![Biral - Visibly Better logo]

USER MANUAL
INSTALLATION - OPERATION - MAINTENANCE

SWS-050T

Biral – P O Box 2, Portishead, Bristol BS20 7JB, UK

Tel: +44 (0)1275 847787

Fax:+44 (0)1275 847303

Email: enquiries@biral.com

www.biral.com

Manual Number : 106480

Revision : 01A

CONTENTS

GENERAL INFORMATION

Biral

LIST OF FIGURES

List Of Tables

Biral

General Information

The sensor covered in this manual:

Sensor Model	**Capability**
SWS-050T	Visibility Obstruction to Vision

Features

Analogue Outputs
> Either MOR or EXCO
> 0 to 10 V
> 4 to 20 mA

Digital Outputs
> MOR and EXCO
> RS232
> RS422/RS485

Relays (Option)
> Relay 0   Fault relay
> Relay 1   Visual range threshold
> Relay 2   Visual range threshold or window contamination

Thank you for choosing Biral as your supplier of visibility sensors

A great deal of time has been invested at Biral to offer the best combination of sensor performance and value with almost three decades of experience and knowledge incorporated into the SWS-050T. We are confident that it will provide you with many years of accurate operation.

Features of the SWS-050T Sensor:

- **full date/time stamp in data string** provided by the real time on-board clock.

- **flexibility to connect to a wide range of data collection/processing units** with a choice of serial, analogue and relay switching outputs.

- **easy installation** due to its light weight and small footprint**.**

- **simple field calibration,** automatic sequence can be initiated after fitting calibration plaque**.**

- **switching of external equipment** based on both visibility and window contamination.

- **Optional connection to the Biral Ambient Light Sensor, model ALS-2.**

Biral

Customer Satisfaction

At Biral we set our standards high and only your complete satisfaction is acceptable to us. If you believe your experience has not met these standards we would be grateful if you would contact us so we can rectify any issues you may have (equally, if you have any positive experiences you would like to share).

After Sales Support

Biral offers support by telephone and email for the lifetime of these sensors, even if there has been a change of ownership, so please get in touch if you require help. Similarly, if you have any questions about your new equipment we are only a mouse-click or telephone call away. Our contact details are given below.

For your convenience our contact details are also on the label fixed to your sensor.

Contacting Biral

If you would like technical assistance, advice or you have any queries regarding the operation of the sensor please do not hesitate to contact us.

For enquiries and technical support:

Contact us by telephone on: + 44 (0)1275 847787

Contact us by fax on: + 44 (0)1275 847303

Contact us by e-mail at: enquiries@biral.com

Three year warranty

The SWS Present Weather Sensors come with a three year limited warranty against defective materials and workmanship. If you have any questions about the warranty please contact Biral.

In order to help us to assist you please be sure to include the following information:

- Model of equipment
- Serial number of equipment
- Nature of defect
- Your full name, address and contact details
- Relevant application details and data output
- Responses to R? command (see paragraph 3.1.1)

If you need to return the sensor

The SWS sensors should give you many years of trouble-free service but in the unlikely event that the equipment proves to be faulty and we have asked you to return the sensor to us please address the equipment to:

BIRAL
Unit 8 Harbour Road Trading Estate
Portishead
Bristol BS20 7BL
UNITED KINGDOM

The customer is responsible for the shipping costs.

CE Certification - Safety

All Biral's SWS sensors comply with the requirements for CE marking. Once installed, it is the user's responsibility to ensure that all connections made to the sensor comply with all Local and National safety requirements.

This product **MUST BE EARTHED.** Failure to install a suitable earth may result in inaccurate readings and / or damage to the product and attached equipment. Failure to install an earth will make the unit potentially unsafe when using the relays to switch hazardous voltages.

Biral

1 SENSOR SET-UP

The format of this section is such that it logically follows these recommended procedural steps:

Step 1 - Unpack equipment and ensure that all required parts are supplied and identified.

Step 2 - Make electrical connection as required for testing and configuration.

Step 3 - Power up and test equipment on bench.

Step 4 - Configure equipment as required for site installation.

Step 5 - Installation including siting considerations, height, orientation, mounting and electrical grounding.

Step 6 - Carry out commissioning test procedure.

Note: Many of the tests specified within this manual require the use of a PC or equivalent. To achieve the two-way serial communication required, Biral recommends the use of a PC running the Biral Sensor Interface Software. If this software is not available, use a terminal program - for example Windows® HyperTerminal™. The Biral Sensor Interface Software is available from our website (www.Biral.com), or contact Biral at: enquiries@Biral.com.

1.1 STEP 1 - Unpacking the Sensor

The sensor is packed in a foam filled shipping container and is fully assembled ready for use.

SWS-050T sensor in foam-filled packaging
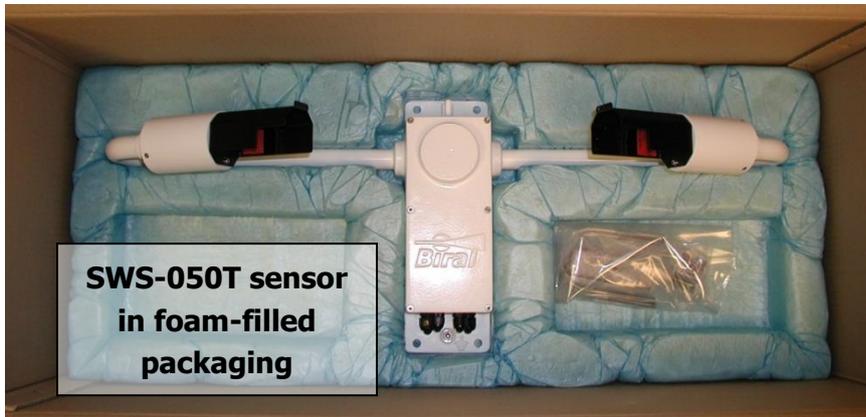
The sensor is delivered with:

- U-bolts for pole mounting

- 2 off ferrites for cable EMC protection

- Documentation

- Other optional items you may have ordered

Figure 1-1 SWS-050T in Packing

<u>Other optional components you may have ordered</u>

Calibration Kit

The calibration kit in a protective carrying case, containing: a calibration screen, a mounting arm (referred to as the calibration reference plaque when assembled) and 3 grey foam plugs (see section 5, Calibration Procedures, for application).

Transit Case

A rigid re-usable transit case designed to provide full protection to the instrument for **regular** shipping. Please note if this is not ordered the sensor is shipped in the standard rugged foam filled box as shown above.

Mains Adapter

A mains adapter to operate the sensor using mains power.

Power and Signal Cables

Power and signal (data) cables if you are not supplying these yourself. The length must be specified at time of order.

Ambient Light Sensor

An ambient light sensor can be supplied as part of the SWS-050T sensor. This provides measurements of the ambient light intensity up to 40,000 Cd/m^2, with its output integrated into the standard SWS-050T data output string.

1.2 STEP 2 - Electrical Connections

> **ALL ELECTRICAL CONNECTIONS SHOULD BE COMPLETED BEFORE APPLYING POWER TO THE SENSOR**

1.2.1 Cables

Unless purchased as an option the sensor is not supplied with power and data cables.

For the power and data cables we recommend you use screened, twisted pair cables in a suitable outdoor EMC and UV resistant sheath (this is particularly important for the data cables). Screens should be earthed by the customers.

24 AWG stranded (7/32) or solid wire conductors, or equivalent are ideal for the low power requirements of the system, however, the connectors can accommodate wires from 20AWG down to 26AWG (0.5 to 0.13mm^2), of solid or stranded construction.

The relay connection cable requirement is dependent on the specific application. For ease of assembly, it is recommended that 22AWG stranded (7/30) or solid cores are used, or equivalent. Each relay connector can accommodate wires from 16AWG down to 26AWG (1.5 down to 0.2mm^2). If mains voltage is to be applied to the relay contacts, it is essential that the cable is suitably rated to comply with all national regulations.

Note: The RS232 configuration is suited to low to moderate electrical noise environments with moderate cable lengths and baud rates. For higher electrical noise environments with higher baud rates and longer cable lengths RS422 is recommended.

1.2.2 Cable Glands

There are two connecting areas within the instrument, one for the DC power and communications and one for the relay connections. These relay connections are separate to retain the necessary isolation required for the 230VAC switching capability.

Biral
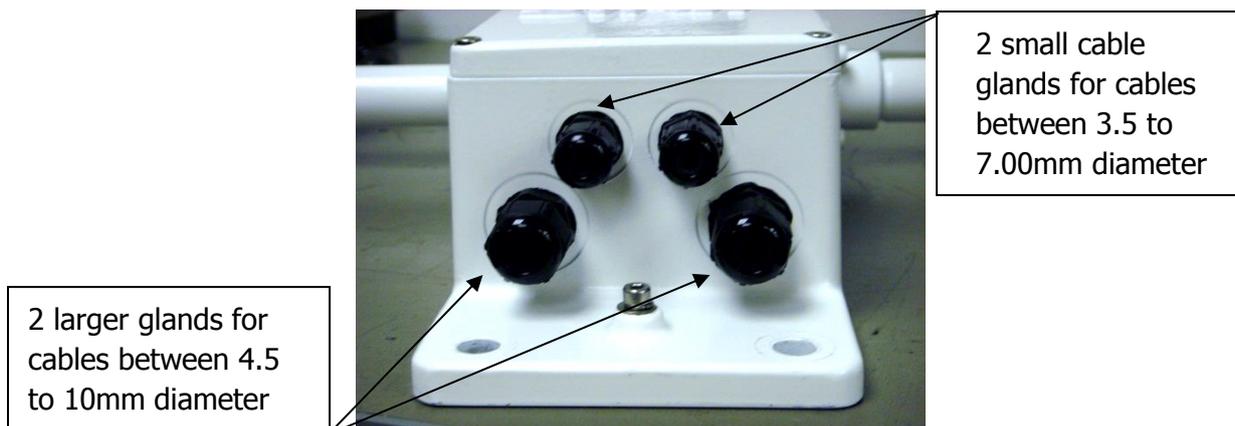
Figure 1-2 Cable Glands

To assist in this four cable glands are provided (see Figure 1-2):

- the 2 small cable glands are for cables between 3.5 to 7.00mm diameter
- the 2 larger glands are for cable between 4.5 to 10mm diameter

Any or all of these glands can be used. The DC power supply can be separated from the signal connection cable, or a single cable can be used for all required connections.

If the fault or alarm relays are being used to switch mains voltages, it will be necessary to use cables approved for mains use for these connections which will, in general, require to be separated from the communications cable.

Unused Glands
Any glands not in use should be sealed with the supplied sealing plugs to retain the integrity of the weatherproof housing.

1.2.3 Connecting the power supply and signal cable

The power and signal cables are connected to the instrument using the connector strip along the bottom edge of the main circuit board adjacent to the cable glands. This connecting strip is of a lever clamp design. The wire is released by pressing on the lever with a small screwdriver with a flat blade of no more than 2.5mm.

For ease of assembly it is recommended that 24AWG stranded (7/32) or solid wires are used, or equivalent. These are ideal for the low power requirements of the system. However, the connectors can accommodate wires from 20AWG down to 26AWG (0.5 to 0.13 mm^2), of solid or stranded construction. They require a strip length of 11 mm.
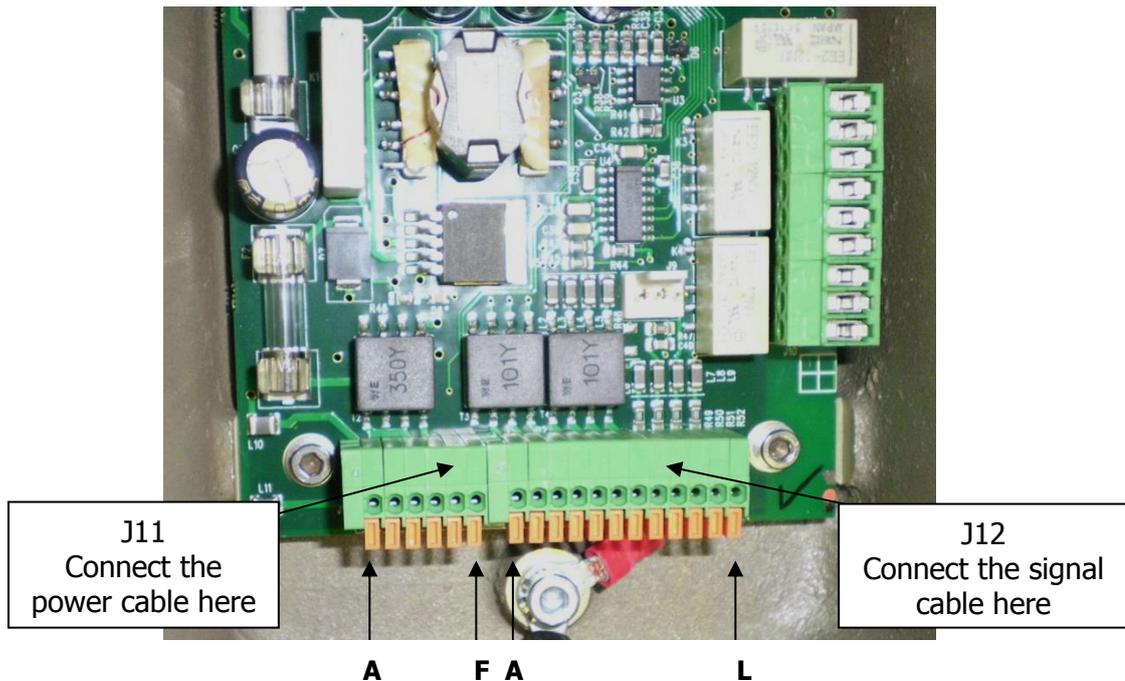
Figure 1-3 Power and Signal Connections

Connecting the power supply:
The SWS-050T sensor requires an input voltage supply between 9 and 36V DC. This is typically 24V DC supply at 3.5W. This will rise to typically 6W if the no-dew window heaters are in use.

See Figure 1-3 Power and Signal Connections, for the identification of the connector strip. This is split into two sections, a 6-way block labelled J11 and a 12-way block labelled J12. The individual connections are labelled A to F and A to L respectively from left to right.

With the power removed from the supply cable, connect the +ve lead to J11/C and the negative lead to J11/D. The negative lead is the internal signal ground reference point. Care must be taken, particularly when long power leads are used, to ensure that this negative supply lead is at near ground potential. If it develops more than ±10V DC with respect to ground, damage will be caused to the sensor.

Note: If an ALS-2 ambient light sensor is being installed with the SWS sensor, these two power leads are to be taken to J1 on the SWS-ALS daughter board, see section 1.2.7.

Connecting the hood heaters
The hood heaters are wired independently and isolated from the instrument power. These should be powered from a 24V supply of either AC or DC. The

Biral

SWS-050T will draw 24W from this source. A higher voltage should not be used as the power will increase above acceptable levels. If a lower voltage is used, the de-icing will be less efficient. The connections are J11/A for the heater supply (switched), and J11/B heater return. See Table 1-1 Pin connections for power supply for full details.

Pin connections for power supply

Pin Number	Designation
J11/A	Hood Heater Supply (Option) 24VAC or DC
J11/B	Hood Heater Return (Option) 24VAC or DC
J11/C	Sensor Power Supply +9 to +36V
J11/D	Sensor Power Supply 0V
J11/E & F	Not Used

Table 1-1 Pin connections for power supply

Pin Connections for RS232 or RS422/RS485 Signal Interfaces

The sensors can be operated with RS232 or RS422 or RS485 communications. It is not possible to operate both the RS232 and the RS422/RS485 together.

See Table 1-2 and Table 1-3 for full connection details.

Pin Number	Designation
J12/A	RS232/422/485 common/0V
J12/B	RS232 Tx (signals FROM sensor)
J12/C	RS232 Rx (signals TO Sensor)

Table 1-2 Pin connections for operating in RS232 interface mode

Pin Number	Designation
J12/A	RS232/422/485 common/0V
J12/D	RS422/RS485 Rx+ (TO sensor)
J12/E	RS422/RS485 Rx- (TO Sensor)
J12/F	RS422/RS485 Tx- (FROM sensor)
J12/G	RS422/RS485 Tx+ (FROM Sensor)

Table 1-3 Pin connections for operating in RS422/RS485 interface mode

Selection of RS232 or RS422/485 communications

To select which output to use, place jumper J7 (see Figure 1-4) onto pins 1 and 2 for RS422/485 outputs and onto pins 2 and 3 to select RS232 outputs.

> Location of J7
>
> 1 2 3
>
> Jumper on 1 & 2 –
> RS422/RS485
> Jumper on 2 & 3 – RS232
> (as in photograph)
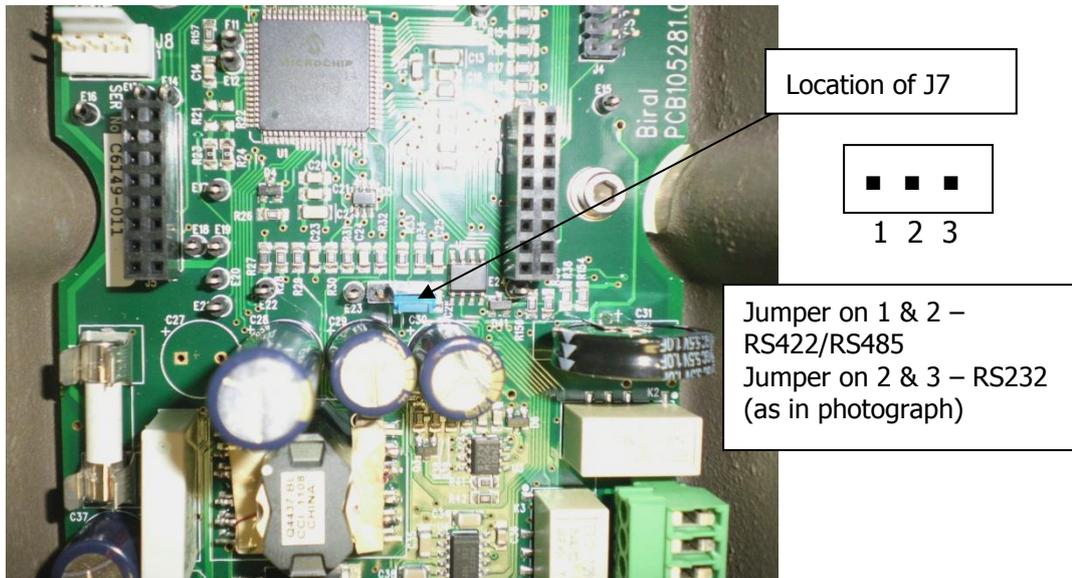
Figure 1-4 Location of J7, RS232/422/485 select

1.2.4 Connecting the relays

Relays are an option on the SWS-050T. The SWS-050T provides the ability to switch equipment using two visibility (fog) relays and one fault relay. Alternatively, the second visibility relay can be used to indicate significant window contamination. This contamination warning is contained in the standard digital data message, but, if only the analogue output of the sensor is being used, this relay will give early warning that the windows require cleaning.

These connections are along the right hand side of the main circuit board at the gland end (see Figure 1-5). They are a two-part connector with pins in the circuit board and a removable plug for the connections. It is advised that the plug is removed from the pins to enable the connections to be made to the cable before re-connecting to the circuit board. The connections are of a screw clamp type.
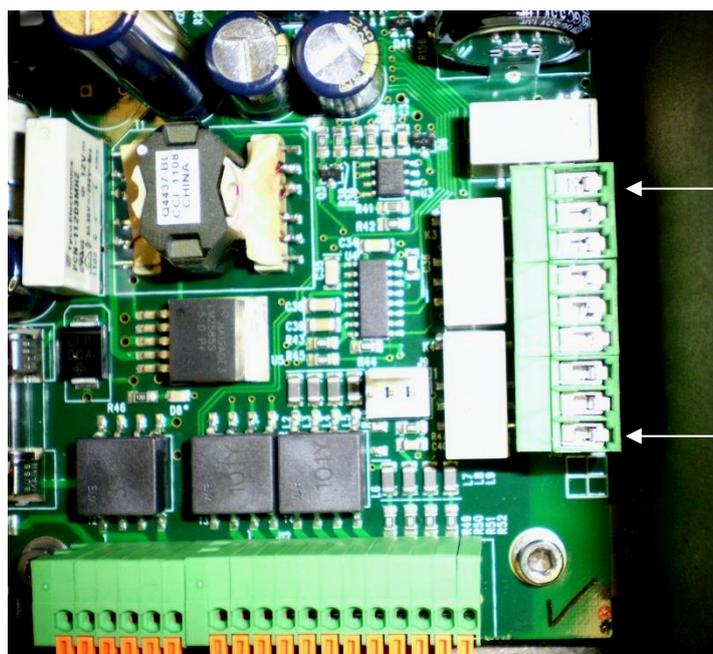
Contacts are defined here when relays are not energised

RL2 NC
RL2 COM
RL2 NO
RL1 NC
RL1 COM
RL1 NO
FAULT NC
FAULT COM
FAULT NO

NB The Fault relay operates in Failsafe mode - i.e. is energised when there is no fault.

**Figure 1-5 Relay Connections.
Relay contacts are rated 2A, 250V AC.**

For ease of assembly it is recommended that 22AWG stranded (7/30) or solid wire conductors, or equivalent are used. These are ideal for the low power requirements of the system. However, each connector can accommodate wires from 16AWG down to 26AWG (1.5 to 0.2 mm2), of solid or stranded construction. They require a strip length of 5 mm.

Care must be taken to ensure that the voltage rating of the cable is correct for the switching application requirement. If the relays are to be used with mains voltages, protective earth bonding of the sensor housing should be carried out to ensure compliance with all national and local safety requirements.

Failure to install a protective earth will make the unit potentially unsafe when using the relays to switch hazardous voltages.

1.2.5 **Pin connections for 0-10 V analogue output**

Analogue outputs representing either Meteorological Optical Range (MOR) or Extinction Co-efficient (EXCO), are standard on the SWS-050T sensor. The analogue output is available as both a 0 to 10V and a 4 to 20 mA signal. To configure the analogue outputs for either MOR or EXCO see section 1.4.12. The connections are as follows.

Pin Number	Designation
J12/H	0-10V Analogue Output +ve
J12/I	0-10V Analogue Output -ve
J12/J	4 – 20 mA Analogue Output +ve
J12/K	4 – 20 mA Analogue Output -ve
J12/L	Not Used

Table 1-4 Connections for SWS-050T analogue output

1.2.6 **EMC Compliance**

This sensor **MUST HAVE FERRITES INSTALLED.** Failure to install the supplied ferrite cores may result in inaccurate readings or lost communications

To comply with the EMC requirements, in particular the susceptibility to conducted interference, some of the leads connected to the sensor should be fitted with ferrites. If this is not carried out, the sensor could be affected by external electromagnetic fields. The ferrites supplied with the unit should be clipped over the power and the signal leads, between the gland and the connector blocks. These are not required on the relay connections or on the hood heater supplies.

1.2.7 **Optional ALS-2 Connections**

The SWS-050T sensor can be supplied with an ambient light sensor, model ALS-2. This sensor will be connected directly to the SWS sensor, drawing its power from the sensor supply. If required, the ALS-2 will be fitted with hood heaters which will operate when the sensor hood heaters operate. The output data is automatically integrated into the main SWS sensor data stream, see section 2 Standard Operating Data.

The ALS-2 connections are taken to a daughter board which is mounted on the main SWS sensor processor board, in the position shown in Figure 1-6.

| SWS/ALS-2 daughter board |
| ALS-2 Connector (J2) |
| Wire Colour List |
| SWS Sensor Power Connector (J1) |
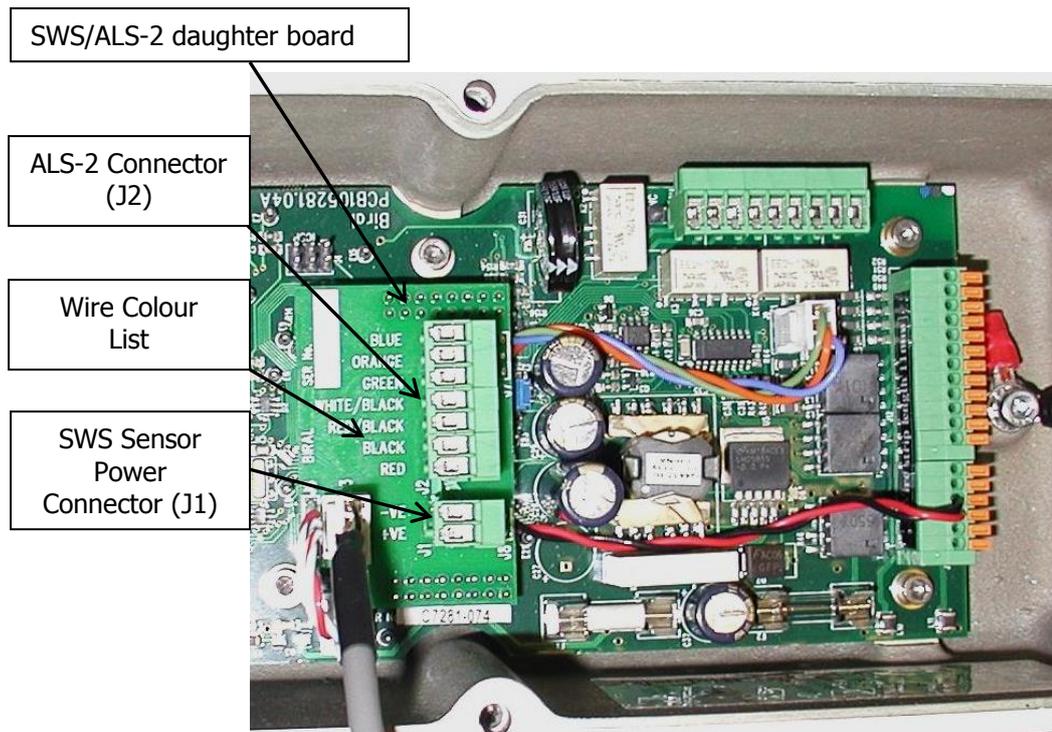
Figure 1-6 ALS-2 Connecting System

The SWS sensor power supply is now connected to J1 on the ALS-2 connection board, with the positive and negative leads as marked on the circuit board. The hood heater supply, if used, is still connected to the main processor terminal strip pins A and B and the data connections are not affected. See section 1.2.3 for details. The ALS-2 cable is connected to J2, with the wire colours as shown on the circuit board adjacent to J2.

Note, both J1 and J2 have removable (reversible) connection plugs for ease of assembly. Check wire colours against list on board before applying power to the combined system.

1.3 STEP 3 - Equipment Test

Biral recommends that the equipment is powered and checked on the bench before site installation. This is to ensure that you are comfortable with the functionality of the sensor and to pre-empt any queries that arise before attempting site installation.

Note: this procedure assumes a default configuration for the sensor - please check the Calibration Certificate supplied with your sensor for specific configuration details.

Note: In this test, and in all subsequent sections of this manual, the following convention MUST be observed:
ALL COMMANDS SHOULD BE TERMINATED WITH <CARRIAGE RETURN> AND <LINE FEED> (ASCII CHARACTERS 13 AND 10). In this manual, this is normally abbreviated to <CRLF>.

1.3.1 Equipment Test Procedure

To enable the configuration setting to be checked and adjusted if necessary, it is recommended that these initial tests are carried out using the digital communication system. If it is only intended to use the analogue signals and the relays, these can be checked by following the instructions in Paragraphs 1.3.3, Analogue Signal Checks and 1.3.4, Relay Checks.

1.3.2 Digital Communication Checks

1. Connect the power pins on the input connector to a local power source (do not turn power source on). Connect sensor earth lug to earth (this may not be necessary but can help prevent communication errors with certain PCs).

2. Connect the signal cable to a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® HyperTerminal™. (For RS422/485 sensors a RS422 to RS232 converter must be used).

    Note: Biral recommends testing to be done with RS232 or RS422 as applicable. When you are confident that the sensor is working it can then be set up for RS485 if required.

3. Configure the terminal program, either the Biral Sensor Interface Software or HyperTerminal as follows:

Default Interface Parameters

Baud Rate..9600
Data Bits 8
Stop Bits...1
Parity ....None
Flow Control ....None

(If using HyperTerminal the options 'Send line ends with line feeds' and 'Echo typed characters locally' in ASCII set up should be checked.)

4. Turn the local power source "ON".

    If communications are working the sensor will respond with "Biral Sensor Startup".

5. Check Data Transmission To Sensor:

    Send the command   R?   from the PC terminal to the sensor:

    The sensor will respond with its Remote Self-Test & Monitoring Message.
    For example:
    100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,107,00,00,00,+021.0,4063

6. Check Data Transmission From Sensor:

    If the sensor is NOT in polled mode:
    Wait for the sensor to transmit a Data Message (approx. 80 seconds from power up).

    If the sensor is in polled mode:
    Send the command   D?   from the PC terminal to the sensor:
    A Data Message will be transmitted immediately.

7. MOR Calibration check:

    > **THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE SWS CALIBRATION KIT AND PC ARE AVAILABLE**

    Carry out the calibration check procedure in section 5.2, to ensure that the MOR value changes (i.e. the sensor responds to changes in visibility).

    Note: if this calibration check is being carried out indoors the MOR value will NOT necessarily agree with that marked on your calibration reference plaque.

NB The sensor is fully calibrated before it leaves Biral.

1.3.3 **Analogue Signal Checks**

1. Connect the power pins on the input connector to a local power source (do not turn the power source on). Connect sensor earth lug to earth (this may not be necessary but can help prevent communication errors with certain PCs).

2. Connect the applicable analogue signal pins on the output connector to a multimeter, set to read volts or current as appropriate. Switch on the power source.

3. The actual reading achieved depends on whether the output is set to register MOR or EXCO, and what the maximum range setting is. Refer to Section 1.4 for instructions for setting the output configurations.

4. As a quick check, assuming that the output is set to register MOR (default), when the transmitter is blocked using the zero plugs from the calibration kit if available, the readings should be approximately 10V and 20mA. If the instrument is set to output EXCO, the readings should be approximately 0V and 4mA. With the transmitter un-blocked, moving a sheet of white paper towards the measurement volume from the front of the instrument simulates reduced visibility. The voltage and current readings for MOR should drop. If the output is set to register EXCO, the readings should increase.

1.3.4 **Relay Checks**

A full explanation of the relay operation can be found in Section 1.4. The following instructions provide a quick check on the relay operation to confirm correct performance. For this quick check of relay operation, it is assumed that the relays are set to switch on visibility threshold.

1. Connect the power pins on the input connector to a local power source (do not turn the power source on). Connect sensor earth lug to earth (this may not be necessary but can help prevent communication errors with certain PCs).

2. Connect the relay signal cable to a multimeter, set to read ohms, or continuity. Connect between the connections **RL1 NO** and **RL1 COM**. See , Section 1.2.4. Switch on the power source.

3. When the transmitter is blocked using the zero plugs from the calibration kit if available, the reading should be high ohms (open circuit). With the transmitter un-blocked, hold an A3 sheet of white paper just above the two hoods, roughly horizontal. This simulates a very low visibility. This should be maintained for 5 minutes, when the relay # 1 should switch on, reducing the reading on the meter to near zero ohms (short circuit). This time delay is the default delay between the visibility reducing below threshold and the operation of the relay.

4. Remove the sheet of white paper and block the transmitter. The relay should switch off after 5 minutes. This is the default delay between achieving good visibility and the removal of the alert state.

1.4 STEP 4 - Configuration Options

There are several configuration options available for the user to select. One of these options, date and time enable, is set using a configuration byte of the **Options Word,** as detailed in sections 1.4.1 and 1.4.2. The remaining options are set directly using commands starting with "OP" or "OS". Each of these is detailed below in sections 1.4.3 to 1.4.12.

An alternative method of configuring the sensor is to use the Biral Sensor Interface Software. The "Sensor Settings" tab provides an easy method of viewing or changing the settings.

1.4.1 Options Word

The options word consists of two bytes. Their current values can be determined by sending the "OP?" command. The reply will be as follows:

aaaaaaaa,bbbbbbbb

The upper byte, (aaaaaaaa) is used to set internal operating parameters and should not be changed. It will in general be '00000000'. For the lower byte, a value is entered as a binary number (1's and 0's). Leading 0's in the value need not be entered. The definition of each bit of this byte is shown below (Table 1-5). *Note: the first bit is bit 8, the last being bit 1.*

Each bit of the lower byte of the **Options Word** is defined as follows:

b b b b b b b b

Bit 1: 1 = Add Date and Time to the start of the data message
0 = No Date and Time at the start of the data message

Bit 2:   Not used

Bit 3: x = Reserved for factory configuration.
This bit value should not be changed.

Bit 4:   Not used

Bit 5:   Not used

Bit 6: x = Reserved for factory configuration.
This bit value should not be changed.

Bit 7: x = Reserved for factory configuration.
This bit value should not be changed.

Bit 8: x = Reserved for factory configuration.
This bit value should not be changed.

Table 1-5 Options word (lower byte)

Biral

1.4.2 **Date and Time Stamp in data string**

By default, the date and time stamp is not included at the start of the data string. This is controlled by the Options Word setting; see Table 1-5 Options word (lower byte).

To enable Date and Time stamp

The sensor can be configured to generate messages with the date and time string by setting the least significant bit in the options word:

1. Read the current value of the options word by sending the command OP?
2. Send the command: CO
3. Send the command: OPxxxxxxx1   Where the values shown as xxxxxxx are the first seven digits, bits 8 to 2, of the lower byte of the options word reported by the OP? command.

For example: If the response to OP? is 00000000,00100000 the following command should be sent to enable the time stamp, OP00100001.

PLEASE BE EXTREMELY CAREFUL IN SETTING THE CORRECT BIT IN STEP 3 AS SETTING THE WRONG BIT WILL RESULT IN THE SENSOR FUNCTIONING INCORRECTLY

To disable Date and Time stamp

To disable the date and time stamp, send the command OPxxxxxxx0 as per step 3 above.

To read the current Date and Time

Send the command TR?
The sensor will respond with the date / time message e.g.:

    FRIDAY   ,19\12\14,13:15:25,000

Note:
1. The format is Day\Month\Year,Hour:Minute:seconds
2. The final ,'000' is a time calibration figure, set during final test.

To set the current Date and Time

There are two commands required to set the current date and time:
%SD sets the date.
The format of the command is: %SDWDDMMYY

where:
W   - is the day of the week (1..7) with Monday being 1

DD   - is the date (01..31)
MM   - is the month (01..12)
YY   - is the year (00..99)

The sensor will respond with 'OK'.

%ST sets the time.
The format of the command is: %STHHMMSS

where:
HH   - is the hours in 24 hour clock (00..23)
MM   - is the minutes (00..59)
SS   - is the seconds (00..59)

The sensor will respond with 'OK'.

1.4.3 Message Checksum

A checksum byte can be included with messages sent by the sensor to verify that noise in the communications link has not changed the message. Generally, noise is not a problem and checksum verification is not required.

Note: if RS485 communications are selected then this checksum is not used.

By default, the sensor is configured at the factory with checksum DISABLED.

To check the setting of the checksum option, send the command: OPCS?
The sensor will respond as follows:
                   00   = Checksum disabled
                   01   = Checksum enabled

To enable the checksum, send the commands: CO followed by OPCS1

To Disable the checksum, send the commands: CO followed by OPCS0

The checksum character is positioned after the message and before the end characters (<crlf>). The checksum value is between 0 and 127, and is the sum modulo 128 (the remainder after the sum is divided by 128) of all the ASCII values of the characters in the message except the end characters.
The checksum value is replaced by its bit wise complement if it happens to be any of the following: ASCII 8 (backspace), ASCII 10 (linefeed), ASCII 13 (carriage return), ASCII 17 through ASCII 20 (DC1 through DC4), or ASCII 33 (exclamation point '!').
For any message:

Biral

C1 ... Cm <cksum><crlf>

The calculation is as follows:

$$< cksum >= \left(\sum_{n-1}^{m} c_n \right) MOD128$$

IF <cksum> = 8 THEN <cksum> = 119
IF <cksum> = 10 THEN <cksum> = 117
IF <cksum> = 13 THEN <cksum> = 114
IF <cksum> = 17 THEN <cksum> = 110
IF <cksum> = 18 THEN <cksum> = 109
IF <cksum> = 19 THEN <cksum> = 108
IF <cksum> = 20 THEN <cksum> = 107
IF <cksum> = 33 THEN <cksum> = 94

1.4.4 RS485 Communications Configuration

The SWS sensor can use either RS232C or RS422/RS485 signal voltage levels. The configuration of the sensor is selected by connecting to the appropriate terminal connections and setting the right jumper position, see section 1.2.3 Connecting the power supply and signal cable.

If the signal voltage levels for RS422/RS485 are set either RS422 or addressable RS485 communication protocols may be used. By default, the sensor is configured at the factory for RS422 protocol unless specifically requested when ordering.

To determine the RS485 communications setting
To query the RS485 setting, send the following command: OP485?
The sensor will respond with:
00   = Disabled
01   = Enabled

Enabling the addressable RS485 Communications
To enable RS485 communications, send the commands: CO followed by OP4851

To disable RS485 Communications
To disable the RS485 communications, send the commands: CO followed by OP4850

RS485 Protocol Format
The RS485 communication protocol is based on the Modbus ASCII Frame Format. Each data request and transfer is configured as follows:

Start: ':' (3A Hex).
Sensor Address: 2 Character address field.
Data: As standard SWS message format, see Section 2.
LRC Checksum: 2 Characters - Longitudinal Redundancy Check.
End: 2 Characters - Carriage return + Line Feed.

Start
The ':' (colon) symbol is used as a start flag which is 3A Hex.

Sensor Address
The 2 character sensor address is defined by the operator for the unit and programmed as specified in Section 1.4.5. It can be any numeric value between 00 and 99. It is used by the sensor to identify the recipient of the message.

Data
This is a variable length ASCII character string as defined in section 2. The master has a defined range of commands available for the SWS sensor. The SWS sensor has a range of defined data messages. These messages can either be sent as a response to a request for data by the master unit, or sent without any request on a timed basis, according to the sensor's configuration. It is recommended that a polled system is used in a multi-sensor application as this can avoid most data contention issues through the design of a suitable system operating schedule.

LRC Checksum
This enables error checking, allowing the master to request a re-send if errors are detected. For RS485 a Longitudinal Redundancy Check (LRC) Checksum is generated on the data.

Note: This checksum is different from the optional RS232/RS422 Checksum.

The LRC is one byte, containing an 8–bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the message. The receiving device calculates an LRC during receipt of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error is implied and the message is discarded.

The LRC is calculated by adding together successive 8–bit bytes of the message, discarding any carries, and then two's complementing the result. It is performed on the ASCII message field contents excluding the 'colon' character that begins the message, and excluding the <crlf> pair at the end

of the message. The LRC byte is converted to 2 ASCII characters and appended to the message.

For example, the message:
:42D?
Checksum is calculated as :
ASCII string 42D?
BYTE Values (in Hex) 34+32+44+3F

Sum is E9
One's compliment (0xFF – 0xE9) = 0x16
Two's compliment 0x16 + 1 = 0x17

Checksum is 0x17 (Hex)
Checksum ASCII characters are "17"
Transmitted string will therefore be:

:42D?17<CRLF>

End
All communications will end with the standard 2 characters, carriage return and line feed <CRLF> pair (ASCII values of 0D & 0A Hex).

Checksum Override
When using addressable RS485 communications, the sensor will disregard any commands that do not have the sensor address or have an incorrect checksum. For a command to be valid, it must be prefixed by :XX (where XX is the address) and have the 2 character checksum on the end. If the checksum character is set to FF then the sensor will accept the message without checking the checksum. This is useful when using programs such as HyperTerminal for diagnostics.

For example.
A sensor with address 00 to request a data message:
Send command:
:00D?FF

Recommendations
When using the sensor on an RS485 network it is recommended that the sensor be set up in polled mode (Automatic message transmission disabled) rather than transmitting a data message automatically. See paragraph 1.4.6 for full instructions for setting this configuration.

Note: When RS485 communications are enabled the sensor will not output the "Biral Sensor Startup" message on power up and reset.

Biral

1.4.5 **Sensor Addressing – RS485 sensors only**

To use addressable RS485 communication each sensor must have a unique
address in the range 0-99. By default, the sensor address is set to 0.

Querying the sensor address
To query the sensor address, send the command: ADR?
The sensor should respond with the address: e.g. 00.

Changing the sensor address
To change the sensor address, send the command: ADRxx
where xx is a number between 00 and 99.
e,g, ADR02 sets the sensor address to 02.
The sensor should respond with: OK.

1.4.6 **Automatic message setting**

The sensor can be set to send a data message automatically after each
measurement period, or to send a data message only when requested (polled
mode). The default setting is for automatic data transmission. To check which
method is programmed send the message:
    OSAM?
The sensor will send the reply:
        00 = Automatic message transmission disabled. Polled mode.
        01 = Automatic message transmission enabled

To set the sensor to the required automatic message setting, send the message:
    OSAMx
Where x is:
        0 = Automatic message transmission disabled. Polled mode.
        1 = Automatic message transmission enabled
The sensor will respond with "OK".

1.4.7 **Optional hood heater operating setting**

The sensor can be set to have the hood heaters disabled, or for them to work automatically. The default setting, is for automatic hood heater operation. To check which configuration is programmed send the message:

OSHH?

The sensor will send the reply:

00 = Hood heaters disabled

01 = Hood heaters on automatic

To set the sensor to the required hood heater configuration, send the message:

OSHHx

Where x is:

0 = Hood heaters disabled

1 = Hood heaters on automatic

The sensor will respond with "OK".

1.4.8 **Window heater operating setting**

The sensor can be set to have the window heaters disabled, permanently enabled, or for them to be controlled according to contamination levels. The default setting is for window heaters enabled and on. To check which configuration is programmed send the message:

OSWH?

The sensor will send the reply:

00 = Window heaters disabled

01 = Window heaters enabled and on

02 = Window heaters enabled and controlled according to contamination levels

To set the sensor to the required window heater configuration, send the message:

OSWHx

Where x is:

0 = Window heaters disabled

1 = Window heaters enabled and on

2 = Window heaters enabled and controlled according to contamination levels

The sensor will respond with "OK".

1.4.9 **Baud Rate Configuration**

Default communication parameters are 9600, 8 data bit, 1 stop bit, no parity, and no flow control. The baud rate may be changed if required as follows.

Send   %B(Number)

Just typing %B will bring up the different baud rate options:

> SELECT REQUIRED BAUDRATE BY TYPING %B(NUMBER)
> 1....1200 BAUD
> 2....2400 BAUD
> 3....4800 BAUD
> 4....9600 BAUD
> 5....19K2 BAUD
> 6....38K4 BAUD
> 7....57K6 BAUD

Select the baud rate to use, for example to select 4800 baud the user would type

> %B3<CRLF>

The user then receives a prompt to send an "OK" to the sensor at the new baud rate setting. The new setting will only be accepted if the user manages to communicate with the sensor at the new baud rate within 60 seconds. Otherwise the sensor will reset and continue operation with the original baud rate settings. If an "OK" command is received at the new baud rate the sensor will update its settings and restart.

Biral

1.4.10 **Configuring the Relays**

To get the current relay configuration send the command JRO?

The sensor will respond with a number which corresponds to:

Value	Description
0	No Relays Configured.
2	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on visibility.
4	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on window contamination warning.

Table 1-6 Relay configuration

The default value is set to 2.

Note: A response of 225 means that no relays are configured (the same as '0').

To change the configuration

To change the relay configuration, send the command JROx

where x is the value from the table above.

e.g.   JRO4

Configures Relay 2 to be a window contamination warning relay.

To read the visibility Threshold levels

To read the visibility threshold levels for Relay 1 and relay 2 send the following command: RLn?

where n is the relay number (either 1 or 2).

The sensor will respond with the visibility threshold in km. Default 1.0 km.

e.g.   10.00 km

To change the visibility Threshold levels

To change the visibility threshold levels for relay 1 or relay 2 send the following command: RLn,xx.xx

where n is the relay number (either 1 or 2)
and xx.xx is the threshold level in km. Range 0.1 km to 20.0 km

e.g. to set the threshold for relay 1 to 1km send the command:
RL1,1.00.

Contamination relay switching delay

When relay 2 is configured to report a window contamination warning, a delay of 300 seconds is included before the relay activates to avoid unnecessary switching around the threshold and to allow small liquid droplets to evaporate. No delay is introduced when switching from warning to no warning.

To read the visibility relay ON delay

To ensure the visibility threshold relays do not continually switch when the visibility fluctuates around the switching point a switch on delay is provided. For example, if the threshold is set to 1km and the delay is 5 minutes, when the visibility is decreasing the relay will switch on only when the visibility has been below 1km for 5 minutes. To read the delay value for a relay, send the following command: RVONn?

> Where n is the relay number.

The response is: AAA
> Where: AAA is the time delay in minutes. Default 5 minutes.

To set the visibility relay ON delay

Send the command: RVONn,xx

> Where: n is the relay number.
> xx is the time delay in minutes. Range 0 – 15 minutes.

To read the visibility relay OFF delay

To ensure the visibility threshold relays do not continually switch when the visibility fluctuates around the switching point a switch off delay is provided. For example, if the threshold is set to 1km and the delay is 5 minutes, when the visibility is increasing the relay will switch off only when the visibility has been above 1km for 5 minutes. To read the delay value for a relay, send the following command: RVOFFn?

> Where n is the relay number.

The response is: AAA
> Where: AAA is the time delay in minutes. Default 5 minutes.

To set the visibility relay OFF delay

Send the command: RVOFFn,xx

> Where: n is the relay number.
> xx is the time delay in minutes. Range 0 – 15 minutes.

To read the visibility threshold switching hysteresis

To ensure the visibility threshold relays do not continually switch when the visibility fluctuates around the switching point a signal hysteresis is provided as a percentage of the threshold. For example, if the threshold is set to 1km and the hysteresis value is 20%, when visibility is decreasing the relay will switch on as the visibility drops below 1km. When the visibility is increasing the relay will

Biral

switch off at 1.2km; the threshold plus the hysteresis value. The hysteresis value can be set independently for each visibility threshold relay, the default value is 20% of the threshold. To read the hysteresis value for a relay, send the following command: RLHn?

   Where n is the relay number.

The response is: AAA%,BBB.BBkm

   Where: AAA is the hysteresis value as a percentage of the threshold.
             BBB.BB KM is the calculated visibility off threshold.

To set the visibility threshold switching hysteresis
Send the command: RLHn,xx

   Where: n is the relay number.
             xx is the threshold hysteresis value. Range 5 to 25%.

1.4.11 Configuring the MOR Output

In the factory default setting the Meteorological Optical Range (MOR) values output in the data messages are expressed in kilometres to a resolution of 10m. The output can also be expressed in metres to a resolution of 1m or kilometres to a resolution of 1m.

Changing the output format of the MOR value does not affect the EXCO output field in the sensor data message.

Querying the MOR Output Resolution
To query the MOR output resolution, send the KM? command. The sensor will respond with five characters as shown below:

   00000   Default Setting, MOR expressed in km to 10m (xx.xx KM)
   00001   Metre output, MOR expressed in m to 1m (xxxxx M)
   00002   Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

Setting the MOR Output Resolution
To set the MOR resolution send the KMn command, with n set as follows:

   KM0   Default Setting, MOR expressed in km to 10m (xx.xx KM)
   KM1   Metre output, MOR expressed in m to 1m (xxxxx M)
   KM2   Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

Note: The sensor will undergo a soft reset when the command is processed.

1.4.12 **Configuring the analogue output mode**

The analogue outputs can be set by the user to represent either Meteorological Optical Range (MOR), or Extinction Co-efficient (EXCO).

To query the output mode, send the command **AN?**
The sensor will respond with a number as follows:

- 0 = MOR (default)
- 1 = EXCO

To set the output mode, send the command **ANx**
where x is the required value as above for MOR or EXCO.

The sensor will respond with OK if the set value is either '0' or '1', or BAD CMD if any other figure is entered.

Analogue output as MOR

When the analogue output is set for MOR (Default), the 0V or 4mA reading represents zero MOR. The 10V or 20mA reading represents the maximum value of MOR selected for that specific instrument. The default maximum is 2.0km. The readings between these two extremes are proportional to the MOR value.

To calculate the MOR value in km from the analogue output, use the following formula

$$MOR = (R_{MOR}/10) * V_{MOR}$$
$$MOR = (R_{MOR}/16) * (I_{MOR} - 4)$$

Where:

R_{MOR} = The maximum Range of the sensor in km

V_{MOR} = The analogue output voltage value in volts

I_{MOR} = The analogue output current value in mA

Analogue output as EXCO

When the analogue output is set for EXCO, the 0V or 4mA reading represents 'zero' EXCO. The 10V or 20mA reading represents the maximum value of EXCO which is 300. The readings between these two extremes are proportional to the EXCO value.

To calculate the EXCO value in km^{-1} from the analogue output, use the following formula.

Biral

$$EXCO = (R_{EXCO}/10) * V_{EXCO}$$
$$EXCO = (R_{EXCO}/16) * (I_{EXCO} - 4)$$

Where:

R_{EXCO} = The EXCO range of the sensor, this has the fixed value of 300

V_{EXCO} = The analogue output voltage value in volts

I_{EXCO} = The analogue output current in mA

Impact of Changing between EXCO and MOR analogue outputs

When changing between MOR and EXCO it is important to understand the consequences of the change.

The relationship between the two outputs is:

$$MOR = 3/EXCO$$
$$EXCO = 3/MOR$$

From the above formula, you can see the relationship is not linear and the two outputs have different uses. The below tables show how this affects the output when the sensor is configured for a 7,500m maximum range.

Example of the MOR and EXCO output change over distance

	MOR	**EXCO**
100m	4.213mA	5.600mA
110m	4.234mA	5.455mA
difference	21uA	145uA

	MOR	**EXCO**
1900m	8.053mA	4.084mA
2000m	8.266mA	4.080mA
difference	210uA	4uA

It can be seen from the tables above that the two outputs are very different and have different applications. The MOR analogue output gives a consistent linear resolution across the output range. This is suitable when interested in visibilities across the whole visibility range of the unit.

EXCO is not linear across the visibility range and has greater resolution at the lower visibility ranges, with corresponding loss of resolution at high visibility ranges.

It is recommended that EXCO is used in applications where emphasis is required at the lower visibility levels, such as fog detection in road applications.

Note: The default maximum visibility range (MOR) is factory set to be 2Km. This corresponds to a minimum EXCO reading of 1.5 Km^{-1}. The maximum range can be configured to any value up to 40Km if specified at time of placing the order.

1.5 STEP 5 - Installation

Please consider the following factors when installing the sensor:

(1) Siting considerations.
(2) Height of the sensor above ground.
(3) Orientation of the sensor.
(4) Mounting the sensor.
(5) Electrical grounding.

Each of these factors is covered in more detail below:

1.5.1 Siting Considerations

Reflected Light – Care should be taken to ensure that the sensor is situated away from any surfaces which could cause reflections of the IR illumination from the transmitter (for example walls, trees and people etc.). Reflected IR illumination entering the sensor's optics will cause errors in the reported visibility measurements.

Air-flow – Care should be taken to ensure that the sensor is situated away from objects that disrupt the 'normal' flow of air to and through the sensor sampling volume (for example walls, trees and other equipment etc.).

RFI Interference – In addition to the above mentioned natural effects that may influence the performance of the sensor, due regard should also be given to radiated electrical interference. Sources of potential interference include radio antennas and radiated transients from high-voltage plant located near to the sensor installation.

Sources of Particulates – Avoid locating the sensor in locations where it will be subject to local sources of particulates. Particulate sources include generator exhausts, air-conditioning cooling towers, kitchen exhausts, fires and vehicle exhausts.

1.5.2 **Height Above Ground:**

The optimum height at which to mount the sensor depends on the application. The table below shows recommended heights.

Application	Typical height	Comment
Highway fog-warning systems	1.5 to 2 metres (4.9 to 6.6 feet)	Recommended height for the sensor sample volume is the average distance of a vehicle driver's eyes above the roadway.
Airport applications	4.3 metres (14 feet) above the runway	This is the standard height for visibility sensors in the U.S. This height may differ in other countries.
General meteorological	1.8 metres (6 feet)	This is a suitable height unless the particular application dictates otherwise.

Table 1-7 Sensor height above ground

1.5.3 **Orientation of Sensor Head**

The orientation of the sensor heads should be such that the rising or setting sun does not appear in the field-of-view of the receiver lenses.

The recommended orientation is shown in Figure 1-7 SWS-050T

For the SWS-050T sensor, the optimum position is with the receiver head pointing directly due North.

For sensors located in the Southern hemisphere point the forward scatter receiver directly due South.
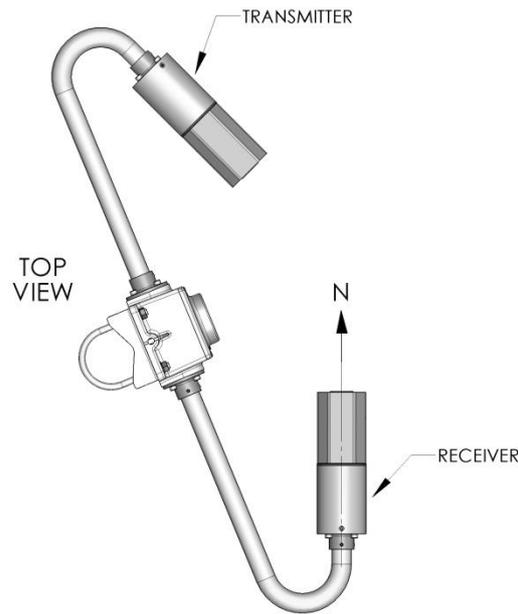
Figure 1-7 SWS-050T

1.5.4 **Mounting the Sensor:**

On a pole
Two stainless steel U-bolts and saddles are provided for securing the sensor to the top of a mast, see Figure 1-8 U-Bolt Mounting Method. The two V-block saddles oppose the U-bolt, thus providing a secure grip on the mast. The sensor can be mounted on a galvanised steel pipe or heavy walled aluminium tube with an outer diameter between 40 to 64 mm. For mast diameters outside this range the U-bolts provided will not be suitable.

The sensor head should be mounted near the very top so that the mast will not interfere more than necessary with the free flow of fog or precipitation through the sample volume. The flat stainless-steel washers should be placed next to the powder coated surface of the mounting plate to prevent gouging by the lock washers as the nuts are tightened.
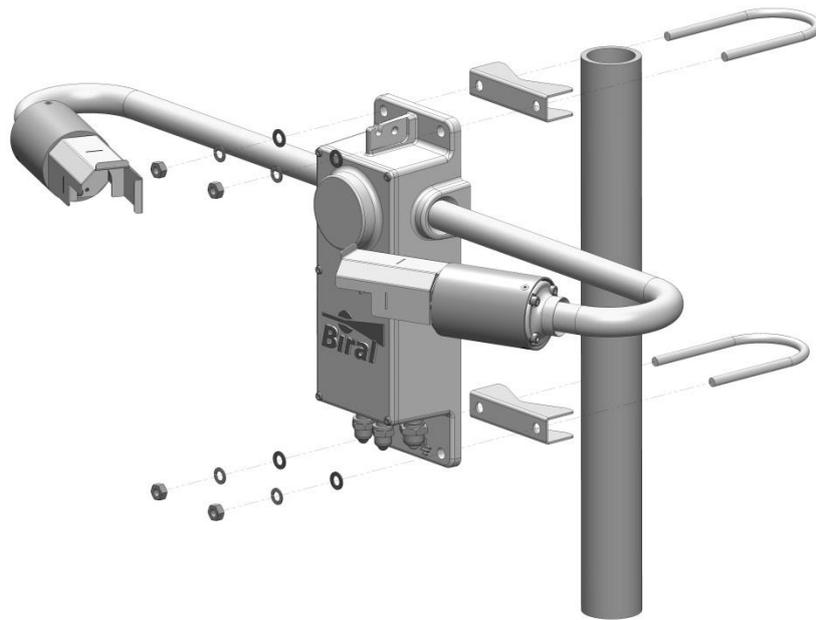
Figure 1-8 U-Bolt Mounting Method

On a wall

The sensor can be bolted directly to a flat surface using the four mounting holes provided. Every effort should be made to ensure that the mounting surface has minimal effect on the air flow and the precipitation flow through the sample volume. Even if mounted at the top of a wall, the airflow will be restricted, reducing the accuracy of the sensor in certain atmospheric conditions.

1.5.5 **Electrical Grounding**

This product **MUST BE EARTHED.** Failure to install a suitable earth may result in inaccurate readings and / or damage to the product and attached equipment.

Failure to install an earth will make the unit potentially unsafe when using the relays to switch hazardous voltages.

Possible instrument failure can result from the damaging effects of over-voltage transients induced on the power line and the signal distribution lines.

Destruction of sensitive components can result from unprotected lines, or instrument failure may occur over a long period of time due to slow device degradation. Destructive over volt transients can occur in many ways; e.g., lightning induced transients, AC power line transients and EMI/RFI electromagnetic noise. The power/control subsystem of the sensor contains

transient surge-arrestors on all power and signal lines as a standard feature. EMI filters are present on the power and data lines entering the power/control subsystem.

It is essential to connect the sensor to earth ground for maximum protection of the instrument. In addition, if relays are in use and are required to switch mains voltages, protective earth bonding will be required to conform with national and local installation safety requirements.

The following notes are intended to provide some guidance in the design and construction of an electrical grounding system.

(1) Ground Rod: An 2.5m ground rod should be used to make contact with moist soil during even the driest periods.

(2) Lead Lengths: No. 6 AWG solid copper wire should be used to connect the instrument (and thus the transient voltage suppressers) to the ground rod. Use the shortest and most direct paths to the ground. Simply connect the ground lead to the grounding screw provided on the front of the lower mounting flange of the instrument.

(3) System Interconnections: Eliminate all isolated ground loops. The shield of the signal output cable, for example, should be attached only at one end of the cable and left floating at the other end. Preferably, it should be attached to ground at the sensor end of the signal cable.

(4) Connections: Use tight corrosion-proof bare metal connections throughout the grounding system.

1.6 STEP 6 - Test and Commissioning

The following steps contain a few basic checks to provide confidence that the unit is functioning correctly after installation.

These checks are recommendations only and are neither essential nor exhaustive.

1.6.1 Checking Power Supply

Before connecting the power cable to the sensor, the supply voltage being provided should be measured to ensure that the voltage present is compatible with the sensor power requirement. Use a multimeter to measure the supply voltage which should be between 9V and 36V DC.

DANGER of electric shock! **Exercise caution when performing this measurement.**

WARNING **Only connect the power cable if it matches the voltage requirements of the sensor. Damage caused by improper voltage connection is not covered under warranty.**

1.6.2 Checking the Data Link

1. Connect the power-input cable to a local power source (do not turn power source on).

2. Connect the signal wires to a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® HyperTerminal™. For RS422/485 sensors a RS422 to RS232 converter must be used).

   Note: Biral recommends testing to be done with RS232 or RS422 as applicable. When you are confident that the sensor is working it can then be set up for RS485 if required.

3. Configure the terminal program as follows:

   Default Interface Parameters
   Baud Rate..9600
   Data Bits 8
   Stop Bits..1
   Parity ....None
   Flow Control ....None

4. Turn the local power source "ON".
    If communications are working the sensor will respond with "Biral Sensor Startup".

5. Check Data Transmission To Sensor:
    Send the command   R?   from the PC terminal to the sensor:
    The sensor will respond with its Remote Self-Test & Monitoring Message.
    For example:
    100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,107,00,00,00,+021.0,4063

6. Check Data Transmission From Sensor:
    If the sensor is NOT in polled mode:
    Wait for the sensor to transmit a Data Message (approx. 80 seconds from power up).

    If the sensor is in polled mode:
    Send the command   D?   from the PC terminal to the sensor:
    A Data Message will be transmitted immediately.

1.6.3 **Remote Self-Test Check**

Send the command *R?* from the PC terminal to the sensor:

The sensor will respond with its Remote Self-Test & Monitoring Message.
For example:
100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,100,00,00,00,+021.0,4063

The Various fields in the response are as follows:

Field	Range / Value	Description
Field 1:	**Space**	The message starts with a space.
Field 2:	**ABC**	Heater state and error flags.
		A = 1 - Window heaters ON.
		A = 2 - Hood Heaters ON.
		A = 4 - A/D control signal error.
		B = 1 - EPROM checksum error.
		B = 2 - Non-volatile memory checksum error.
		B = 4 - RAM error.
		B = 8 - Not used.
		C = 1 - Not Used.
		C = 2 - Ired commanded OFF.
		C = 4 - Receiver test in progress (Ired OFF).
		C = 8 - Sensor power reset since last R? Command.
		or any combination of these.
Field 3:	2.450 - 2.550	Internal reference voltage.
Field 4:	9.00 - 36.00	Supply voltage.
Field 5:	11.2 - 17.5	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	11.2 – 17.5	Internal operating voltage.
Field 8:	0.00 - 6.00	Forward scatter background brightness.
Field 9:	0.00	Not Used.
Field 10:	85 - 105	Transmitter power monitor.
Field 11:	80 - 120	Forward receiver monitor.
Field 12:	00	Not Used.
Field 13:	00 - 99	Transmitter window contamination.
Field 14:	00 - 99	Forward receiver window contamination.
Field 15:	00	Not Used.
Field 16:		Temperature °C.
Field 17:	3300-4200	ADC interrupts per second.

Table 1-8 Remote self-test and monitoring check fields

1.6.4 **Calibration Check**

The sensor is fully calibrated before it leaves Biral. However, if you would like to carry out a user confidence calibration check please follow the calibration check procedure in section 5, to ensure that the MOR value changes ie the sensor responds to changes in visibility.

<div style="border:1px solid black; padding:10px; text-align:center;">

THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE SWS CALIBRATION KIT IS AVAILABLE

</div>

1.6.5 **Using the *Test* Command**

If you wish to test the connections to the outputs of the sensor, use the TEST command. This command allows the sensor to be set to a known condition for a set period of time allowing the unit to temporarily simulate foggy and clear conditions, which will allow checking of the sensor and overall system performance.

Command Syntax

To ensure the TEST command is not used inadvertently it must be proceeded by the Calibration Enable command, CO.

The TEST command takes the following form:

TEST,tt,vv.vv,f,c<CRLF>

Where:
- tt   Duration of test in minutes – range 00-60,
(00 will stop the test).

- vv.vv   Visibility will be in km
Range 0.01 to maximum range of sensor.

- f   State of the Other Selftest digit in the Selftest & Monitoring field of the data message.
0 = No Fault,
1 = Other selftest fault exists.

- c   Window Contamination Indicator digit in the Selftest & Monitoring field of the data message.
0= Windows not contaminated
1= Window Contamination Warning
2= Window Contamination Fault.

- pw   Present weather code – For available codes see below.

Available PW Codes: 00,04,10,27,30
    An invalid code will return code 00 in the sensor message string.
    Note: The available codes are not all valid for the SWS-050T.

Example:
TEST,02,07.50,0,0 – Outputs a visibility of 7.5 km for 2 min (Clear conditions)
TEST,06,00.10,0,0 – Outputs a visibility of 0.1 km for 6 min (Foggy conditions)

Command Operation
Where trailing fields of the TEST command are omitted they will be automatically substituted by the value zero.

Example:
TEST,5,2.34<CRLF>   (Sets the visibility to 2.34km for 5 minutes)
has the same meaning as,
TEST,5,2.34,0,0

Where a parameter is outside of the allowable range for the configuration of the sensor, the sensor will respond with BAD CMD. For example, if a SWS-050T has been configured to have a maximum reporting range of 20km and the TEST command states 50km the sensor will respond with BAD CMD.

At the end of the test period, or when the test period is terminated using TEST,0, the sensor will undergo an automatic soft reset.

For the duration of the test output the first character of the Selftest & Monitoring field of the data message will be set to T. This allows the system to which the sensor is connected to be aware that the data message contains test values and should not be used operationally.

Example output:

    SWS050,000,060,15.76 KM,00,000.19,TOO

CONGRATULATIONS

YOUR SENSOR SHOULD NOW BE FULLY CONFIGURED, TESTED AND INSTALLED READY FOR USE

THE REMAINDER OF THIS MANUAL COVERS:

- **STANDARD DATA MESSAGES**

- **COMMANDS AND RESPONSES**

- **OPERATIONAL AND MAINTENANCE PROCEDURES**

- **CALIBRATION CHECK AND RE-CALIBRATION PROCEDURE**

- **SENSOR DETAILS AND SPECIFICATIONS**

2 STANDARD OPERATING DATA

When in standard mode a data message will be output from the sensor every measurement period (default 60 seconds). When in polled mode the same message is output only in response to the D? command. The operating mode is checked by sending command "OSAM?". The standard mode (default) is selected if the response is "01". If the response is "00", the polled mode is selected. Instructions for setting this configuration are provided in section 1.4.6.

Note: All responses from the sensor are appended with carriage return and line feed characters (<crlf>, see paragraph 1.3).

The standard messages are detailed below in Table 2-1 SWS-050T Operating data message format.

2.1 Standard Operating Data Message for the SWS-050T

The data message format for the SWS-050T is:
<Date>,<Time>,SWS050,NNN,XXX,AA.AA KM,BB,CCC.CC,DDD, <cs>crlf

Note: <   > denotes an optional field.

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
SWS050	SWS-050 message prefix.
NNN	Instrument identification number set by the user.
XXX	Averaging Time period in seconds.
AA.AA KM	Meteorological Optical Range (km). This is the averaged value. See Note 1.
BB	Obstruction to vision code. From WMO table 4680: XX Not Ready (first 5 measurement periods from restart). 00 No significant weather observed. 04 Haze or Smoke. 30 Fog.
CCC.CC	Total Forward Scatter Exco value.
DDD	Self-test and Monitoring (see section 1.6.3): DDD O = other self-test values OK. X = other self-test faults exist. O = windows not contaminated. X = window contamination warning – cleaning recommended. F = Window contamination fault – cleaning required. T = sensor in Test Mode. O = sensor not reset since last "R?" command. X = sensor reset since last "R?" command.
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 2-1 SWS-050T Operating data message format

A typical data message from an SWS-050T sensor in default configuration is as follows:

> SWS050,001,060,00.14 KM,30,021.43,XOO

Note: *The format and resolution of the MOR value reported can be configured using the KMn command, see section 1.4.11. The available options are:*

- o *Default Setting, MOR expressed in km to 10m (xx.xx KM)*
- o *Metre output, MOR expressed in m to 1m (xxxxx M)*
- o *Kilometre output, MOR expressed in km to 1m (xx.xxx KM)*

A data message with the sensor configured for 1m resolution MOR is as follows:

> SWS050,001,060,00142 M,30,021.43,XOO

Biral

2.2 Data Message Variations For ALS-2

For SWS sensors fitted with an Ambient Light Sensor, ALS-2, the data output strings are identical to the standard message with the following appended to the message, prior to the optional checksum<cs> and the carriage return and line feed <crlf>.

,ALS,±AAAAA,BBB

Message	Meaning
ALS	ALS data message prefix.
±AAAAA	ALS Signal, 1 minute averaged value (cd/m^2).
BBB	ALS Self-Test and Monitoring If ALS not connected set to field set to OOO O = Other self-test values OK. X = Other self-test faults exist. O = windows not contaminated. X = window contamination warning – cleaning recommended. F = Window contamination fault – cleaning required. S = Sensor input saturated. O = sensor not reset since last "R?" command. X = sensor reset since last "R?" command.

Table 2-2 Message extension for ALS-2

A typical data message from the SWS-050T sensor with an ALS-2 is as follows:

SWS050,001,060,00.14 KM,30,021.43,XOO,ALS,+00118,XOO

3   COMMANDS AND RESPONSES

3.1 Sensor Commands

Note: All commands should be terminated with <Carriage Return> and <Line Feed>
(<crlf>, see paragraph 1.3).
Commands marked with * cause the sensor to restart.
Commands marked with # must be preceded by the CO command.

Command	Function	Response
ADR?	Query RS485 address. See **section 1.4.5**	**xx**
ADRxx	Set RS485 address. Range 00 to 99. See **section 1.4.5.**	**OK**
AN?	Query the analogue output type. See **section 1.4.12**	**0 = MOR** **1 = EXCO**
ANn*	Set the analogue output type. See **section 1.4.12**	**OK**
BT?	Query instantaneous value of Total EXCO.	**xxx.xx**
CE#	Perform EXCO calibration. Calibration must be enabled.	**See section 5.3**
CO	Enable calibration.	**OK**
CX*	Disable calibration.	**OK**
D?	Send latest data message.	**See section 2**
DHO	Turn hood heaters on temporarily. If off prior to the command, the heaters will turn off after 2 minutes (for maintenance only).	**OK**
DHX	Turn hood heaters off temporarily. If on prior to the command, the heaters will turn on after 2 minutes (for maintenance only).	**OK**
IDx*	Set instrument identification number displayed in data message. Range x = 0 to 999. (Default = 1).	**OK**
JRO?	Query current relay configuration	**See section 1.4.10**
JROx*	Set current relay configuration.	**See section 1.4.10**
KM?	Query current MOR output resolution configuration	**See section 1.4.11**

Command	Function	Response
KMn*	Set MOR output resolution.	**See section 1.4.11**
OP?	Query the Options Word.	**See section 1.4.1**
OPxxxxxxxx*#	Set configuration options. See **section. 1.4.1.**	**OK**
OPCS?	Query checksum option setting. **See section 1.4.3**	**00 = Disabled** **01 = Enabled**
OPCSx*#	Set checksum option. **See section 1.4.3**	**OK**
OP485?	Query Addressable 485 communications setting. **See section 1.4.4**	**00 = Disabled** **01 = Enabled**
OP485x*#	Set Addressable RS485 communications. **See section 1.4.4**	**OK**
OSAM?	Query automatic message setting.	**See section 1.4.6**
OSAMx*	Set automatic message setting, **section 1.4.6**	**OK**
OSHH?	Query hood heater setting.	**See section 1.4.7**
OSHHx*	Set hood heater setting. See **section 1.4.7**	**OK**
OSWH?	Query window heater setting.	**See section 1.4.8**
OSWHx*	Set window heater setting. See **section 1.4.8**	**OK**
PV?	Query program version message.	**SI xxxxxx.yy**
R?	Send remote self-test and monitoring message.	**See section 3.1.1**
RLn?	Query relay 'n' visibility threshold setting. **See section 1.4.10**	**XX.XX KM**
RLn,xx.xx*	Set relay 'n' visibility threshold in km. **See section 1.4.10**	**OK**
RLHn?	Query the relay threshold hysteresis.	**See section 1.4.10**
RLHn,xx*	Set the relay threshold hysteresis.	**OK**
RVONn?	Query the threshold hysteresis on time for relay n.	**See section 1.4.9**
RVONn,xx*	Set the threshold hysteresis on time for relay n	**OK**
RVOFFn?	Query the threshold hysteresis off time for relay n.	**See section 1.4.9**
RVOFFn,xx*	Set the threshold hysteresis off time for relay n.	**OK**
RST*	Restart instrument.	**OK**

Command	Function	Response
SN?	Query instrument serial number	**xxxxxx.xx**
T?	Query instrument times message.	**See section 3.1.2**
TAx*	Set auxiliary measurement sample period. Range x= 2 to 20 (seconds). Default = 5. **See section 3.1.2**	**OK**
TEST,tt,vv.vv,f, c,pw*#	Set the sensor into a test mode.	**See section 1.6.5**
TMx*	Set measurement interval. Range x = 10 to 300 (seconds). Default= 60. **See section 3.1.2**	**OK**
TR?	Query current date and time. **See section 1.4.2.**	**FRIDAY , 23/03/12, 13:15:25,000**
WF?	Query Window Contamination Fault Threshold Percentage	**XX**
WFn *#	Set Window Contamination Fault Threshold Percentage. Range n= 0 to 50. Calibration must be enabled. Default 30%.	**OK**
WT?	Query current window contamination threshold for warning indication.	**XX**
WTx*#	Set window contamination threshold for a warning indication. Range: 0 to window contamination fault threshold (%) Calibration must be enabled. Default = 10%.	**OK**
%Bx*	Set communication baud rate. Range: n = 1 to 7.	**See section 1.4.9**
%SDWDDMMYY	Set current date. **See section 1.4.2.**	**OK**
%STHHMMSS	Set current time. **See section 1.4.2.**	**OK**

Table 3-1 Commands for SWS-050T sensor

3.1.1 **Command R? - Send Remote Self-Test and Monitoring Message**

Example response:

100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,107,00,00,00,

+021.0,4063

The various fields in the response are as follows:

Field	Range / Value	Description
Field 1:	**Space**	The message starts with a space.
Field 2:	**ABC**	Heater state and error flags.
		A = 1 - Window heaters ON.
		A = 2 – Hood Heaters ON.
		A = 4 - A/D control signal error.
		B = 1 - EPROM checksum error.
		B = 2 - Non-volatile memory checksum error.
		B = 4 - RAM error.
		B = 8 – Not used.
		C = 2 - Ired commanded OFF.
		C = 4 - Receiver test in progress (Ired OFF).
		C = 8 - Sensor power reset since last R? Command.
		or any combination of these.
Field 3:	2.450 - 2.550	Internal reference voltage.
Field 4:	9.00 - 36.00	Supply voltage.
Field 5:	11.2 - 17.5	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	11.2 – 17.5	Internal operating voltage.
Field 8:	0.00 - 6.00	Forward scatter background brightness.
Field 9:	0.00	Not used.
Field 10:	85 - 105	Transmitter power monitor.
Field 11:	80 - 120	Forward receiver monitor.
Field 12:	00	Not used.
Field 13:	00 - 99	Transmitter window contamination.
Field 14:	00 - 99	Forward receiver window contamination.
Field 15:	00	Not used.
Field 16:		Temperature °C.
Field 17:	3300-4200	ADC interrupts per second.

Table 3-2 Command R? response

3.1.2 Command T? - Send Instrument Times Message

Response: **aaaa,bbbb,ccccc,dddd**

aaaa: Measurement interval for each operational data message (10 to 300 seconds)

(default = 60).

bbbb: Auxiliary measurement sample period - time between measurement of peripheral signals during measurement interval. (2 to 20 seconds) (default = 5).

ccccc: Not used.

dddd: Not used.

The auxiliary measurement period should always be set such that the measurement interval is an integer multiple of the auxiliary period. For example, if the measurement period is set to 15 seconds, set the auxiliary period to 3 seconds. Recommended values are shown below:

TM ≥ 60	TA = 5
TM = 30	TA = 5
TM = 15	TA = 3
TM = 10	TA = 2

To set the auxiliary measurement period use the following command: Tax

Where x is the time in seconds. Range 2 to 20 seconds. Default 5 seconds.

3.2 Sensor Responses

RESPONSE	MEANING
BAD CMD	The command was not understood by the sensor. Check the text of the command and re-send.
COMM ERR	An error was detected in a character in the command. Re-send the command.
OK	Command with no quantitative response was understood and executed.
TIMEOUT	Command was sent with more than 10 seconds between characters. Re-send the command.
TOO LONG	Command message was longer than 24 characters including end characters. Check the text of the command and re-send.

Table 3-3 Sensor responses

4 MAINTENANCE PROCEDURES

The SWS-050T sensor requires very little maintenance. The following sections detail the checks that are advisable to ensure continued good operation of the sensor. The frequency of these checks depends upon the location and environmental conditions under which the sensor operates.

It is suggested that a general check, plus window cleaning should take place typically at three monthly intervals. This period may be increased or decreased dependent on the contamination determined during these inspections. It is also recommended that a calibration check (See Paragraph 5.2) is carried out at six monthly intervals to verify that the instrument is continuing to perform within the specification.

4.1 General Checks

A general check of the physical condition of the sensor should be carried out at regular intervals. Attention should be paid to the condition of the cable(s) from the base of the unit. It is suggested that this is carried out at least every three months, in conjunction with window cleaning (see 4.1.3 below).

4.1.1 De-mister Heaters

The window de-misters are low powered heaters designed primarily to prevent condensation. They maintain the temperature of the windows at a few degrees above ambient temperature.

The default setting is ON. See section 1.4.8 for details.

The warmth may be detected with the finger on the window but is easier to detect using a thermometer with surface temperature probe. The windows should be between 2°C and 8°C above ambient temperature after at least 10 minutes operation. Ensure that windows are cleaned after coming into contact with the skin.

4.1.2 Hood Heaters

Hood heaters are fitted as standard on the SWS-050T. They are fitted to the inside of each of the hoods. See Figure 4-1 Hood Heater.

The hood heaters are high-power heaters designed to prevent the build-up of frozen precipitation in the hoods. These heaters operate according to the ambient temperature only being switched on when the temperature is below 2°C. When switched on, it is easy to detect the heating by placing a finger on the end of each hood.

The hood heater is the raised red mat on the inside of the hood near the window
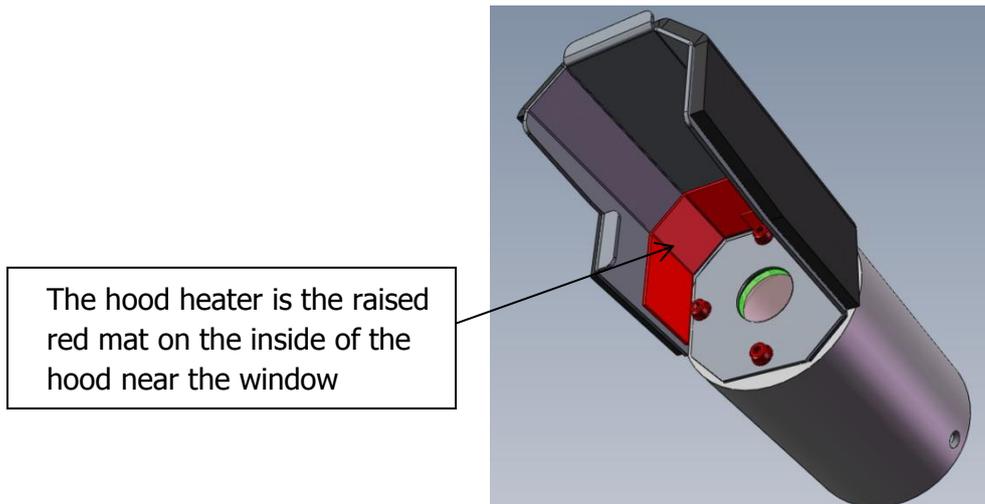
Figure 4-1 Hood Heater

When the temperature is above the 4°C the heaters will be switched off but may be controlled using a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® HyperTerminal™. The heaters may be switched on temporarily using the command DHO and off again using the command DHX, see section 3.1.

4.1.3 Window Cleaning

SWS sensors are optical instrument and are therefore susceptible to accumulation of contaminants on the windows in the hoods. The windows should be cleaned by gently wiping the windows using a dilute detergent solution or pure alcohol (propanol) and a soft cloth *(appropriate safety precautions must be taken when using pure alcohol)*.

All SWS-050T sensors are fitted with a Transmitter Window monitoring system and a Receiver Window monitoring system, which compensates for contamination and will flag a warning when the contamination on either window reduces the signal by more than a pre-set amount (default 10%). When this occurs, the appropriate part of Self-test and Monitoring message in the sensor Data Output Message changes from O (no contamination) to X (warning) – see paragraphs 2.1 and 4.2.2. If this registers an 'X', the windows should be cleaned at the earliest convenient opportunity. If the contamination continues to increase above the window contamination fault limit, default 30%, on either window, the accuracy of the instrument may begin to deteriorate. The self-test monitoring message will change to 'F', and the windows should be cleaned as a matter of urgency.

Note: Relay 2 can be set to switch when the window contamination exceeds the warning level, see Section 1.4.10. This is of particular importance if the analogue outputs are used, rather than the digital output which contains the window contamination warning.

4.2 Self-Test Codes

Self-Test and Monitoring information is provided in the standard Operating Data Message. This information consists of three alpha-numeric characters which have the following meanings.

Note: The command "R?" provides a response with full diagnostic information. This response is detailed in paragraph 3.1.1.

4.2.1 Most Significant Character (Sensor Reset Flag)

This will be set to "X" on start-up. It will only be set to "O" following receipt of an "R?" command. If it subsequently is set to "X", this is an indication that a fault, such as a power interruption, has caused the processor to reset. This is generally of no importance, but may assist in the diagnosis of installation problems.

The character will be set to "T" when the sensor is in Test mode. See section 1.6.5.

4.2.2 Central Character (Window Contamination)

SWS-050T sensors have monitoring of contamination on the transmitter window and on the receiver window.   The processor compensates the visibility reading to allow for this contamination and checks both the contamination figures against the warning and fault thresholds. This Self-test code can be one of three characters, O, X or F dependent on the contamination reading received. These have the following meaning:

"O":	Window contamination is less than the warning threshold on both transmitter and receiver. No action required.
"X":	Window contamination warning. The window contamination is between the warning and fault thresholds on one or more windows and below the fault threshold on both. The visibility reading provided is corrected utilising this contamination figure, but it is recommended that the windows are cleaned at the earliest possible opportunity.
"F":	Window contamination fault. The window contamination is above the fault threshold on one or more windows. Although the visibility reading is still corrected using this

contamination figure, the accuracy may deteriorate as the contamination increases. The windows require cleaning.

Note: *The ALS-2 has an additional code of "S". This indicates that the sensor is saturated with a VERY bright light source (such as direct view of the sun). Although the reported light level will be in error, it can be implied that the true ambient light level is high.*

4.2.3 **Least Significant Character (Other Self-Test errors)**

A variety of operating parameters are regularly checked against normal operational figures as an early warning of possible sensor faults. This character indicates whether all parameters other than window contamination are normal. This Self-test code can be one of two characters, O, or X. These have the following meaning:

"O":   No Fault. No action required.

"X":   Internal error. Send command "R?" to list all internally monitored parameters. Check against paragraph 3.1.1 to determine the cause of this error. Send command "RST" to restart the sensor. If the fault persists, arrange for the sensor to be serviced at the earliest possible opportunity.

4.3 User Confidence Checks

> **The following user confidence checks require bi-directional communications with a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows HyperTerminal.**

It is suggested that these should be carried out at least every year, to provide continuing confidence in the correct operation of the system.

4.3.1 Calibration Check

If you wish to carry out a user confidence calibration check please follow the calibration check procedure in section 5, to ensure that the sensor calibration values are still within specified limits.

> **THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE SWS CALIBRATION KIT AND PC ARE AVAILABLE**

4.3.2 Window Monitor Checks

The SWS-050T sensor monitors the transmitter window for contamination. The values measured are used to adjust the MOR value, and are also used to determine when the windows should be cleaned.

The performance of the monitoring circuit can be checked by the following procedures:

Transmitter Window Monitor
Step 1. Clean the transmitter window.

Step 2. Send the command: R?

Step 3. Verify that the 'Transmitter Window Contamination' field value is 00 to 02.

Step 4. Insert a white card (or paper) in the transmitter hood that blocks and almost touches the window (see Figure 4-2 Transmitter Hood with White Card).
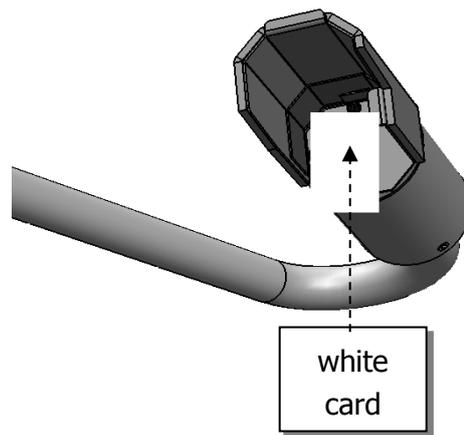
Figure 4-2 Transmitter Hood with White Card

Step 5. Send the command: R?

Step 6. Verify that the 'Transmitter Window Contamination' field value is much greater than 10 (eg 99).

Step 7. Remove the white card.

Receiver Window Monitor(s)

The SWS-050T sensor monitors the receiver window for contamination. The values measured are used to adjust the MOR value, and are also used to determine when the windows should be cleaned. Carry out the following procedure for the forward scatter window.

Step 1. Clean the forward scatter receiver window.

Step 2. Wait for operational data in message from the sensor.

Step 3. Send the command: R?

Step 4. Verify that the 'Forward Scatter Receiver Window Contamination' field value is 00 to 02.

Step 5. Insert a white card in the forward scatter receiver hood that blocks the window, and almost touches it (similar to Figure 4-2 Transmitter Hood with White Card).

Step 6. Wait for operational data message from the sensor.

Step 7. Send the command: R?

Step 8. Verify that the 'Forward Scatter Receiver Window Contamination' field value is much greater than 10 (i.e. 99).

Step 9. Remove the white card.

4.3.3 Receiver Background Brightness Measurement Checks

The receiver background brightness value measures the optical signal detected by the receiver caused by the ambient background. This value is used to set the threshold values for precipitation particle detection. The following procedure will check this function for the forward scatter receiver.

Step 1. Insert grey foam plugs ('Zero Plugs', supplied in the calibration kit) into the forward scatter receiver hood, blocking all light from the window.

Step 2. Send the command: R?

Step 3. Verify that the value in the 'Forward Scatter Receiver Background Brightness' field is less than 00.06. (forward scatter is field 8, see section 3.1.1).

Step 4. Remove the zero plugs from the Sensor Head receiver hoods.

Step 5. While shining a flashlight directly into the appropriate receiver window send the command: R?

Note: *This test requires the use of a filament bulb flashlight. There is insufficient IR radiation from a visible LED source to carry out this test successfully.*

Step 6. Verify that the value in the 'Forward Scatter Receiver Background Brightness' field is much greater than 00.06.

5 CALIBRATION PROCEDURES

This section explains how to CHECK the calibration of the sensor and ONLY IF NECESSARY how to recalibrate it.

<div style="border:1px solid black; padding:1em; text-align:center">

**ALL THE PROCEDURES IN THIS SECTION REQUIRE
A SWS CALIBRATION KIT**

</div>

<div style="border:1px solid black; padding:1em">

⚠️ **ENSURE THE CORRECT MODEL AND REVISION OF CALIBRATION KIT IS AVAILABLE.**
Use of the wrong calibration kit will result in incorrect calibration of the sensor.
See section 5.1 for details.

</div>

The calibration of the forward scatter channel is checked using the procedure detailed below (section 5.2).

The Calibration Reference Plaque used for the calibration check has been assigned a forward scatter calibration value and a back scatter calibration value. Only the forward scatter value is required for the SWS-050T These values are shown on the label on the arm of the Calibration Reference Plaque.

Each Calibration Reference Plaque also has a MOR equivalent value assigned to it. This value is shown on the surround of the Calibration Reference Plaque.

All these calibration values are also provided on the Calibration Certificate sent with the Calibration Kit.

Assembly of the Calibration Reference Plaque is shown in Figure 5-1.

5.1 Calibration Plaque Identification

Only the Calibration Kit designed for use with the SWS sensor family should be used. Use of a Calibration Kit intended for use with another sensor family is not possible due to the unique mounting arrangements. Any attempt to use an incompatible Calibration Kit may result in damage to the sensor and Calibration Kit. The carry case of the SWS Calibration Kit is fitted with a label stating "SW Calibration Plaque" or "SWS.CAL".

In January of 2014 the main IRED light source of the SWS sensor family was changed from a device operating at 880nm to one operating at 850nm; this

change was necessary due to component obsolescence. A consequence of the change of wavelength is that calibration plaques intended for use at 880nm are not compatible with sensors operating at 850nm and vis versa.

To ensure that it is not possible to use an incompatible calibration plaque the alignment features that control the fitting of the plaque to the sensor and the fitting of the plaque disk to the plaque arm are different on plaques intended for 880nm use compared to those intended for 850nm use.

IF THE PLAQUE DOES NOT FIT EASILY ON TO THE SENSOR IN THE CORRECT POSITION IT IS NOT COMPATIBLE WITH THE SENSOR.

UNDER NO CIRCUMSTANCE MUST THE PLAQUE BE FORCED INTO POSITION OR THE ALIGNMENT FEATURES BE TAMPERED WITH.

To provide a quick and simple method of checking the compatibility of a plaque with a sensor the colour of the sensor label, Calibration Kit case and plaque metalwork are used. See the table below for details.

Feature	880nm	850nm
Sensor Label	White	Silver
Calibration Kit box colour	Black	Blue
Calibration plaque frame colour	Black	Silver

5.2 Calibration Check

The following instructions show how to check the calibration of a SWS series sensor. This procedure can only be completed with:

1.   A SWS Calibration Kit

2.   Connection to a PC running the Biral Sensor Interface Software, or, if this is not available, terminal emulation software (such as Windows ® HyperTerminal™) using the serial connection. *If you need help with this please do not hesitate to contact us (contact details on page vi)*.

CALIBRATION CHECK NOTES

PLEASE READ THESE NOTES BEFORE CONTINUING

The MOR (Meteorological Optical Range or visibility) values depend heavily on the location and prevailing weather conditions and should only be carried out with the sensor:

1. **MOUNTED OUTSIDE AND ON A CLEAR DRY DAY (VISIBILITY>10KM)**

2. **POWERED FOR AT LEAST 1 HOUR**
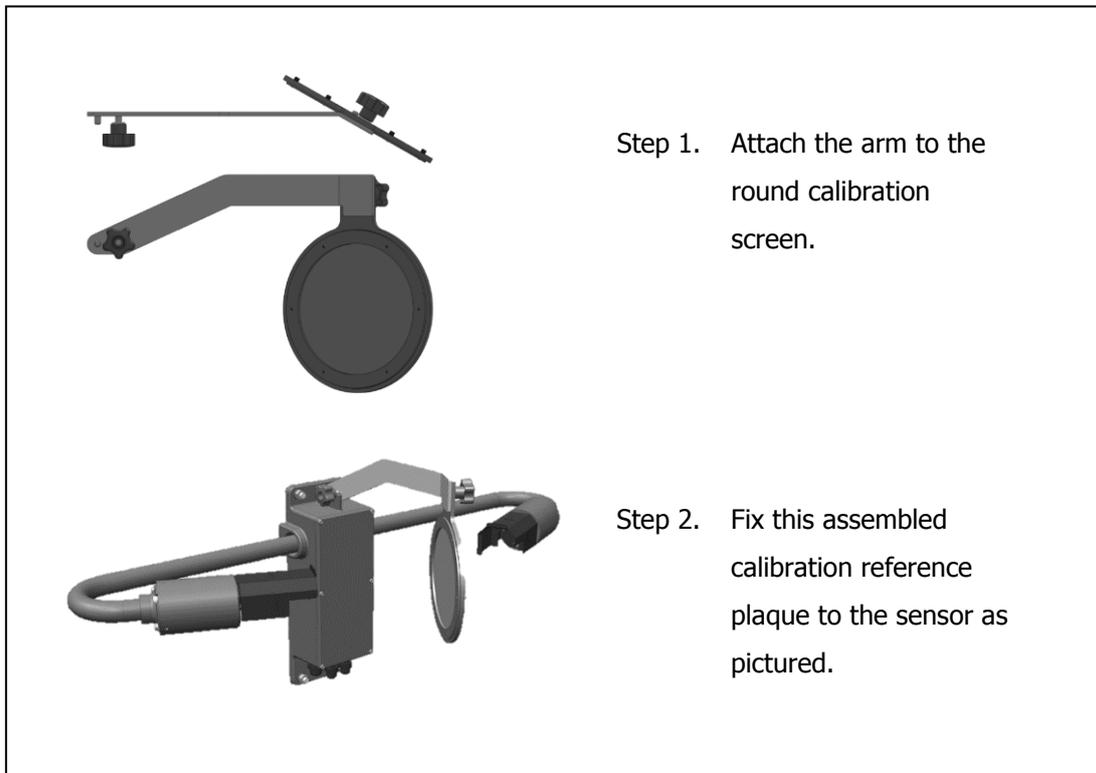
Step 1.   Attach the arm to the round calibration screen.

Step 2.   Fix this assembled calibration reference plaque to the sensor as pictured.

Figure 5-1 Assembly of Calibration Reference Plaque

Note: All commands should be terminated with <Carriage Return> and <Line Feed> <crlf>, (see Paragraph 1.3).

STEP 1: Clean all windows on the sensor using a mild detergent solution or pure alcohol (propanol) and soft cloth or tissue, preferably lens tissue. Check the cleanliness using a portable light if possible.
(Step 1 may not be necessary if checking or commissioning a new sensor)

STEP 2: Attach the calibration reference plaque to the sensor as shown in Figure 5-1 (power to the sensor need not be removed). Do not stand close to the sensor during calibration as reflections may cause errors in the reported values.

Zero Check:

STEP 3: Insert GREY FOAM PLUGS in the front of each window blocking out all light. (There are 3 foam plugs top left in the calibration case - you will only use 2 of these for the SWS-050T).

STEP 4: Send the command "RST<crlf>". Verify the response "OK".

STEP 5: If the sensor is operating in the polled mode, send the "D?" command at 60 seconds intervals. (If the sensor is set to automatically output data then the sensor will output data every 60 seconds.)

STEP 6: Wait for the fifth (5th) data message from the sensor. Send the command "BT? <crlf>". Verify that the response value is between 0.00 and 0.05.

STEP 7: Remove the foam plugs.

Gain Check:

STEP 8: Send the command "RST<crlf>" to restart the sensor.
Verify the response is "OK".

STEP 9: If the sensor is operating in the polled mode, send "D?" command at 60 seconds intervals. (If the sensor is set to automatically output data then the sensor will output data every 60 seconds.)

STEP 10: Wait for the fifth (5th) data message from the sensor. Send the command "BT? <crlf>". Verify that the response value is within ±10% of the forward scatter calibration value assigned to the Calibration Reference Plaque.

STEP 11:   Remove the calibration reference plaque from the sensor.

If the results of the calibration check have agreed with the value on the label attached to the calibration reference plaque within the limits stated above, re-calibration is NOT required.

A re-calibration is required ONLY if the MOR values are outside those on the calibration reference plaque AND the calibration check has been carried out ACCORDING TO THE CALIBRATION CHECK NOTES of page 60.

5.3 Sensor Re-Calibration

> **RE-CALIBRATING THE METEOROLOGICAL OPTICAL RANGE SHOULD ONLY BE CARRIED OUT IF THE SENSOR HAS FAILED A CORRECTLY PERFORMED USER CONFIDENCE CHECK**

> **WARNING**
> **ERRORS DURING THIS RE- CALIBRATION PROCEDURE WILL CAUSE THE SENSOR TO GIVE INCORRECT DATA**

> **BEFORE CONTINUING ENSURE THAT THE SENSOR:**
>
> 1. **IS MOUNTED OUTSIDE**
> 2. **VISIBILITY IS GREATER THAN 10KM AND NO PRECIPITATION**
> 3. **HAS BEEN IN CONTINUOUS OPERATION FOR AT LEAST 1 HOUR**
> 4. **WINDOWS ARE CLEAN**
> 5. **IS NOT LOCATED NEAR A WALL OR OTHER OBSTRUCTION**
> 6. **IS NOT RECEIVING OPTICAL REFLECTIONS (from surfaces or clothing)**

STEP 1.   Set up the sensor with the calibration reference plaque in place - see section 5.2 (power to the sensor need not be removed).

STEP 2.   Send command CO.
Sensor replies: OK.

STEP 3.   Send command: CE.
Sensor replies:
   CLEAN WINDOWS,
   BLOCK FWD SCAT RCVR OPTICS,
   BLOCK TRANSMITTER OPTICS
   INSTALL REF STD,
   ENTER FWD SCAT VALUE
   FORM: XXX.XX

STEP 4.   Fit the grey foam plugs (supplied with the calibration kit) against the windows (only two needed for the SWS-050T).

STEP 5.   Enter the forward scatter calibration value from the calibration plaque.

STEP 6.   Sensor replies:
                         CAL IN PROGRESS
                Wait for approximately 2 minutes.
                Sensor replies:
                         REMOVE OPTICS BLOCKS,
                         ENTER   "OK"

STEP 7.   Remove grey foam plugs from all windows and send text: OK.
                Sensor replies:
                         CAL CONTINUES

STEP 8.   Wait for approximately 2 minutes.
                Sensor replies:
                         CAL COMPLETE
                         REMOVE REF STD
                Note: Do not remove the calibration reference plaque at this point.

STEP 9.   Wait for the third data message to be received at the PC.

STEP 10.   Send the command BT? and note the response value.

STEP 11.   If the response to the BT? command is within ±3% of the forward scatter
                calibration value of the plaque then the sensor is within its calibration
                limits. The sensor can be returned to its operational configuration with
                confidence. If the values are outside these limits carefully repeat the
                calibration procedure. If the limits are again exceeded contact Biral.

6 PRODUCT OVERVIEW

6.1 SWS-050T Present Weather Sensor

The SWS-050T is one of 5 sensors in the SWS range of Biral products. All models have the same time-proven software for measuring visibility and precipitation type (where applicable) and performing remote self-test diagnostics.

The measurement capabilities of the model SWS-050T are as follows:

SWS-050T   Visibility
            Obstruction to Vision

            Features

            Analogue Outputs
                    Either MOR or EXCO
                    0 to 10 V
                    4 to 20 mA
            Digital Outputs
                    RS232 or
                    RS422/RS485
            Relays (option)
                    1 Relay for fault reporting
                    1 Relay for visibility
                    1 Relay for visibility or window contamination

6.1.1 Instrument Components

Each sensor in the SWS range has been engineered and manufactured with high-reliability components to provide accurate measurements under all weather conditions. Its rugged aluminium powder-coated construction is intended to serve you in the severest of environmental conditions throughout the long life of the instrument. All models are shipped fully assembled.

6.1.2 **Accessories**

Calibration Kit

The calibration kit, containing a reference standard calibration plaque in a protective carrying case, is employed only at those times that the instrument calibration is being checked, see section 5 for a full description of the calibration process.

Transit Case

A rigid re-usable transit case designed to provide full protection to the instrument for regular shipping is available.

Mains Adapter

A mains adapter is available if required.

Power, Signal and Relay Cables

These may be ordered if required. The length must be specified at time of order.

Ambient Light Sensor

The Biral ALS-2 ambient light sensor can be readily integrated with any SWS sensor. This provides an accurate measure of the prevailing apparent light intensity in any specific direction. The intensity measurement over a very wide range (< 2 up to 40,000 cd m^{-2}) is integrated into the standard sensor output data stream; see section 2.2 Data Message Variations For ALS-2.

6.2 Sensor Features

The SWS-050T sensor is a visibility sensor. It has the necessary optimum configuration for accurate measurement of visibility in the densest of fogs to very clear air conditions. It measures the Meteorological Optical Range (MOR) and the atmospheric extinction co-efficient (EXCO). Both these values are output in the digital data stream. The analogue outputs can be set to be proportional to either MOR or EXCO. The visibility relay switching points are always set in MOR units.

In addition to its optimal and unique measurement capabilities, the SWS series of sensors have a number of distinctive physical features.

Compactness:

The sensor is a single package, small in size and weight. It can be readily installed by one person and can be used in portable or fixed installations.

Proven Software:

The basic software incorporated into the sensor has evolved over a long period of time and has been tested and proven in hundreds of sensors.

Ease of Maintenance and Calibration:

Routine maintenance, including a check on calibrations, is performed in a matter of a few minutes. A re-calibration, if required takes only slightly longer and is easily performed by one person.

6.2.1 Real Time Data Displays

The output of the sensor is provided both as a serial digital message at a sample time interval selected by the operator (a typical sample time interval is one minute) and as a real time analogue output. The digital message is provided automatically, or if the sensor is in the polled mode the data message is transmitted after the polling command is sent to the sensor.

1. Each message can be time-tagged with the date and time.

2. Data processing can occur, such as the application of Allard's Law for visibility of point light sources.

3. All or selected parts of the data message can be archived.

6.2.2 Visibility Measurement Capability

The visibility measurement capabilities of the sensor are summarised in Table 6-1 Visibility Measurement Capabilities. Determination of visual range is based on measurements of the atmospheric extinction coefficient (EXCO). Note that EXCO includes the attenuating effects of both suspended particles and precipitating particles. Meteorological optical range (MOR) is determined by application of the standard relation,

$$MOR = 3.00/EXCO$$

Haze and fog are the two most common forms of obstructions to vision. In the absence of precipitation, the sensor determines the presence of haze or fog based on the MOR. If the MOR is less than 1 km, then fog (30) is indicated in the output message. If the MOR is between 1 and 10 km, then haze (04) is indicated in the

output message. If MOR is greater than 10 km, no obstruction to vision is indicated.

Function	Details
Meteorological Optical Range (MOR)	10m to 40km (Default Maximum range is 2km)
Extinction Co-efficient (EXCO)	0.075 to 300 km^{-1} (Default is 1.5 to 300 km^{-1})
Measurement Accuracy	MOR ~ 2km Better than 5% MOR ~ 10km Better than 10% MOR ~ 20km Better than 15%
Obstruction to vision	Identifies Fog or Haze.

Table 6-1 Visibility Measurement Capabilities

6.3 Sensor Specifications

The specifications for the SWS-050T sensor are summarised in the following pages.

Visibility Measurements (MOR) and Atmospheric Extinction Co-efficient

Function	Details
Meteorological Optical Range (MOR)	10m to 40km (Default Maximum range is 2km)
Extinction Co-efficient (EXCO)	0.075 to 300 km^{-1} (Default is 1.5 to 300 km^{-1})
Measures:	Visibility (MOR – Meteorological Optical Range), reductions caused by: fog, haze, smoke, sand, drizzle, rain, snow and general precipitation.
Measurement Accuracy	MOR ~ 2km Better than 5% MOR ~ 10km Better than 10% MOR ~ 20km Better than 15%
Measurement Time Constant	30 seconds

Table 6-2 Sensor Specifications

Maintenance

Function	Details
MTBF (Calculated)	52,500 hrs (6 years).
Calibration Check	6 months.
Clean Windows	3 months.
Remote Self-Test Monitoring	Included.

Table 6-3 Maintenance

6.4 Instrument Characteristics

Physical

Function	Details
Scattering Angle	45° with ± 6° cone angle
Sample Volume	400 cm^3
Weight	3.8Kg (4.3Kg including pole mounting kit)
Length	0.81 m

Table 6-4 Physical Characteristics

Light Source

Function	Details
Type	IRED
Central Wavelength	0.85μm
Bandwidth	0.04μm
Lifetime (at maximum working temperature)	>10 years
Modulation Frequency	2,000 Hz

Table 6-5 Light Source Characteristics

Detector

Function	Details
Type (Photovoltaic)	Silicon
Response	Silicon
Filter Bandwidth	$0.08\mu m$ at $0.85\mu m$

Table 6-6 Detector Characteristics

Temperature Sensor

Function	Details
Type	Circuit mounted IC
Range	-60°C to 100°C

Table 6-7 Temperature Sensor Characteristics

Power Requirements

Function	Details
Power Source Sensor (Voltage)	9V to 36V DC (24V typical)
Power Source Sensor (Power)	3.5 W
Power Source Hood Heaters (Voltage)	24V DC or AC
Power Source Hood Heater (Power)	24W
Additional Power for: No-Dew Window Heaters	1.7W (User selectable)
Additional Power for ALS-2 Option	1.2 W no window heater 2.0 W with window heater

Table 6-8 Power Requirements

Environmental

Function	Details
Sensor Operating Temperature Range	-40°C to +60°C
Altitude	0 to 20,000 ft
Precipitation	All weather
Humidity	0 to 100%
Protection Rating	IP66/7
CE Certified	√
EMC Compliant	EN61326-1 2006
RoHS and WEE Compliance	√

Table 6-9 Environmental Specifications

6.5 Digital Communication Interface

Communication Protocol

Function	Details
Interface Type	RS232C, (Full Duplex)
User Selectable	RS422/RS485

Table 6-10 Communication Standards

Communication Parameters:

Function	Details
Baud Rates (User selectable)	1200 Baud to 57K6 Baud (Default 9600 Baud)
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None
Message Termination	<CR,LF>
Message Checksum:	Selectable (sum modulo 128) for RS232/422 LRC for RS485
Reporting Interval	Programmable (Response to poll, or Automatic at programmable intervals: 10 seconds to 5 minutes; 1 minute typical)
Message Content:	• Instrument Identification Number (Programmable) • Reporting Interval • Meteorological Optical Range • Precipitation Type • Obstruction to Vision (Fog, Haze, None) • Temperature • Remote Self-Test & Monitoring Flags • Date and time tags

Table 6-11 Digital communication interface specifications

6.6 Analogue Outputs

Function	Details
Voltage	0 to 10 Volts.
Current	4 to 20 mA.

Table 6-12 Analogue output specification

6.7 Relay Outputs

Relays are a factory fitted option for the SWS-050T.

Function	Details
Fault	Normally energised. Releases on fault condition
Relay # 1	Settable for visibility range 0.10 km to 20.00 km or $MOR_{MAX.}$
Relay # 2	Settable for visibility range 0.10 km to 20.00 km MOR_{MAX} **OR** Triggered by window contamination warning
Switching Voltage (Max)	220 Vdc, 250 Vac
Switching Current (Max)	2A
Switching Power (Max)	60 W, 125 VA
Contact Type	Silver alloy with gold alloy overlay

Table 6-13 Relay specification

6.8 Sensor Remote Self-Test Capabilities

- Optical Source Power.
- Forward Scatter Receiver Sensitivity.
- Transmitter Window Contamination.
- Forward Scatter Receiver Window Contamination
- Power Supply Voltages.
- Non-Volatile Memory Checksum Test.
- EPROM Check-Sum Test.
- Restart Occurrence.
- Sensor Sample Interrupt Verification.
- RAM Read/Write Verification.
- Register Read/Write Verification.
- A/D Control Signal Test.
- A/D Conversion Accuracy Check.
- Input Voltage Check.
- Forward Scatter Background Illumination Level.

Biral

6.9 SWS-050T Sensor – external dimensions

The SWS sensor has dimensions as shown below.
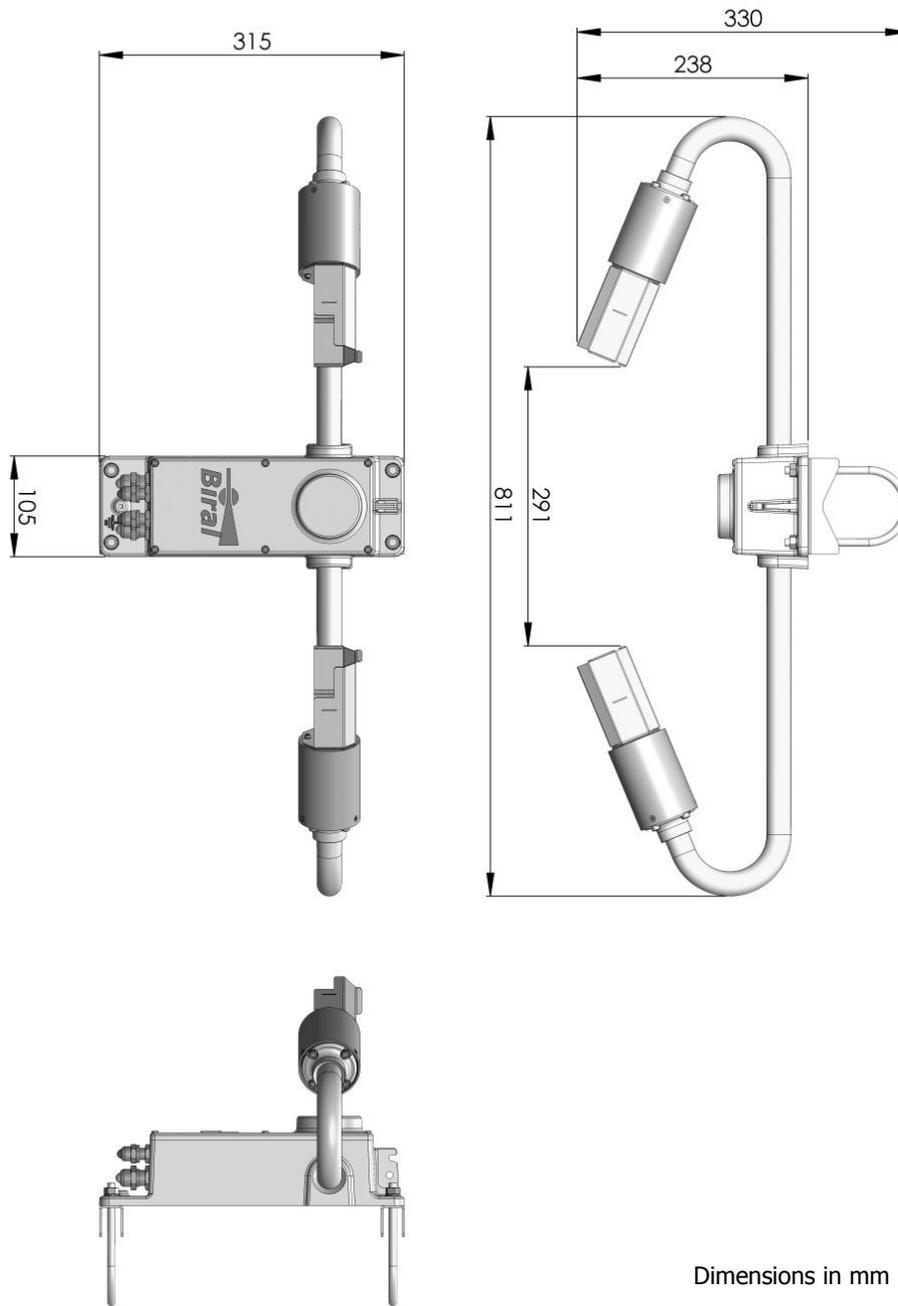
Dimensions in mm

Figure 6-1 External Dimensions of SWS-050T Sensor

7 INDEX

D

E

H

I

S

T

V

W

Notes:

Biral