside) Air Temperature for the day in Degrees Celsius (Decimal).

[ExAir TC\\_Max](#) - Maximum External (Outside) Air Temperature for the day in Degrees Celsius (Decimal).

[ExAir TC\\_TMx](#) - Time of Maximum Air Temperature (DateTime).

[ExAirTC\\_Min](#) - Minimum External (Outside) Air Temperature for the day in Degrees Celsius (Decimal).

[ExAirTC\\_TMn](#) - Time of Minimum Air Temperature (DateTime).

[ExAirRH\\_Max](#) - Maximum External (Outside) Air Relative Humidity for the day in Percent (Decimal).

[ExAirRH\\_TMx](#) - Time of Maximum Air Relative Humidity (DateTime).

[ExAirRH\\_Min](#) - Minimum External (Outside) Air Relative Humidity for the day in Degrees Celsius (Decimal).

[ExAirRH\\_TMn](#) - Time of Minimum Air Relative Humidity (DateTime).

## Data Tables

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### External Hourly Barometric Pressure, Temperature and Humidity (Optional)

This data table provides an hourly record of the barometric pressure measurements, external (outside) temperature and relative humidity. It enables analysis of atmospheric conditions on an hourly basis and can be easily correlated with enclosure conditions for research purposes.

Table Name - [EXT\\_BARO\\_60M](#)

[TIMESTAMP](#) - Record date and time (DateTime).

[RECORD](#) - Record number (Integer).

[ExBaroStn\\_Avg](#) - Average barometric pressure at the station in hectopascals (Decimal).

[ExBaroMsl\\_Avg](#) - Average barometric pressure, corrected to Mean Sea Level, in hectopascals (Decimal).

[ExAirTC\\_Avg](#) - Average external (outside) temperature in degrees Celsius (Decimal).

[ExAirRH\\_Avg](#) - Average external (outside) relative humidity in percent (Decimal).

### Portable Sensors Ten Minute Temperature and Relative Humidity (Optional)

The ZooCADA-Lab program is designed for nine portable sensors. Each portable sensor has its own data table and all nine data tables have an identical format. The table naming convention is PSx\_10M where x is a number from 1 to 9, the same as the sensor's SDI-12 address, to indicate which portable sensor the data table belongs to. The table definition shown below is for portable sensor number 1.

Table Name - [PS1\\_10M](#)

[TIMESTAMP](#) - Record Date and Time (DateTime).

[RECORD](#) - Record Number (Integer).

[Ps1\\_TC](#) - Instantaneous Temperature in Degrees Celsius (Decimal).

[Ps1\\_RH](#) - Instantaneous Relative Humidity in Percent (Decimal).

# Using The Web Interface

## Using The Web Interface

The datalogger has a built-in web server and web page 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 offers several administrative functions that can be accessed by logging on to the datalogger. These functions are locked out when the user is not logged on.

**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 screenshot displays the 'Status' page of the Campbell Scientific web interface. At the top, there is a navigation bar with the Campbell Scientific logo and icons for various functions, and a menu with 'Status', 'Data', 'Files', and 'Utilities'. The main content area is titled 'Status' and includes a 'Refresh' button. The information is presented in two columns:

Datalogger Information	Program Information
<b>Name</b> 21182	<b>Current</b> CPU:OKH_WL1_CR1000X_REV1.CR1X
<b>Timestamp</b> 26/09/2021, 10:18:30 pm	<b>Start Time</b> 26/09/2021, 3:26:31 pm
<b>OS</b> CR1000X.Std.05.01	<b>Run Signature</b> 42984
<b>Panel Temperature</b> 21.04°C	<b>Program Signature</b> 56104
<b>Battery</b> 12.39 V	<b>Results for Last Program Compiled</b> CPU:OKH_WL1_CR1000X_REV1.CR1X -- Compiled in SequentialMode.
<b>Memory</b> 4194304 bytes	<b>Memory Free</b> 45580 bytes
<b>Errors</b> Watchdog:0	<b>Errors</b> Skipped Scans:0 Variables Out of Bounds:0

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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.

## Using The Web Interface

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The web interface status page displays a subset of the information in the dataloggers status table, which is an automatically generated default table. The complete status 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 "10.2 Status Table System Information" in the CR1000X 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 programatically.

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

**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.

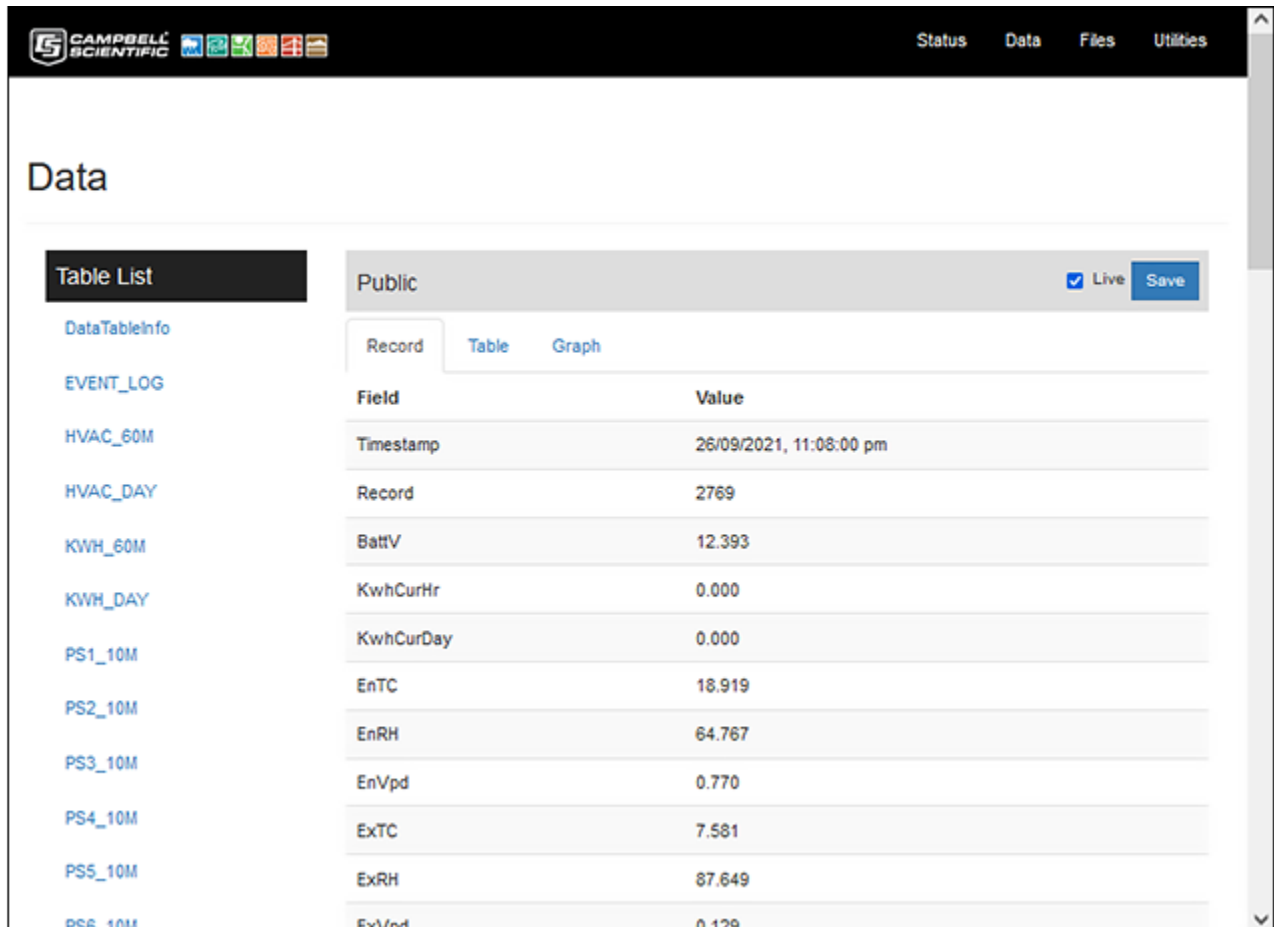
**Memory Free** - Unallocated final-data memory in the datalogger (bytes). Free memory is not necessarily available for data tables. As memory is allocated and freed, small sections of unallocated memory, which are unusable for data tables, may be created. Updated after compile completes.

**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



Field	Value
Timestamp	26/09/2021, 11:08:00 pm
Record	2769
BattV	12.393
KwhCurHr	0.000
KwhCurDay	0.000
EnTC	18.919
EnRH	64.767
EnVpd	0.770
ExTC	7.581
ExRH	87.649
ExVpd	0.129

The Data page enables data tables stored in the datalogger to be viewed and downloaded, or selected fields 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 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 tabs below the grey header allow different views of the available data as follows.

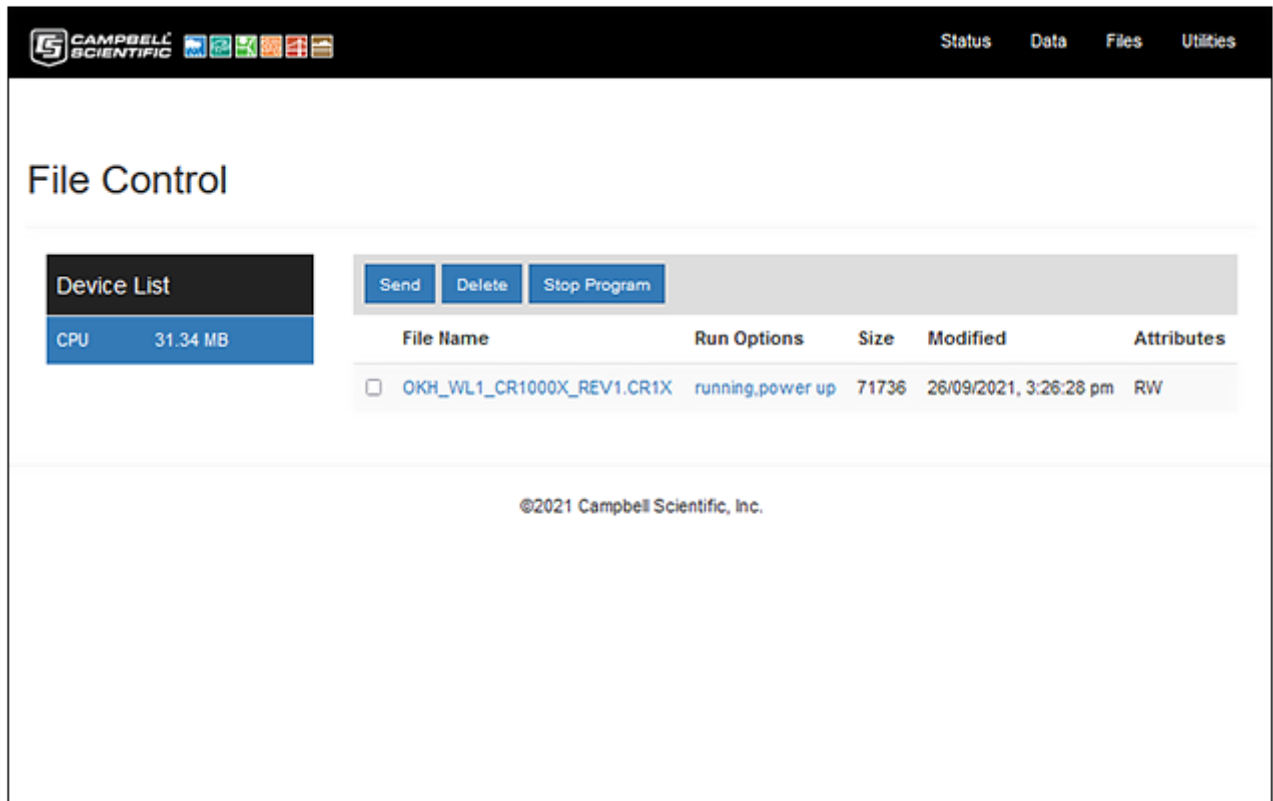
[Record](#) - Displays a scrolling list of Fields in current record of the table with the Value displayed next to it.

[Table](#) - Displays a scrolling list of all the records in the table.

[Graph](#) - Displays a realtime graph of the selected field values as they arrive.

To produce a graph of the incoming data values for one or more fields, select the desired field name(s) by clicking their checkbox in the Fields list. Set the Records box to the number of records for the graph to display. As each new data value arrives it will be plotted on the graph. Earlier data in the data table is not graphed. The graph is only retained while the graph page is displayed, moving away from the page clears the graph.

## File Control Page



The File Control page enables management of the datalogger files. Files can be sent, deleted, activated, and deactivated. It 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.

## Using The Web Interface

---

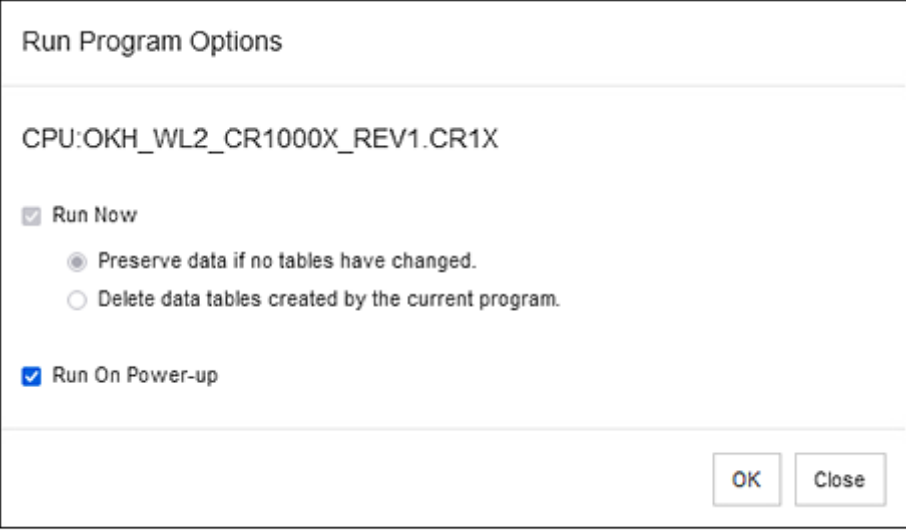
### File Name Click

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.



The image shows a dialog box titled "Run Program Options". At the top, it displays the file path "CPU:OKH\_WL2\_CR1000X\_REV1.CR1X". Below this, there are two main sections. The first section is "Run Now", which is currently greyed out. It contains two radio button options: "Preserve data if no tables have changed." (which is selected) and "Delete data tables created by the current program." The second section is "Run On Power-up", which is checked with a blue checkmark. At the bottom right of the dialog box, there are two buttons: "OK" and "Close".

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.

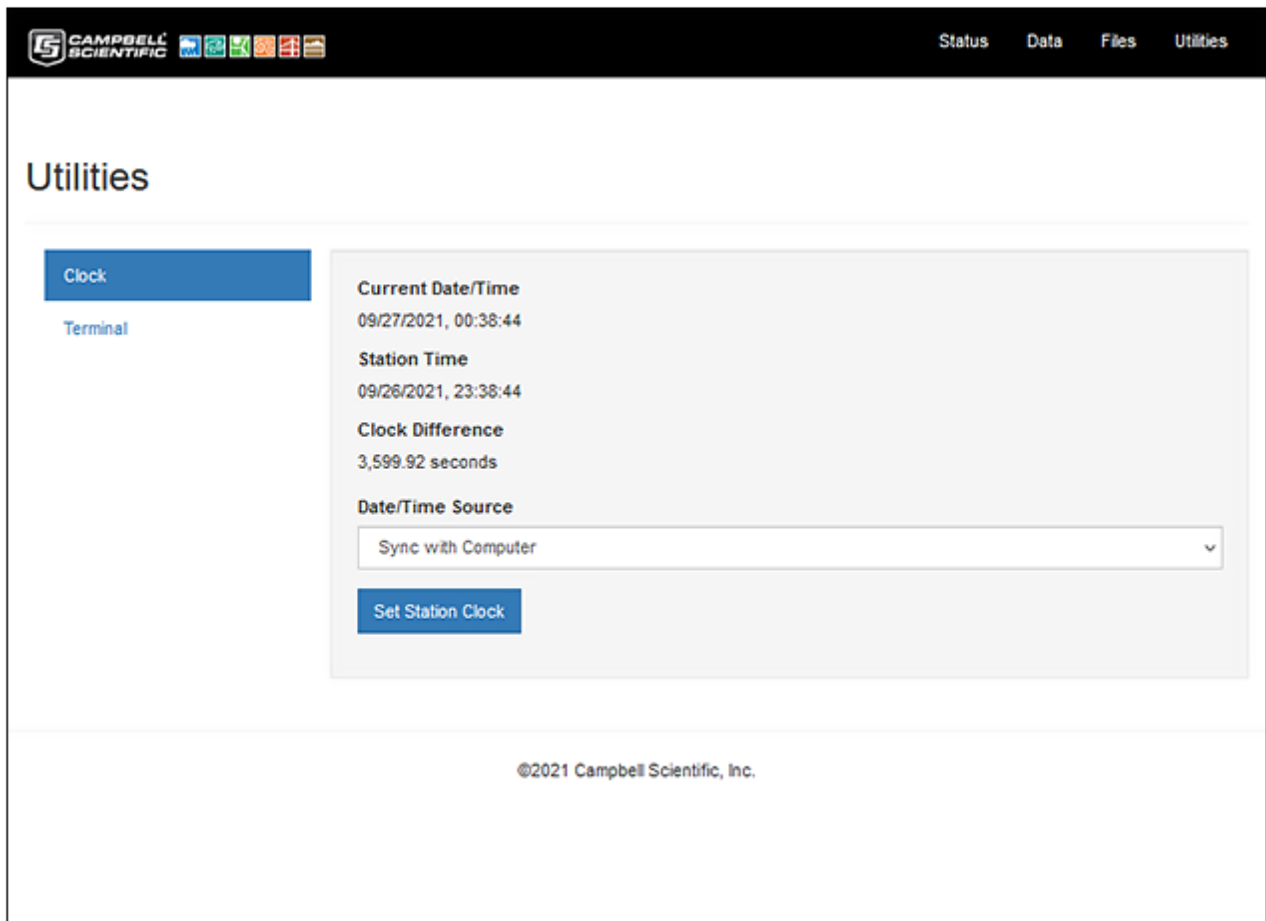
**Run On Power-up** - Select to enable the program to start automatically when the datalogger is powered up.

**WARNING:** Failure to select Run On Power-up will cause the control 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.

# Using The Web Interface

## 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.

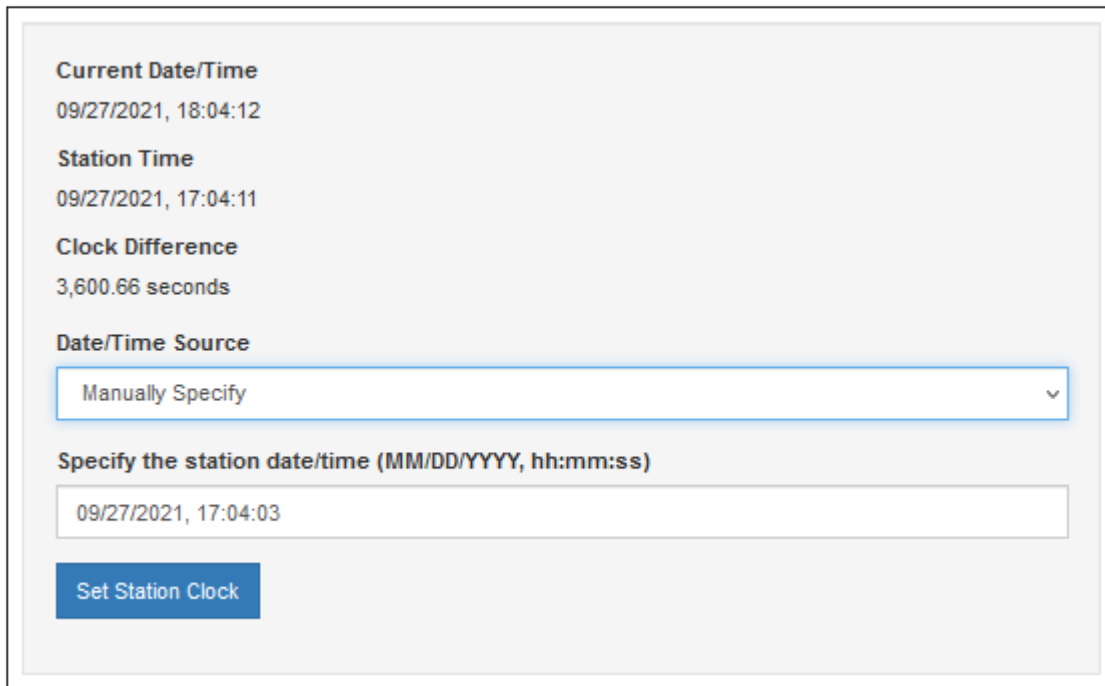
**IMPORTANT:** Always use the Manually Specify option when setting the station (datalogger) clock to avoid inadvertently setting the station to the computer's daylight savings time, which may cause data loss.

## Using The Web Interface

---

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.



The screenshot shows a web interface for configuring the datalogger's date and time. It includes the following elements:

- Current Date/Time:** 09/27/2021, 18:04:12
- Station Time:** 09/27/2021, 17:04:11
- Clock Difference:** 3,600.66 seconds
- Date/Time Source:** A dropdown menu currently set to "Manually Specify".
- Specify the station date/time (MM/DD/YYYY, hh:mm:ss):** A text input field containing "09/27/2021, 17:04:03".
- Set Station Clock:** A blue button located below the text input field.

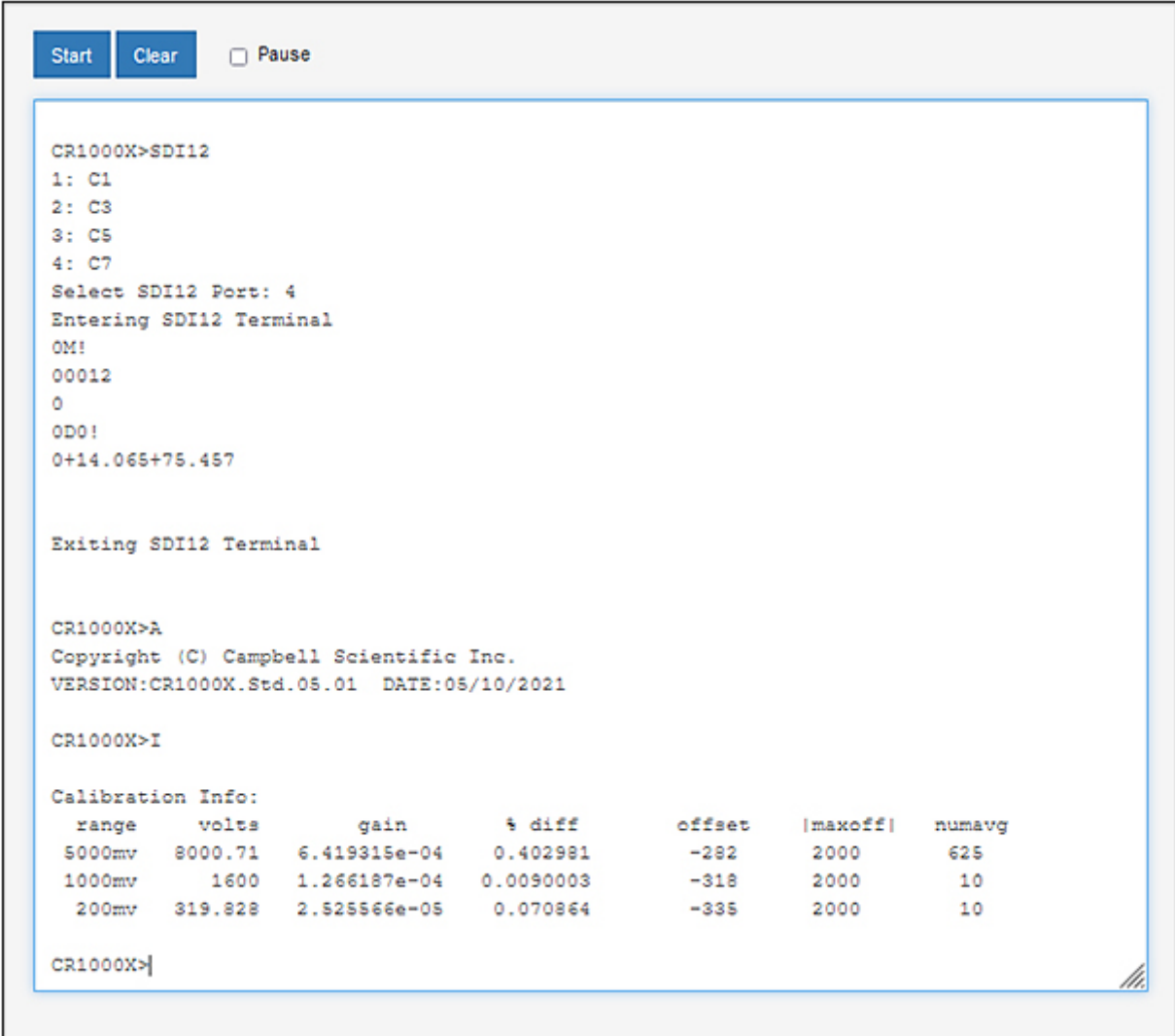
2. Edit the displayed date and/or time as necessary so the correct date and time is displayed.
3. Click the [\[Set Station Clock\]](#) button. A confirmation dialog box appears.
4. Click the [\[Yes\]](#) button to immediately update the station clock, or [\[No\]](#) to cancel the operation.

**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.

## Using The Web Interface

### Terminal



```

CR1000X>SDI12
1: C1
2: C3
3: C5
4: C7
Select SDI12 Port: 4
Entering SDI12 Terminal
OM!
00012
0
0D0!
0+14.065+75.457

Exiting SDI12 Terminal

CR1000X>A
Copyright (C) Campbell Scientific Inc.
VERSION:CR1000X.Std.05.01 DATE:05/10/2021

CR1000X>I

Calibration Info:
  range   volts   gain      % diff   offset  |maxoff|  numavg
5000mv   8000.71  6.419315e-04  0.402981  -282    2000    625
1000mv   1600     1.266187e-04  0.0090003  -318    2000    10
200mv    319.828  2.525566e-05  0.070864  -335    2000    10

CR1000X>|

```

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 below.

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 `OM!` 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

---

## Sensor Measurements

This section provides information about how the datalogger program obtains the various climate measurements that are used to control the HVAC equipment that maintains the enclosure climate. The measurements also provide information that can assist users with managing the enclosure and caring for the animals held in it. All sensors are read and processed automatically by the datalogger program.

### Enclosure Temperature and Relative Humidity Measurements

Two Campbell Scientific HygroVUE5 SDI-12 combined temperature and relative humidity (RH) sensors are installed in the enclosure and are wired back to the datalogger which measures the sensors once every minute.

Each time the sensors are measured, the program carries out a test to ensure the measurement values obtained from the sensors are within the manufacturers specified operating range. If a sensor fails, it typically returns a measurement value that is out of range such as -9999 or NAN (Not A Number) so detecting such values enables the program to automatically disregard a sensor that is obviously defective.

The test criteria for HygroVUE5 temperature and RH sensor measurement values are:

*T° C greater than -40 and T° C less than 70 and T° C is not NAN  
RH % greater than 5 and RH % less than or equal to 100 and RH % is not NAN*

**NOTE:** This check cannot verify that functioning sensors are also accurately calibrated, periodic calibration tests are recommended for this purpose.

For maximum accuracy and fail-safe redundancy two temperature and RH sensor measurements are used. The two measurements are tested and if both sensors are ok their measurement values are averaged. If one sensor fails the station continues operating using the remaining good sensor.

The following logic is applied to error check and average the external Temperature and RH sensors:

*Test Sensor 1 and if Sensor 1 is Ok then*

*Test Sensor 2 and if Sensor 2 is Ok Then*

*Set Result to the Calculated average of Sensor 1 Value and Sensor 2 Value*

*Otherwise Sensor 2 is Defective so*

*Set Result to the Sensor 1 Value.*

*Otherwise Sensor 1 is Defective so Test Sensor 2 and if Sensor 2 is Ok then*

*Set Result to the Sensor 2 Value.*

*Otherwise Sensor 1 and Sensor 2 are Both Defective so*

*Set Result to NAN*

The enclosure sensor state [E01SensState](#) is displayed in the [Public](#) data table. Normally the sensor state displays "TC OK, RH OK" to indicate that the sensors are working normally. If a sensor measurement fails the above test, the state for that sensor changes to indicate the nature of the fault. The state "TC OK, RHx FAIL" indicates the RH sensor has failed, "TCx FAIL, RH OK" indicates the temperature sensor has failed, and "TCx FAIL, RHx FAIL" indicates that both sensors have failed. The 'x' will be either the numeral '1' to indicate sensor 1, or the numeral '2' to indicate sensor 2.

## Sensor Measurements

---

The average measurements from the two sensors is determined using the following equation:

$$\text{Average} = (\text{Value1} + \text{Value 2}) \div 2$$

The measurement values for the temperature [E01AirTC](#) and relative humidity [E01AirRH](#) are displayed in the [Public](#) data table and logged every ten minutes. A daily summary is also logged with the minimum, maximum, and average values. NAN (Not A Number) is displayed and logged in place of the measurement value in the event that no valid measurement value can be obtained from the sensors, which may be the result of sensor failure or if the sensors have yet to be measured after a program restart.

### External Temperature and Relative Humidity Measurements

ZooCADA-Lab requires external air temperature and relative humidity measurements for the HVAC control system. An external sensor installed on the local station is required when ZooCADA-Lab is configured as a standalone station, or when it is configured as a primary or secondary external sensor data server to other networked stations.

A Campbell Scientific HygroVUE5 SDI-12 combined temperature and relative humidity sensor is used for the external (outside) air sensor. If installed, the external sensor is measured once every minute.

When a site has multiple network connected stations, one or more remote stations can provide the external sensor measurement values which the local station then obtains via network communications every five minutes.

Each time the external sensors are measured, the program carries out a test to ensure the measurement values obtained from the sensors are within the manufacturers specified operating range. If a sensor fails, it typically returns a measurement value that is out of range such as -9999 or NAN (Not A Number) so detecting such values enables the program to automatically disregard a sensor that is obviously defective.

The test criteria for HygroVUE5 temperature and RH sensor measurement values are:

*T° C greater than -40 and T° C less than 70 and T° C is not NAN*

*RH % greater than 5 and RH % less than or equal to 100 and RH % is not NAN*

**NOTE:** This check cannot verify that functioning sensors are also accurately calibrated, periodic calibration tests are recommended for this purpose.

If an external sensor is installed on the datalogger, the external sensor state [ExtSensState](#) is displayed in the [Public](#) data table. Normally the sensor state displays "TC OK, RH OK" to indicate that the sensors are working normally. If a sensor measurement fails the above test, the state for the sensor changes to indicate the nature of the fault. The state "TC OK, RH FAIL" indicates the RH sensor has failed, "TC FAIL, RH OK" indicates the temperature sensor has failed, and "TC FAIL, RH FAIL" indicates that both sensors have failed.

**NOTE:** When external sensor values are acquired from remote stations via the network, a sensor failure does not raise an external sensor failure alarm on the local station. External sensor failure alarms are only generated by stations that have an external sensor installed on them.

The external air temperature and RH measurement values from the sensors, regardless of whether the sensors are local or remote, are placed into the [Public](#) data table fields [CommsEx1TC](#), [CommsEx1RH](#), [CommsEx2TC](#), and [CommsEx2RH](#) (the communications array), so they are available to all dataloggers across the network.

For fail-safe redundancy two temperature and RH sensor measurements can be used, either with one sensor on the local station and one at a remote station, or with both at remote stations. If two measurements are available they are averaged and if one sensor fails the station continues operating using the remaining good sensor.



## Sensor Measurements

---

The following logic is applied to error check and average the external Temperature and RH sensors:

*Test Sensor 1 and if Sensor 1 is Ok then*

*Test Sensor 2 and if Sensor 2 is Ok Then*

*Set Result to the Calculated average of Sensor 1 Value and Sensor 2 Value*

*Otherwise Sensor 2 is Defective so*

*Set Result to the Sensor 1 Value.*

*Otherwise Sensor 1 is Defective so Test Sensor 2 and if Sensor 2 is Ok then*

*Set Result to the Sensor 2 Value.*

*Otherwise Sensor 1 and Sensor 2 are Both Defective so*

*Set Result to NAN*

If two external sensors are in use, the average measurements are determined using the following equation:

$$\text{Average} = (\text{Value1} + \text{Value 2}) \div 2$$

The resultant external temperature and relative humidity measurements, [ExtAirTC](#) and [ExtAirRH](#) are displayed in the [Public](#) data table and logged every ten minutes. A daily summary is also logged with the minimum, maximum, and average values. NAN (Not A Number) is displayed and logged in place of the measurement value in the event that no valid measurement value can be obtained from the sensors, which may be the result of sensor failure or if the sensors have yet to be measured after a program restart.

### 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:

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

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 enclosure and external air are usually at different temperatures so RH cannot be used to compare their water vapour content for HVAC control purposes, their vapour pressures must be used instead.

## Sensor Measurements

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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 external vapour pressure deficit [ExtAirVpd](#) and the enclosure vapour pressure deficit [E01AirVpd](#) values are displayed in the [Public](#) data table and logged every ten minutes.

### Electricity kWh Meter Measurement

A kWh meter can be installed in the switchboard to monitor the building's electricity use.

These meters have a pulse output that produces 1 pulse for every 0.01 kWh of electricity used. The pulse output from the kWh meter is applied to a pulse counter input on the datalogger which counts the number of pulses that occur between each program scan. The datalogger program reads each pulse counter and accumulates the count as hourly and daily kWh totals.

#### Maintenance Procedure

During maintenance when the datalogger program is not running, such as program updates, any pulses applied to the datalogger pulse counter input will not be counted and pulse counts not yet logged will be

## Sensor Measurements

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lost. To avoid logging inaccurate kWh data when the datalogger is restarted, it is necessary to enter the correct kWh totals into the **Public** data table **PowerCurDay** and **PowerCurHr** fields after restarting the datalogger.

When commencing maintenance, write down the kWh reading from the meter, and the **PowerCurDay** and **PowerCurHr** values from the fields in the datalogger **Public** data table. At the conclusion of maintenance, write down the kWh reading from the meter and subtract the start reading from the end reading to obtain the kWh used during maintenance. Add the kWh used during maintenance to the **PowerCurDay** and **PowerCurHr** values you wrote down at the start then enter those new values into the **PowerCurDay** and **PowerCurHr** fields in the datalogger **Public** data table using the LoggerNet software or the Web Interface.

### Barometric Pressure Measurements (Optional)

A Campbell Scientific BaroVUE10 barometric pressure sensor may be installed on one station. If installed, the sensor is measured every six minutes. The resulting station pressure measurement (the pressure at that station's elevation) is placed into the communications array where it can be accessed by all stations on the network.

On the station where the barometric pressure sensor is installed, the station constant **BARO\_SDI\_ADDR** is set to the sensor's SDI-12 address and the station constant **BARO\_LOCAL** is set to True to enable the datalogger program to obtain the measurement values from the sensor.

In order to display and log the barometric pressure values, the station constant **BARO\_ENAB** must be set to True and the station's elevation above Mean Sea Level, 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 required.

The station pressure is always displayed in the communications array **Public** table **CommsExBaro** variable whilst the pressure corrected to Mean Sea Level is calculated and displayed in the **Public** table **ExtBaroMsl** variable. The station pressure is useful in situations where a measure of the actual pressure is required, whilst the barometric pressure is consistent with the pressure 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 BaroVUE10 Product Manual.

The datalogger logs the station pressure, barometric pressure, external (outside) temperature, and relative humidity every hour. These pressure measurements are recorded to assist zoo personnel with research activities and are not used by the datalogger program HVAC and lighting control functions.

### Portable Sensor Temperature and Relative Humidity Measurements (Optional)

The ZooCADA-Lab program supports up to nine portable SDI-12 temperature and RH sensors.

These optional sensors are connected to Port C7 and each sensor is allocated an SDI-12 address from 1 to 9. The datalogger attempts to communicate with each of the nine sensors every five minutes.

## Sensor Measurements

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These temperature and relative humidity (RH) sensors can be used to measure the microclimate in individual vivariums or other small enclosures in applications where the main enclosure is a room containing multiple smaller enclosures, such as in an animal breeding lab.

The datalogger displays the temperature and RH measurement values for each portable sensor that is present in the Public data table. The field names are in the format PsXTC and PsXRH where X is the sensor's SDI-12 address, so Ps2TH is portable sensor 2 temperature and Ps2RH is portable sensor 2 relative humidity.

The datalogger records the temperature and RH values for each sensor, as an instantaneous sample, every ten minutes. Each portable sensor has a data table of its own which is only activated when the portable sensor is in use to avoid storing data tables full of zeros for any sensors that are not currently in use.

The data table name for each sensor is in the format PSX\_10M where X is the sensor's SDI-12 address, so the data table PS2\_10M would correspond to portable sensor 2.

### SDI-12 Sensor Address Settings

The SDI-12 addresses should be set on the external and enclosure sensors as follows...

External (Ext) Temperature & Relative Humidity	-	Port C5 - Address '0'
Enclosure (E01) Temperature & Relative Humidity	-	Port C5 - Address '1'
Enclosure (E02) Temperature & Relative Humidity	-	Port C5 - Address '2'
External (Ext) Barometric Pressure	-	Port C5 - Address '3'

The SDI-12 addresses should be set on the optional portable sensors as follows...

Portable Sensor 1 Temperature & Relative Humidity	-	Port C7 - Address 1
Portable Sensor 2 Temperature & Relative Humidity	-	Port C7 - Address 2
Portable Sensor 3 Temperature & Relative Humidity	-	Port C7 - Address 3
Portable Sensor 4 Temperature & Relative Humidity	-	Port C7 - Address 4
Portable Sensor 5 Temperature & Relative Humidity	-	Port C7 - Address 5
Portable Sensor 6 Temperature & Relative Humidity	-	Port C7 - Address 6
Portable Sensor 7 Temperature & Relative Humidity	-	Port C7 - Address 7
Portable Sensor 8 Temperature & Relative Humidity	-	Port C7 - Address 8
Portable Sensor 9 Temperature & Relative Humidity	-	Port C7 - Address 9

### 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`

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## Communications to Remote Stations

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### 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 external sensor is disabled. 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 external sensor is disabled. 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` - The primary external temperature in degrees C (Decimal).

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

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

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

`CommsExBaro` - The barometric pressure sensor measurement in hectopascals (Decimal).

`CommsExSolar` - Reserved for solar radiation sensor measurement.

`CommsExRain` - Reserved for rainfall sensor measurement.

`CommsExWspd` - Reserved for wind speed sensor measurement.

`CommsExWdir` - Reserved for wind direction sensor measurement.

## Communications to Remote Stations

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If a sensor is not present, or the sensor measurement returns an error, the corresponding communications array fields 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`

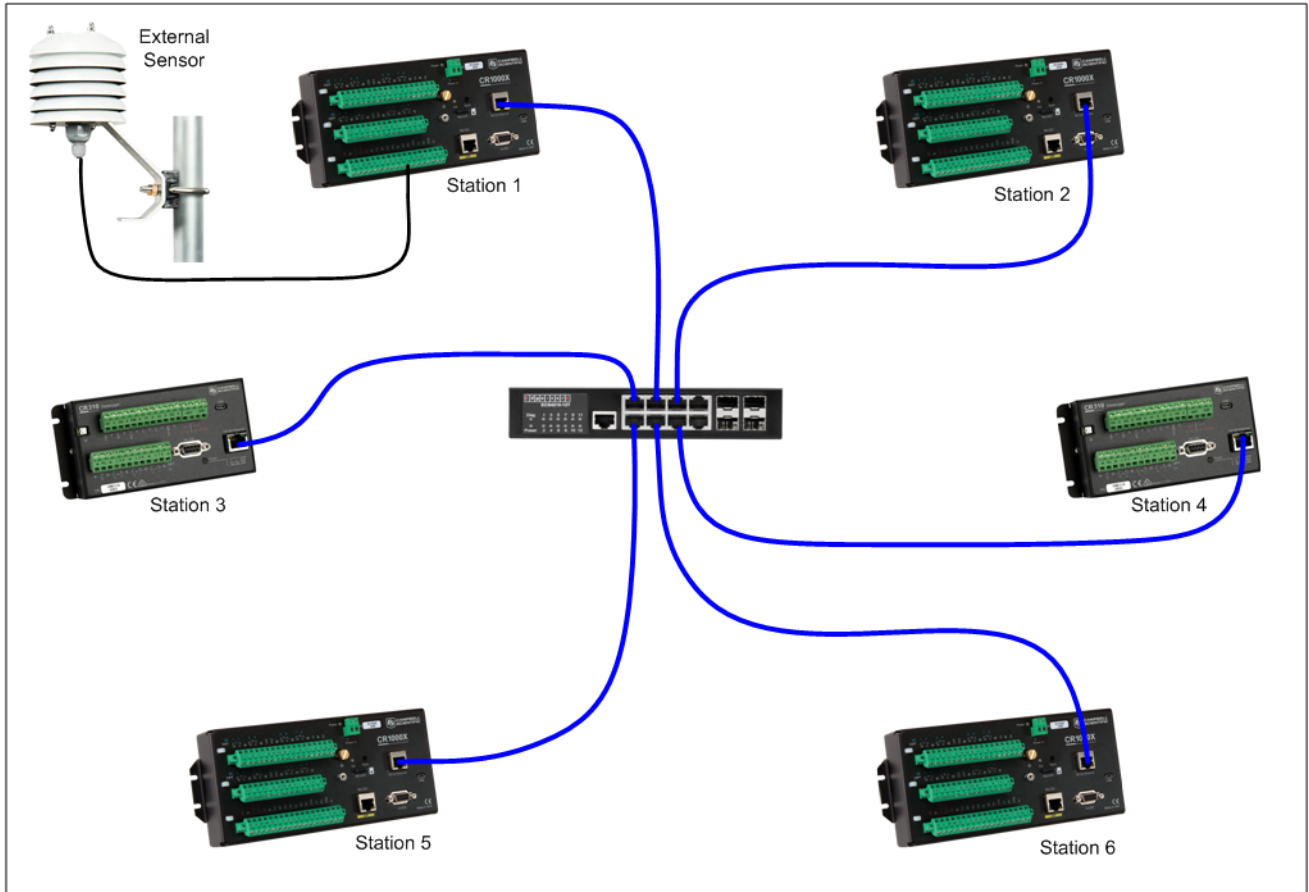
To disable the secondary remote station, set:

`EXT_TRH2_ENABLE = False`

# Communications to Remote Stations

## 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

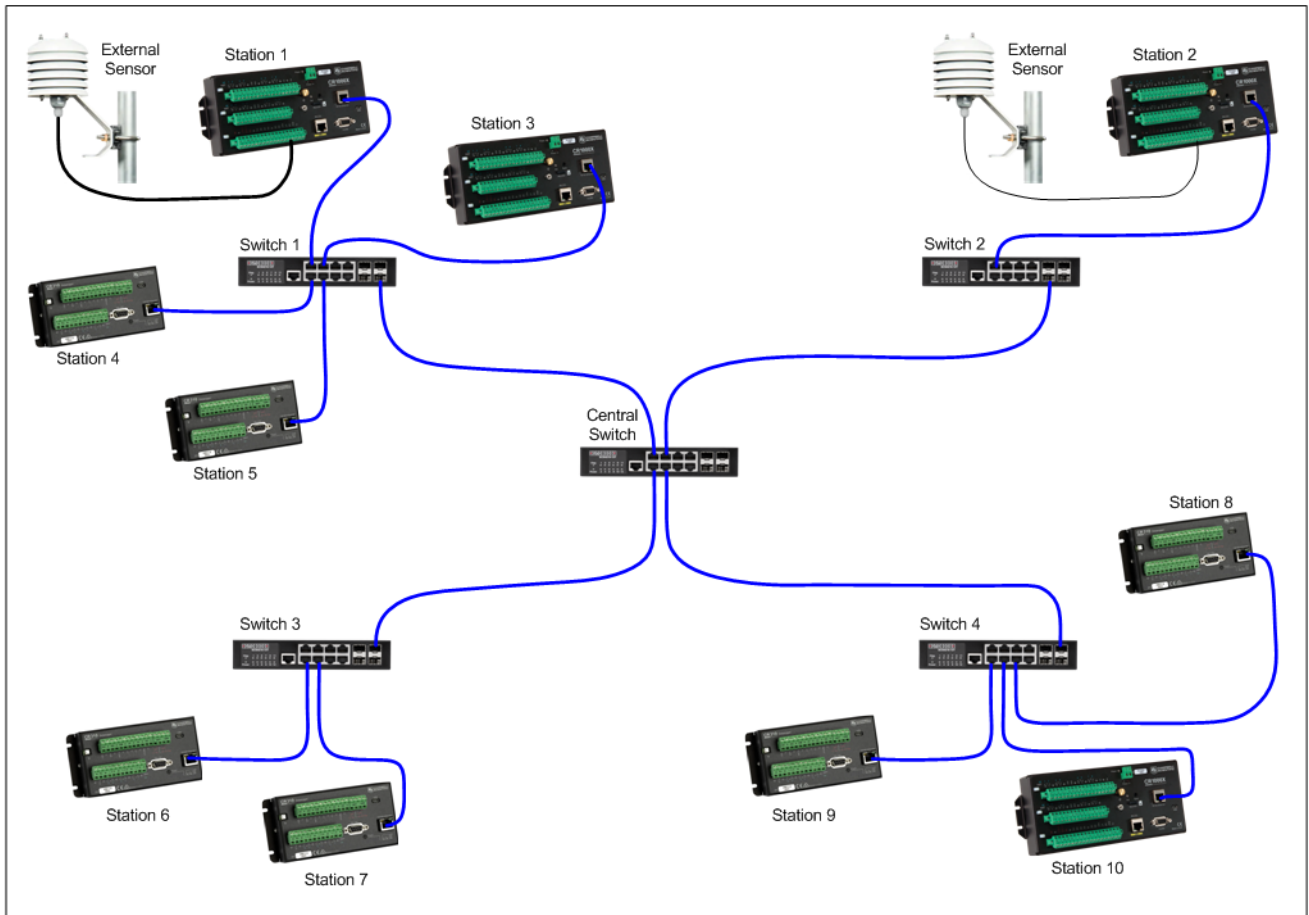
EXT\_TRH\_LOCAL = False  
EXT\_TRH\_PRIMARY = False  
EXT\_TRH1\_ENABLE = True  
EXT\_TRH1\_PK = 1  
EXT\_TRH1\_IP = 192.168.1.1  
EXT\_TRH2\_ENABLE = False  
EXT\_TRH2\_PK = 2 (ignored)  
EXT\_TRH2\_IP = 192.168.1.2 (ignored)



# Communications to Remote Stations

## 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.

## Communications to Remote Stations

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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 to Remote Stations

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## 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 all the operation of all functions. The current setting of each state switch is displayed in the [Public](#) data table fields so system users can see what state each program function is in. Each of the state switches is detailed below.

### Enclosure Air Temperature State

The enclosure temperature state is displayed in the [Public](#) data table field [E00TcState](#). The temperature measurements from the two sensors are averaged to provide a temperature state that is properly representative of both enclosures as this is used for HVAC control.

The possible enclosure temperature states are:

[HIGH](#) - The enclosure air temperature is above the high temperature A/C run setpoint.

[OK](#) - The enclosure air temperature is in the normal range.

[LOW](#) - The enclosure air temperature is below the low temperature A/C run setpoint.

[ERROR](#) - The enclosure air temperature is in an indeterminate state.

### Enclosure Air Relative Humidity State

The enclosure relative humidity stat is displayed in the [Public](#) data table field [E00RhState](#). The relative humidity measurements from the two sensors are averaged to provide a relative humidity state that is properly representative of both enclosures as this is used for HVAC control.

The possible enclosure relative humidity states are:

[HIGH](#) - The enclosure air relative humidity is above the high humidity setpoint.

[OK](#) - The enclosure air relative humidity is in the normal range.

[LOW](#) - The enclosure air relative humidity is below the low humidity setpoint.

[ERROR](#) - The enclosure air relative humidity is in an indeterminate state.

### External Air Temperature State

The external temperature state is displayed in the [Public](#) data table field [ExtTcState](#). This state is used by the HVAC control system to control the ventilation fan to manage the enclosure temperature within the band set in the [STATION\\_SETPOINTS](#) file and prevent the ventilation fan from running when the external air temperature is so high or so low that using the external air for ventilation would only cause the air conditioning system to run excessively. The ventilation is only able to run when this state is [OK](#).

The possible enclosure temperature states are:

[TOO\\_HOT](#) - The external air temperature is above the too high setpoint (Ventilation not possible).

[OK](#) - The external air temperature is in the normal range.

[TOO\\_COLD](#) - The external air temperature is below the too low setpoint (Ventilation not possible).

[ERROR](#) - The external air temperature is in an indeterminate state.

# Functional States

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## External Air Relative Humidity State

The external relative humidity state is displayed in the [Public](#) data table field [ExtRhState](#). This state is used by the HVAC control system to control the ventilation fan and dehumidifier to manage the enclosure relative humidity within the range set in the [STATION\\_SETPOINTS](#) file and prevent the ventilation fan from running when the external air relative humidity is so high that using the external air for ventilation would only cause the air conditioning system to run excessively. The ventilation is only able to run when this state is [OK](#) or [BETTER](#).

The possible enclosure relative humidity states are:

[WORSE](#) - The external air relative humidity is worse (higher) than the enclosure air relative humidity.

[OK](#) - The external air relative humidity is in the normal range.

[BETTER](#) - The external air relative humidity is better (lower) than the enclosure air relative humidity.

[ERROR](#) - The external air relative humidity is in an indeterminate state.

## Ventilation Fan Switch State

The current ventilation fan switch state is displayed in the [Public](#) data table field [FanSwitch](#). The ventilation fan manual control switch determines whether the ventilation system is set to run automatically, continuously, or not at all.

The possible ventilation fan switch states are:

[MANUAL](#) - The ventilation is manually switched ON and will run continually.

[AUTO](#) - The ventilation fan is set to automatic control.

[OFF](#) - The ventilation fan is manually switched OFF and will not run.

## Ventilation Fan State

The ventilation fan state is displayed in the [Public](#) data table field [FanState](#). The ventilation system is designed to increase and decrease the enclosure temperature so that the enclosure temperature follows the diurnal external temperature variation within the enclosure setpoint limits.

The possible ventilation fan states are:

[RUN MANUAL](#) - The fan was started manually by staff and will run continually.

[RUN \(Timer\)](#) - The fan was started automatically by the timer.

[RUN WARMING](#) - The fan was started automatically to increase the enclosure temperature.

[RUN COOLING](#) - The fan was started automatically to decrease the enclosure temperature.

[IDLE](#) - The fan was stopped automatically.

[OFF](#) - The fan was stopped manually by staff and will not run.

# Functional States

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## Air Conditioning Switch State

The current air conditioning switch state is displayed in the [Public](#) data table field [AcSwitch](#). The A/C manual control switch determines whether the A/C system is set run automatically, continuously warming, continuously cooling, or to not run at all.

The possible ventilation fan switch states are:

[MANUAL HEAT](#) - The air conditioning is manually switched ON heating and will run continually.

[MANUAL COOL](#) - The air conditioning is manually switched ON cooling and will run continually.

[AUTO](#) - The air conditioning is set to automatic control.

[OFF](#) - The air conditioning is manually switched OFF and will not run.

## Air Conditioning State

The air conditioning (A/C) state is displayed in the [Public](#) data table field [AcState](#). The A/C system is designed to increase the enclosure temperature whenever the enclosure temperature is below the low setpoint and to decrease the enclosure temperature whenever the enclosure temperature is above the high setpoint to keep the enclosure temperature within the band set in the [STATION\\_SETPOINTS](#) file during times when the external air is unsuitable for controlling the enclosure temperature using the ventilation fan on its own.

The possible A/C states are:

[RUN MANUAL HEAT](#) - The air conditioning was started manually by staff and will heat continually.

[RUN MANUAL COOL](#) - The air conditioning was started manually by staff and will cool continually.

[RUN WARMING](#) - The fan was started automatically to increase the enclosure temperature.

[RUN COOLING](#) - The fan was started automatically to decrease the enclosure temperature.

[IDLE](#) - The air conditioning was stopped automatically.

[OFF](#) - The air conditioning was stopped manually by staff and will not run.

## Dehumidifier Switch State

The current dehumidifier switch state is displayed in the [Public](#) data table field [DhuSwitch](#). The dehumidifier manual control switch determines whether the dehumidifier system is set to run automatically, continuously, or not at all.

The possible dehumidifier switch states are:

[MANUAL](#) - The dehumidifier is manually switched ON and will run continually.

[AUTO](#) - The dehumidifier is set to automatic control.

[OFF](#) - The dehumidifier is manually switched OFF and will not run.

# Functional States

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## Dehumidifier State

The dehumidifier state is displayed in the [Public](#) data table field [DhuState](#). The dehumidifier system is designed to reduce the enclosure relative humidity to prevent it rising too high.

The possible dehumidifier states are:

[RUN MANUAL](#) - The dehumidifier was started manually by staff and will run continually.

[RUN](#) - The dehumidifier was started automatically to reduce the enclosure relative humidity.

[IDLE](#) - The dehumidifier was stopped automatically.

[OFF](#) - The dehumidifier was stopped manually by staff and will not run.

## Lighting Switch State

The current lighting switch state is displayed in the [Public](#) data table field [LxSwitch](#). The lighting manual control switch determines whether the lighting system is set run automatically, continuously on LX1, continuously on LX2, or to not run at all.

The possible lighting switch states are:

[MANUAL LX2](#) - The lighting is manually switched to LX2 ON and will run continually.

[MANUAL LX1](#) - The lighting is manually switched to LX1 ON and will run continually.

[AUTO](#) - The lighting is set to automatic control.

[OFF](#) - The lighting is manually switched OFF and will not run.

## Lighting Mode State

The current lighting mode is displayed in the [Public](#) data table field [LxMode](#). The lighting mode determines how the two lighting circuits operate during the different phases of the lighting cycle and is determined by the position of two slide switches on the lower edge of the control panel. For details on the switch settings and their effect please refer to the sections "Manual Control Panel" and "Automated Control - Lighting".

The possible lighting modes are:

[DIURNAL STEPPED](#) - Lighting option switches set to Stepped mode.

[DIURNAL BUILD](#) - Lighting option switches set to Build mode.

[DIURNAL](#) - Lighting option switches set to Diurnal mode.

[NOCTURNAL](#) - Lighting option switches set to Nocturnal mode.



# Functional States

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## Lighting States

The lighting state is displayed in the [Public](#) data table field `LxState`. The lighting system is designed to enable keepers to set a range of lighting regimes to best suit the animals housed in the room. The lighting states will vary depending upon the option switch settings and the time of day.

The possible lighting states are:

[DAY](#) - LX switched to AUTO, in Day state, Diurnal, Diurnal Build or Stepped mode, LX1 is ON.

[DAY \(Step Sup\)](#) - LX switched to AUTO, in Day Stepped state, Diurnal Stepped mode, LX2 is ON.

[DAY \(Build Sup\)](#) - LX switched to AUTO, in Day Build state, Diurnal Build mode, LX1 and LX2 ON.

[NIGHT](#) - LX switched to AUTO, in Night state, Diurnal mode, LX2 is ON.

[NIGHT \(Off\)](#) - LX switched to AUTO, in Night state, Diurnal Build or Stepped, LX1 and LX2 OFF.

[GROW LIGHTS](#) - LX switched to AUTO, in Day (grow lights) state, Nocturnal mode, LX1 is ON.

[MOONLIGHT](#) - LX switched to AUTO, in Moonlight state, Nocturnal mode, LX2 is ON.

[MANUAL LX1](#) - LX switched to LX1, LX1 is ON continuously.

[MANUAL LX2](#) - LX switched to LX2, LX2 is ON continuously.

[MANUAL LX1 \(Sup\)](#) - LX switched to LX1, in Diurnal Build mode, LX1+ LX2 are ON continuously.

[OFF](#) - The lighting is manually switched OFF and will not run.

## Enclosure Temperature and Relative Humidity Sensors State

The enclosure sensors state is displayed in the [Public](#) data table field `E01SensState`. A sensor failure alarm is triggered if the sensor state indicates that one or more of the the temperature and/or relative humidity sensors have failed.

The possible enclosure sensor states are:

[TC OK, RH OK](#) - Both temperature and RH sensors are OK.

[TC OK, RH1 FAIL](#) - Temperature sensors Ok, RH sensor failed at SDI-12 address 1.

[TC OK, RH2 FAIL](#) - Temperature sensors Ok, RH sensor failed at SDI-12 address 2.

[TC OK, RH FAIL](#) - Temperature sensors both OK, RH sensors both failed.

[TC1 FAIL, RH OK](#) - Temperature sensor failed at SDI-12 address 1, RH sensors OK.

[TC2 FAIL, RH OK](#) - Temperature sensor failed at SDI-12 address 2, RH sensors OK.

[TC FAIL, RH OK](#) - Temperature sensors both failed, RH sensors both OK.

[TC1 FAIL, RH1 FAIL](#) - Temperature sensor and RH sensor both failed at SDI-12 address 1.

[TC2 FAIL, RH2 FAIL](#) - Temperature sensor and RH sensor both failed at SDI-12 address 2.

[TC FAIL, RH FAIL](#) - Both temperature and RH sensors have failed.

# Functional States

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## External Temperature and Relative Humidity Sensor State (Optional)

The external sensor state is displayed in the [Public](#) data table field [ExtSensState](#). This state switch is only displayed if the optional external temperature and relative humidity sensor is installed on the local station. An external sensor can be installed to measure the external air temperature and relative humidity and make these measurements available to the datalogger network. A sensor failure alarm is triggered if the sensor state indicates that the temperature sensor, the relative humidity sensor, or both have failed.

The possible external sensor states are:

[TC OK, RH OK](#) - The temperature and relative humidity sensors are both ok.

[TC OK, RH FAIL](#) - The temperature sensor is ok and the relative humidity sensor has failed.

[TC FAIL, RH OK](#) - The temperature sensor has failed and the relative humidity sensor is ok.

[TC FAIL, RH FAIL](#) - The temperature sensor and the relative humidity sensor have both failed.

## Barometric Pressure Sensor State (Optional)

The barometric pressure sensor state is displayed in the [Public](#) data table field [BaroSensState](#). This state switch is only displayed if the optional barometric pressure sensor is installed, either on the local station or a remote station, and the station constant [BARO\\_ENAB](#) is set to True. A barometric pressure sensor failure alarm is triggered if the sensor state indicates that the sensor has failed.

The current QM (Quality Metric) value is reported in the [BaroSensState](#) variable to provide a visible indication of the current calibration accuracy of the barometric pressure sensor card. 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 sensor card.

The possible barometric pressure sensor states are:

[OK \(QM n.nn\)](#) - The barometric pressure sensor is working normally.

[RECALIBRATE SOON](#) - The sensor will need recalibrating in two to three months.

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

## Power State

The mains power state is displayed in the [Public](#) data table field [PowerState](#). 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.

# Functional States

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## Alarm State

The alarm state is displayed in the [Public](#) data table field [AlarmState](#). The alarm system is designed record all alarm events into an Event Log data table so users can check on 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 fields. 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.

# Functional States

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# Automated Control - Ventilation Fan

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## Automated Control - Ventilation Fan

This section provides information about how the datalogger program functions when the ventilation fan is set to AUTO on the control switch panel.

When the ventilation fan switch is set to AUTO, the datalogger program controls the ventilation fan to provide effective ventilation of the enclosure whilst maintaining the enclosure air temperature as close to the natural diurnal variation as possible but within the user defined, seasonal, temperature range. The ventilation fan is the primary means of controlling the enclosure temperature, the air conditioning takes over during adverse external conditions.

### Fan Control Setpoints

A pair of user defined temperature setpoints, one pair for each month of the year, is automatically selected by the datalogger program based on the datalogger's realtime clock/calendar as the months change. The current month and its setpoints are displayed in the [Month](#), [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) fields in the [Public](#) data table. These setpoints are used by the ventilation and air conditioning systems to determine the desired temperature operating range in the enclosure.

The user defined [SET\\_TOO\\_HOT](#) and [SET\\_TOO\\_COLD](#) temperature setpoints, along with the [SET\\_RH\\_HI](#) and [SET\\_RH\\_DAY](#) relative humidity setpoints, determine when the external air is too hot, too cold, or too humid, respectively, to be used for ventilating the enclosure. Ventilation with unsuitable external air results in unnecessarily increasing the air conditioner run time, which would also increase energy and maintenance costs.

The enclosure temperature setpoints must be within the range determined by the [SET\\_TOO\\_HOT](#) and [SET\\_TOO\\_COLD](#) setpoints, and there must always be at least 4 degrees difference between the high and low temperature setpoint values for each month.

Please refer to the section "Setpoints Table" for more information about setpoints and manual overrides.

The setpoints are stored in the [STATION\\_SETPOINTS](#) file and default setpoints are provided that are suitable for many applications. Any changes desired can either be entered into the program before it is sent to the datalogger, or they can be changed at any time by editing the [Setpoints](#) data Table.

### Control Principles

The ventilation fan control algorithm tracks the difference between the enclosure air temperature and the external air temperature, then starts and stops the ventilation fan as needed to try to keep the enclosure temperature as close as possible to the external temperature within the range defined by the [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) monthly setpoints.

#### Fan Start Conditions

The following conditions must be met for the ventilation fan to start running::

- The fan debounce timer is not active, and

- The fan is not running on the cycle timer, or set to fixed cycle timer only and

- The temperature sensors have been read and returned valid measurements, and

- The external air temperature [ExtTcState](#) and relative humidity [ExtRhState](#) are within limits, and

- The A/C is running to reduce the enclosure temp and the external temp is [AC\\_OFFSET](#) degrees lower, or

- The A/C is running to increase the enclosure temp and the external temp is [AC\\_OFFSET](#) degrees higher, or

- The A/C is idle and the enclosure temp is lower than the external temp, or.

- The A/C is idle and the enclosure temp is higher than the external temp.

## Automated Control - Ventilation Fan

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If the above conditions are satisfied then:

If the external air is warmer than than the enclosure air the **FanState** is set to "RUN WARMING", or

If the external air is cooler than than the enclosure air the **FanState** is set to "RUN COOLING".

### Fan Stop Conditions

When the ventilation fan is running, it will be stopped whenever the following conditions are met:

The fan debounce timer is not active, and

The fan cycle timer is not active, and

The enclosure and external temperatures are within station constant **TC\_HYST** of each other, or

The fan is increasing the enclosure temperature and the setpoint **SetPointTC\_HI** is reached, or

The fan is reducing the enclosure temperature and the setpoint **SetPointTC\_LO** is reached, or

The external air temperature limit station constant **SET\_TOO\_HOT** or **SET\_TOO\_COLD** is reached, or

The enclosure air relative humidity station constant **SET\_RH\_HI** is reached, or

The A/C is running cooling and the external temp is NOT **AC\_OFFSET** degrees lower, or

The A/C is running warming and the external temp is NOT **AC\_OFFSET** degrees higher, or

The A/C is set to run on manual.

If the above conditions are satisfied the ventilation fan is stopped by setting the **FanState** to "IDLE".

It is anticipated that the enclosure air temperature is unlikely to achieve an exact match with the external air temperature so the hysteresis constant **TC\_HYST** is used to ensure the ventilation fan stops more reliably.

### When External Temperature is Increasing

Provided that all the base conditions, **ExtTcState**, **ExtRhState**, **AcState**, **SetPointTC\_HI**, and timers are satisfied and the external air is warmer than the enclosure air, the ventilation fan will run to transfer warmer external air into the enclosure to increase the temperature of the enclosure air.

For example:

If the enclosure air temperature **E01AirTC** is 18 degrees, and the external air temperature is 19 degrees, the ventilation fan will be started by setting **FanState** to "RUN WARMING" until either the difference in temperature between the enclosure and external air temperatures becomes less than **TC\_HYST** (typically 0.5 degrees), or the enclosure air temperature reaches **SetPointTC\_HI**, at which time the ventilation fan is stopped by setting **FanState** to "IDLE".

### When External Temperature is Decreasing

Provided that all the base conditions, **ExtTcState**, **ExtRhState**, **AcState**, **SetPointTC\_LO**, and timers are satisfied and the external air is cooler than the enclosure air, the ventilation fan will run to transfer cooler external air into the enclosure to reduce the temperature of the enclosure air.

For example:

If the enclosure air temperature **E01AirTC** is 18 degrees, and the external air temperature is 17 degrees, the ventilation fan will be started by setting **FanState** to "RUN COOLING" until either the difference in temperature between the enclosure and external air temperatures becomes less than **TC\_HYST** (typically 0.5 degrees), or the enclosure air temperature reaches **SetPointTC\_LO**, at which time the ventilation fan is stopped by setting **FanState** to "IDLE".

# Automated Control - Ventilation Fan

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## Fan Debounce Timer

The debounce timer prevents rapid ON/OFF cycling of the ventilation fan control relay in order to prevent possible damage to equipment. Rapid cycling is when the control relay is energised or deenergised for a few seconds before being returned to its previous state, perhaps even in a repeating cycle. It can have numerous causes but typically results from a problem with a sensor or an unforeseen set of conditions being acted upon by the control program.

The debounce timer is set to 60 seconds every time the ventilation fan state [FanState](#) changes. The timer then prevents any more state changes from occurring, and therefore the ventilation fan cannot start, or stop, until the timer returns to zero. The debounce time is determined by the [DEBOUNCE](#) constant set in the program and should not be changed by users.

The manual switch is not affected by the debounce timer as it overrides the automated controls.

## Fan Cycle Timer

It is important to maintain a base level of ventilation during any extended periods of time where the normal fan start conditions cannot be satisfied, as may happen on very hot summer days or very cold winter days, when the temperature and/or relative humidity of the external air makes it unsuitable for ventilation. During these periods of time, the air conditioning operates to maintain the enclosure air temperature within the range determined by the setpoints [SetPointTC\\_HI](#) and [SetPoint\\_TC\\_LO](#) and the ventilation fan state [FanState](#) remains set to [IDLE](#). Excessive fan IDLE times can also occur on days when the weather is such that the enclosure and external temperatures happen to hold quite constant somewhere within the desired enclosure temperature range so there is insufficient temperature change to trigger the ventilation fan to run, and the air conditioning also doesn't need to run.

The fan cycle timer monitors the length of time that the [FanState](#) is set to [IDLE](#) when the ventilation fan is under automatic control. If the [IDLE](#) time exceeds the station constant [FAN\\_IDLE\\_LIMIT](#) (typically 3 or 4 hours), the ventilation fan is automatically started by setting the [FanState](#) to [RUN \(Timer\)](#) which forces the fan to run for thirty minutes after which it returns to [IDLE](#) again. The [RUN \(Timer\)](#) state overrides all other automatic ventilation fan control parameters to ensure the base level of ventilation is maintained.

**NOTE:** Having the timer force the ventilation fan to run while the air conditioning is running, or while the external air is in a state that's likely to cause the air conditioning to run if that air is brought into the enclosure, does reduce energy efficiency a little but it's a necessary compromise to ensure stale air does not build up in the enclosure and possibly adversely affect animal welfare.

The datalogger program also can be configured in the station constants to run the ventilation fan in a fixed timer controlled mode for enclosures where full-time air conditioning is used to maintain the enclosure air temperature at a constant temperature.

## Output Module SDM-CD8S - Ventilation Fan Relay Port

The ventilation fan state ([FanState](#)) controls the setting of the SDM-CD8S control bit 1, which corresponds to output port 1.

A 12 Vdc relay in the switchboard is connected to SDM-CD8S output port 1 so that the relay is energised, which closes the relay contacts, when output port 1 is ON. The relay contacts switch the 230 Vac control circuit for the ventilation fan contactor, which in turn switches the 230Vac mains to the ventilation fan motor ON and OFF to start and stop the ventilation fan.

# Automated Control - Ventilation Fan

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## Ventilation Fan Run Counters

The datalogger program has two counters operating in the background that monitor the amount of time the ventilation fan runs. Both counters accumulate the number of seconds the equipment is running.

The hourly counter is logged every hour on the hour then reset.

The daily counter is logged every day at midnight then reset.

Both counters are logged in minutes, so 15 minutes and 30 seconds would be logged as 15.5 minutes.

These data are logged in the [E00\\_HVAC\\_60M](#) data table [FanHrRunMins](#) field for the hourly counters and the [E00\\_HVAC\\_DAY](#) data table [FanDayRunMins](#) field for the daily counters.

Each data table contains the counters for the ventilation fan, the air conditioning, and the dehumidifier to enable easy analysis of the interaction between the three components of the HVAC system. The downloaded data file can be graphed using the View Pro utility in the Campbell LoggerNet software or it can be imported into a spreadsheet for further analysis.

## Ventilation Fan Switch State

The current ventilation fan switch state is displayed in the [Public](#) data table field [FanSwitch](#). The ventilation fan manual control switch determines whether the ventilation system is set to run automatically, continuously, or not at all.

The possible ventilation fan switch states are:

[MANUAL](#) - The ventilation is manually switched ON and will run continually.

[AUTO](#) - The ventilation fan is set to automatic control.

[OFF](#) - The ventilation fan is manually switched OFF and will not run.

## Ventilation Fan State

The ventilation fan state is displayed in the [Public](#) data table field [FanState](#). The ventilation system is designed to increase and decrease the enclosure temperature so that the enclosure temperature follows the diurnal external temperature variation within the enclosure setpoint limits.

The possible ventilation fan states are:

[RUN MANUAL](#) - The fan was started manually by staff and will run continually.

[RUN \(Timer\)](#) - The fan was started automatically by the timer.

[RUN WARMING](#) - The fan was started automatically to increase the enclosure temperature.

[RUN COOLING](#) - The fan was started automatically to decrease the enclosure temperature.

[IDLE](#) - The fan was stopped automatically.

[OFF](#) - The fan was stopped manually by staff and will not run.



# Automated Control - Air Conditioning

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## Automated Control - Air Conditioning

This section provides information about how the datalogger program functions when the air conditioning is set to [AUTO](#) on the manual control panel.

When the air conditioning switch is set to [AUTO](#), the datalogger program controls the air conditioning system so that it warms or cools the enclosure air whenever the enclosure air temperature cannot be maintained within the user defined temperature range by the ventilation system alone.

### Air Conditioning Control Setpoints

A pair of user defined temperature setpoints, one pair for each month of the year, is automatically selected by the datalogger program based on the datalogger's realtime clock/calendar as the months change. The current month and its setpoints are displayed in the [Month](#), [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) fields in the [Public](#) data table. These setpoints are used by the ventilation and air conditioning systems to determine the desired temperature operating range in the enclosure.

The air conditioning control algorithm only uses the enclosure air temperature setpoints. It doesn't need the enclosure or external relative humidity values, or the external air temperature setpoints that are used by the ventilation fan control algorithm.

Please refer to the section "Station Setpoints" for more information about setpoints and manual overrides.

The setpoints are stored in the [STATION\\_SETPOINTS](#) file and default setpoints are provided that are suitable for many applications. Any changes desired can either be entered into the program before it is sent to the datalogger, or they can be changed at any time by editing the [Setpoints](#) data Table.

### Control Principles

The software is designed to emulate a traditional thermostat. The air conditioning control algorithm uses the [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) setpoints as thermostat settings and switches the air conditioning to warm or cool the air as needed depending upon which setpoint the enclosure temperature has crossed.

The hysteresis of the thermostat is determined by the [TC\\_HYST](#) station constant (typically 0.5 degrees) and is the temperature change in degrees above and below the thermostat setting at which the thermostat is required to change the air conditioners state between run and stop.

#### Air Conditioning Start Conditions

The air conditioning will start when the following conditions are met:

- The air conditioning debounce timer is not active, and
- The temperature sensors have been read and returned valid measurements, and
- The enclosure air temperature is higher than [SetPointTC\\_HI](#) plus [TC\\_HYST](#), and
- The enclosure air temperature is higher than station constant [LOWEST\\_AC +1](#), or
- The enclosure air temperature is lower than [SetPointTC\\_LO](#) minus [TC\\_HYST](#).

#### Air Conditioning Stop Conditions

The air conditioning will stop when the following conditions are met:

- The air conditioning debounce timer is not active, and
- The enclosure air temperature is lower than [SetPointTC\\_HI](#) minus [TC\\_HYST](#), and
- The enclosure air temperature is higher than [SetPointTC\\_LO](#) plus [TC\\_HYST](#).

# Automated Control - Air Conditioning

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## Upper Temperature Control

When the enclosure air temperature is being held at the upper limit of the user determined range by the air conditioning system, the setpoint `SetPointTC_HI` becomes the active “thermostat” setting.

When the enclosure air increases to a temperature that is `TC_HYST` higher than `SetPointTC_HI` and the enclosure air temperature is higher than station constant `LOWEST_AC + 1`, the air conditioning is started by setting `AcState` to “RUN COOLING”. The air conditioning continues to run until the enclosure air reduces to a temperature that is `TC_HYST` lower than `SetPointTC_HI` at which time the air conditioning is stopped by setting `AcState` to “IDLE”.

For example:

If `SetPointTC_HI` is 20 degrees C and `TC_HYST` is 0.5 degrees C

The air conditioning will start in cooling mode at 20.5 degrees C and stop at 19.5 degrees C.

**NOTE:** Heat pump air conditioners have a minimum cooling temperature, typically about 16 degrees Celsius, that they can be set to cool down to. This is entered into the station constant `LOWEST_AC` during installation. If the enclosure high setpoint `SetPointTC_HI` is below that minimum temperature, the air conditioner will not be started until the enclosure air temperature increases to `LOWEST_AC + 1` degrees or higher to prevent the system issuing commands to the air conditioner that may conflict with its built-in control and safety systems and cause unpredictable results.

## Lower Temperature Control

When the enclosure air temperature is being held at the lower limit of the user determined range by the air conditioning system, the setpoint `SetPointTC_LO` becomes the active “thermostat” setting.

When the enclosure air decreases to a temperature that is `TC_HYST` lower than `SetPointTC_LO` the air conditioning is started by setting `AcState` to `RUN WARMING`. The air conditioning continues to run until the enclosure air increases to a temperature that is `TC_HYST` higher than `SetPointTC_LO` at which time the air conditioning is stopped by setting `AcState` to `IDLE`.

For example:

If `SetPointTC_LO` is 10 degrees C and `TC_HYST` is 0.5 degrees C

The air conditioning will start in warming mode at 9.5 degrees C and stop at 10.5 degrees C.

## Air Conditioning Debounce Timer

The debounce timer prevents rapid ON/OFF cycling of the air conditioner control relay in order to prevent possible damage to equipment. Rapid cycling is when the control relay is energised or deenergised for a few seconds before being returned to its previous state, perhaps even in a repeating cycle. It can have numerous causes but typically results from a problem with a sensor or an unforeseen set of conditions being acted upon by the control program.

The debounce timer is set to 60 seconds every time the air conditioner state `AcState` changes. The timer then prevents any more state changes from occurring, and therefore the air conditioner cannot start, or stop, until the timer returns to zero. The debounce time is determined by the `DEBOUNCE` constant set in the program and should not be changed by users.

The manual switch is not affected by the debounce timer as it overrides the automated controls.

# Automated Control - Air Conditioning

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## Output Module SDM-CD8S - Air Conditioning Relay Ports

The air conditioning state ([AcState](#)) controls the setting of the SDM-CD8S control bits 2 and 3, which correspond to output ports 2 and 3.

A 12 Vdc relay in the switchboard is connected to SDM-CD8S output port 2 and another relay is connected to output port 3. In both cases the relay is energised, which closes the relay contacts, when the port is ON. The contacts of both relays are wired to the air conditioning system's electronic control interface board.

The relay on port 2 starts and stops the air conditioning. When the contacts are closed the air conditioning runs. When the contacts are open the air conditioning stops.

The relay on port 3 selects the air conditioning mode. When the contacts are closed the air conditioning runs in heating mode. When the relay contacts are open the air conditioner runs in cooling mode.

A bespoke air conditioning system designed and built for the specific needs of the enclosure can be very effectively controlled by the the datalogger program to achieve whatever climate conditions are needed by the animals the enclosure is designed to house. Off-the-shelf heat pump systems can also be effectively controlled over a wide temperature range that is suitable for many enclosure applications but differences in equipment design technologies used by various manufacturers will determine the extent of control possible so selection of the most appropriate heat pump model for any given enclosure design is necessary.

## Air Conditioning Run Counters

The datalogger program has two counters operating in the background that monitor the amount of time the air conditioning system runs. Both counters accumulate the number of seconds the equipment is running.

The hourly counter is logged every hour on the hour then reset.

The daily counter is logged every day at midnight then reset.

Both counters are logged in minutes, so 15 minutes and 30 seconds would be logged as 15.5 minutes.

These data are logged in the [E00\\_HVAC\\_60M](#) data table [AcHrRunMins](#) field for the hourly counters and the [E00\\_HVAC\\_DAY](#) data table [AcDayRunMins](#) field for the daily counters.

Each data table contains the counter values for the ventilation fan, the air conditioning, and the dehumidifier to enable easy analysis of the interaction between the three components of the HVAC system. The downloaded data file can be graphed using the View Pro utility in the Campbell LoggerNet software or it can be imported into a spreadsheet for further analysis.

## Air Conditioning Switch State

The current air conditioning switch state is displayed in the [Public](#) data table field [AcSwitch](#). The A/C manual control switch determines whether the A/C system is set run automatically, continuously warming, continuously cooling, or to not run at all.

The possible ventilation fan switch states are:

[MANUAL HEAT](#) - The air conditioning is manually switched ON heating and will run continually.

[MANUAL COOL](#) - The air conditioning is manually switched ON cooling and will run continually.

[AUTO](#) - The air conditioning is set to automatic control.

[OFF](#) - The air conditioning is manually switched OFF and will not run.

## Automated Control - Air Conditioning

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### Air Conditioning State

The datalogger program displays the current air conditioning system state [AcState](#) in the [Public](#) data table so users can easily check on the air conditioning operation.

The possible air conditioning states are:

[RUN MANUAL HEAT](#) - The air conditioning was started manually by staff and will heat continually.

[RUN MANUAL COOL](#) - The air conditioning was started manually by staff and will cool continually.

[RUN WARMING](#) - The fan was started automatically to increase the enclosure temperature.

[RUN COOLING](#) - The fan was started automatically to decrease the enclosure temperature.

[IDLE](#) - The air conditioning was stopped automatically.

[OFF](#) - The air conditioning was stopped manually by staff and will not run.

# Automated Control - Dehumidifier

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## Automated Control - Dehumidifier

This section provides information about how the datalogger program functions when the dehumidifier is set to AUTO on the manual control panel.

When the dehumidifier switch is set to AUTO, the datalogger program controls the dehumidifier to reduce the relative humidity in the enclosure when it becomes higher than the user defined setpoint.

**IMPORTANT:** Only dehumidifier models that “remember” their settings when power is switched off and restart with those same settings when the power is switched back on can be used with this control system.

### Dehumidifier Control Setpoints

The constant [SET\\_RH\\_HI](#) determines the highest humidity level that is desired in the enclosure during the night and is also used to stop the ventilation fan if the enclosure relative humidity is already high and continuing to ventilate the enclosure with humid external air will only make the enclosure relative humidity worse.

The constant [SET\\_RH\\_DAY](#) determines the highest humidity level that is desired in the enclosure during the day.

The constant [SET\\_RH\\_LO](#) is the low RH setpoint and is used for humidity state display purposes only.

The program selects the day [SET\\_RH\\_DAY](#) setpoint or the night [SET\\_RH\\_HI](#) setpoint at a time based on the datalogger’s realtime clock and whether the datalogger program is set to operate in nocturnal or diurnal mode. The selected setpoints are used to control the dehumidifier, and to determine the enclosure relative humidity state which is displayed in the Public data table [E00RhState](#) field.

### Control Principles

Control of the dehumidifier is a simple run or stop decision based on the current relative humidity measurement in the enclosure. The selected day or night setpoint, [SET\\_RH\\_HI](#) or [SET\\_RH\\_DAY](#) respectively, is used as the high RH setpoint for dehumidifier control purposes.

#### Dehumidifier Start Conditions

The dehumidifier will start when the following conditions are met:

- The dehumidifier debounce timer is not active, and
- The enclosure relative humidity is greater than the selected high RH setpoint.

#### Dehumidifier Stop Conditions

The dehumidifier will stop when the following conditions are met:

- The dehumidifier debounce timer is not active, and
- The enclosure relative humidity is 2% lower than the selected high RH setpoint.

#### Dehumidifier Debounce Timer

The debounce timer prevents rapid ON/OFF cycling of the dehumidifier control relay in order to prevent possible damage to equipment. Rapid cycling is when the control relay is energised for a few seconds, then de-energised for a few seconds, in a repeating cycle. It can have numerous causes but typically results from a problem with a sensor or an unforeseen set of conditions being acted upon by the control program.

The debounce timer is set to 60 seconds every time the dehumidifier state [DhuState](#) changes. The timer then prevents any more state changes from occurring, and therefore the dehumidifier cannot start, or stop, until

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## Automated Control - Dehumidifier

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the timer returns to zero. The debounce time is determined by the [DEBOUNCE](#) constant set in the datalogger program and should not be changed by users.

The manual switch is not affected by the debounce timer as it overrides the automated controls.

### Output Module SDM-CD8S - Dehumidifier Port

The dehumidifier state ([DhuState](#)) controls the setting of the SDM-CD8S control bit 4, which corresponds to output port 4.

A 12 V dc relay in the switchboard is connected to SDM-CD8S output port 4 so that the relay is energised, which closes the relay contacts, when the port is ON. The relay contacts switch the 230 V ac control circuit for the dehumidifier contactor, which in turn switches the 230V ac mains to the dehumidifier ON and OFF.

### Dehumidifier Run Counters

The datalogger program has two counters operating in the background to monitor the amount of time the dehumidifier runs. Both counters accumulate the number of seconds the equipment is running.

The hourly counter is logged every hour on the hour then reset, and the daily counter is logged every day at midnight then reset. Both counters are logged in minutes, so 15 minutes and 30 seconds would be logged as 15.5 minutes.

These data are logged in the [E00\\_HVAC\\_60M](#) data table [DhuHrRunMins](#) field for the hourly counters and the [E00\\_HVAC\\_DAY](#) data table [DhuDayRunMins](#) field for the daily counters.

Each data table contains the counters for the ventilation fan, the air conditioning, and the dehumidifier to enable easy analysis of the interaction between the three aspects of the HVAC system. The downloaded data file can be graphed using the View Pro utility in the Campbell LoggerNet software or it can be imported into a spreadsheet for further analysis.

### Dehumidifier Switch State

The current dehumidifier switch state is displayed in the [Public](#) data table field [DhuSwitch](#). The dehumidifier manual control switch determines whether the dehumidifier system is set to run automatically, continuously, or not at all.

The possible dehumidifier switch states are:

[MANUAL](#) - The dehumidifier is manually switched ON and will run continually.

[AUTO](#) - The dehumidifier is set to automatic control.

[OFF](#) - The dehumidifier is manually switched OFF and will not run.

### Dehumidifier State

The dehumidifier state is displayed in the [Public](#) data table field [DhuState](#). The dehumidifier system is designed to reduce the enclosure relative humidity to prevent it rising too high.

The possible dehumidifier states are:

[RUN MANUAL](#) - The dehumidifier was started manually by staff and will run continually.

[RUN](#) - The dehumidifier was started automatically to reduce the enclosure relative humidity.

[IDLE](#) - The dehumidifier was stopped automatically.

[OFF](#) - The dehumidifier was stopped manually by staff and will not run.

## Automated Control - Lighting

This section provides information about how the datalogger program functions when the lighting is set to AUTO on the manual control panel.

When set to AUTO, the datalogger program controls the lighting cycle with timing that closely approximates the natural lighting cycle, including seasonal variation.

### Control Principles

The lighting control system automatically switches two electrical circuits, named LX1 and LX2, using relays to select the enclosure lighting scenes. The control timing is based on the day of the year, the time of the day, and the site latitude. The datalogger's realtime clock provides the day of year and time of day references. The station constant [LATITUDE](#) provides the geographical latitude value for the day length calculations. A pair of option switches enables users to select the desired lighting mode for the enclosure to suit whatever animals are housed in the enclosure from time to time.

### Calculation of Day and Night Length

Calculation of the day length is done using the CBM model published by the Centre for Biosystems Modelling, Department of Industrial Engineering, Texas A & M University, College Station, Texas, USA.

The day length is determined using the following equation:

$L = \text{Latitude}$

$J = \text{Day of Year}$

$P = \text{asin}[0.39795 \times \cos(0.2163108 + 2 \times \text{atan}\{0.9671396 \times \tan[0.00860 \times (J - 186)]\})]$

$$\text{DayLength} = 1440 - (1440 \div \pi) \times \text{acos}\left(\frac{\sin(0.8333 \times \pi \div 180) + \sin(L \times \pi \div 180) \times \sin(P)}{\cos(L \times \pi \div 180) \times \cos(P)}\right)$$

The night length is determined using the following equation:

$$\text{NightLengthMinutes} = 1440 - \text{DayLengthMinutes}$$

The current day and night lengths are calculated in minutes for programming purposes, and are used to calculate the trigger times that change the lighting state.

### Calculation of Lighting State Change Triggers

For programming purposes, the trigger times are calculated and stored in the datalogger as the number of minutes after midnight at which the trigger is to occur, and are then formatted as hours and minutes (HH:MM) for display in the [Public](#) data table fields [TimeSunrise](#), [TimeSupOn](#), [TimeSupOff](#), and [TimeSunset](#). Each trigger time remains active until the next trigger time becomes active so if the datalogger is restarted the lighting will always start immediately in the correct part of the lighting cycle.

The lighting state change trigger times are calculated slightly differently for the nocturnal and diurnal operating modes so the required mode for the exhibit aligns with public visiting hours.

# Automated Control - Lighting

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## Diurnal Modes

In the Diurnal mode the lighting cycle is calculated with the enclosure daytime linked to the reference time that is set by station constant `SET_REF_TIME_MINS`, which is the latest time (minutes after midnight) by which the enclosure must be in the sunlight lighting scene ready for visitors. The `SET_REF_TIME_MINS` time must be set to a time shortly before the exhibit opens for visitor viewing. The default is 480 minutes (08:00 am). The actual time the lighting begins the transition from the moonlight scene to the sunlight scene will vary depending upon the calculated amount of seasonal variation for the current day, and the fade time setting `FADE_TIME_MINS` of the dimming system.

The station constant `MIN_EXHIBIT_MINS` limits how short the sunlight scene can become in winter, thus limiting the total amount of seasonal variation to extend the length of the shortest days. This is done to prevent the diurnal exhibit's sunlight scene becoming shorter than public visiting hours.

The seasonal variation offset for the current day is calculated using the following formula:

$$\textit{SeasonalOffsetMins} = (\textit{DayLengthMins} - \textit{MIN\_EXHIBIT\_MINS}) \times \textit{REF\_VARIATION}$$

The diurnal trigger times are calculated using the following equation:

$$\textit{TrigMinsDay} = (\textit{REF\_TIME\_MINS} - \textit{FADE\_TIME\_MINS}) - \textit{SeasonalOffsetMins}$$

$$\textit{TrigMinsNight} = \textit{TrigMinsDay} + \textit{DayLengthMins}$$

## Nocturnal Mode

In the Nocturnal mode the lighting cycle is calculated with the enclosure nighttime linked to the reference time that is set by station constant `SET_REF_TIME_MINS`, which is the latest time (minutes after midnight) by which the enclosure must be in the moonlight lighting scene ready for visitors. The `SET_REF_TIME_MINS` time must be set to a time shortly before the exhibit opens for visitor viewing. The default is 480 minutes (08:00 am). The actual time the lighting begins the transition from the sunlight scene to the moonlight scene will vary depending upon the calculated amount of seasonal variation for the current day, and the fade time setting `FADE_TIME_MINS` of the dimming system.

The station constant `MIN_EXHIBIT_MINS` limits how short the duration of the moonlight scene can become in winter, thus limiting the total amount of seasonal variation to extend the length of the shortest days. This is done to prevent the nocturnal exhibit's moonlight scene becoming shorter than public visiting hours.

The seasonal variation offset for the current day is calculated using the following formula:

$$\textit{SeasonalOffsetMins} = (\textit{NightLengthMins} - \textit{MIN\_EXHIBIT\_MINS}) \times \textit{REF\_VARIATION}$$

The nocturnal trigger times are calculated using the following equation:

$$\textit{TrigMinsNight} = (\textit{REF\_TIME\_MINS} - \textit{FADE\_TIME\_MINS}) - \textit{SeasonalOffsetMins}$$

$$\textit{TrigMinsDay} = \textit{TrigMinsNight} + \textit{NightLengthMins}$$



## Automated Control - Lighting

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**NOTE:** The constant [REF\\_VARIATION](#) can be set to 0.0 which locks the start of the enclosure moonlight scene, in nocturnal mode, or the start of the enclosure sunlight scene in diurnal mode, to the reference time plus the fade time [FADE\\_TIME\\_MINS](#). This causes all the seasonal variation time to be added to the end of the exhibit lighting scene which is less natural, and therefore not our recommended practice, than setting [REF\\_VARIATION](#) to a value (default 0.25) which better approximates the natural diurnal cycle. This can be used to provide keepers with a fixed window of time at the beginning of each day, before the lighting transition ends, for enclosure maintenance to be carried out.

### Supplementary Lighting

The supplementary lighting is used for such things as reptile basking heat-lamps or UV lamps that may be necessary or desirable to cater to the needs of the animals housed in the enclosure. The supplementary lighting operates in the [DAY BUILD](#) and [DAY STEPPED](#) modes and always runs during the middle portion of the sunlight scene in the lighting cycle so that it is representative of the hottest/brightest part of natural daily sunlight.

The supplementary lighting trigger times are calculated using the following equation:

$$SupLengthMins = DayLengthMins \times (SUP\_PERCENT \div 100)$$

$$TrigMinsSupOn = TrigMinsDay + ((DayLengthMins - SupLengthMins) \div 2)$$

$$TrigMinsSupOff = TrigMinsSupOn + SupLengthMins$$

Lighting circuit LX1 is the primary lighting circuit and LX2 is the supplementary lighting circuit. In a reptile enclosure, LX1 would control the main reptile lights that run all day while LX2 would control the basking lights that only run during the middle portion of the day. This provides better emulation of natural sunlight to cater to the needs of the animals housed in the enclosure.

### Lighting State Change Triggers

Every two seconds the datalogger compares the current minutes after midnight with the triggers for the selected lighting mode to determine the active lighting state ([LxState](#)). The lighting states determine which output module ports, and therefore which lighting circuits are switched ON or OFF at each trigger time. Each trigger is active from the time shown in the [Public](#) data table field until the time of the next trigger. This ensures that the datalogger program will select the correct lighting state irrespective of when it is started.

The table below shows the relationship between the lighting triggers, states and circuits for the [NOCTURNAL](#) and [DIURNAL](#) modes:

Trigger Time	Diurnal Mode			Nocturnal Mode		
	LxState	LX1 RED	LX2 BLK	LxState	LX1 RED	LX2 BLK
TimeSunrise	DAY	ON	OFF	GROW LIGHTS	ON	OFF
TimeSupOn	n/a	n/a	n/a	n/a	n/a	n/a
TimeSupOff	n/a	n/a	n/a	n/a	n/a	n/a
TimeSunset	NIGHT	OFF	ON	MOONLIGHT	OFF	ON

## Automated Control - Lighting

The ability to utilise and automate supplementary lighting enables keepers to set up supplementary lighting equipment that is specific to the species living in the enclosure. A good example is basking lights that provide heat for reptiles. Another possibility is the addition of UV A/B lights when it's desirable to replicate the UV in sunlight that's not present in most grow light fixtures.

The table below shows the relationship between the lighting triggers, states and circuits for the **DIURNAL BUILD** and **DIURNAL STEPPED** modes:

Trigger Time	Day Stepped Mode			Day Build Mode		
	LxState	LX1 RED	LX2 BLK	LxState	LX1 RED	LX2 BLK
TimeSunrise	DAY	ON	OFF	DAY	ON	OFF
TimeSupOn	DAY (Step Sup)	OFF	ON	DAY (Build Sup)	ON	ON
TimeSupOff	DAY	ON	OFF	DAY	ON	OFF
TimeSunset	NIGHT (Off)	OFF	OFF	NIGHT (Off)	OFF	OFF

These two sunlight modes enable keepers the flexibility of using two sets of lights that can be configured in **DIURNAL BUILD** mode to run the sunlight scene all day and add in bright/hot basking lights in the middle of the day or, in **DIURNAL STEPPED** mode, to run reddish orange colours to represent the early morning and late afternoon sunlight and brighter white colours to represent full sunlight during the main portion of the day. This allows the enclosure to be configured for a variety of animal species that depend upon different aspects of sunlight for their natural biorhythms.

### Output Module SDM-CD8S - Lighting Relay Ports

The lighting state (**LxState**) controls the setting of the SDM-CD8S control bits 5 and 6, which correspond to output ports 5 and 6 respectively. A 12 Vdc relay in the switchboard is connected to SDM-CD8S output port 5 and another relay is connected to output port 6. Each relay is energised, which closes the relay contacts, when its respective output port is ON.

#### Non-Dim Systems

The relay contacts switch the 230 Vac control circuits for the LX1 and LX2 lighting circuit contactors, which in turn switch the 230 Vac mains to each lighting circuit ON and OFF.

Non-dim is the recommended configuration when the control of pluggable lighting loads is required as it can be used with all the programmed lighting modes without keepers needing to be concerned with whether or not the light sources they need to use are compatible with the control system, any type of light will work

#### Dimming Systems

The relay contacts switch the dimmer inputs so that when the relay is energised the dimmer is set to fade UP to full intensity where it remains until the relay is deenergised at which time the dimmer fades DOWN to off. Using one dimmer for the LX1 circuit and a second dimmer for the LX2 circuit can provide a crossfade between the two lighting circuits. The dimmers control the 230 Vac lighting circuits.

This configuration is only recommended when the lighting loads on LX1 and LX2 are permanently wired as not all lighting loads are suitable for dimming. Connecting a load that is incompatible with dimming systems will result in serious damage to either the load, the dimmers, or both, and create a potential fire hazard.

# Automated Control - Lighting

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## Lighting Switch State

The current lighting switch state is displayed in the [Public](#) data table field [LxSwitch](#). The lighting manual control switch determines whether the lighting system is set run automatically, continuously on LX1, continuously on LX2, or to not run at all.

The possible lighting switch states are:

[MANUAL LX2](#) - The lighting is manually switched to LX2 ON and will run continually.

[MANUAL LX1](#) - The lighting is manually switched to LX1 ON and will run continually.

[AUTO](#) - The lighting is set to automatic control.

[OFF](#) - The lighting is manually switched OFF and will not run.

## Lighting Mode

The datalogger program displays the current lighting mode [LxMode](#) in the [Public](#) data table so users can easily check on the lighting operation.

The possible modes are:

[DIURNAL STEPPED](#) - Lighting option switches set to Stepped mode.

[DIURNAL BUILD](#) - Lighting option switches set to Build mode.

[DIURNAL](#) - Lighting option switches set to Diurnal mode.

[NOCTURNAL](#) - Lighting option switches set to Nocturnal mode.

## Lighting State

The datalogger program displays the current lighting state [LxState](#) in the [Public](#) data table so users can easily check on the lighting operation.

The possible lighting states are:

[DAY](#) - LX switched to AUTO, in Day state, Diurnal, Diurnal Build or Stepped mode, LX1 is ON.

[DAY \(Step Sup\)](#) - LX switched to AUTO, in Day Stepped state, Diurnal Stepped mode, LX2 is ON.

[DAY \(Build Sup\)](#) - LX switched to AUTO, in Day Build state, Diurnal Build mode, LX1 and LX2 ON.

[NIGHT](#) - LX switched to AUTO, in Night state, Diurnal mode, LX2 is ON.

[NIGHT \(Off\)](#) - LX switched to AUTO, in Night state, Diurnal Build or Stepped, LX1 and LX2 OFF.

[GROW LIGHTS](#) - LX switched to AUTO, in Day (grow lights) state, Nocturnal mode, LX1 is ON.

[MOONLIGHT](#) - LX switched to AUTO, in Moonlight state, Nocturnal mode, LX2 is ON.

[MANUAL LX1](#) - LX switched to LX1, LX1 is ON continuously.

[MANUAL LX2](#) - LX switched to LX2, LX2 is ON continuously.

[MANUAL LX1 \(Sup\)](#) - LX switched to LX1, in Diurnal Build mode, LX1+ LX2 are ON continuously.

[OFF](#) - The lighting is manually switched OFF and will not run.

## Automated Control - Lighting

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### Daylight Savings Time Operation

The ZooCADA system keeps the realtime clock in all dataloggers on the network set to Standard Time so the logged data remains at the same times all year round. This prevents the anomalies in the data that occur if the datalogger clock is changed for daylight savings but creates a potential problem with "on-display" enclosures because the exhibit lighting will continue to operate with lighting state change triggers at standard time causing the lighting state changes to effectively become one hour late during daylight savings time.

For example, if a lighting change trigger is 08:00 standard time and the current daylight savings time is 08:00 the lighting change will not occur because the datalogger clock is actually at 07:00 Standard Time. The lighting change will occur at 09:00 Daylight Saving Time when the datalogger clock reaches 08:00 Standard Time.

To prevent this issue, daylight savings adjustments can be enabled by setting the station constant `ADJ_REF_DST` to `True` (the default setting) which sets the program to automatically adjust the lighting reference time for daylight savings.

During Daylight Saving Time, the station setpoint `SET_REF_TIME_MINS` does not change but the value used in the program is automatically adjusted to `SET_REF_TIME_MINS - 60` so the program triggers the lights one hour earlier. The program also adjusts the lighting change trigger times displayed in the `Public` data table by adding one hour and appending the suffix `DST` so users know the displayed time is Daylight Saving Time.

The result of these automatic daylight savings time adjustments is that the lighting changes occur at daylight savings time and the displayed lighting change trigger times are shown in daylight savings time, while the datalogger clock, `TimeStamp` displayed in the `Public` data table, and all data logging, continue to operate in Standard Time.

# Event Log

## Event Log

TOA5, OKH WL2 DL01, CR1000X, 27252, CR1000X.Std.05.01, CPU:OKH WL2 DL01 R05.CR1X, 7251, E00 EVENT LOG		
TIMESTAMP	RECORD	EventDetected
TS	RN	
		Smp
2023-10-3000:44:41	0	Datalogger Program Started
2023-10-3000:44:42	1	Fan Set to AUTO
2023-10-3000:44:42	2	A/C Set to AUTO
2023-10-3003:44:40	3	Fan RUN TIMER
2023-10-3004:14:40	4	Fan IDLE (Temp High Setpoint)
2023-10-3007:14:40	5	Fan RUN TIMER
2023-10-3007:44:40	6	Fan IDLE (Temp High Setpoint)
2023-10-3010:44:40	7	Fan RUN TIMER
2023-10-3011:14:40	8	Fan IDLE (Temp High Setpoint)
2023-10-3014:14:40	9	Fan RUN TIMER
2023-10-3014:44:40	10	Fan IDLE (Temp High Setpoint)
2023-10-3015:00:14	11	A/C Set to OFF
2023-10-3015:00:30	12	A/C Set to AUTO

The [EVENT\\_LOG](#) data table contains a descriptive indication of each event that occurs. This data table can hold up to 2000 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 fields 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-Lab program, and provides an explanation of their meaning.

### Ventilation Fan

[Fan IDLE \(Temp High Setpoint\)](#) - The enclosure is at the high setpoint, the ventilation fan is stopped.

[Fan IDLE \(Temp Low Setpoint\)](#) - The enclosure is at the high setpoint, the ventilation fan is stopped.

These events occur when the enclosure air temperature reaches either the high setpoint [SetPointTC\\_HI](#) or the low setpoint [SetPointTC\\_LO](#) during a normal run cycle of the ventilation fan, resulting in the ventilation fan being set to [IDLE](#). This event also occurs when the ventilation fan has been running under a timer start and the timer elapses while the enclosure air temperature is at a setpoint and may occur in repeated cycles.

## Event Log

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**Fan IDLE (Ext Temp Limit)** - The external air temperature has reached a limit, the ventilation fan is stopped.

This event occurs when the external air temperature reaches either the **SET\_TOO\_COLD** or **SET\_TOO\_HOT** constant while the ventilation fan is running, resulting in the ventilation fan being set to **IDLE**. These limits prevent the ventilation system drawing in external air under conditions where doing so would cause the air conditioner to run unnecessarily.

**Fan IDLE (Ext RH Limit)** - The external air humidity has reached the limit, the ventilation fan is stopped.

This event occurs when external air relative humidity reaches the **SET\_RH\_HI** constant while the ventilation fan is running, resulting in the ventilation fan being set to **IDLE**. This limit prevents the ventilation system drawing in external air under conditions where doing so would cause the air conditioner to run unnecessarily.

**Fan IDLE (Sensor Fail)** - An air temperature sensor has failed, the ventilation fan is stopped.

This event occurs when a temperature sensor fails while the ventilation fan is running, resulting in the ventilation fan being set to **IDLE**. The ventilation fan will no longer run on a normal automatic cycle because the system has no way of determining the temperature conditions, but it will continue to run on the timer controlled back up cycle. Sensor failures trigger a sensor failure alarm.

**Fan IDLE (Temps Equal)** - The enclosure and external temperatures are equal, the ventilation fan is stopped.

This event occurs when the enclosure **E01AirTC** and the external **ExtAirTC** air temperatures become equal while the ventilation fan is running, resulting in the ventilation fan being set to **IDLE** as a normal function of the system.

**Fan IDLE (A/C Cooling)** - The fan was set to IDLE because the air conditioner is running.

This event occurs when the air conditioner is running to cool the enclosure air and the external air temperature has become sufficiently warm that ventilation of the enclosure would be counter productive, resulting in the ventilation fan being automatically set to **IDLE** to prevent conditioned air wastefully being blown out of the enclosure by the ventilation system.

**Fan IDLE (A/C Warming)** - The fan was set to IDLE because the air conditioner is running.

This event occurs when the air conditioner is running to warm the enclosure air and the external air temperature has become sufficiently cool that ventilation of the enclosure would be counter productive, resulting in the ventilation fan being automatically set to **IDLE** to prevent conditioned air wastefully being blown out of the enclosure by the ventilation system.

**Fan IDLE (A/C Run Manual)** - The fan was set to IDLE because the air conditioner is running on Manual.

This event occurs when the air conditioner is set to run on Manual resulting in the ventilation fan being automatically set to **IDLE** to prevent conditioned air wastefully being blown out of the enclosure by the ventilation system. The timer controlled minimum ventilation will still occur.

**Fan IDLE (Timer)** - The run timer elapsed, the ventilation fan is stopped.

This event occurs when the ventilation fan is running on the timer and the preset run time has elapsed, resulting in the ventilation fan being set to **IDLE** as a normal function of the system.

**Fan RUN WARMING** - The ventilation fan is running normally to increase the enclosure temperature.

This event occurs when the external temperature **ExtAirTC** is higher than the enclosure temperature **E01AirTC**, resulting in the ventilation fan being set to **RUN WARMING** so the warmer external air is drawn into the enclosure to increase the enclosure air temperature.

## Event Log

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**Fan RUN COOLING** - The ventilation fan is running normally to reduce the enclosure temperature.

This event occurs when the external temperature **ExtAirTC** is lower than the enclosure temperature **E01AirTC**, resulting in the ventilation fan being set to **RUN COOLING** so the cooler external air is drawn into the enclosure to reduce the enclosure air temperature.

**Fan RUN (Timer)** - The ventilation fan is running on the timer.

This event occurs when ventilation fan has been **IDLE** for longer than the preset limit, resulting in the fan being set to **RUN (Timer)** by the timer. This function ensures that the enclosure always receives at least the minimum amount of ventilation required for the wellbeing of the animals housed in the enclosure.

**Fan Set to RUN MANUAL** - The ventilation fan was switched to **MANUAL** and will run continuously.

This event occurs when a staff member turns the ventilation fan switch to the **MANUAL** position. The ventilation fan will run continuously, irrespective of the temperature conditions in the enclosure, until the switch is moved back to either the **AUTO** or the **OFF** position.

**Fan Set to OFF** - The ventilation fan was switched **OFF** so it cannot run.

This event occurs when a staff member turns the ventilation fan switch to the **OFF** position. The ventilation fan will not run, irrespective of the temperature conditions in the enclosure, until the switch is moved back to either the **AUTO** or the **MANUAL** position.

**Fan Set to AUTO** - The ventilation fan was switched to **AUTO** and will run automatically.

This event occurs when a staff member turns the ventilation fan switch to the **AUTO** position. This is the normal setting for the switch. The ventilation fan will run under automatic control based on the temperature conditions in the enclosure.

### Air Conditioner

**A/C IDLE** - The air conditioner has stopped normally.

This event occurs when the enclosure air temperature has reached either the **SetPointTC\_LO + TC\_HYST** or **SetPointTC\_HI - TC\_HYST** resulting in the air conditioner being set to **IDLE**.

**A/C RUN WARMING** - The air conditioner is running normally to increase the enclosure temperature.

This event occurs when the enclosure temperature **E01AirTC** is lower than the enclosure low setpoint **SetPointTC\_LO**, resulting in the air conditioner being set to **RUN WARMING** to increase the temperature of the enclosure air.

**A/C RUN COOLING** - The air conditioner running normally to reduce the enclosure temperature.

This event occurs when the enclosure temperature **E01AirTC** is higher than the enclosure high setpoint **SetPointTC\_HI**, resulting in the air conditioner being set to **RUN COOLING** to reduce the temperature of the enclosure air.

**NOTE:** Heat pump air conditioners have a minimum cooling temperature, typically about 16 degrees Celsius, that they can be set to cool down to. This is entered into the station constant **LOWEST\_AC** during installation. If the enclosure high setpoint **SetPointTC\_HI** is below that minimum temperature, the air conditioner will not be started until the enclosure air temperature increases to **LOWEST\_AC + 1** degrees or higher to prevent the system issuing commands to the air conditioner that may conflict with its built-in control and safety systems and cause unpredictable results.

## Event Log

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**A/C Set to RUN MANUAL HEAT** - The A/C was switched to **MANUAL HEAT** and will run continuously.

This event occurs when a staff member turns the air conditioner switch to the **MANUAL HEAT** position. The air conditioner will run continuously to heat the enclosure, irrespective of the availability of external air exchange for use as temperature control, until the switch is moved back to either the **AUTO** or the **OFF** position. If the air conditioner has its own built-in thermostat (usually with a remote control) it may be able to cycle about whatever temperature that thermostat is set to.

**A/C Set to RUN MANUAL COOL** - The A/C was switched to **MANUAL COOL** and will run continuously.

This event occurs when a staff member turns the air conditioner switch to the **MANUAL COOL** position. The air conditioner will run continuously to cool the enclosure, irrespective of the availability of external air exchange for use as temperature control, until the switch is moved back to either the **AUTO** or the **OFF** position. If the air conditioner has its own built-in thermostat (usually with a remote control) it may be able to cycle about whatever temperature that thermostat is set to.

**A/C Set to OFF** - The air conditioner was switched **OFF** so it cannot run.

This event occurs when a staff member turns the air conditioner switch to the **OFF** position. The air conditioner will not run, irrespective of the temperature conditions in the enclosure, until the switch is moved back to either the **AUTO**, **MANUAL HEAT**, or **MANUAL COOL** position.

**A/C Set to AUTO** - The ventilation fan was switched to **AUTO** and will run automatically.

This event occurs when a staff member turns the air conditioner switch to the **AUTO** position. This is the normal setting for the switch. The air conditioner will run under automatic control based on the temperature conditions in the enclosure.

### Dehumidifier

**Dehumidifier RUN** - The dehumidifier is running.

This event occurs when the enclosure relative humidity **E00AirRH** exceeds the automatically selected setpoint **SET\_RH\_HI** (nighttime setting) or **SET\_RH\_HI\_DAY** (daytime setting) at which time the program switches the dehumidifier ON. The dehumidifier remains switched on until the relative humidity returns to a level that is 2% RH below the setpoint.

**Dehumidifier IDLE** - The dehumidifier has stopped normally.

This event occurs when the enclosure relative humidity **E00AirRH** returns to a level that is 2% RH below the automatically selected setpoint **SET\_RH\_HI** (nighttime setting) or **SET\_RH\_HI\_DAY** (daytime setting) at which time the program switches the dehumidifier OFF. The dehumidifier remains switched off until the relative humidity again rises to a point that exceeds the selected setpoint.

**Dhu Set to RUN MANUAL** - The dehumidifier was switched to **MANUAL** and will run continuously.

This event occurs when a staff member turns the dehumidifier switch to the **MANUAL** position. The ventilation fan will run continuously, irrespective of the relative humidity conditions in the enclosure, until the switch is moved back to either the **AUTO** or the **OFF** position.

**Dhu Set to OFF** - The dehumidifier was switched **OFF** so it cannot run.

This event occurs when a staff member turns the dehumidifier switch to the **OFF** position. The dehumidifier will not run, irrespective of the relative humidity conditions in the enclosure, until the switch is moved back to either the **AUTO** or the **MANUAL** position.



# Event Log

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**Dhu Set to AUTO** - The dehumidifier was switched to **AUTO** and will run automatically.

This event occurs when a staff member turns the dehumidifier switch to the **AUTO** position. This is the normal setting for the switch. The dehumidifier will run under automatic control based on the relative humidity conditions in the enclosure.

## Lighting

**LX Set to MANUAL LX2** - The lighting was switched to **LX2** and the LX2 circuit will run continuously.

This event occurs when a staff member turns the lighting switch to the **LX2** position. The lighting circuit LX2 will run continuously, irrespective of the lighting state change triggers, until the switch is moved to either the **LX1**, the **AUTO** or the **OFF** position.

**LX Set to MANUAL LX1** - The lighting was switched to **LX1** and the LX1 circuit will run continuously.

This event occurs when a staff member turns the lighting switch to the **LX1** position. The lighting circuit LX1 will run continuously, irrespective of the lighting state change triggers, until the switch is moved to either the **LX2**, the **AUTO** or the **OFF** position.

**LX Set to OFF** - The lighting was switched **OFF** so it cannot run.

This event occurs when a staff member turns the lighting switch to the **OFF** position. The lighting will not run, irrespective of the lighting state change triggers, until the switch is moved to either the **AUTO**, the **LX1**, or the **LX2** position.

**LX Set to AUTO** - The lighting was switched to **AUTO** and will run automatically.

This event occurs when a staff member turns the ventilation fan switch to the **AUTO** position. This is the normal setting for the switch. The lighting system will automatically run either the LX1 or the LX2 lighting circuits according to the lighting state change triggers.

**LX Mode Set to NOCTURNAL** - The lighting mode switches were changed to **NOCTURNAL** mode.

This event occurs each time the lighting mode option switches are changed to the **NOCTURNAL** setting. This is the option setting to run grow lights during the night and moonlights during the day.

**LX Mode Set to DIURNAL** - The lighting mode switches were changed to **DIURNAL** mode.

This event occurs each time the lighting mode option switches are changed to the **DIURNAL** setting. This is the option setting to run moonlights during the night and daytime lights during the day.

**LX Mode Set to DIURNAL BUILD** - The lighting mode switches were changed to **DIURNAL BUILD** mode.

This event occurs each time the lighting mode option switches are changed to the **DIURNAL BUILD** setting. This is the option setting to run daytime lights all day and add in supplementary lights (typically basking lights for reptiles) during the middle portion of the day. No lights run at night.

**LX Mode Set to DIURNAL STEPPED** - The lighting mode switches changed to **DIURNAL STEPPED** mode.

This event occurs each time the lighting mode option switches are changed to the **DIURNAL STEPPED** setting. This is the option setting to run daytime lights in the morning and afternoon and change to the supplementary lights during the middle portion of the day. No lights run at night.

**LX DAY** - The lighting state automatically changed to **DAY**.

This event occurs each time the lighting state changes to **DAY** lighting (LX1=ON, LX2=OFF) . This is part of the automatic cycle when operating in **DIURNAL**, **DIURNAL BUILD**, or **DIURNAL STEPPED** modes.

## Event Log

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**LX DAY (Step Sup)** - The lighting state automatically changed to **DAY (Step Sup)**.

This event occurs each time the lighting state changes to **DAY (Step Sup)** lighting (LX2=ON). This is part of the automatic cycle when operating in **DIURNAL STEPPED** mode.

**LX DAY (Build Sup)** - The lighting state automatically changed to **DAY (Build Sup)**.

This event occurs each time the lighting state changes to **DAY (Build Sup)** lighting (LX1=ON, LX2=ON). This is part of the automatic cycle when operating in **DAY BUILD** mode.

**LX NIGHT** - The lighting state automatically changed to **NIGHT**.

This event occurs each time the lighting state changes to **NIGHT** lighting (LX2=ON). This is part of the automatic cycle when operating in **DIURNAL** mode.

**LX NIGHT (Off)** - The lighting state automatically changed to **NIGHT (Off)**.

This event occurs each time the lighting state changes to **NIGHT (Off)** lighting (LX1=OFF, LX2-OFF). This is part of the automatic cycle when operating in **DIURNAL BUILD** or **DIURNAL STEPPED** modes.

**LX GROW LIGHTS** - The lighting state automatically changed to **GROW LIGHTS** (Nocturnal Day).

This event occurs each time the lighting state changes to **GROW LIGHTS** lighting (LX1=ON, LX2-OFF). This is part of the automatic cycle when operating in **NOCTURNAL** mode.

**LX MOONLIGHT** - The lighting state automatically changed to **MOONLIGHT** (Nocturnal Night).

This event occurs each time the lighting state changes to **MOONLIGHT** lighting (LX1=OFF, LX2-ON). This is part of the automatic cycle when operating in **NOCTURNAL** mode.

**LX MANUAL OFF** - The lighting state was manually changed to **OFF**.

This event occurs each time the lighting state is manually switched to **OFF** lighting (LX1=OFF, LX2-OFF). This is a manual control function. All lights are OFF and will remain OFF until the manual control switch is moved to a different selection.

**LX MANUAL LX1** - The lighting state was manually changed to **LX1**.

This event occurs each time the lighting state is manually switched to **LX1** lighting (LX1=ON, LX2-OFF). This is a manual control function. The **LX1** lights are ON and will remain ON until the manual control switch is moved to a different selection.

**LX MANUAL LX2** - The lighting state was manually changed to **LX2**.

This event occurs each time the lighting state is manually switched to **LX2** lighting (LX1=OFF, LX2-ON). This is a manual control function. The **LX2** lights are ON and will remain ON until the manual control switch is moved to a different selection.

**LX MANUAL LX1 (Sup)** - The lighting state was manually changed to **LX2**. (**DIURNAL BUILD** mode only)

This event occurs each time the lighting state is manually switched to **LX2** lighting while the system is set to **DIURNAL BUILD** mode (LX1=ON, LX2-ON). This is a manual control function. The **LX1** and **LX2** lights are ON and will remain ON until the manual control switch is moved to a different selection.

# Event Log

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## Enclosure

**Alarm E01: Temp Too High** - The enclosure high temperature alarm was triggered.

**E01: Temp Too High Cleared** - The enclosure high temperature alarm was cleared.

These events occur when the enclosure temperature becomes too high and when it is subsequently cleared. The high temperature alarm is triggered when the enclosure temperature **E01AirTC** rises to or above the enclosure high temperature setpoint **SetPointTC\_HI** plus the station constant **ALARM\_DEGREES**. The alarm resets when the enclosure temperature **E01AirTC** falls below the enclosure high temperature setpoint **SetPointTC\_HI** plus the station constant **ALARM\_RESET**.

**Alarm E01: Temp Too Low** - The enclosure low temperature alarm was triggered.

**E01: Temp Too Low Cleared** - The enclosure low temperature alarm was cleared.

These events occur when the enclosure temperature becomes too low and when it is subsequently cleared. The low temperature alarm is triggered when the enclosure temperature **E01AirTC** falls to or below the enclosure low temperature setpoint **SetPointTC\_LO** minus the station constant **ALARM\_DEGREES**. The alarm resets when the enclosure temperature **E01AirTC** rises above the enclosure low temperature setpoint **SetPointTC\_LO** minus the station constant **ALARM\_RESET**.

**Alarm E01: Sensor 1 Failure** - The enclosure temperature and RH sensor 1 failure alarm was triggered.

**E01: Sensor 1 Failure Cleared** - The enclosure temperature and RH sensor 1 failure alarm was cleared.

These events occur when the enclosure temperature and relative humidity sensor 1 fails and when it is subsequently restored to normal operation. Sensor failures usually require repair or replacement of the sensor by a service technician to clear the alarm.

**Alarm E01: Sensor 2 Failure** - The enclosure temperature and RH sensor 2 failure alarm was triggered.

**E01: Sensor 2 Failure Cleared** - The enclosure temperature and RH sensor 2 failure alarm was cleared.

These events occur when the enclosure temperature and relative humidity sensor 1 fails and when it is subsequently restored to normal operation. Sensor failures usually require repair or replacement of the sensor by a service technician to clear the alarm.

## Barometric Pressure Sensor

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

**Barometric Sensor RECALIBRATE 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.

These events indicate a change of the barometric pressure sensor's state switch **BaroSensState** 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.

**Alarm Barometric Sensor Failure** - The barometric pressure sensor failure alarm was triggered.

**Barometric Sensor Failure Cleared** - The barometric pressure sensor failure alarm was cleared.

These events occur when the barometric pressure sensor fails and when it is subsequently restored to normal operation. Sensor failures usually require replacement of the sensor card to clear the alarm.

# Event Log

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## External Sensor

[Alarm EXT: Sensor Failure](#) - The external temperature and RH sensor failure alarm was triggered.

[EXT: Sensor Failure Cleared](#) - The external temperature and RH sensor failure alarm was cleared.

These events occur when an optional external temperature and relative humidity sensor connected to the local station fails and when it is subsequently restored to normal operation. Sensor failures usually require repair or replacement of the sensor by a service technician to clear the alarm.

## Datalogger Program Restarts

[Datalogger Program Started](#) - Logged each time the datalogger program is started.

This event is logged to provide an indication of when the datalogger program was restarted. Restarts usually occur when a program update is loaded or the [Setpoints](#) table is edited but it can also happen if the datalogger detects an internal error (watchdog error) and automatically restarts itself. An occasional watchdog error is acceptable but frequent watchdog errors should be investigated.

## 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. Staff may need to respond to power outages of extended duration to prevent spoilage of refrigerated food, such as by installing a temporary generator to supply the building.

## HVAC Circuit Breaker Trip

[Alarm HVAC Circuit Breaker Trip](#) - One or more of the HVAC circuit breakers has tripped.

[HVAC Circuit Breaker Trip Cleared](#) - The the HVAC circuit breakers alarm was cleared.

These events occur when one or more of the HVAC circuit breakers in the switchboard has tripped and when the circuit breakers are subsequently returned to their normal positions. A tripped circuit breaker typically indicates an electrical failure of the HVAC equipment, or that the HVAC plant has been shut down and electrically isolated for maintenance purposes.

## LX Circuit Breaker Trip

[Alarm LX Circuit Breaker Trip](#) - One or more of the lighting circuit breakers has tripped.

[LX Circuit Breaker Trip Cleared](#) - The the HVAC circuit breakers alarm was cleared.

These events occur when one or more of the lighting circuit breakers in the switchboard has tripped and when the circuit breakers are subsequently returned to their normal positions. A tripped circuit breaker typically indicates an electrical failure of some lighting equipment, or that the lighting system has been shut down and electrically isolated for maintenance purposes.

# Event Log

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## 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.

## Event Log

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**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 times 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. This is an informative diagnostic message, not a fault in the system.

# Alarms Module

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## Alarms Module

The datalogger program monitors the temperatures of the enclosures, the functioning of the temperature sensors, 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 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 [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 field 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.

# Alarms Module

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## Temperature Alarms Operation

The temperature alarms process is entirely automatic, once the cause of the temperature alarm has been remedied and the temperatures return to normal, the alarms will automatically reset. The enclosure has its own high and low temperature alarms.

The desired operating temperature range for the enclosure(s) is determined by HVAC high temperature and low temperature setpoints, [SetPointTC\\_HI](#) and [SetPointTC\\_LO](#) respectively. When the temperature in the enclosure moves too far beyond one of these setpoints a temperature alarm is triggered.

The HVAC setpoints in the [Setpoints](#) data table for each month of the year enable keepers to configure seasonal temperature variation in the enclosure and by necessity the alarm trigger points vary with the HVAC setpoints. The air conditioning is started when the temperature crosses a setpoint, and the temperature alarms are triggered when the temperature moves further, beyond the region of normal air conditioner operation.

The temperature sensors are measured once every minute and a temperature alarm is triggered if the enclosure temperature [E01AirTC](#) reaches the alarm trigger point. The high temperature alarm trigger point is the high setpoint [SetPointTC\\_HI](#) plus [ALARM\\_DEGREES](#). The low temperature trigger point is the low setpoint [SetPointTC\\_LO](#) minus [ALARM\\_DEGREES](#). The constant [ALARM\\_DEGREES](#) is set in the [STATION\\_CONSTANTS](#) file.

Once an alarm is triggered it remains in that state until that alarm's reset conditions are met. The high temperature alarm resets when the enclosure temperature becomes lower than the high temperature setpoint [SetPointTC\\_HI](#) plus [ALARM\\_RESET](#). The low temperature alarm resets when the enclosure temperature becomes higher than the low temperature setpoint [SetPointTC\\_LO](#) minus [ALARM\\_RESET](#). The constant [ALARM\\_RESET](#) is set in the [STATION\\_CONSTANTS](#) file.

The alarm trigger constant [ALARM\\_DEGREES](#) is normally set to about 4 degrees and the alarm reset 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 is  $\geq$  SetPointTC\_HI + ALARM\_DEGREES*

*Set AlarmState to HighAlarm*

*Otherwise if Temperature is  $\leq$  SetPointTC\_LO - ALARM\_DEGREES*

*Set AlarmState to LowAlarm*

*Otherwise if Temperature is  $>$  SetPointTC\_LO - ALARM\_RESET and  $<$  SetPointTC\_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.

## Temperature & Relative Humidity Sensor Failure Alarms Operation

The sensor failure alarms process is entirely automatic, once the faulty sensor has been repaired, the alarms will automatically reset. The enclosure has two temperature sensors. An external temperature sensor may also be installed. These are normally very reliable and require little maintenance.

In the event that a sensor does fail, 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 sensors are read by the datalogger program, the program tests the measurement value for any out of range values. If an out of range value is detected the program sets the applicable sensors state field [E01SensState](#) for the enclosure or [ExtSensState](#) for the external sensor to indicate the failure.

The ZooCADA system uses Campbell Scientific HygroVUE-5 SDI-12 combined temperature and relative humidity sensors for the enclosures and the external sensors.



# Alarms Module

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The possible enclosure sensor states are:

- TC OK, RH OK - Both temperature and RH sensors are OK.
- TC OK, RH1 FAIL - Temperature sensors Ok, RH sensor failed at SDI-12 address 1.
- TC OK, RH2 FAIL - Temperature sensors Ok, RH sensor failed at SDI-12 address 2.
- TC OK, RH FAIL - Temperature sensors both OK, RH sensors both failed.
- TC1 FAIL, RH OK - Temperature sensor failed at SDI-12 address 1, RH sensors OK.
- TC2 FAIL, RH OK - Temperature sensor failed at SDI-12 address 2, RH sensors OK.
- TC FAIL, RH OK - Temperature sensors both failed, RH sensors both OK.
- TC1 FAIL, RH1 FAIL - Temperature sensor and RH sensor both failed at SDI-12 address 1.
- TC2 FAIL, RH2 FAIL - Temperature sensor and RH sensor both failed at SDI-12 address 2.
- TC FAIL, RH FAIL - Both temperature and RH sensors have failed.

The possible external sensor states are:

- TC OK, RH OK - External sensor is installed, Temperature sensor is OK, RH sensor is OK.
- TC FAIL, RH OK - External sensor is installed, Temperature sensor has failed, RH sensor is OK.
- TC OK, RH FAIL - External sensor is installed, Temperature sensor is OK, RH sensor has failed.
- TC FAIL, RH FAIL - External sensor is installed, Temperature sensor has failed, RH sensor has failed.

The nature of the alarm is logged in the [EVENT\\_LOG](#) data table and sent to staff in the alarms email messages.

## Barometric Pressure Sensor Failure Alarms Operation

The barometric pressure sensor failure alarms process is entirely automatic, once the faulty sensor has been repaired, the alarms will automatically reset. A sensor failure alarm can occur if the sensor card requires recalibration or if the sensor returns a pressure measurement value that is out of the manufacturers specified operating range. The sensor state is displayed in the Public table [BaroSensState](#) variable.

The possible states are:

- OK (QM n.nn) - The barometric pressure sensor is working normally.
- RECALIBRATE SOON - The sensor will need recalibrating in two to three months.
- FAIL (QM n.nn) - The barometric pressure sensor needs recalibrating or has failed.

**NOTE:** The barometric pressure sensor card requires periodic recalibration, typically every one to two years.

The QM (Quality Metric) value is produced by the sensor each time it's measurement values are retrieved by the datalogger program. The QM value is displayed in the [Public](#) table [BaroSensState](#) variable. 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 [RECALIBRATE SOON](#). If a sensor failure is displayed, check the QM value first. 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.

Please see the Campbell Scientific BaroVUE10 Product Manual for more information on recalibration procedures.

# Alarms Module

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## Power Failure Alarm Operation

The power failure alarm is entirely automatic. The alarm 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** field 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

The ZooCADA-Lab system requires external temperature and relative humidity measurement values for HVAC control and 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** field 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.

# Alarms Module

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## HVAC Circuit Breaker Trip Alarm Operation

The HVAC system electrical circuit breakers in the switchboard are monitored by the datalogger program, and if a circuit breaker trips the HVAC Circuit Breaker Trip alarm is triggered. Tripped circuit breakers typically occur because of an electrical fault in the HVAC equipment but may also be tripped intentionally by a maintenance engineer to isolate the equipment while it is being worked on. The alarm automatically resets when the tripped circuit breaker is reset.

The nature of the alarm is logged in the [EVENT\\_LOG](#) data table and sent to staff in the alarms email messages.

**WARNING:** DO NOT attempt to reset a tripped HVAC circuit breaker until you have confirmed that nobody is working on the equipment and it is safe to attempt a reset. **ELECTRIC SHOCK CAN BE FATAL!**

## Lighting (LX) Circuit Breaker Trip Alarm Operation

The LX lighting system electrical circuit breakers in the switchboard are monitored by the datalogger program, and if a circuit breaker trips the LX Circuit Breaker Trip alarm is triggered. Tripped circuit breakers typically occur because of an electrical fault in the lighting equipment but may also be tripped intentionally by a maintenance engineer to isolate the equipment while it is being worked on. The alarm automatically resets when the tripped circuit breaker is reset.

The nature of the alarm is logged in the [EVENT\\_LOG](#) data table and sent to staff in the alarms email messages.

**WARNING:** DO NOT attempt to reset a tripped LX circuit breaker until you have confirmed that nobody is working on the equipment and it is safe to attempt a reset. **ELECTRIC SHOCK CAN BE FATAL!**

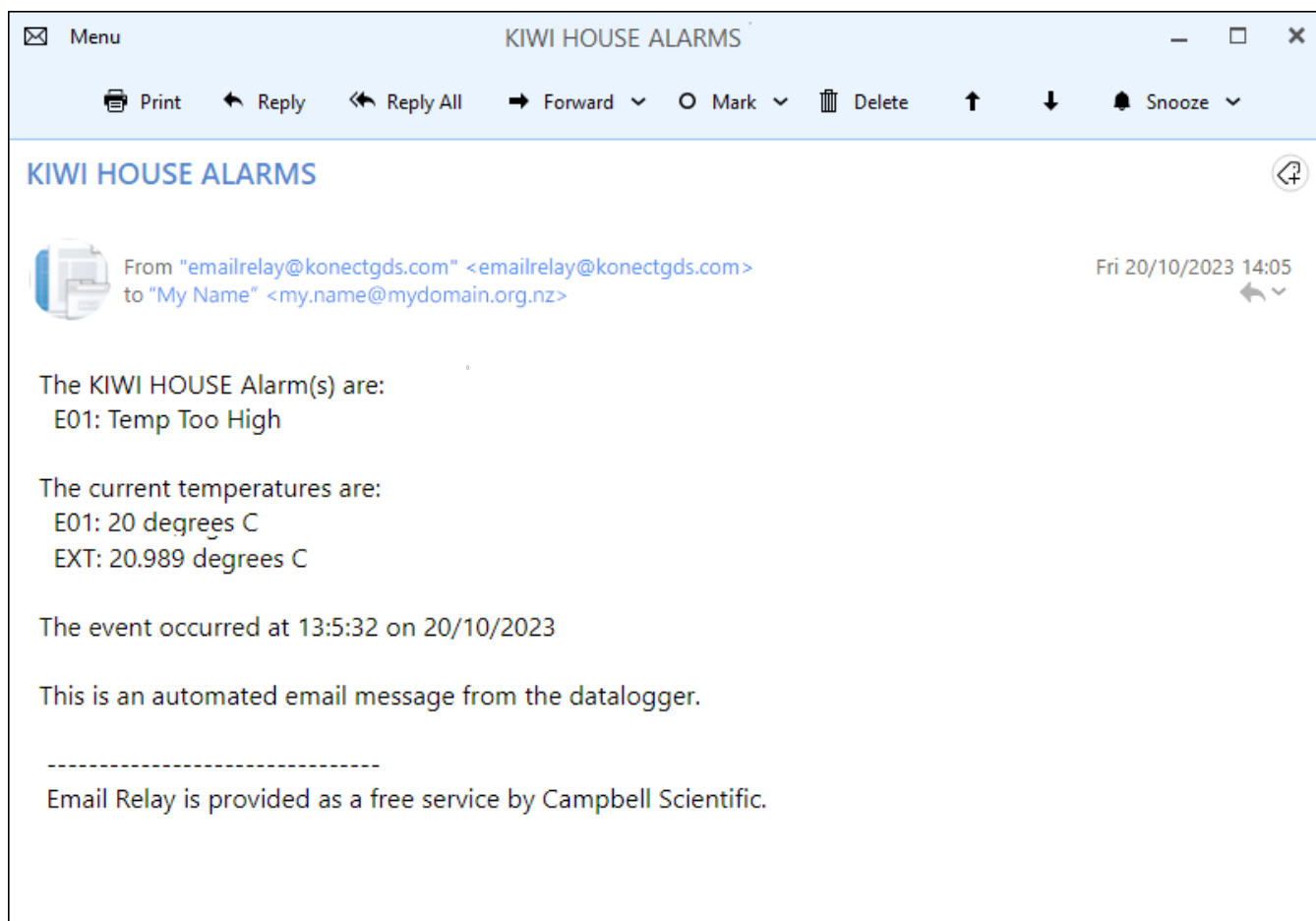
## Alarms Module

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# Email Messaging System

## 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. The current enclosure temperature measurements are added to the email message body along with the date and time the event occurred.

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.

# Email Messaging System

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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 `STATION_CONSTANTS` file.

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.

# Email Messaging System

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**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 **ENCLOSURE** plus the word "ALARMS".

Daily Re-sent Alarms - The **ENCLOSURE** plus the words "ALARMS (RE-SENT)".

Alarms Cleared - The **ENCLOSURE** plus the words "ALARMS CLEARED".

The first line in the message body "The **ENCLOSURE** 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 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 temperatures are:"

Following the second list heading the current temperatures for each enclosure at the station and the external temperature are listed. These temperatures are listed on every alarms email message, and the alarms cleared message, to give staff an immediate indication of the current situation and assist them with making decisions on their alarm response. The temperatures 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.

# Email Messaging System

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## Enclosure Alarms Messages

**E01: Temp Too High** - The enclosure high temperature alarm was triggered.

This alarm is triggered when the temperature in the enclosure rises above the [SetPointTC\\_HI](#) setpoint by the station constant [ALARM\\_DEGREES](#) amount. Enclosure high temperature alarms typically result from an issue with the air conditioner that is preventing it maintaining the desired upper temperature limit.

**E01: Temp Too Low** - The enclosure low temperature alarm was triggered.

This alarm is triggered when the temperature in the enclosure falls below the [SetPointTC\\_LO](#) setpoint by the station constant [ALARM\\_DEGREES](#) amount. Enclosure low temperature alarms typically result from an issue with the air conditioner that is preventing it maintaining the desired lower temperature limit.

**E01: Sensor 1 Failure** - The enclosure temperature and RH sensor 1 failure alarm was triggered.

**E01: Sensor 2 Failure** - The enclosure temperature and RH sensor 2 failure alarm was triggered.

These alarm(s) are triggered when one or both temperature and RH sensors in the enclosure fails. Sensor failures will most likely require replacement of the sensor.

## Barometric Pressure Sensor Alarm Message

**Barometric Sensor Failure** - The barometric pressure sensor failure alarm was triggered.

This alarm is triggered when the sensor's Quality metric value falls below 4, or if the measurement value returned by the sensor is outside of the manufacturers operating range. Check the QM value in the [Public](#) table [BaroSensState](#) variable first. If the QM values are greater than 3.99 the failure may not be due to the sensor card, it could be in the instrument electronics or elsewhere. If the QM values are less than 4 the sensor card requires recalibration.

## External Temperature and Relative Humidity Sensor Alarm Message

**Ext: Sensor Failure** - The external temperature and RH sensor failure alarm was triggered.

This alarm is triggered when the external temperature and RH sensor fails. Sensor failures will most likely require replacement of the sensor.

**WARNING:** Failure of the external sensor is a critical failure when there is only one external sensor on site as the HVAC operation in every enclosure controlled by the ZooCADA system will be compromised.

## 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 Messaging System

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**HVAC Circuit Breaker Trip** - One or more of the HVAC circuit breakers has tripped.

This alarm is triggered when one or more of the HVAC circuit breakers in the switchboard has tripped. Tripped circuit breakers typically occur because of an electrical fault in the HVAC equipment but may also be tripped intentionally by a maintenance engineer to isolate the equipment while it is being worked on.

**LX Circuit Breaker Trip** - One or more of the LX (lighting) circuit breakers has tripped.

This alarm is triggered when one or more of the LX circuit breakers in the switchboard has tripped. Tripped circuit breakers typically occur because of an electrical fault in the HVAC equipment but may also be tripped intentionally by a maintenance engineer to isolate the equipment while it is being worked on.

## 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** field 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 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 Messaging System

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## 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 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.





## Templates for Record Keeping

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### 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.

## Templates for Record Keeping

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# Templates for Record Keeping

## ZooCADA-Lab Station Configuration Record (Page 1 of 3)

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_TOO_HOT =
SET_MAY_LO =	SET_TOO_COLD =
SET_JUN_HI =	SET_RH_HI =
SET_JUN_LO =	SET_RH_HI_DAY =
SET_JUL_HI =	SET_RH_LO =
SET_JUL_LO =	SET_REF_TIME_MINS =
SET_AUG_HI =	SET_REF_VARIATION =
SET_AUG_LO =	SET_SUP_PERCENT =

Complete a new page each time the configuration is changed so an auditable record of changes is created.

## Templates for Record Keeping

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### ZooCADA-Lab Station Configuration Record (Page 2 of 3)

#### Station Constants - General

ENCLOSURE =	E01TRH_SDI_ADDR =
CUSTOM_FILE =	E02TRH_SDI_ADDR =
FAN_IDLE_LIMIT =	BARO_ENAB =
FAN_RUN_TIME =	BARO_STN_ELEV =
FAN_TIMER_ONLY =	BARO_LOCAL =
LOWEST_AC =	BARO_SDI_ADDR =
LATITUDE =	PORT_SENS_ENAB =
ADJ_REF_DST =	PS1TRH_SDI_ADDR =
FADE_TIME_MINS =	PS2TRH_SDI_ADDR =
MIN_EXHIBIT_MINS =	PS3TRH_SDI_ADDR =
ALARM_ENABLE =	PS4TRH_SDI_ADDR =
ALARM_DEGREES =	PS5TRH_SDI_ADDR =
ALARM_RESET =	PS6TRH_SDI_ADDR =
EMAIL_ENABLE =	PS7TRH_SDI_ADDR =
EMAIL_TEST =	PS8TRH_SDI_ADDR =
EMAIL_RESEND =	PS9TRH_SDI_ADDR =
EMAIL_TRIES =	DST_N_START =
EMAIL_NAG =	DST_D_START =
EMAIL_NAG_HOUR =	DST_M_START =
EMAIL_ATTACH =	DST_N_END =
EXT_TRH_LOCAL =	DST_D_END =
EXT_TRH_PRIMARY =	DST_M_END =
EXT_SDI_ADDR =	DST_HOUR =

Complete a new page each time the configuration is changed so an auditable record of changes is created.

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# Templates for Record Keeping

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## ZooCADA-Lab Station Configuration Record (Page 3 of 3)

### 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 =	

### Configuration Notes


Complete a new page each time the configuration is changed so an auditable record of changes is created.

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## Templates for Record Keeping

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# Templates for Record Keeping

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## 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:	

# Templates for Record Keeping

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## 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:	