Biral
Visibly Better

USER MANUAL
INSTALLATION - OPERATION - MAINTENANCE

SWS-050
SWS-100
SWS-200
SWS-250

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General Information

The sensors covered in this manual:

Sensor Model	Capability
SWS-050	Visibility Obstruction to Vision

Sensor Model	Capability
SWS-100	Visibility Precipitation type identification 1 Fault relay switch 1 Relay for visibility 1 Relay for precipitation, window contamination or visibility

Sensor Model	Capability
SWS-200	Visibility Precipitation type identification 1 Fault relay switch 1 Relay for visibility 1 Relay for precipitation, window contamination or visibility

This model has an extra backscatter receiver for:

Rain rate
Snowfall rate
Precipitation accumulation

Sensor Model	Capability
SWS-250	Visibility Precipitation type identification Rain rate Snowfall rate Precipitation accumulation

This model will additionally report:

42 weather codes (from WMO
Code Table 4680), including
  Past weather
  Freezing Fog
  Ice Pellets

	RoHS compliant
CE	

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 Sensors:

- **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 precipitation outputs** (Model dependent).

- **Reports WMO 4680 codes**.

- **Reports 35 METAR codes in addition to 42 WMO 4680 codes** (SWS-250 only).

There are five sensors in the SWS sensor range, four of which are described in this manual. These are the SWS-050, the SW-100, the SW-200 and the SWS-250. Any of these can be supplied to be used with the Biral Ambient Light Sensor, model ALS-2. Throughout this manual, the term SWS Sensor is used to refer to features common to all these sensors.

Customer Satisfaction

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

After Sales Support

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

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

Contacting Biral

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

For enquiries and technical support:

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

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

Three year warranty

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

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

- Model of equipment
- Serial number of equipment
- Nature of defect
- Your full name, address and contact details
- Relevant application details and data output
- Responses to R? command (see paragraph 3.1.3)

If you need to return the sensor

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

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

The customer is responsible for the shipping costs.

CE Certification - Safety

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

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

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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 from our website:
http://www.biral.com/technical-support/downloads/software-downloads/
or contact Biral at:
enquiries@Biral.com

1.1 STEP 1 - Unpacking the Sensor

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

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
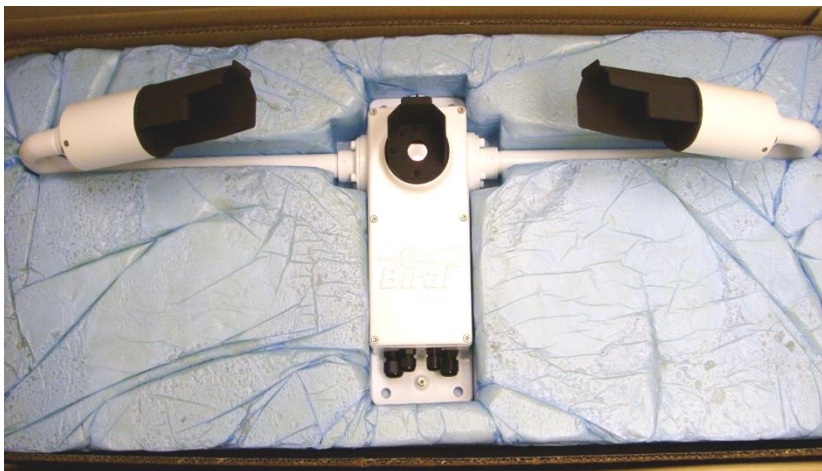
Figure 1-1 SWS-200 in Packing

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 sensor for **regular** shipping. Please note if this is not ordered the sensor is shipped in the standard rugged foam filled box as shown above.

Mains Adapter

A mains adapter to operate the sensor using mains power.

Power and Signal Cables

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

1.2 STEP 2 - Electrical Connections

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

1.2.1 Cables

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

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

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.

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

1.2.2 Cable Glands

There are two connecting areas within the sensor, 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.

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

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

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

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

Unused Glands

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

2 small cable glands for cables between 3.5 to 7.00mm diameter

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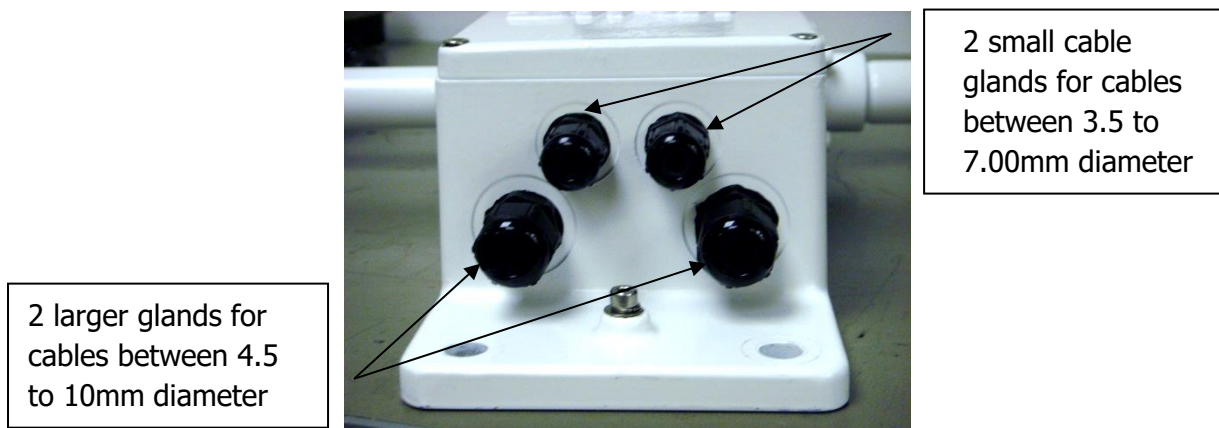
Figure 1-2 Cable Glands

1.2.3 Connecting the power supply and signal cable

The power and signal cables are connected to the sensor using the connector strip along the bottom edge of the main circuit board adjacent to the cable glands.

J11
Connect the power cable here

J12
Connect the signal cable here

A   F A   L
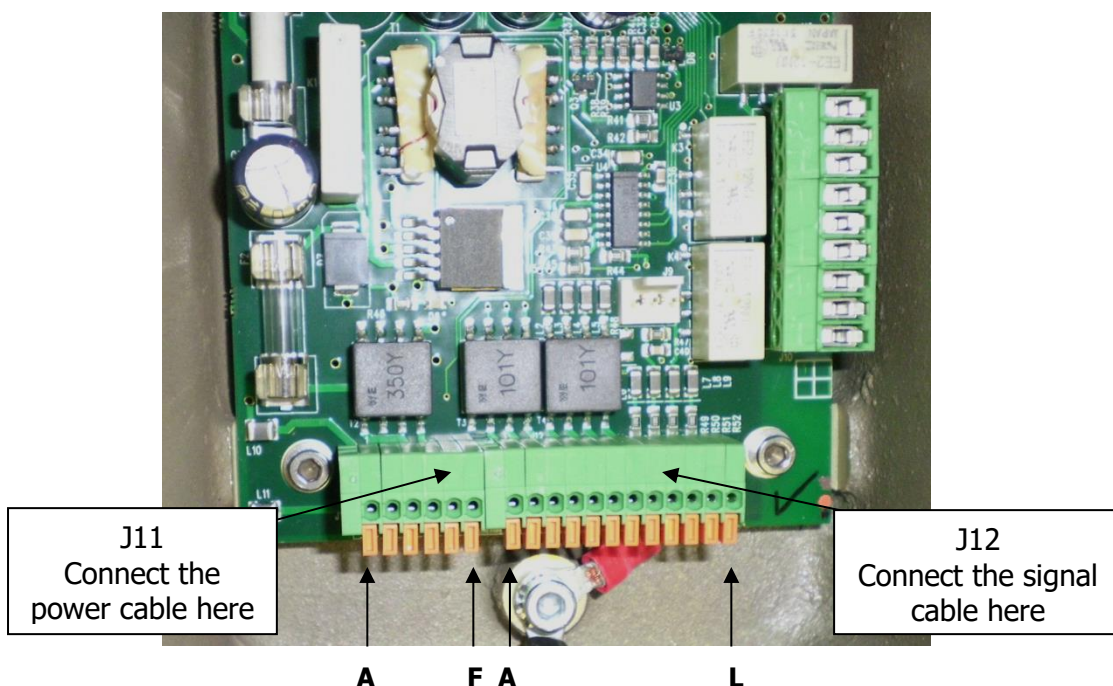
Figure 1-3 Power and Signal Connections

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.

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 1.2.8.

Connecting the hood heaters (optional on SWS-100 and SWS-200)

The hood heaters, if fitted, may be used if required. They are wired independently and isolated from the sensor power. These should be powered from a 24V supply of either AC or DC. The SWS-050 and SWS-100 will draw 24W from this source, and the SWS-200 and SWS-250 will draw 36W. A higher voltage should not be used as the power will increase above acceptable levels. If a lower voltage is used, the de-icing will be less efficient. The connections are J11/A for the heater supply (switched), and J11/B heater return. See Table 1 Pin connections for power supply for full details.

Pin connections for power supply

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

Table 1 Pin connections for power supply

Pin Connections for RS232 or RS422/RS485 Signal Interfaces

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

See Table 2 and Table 3 for full connection details.

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

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

Selection of RS232 or RS422/485 communications

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

Location of J7

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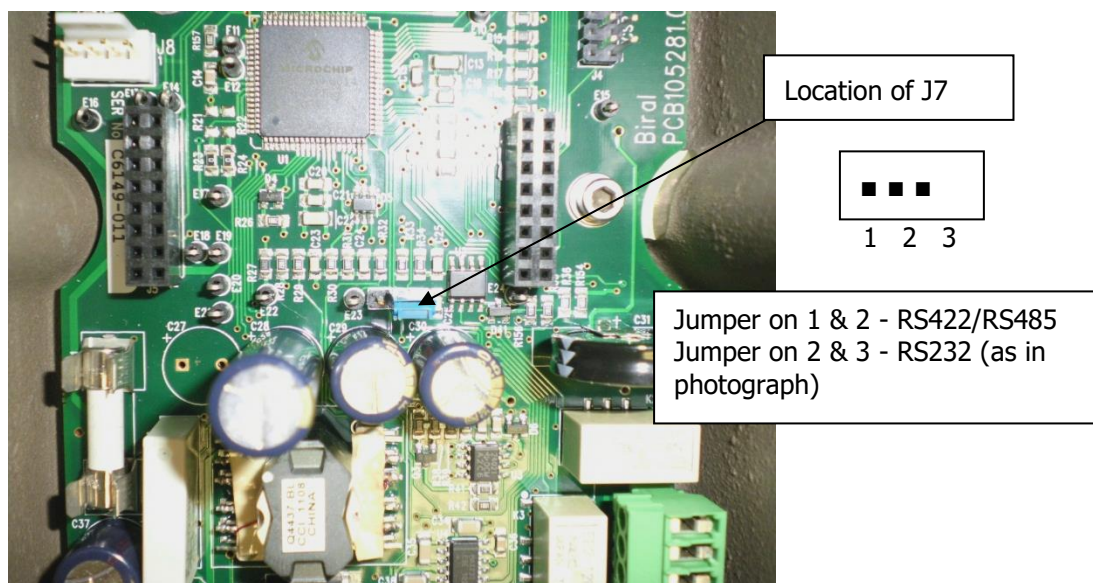
Figure 1-4 Location of J7, RS232/422/485 select

1.2.4 **Connecting the relays**

The unique ability to switch equipment using a visibility (fog) relay and / or a precipitation (rain, snow) relay is a feature of the SWS-100 and SWS-200 sensors. For example you can set relays to automatically switch a speed reduction sign when visibility is below 100 m and then switch an additional 'danger of aquaplaning' alert when it rains.

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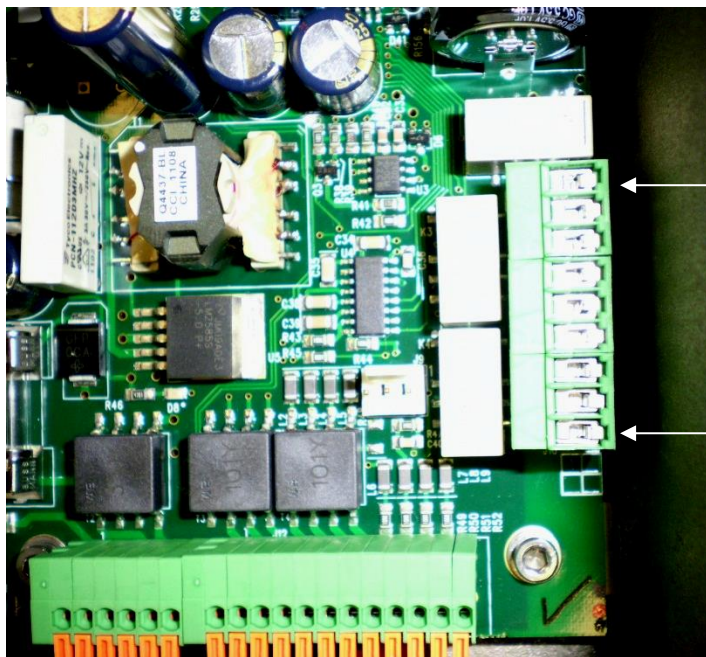
Contacts are defined here when relays are not energised

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

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

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

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

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

An analogue output representing Meteorological Optical Range (MOR) as a signal between 0 and 10V is standard on the SWS-100 and SWS-200 sensors. The connections are as given in Table 4.

Pin Number	Designation
J12/H	0-10V Analogue Output (MOR) +ve
J12/I	0-10V Analogue Output (MOR) -ve

Table 4 Connections for 0-10V analogue output

The output is scaled such that 0V represents 0m MOR and 10V represents the maximum MOR range value of the sensor.

1.2.6 **Pin connections for sensors ordered with the OPTIONAL 4 − 20mA or 0 − 20mA analogue output current loop**

An additional analogue output representing MOR as a current between 4 and 20mA or 0 and 20mA is available as an option on the SWS-100 and SWS-200 sensors. The connections are as given in Table 5.

Pin Number	Designation
J12/J	0 or 4 − 20mA Analogue Output (MOR) +ve
J12/K	0 or 4 − 20mA Analogue Output (MOR) -ve
J12/L	Not Used

Table 5 Connections for 0/4-20mA analogue output

The output is scaled such that 0 or 4mA represents 0m MOR and 20mA represents the maximum MOR range value of the sensor. The lower limit of 0mA or 4mA is a factory setting according to the sensor configuration requested at time of order.

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

1.2.7 **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.

1.2.8 **Optional ALS-2 Connections**

Any of the SWS sensors 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.

SWS/ALS-2 daughter board

ALS-2 Connector (J2)

Wire Colour List

SWS Sensor Power Connector (J1)
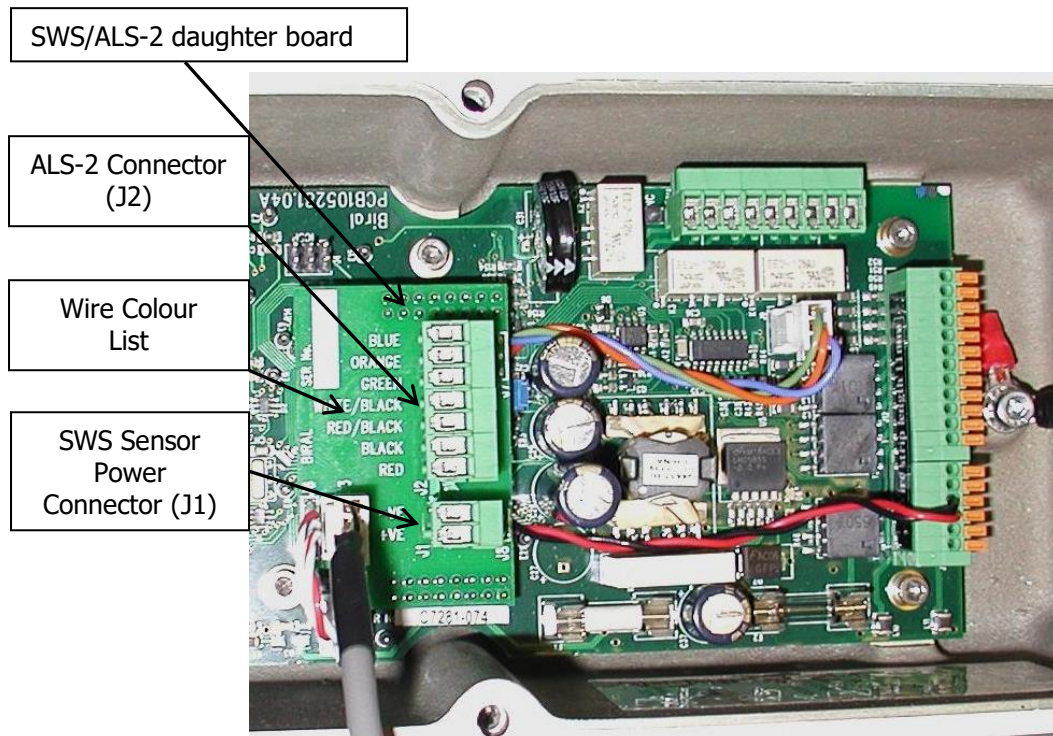
Figure 1-6 ALS-2 Connecting System

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

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

1.3 STEP 3 - Equipment Test

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

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

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

1.3.1 Equipment Test Procedure

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

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

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

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

   Default Interface Parameters

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

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

1. Turn the local power source "ON".

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

2. 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

3. 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.

4. MOR Calibration check:

   ┌───┐
   │ **THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE**   │
   │ **SWS CALIBRATION KIT AND PC ARE AVAILABLE**   │
   └───┘

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

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

   The sensor is fully calibrated before it leaves Biral.

1.4 STEP 4 - Configuration Options

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

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

1.4.1 Options Word

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

aaaaaaaa,bbbbbbbb

The upper byte, (aaaaaaaa) is used to set internal operating parameters and should not be changed. It will in general be '00000000'. For the lower byte, a value is entered as a binary number (1's and 0's). Leading 0's in the value need not be entered. The definition of each bit of this byte is shown in Table 6 below. *Note: the first bit is bit 8, the last being bit 1.*

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

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

Bit 2:   Not used

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

Bit 4:   Not used

Bit 5:   Not used

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

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

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

Table 6 Options word (lower byte)

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

By default, the date and time stamp is not included at the start of the data string. This is controlled by the Options Word setting; see 1.4.1.

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

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

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

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

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

To read the current Date and Time
Send the command TR?
The sensor will respond with the date / time message e.g.:
    FRIDAY   ,19\12\14,13:15:25,000

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

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

where:
W   - is the day of the week (1..7) with Monday being 1
DD   - is the date (01..31)

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

The sensor will respond with 'OK'.

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

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

The sensor will respond with 'OK'.

1.4.3 Message Checksum

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

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

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

To check the setting of the checksum option, send the command: OPCS?
The sensor will respond as follows:

                                    00   = Checksum disabled
                                    01   = Checksum enabled

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

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

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

For any message:
C1 ... Cm <cksum><crlf>

The calculation is as follows:

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

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

1.4.4 RS485 Communications Configuration

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

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

To determine the RS485 communications setting
To query the RS485 setting, send the following command: OP485?
The sensor will respond with:

> 00   = Disabled
> 01   = Enabled

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

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

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

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

Start

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

Sensor Address

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

Data

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

LRC Checksum

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

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

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

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

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

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

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

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

:42D?17<CRLF>

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

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

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

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

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

1.4.5 **Sensor Addressing – RS485 sensors only**

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

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

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

1.4.6 **Automatic message setting**

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

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

1.4.7 **Optional hood heater operating setting**

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

    OSHH?

The sensor will send the reply:

00 = Hood heaters disabled

01 = Hood heaters on automatic

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

    OSHHx

Where x is:

0 = Hood heaters disabled

1 = Hood heaters on automatic

The sensor will respond with "OK".

1.4.8 **Window heater operating setting**

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

    OSWH?

The sensor will send the reply:

00 = Window heaters disabled

01 = Window heaters enabled and on

02 = Window heaters enabled and controlled according to contamination levels

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

    OSWHx

Where x is:

0 = Window heaters disabled

1 = Window heaters enabled and on

2 = Window heaters enabled and controlled according to contamination levels

The sensor will respond with "OK".

1.4.9 **Baud Rate Configuration**

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

Send   %Bn
        Where n is a number from 1 to 7.

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.

1.4.10 Configuring the Relays

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

Relays are fitted as standard on the SWS-100 and SWS-200 sensors. Relays are not available on the SWS-050 and SWS-250 sensors. Where fitted, the relays may be configured to perform a number of 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.
1	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on the detection of precipitation.
2	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on visibility.
3	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on the detection of snow.
4	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on window contamination warning.

Table 7 Relay configuration

The default value is set to 1.

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.   JRO2
Configures Relay 2 to be a second visibility relay.

To read the visibility Threshold levels
To read the visibility threshold levels for Relay 1 and relay 2 send the following command: RL*n*?
    where *n* is the relay number (either 1 or 2).

The sensor will respond with the visibility threshold in km. Default 1.00km
    e.g.   10.00 km

To change the visibility Threshold levels
To change the visibility threshold levels for relay 1 or relay 2 send the following command: RL*n,xx.xx*

where *n* is the relay number (either 1 or 2)
and *xx.xx* is the threshold level in km. Range 0.10 to 20.00km.

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

To read the relay switching delay
To ensure the relays do not continually switch, for example when the visibility fluctuates around the switching point, a time delay is provided. The time delay applies to switching on and switching off of all relays. The default delay is 3 minutes. To view the delay time, send the following command: RD?

The sensor will respond with the delay time in minutes.

To set the visibility threshold switching delay
Send the command: RDxx

Where xx is the required delay in minutes. Range 1 to 15 minutes.

To read the visibility threshold switching hysteresis
To ensure the visibility threshold relays do not continually switch when the visibility fluctuates around the switching point a signal hysteresis is provided as a percentage of the threshold. For example, if threshold is set to 1km and the hysteresis value is 20%, when visibility is decreasing the relay will switch on as the visibility drops below 1km. When the visibility is increasing the relay will switch off at 1.2km; the threshold plus the hysteresis value. The hysteresis value can be set independently for each visibility threshold relay, the default value is 20% of the threshold. To read the hysteresis value for a relay, send the following command: RLHn?

Where n is the relay number.

The response is: AAA%,BBB.BBkm

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

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

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

1.4.11 **Configuring the MOR Output**

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

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

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

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

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

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

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

1.4.12 **Configuring the EXCO Output**

In the factory default condition, where a sensor reports a single EXCO parameter the value reported is the total forward scatter EXCO, reported in km^{-1}. Sensors reporting a single EXCO value can be configured to report TEXCO in place of EXCO. Sensors that do not normally report EXCO can be configured to report TEXCO as an additional data field at the end of the data message. TEXCO is reported as xxx.xx in units of km^{-1}.

TEXCO is Transmissometer equivalent EXCO. This is the forward scatter total EXCO adjusted to compensate for the difference in reporting between transmissometers and forward scatter sensors during liquid precipitation events.

Querying the EXCO output Setting

To query the EXCO output setting, send the PE? Command. The sensor will respond with five characters as shown below:

      00000   Default Setting, forward scatter EXCO or no EXCO value

      00001   TEXCO output.

Note: The SWS-250 always reports both total EXCO and TEXCO in the standard data message. The SWS-250 output is not affected by the PE setting.

Setting the EXCO Output

To set the EXCO output send the PEn command, with n set as follows:

      PE0   Default Setting, EXCO field is total forward scatter or EXCO not reported (depending on sensor type)

      PE1   TEXCO reported in EXCO field or TEXCO appended to end of data message (depending on sensor type)

The effect of the PEn command on the data message of each sensor is described in section 2.

Example:

SWS-100 in default configuration. Data message:

      SWS100,000,060,10.37 KM,00.000,00,+21.7 C,10.37 KM,OOO

SWS-100 configured for TEXCO output, PE1. Data message:

      SWS100,000,060,10.37 KM,00.000,00,+21.7 C,10.37 KM,OOO,003.46

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

Pollutants – Care should be taken to ensure that the sensor is situated away from any possible sources of pollutants (for example car exhausts, air-conditioning outlets, etc.). Particulates entering the sensor's sample volume will cause errors in the reported visibility measurements.

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

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

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

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1.5.2 **Height Above Ground:**

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

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

Table 8 Sensor height above ground

1.5.3 **Orientation of Sensor Head**

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

It is desirable to avoid sunlight from flooding the receiver optics and to avoid
sunlight induced noise spikes from creating false precipitation counts, although
false-alarm algorithms in the sensors invariably eliminate such false counts.

The recommended orientation is shown in the following two diagrams (Figure 1-7
SWS-050 and SWS-100 Orientation, and Figure 1-8 SWS-200 and SWS-250
Orientation).

For the SWS-050 and SWS-100 sensors, the optimum position is with the receiver
head pointing directly due North.

For the SWS-200 and SWS-250, the optimum position is with the forward scatter
receiver and the backscatter receiver oriented equally either side of due North.
This is with the backscatter head pointing 34° East of North.

For sensors located in the Southern hemisphere, 180° should be added to the
above directions. That is, for the SWS-200 and SWS-250 point the backscatter

head 34°West of South, and for the SWS-050 and SWS-100, point the forward scatter receiver directly due South.
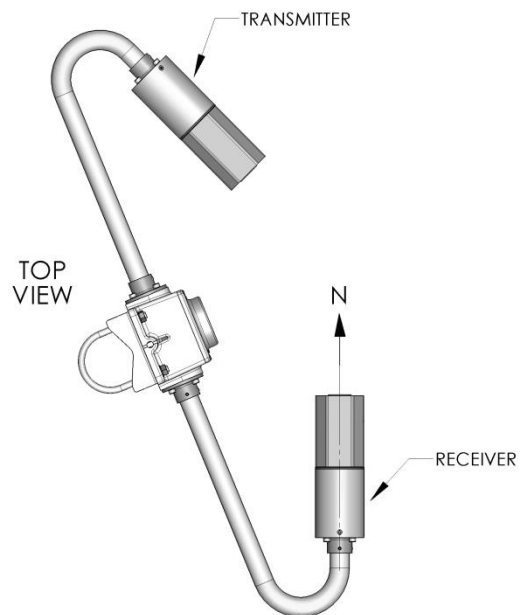
Figure 1-7 SWS-050 and SWS-100 Orientation
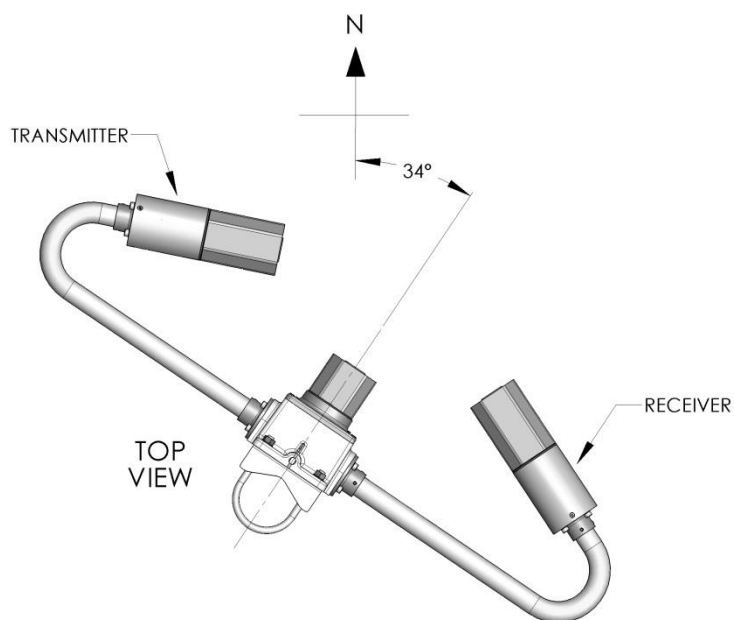
Figure 1-8 SWS-200 and SWS-250 Orientation

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 1-9 U-Bolt Mounting Method. The two V-block saddles oppose the U-bolt, thus providing a secure grip on the mast. The sensor can be mounted on a galvanised steel pipe or heavy walled aluminium tube with an outer diameter between 40 to 64 mm. For mast diameters outside this range the U-bolts provided will not be suitable.

The sensor head should be mounted near the very top so that the mast will not interfere more than necessary with the free flow of fog or precipitation through the sample volume. The flat stainless steel washers should be placed next to the powder coated surface of the mounting plate to prevent gouging by the lock washers as the nuts are tightened.
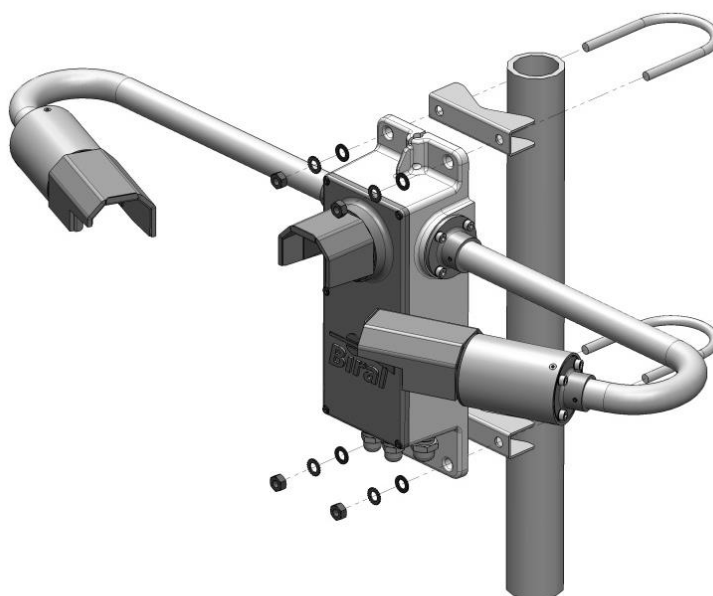
Figure 1-9 U-Bolt Mounting Method

On a wall

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

1.5.5 **Electrical Grounding**

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

Possible sensor 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 sensor 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 sensor. In addition, if relays are in use and are required to switch mains voltages, protective earth bonding will be required to conform with national and local installation safety requirements. The following notes are intended to provide some guidance in the design and construction of an electrical grounding system.

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

(2) Lead Lengths: No. 6 AWG solid copper wire should be used to connect the sensor (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 sensor.

(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

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

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

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

3. Configure the terminal program as follows:

    Default Interface Parameters

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

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

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

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

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

1.6.3 Remote Self-Test Check

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 9 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:	11.2 -17.5	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	11.2 -17.5	Internal operating voltage.
Field 8:	00.00 - 6.00	Forward scatter background brightness.
Field 9:	00.00 – 6.00	Backscatter background brightness (SWS-200 and SWS-250 only).
Field 10:	85 - 105	Transmitter power monitor.
Field 11:	80 - 120	Forward receiver monitor (Option for SWS-100 and SWS-200).
Field 12:	80 - 120	Back receiver monitor (SWS-200 and SWS-250 only).
Field 13:	00 - 99	Transmitter window contamination.
Field 14:	00 - 99	Forward receiver window contamination (Option).
Field 15:	00 - 99	Back receiver window contamination (Option).
Field 16:		Temperature ^{o}C.
Field 17	3300-4200	ADC Interrupts per second.

Table 9 Remote self-test and monitoring check fields

1.6.4 **Calibration Check**

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

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

1.6.5 **Using the *Test* Command**

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

Command Syntax

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

The TEST command takes the following form:

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

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

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

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

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

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

Available PW Codes:
   SWS-050: 00,04,10,27,30
   SWS-100, SWS-200 & SWS-250:
            00,04,10,27,30,40,50,51,52,53,60,61,62,63,70,71,72,73,89
   An invalid code will return code 00 in the sensor message string.
   Note: The available codes may not be valid for the sensor in question and not all codes are available.

Example:
TEST,02,07.50,0,0,00 – Outputs a visibility of 7.5 km for 2 min (Clear conditions)
TEST,06,00.10,0,0,30 – Outputs a visibility of 0.1 km for 6 min (Foggy conditions)

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

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

Where a present weather code is supplied in the TEST command sent to a visibility only sensor such as a SWS-050, the present weather code is ignored.

Where a parameter is outside of the allowable range for the configuration of the sensor, the sensor will respond with BAD CMD. For example, if a SWS-100 has been configured to have a maximum reporting range of 20km and the TEST command states 50km the sensor will respond with BAD CMD.

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

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

Example:
  SWS-100 Sensor
      SWS100,000,060,03.24 KM,99.999,04,+99.9,03.26 KM,TOO

  SWS-050 Sensor
      SWS050,000,060,15.76 KM,00,000.19,TOO

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CONGRATULATIONS

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

THE REMAINDER OF THIS MANUAL COVERS:

- **STANDARD DATA MESSAGES**
- **COMMANDS AND RESPONSES**
- **OPERATIONAL AND MAINTENANCE PROCEDURES**
- **CALIBRATION CHECK AND RE-CALIBRATION PROCEDURE**
- **SENSOR DETAILS AND SPECIFICATIONS**

2 STANDARD OPERATING DATA

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

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

There are four different standard messages, dependent on the model number. These are detailed below in Table 10 SWS-050 Operating data message format, Table 11 SWS-100 Operating data message format, Table 12 SWS-200 Operating data message format and Table 13 SWS-250 Operating data message format.

2.1 Standard Operating Data Message for the SWS-050

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

Note: < > denotes an optional field.

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
SWS050	SWS-050 message prefix.
NNN	Sensor identification number set by the user.
XXX	Averaging Time period in seconds.
AA.AA KM	Meteorological Optical Range (km). This is the averaged value. See Note 1.
BB	Obstruction to vision code. From WMO table 4680: XX Not Ready (first 5 measurement periods from restart). 00 No significant weather observed. 04 Haze or Smoke. 30 Fog.
CCC.CC	Total Forward Scatter Exco value. See Note 2.
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 alert – cleaning required. T = Sensor in Test Mode. O = Sensor not reset since last "R?" command. X = Sensor reset since last "R?" command.
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 10 SWS-050 Operating data message format

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

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

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

SWS050,001,060,000142 M,30,021.43,XOO

Note 1: The format and resolution of the MOR value reported can be configured using the KMn command, see section 1.4.11. The available options are:

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

Note 2: The value reported in the EXCO field can be configured using the PEn command, see section 1.4.12. The available options are:

- o Default Setting, EXCO field is total forward scatter
- o TEXCO reported in EXCO field

2.2 Standard Operating Data Message for the SWS-100

The data message format is:

<Date>,<Time>,SWS100,NNN,XXX,AA.AA KM,BB.BBB,CC,±DD.D C,EE.EE KM,FFF,<GGG.GG><cs>crlf

Note: < > denotes an optional field.

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
SWS100	SWS100 message prefix.
NNN	Sensor identification number set by the user.
XXX	Averaging Time period in seconds.
AA.AA KM	Meteorological Optical Range (km). This is the averaged value. See Note 1.
BB.BBB	Not used in the SWS100. Set to 99.999.
CC	Present weather codes. From WMO Table 4680 (Automatic Weather Station). XX — Not Ready (first 5 measurement periods from restart). 00 — No Significant weather observed. 04 — Haze or smoke. 30 — Fog. 40 — Indeterminate precipitation type. 50 — Drizzle. 60 — Rain. 70 — Snow.
±DD.D C	Not used in the SWS100. Set to 99.9 C.
EE.EE KM	Meteorological Optical Range (km). This is the instantaneous value.

MESSAGE	MEANING
FFF	Self-test and Monitoring (see section 4.2): F F F 　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 alert – cleaning required. 　T = Sensor in Test Mode. 　O = Sensor not reset since last "R?" command. 　X = Sensor reset since last "R?" command.
<GGG.GG>	Transmissometer equivalent EXCO (km^{-1}). Not included in default configuration. See Note 2.
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 11 SWS-100 Operating data message format

A typical data message from an SWS-100 sensor in default configuration is as follows:

　　SWS100,001,060,00.14 KM,99.999,30,+99.9 C,00.14 KM,XOO

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

　　SWS100,001,060,00142 M,99.999,30,+99.9 C,00.14 KM,XOO,021.43

Note 1:　The format and resolution of the MOR value reported can be configured using the KMn command, see section 1.4.11. The available options are:
- o　Default Setting, MOR expressed in km to 10m (xx.xx KM)
- o　Metre output, MOR expressed in m to 1m (xxxxx M)
- o　Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

Note 2:　The TEXCO parameter can optionally be appended to the end of the data message using the PEn command, see section 1.4.12. The available options are:
- o　TEXCO not reported
- o　TEXCO reported at the end of the data message

2.3 Standard Operating Data Message for the SWS-200

The data message format is:

<Date>,<Time>,SWS200,NNN,XXX,AA.AA KM,BB.BBB,CC,±DD.D C,EE.EE KM,FFF,<GGG.GG>,<cs>crlf

Note: <   > denotes an optional field.

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
SWS200	SWS200 message prefix.
NNN	Sensor identification number set by the user.
XXX	Averaging Time period in seconds.
AA.AA KM	Meteorological Optical Range (km). This is the averaged value. See Note 1.
BB.BBB	Amount of water in precipitation in last measurement period (mm).
CC	Present weather codes. From WMO Table 4680 (Automatic Weather Station). XX Not Ready (first 5 measurement periods from restart). 00 No Significant weather observed. 04 Haze or smoke 30 Fog 40 Indeterminate precipitation type 51 Light Drizzle 52 Moderate Drizzle 53 Heavy Drizzle 61 Light Rain 62 Moderate Rain 63 Heavy Rain 71 Light Snow 72 Moderate Snow 73 Heavy Snow 89 Hail
±DD.D C	Temperature (°C).
EE.EE KM	Meteorological Optical Range (km). This is the instantaneous value.

MESSAGE	MEANING
FFF	Self-test and Monitoring (see section 4.2): F F F 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 alert – cleaning required. T = Sensor in Test Mode. O = Sensor not reset since last "R?" command. X = Sensor reset since last "R?" command.
<GGG.GG>	Transmissometer equivalent EXCO (km^{-1}). Not included in default configuration. See Note 2.
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 12 SWS-200 Operating data message format

A typical data message from an SWS-200 sensor in default configuration is as follows:

    SWS200,001,060,00.14 KM,00.000,30,+24.5 C,00.14 KM,XOO

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

    SWS200,001,060,00142 M,00.000,30,+24.5 C,000142 M,XOO,021.43

Note 1:   The format and resolution of the MOR value reported can be configured using the KMn command, see section 1.4.11. The available options are:
- Default Setting, MOR expressed in km to 10m (xx.xx KM)
- Metre output, MOR expressed in m to 1m (xxxxx M)
- Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

Note 2:   The TEXCO parameter can optionally be appended to the end of the data message using the PEn command, see section 1.4.12. The available options are:
- TEXCO not reported
- TEXCO reported at the end of the data message

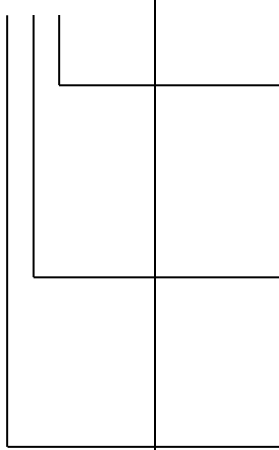## 2.4 Standard Operating Data Message for the SWS-250

The data message format is:

<Date>,<Time>,SWS250,NNN,XXXX,AA.AA KM,CC,W$_1$,W$_2$,,DD,EEEEE, FFF.FFF,GG.GG KM,HHH.HH, III.II,±JJJ.JJ,±KKK.K C,±LLLLL,MMM, NNNN,OO.OOOO,PPP<cs>crlf

Note: <   > denotes an optional field.

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
SWS250	SWS250 message prefix.
NNN	Sensor identification number set by the user.
XXXX	Averaging time period in seconds.
AA.AA KM	Meteorological Optical Range (km). This is the averaged value. See Note1.
CC	Present weather codes. From WMO Table 4680 (Automatic Weather Station).
	XX Not Ready (first 5 minutes from restart)
	00 No significant weather observed
	04 Haze or Smoke or Dust
	11 Diamond Dust
	20 Fog in last hour but not at time of observation
	21 Precipitation in last hour but not at time of observation
	22 Drizzle in last hour but not at time of observation
	23 Rain in last hour but not at time of observation
	24 Snow in last hour but not at time of observation
	28 Blowing or drifting snow, visibility ≥ 1km
	29 Blowing or drifting snow, visibility < 1km
	30 Fog
	31 Fog in patches
	32 Fog becoming thinner in last hour
	33 Fog no appreciable change in last hour
	34 Fog begun or becoming thicker in last hour
	35 Freezing Fog
	40 Indeterminate Precipitation Type
	51 Slight Drizzle
	52 Moderate Drizzle

MESSAGE	MEANING
	53 Heavy Drizzle
	57 Slight Drizzle and Rain
	58 Moderate or Heavy Drizzle and Rain
	61 Slight Rain
	62 Moderate Rain
	63 Heavy Rain
	67 Slight Rain and Snow
	68 Moderate or Heavy Rain and Snow
	71 Slight Snow
	72 Moderate Snow
	73 Heavy Snow
	74 Slight Ice Pellets
	75 Moderate Ice Pellets
	76 Heavy Ice Pellets
	77 Snow Grains
	78 Ice Crystals
	81 Slight Rain Showers
	82 Moderate Rain Showers
	83 Heavy Rain Showers
	85 Slight Snow Showers
	86 Moderate Snow Showers
	87 Heavy Snow Showers
	89 Hail or Small Hail (Graupel)
W_1	Past Weather Type1 SYNOP Code:
	/ No past weather code
	4 Fog or Thick Haze
	5 Drizzle
	6 Rain
	7 Snow or Mixed rain & snow
	8 Showers
W_2	Past Weather Type2 SYNOP Code:
	/ No past weather code
	4 Fog or Thick Haze
	5 Drizzle
	6 Rain
	7 Snow or Mixed rain & snow
	8 Showers
DD	Obstruction to Vision Message:
	(Blank) No obstruction
	HZ Haze
	FG Fog
EEEEE	METAR Reporting Code. See Section 2.4.1.

MESSAGE	MEANING
FFF.FFF	Precipitation Rate (mm/hr).
GG.GG KM	Meteorological Optical Range (km). This is the instantaneous value. See Note 1.
HHH.HH	Total Exco (km^{-1}). This is the averaged value.
III.II	Transmissometer equivalent EXCO (km^{-1}).
±JJJ.JJ	Back Scatter Channel Exco (km^{-1}). This is the averaged value.
±KKK.K C	Temperature (°C).
±LLLLL	ALS signal, 1 minute average value (cd/m^2). Optional, if not fitted set to 99999.
MMM	Self-test and Monitoring (see section 4.2): O = Other self-test values OK. X = Other self-test faults exist. F = Forward Scatter Receiver Flooded with light. B = Back Scatter Receiver Flooded with Light. O = Windows not contaminated. X = Window contamination warning – cleaning recommended. F = Window contamination alert – cleaning required. T = Sensor in Test Mode. O = Sensor not reset since last "R?" command. X = Sensor reset since last "R?" command.
NNNN	Number of precipitation particles detected in last minute.
OO.OOOO	Amount of water in precipitation in last minute (mm).

MESSAGE	MEANING
PPP	ALS Self-Test and Monitoring If ALS not fitted set to FFF, See section 4.2. 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 alert – cleaning required. S = Sensor input saturated. 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 13 SWS-250 Operating data message format

A typical data message from an SWS-250 sensor is as follows:

SWS250,001,0060,00.14 KM,30,/,/,FG,FG   ,000.000,00.14 KM,021.19, 021.40,+073.54, +022.0 C,+99999,XOO,0000,00.0000,OOO

Note 1:   The format and resolution of the MOR value reported can be configured using the KMn command, see section 1.4.11. The available options are:
- o   Default Setting, MOR expressed in km to 10m (xx.xx KM)
- o   Metre output, MOR expressed in m to 1m (xxxxx M)
- o   Kilometre output, MOR expressed in km to 1m (xx.xxx KM)

2.4.1 **METAR Codes**

CODE NUMBER	METAR CODE	MEANING
XX	X	Not Ready (first 5 minutes from restart)
00		No significant weather observed
04	HZ	Haze, visibility greater than or equal to 1km
11	IC	Diamond Dust.
20		Fog in last hour but not at time of observation
21		Precipitation in last hour but not at time of observation
22		Drizzle in last hour but not at time of observation
23		Rain in last hour but not at time of observation
28	BLSN	Blowing or drifting snow, visibility ≥ 1km.
29	+BLSN	Blowing or drifting snow, visibility < 1km.
24		Snow in last hour but not at time of observation
30	FG	Fog
31	BCFG	Fog in patches
32	FG	Fog becoming thinner in last hour
33	FG	Fog no appreciable change in last hour
34	FG	Fog begun or becoming thicker in last hour
35	FZFG	Freezing Fog
40	UP	Indeterminate precipitation type
51	-DZ	Drizzle, not freezing, slight
52	DZ	Drizzle, not freezing, moderate
53	+DZ	Drizzle, not freezing, heavy
57	-RADZ	Drizzle and Rain, slight
58	RADZ	Drizzle and Rain, moderate
58	+RADZ	Drizzle and Rain, heavy
61	-RA	Rain, not freezing, slight

CODE NUMBER	METAR CODE	MEANING
62	RA	Rain, not freezing, moderate
63	+RA	Rain, not freezing, heavy
67	-RASN	Rain (or Drizzle) and Snow, slight
68	RASN	Rain (or Drizzle) and Snow, moderate
68	+RASN	Rain (or Drizzle) and Snow, heavy
71	-SN	Snow, slight
72	SN	Snow, moderate
73	+SN	Snow, heavy
74	-PL	Ice Pellets, slight
75	PL	Ice Pellets, moderate
76	+PL	Ice Pellets, heavy
77	SG	Snow Grains
78	IC	Ice Crystals
81	-SHRA	Rain Showers, slight
82	SHRA	Rain Showers, moderate
83	+SHRA	Rain Showers, heavy
85	-SHSN	Snow Showers, slight
86	SHSN	Snow Showers, moderate
87	+SHSN	Snow Showers, heavy
89	GR	Hail
89	GS	Small Hail / Graupel

Table 14 METAR codes

Biral

SWS-250 WMO 4680 and METAR Codes

The SWS-250 reports weather phenomena using both WMO Table 4680 and METAR codes (WMO Table 4678). As there is not always a METAR code associated with the WMO Table 4680 code the following logic is used to determine what codes to report:

Field cc Present Weather Code Table 4680	The sensor reports the highest Table 4680 number associated with the current conditions as before.
Field dd Obstruction to Vision METAR	The sensor examines the Table 4680 codes associated with the current conditions that are classed as obstruction to vision codes and converts the highest Table 4680 numeric code to the associated METAR code. If the Table 4680 code has no direct METAR equivalent the next lower Table 4680 obstruction to vision code with a METAR equivalent that is currently valid is reported.
Field eeeee METAR Reporting Code	The sensor takes the Table 4680 code numeric code as used in field cc and converts it to the associated METAR code. If the Table 4680 code has no direct METAR equivalent the next lower Table 4680 code with a METAR equivalent that is currently valid is reported.

Code IC is used in field eeeee to represent the METAR equivalent code for WMO Table 4680 codes 11 and 78, respectively Diamond Dust and Ice Crystals. Code IC is not referenced in WMO Table 4678 but is recognised by the WMO as a code used in METAR reports produced in the United States of America.

2.4.2 SWS-250 Present Weather Measurement Timing

For the SWS-250 only, the present weather coding and the precipitation type and intensity are always calculated at one minute intervals. The measurement timing command TMx will set the timing interval for all visibility related measurements, but not the present weather coding or precipitation details. It is recommended that this visibility timing is set to 1 minute intervals (command TM60), the default value, for consistency with the precipitation measurements and coding.

2.5 Data Message Variations For ALS-2

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

Note: for the SWS250, the ALS-2 data is integrated into the standard data message format, see section 2.4.

,ALS,±AAAAA,BBB

Message	Meaning
ALS	ALS data message prefix.
±AAAAA	ALS Signal, 1 minute averaged value (cd/m^2).
BBB	ALS Self-Test and Monitoring If ALS not fitted set to FFF, See section 4.2. 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 alert – cleaning required. S = Sensor input saturated. O = Sensor not reset since last "R?" command. X = Sensor reset since last "R?" command.

Table 15 Message extension for ALS-2

A typical data message from an SWS-200 sensor with an ALS-2 is as follows:

SWS200,001,060,00.13 KM,00.000,30,+24.5 C,00.13 KM,XOO,ALS,+00118,XOO

3   COMMANDS AND RESPONSES

3.1 Sensor Commands

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

Command	Function	Response	Applicability SWS-			
			050	100	200	250
A?	Query precipitation accumulation amount.	**See Section 3.1.1**			√	√
AC	Clear accumulated precipitation.	**See Section 3.1.1**			√	√
ADR?	Query RS485 address. See **section 1.4.4.**	**xx**	√	√	√	√
ADRxx	Set RS485 address. Range 00-99. See **section 1.4.5.**	**OK**	√	√	√	√
BB?	Query instantaneous value of backscatter EXCO.	**±xxx.xx**			√	√
BL?	Query instantaneous value of Total EXCO less precipitation particle component.	**±xxx.xx**			√	√
BT?	Query instantaneous value of Total EXCO.	**±xxx.xx**	√	√	√	√
CA#	Perform precipitation amount calibration (Calibration must be enabled).	**See section 5.4**			√	√
CE#	Perform both EXCO calibration. (Calibration must be enabled).	**See section 5.3**	√	√	√	√
CO	Enable calibration.	**OK**	√	√	√	√
CX★	Disable calibration.	**OK**	√	√	√	√
D?	Send latest data message.	**See section 2**	√	√	√	√
DHO	Turn hood heaters on temporarily. If off at time of command, the heaters will turn off after 2 minutes (for maintenance only).	**OK**	√	√	√	√
DHX	Turn hood heaters off temporarily. If on at time of command, the heaters will turn on after 2 minutes (for maintenance only).	**OK**	√	√	√	√

Command	Function	Response	Applicability SWS-			
			050	100	200	250
IDx*	Set sensor identification number displayed in data message. Range x = 0 to 999. (Default = 1).	**OK**	√	√	√	√
JRO?	Check Current Relay Configuration.	**See section 1.4.10**		√[1]	√[1]	
JROx*	Set Current Relay Configuration, **See section 1.4.10.**			√[1]	√[1]	
KM?	Check current MOR output resolution configuration.	**See section 1.4.11**	√	√	√	√
KMn*	Set MOR output resolution.	**See section 1.4.11**	√	√	√	√
M?	Send precipitation matrix accumulated over last five measurement periods. This is a matrix of 16 rows with up to 21 readings. Zeros to right not displayed.	**Mnnn (,nnn,nnn…) See Section 3.1.1**				√
OP?	Check Option Word configuration.	**See section 1.4.1**	√	√	√	√
OPxxxxxxxx* #	Set configuration options. See **section 1.4.1.**	**OK**	√	√	√	√
OPCS?	Query checksum option setting. **Section 1.4.3.**	**See section 1.4.3**	√	√	√	√
OPCSx*#	Set checksum option. **Section 1.4.3.**	**OK**	√	√	√	√
OP485?	Query Addressable 485 communications setting. **Section 1.4.4.**	**See section 1.4.4**	√	√	√	√
OP485x*#	Set Addressable RS485 communications. **Section 1.4.4.**	**OK**	√	√	√	√
OSAM?	Check automatic message setting.	**See section 1.4.6**	√	√	√	√
OSAMx*	Set automatic message setting, **section 1.4.6.**	**OK**	√	√	√	√
OSHH?	Check hood heater setting.	**See section 1.4.7**	√	√	√	√
OSHHx*	Set hood heater setting. See **section 1.4.7.**	**OK**	√	√	√	√
OSWH?	Check window heater setting.	**See section 1.4.8**	√	√	√	√
OSWHx*	Set window heater setting. See **section 1.4.8.**	**OK**	√	√	√	√
PE?	Check current EXCO output configuration.	**See section 1.4.12**	√	√	√	

Command	Function	Response	Applicability SWS-			
			050	100	200	250
PEn	Set EXCO output configuration.	**See section 1.4.12**	√	√	√	
PV?	Query program version message.	**SI xxxx.yy**	√	√	√	√
R?	Send remote self-test and monitoring message.	**See section 3.1.3**	√	√	√	√
RD?	Query the relay hysteresis time delay.	**See section 1.4.10**		√	√	
RDn*	Set the relay hysteresis time delay.	**See section 1.4.10**		√	√	
RLn?	Check relay 'n' visibility threshold setting. **Section 1.4.10**	**XX.XX KM**		√[1]	√[1]	
RLHn?	Query the relay threshold hysteresis. **Section 1.4.10**	**See section 1.4.10**		√	√	
RLHn,xx*	Set the relay threshold hysteresis.	**See section 1.4.10**		√	√	
RLn,XX.XX*	Set relay 'n' visibility threshold in km. **Section 1.4.10**	**OK**		√[1]	√[1]	
RST*	Restart sensor.	**OK**	√	√	√	√
SN?	Query sensor serial number.	**Jxxxx.xx**	√	√	√	√
T?	Query sensor times message.	**See section 3.1.4**	√	√	√	√
TAx*	Set auxiliary measurement sample period. **Section 3.1.4**	**OK**	√	√	√	√
TEST,tt,vv.vv ,f,c,pw*#	Set the sensor into a test mode. **Section 1.6.5**	**Section 1.6.5**	√	√	√	√
TMx*	Set measurement interval. Range x = 10-300 (seconds). (Default= 60).	**OK**	√	√	√	√
TR?	Query current date and time. **Section 1.4.2.** (The final 000 is an internal fixed constant).	**FRIDAY , 23/03/12, 13:15:25,000**	√	√	√	√
WF?	Query Window Contamination Alert Threshold Percentage.	**XX**				
WFn *#	Set Window Contamination Alert Threshold Percentage. Range n= WT to 40%. Calibration must be enabled. Default 30%.	**OK**				

Command	Function	Response	Applicability SWS-			
			050	100	200	250
WT?	Query current window contamination threshold for warning indication.	**XX**	√	√	√	√
WTx*#	Set window contamination threshold for a warning indication. Range: 10 to window contamination Alert threshold (%) Calibration must be enabled. Default = 10%.	**OK**	√	√	√	√
%Bx*	Set communication baud rate. Range: n = 1 to 7. **See section 1.4.9**	**See section 1.4.9**	√	√	√	√
%SDWDDMMYY	Set current date. **See section1.4.2.**	**OK**	√	√	√	√
%STHHMMSS	Set current time. **See section1.4.2.**	**OK**	√	√	√	√

Table 16 Commands for SWS series of sensors

√[1] *indicates that these commands are only applicable if the relay option has been taken, which is only available on the following models: SWS100 & SWS200.*

3.1.1 **Commands A? and AC – Precipitation Accumulation**

These commands apply only to the SWS-200 and SWS-250.

The sensor records the total amount of precipitation detected in a 24-hour period. The 24-hour period starts when the sensor is powered or when the accumulated precipitation value is reset. The value can be queried at any time, with the total recorded at that time being reported. The precipitation amount is reported in mm.

The following commands are used:

A?   Reports the accumulation amount in mm and the accumulation time in minutes. For accumulation amounts less than 600mm the value is reported as xxx.xx, for accumulation amounts greater than 600mm the amount is reported as xxxx.x.
Example: Sensor responds **105.65,1224** This equates to 105.65mm of accumulated precipitation in the last 1224 minutes.
Example: Sensor responds **1022.8,1392** This equates to 1022.8mm of accumulated precipitation in the last 1392 minutes.

AC   Clears the accumulated precipitation amount and resets the accumulation period. The sensor responds with OK.

3.1.2 **Command M? – Send Precipitation message**

This command is only available in the SWS-250 sensor. The sensor responds by sending a precipitation matrix accumulated over the last five measurement periods. This is a matrix of 16 rows with up to 21 readings, each being the number of precipitation particles of that specific size and velocity. Zeros to right are not displayed. The meaning of the matrix is described graphically in section 6.3.2, Figure 6-3 Precipitation Recognition Matrix.

An example response, recorded during a period of heavy rain, is provided below:

```
M001
M001,001,002,001,001,000,000,000,001
M009,002,006,002,001,001
M009,019,020,020,010,002,000,000,001,001
M011,033,068,078,056,042,020,005,001,000,001
M003,031,048,041,047,033,038,027,014,009,008,003
M004,007,027,020,013,016,011,007,002,008,006,007,004
M000,005,006,005,007,003,000,002,003,001,000,000,000,001
M000,000,006,004,005,000,001,002,001,000,000,001
M000,001,007,000,005,002,001,000,001
M000,000,001,000,001
M000,000,000,001
M000,000,000,000,001
M000
M000
M000
```

This shows the greatest precipitation amount in rows 5 and 6, relatively slow hydrometeor velocity (~3.3m/sec) and in columns 2 to 8, relatively small hydrometeor size (~0.5mm).

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

Example response:

**100,2.509,24.1,12.3,5.01,12.5,00.00,00.00,100,105,107,00,00,00,+021.0
,4063**

The various fields in the response are as follows:

Field	Range / Value	Description
Field 1:	**Space**	The message starts with a space.
Field 2:	**ABC**	Heater state and error flags.
		A = 1 - Window heaters ON.
		A = 2 – Hood Heaters ON.
		A = 4 - A/D control signal error.
		B = 1 - EPROM checksum error.
		B = 2 - Non-volatile memory checksum error.
		B = 4 - RAM error.
		B = 8 – Not used.
		C = 2 - Ired commanded OFF.
		C = 4 - Receiver test in progress (Ired OFF).
		C = 8 - Sensor power reset since last R? Command.
		or any combination of these.
Field 3:	2.450 - 2.550	Internal reference voltage.
Field 4:	9.00 - 36.00	Supply voltage.
Field 5:	11.2 - 17.5	Internal operating voltage.
Field 6:	4.5 - 5.5	Internal operating voltage.
Field 7:	11.2 – 17.5	Internal operating voltage.
Field 8:	0.00 - 6.00	Forward scatter background brightness.
Field 9:	0.00 - 6.00	Backscatter background brightness (not SWS-050 or SWS-100).
Field 10:	85 - 105	Transmitter power monitor.
Field 11:	80 - 120	Forward receiver monitor (option for SWS-100 and SWS-200).
Field 12:	80 - 120	Back receiver monitor (not SWS-050 or SWS-100, option for SWS-200).
Field 13:	00 - 99	Transmitter window contamination.
Field 14:	00 - 99	Forward receiver window contamination (option for SWS-100 and SWS-200).
Field 15:	00 - 99	Back receiver window contamination (option for SWS-200).
Field 16:		Temperature °C.
Field 17:	3300-4200	ADC interrupts per second.

Table 17 Command R? response

3.1.4 Command T? - Send Sensor Times Message

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

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

(default = 60).

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

(default = 5).

ccccc: Not used.

dddd: Not used.

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

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

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

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

3.2 Sensor Responses

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

Table 18 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.

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

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 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).

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 1.4.8 for details.

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

4.1.2 Hood Heaters (optional)

Hood heaters are fitted as standard on the SWS-050 and SWS-250 sensors, and are an option for the other models. They are fitted to the inside of each of the hoods (2 on the SWS-050 and SWS-100 with 3 on the SWS-200 and SWS-250). See Figure 4-1 Hood Heater.

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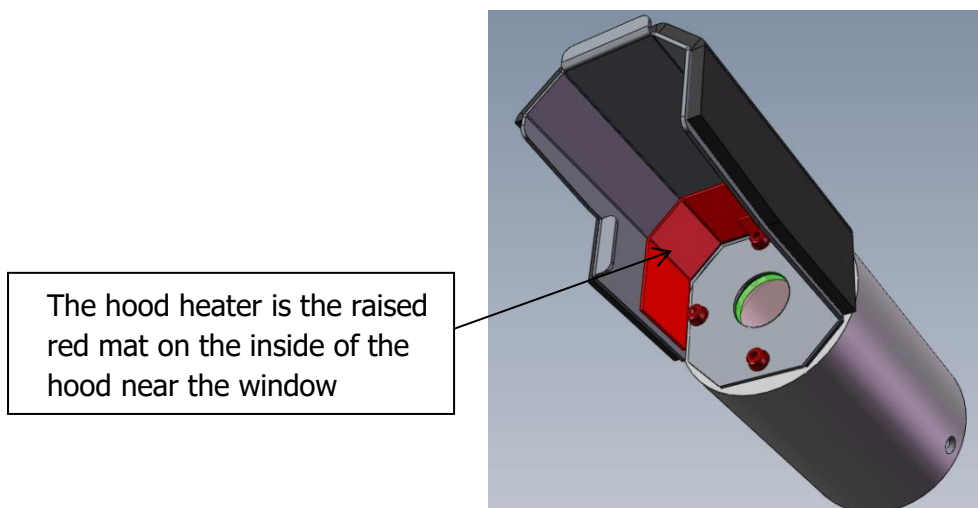

The hood heater is the raised red mat on the inside of the hood near the window

Figure 4-1 Hood Heater

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

4.1.3 Window Cleaning

SWS sensors are optical instruments 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 mild detergent solution or pure alcohol (propanol) and a soft cloth *(appropriate safety precautions must be taken when using pure alcohol)*.

All SWS sensors are fitted with a Transmitter Window monitoring system which compensates for contamination and will flag a warning when the contamination 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', all windows should be cleaned at the earliest convenient opportunity. If the contamination continues to increase above a pre-set limit (default 30%), the accuracy of the sensor may begin to deteriorate. The self-test monitoring message will change to 'F', and the windows should be cleaned as a matter of urgency.

The SWS-050 and SWS-250 sensors are additionally fitted with receiver window monitors. These monitor the forward scatter window and, if fitted, the back scatter window. This provides better accuracy if there is likely to be different contamination on each window. Receiver window monitoring is an available option for the SWS-100 and SWS-200 models.

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 3.1.3.

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 other problem associated with the installation.

4.2.2 **Central Character (Window Contamination)**

All SWS sensors have monitoring of contamination on the transmitter window. The processor compensates the visibility reading to allow for this contamination and also checks the contamination figure against a warning limit, WT, (default 10%) or the alert limit, WF, of (default 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**": Window contamination is less than warning threshold on all monitored windows. No action required.

"**X**": Window contamination warning. The window contamination is between WT and WF on one or more monitored windows and below WF on all monitored windows. The visibility reading provided is corrected utilising this contamination figure, but it is recommended that the windows are cleaned at the earliest possible opportunity.

"**F**": Window contamination alert. The window contamination is above WF on one or more monitored window. Although the

visibility reading is still corrected using this contamination figure, the accuracy may deteriorate as the contamination increases. The windows require cleaning.

The values of WT and WF can be queried and set using the WT and WF commands as described in section 3.1.

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

4.2.3 Least Significant Character (Other Self-Test errors)

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

"O":   No Fault. No action required.

"X":   Internal error. Send command "R?" to list all internally monitored parameters. Check against paragraph 3.1.3 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.

"F" (250 only): This indicates that the Forward scatter receiver is saturated with a bright light source (such as direct view of the sun). This will affect the visibility reading and any precipitation readings. If possible, the sensor should be repositioned (see section 1.5.3) to prevent this occurrence.

"B" (250 only): This indicates that the Backscatter receiver is saturated with a bright light source (such as direct view of the sun). This will affect the visibility reading and any precipitation readings. If possible, the sensor should be repositioned (see section 1.5.3) to prevent this occurrence.

4.3 User Confidence Checks

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

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

4.3.1 Calibration Check

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

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

4.3.2 Window Monitor Checks

All SWS sensors monitor the transmitter window for contamination. The values measured are used to adjust the MOR value, and are also used to determine when the windows should be cleaned.

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

Transmitter Window Monitor

Step 1. Clean the transmitter window.

Step 2. Send the command: R?

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

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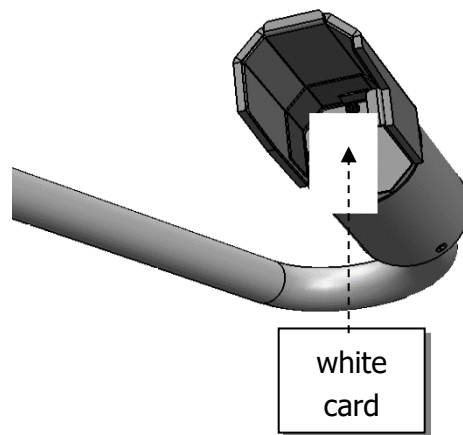
Figure 4-2 Transmitter Hood with White Card

Step 5. Send the command: R?

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

Step 7. Remove the white card.

Receiver Window Monitor(s)

This procedure is used for the forward scatter receivers on the SWS-050 sensor (optional on the SWS-100) and both the forward and back scatter receivers on the SWS-250 sensor (optional on the SWS-200). Carry out the following procedure for the forward scatter window, and then the backscatter window if applicable.

Step 1. Clean the forward (or back) 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 (or Back) Scatter Receiver Window Contamination' field value is 00 to 02.

Step 5. Insert a white card in the forward (or back) 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 (or Back) Scatter Receiver Window Contamination' field value is much greater than 10 (i.e. 99).

Step 9. Remove the white card.

Note: *A delay of 5 minutes is introduced between a window contamination threshold being exceeded and the appropriate flag being set in the data message. This delay is introduced to remove repeated warnings caused by transient events such small water droplets being deposited on the windows. Small droplets evaporate quickly due to the heated windows.*

4.3.3 Receiver Background Brightness Measurement Checks

The receiver background brightness value measures the optical signal detected by the receiver caused by the ambient background. This value is used to set the threshold values for precipitation particle detection. The following procedure will check this function for the forward scatter receiver on all SWS sensors, and additionally the backscatter receiver on models SWS-200 and SWS-250.

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

Step 2. Send the command: R?

Step 3. Verify that the value in the 'Forward (and Back) Scatter Receiver Background Brightness' field is less than 00.06. (forward scatter is field 8, backscatter is field 9, see section 3.1.3).

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

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

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

Step 6. Verify that the value in the 'Forward (and Back) 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.

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

</div>

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

The calibration of the forward scatter EXCO for all sensors, and the backscatter EXCO for SWS-200 and SWS-250 sensors, are checked using the procedure detailed in section 5.2.

The Calibration Reference Plaque used for the calibration check has been assigned a forward scatter calibration value and a backscatter calibration value. These values are shown on the label on the arm of the Calibration Reference Plaque.

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

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

Assembly of the Calibration Reference Plaque is shown in Figure 5-1. This shows it attached to a SWS-200, but the assembly is identical for all other models in this range.

5.1 Calibration Plaque Identification

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

In January of 2014 the main IRED light source of the SWS sensor family was changed from a device operating at 880nm to one operating at 850nm; this change was necessary due to component obsolescence. A consequence of the change of wavelength is that calibration plaques intended for use at 880nm are not compatible with sensors operating at 850nm and vis versa.

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

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

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

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

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

5.2 Calibration Check

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

1. A SWS Calibration Kit.

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

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CALIBRATION CHECK NOTES

PLEASE READ THESE NOTES BEFORE CONTINUING

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

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

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

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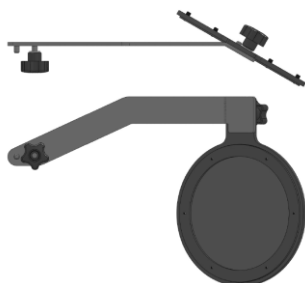
Step 1. Attach the arm to the round calibration screen.
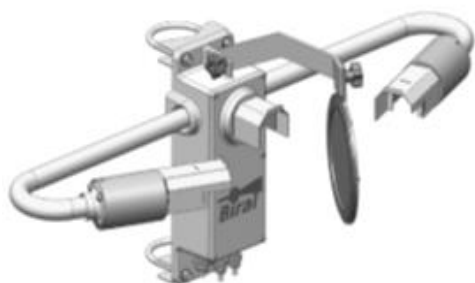
Step 2. Fix this assembled calibration reference plaque to the sensor as pictured to the left.

</div>

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

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

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

Zero Check:

STEP 3:   Insert GREY FOAM PLUGS in the front of each window blocking out all light. There are 3 foam plugs top left in the calibration case - you will only use 2 of these for the SWS-050 or SWS-100.

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:   **SWS-200 and SWS-250 ONLY**: Send the command "BB? <crlf>". Verify that the response value is between -1.0 and +1.0.

STEP 8:   Remove the foam plugs.

Gain Check:

STEP 9:   Send the command "RST<crlf>" to restart the sensor.
Verify the response is "OK".

STEP 10:   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 11: 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 12: **SWS-200 and SWS-250 ONLY**: Send the command "BB? <crlf>". Verify that the response value is within ± 20% of the backscatter calibration value assigned to the Calibration Reference Plaque.

STEP 13: 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 68.

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

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

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

STEP 3. Send command: CE.
Sensor replies:
> CLEAN WINDOWS,
> BLOCK FWD SCAT RCVR OPTICS,
> BLOCK TRANSMITTER OPTICS
> BLOCK BK SCAT RCVR OPTICS (*not for the SWS-050 or SWS-100*)
> INSTALL REF STD,
> ENTER FWD SCAT VALUE
> FORM: XXX.XX

STEP 4. Fit the grey foam plugs supplied with the calibration kit against all three of the windows; only two are needed for the SWS-050 and SWS-100.

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

STEP 6.   **SWS-200 and SWS-250 Only**
               Sensor replies:
                         ENTER BACK SCAT VALUE
                         FORM: XXX.XX
               Enter the back scatter calibration value from the calibration reference plaque.

STEP 7.   Sensor replies:
                         CAL IN PROGRESS
               Wait for approximately 2 minutes.
               Sensor replies:
                         REMOVE OPTICS BLOCKS,
                         ENTER   "OK"

STEP 8.   Remove grey foam plugs from all windows and send text: OK.
               Sensor replies:
                         CAL CONTINUES

STEP 9.   Wait for approximately 2 minutes.
               Sensor replies:
                         CAL COMPLETE
                         REMOVE REF STD
               Note: Do not remove the calibration reference plaque at this point.

STEP 10.   Wait for the third data message to be received at the PC.

STEP 11.   Send the command BT? and note the response value.

STEP 12.   **SWS-200 and SWS-250 Only**
               Send the command BB? and note the response value.

STEP 13.   If the response to the BT? command is within ±3% of the forward scatter calibration value of the plaque, and the response to the BB? command is within ±5% of the backscatter calibration value of the plaque then the sensor is within its calibration limits. The sensor can be returned to its operational configuration with confidence. If the values are outside these limits carefully repeat the calibration procedure. If the limits are again exceeded contact Biral.

5.4 Precipitation Amount Calibration

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

This section is only applicable to models SWS-200 and SWS-250.

This process provides for adjusting the calibration factor of the sensor precipitation measurement. The amount of adjustment to this factor is determined by making an independent measurement of the liquid accumulation over several rain episodes and comparing the accumulation reported by the sensor to this independently measured accumulation.

The value to be entered to adjust the precipitation amount factor is calculated as follows:

$$\text{Value entered} = \frac{\text{Desired precipitation accumulation}}{\text{Sensor's reported precipitation accumulation}} * 100$$

EXAMPLE: Over several rainstorms, a reference sensor measures an accumulation of 225 millimetres. The SWS sensor reported an accumulation of 244 millimetres. To adjust the sensor's precipitation accumulation factor, the value to be entered is:

$$\frac{225}{244} \text{ x } 100 = 92.2$$

The suggested procedure to be used for precipitation amount calibration is as follows:

STEP 1.   Send the parameter command: "CO". The sensor replies: OK.

STEP 2.   Send the precipitation amount calibration command: "CA". Sensor replies:

ENTER PRECIP AMT ADJ FACTOR
IN PERCENT (30.0 TO 300.0)
FORM: XXX.X

STEP 3.   Send the required adjustment factor: (e.g. 92.2). Sensor replies:

CAL COMPLETE

STEP 4.   The precipitation amount calibration process is complete.

6 PRODUCT OVERVIEW

6.1 SWS Series Visibility and Present Weather Sensors

There are five models in the SWS series of present weather sensors, four of which are covered in this manual, they are SWS-050, SWS-100, SWS-200 and SWS-250. They all use the same basic opto-mechanical and electronic components and have an optical transmitter and forward scatter receiver. The SWS-200 and SWS-250 also have a backscatter receiver to aid in precipitation identification.

All models have the same time-proven software for measuring visibility and precipitation type and performing remote self-test diagnostics.

The measurement capabilities of the models are as follows:

Sensor Model   **Capability**

SWS-050   Visibility
                    Obstruction to Vision

SWS-100   Visibility
                    Precipitation type identification
                    1 Fault relay switch
                    1 Relay for visibility
                    1 Relay for precipitation, window contamination or visibility

Figure 6-1 SWS-050 and SWS-100 Capabilities

Sensor Model   **Capability**

SWS-200   Visibility
Precipitation type identification
1 Fault relay switch
1 Relay for visibility
1 Relay for precipitation, window contamination or visibility

This model has an extra backscatter receiver for:
Rain rate
Snowfall rate
Precipitation accumulation

SWS-250   Visibility
Precipitation type identification
Rain rate
Snowfall rate
Precipitation accumulation

This model will additionally report:
42 weather codes (from WMO
Code Table 4680), including
Past weather
Freezing Fog
Ice Pellets

Figure 6-2 SWS-200 and SWS-250 Capabilities

6.1.1 **Sensor Components**

Each sensor 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 sensor. All models are shipped fully assembled and calibrated.

6.1.2 **Optional Items**

Hood Heaters (standard on the SWS-050 and SWS-250)

Heaters for the transmitter and receiver hoods. These are to minimise any build-up of ice within the optical paths. They require 12W per hood, supplied from an independent customer supplied source of 24 V, either AC or DC (Not to be confused with window heaters which are included in all sensors).

Analogue Data Output (only applicable to SWS-100 and SWS-200)

In addition to the standard 0 to 10V MOR analogue output, a 4 to 20mA or 0 to 20mA current loop output can be supplied. The type of current output must be specified by the customer when ordering the sensor.

Window Contamination Monitoring

All SWS sensors have continual monitoring of the transmitter window contamination, with automatic compensation of the visibility measurements. Additional monitoring of the receiver window(s) is provided as standard on the SWS-050 and SWS-250, but is optional on the SWS-100 and SWS-200. This provides additional warning of localised contamination build-up on all sensor windows. See "window monitoring" information in section 4.2 Self-Test Codes.

6.1.3 **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 sensor calibration is being checked, see section 5 for a full description of the calibration process.

Transit Case

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

Mains Adapter

A mains adapter is available if required.

Power and Signal 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. 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 2.5 Data Message Variations For ALS-2.

6.2 Sensor Features

The SWS sensors are both visibility sensors and present weather sensors. They have the necessary optimum configuration for accurate measurement of visibility in the densest of fogs to very clear air conditions. They can detect the onset of precipitation as readily as a human observer and can measure the size and velocity of precipitation particles. Unique patented techniques utilising precipitation size/velocity distributions and backscatter/forward scatter ratios provide essentially error-free identification of the type of precipitation. False alarms and false identifications are kept to a minimum by the application of empirically derived algorithms sensitive to the characteristic of electronic noise and insects. Also unique is the sensor's capability for separating the contribution of extinction due to precipitation from the total atmospheric extinction coefficient, thus giving the sensor the capability to identify fog whenever it is simultaneously present during a precipitation episode.

In addition to its optimal and unique measurement capabilities, the SWS sensor has a number of distinctive physical features:

Compactness:

The sensor is a single package, small in size and low in 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 thousands 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.

6.3 Present Weather Measurements

6.3.1 Present Weather Definition

The term "Present Weather" is generally employed to define a large class of atmospheric phenomena that includes tornado activity, thunderstorm activity, precipitation, obstructions to vision, and "other atmospheric phenomena" such as aurora. For purposes of Automated Present Weather Sensors, the term "present weather" is restricted to those atmospheric phenomena that are local to the sensor. These phenomena include:

1. All forms of liquid and frozen precipitation; e.g., rain, drizzle, snow, snow pellets, snow grains, ice pellets (formerly sleet) and hail, and
2. Those suspended particles that are classed as obstructions to vision; namely, mist, fog, haze, dust and smoke.

6.3.2 Automated Measurements

The present weather sensor utilises microprocessor technology to perform automatic visibility, precipitation and temperature measurements. The standard version is DC power operated; however, a mains converter is also available. Patented techniques are employed to identify precipitation and to determine the presence of fog during episodes of precipitation.

6.4 Visibility Measurements

6.4.1 Visibility Measurement Capability

The visibility measurement capabilities of the sensor are summarised in Table 19. 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.

Note: Definitions of haze and fog may change dependent on the country of use. These definitions can be adjusted at time of manufacture for SWS200 and SWS250 sensors, in conjunction with the precipitation intensity definitions, see section 6.5.2 for details. The above definitions for haze and fog are always used by the SWS050 and SWS100 sensors.

In the presence of precipitation, the sensor software measures the fraction of the atmospheric extinction coefficient due to precipitation and subtracts it from the total extinction coefficient to obtain a quantity we have named EXCO-EVENTS. If the value of EXCO-EVENTS is greater than 3.00 (MOR less than 1km), then fog is declared to be present in addition to the precipitation as an obstruction to vision.

Function	Details
Meteorological Optical Range (MOR)	**SWS-050 –** 10m to 40km **SWS-100 and SWS-200 -** Selectable from the following options at time of order: 10m to 2km 10m to 10km 10m to 20km 10m to 32km 10m to 50km 10m to 75km Other ranges between 10m and 99.99km by special request. **SWS-250 –** 10m to 75km Other ranges between 10m and 99.99km by special request.
Measurement Accuracy	MOR ~ 10km Better than 10% MOR ~ 20km Better than 15% MOR ~ 30km Better than 20%
Obstruction to vision	Identifies Fog or Haze (Precipitation Absent). Identifies Fog in Presence of Precipitation.

Table 19 Visibility measurement capabilities

6.5 Precipitation Measurements

6.5.1 **Precipitation Measurement Sensitivity**

The sensor identifies a variety of forms of precipitation, dependent on the model selected. Detection of the onset of precipitation in all the sensors is extremely sensitive, being 0.00025 mm per minute for rain and approximately 0.000025 water equivalent mm per minute for frozen precipitation. The actual limits of measurements are given in Table 20.

Function	Details
Liquid Precipitation (minimum detection limit):	0.00025 mm/min (0.00001 in/min). 0.015 mm/hr (0.00060 in/hr).
Snow (H_2O Equivalent) (minimum detection limit)	0.000025 mm/min (0.000001 in/min). 0.0015 mm/hr (0.000060 in/hr).
Precipitation rate (maximum)	Rain – Up to 500 mm/hr (20 in/hr). Snow – Rain Equivalent up to 500 mm/hr (20 in/hr).

Table 20 Precipitation measurement limits

6.5.2 **Precipitation Intensity Measurements**

In addition to the basic precipitation identification, carried out in the SWS-100, SWS-200 and SWS-250 sensors, the SWS-200 and SWS-250 sensors are designed to measure the intensity of precipitation. The intensity for each type of precipitation is classified as slight, moderate or heavy.

Intensity of precipitation may be defined differently from one country to another. In both the United Kingdom and the United States, the intensity of precipitation is defined differently for drizzle and rain than for snow. For drizzle and rain, the intensity (slight, moderate and heavy) is based on the rate of fall of precipitation. For snow the intensity is based on visual range. In classifying precipitation intensity, the sensor utilises the precise definitions given by the UK CAA CAP 746 document. These definitions are given in the table below (Table 21).

Note: If a sensor is intended for installation in a country where the definitions of precipitation intensity differ from the U.K. definitions, it is possible for the sensor to be produced with the appropriate definitions installed. BIRAL must be informed of this requirement at the time of order.

The precipitation intensity definitions used are specified on the sensor's calibration certificate.

UK Precipitation Definitions

Based on CAA CAP 746 'Requirements for Meteorological Observations at Aerodromes'

Drizzle

Slight	A trace to 0.26mm/hour.
Moderate	Greater than 0.26mm/hour to 1.0 mm/hour.
Heavy	More than 1.0 mm/hour.

Rain

Slight	A trace to 1.0 mm/hour.
Moderate	Greater than 1.0 mm/hour to 3.99 mm/hour.
Heavy	More than 3.99mm/hour.

Snow

Slight	Visibility greater than 800m.
Moderate	Visibility between 400 and 800 metres.
Heavy	Visibility less than 400 metres.

Table 21 UK precipitation intensity definitions

6.5.3 **Precipitation Reporting**

Any precipitation identified is reported according to the present weather codes from the WMO table 4680 (Automatic Weather Station). Additionally, the SWS-250 reports METAR present weather codes, see Table 14 METAR codes. The WMO codes utilised by each SWS sensor model are listed below.

Present Weather Codes – SWS-050

Code	Description
XX	Not Ready (first 5 measurement periods from restart).
00	No Significant weather observed.
04	Haze or smoke.
30	Fog.

Table 22 SWS-050 WMO codes

Present Weather Codes – SWS-100

Code	Description
XX	Not Ready (first 5 measurement periods from restart).
00	No Significant weather observed.
04	Haze or smoke.
30	Fog.
40	Indeterminate precipitation type.
50	Drizzle.
60	Rain.
70	Snow.

Table 23 SWS-100 WMO codes

Present Weather Codes – SWS-200

Code	Description
XX	Not Ready (first 5 measurement periods from restart).
00	No Significant weather observed.
04	Haze or smoke.
30	Fog.
40	Indeterminate precipitation type.
51	Light Drizzle.
52	Moderate Drizzle.
53	Heavy Drizzle.
61	Light Rain.
62	Moderate Rain.
63	Heavy Rain.
71	Light Snow.
72	Moderate Snow.
73	Heavy Snow.
89	Hail.

Table 24 SWS-200 WMO codes

Present Weather Codes – SWS-250

Code	METAR	Description
XX		Not Ready (first 5 minutes from restart).
00		No significant weather observed.
04	HZ	Haze, visibility greater than or equal to 1km.
11	IC	Diamond Dust.
20		Fog in last hour but not at time of observation.
21		Precipitation in last hour but not at time of observation.
22		Drizzle in last hour but not at time of observation.
23		Rain in last hour but not at time of observation.
24		Snow in last hour but not at time of observation.
28	BLSN	Blowing or drifting snow, visibility ≥ 1km.
29	+BLSN	Blowing or drifting snow, visibility < 1km.
30	FG	Fog.
31	BCFG	Fog in patches.
32	FG	Fog becoming thinner in last hour.
33	FG	Fog no appreciable change in last hour.
34	FG	Fog begun or becoming thicker in last hour.
35	FZFG	Freezing Fog.
40	UP	Indeterminate precipitation type.
51	-DZ	Drizzle, not freezing, slight.
52	DZ	Drizzle, not freezing, moderate.
53	+DZ	Drizzle, not freezing, heavy.
57	-RADZ	Drizzle and Rain, slight.
58	RADZ	Drizzle and Rain, moderate.
58	+RADZ	Drizzle and Rain, heavy.
61	-RA	Rain, not freezing, slight.
62	RA	Rain, not freezing, moderate.
63	+RA	Rain, not freezing, heavy.
67	-RASN	Rain (or Drizzle) and Snow, slight.
68	RASN	Rain (or Drizzle) and Snow, moderate.

Code	METAR	Description
68	+RASN	Rain (or Drizzle) and Snow, heavy.
71	-SN	Snow, slight.
72	SN	Snow, moderate.
73	+SN	Snow, heavy.
74	-PL	Ice Pellets, slight.
75	PL	Ice Pellets, moderate.
76	+PL	Ice Pellets, heavy.
77	SG	Snow Grains .
78	IC	Ice Crystals.
81	-SHRA	Rain Showers, slight.
82	SHRA	Rain Showers, moderate.
83	+SHRA	Rain Showers, heavy .
85	-SHSN	Snow Showers, slight.
86	SHSN	Snow Showers, moderate.
87	+SHSN	Snow Showers, heavy.
89	GR	Hail.
89	GS	Small Hail / Graupel.

Table 25 SWS-250 WMO and METAR codes

6.5.4 **Precipitation Recognition Matrix**

The SWS series of sensors measure the amplitude and duration of the light pulse created by each precipitation particle as it falls through the sample volume. From the amplitude and duration it then determines the particle size and velocity. The size and velocity information is collected in a data matrix by the microcomputer and is stored for a time interval (the measurement time period, usually one minute) adequate to provide a statistically significant and representative sample of particle sizes and velocities. The size and velocity distributions of particles in the matrix are available to determine the type of precipitation. Small numbers of particles with distributions not indicative of rain or snow are considered not to be precipitation and are rejected by false alarm algorithms.

Once precipitation occurrence has been determined, the particle size distribution is used to measure the intensity. To measure the intensity, the number of particles in each size bin of the matrix are summed, and then multiplied by the equivalent volume of water and a calibration constant. If the precipitation is identified as snow, a density factor is applied to determine the equivalent water content.

Because the size/velocity matrix is a convenient presentation for identifying various forms of precipitation we have termed it the "Precipitation Recognition Matrix". Types of precipitation are identified from their "Signature" in the Precipitation Recognition Matrix. The "Signature" is the particle size/velocity distribution that is characteristic of each type of precipitation phenomena.

An example of a precipitation recognition matrix is shown in Figure 6-3 Precipitation Recognition Matrix. This figure portrays a 16 x 21-matrix array of particle sizes and velocities. Sizes are arranged in columns and velocities in rows.

COLUMNS		
NO.	Equivalent Particle Radius (mm)	
1	<0.200	
2	.200-.250	
3	.250-.300	
4	.300-.350	
5	.350-.400	
6	.400-.450	
7	.450-.500	
8	.500-.550	
9	.550-.600	
10	.600-.650	
11	.650-.700	
12	.700-.800	
13	.800-.950	
14	.950-1.130	
15	1.130-1.345	
16	1.345-1.600	
17	1.600-1.900	
18	1.900-2.260	
19	2.260-2.690	
20	2.690-3.200	
21	>3.200	

ROWS		
NO.	Particle Velocity (m/sec.)	
1	.40-.70	
2	.70-1.20	
3	1.20-1.62	
4	1.62-2.06	
5	2.06-2.87	
6	2.87-3.67	
7	3.67-4.35	
8	4.35-4.90	
9	4.90-5.65	
10	5.65-7.00	
11	7.00-8.26	
12	8.26-10.76	
13	10.76-12.73	
14	12.73-15.55	
15	15.55-20.00	
16	>20.00	

Figure 6-3 Precipitation Recognition Matrix

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6.6 Sensor Specifications

The specifications for all versions of the SWS sensor series are summarised in the following pages. Where certain specifications are only applicable to certain models within the range, this is stated within that table.

Visibility Measurement

Function	Details
Measurement Range – MOR (Meteorological Optical Range)	**SWS-050 –** 10m to 40km **SWS-100 and SWS-200 -** Selectable from the following options at time of order: 10m to 2km 10m to 10km 10m to 20km 10m to 32km 10m to 50km 10m to 75km Other ranges between 10m and 99.99km by special request. **SWS-250 –** 10m to 75km Other ranges between 10m and 99.99km by special request.
Measures:	Visibility (MOR – Meteorological Optical Range), reductions caused by: fog, haze, smoke, sand, drizzle, rain, snow and general precipitation.
Measurement Accuracy	MOR ~ 10km Better than 10% MOR ~ 20km Better than 15% MOR ~ 30km Better than 20%
Measurement Time Constant	30 seconds

Table 26 Visibility Measurement

Stability of MOR Zero Setting

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

Table 27 Zero Stability

Precipitation Measurements (Not SWS-050)

Function	Details
Detection Threshold: Rain	0.015mm/hr (0.0006 in/hr.)
Detection Threshold: Snow (H_2O Equivalent)	0.0015mm/hr (0.00006 in/hr.)
Rain Rate (Maximum)	~ 500mm/hr (20 in/hr.)

Table 28 Precipitation Measurement

Maintenance

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

Table 29 Maintenance

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6.7 Sensor Characteristics

Physical

Function	Details
Scattering Angle	45° with ± 6° cone angle
Sample Volume	400 cm^3
Weight SWS-050 and SWS-100 SWS-200 and SWS-250	3.8Kg (4.3Kg including pole mounting kit) 4.0Kg (4.5Kg including pole mounting kit
Length	0.81 m

Table 30 Physical Characteristics

Light Source

Function	Details
Type	IRED
Central Wavelength	0.85μm
Bandwidth	0.04μm
Lifetime	>10 years
Modulation Frequency	2,000 Hz

Table 31 Light Source

Detector

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

Table 32 Detector Characteristics

Temperature Sensor

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

Table 33 Temperature Sensor Characteristics

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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)	**SWS-050 and SWS-100** 24W **SWS-200 and SWS-250** 36W **Additional for ALS-2 option** 12W
Additional Power for: No-Dew Window Heaters	**SWS-050 and SWS-100** 1.7W **SWS-200 and SWS-250** 2.5W
Additional Power for ALS-2 Option	1.2 W no window heater 2.0 W with window heater

Table 34 Power Requirements

Environmental

Function	Details
Sensor Operating Temperature Range	-40°C to +60°C
Altitude	0 to 20,000 ft
Precipitation	All weather
Humidity	0 to 100%
Protection Rating	IP66/67
CE Certified	√
EMC Compliant	EN61326-1 2006
RoHS and WEE Compliant	√

Table 35 Environmental Specifications

6.8 Digital Communication Interface

Communication Protocol

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

Table 36 Communication Protocols

Communication Parameters:

Function	Details
Baud Rates (User selectable)	1200 Baud to 57K6 Baud (Default 9600 Baud)
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None
Message Termination	<CR,LF>
Message Checksum:	Selectable (sum modulo 128) for RS232/422 LRC for RS485
Reporting Interval	Programmable (Response to poll, or Automatic at programmable intervals: 10 seconds to 5 minutes; 1 minute typical)
Message Content:	• Sensor Identification Number (Programmable) • Reporting Interval (seconds) • Meteorological Optical Range (Kilometres) • Precipitation Type • Obstruction to Vision (Fog, Haze, None) • Precipitation Amount (One Minute Interval) • Temperature (Not SWS-050 or SWS-100) • Remote Self-Test & Monitoring Flags • Date and time tags

Table 37 Communication Parameters

6.9 Analogue Outputs

These are available only on models SWS-100 and SWS-200.

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} (option) 0 to 20 mA. Equivalent to 0 to MOR_{MAX} (option)

Table 38 Analogue Outputs

6.10 Relay Outputs

These are available only on models SWS-100 and SWS-200.
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 0.10 km to 20km or $MOR_{MAX.}$
Relay # 2	Settable for visibility range 0. 10 km to 20km or $MOR_{MAX.}$ **OR** Triggered by presence of Precipitation **OR** Triggered by presence of Snow **OR** Window contamination
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 39 Relay specification

6.11 Sensor Remote Self-Test Capabilities

- Optical Source Power.
- Forward Scatter Receiver Sensitivity.
- Back Scatter Receiver Sensitivity (not SWS-050 or SWS-100).
- Transmitter Window Contamination.
- Forward Scatter Receiver Window Contamination (optional on SWS-100 and SWS-200).
- Back Scatter Receiver Window Contamination (optional on SWS-200).
- Power Supply Voltages.
- Non-Volatile Memory Checksum Test.
- EPROM Check-Sum Test.
- Restart Occurrence.
- Sensor Sample Interrupt Verification.
- RAM Read/Write Verification.
- A/D Control Signal Test.
- A/D Conversion Accuracy Check.
- Input Voltage Check.
- Forward Scatter Background Illumination Level.
- Back Scatter Background Illumination Level (SWS-200 and SWS-250 only).

6.12 SWS Sensors – External Dimensions

All SWS sensors have dimensions as shown below. The diagrams show the SWS-200 and SWS-250 versions. The SWS-050 and SWS-100 versions do not have the backscatter hood and window.
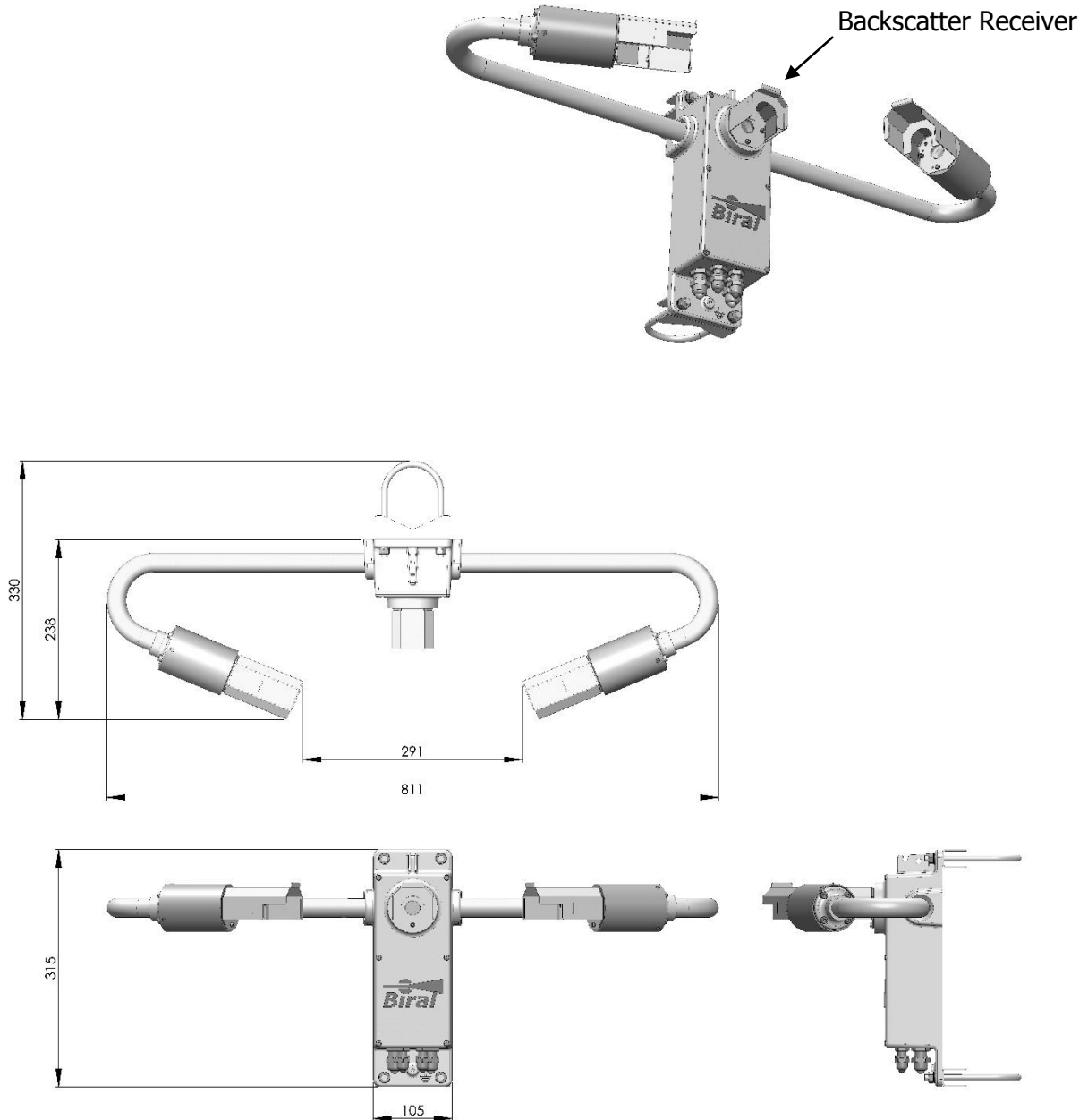
Dimensions in mm

Figure 6-4 External Dimensions of SWS Sensors

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R

S

T

V

W

Notes:

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