ZooCADA™ - Life

Enclosure Environment Control & Monitoring System

Version R01

Reference Manual

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ZooCADA-Life Version R01 Reference Manual

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System Overview

The ZooCADA-Life Enclosure Environment Control and Monitoring System is a software program and hardware system designed to control the temperature, relative humidity and lighting within an indoor animal enclosure for zoological or conservation purposes. The general design concept is to eliminate any need for staff to to control HVAC and lighting manually every day, and regularly adjust seasonal timings to maintain the environment; instead ZooCADA-Life does it automatically, allowing staff to focus on more productive activities.

Each ZooCADA-Life system comprises of a datalogger, it's peripherals and sensors, and is designed for up to two animal enclosures that share a common HVAC system and lighting cycle timing. 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 of the temperature and the lighting cycle, 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-Life 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 temperature range can also be deliberately narrowed to achieve an optimal temperature range to meet the particular requirements that keepers consider appropriate for the animals in their care.

Throughout the daily cycle ZooCADA-Life 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, 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 selectable between diurnal and nocturnal operation to suit the intended operation of the enclosure, with seasonal variation operating in both modes. This selection is made in the site configuration settings file in the datalogger. The transition between artificial sunlight (full spectrum LED plant grow lights) and artificial moonlight (colour filtered LED ribbon lighting) is controlled by dimmers with an adjustable transition time of up to 60 minutes. The dimmers transition between preset light levels for the sunlight and moonlight scenes. Supplementary lighting, which may be "basking heat lights" for reptiles and/or UV lights for various species, are automatically switched on during the middle portion of the enclosure sunlight scene. This enables enclosure lighting to meet the needs of a wide variety of diurnal and nocturnal animals with lighting that reasonably represents natural conditions in the best interests of the welfare of the animals housed in the enclosure.

ZooCADA-Life 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 and electricity use. Barometric pressure can also be recorded as an option. This data can be used by staff to assist with research and animal welfare 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.

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.
- Enclosure soil volumetric water content and temperature logged hourly .
- Ventilation, air conditioning and dehumidifier run time each logged as hourly and daily totals.
- 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 setpoints for each month to provide seasonal variation.
- High relative humidity (RH) setpoint to control dehumidifier.
- Low relative humidity (RH) setpoint to control humidifier.
- 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 four dimmable lighting circuits for moonlight and sunlight scenes.
- Automatically controls a non-dimmable lighting circuit for UV lights or reptile basking lights.
- Automatically adjusts lighting timing each day for natural seasonal variation.
- Customer adjustable transition time between moonlight and sunlight scenes.
- Customer adjustable lighting level settings to suit different species.
- Selectable for Diurnal or Nocturnal enclosure lighting operation.

General

- 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-Life 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

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.

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.

IMPORTANT: The temperature setting on the air conditioner's remote control MUST be set to a value that is within the enclosure high and low setpoints for the current month.

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.

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 AC_LOWEST_TEMP 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 minimise wasteful exhaust of conditioned air by the ventilation system.

Humidity Switch

IMPORTANT: Only dehumidifier and humidifier 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 Humidity switch has four positions, AUTO, OFF, DEC, and INC 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 and humidifier based on the the programmed relative humidity setpoints for the enclosure air. The humidity has a high setpoint for daytime and a higher setpoint for nighttime running to maintain natural diurnal variation.

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

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

The system will switch the dehumidifier and humidifier OFF when the relative humidity in the enclosure is within the high and low relative humidity setpoints.

OFF

Select the OFF position to stop the dehumidifier and humidifier from operating.

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

DEC

Select the DEC 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 to decrease the relative humidity in the enclosure.

INC

Select the INC position to force the humidifier to operate continuously.

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

Lighting Switch

The Lighting switch has six positions, BUMP, AUTO, OFF, LX1, LX2, and LX1SUP which operate as follows.

BUMP

Select the BUMP position to temporarily increase the lighting level in the enclosure.

The Bump function fades up the bump preset dimmer channel levels over the top of the automatically controlled scene preset levels to increase the light level in the enclosure for staff while they are working in the enclosure. Any dimmer channels can be assigned a bump level in the STATION_SETTINGS file.

The Bump function is available while the enclosure lighting is under automatic control, and the automatic functions continue to operate while the Bump function is activated. If the lighting switch is set to LX1, LX2, LX1SUP, or OFF the bump function is disabled.

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 three lighting circuits, LX1, LX2 and LX3, ON or OFF, and carry out the automatic dimmer crossfades, based on the time of day and the selected lighting mode. The software also calculates automatic adjustments for seasonal variation.

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

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 powering the lighting equipment that produces the enclosure sunlight scene, which is usually provided by full spectrum horticultural grow lights. In Diurnal mode, the sunlight scene runs during the natural daytime period whereas in Nocturnal mode the sunlight scene runs during the natural nighttime period. In Diurnal and Nocturnal modes, think of LX1 as being the enclosure sunlight 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.

LX2 is the lighting circuit powering the lighting equipment that produces the enclosure moonlight scene, which is usually provided by colour filtered LED ribbon lights. In Diurnal mode, the moonlight scene runs during the natural nighttime period whereas in Nocturnal mode the moonlight scene runs during the natural daytime period. In Diurnal and Nocturnal modes, think of LX2 as being the enclosure moonlight 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.

LX1SUP

Select the LX1SUP position to force the LX1 and LX3 circuits to operate continuously.

LX3 is the circuit powering the lighting equipment that provides the enclosure supplementary lighting, usually artificial UV light or reptile basking lights. The datalogger program is designed to ensure that LX3 can only operate while LX1 is operating and the manual switch is designed to do the same.

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 Nocturnal/Diurnal Mode Selection

The selection between Nocturnal mode and Diurnal mode is made by setting the LX_NOCTURNAL constant in the STATION_CONSTANTS file to True for Nocturnal mode and False for Diurnal mode.

This setting is normally set during commissioning of the enclosure and doesn't need changing unless the enclosure is subsequently reconfigured for a different species.

Lighting Fade Times

The lighting control system system uses the normal fade time FADE_TIME_MINS (typically 30 minutes) set in the STATION_CONSTANTS file to control the crossfade duration.

This setting is normally set during commissioning of the enclosure and doesn't need changing unless the enclosure is subsequently reconfigured for a different species.

Whenever the lighting switch position is changed the control system uses a fast-fade rate, fixed at 30 seconds, so the newly selected lighting state is quickly faded in.

If the lighting switch is moved from AUTO to LX1, LX2, or LX1SUP while an automatic cross fade is in progress, the automatic crossfade ends and the manually selected scene is faded in at the fast-fade rate. As soon as a fast fade has completed the system automatically switches back to the normal fade time.

The Bump function also uses the fast-fade rate of 30 seconds. If an automatic lighting scene change is triggered while a Bump fade is in progress, or if the Bump function is activated/deactivated while an automated lighting scene change is in progress, the automated scene change is paused until the bump fade is complete. When the bump fade is complete the automatic scene change continues as normal.

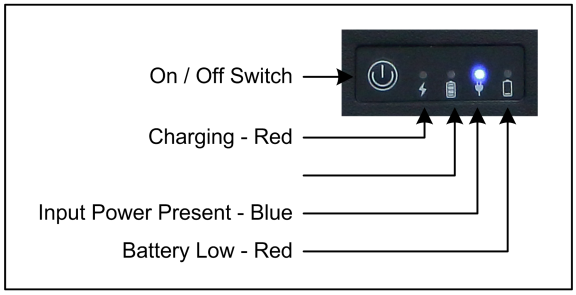
Uninterruptible Power Supply

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

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

UPS Power Switch and LED Indicators

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



On / Off Switch

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

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

Charging Indicator

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

The indicator is lit while the battery being charged.

The indicator is off when the battery is fully charged.

Battery Power Only Indicator

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

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

The indicator is off when input power is available.

Input Power Present Indicator

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

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

The indicator is off when input power is not available.

Battery Low Indicator

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

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

The indicator is off when the battery is charged.

UPS Run Time

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

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

Storing the UPS

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

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

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

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

6 months at 20^{O} C

3 months at 30^{O} C

2 months at 35^{O} C

UPS Specifications

Input: 12 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)

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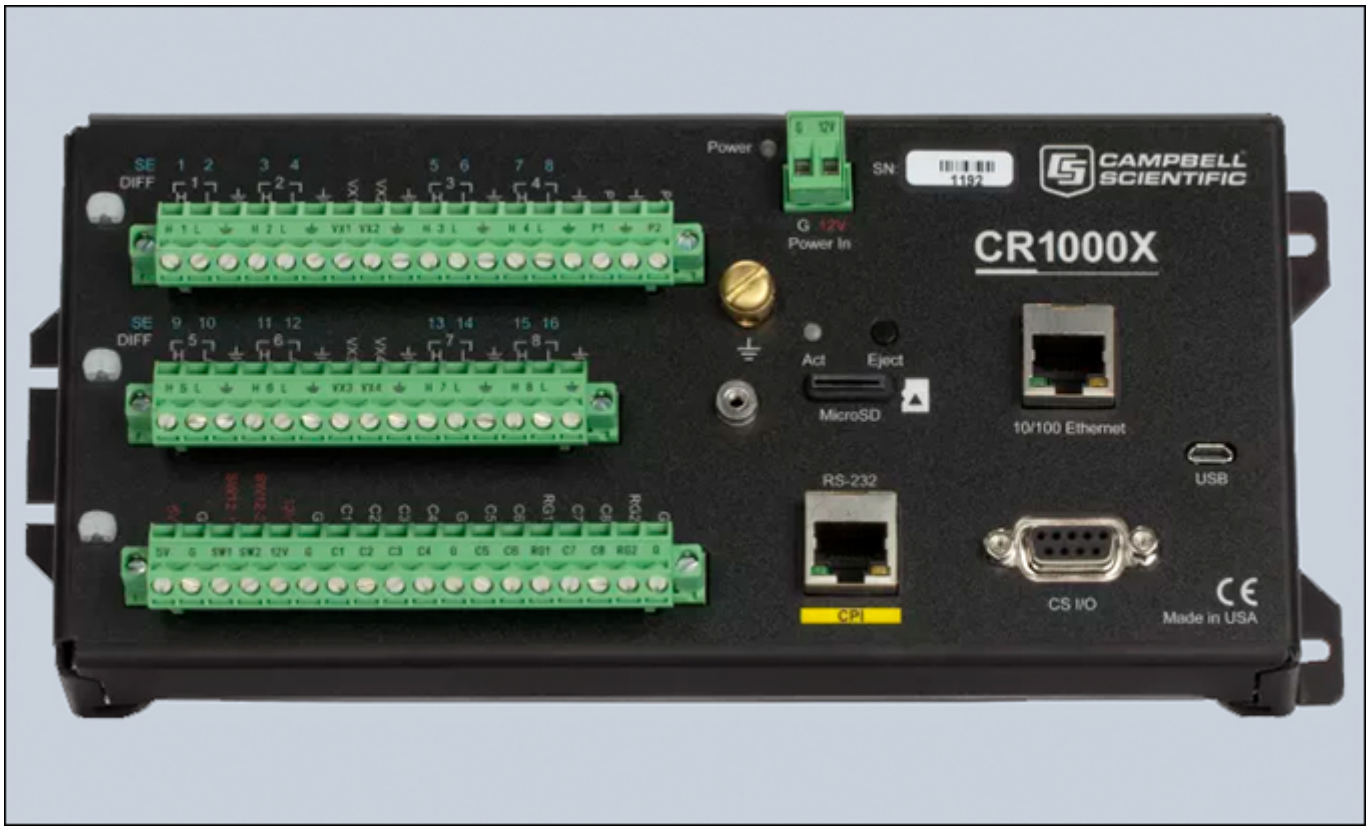
Datalogger CR1000X(e)



This chapter 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(e) datalogger is the programmable heart of a ZooCADA-Life 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 the section "Setting up Communications with the Datalogger" in the CR1000X(e) Product Manual, which can be downloaded from the Campbell Scientific web site, for full information on set up procedures.

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

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

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

The datalogger can obtain a dynamic IP address from the DHCP server on the LAN but we strongly recommend that it be configured with a static IP address 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 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, fifteen 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.

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 - Humidifier On.

When the humidifier 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.

SE10 - 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.

SE11 - 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.

SE12 - 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.

SE13 - Lighting LX1SUP.

When the lighting switch is in the LX1SUP position this input will receive 2400 mV pulses.

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

SE14 - Lighting Bump Switch.

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

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

SE15 - Spare.

SE16 - Spare.

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 dc. 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 two seconds so VX1 will produce one brief excitation pulse every two seconds.

VX2 - Lighting LX1A.

This port is switched between 0 Vdc (OFF) and 5 Vdc (ON) and is used via a relay driver module to control a 12 Vdc relay. The relay driver module boosts the 5 Vdc up to 12 Vdc with a higher current suitable to operate a 12 Vdc relay, essentially doing the same thing as each channel of the SDM-CD8S.

This circuit switches on when the fade time FADE_TIME_MINS set in the STATION_CONSTANTS file has elapsed, the same time that dimmable grow lights on LX1 circuit would reach maximum intensity. This function enables non-dim grow lights to be distributed across the LX1 and LX1A circuits, with the two circuits switching on FADE_TIME_MINS apart to provide a less harsh transition from the moonlight scene to the sunlight (grow lights) scene.

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 and SDM-AO4A output modules 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 and SDM-AO4A modules. The cables connecting the datalogger to the SDM modules 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 two SDM modules are used with the SDM-CD8S set to address "0" and the SDM-AO4A set to address "2".

C4 - Spare.

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.

The SDI-12 bus on control port C5 is used for the sensors that are permanently installed for the enclosure air temperature and relative humidity and, if installed, the external (outside) air temperature, relative humidity, and barometric pressure.

The address allocations normally used as standard by the ZooCADA system are:

Address 0 - Outside air temperature and relative humidity, or ClimaVue50 weather sensor.

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 logs the measurements from each of the sensors. If two enclosures are installed, both of the enclosure temperature & RH sensors are averaged to provide an optimum measurement of the enclosure air temperature and relative humidity for HVAC control.

When two enclosures are installed, if one of the temperature & RH 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.

C6 - 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 be at 5000 mV dc.

C7 - SDI-12 Data Bus (Soil Moisture 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 soil moisture sensors that are permanently installed in the enclosure soil to monitor the soil volumetric water content and soil temperature.

The address allocations normally used as standard by the ZooCADA system are:

Address "a" - Enclosure 1 soil moisture and temperature.

Address "b" - Enclosure 2 soil moisture and temperature.

The datalogger program normally measures and logs the measurements from each of the sensors.

C8 - 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 be at 5000 mV dc.

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.

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 currently 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(e) 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, and is the main power to the system. Unplugging this connector will power down the datalogger, the SDM-CD8S and SDM-AO4A modules 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 and SDM-AO4A modules, 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 ⏚ are analog ground for single ended analog inputs, excitation returns, and sensor shield wires. Do not connect power ground wires to the analog ground. In this system all analogue ground circuits are GREEN wires.

IMPORTANT: Cables from the datalogger to the sensors do not usually comply with the above wire colour code. Always check the sensor manual for the correct wire colours.

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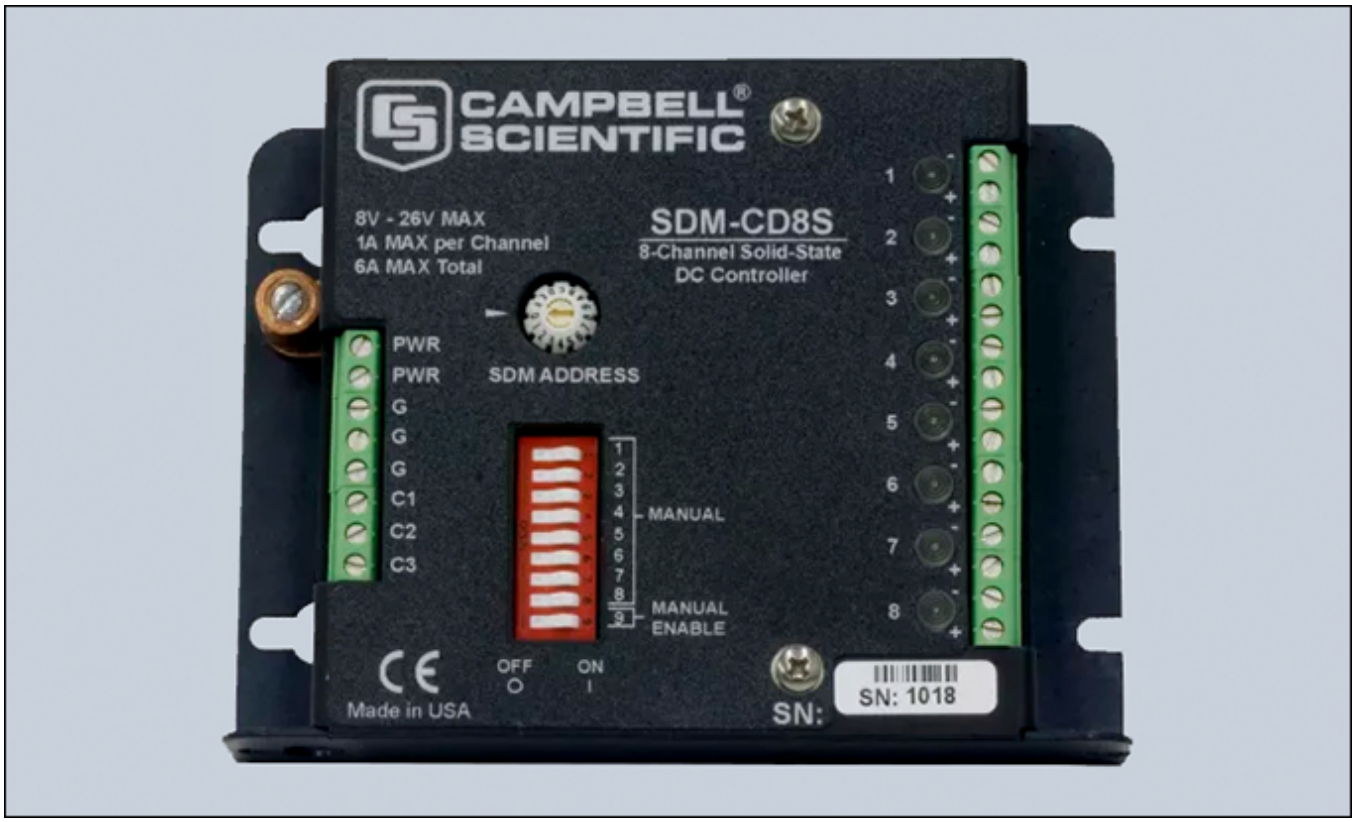
Output Module SDM-CD8S



This chapter 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.

Connections to Relays

The seven 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 Relay 1 Control (A/C ON-OFF or A/C Cooling ON-OFF).

When station constant AC_RELAY_ALT = False

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

Channel 3 selects the A/C to its heating or cooling cycle in this operating mode.

When station constant AC_RELAY_ALT = True

ON to run the air conditioning system in cooling mode. OFF at all other times.

Channel 3 - A/C Relay 2 Control (A/C Heating-Cooling Selector or A/C Heating ON-OFF).

When station constant AC_RELAY_ALT = False

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

Channel 2 switches the A/C ON and OFF in this operating mode.

When station constant AC_RELAY_ALT = True

ON to run the air conditioning system in heating mode. OFF at all other times.

Channel 4 - Dehumidifier.

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

Channel 5 - Humidifier.

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

Channel 6 - Lighting Circuit LX1.

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

Channel 7 - Lighting Circuit LX2.

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

Channel 8 - Lighting Circuit LX3.

ON when the lighting circuit LX3 is switched on. OFF when the lighting circuit LX3 is switched off.

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.

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-Life systems is "0".

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

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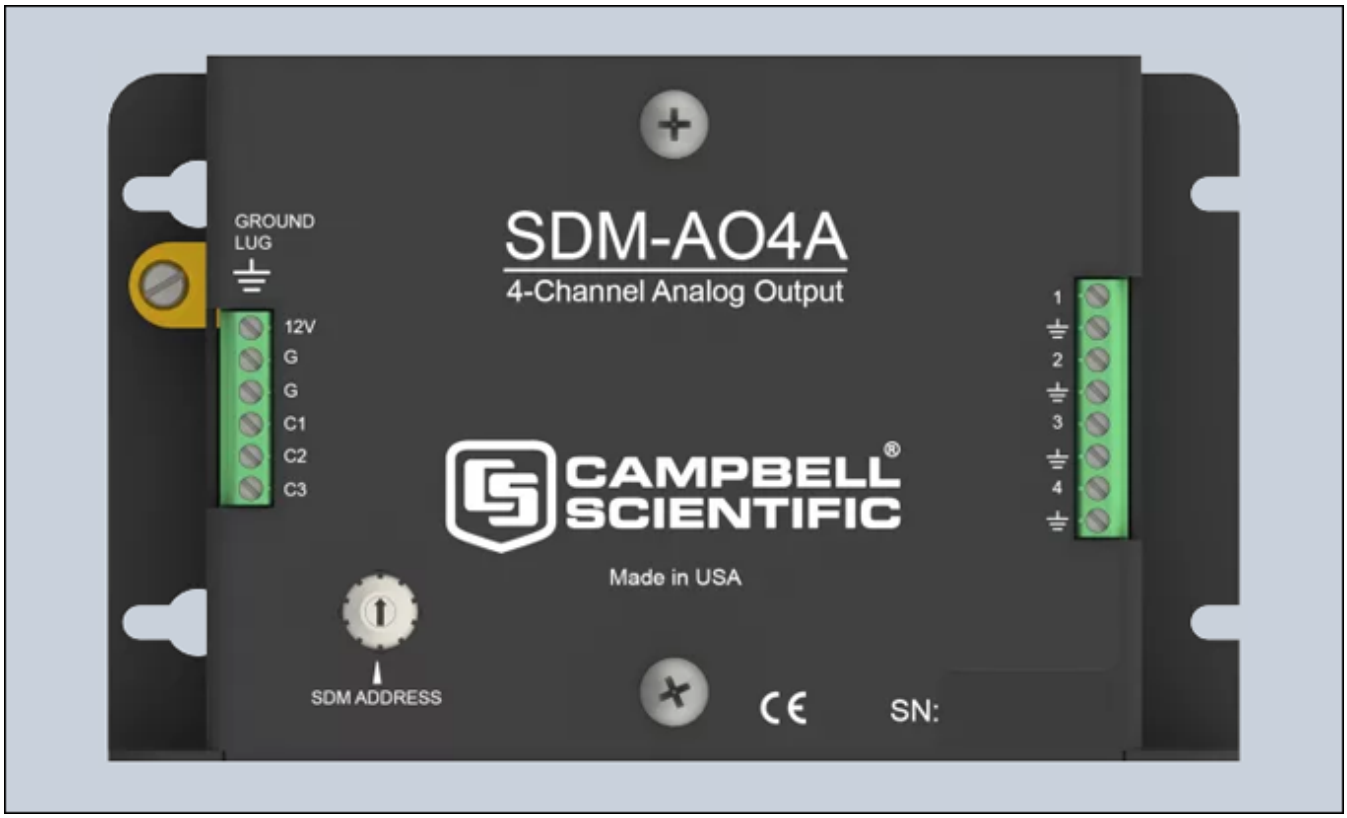
Output Module SDM-AO4A



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

The SDM-AO4A output module links the datalogger to the lighting PWM dimmers in the switchboard. It provides four analogue output voltage channels with 16Bit resolution, and an address selector switch. The datalogger program determines whether the SDM-AO4 operates in +/- 5V mode or 0-10V mode. ZooCADA-Life always uses the 0-10V mode for dimmers controlled by an analogue voltage between 0V (lights OFF) and 10V (lights fully ON).

The datalogger uses a data bus to send the desired numeric value for each output channel, in millivolts, from the datalogger program to the output module. First, the datalogger sends an 8 bit address to select the output module, then it sends the values for the voltage each output is to produce. The output signal can take up to 1 ms to settle (worst case with a 10V step change) and the four outputs then update 1 ms apart with the analogue outputs being set sequentially.

The analogue outputs can source or sink the 0-10V control signal for dimmer control signals up to the rated current limits specified in the SDM-AO4A Product manual, which is a maximum of 50mA per output with a maximum of 100mA in total for all four outputs combined.

Analogue Lighting Control Standards

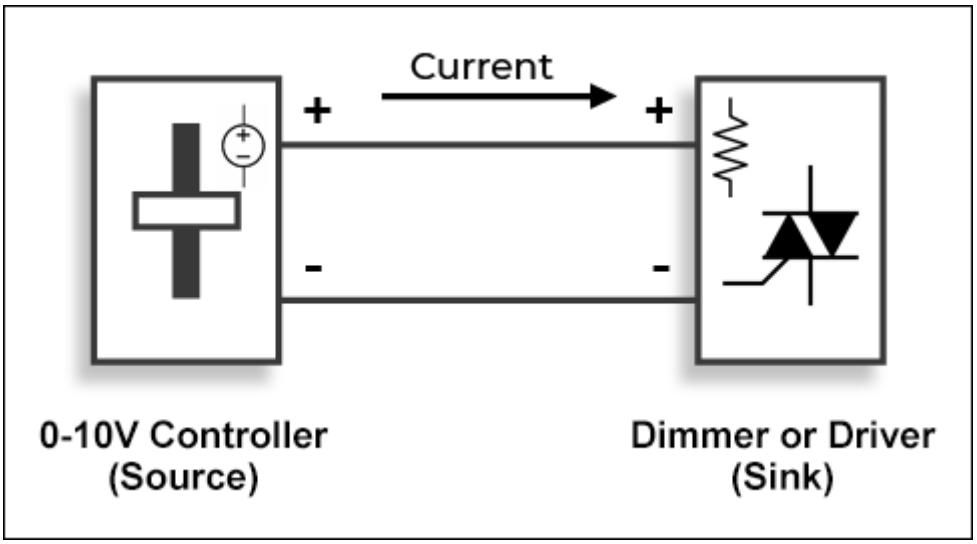
There are two different 0-10V control standards in common use. These two standards are very different so dimmers or drivers conforming to each standard operate differently. In both systems the lighting will be at maximum intensity when the control voltage at the dimmer or driver input is at 10V and at minimum when the control voltage is at 0V.

The difference between the two standards is that the current in the control circuit flows in opposite directions.

The SDM-AO4A can be used with either type of dimmer or driver but the two types must not be mixed.

ESTA (ANSI) Standard E1.3

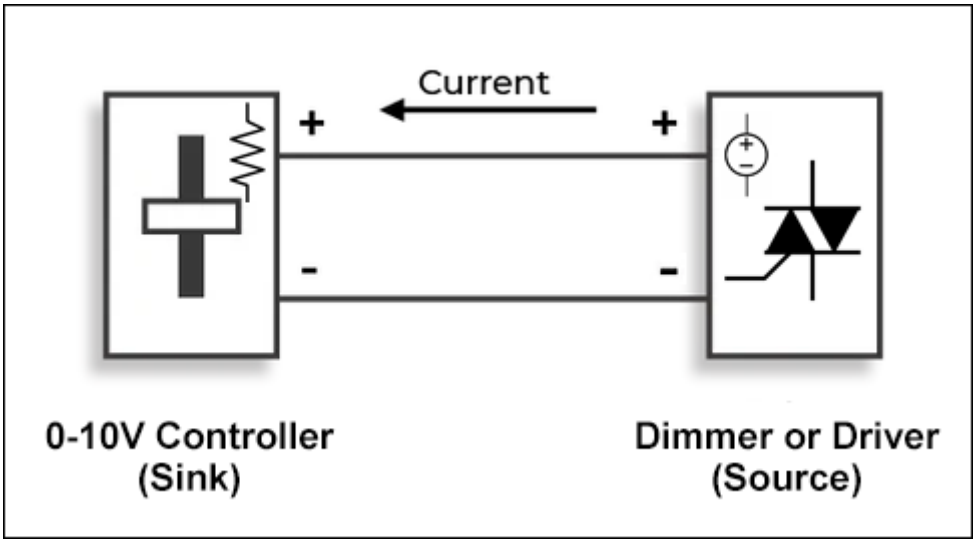
This standard defines the operation of current sourcing control systems where the control system supplies the 0-10V control signal to the dimmers. It was most commonly used in theatre lighting systems. In this system the control current flows from the controller to the dimmer or driver. Maximum current flow will occur when the control voltage is set to 10V (lights set to fully ON).



ESTA E1.3 specifies that controllers must be able to source a minimum of 2 mA., It further specifies that dimmers or drivers must have a nominal input impedance of 100K Ohms. This means that a fully compliant dimmer should only draw only about 0.1 mA from the controller when the control voltage is set at 10V which allows several dimmers or drivers to be connected to a single controller channel.

IEC Standard 60929 Annex E

This standard defines the operation of current sinking control systems where the dimmer or driver supplies the 0-10V control signal which is then regulated by the controller. It was most commonly used in dimming ballasts for fluorescent lighting and is now the most common standard used for LED drivers. In this system the control current flows from the dimmer or driver to the controller. Maximum current flow will occur when the control voltage is set to 0V (lights set to OFF).



IEC 60929 Annex E specifies that the control current must not exceed 2 mA. Given that most LED drivers only require a fraction of that current, several LED drivers can usually be connected to a single controller channel.

To determine the current sink requirements of a group of LED drivers that will all be connected to the same controller channel, it is necessary to measure the current required to sink each LED driver's 10V to zero, then add the measurement from each LED driver together.

For example, if 24 LED grow light fixtures are needed and the control current of each fixture is 0.25mA then:

24 x 0.25mA = 6mA

The total current of 6mA is within the specifications for the SDM-AO4A so it is safe to connect them.

WARNING: Never assume that dimmers and LED drivers comply with these standards. Serious damage may occur if non-compliant equipment is connected. Prior to connecting a dimmer to the SDM-AO4A, use a bench power supply to apply a 0-10V dc control voltage to the dimmers 0-10V input and measure the input current. Never exceed the maximum ratings of the SDM-AO4A outputs.

Connections to Datalogger

The output module receives power from the datalogger 12V supply on the 12V terminal and power ground on the G terminal, so the SDM-AO4A 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-AO4A module and these are wired to control ports C1 to C3 on the datalogger.

The wiring between the datalogger and the output modules must be kept as short as possible to minimise the risk of signal corruption and damage caused by electrical interference.

Connections to Lighting Dimmers

Each analogue output channel on the SDM-AO4A is connected to one or more PWM dimmers or LED drivers.

The control cable size must be selected to minimise any voltage drop of the 0-10V control signal between the SDM-AO4A and the dimmers. Careful consideration must also be given to equipment positioning as the cable length between the output of PWM dimmers and the LED ribbon is limited to about 5 to 15 metres depending on the LED ribbon type. It is preferable to achieve most of the cable length with the 0-10V control cable rather than with the PWM dimmer output cable.

Usually the LED ribbon that provides the moonlight scene lighting in an enclosure will only require one or two LED drivers per dimmer channel as one LED driver can supply an entire row of LED ribbon.

LED grow light fixtures usually have a dimming driver built into each fixture and each enclosure will require many grow light fixtures. This makes it vital that the control current for each fixture type is known, and proven by measuring it, before connecting the grow light fixtures to the SDM-AO4A output channel(s).

The ZooCADA-Life system allows each SDM-AO4A output channel to be soft patched to either the moonlight master fader or the sunlight (grow lights) master fader during commissioning of the control system to provide flexibility of enclosure lighting design, and easy spreading of control circuit load across the dimmers if necessary. The soft patch settings are contained in the STATION_CONSTANTS file.

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-AO4A on ZooCADA-Life systems is "2".

Do not change this setting, it must be set to address "2" at all times.

Dimmers Test Function

The ZooCADA-Life program provides a function to enable testing of the dimmer control electronics. This is achieved using the DimmersTest variable at the bottom of the Public data table.

The DimmersTest variable must be set to -1 for normal operation of the dimming system. When set to a value other than -1, the OFF position of lighting manual control switch effectively becomes the TEST position.

Setting the DimmersTest variable to any value from 0 to 10000, (0-10V) while the lighting manual control switch is selected to the OFF position, results in the SDM-AO4A module producing a voltage on all four of its outputs that is equal to the value of the DimmersTest variable in millivolts (mV). This voltage, divided by 100, is equal to the percentage of fully on for the dimmer controlled lighting load, for example 5000 mV should produce 50% of full lighting intensity, 9000 mV should produce 90% of full lighting intensity.

The test voltage is an absolute voltage that appears immediately the value is entered into the DimmersTest variable, and it completely overrides all the ZooCADA-Life program fader control functions.

This allows technicians to test the response of the SDM-AO4A module and the installation's lighting dimmers at any points on their 0-10V control voltage range.

If the SDM-AO4A produces a voltage on one or more of its output channels that is not equal to the DimmersTest value, it indicates a possible fault in the SDM-AO4A module. Similarly, if the SDM-AO4A module produces the correct output voltage but one or more dimmer channels produces a lighting level that is not at the same percentage, it indicates a possible fault in the dimmer electronics or a lighting load that is not correctly matched to the dimmer type.

Station Setpoints File

```
'*************************************************************************************************************************
'* ZooCADA-Life Exhibit Environment Control and Monitoring System                                                        *
'* Station Setpoints File For:                                                                                           *
'* Copyright 2015-2024 Adena Scientific Limited                                                                          *
'* Datalogger: Campbell Scientific CR1000X                                                                               *
'* File name: STATION_SETPOINTS_ZLIFE_R01.CR1X                                                                           *
'* Revision Date: 2024-12-06                                                                                             *
'*************************************************************************************************************************

'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_NITE = 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 = 70.0                      'Setpoint RH Lo % (Lowest RH Value)
'
'Enclosure Lighting Timing Settings.
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 supplimentary lighting (1-100)
'
'Dimmer level settings.
Const SET_LEVEL_DIM1 = 50                   'Dimmer 1 level in percent (Usually Moonlight Row 1)
Const SET_LEVEL_DIM2 = 100                  'Dimmer 2 level in percent (Usually Moonlight Row 2)
Const SET_LEVEL_DIM3 = 50                   'Dimmer 3 level in percent (Usually Moonlight Row 3)
Const SET_LEVEL_DIM4 = 100                  'Dimmer 4 level in percent (Usually Grow Lights)

'Dimmer bump level settings.
Const SET_LEVEL_BUMP1 = 100                 'Dimmer 1 bump level in percent (Usually Moonlight Row 1)
Const SET_LEVEL_BUMP2 = 0                   'Dimmer 2 bump level in percent (Usually Moonlight Row 2)
Const SET_LEVEL_BUMP3 = 100                 'Dimmer 3 bump level in percent (Usually Moonlight Row 3)
Const SET_LEVEL_BUMP4 = 0                   'Dimmer 4 bump level in percent (Usually Grow Lights)
'
EndConstTable                               'End of editable constants table

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

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 and dimmer level 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_ZLIFE_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.

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 variable.

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_NITE = 95.0
Const SET_RH_HI_DAY = 80.0
Const SET_RH_LO = 70.0
```

Decimal Values. The constant SET_RH_HI_NITE determines the highest humidity level that is desired in the enclosure during the night. The constant SET_RH_HI_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_HI_DAY setpoint or the night SET_RH_HI_NITE 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 are 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 would make the enclosure relative humidity worse.

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.

Reference Time

The time, in minutes, after midnight at which the 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 is stabilised (all dimmer fades completed) in the correct lighting 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 portion 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 scene 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 duration to full day lighting duration.

```
Const SET_SUP_PERCENT = 60
```

Decimal values. This constant is the percentage of the sunlight lighting duration which supplementary lighting, such as basking lights for reptiles or UV lights, will run when the system is running in either the DIURNAL or NOCTURNAL 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 sunlight lighting phase to approximate the hottest or brightest portion of a typical day. The TimeSupOn and TimeSupOff variables in the Public data table display the times at which the supplementary lighting switches on and off.

Lighting Dimmer Levels for Moonlight and Sunlight Scenes

The dimmer levels, as a percentage of fully on, for the preset moonlight and sunlight scenes in the enclosure.

```
Const SET_LEVEL_DIM1 = 50
Const SET_LEVEL_DIM2 = 100
Const SET_LEVEL_DIM3 = 50
Const SET_LEVEL_DIM4 = 100
```

Decimal Values. The valid range is 0 to 100 percent. At 0 the lights connected to that dimmer channel are OFF. At 100 the lights connected to that dimmer channel are fully ON. Dimmer channels controlling the moonlight (LED ribbons) are usually set quite low, often the the 30-40 percent range. Dimmer channels controlling the sunlight (LED grow lights) are usually set at 100 percent.

Each of these constants is labelled with its dimmer number, SET_LEVEL_DIM1 is dimmer 1, SET_LEVEL_DIM2 is dimmer 2, etc, and are assigned to a master, either the moonlight master or sunlight master during installation. To identify which dimmer number(s) are moonlight and which are sunlight it is necessary to look at the Public table variables where each dimmer channel number is appended with its master. For example, if the Public table variable is LevelDim1_Moon this indicates that dimmer 1 is assigned to the moonlight master, therefore the constant SET_LEVEL_DIM1 is the level setting for one of the moonlight lighting ribbons.

Lighting Dimmer Bump Levels

The dimmer bump levels, as a percentage of fully on, for increasing the enclosure light level on demand.

```
Const SET_LEVEL_BUMP1 = 90
Const SET_LEVEL_BUMP2 = 0
Const SET_LEVEL_BUMP3 = 90
Const SET_LEVEL_BUMP4 = 0
```

Decimal Values. The valid range is 0 to 100 percent. The bump levels set an increased light level that can be selected on demand with the bump switch. Normally a lighting level bump is instantaneous but, to prevent startling the animals in the enclosure, a gentler fade up by the bump master is used.

There is a bump level preset for each dimmer channel so any combination of dimmer channels can be bumped. Typically it is used to move the moonlight LED ribbon level from its normal low level to a higher level (often fully on) to provide extra light so keepers can enter the enclosure more safely during the usually very dim moonlight scene lighting. Some operators may prefer to bump in the sunlight (grow lights) at a low level instead of using the moonlight.

Each of these constants is labelled with its dimmer number, SET_LEVEL_BUMP1 is dimmer 1, SET_LEVEL_BUMP2 is dimmer 2, etc. These are all assigned to the bump master. To identify which dimmer number(s) are moonlight and which are sunlight it is necessary to look at the Public table variables where each dimmer channel number is appended with its master. For example, if the Public table variable is LevelDim1_Moon this indicates that dimmer 1 is assigned to the moonlight master, therefore the constant SET_LEVEL_BUMP1 is the bump level setting for one of the moonlight lighting ribbons.

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 Set_E00AirTC_HI and Set_E00AirTC_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 variables 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 Set_E00AirTC_HI and if ManualTC_LO is non-zero its value replaces Set_E00AirTC_LO. The Month variable changes to display MANUAL OVERRIDE and the variables Set_E00AirTC_HI and Set_E00AirTC_LO display the values that are 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 Set_E00AirTC_HI is set to 17 degrees and Set_E00AirTC_LO is set to 10 degrees, and then ManualTC_HI is set to 19 degrees, the result will be Set_E00AirTC_HI will change to 19 degrees while Set_E00AirTC_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 variables list. Use the mouse to select the variable to be edited by clicking on the value beside the variable name. This highlights the variable. Click on the variable again. This will highlight just the digits in the variable. Edit the digits to the desired new value then press the [Enter] key. The newly edited values are effective immediately and the Month variable 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 variable 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 Set_E00AirTC_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 Set_E00AirTC_HI value.

Station Constants File

```
'*****************************************************************************************************************
'* ZooCADA-Life Enclosure Environment Control & Monitoring System                                                *
'* Station Constants File For:                                                                                   *
'* Copyright 2015-2023 Adena Scientific Limited                                                                  *
'* Datalogger: Campbell Scientific CR1000X                                                                       *
'* File name: STATION_CONSTANTS_ZLIFE_R01.CR1X                                                                   *
'* Revision Date: 2025-03-18                                                                                     *
'*****************************************************************************************************************

'Declare General Station Constants.
Const ENCLOSURE As String = "NEW STATION"       'Enclosure name
Const CUSTOM_FILE = False                       'Customisation file enabled (True/False)
Const DUAL_ENCL = True                          'Dual enclosures (True/False)
Const KWH_INSTALLED = False                     'Electricity meter installed (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 AC_RELAY_ALT = False                      'A/C Relay operation. SEE MANUAL!
Const AC_LOWEST_TEMP = 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 = 30                       'Fade time in minutes for day-night crosfade
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 triger +/- From enclosure setpoints
Const ALARM_RESET = 1.0                         'Alarm temperature reset +/- From alarm setpoints
Const ALARM_PERCENT = 5.0                       'Alarm relative humidity trigger +/- from enclosure setpoints
Const ALARM_RESET_PERCENT = 1.0                 'Alarm relative humidity 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 (Usually 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
Const COMMS_PRIORITY = 2                        'Comms priority. REFER TO MANUAL!
```

```
'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, SDI-12 address (Usually "0")

'Declare Enclosure 1 Sensor Constants.
Const E01TRH_SDI_ADDR As String = "1"           'Enclosure 1 T/RH sensor, SDI-12 address (Usually "1")
Const E01SOIL_SDI_ADDR As String = "a"          'Enclosure 1 Soil sensor, SDI-12 address (Usually "a")

'Declare Enclosure 2 Sensor Constants.
Const E02TRH_SDI_ADDR As String = "2"           'Enclosure 2 T/RH sensor, SDI-12 address (Usually "2")
Const E02SOIL_SDI_ADDR As String = "b"          'Enclosure 1 Soil sensor, SDI-12 address (Usually "b")

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

'Declare Lighting Operational Mode.
Const LX_NOCTURNAL = True                       'Set lighting mode, False=Diurnal True=Nocturnal
Const LX_SUP_ENABLE = True                      'Enable supplimentary lighting (True/False)

'Declare Dimmer Channel to Master Fader Patch. 1=LX1, 2=LX2.
Const DIM1_MAST = 2                             'Dimmer 1 patch to master (Usually LX2 Moonlight Row 1)
Const DIM2_MAST = 1                             'Dimmer 2 patch to master (Usually LX2 Moonlight Row 2)
Const DIM3_MAST = 2                             'Dimmer 3 patch to master (Usually LX2 Moonlight Row 3)
Const DIM4_MAST = 1                             'Dimmer 4 patch to master (Usually LX1 Grow Lights)

'Declare Dimmer Channel "Off" Level Trim.
Const DIM1_TRIM = 1400                          'Dimmer 1 low level trim mV
Const DIM2_TRIM = 1400                          'Dimmer 2 low level trim mV
Const DIM3_TRIM = 1400                          'Dimmer 3 low level trim mV
Const DIM4_TRIM = 1400                          'Dimmer 4 low level trim mV

'Declare Lighting Relay Master Cutoff Levels.
Const LX1_CUTOFF = 1                            'Master 1 LX1 Relay cut off (Usually 0 or 1)
Const LX2_CUTOFF = 1                            'Master 2 LX2 Relay cut off (Usually 0 or 1)

'Declare Daylight Savings Function Constants (Default 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                                                  *
'*****************************************************************************************************************
```

Station Constants File

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

The station constants are stored in a separate program file named STATION_CONSTANTS_ZLIFE_R01, hereinafter simply referred to as the STATION_CONSTANTS file, so they are not overwritten whenever an updated program is uploaded to the datalogger.

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

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

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.

Enable Dual Enclosures

Flag determines if the system is to monitor a single enclosure or two enclosures.

```
Const DUAL_ENCL = -True
```

A logical value. Normally set to False so the system monitors and controls a single enclosure. When set to True the system monitors and logs data for dual (two separate) enclosures. The lighting control, HVAC control and all control timings are common to the two enclosures, except that with dual enclosures the enclosure climate sensors in the two enclosures are averaged to provide the HVAC control.

Electricity Meter Installed

Flag determines whether or not the station is monitoring two enclosures.

```
Const KWH_INSTALLED = False
```

Logical True or False. Set to True when a kWh meter is installed, otherwise set to False. Setting this flag to True instructs the program compiler to include the necessary program code for logging electricity use.

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 required 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.

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 Relay Alternative Mode

Flag determines how the two A/C relays operate.

```
Const AC_RELAY_ALT = False
```

Logical True or False. Normally False. When set to False relay 1 is A/C on-off and relay 2 is cooling-heating cycle selector. When set to True relay 1 is cooling on-off and relay 2 is heating on-off. The False setting is normally needed for heat pumps that heat and cool whereas the True setting is an alternative mode that may be needed for installations with separate cooling and heating equipment.

Air Conditioning System Lowest Cooling Temperature

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

```
Const AC_LOWEST_TEMP = 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 lighting reference time is 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 by 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 occur one hour late during daylight savings time, because they are running on standard 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 = 30
```

An integer value. Normally in the range 10 to 30. This sets the duration, in minutes, for the dimmers crossfade that controls the sunset and sunrise lighting transitions. This value is also applied to the calculation of the lighting cycle times to ensure the dimmers can complete the crossfade between the moonlight and sunlight scenes before the exhibit opens for visitors. The default is 30 minutes.

Minimum Exhibit Lighting Time

The minimum time, in minutes, that the enclosure lighting scene must operate for visitor viewing.

```
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 visitor viewing portion of the lighting cycle in the DIURNAL or NOCTURNAL modes. In DIURNAL mode the duration of the sunlight scene of the lighting cycle 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 (Temperature)

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 because 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. Similarly if the enclosure low setpoint is 10 degrees the low temperature alarm will be triggered at 6 degrees.

Alarm Reset Level (Temperature)

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

```
Const ALARM_RESET = 2
```

A decimal value. Typically about 2 degrees. The temperature alarms reset when the enclosure temperature returns to less than ALARM_RESET past the high or low temperature setpoint.

For example, if the enclosure high temperature setpoint is 16 degrees and ALARM_RESET is set to 2, the high temperature alarm will reset at 18 degrees Celsius. Similarly if the enclosure low setpoint is 10 degrees the low temperature alarm will reset at 8 degrees.

Alarm Trigger Level (Relative Humidity)

The number of percent beyond the enclosure relative humidity setpoint at which an alarm is triggered.

```
Const ALARM_PERCENT = 10
```

A decimal value. Typically about 10 percent RH. This value MUST not be less than 2.0 percent because the dehumidifier and humidifier normally cycle on and off about 2 percent either side of the the high or low setpoint. If the enclosure relative humidity either rises above the high setpoint or falls below the low setpoint by ALARM_PERCENT, it will trigger a relative humidity alarm.

For example, if the enclosure high setpoint is 80 percent and ALARM_PERCENT is set to 10, the high relative humidity alarm will be triggered at 90 percent. Similarly if the enclosure low setpoint is 50 percent the low relative humidity alarm will be triggered at 40 percent.

Alarm Reset Level (Relative Humidity)

The number of percent beyond the enclosure relative humidity at which to reset the humidity alarm.

```
Const ALARM_RESET_PERCENT = 5
```

A decimal value. Typically about 5 percent RH. The relative humidity alarms reset when the enclosure relative humidity returns to less than ALARM_RESET_PERCENT past the high or low relative humidity setpoint.

For example, if the high relative humidity setpoint is 80 percent and ALARM_RESET_PERCENT is set to 5, the high relative humidity alarm will reset at 75 percent. Similarly if the low relative humidity setpoint is 50 percent the low relative humidity alarm will reset at 45 percent.

Email Enable

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

```
Const EMAIL_ENABLE = True
```

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

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

Email Test

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

```
Const EMAIL_TEST = False
```

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

Email Resend

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

```
Const EMAIL_RESEND = 300
```

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

Email Tries

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

```
Const EMAIL_TRIES = 3
```

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

Email Daily Resend Enable

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

```
Const EMAIL_NAG = True
```

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

Email Daily Resend Time

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

```
Const EMAIL_NAG_HOUR = 8
```

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

Email Attachment File Name

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

```
Const ATTACH = ""
```

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

Email Message Recipients

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

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

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

Primary Remote Station Communications

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

```
Const EXT_TRH1_ENABLE = False
```

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

Primary Remote Station PakBus Address

The PakBus address of the primary remote station.

```
Const EXT_TRH1_PK = 91
```

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

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 a simple network with small number of dataloggers, 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 three 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.

Communications Priority

The communications priority for communications by this station.

```
Const COMMS_PRIORITY = 2
```

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

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 this station 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.

External Temperature and Relative Humidity Installed Is Primary Sensor

Flag indicates if the external air Temperature and RH sensor 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. If set to False when an external Temperature and RH sensor is installed on this station, the sensor becomes 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 communications 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. Usually set to "1" for the sensor in enclosure 1, and "2" for the sensor in enclosure 2, 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.

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 station an address must be set.

Enclosure Soil Moisture and Soil Temperature Sensors SDI-12 Addresses

The SDI-12 address for each of the two enclosure soil moisture and soil temperature sensors.

```
Const E01SOIL_SDI_ADDR = "a"
Const E01SOIL_SDI_ADDR = "a"
```

Integer values. Usually set to "a" for the sensor in enclosure 1, and "b" for the sensor in enclosure 2, with both sensors wired to port C7. May be any other valid SDI-12 address value provided the sensor is wired to port C7 and the address is unique for all sensors wired to that port.

Nocturnal / Diurnal Selection

Flag determines whether the enclosure lighting is to be on a nocturnal or diurnal cycle.

```
Const LX_NOCTURNAL = True
```

Logical True or False. Set to True to use nocturnal lighting cycle timing or set to False to use diurnal lighting cycle timing. The nocturnal cycle reverses the normal day/night cycle so the enclosure moonlight scene operates during the natural daytime and the enclosure sunlight scene (grow lights) operates during the natural nighttime.

Supplementary Lighting Enable

Flag determines whether or not the supplementary lighting is to operate.

```
Const LX_SUP_ENABLE = True
```

Logical True or False. Normally set to True. When set to True the enclosure supplementary lighting will operate during the middle portion of the sunlight (grow lights) lighting scene. When set to False the supplementary lighting does not operate. Supplementary lighting is intended for basking lights in reptile enclosures and/or UV lights for species that require supplementary UV light when kept in indoor enclosures.

Dimmers To Masters Patching

The dimmer channel assignment to the moonlight master or the sunlight master.

```
Const DIM1_MAST = 2
Const DIM2_MAST = 1
Const DIM3_MAST = 2
Const DIM4_MAST = 1
```

Integer values. Set each dimmer to either 1 for LX1 the sunlight master fader, or 2 for LX2 the moonlight master fader. Any dimmer can be selected to any master but the selections here must match the physical electrical wiring of the installation.

Dimmers Minimum Level Trim

The dimmer channel control voltage in mV when the channel faders are set to 0% (OFF).

```
Const DIM1_TRIM = 1400
Const DIM2_TRIM = 1400
Const DIM3_TRIM = 1400
Const DIM4_TRIM = 1400
```

Integer values. Set each dimmer trim to the mV value desired for the minimum level of the control voltage sent to the dimmers/lighting fixtures. The value will vary for different dimmer and lighting fixture models, and must be determined by testing the dimmer and LED ribbon combinations, or the LED lighting fixtures for fixtures with built-in dimmers, prior to installation. A value should be chosen where the LEDs are just glowing faintly when looked at directly, and where the LEDs increase in intensity smoothly as the control voltage is slowly increased.

Lighting Relay Master Cutoff Levels

The master fader level at which it's relay will switch off the power to the dimmers or lighting fixtures.

```
Const LX1_CUTOFF = 1
Const LX2_CUTOFF = 1
```

Integer values. Normally set to 0 or 1. Set each cut-off level to the master fader level percentage at which the relay is required to switch off the mains power to the dimmers or lighting fixtures on that circuit. Powering down the circuits after they have been faded down to zero ensures the dimmers or lighting fixtures are not wasting electricity when not in use if the dimmer trim level, or the minimum dim level of the lighting fixtures, leaves the lighting LEDs running at a "barely on" low level.

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.

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.

Station Sensors File

```
'*****************************************************************************************************************
'* ZooCADA-Life Enclosure Environment Control & Monitoring System                                                *
'* Station Sensors Configuration File For:                                                                       *
'* Copyright 2015-2025 Adena Scientific Limited                                                                  *
'* Datalogger: Campbell Scientific CR300 Series                                                                  *
'* File name: STATION_SENSORS_ZLIFE_R01.CR1X                                                                     *
'* Revision Date: 2025-02-03                                                                                     *
'*****************************************************************************************************************
'
'NOTE: Leave sections unchanged for Optional Sensors if not installed.
'      Temperatures must be calibrated to degrees Celsius (deg C).
'      Relative Humidity must be calibrated to percent (%)
'      Barometric pressure must be calibrated to hectopascals (hPa).


'DECLARE SENSOR VARIABLES (IF NEEDED)
'------------------------------------
'
'Leave this section empty if no sensor variables are needed.
#If Section = "SensorVars" Then
  '
  'Declare External Sensor Arrays.
  #If EXT_TRH_LOCAL = True Then                  'Compiler Directive - If local T&RH sensor installed
    Dim ExtTRHData(2)                            'External temperature & relative humidity sensor
    #If BARO_LOCAL = True Then                   'Compiler Directive - If local barometric sensor installed
      Dim ExtBaroData(3)                         'External barometric pressure sensor
    #EndIf                                       'End Compiler Directive
  #EndIf                                         'End Compiler Directive
  '
  'Declare Enclosure 1 Sensor Arrays
  Dim E01TRHData(2)                              'Enclosure 1 temperature & relative humidity sensor
  Dim E01SoilData(6)                             'Enclosure 1 soil moisture sensor
  '
  'Declare Enclosure 2 Sensor Arrays
  #If DUAL_ENCL = True Then                      'Compiler Directive - If dual enclosures enabled
    Dim E02TRHData(2)                            'Enclosure 2 temperature & relative humidity sensor
    Dim E02SoilData(6)                           'Enclosure 2 soil moisture sensor
  #EndIf                                         'End Compiler Directive
  '
#EndIf


'MEASURE EXTERNAL TEMPERATURE & RELATIVE HUMIDITY SENSOR (OPTIONAL)
'-----------------------------------------------------------------
'
#If Section = "SlowScanExtTRH" Then
  '
  'Measure Campbell Scientific HygroVue 5 SDI-12 Sensor.
  SDI12Recorder(ExtTRHData(),CS,EXT_SDI_ADDR,"M!",1,0,-1)
  '
  'Patch sensor measurement array values to program inputs.
  RawExtAirTC = ExtTRHData(1)
  RawExtAirRH = ExtTRHData(2)
  '
#EndIf


'MEASURE ENCLOSURE 1 TEMPERATURE & RELATIVE HUMIDITY SENSOR
'----------------------------------------------------------
'
#If Section = "SlowScanE01TRH" Then
  '
  'Measure Campbell Scientific HygroVue 5 SDI-12 Sensor.
  'Measurements Temperature, Relative Humidity
  SDI12Recorder(E01TRHData(),CS,E01TRH_SDI_ADDR,"M!",1,0,-1)
  '
  'Patch sensor measurement array values to program inputs.
  RawE01AirTC = E01TRHData(1)
  RawE01AirRH = E01TRHData(2)
  '
#EndIf
```

```
'MEASURE ENCLOSURE 2 TEMPERATURE & RELATIVE HUMIDITY SENSOR (OPTIONAL)
'-----------------------------------------------------------------------
'
#If Section = "SlowScanE02TRH" Then
  '
  'Measure Campbell Scientific HygroVue 5 SDI-12 Sensor.
  'Measurements Temperature, Relative Humidity
  SDI12Recorder(E02TRHData(),C5,E02TRH_SDI_ADDR,"M!",1,0,-1)
  '
  'Patch sensor measurement array values to program inputs.
  RawE02AirTC = E02TRHData(1)
  RawE02AirRH = E02TRHData(2)
  '
#EndIf


'MEASURE BAROMETRIC PRESSURE SENSOR (OPTIONAL)
'--------------------------------------------
'
#If Section = "SlowScanBaro" Then
  '
  'Measure Campbell Scientific BaroVue 10 Barometric Pressure sensor.
  SDI12Recorder(ExtBaroData(),C5,BARO_SDI_ADDR,"M!",1,0,-1)
  '
  'Patch sensor measurement array values to program inputs.
  RawBaroPres = ExtBaroData(1)
  RawBaroQM = ExtBaroData(3)
  'Set RawBaroQM=NAN if barometer model doesn't produce a QM value.
  '
#EndIf

'MEASURE ENCLOSURE 1 SOIL SENSOR
'------------------------------
'
#If Section = "SlowScanE01Soil" Then
  '
  'Measure Enclosure 1 Water Content Reflectometer Sensor on Port C1.
  'Measurements 'VWC', 'EC', 'T', 'Pm', 'Pd' & 'Vr'
  'Optionally use "M4!" instruction for probes with OS2 - see CS650 Users Manual.
  SDI12Recorder(E01SoilData(),C7,E01SOIL_SDI_ADDR,"M3!",1,0)
  '
  RawE01SoilVWC = E01SoilData(1)
  RawE01SoilEC = E01SoilData(2)
  RawE01SoilTC = E01SoilData(3)
  '
#EndIf


'MEASURE ENCLOSURE 2 SOIL SENSOR (OPTIONAL)
'-----------------------------------------
'
#If Section = "SlowScanE02Soil" Then
  '
  'Measure Enclosure 2 Water Content Reflectometer Sensor on Port C1.
  'Measurements 'VWC', 'EC', 'T', 'Pm', 'Pd' & 'Vr'
  'Optionally use "M4!" instruction for probes with OS2 - see CS650 Users Manual.
  SDI12Recorder(E02SoilData(),C7,E02SOIL_SDI_ADDR,"M3!",1,0)
  '
  RawE02SoilVWC = E02SoilData(1)
  RawE02SoilEC = E02SoilData(2)
  RawE02SoilTC = E02SoilData(3)
  '
#EndIf

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

Station Sensors File

The CRBasic code required to obtain the measurements from the station's sensors, and calibrate them into the standard units used within the ZooCADA system, is contained in a file named STATION_SENSORS_ZLIFE_R01, hereinafter simply referred to as the STATION_SENSORS file.

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

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

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

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

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

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

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

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

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Data Tables

"TOA5","ASL_TEST_RIG","CR1000X","49740","CR1000X.Std.07.02","CPU:ZOOLIFE_R01.CR1X","51942","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.

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.

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

CR1000X - The datalogger model.

49740 - The datalogger serial number.

CR1000X.Std.07.02 - The datalogger operating system version.

CPU:ZOOLIFE_R01.CR1X - Datalogger program name. Can change by sending new program.

51942 - Datalogger program signature. Changed by revising program or sending a new program.

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

Second Row

The second header row of the data table contains the field names. The default field names are 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 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 chapter 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 18th 2021.

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(e) that support multiple storage options.

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 the section "Status Table System Information" in the CR1000X(e) 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-Life 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-Life.

Station - The name of the station (Text).

BattV - Battery Voltage in Volts (Decimal).

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

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

E01AirDP - Enclosure 1 air dew point in degrees C (Decimal).

E01AirVp - Enclosure 1 air vapour pressure in kilopascals (Decimal).

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

E01SoilTC - Enclosure 1 soil temperature in degrees C (Decimal).

E01SoilVWC - Enclosure 1 soil volumetric Water Content in cubic metres per cubic metre (Decimal).

Optional Second Enclosure Display

E02AirTC - Enclosure 2 air temperature in degrees C (Decimal).

E02AirRH - Enclosure 2 air relative humidity in percent (Decimal).

E02AirDP - Enclosure 2 air dew point in degrees C (Decimal).

E02AirVp - Enclosure 2 air vapour pressure in kilopascals (Decimal).

E02AirVpd - Enclosure 2 air vapour pressure deficit in kilopascals (Decimal).

E02SoilTC - Enclosure 2 soil temperature in degrees C (Decimal).

E02SoilVWC - Enclosure 2 soil volumetric Water Content in cubic metres per cubic metre (Decimal).

End of Optional Second Enclosure Display

ExtAirTC - External (outside) air temperature in degrees Celsius (Decimal).

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

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

ExtAirVp - External (outside) air vapour pressure in kilopascals (Decimal).

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

Optional Barometric Pressure Sensor Display

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

BaroMSL - Barometric pressure, corrected to mean sea level, in hectopascals.

BaroTend - External (Outside) barometric pressure tendency and amount of change in hectopascals.

End of Optional Barometric Pressure Sensor Display

Optional Electricity Usage Display

PowerCurHr - Electricity used in enclosure(s) in current hour in kWh (Decimal).

PowerCurDay - Electricity used in enclosure(s) in current day in kWh (Decimal).

End of Optional Electricity Usage Display

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

Set_E00AirTC_HI - The current high temperature setpoint in degrees Celsius (Decimal).

Set_E00AirTC_LO - The current low temperature setpoint in degrees Celsius (Decimal).

Set_E00AirRH_HI - The current high relative humidity setpoint in percent (Decimal).

Set_E00AirRH_LO - The current low relative humidity setpoint in percent (Decimal).

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).

IMPORTANT: These times are appended with DST when daylight savings time is active.

Master_Sunlight - The current level of the LX1 (Sunlight) master fader in percent of full (Decimal).

Master_Moonlight - The current level of the LX2 (Moonlight) master fader in percent of full (Decimal).

Master_Bump - The current level of the Bump master fader in percent of full (Decimal).

LevelDim1_xxxx - The current level of the dimmer 1 fader in percent of full (Decimal).

LevelDim2_xxxx - The current level of the dimmer 2 fader in percent of full (Decimal).

LevelDim3_xxxx - The current level of the dimmer 3 fader in percent of full (Decimal).

LevelDim4_xxxx - The current level of the dimmer 4 fader in percent of full (Decimal).

IMPORTANT: Dimmers are individually assignable to either the moonlight or the sunlight master fader.

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.

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.

HumidSwitch - 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.

HumidState - 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.
- MANUAL LX1SUP - The lighting is manually switched to LX1SUP ON and will run continually.
- AUTO - The lighting is set to automatic control.
- AUTO (BUMP) - The lighting is set to automatic control and the bump switch is ON.
- OFF - The lighting is manually switched OFF and will not run.

LxMode - Lighting Operating Mode (Text).

- NOCTURNAL - System configured for Nocturnal enclosure operation.
- NOCTURNAL + SUP - System configured for Nocturnal enclosure with supplementary lighting.
- DIURNAL - System configured for Diurnal enclosure operation.
- DIURNAL + SUP - System configured for Diurnal enclosure operation with supplementary lighting.

LxState - Lighting State (Text).

- DAY - LX switched to AUTO, in Day state, Diurnal or Diurnal+Sup mode, LX1 is ON.
- DAY (Build Sup) - LX switched to AUTO, in Day Build Sup state, Diurnal+Sup mode, LX1+LX3 is ON.
- NIGHT - LX switched to AUTO, in Night state, Diurnal or Diurnal+Sup mode, LX2 is ON.
- GROW LIGHTS - LX switched to AUTO, in Dayl state, Nocturnal or Nocturnal + Sup mode, LX1 is ON.
- GROW LIGHTS (Sup) - LX switched to AUTO, in Day state, Nocturnal+Sup mode, LX1+LX3 are ON.
- MOONLIGHT - LX switched to AUTO, in Night state, Nocturnal or Nocturnal+Sup 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 LX3, LX1+LX3 are ON continuously.

E01SenState - Enclosure 1 sensors operational state (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.

Optional Second Enclosure Display

E02SenState - Enclosure 2 sensors operational state (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 Second Enclosure Display

Optional External Sensor Display 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 Display

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.

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

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

End of Optional Local Barometric Pressure Sensor

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

OK - Mains power supply s OK.

POWER FAIL - Mains power supply has failed.

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

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

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

NO ALARMS - All alarms are cleared.

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

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

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

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

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

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

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

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

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

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

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

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

INITIALISING - The communications system is starting up.

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

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

COMMS OK - Communications with the primary remote station succeeded.

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

COMMS FAIL, *code1, code2* - All attempts to contact a remote station have failed.

Communications Array

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

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

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

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

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

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

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

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

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

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

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

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

End of Communications Array

ManualTC_HI - User entry of manual override for the Set_E00AirTC_HI month setting (Decimal).

ManualTC_LO - User entry of manual override for the Set_E00AirTC_LO month setting (Decimal).

DimmersTest - Dimmers technical test function. Normally set to -1 mV. DO NOT CHANGE!

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-Life 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).

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).

FanRunCurHr - Ventilation fan accumulated run time for the past hour in minutes (Decimal).

AcRunCurHr - Air conditioning accumulated run time for the past hour in minutes (Decimal).

DhuRunCurHr - Dehumidifier accumulated run time for the past hour in minutes (Decimal).

HumRunCurHr - Humidifier 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).

FanRunCurDay - Ventilation fan accumulated run time for the past day in minutes (Decimal).

AcRunCurDay - Air conditioning accumulated run time for the past day in minutes (Decimal).

DhuRunCurDay - Dehumidifier accumulated run time for the past day in minutes (Decimal).

HumRunCurDay - Humidifier 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).

Enclosure 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) scene of the lighting cycle in hours (Decimal.

SupTime - The time the supplementary lighting was switched on (HH:MM).

LengthSup - The duration of the supplementary lighting in hours (Decimal).

Enclosure 1 Ten Minute Temperature, Relative Humidity, Dew Point, and Vapour Pressures

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 - Enclosure air temperature in degrees Celsius (Decimal).

EnAirRH - Enclosure air relative humidity in percent (Decimal).

EnAirDP - Enclosure air dew point in degrees C (Decimal).

EnAirVp - Enclosure air vapour pressure in kilopascals (Decimal).

EnAirVPD - Enclosure air vapour pressure deficit in kilopascals (Decimal).

ExAirTC - External (outside) air temperature in degrees Celsius (Decimal).

ExAirRH - External (outside) air relative humidity in percent (Decimal).

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

ExAirVp - External (outside) air vapour pressure in kilopascals (Decimal).

ExAirVPD - External (outside) air vapour pressure deficit in kilopascals (Decimal).

Enclosure 2 Ten Minute Temperature, Relative Humidity, Dew Point, and Vapour Pressures

Table Name - E02_T_RH_10M

The format of this file is the same as “Enclosure 1 - 10 Minute Temperature and Relative Humidity”.

Enclosure 1 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 air temperature in degrees Celsius (Decimal).

EnAirTC_Max - Maximum enclosure air temperature in degrees Celsius (Decimal).

EnAirTC_TMx - Time of maximum enclosure air temperature (DateTime).

EnAirTC_Min - Minimum enclosure air temperature in degrees Celsius (Decimal).

EnAirTC_TMn - Time of minimum enclosure air temperature (DateTime).

EnAirRH_Max - Maximum enclosure air relative humidity in percent (Decimal).

EnAirRH_TMx - Time of maximum enclosure air relative humidity (DateTime).

EnAirRH_Min - Minimum enclosure air relative humidity in percent (Decimal).

EnAirRH_TMn - Time of minimum enclosure air relative humidity (DateTime).

Enclosure 2 Daily Temperature and Relative Humidity Summary

Table Name - E02_T_RH_DAY

The format of this file is the same as “Enclosure 1 - Daily Minute Temperature and Relative Humidity”.

Enclosure 1 Hourly Soil Moisture and Temperature

This data table provides hourly soil moisture measurements for enclosures with a soil floor, such as nocturnal houses, to help with managing irrigation for the plants in the enclosure and maintaining appropriate soil conditions for the welfare of the animals living in the enclosure.

Table Name - E01_SOIL_60M

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

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

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

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

Enclosure 2 Hourly Soil Moisture and Temperature

Table Name - E02_SOIL_60M

The format of this file is the same as “Enclosure 1 - Hourly Soil Moisture and Temperature”.

Enclosure 1 Daily Soil Moisture and Temperature Summary

This data table provides a daily summary, logged at midnight (00:00), of the soil conditions in the enclosure over the previous day.

Table Name - E01_SOIL_DAY

TIMESTAMP - Record date and time (DateTime).

RECORD - Record number (Integer).

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

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

EnSoilTC_TMx - Time of maximum soil temperature (DateTime).

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

EnSoilTC_TMn - Time of minimum soil temperature (DateTime).

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

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

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

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

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

Enclosure 2 Daily Soil Moisture and Temperature Summary

Table Name - E02_SOIL_DAY

The format of this file is the same as “Enclosure 1 - Daily Soil Moisture and Temperature Summary”.

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 external (outside) air temperature (DateTime).

ExAirTC_Min - Minimum external (outside) air temperature for the day in Degrees Celsius (Decimal).

ExAirTC_TMn - Time of minimum external (outside) air temperature (DateTime).

ExAirRH_Max - Maximum external (outside) air relative humidity for the day in Percent (Decimal).

ExAirRH_TMx - Time of maximum external (outside) air relative humidity (DateTime).

ExAirRH_Min - Minimum external (outside) air relative humidity for the day in Degrees Celsius (Decimal).

ExAirRH_TMn - Time of minimum external (outside) air relative humidity (DateTime).

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

ExBaroMSL - Barometric pressure, corrected to Mean Sea Level, in hectopascals (Decimal).

ExAirTC - External (outside) air temperature in degrees Celsius (Decimal).

ExAirRH - External (outside) air relative humidity in percent (Decimal).

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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.

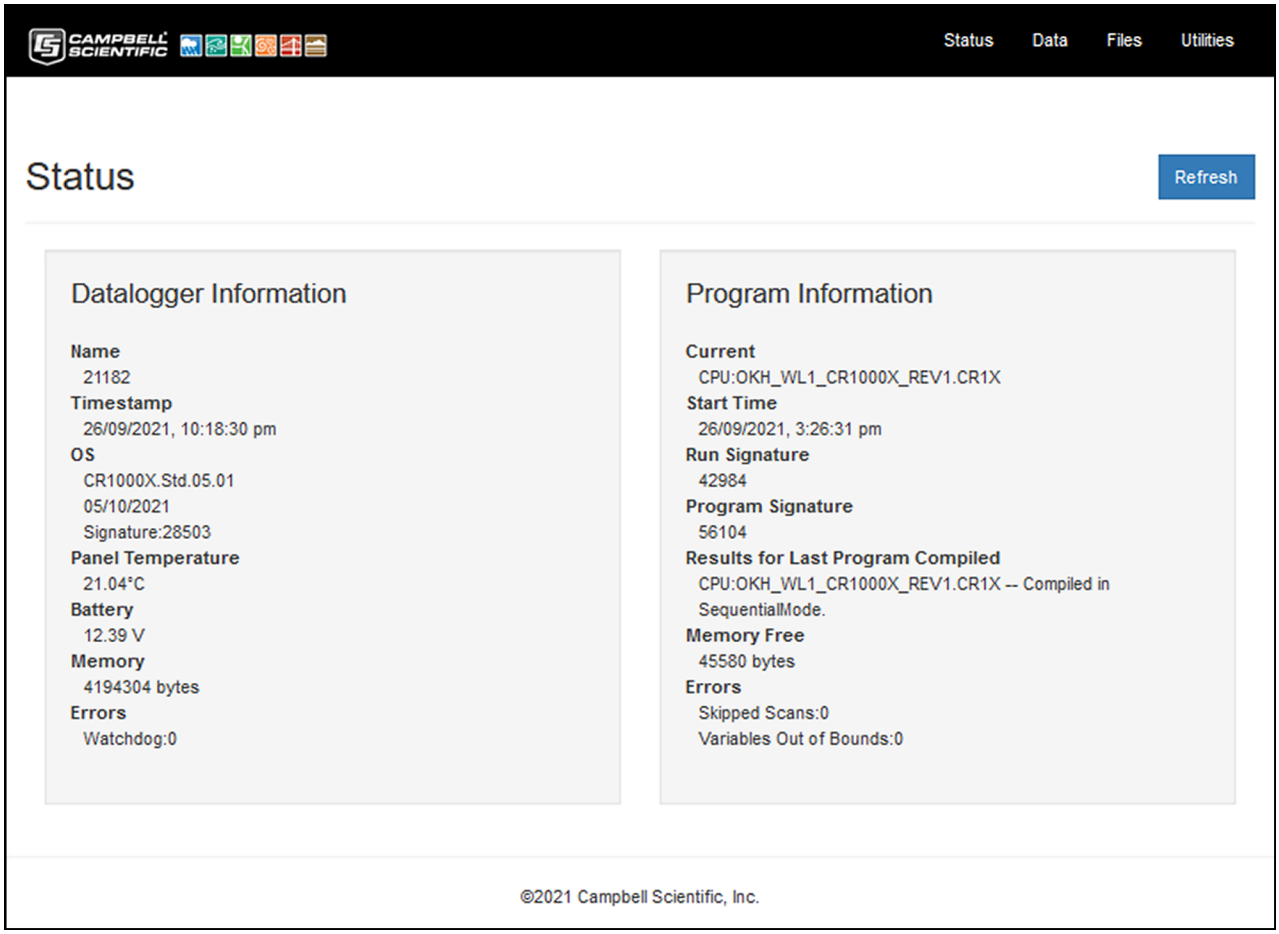
We recommend using the web interface for viewing data, and LoggerNet software for administrative tasks.

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

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

The web interface status page displays a subset of the information in the dataloggers status 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 the section "Status Table System Information" in the CR1000X(e) 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.

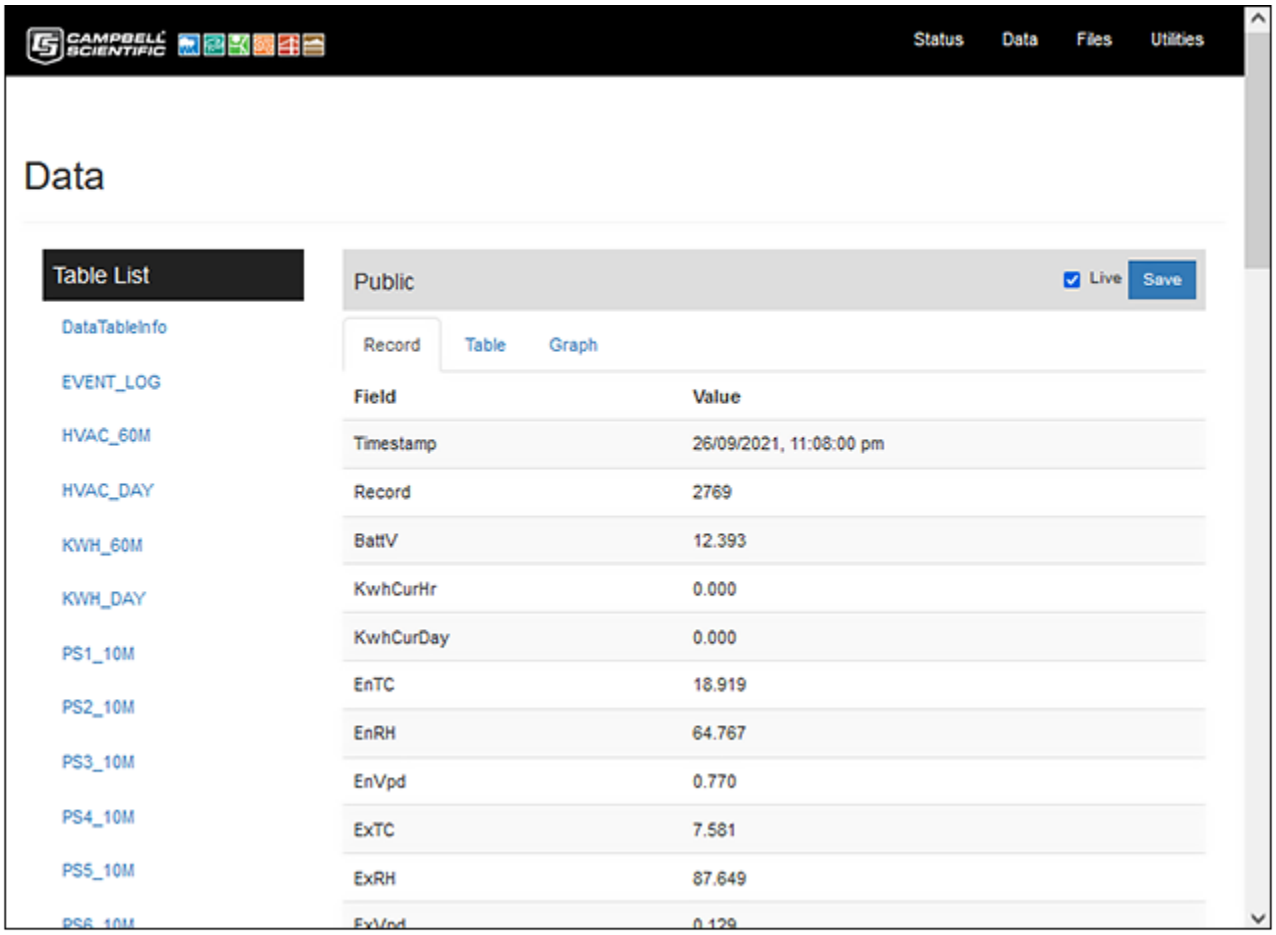
Results for Last Program Compiled - Contains messages generated at compilation or during runtime. Updated after compile and for runtime errors such as variable out of bounds.

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



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.

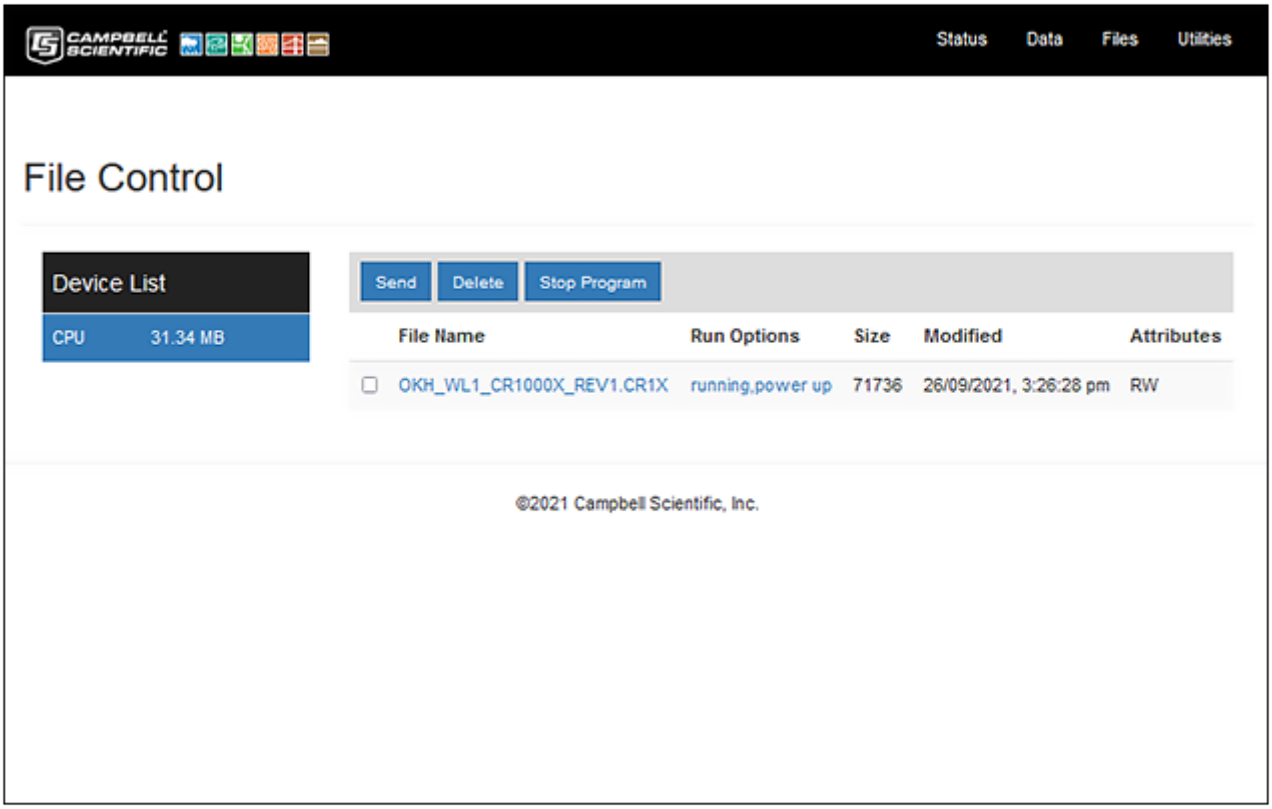
Record - Displays a scrolling list of Fields in current record of the table with the Value displayed next to it.

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 variables, select the desired variable 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.

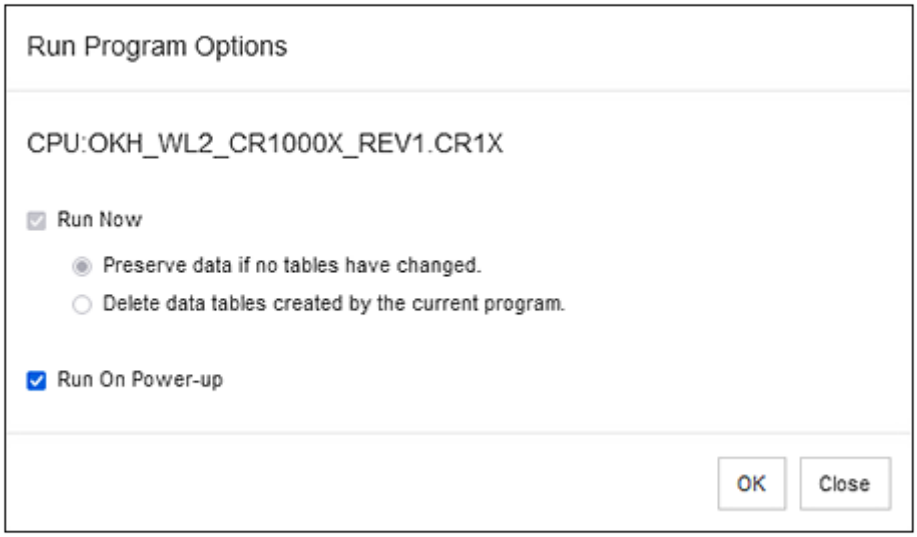
File Name Click

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

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

Run Options Click

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



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

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

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

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

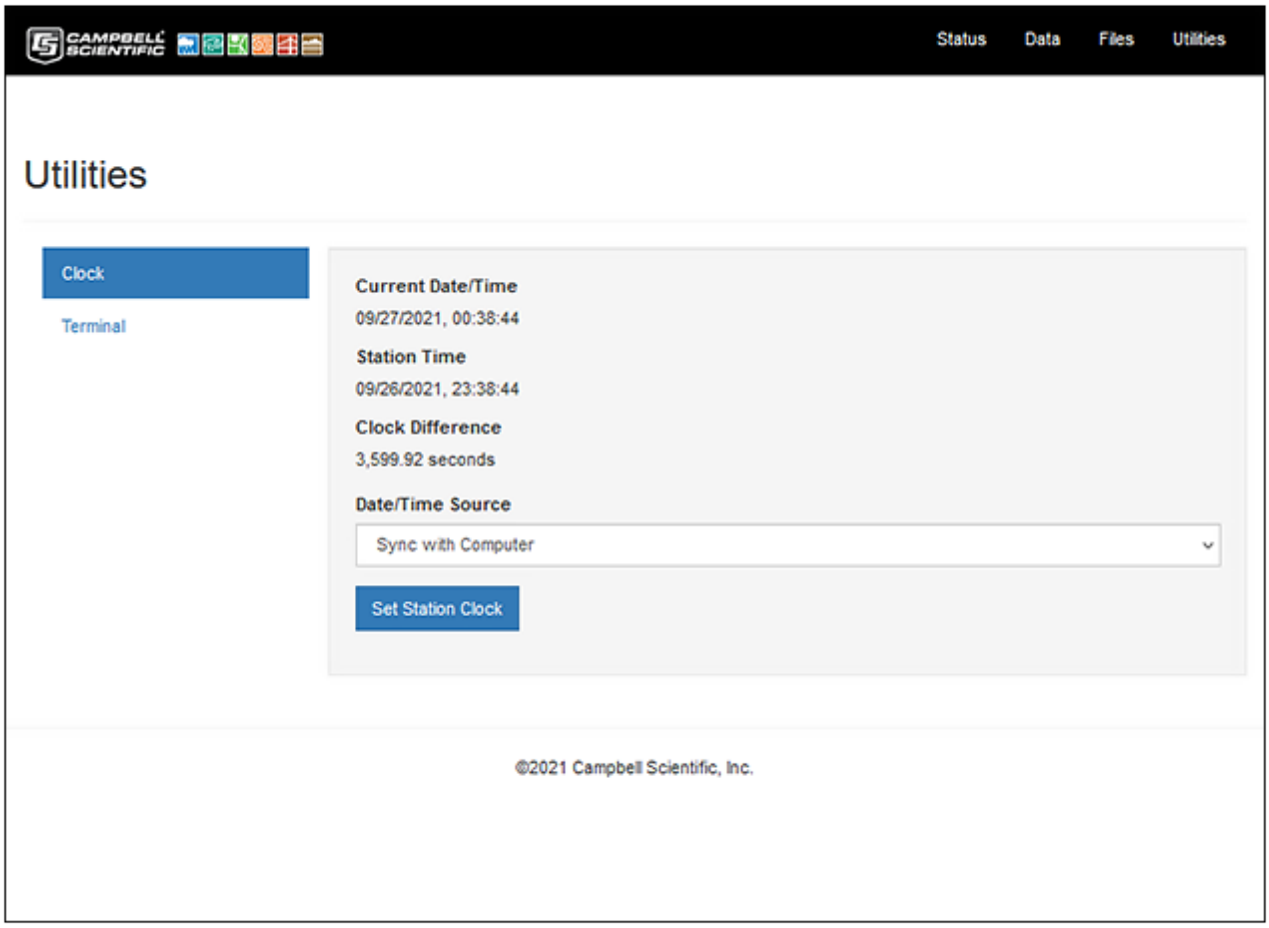
Delete data tables created by the current program - The data tables will be deleted.

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

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

Utilities Page



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

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

Clock Setting

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

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

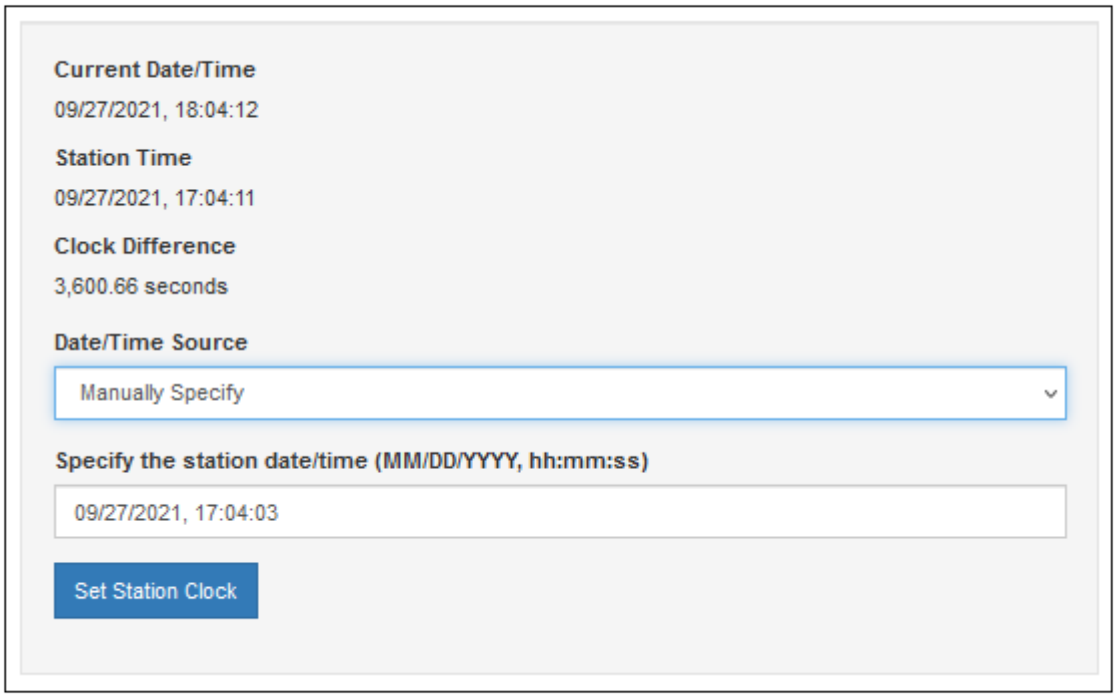
Sync With Computer - Click to set the station to the computer's time. Beware of daylight savings!

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

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

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

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



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

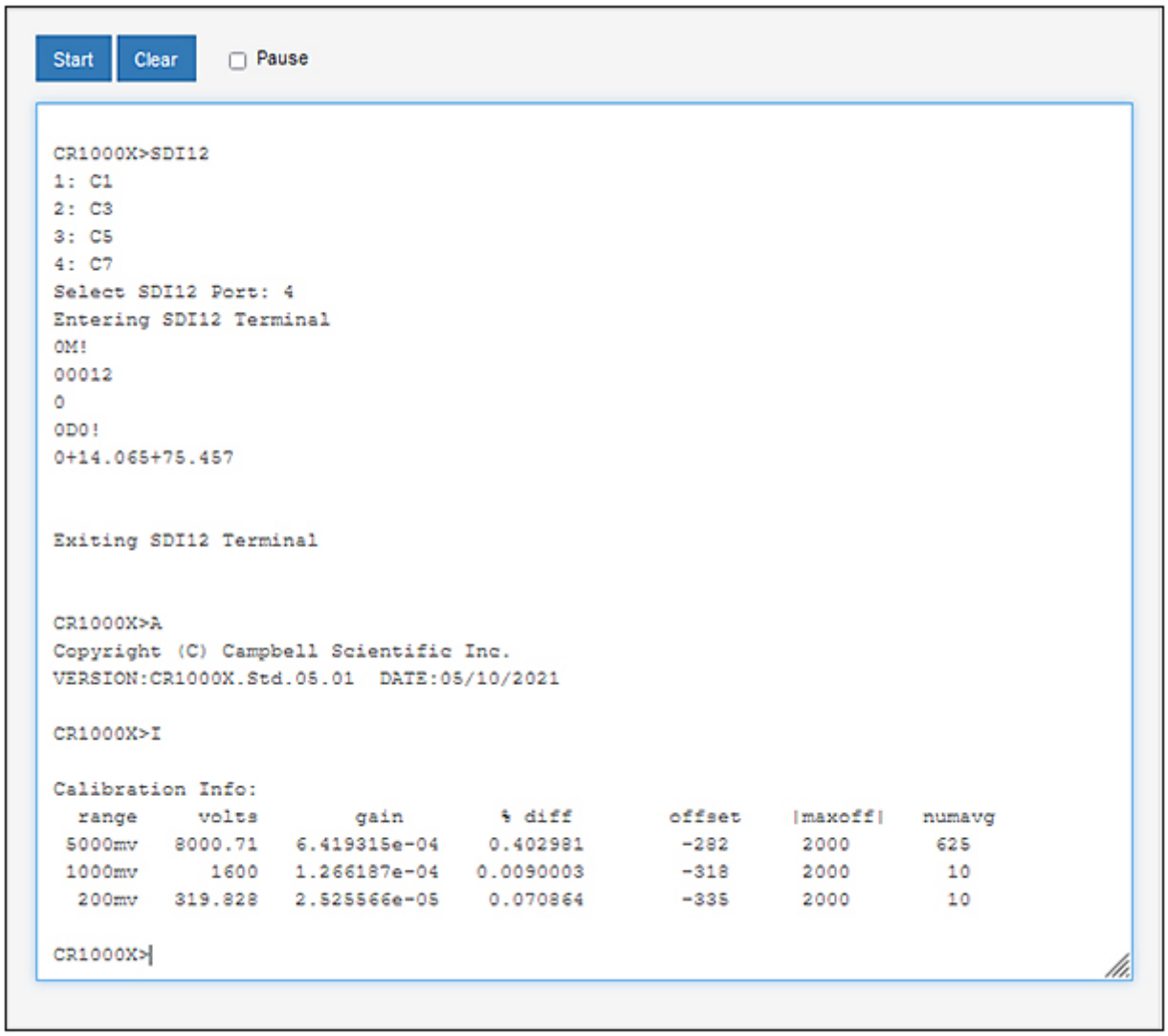
3. Click the [Set Station Clock] button. A confirmation dialog box appears.

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

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

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

Terminal



The terminal function is primarily an engineering tool. It is not necessary to use it for routine datalogger operations other than configuring SDI-12 sensors. A sample Terminal session is shown 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 0M! was issued to request the sensor initiate measurement. The 0 is the sensor SDI-12 address, M is the measurement instruction, and ! is the command terminator.

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

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

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

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

Sensor Measurements

This chapter provides information about how the datalogger program obtains the 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

A temperature and relative humidity (RH) sensor is installed in the enclosure, or each enclosure if it's a dual enclosure installation, and is wired back to the datalogger which measures the sensors once every minute. The recommended sensor type is a Campbell Scientific HygroVue 5 SDI-12 combined temperature and RH sensor.

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 temperature and RH sensor measurement values are:

T^o C greater than -40 and T^o C less than 70 and T^o 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.

The enclosure sensor state E01SensState, and E02SensState if two enclosures are installed, 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, 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.

If two enclosures are installed the measurements from both temperature and relative humidity sensors are averaged to obtain the control values for the HVAC system. The following logic is applied to error check and average the enclosure 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 average measurements from the two sensors is determined using the following equation:

$$Average = (Value1 + Value\,2) \div 2$$

The enclosure temperature and relative humidity values, either from enclosure 1 when a single enclosure is installed, of the average of the enclosure 1 and enclosure 2 values when two enclosures are installed, are used to determine the control states, E00TcState and E00RhState that are used to control the HVAC system. These two states are displayed in the Public data table.

The measurement values for the temperature E01AirTC and relative humidity E01AirRH, for enclosure 1, along with the temperature E02AirTC and relative humidity E02AirRH for enclosure 2 if two enclosures are installed, 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-HVAC requires external air temperature and RH measurements for the HVAC control system.

An external sensor installed on the local station is required when ZooCADA-HVAC is configured as a standalone station, or when it is configured to operate as a primary or secondary external sensor data provider to other networked stations. The recommended sensor type is a Campbell Scientific HygroVue 5 SDI-12 combined temperature and relative humidity sensor 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 external sensor measurement values which the local station then obtains via network communications every three 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 temperature and RH sensor measurement values are:

T^{o} C greater than -40 and T^{o} C less than 70 and T^{o} 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 variables 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.

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:

$$Average = (Value1 + Value\,2) \div 2$$

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.

Electricity kWh Meter Measurement (Optional)

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 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 variables after restarting the datalogger.

When commencing maintenance, write down the kWh reading from the meter, and the PowerCurDay and PowerCurHr values from the variables 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 variables in the datalogger Public data table using the LoggerNet software or the Web Interface.

Vapour Pressure Measurements

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

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

The RH is determined using the following equation:

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

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

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.

Dew Point Temperature Measurements

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

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

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

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

Soil Moisture and Temperature Measurements

A Campbell Scientific CS650 soil moisture reflectometer is used to measure the soil volumetric water content, the bulk electrical conductivity, and the soil temperature. This sensor comprises of an epoxy block that contains the electronics and holds two parallel, 300mm long, stainless steel rods that are inserted into the soil. A thermistor in the bottom of the epoxy block senses the soil temperature. Using a technique known as time domain reflectometry, the CS650 sends a signal along the stainless steel rods and measures the propagation time, signal attenuation, and temperature. Dielectric permittivity, volumetric water content, and bulk electrical conductivity are then derived from these values by the sensor's microprocessor and sent to the datalogger.

Barometric Pressure Measurements (Optional)

To display and log barometric pressure measurements, a barometric pressure sensor must be installed on the ZooCADA network. The recommended sensor type is Campbell Scientific BaroVue 10. If a barometric pressure sensor is present on the network its value is displayed in the CommsExBaro variable in the Public data table.

To enable the barometer display on a station, 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. If the barometer display is enabled the station pressure is displayed in the BaroStn variable in the Public data table and the pressure corrected to Mean Sea Level is calculated and displayed in the BaroMSL variable in the Public data table. 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.

A barometric pressure sensor must only be installed on one station on the ZooCADA network. 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.

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

The difference pressure is determined using the following equation:

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

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

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

Barometric Pressure Tendency Indication (Optional)

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

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

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

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 soil moisture sensors as follows...

Enclosure (E01) Soil Moisture & Temperature	-	Port C7 - Address "a"
Enclosure (E02) Soil Moisture & Temperature	-	Port C7 - Address "b"

Communications to Remote Stations

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

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

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

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

External Temperature and Humidity Sensor Configuration Options

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

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

Single Primary Local Sensor Only

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

The station constants settings are:

EXT_TRH_LOCAL = True

EXT_TRH_PRIMARY = True

Primary Local Sensor with a Remote Sensor

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

The station constants settings are:

EXT_TRH_LOCAL = True

EXT_TRH_PRIMARY = True

Secondary Local Sensor with a Remote Sensor

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

The station constants settings are:

EXT_TRH_LOCAL = True

EXT_TRH_PRIMARY = False

Single Remote Sensor Only

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

The station constants settings are:

EXT_TRH_LOCAL = False

EXT_TRH_PRIMARY = False

Two Remote Sensors

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

The station constants settings are:

EXT_TRH_LOCAL = False

EXT_TRH_PRIMARY = False

The Communications Array

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

Communications array values are:

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

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

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

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

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

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

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

CommsExRainDay - Rainfall daily total in mm (Decimal).

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

CommsExWindDir - Wind vector direction in degrees (Int).

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

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

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

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

Remote Station Communication Configuration Options

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

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

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

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

Primary Remote Station

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

The station constants settings are:

EXT_TRH1_ENABLE = True

EXT_TRH1_PK = 82

EXT_TRH1_IP = 192.168.1.82

To disable the primary remote station, set:

EXT_TRH1_ENABLE = False

Secondary Remote Station

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

The station constants settings are:

EXT_TRH2_ENABLE = True

EXT_TRH2_PK = 92

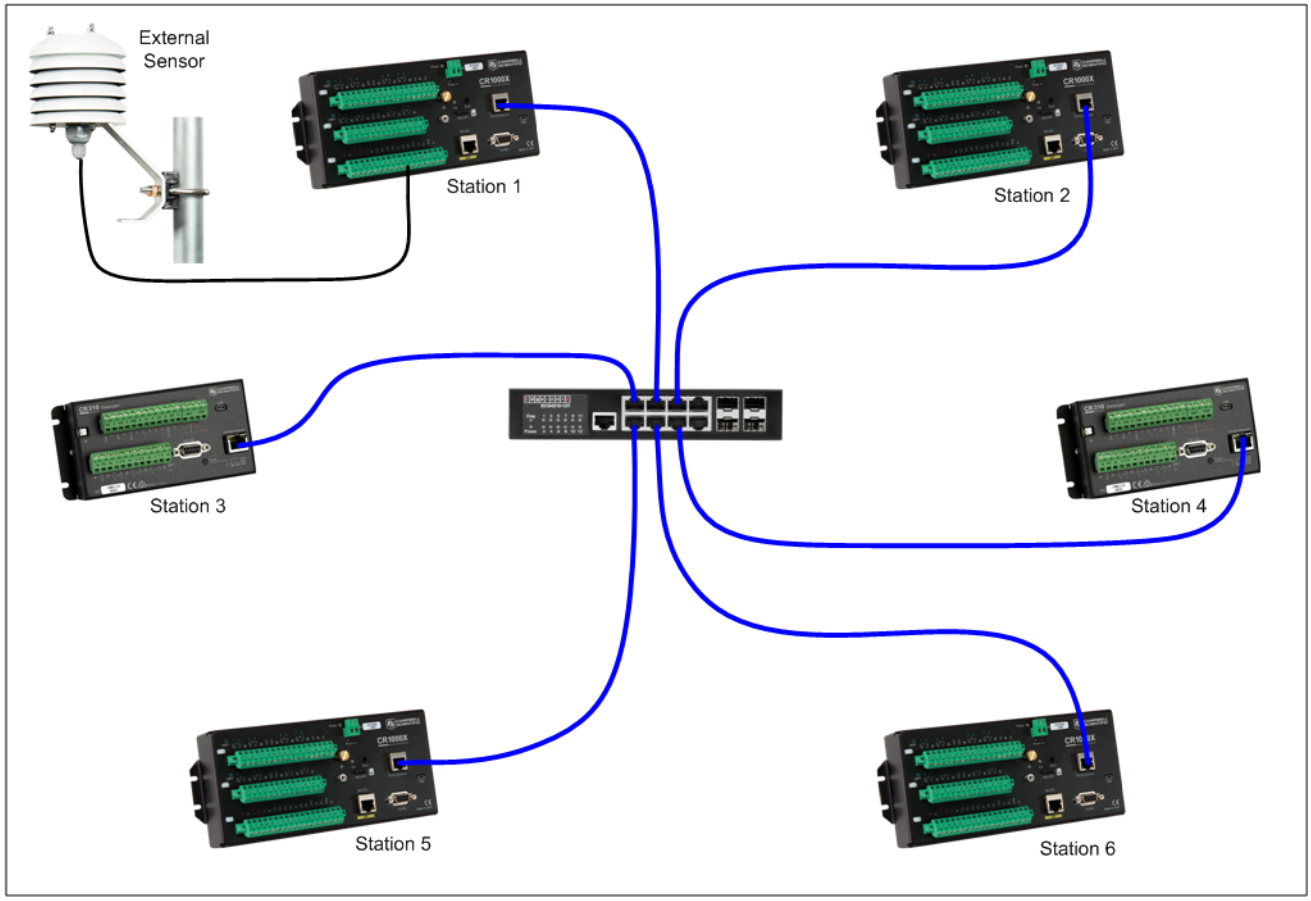
EXT_TRH2_IP = 192.168.1.92

To disable the secondary remote station, set:

EXT_TRH2_ENABLE = False

Small Network Example

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



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

Station 1

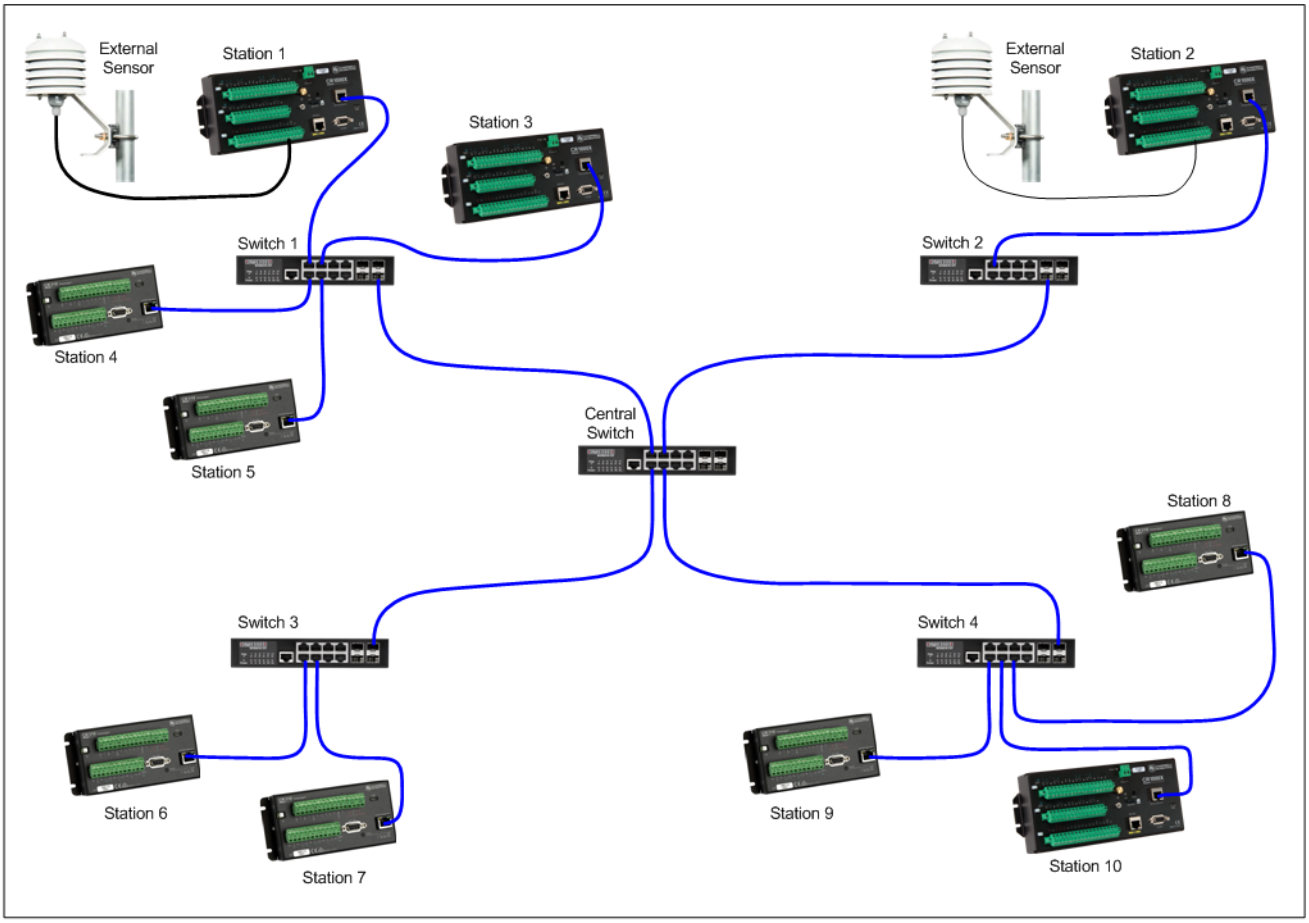
EXT_TRH_LOCAL = True
EXT_TRH_PRIMARY = True
EXT_TRH1_ENABLE = False
EXT_TRH1_PK = 1 (ignored)
EXT_TRH1_IP = 192.168.1.1 (ignored)
EXT_TRH2_ENABLE = False
EXT_TRH2_PK = 2 (ignored)
EXT_TRH2_IP = 192.168.1.2 (ignored)

All Other Stations

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

Large Network Example

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



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

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

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

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

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

Station 1

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

Station 2

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

Stations 3, 4 and 5

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

Stations 6 and 8

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

Station 7

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

Stations 9 and 10

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

Communications States

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

The possible communication states are:

COMMS ATTEMPT X - Attempting to contact a remote station.

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

COMMS OK - Primary remote station contacted successfully.

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

COMMS SEC OK - Secondary remote station contacted successfully.

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

COMMS FAIL, *code1, code*2 - Communications failure, remote stations cannot be contacted.

This state is displayed when communications to the remote station(s) has been unsuccessful and the maximum number of retries has been reached. This state triggers a Comms Failure alarm and is written to the Event Log.

The COMMS FAIL message is followed by two error codes, *code1* and *code2*. The first, code1, is for communications to the primary remote station and the second, code2, is for communications to the secondary remote station. These codes point to failures of, or incompatibilities between, the station program requesting data and/or the station program providing the data, or possible network problems.

The codes that can be returned are as follows:

- -1 - A response was received but permission denied.
- -16 - The table name and/or field name is not present in the source datalogger, or the field is read only in the destination datalogger.
- -17 - The data type is not supported.
- -18 - The array in the source datalogger is not dimensioned large enough to hold the values to be sent or the array in the destination datalogger is not large enough to receive them.
- -20 - Out of Comms memory.
- -21 - Failed to route the packet when routing is set to auto-discover and the route isn't yet known.
- -22 - Communication port buffer exceeded.
- -27 - The DialSequence/EndDialSequence returned False so communication did not occur.
- -99 - The the remote station could not be contacted.
- 1, 2...n - A positive number is the number of timeouts while waiting for a response. The value increments with each successive failure. After a 0 or negative response, the value will reset and start over at 1.

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.

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.

Functional States

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

Enclosure Air Temperature State

The enclosure temperature state is displayed in the Public data table E00TcState variable. This state is derived from temperature measurements from the enclosure sensor, or the average from the enclosure 1 and enclosure 2 sensors if two enclosures are installed, to provide the enclosure temperature state 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 E00RhState variable. This state is derived from relative humidity measurements from the enclosure sensor, or the average from the enclosure 1 and enclosure 2 sensors if two enclosures are installed, to provide the enclosure RH state 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 ExtTcState variable. 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.

External Air Relative Humidity State

The external relative humidity state is displayed in the Public data table ExtRhState variable. This state is used by the HVAC control system to control the ventilation fan, dehumidifier and humidifier to manage the enclosure relative humidity within the range set in the STATION_SETPOINTS file and prevent the ventilation fan from running when drawing in external air for ventilation would result in the air conditioning, dehumidifier or humidifier 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 than the enclosure air relative humidity.

OK - The external air relative humidity is close to the upper or lower relative humidity setpoint.

BETTER - The external air relative humidity is comfortably within the upper and lower setpoint range.

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 FanSwitch variable. 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 FanState variable. The ventilation system is designed to increase and decrease the enclosure temperature so that the enclosure temperature follows the diurnal external temperate 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.

Air Conditioning Switch State

The current air conditioning switch state is displayed in the Public data table AcSwitch variable. 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 AcState variable. 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.

Humidity Switch State

The current humidity control switch state is displayed in the Public data table HumidSwitch variable. This setting determines whether the humidifier and dehumidifier are set to run automatically, continuously, or not at all.

The possible humidity control switch states are:

MANUAL DEC - The dehumidifier is manually switched ON and will run continually to reduce the humidity.

MANUAL INC - The humidifier is manually switched ON and will run continually to increase the humidity.

AUTO - The humidity control system is set to automatic control.

OFF - The humidity control system is manually switched OFF and will not run.

Humidity Control System State

The humidity control system state is displayed in the Public data table HumidState variable. The humidity control system is designed to reduce or increase the enclosure relative humidity to keep it within the Set_E00AirRH_HI and Set_E00AirRH_LO setpoints.

The possible humidity control system states are:

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

RUN MANUAL INC - The humidifier was started manually by staff and will run continually.

RUN DEC - The dehumidifier was started automatically to reduce the enclosure relative humidity.

RUN INC - The humidifier was started automatically to increase 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 LxSwitch variable. 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.

MANUAL LX1SUP - The lighting is manually switched to LX1SUP ON and will run continually.

AUTO - The lighting is set to automatic control.

AUTO (BUMP) - The lighting is set to automatic control and the bump switch is ON.

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 LxMode variable. The lighting mode determines how the three lighting circuits operate during the lighting cycle and is determined by the setting of the constants LX_NOCTURNAL and LX_SUP_ENABLE in the STATION_CONSTANTS file. For details on these settings and their effect please refer to the chapters “Station Constants File” and “Automated Control - Lighting”.

The possible lighting modes are:

NOCTURNAL - System configured for Nocturnal enclosure operation.

NOCTURNAL + SUP - System configured for Nocturnal enclosure with supplementary lighting.

DIURNAL - System configured for Diurnal enclosure operation.

DIURNAL + SUP - System configured for Diurnal enclosure operation with supplementary lighting.

Lighting States

The lighting state is displayed in the Public data table LxState variable. The lighting system is designed to enable an enclosure to be configured for Nocturnal or Diurnal operation, with or without supplementary UV lights or reptile basking lights. The operational lighting states will vary depending upon the constants settings X_NOCTURNAL and LX_SUP_ENABLE in the STATION_CONSTANTS file, and the time of day.

The possible lighting states are:

DAY - LX switched to AUTO, in Day state, Diurnal or Diurnal+Sup mode, LX1 is ON.

DAY (Build Sup) - LX switched to AUTO, in Day Build Sup state, Diurnal+Sup mode, LX1+LX3 is ON.

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

GROW LIGHTS - LX switched to AUTO, in Dayl state, Nocturnal or Nocturnal + Sup mode, LX1 is ON.

GROW LIGHTS (Sup) - LX switched to AUTO, in Day state, Nocturnal+Sup mode, LX1+LX3 are ON.

MOONLIGHT - LX switched to AUTO, in Night state, Nocturnal or Nocturnal+Sup 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 LX3, LX1+LX3 are ON continuously.

Enclosure 1 Temperature and Relative Humidity Sensors State

The enclosure 1 sensor state is displayed in the Public data table E01SensState variable. A sensor failure alarm is triggered if the sensor state indicates that the temperature and/or relative humidity sensor has failed.

The possible enclosure 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.

Enclosure 2 Temperature and Relative Humidity Sensors State

The enclosure 2 sensor state is displayed in the Public data table E02SensState variable. A sensor failure alarm is triggered if the sensor state indicates that the temperature and/or relative humidity sensor has failed. This variable is only displayed when two enclosures are installed.

The possible enclosure 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.

External Temperature and Relative Humidity Sensor State (Optional)

The external sensor state is displayed in the Public data table ExtSensState variable. 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 BaroSensState variable. 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, if available, 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 (systems with QM value) are:

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

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

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

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

OK - The barometric pressure sensor is working normally.

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

Power State

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

The possible power states are:

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

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

Alarm State

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

The possible alarms states are:

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

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

NO ALARMS - All alarms are cleared.

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

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

Other State Switches

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

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Automated Control - Ventilation Fan

This chapter 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, Set_E00AirTC_HI and Set_E00AirTC_LO variables 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_NITE 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, dehumidifier or humidifier 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 chapter "Station Setpoints File" 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 Set_E00AirTC_HI and Set_E00AirTC_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.

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 Set_E00AirTC_HI is reached, or

The fan is reducing the enclosure temperature and the setpoint Set_E00AirTC_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 setpoint Set_E00AirRH_HI is reached, or

The enclosure air relative humidity setpoint Set_E00AirRH_LO 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, Set_E00AirTC_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 Set_E00AirTC_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, Set_E00AirTC_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 Set_E00AirTC_LO, at which time the ventilation fan is stopped by setting FanState to "IDLE".

Relative Humidity Considerations

The ventilation fan is prevented from running during times when the enclosure relative humidity is higher than the Set_E00AirRH_HI setpoint and the external air water vapour pressure is higher than that of the enclosure, or when the enclosure relative humidity is lower than the Set_E00AirRH_LO setpoint and external air water vapour pressure is lower than that of the enclosure which, in either case, would make the enclosure relative humidity worse if that external air was used to ventilate the enclosure.

The program uses the external and enclosure air water vapour pressures for the comparison because they are absolute measurements of the amount of water vapour in each air mass. By contrast, relative humidity is a ratio between the current water vapour pressure and the saturation (highest possible) water vapour pressure for an air mass at its current temperature, so comparing the relative humidities of two air masses that are at different temperatures would produce an erroneous result.

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 Set_E00AirTC_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.

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 FanRunCurHr field for the hourly counters and the E00_HVAC_DAY data table FanRunCurDay 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 FanSwitch variable. 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 FanState variable. The ventilation system is designed to increase and decrease the enclosure temperature so that the enclosure temperature follows the diurnal external temperate 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

This chapter 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, Set_E00AirTC_HI and Set_E00AirTC_LO variables 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 chapter "Station Setpoints File" 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 Set_E00AirTC_HI and Set_E00AirTC_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 Set_E00AirTC_HI plus TC_HYST, and

The enclosure air temperature is higher than station constant AC_LOWEST_TEMP+1, or

The enclosure air temperature is lower than Set_E00AirTC_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 Set_E00AirTC_HI minus TC_HYST, and

The enclosure air temperature is higher than Set_E00AirTC_LO plus TC_HYST.

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 Set_E00AirTC_HI becomes the active "thermostat" setting.

When the enclosure air increases to a temperature that is TC_HYST higher than Set_E00AirTC_HI and the enclosure air temperature is higher than station constant AC_LOWEST_TEMP+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 Set_E00AirTC_HI at which time the air conditioning is stopped by setting AcState to IDLE.

For example:

If Set_E00AirTC_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 AC_LOWEST_TEMP during installation. If the enclosure high setpoint Set_E00AirTC_HI is below that minimum temperature, the air conditioner will not be started until the enclosure air temperature increases to AC_LOWEST_TEMP+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 Set_E00AirTC_LO becomes the active "thermostat" setting.

When the enclosure air decreases to a temperature that is TC_HYST lower than Set_E00AirTC_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 Set_E00AirTC_LO at which time the air conditioning is stopped by setting AcState to IDLE.

For example:

If Set_E00AirTC_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.

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.

When the station constant AC_RELAY_ALT = False the relay on port 2 starts and stops the air conditioning. When the contacts are closed the air conditioning runs in cooling mode. When the contacts are open the air conditioning stops. The relay on port 3 selects the air conditioning mode. When the contacts are closed heating mode is selected. When the relay contacts are open cooling mode is selected.

When AC_RELAY_ALT = True the relay on port 2 starts and stops the air conditioning in cooling mode. When the contacts are closed the air conditioning runs cooling. When the contacts are open the air conditioning stops. The relay on port 3 starts and stops the air conditioning in heating mode. When the contacts are closed the air conditioning runs heating. When the relay contacts are open the air conditioning stops.

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 AcRunCurHr field for the hourly counters and the E00_HVAC_DAY data table AcRunCurDay 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 AcSwitch variable. 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 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 and Humidifier

This chapter provides information about how the datalogger program functions when the humidity switch is set to AUTO on the manual control panel.

When the humidity switch is set to AUTO, the datalogger program controls the dehumidifier and humidifier to control the relative humidity in the enclosure when it becomes higher or lower than the user defined setpoints.

IMPORTANT: Only dehumidifier and humidifier models that "remember" their settings when power is switched off and restart with the same settings when the power is switched back on can be used with this control system.

Humidity Setpoints

The constant SET_RH_HI_NITE determines the highest humidity level for the enclosure during the night while SET_RH_HI_DAY determines the highest humidity level for the enclosure during the day.

The constant SET_RH_LO is the lowest humidity that is desired in the enclosure.

The program selects the day SET_RH_HI_DAY setpoint or the night SET_RH_HI_NITE 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 humidifier to manage the enclosure relative humidity state which is displayed in the Public data table E00RhState variable.

Control Principles

Control of the dehumidifier is a run or stop decision based on the current relative humidity measurement in the enclosure. The selected day or night setpoint, SET_RH_HI_DAY or SET_RH_HI_NITE respectively, is displayed in the Public data table Set_E00AirRH_HI variable and used as the high relative humidity setpoint for dehumidifier control purposes.

Dehumidifier Start Conditions

The dehumidifier will start when the following conditions are met:

The humidity control 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 humidity control debounce timer is not active, and

The enclosure relative humidity is 5% lower than the selected high RH setpoint.

Control of the humidifier is a run or stop decision based on the current relative humidity measurement in the enclosure. The SET_RH_LO setpoint is displayed in the Public data table Set_E00AirRH_LO variable and used as the low relative humidity setpoint for humidifier control purposes.

Humidifier Start Conditions

The humidifier will start when the following conditions are met:

The humidity control debounce timer is not active, and

The enclosure relative humidity is greater than the selected high RH setpoint.

Humidifier Stop Conditions

The humidifier will stop when the following conditions are met:

The humidity control debounce timer is not active, and

The enclosure relative humidity is 5% lower than the selected high RH setpoint.

Humidity Control Debounce Timer

The debounce timer prevents rapid ON/OFF cycling of the dehumidifier and/or humidifier control relays in order to prevent possible damage to equipment. Rapid cycling is when a 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 30 seconds every time the dehumidifier state HumidState changes. The timer then prevents any more state changes from occurring, and therefore the dehumidifier and humidifier cannot start, or stop, until 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 Relay Port

The humidity state (HumidState) controls the setting of the SDM-CD8S control bit 4, which corresponds to output port 4.

A 12 Vdc 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 Vac control circuit for the dehumidifier contactor, which in turn switches the 230V ac mains to the dehumidifier ON and OFF.

Output Module SDM-CD8S - Humidifier Relay Port

The humidity state (HumidState) controls the setting of the SDM-CD8S control bit 5, which corresponds to output port 5.

A 12 Vdc relay in the switchboard is connected to SDM-CD8S output port 5 so that the relay is energised, which closes the relay contacts, when the port is ON. The relay contacts switch the 230 Vac 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 DhuRunCurHr field for the hourly counters and the E00_HVAC_DAY data table DhuRunCurDay field for the daily counters.

Each data table contains the counters for the ventilation fan, air conditioning, dehumidifier and the humidifier to enable easy analysis of the interaction between the four 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.

Humidifier Run Counters

The datalogger program has two counters operating in the background to monitor the amount of time the humidifier 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 HumRunCurHr field for the hourly counters and the E00_HVAC_DAY data table HumRunCurDay field for the daily counters.

Each data table contains the counters for the ventilation fan, air conditioning, dehumidifier and the humidifier to enable easy analysis of the interaction between the four 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.

Humidity Switch State

The current humidity control switch state is displayed in the Public data table HumidSwitch variable. This setting determines whether the humidifier and dehumidifier are set to run automatically, continuously, or not at all.

The possible humidity control switch states are:

MANUAL DEC - The dehumidifier is manually switched ON and will run continually to reduce the humidity.

MANUAL INC - The humidifier is manually switched ON and will run continually to increase the humidity.

AUTO - The humidity control system is set to automatic control.

OFF - The humidity control system is manually switched OFF and will not run.

Humidity Control System State

The humidity control system state is displayed in the Public data table HumidState variable. The humidity control system is designed to reduce or increase the enclosure relative humidity to keep it within the Set_E00AirRH_HI and Set_E00AirRH_LO setpoints.

The possible humidity control system states are:

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

RUN MANUAL INC - The humidifier was started manually by staff and will run continually.

RUN DEC - The dehumidifier was started automatically to reduce the enclosure relative humidity.

RUN INC - The humidifier was started automatically to increase the enclosure relative humidity.

IDLE - The dehumidifier was stopped automatically.

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

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Automated Control - Lighting

This chapter 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 operates three electrical circuits, named LX1, LX2, and LX3 using a combination of relays and dimmers to produce 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. The station constants LX_NOCTURNAL and LX_SUP_ENABLE determine whether the system operates in NOCTURNAL or DIURNAL mode and whether or not the supplementary lighting is in use.

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:

$$L = Latitude$$
$$J = Day\ of\ Year$$

$$P = asin[0.39795 \times cos(0.2163108 + 2 \times atan\{0.9671396 \times tan[0.00860 \times (J - 186)]\})]$$

$$DayLength = 1440 - (1440 \div \pi) \times acos\left(\frac{sin(0.8333 \times \pi \div 180) + sin(L \times \pi \div 180) \times sin(P)}{cos(L \times \pi \div 180) \times cos(P)}\right)$$

The night length is determined using the following equation:

$$NightLengthMinutes = 1440 - DayLengthMinutes$$

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 variables TimeSunrise, TimeSupOn, TimeSupOff, and TimeSunset. Each trigger time remains active until the next trigger 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 enclosure aligns with public visiting hours.

Diurnal Mode

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 enclosure's sunlight scene becoming shorter than public visiting hours.

The seasonal variation offset for the current day is calculated using the following formula:

$$SeasonalOffsetMins = (DayLengthMins - MIN\_EXHIBIT\_MINS) \times REF\_VARIATION$$

The diurnal trigger times are calculated using the following equation:

$$TrigMinsDay = (REF\_TIME\_MINS - FADE\_TIME\_MINS) - SeasonalOffsetMins$$

$$TrigMinsNight = TrigMinsDay + DayLengthMins$$

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 enclosure's moonlight scene becoming shorter than public visiting hours.

The seasonal variation offset for the current day is calculated using the following formula:

$$SeasonalOffsetMins = (NightLengthMins - MIN\_EXHIBIT\_MINS) \times REF\_VARIATION$$

The nocturnal trigger times are calculated using the following equation:

$$TrigMinsNight = (REF\_TIME\_MINS - FADE\_TIME\_MINS) - SeasonalOffsetMins$$

$$TrigMinsDay = TrigMinsNight + NightLengthMins$$

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 enclosure 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 DIURNAL + SUP and NOCTURNAL + SUP 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:

$$SupLengthMins = DayLengthMins \times (SUP\_PERCENT \times 0.01)$$

$$TrigMinsSupOn = TrigMinsDay + ((DayLengthMins - SupLengthMins) \div 2)$$

$$TrigMinsSupOff = TrigMinsSupOn + SupLengthMins$$

Lighting circuit LX1 is the sunlight lighting circuit and LX3 is the supplementary lighting circuit. In a reptile enclosure, LX1 would control the main reptile lights that run all day while LX3 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 to determine the active lighting state (LxState). The lighting states determine which output module ports and which master faders are activated, and thus which which lighting circuits are operating at each trigger time. Each trigger is active from the time shown in the Public data table variable 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 with the supplementary lighting disabled:

	Diurnal Mode				Nocturnal Mode			
Trigger Time	LxState	LX1	LX2	LX3 RED	LxState	LX1	LX2	LX3 RED
TimeSunrise	DAY	ON	OFF	OFF	GROW LIGHTS	ON	OFF	OFF
TimeSupOn	n/a	n/a	n/a	OFF	n/a	n/a	n/a	OFF
TimeSupOff	n/a	n/a	n/a	OFF	n/a	n/a	n/a	OFF
TimeSunset	NIGHT	OFF	ON	OFF	MOONLIGHT	OFF	ON	OFF

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 NOCTURNAL and DIURNAL modes with the supplementary lighting enabled:

	Diurnal Mode + Supplementary				Nocturnal Mode + Supplementary			
Trigger Time	LxState	LX1	LX2	LX3 RED	LxState	LX1	LX2	LX3 RED
TimeSunrise	DAY	ON	OFF	OFF	GROW LIGHTS	ON	OFF	OFF
TimeSupOn	DAY (Build Sup)	ON	OFF	ON	GROW LIGHTS (Sup)	ON	OFF	ON
TimeSupOff	DAY	ON	OFF	OFF	GROW LIGHTS	ON	OFF	OFF
TimeSunset	NIGHT	OFF	ON	OFF	MOONLIGHT	OFF	ON	OFF

Output Module SDM-CD8S - Lighting Relay Ports

The lighting state (LxState) and crossfader positions determine the state of the SDM-CD8S control bits 6, 7, and 8, which correspond to it's output ports 6, 7, and 8 respectively. A 12 Vdc relay in the switchboard is connected to each SDM-CD8S output port to switch the 230 Vac mains power to the dimmer or lighting fixtures. Each relay is energised, which closes the relay contacts, when its respective output port is ON.

When the lighting control switch on the manual control panel is set to AUTO the SDM-CD8S outputs are controlled according to the master faders level settings and LxState setting. If the LX1 master fader is at a level greater than the constant LX1_CUTOFF, the SDM-CD8S output 6 energises the LX1 relay. If the LX2 master fader is at a level greater than the constant LX2_CUTOFF, the SDM-CD8S output 7 energises the LX2 relay. Most of the time only one master fader, either sunlight LX1 or moonlight LX2, is active so only one relay is energised but during sunrise and sunset transitions both relays are energised.

The supplementary lighting circuit, LX3, is controlled by a relay connected to the SDM-CD8S output port 8. LX3 is switched ON and OFF in response to the trigger times TimeSupOn and TimeSupOff respectively. To prevent the supplementary lighting running when the LX1 sunlight (grow lights) scene is not at full intensity, the LX1 master fader must be at a level above 90% before output port 8 can energise the LX3 relay. If the LX1 master fader drops to below 90% output port 8 will deenergise the LX3 relay. The supplementary lighting circuit is designed to support non-dimmable loads such as fluorescent lamps, discharge lamps, etc, so any type of special purpose light fixtures that may be required for the supplementary function can be used.

If non-dimmable grow lights are to be used, they are switched by relays connected to the SDM-CD8S output 6 (LX1) and and an additional relay (LX1A) controlled via a relay driver module from Port VX2. The non-dimmable grow lights should be split into two circuits with about one third controlled by the LX1 relay on output port 6, and the remaining two thirds controlled by the LX1A relay. When used in this way the LX1 relay energises as soon as the LX1 master fader level is at a level greater than the constant LX1_CUTOFF as usual. The LX1A relay energises when the LX1 master fader is at 100%. This arrangement enables some of the non-dimmable grow lights to be switched on when the sunlight scene is initially triggered and the remainder of the non-dimmable grow lights to be switched on after a delay that is determined by the FADE_TIME_MINS setting in the STATION_CONSTANTS file. At the end of the sunlight scene the LX1A circuit is switched off as soon as the LX1 master fader reduces from 100% and the LX1 circuit is switched off when the LX1 master fader reaches the LX1_CUTOFF point. This technique provides less harsh transitions between moonlight and sunlight when legacy non-dimmable grow lights are being used.

The bump function is able to be activated while automatic lighting control is operating. When the bump master fader is at a level greater than the constant LX1_CUTOFF, the SDM-CD8S output 5 energises the LX1 relay and when it's at a level greater than the constant LX2_CUTOFF, the SDM-CD8S output 6 energises the LX2 relay. In this way, either the LX1 relay, the LX2 relay, or both relays are activated depending upon which dimmer channels are assigned preset levels on the bump master fader.

Output Module SDM-AO4A - Lighting 0-10V Control Ports

The SDM-AO4A analogue output module provides four 0-10V output ports which are used to control dimmers. The dimmers may be standalone LED ribbon dimmers or they may be built into lighting fixtures, such as grow lights, that have a 0-10V dimmer control input. The ZooCADA-Life control system controls the dimmers using the standard 0-10V analogue control signal irrespective of whether the dimmers are standalone single channel models, standalone multi-channel models, or built into lighting fixtures.

Each analogue output port on the SDM-AO4A module represents one dimmer channel and can be wired to one or more physical dimmers. The LED ribbon lighting for a nocturnal house typically has one dimmer channel for each row of LED ribbon (up to three rows) to provide optimum control of the moonlight scene, whereas multiple rows of grow lights are often controlled by a single dimmer channel.

Master Crossfader Moonlight and Sunlight Scenes

Each dimmer channel is assigned a preset level in the STATION_SETPOINTS file which can be changed by keepers when necessary. Each dimmer channel is also assigned to either the LX1 (sunlight) master fader or the LX2 (moonlight) master fader in the STATION_CONSTANTS file, which must be set to match the physical electrical installation in the enclosure. The dimmer level settings create the moonlight lighting scene and the

$$Channel\ \% = Master\ \% \times Preset\ \%$$

sunlight lighting scene and the master faders control the transition between the two scenes.

The current level for the two master faders is displayed in the Public table variables Master_Sunlight and Master_Moonlight, as a percentage of fully ON. These two masters are arranged to operate as a crossfader which means that one master is increasing in level to fade in a lighting scene while the other is decreasing in level to fade out a lighting scene.

When the trigger TimeSunrise is active it fades up the master fader Master_Sunlight from 0% (lights off) to 100% (lights on) while fading down the master fader Master_Moonlight from 100% to 0%. Conversely, when the trigger TimeSunset is active it fades up the master fader Master_Moonlight from 0% to 100% while fading down the master fader Master_Sunlight from 100% to 0%.

The fade rate is set by the constant FADE_TIME_MINS in the STATION_CONSTANTS file and is typically set to 30 minutes to provide realistic sunrise and sunset lighting level transitions in the enclosure.

The formula below describes the operation of the masters:

Example 1. If the preset is set to 60% and the master is at 0% the channel will be at 0%, if the master is moved to 50% the channel will be at 30%, and if the master is moved to 100% the channel will be at 60%.

Example 2. If the preset is set to 100% and the master is at 0% the channel will be at 0%, if the master is moved to 50% the channel will be at 50%, and if the master is moved to 100% the channel will be at 100%.

The current level for each dimmer channel is displayed in the Public table LevelDim1 through to LevelDim4 variables. These variables have the master assignment, either "_Moon" or "_Sun" appended for convenience.

Master Fader Bump Channels

Selecting the bump function retains the moonlight and sunlight scene channel preset levels, activates the bump master fader to add the preset channel bump levels on top of the moonlight and sunlight preset scene channel levels in a highest takes precedence (pile on) operation, and sets the fade rate to fast (30 seconds) so the lighting in the enclosure quickly fades up to the preset channel bump levels. The normal fade rate is automatically reinstated as soon as a running fast fade has completed. The master faders Master_Sunlight and Master_Moonlight stay at their current settings while the bump function is active.

NOTE: The normal automatic crossfades will continue to occur, if a trigger time is reached, while the bump function is active. If a fast fade is currently running the crossfade will pause until the fast fade completes, then it will resume as normal.

For the following examples, assume the moonlight scene channel presets are set at 50%, the sunlight scene channel presets are set at 100%, the moonlight bump channel presets are set at 100% and the sunlight bump channel presets are set at 0%

Example 1. The control system is in the automatically controlled moonlight scene with the moonlight at 50% and the sunlight at 0%. If the bump function is selected, the moonlight will fade up to 100%, remember highest takes precedence, while the sunlight remains at 0%. If the bump function is then deselected, the moonlight will return to the scene channel presets of 50% and the sunlight will remain at 0%.

Example 2. The control system is in the automatically controlled moonlight scene with the moonlight at 50% and the sunlight at 0%. If bump function is selected the moonlight will fade up to 100%, remember highest takes precedence, while the sunlight remains at 0%. If the sunrise trigger time now occurs, the moonlight will remain at 100% (held by the bump function) while the sunlight will fade up to 100% due to the sunlight scene channel presets. If the bump function is then deselected the moonlight will fade to 0% due to the sunlight scene channel presets and the sunlight will remain at 100%.

Dimmer Levels During Manual Operation

When the lighting switch is set to the LX1 (sunlight) the sunlight scene channel preset levels are used. When the lighting switch is set to LX2 (moonlight) the moonlight scene channel preset levels are used. When the lighting switch is set to LX1SUP (sunlight with supplementary lights) the the sunlight scene preset levels are used and the supplementary lights are also switched ON. This ensures that manually selecting a lighting scene produces the same lighting levels in the enclosure as that scene normally has when under automatic control. The lighting transition between the manual settings, when the manual control switch is changed, is controlled by the crossfaders using the fast fade rate (30 seconds).

Lighting Switch State

The current lighting switch state is displayed in the Public data table LxSwitch variable. The lighting manual control switch determines whether the lighting system is set to run automatically, continuously on LX1, continuously on LX2, continuously on LX1 with supplementary lights, or to not run at all.

The possible lighting switch states are:

AUTO (BUMP) - The lighting is set to automatic control and the bump switch is ON.

AUTO - The lighting is set to automatic control.

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

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

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

MANUAL LX1SUP - The lighting is manually switched to LX1 and Supplementary ON and will run continually.

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 - Lighting is configured for Diurnal operation.

DIURNAL + SUP - Lighting is configured for Diurnal operation with supplementary lighting.

NOCTURNAL - Lighting is configured for Nocturnal operation.

NOCTURNAL + SUP - Lighting is configured for Nocturnal operation with supplementary lighting.

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 or Diurnal+Sup mode, LX1 is ON.

DAY (Build Sup) - LX switched to AUTO, in Day Build Sup state, Diurnal+Sup mode, LX1+LX3 is ON.

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

GROW LIGHTS - LX switched to AUTO, in Dayl state, Nocturnal or Nocturnal + Sup mode, LX1 is ON.

GROW LIGHTS (Sup) - LX switched to AUTO, in Day state, Nocturnal+Sup mode, LX1+LX3 are ON.

MOONLIGHT - LX switched to AUTO, in Night state, Nocturnal or Nocturnal+Sup 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 LX3, LX1+LX3 are ON continuously.

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 enclosure 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 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.

These automatic daylight savings time adjustments cause the lighting changes to occur at daylight savings time with the displayed lighting change trigger times 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.

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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
2023-10-30 00:44:41	0	Datalogger Program Started
2023-10-30 00:44:42	1	Fan Set to AUTO
2023-10-30 00:44:42	2	A/C Set to AUTO
2023-10-30 03:44:40	3	Fan RUN TIMER
2023-10-30 04:14:40	4	Fan IDLE (Temp High Setpoint)
2023-10-30 07:14:40	5	Fan RUN TIMER
2023-10-30 07:44:40	6	Fan IDLE (Temp High Setpoint)
2023-10-30 10:44:40	7	Fan RUN TIMER
2023-10-30 11:14:40	8	Fan IDLE (Temp High Setpoint)
2023-10-30 14:14:40	9	Fan RUN TIMER
2023-10-30 14:44:40	10	Fan IDLE (Temp High Setpoint)
2023-10-30 15:00:14	11	A/C Set to OFF
2023-10-30 15:00:30	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 variables displayed in the datalogger Public data table. Logging these events in the EVENT_LOG data table provides significant insights into the system operation and assists with problem resolution.

Viewing The Event Log

The Event log can be viewed two ways:

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

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

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

Event Messages

This section lists all the events that may be logged in the EVENT_LOG data table, for the ZooCADA-Life 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 low setpoint, the ventilation fan is stopped.

These events occur when the enclosure air temperature reaches either the high setpoint Set_E00AirTC_HI or the low setpoint Set_E00AirTC_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.

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 Worse) - The external air humidity has reached the limit, the ventilation fan is stopped.

This event occurs when external air relative humidity reaches the Set_E00AirRH_HI setpoint 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 is occurs when the enclosure E01AirTC, or average of E01AirTC and E02AirTC if dual enclosures are installed, 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, or average of E01AirTC and E02AirTC if dual enclosures are installed, 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.

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, or average of E01AirTC and E02AirTC if dual enclosures are installed, 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 Set_E00AirTC_LO + TC_HYST or Set_E00AirTC_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, or average of E01AirTC and E02AirTC if dual enclosures are installed, is lower than the enclosure low setpoint Set_E00AirTC_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, or average of E01AirTC and E02AirTC if dual enclosures are installed, is higher than the enclosure high setpoint Set_E00AirTC_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 AC_LOWEST_TEMP during installation. If the enclosure high setpoint Set_E00AirTC_HI is below that minimum temperature, the air conditioner will not be started until the enclosure air temperature increases to AC_LOWEST_TEMP+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.

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 at 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 at 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 air conditioner 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 and Humidifier

Dehumidifier RUN MAN DEC - The dehumidifier is running manually.

This event occurs when a staff member turns the Humidity control switch to the DEC position. The dehumidifier 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.

Dehumidifier RUN DEC - The dehumidifier is running.

This event occurs when the enclosure relative humidity E00AirRH exceeds the Set_E00AirRH_HI setpoint at which time the program switches the dehumidifier ON. The dehumidifier remains switched on until the relative humidity returns to a level that is 5% RH below the Set_E00AirRH_HI setpoint.

Dehumidifier IDLE - The dehumidifier has stopped normally.

This event occurs when the enclosure relative humidity E00AirRH returns to a level that between 5% RH below the Set_E00AirRH_HI setpoint and 5% above the Set_E00AirRH_LO setpoint at which time the program switches the dehumidifier OFF. The dehumidifier remains switched off until the relative humidity again rises above the Set_E00AirRH_HI setpoint.

Humidifier RUN MAN INC - The humidifier is running manually.

This event occurs when a staff member turns the Humidity control switch to the INC position. The humidifier 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.

Humidifier RUN INC - The humidifier is running.

This event occurs when the enclosure relative humidity E00AirRH falls below the Set_E00AirRH_LO setpoint at which time the program switches the humidifier ON. The humidifier remains switched on until the relative humidity returns to a level that is 5% RH above the Set_E00AirRH_LO setpoint.

Humidifier IDLE - The humidifier has stopped normally.

This event occurs when the enclosure relative humidity E00AirRH returns to a level that between 5% RH below the Set_E00AirRH_HI setpoint and 5% above the Set_E00AirRH_LO setpoint at which time the program switches the humidifier OFF. The humidifier remains switched off until the relative humidity again falls below the Set_E00AirRH_LO setpoint.

Humidity Set to RUN MANUAL DEC - The Humidity control was switched to DEC.

This event occurs when a staff member turns the Humidity control switch to the DEC position. The dehumidifier 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.

Humidity Set to RUN MANUAL INC - The Humidity control was switched to INC.

This event occurs when a staff member turns the Humidity control switch to the INC position. The humidifier 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.

Humidity Set to OFF - The humidity control was switched OFF.

This event occurs when a staff member turns the Humidity control switch to the OFF position. The dehumidifier and humidifier 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.

Humidity Set to AUTO - The Humidity control was switched to AUTO.

This event occurs when a staff member turns the Humidity control switch to the AUTO position. This is the normal setting for the switch. The dehumidifier and humidifier will run under automatic control based on the relative humidity conditions in the enclosure.

Lighting

LX Set to MANUAL LX1SUP - The lighting was switched to LX1SUP, LX1 and LX3 will run continuously.

This event occurs when a staff member turns the lighting switch to the LX1SUP position. The lighting circuit LX1 and the Supplementary lights will run continuously, irrespective of the lighting state change triggers, until the switch is moved to either the LX1, LX2, AUTO or OFF position.

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 LX1SUP, LX1, AUTO or 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 LX1SUP, LX2, AUTO or 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 LX1SUP, LX2, LX1, or AUTO 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 the LX1, LX2 and Supplementary (LX3) lighting circuits according to the lighting state change triggers.

LX Mode Set to NOCTURNAL - The system is configured for NOCTURNAL operation.

This event occurs at program startup only as an advisory message. The mode can only be changed by editing the STATION_CONSTANTS file.

LX Mode Set to NOCTURNAL + SUP - The system is configured for NOCTURNAL + Supplementary operation.

This event occurs at program startup only as an advisory message. The mode can only be changed by editing the STATION_CONSTANTS file.

LX Mode Set to DIURNAL - The system is configured for DIURNAL operation.

This event occurs at program startup only as an advisory message. The mode can only be changed by editing the STATION_CONSTANTS file.

LX Mode Set to DIURNAL + SUP - The system is configured for DIURNAL + Supplementary operation.

This event occurs at program startup only as an advisory message. The mode can only be changed by editing the STATION_CONSTANTS file.

LX DAY - The lighting state automatically changed to DAY.

This event occurs each time the lighting state changes to DAY (LX1=ON, LX2=OFF, LX3=OFF). It is part of the automatic cycle when operating in DIURNAL or DIURNAL + SUP modes.

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) (LX1=ON, LX2=OFF, LX3=ON). It is part of the automatic cycle when operating in DIURNAL+SUP mode.

LX NIGHT - The lighting state automatically changed to NIGHT.

This event occurs each time the lighting state changes to NIGHT (LX1=OFF, LX2=ON, LX3=OFF). It is part of the automatic cycle when operating in operating in DIURNAL or DIURNAL+SUP modes.

LX GROW LIGHTS - The lighting state automatically changed to GROW LIGHTS.

This event occurs each time the lighting state changes to GROW LIGHTS (LX1=ON, LX2=OFF, LX3=OFF). It is part of the automatic cycle when operating in NOCTURNAL or NOCTURNAL+SUP mode.

LX GROW LIGHTS (Sup) - The lighting state automatically changed to GROW LIGHTS (Sup).

This event occurs each time the lighting state changes to GROW LIGHTS (Sup) (LX1=ON, LX2=OFF, LX3=ON). It is part of the automatic cycle when operating in NOCTURNAL+SUP mode.

LX MOONLIGHT - The lighting state automatically changed to MOONLIGHT.

This event occurs each time the lighting state changes to MOONLIGHT (LX1=OFF, LX2-ON, LX3=OFF). It is part of the automatic cycle when operating in NOCTURNAL or NOCTURNAL + SUP modes.

LX MANUAL OFF - The lighting state was manually changed to OFF.

This event occurs each time the lighting state is manually switched to OFF (LX1=OFF, LX2-OFF, LX3=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 (LX1=ON, LX2-OFF, LX3=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 (LX1=OFF, LX2-ON, LX3=OFF). 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 LX1SUP.

This event occurs each time the lighting state is manually switched to LX1SUP (LX1=ON, LX2-OFF, LX3=ON). This is a manual control function. The LX1 and LX3 lights are ON and will remain ON until the manual control switch is moved to a different selection.

LX Bump ON - The lighting bump master was activated.

This event occurs each time the bump master is activated. It is an advisory message only.

LX Bump OFF - The lighting bump master was deactivated.

This event occurs each time the bump master is deactivated. It is an advisory message only.

LX Control Error xxx - The SDM-AO4A module produced an error where xxx is the error code.

This event occurs each time an error occurs.

Error code 241 is a signature error

Error Code 242 is an over current condition

Error code 243 is a signature error and an over current condition.

The occurrence of an alarm and an error message will most likely accompany a noticeable failure of the lighting system and will usually require repair by a service technician.

Enclosure 1

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 Set_E00AirTC_HI plus the station constant ALARM_DEGREES. The alarm resets when the enclosure temperature E01AirTC falls below the enclosure high temperature setpoint Set_E00AirTC_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 Set_E00AirTC_LO minus the station constant ALARM_DEGREES. The alarm resets when the enclosure temperature E01AirTC rises above the enclosure low temperature setpoint Set_E00AirTC_LO minus the station constant ALARM_RESET.

Alarm E01: Humidity Too High - The enclosure high relative humidity alarm was triggered.

E01: Humidity Too High Cleared - The enclosure high relative humidity alarm was cleared.

These events occur when the enclosure relative humidity becomes too high and when it is subsequently cleared. The high relative humidity alarm is triggered when the enclosure relative humidity E01AirRH rises to or above the enclosure high relative humidity setpoint Set_E00AirRH_HI plus the station constant ALARM_PERCENT. The alarm resets when the enclosure relative humidity E01AirRH falls below the enclosure high relative humidity setpoint Set_E00AirRH_HI plus the station constant ALARM_RESET.

Alarm E01: Humidity Too Low - The enclosure low relative humidity alarm was triggered.

E01: Humidity Too Low Cleared - The enclosure low relative humidity alarm was cleared.

These events occur when the enclosure relative humidity becomes too low and when it is subsequently cleared. The low relative humidity alarm is triggered when the enclosure relative humidity E01AirRH falls to or below the enclosure low relative humidity setpoint Set_E00AirRH_LO plus the station constant ALARM_PERCENT. The alarm resets when the enclosure relative humidity E01AirRH increases above the enclosure low relative humidity setpoint Set_E00AirRH_LO plus the station constant ALARM_RESET.

Alarm E01: Sensor Failure - The enclosure temperature and RH sensor 1 failure alarm was triggered.

E01: Sensor 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.

Enclosure 2

Alarm E02: Temp Too High - The enclosure high temperature alarm was triggered.

E02: 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 E02AirTC rises to or above the enclosure high temperature setpoint Set_E00AirTC_HI plus the station constant ALARM_DEGREES. The alarm resets when the enclosure temperature E02AirTC falls below the enclosure high temperature setpoint Set_E00AirTC_HI plus the station constant ALARM_RESET.

Alarm E02: Temp Too Low - The enclosure low temperature alarm was triggered.

E02: 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 E02AirTC falls to or below the enclosure low temperature setpoint Set_E00AirTC_LO minus the station constant ALARM_DEGREES. The alarm resets when the enclosure temperature E02AirTC rises above the enclosure low temperature setpoint Set_E00AirTC_LO minus the station constant ALARM_RESET.

Alarm E02: Humidity Too High - The enclosure high relative humidity alarm was triggered.

E02: Humidity Too High Cleared - The enclosure high relative humidity alarm was cleared.

These events occur when the enclosure relative humidity becomes too high and when it is subsequently cleared. The high relative humidity alarm is triggered when the enclosure relative humidity E01AirRH rises to or above the enclosure high relative humidity setpoint Set_E00AirRH_HI plus the station constant ALARM_PERCENT. The alarm resets when the enclosure relative humidity E01AirRH falls below the enclosure high relative humidity setpoint Set_E00AirRH_HI plus the station constant ALARM_RESET.

Alarm E02: Humidity Too Low - The enclosure low relative humidity alarm was triggered.

E02: Humidity Too Low Cleared - The enclosure low relative humidity alarm was cleared.

These events occur when the enclosure relative humidity becomes too low and when it is subsequently cleared. The low relative humidity alarm is triggered when the enclosure relative humidity E01AirRH falls to or below the enclosure low relative humidity setpoint Set_E00AirRH_LO plus the station constant ALARM_PERCENT. The alarm resets when the enclosure relative humidity E01AirRH increases above the enclosure low relative humidity setpoint Set_E00AirRH_LO plus the station constant ALARM_RESET.

Alarm E02: Sensor Failure - The enclosure temperature and RH sensor 2 failure alarm was triggered.

E02: Sensor 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

Systems with QM reporting:

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

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

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

Systems without QM reporting:

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

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

These events indicate a change of the barometric pressure sensor's state switch 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.

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.

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 lighting 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.

Remote Station Communications

COMMS FAIL, *code1, code2* - 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.

For more information on the failure codes see the “Communications To Remote Stations” chapter.

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

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

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

Email System

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

This event occurs when an email message would have been sent but the email system was set to Test Mode which diverts the messages to a file for test purposes. This is an informative diagnostic message, not a fault in the system.

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.

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 chapter "Email Messaging System" for further information.

Alarms Delay

The alarm delay time AL_DELAY (10 seconds) is set in the datalogger program 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 required 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 chapter "Event Log" 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 alarm 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 variable are:

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

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

NO ALARMS - All alarms are cleared.

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

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

Temperature Alarms Operation

The temperature alarm process is entirely automatic, once the cause of the temperature alarm has been remedied and the temperature returns to normal, the alarm will automatically reset. Each 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, Set_E00AirTC_HI and Set_E00AirTC_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 or E02AirTC reaches the alarm trigger point. The high temperature alarm trigger point is the high setpoint Set_E00AirTC_HI plus ALARM_DEGREES. The low temperature trigger point is the low setpoint Set_E00AirTC_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 Set_E00AirTC_HI plus ALARM_RESET. The low temperature alarm resets when the enclosure temperature becomes higher than the low temperature setpoint Set_E00AirTC_LO minus ALARM_RESET. The constant ALARM_RESET is set in the STATION_CONSTANTS file and is shared between the temperature alarms and the relative humidity alarms as the value for both would typically be the same.

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 the high and low setpoints becomes the temperature alarm hysteresis value and must be at least one degree.

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

If Temperature >= Set_E00AirTC_HI + ALARM_DEGREES

Set AlarmState to HighAlarm

Otherwise if Temperature <= Set_E00AirTC_LO - ALARM_DEGREES

Set AlarmState to LowAlarm

Otherwise if Temperature > Set_E00AirTC_LO - ALARM_RESET and Temperature < Set_E00AirTC_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.

Relative Humidity Alarms Operation

The relative humidity alarm process is entirely automatic, once the cause of the alarm has been remedied and the relative humidity returns to normal, the alarm will automatically reset. Each enclosure has its own high and low relative humidity alarms.

The desired operating relative humidity range for the enclosure(s) is determined by HVAC high relative humidity and low relative humidity setpoints, Set_E00AirRH_HI and Set_E00AirRH_LO respectively. When the relative humidity in the enclosure moves too far beyond one of these setpoints a relative humidity alarm is triggered.

The HVAC setpoints in the Setpoints data table enable keepers to configure daytime and nighttime high relative humidity settings as well as the low relative humidity setting for the enclosure. This enables keepers to maintain a more natural diurnal relative humidity operating range in the enclosure.

The "relative" in relative humidity means the humidity measurement is relative to the temperature. Remember, for any given air mass, if the temperature of the air increases, the relative humidity decreases, and vice-versa. Relative humidity provides users with a familiar point of reference for the amount of humidity but it is not an absolute measurement of the amount of water vapour in the air. For this reason the enclosure vapour pressure, an absolute measure of the water vapour present, is also displayed in the Public data table E01AirVp and E02AirVp for the enclosure(s).

The dehumidifier is started when the relative humidity crosses the Set_E00AirRH_HI setpoint, the humidifier is started when the relative humidity crosses the Set_E00AirRH_LO setpoint, and the relative humidity alarms are triggered when the relative humidity moves further, beyond the region of normal dehumidifier and humidifier operation.

The relative humidity sensors are measured once every minute and a relative humidity alarm is triggered if the enclosure relative humidity E01AirRH (or E02AirRH if dual enclosures are in stalled) reaches the alarm trigger point. The high relative humidity alarm trigger point is the setpoint Set_E00AirRH_HI plus ALARM_PERCENT. The low relative humidity alarm trigger point is the setpoint Set_E00AirRH_LO minus ALARM_PERCENT. The constant ALARM_PERCENT 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 relative humidity alarm resets when the enclosure relative humidity becomes lower than the high relative humidity setpoint Set_E00AirRH_HI plus ALARM_RESET. The low relative humidity alarm resets when the enclosure relative humidity becomes higher than the low relative humidity setpoint Set_E00AirRH_LO minus ALARM_RESET. The constant ALARM_RESET is set in the STATION_CONSTANTS file and is shared between the temperature alarms and the relative humidity alarms as the value for both would typically be the same.

The alarm trigger constant ALARM_PERCENT is normally set to about 5 percent and the alarm reset constant ALARM_RESET is normally set to about 2 percent. The difference between the high and low setpoints becomes the relative humidity alarm hysteresis value and must be at least one percent.

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

If Relative Humidity >= Set_E00AirRH_HI + ALARM_PERCENT

Set AlarmState to HighAlarm

Otherwise if Relative Humidity <= Set_E00AirTRHLO - ALARM_PERCENT

Set AlarmState to LowAlarm

Otherwise if Relative Humidity > Set_E00AirRH_LO - ALARM_RESET and Relative Humidity < Set_E00AirRH_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. Each enclosure has a temperature and RH sensor. An external temperature and RH 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 sensor state variables E01SensState for enclosure 1, E02SensState for enclosure 2, and ExtSensState for the external sensor to indicate the failure.

The ZooCADA system uses combined temperature and relative humidity sensors for the enclosures and the external sensors.

The possible enclosure 1 sensor states displayed in the Public data table variable 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.

The possible enclosure 2 sensor states displayed in the Public data table variable 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.

The possible external sensor states displayed in the Public data table variable 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.

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 alarm process is entirely automatic, so 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, with QM value, are:

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

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

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

The possible states, without QM value, are:

OK - The barometric pressure sensor is working normally.

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

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

The QM (Quality Metric) value, if available, 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 RECALIB 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.

Power Failure Alarm Operation

The power failure alarm is entirely automatic. The alarm triggers when the power fails and resets when power is restored. A power failure alarm can be caused by failure of the mains electricity supply to the building or failure of the 12 Vdc power supply that powers the station.

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

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

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

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

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

Communications Failure Alarm Operation

The ZooCADA-Life 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. Typically there are one or two stations installed with external sensors on 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 the 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 is not achieved within the constant MAX_COMMS_FAILS number of retries, a communications failure alarm is triggered. The alarm automatically resets when communications is restored.

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

The possible communications states displayed in the Public data table variable 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, *code1, code2* - 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.

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.

There is no state display for HVAC circuit breaker trip in the Public table, it is purely an alarm trigger.

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 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.

There is no state display for LX circuit breaker trip in the Public table, it is purely an alarm trigger.

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!**

Lighting (LX) Control Error Alarm Operation

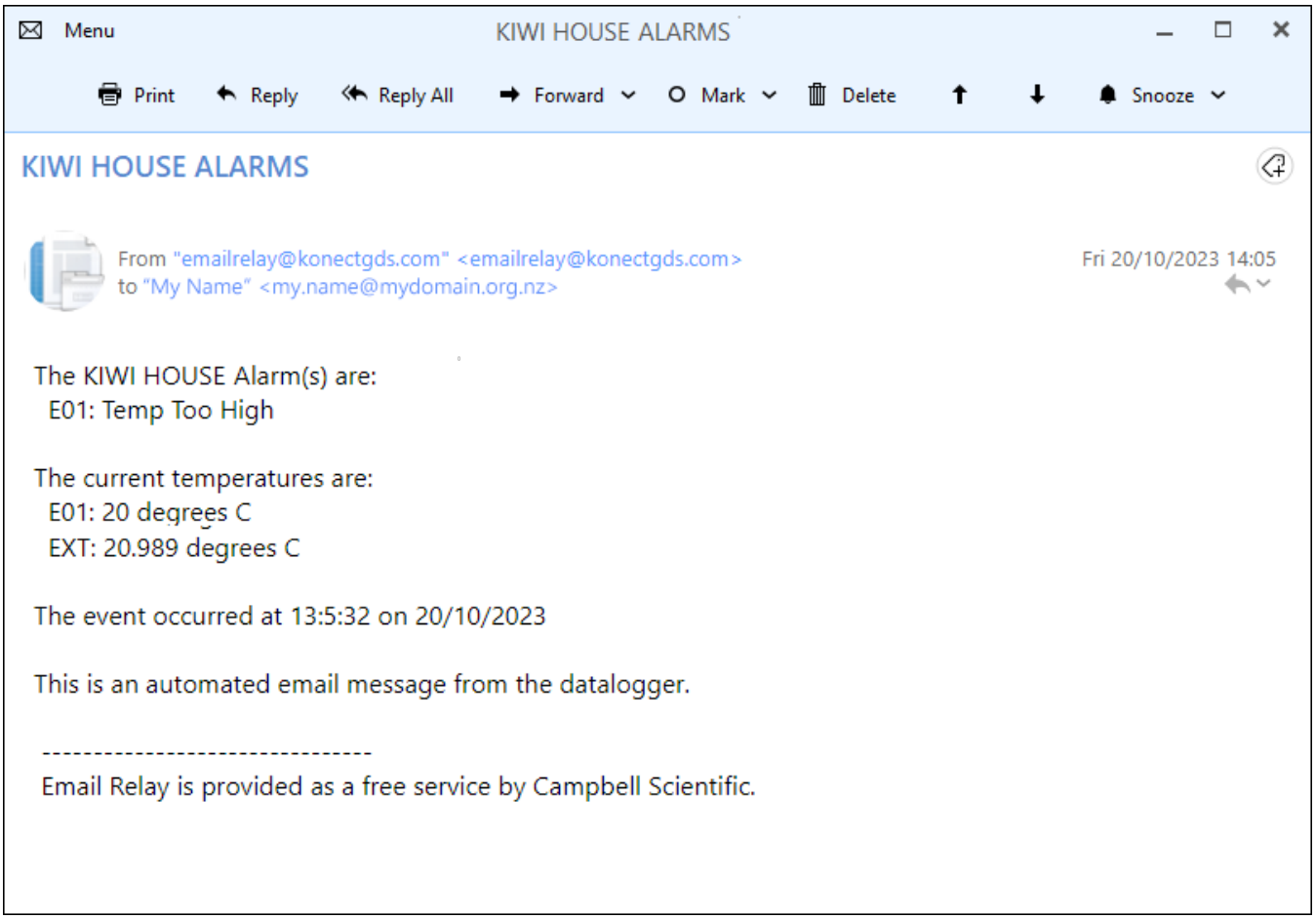
The lighting control system utilises an SDM-AO4A output module to produce a 0-10V analogue control signal for each of the dimmer channels that set the lighting levels in the enclosure. The datalogger sends a digital instruction to the SDM-AO4A each time the level of one or more dimmer channels needs to be changed, such as during a crossfade. The SDM-AO4A returns a response code to the datalogger which is checked by the datalogger program and if the returned code is an error code the LX Control Error alarm is triggered. The alarm is automatically reset when the SDM-AO4A subsequently returns a normal code.

There is no state display for LX circuit breaker trip in the Public table, it is purely an alarm trigger.

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

WARNING: A lighting control error alarm must be checked promptly. If the system cannot control the lighting dimmers the enclosure lighting cycle won't function correctly which may result in the lighting entering an unknown or unstable state. If not resolved quickly, animal welfare could be adversely affected.

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.

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 displayed in the Public data table variable are:

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

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

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

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

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

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

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

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

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

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

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

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

This state is displayed when an email message would normally have been sent but the email system is set to Test Mode so the message was diverted to a file for test purposes. This is an informative diagnostic message, not a fault in the system.

Email Message Format

The email message subject is set as follows:

New Alarms - The 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.

Enclosure 1 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 Set_E00AirTC_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 Set_E00AirTC_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: Humidity Too High - The enclosure high relative humidity alarm was triggered.

This alarm is triggered when the enclosure relative humidity E01AirRH rises to or above the enclosure high relative humidity setpoint Set_E00AirRH_HI plus the station constant ALARM_PERCENT. Enclosure high relative humidity alarms typically result from an issue with the dehumidifier.

E01: Humidity Too Low - The enclosure low relative humidity alarm was triggered.

This alarm is triggered when the enclosure relative humidity E01AirRH falls to or below the enclosure low relative humidity setpoint Set_E00AirRH_LO plus the station constant ALARM_PERCENT. Enclosure low relative humidity alarms typically result from an issue with the humidifier.

E01: Sensor Failure - The enclosure temperature and RH sensor failure alarm was triggered.

This alarm is triggered when the temperature or the RH sensor in the enclosure fails. Sensor failures will most likely require replacement of the sensor.

Enclosure 2 Alarms Messages

E02: Temp Too High - The enclosure high temperature alarm was triggered.

This alarm is triggered when the temperature in the enclosure rises above the Set_E00AirTC_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.

E02: Temp Too Low - The enclosure low temperature alarm was triggered.

This alarm is triggered when the temperature in the enclosure falls below the Set_E00AirTC_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.

E02: Humidity Too High - The enclosure high relative humidity alarm was triggered.

This alarm is triggered when the enclosure relative humidity E01AirRH rises to or above the enclosure high relative humidity setpoint Set_E00AirRH_HI plus the station constant ALARM_PERCENT. Enclosure high relative humidity alarms typically result from an issue with the dehumidifier.

E02: Humidity Too Low - The enclosure low relative humidity alarm was triggered.

This alarm is triggered when the enclosure relative humidity E01AirRH falls to or below the enclosure low relative humidity setpoint Set_E00AirRH_LO plus the station constant ALARM_PERCENT. Enclosure low relative humidity alarms typically result from an issue with the humidifier.

E02: Sensor Failure - The enclosure temperature and RH sensor failure alarm was triggered.

This alarm is triggered when the temperature or the RH sensor 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 measurement value returned by the sensor is outside of the expected operating range, or if available, the sensor's Quality Metric value falls below 4. If its available, the QM value is displayed next to the state in the Public table BaroSensState variable. 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 if 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.

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.

LX Control Error - The SDM-AO4A returned an error in response to the datalogger's command.

This alarm is triggered when the SDM-AO4A returned one of the following error codes:

Error code 241 is a signature error

Error Code 242 is an over current condition

Error code 243 is a signature error and an over current condition.

The error code is logged in the EVENT_LOG along with the alarm message.

The occurrence of an alarm and an error message will most likely accompany a noticeable failure of the lighting system and will usually require repair by a service technician.

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.

Email Messages Daily Limit

The maximum number of email messages that can be sent by a datalogger in any one day is 100. This is a function of the Email Relay server provided by Campbell Scientific and is designed to ensure the system is not open to abuse. It is highly unlikely this will be exceeded by a station operating with ZooCADA system software.

If a station does exceed the limit, the email server will respond with an error which is displayed in the Public data table EmailState variable as "EMAIL COMMS ERROR". The Email Relay server will automatically reset at the end of the day, the time of which is determined by the server time (USA time).

Recipient Email Addresses

The automated alarm email messages are sent to the list of recipients whose email addresses are set in the TO_ADDR station constant. There must be at least one email recipient address if the alarms are enabled.

The format is:

TO_ADDR = keeper1@myisp.co.nz, keeper2@myisp.co.nz, manager@myisp.co.nz

Each address in the list must be separated from the next address with a comma.

It is best to send the email messages to at least two staff members to ensure the alarms have the best chance of being received by someone who can respond in a timely manner.

Email Test Function

The email module has a test function that enables the alarms and email system to be tested, without actually sending email messages, by diverting the messages to a file in the datalogger memory. This test function is enabled, or disabled, by setting the EMAIL_TEST station constant follows:

EMAIL_TEST = True - Email messages are diverted to a file.

EMAIL_TEST = False - Email messages are sent to the email recipients.

The EMAIL_ENABLE constant must also be set to True.

When in the email test mode each email message is sent to a text file named EmailTest.txt in the datalogger. This file stores the exact text of every email message that is "sent" while the test mode is operating, including the email send retries because there is no confirmation from an Email Relay server. The file can be accessed using the Campbell Scientific LoggerNet software and a text editor or by using the File Control Page from the datalogger's built-in web interface.

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Installation Notes

Use these pages to record any notes specific to the site installation or operation.

Templates for Record Keeping

The following pages are intended to assist users with record keeping.

Good records are essential for audit, research and maintenance purposes. We recommend that users keep an ongoing file of all system settings in a manner that is appropriate to their business operations.

Each time settings are changed, a new record of the settings should be created and added to the file. Previous records should be retained when new records are added. This will provide an auditable trail of all setting changes that can assist research with site specific records of what works well for the animal species on display at that site.

These records also assist with maintenance. In the event that system settings have to be reinstated after maintenance work, the correct set of documented settings can be used to complete the reinstatement.

Please photocopy the following pages as needed and use them to create your own record keeping system.

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ZooCADA-Life 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_NOV_HI =
SET_JAN_LO =	SET_NOV_LO =
SET_FEB_HI =	SET_DEC_HI =
SET_FEB_LO =	SET_DEC_LO =
SET_MAR_HI =	SET_TOO_HOT =
SET_MAR_LO =	SET_TOO_COLD =
SET_APR_HI =	SET_RH_HI_NITE =
SET_APR_LO =	SET_RH_HI_DAY =
SET_MAY_HI =	SSET_RH_LO =
SET_MAY_LO =	SET_REF_TIME_MINS =
SET_JUN_HI =	SET_REF_VARIATION =
SET_JUN_LO =	SET_SUP_PERCENT =
SET_JUL_HI =	SET_LEVEL_DIM2 =
SET_JUL_LO =	SET_LEVEL_DIM2 =
SET_AUG_HI =	SET_LEVEL_DIM3 =
SET_AUG_LO	SET_LEVEL_DIM4 =
SET_SEP_HI =	SET_LEVEL_BUMP1 =
SET_SEP_LO =	SET_LEVEL_BUMP2 =
SET_OCT_HI =	SET_LEVEL_BUMP3 =
SET_OCT_LO =	SET_LEVEL_BUMP4 =

Complete a new page each time the configuration is changed so an auditable record of changes is created.

ZooCADA-Life Station Configuration Record (Page 2 of 3)

Station Constants - General

ENCLOSURE =	EXT_SDI_ADDR =
CUSTOM_FILE =	E01TRH_SDI_ADDR =
DUAL_ENCL =	E02TRH_SDI_ADDR =
KWH_INSTALLED =	BARO_ENAB =
FAN_IDLE_LIMIT =	BARO_STN_ELEV =
FAN_RUN_TIME =	BARO_LOCAL =
FAN_TIMER_ONLY =	BARO_SDI_ADDR =
AC_RELAY_ALT =	E01SOIL_SDI_ADDR =
AC_LOWEST_TEMP =	E02SOIL_SDI_ADDR =
LATITUDE =	LX_NOCTURNAL =
ADJ_REF_DST =	LX_SUP_ENABLE =
FADE_TIME_MINS =	DIM1_MAST =
MIN_EXHIBIT_MINS =	DIM2_MAST =
ALARM_ENABLE =	DIM3_MAST =
ALARM_DEGREES =	DIM4_MAST =
ALARM_RESET =	DIM1_TRIM =
ALARM_PERCENT =	DIM2_TRIM =
ALARM_RESET_PERCENT =	DIM3_TRIM =
EMAIL_ENABLE =	DIM4_TRIM =
EMAIL_TEST =	DST_N_START =
EMAIL_RESEND =	DST_D_START =
EMAIL_TRIES =	DST_M_START =
EMAIL_NAG =	DST_N_END =
EMAIL_NAG_HOUR =	DST_D_END =
EMAIL_ATTACH =	DST_M_END =
EXT_TRH_LOCAL =	DST_HOUR =
EXT_TRH_PRIMARY =	

Complete a new page each time the configuration is changed so an auditable record of changes is created.

ZooCADA-Life 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 =	COMMS_PRIORITY =

Configuration Notes

Complete a new page each time the configuration is changed so an auditable record of changes is created.

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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:	

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:	