OPERATION and MAINTENANCE MANUAL

SWS Present Weather Sensors

SWS-100
SWS-200

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

Tel: +44 (0)1275 847787

Fax:+44 (0)1275 847303

Email: info@biral.com

www.biral.com

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CONTENTS

Index Of Figures

Index Of Tables

General Information

The sensors covered in this manual :

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

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

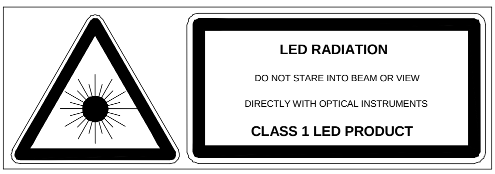
This model has an extra backscatter receiver for:

Rain rate
Snowfall rate
Precipitation accumulation

PATENT COVERAGE

The Present Weather Measurement Techniques are protected by the following Patents.

U.S. Patent No.	4,613,938
Canadian Patent No.	1,229,240
German Patent No.	3,590,723



CE

RoHS compliant

Biral

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 onboard 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
- **switching of external equipment based on both visibility and precipitation outputs** (ie fog and rain, or fog and snow or 2 different fog thresholds).
- **connection to a fail safe system is easy** using the fault relay output
- **identification of precipitation type as well as accumulation totals** (SWS-200 only)

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 on the following page.

(NB For your convenience our contact details are also on the label fixed to your sensor)

Contacting Biral

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

For enquiries and technical support:

Contact us by telephone on :	+ 44 (0)1275 847787
Contact us by fax on :	+ 44 (0)1275 847303
Contact us by e-mail at :	service@biral.com

Two year warranty

The SWS Present Weather Sensors come with a two 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

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.

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.

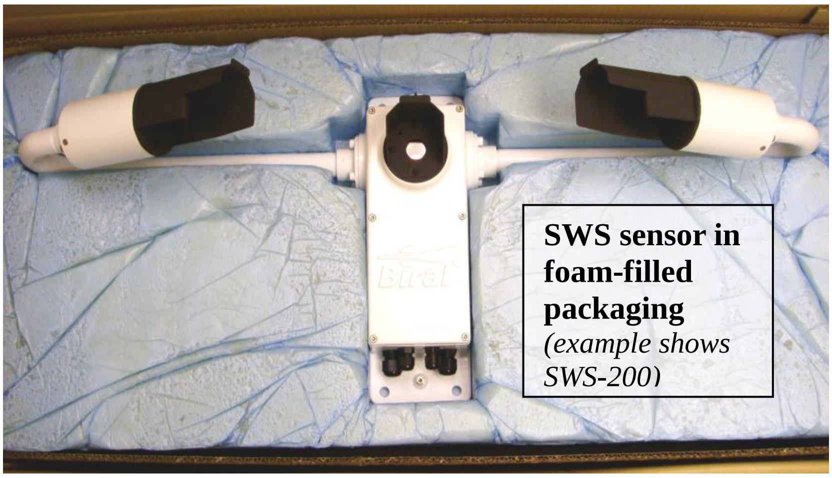
Step 4 - Configure equipment as required for site installation.

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

Step 6 - Carry out commissioning test procedure.

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:

- 3 m auxiliary RS232 cable
- U-bolts for pole mounting
- 2 off ferrites for cable EMC protection
- Documentation
- other optional items you may have ordered

Figure 1 SWS-200 in packing

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

Calibration Kit

The calibration kit in a protective carrying case, containing: a calibration screen, mounting arm and connector (referred to as the calibration reference plaque when assembled) and 3 x grey foam plugs (hiding in the top left hand corner of the case!).

Transit Case

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

Mains Adapter - a mains adapter to operate the sensor using mains power.

Power and Signal Cables

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

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. *Apart from a 3 m auxiliary RS232 cable for connection to your junction box (enabling future checks and maintenance to be carried out without removing the sensor cover).*

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

A 24AWG stranded (7/32) or solid wires 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.

1.2.2 Cable Glands

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

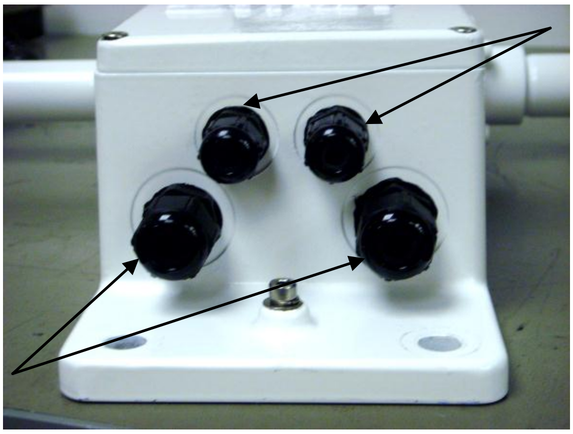


Figure 2 Cable Glands

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

- the 2 small cable glands for cables between 3.5 to 7.00mm diameter
- the 2 larger glands 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 rods to retain the integrity of the weatherproof housing.

1.2.3 Connecting the power supply and signal cable

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

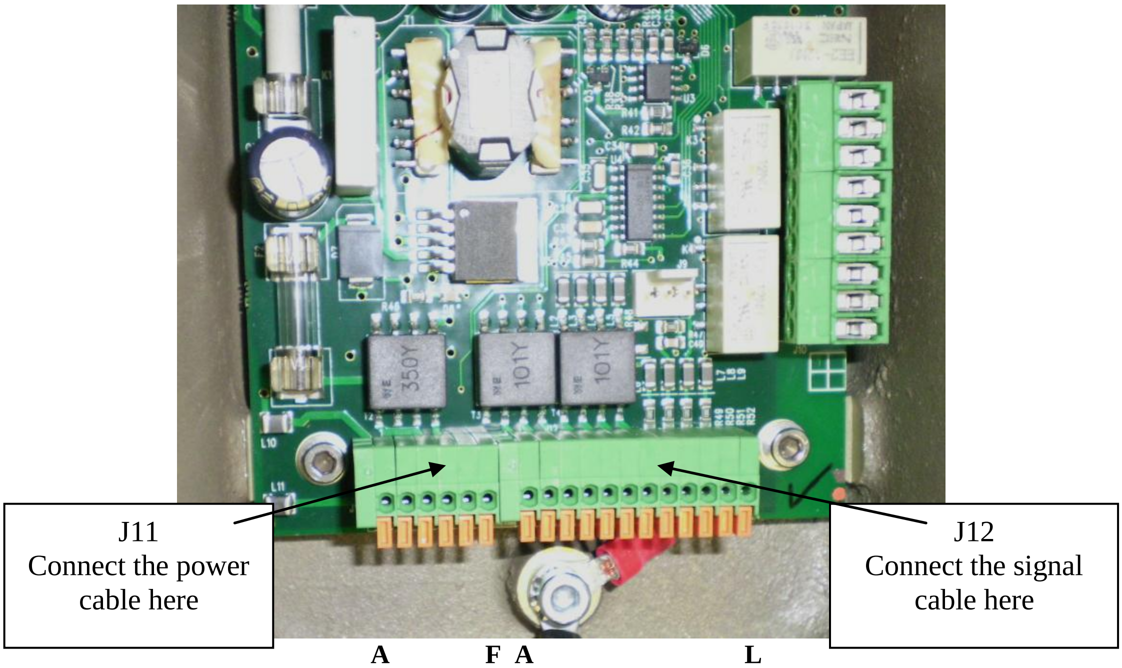


Figure 3 Power and signal connections

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:

For models WITHOUT optional hood heaters

All models in this range require an input voltage supply between 9 and 36V DC. Typically 24V DC supply at 3.5W.

See figure 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.

For models WITH the optional hood heaters

The hood heaters are wired independently and isolated from the instrument power. These should be powered from a 24V supply of either AC or DC. The SWS-100 will draw 24W from this source, and the SWS-200 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.

Pin connections for power supply

Pin Number	Designation
J11/A	Hood Heater Supply (Option) 24VAC or DC
J11/B	Hood Heater Return (Option) 24VAC or DC
J11/C	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 either RS232 OR RS422 OR RS485 communications. It is not possible to operate both the RS232 and the RS422/RS485 together.
If there is to be a long distance between the sensor and its control computer (more than 40 metres), then the RS422 or RS485 configuration should be used and a RS422 communications port installed in the control computer. RS232 may be used up to 100 m but reliable communications cannot be guaranteed for more than 40 m.

Pin Number	Designation
J12/A	RS232/422 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

Jumper J7, located as shown in Figure 4, needs to be set to select which serial format is in use. Set to link pins 2 and 3 for RS 232 communications. Set to link pins 1 and 2 for RS422/RS485 communications.

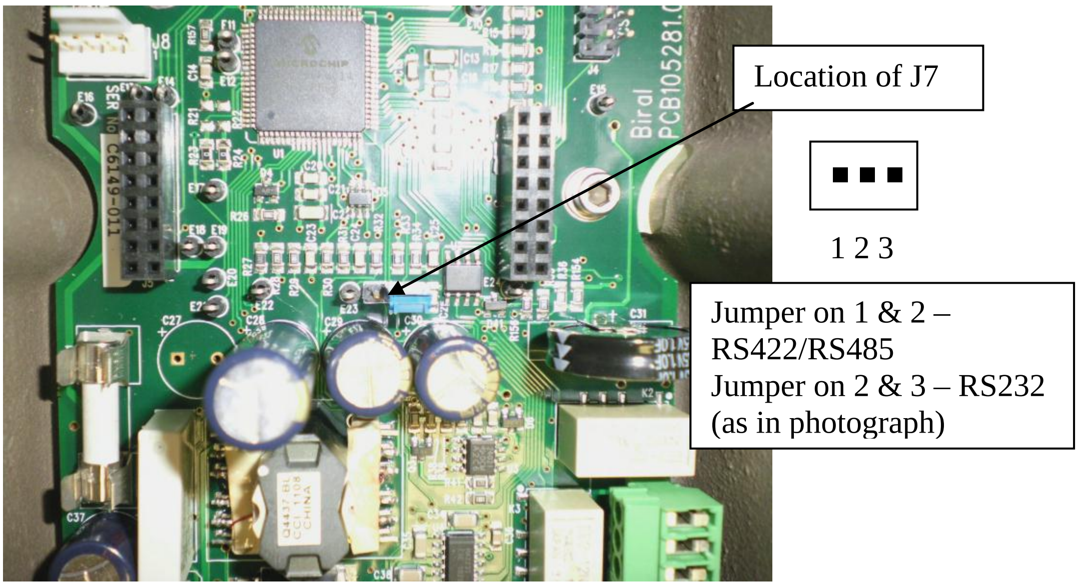
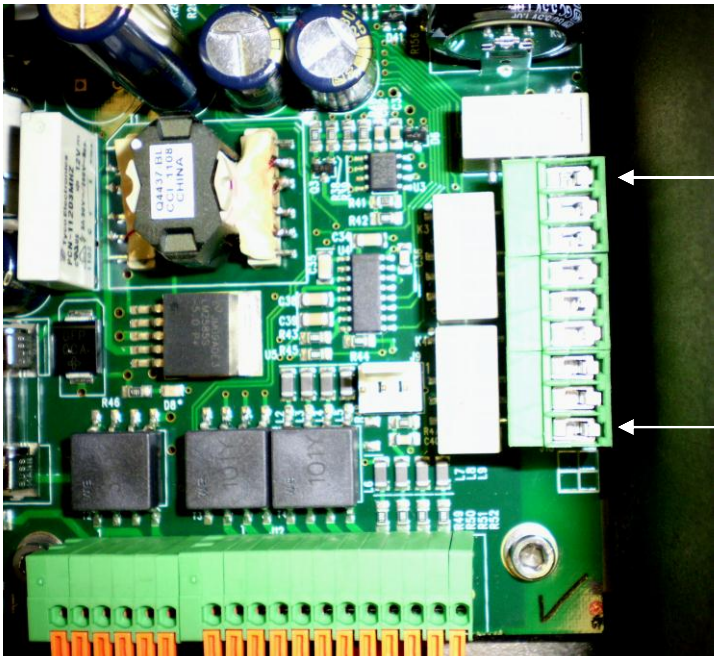


Figure 4 Location of J7, RS232/422/485 select

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 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 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 5 Relay connections
Relay contacts are rated 2A, 250V AC.

For ease of assembly it is recommended that 22AWG stranded (7/30) or solid wires are used, or equivalent. 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 is correct for the switching application requirement.

1.2.5 Auxiliary RS232 connection to your junction box (if required)

A three pin connector on the main circuit board is available for an auxiliary RS232 connection to a local terminal. If connected it takes precedence over the fixed RS232 connection allowing checks and maintenance to be carried out without removing the sensor cover and disconnecting the data cable.

A 3 m auxiliary RS232 cable is supplied with the sensor to make this connection.

Connections for auxiliary cable

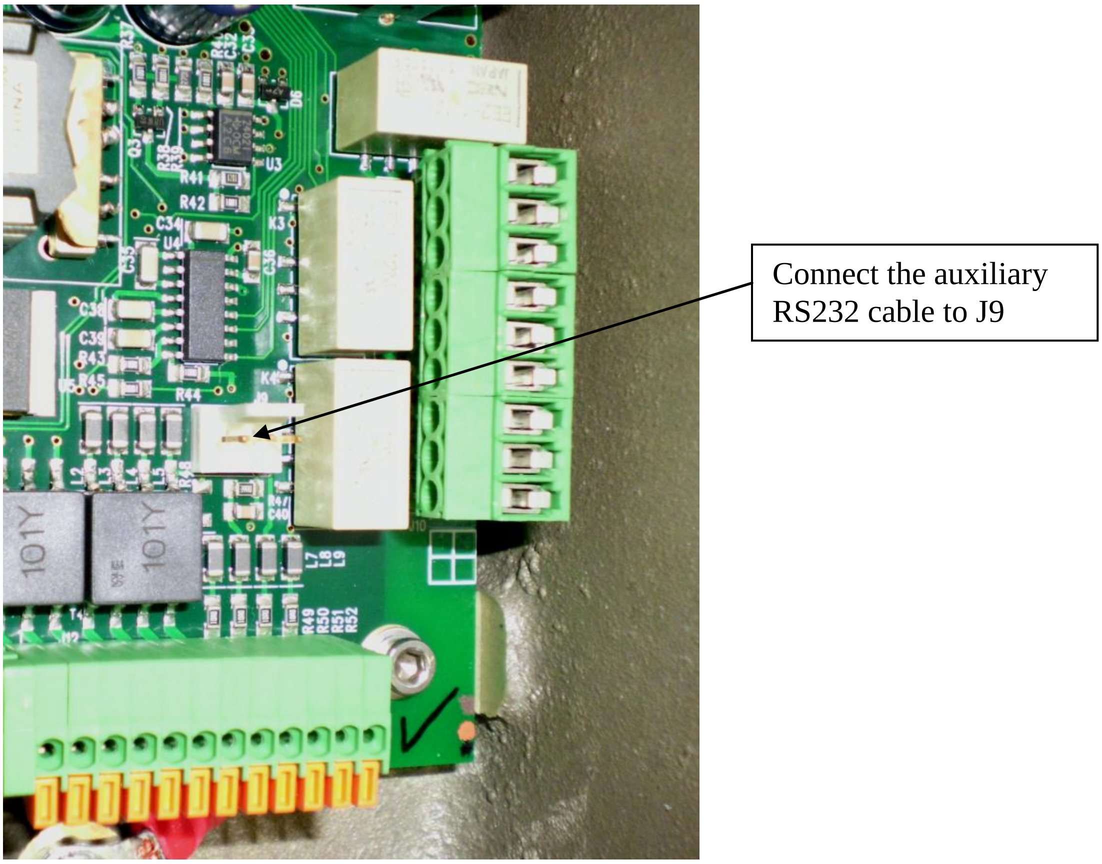


Figure 6 Auxiliary RS232 cable connections

Pin Number	Function	Colour
1	Transmit data (out)	Red
2	Receive data (in)	White
3	Ground	Black

Table 4 Pin connections for auxiliary RS232 cable

1.2.6 Pin connections for 0-10 V analogue output

An analogue output representing Meteorological Optical Range (MOR) as a signal between 0 and 10 V is standard on these sensors. The connections are as follows:

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

Table 5 Connections for 0-10 V analogue output

1.2.7 Pin connections for sensors ordered with the OPTIONAL 4 – 20mA or 0 – 20 mA analogue output current loop

An additional analogue output representing MOR as a current between 4 and 20 mA or 0 and 20 mA is an option on these sensors. The connections are as follows:

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

Table 6 Connections for 0 / 4-20mA analogue output

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

1.2.8 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.

1.3 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.

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

Equipment Test Procedure

1. Connect the power-input cable 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 a terminal program - for example Windows® Hyper Terminal™. (For RS422 sensors a RS422 to RS232 converter must be used). Note: Biral recommends testing to be done with RS232 or RS422. 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:

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

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

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

4. Turn the local power source "ON".

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

5. Check Data Transmission To Sensor:

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

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

6. Check Data Transmission From Sensor:

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

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

7. MOR Calibration check:
   Carry out the calibration check procedure in section 5, page 39 (or see the laminated sheet which is supplied if a calibration kit has been ordered) to ensure that the MOR value changes ie the sensor responds to changes in visibility.

   NOTE
   As this calibration check is being carried out indoors the MOR value will NOT agree with that marked on your calibration reference plaque

   NB The sensor is fully calibrated before it leaves Biral.

THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE

SWS CALIBRATION KIT AND PC ARE AVAILABLE

1.4 STEP 4 - Configuration Options

1.4.1 Communications Parameters

The SWS sensor can use either RS232C or RS422/RS485 signal voltage levels. The configuration of the sensor is selected by connecting to the appropriate terminal connections and jumper position, see page 6.

1.4.2 RS485 Configuration

The SWS sensor can be set to use addressable RS485 communication protocols. See page 6 for setting up the appropriate terminal connections and jumper position. In addition to the hardware connections the sensor software needs to be configured to use this protocol.

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

RS485 Protocol Format

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

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

Start

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

Address

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

Data

This is a variable length ASCII character string as defined in section 2.1. The master has a defined range of commands available for the SW sensor. The SW 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 instrument user settable configuration. However, 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 standard SWS Checksum.

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

The LRC is calculated by adding together successive 8–bit bytes of the message, discarding any carries, and then two's complementing the result. It is performed on the ASCII message field contents excluding the 'colon' character that begins the message, and excluding the CRLF pair at the end of the message.
The LRC byte is converted to 2 ASCII characters and appended to the message.

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

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

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

:42D?17<CRLF>

End

All communications will end with the standard 2 characters, carriage return – line feed (CRLF) pair (ASCII values of 0D & 0A hex)

Sensor Addressing

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

Querying the sensor address

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

Changing the sensor address

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

Enabling the addressable RS485 Communications

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

Step 1 - Send the command: CO
Step 2 - Send the instruction: OP10000000
(Note: to enable RS485 and time/date-stamp send OP10000001)

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

To check the setting of the options-word send the command: :00OP?FF
The sensor should respond: :0000000000,1000000073

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

To disable RS485 Communications

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

Checksum Override

When using addressable RS485 communications, the sensor will disregard any commands that do not have the sensor address or have an incorrect checksum. When transmitting to the sensor all commands must be prefixed by :XX (where XX is the address) and have the 2 character checksum on the end. If the checksum 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 (see below for instructions) rather than transmitting a data message automatically.

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

1.4.3 Baud-Rate Configuration

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

The baudrate for the communication with both the customer’s system (COM1) and the local auxiliary terminal (COM2) can be set as follows.

Send	%B(Number)	For COM1 settings from customer’s system (COM1)
Send	%C(Number)	For COM2 settings from auxiliary terminal (COM2)

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 baudrate to use, for example to select 9600 baud the user would type

%B4<enter>

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

Changing the baudrate for COM2 is identical except use %C instead of %B

Table 7 Baud rate settings

1.4.4 Operating State Configuration

The numeric value included with the operating state command determines the operating configuration of the instrument. This value is entered as a binary number (1's and 0's). Leading 0's in the value need not be entered. The value is stored in non-volatile memory and the operating configuration when power is applied is that set by the last entered operating state (OS.….) command. The value can be determined by sending the "P?" command and observing the "operating state" field in the instrument's response (cccccccc below).

The complete message will be as follows:

TSWSz00,NNN,bbbbbbbb,cccccccc,dd,eee,fffff,gggg,hhh,iii,jjjj,kkkk,lll,mm<crlf>

SWSz00
Parameter message prefix - SWS Sensor, where z is 1 for SWS-100 and 2 for SWS-200.

NNN
Instrument identification number for SW sensors, set by the user.

bbbbbbbb
Program revision date, the date the software was compiled by the programmer.

cccccccc
Operating state (lower byte) of the sensor.

Table 8 Operating state configuration

The remainder of the figures are set up parameters for weather identification which are NOT user entry items.

The meaning of the operating state byte is given in the following table.

CCCCCCCC

Bit 1: 1 = Standard Mode: Data message sent automatically after calculation
0 = Polled Mode: Data message sent only in response to "D?"' command

Bit 2: 1 = Calculate values and determine data message in response to "D?" command, ignoring measurement interval timing (Bits 1 and 3 must be 000)
0 = Values calculated and data message determined after each measurement interval

Bit 3: Reserved

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

Bit 5: Reserved

Bit 6: Reserved

Bits 7 and 8: Window Heater Control
00 = Window demisters always on
01 = Window demisters controlled by window contamination. If any window's attenuation increases, caused by contamination or condensation, to more than the percentage specified by WT command, the heaters will turn on for 300 seconds or until the attenuation in reduced to 4/5 of the turn on threshold.
11 = Window demisters always off

Table 9 Operating state byte

1.4.5 Changing the Defaults

Default setting for units WITH hood heaters

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

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

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

Default setting for units WITHOUT hood heaters

Any combination of operating bits may be set but **Biral strongly recommends:**
1. For all sensors the **window demisters are always on** (bits 7 and 8 set to 0)
2. For **sensors without hood heaters the heaters are always off** (bit 4 set to 1)

The default setting is OS00001001 which is:
- window demisters always on
- hood heaters disabled,
- values calculated and data message sent automatically after each measurement interval.

(To set this operating state, send the command: OS1001)

Default setting for all sensors running in polled mode

OS00000000 (polled mode)

- window demisters always on
- hood heaters enabled
- values calculated and data message determined automatically after each measurement interval data message sent only in response to D? command.

(To set this operating state, send the command: OS0)

1.4.6 Checksum to verify message

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

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

Step 1 - Send the command: CO
Step 2 - Send the instruction: OP100000
(Note: to enable checksum and time/date-stamp send OP100001)

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

To check the setting of the options-word send the command: OP?
The sensor should respond: 00000000,00100000M

(NB. M is the checksum character)

To disable checksum

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

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

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

1.4.7 Date and Time Stamp in data string

By default the date and time stamp is not included at the start of the data string.

To enable Date and Time stamp

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

Step 1 - Send the command: CO
Step 2 - Send the instruction: OP1
(Note: to enable checksum and time/date-stamp send OP100001)

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

To check the setting of the options-word send the command: OP?
The sensor should respond: 00000000,00000001

To disable Date and Time stamp

To disable the date and time stamp, send the instruction OP0 in step 2 above.

To read the current Date and Time

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

MONDAY ,23\03\09,13:15:25,000

To set the current Date and Time

There are two commands to use to set the current date and time

%SD sets the real time clock date

The format of the command is: %SDWDDMMYY

where:

W - is the day of the week (1..7) with Sunday being 7

DD - is the date (01..31)

MM - is the month (01..12)

YY - is the year (00..99)

The sensor will respond with 'OK'.

%ST sets the real time clock time.

The format of the command is : %STHHMMSS

where:

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

MM - is the minutes(00..59)

SS - is the seconds (00..59)

The sensor will respond with 'OK'.

1.4.8 Configuring the Relays

To get the current relay configuration send the command JRO?

The sensor will respond with a number which corresponds to:

Value	**Description**
255	No Relays Configured
1	Fault Relay, Relay 1 triggered on visibility and Relay 2 triggered on 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 snow

Table 10 Relay configuration

By default the value is set to 1.

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.
e.g.

10.00 KM

To change the visibility Threshold levels

To change the visibility threshold levels for Relay 1 and 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.

e.g. to set the threshold for relay 1 to 1KM send the command

RL1,1.00

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 are 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 causes of reflected light (for example walls, trees and people etc). Reflected light entering the sensor's optics will cause errors in the reported visibility measurements.

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

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

1.5.2 Height Above Ground:

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

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

Table 11 Sensor height above ground

1.5.3 Orientation of Sensor Head

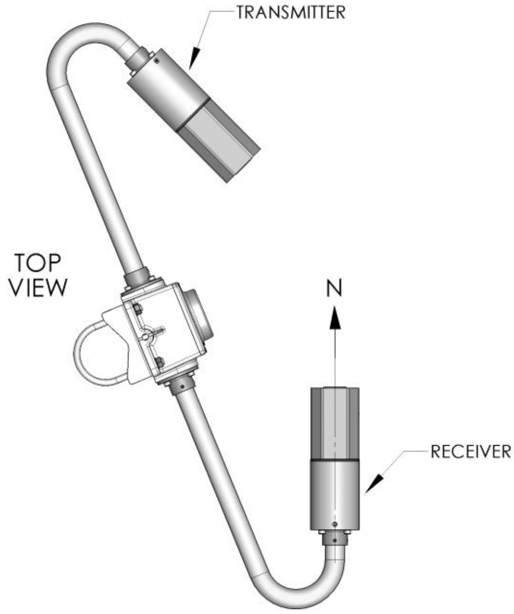
The orientation of the sensor head should be such that the rising or setting sun does not appear in the field-of-view of the receiver lens(es).

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 those sensors invariably eliminate such false counts.

SWS-100 Orientation

The SWS-100 receiver optics should be aligned with true North (true South in the Southern Hemisphere) as shown in Fig 3.2

Figure 7 SWS-100 Orientation

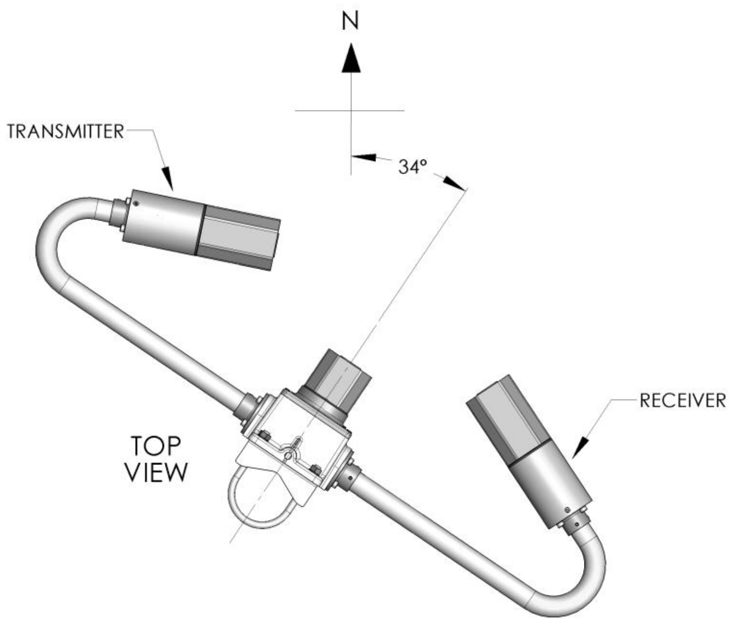


SWS-200 Orientation

The SWS-200 alignment should be such that neither the forward nor the backscatter receiver optics are aligned with the rising or setting sun.

For the Northern Hemisphere the best mounting orientation is shown in the picture below (for the Southern Hemisphere the bearings should be increased by 180°)

Figure 8 SWS-200 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 the mast. The two V-block saddles oppose the U-bolt, thus providing a secure grip on the mast.

The sensor can be mounted on a galvanised steel pipe or heavy walled aluminium tube with an outer diameter between 40 to 64 mm. For mast diameters outside this range the U-bolts provided will not be suitable.

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

The sensor head should be mounted near the very top so that the mast will not interfere more than necessary with the free flow of fog 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.

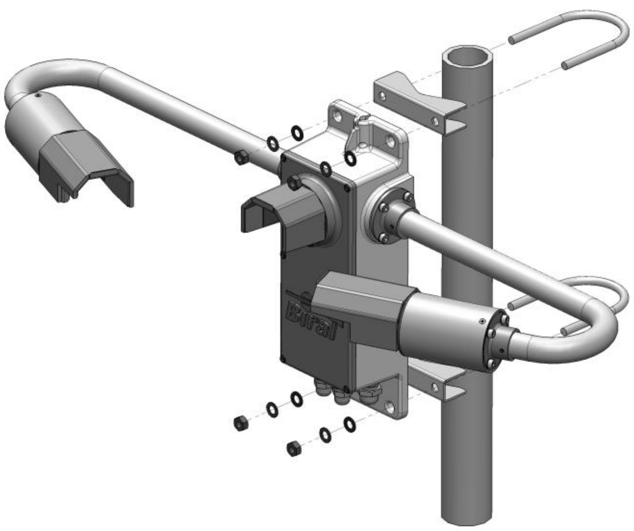


Figure 9 U-Bolt Mounting Method

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

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

Destruction of sensitive components can result from unprotected lines, or instrument failure may occur over a long period of time due to slow device degradation. Destructive over volt transients can occur in many ways; e.g., lightning induced transients, AC power line transients and EMI/RFI electromagnetic noise. The power/control subsystem of the sensor contains transient surge-arrestors on all power and signal lines as a standard feature. EMI filters are present on the power and lines entering the power/control subsystem.

It is essential to connect the sensor to earth ground for maximum protection of the instrument. The following notes are intended to provide some guidance in the design and construction of an electrical grounding system.

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

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

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

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

1.6 STEP 6 - Test And Commissioning

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

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

1.6.1 Checking Power Supply

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

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

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

1.6.2 Checking Data link

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

2. Connect the signal cable to a PC running a terminal program - for example Windows® Hyper Terminal™. (For RS422 or RS485 sensors a suitable data converter must be used).

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 Link check are within the ranges indicated below:

Field 1:	Space	Message starts with a space
Field 2:	100 or 108	Heater state and error flags
Field 3:	2.450 - 2.550	Internal Reference voltage
Field 4:	9.00 - 36.00	Supply Voltage
Field 5:	10.8 -13.2	Internal operating voltage
Field 6:	4.5 - 5.5	Internal operating voltage
Field 7:	10.8 -13.2	Internal operating voltage
Field 8:	*00.00*	*Not applicable in this check*
Field 9:	*00.00*	*Not applicable in this check*
Field 10:	85 - 105	Transmitter power monitor
Field 11:	80 - 120	Forward Receiver monitor (optional)
Field 12:	80 - 120	Back Receiver monitor (SWS-200 only)
Field 13:	00 - 99	Transmitter Window Contamination (Optional)
Field 14:	00 - 99	Forward Receiver Window Contamination (Optional)
Field 15:	00 - 99	Back Receiver Window Contamination (Optional)
Field 16:		Temperature ^{o}C
Field 17	3300-4200	ADC Interrupts per second

Table 12 Remote maintenance check fields

1.6.4 Calibration Check

The sensor is fully calibrated before it leaves Biral. However, if you would like to carry out a user confidence calibration check please follow the calibration check procedure in section 5, page 39 (or see the laminated sheet which is supplied if a calibration kit has been ordered) to ensure that the MOR value changes ie the sensor responds to changes in visibility.

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

CONGRATULATIONS

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

THE REMAINDER OF THIS MANUAL COVERS:

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

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.

Note: All responses from the sensor are appended with carriage return and line feed characters (ASCII characters 13 and 10 decimal).

2.1 Standard Operating Data Message

The data message format is:

<Date>,<Time>,SWSz00,NNN,XXX,AA.AA KM,BB.BBBB,CC,±DD.D C,EE.EE KM,FFF<cs><crlf>

MESSAGE	MEANING
<Date>	Optional Date string in the form DD/MM/YY
<Time>	Optional time string in the form HH:MM:SS
SWSz00	Either SWS-100 or SWS-200 dependent on model
NNN	Instrument identification number set by the user
XXX	Averaging Time period in seconds.
AA.AA KM	Meteorological Optical Range (KM). This is the averaged value.
BB.BBB	Amount of water in precipitation in last measurement period (mm) (SWS-200 only, otherwise 99.999)
CC	Present weather codes. From WMO Table 4680 (Automatic Weather Station) **For SWS-100:** XX Not Ready (first 5 measurement periods from restart) 00 No Significant weather observed or sensor starting 04 Haze or smoke 30 Fog 40 Indeterminate precipitation type 50 Drizzle 60 Rain 70 Snow

CC	Present weather codes. From WMO Table 4680 (Automatic Weather Station) **For SWS-200** XX Not Ready (first 5 measurement periods from restart) 00 No Significant weather observed or sensor starting 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) (SWS-200 only, otherwise 99.9 C)
EE.EE KM	Meteorological Optical Range (KM). This is the instantaneous value.
FFF	Remote maintenance (RM) (Remote self-test) F.F.F O - no RM fault X - RM fault exists O = windows not contaminated X = windows contaminated – cleaning recommended/required F = windows contaminated – fault 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 Operating data message format

3 COMMANDS AND RESPONSES

3.1 Sensor Commands

All commands should be terminated with <Carriage Return> and <Line Feed> (ASCII characters 13 and 10).

Commands specific to SWS-200 sensors only

Command	Function	Response
A?	Send Accumulated Precipitation Message **(SWS-200 only)**. Note: The accumulated Precipitation will reset to zero every 24 hours.	**xxx.xx** OR **xxxx.x (a**ccumulated precipitation in mm) **,xxxx** (total time of accumulation in minutes, max = 1440)
AC	Clear accumulated precipitation and time **(SWS-200 only)**.	**OK**
BB?	Send instantaneous value of Backscatter EXCO. **(SWS-200 only).**	**XX.XX**
BL?	Send instantaneous value of EXCO less precipitation particle component. **(SWS-200 only).**	**XX.XX**

Table 14 Commands specific for SWS-200 sensor

Commands applicable to SWS-100 and SWS-200 sensors

Command	Function	Response
ADR?	Send RS485 Address. See **section 1.4.2**	**XX**
ADRxx	Set RS485 Address. Range 00-99. See **section 1.4.2**	**OK**
BT?	Send instantaneous value of Total EXCO	**±XXX.XX**
CE	Perform both Forward Calibration and Backscatter MOR calibration (Calibration must be enabled)	**See section 5** (page 43)
CO	Enable calibration	**OK**
CX	Disable calibration	**OK**
D?	Send latest data message	**See Section 2, (**page 32)
DHO	Turn on hood heaters temporarily. If they would not be on normally, the heaters will turn off within 2 minutes (for maintenance only).	**OK**
DHX	Turn off hood heaters temporarily. If they would be on normally, the heaters will turn on within 2 minutes (for maintenance only).	**OK**
IDx	Set instrument identification number displayed in Data Message Range x = 1 to 999 (Default = 1) (if enter value > 999 only first 3 digits will be used)	**OK**
OSXXXXXXXX	Set Operational State. See Operating State Configuration **section 1.4.3**	**OK**
OP?	Check configuration options	**See sections 1.46 and 1.47** (pages 20 - 21)
OPXXXXXXXX	Set configuration options. See **section 1.4.5**	**OK**
P?	Send Parameter Message	**See section 1.43** (page 16)
R?	Send Remote Self-Test and Monitoring Message	**See section 3.1.1** (page 36)
RST	Restart instrument	**OK**
T?	Send Instrument Times Message	**See section 3.1.2** (page 37)
TMx	Set measurement interval. Range x = 10-300 (seconds). (Default= 60)	**OK**
TAx	Set auxiliary measurement sample period. Range x= 2-20 (seconds) (Default = 5)	**OK**
TR?	Send current date and time	**See section 1.47** (page 21)
%SDWDDMMYY	Set current date	**See section 1.47** (page 21)
%STHHMMSS	Set current time	**See section 1.47** (page 21)

Command	Function	Response
%Bx	Set COM1 Baud Rate Range 1-7	**See section 1.4.3**
%Cx	Set COM2 Baud Rate Range 1-7	**See section 1.4.3**
WT?	Send current window contamination threshold for fault indication	**XX**
WTx	Set window contamination threshold for fault indication, % transmission. Range: 0 to 40 (%) (Calibration must be enabled). (Default = 10)	**OK**

Table 15 Commands for SWS-100 and SWS-200 sensor

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

Response: The various fields in the response are as follows:

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

A=1 - Window heaters ON
A=2 - De-icer (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 - Register error
C=2 - Ired commanded OFF
C=4 - Receiver test in progress (Ired OFF)
C=8 - Sensor power reset since last R? command

or any combination of these (i.e. if both the window and hood heaters are on the first character A would be 3)

Field 3:	2.450 - 2.550	Internal Reference voltage
Field 4:	9.00 - 36.00	Supply Voltage
Field 5:	11.5 - 14.0	Internal operating voltage
Field 6:	4.5 - 5.5	Internal operating voltage
Field 7:	11.5 - 14.0	Internal operating voltage
Field 8:	0.00 - 6.00	Forward Scatter background brightness
Field 9:	0.00 - 6.00	Backscatter background brightness (SWS-200 only)
Field 10:	85 - 105	Transmitter power monitor
Field 11:	80 - 120	Forward Receiver monitor (optional)
Field 12:	80 - 120	Back Receiver monitor (SWS-200 only)
Field 13:	00 - 99	Transmitter Window Contamination (Optional)
Field 14:	00 - 99	Forward Receiver Window Contamination (Optional)
Field 15:	00 - 99	Back Receiver Window Contamination (Optional)
Field 16:		Temperature ^{o}C
Field 17:	3300-4200	ADC Interrupts per second

3.1.2 Command T? - Send Instrument Times Message

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

aaaa: Measurement interval for each operational data message (10 to 300 seconds) (default = 60)
bbbb: Auxiliary measurement sample period - time between measurement of peripheral signals during measurement interval (2 to 20 seconds) (default = 5)
ccccc: Not used.
dddd: Min Window Heat Time in seconds (when Operating State bits 7 and 8 = 01) (=300 seconds)

3.2 Sensor Responses

RESPONSE	MEANING
BAD CMD	Your 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. Re-send the command.

4 OPERATIONAL & MAINTENANCE PROCEDURES

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

4.1 General Checks

A general check of the physical condition of the sensor should be carried out at regular intervals. Particular attention should be paid to the condition of the cables from the base of the unit.

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 1.4.4 for details

The warmth may be detected with the finger on the window but is easier to detect using a thermometer with surface temperature probe. The windows should be between 5 and 10°C above ambient temperature after at least 10 minutes operation. Ensure that windows are cleaned after coming into contact with the skin.

4.1.2 Hood Heaters (optional)

Hood heaters, if ordered, are fitted to the inside of each of the hoods (2 on the SWS-100 and 3 on the SWS-200) (see figure 8).

The hood heaters are high-power heaters to prevent the build-up of frozen precipitation in the hoods. These heaters are temperature dependent (by default) and are only switched on when the temperature is below 4°C. When switched on, it is easy to detect the heat from these heaters by placing a finger on the end of the hood.

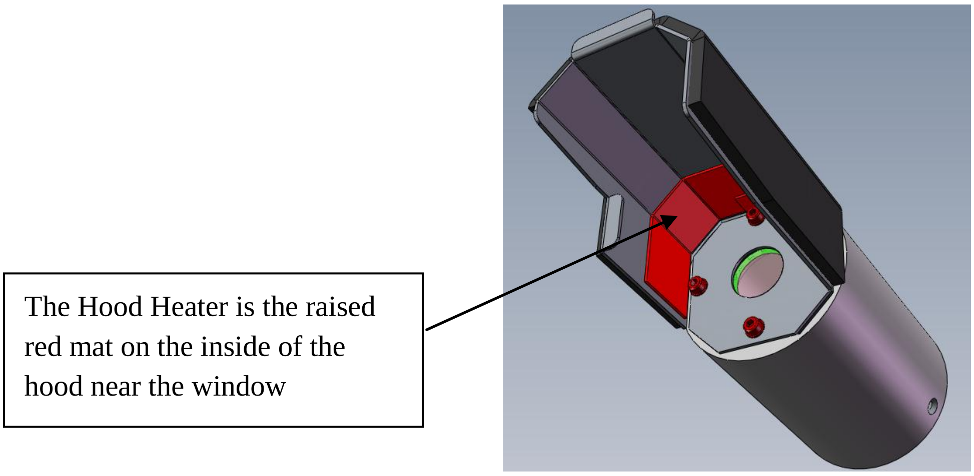


Figure 10 Hood Heater (optional)

When the temperature is above the switching temperature the heaters will be switched off but may be controlled using a PC running a terminal program such as Windows Hyper Terminal: The heaters may be switched on temporarily using the command DHO and off again using the command DHX.

4.1.3 Window Cleaning

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

All SWS sensors can be fitted with optional Transmitter and Receiver Window monitoring systems which compensate for contamination and will flag an error when the contamination reduces the signal by more than 10% - when this error flag occurs the window should be cleaned at the earliest possible opportunity.

4.2 User Confidence Checks

The following user confidence checks require bi-directional communications with a PC running terminal emulation software (such as Windows Hyper Terminal).

4.2.1 MOR Calibration Check

If you wish to carry out a user confidence calibration check please follow the calibration check procedure in section 5, page 39 (or see the laminated sheet which is supplied if a calibration kit has been ordered) to ensure that the MOR value changes ie the sensor responds to changes in visibility.

THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE

SWS CALIBRATION KIT AND PC ARE AVAILABLE

4.2.2 Window Monitor Checks

The SWS sensors monitor the transmitter window for contamination. Sensors can also be ordered with optional forward scatter receiver monitoring and the SWS-200 has the further option of backscatter receiver monitoring. 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 circuits can be checked by the following procedures:

Transmitter Window Monitor (this section applies to all SWS sensors)

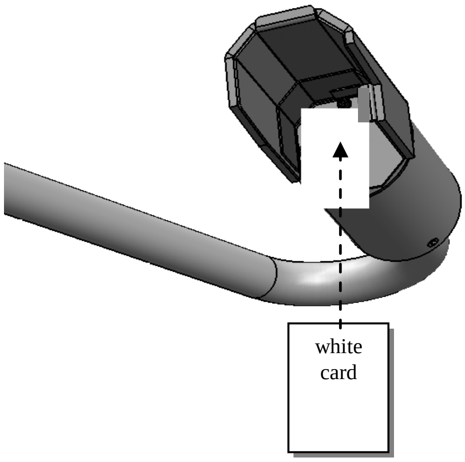
Step 1. Clean the transmitter window.

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 in the transmitter hood that blocks and almost touches the window (see figure 9).

Figure 11 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.

<u>Receiver Window Monitor(s)</u> (for sensors with optional forward and backscatter monitoring)

This procedure is used for the forward scatter receivers on the SWS-100 and SWS-200 sensors and the additional backscatter receiver on the SWS-200.

Step 1. Clean the forward scatter receiver window.

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

Step 3. Send the command: R?

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

Step 5. Insert a white card in the forward scatter receiver hood that blocks the window, and almost touches it (similar to picture above).

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 (ie 99).

Step 9. Remove the white card

4.2.3 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 (this procedure is used for both the forward scatter and backscatter receivers) For SWS-100 sensor only do the forward scatter test.:

Step 1. Insert a zero plug in the receiver hoods, blocking all light from the window.

Step 2. Send the command: R?

Step 3. Verify that the value in the 'Forward (Back) Scatter Receiver Background Brightness' field is less than 00.06. (Forward scatter is field 7, backscatter is field 8)

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

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

Step 6. Verify that the value in the 'Forward (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.

ALL THE PROCEDURES IN THIS SECTION REQUIRE A SWS CALIBRATION KIT

The Meteorological Optical Range (MOR) calibration of the forward scatter channel and the backscatter channel are checked by the procedure outlined below.

The Calibration Reference Plaque used for the calibration check has been assigned a forward scatter value which is a simulation of a MOR expressed in kilometres. This value is shown on the label on the black plastic connector which attaches the arm to the calibration screen.

The SWS-200 plaque also has a backscatter value which although it also is expressed in kilometres, is an artificial value assigned only for the purpose of checking that the sensitivity of the backscatter channel is within its proper limits.

Please see the following page for a diagram of Calibration Reference Plaque.

5.1 Calibration Check

The following instructions show you how to check the calibration of a SWS-100 or SWS-200 sensor. This procedure can only be completed with:

1. A SWS Calibration Kit
2. Connection to a PC running terminal emulation software (such as Windows ® Hyper Terminal™) using one of the two serial connectors. *If you need help with this please do not hesitate to contact us (contact details on page iv)*

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:

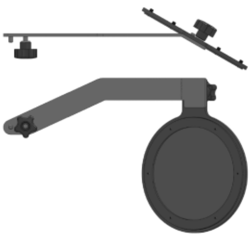
1. MOUNTED OUTSIDE AND ON A CLEAR DAY (VISIBILITY>10KM)

2. POWERED FOR AT LEAST 1 HOUR

3. NOT LOCATED NEAR A WALL OR OTHER OBSTRUCTION

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

ASSEMBLING THE CALIBRATION REFERENCE PLAQUE



1. Attach the arm to the round calibration screen.
2. Fix this assembled calibration reference plaque to the sensor as pictured right.

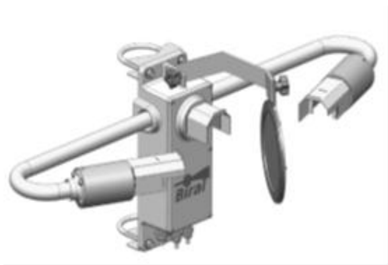


Figure 12 Assembly of calibration reference plaque
(Example of plaque in-situ on SWS-200)

STEP 1: Clean all windows on the sensor using pure alcohol (propanol) and soft cloth or tissue, preferably lens tissue. Check the cleanliness using a portable light if possible.

(Step 1 may not be necessary if checking or commissioning a new sensor)

STEP 2: Attach the calibration reference plaque to the sensor as shown in figure 11 (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.

MOR 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-100).

STEP 4: Send the command “RST<end char>”. 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 (5^{th}) data message from the sensor. Verify that the forward-scatter MOR (located in 4^{th} field) is 20Km for SWS-200 sensors and 2KM for SWS-100 sensors.

STEP 7: **SWS-200 ONLY**: Send the command “BB? <end char>”.
Verify that the response value is approximately 000.00 ± 1.

STEP 8: Remove the foam plugs.

MOR gain Check:

STEP 9: Send the command “RST<end chars>” 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 (5^{th}) data message from the sensor. Verify that the forward-scatter MOR (located in 4^{th} field) is within ± 10% of the value assigned to the calibration reference plaque (the value on the label attached to the plaque).

STEP 12: **SWS-200 ONLY**: Send the command “BB? <end char>”.
Verify that the response value is within ± 20% of the 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 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 40.

5.2 Sensor Re-calibration

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

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

BEFORE CONTINUING ENSURE THAT THE SENSOR:

1. **IS MOUNTED OUTSIDE AND THAT VISIBILITY IS GREATER THAN 10KM.**
2. **HAS BEEN IN CONTINUOUS OPERATION FOR AT LEAST 1 HOUR.**
3. **WINDOWS ARE CLEAN**
4. **IS NOT LOCATED NEAR A WALL OR OTHER OBSTRUCTION**
5. **IS NOT RECEIVING OPTICAL REFLECTIONS (from surfaces or clothing)**

STEP 1. Set up the sensor with the calibration reference plaque in place - see previous section (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 BK SCAT RCVR OPTICS,
INSTALL REF STD,
ENTER FWD SCAT VALUE
FORM: XXX.XX

STEP 4. Fit the foam plugs (supplied with the calibration kit) against all the windows (2 windows on the SWS-100 and 3 on the SWS-200.

STEP 5. Enter Forward CAL value of calibration plaque.

STEP 6. **SWS-200 Only:**

Sensor replies: ENTER BACK SCAT VALUE FORM: XXX.XX

Enter Backscatter CAL value of calibration reference plaque.

STEP 7. Wait for approximately 2 minutes
Sensor replies: REMOVE BOTH RCVR OPTICS BLOCKS, ENTER "OK"

STEP 8. Remove 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. Note the 'Total MOR' value reported by the sensor.

STEP 12. Send the BB? Command and note the value.

STEP 13. If the Total MOR reported is within 3% of the Forward MOR 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.

6 PRODUCT OVERVIEW

6.1 SWS-100 and SWS-200 Present Weather Sensors

There are two models in the SWS series of present weather sensors, the SWS-100 and SWS-200. They use the same basic optomechanical and electronic components and have an optical transmitter and forward scatter receiver. The SWS-200 also has 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 SWS-200 has expanded software to perform intensity measurements.

The measurement capabilities of the models is as follows:

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

Figure 13 SWS-100

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

This model has an extra backscatter receiver for :

Rain rate
Snowfall rate
Precipitation accumulation

Figure 14 SWS-200

6.2 Instrument 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 instrument.

A SWS sensor system consists of the major components listed below:

Item	**QUANTITY**
Basic Sensor assembly incorporating: transmitter, receiver and electronics housing	1
Backscatter receiver (SWS-200 only)	1
Remote self-test monitoring	1
Stainless steel mounting U-bolt kit for fixing to a pole	1
Volt free independent relay C/O outputs	3
Both RS232 and RS422/RS485 digital outputs	
Digital and analogue MOR outputs	
Transmitter window contamination monitor	

6.3 Optional Items

Hood Heaters

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

Analogue Data Output

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

Window Contamination Monitoring

In addition to the standard self-test transmitter window monitoring the sensors can have the optional forward scatter receiver window monitoring to provide warning of additional contamination build-up. A further option for the SWS-200 is window contamination monitoring on both the forward and the backscatter windows. See "window monitoring" checks on pages 40-41.

6.4 Accessories

Calibration Kit

The calibration kit, containing a reference standard calibration plaque in a protective carrying case, is employed only at those times that the instrument calibration is being checked.

Transit Case

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

Mains Adapter

A mains adapter is available if required.

Power and Signal Cables

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

6.5 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 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 weight. It can be readily installed by one person and can be used in portable or fixed installations.

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

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

6.5.1 Real Time Data Displays

The output of the sensor is a serial-digital message that is provided at the signal interface at a sample time interval selected by the operator (a typical sample time interval is one minute). The message is provided automatically, or if the sensor is in the polled mode the data message is transmitted after the polling command is sent to the sensor.
A printer can be used to record the data message. However, a PC terminal offers much more flexibility:

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

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

3. Precipitation accumulation for selected intervals of time (e.g., every hour, every six hours, every 24 hours, etc.) can be obtained

4. All or selected parts of data message can be archived

6.6 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.

6.7 Automated Measurements

6.7.1 General

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.

6.7.2 Visibility Related Measurements

The measurement capabilities of the sensor are summarised in the table below. 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 (F) is indicated in the output message. If the MOR is between 1 and 10 km, then haze (H) is indicated in the output message. If MOR is greater than 10 km, no obstruction to vision is indicated.

Visibility Measurements

Daytime visual range	SWS-100 - 10 meters to 2 km (30 feet to 1.2 miles) SWS-200 - 10 meters to 20 km (30 feet to 12 miles)
Error	≤ 10% 0 to 10 km ≤ 20% 10 to 20 km
Obstruction to vision	(1) Identifies Fog or Haze (Precip. Absent) (2) Identifies Fog in Presence of Precipitation

Table 16 Measurement Capabilities of the SWS-100 and SWS-200

Precipitation Measurements (SWS-200 only)

(a) Liquid Precipitation:	0.00025 mm/min (0.00001 in/min) 0.015 mm/hr (0.00060 in/hr).
(b) Snow (H_20 Equivalent):	0.000025 mm/min (0.000001 in/min) 0.0015 mm/hr (0.000060 in/hr).
Precipitation rate (error)	Rain-Up to 10 in/hr (±10%) (250 mm/hr ±10%) Snow-Rain Equivalent (±20%)

Table 17 Additional measurement capabilities of the SWS-200

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, then fog is declared to be present in addition to the precipitation as an obstruction to vision.

6.7.3 Precipitation Measurements

The sensor identifies three forms of precipitation, namely drizzle, rain and snow. All forms of frozen precipitation are classified as snow. Detection of the onset of precipitation is extremely sensitive, being 0.00025 mm per minute for rain and approximately 0.000025 water equivalent mm per minute for snow.

The following present weather codes are used on the SWS sensors:

Present weather code. From WMO Table 4680

SWS-100 present weather codes:

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

SWS-200 present weather codes:

XX No Significant weather observed or sensor starting
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

6.8 Sensor Specifications

The specifications for all versions of the SWS sensor series are summarised in the following pages. To adapt the table to a particular sensor model, disregard non-pertinent information. For example, in the case of the Model SWS-100 visibility sensor, disregard those portions of the specification pertaining to precipitation measurements.

Visibility Measurements (MOR) and Precipitation Measurements

Measurement Range	SWS-100 <10 m to 2 km (1.2 miles) SWS-200 <10 m to 20 km (12 miles)
Measures:	Visibility (MOR – Meteorological Optical Range), reductions caused by: for, haze, smoke, sand, drizzle, rain, snow and general precipitation
Measurement Error at 16 km	<= 15%
Measurement Error at 2 km	<= 10%
Measurement Time Constant	30 seconds

Stability of MOR Zero Setting

Ambient Temperature Effects	<= 0.02/km
Long Term Drift	<= 0.02/km

Precipitation Measurements (SWS-200)

Detection Threshold: Rain	0.015mm/hr (0.0006 in/hr.)
Detection Threshold: Snow (H20 Equiv.)	0.0015mm/hr (0.00006 in/hr.)
Rain Rate (Maximum)	~ 250mm/hr (10 in/hr.)
Rain Rate Accuracy	<= 15%

Maintenance

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

Table 18 Sensor Specifications

6.9 Instrument Characteristics

Physical

Scattering Angle Coverage	39° to 51°
Sample Volume	400 cm^3
Weight SWS-100 SWS-200	3.3Kg 3.5Kg
Length	0.81 m

Light Source

Type	IRED
Central Wavelength	0.88µm
Bandwidth	0.08µm
Lifetime	>10 years
Modulation Frequency	2000 Hz

Detector

Type (Photovoltaic)	Silicon
Response	Silicon
Filter Bandwidth	0.08µm at 0.88µm

Temperature Sensor

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

Power Requirements

Basic Sensor	3.5 W
De-Icing Heaters (Optional)	**SWS-200:** 36 W **SWS-100:** 24 W
No-Dew Window Heaters	**SWS-200:** 2.5 W **SWS-100:** 1.7 W

Environmental

Temperature Range	-40°C to +60°C
Altitude	0 to 20,000 ft
Precipitation	All weather
Humidity	0 to 100%

Table 19 Instrument Characteristics

6.10 Digital Communication Interface

Interface Type	RS232C, (Full Duplex)
Optional	RS422/RS485
Selectable Parameters:	
Baud Rates	1200 Baud to 57K6 Baud
Data Bits	7 or 8
Parity	Even, Odd, None, Ignore on Receive
Stop Bits	1 or 2
Flow Control	None
Message Termination (Selectable)	CR, LF, CR-LF
Message Check Sum:	Selectable
Reporting Interval	Programmable (Response to poll, or Automatic at programmable intervals: e.g., 30 seconds to several minutes; 1 minute typical)
Message Content:	• Instrument Identification Number (Programmable) • Reporting Interval (seconds) • Daytime Visual Range (Kilometres) • Precipitation Type • Obstruction to Vision (Fog, Haze, None) • Precipitation Amount (One Minute Interval) • Temperature • Remote Self-Test & Monitoring Flags

Table 20 Digital Communication Interface Specifications

6.11 Sensor Remote Self-Test Capabilities

- Optical Source Power
- Forward-Scatter Receiver Sensitivity
- Back-Scatter Receiver Sensitivity
- Transmitter Window Contamination
- Forward-Scatter Receiver Window Contamination (optional)
- Back-Scatter Receiver Window Contamination (optional)
- Power Supply Voltages
- Non-Volatile Memory Check Sum Test
- EPROM Check-Sum Test
- Restart Occurrence
- Sensor Sample Interrupt Verification
- RAM Read/Write Verification
- Register Read/Write Verification
- A/D Control Signal Test
- A/D Conversion Accuracy Check
- Input Voltage Check
- Forward-Scatter Background Illumination Level
- Back-Scatter Background Illumination Level (SWS-200 only)

6.12 SWS Sensors – external dimensions

The SWS-200 model shown below has an additional backscatter hood on the sensor body but otherwise is identical to SWS-100.

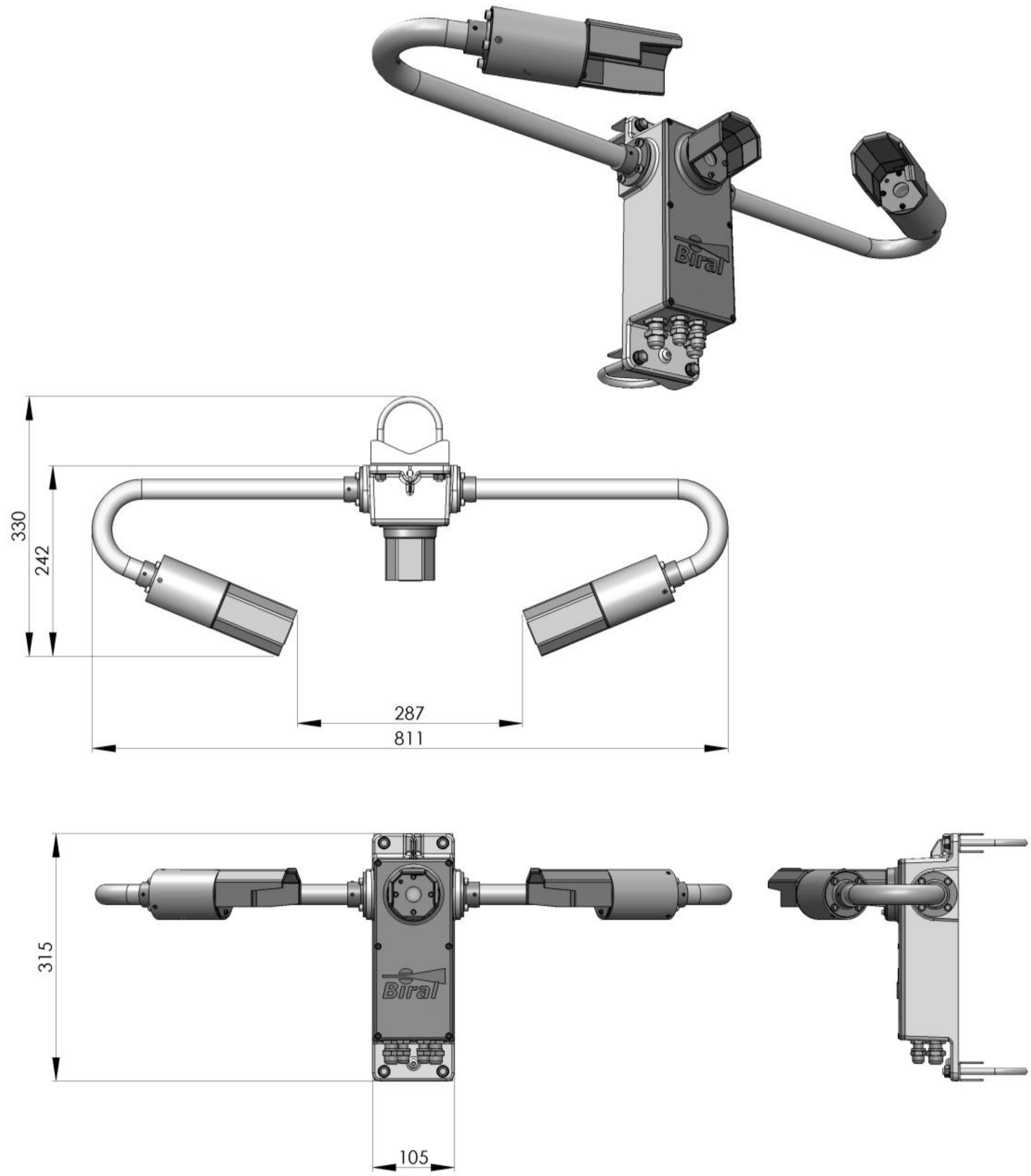


Figure 15 External Dimensions of SWS-sensors (Dimensions in mm)

7 INDEX

A

B

C

D

E

H

I

M

O

P

R

S

T

V

W

Notes: