OPERATION and MAINTENANCE MANUAL

SWS Present Weather Sensors

SWS-050T

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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)
  1 Fault relay switch
  1 Relay for visibility
  1 Relay for visibility or window contamination

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Thank you for choosing Biral as your supplier of present weather sensors

A great deal of time has been invested at Biral to offer the best combination of sensor performance and value and almost three decades of experience and knowledge have been incorporated into the SWS series. We are confident that they 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 outputs.

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

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.

(NB 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 :	service@biral.com

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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, page 39)

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.

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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® Hyper Terminal™. The Biral Sensor Interface Software is available by contacting Biral at: Info@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

Other optional components you may have ordered

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, Signal and Relay Cables

Power, signal (data) and relay 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. See paragraph 2.2.

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, data or relay 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: If mains power is being switched, it is essential to provide a protective earth conductor in the relay cable to comply with all national and international safely regulations.

1.2.2   Cable Glands

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

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2 small cable glands for cables between 3.5 to 7.0mm diameter

2 larger glands for cables between 4.5 to 10mm diameter
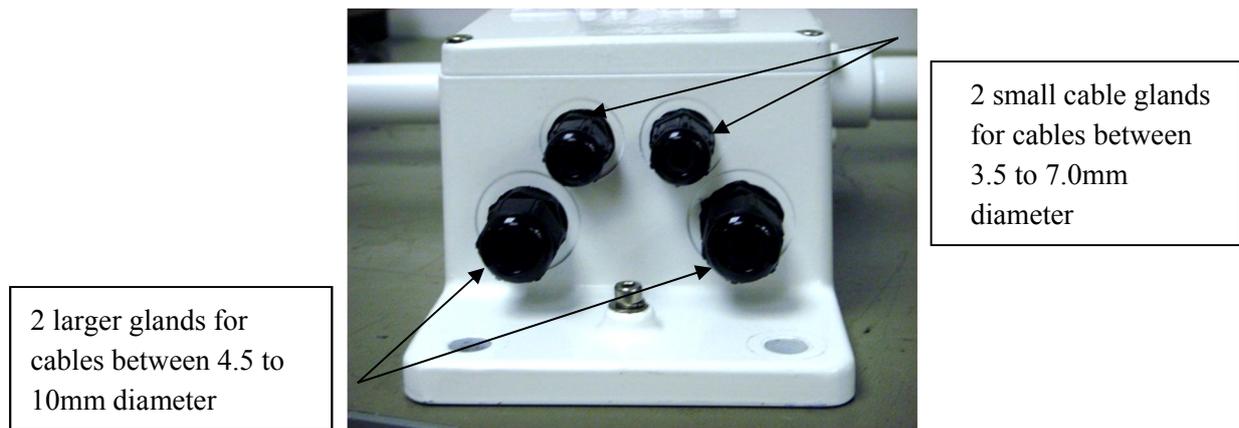
Figure 1-2 Cable Glands

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 7.0mm 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. See Figure 1-3.

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.

Connecting the power supply:

All SWS sensors require 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.

J11
Connect the power cable here

J12
Connect the signal cable here

A   F A   L
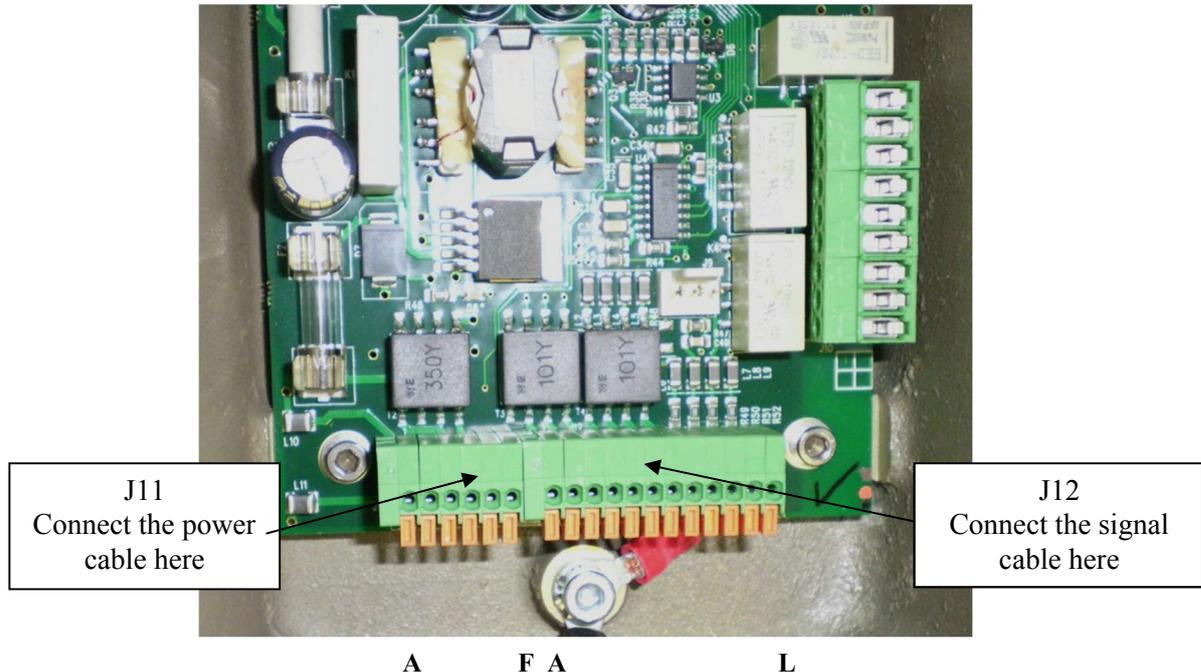
Figure 1-3 Power and signal connections

See Figure 1-3 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 may be used if required. They are wired independently and isolated from the instrument power. These should be powered from a 24V supply of either AC or DC. The 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-

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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 24VAC or DC
J11/B	Hood Heater Return24VAC or DC
J11/C	Power +9 to +36V Supply
J11/D	Power 0V Supply
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 either RS232 OR RS422 OR RS485 communications. It is not possible to operate both the RS232 and the RS422/RS485 together. If there is to be a long distance between the sensor and its control computer (more than 40 metres), then the RS422 or RS485 configuration should be used and a RS422 communications port installed in the control computer. RS232 may be useable at low baud rates up to 100 m but reliable communications cannot be guaranteed for more than 40 m. See Table 1-2 and Table 1-3 for full connection details.

Pin Number	Designation
J12/A	RS232/422 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.

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Location of J7

■ ■ ■

1 2 3

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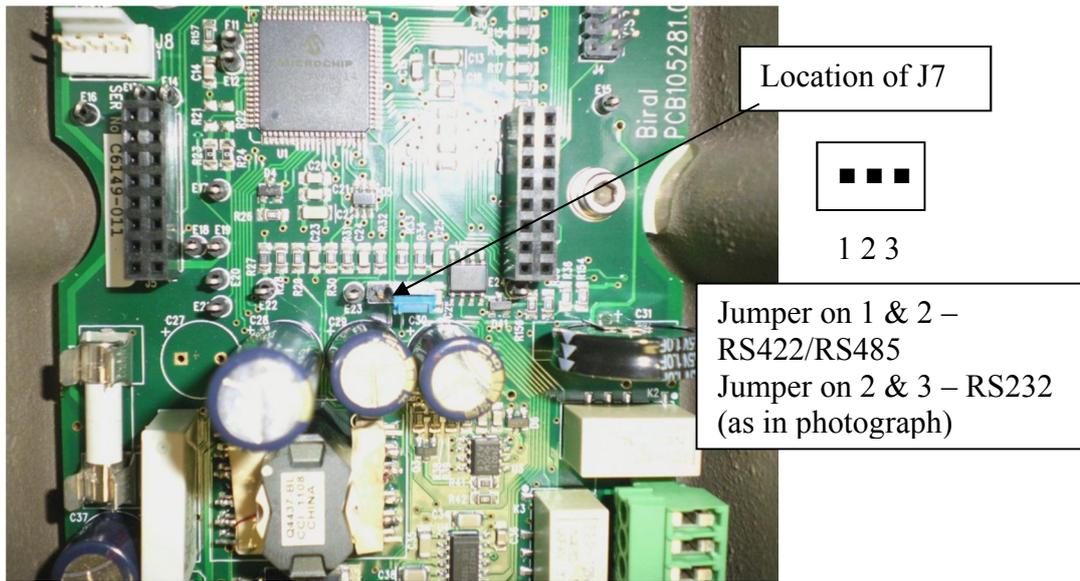
Figure 1-4 Location of J7, RS232/422/485 select

1.2.4 Connecting the relays (option)

The SWS-050T provides the ability to switch equipment using two visibility (fog) relays
set at two different visibility ranges. Alternatively, the second 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.

RL2 NC
RL2 COM
RL2 NO
RL1 NC
RL1 COM
RL1 NO
FAULT NC
FAULT COM
FAULT NO
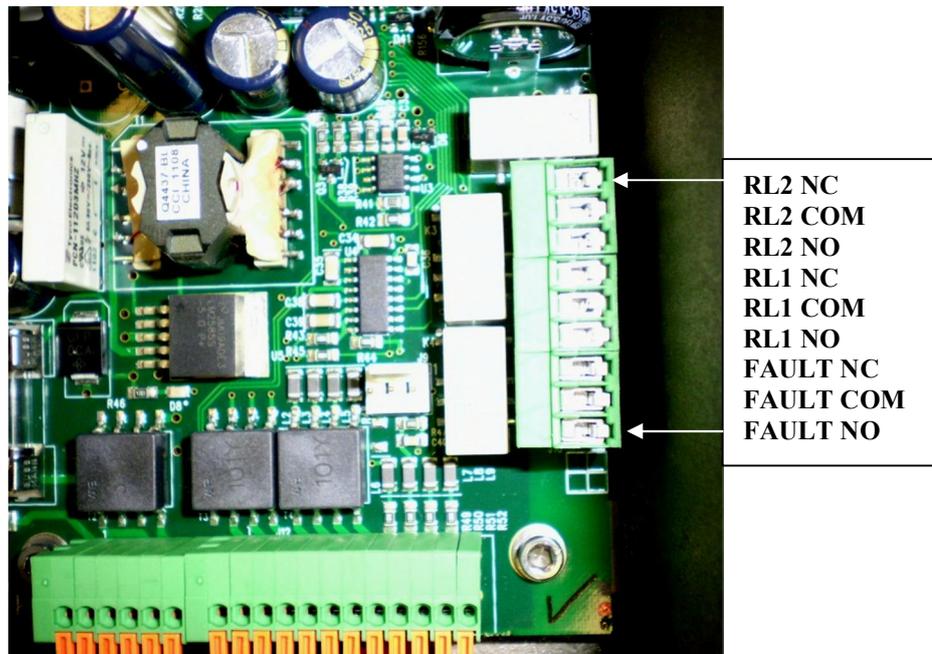
Figure 1-5 Relay connections. Relay contacts are rated 2A, 250V AC.

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

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

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 mm^2), 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.

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

An analogue output representing either Meteorological Optical Range (MOR) or Extinction Co-efficient (EXCO), is standard on the SWS-050T sensor. This analogue output is available as both a 0 to 10Volt and a 4 to 20 mA signal. The connections are as follows, Table 1-4.

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

When the output is set for MOR, 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 2Km. The readings between these two extremes are proportional to the MOR value.

When the 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, equivalent to an MOR of 10m. The readings between these two extremes are proportional to the EXCO value. The minimum EXCO reading will be the EXCO value for the maximum MOR set

for that instrument. As an example, the default maximum MOR is 2Km, or an EXCO of 1.5. For the 0 to 10V output, an EXCO of 300 is represented by 10V output, so an EXCO of 1.5 is represented by an output of (10/300)*1.5 V = 17mV. The analogue voltage output will never go below 17mV, as this is the EXCO minimum set point for the default MOR range of 2Km.

The analogue voltage output should be monitored using a high impedance circuit. Monitor impedance values below about 10KΩ may introduce errors in the reading.

The analogue current output is sourced from the sensor. It is derived from a 10 V digital to analogue output and is not isolated. It should be terminated with a resistance not greater than 500 Ω to enable the maximum current of 20 mA to be available.

1.2.6 EMC Compliance

In order 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 ALS-2 connecting system.
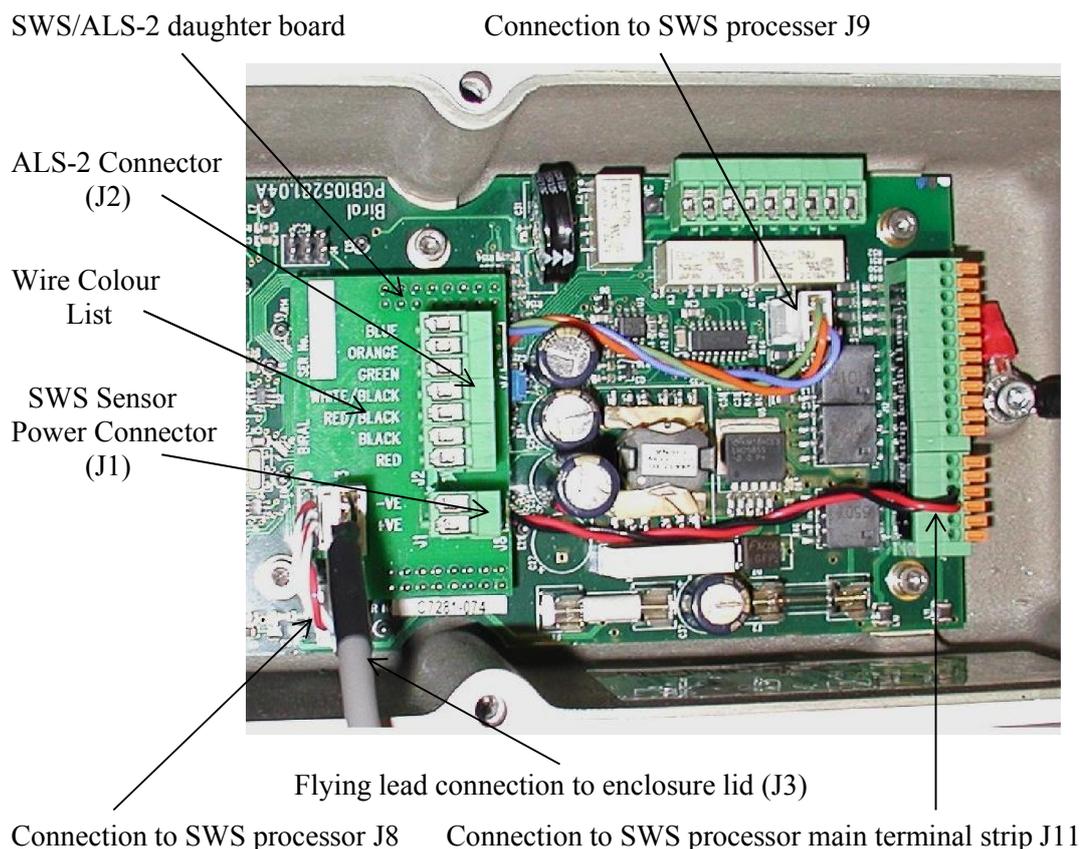
Figure 1-6 ALS-2 connecting system

The SWS sensor power supply is now connected to J1 on this 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 applicable digital signal pins to a PC running the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® Hyper Terminal™. (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 Hyper Terminal as follows:

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<u>**Default Interface Parameters**</u>

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

(If using Hyper Terminal 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 5.1, page 47 to ensure that the MOR value changes ie the sensor responds to changes in visibility.

NOTE: as 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 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 reading should be approximately 10V. If the instrument is set to output EXCO, the reading should be approximately zero. 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 (current) reading for MOR should drop. If the output is set to register EXCO, the reading 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.

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. For a quick check of relay operation, it is assumed that the relays are set to switch on visibility threshold.

3. Connect the relay signal cable to a multimeter, set to read ohms, or continuity. Connect between the connections **RL1 NO** and **RL1 COM**. See Figure 1-5, Section 1.2.4. Switch on the power source.

4. 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

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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.

5. 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

Two configuration bytes determine many of the configuration selections which are available for the SWS-050T sensor. These two bytes are the lower byte of the **Options Word** and the lower byte of the **Operating State Word**. These are described below and their functions specified in the remainder of this section.

For both these bytes, the value is entered as a binary number (1's and 0's). Leading 0's in the value need not be entered. The value is stored in non-volatile memory and the operating configuration when power is applied is that set by the last entered options word and operating state word.

1.4.1   Options Word

The binary value of this word can be determined by sending the 'OP?' command. The response 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'.

Each bit of the lower byte of the Options Word is defined as follows, in Table 1-5 Options Word (lower byte).

To set this word, send command CO to enable changes and then command OPx0x0000x to set the Option Word as required (where x is '0' or '1'). For example, send OP100000 to enable the checksum with no date and time stamp and not using RS485 (leading '0's are not necessary in this command).

Bit 1 (Date and Time enable), Bit 6 (Check Sum enable) and Bit 8 (RS485 enable) are the only bits which may be set to '1' by the user. All other bits MUST be left at '0' for correct sensor operation.

The Default setting = 00000000

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:   Not used.

Bit 4:   Not used.

Bit 5:   Not used.

Bit 6:   1 = Add a check sum character to all sensor output messages.

0 = Don't add check sum character to all sensor output messages.

Bit 7:   0 = Adjust MOR values in data messages for measured

transmitter window contamination.

This bit should not be changed.

Bit 8:   1 = Use RS485 addressable Communications protocol

0 = Do not use RS485 addressable Communications protocol

.

Table 1-5 Options Word (lower byte)

1.4.2 **Operating State Word.**

The binary value of this word can be determined by sending the 'OS?' command.
The response 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'.

Each bit of the lower byte of the Operating State word is defined as follows, in Table 1-6
Operating State Word (lower byte)

To set this word, send command OSxx00x0xx to set the Operating State Word as required
(where x is '0' or '1'), see Table 1-6 Operating State Word (lower byte). For example,
send OS11000000 to set the window heaters to permanently off and operating in polled
mode.

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b b b b b b b

Bit 1: 1 = Standard Mode: Data message sent automatically after calculation.

0 = Polled Mode: Data message sent only in response to "D?'" command.

Bit 2: 1 = Calculate values and determine data message in response to "D?" command, ignoring measurement interval timing (Bits 1 and 3 must be "0").

0 = Values calculated and data message determined after each measurement interval.

Bit 3: Reserved.

Bit 4: 0 = Hood Heaters enabled (heaters will turn on if the temperature is less than 4°C then off when the temperature exceeds 7°C)

1 = Hood Heaters always off.

Bit 5: Reserved.

Bit 6: Reserved.

Bits 7 and 8: Window Heater Control (demisters).

00 = Window demisters always on.

01 = Window demisters controlled by window contamination. If any window's attenuation increases, caused by contamination or condensation, to more than the percentage specified by WT command (see section 3.1), the heaters will turn on for 300 seconds or until the attenuation is reduced to 4/5 of the turn-on threshold.
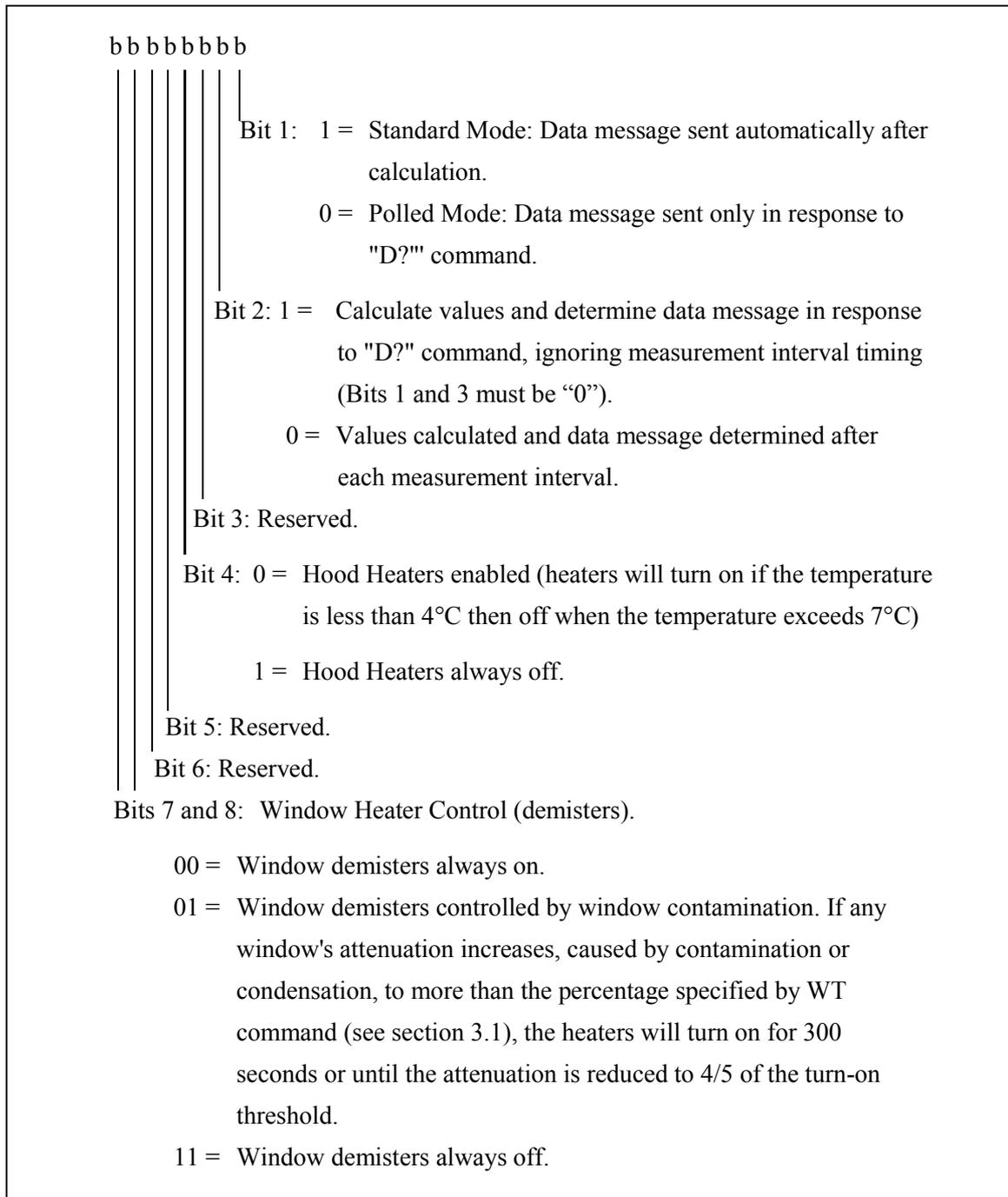
11 = Window demisters always off.

Table 1-6 Operating State Word (lower byte)

Bit 1 (standard/polled data message), Bit 2 (data message timing), bit 4 (hood heater control) and Bits 7 and 8 (window heater modes) are the only bits which may be set to '1' by the user. All other bits MUST be left at '0' for correct sensor operation.

Default setting = 00000001.

1.4.3 Changing the Sensor Default Settings

The default setting for the lower byte of the Options Word is '00000000' and the default setting for the lower byte of the Operating State word is '00000001'. The following paragraphs detail the changes to these defaults which can be undertaken by the user, together with instructions for achieving the required sensor configuration.

PLEASE BE EXTREMELY CAREFUL IN SETTING THE CORRECT BITS IN THE FOLLOWING INSTRUCTIONS AS SETTING THE WRONG BIT WILL RESULT IN THE SENSOR FUNCTIONING INCORRECTLY

Default setting for units running in timed output mode
Any combination of operating bits may be set but **Biral strongly recommends** that for all sensors the **window demisters are always on** (bits 7 and 8 set to 0).

The default setting is OS00000001 which is:
- window demisters always on.
- hood heaters enabled.
- values calculated and data message sent automatically after each measurement interval.

(To set this operating state, send the command: OS1).

Default setting for all sensors running in polled mode
Any combination of operating bits may be set but **Biral strongly recommends** that for all sensors the **window demisters are always on** (bits 7 and 8 set to 0).

The polled mode default setting is OS00000010 which is:
- Window demisters always on.
- Hood heaters enabled.
- Values calculated and data message determined in response to D? command .

(To set this operating state, send the command: OS10).

1.4.4 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:

Step 1 - Send the command: CO.

Step 2 - Send the command: OP1.

(Note: to enable checksum and time/date-stamp send OP100001).

To check the setting of the options word, send the command: OP?

The sensor should respond: 00000000,00000001.

> **PLEASE BE EXTREMELY CAREFUL IN SETTING THE CORRECT BIT IN STEP 2 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 OP0 in step 2 above.

To read the current Date and Time

Send the command TR?

The sensor will respond with the date / time message e.g.:

FRIDAY   ,23\03\12,13:15:25,000

NOTE: the final ,000 is a time calibration figure, set during sensor final test.

To set the current Date and Time

There are two commands required to set the current date and time:

%SD sets the real time clock date.

The format of the command is: %SDWDDMMYY

> where:
> W   - is the day of the week (1..7) with Sunday being 7.
> 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 real time clock time.

The format of the command is: %STHHMMSS

where:

HH   - is the hours in 24 hour clock format (00..23).

MM   - is the minutes(00..59).

SS   - is the seconds (00..59).

The sensor will respond with 'OK'.

1.4.5 Baud Rate Configuration

Default communication parameters are 9600 Baud, 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.

Table 1-7 Baud-Rate Configuration

1.4.6 Checksum to verify message

A check sum 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

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and checksum verification is not required. This is controlled by the Options Word setting; see Table 1-5 Options Word (lower byte).

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

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

To enable checksum

The sensor can be configured to generate messages with a check sum byte by setting the sixth bit in the options word:

Step 1 - Send the command: CO.

Step 2 - Send the command: OP100000.

(Note: to enable checksum and time/date-stamp send OP100001).

PLEASE BE EXTREMELY CAREFUL IN SETTING THE CORRECT BIT IN STEP 2 AS SETTING THE WRONG BIT WILL RESULT IN THE SENSOR FUNCTIONING INCORRECTLY

To check the setting of the options word, send the command: OP?

The sensor should respond: **00000000,00100000M**.

(Note: M is the checksum character).

To disable checksum

To disable the checksum send the command OP0 in step 2 above.

The check sum is positioned after the message and before the end characters (<crlf>). The check sum 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 check sum 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 Message:

C1 ... Cm <cksum><crlf>

The calculation is as follows:

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

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

1.4.7 Communications Parameters

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.

1.4.8 RS485 Configuration for addressable sensors

The SWS sensor can be set to use addressable RS485 communication protocols. In addition to the hardware connections as above, the sensor software needs to be configured to use this protocol.

By default the sensor is configured at the factory with RS485 communications DISABLED unless specifically requested when ordering.

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

Start:	':' (3A Hex).
Station Address:	2 Character address field.
Data:	As standard SW message format.
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.

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Station Address

The 2 character address is defined by the operator for the unit and programmed as specified in the set-up instructions. It can be any numeric value between 00 and 99. It is used by the unit to define the recipient of the message and by the slave to define the source of the message.

Data

This is a variable length ASCII character string as defined in section 2. The control computer has a defined range of commands available for the SWS sensor and the SWS sensor has a range of defined data messages, see section 3, Commands and Responses. These messages can either be sent as a response to a request for data by the control, or sent without any request on a timed basis, according to the instrument user settable configuration. It is strongly 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 control 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 standard SWS 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.

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, for the message:

:42D?

the checksum is calculated as :

ASCII string 42D?

BYTE Values (in HEX) 34+32+44+3F

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Checksum 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 – line feed (CRLF) pair (ASCII values of 0D & 0A hex).

1.4.9 Sensor Addressing

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

Enabling the addressable RS485 Communications

The sensor can be configured to use addressable RS485 communications by setting the eighth bit in the options word:

Step 1 - Send the command: CO.

Step 2 - Send the instruction: OP10000000.

(Note: to enable RS485 and time/date-stamp send OP10000001).

PLEASE BE EXTREMELY CAREFUL IN SETTING THE CORRECT BIT IN STEP 2
AS SETTING THE WRONG BIT WILL RESULT IN THE SENSOR FUNCTIONING
INCORRECTLY

To check the setting of the options word send the command: :00OP?FF.

The sensor should respond: :0000000000,1000000073.

(NB. :00 is the address and 73 is the LRC checksum character).

To disable RS485 Communications

To disable the RS485 communications send the instruction OP0 in step 2 above (or OP1 to enable time/date-stamp).

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. When transmitting to the sensor all commands must be prefixed by :XX (where XX is the address) and have the 2 character checksum on the end. If the checksum characters are 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.

For 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 (see section 1.4.3, Changing the Sensor Default Settings) rather than transmitting a data message automatically.

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

1.4.10 **Configuring the Relay Functions**

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 high window contamination.

Table 1-8 Relay configuration

The default value is set to 2 when the relay option has been selected.

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.

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.

   e.g.   1.00 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.

   e.g. to set the threshold for relay 1 to 0.5km send the command: RL1,0.50.

   NOTE: The visibility relay settings are always determined as MOR values.

1.4.11 **Relay Function Description**

To ensure that the relays will only switch on and off once stable visibility conditions have been achieved, a delay has been incorporated into the relay ON and the relay OFF operation. This delay is set to 5 minutes for both switching to ON and switching to OFF. For example, the visibility must remain below the turn on threshold for a period of 5 minutes before the relay is switched on.

To avoid continual switching of the relay if the visibility remains close to the set threshold, a hysteresis is implemented between the turn on value and the turn off value. This hysteresis value is set to20%. For example, the visibility relay will turn on when the visibility drops below the set threshold, e.g.1km, but it will only turn off when the visibility rises to {set point + 20%}, which for this case would be 1.2km.

1.4.12 **Configuring the visibility output mode**

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

Note: Full details of the analogue output scaling is provided in Section 1.2.5, page 8.

To get the current output mode send the command **AN?**

The sensor will respond with a number as follows:

- 0 = MOR (default)

OR

- 1 = EXCO

To set the current 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..

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}. This maximum range can be set 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 causes of 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.

1.5.2   Height Above Ground:

The optimum height at which to mount the sensor depends on the application. The table below (Table 1-9 Sensor height above ground) shows recommended heights.

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Application	Typical height	Comment
Highway fog-warning systems	1.5 to 2 meters (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 meters (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 meters (6 feet)	This is a suitable height unless the particular application dictates otherwise.

Table 1-9 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 lens.

It is desirable to avoid sunlight from flooding the receiver optics.

The recommended orientation is shown in the following diagram, Figure 1-7 SWS-050T Orientation.

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

For sensors located in the Southern hemisphere, 180˚ should be added to the above directions. That is, point the forward scatter receiver directly due South.
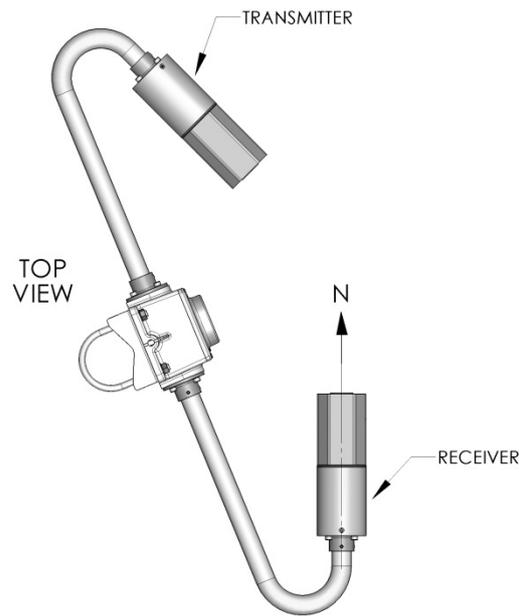
Figure 1-7 SWS-050T Orientation

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.

Note: pipe sizes often refer to their inside diameter; some 60 mm (ID) pipe may be too large for the U-bolts to fit around.

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 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.
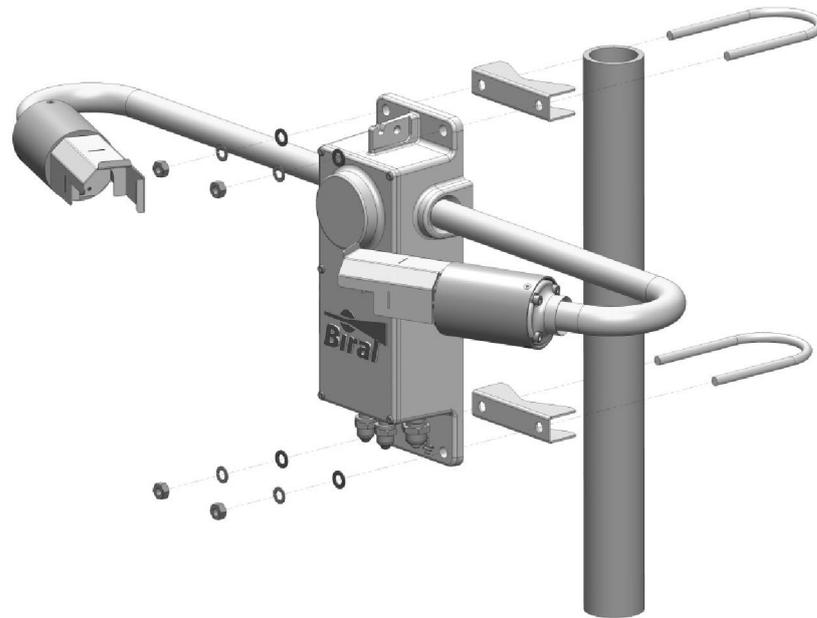
Figure 1-8 U-Bolt Mounting Method

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 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

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

(1) Ground Rod: An eight-foot 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 Data link

Use of the digital data link is the most direct route to determining the correct operational state of the instrument.

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® Hyper Terminal™. 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**

Check that the values in the Remote Self-Test & Monitoring Message from the previous 'Data Transmission to Sensor' check are within the ranges indicated below in Table 1-10 Remote Self-test and Monitoring check fields (response to R? command).

Field 1:	Space	Message starts with a space.
Field 2:	100 or 108	Heater state and error flags.
Field 3:	2.450 - 2.550	Internal Reference voltage.
Field 4:	9.00 - 36.00	Supply Voltage.
Field 5:	10.8 -13.2	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	10.8 -13.2	Internal operating voltage.
Field 8:	*00.00*	*Not applicable in this check.*
Field 9:	*00.00*	*Not applicable in this check.*
Field 10:	85 - 105	Transmitter power monitor.
Field 11:	80 - 120	Receiver monitor.
Field 12:	100	Not applicable to this sensor.
Field 13:	00 - 99	Transmitter Window Contamination.
Field 14:	00 - 99	Receiver Window Contamination.
Field 15:	00	Not applicable to this sensor.
Field 16:	000.0	Temperature °C.
Field 17	3300-4200	ADC Interrupts per second.

Table 1-10 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, page 47 to ensure that the MOR value changes i.e. the sensor responds to changes in visibility.

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

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**

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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 determined by Bit 1 of the Operating State Word. The standard mode (default) is used when Bit 1 is set to "1". If set to "0", the polled mode will be selected. Instructions for setting this bit are provided in paragraph 1.4.2 page 15.

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

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>

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
SWS050	SWS-050T 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.
BB	Obstruction to vision code. From WMO table 4680: 00 No significant weather observed, or sensor starting. 04 Haze or Smoke. 30 Fog. XX Initial value, or Error.
CCC.CC	Total Forward Scatter EXCO value.
DDD	Self-test and Monitoring (see section 4.2): 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. 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

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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 check sum<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 (see section 4.2). O = Other self-test values OK X = Other self-test fault exists O = Window not contaminated X = Window contaminated – cleaning recommended/required F = Window contaminated – fault 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

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).

Command	Function	Response
ADR?	Send the RS485 sensor address. RS485 comms. configuration only. **See section 1.4.8**.	**xx**
ADRxx	Set the RS485 sensor address. RS485 comms. configuration only. **See section 1.4.8**.	**OK**
AN?	Send the current selected visibility type for the analogue output. **See section 1.4.12**	**x**
ANx	Set the current selected visibility type for the analogue output. **See section 1.4.12**	**OK**
BT?	Send instantaneous value of Total EXCO.	**±XXX.XX**
CE	Perform Calibration (Calibration must be enabled).	**See section 5,** (page 47)
CO	Enable calibration.	**OK**
CX	Disable calibration.	**OK**
D?	Send latest data message.	**See Section 2, (**page 34)
DHO	Turns hood heaters ON (if off), for 5 minutes	**OK**
DHX	Turns hood heaters OFF (if on) for 5 minutes	**OK**
IDx	Set instrument identification number displayed in Data Message. Range x = 1 to 999. (Default = 1). *Note: if enter value > 999 only first 3 digits will be used.*	**OK**
JRO?	Check Current Relay Configuration..	**X, See section 1.4.10 (**page 24)
JROx	Set Current Relay Configuration. **See section 1.4.10**	**OK**
OP?	Check Option Word configuration.	**See section 1.4.1** (page 14)
OPXXXXXXXX	Set Option Word configuration. See **section 1.4.1.**	**OK**
OS?	Check Operating State Word configuration.	**See section 1.4.2 (**page 15)

Command	Function	Response
OSXXXXXXXX	Set Operating State Word configuration. See **section 1.4.2.**	**OK**
PV?	Send program version message.	**SIxxxxxx.yyy**
R?	Send Remote Self-Test and Monitoring Message.	**See section 3.1.1** (page 39)
RLn?	Check 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**
RST	Restart instrument.	**OK**
SN?	Send instrument serial number.	**Jxxxx.xx**
T?	Send Instrument Times Message.	**See section 3.1.2** (page 40)
TAx	Set auxiliary measurement sample period. Range x= 2-20 (seconds). (Default = 5).	**OK**
TMx	Set measurement interval. Range x = 10-300 (seconds). (Default= 60).	**OK**
TR?	Send current date and time.	**See section 1.4.4** (page 17)
WT?	Send current window contamination threshold for warning indication.	**XX**
WTxx	Set window contamination threshold for warning indication, % transmission. Range: 0 to 40 (%) (Calibration must be enabled). (Default = 10).	**OK**
%Bx	Set Current Baud Rate. Range 1-7.	**See section 1.4.5** (page 19)
%SDWDDMMYY	Set current date.	**See section 1.4.4** (page 17)
%STHHMMSS	Set current time.	**See section 1.4.4** (page 17)

Table 3-1 Commands for SWS-050T sensors

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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 1: **Space**   The message starts with a space.
Field 2: **ABC**   Heater state and error flags.

        A = 1 - Window heaters ON.
        A = 2 - Not used.
        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 - Register error.
        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: 11.5 - 14.0   Internal operating voltage.
Field 6: 4.5 - 5.5   Internal operating voltage.
Field 7: 11.5 - 14.0   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   Receiver monitor.
Field 12: 100   Not Used
Field 13: 00 - 99   Transmitter Window contamination.
Field 14: 00 - 99   Receiver window contamination.
Field 15: 00   Not Used
Field 16:   Temperature $^{\circ}$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.

Table 3-3 Command T? Response

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 3-4 Sensor Responses

4 MAINTENANCE PROCEDURES

The SWS series of sensors require 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.

4.1 General Checks

A general check of the physical condition of the sensor should be carried out at regular intervals. Particular 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).

Paragraph 4.2, Self-Test Codes, describes the meaning of the self-test codes provided in all the standard data messages. It specifies what actions, if any, are required to restore the sensor to full operational capability.

4.1.1 De-mister Heaters (fitted as standard to all sensors)

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 1.4.2 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 5 and 10°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 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.
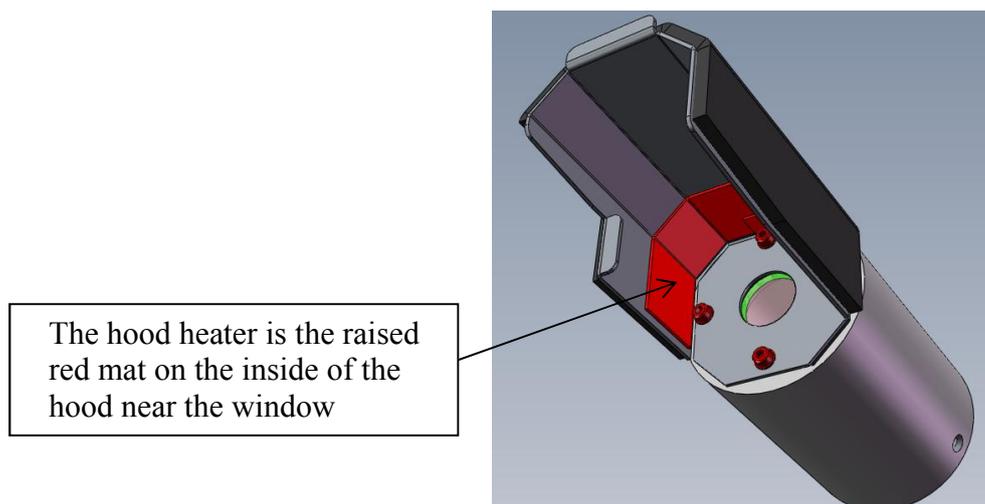
The hood heater is the raised red mat on the inside of the hood near the window

Figure 4-1 Hood Heater

When the temperature is above the switching temperature 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® Hyper Terminal™. 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 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 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 a pre-set limit of 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 use, 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. The extent of this information depends on the sensor configuration specified at time of purchase. 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 any other problem which may have occurred previously.

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 also checks both the contamination figures against a value of either 10% (default value) or 30%. 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":	Both window contamination values are less than 10% (Default value; can be adjusted by the user, see command WTxx, paragraph 3.1). No action required.
"X":	Window contamination warning. One (or both) of the window contamination values is above 10% and both values are below 30% contamination. The visibility reading provided is corrected utilising the contamination figures, but it is recommended that the windows are cleaned at the earliest possible opportunity.
"F":	Window contamination fault. The value of either window contamination is above 30%. Although the visibility reading is still corrected using these contamination figures, 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

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> *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 3.1.10 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 Hyper Terminal.**

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, page 47 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**

SWS-050T sensors monitor the transmitter and receiver windows 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:

<u>Transmitter Window Monitor</u>

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).
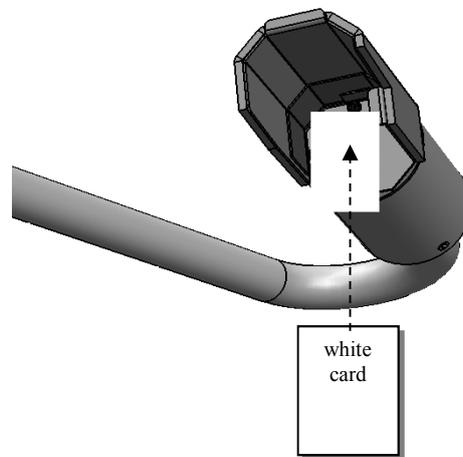
white card

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 (e.g. 99).

Step 7.   Remove the white card.

<u>Receiver Window Monitor</u>

This procedure is used for the forward scatter receiver on the SWS-050T. Carry out the following procedure for the receiver 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. The following procedure will check this function for the forward scatter receiver on all SWS sensors.

Step 1. Insert a grey foam plug ('Zero Plug', 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 plug from the Sensor Head receiver hood.

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 with a LED torch.

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.

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

The calibration of the forward scatter channel is checked using the procedure detailed below (section 5.1).

The Calibration Reference Plaque used for the calibration check has been assigned a forward scatter calibration value. This value is 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 page 48.

5.1   Calibration Check

The following instructions show how to check the calibration of a SWS-050T 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 ® Hyper Terminal™) 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.   **REGISTERING THE MAXIMUM MOR VALUE (DEFAULT 2KM), PREFERABLY WITH THE VISIBILITY>10KM.**

2.   **POWERED FOR AT LEAST 1 HOUR**

3.   **NOT LOCATED NEAR A WALL OR OTHER OBSTRUCTION**

4.   **NOT RECEIVING OPTICAL REFLECTIONS (FROM SURFACES OR CLOTHING)**

ASSEMBLING THE CALIBRATION REFERENCE PLAQUE
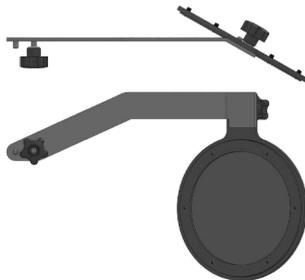
Step 1.   Attach the arm to the round calibration screen.
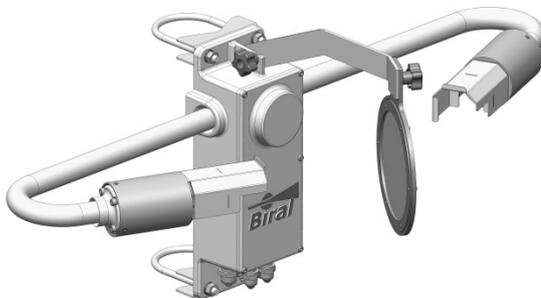
Step 2.   Fix this assembled calibration reference plaque to the sensor as pictured to the left.

Figure 5-1 Assembly of calibration reference plaque
(Assembled to a SWS-050T Sensor)

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

STEP 1:   Clean both windows on the sensor using 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 on page 48.

5.2 Sensor Re-calibration

RE-CALIBRATING THE METEOROLOGICAL OPTICAL RANGE

SHOULD <u>ONLY</u> BE CARRIED OUT IF THE SENSOR HAS FAILED A

CORRECTLY PERFORMED USER CONFIDENCE CHECK

<u>WARNING</u>

ERRORS DURING THIS RE- CALIBRATION PROCEDURE WILL CAUSE THE

SENSOR TO GIVE INCORRECT DATA

> **BEFORE CONTINUING ENSURE THAT THE SENSOR:**
>
> 1. **REGISTERING THE MAXIMUM MOR VALUE (DEFAULT 2KM),**
>
>   **PREFERABLY WITH THE VISIBILITY>10KM.**
>
> 2. **HAS BEEN IN CONTINUOUS OPERATION FOR AT LEAST 1 HOUR.**
>
> 3. **WINDOWS ARE CLEAN**
>
> 4. **IS NOT LOCATED NEAR A WALL OR OTHER OBSTRUCTION**
>
> 5. **IS NOT RECEIVING OPTICAL REFLECTIONS (from surfaces or clothing)**

STEP 1. Set up the sensor with the calibration reference plaque in place - see section 5.1 (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 both of the windows.

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 both windows and send text: OK.

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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, the sensor can be returned to its operational
configuration with confidence.

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 Fault relay switch
                            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 page 47 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 SWS050T 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.

A printer can be used to record the data message. However, a PC terminal offers much more flexibility:

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. 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.

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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

Stability of MOR Zero Setting

Function	Details
Ambient Temperature Effects	≤ 0.02/km
Long Term Drift	≤ 0.02/km

Maintenance

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

Table 6-2 Sensor Specifications

6.4 Instrument Characteristics

Physical

Function	Details
Scattering Angle	45° with ± 6° cone angle
Sample Volume	400 cm^3
Weight SWS-050 and SWS-100	3.3Kg
Length	0.81 m

Light Source

Function	Details
Type	IRED
Central Wavelength	0.85μm
Bandwidth	0.04μm
Lifetime (at maximum working temperature)	>10 years
Modulation Frequency	2000 Hz

Detector

Function	Details
Type (Photovoltaic)	Silicon
Response	Silicon
Filter Bandwidth	0.08μm at 0.85μm

Temperature Sensor

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

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

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	EN61326-1997,1998.2001
RoHS and WEE Compliance	√

Table 6-3 Instrument Characteristics

6.5 Digital Communication Interface

Communication Protocol

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

Communication Parameters:

Function	Details
Baud Rates	1200 Baud to 57K6 Baud
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None
Message Termination	<CR,LF>
Message Check Sum:	Selectable (sum modulo 128) for RS232/422 LRC for RS485
Reporting Interval	Programmable (Response to poll, or Automatic at programmable intervals: e.g., 30 seconds to several minutes; 1 minute typical)
Message Content:	• Instrument Identification Number (Programmable) • Reporting Interval (seconds) • Meteorological Optical Range (Kilometres) • Obstruction to Vision (Fog, Haze, None) • EXCO • Remote Self-Test & Monitoring Flags • Date and time tags

Table 6-4 Digital Communication Interface Specifications

6.6   Analog Outputs

Function	Details
Voltage	0 to 10 Volts out. Equivalent to 0 to $MOR_{MAX.}$
Current	4 to 20 mA. Equivalent to 0 to MOR_{MAX}

Table 6-5 Analog Output Specification (MOR)

Function	Details
Voltage	0 to 10 Volts out. Equivalent to 0 to $EXCO_{MAX.}$ $(300km^{-1})$
Current	4 to 20 mA. Equivalent to 0 to $EXCO_{MAX}$ $(300km^{-1})$

Table 6-6 Analog Output Specification (EXCO)

Note: Full details of the analogue output scaling is provided in Section 1.2.5, page 8.

6.7   Relay Outputs

Each relay has a Common terminal and NC and NO terminals.

Function	Details
Fault	Normally energised. Releases on fault condition
Relay # 1	Settable for visibility range 0.02 km to $MOR_{MAX.}$
Relay # 2	Settable for visibility range 0.02 km to MOR_{MAX} **OR** Triggered by window contamination exceeding Warning Threshold
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 6-7 Relay Specification

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6.8   Sensor Remote Self-Test Capabilities

- Optical Source Power.
- Receiver Sensitivity.
- Transmitter Window Contamination.
- Receiver Window Contamination.
- Power Supply Voltages.
- Non-Volatile Memory Check Sum 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.
- Background Illumination Level.

6.9   SWS-050T Sensor – external dimensions

The dimensions of the SWS-050T are shown below,
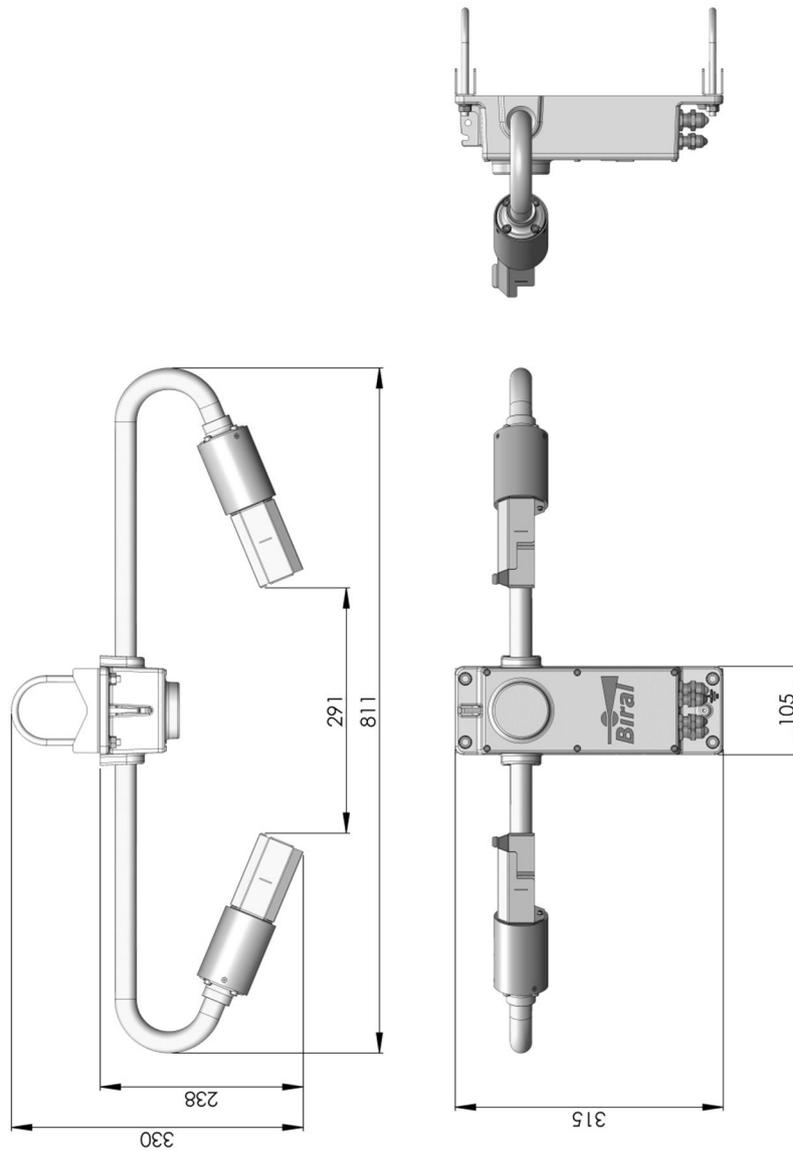
Figure 6-1 External Dimensions of SWS-050T sensor (Dimensions in mm)

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R

S

T

V

W

Notes:

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