Access DTS User Manual v0.7

Document History

Version	Date	Editor	notes
0.1	4/3/2016	KWL	
0.2			DB25 input fix
0.3			s/w official name ACE
0.4			Change fc/apc connector shape
0.5			
0.6	8/3/2017	KWL	Function update for text data saving s/w version ACE201705xxxx
0.7			

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Introduction

Access series of distributed temperature sensor, developed by Bandweaver, is a compact sensor which employs an optical fibre as the sensor. It provides high performance temperature sensing and alarm functionality with a MODBUS interface.

The Access system can probe the temperature at every 1m interval along the whole optical fibre up to 500m with a temperature resolution better than 1°C. It also provides a series of alarm conditions such as a temperature maximum threshold, and temperature rate of rise threshold. Also as an essential fail-safe scheme, it can detect a fibre break condition.

This product is particularly well suited to application of fire detection and it offers many distinct advantages over historical solutions to the Line Type Heat Detector solution.

An important advantage of a distributed fibre optic sensor is that, the roles of the sensing elements and the transmission medium are combined utilising a single fibre. One distributed sensor, using a single fibre, can collect temperature data over a wide range, e.g. 500m is like having 500 measurement points. The Access also has excellent temperature resolution and position accuracy. Comparing this to the historical sensing techniques used in the fire industry, there is a great simplification of the whole system, therefore reducing the commissioning time and costs.

High-speed optical signal detection and processing technology also provides for a quick system response time, which is critical in fire detection and power cable monitoring.

The interrogation of the sensing fibre uses light and the nature of the fibre means that it does not need any electric power nor does it generate any electrical signals. Therefore, the fibre is immune to electromagnetic interference and is an ideal sensor for electric field sensitive applications e.g. electrified railway tunnel applications, urban metros.

The fibre contains is a totally passive sensor and has a very long life. Over its lifetime, it will require little or no maintenance and is therefore suitable for applications where access for maintenance is a cost consideration.

Additionally the optical fibre sensor has other advantages:

- The sensor cable is made from readily available standard communications optical fibre;
- Measurements are provided for the entire length of the sensing cable;
- Simple and low cost installation, with minimal planning required for the position of the cable;
- No electronics or moving parts;
- 30 year life time for the optical fibre;

- Low maintenance costs;
- Immune to shock/vibration and electromagnetic interference;
- Intrinsically safe for use in hazardous zones – the sensing cable cannot cause an ignition.

The following user guide has been written to fully explain the Access system, its connection, operation and system maintenance. The guide will also aim to explain the measurement principles and optical fibre technology used within the system.

Safety

Please BE SURE to read these INSTRUCTIONS, and Safety Notes before using this system for the first time.

General Safety Explanation

The following section provides Warnings, Cautions and Notes covering the general safety aspects of the Access system. Please read all of the safety and operational warnings before connecting and operating this product.

General warning symbol

There are no user serviceable parts in the Access system. Do not attempt to open the unit.

If there is smoke or similar burning smell emitted from the case or any other emergency, immediately cut the power supply and then inform our company or authorized agents.

This symbol is used throughout the user manual whenever there is a mandatory requirement or a risk of personal injury or probability of damaging our products.

Laser radiation warning symbol

The Access linear temperature sensing system incorporates a pulsed laser device whose invisible output radiation is potentially hazardous if viewed directly by eye.

Do not look at or examine exposed fibre or connector ends whenever the Access system is in operation.

Do not undertake fusion splicing or similar fibre joining when Access is in operation.

High-voltage warning symbol

Access DTS has HV components inside; do not attempt to open the unit otherwise there is a risk of electric shock. And don’t go poking

around inside!!

Do not get the Access wet. If there is water or other liquid intrusion, please disconnect the power supply and inform our company or authorized agents.

Laser Safety

The Access system incorporates a pulsed laser device whose invisible output radiation is potentially hazardous if viewed directly by eye. The laser radiation emission from the laser, within the system, is permanently coupled into a 62.5/125µm multimode optical fibre whose end is terminated with an FC/APC angled optical fibre connector.

The Access system should be interfaced to the test fibre, using a patch cord or pigtail assembly. It is recommend that the Access system is connected to a test fibre or use the FC/APC connector cap to prevent the light emitting to free space, and the far end of the test fibre should be optically cut off.

Laser classification

The laser radiation from the Access system has been classified in accordance with international standard IEC 60825-1 Edition 1.2 E2001-03, with the following classification outcome:

Access Laser System Classification: Class 1M

In accordance with the international standard document for Class 1M laser radiation:

Class 1M lasers are safe under reasonably foreseeable conditions of operation, but may be hazardous if the user employs optics within the beam

Glossary

DTS: Distributed Temperature Sensor often referring to the acquisition unit

Product Name: Access

Software Executable: ACE.exe

Software Name: ACE Access Configuration Environment

Document version: v0.7

System Design

The Access Distributed Temperature Sensor provides temperature measurements along the whole length of an optical fibre up to 500m. The measurement is singled ended only and no other optical equipment that uses a laser should be active on the far end.

The system provides 10 user configurable temperature zones, which can be programmed with different threshold levels, and alarm types. Interfacing can be performed using MODBUS allowing Access to interface to SCADA systems or existing fire panel. Additional relays are also available.

Temperature Sensor Unit

A complete system consists of:

1. Access DTS unit
2. Multimode graded index optical fibre 62.5um.

A PC is only required for configuration and viewing temperature data. Access DTS can operate in standalone mode. The PC software, ACE - Access Configuration Environment, is a Windows based application, that connects to Access using a MODBUS protocol over a RS485 or USB interface.

Item	Description	Type	Function	Notes
A	Power Switch	Main power switch	Push to turn on Press and hold >5s to turn off	Illuminates green when powered
B	USB	Mini-B	Direct PC interface	
C	Control	DB25 Female	Control inputs and system light outputs	See: section for more details
D	System Error indicator	Yellow LED	This will illuminate on a system error	ON: fibre break FLASH: data save error
E	Alarm indicator	Red LED	Illuminates on a temperature alarm	ON: temperature alarm
F	Optics Power switch	Push switch with integrated Blue indicator	Controls power supply to laser and HV supplies. Push and hold >3s to toggle between on and off states	ON: optics is powered FLASH: optics is powered and laser is active OFF: optics power is off
G	Sensor Cable	FC/APC 62.5um graded index multimode fibre	Connection to sensing fibre	
H	Alarm Reset	Push switch with integrated Red Indicator	Resets the triggered alarms	Push and hold >2s to reset alarms
I	Relay Error indicator	Orange LED	This will illuminate if a relay output fails to close	

J	Relay Output	DB25 Female	Relay outputs Max 48VDC 1A	See: section for more details
K	RS485	3 Pin 5.08mm terminal block	RS485 communications	TOP: GND MID: B (-VE) BOT: A (+VE)
L	Power	2 Pin 5.08mm terminal block	Main power 24VDC	TOP: –VE BOT: +VE

Front Panel

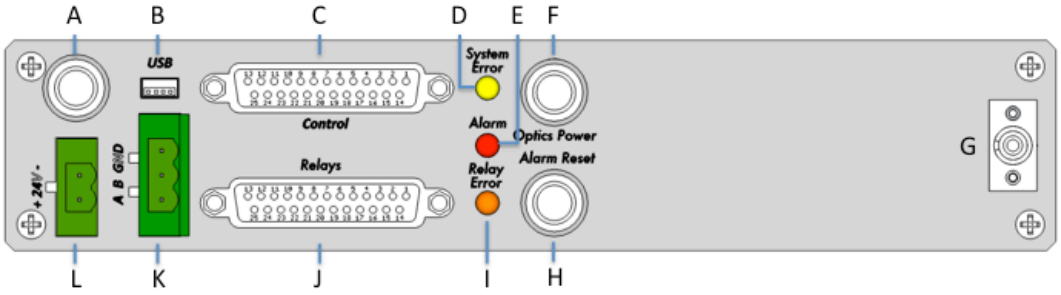


Figure 1, front panel diagram

Front Panel Description

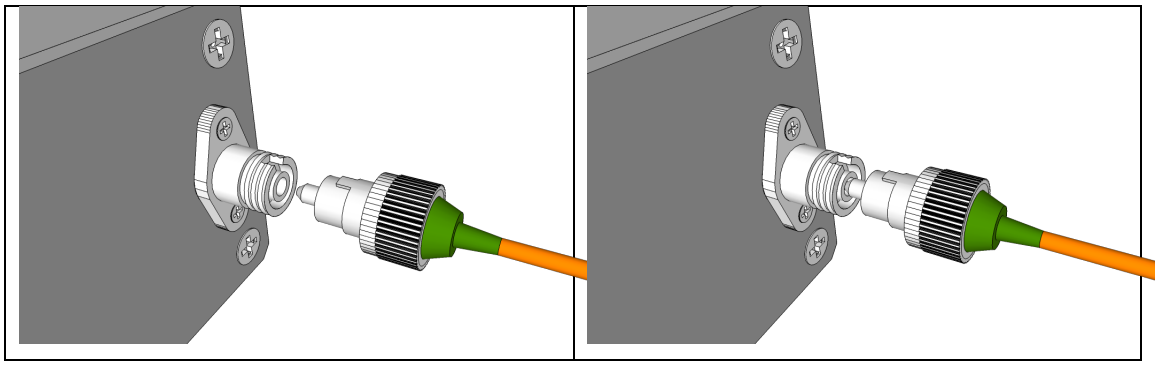
Table 1, front panel item descriptions

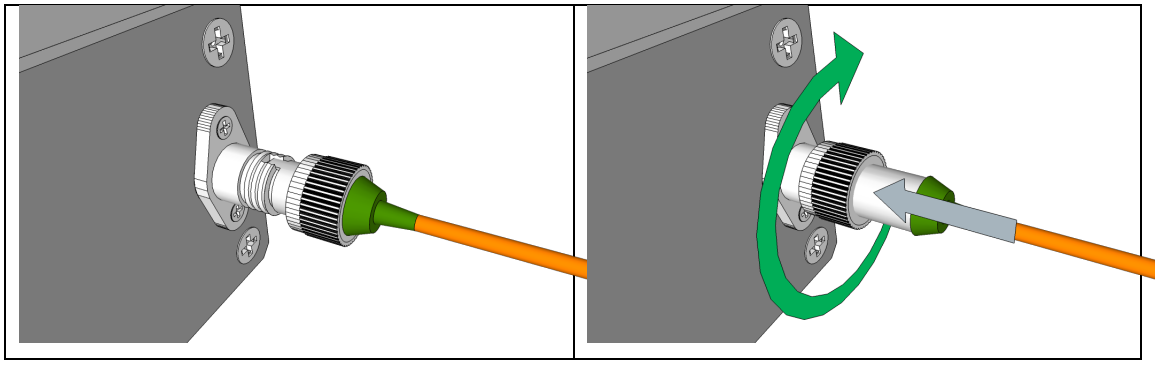
Optical Fibre Connection

It is recommend turning off the laser or powering off the DTS when removing the optical fibre.

The optical connector type is FC/APC. The optical head has a polished angled edge and is the only type of connector compatible with Access DTS.

When inserting the cable into the DTS ensure that the tab on the connector lines up with the notch on the receiving part. The notch is in the 12 o'clock position.



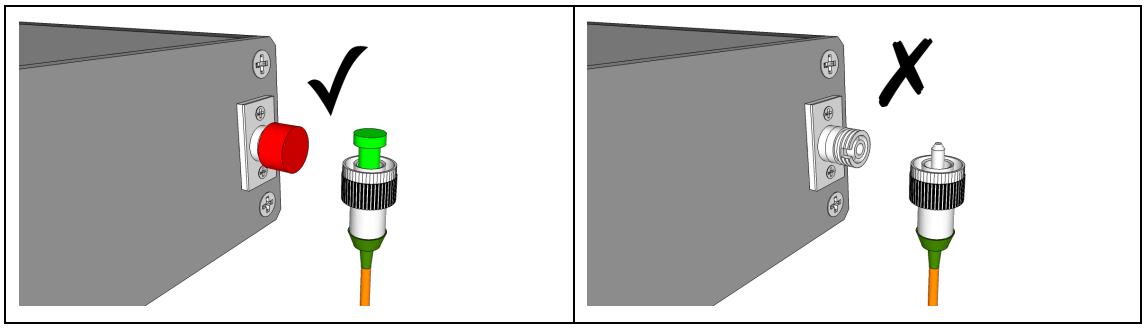


1. Carefully align the tip of the connector to the centre of the receptacle, and ensure the tip doesn't touch the connector sides
2. Push the connector in
3. Make sure the tab of the connector is aligned with the notch on the receptacle
4. Push in and rotate clockwise the outer metal sleeve to screw into place.

Do not leave the connectors exposed when not in use. Dust and damage to the end of the connector can severely affect the machines performance. They should be covered with their dust caps when not in use.

Do not touch the end of the connector.

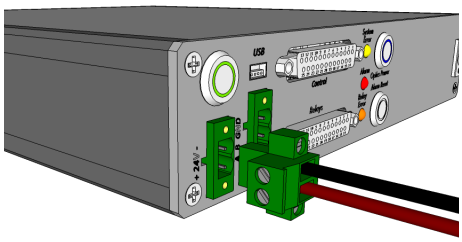
When inserting the connecter take great care not let the tip of the connector touch the sides. It the tip does touch anything it should be cleaned with alcohol and a lint free cloth.

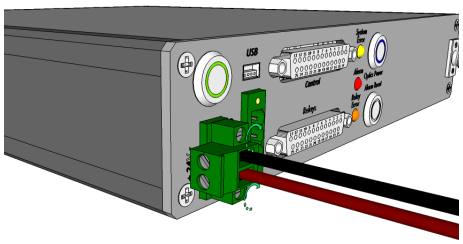


Power Connection

Access DTS requires 24V DC. A 2 pin 5.08mm pitch terminal block with flange screw terminal block can be used[1].

[1] recommended part - Wurth Elecktronik 691 340 500 02





With the 24V DC flying leads already connected to the terminal block, simply insert the connector into the front panel. It is recommended to tighten the fastening screws during long-term operation.

Relays

The relay outputs are used to send a system or alarm event signal to another control system such as a fire alarm panel or SCADA system. The relay connector is the lower of the two DB25 connectors as shown in Figure 1, on page 6.

The Access DTS has 8 relays. Each relay has three connections a common signal, COM, a normally closed connection, N/C, and normally open, N/O. In a normal state the common and normally closed outputs are connected. In an alarmed state the relay is energized making the common and N/O connect.

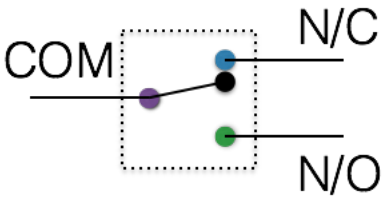


Figure 2, normal state

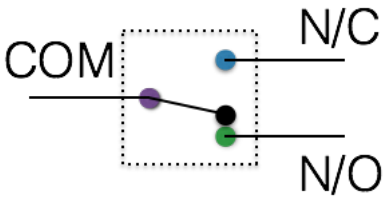


Figure 3, energized state

The DB25 connector has 25 pins and the numbering is shown in Figure 4. The connection to the front panel DB25 female connector and its relation to the relays is shown in Figure 5. The N/O and common connections are grouped closely together, while the N/C connections are placed in the next available space.

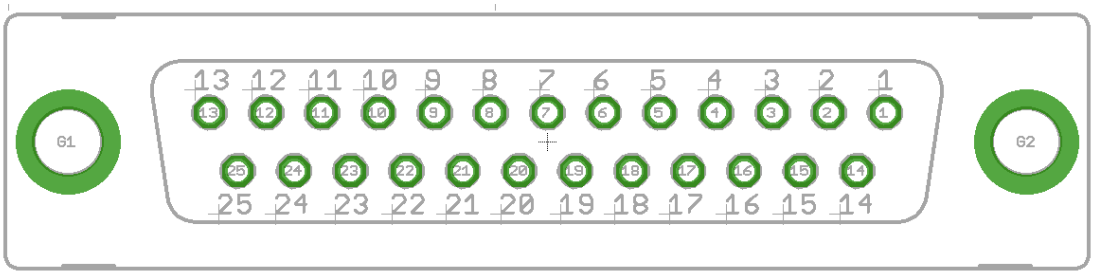


Figure 4, DB25 female connector on the front panel pin numbering

Figure 5, expanded view of DB25 pin functions

The normally open (N/O) and normally closed connections (N/C) are available for all relays. The first three relays are reserved and cannot be access by the user. The user relays can be configured to close when a temperature alarm has triggered and the N/C or N/O connections can be used to send this information to an external monitoring circuit.

Relay Output Assignments

Relay	COM	NO	NC	Function
RL0	2	14	1	Power fault relay
RL1	3	15	10	System fault relay
RL2	4	16	23	General Alarm relay
RL3	5	17	11	User relay 3
RL4	6	18	24	User relay 4
RL5	7	19	12	User relay 5
RL6	8	20	25	User relay 6
RL7	9	21	13	User relay 7

DB25 PIN Assignments

PIN	Relay	Function
1	RL0	Power fault relay NC
2	RL0	Power fault relay COM
3	RL1	System fault relay COM
4	RL2	Gen Alarm relay COM
5	RL3	User relay 3 COM
6	RL4	User relay 4 COM
7	RL5	User relay 5 COM
8	RL6	User relay 6 COM
9	RL7	User relay 7 COM
10	RL1	System fault relay NC
11	RL3	User relay 3 NC
12	RL5	User relay 5 NC
13	RL7	User relay 7 NC
14	RL0	Power fault relay NO
15	RL1	System fault relay NO
16	RL2	Gen Alarm relay NO
17	RL3	User relay 3 NO

18	RL4	User relay 4 NO
19	RL5	User relay 5 NO
20	RL6	User relay 6 NO
21	RL7	User relay 7 NO
22	NU	NU
23	RL2	User relay 2 NC
24	RL4	User relay 4 NC
25	RL6	User relay 6 NC

Control Port

In addition to the relay port the Access DTS has an external control I/O port. There are four inputs one of which can be used to reset the alarms. Five outputs are available which replicate the front panel status of the LEDS. These are intended for applications where Access is placed in another enclosure but the light indicators need to be visible on the external unit.

Their locations on the control port are shown below in Figure 6.

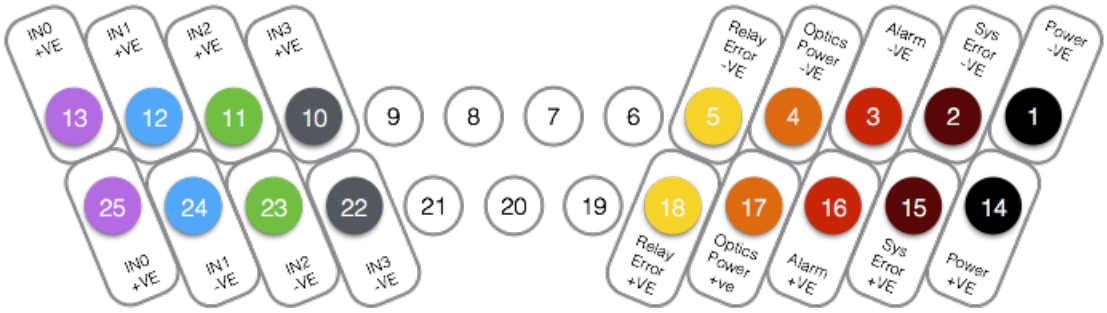


Figure 6, input and output

Inputs

Description describing voltages and connection direction

External Alarm Reset on IN0 needs to be held at 5v at least 2 seconds before a reset occurs

Input	+VE Terminal	-VE Terminal	Trigger voltage (V)	function
IN0	13	25	5V	Alarm Reset
IN1	12	24	5V	-
IN2	11	23	5V	-
IN3	10	22	5V	-

Outputs

Connections to external LEDs are provided from the following connections.

	+VE Terminal	-VE Terminal	Output Voltage	Function
Power	14	1		Power Light
System Error	15	2		Fibre break and laser error
Alarm	16	3		Alarm
Optics Power	17	4		Optics Power
Relay Error	18	5		Relay failed to respond

Front Panel Buttons and Indicators

The front panel buttons and indicators as described in Figure 1.

Power Button

Once power is applied to the 24VDC input the Access DTS will normally power up or when the power button is momentarily pressed. The power button has an integrated LED indicator and will illuminate green when powered. To turn off the Access DTS the button must be pressed and held for at least 5 seconds.

Laser Power Button

During data acquisition the button will flash blue. If the laser is power on, but the DTS is not acquiring, the LED will be powered on. To turn off the laser and halt the measurement press and hold the button for at least 2 seconds. Press and hold again for at least 2 seconds and the system will resume measuring.

Alarm Reset Button

When a temperature alarm occurs the integrated LED on the alarm reset button will illuminate red and so will the Alarm LED. To reset the alarm press and hold the alarm reset button for at least 2 seconds. The alarm will re-assert itself after the completion of the next measurement if the temperature on the fibre is not resolved.

System Error LED

This will illuminate on when the optical cable has been broken or disconnected from the DTS.

This LED will flash intermittently when there is a data save error.

Relay Error LED

This will illuminate if a relay has failed to closed.

Item	Description	Type	Function	Notes
A	Power Switch	Main power switch	Push to turn on Press and hold >5s to turn off	Illuminates green when powered
F	Optics Power switch	Push switch with integrated Blue indicator	Controls power supply to laser and HV supplies. Push and hold >2s to toggle between on and off states	ON: optics is powered FLASH: optics is powered and laser is active OFF: optics power is off
H	Alarm Reset	Push switch with integrated Red Indicator	Resets the triggered alarms	Push and hold >2s to reset alarms
D	System Error indicator	Yellow LED	This will illuminate on a system error	ON: fibre break FLASH: data save error

Figure 7, summary of the buttons and switches functions

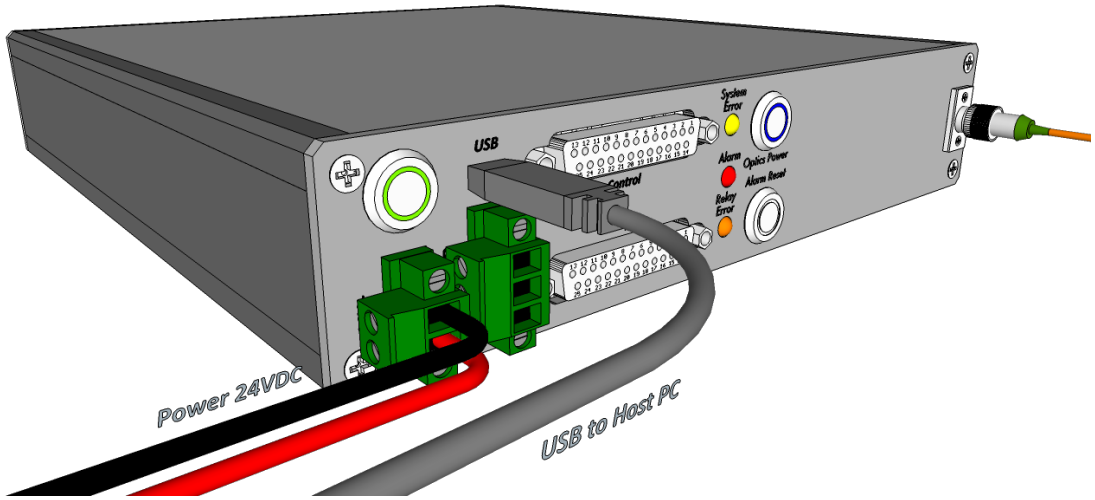
Connecting to Access DTS to a computer

The DTS comes with RS485 and USB interfaces. The data protocol is MODBUS so any generic MODBUS software can be used to access the data. The interfaces cannot be used simultaneously. If the USB connection is used the RS485 interface will be automatically disabled.

Direct Connection using USB

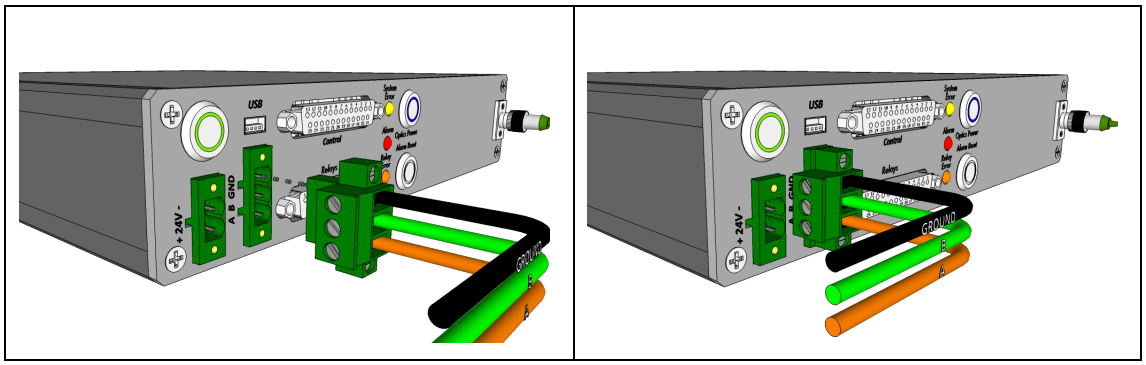
The Access DTS has a front panel USB connection for a direct connection to a PC. Internally Access DTS converts the MODBUS serial data into a more convenient USB interface, without the need for a cumbersome RS232 to USB converters. A standard USB cable with a Type A to Mini-B connector is required.

The USB drivers can be obtained from http://www.ftdichip.com/Drivers/VCP.htm



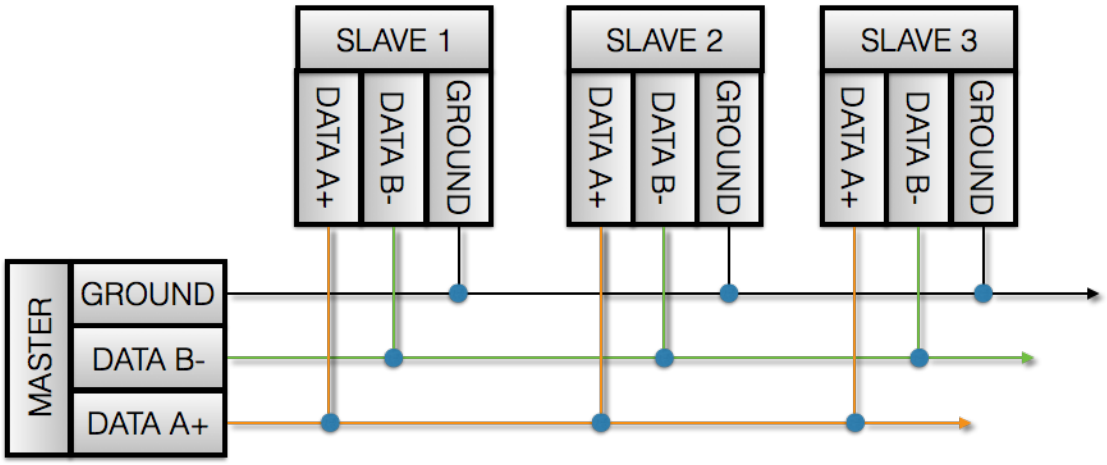
2-Wire RS485 Connection

In this configuration the PC, with ACE, is setup as a Master and connects to one or more slave devices. Before connecting to a bus each machine should be assigned a unique slave address. This process should be performed using a direct USB connection. Up to 5 machines can be used with the ACE software.



With the three flying leads already connected to the 3 pin terminal block[2], simply insert the connector into the front panel. It is recommended to tighten the fastening screws during long-term operation.

When connecting multiple units to an RS485 bus the units should be connected as described below.



Communication Parameters

ACE and the DTS communication settings are set to:

- Baud rate: 115200bps
- Parity: None
- Stopbits: 1

[2] The recommended terminal block can be obtained from Wurth Elecktronik part no. 691 340 500 003 5.08mm 3pin terminal block with flange.

Brief Note Regarding MODBUS

MODBUS is a serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers. MODBUS is now widely used as a means of connecting industrial electronic device and allows for communications among many devices connected to the same network bus.

The data is presented on a register table. A register is simply a location where a piece of information is stored, and a table is a collection of registers. MODBUS has several tables either holding binary data, where data is simply ON or OFF, or a 16bit value, such as a temperature. Some tables can be read and modified while some tables can only be read from. Parameters that define the measurement time or zone location are defined in a read and write table register. However, a temperature reading from the optical fibre is placed in a read only table.

The developer defines the data contained on the register table, and this information is supplied to the end user so that they can successfully retrieve the information they require from the device.

MODBUS works on the Master-Slave or Client-Server principle. The slave/server only responds to requests that are specifically directed to them. This is achieved by assigning a unique address to each slave. This allows multiple devices to be connected to the same network bus.

Data corruption is detected, but not corrected, using a CRC code (cyclic redundancy check). Two bytes are appended to each MODBUS data frame, which is used to check the frame's validity.

Notes to application developer

Please see BW-ACS-DOC-006 MODBUS Application Note for in depth instructions regarding Access' MODBUS implementation.

Since Access DTS uses a MODBUS protocol it allows end users to develop their own software to view data from the system. The following notes must be adhered to when developing 3rd party software.

1. Do not repeatedly request data from Access. Long data requests such as temperature data should be limited to once very 5s, this is matched to the minimum measurement time of 5s. The data acquisition system is paused each time to handled MODBUS requests.
2. Handle the error codes generated by MODBUS.
3. The distributed temperature data requires downloading in sections to overcome the MODBUS instruction size limit.
4. Zone details are always calculated irrespective of the zone's enabled status.

System Specification

The sensor unit

Enclosure

Electrical

Laser

Environmental

Outputs

Installation and Commissioning

Equipment installation

Access is a 1U half rack width device and should be placed in a well ventilated wall mounted cabinet.

Cable connections

Power 24VDC

Fibre optic cable 62.5um multimode graded index fibre.

RS485 Connection or USB

Relay port

i/o port connection

Software Installation

Prerequisites

- PC capable of running Windows 7 or higher, please consult Bandweaver for support regarding alternative operating systems (Linux and OSX).
- An ideal system should have Core i5 processor with 4GB RAM
- Screen resolution minimum 1280 by 800 pixels
- The Access Configuration Environment, ACE, requires Microsoft Visual C++ Redistributable Package. This can be obtained from the Microsoft website https://www.microsoft.com/en-us/download/details.aspx?id=40784. Download and run **vcredist_x86.exe**
- Virtual COM Port Drivers – Access DTS has a USB interface for direct connection. The drivers can be downloaded from: http://www.ftdichip.com/Drivers/VCP.htm. Installation guides for your operating system can be downloaded from: http://www.ftdichip.com/Support/Documents/InstallGuides.htm

ACE Installation

Please **follow** the following steps:

1. Install Virtual COM Port Drivers if using USB interface or relevant drivers for a RS485 converter.
2. Run **vcredist_x86.exe**
3. The software does not use an installer. Simply unzip **ACE2017XXXXXX.ZIP** into any directory of your choice, open the directory and run ACE.exe.

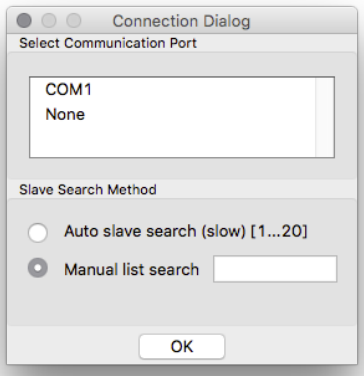
File Structure

During operation data is saved into the following directories.

C:\Users\[username]\Access-data\db\[DTS slave] – Windows 7

ACE - Access Configuration Environment Software

1. Locate and run ACE.exe
2. A **Connection Dialog** will display showing the possible communications ports and a Slave Search Method.
    a. Choose the corresponding connection to the Access DTS, for example **[COM1]**. If **[None]** or nothing is selected the software won't connect to a DTS. The other communication parameters are already set. Please refer to page 14 Communication Parameters for more details.
    b. Select the **[Slave Search Method] -> [Automatic slave search]** will search for a DTS at each address from 1 to 20. The process will take a several seconds. If the slave address is/are already known they can be entered in the **[Manual search list]**. Separate the search list with commas e.g. 10, 11, 12 etc.
    c. Select **[OK]** and the software will search for Access units.



3. The software will start and it will scan for the attached Access DTS units. If you have a direct USB connection only one unit will appear, however it will still scan all available MODBUS slave addresses.
4. The temperature will display in **[Temperature Display]** tab. Select **[Operation->Poll Devices]** to poll each DTS. The software will poll the machines every 5s. If multiple systems are connected on a RS485 bus selecting the different slave address will display the corresponding temperature details.
    a. If no data appears after a while check the measurement period.
    b. Ensure the slave number is selected in the left hand tree display.

NOTE:

USB and RS485 connection cannot be used at the same time. If a USB cable is connected it will take priority over an RS485 connection.

ACE User Interface

On the left side of the main window, Figure 8, the connected DTS units are shown in the **[live]** section and in the **[db]** section the current saved data.

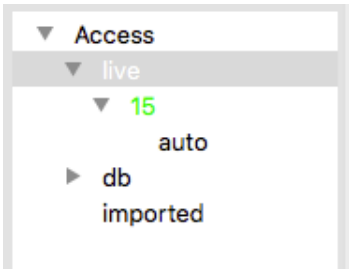


Figure 8, DTS device tree

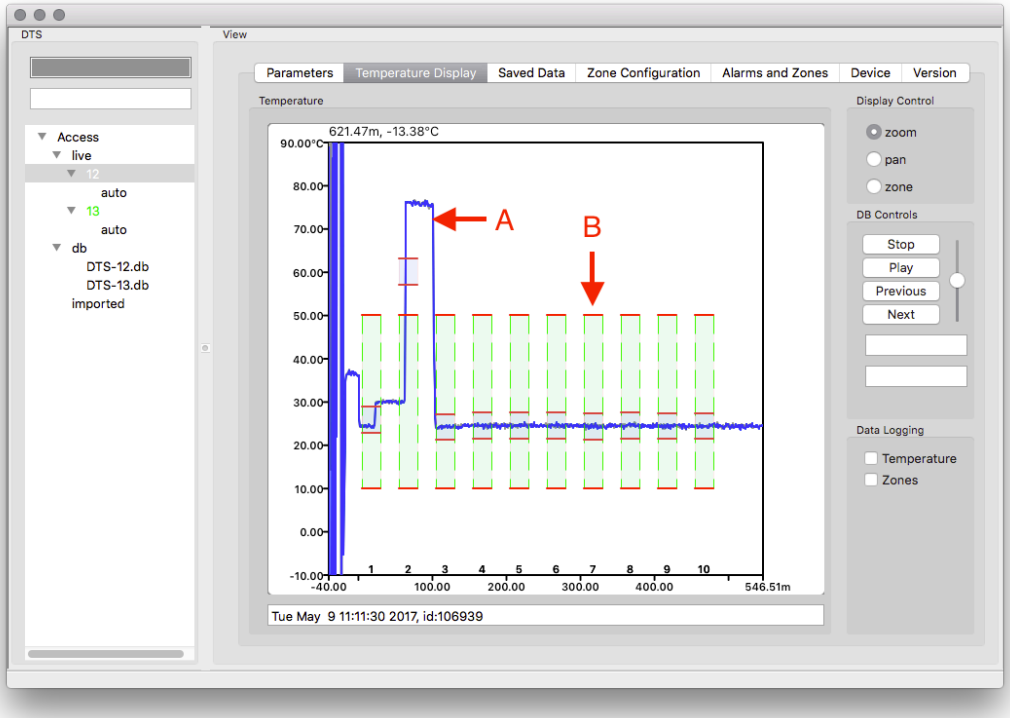
In the **[live]** section each number corresponds to the MODBUS slave address of each Access unit. Below each DTS unit in the **[live]** section there is an indication of the current state. The typical states are **[auto]** or **[stopped]**.

If multiple units are connected on the RS485 bus the **[live]** section will have a list of each slave address corresponding to a DTS unit. Using the mouse to select a DTS unit will force the software to display the relevant data to that machine.

In the **[db]** section are the saved data for each DTS unit. **[*.db]** is the file name of the data saved on the computer's hard drive.

Temperature Display

An example temperature trace is shown below, A – temperature trace, B – zone positions with maximum and minimum temperature thresholds.



Navigation

This section details how to manipulate the **Temperature Display** by using the mouse.

Zoom in

Left Mouse Button click and drag on the temperature display to zoom into a temperature feature.

Zoom out to the whole display

Shift + Left Mouse Button or **Right Mouse Button** to zoom out to see the whole temperature display.

Pan

Select **[pan]** is selected from Display Control. Left Mouse Button click and drag to pan the temperature display.

Zone

When **[zone]** is selected on **[Display Control]** the user can move the zones directly on the temperature graph. After any changes are made the user must enter the **[Zone Configuration]** tab and **[Update]** the values. If the changes are to be made permanent after a power cycle **[Save Zones]** must also be selected.

Currently only the position of a zone can be modified in this way.

Data Logging

Data logging allows the user to select which slave data is saved to a text file. The temperature or zone text files are saved in **C:\Users\[username]\Access-data\.**

Temperature

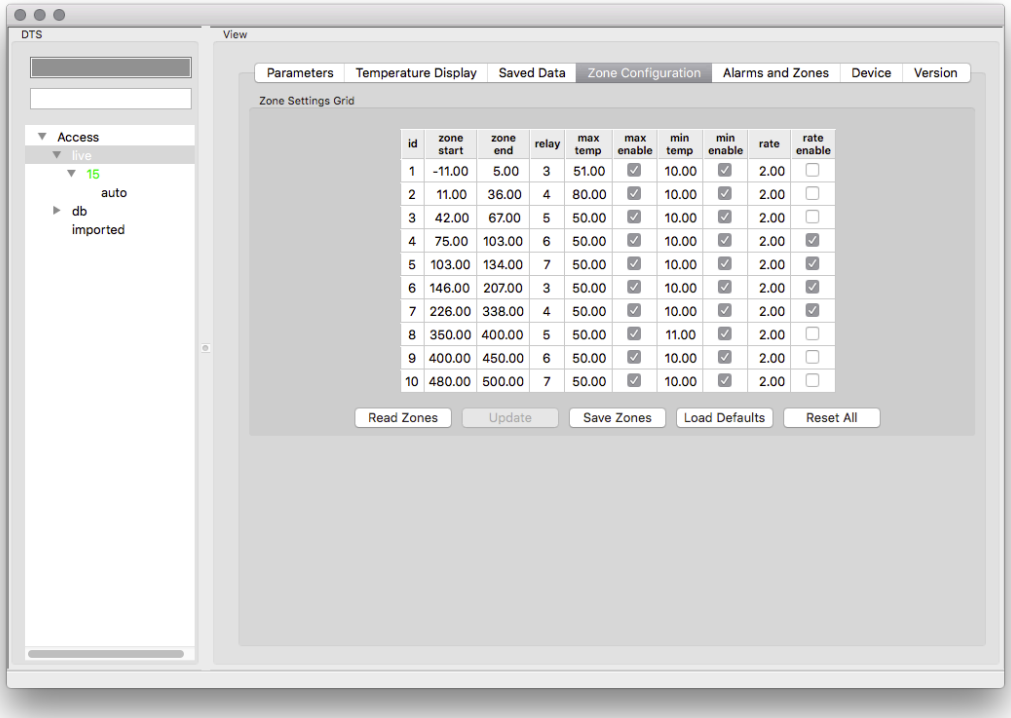
The temperature data can be saved in a more convenient text file using this option. Select the desired slave unit and select the **Temperature** option. The text file is saved with the filename **.[slave_id].txt**. If the file becomes larger than 5MB in size it will be automatically renamed to temp-[slave_id][YYYYMMDD-hhmmss].txt, and a new file will then be created for the latest data.

Zones

The average temperature from each zone can be saved as a text file using this option. The text file is saved with the file name **zones-[slave_id].txt**. If the file becomes larger than 5MB in size it will be automatically renamed to zones-[slave_id][YYYYMMDD-hhmmss].txt, and a new file will then be created for the latest data.

Zone Configuration

When ACE is first started the zone information is automatically downloaded from the hardware unit so that the zone positions can be overlaid on the temperature display. The zone settings are also displayed in the Zone Configuration information grid.



id	zone start	zone end	relay	max temp	max enable	min temp	min enable	rate	rate enable
1	-11.00	5.00	3	51.00	☑	10.00	☑	2.00	☐
2	11.00	36.00	4	80.00	☑	10.00	☑	2.00	☐
3	42.00	67.00	5	50.00	☑	10.00	☑	2.00	☐
4	75.00	103.00	6	50.00	☑	10.00	☑	2.00	☑
5	103.00	134.00	7	50.00	☑	10.00	☑	2.00	☑
6	146.00	207.00	3	50.00	☑	10.00	☑	2.00	☑
7	226.00	338.00	4	50.00	☑	10.00	☑	2.00	☑
8	350.00	400.00	5	50.00	☑	11.00	☑	2.00	☐
9	400.00	450.00	6	50.00	☑	10.00	☑	2.00	☐
10	480.00	500.00	7	50.00	☑	10.00	☑	2.00	☐

Zone Settings Memory Overview

The DTS unit has two memory locations, RAM and FLASH. The RAM memory is not permanent and the information is lost during once power is disconnected, such as a power cycle, while the data in the FLASH memory is permanent and is not lost when there is no power.

The zones configurations reside in FLASH and are copied to the RAM on boot up. All changes are made to the settings in RAM and then must be copied back to FLASH in order to become the default settings after a power cycle.

Operations of Buttons

Read Zones

Manually download the current zone information from the DTS unit's RAM. This may be required if not zones are overlaid on the temperature graph.

Update

After any changes are made parameter **Update** will transfer the settings to the DTS unit's RAM memory. If the machine is power cycled any changes will be lost and the zone configuration will be taken from flash memory (permanent).

Save Zones
The zone configuration currently present in the DTS unit will be transferred to permanent FLASH memory. These values become the default values and will then be used if the machine is power cycled.

Load Defaults
The default parameters from the flash memory are downloaded to the computer and used as the current zone configuration. This is will overwrite any recent changes to the DTS unit's RAM settings.

Reset All Zones
This will overwrite all zones with a default layout and automatically save them to the FLASH memory. The default layout is 25m zones separated by 5m with a max, min and rate alarm of 50ºC, 10ºC and 3.00ºC respectively.

Zone Parameters Setup

Access can configure up to 10 zones. Each zone is number from 1 to 10. Description of the alarm parameters:

Zone Start and Zone End
These define the start and end position of a zone to the nearest meter.

Relay
An output mechanical relay can be closed or opened when an alarm is triggered. There are 5 user accessible relays these are numbered 3 to 7. Relays 0 to 2 are reserved for system alarms, such as power, fibre break and general alarm.

Max Temp and Min Temp
These values determine the alarm threshold in degrees centigrade.

Rate
This is the temperature change threshold between measurements. If a temperature change between measurements is greater than this value an alarm will be generated (**[rate enable]** must also be set). To reduce the chance of false alarms the average rate between two rate readings is taken.

Max Enable, Min Enable, Rate Enable
These tick boxes enable or disable the alarm type. To disable an alarm function for a zone unselect all these options.

Modifying Values

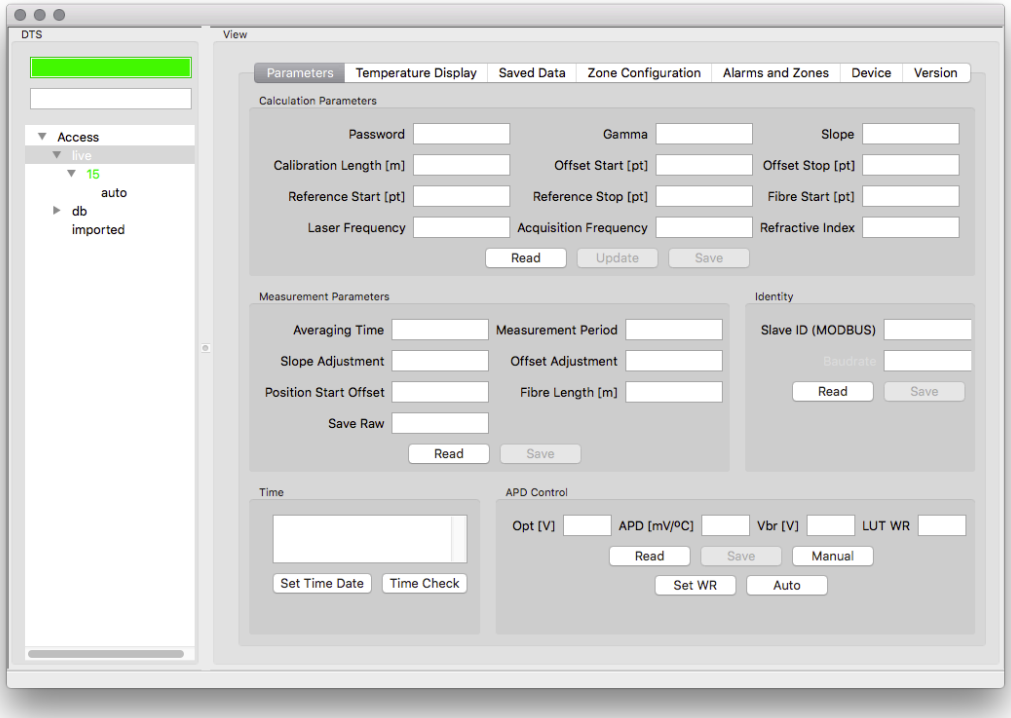
To change any numerical values double click the cell and enter new values.

Value limits
If the **[zone start]** is greater than **[zone end],** the **[zone end]** value will be modified automatically.

If **[relay]** is set less than 3, the **[relay]** will be fixed to 3. Relays 0, 1 and 2 are system related.

Parameters

Parameters are not automatically displayed use **[READ]** command to update the information.



Calculation Parameters

Password – must be set before changes to **[Calculation Parameters]** will work

Gamma – parameter 300-700

Slope – differential slope constant db/km

Calibration Length – distance between start of raw data and fibre 0m location

Offset Start and **Offset Stop** – calibration location in points

Reference Start and **Reference Stop** – calibration location in points

Fibre Start – start position of fibre in points

Laser Frequency – laser frequency read only

Acquisition Frequency – acquisition frequency read only

Refractive Index – fibre refractive index

Measurement Parameters

Averaging Time – period of time the DTS measures the fibre temperature, maybe less than or equal to measurement period. Typical value 5s.

Measurement Period – refers to the total period of time between the start of each measurement. Typical value 5s and must be larger than or equal to Averaging Time.

Offset Adjustment – offset adjustment value in degrees centigrade

If the averaging time is set to be greater than the measurement period, the software will automatically set the measurement period to be equal to the averaging time.

Save Raw – this option will allow the raw Stokes and Anti-stokes data to be saved to memory.

Fibre Length – initial fibre length value, any zones defined outside this range will be ignored. If the fibre is broken and shorter than this length the system error alarm will activiate.

Position Start Offset – Reserved.

APD control

The user should not change these values – ever!

Identity

Slave ID – refers to the MODBUS slave address of the attached unit. The slave id address can only be changed if the address is not in use by another DTS unit.

Time

These setting adjust or view the real time clock data in Access. The time setting can be checked and set using the following commands.

[Time Date Check]

[Set Time Date] will use the PC time to set the onboard real time clock.

NOTE:

When ACE is first connected to a DTS it will automatically attempt to update the on board real time clock to the computers time.

Alarm Zones

In this panel the state of the Access unit is shown.

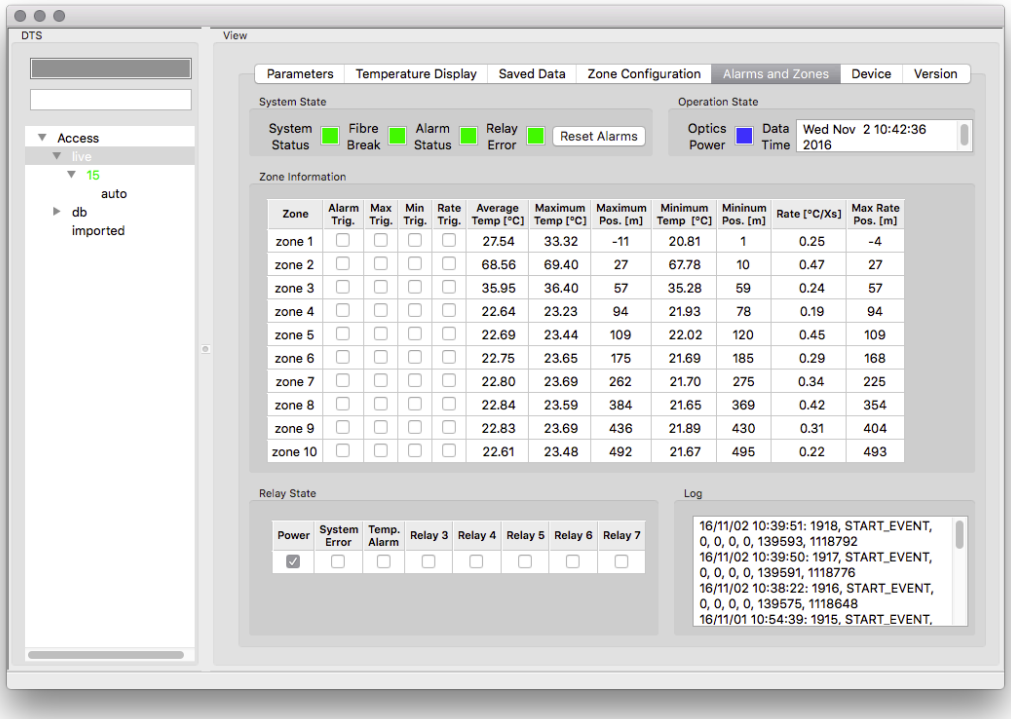
System State

Like the DTS unit's front panel these indicators show the **[System State]** indicators for the **[Fibre Break], [Alarm Status]** and **[Relay Error]** state of the machine. There is also a **[Reset Alarms]** button.

Zone Information shows the state of each zone. The state includes the alarm situation and the temperature details of each zone.

Relay State shows the relay state. A ticked box means that the relay is closed.

Log – important timing information regarding events from the DTS including alarm information, fibre break, alarm reset, power on etc.. This requires that the on board SD card is operating correctly.



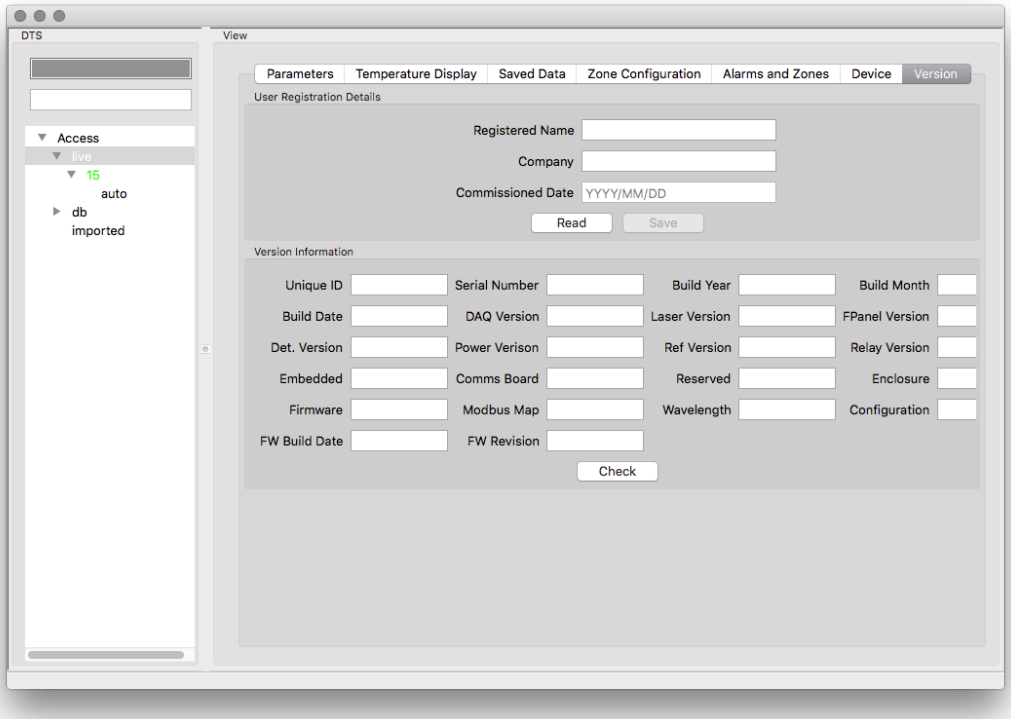
Version

User Registration Details

TBC

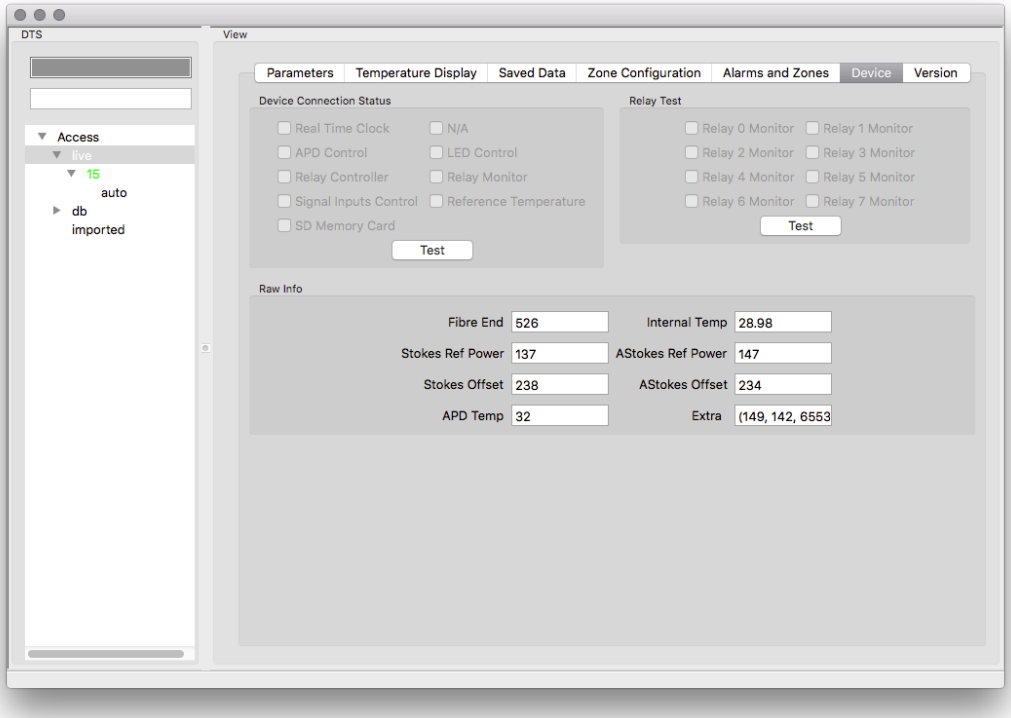
Version Information

TBC.



Device

In the **Device** tab various machine functions can be tested and internal measurements checked. There are three parts:



Device Connection Status

Here we can test to see the status of the internal devices. Each device can be checked for connection. After running the test a checked box means the device is connected.

Relay Test

The relay test will close the relays and the relay monitor will check if the relays have actually closed. The measurement should be stopped for this test. A checked box means that the relay was tested successfully.

Raw Info

During an acquisition the information regarding the raw data is displayed here.

Fibre End – end of fibre position to nearest metre

Internal Temperature – internal reference section temperature

Stokes Ref Power – Stokes power level in the reference section

Anti-stokes Ref Power – Anti-stokes power level in the reference section

Stokes Offset – ADC raw offset level for the Stokes. Typical values between 210 - 245

Anti-stokes Offset – ADC raw offset level for the Anti-stokes. Typical values between 210 - 245

APD Temp – APD temperature

Extra – power level of stokes and anti-stokes according to the start of Zone 1. By the start of Zone 1 just after the connector at 0m the loss due to the optical connector can be monitored.

NOTE: The references power and offset values are direct values from the data acquisition system. The signal is inverted as such the offset values are higher than the reference powers, and an increasing signal will cause the reference powers to decrease towards 0.

Save Data

Download Data

Access can be used standalone without a PC attached. When reconnected to a PC it may be desirable to obtain the temperature data stored within the DTS and synchronise it with the PC database.

Each data set has a unique Measurement ID, this consists of a 32bit number.

Summary of buttons

Mem Scan

- Finds the first and last recorded measurement
- Updates the IDs and dates in the related fields

Verify IDs

- Manually enter an ID into the First Measurement ID or Last Measurement ID

Download

- Download the data from the First Measurement ID to the Last Measurement ID – If the measurement ID is already recorded the data will be skipped

Stop Download

Sample Step

- Download every Nth value – If the data quantity is large it may be necessary to skip some data sets. The MODBUS baud rate setting is 115200bps so it may take time to download data.

Operation

1. Select **Mem Scan** to initially find the first and last measurement ids
2. Change the ID values and select **Verify IDs** to see the date of the data sets
3. Download the data
4. If the data is taking too long to download
5. Stop Download, Change the first and last Measurement ID or set a larger sample step.

Manual MODBUS commands

The communications protocol between the PC and Access is MODBUS. This part of the software allows the user to enter actual MODBUS commands and send them to the DTS unit. The software also appends the CRC code so that a fully valid MODBUS command can be created.

Usage:

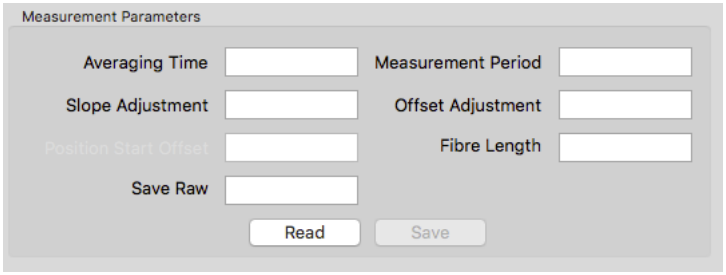
Enter the command in the first field and select **Append CRC**. The command will be copied over to the next field with all spaces removed and the correct CRC appended. Select **Send MODBUS Command** to send the command to the DTS unit.

Calibration and Measurement Adjustments

Connect the DTS and start a measurement as normal. The default values should give a working setup.

Measurement Parameters

- Setup up measurement periods for **Averaging Time** and **Measurement Period**. The longer the averaging time the better the temperature resolution.
- **Slope** and **Offset Adjustment** should only be modified if the correct equipment is available to generate accurate temperatures on coils of fixed length fibre. The default slope is 1.0 and offset 0.0.
- The **Fibre Length** value should be set to a few meters less than the length of attached optical cable.
- **Save Raw** will allow the raw data to be saved to the internal memory. Temperature is always saved by default.



System Parameter Setup

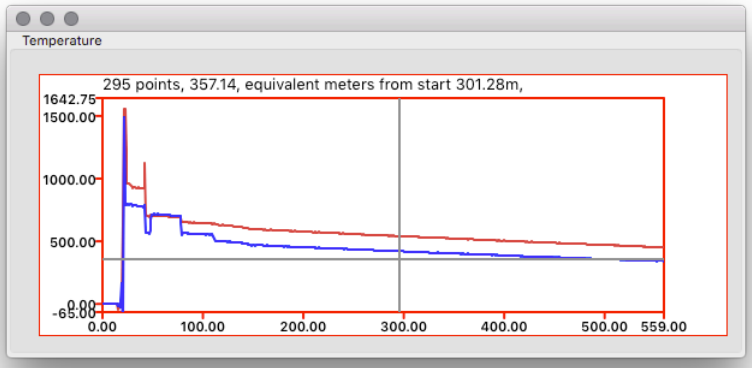
These values are intended for experienced users and can only be changed with a user password. It should be noted that some parameters use points instead of distance in meters. The number of points related to the data acquisition system.

- **Password** – must be set before changes to **[Calculation Parameters]** will work
- **Gamma** – parameter 300-700
- **Slope** – differential slope constant db/km
- **Calibration Length** – distance in meters between the start of raw data and where the fibre exits the DTS unit. This is the 0.0m location
- **Offset Start** and **Offset Stop** – a calibration location in points
- **Reference Start** and **Reference Stop** – a second calibration location in points
- **Fibre Start** – start position of fibre in points
- **Laser Frequency** – laser frequency read only
- **Acquisition Frequency** – acquisition frequency read only
- **Refractive Index** – fibre refractive index

Distance parameters

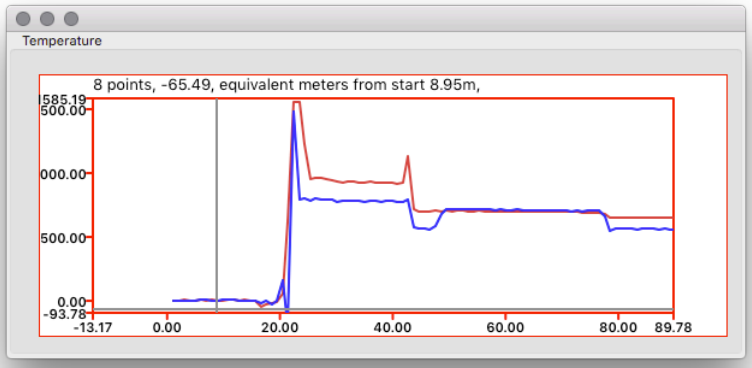
Open **[Saved Data]** tab and select **[Raw Data]**, after a few moments a new window will appear shown raw Stokes (red) and Anti-stokes (blue) data. The following

parameters define key locations on the raw data trace. These points are important for the calibration.

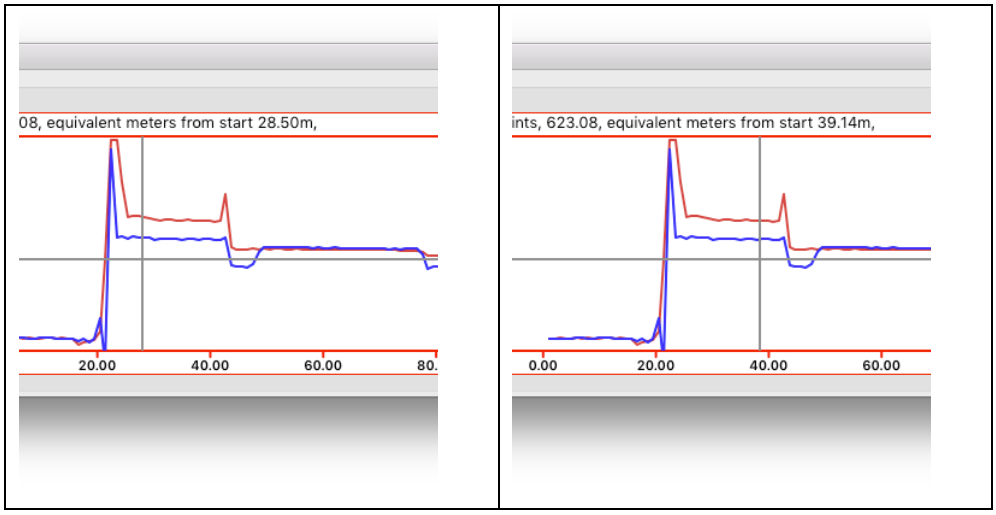


Using the left mouse button click and drag to zoom into the section between 0 and 60 points.

Calibration Length – set this value to the equivalent meter length displayed at the top of the graph window e.g. 42.83m.



Offset Start and **Offset Stop** – this defines the first calibration area where there is no signal in the optical fibre and is equivalent to absolute zero. Offset start should be 0 points and offset stop at 8 points



Reference Start and **Reference Stop** – this is the second calibration point and a refers to an internal coil of fibre at a known temperature. The start is about 28 points and reference stop is about 38 points. These are chosen to be in a flat section of the raw data.

Fibre Start – the fibre start position is at 22 points, it is defined as the location of the initial rise of signal due to the start of the laser pulse.

Temperature Calibration

- **Gamma** – parameter 300-700. The Gamma parameter scales the temperature
- **Slope** – differential slope constant [db/km]. The Slope adjusts the flatness of the temperature trace.

Calibrating Gamma

Setup requirement

The setup requires three sections of optical fibre. In this calibration, bare 250um graded index multi-mode fibre can be used. The temperature ovens can be two water baths or convection ovens. The fibre should consist of a continuous length of optical fibre without splices or connectors.

Each coil of fibre should be small enough to fit into the water bath or oven but should not exceed the manufactures minimum bend radius.

1. External reference 1 - 50m of fibre at a high fixed temperature 70ºC
2. External reference 2 - 50m of fibre at a second temperature 40ºC
3. A third section of about 500m

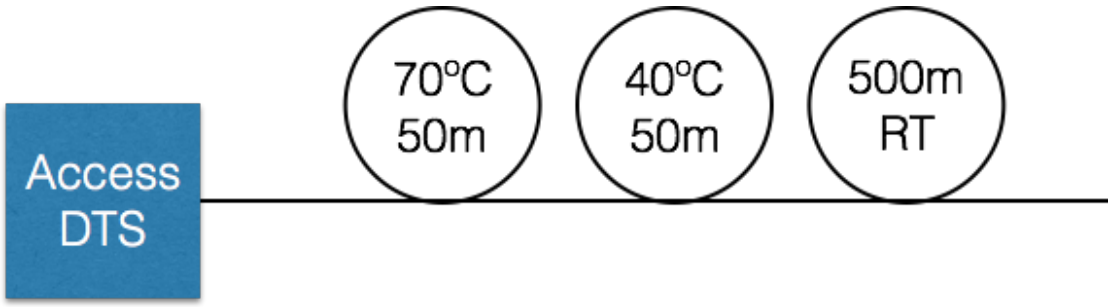


Figure 9, three sections of optical fibre for slope and offset calibration

Calibration method

1. Ensure the external reference at their fixed values and Access at room temperature.
2. Open **[Saved Data]** tab and select **[Raw Data]**, after a few moments a new window will appear shown raw Stokes (red) and Anti-stokes (blue) data.
3. Start an automatic temperature measurement and increase or decrease Gamma until the distributed temperature at the two external references match the expected reference values.

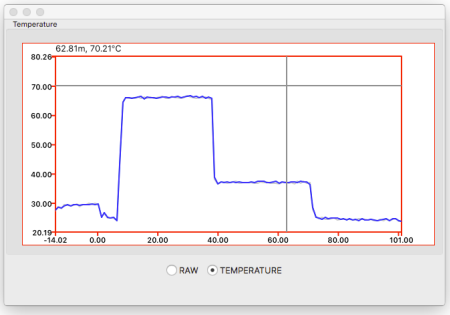


Figure 10, gamma too high

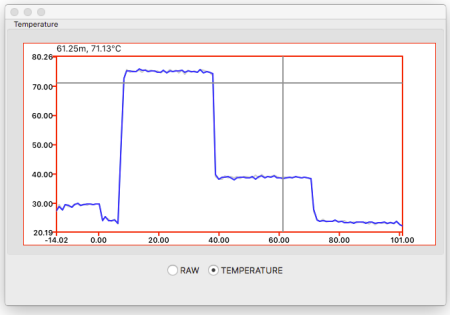


Figure 11, gamma too low

   a. Decreasing gamma will result in an increase in temperature difference between the two external references temperatures.
   b. Increase gamma will result in a decrease in temperature difference between the two external references temperatures.

Calibration Temperature Slope

In this step the slope parameter is adjusted so that the section of fibre at a constant temperature is measured as a flat constant value. In Figure 9 this refers to the last 500m section of fibre at room temperature.

The third section of fibre must be held at a constant temperature. It is sufficient to use a drum of bare fibre at room temperature. Avoid placing the drum of fibre near fan exhausts, from computers or other machinery, which may create temperature variations across the fibre.

Calibration method

1. ensure the attached fibre is at a stable temperature
2. Open **[Saved Data]** tab and select **[Raw Data]**, after a few moments a new window will appear shown raw Stokes (red) and Anti-stokes (blue) data.
3. Start an automatic temperature measurement and increase or decrease the slope value in small increments until the last section of fibre is flat.

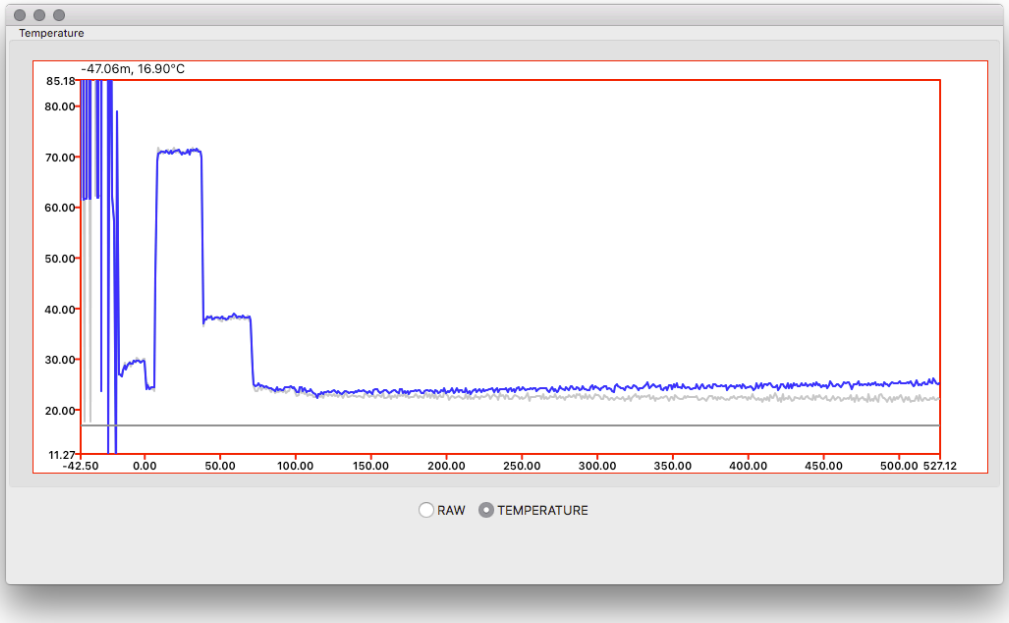


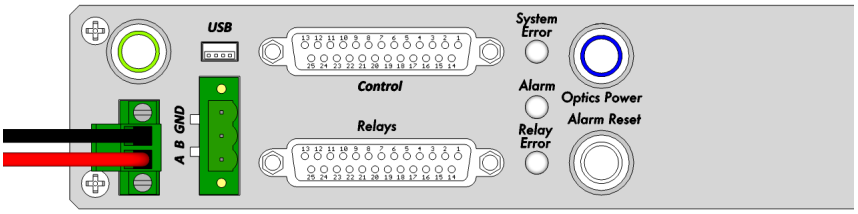
Figure 12, temperature trace with an incorrect slope calibration

Operations

This section describes those tasks that occur during day to day operations of the system.

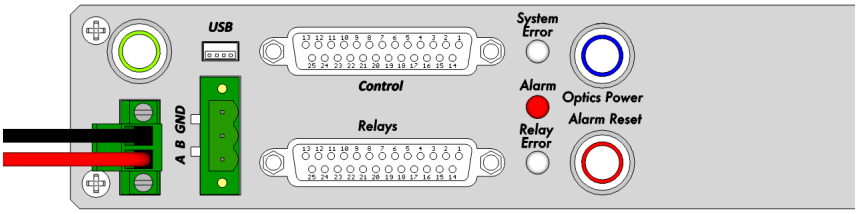
Normal Operation

Power on LED and the blue laser power LED will flash continuously indicating the laser is on and the system is acquiring data.



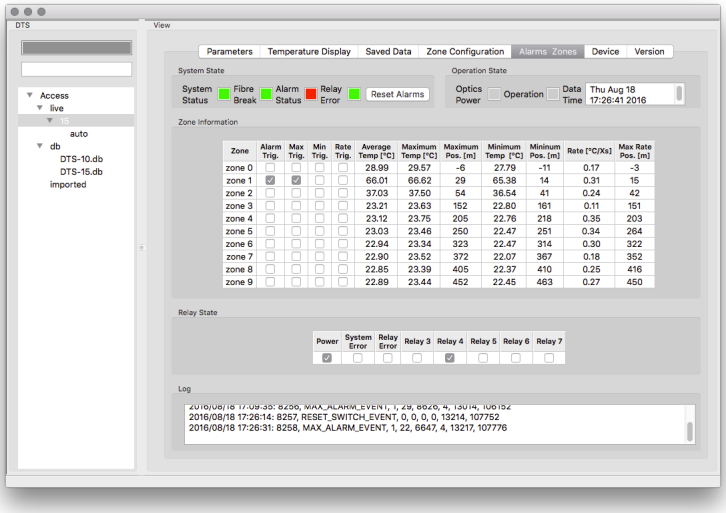
Temperature events

When a temperature exceeds the thresholds specified in the alarm configuration the Alarm LED will illuminate as well as the Alarm Reset button.



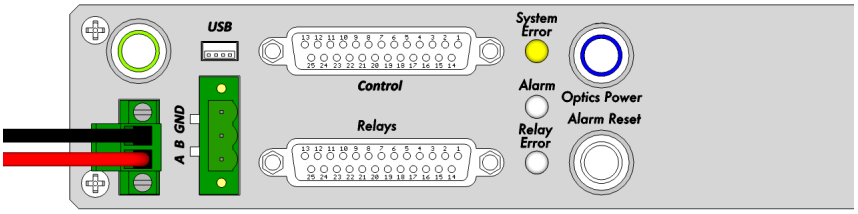
In the Alarms Zones tab more information is displayed:

a. System Status show an alarm
b. The Zone Information table will show which alarm has triggered, the type of alarm and the temperature information.
c. Relay State will indicate if any relays have closed due to the alarm event.
d. The log will display the exact time of the alarm and some further log information.



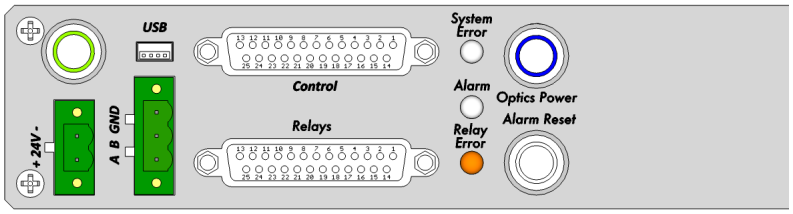
The alarm can be reset via the on screen button **Reset Alarms** or from the front panel button.

Fibre Break event



Relay Error

In the event that a relay fails to close properly during an alarm event the Relay Error LED will illuminate.



Optics enable/disable

Pressing and holding this button for more than 2 seconds will switch off the laser and stop the data acquisition. Pressing and holding the button again will cause the acquisition to start regardless of the previous acquisition state.

External I/O connection

Database Format

In this section the database for the control and interface software is described. The recommend method of retrieving data from the Access DTS is directly via the MODBUS interface, rather than through the ACE software.

Data storage

When Access DTS is connected to a PC the data is saved locally on the PC in an SQLite database. The following information is a description of the database and methods of dealing with the data.

The data has been written into the database in a human readable format. The easiest way to manipulate the data is by using Python. Any SQL text can be converted into real Python data structures using the following code

```
import ast
ast.literal_eval("—database text –")
```

The text data must be copied into the section between the double quotes.

Database Structure

The database table was generated using the following command

```
CREATE TABLE IF NOT EXISTS blobtable (o_id INTEGER,
                measurement_id INTEGER PRIMARY KEY,
                timestamp REAL,
                temperature CLOB,
                zone_info CLOB,
                alarm_events CLOB,
                corestate CLOB)
```

Meaurement ID

The measurement_id is the primary key to the database.

Timestamp

The timestamp is a real number of seconds since 00:00 1st January 1970

Temperature

Temperature is stored as a CLOB, a large character object. The format of which follows, where x is the distance and T is the temperature.

[[x0,T0], [x1,T1], ..., [xn,Tn]]

Zone Information

Zone information is a Python dictionary. There are 10 zones holding the following information key:

1. id – zone id
2. mean_temp – average zone temeprature

3. max_temp – highest temperature in zone
4. max_temp_pos – position of the highest temperature in meters
5. min_temp – lowest temperature in zone
6. min_temp_pos – position of the lowest temperature
7. max_rate – highest zone rate per measurement
8. max_rate_pos – position of the highest temperature rate

Example data

The example below shows the first 3 zones

```
[{'max_temp_pos': 35, 'max_rate_pos': 12, 'min_temp_pos':
12, 'min_temp': 27.62, 'mean_temp': 28.42, 'max_rate': -
0.55, 'id': 0, 'max_temp': 29.09},
{'max_temp_pos': 44, 'max_rate_pos': 54, 'min_temp_pos':
50, 'min_temp': 27.5, 'mean_temp': 28.18, 'max_rate':
0.09, 'id': 1, 'max_temp': 28.77},
{'max_temp_pos': 84, 'max_rate_pos': 84, 'min_temp_pos':
91, 'min_temp': 27.14, 'mean_temp': 28.22, 'max_rate':
0.28, 'id': 2, 'max_temp': 29.35},  .{data is repeated in
this manner},
{'max_temp_pos': 463, 'max_rate_pos': 455,
'min_temp_pos': 460, 'min_temp': 26.28, 'mean_temp':
27.02, 'max_rate': 0.40, 'id': 9, 'max_temp': 28.71}
...]
```

Alarm Events

Here each alarm type is said to be True or False depending on their alarm state for each zone. Each zone is listed in order.

1. alarm_status – general alarm statue of the zone
2. max_alarm_status – maximum alarm triggered
3. min_alarm_status – minimum alarm triggered
4. rate_alarm_status – rate alarm tirggered

Example data

The example below shows the first 3 zones

```
[{'rate_alarm_status': False, 'alarm_status': False,
'max_alarm_status': False, 'min_alarm_status': False},
{'rate_alarm_status': False, 'alarm_status': False,
'max_alarm_status': False, 'min_alarm_status': False},
{'rate_alarm_status': True, 'alarm_status': True,
'max_alarm_status': False, 'min_alarm_status': False},
...]
```

Core State

The core state defines 8 values:

1. fibre end position
2. internal reference oven temperature x 100
3. stokes reference power

4. astokes reference power
5. stokes offset
6. astokes offset
7. apd temperature
8. relay monitor state

Text File Format

ACE also includes data saving to text files. The temperature and zone data are saved to the default location:

`C:\Users\[username]\Access-data`

Temperature Data File Format

The file name is `temp-[slave_id].txt`

First Line

Distance length array for each point separated by tabs. This point starts at a negative number since it also includes data from within the DTS. This distance separation is not exactly equal to 1.0m

Example:

```
-41.750    -40.734    -39.718 …. 546.514
```

2nd line and subsequent lines

The first item is a date and time stamp of the temperature data followed by the temperature data separated by tabs. The first 50 data items may be random negative and positive values. This is normal since this data occurs when no light has been detected by the system.

Example:

```
2017-05-08 09:10:50 14.87      -18.63     -69.03     119.53
```

Zone Data File Format

The file name is `zones-[slave_id].txt`. It contains the average temperature in each of the 10 zones.

First Line

The first line contains the zone id names

Example:

```
      Z1    Z2    Z3    Z4    Z5    Z6    Z7    Z8    Z9    Z10
```

Second Line and subsequent lines

The first item is a date and time stamp of the zone data followed by the average value of each zone separated by a tab.

Example:

```
2017-05-09 10:11:05 23.83      24.31      24.19      24.15
      24.10      23.92      23.88      23.87      23.76
      23.84
```

Cable Types

TBC

Cable installation

System Maintenance

These following tests should be performed every 3 months

- Relay check
  - Stop measurement (right mouse click on slave and select stop)
  - Device -> Relay Test -> Test
  - Make sure all boxes are ticked
- Alarm check by artificially heating cable
- Fibre break check
  - During measurement remove connector and check the system error alarm appears.
- Clean fibre connector
  - If the cable is often removed and reinserted the tip of the connector may require cleaning. Clean the tips of the FC/APC connector with alcohol using a lint free tissue. Special FC/APC cleaning sticks can also be used to clean the receiving connector on the DTS.
- Raw Data check
  - Using the **Device->Raw Info** data The stokes/astokes ref power and offset values should be checked over time.

Troubleshooting

Software has just started but no data is displayed in the temperature graph, blue optics power is flashing on the front panel

- Select a slave id in under the **[live]**
- Check the measurement time, if it is long you will have to wait until the measurement time has elapsed before a temperature trace is displayed. For averaging times > 2min the temperature display will update after 2minutes.
- Operation -> Port Connect re-establish connection to DTS.

FAQ

Only one communication port (COM port) can be used with ACE.exe. Therefore it is not possible to simultaneously monitor multiple DTS machines connected via USB to a PC. However multiple machines can be monitored using RS485 networking.