Bandweaver

OPERATION, INSTALLATION AND MAINTENANCE MANUAL

DISTRIBUTED TEMPERATURE SENSING

Bandweaver Product Family: **Access**

DTS-AC-01-MAN-001

Revision 3.3, April 2020

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Revision History

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2	23 Jul 2018	corrections	Kin Wei Lee		
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3.2	18 Mar 2020	Corrections, fiber termination info deleted	Ryan Da Costa		
3.3	17 Apr 2020	Updated section 3.1, Product standard packing list	Ryan Da Costa		

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1 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[1]. 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.

A safety monitoring system that uses optical fiber sensing technology has the following characteristic advantages:

- Optical fiber is the sensing element, therefore, it is passive, immune to electromagnetic interference, water, acid, lightning, and explosion. This also means that it is an ideal sensor for electric field sensitive applications like electrified railway tunnel applications and urban metros.
- The sensing fiber has no electronics or moving parts, is immune to shock, vibration and electromagnetic interference and is intrinsically safe for use in hazardous zones as the sensing cable cannot cause an ignition;
- Its distributed nature can achieve large-scale long-distance monitoring and accurate positioning;
- Fiber optic sensor has high sensitivity with adjustable alarm thresholds that can be configured according to the complex environment and site topography.
- The system is simple to install. The cable has a long working lifetime of 30 years and low maintenance requirements.
- It has real-time online monitoring capabilities and can provide early warning to potentially destructive events.
- It can be integrated with other security equipment to offer a variety of alarm modes to form a safe and reliable monitoring area.

[1] Please contact Bandweaver regarding 1500m version

2 Safety

Please read the following safety information and warnings before connecting or operating this product.

2.1 Safety Warning Information and Symbols

General Warning Symbol

DO NOT ATTEMPT TO OPEN THE UNIT.
The product does not contain any user serviceable parts.

If smoke or any burning smell is emitted from the product, or in the event of any other emergency, immediately cut the power supply to the product and inform Bandweaver or its authorised 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 the product.

Laser Radiation Warning Symbol

DO NOT EXAMINE OR LOOK DIRECTLY INTO THE EXPOSED FIBRE OR CONNECTOR DURING MEASUREMENT.
DO NOT UNDERTAKE FUSION SPLICING OR SIMILAR FIBRE JOINING WHEN THE PRODUCT IS IN OPERATION AND CONNECTED TO THE FIBER.

This product incorporates a pulsed laser device whose invisible output radiation is potentially hazardous if viewed directly by eye.

Always turn off the product, and if possible disconnect the fibre/connector, before any examination of the fibre.

High Voltage warning Symbol

DO NOT ATTEMPT TO OPEN THE UNIT.
This product has High Voltage (HV) components inside and voltages within the equipment are high enough to endanger life.
Only manufacturer trained and approved service personnel are authorised to remove the covers.

DO NOT GET THE PRODUCT WET, OR EXPOSE TO EXCESSIVE MOISTURE.
In the event of water (or other liquid) ingress, disconnect the power and inform Bandweaver or its authorised agents. Do not touch the case during a lightning storm.

2.2 Laser Safety

The 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 recommended 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.

It is recommended that the unit is located where only authorised personnel have access to the front and rear connectors. Similarly, all personnel with such access must be made aware of the risks of working with such equipment. For unused output fiber optic connectors on the instrument, the protective caps must be utilised.

2.2.1 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.

2.2.2 Additional Warnings

Avoid exposing the device to direct sunlight or other heat sources to protect sensitive components.

3 Product Specifications

System Specifications		
Measurement range	500m	1500m
Temperature sensing range	Cable dependent	
Temperature resolution	0.5°C @ 5 seconds	1.6°C @ 5 seconds
Spatial resolution	1.6m (best)	<3.5m
Sampling resolution	1m	2m
Measurement time	5s < t < 20min	5s < t < 20min
Number of channels	1	
Laser Wavelength	975nm	
Zone Information	10 Configurable smart zones	
Alarms	Max. Temp / Min. Temp / Rate of change	
Data Storage	4GB	
Operating Environment		
Operating temperature	-10°C to +50°C	
Operating Humidity	0 to 95% RH NC	
Storage temperature	-40°C to +85°C	
Ingress Protection	IP40 Note: Installing Access inside an appropriate cabinet may significantly improve the IP rating.	
Physical Characteristics		
Dimensions	1-U, half rack width 44mm (H) x 220mm (W) x 246mm (D)	
Weight	2 Kg	
Material	Aluminum	
Colour/Finish	Black powered coating	
Electrical Characteristics		
Supply Voltage	24V DC	
Power Consumption	8.5 W	
Relays	Relay outputs - 3 system, 5 user (System: power off, general alarm, system error)	
Electrical Interfaces	USB and RS485 (MODBUS supported functions: 0x02, 0x03, 0x04, 0x05, 0x06, 0x10)	
Sensor Cable		
Fiber Type	62.5µm graded index multimode sensing fiber	
Connection for sensor cable	FC/APC	

3.1 Product Standard Packing List

No	Item description	Qty
1	Packing list	1
2	Test report	1
3	Access Control Unit	1
4	DB25 cable	2
5	Fiber pigtail	1
6	Power adapter	1
7	3-way RS-485 connector	1
8	Mini USB cable	1
9	AC Power cable	1
10	CD	1

Table 3-1 Packing List

4 Product Start-Up and Operation

4.1 Front Panel View

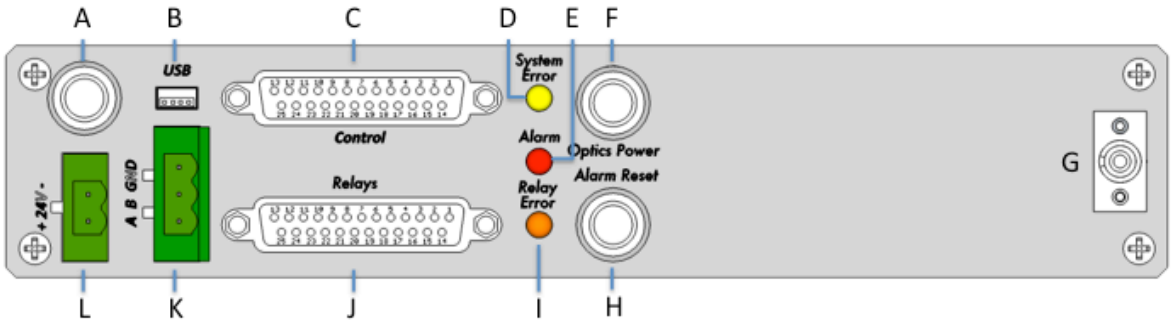


Figure 4-4-1 - Front Panel View

4.1.1 Front Panel Components

Item	Description	Type	Function
A	Main Power switch	Push button with GREEN indicator	Push to turn on. Press and hold >5s to turn off Steady Green: Powered ON
B	USB Interface	Mini-B	Direct PC interface
C	Control Interface	DB-25 female	Control inputs and system light outputs
D	Indicator: System error	YELLOW LED	Indicates system error Steady Yellow: Fiber break error Flashing Yellow: Data save error
E	Indicator: Alarm	RED LED	Indicates temperature alarm Steady Red: Temperature alarm
F	Optics power switch	Push button with BLUE indicator	Switches laser on or off. Push and hold >3s to toggle between on / off states Steady Blue: Optics power is ON Flashing Blue: Data acquisition in progress. Optics powered + Laser is active OFF: Optics power is OFF
G	Sensor cable connector	FC/APC connector	Connection point for 62.5um graded index multimode sensing fibre
H	Alarm reset	Push button with RED indicator	Resets the triggered alarm. Press and hold >2s to reset alarms
I	Indicator: Relay error	ORANGE LED	Indicates that a relay output has failed to close
J	Relay output connector	DB-25 female	Relay outputs. Max 48VDC 1A. See 6.1 for more detail
K	RS-485	3-pin 5.08mm terminal block	RS-485 communication TOP: GND MID: B (-ve) BOT: A (+ve)

L	Power input	2-pin 5.08mm terminal block	Main power in: 24VDC TOP: -ve BOT: +ve

Table 4-1 Front panel components

4.2 Rear Panel View

4.2.1 Rear Panel Components

There are no components mounted on the rear panel.

4.3 Product Configuration

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.

Relays are also available.

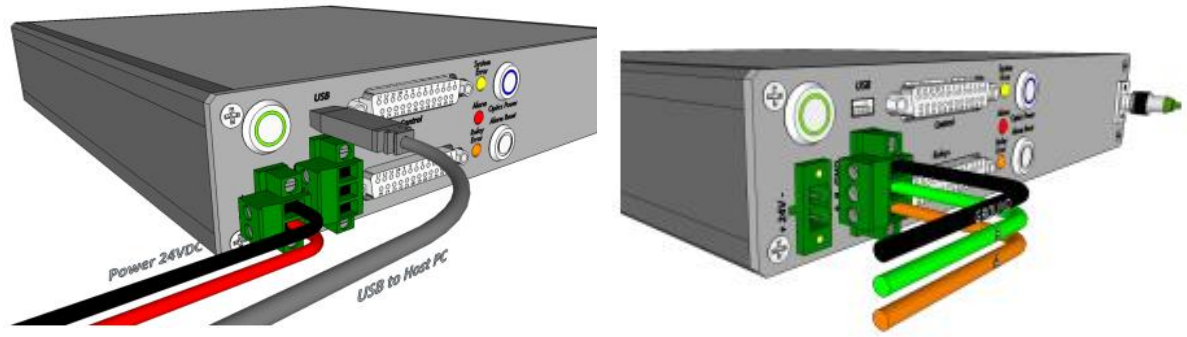


Figure 4-2 Connection for Product Configuration: USB (left) / RS-485 (right)

Required Equipment:

1. Access Distributed Temperature Sensing unit
2. Suitable Power Supply:
   Access requires 24V DC power supply.
3. Laptop / PC:
   To configure the Access.
   Must be capable of running Windows® 7 or higher. Please consult Bandweaver for support regarding alternate operating systems such as Linux or OSX. ⚠
   - *Windows® 7*
   - *Intel i5 processor with 4GB RAM or more recommended*
   - *Min screen resolution: 1280 x 800 pixels*
4. Microsoft Visual C++ Redistributable package
   This can be obtained from the Microsoft website at:
   https://www.microsoft.com/en-us/download/details.aspx?id=40784
   Download and run ***vcredist_x86.exe***
5. Virtual COM Port Driver
   Access has a built-in Serial to 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
6. ACE Configuration Software
   Software Installation:

Install Virtual COM Port Drivers if using USB interface or relevant drivers for an RS-485 converter.
*Run **vcredist_x86.exe**.*
*The software does not need an installer. Simply unzip **ACE2017XXXXXX.zip** into any directory of your choice, open the directory, and run **ACE.exe**.*

Uninstalling the software (if required):
Delete the software directory

4.3.1 File Structure

During operation, data is saved into the following directories:
Windows 7:
Database

C:\Users\[USERNAME]\Access-data\db\DTS-[SLAVE_ID].db

Temperature

C:\Users\[USERNAME]\Access-data\temp-[SLAVE_ID].txt

Events

C:\Users\[USERNAME]\Access-data\events-[SLAVE_ID].txt

Zones

C:\Users\[USERNAME]\Access-data\zones-[SLAVE_ID].txt

Core status values

C:\Users\[USERNAME]\Access-data\cs-[SLAVE_ID].txt

Further information regarding data logs and formats can be found in chapters 7 and 8.

4.4 Startup

Locate and run ACE.exe
A connection dialog pops up showing the available **Communication Port**s (option 1) and a **Slave Search** (option 2).

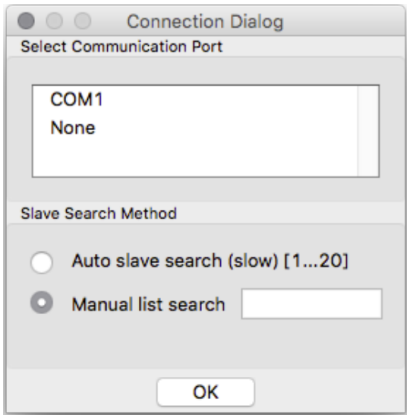


Figure 4-3 ACE Connection Dialog

Option 1:

- Choose the appropriate connection to the Access DTS. Eg. **COM1**.
  Note: If **None** is selected or no selection is made, the software will not connect to any Access.
- The remaining communication parameters are already set.
  Please refer to Sections 6.3.1 and 6.3.2 for more details.

Option 2:

- Select **Slave Search** < **Automatic Search**. This will search for a DTS at each address from 1 to 20. The process may take several seconds.
- If the slave address(es) is/are already know, they can be entered in the **Manual list search**. Separate the search list with commas, eg.: 10, 11, 12 etc.

Click **OK** and the software will search for attached Access units.

In the case of a direct USB connection no more than one unit will appear. However, it will still scan all available MODBUS slave addresses.

Once connected to an Access unit, the temperature will display in the **Temperature Display** tab.

Select **Operation** < **Poll Devices** to poll each Access. The software will poll the machines every 5 seconds. If multiple systems are connected on the RS-485 bus, selecting the different slave addresses will display the corresponding temperature details.

If after some time, no data has appeared:

- Check the measurement period
- Ensure the slave number is selected in the tree display on the left hand side

Note:
The USB and RS-485 interfaces cannot be using simultaneously. If a USB cable is connected, it will take priority over the RS-485 connection.

4.5 Product operation

For temperature data to be displayed, a fibreoptic sensing cable must be connected.

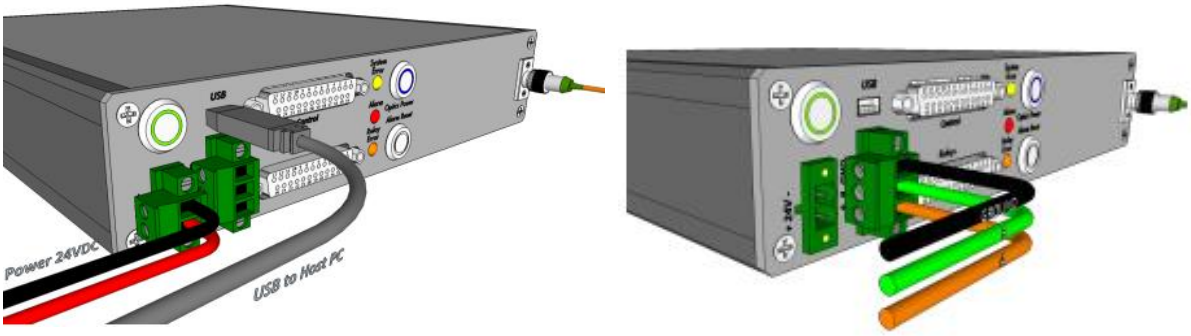


Figure 4-4 Connection for Product Operation: USB (left) / RS-485 (right)

Required Equipment:

1. Access Distributed Temperature Sensing unit
2. Suitable Power Supply:
   Access requires 24V DC power supply.
3. Laptop / PC:
   With all required software installed as described in 4.3.
4. Fiber Optic Sensor Cable:
   Standard 62.5µm/125µm graded index multimode optical fibre terminated with an FC/APC connector

As a safety precaution before inserting the connector into the optical connectors into the Access **please turn off the laser or turn off the machine.**

Also see 4.5.1 for making the connection to the Access.

4.5.1 Connecting to the Access ⚠

When the optical fibre is ready, the FC/APC connector can be connected to the Access DTS.

See the instructions below to correctly insert and mate the FC/APC connector of sensing cable to the Access DTS. Following the below instructions will keep you for inadvertently damaging the connectors.

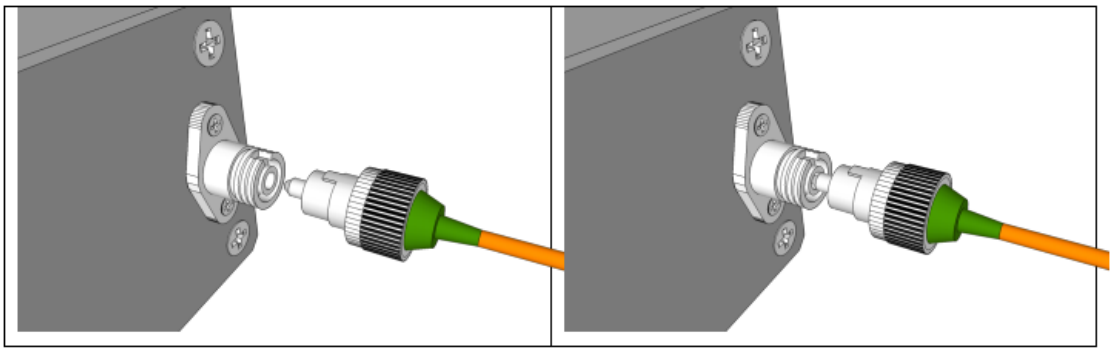


Figure 4-5 Inserting the sensing fiber.
Notch shown in 12 o'clock position must be aligned with the tab of the mating connector.

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

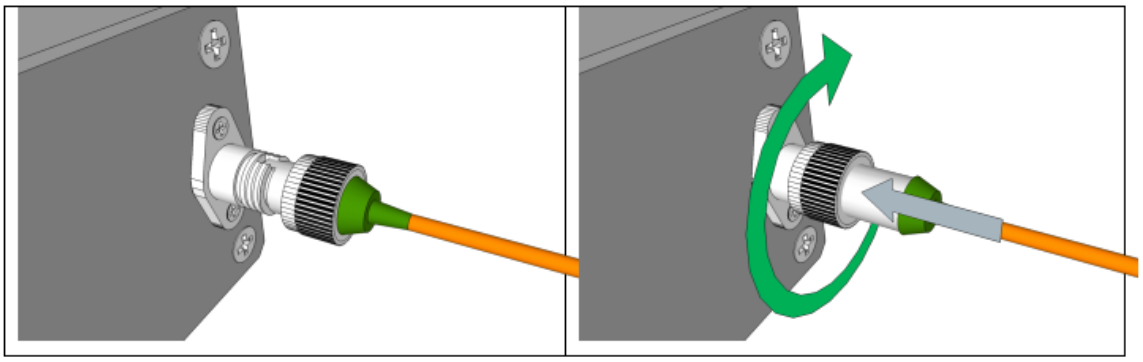


Figure 4-6 Push in the connector and screw into place

NOTE:

1. Turn the laser off before plugging or unplugging the optical connector;
2. Do not look directly at the connector when the laser is on;
3. Do not touch the end of the connector or allow the end of the connector to touch anything;
4. If the tip does touch anything, use alcohol and lint free cloth to clean it;
5. Do not force the connectors. This can deviate the optical fiber from its original position and affect communication.
6. Do not over bend or wind the patch cord as this can increase the attenuation in transmission.
7. Do not continue to use a connector if it has been damaged, but rather replace it as soon as possible.

8. After use, ensure the connectors are well protected against dusts or grease contamination with a suitable cap.

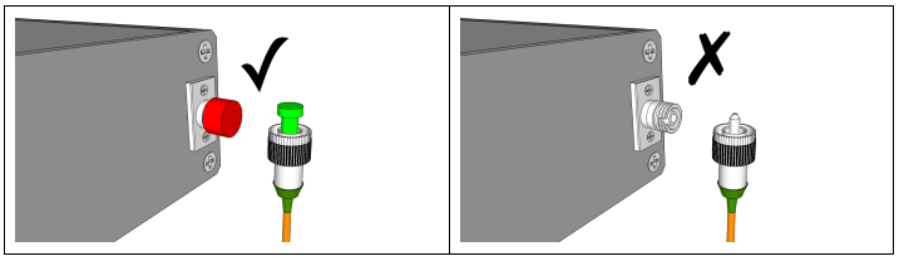


Figure 4-7 Always protect the connectors with the cap when not in use

4.6 Start Measurement

Before operating Access, ensure all users have read and fully understood the safety sections of this user manual.

Once the optical fibre and communication cable have been connected, return power to the Access and turn on the laser (see Section 4.6.2 below).
Run the ACE software and reconnect to the available Access units as detailed in 1.1.

Detailed instructions on the ACE user interface can be found in Section 6.

4.6.1 Normal Operation

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

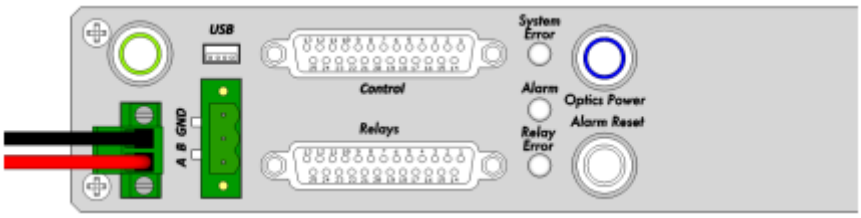


Figure 4-8 Normal Operation

4.6.2 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.

5 ACE User Interface

On the left side of the main window, show in Figure 5-1, the connected DTS units are shown in the **live** section and in the **db** section the current saved data.

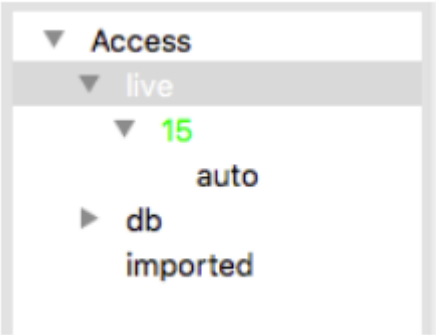


Figure 5-1 DTS device tree

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.

5.1 Temperature Display

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

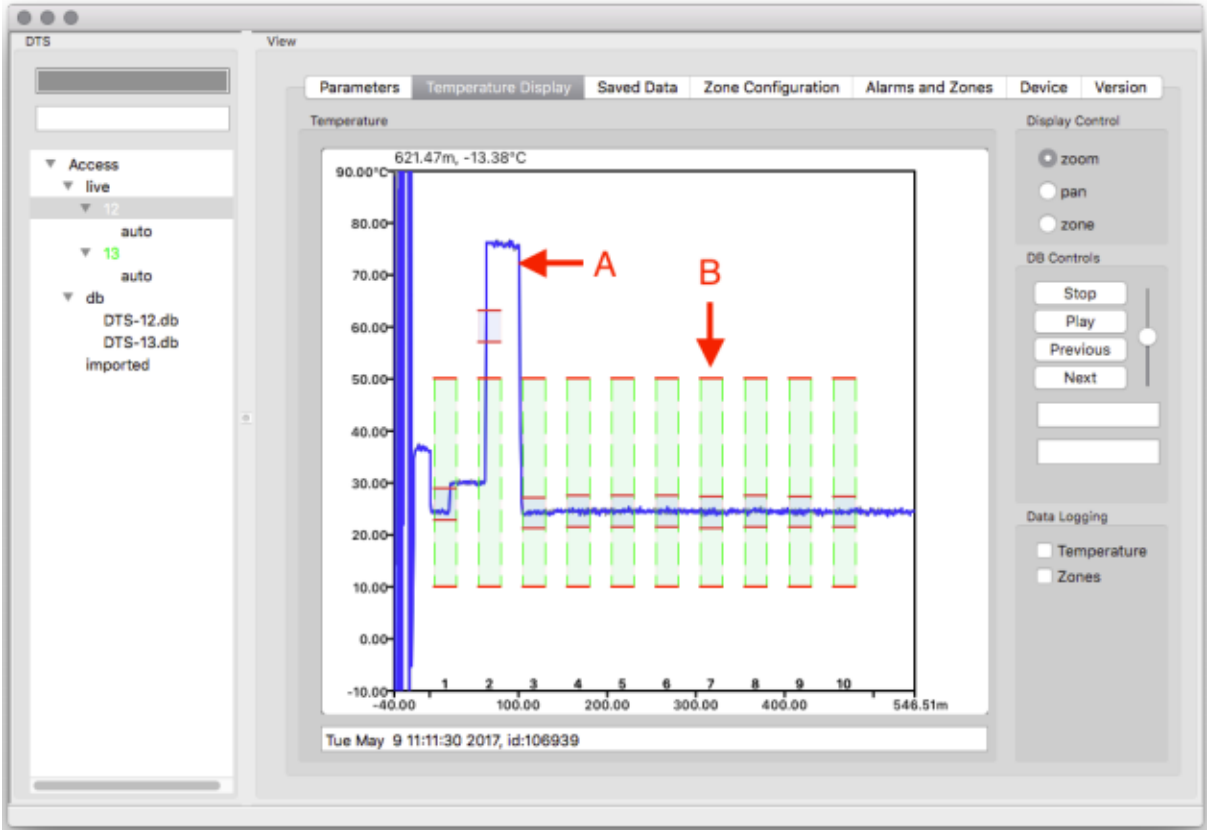


Figure 5-2 Temperature display

5.1.1 Navigation

This section details how to manipulate the temperature display 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** 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.

5.1.2 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 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 automatically be renamed to **zones-<slade_id><yyyymmdd-hhmmss>.txt**, and a new filename will be created for the latest data.

5.2 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 zones are displayed as light green rectangles. The zone settings are also displayed in the **Zone Configuration** information grid.

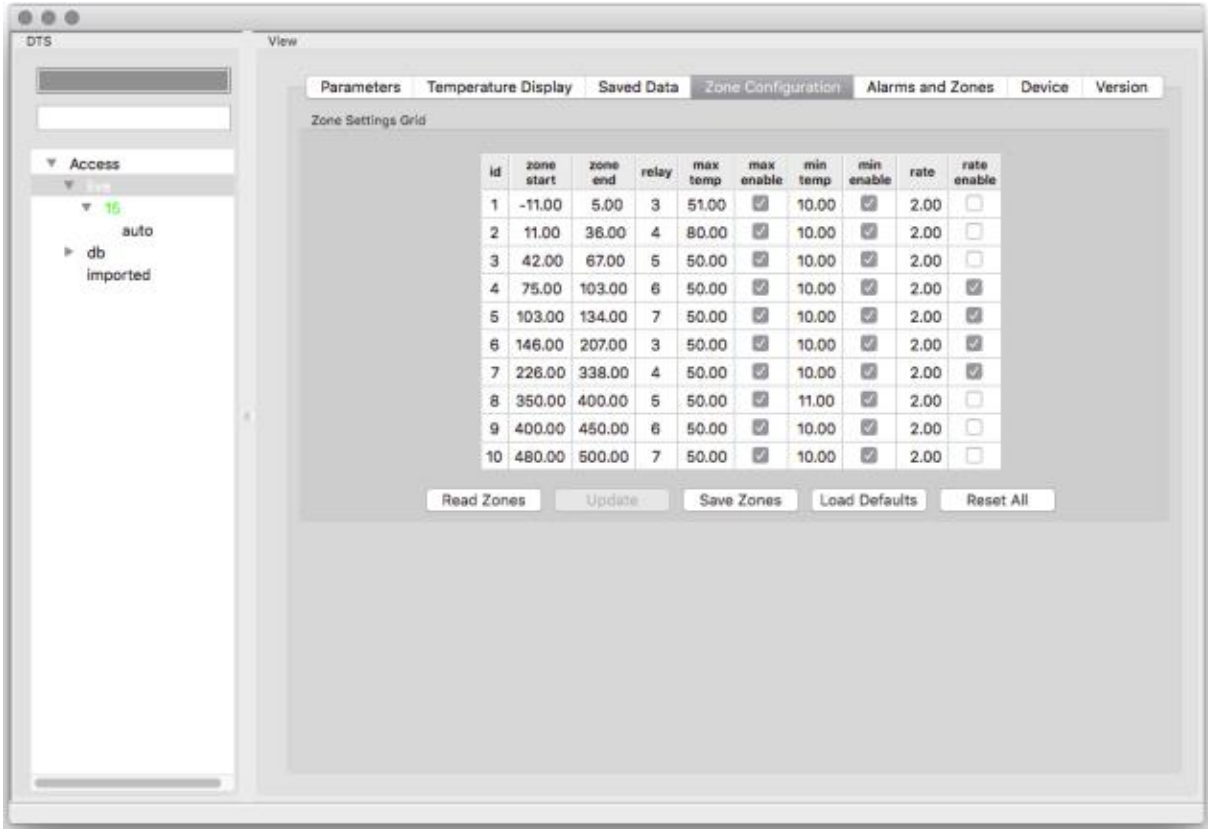


Figure 5-3 Zone Configuration display

5.2.1 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 once power is disconnected, such as during a power cycle.

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. Any changes are initially 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.

5.2.2 Operation of Buttons

Read Zones:

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

Update:

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

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 consist of 25m zones separated by 5m with a max, min and rate alarm of 50ºC, 10ºC and 3.00ºC respectively.

5.2.3 Zone Parameters Setup

Access can be configured with a maximum of 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 and Rate Enable:

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

5.2.4 Modifying Values

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

5.2.5 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 and as such are not user configurable.

5.3 Parameters

Parameters are not automatically displayed. Use the **READ** command to update the information.

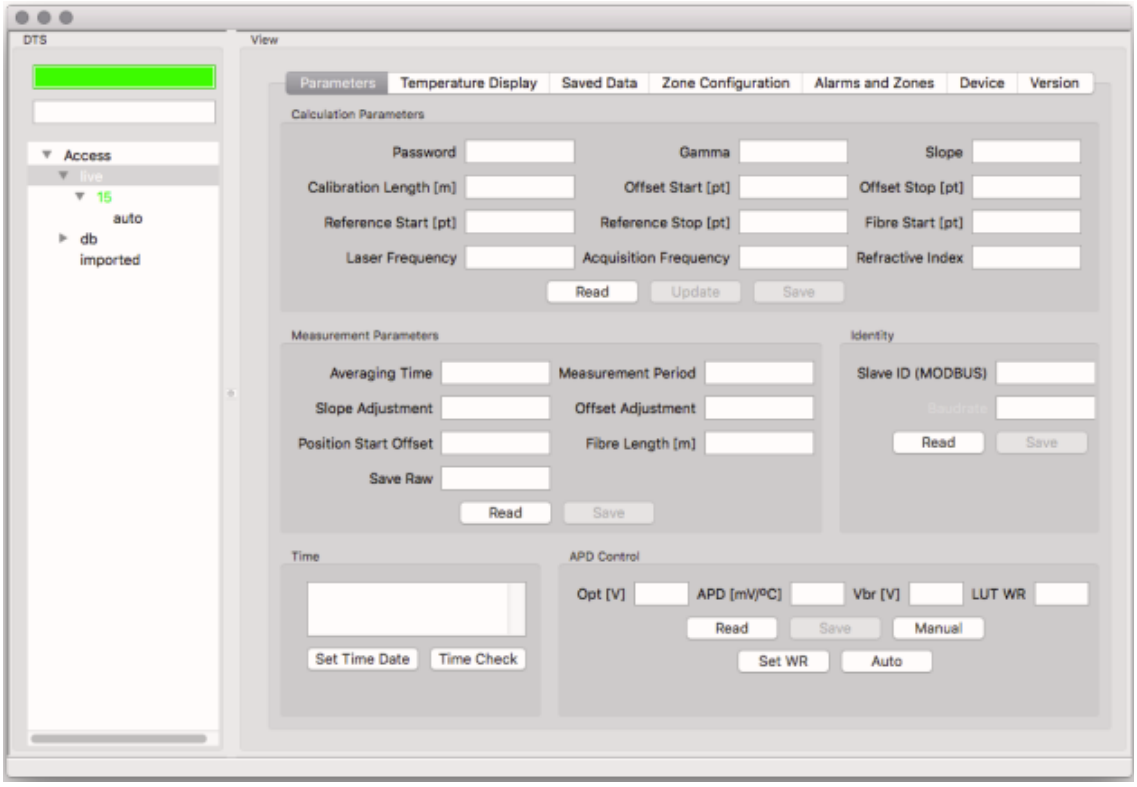


Figure 5-4 Parameters display

5.3.1 Calculation Parameters

These are factory set and should not be changed.

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 / Offset Stop: *calibration location in points*

Reference Start / Reference Stop: *calibration location in points*

Fiber Start: *start position of fibre in points*

Laser Frequency: *laser frequency – read only*

Acquisition Frequency: *acquisition frequency – read only*

Refractive Index: *refractive index of the fiber*

5.3.2 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 activate.*

Position Start Offset *Reserved.*

5.3.3 APD Control

Do not change these values!

5.3.4 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.*

5.3.5 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.

5.4 Alarms and Zones

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

5.4.1 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.

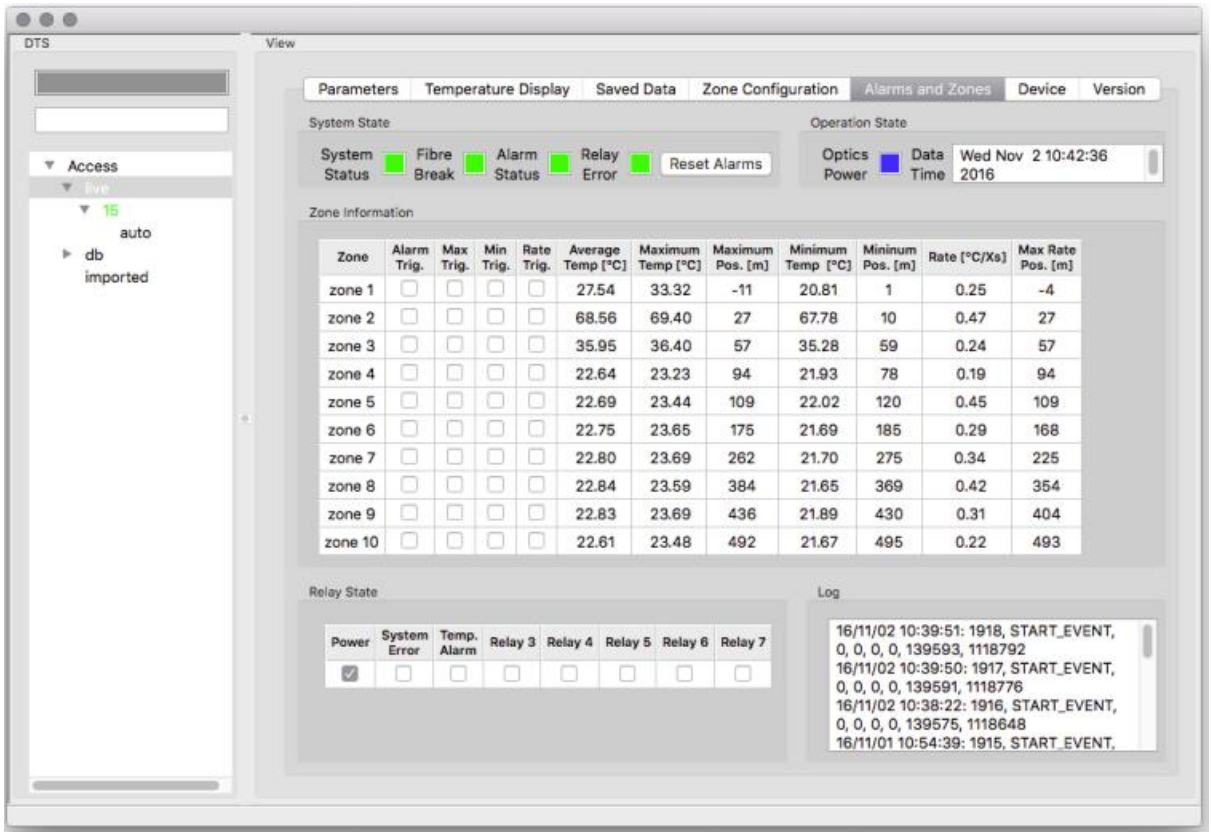


Figure 5-5 Alarms and Zones display

5.5 Version

Use the **Read** command to obtain the version information.

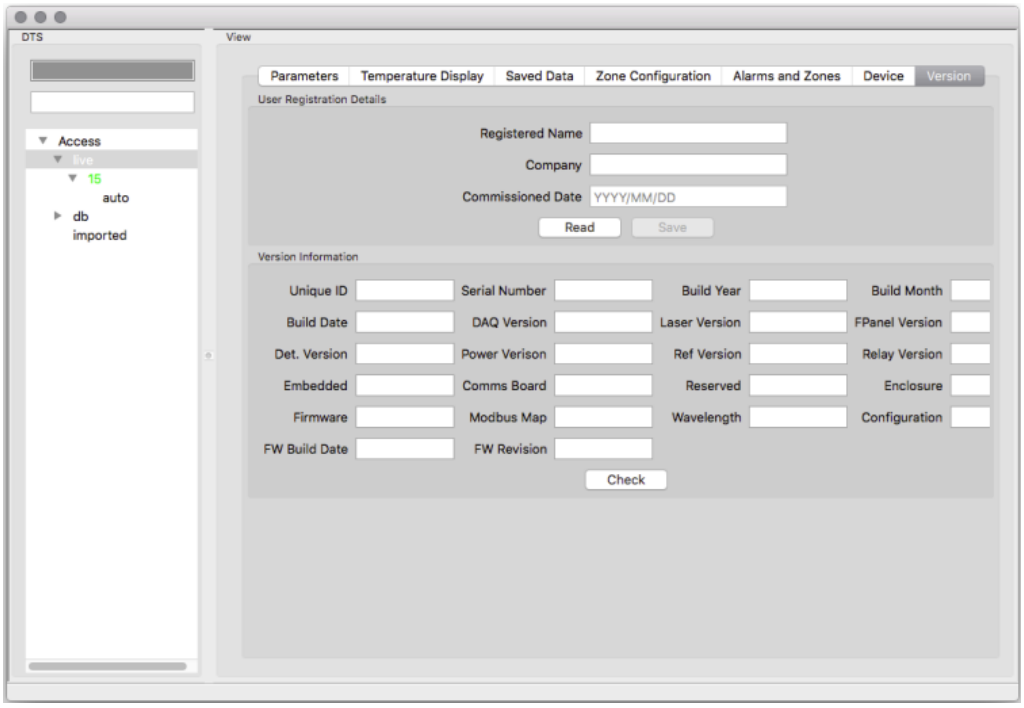


Figure 5-6 Version display

Unique	*ID 32bit random number*
Serial Number	*S/N:309XXXXX official serial number set by the factory*
Build Year, Month, Date	*Build details*
DAQ Version	*DAQ PCB version*
Laser Version	*pcb version*
FPanel Version	*pcb version*
Det. Version	*detector board pcb version*
Power Version	*pcb version*
Ref Version	*reference oven pcb version*
Relay version	*relay board pcb version*
Embedded	*for future use*
Comms board	*for future use*
Enclosure	*box design version*
Firmware	*redundant use FW Build date/ FW revision*
Modbus map	*Modbus registery map version*
Wavelength	*laser wavelength in nm*
Configuration	*not used*
FW build date	*firmware date generated by DAQ firmware*
FW revision	*firmware revision generated by SVN*

5.6 Device

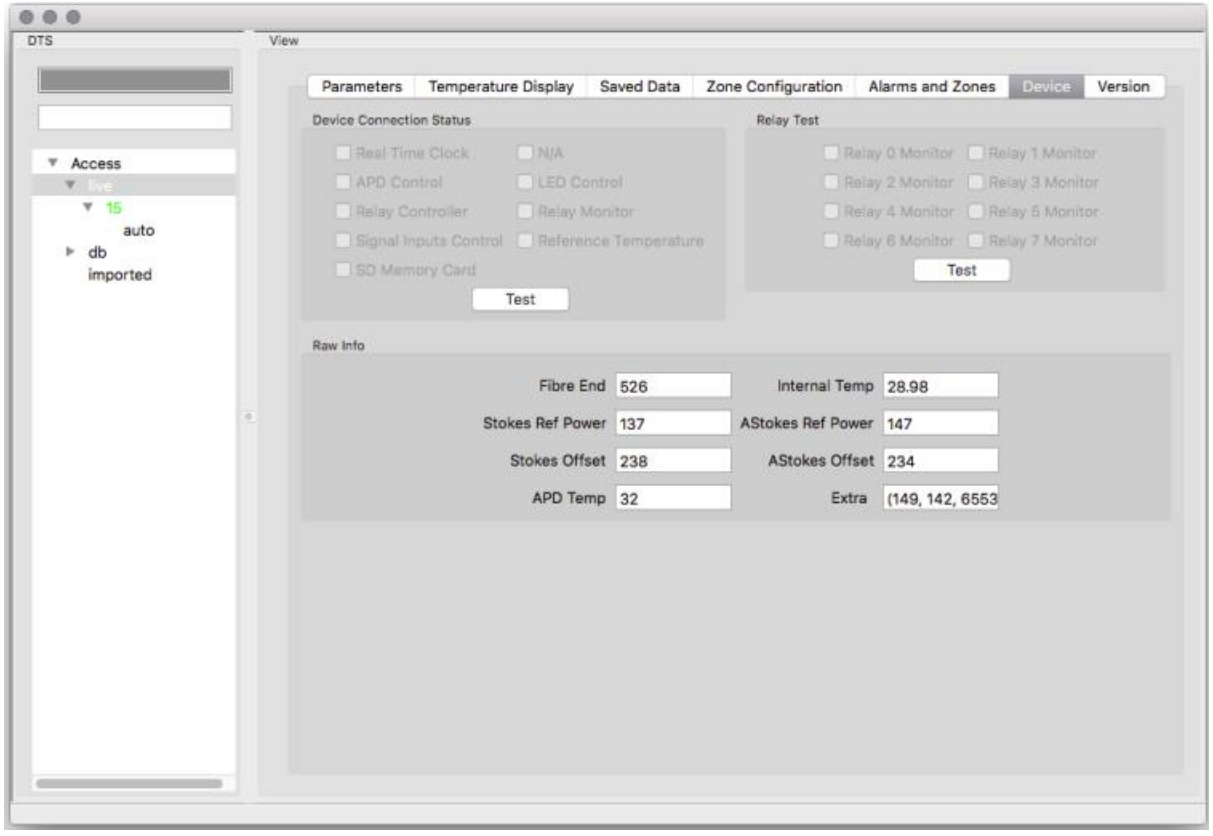


Figure 5-7 Device display

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

5.6.1 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. The tick boxes remain greyed until the test button is activated.

5.6.2 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. The tick boxes remain greyed until the test button is activated.

5.6.3 Raw Info

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

Fibre End	*end of fibre position to nearest metre (up to a 1600m)*
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: 210 - 245*
Anti-stokes Offset	*ADC raw offset level for the Anti-stokes. Typical values: 210 - 245*
APD Temp	*APD temperature – optical to electrical detectors 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.

5.7 Saved Data

5.7.1 Downloaded 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.

5.7.2 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

Stop the download process.

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:

- Select Mem Scan to initially find the first and last measurement IDs
- Change the ID values and select Verify IDs to see the date of the data sets
- Download the data
- If the data is taking too long to download
    - Stop Download; change the first & last Measurement ID or set a larger sample step

5.7.3 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.

5.8 Calibration and Measurement Adjustments

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

5.8.1 Measurement Parameters

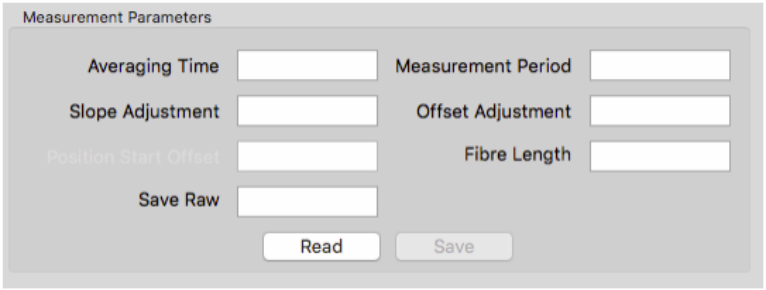


Figure 5-8 Measurement Parameters

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 enables raw data to be saved to the internal memory. Temperature is saved by default.

5.8.2 System Parameter Setup

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

Password *required for changes to **Calculation Parameters** – Bandweaver use*

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 / Offset Stop *a calibration location in points*

Reference Start / 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*

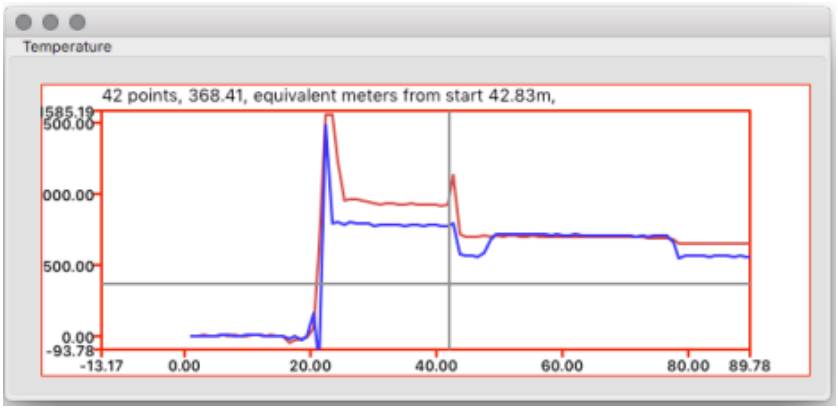
Refractive Index *fibre refractive index*

5.8.3 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.

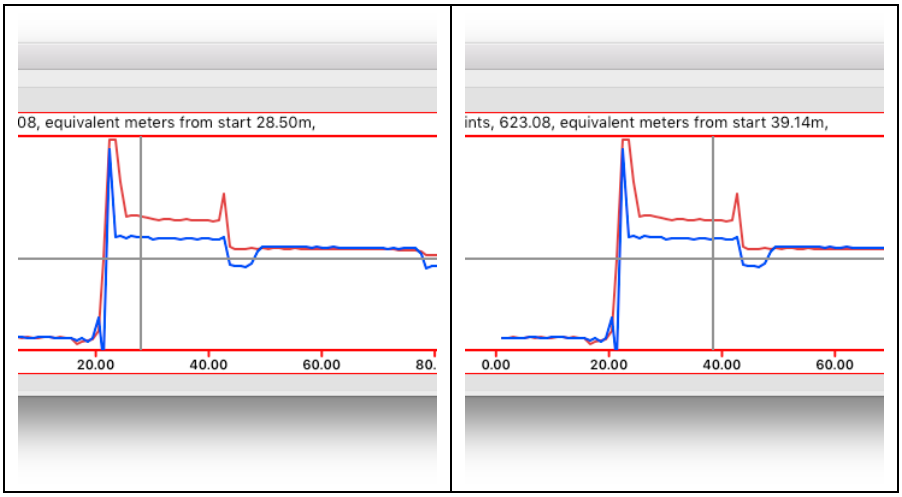
The following parameters define key locations on the raw data trace. These points are important for the calibration.

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 / 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 / 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.*

5.9 Temperature Calibration

Gamma *constant determined during factory calibration – parameter 300-700. The Gamma parameter scales the temperature*.

Slope *differential slope constant [db/km]. The Slope adjusts the flatness of the temperature trace.*

5.9.1 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

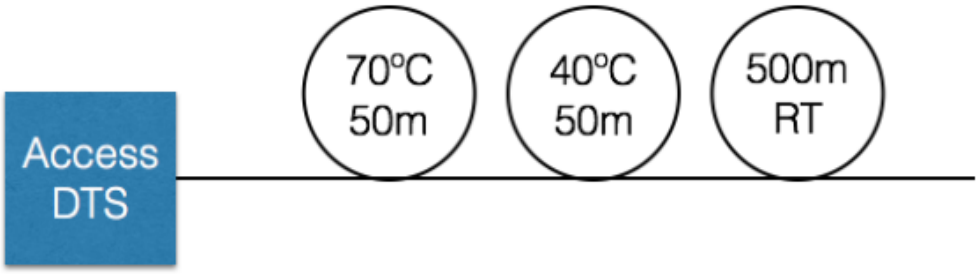


Figure 5-9 Three sections of optical fiber for slope and offset calibration

Calibration method:

1. Ensure the external references are at their fixed values and Access is 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.

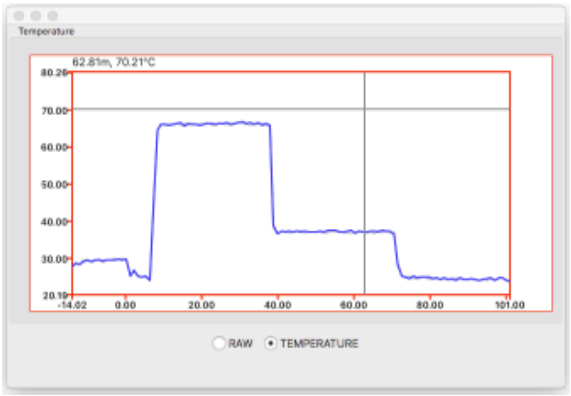


Figure 5-10 Gamma too high

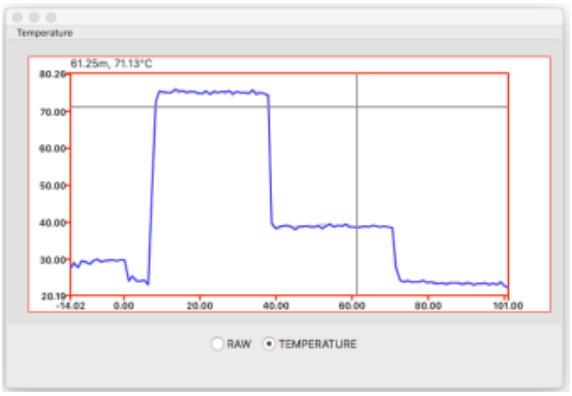


Figure 5-11 Gamma too low

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

Increasing gamma will result in a decrease in temperature difference between the two external references temperatures.

5.9.2 Calibrating 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 5-9 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.

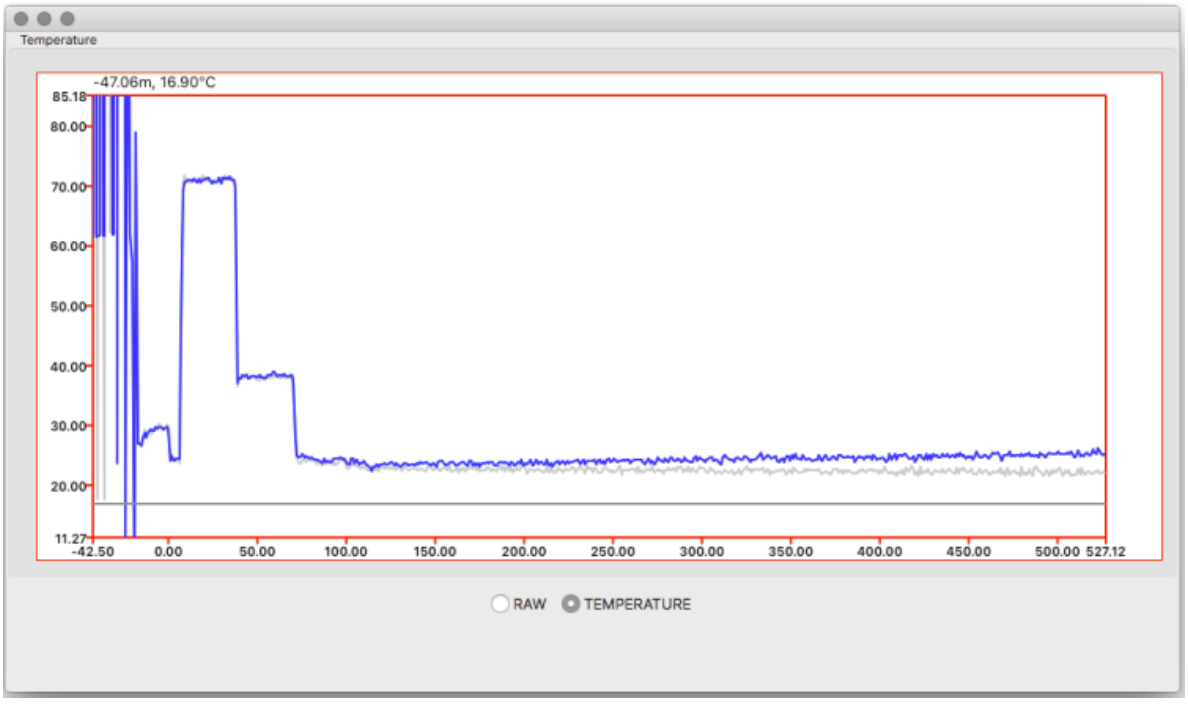


Figure 5-12 Temperature trace with an INCORRECT slope calibration

6 Additional Connections and Interfaces

6.1 Relay Outputs and System Faults

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 4-4-1.

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. See Figure 6-1 and Figure 6-2 below.

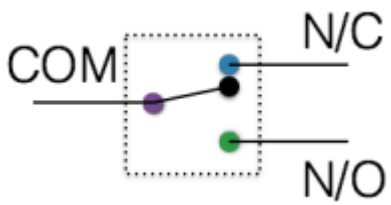


Figure 6-1 Normal state

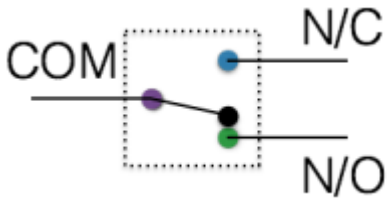


Figure 6-2 Energised state

The DB25 connector has 25 pins and the numbering is shown in Figure 6-3 below.

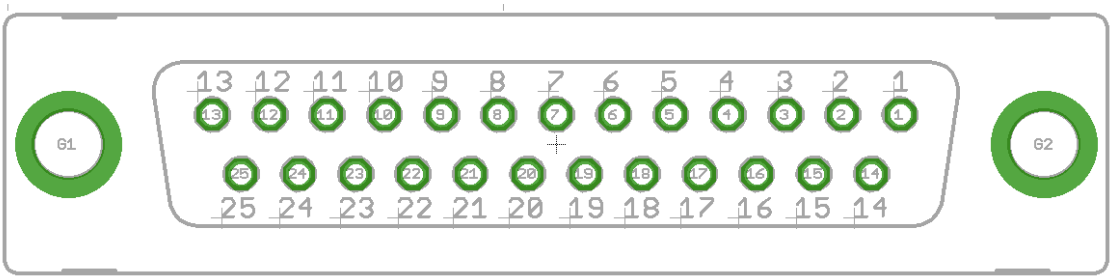


Figure 6-3 Pin numbering of the Relay connector

The connection to the front panel DB25 female connector and its relation to the relays is shown in Figure 6-4. The N/O and common connections are grouped closely together, while the N/C connections are placed in the next available space.

Figure 6-4 Pin functions of the Relay connector

PIN	Relay	Function
1	RL0	Power fault relay NC
2	RL0	Power fault relay COM
3	RL1	System fault relay COM
4	RL2	General 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	General 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	General alarm relay NC
24	RL4	User relay 4 NC
25	RL6	User relay 6 NC

Table 6-1 Pins assignments

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	COM	NO	NC	FUNCTION
RL0	2	14	1	Power fault relay
RL1	3	15	10	System fault relay
RK2	4	16	23	General alarm relay
RK3	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

Table 6-2 Relay output assignments

6.2 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.

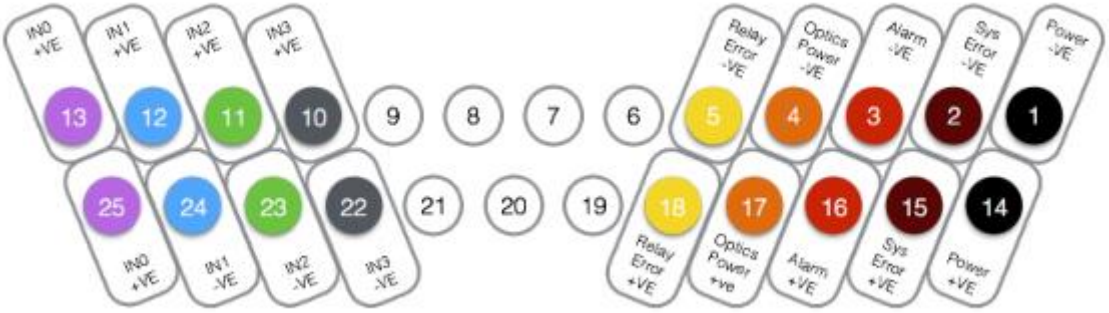


Figure 6-5 Pin functions of the Control connector

6.2.1 Control Inputs

Please see the table below for information on voltages and

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	-

Table 6-3 Control inputs

6.2.2 Control Outputs

The front panel LEDs can be connected to an external LED circuit as shown in Figure 6-6. By using the +5V power supply available from PIN14 a series of LEDs can duplicated the front panel indicators.

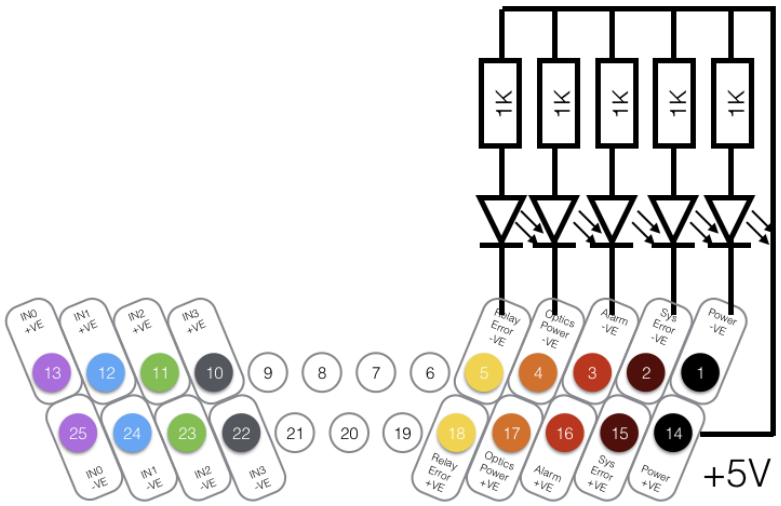


Figure 6-6, External LED connection to Control Outputs

Indicator	LED Cathode connection	Function
Power	1	Power LED
System Error	2	Fiber break / Laser Error
Alarm	3	Alarm
Optics Power	4	Optics Power
Relay Error	5	Relay failed to respond

6.3 Modbus

Any generic MODBUS master software can be used to communicated with Access.

Access has RS485 and USB interfaces. These interfaces cannot be used simultaneously. If the USB connection is used the RS485 interface will be automatically disabled.

Notes to application developers:

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.

6.3.1 Connecting Access to a Computer via 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

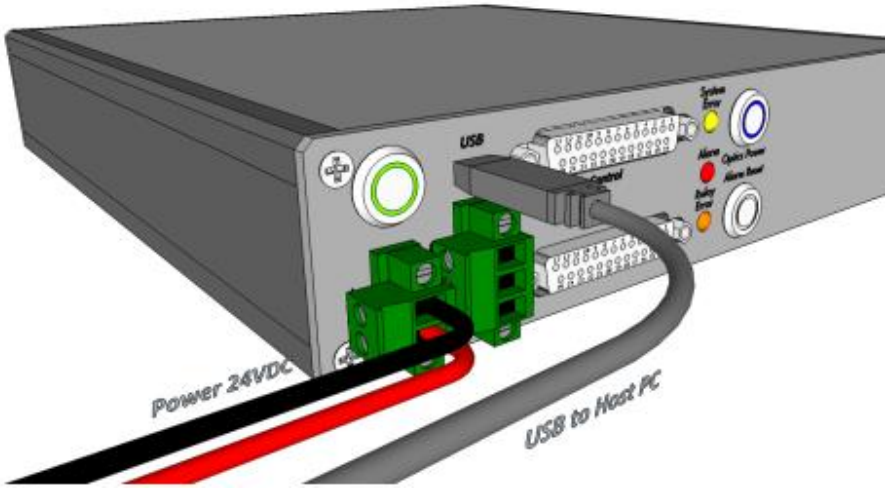


Figure 6-7 Connecting to Access with USB

6.3.2 Connecting Access to a Computer via RS-485

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 (see 6.3.1).

Up to 5 machines can be used with the ACE software.

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

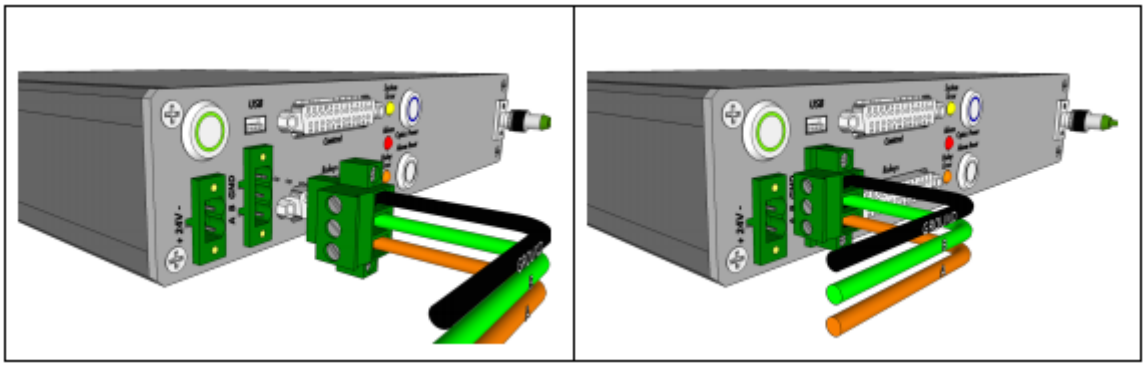


Figure 6-8 RS-485 connection

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

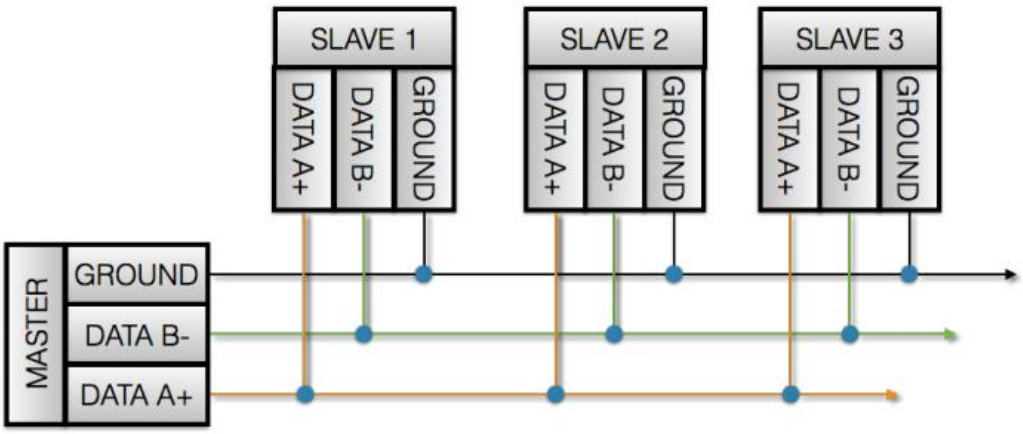


Figure 6-9 Multiple RS-485 connections

Communication Parameters:

Baud Rate:	115200bps
Parity:	None
Stop Bits:	1

6.4 Alarms

Refer to Figure 4-4-1 to locate the following indicators on the front panel of the Access product.

6.4.1 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.

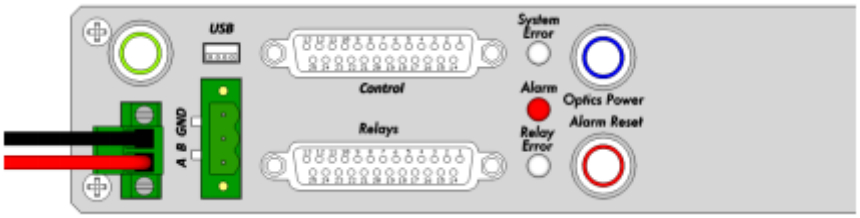
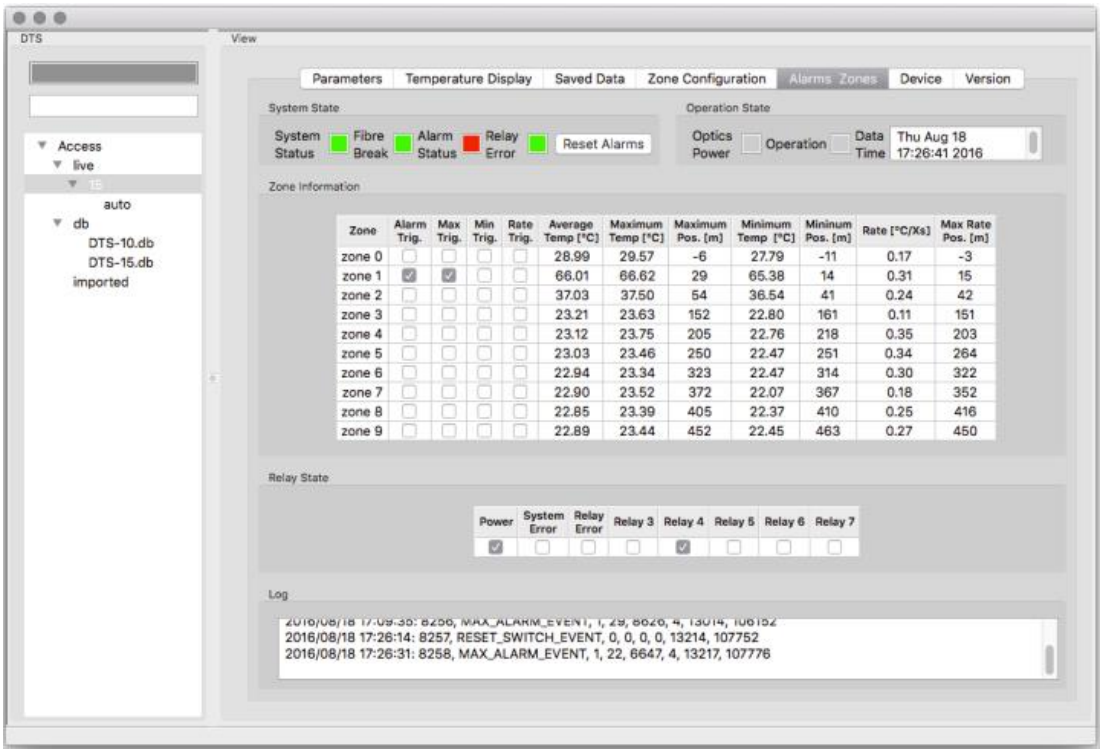


Figure 6-10 Temperature events

In the **Alarms Zones** tab more information is displayed:

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



Zone	Alarm Trig.	Max Trig.	Min Trig.	Rate Trig.	Average Temp [°C]	Maximum Temp [°C]	Maximum Pos. [m]	Minimum Temp [°C]	Mininum Pos. [m]	Rate [°C/Xs]	Max Rate Pos. [m]
zone 0					28.99	29.57	-6	27.79	-11	0.17	-3
zone 1	☑	☑			66.01	66.62	29	65.38	14	0.31	15
zone 2					37.03	37.50	54	36.54	41	0.24	42
zone 3					23.21	23.63	152	22.80	161	0.11	151
zone 4					23.12	23.75	205	22.76	218	0.35	203
zone 5					23.03	23.46	250	22.47	251	0.34	264
zone 6					22.94	23.34	323	22.47	314	0.30	322
zone 7					22.90	23.52	372	22.07	367	0.18	352
zone 8					22.85	23.39	405	22.37	410	0.25	416
zone 9					22.89	23.44	452	22.45	463	0.27	450

Figure 6-11 Alarm and Zones display on Temperature event

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

6.4.2 Fiber Break Event

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

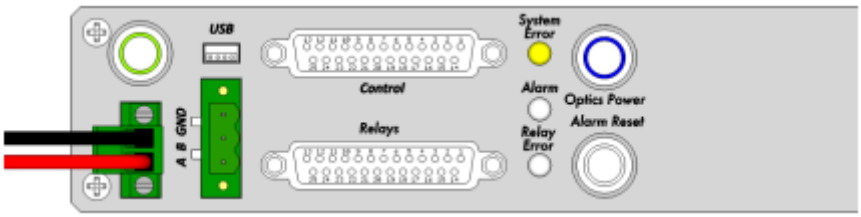


Figure 6-12 Fiber break event

6.4.3 Relay Error

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

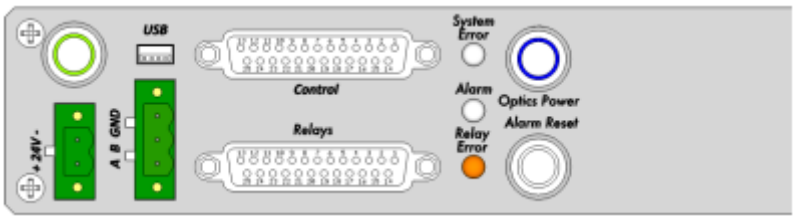


Figure 6-13 Relay Error

6.4.4 Alarm Reset

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.

7 Saved Data: Database Format

In this section the database format 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.

7.1 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 with SQLite module.

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.

7.2 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)
```

Parameter	Description
measurement_id	Primary key to the database
timestamp	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]]

Parameter	Description
zone_info	Zone information is a Python dictionary. There are 10 zones holding the following information key: 1. id – zone id 2. mean_temp – average zone temperature 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 triggered 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}, ...]`

Parameter	Description
`corestate`	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

8 Saved Data: 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

8.1 Temperature Data file format

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

8.1.1 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
```

8.1.2 Second 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
```

8.2 Zone Data file format

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

8.2.1 First line

The first line contains the zone id names

Example:

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

8.2.2 Second 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
```

9 Troubleshooting

Problem	Common causes	Recommended solution
Software has started but no data is displayed in the temperature graph	- Long measurement time - No device selected - Communication settings incorrect	- Check the RS-485 OR USB cable is connected (not both) - Select **Operation** < **Port Connect** to re-establish connection to DTS. - If the measurement time is long, you must wait until the measurement time has elapsed before a temperature trace is displayed. For averaging times > 2mins the temperature display will update after 2mins.
Raw data signal is all zero	- Laser disabled, or the fiber optic cable is not inserted	- Check the optical fiber connector - Turn on the laser

If any problem persists or if the user is unable to resolve it, please contact Bandweaver or an authorized distributor.

Please include the following information when requesting support:

1. Serial number of the product;
2. Full description of the problem and any troubleshooting measures already attempted;
3. Configuration of the product when the issue is experienced;
4. Data files while the issue is experienced.

10 Care and Maintenance

The Access system is designed to provide a low-cost monitoring solution for many years.

There are measures that the user can take to extend the life of the product and ensure trouble free operation of the Access DTS:

10.1 Installation environment

- Ensure the instrument is positioned in a well-ventilated area, with free air flow around the unit.
- Ensure that the operating environment of the Access system is within specification.

10.2 Connector Care and Maintenance

- Ensure all optical connectors are clean before mating and are tightened firmly.

The FC/APC optical connectors should be cleaned and/or inspected before attaching to the Access system. Failure to ensure connectors are clean and free of foreign matter can severely compromise the performance of the system and may possibly damage the integral system connector.

There are two methods for cleaning connectors which are approved by Bandweaver. The technique used is dependent on the type of contamination.

Ensure the laser is off before cleaning any fibres. ⚠
Use alcohol and a lint-free cloth to clean the connector before connecting it into the optical unit ⚠

1. *If the connector has been exposed to slight dust contamination, the preferred method is using a 'cassette style' cleaning tape. When cleaning the connector, please wipe gently several times following the same direction.*

2. *If the connector has been exposed to grease, lint free tissues wetted with alcohol or pre-soaked wet wipes should be used. When using pre-soaked wet wipes, excess residue should be removed using dry lint free tissues. When cleaning the connector, please wipe gently several times following the same direction.*

10.3 Fiber Optic Sensor Cable

- It is good practice to take a baseline reading of the fiber loss after installation. Periodic examination of the fibre loss can then be taken and compared to a baseline. This will help track any aging of the optical fibre.

10.4 Data Storage

- If data is being collected frequently, periodic examination of the hard disk will be needed to ensure sufficient free space. Excess data should be cleared before the hard disk reaches 95% capacity.

10.5 Quarterly Inspection and Test

The cables and control unit should be visually inspected for mechanical damage, or other conditions, likely to interfere with correct operation.

These following tests should be performed every 3 months

10.5.1 Relay Check

- Stop measurement (right mouse click on slave and select **Stop**)
- **Device** < **Relay Test** < **Test**
- Make sure all boxes are ticked.

10.5.2 Alarm Test

Artificially heat a section of cable to generate an alarm and ensure that the system behaves as expected.

10.5.3 Fiber Break Test

During measurement remove connector and check the system error alarm appears.

10.5.4 Clean Fiber connectors

Clean fibre connector o If the cable is often removed and reinserted the tip of the connector may require cleaning. Refer to Section 10.2 for connector maintenance.

10.5.5 Raw data check

Ideally every quarter some baseline raw vibration data should be recorded for reference. The optical loss of all connectors and splices should be measured and compared with the previous quarter to see if there is any degradation of the connections.

Use **Device** < **Raw Info** data to check the **Stokes Ref Power**, **Stokes Offset**, **AStokes Ref Power** and **AStokes Offset** values over time.

11 Contacts

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