Biral

OPERATION and MAINTENANCE MANUAL

VPF Present Weather Sensors

VPF710
VPF730
VPF750

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General Information

The sensors covered in this manual :

Sensor Model	Capability
VPF710	Visibility

VPF730	Visibility Precipitation type identification

This model has an extra backscatter receiver for:

Rain rate
Snowfall rate
Precipitation accumulation

VPF750	Visibility Precipitation type identification

This model has an extra precipitation sensor and an extra high accuracy temperature and humidity sensor for:

50 weather codes (from WMO Code Table 4680), including:
- Past Weather
- Freezing Rain
- Ice Pellets

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

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 HSS Sensors. We are confident that they will provide you with many years of reliable, accurate operation.

Features of the HSS 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 RS232, RS422 or RS485 serial outputs.

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

- **Identification of precipitation type as well as accumulation totals** (Not VPF710).

- **Identification of 50 weather codes (from WMO Code Table 4680)** (VPF750 only).

There are currently three sensors in Biral's HSS sensor range. These are the VPF710, the VPF730 and the VPF750. Throughout this manual, the term 'VPF700 Series of Sensors' is used to refer to features common to all three of these sensors. Biral may introduce other HSS sensors based on the original HSS designs, which fulfil alternative functions, but do not form part of the VPF700 series and are not covered by this User manual.

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

Five year warranty

The HSS Present Weather Sensors come with a Five 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
- Data Output Strings
- Responses to R? command
- Relevant application details
- Your full name, address and contact details

If you need to return the sensor

The HSS 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 HSS 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.

In order for the mains version of any sensor to comply with the requirements of EN 61010-1:2010, 'Safety requirements for electrical equipment for measurement, control, and laboratory use', the following should be observed:

A switch or circuit breaker must be included in the installation. This switch or circuit breaker must be suitably located and easily reached. It must be marked as the disconnecting device for this equipment.

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.

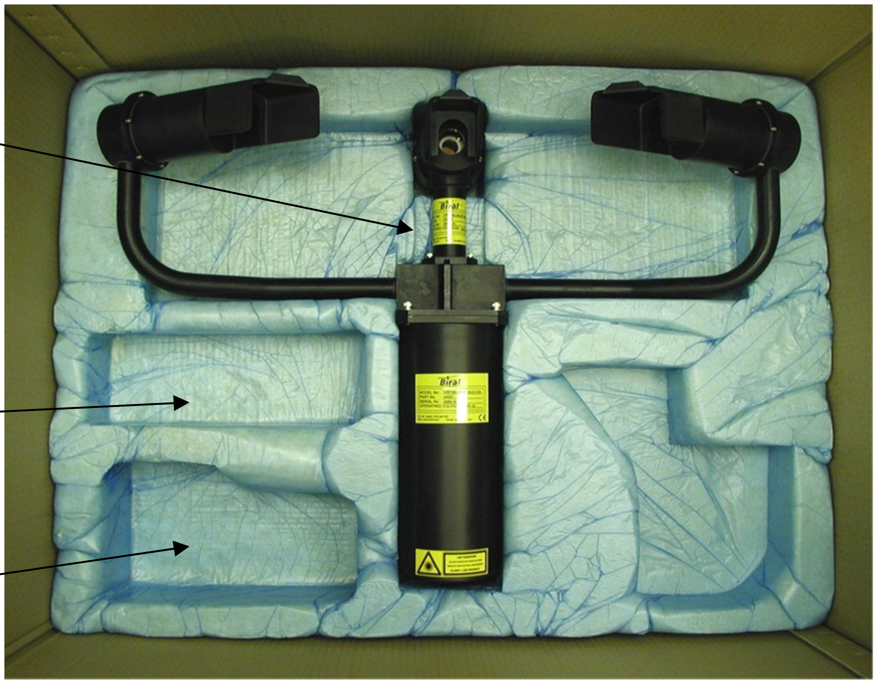
Step 5 - Installation including siting considerations, height, orientation, mounting and electrical grounding.

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 (www.Biral.com), or contact Biral at: Info@Biral.com.

1.1 STEP 1 - Unpacking the sensor

Top Layer



Bottom Layer

Figure 1-1 - VPF730 in its packaging

Other optional components you may have ordered:

Calibration Kit

The calibration kit is supplied 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 (these are the ZERO PLUGS referred to in the calibration sections).

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 in Figure 1-1 - VPF730 in its packaging.

Mains Adapter

A mains adapter to operate a 12V or 24V sensor using mains power.

Ambient Light Sensor

A very wide range (greater than four decades) background light meter that measures from 2 to 40,000 cd.m^{-2}. This sensor connects via a 1m cable to factory installed input on any of the VPF700 series of sensors. Light levels are appended to the sensor data string as a 5 digit ASCII character string giving the luminance value in cd.m^{-2} (see section 2).

Weather Station Module

3 off 0-10V analogue inputs supplied with 1m interface cable. Input levels are displayed in the data message (see paragraph 2.3.1).

External High Accuracy Temperature and Humidity Sensor

Supplied as standard on the VPF750. Not applicable to the VPF710. When fitted to the VPF730 it enables Dust, Smoke and Mist to be identified, distinguishing these from Haze and Fog.

1.2 STEP 2 - Electrical Connections

All electrical connections should be completed before applying power to the sensor.

1.2.1 Cables

The VPF700 series of sensors are supplied with all necessary cables. Generally two cables are required, one for power and one for data. These two cables are supplied in a standard length of 6m. Any other length up to 25m can be supplied as an option if specified at time of order.

A single power and data cable can be supplied as an option if specified at time of order. This single cable version can only be supplied configured for RS232 data communication option, and only in the 12V DC or 24V DC models.

Note: For RS232 data configuration, cable lengths above 6m will not work reliably at high baud rates. It is strongly recommended that baud rates no higher than 4800 are used for cable lengths up to 25m.

All the cables are supplied terminated at one end with the applicable military style connectors with metal coupling nuts. Contacts in the plugs and receptacles are gold over nickel-plated copper for maximum corrosion resistance. Internal gaskets assure watertight performance. The cables are terminated with tinned tails at the other end for user connections. Each connector configuration is specific to its sensor function so that each can only be mated to the correct cable. An option for the cables to be permanently connected to the sensor via cable glands is available (see paragraph 1.2.7).

1.2.2 Sensor Connections – VPF710 and VPF730

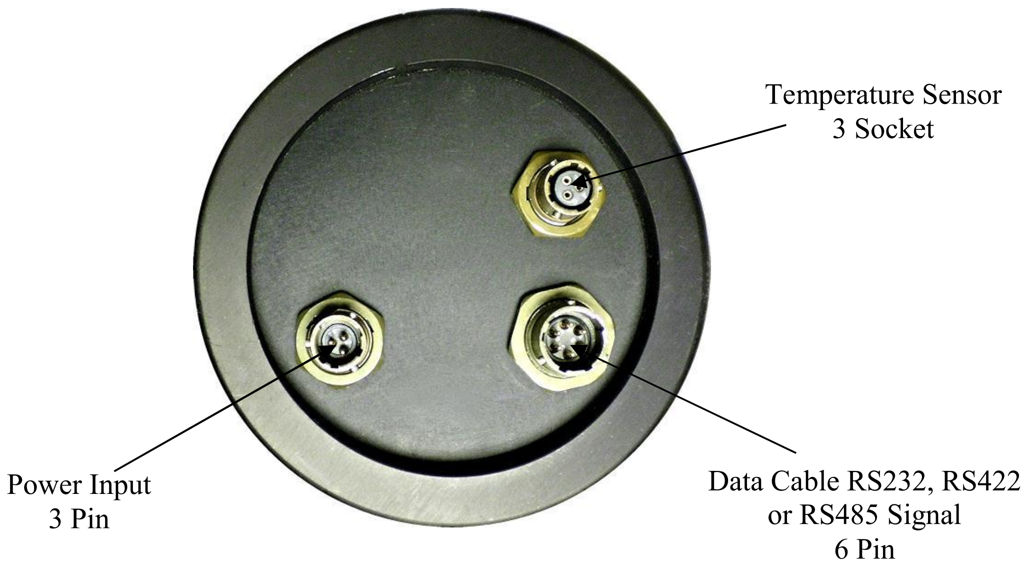


Figure 1-2 – Example of VPF710 and VPF730 Connectors

Figure 1-2 – Example of VPF710 and VPF730 Connectors, shows the base of a typical sensor. The sensor will only be fitted with the required connectors, so the actual number and position of the connectors may not be as shown. The cables supplied will be correct for the specific sensor and can only be mated with the correct sensor socket for each function.

1.2.3 **Sensor Connections – VPF750**

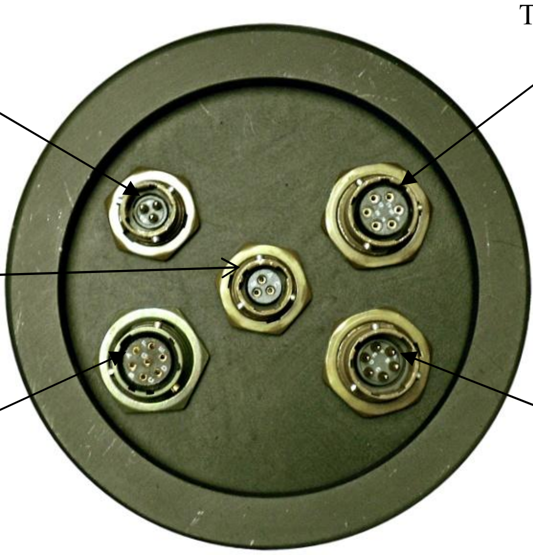


Figure 1-3 - VPF750 Connectors

Figure 1-3 - VPF750 Connectors, shows the base of a typical VPF750 sensor. It shows the option of separate power and data connection, the connection for the temperature and humidity sensor, the precipitation sensor connection and the ambient light sensor connection. The sensor will only be fitted with the required connectors, so the actual number and position of the connectors may not be as shown. Each of the items in the system is fitted with the appropriate plug which only fits the correct connector.

1.2.4 **Power Input Connections (not combined power/data cable – see para. 1.2.6)**

The power cable furnished with the sensor has the following pin and conductor assignments.

110 and 230VAC Models

Pin Number	Conductor Colour	Function
A	Brown	AC Live
B	Blue	AC Neutral
C	Yellow/Green	Sensor Ground

Table 1-1 - AC Power Connections

12 and 24VDC Models

Pin Number	Conductor Colour	Function
A	Brown	12V DC or 24V DC
B	Blue	0V
C	Yellow/Green	Sensor Ground

Table 1-2 - DC Power Connections

1.2.5 Data Connections (not combined power/data cable – see para. 1.2.6)

RS232 Signal Connections

When operating in the RS232 interface mode, the output signal cable furnished with the sensor has the following pin and conductor assignments. The cable consists of 3 sets of twisted pairs. The Function data refers to the SENSOR function.

Pin Number	Pair Number	Conductor Colour	Function
A	1	Red	Tx Data
B	1	White	Not Used
C	2	Brown	Rx Data
D	2	White	Not Used
E	3	Grey	Signal Ground
F	3	White	Sensor Chassis Ground

Table 1-3 - RS232 Signal Connections

RS422/485 Signal Connections

When operating with the RS422 or RS485 interface protocols, the output signal cable furnished with the sensor has the following pin and conductor assignments. The cable consists of 3 sets of twisted pairs. The Function data refers to the SENSOR function.

Pin Number	Pair Number	Conductor Colour	Function
A	1	Red	Tx Data +
B	1	White	Tx Data -
C	2	Brown	Rx Data +
D	2	White	Rx Data -
E	3	Grey	Signal Ground
F	3	White	Sensor Chassis Ground

Table 1-4 - RS422/485 Signal Connections

1.2.6 Option – Single Combined Power and Data Cable.

When configured for a single combined power and data cable, the cable furnished with the sensor has the following pin and conductor assignments. The cable consists of 3 sets of twisted pairs. The Function data refers to the SENSOR function.
Note: this configuration is only available with the RS232 communication protocol used on a DC power supply sensor.

Pin Number	Pair Number	Conductor Colour	Function
A	1	Red	+ve DC
B	1	White	-ve DC
D	2	Brown	Rx Data
E	2	White	Tx Data
C	3	Grey	Signal Ground
G	3	White	Sensor Chassis Ground
F			Not Used

Table 1-5 - Combined Power and Data Connections

1.2.7 Option – Glanded cable outlets (Not available for the VPF750 sensor)

For extreme environments, in particular continual salt spray, even the MIL type passivated aluminium connectors can suffer serious corrosion over a few years. Biral can provide a sensor with cables passing through plastic environmentally secure glands as a replacement for the standard connectors. The cables in this option of the sensor are permanently connected to the sensor during manufacture.

The cables fitted will be as specified above. See Table 1-1 - AC Power Connections to Table 1-5 - Combined Power and Data Connections, for the connection details for the free end of the glanded cables.

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>.

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 the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® Hyper Terminal™. (For RS422/485 sensors a RS422 to RS232 converter must be used).
   Note: Biral recommends testing to be done with RS232 or RS422 as applicable. When you are confident that the sensor is working it can then be set up for RS485 if required.

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

   <u>Default Interface Parameters</u>

   Baud Rate..1200 (9600 on VPF750)
   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. EXCO Calibration check:

THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE

VPF700 SERIES CALIBRATION KIT AND PC ARE AVAILABLE

Carry out the calibration check procedure in paragraph 5.1, page 61 to ensure that the EXCO value changes i.e. the sensor responds to changes in visibility.

NOTE: As this calibration check is being carried out indoors the EXCO value may NOT agree with that marked on your calibration reference plaque.

NB The sensor is fully calibrated before it leaves Biral.

1.4 STEP 4 - Configuration Options

There are a number of configuration options available for the user to select.

Three options are set using a configuration byte of the **Options Word,** detailed in sections 1.4.1 to 1.4.6**.** The remainder are set using a configuration byte of the **Operating State** word. These are set directly using commands starting with "OS". Each of these is detailed below in sections 1.4.7 to 1.4.10.

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 value is stored in non-volatile memory and the operating configuration when power is applied is that set by the last entered options word. The definition of each bit of this byte is shown below (Table 1-6).

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: 0 - Use temperature sensor value in PW determination
  This bit should not be changed.
- Bit 4: Not used
- Bit 5: Not used
- Bit 6: 1 - Add a check sum character to all sensor output messages
  0 - Don't add check sum character to all sensor output messages
- Bit 7: 1 - Don't adjust EXCO and MOR values in data messages for measured window contamination
  0 - Adjust EXCO and MOR values in data messages for measured window contamination
- Bit 8: 1 - Use RS485 addressable Communications protocol
  0 - Do not use RS485 addressable Communications protocol

Table 1-6 – Options Word (lower byte)

To set this word, send command CO to enable changes and then command OPa0b0000c to set the Option Word as required. For example, send OP100000 to enable the checksum with no date and time stamp and not using RS485 (leading '0's are not necessary in this command).

Bit 1 (Date and Time enable), Bit6 (Check Sum enable) and Bit 8 (RS485 enable) are the only bits which may be set to '1'by the user. All other bits MUST be left at '0' for correct sensor operation. The functions controlled by this byte are detailed in sections 1.4.2 to 1.4.6.

The Default setting = 00000000

1.4.2 Date and Time Stamp in data string

By default the date and time stamp is not included at the start of the data string. This is controlled by the Options Word setting; see Table 1-6 – Options Word (lower byte).

To enable Date and Time stamp

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

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

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 command OP0 in step 2 above.

To read the current Date and Time

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

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

To set the current Date and Time

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

%SD sets the real time clock date.

The format of the command is: %SDWDDMMYY

where:

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

DD - is the date (01..31)

MM - is the month (01..12)

YY - is the year (00..99)

The sensor will respond with 'OK'.

%ST sets the real time clock time.

The format of the command is: %STHHMMSS

where:

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

MM - is the minutes(00..59)

SS - is the seconds (00..59)

The sensor will respond with 'OK'.

1.4.3 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 checksum verification is not required. This is controlled by the Options Word setting; see Table 1-6 – Options Word (lower byte)

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 command: OP100000.

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

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

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

(NB. M is the checksum character).

To disable checksum

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

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

For Message:

C1 ... Cm <cksum><crlf>

The calculation is as follows:

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

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 Communications Configuration

TheVPF700 series sensor can use either RS232C or RS422/RS485 signal voltage levels. The configuration of the sensor is selected when ordering, since the change in protocol and line drivers involves changes to internal wiring. Check with the delivery paperwork to confirm the required configuration.

The configuration between RS422 and RS485 is user selectable. The following paragraphs provide the instructions for this adjustment and details for setting up the RS485 communication if required.

1.4.5 RS485 Configuration

Any of the VPF700 series of sensors, purchased with RS422/485 communication protocol can be set by the user for either RS422 or addressable RS485 communication protocols. The software needs to be configured to use this protocol.

By default the sensor is configured at the factory for RS422 protocol unless specifically requested when ordering.

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 HSS 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 address is defined by the operator for the unit and programmed as specified in the set-up instructions (Paragraph 1.4.6). 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 for each of the models in this range. The master has a defined range of commands available for the HSS sensor. The HSS 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 HSS 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

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).

1.4.6 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, see Table 1-6 – Options Word (lower byte).

Step 1 - Send the command: CO.
Step 2 - Send the command: 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 (i.e. revert to RS422 protocol) send the command: :00OP0FF in step 2 above (or :00OP1FF to enable time/date-stamp).

(NB. :00 is the address and FF is the LRC checksum override character, see below).

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 (Automatic message transmission disabled) rather than transmitting a data message automatically. See paragraph 1.4.7 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.

1.4.7 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 sensor). 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".

1.4.8 Data message type setting

The sensor can be set to send a compressed data message or an expanded data message, as detailed in section 2. The default setting is for expanded data message. To check which message is programmed send the message:

OSCM?

The sensor will send the reply:

00 = Expanded data message enabled

01 = Compressed data message enabled

To set the sensor to the required data message setting, send the message:

OSCMx

Where x is:

0 = Expanded data message enabled

1 = Compressed data message enabled

The sensor will respond with “OK”.

1.4.9 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”.

1.4.10 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”.

1.4.11 Baud Rate Configuration

Default communication parameters are 1200 Baud (9600 for VPF750), 8 data bit, 1 stop bit, no parity, and no flow control. The baud rate may be changed if required as follows.

Send %B(Number)

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

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

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

%B4<CRLF>

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

Table 1-7 - Baud-Rate Configuration

1.5 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 and precipitation reports.

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 some 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 1-8 - Recommended 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 the sensors invariably eliminate such false counts.

VPF710 Orientation

The VPF710 receiver optics should be aligned with true North (true South in the Southern Hemisphere) as shown in Figure 1-4 - VPF710 Orientation.

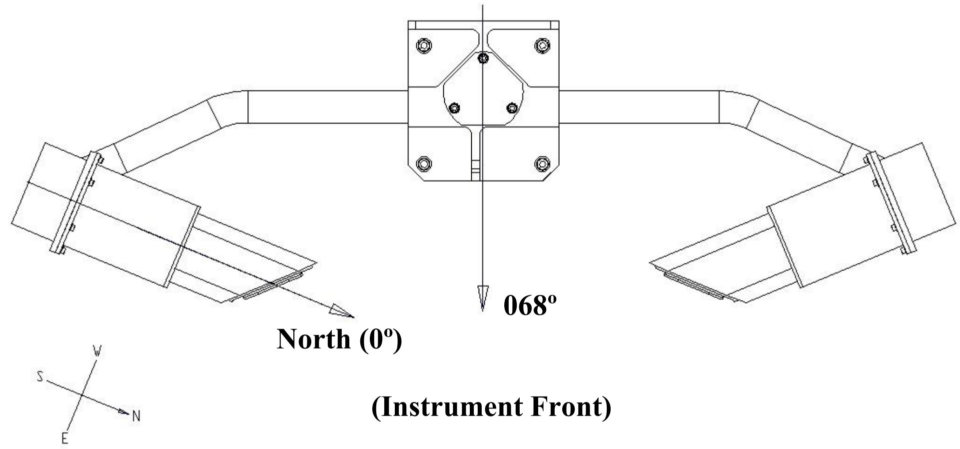


Figure 1-4 - VPF710 Orientation

VPF730 and VPF750 Orientation

The VPF730 and VPF750 alignment should be such that neither the forward nor the backscatter receiver optics is aligned with the rising or setting sun.

For the Northern Hemisphere the best mounting orientation is shown in Figure 1-5 - VPF730 and VPF750 Orientation (for the Southern Hemisphere the bearings should be increased by 180°).

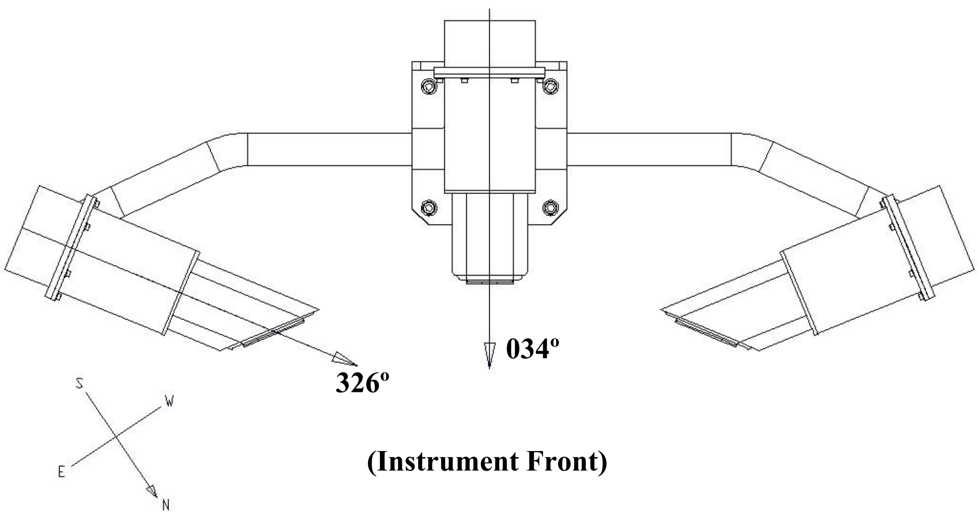


Figure 1-5 - VPF730 and VPF750 Orientation

1.5.4 Mounting the Sensor – All Models

The sensor head should be attached at the very top of the mounting pedestal with a U-bolt. The mast should be made from galvanised steel pipe or heavy walled aluminium tube whose outer diameter is in the range from 40 to 64 mm. *(NOTE: The maximum diameter for the VPF750 temperature and humidity radiation shield is 50mm).* Pipe or tubing with an outer diameter greater than 66 mm will not permit use of the U-bolt provided with the instrument. Pipe diameters less than 40 mm may not provide the U-bolt with adequate bearing surface. *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.*

A stainless steel closed-circle U-bolt with hardware is provided for securing the sensor to the top of the mast. A V-block saddle is attached to the sensor head mounting plate to oppose the U-bolt, thus providing a secure grip on the mast. The sensor head should be mounted near the very top so that the mast will not interfere with the free flow of fog or precipitation through the sample volume. The flat stainless steel washers should be placed next to the anodised surface of the mounting plate to prevent gouging by the lock washers as the nuts are tightened.

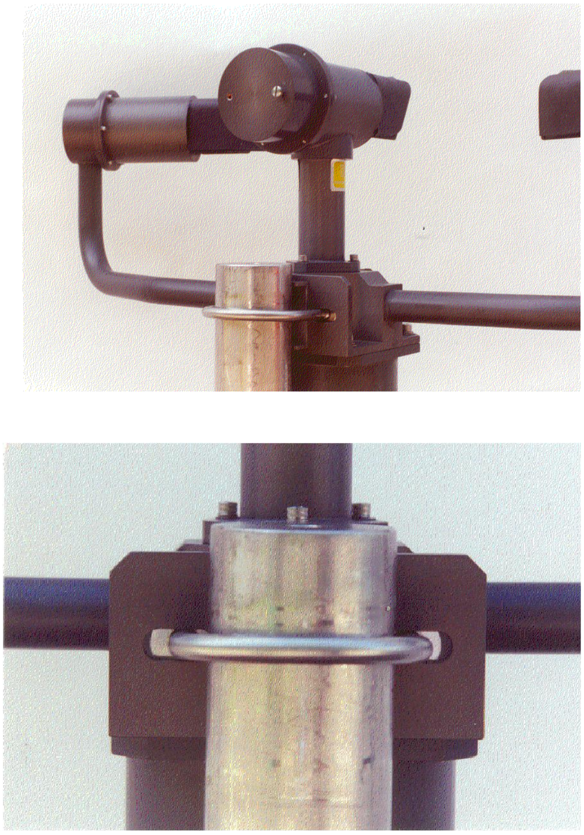


Figure 1-6 - U-bolt Mounting Method

1.5.5 **Mounting the Sensor – VPF750 Specific**

The VPF750 consists of a VPF 730 Present Weather Sensor, combined with a Precipitation Sensor, a Precision Temperature and Humidity sensor with radiation shield and an optional Ambient Light Sensor. The complete system is assembled as shown in Figure 1-7 - VPF750 System:

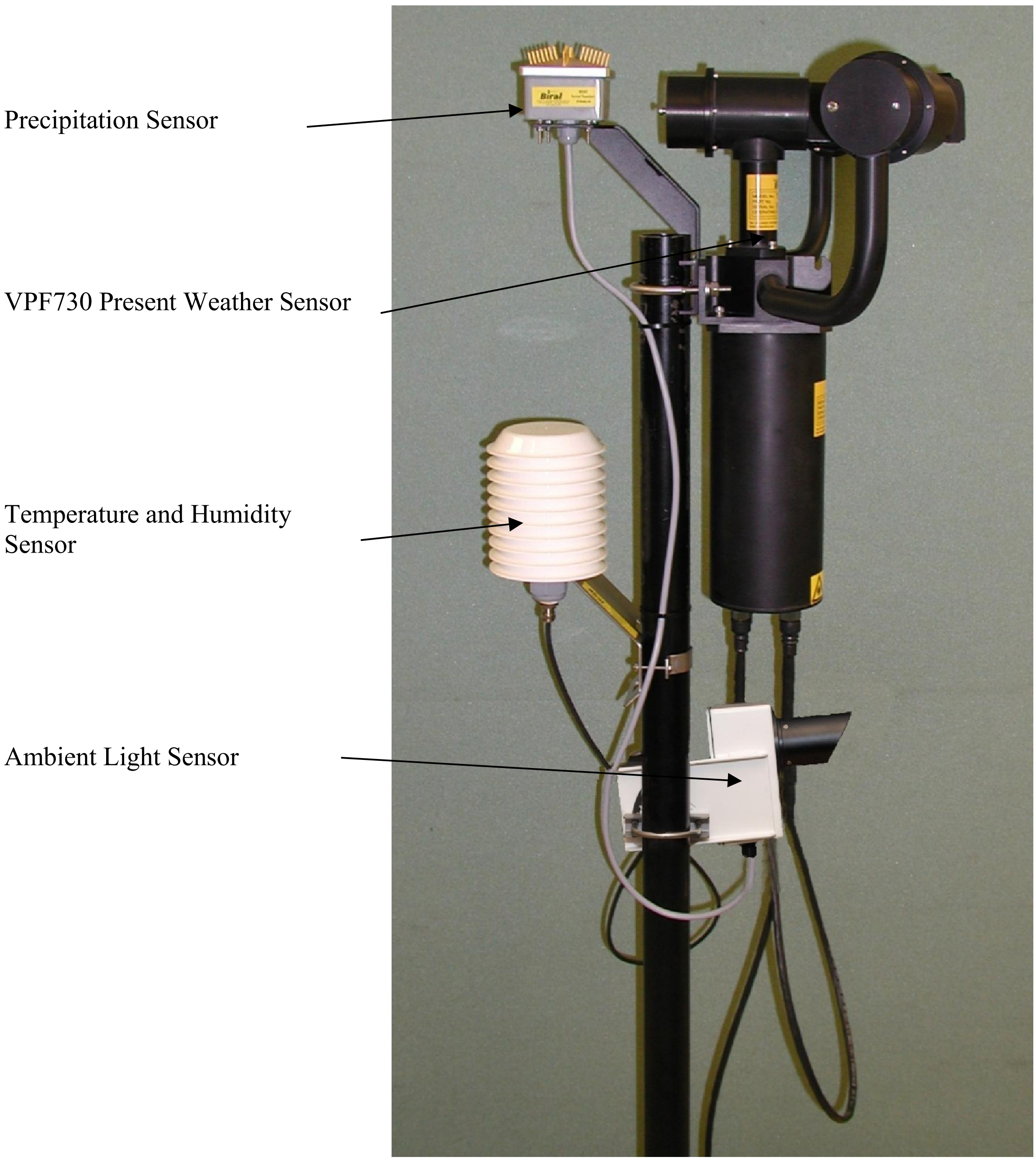


Figure 1-7 - VPF750 System

1.5.6 **Assembly Instructions VPF750**

On the rear of the present weather sensor, unscrew the small saddle which locates the system onto the mounting pole. Place the appropriate end of the Precipitation Sensor mounting bracket under this saddle and replace. This will locate the Precipitation Sensor immediately behind the back-scatter head as shown in Figure 1-8 - Precipitation Sensor Mounting Details.

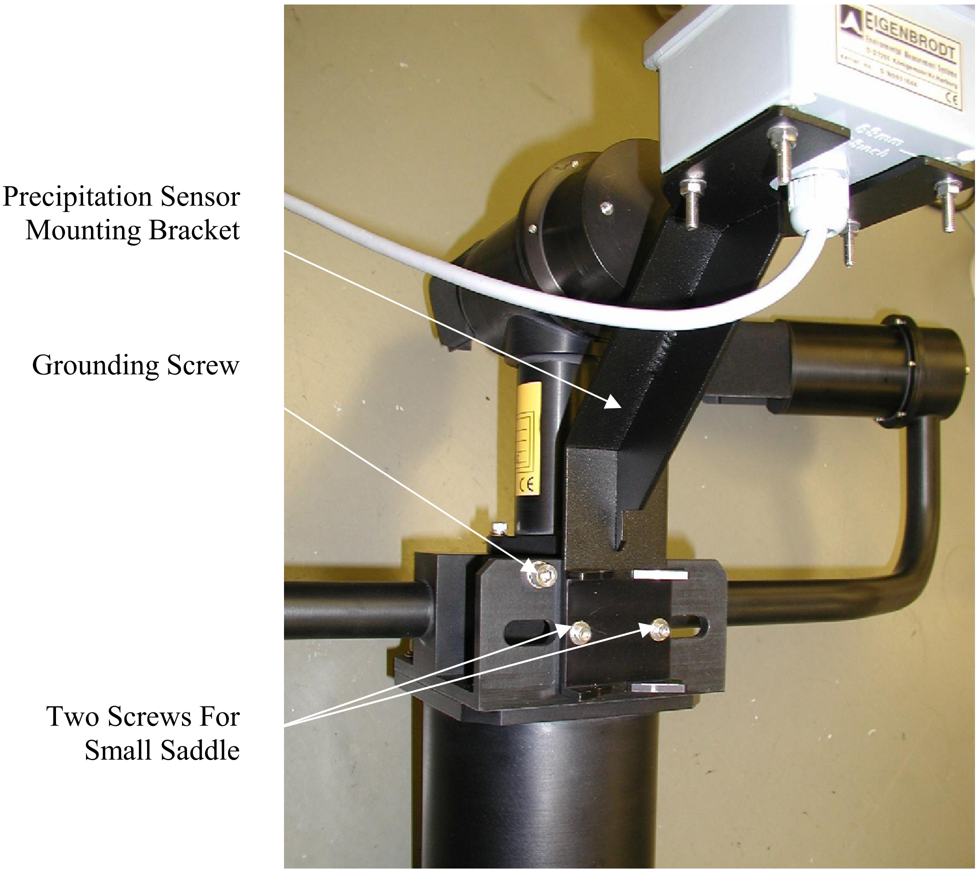


Figure 1-8 - Precipitation Sensor Mounting Details

Mount the Precipitation Sensor to the mounting bracket as shown.

Mount the Present weather Sensor to the mast keeping the Present Weather Sensor orientation as shown in paragraph 1.5.3.

Mount both the Temperature and Humidity Sensor and the optional Ambient Light Sensor to the mast as shown in Figure 1-7 - VPF750 System. Align the Ambient Light Sensor (if fitted) at a suitable angle above horizontal as defined by local requirements.

The Present Weather Sensor has between three to five connectors on its lower face. A typical configuration is specified in paragraph 1.2.3, but the number and position of the connectors may vary depending on the exact configuration purchased. The cables provided will only fit the appropriate connectors on the sensor.

1.5.7 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 (Figure 1-8 - Precipitation Sensor Mounting Details).

(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 AC/DC voltage (dependent on sensor voltage according to order). For AC supplies, check conformity with local and National installation requirements (see CE Certification – Safety, page vii)

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 the Biral Sensor Interface Software. If this is not available, use a terminal program - for example Windows® Hyper Terminal™. (For RS422/485 sensors a RS422 to RS232 converter must be used).
   Note: Biral recommends testing to be done with RS232 or RS422 as applicable. When you are confident that the sensor is working it can then be set up for RS485 if required.

3. Configure the terminal program as follows:

Default Interface Parameters

Baud Rate..1200 (9600 on VPF750)
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 (see paragraph 1.6.3 for explanation):

   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

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 -15	Internal operating voltage
Field 6:	4.5 - 5.5	Internal operating voltage
Field 7:	11 -15	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 (Not VPF710) (Optional)
Field 13:	00 - 99	Transmitter Window Contamination
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 1-9 - Remote Self-Test and Monitoring Message Fields

Check that the values in the remote Self-Test & Monitoring message from the previous Data Transmission To Sensor Check are within the ranges indicated in Table 1-9 - Remote Self-Test and Monitoring Message 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 paragraph 5.1, page 61 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

VPF700 SERIES 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**
- **MEASUREMENT PRINCIPLES**
- **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 1.4.7 page 17.

For each model in the VPF700 series of sensors, either a compressed data message or an expanded data message can be selected. The type of message is checked by sending command "OSCM?". The expanded data message (default) is selected if the response is "00". If the response is "01", the compressed data message is selected. Instructions for setting this configuration are provided in paragraph 1.4.8 page18.

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

The following paragraphs provide full details of the compressed and the expanded data messages for each sensor in the series.

2.1 Data Output Message VPF710

2.1.1 VPF710 Compressed Data Message

The data message format is:

<Date>,<Time>,CPaa,bbb.bb,ccc<cs><crlf>

Message	Meaning
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
CP	Compressed message header.
aa	Instrument identification number set by the user.
bbb.bb	Total EXCO in km^{-1}.
c c c	Self-Test and Monitoring (see paragraph 4.2). Third c: O = Other self-test values OK X = Other self-test fault exists Second c: O = Windows not contaminated X = Windows contaminated – cleaning recommended/required F = Windows contaminated – fault First c: O = Sensor not reset since last "R?" command X = Sensor reset since last "R?" command
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 2-1 - VPF710 Compressed Data Massage

Two typical compressed data messages from a VPF710 are as follows:

```
CP01,000.10,OOO
CP01,000.12,OOO
```

2.1.2 VPF710 Expanded Data Message

The data message format is:

<Date>,<Time>,VSaa,bbb.bb,ccc,dddddd,e.eee,ff.ff,ggg,hh,iii,jj,kkkk,±lll.l,mmmm <cs><crlf>

Message	Meaning
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
VS	Expanded visibility sensor message header.
aa	Instrument identification number set by the user.
bbb.bb	Total EXCO in km^{-1}.
c c c	Self-Test and Monitoring (see paragraph 4.2). Third c: O = Other self-test values OK X = Other self-test fault exists Second c: O = Windows not contaminated X = Windows contaminated – cleaning recommended/required F = Windows contaminated – fault First c: O = Sensor not reset since last "R?" command X = Sensor reset since last "R?" command
dddddd	Error Status: Bit 1: Transmitter Sync Signal Missing Bit 2: A/D control signal error Bit 3: RAM Error Detected Bit 4: EPROM check sum error Bit 5: Non-volatile memory check sum error Bit 6: Sensor reset has occurred
e.eee	A/D reference channel measured voltage (2.450 to 2.550).
ff.ff	Forward scatter receiver background illumination (00.00 to 10.00).
ggg	Infra red optical power (85 to 110).

Message	Meaning
hh	Transmitter window contamination (00 to 99).
iii	Forward scatter receiver gain (80 to 120).
jj	Receiver window contamination (00 to 99).
kkkk	AC interrupts per second.
±lll.l	Temperature (ºC).
mmmm	Not used.
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 2-2 - VPF710 Expanded Data Message

Two typical expanded data messages from a VPF710 are as follows:

```
VS01,000.55,XOO,100000,2.510,00.82,100,00,100,00,4040,+002.5,0000
VS01,000.56,XOO,100000,2.509,00.82,100,00,100,00,4040,+003.0,0000
```

2.2 Data Output Message VPF730

2.2.1 VPF730 Compressed Data Message

The data message format is:

<Date>,<Time>,CPaa,bb,ccc.cc,dd.dddd,±eee.e,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.
CP	Compressed message header.
aa	Instrument identification number set by the user.
bb	Present weather codes. From WMO Table 4680 (Automatic Weather Station). 00 No significant weather observed, or sensor starting 04 Haze or Smoke or Dust 30 Fog 40 Indeterminate precipitation type

Message	Meaning
	51 Slight Drizzle 52 Moderate Drizzle 53 Heavy Drizzle 61 Slight Rain 62 Moderate Rain 63 Heavy Rain 71 Slight Snow 72 Moderate Snow 73 Heavy Snow 89 Hail
ccc.cc	Transmissometer equivalent EXCO (km^{-1}).
dd.dddd	Amount of water in precipitation in last measurement period (mm).
±eee.e	Temperature (°C).
f f f	Self-Test and Monitoring (see paragraph 4.2). O = Other self-test values OK X = Other self-test 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 2-3 - VPF730 Compressed Data Message

Two typical compressed data messages from a VPF730 are as follows:

```
CP01,71,000.96,00.0048,-005.4,OOO
CP01,71,000.11,00.0005,-005.3,OOO
```

2.2.2 VPF730 Expanded Data Message

The data message format is:

<Date>,<Time>,PWaa,bbbb,cccc,ddd.dd KM,eee,ff,gg.gg,hh.hhhh,±iii.i C,jjjj,kkk.kk, lll.ll,±mmm.mm, nnnn,ooo,ppp,qqq.qq<cs><crlf>

Message	Meaning
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
PW	Present Weather message header.
aa	Instrument identification number set by the user.
bbbb	Last measurement period (seconds).
cccc	Time since this report was generated (seconds).
ddd.dd KM	Meteorological optical range (km).
eee	Precipitation type message: NP No precipitation DZ- Slight drizzle DZ Moderate drizzle DZ+ Heavy drizzle RA- Slight rain RA Moderate rain RA+ Heavy rain SN- Slight snow SN Moderate snow SN+ Heavy snow UP Indeterminate precipitation type GR Hail XX Initial value or error
ff	Obstruction to vision message: (blank) No obstruction HZ Haze FG Fog DU Dust FU Smoke BR Mist (DU, FU, BR: Only if external temperature/humidity sensor fitted)
gg.gg	Receiver background illumination.

Message	Meaning
hh.hhhh	Amount of water in precipitation in last measurement period (mm).
±iii.i C	Temperature (ºC).
jjjj	Number of precipitation particles detected in last measurement period.
kkk.kk	Transmissometer equivalent EXCO (km^{-1}).
lll.ll	EXCO less precipitation particle component (km^{-1}).
±mmm.mm	Backscatter EXCO (km^{-1}).
	Two spaces – delimiter.
nnnn	Precipitation message index.
ooo	Precipitation indicator 2.
p p p	Self-Test and Monitoring (see paragraph 4.2). Third p: O = Other self-test values OK X = Other self-test fault exists Second p: O = Windows not contaminated X = Windows contaminated – cleaning recommended/required F = Windows contaminated – fault First p: O = Sensor not reset since last "R?" command X = Sensor reset since last "R?" command
qqq.qq	Total EXCO (km^{-1}).
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 2-4 - VPF730 Expanded Data Message

Two typical expanded data messages from a VPF730 are as follows:

```
PW01,0060,0000,000.42 KM,NP ,FG,00.41,00.0000,+013.0 C,0000,007.12,
                            007.12,+026.17,  0001,000,OOO,007.12
PW01,0060,0000,000.42 KM,NP ,FG,00.45,00.0000,+012.5 C,0000,007.12,
                            007.12,+026.18,  0001,000,OOO,007.12
```

2.3 Data Message Variations For ALS or WSM (VPF710 and VPF730)

For sensors fitted with an Ambient Light Sensor or Weather Station Module, data output strings are identical to the standard message with the following appended to the message, prior to the optional check sum<cs> and the carriage return and line feed <crlf>.

2.3.1 Weather Station Module

, EXT:aaaa,bbbb,cccc,dddd

Message	Maning
EXT:	Optional external inputs.
aaaa	WSM Channel 1 (0000=0.00V, 1000=10.00V).
bbbb	WSM Channel 2 (0000=0.00V, 1000=10.00V).
cccc	WSM Channel 3 (0000=0.00V, 1000=10.00V).
dddd	Not used.

Table 2-5 - Message Extension for WSM

2.3.2 **Ambient Light Sensor**

, ALS,±aaaaa,bbb

Message	Meaning
ALS	ALS data message prefix.
±aaaaa	ALS Signal, 1 minute averaged value (cd/m^2).
b b b	ALS Self-Test and Monitoring (see paragraph 4.2). (third b) O = Other self-test values OK X = Other self-test fault exists (second b) O = Window not contaminated X = Window contaminated – cleaning recommended/required F = Window contaminated – fault S = Sensor input saturated (first b) O = Sensor not reset since last "R?" command X = Sensor reset since last "R?" command

Table 2-6 - Message Extension for ALS

2.4 Data Output Message VPF750

2.4.1 VPF750 Compressed Data Message

The data message format is:

<Date>,<Time>,CP,nnn,ww,aa.aa KM,bb.bbbb,±ccc.c,ddd,+eeeee,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.
CP	Compressed message header.
nnn	Instrument identification number set by the user.
ww	Present weather codes. From WMO Table 4680 (Automatic Weather Station). XX Not Ready (first 5 minute from restart) 00 No significant weather observed 04 Haze or Smoke or Dust 10 Mist 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 25 Freezing Drizzle or Freezing Rain in last hour but not at time of observation 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 53 Heavy Drizzle 54 Freezing Slight Drizzle 55 Freezing Moderate Drizzle 56 Freezing Heavy Drizzle 57 Slight Drizzle and Rain 58 Moderate or Heavy Drizzle and Rain

Message	Meaning
	61 Slight Rain 62 Moderate Rain 63 Heavy Rain 64 Freezing Slight Rain 65 Freezing Moderate Rain 66 Freezing 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
aa.aa KM	Meteorological Optical Range (KM).
bb.bbbb	Amount of water in precipitation in last minute (mm).
±ccc.c	Temperature (°C)
d d d	Self-Test and Monitoring (see paragraph 4.2). (third d) O = Other self-test values OK X = Other self-test fault exists F = Forward Scatter Receiver Flooded with Light B = Back Scatter Receiver Flooded with Light T = Temperature / Humidity sensor Fault (second d) O = Windows not contaminated X = Windows contaminated – cleaning recommended/required F = Windows contaminated – fault (first d) O = Sensor not reset since last "R?" command X = Sensor reset since last "R?" command

Message	Meaning
±eeeee	ALS signal, 1 minute average value (cd/m^2).
f f f	ALS Self-Test and Monitoring (see paragraph 4.2). (third f) O = Other self-test values OK X = Other self-test fault exists (second f) O = Window not contaminated X = Window contaminated – cleaning recommended/required F = Window contaminated – fault S = Sensor input saturated (first f) O = Sensor not reset since last "R?" command X = Sensor reset since last "R?" command
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 2-7 - VPF750 Compressed Data Message

Two typical compressed data messages from a VPF750 are as follows:

```
CP,001,52,09.30 KM,00.0426,+008.6,OOO,+00071,OOO
CP,001,62,09.87 KM,00.0612,+008.6,OOO,+00102,OOO
```

2.4.2 VPF750 Expanded Data Message

The data message format is:

<Date>,<Time>,VPF750,nnn,xxxx,aa.aa KM,cc, w_1, w_2,dd,eeeee,fff.fff,gg.gg KM, hhh.hh,±iii.ii,±jjj.j C,kkk %,lll,±mmmmm,nnn,oo.oooo,ppp,qqqq<cs><crlf>

Message	Meaning
<Date>	Optional Date string in the form DD/MM/YY.
<Time>	Optional Time string in the form HH:MM:SS.
VPF750	Model number.
nnn	Instrument identification number set by the user.
xxxx	Averaging time period in seconds.
aa.aa KM	Meteorological Optical Range (KM). This is the averaged value.
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 10 Mist 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 25 Freezing Drizzle or Freezing Rain in last hour but not at time of observation 30 Fog 31 Fog in patches 32 Fog become thinner in last hour 33 Fog no appreciable change in last hour 34 Fog begun or become thicker in last hour 35 Freezing Fog 40 Indeterminate Precipitation Type 51 Slight Drizzle 52 Moderate Drizzle 53 Heavy Drizzle 54 Freezing Slight Drizzle 55 Freezing Moderate Drizzle 56 Freezing Heavy Drizzle 57 Slight Drizzle and Rain 58 Moderate or Heavy Drizzle and Rain 61 Slight Rain

Message	Meaning
	62 Moderate Rain 63 Heavy Rain 64 Freezing Slight Rain 65 Freezing Moderate Rain 66 Freezing 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
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 DU Dust FU Smoke BR Mist
eeeee	METAR Reporting Code. See Table 2-9 - METAR Codes, paragraph 2.4.3.

Message	Meaning
fff.fff	Precipitation Rate (mm/hr).
gg.gg KM	Meteorological Optical Range (KM). This is the instantaneous value.
hhh.hh	Total Exco (/KM). This is the averaged value.
±iii.ii	Back Scatter Channel Exco (/KM). This is the averaged value.
±jjj.j C	Temperature (°C).
kkk %	Relative Humidity (%).
lll	Precipitation Indication
±mmmmm	ALS signal, 1 minute average value (cd/m^2).
n n n	Self-Test and Monitoring (see paragraph 4.2). O = Other self-test values OK X = Other self-test fault exists F = Forward Scatter Receiver Flooded with Light B = Back Scatter Receiver Flooded with Light T = Temperature / Humidity sensor Fault 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
oo.oooo	Amount of water in precipitation in last minute (mm).
p p p	ALS Self-Test and Monitoring (see paragraph 4.2). O = Other self-test values OK X = Other self-test fault exists O = Window not contaminated X = Window contaminated – cleaning recommended/required F = Window contaminated – fault S = Sensor input saturated O = ALS not reset since last "R?" command X = ALS reset since last "R?" command
qqqq	One minute particle count
<cs>	If selected this will be the checksum character. The checksum is off by default.

Table 2-8 - VPF750 Expanded Data Message

Two typical expanded data messages from a VPF750 are as follows:

```
VPF750,001,0060,09.30 KM,52,/,/,  ,DZ   ,000.426,08.76 KM,000.32,
          +000.14,+008.6 C,086 %,099,+00125,OOO,00.0071,OOO,0148
VPF750,001,0060,09.87 KM,62,5,/,  ,RA   ,000.612,08.35 KM,000.30,
          +000.12,+008.6 C,086 %,099,+00131,OOO,00.0102,OOO,0160
```

2.4.3 METAR Codes

Code Number	METAR Code	Description
XX		Not Ready (first 5 minutes from restart)
00		No significant weather observed, or sensor starting
04	HZ	Haze, visibility greater than or equal to 1KM
04	FU	smoke, visibility greater than or equal to 1KM
04	DU	Dust, visibility greater than or equal to 1KM
10	BR	Mist (only available with separate temperature and humidity sensor as analogue input)
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
25		Freezing Drizzle or Freezing Rain in last hour but not at time of observation
30	FG	Fog
31	BCFG	Fog in patches
32	PRFG	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
54	-FZDZ	Drizzle, freezing, slight
55	FZDZ	Drizzle, freezing, moderate
56	+FZDZ	Drizzle, freezing, heavy
57	-RADZ	Drizzle and Rain, slight

Code Number	METAR Code	Description
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
64	-FZRA	Rain, freezing, slight
65	FZRA	Rain, freezing, moderate
66	+FZRA	Rain, 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	GS	Small Hail
89	GR	Hail

Table 2-9 - METAR Codes

3 COMMANDS AND RESPONSES

3.1 Sensor Commands

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

Command	Function	Response	710	730	750
A?	Send accumulated precipitation message. (Accumulated precipitation in mm) ,(Accumulation time in minutes).	**xxx.xx (xxxx.x) ,xxxx**		√	√
AC	Clear accumulated precipitation.	**OK**		√	√
ADR?	Send RS485 address. See **para. 1.4.6.**	**xx**	√	√	√
ADRxx	Set RS485 address. Range 00-99. See **paragraph 1.4.6.**	**OK**	√	√	√
BB?	Send instantaneous value of backscatter EXCO.	**±xxx.xx**		√	√
BL?	Send instantaneous value of Total EXCO less precipitation particle component.	**±xxx.xx**		√	√
BT?	Send instantaneous value of Total EXCO .	**±xxx.xx**	√	√	√
CA	Perform precipitation amount calibration (Calibration must be enabled).	**See para. 5.4**		√	√
CE	Perform both forward scatter and backscatter (Not 710) EXCO calibration. (Calibration must be enabled).	**See para. 5.2**	√	√	√
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**	√	√	√
IDx	Set instrument identification number displayed in data message. 710/730 - Range x = 1 to 99. (Default = 1). 750 - Range x = 1 to 999. (Default = 1).	**OK**	√	√	√

Command	Function	Response	710	730	750
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 Para 3.1.3**		√	√
OP?	Check Option Word configuration.	**See para. 1.4.1**	√	√	√
OPXXXXXXXX	Set configuration options. See **para. 1.4.1.**	**OK**	√	√	√
OSAM?	Check automatic message setting	**See para 1.4.7**	√	√	√
OSAMx	Set automatic message setting, **para 1.4.7**	**OK**	√	√	√
OSCM?	Check message type setting	**See para 1.4.8**	√	√	√
OSCMx	Set message type setting. See **para 1.4.8**	**OK**	√	√	√
OSHH?	Check hood heater setting	**See para 1.4.9**	√	√	√
OSHHx	Set hood heater setting. See **para 1.4.9**	**OK**	√	√	√
OSWH?	Check window heater setting	**See para 1.4.10**	√	√	√
OSWHx	Set window heater setting. See **para 1.4.10**	**OK**	√	√	√
PV?	Send program version message.	**SI xxxx.yy**	√	√	√
R?	Send remote self-test and monitoring message.	**See Para 3.1.1**	√	√	√
RST	Restart instrument.	**OK**	√	√	√
T?	Send instrument times message.	**See Para 3.1.2**	√	√	√
SN?	Send instrument serial number.	**Jxxxx.xx**	√	√	√
TAx	Set auxiliary measurement sample period. Range x= 2-20 (seconds). (Default = 5).	**OK**	√	√	√
TMx	Set measurement interval. Range x = 10-300 (seconds). (Default= 60).	**OK**	√	√	√
TR?	Send current date and time. **See paragraph 1.4.2.** (The final ,000 is an internal fixed constant).	**FRIDAY , 23/03/12, 13:15:25,000**	√	√	√
%SDWDDMMYY	Set current date. **See paragraph 1.4.2.**	**OK**	√	√	√
%STHHMMSS	Set current time. **See paragraph 1.4.2.**	**OK**	√	√	√
WT?	Send current window contamination threshold for warning indication.	**XX**	√	√	√

Command	Function	Response	710	730	750
WTx	Set window contamination threshold for a warning indication, % transmission. Range: 0 to 30 (%) (Calibration must be enabled). (Default = 10).	**OK**	√	√	√
%Bx	Set communication baud rate. Range 1-7.	**See para. 1.4.11**	√	√	√

Table 3-1 - Commands for VPF700 Series of Sensors

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

Example response:

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

The various fields in the response are as follows:

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

A = 1 - Window heaters ON
A = 2 - 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). The normal running value for this is '100', which is widow heaters ON and no fault condition.

Field 3:	2.450 - 2.550	Internal reference voltage
Field 4:	9.00 - 36.00	Supply voltage for DC sensors only
Field 5:	11 - 15.0	Internal operating voltage
Field 6:	4.5 - 5.5	Internal operating voltage
Field 7:	11 - 15.0	Internal operating voltage
Field 8:	0.00 - 6.00	Forward scatter background brightness
Field 9:	0.00 - 6.00	Backscatter background brightness (Not VPF710)
Field 10:	85 - 105	Transmitter power monitor
Field 11:	80 - 120	Forward receiver monitor (Advanced self-test only)
Field 12:	80 - 120	Back receiver monitor (Advanced self-test only – Not VPF710)
Field 13:	00 - 99	Transmitter window contamination
Field 14:	00 - 99	Forward receiver window contamination (Optional) (Advanced self-test only)
Field 15:	00 - 99	Back scatter receiver window contamination (Optional) (Advanced self-test only – Not VPF710)
Field 16:		Temperature ^{o}C
Field 17:	3300-4200	ADC interrupts per second

Table 3-2 - Command R? Response

3.1.2 Command T? - Send Instrument Times Message

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

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

Table 3-3 - Command T? Response

3.1.3 Command M? – Send Precipitation message

This 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 graphically presented in Section 6, Figure 6-3 - Precipitation Matrix

An example response, which was 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).

3.2 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.

Table 3-4 - Responses From Sensor

4 MAINTENANCE PROCEDURES

The VPF700 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 instrument 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 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 paragraph 1.4.10 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 or other sources of contamination.

4.1.2 Hood Heaters (optional)

Hood heaters, if ordered, are fitted to the inside of each of the hoods (2 on the VPF710 and 3 on the VPF730 and VPF750).

The hood heaters are high-power heaters to help prevent the build-up of frozen precipitation in the hoods. The operation of these heaters is dependent on the ambient temperature (by default); they are only switched on when the temperature is below 2°C. They will then switch off when the temperature rises above 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. 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 the Biral Sensor Interface Software, or Windows Hyper Terminal, see page 1. The heaters may be switched on temporarily using the command DHO and off again using the command DHX.

The default setting is ON with automatic control. These can be switched OFF permanently to save power if required. See paragraph 1.4.9 for details.

4.1.3 **Window Cleaning**

A VPF700 series sensor 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 VPF700 series of sensors are fitted with a Transmitter Window monitoring system. An equivalent Receiver Window monitoring system may be fitted as an option if required. This monitoring system measures the optical contamination of the window and corrects the measured EXCO or MOR to compensate for this contamination. A warning is generated when the contamination reduces the signal by more than a pre-set amount (default 10%). When this warning occurs, the windows should be cleaned at the earliest possible opportunity. If the contamination continues to increase up to a pre-set limit of 30%, the appropriate part of the remote maintenance and self-test message in the sensor Data Output Message changes from X (warning) to F (fault) – see paragraphs 2 and 4.2.2. The accuracy of the instrument, if operated at greater contamination levels, may begin to deteriorate. The windows require cleaning as a matter of urgency.

4.2 Self-Test Codes

Self-Test and Monitoring information is provided in all standard Operating Data Messages, both of compressed and expanded formats. This information consists of three alpha-numeric characters which have the following meanings.

NOTE: The command "R?" provides a response with full diagnostic information. The extent of this information depends on the sensor configuration specified at time of purchase. This response is detailed in paragraph 3.1.1.

4.2.1 Most Significant Character (Sensor Reset Flag)

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

4.2.2 Central Character (Window Contamination)

All 700 series sensors have monitoring of contamination on the transmitter window. Monitoring of the receiver window(s) is an option available at time of purchase. The processor compensates the visibility reading to allow for this contamination and also checks each of the contamination figures against a value of either 10% (default value) or 30%. This Self-test code can be one of three characters, O, X or F dependent on the contamination reading(s) received. These have the following meaning:

"O": Window contamination is less than 10% (Default value; can be adjusted by the user, see command WTx, paragraph 3.1). No action required.

"X": Window contamination warning. The window contamination is between 10% and 30%. The visibility reading provided is corrected utilising this contamination figure, but it is recommended that the windows are cleaned at the earliest possible opportunity.

"F": Window contamination fault. The window contamination is above 30%. Although the visibility reading is still corrected using this contamination figure, the accuracy may deteriorate as the contamination increases. The windows require cleaning.

NOTE: The ALS 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 (The VPF750 has an additional three possible codes, F, B and T). These have the following meaning:

"O": No Fault. No action required.

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

"F" (750 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 paragraph 1.5.3) to prevent this occurrence.

"B" (750 only): This indicates that the Back 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 paragraph 1.5.3) to prevent this occurrence.

"T" (750 only): This indicates a fault in the external temperature and humidity sensor. Arrange for the temperature and humidity sensor to be serviced at the earliest possible opportunity. The VPF750 will continue to work correctly as a visibility sensor with either this fault present or the temperature and humidity sensor disconnected. It will also detect the presence of precipitation correctly, but may provide incorrect precipitation type indications.

4.3 User Confidence Checks

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

4.3.1 EXCO Calibration Check

If you wish to carry out a user confidence calibration check please follow the calibration check procedure in paragraph 5.1 page 61, to ensure that the Exco value changes i.e. the sensor responds to changes in visibility.

THIS PROCEDURE CAN ONLY BE COMPLETED IF A SUITABLE VPF700 SERIES CALIBRATION KIT AND PC ARE AVAILABLE

4.3.2 Temperature Calibration Check *(Note: temperature is not shown for model VPF710 with compressed data message.)*

The temperature sensor has a long thermal lag. The temperature reading can be incorrect for at least 30 minutes if the sensor is moved from one location to another of different temperature just prior to testing. In operation, at a fixed site, this is not a problem because ambient temperature changes are slow. If a very accurate check of the temperature reading is required, the sensor should be operated for at least 60 minutes at a fairly constant temperature before making the check. A verification of correct operation of the temperature sensor can be made without this "warm up" period. The check is made as follows:

Step 1. Use as a reference standard a thermometer accurate to ± 1 degree C. Ensure the standard thermometer has had time to stabilise to the ambient temperature environment.

Step 2. Verify that the value in the temperature field in the sensor data message matches the reference thermometer reading to within ±3°C (±5ºC for VPF710).

4.3.3 Window Monitor Checks

The VPF700 series of sensors monitor the transmitter window and, if the option has been specified at time of order, the forward and back scatter receiver windows. The values measured are used to adjust the EXCO 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:

<u>Transmitter Window Monitor</u>

Step 1. Clean the transmitter window.

Step 2. Send the command: R?

Step 3. Verify that the 'Transmitter Window Contamination' field value (see paragraph 3.1.1) in the sensor response is 00 to 02.

Step 4. Insert a piece of white card or paper in the transmitter hood that blocks and almost touches the window.

Step 5. Send the command: R?

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

Step 7. Remove the white card.

<u>Receiver Window Monitor(s)</u> (advanced self-test configured sensors only).

This procedure is used for the forward scatter receivers on all sensors and the additional backscatter receiver on the VPF730 and VPF750 sensors.

Step 1 Clean the forward scatter receiver window.

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

Step 3. Send the command: R?

Step 4. Verify that the 'Forward Scatter Receiver Window Contamination' field value (see paragraph 3.1.1) in the sensor response is 00 to 02.

Step 5. Insert a piece of white card or paper in the forward scatter receiver hood so that it blocks the window, and almost touches it.

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

Step 7. Send the command: R?

Step 8. Verify that the 'Forward Scatter Receiver Window Contamination' field value in the sensor response is much greater than 10 (ie 99).

Step 9. Remove the white card.

Step 10. For the VPF730 and VPF750, repeat steps 1 to 9, but applying to the back scatter head and the 'Back Scatter Receiver Window Contamination' field value in the sensor response.

4.3.4 Receiver Background Brightness Measurement Checks

The receiver background brightness value measures the optical signal detected by the receiver caused by the intensity of the ambient background. This value is used to set the threshold values for precipitation particle detection and interpretation. The following procedure will check this function (this procedure is used for both the forward scatter and backscatter receivers). For the VPF710 sensor only carry out the forward scatter test:

Step 1. Insert a zero plug (part of the VPF 700 sensor calibration kit) 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 Scatter Receiver Background Brightness' field in the sensor response (see paragraph 3.1.1) is less than 00.06.

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?
NOTE: This test requires the use of a filament bulb flashlight. There is insufficient IR radiation from a visible LED source.

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

Step 7. For the VPF730 and VPF750, repeat steps 1 to 6, but applying to the back scatter head and the 'Back Scatter Receiver Background Brightness' field value in the sensor response.

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 VPF700 SERIES CALIBRATION KIT

The Extinction Coefficient (EXCO) 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 an EXCO expressed in $(\text{kilometres})^{-1}$. This value is shown on the label which is attached to the arm of the calibration plaque. This label also states the serial number of the calibration plaque to ensure that the correct plaque is used with that arm.

Each calibration plaque also has a backscatter value which although it also is expressed in $(\text{kilometres})^{-1}$, is an artificial value assigned only for the purpose of checking that the sensitivity of the backscatter channel is within its proper limits. This is not used for the VPF710 sensors.

Please see Figure 5-1 - Assembly of Calibration Reference Plaque for a diagram of the Calibration Reference Plaque attached to a sensor.

5.1 Calibration Check

The following instructions show you how to check the calibration of a VPF700 series sensor. This procedure can only be completed with:

1. A VPF700 Series Calibration Kit.
2. Connection to a PC running the Biral Sensor Interface Software, or, if this is not available, terminal emulation software (such as Windows ® Hyper Terminal™). This will use the signal data cable as provided. *If you need help with this please do not hesitate to contact us (contact details on page vi).*

CALIBRATION CHECK NOTES

PLEASE READ THESE NOTES BEFORE CONTINUING

The EXCO (Extinction Coefficient) 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)**

Assembly of the calibration plaque to the sensor

The calibration reference plaque should first be attached to the arm. Confirm that the serial number marked on the calibration reference plaque matches that on the label on the calibration arm. If not, do NOT use this assembly as it may not give a true calibration. This assembly should then be attached to the sensor as shown in Figure 5-1 - Assembly of Calibration Reference Plaque.

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

The figure shows the calibration plaque assembly fixed to a VPF730, but the same configuration is used for the VPF710 and VPF750.

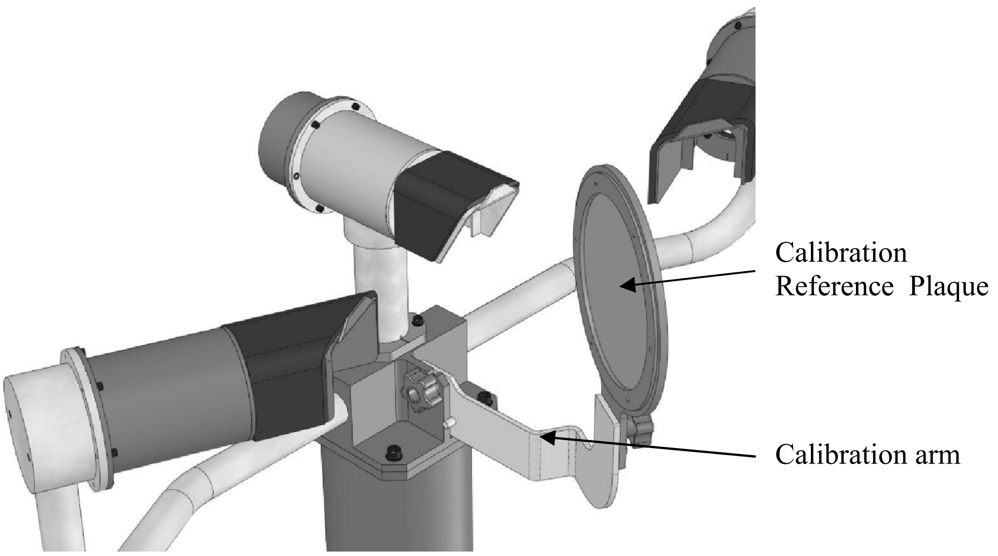


Figure 5-1 - Assembly of Calibration Reference Plaque

(Example of calibration plaque in-situ on VPF730)

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 5-1 - Assembly of Calibration Reference Plaque (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.

EXCO 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 VPF710).

Step 4: Send the command “RST”. 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. Send the command “BT?” Check that the response is between 0.00 and 0.05.

Step 7: **NOT for VPF710**: Send the command “BB? ”. Verify that the response is between -0.10 and 0.10.

Step 8: Remove the foam plugs.

EXCO gain Check:

Step 9: Send the command “RST” 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. Send the command “BT?” Check that the response is within ± 5% of the Forward EXCO value assigned to the calibration reference plaque (the value on the label attached to the plaque).

Step 12: **NOT for VPF710**: Send the command “BB? ”. Check that the response is within ± 10% of the Back EXCO value assigned to the calibration reference plaque (the value on the label attached to the plaque).

Step 13: Remove the calibration reference plaque from the sensor, dismantle it and return it to its protective case for storage.

> **If the results of the calibration check have agreed with the value on the label attached to the calibration reference plaque within the above limits, re-calibration is NOT required.**
>
> **A re-calibration is required ONLY if the EXCO 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 62.**

5.2 Sensor Re-calibration

> **RE-CALIBRATING THE EXTINCTION COEFFICIENT**
>
> **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)**

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

Step 1. Set up the sensor with the calibration reference plaque in place - see previous section, paragraph 5.1 (power to the sensor need not be removed).

Step 2. Send command "CO". Sensor replies: OK.

Step 3. Send command: "CE". Sensor replies:

CLEAN WINDOWS,
BLOCK FWD SCAT RCVR OPTICS,
BLOCK TRANSMITTER OPTICS,
BLOCK BK SCAT RCVR OPTICS, *(not for VPF710),*
INSTALL REF STD,
ENTER FWD SCAT EXCO (/KM)
FORM: XXX.XX

Step 4. Ensure that the windows are clean. Fit the three foam plugs (supplied with the calibration kit) against the windows (only 2 used for the VPF710).

Step 5. Enter Forward scatter EXCO value as written on the calibration plaque.

Step 6. **NOT VPF710:**
Sensor replies:

ENTER BACK SCAT EXCO (/KM)
FORM: XXX.XX.

Enter back scatter EXCO value as written on the calibration plaque.

Step 7. Sensor Replies: CAL IN PROGRESS
Wait for approximately 2 minutes.
Sensor replies:

REMOVE 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 EXCO' and the back scatter EXCO (NOT VPF710) value(s) reported by the sensor.

Step 12. If the Total EXCO reported is within 3% of the Forward EXCO value of the calibration plaque and (Not for VPF710) the back scatter EXCO reported is within 5% of the Back EXCO value of the calibration plaque then the sensor is within its calibration limits. The sensor can be returned to its operational configuration with confidence.

Step 13. Remove the calibration reference plaque assembly from the sensor, dismantle it and return it to its protective case for storage.

5.3 Temperature Calibration (Not VPF750)

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

Step 1. Send the command: “CO”. Sensor replies: OK.

Step 2. Send the temperature calibration command: “CT”. Sensor replies:

ENTER TEMP DEG C
FORM: (-)XX.X

Step 3. Enter the ambient temperature in ^{o}C (e.g.19.3). Sensor replies:

CAL IN PROGRESS

Step 4. Almost immediately, the sensor will send the message:

CAL COMPLETE

Step 5. The calibration process is complete.

5.4 Precipitation Amount Calibration

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

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 sensor reported an accumulation of 244 millimetres. To adjust the sensor's precipitation accumulation factor, the value to be entered is:

$$\frac{225}{244} \times 100 = 92.2$$

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 MEASUREMENT PRINCIPLES

6.1 Visibility Measurement Terminology

The VPF700 Sensor of Series has all the capabilities of a forward scatter meter (FSM); i.e. it belongs to the class of nephelometers which measure the amount of light scattered at angles less than 90 degrees by small particulates suspended in, or large particles passing through its sample volume. In the case of the VPF700 Series of Sensors, the sample volume is defined by the intersection of the transmitted beam of light and the ray-cone which defines the field of view of the forward scatter receiver as shown in Figure 6-1 - Sensor Sample Volume.

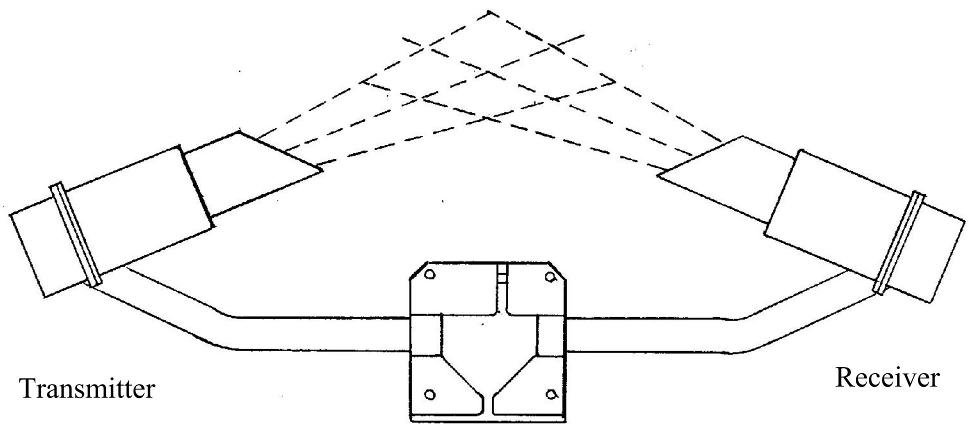


Figure 6-1 - Sensor Sample Volume

Suspended particles such as fog, haze and smoke aerosols and precipitating particles such as rain, snow, ice pellets, drizzle and mist account for essentially all of the atmospheric extinction of visible and near-visible optical radiation for horizontal visual ranges up to approximately 100 kilometres. Beyond that range scattering by the molecular constituents of the atmosphere begin to play a role. In the visible and near visible spectral regions the dominant aerosol attenuation process is Mie-scattering. Aerosol absorption plays a negligible role in most natural environments, thus the atmosphere scattering coefficient and extinction coefficient are synonymous.

6.2 Visual Range Determination

Nearly all instrumental methods of determining visual range start with a quantitative measurement of the atmospheric extinction coefficient β. Because β is measured in the vicinity of the instrument an assumption must be made that the prevailing environmental conditions are uniform over the scale of visual ranges of interest. The extinction coefficient is converted to visual range by application of:

(1) Koschmieder's Law (for daytime visual range),
(2) Allard's Law (for night-time visual range), or
(3) Variations on Koschmieder and Allard's Laws.

When an observer looks at a distant target the light from the target that reaches the observer is diminished by absorption and scattering (the two components of extinction). In addition to the light that originates at the target and ultimately reaches the observer, extraneous light scattered into the line-of-sight by the intervening atmosphere is also seen by the observer. It is this air light which we recognise as haze or fog.

The effect of extinction and added air light on the perceived brightness of visual targets is shown graphically below in Figure 6-2 - Effects of Atmosphere on Perceived Brightness of Target Objects From this illustration we note that the apparent contrast between object and horizon sky decreases with increasing distance from the target. This is true for both bright and dark objects.

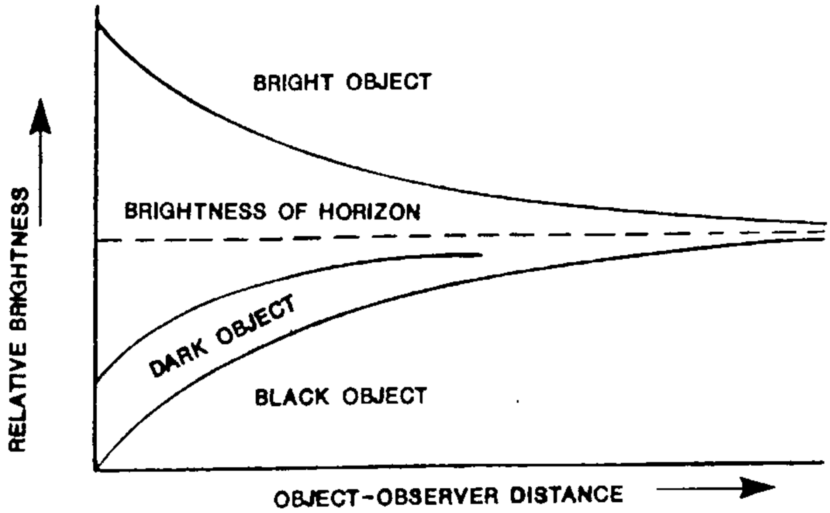


Figure 6-2 - Effects of Atmosphere on Perceived Brightness of Target Objects

6.2.1 Daytime Visual Range

The original formula for calculating daytime visual range VR that was formulated by Koschmieder in 1924 is:

$$V_R = \frac{3.912}{\beta}$$

Where β is the atmospheric extinction coefficient.

Subsequent investigations concluded that Koschmieder used too optimistic a value (0.02) for the liminal contrast threshold value of the human eye. A liminal value of 0.05 is believed to be more realistic. For the latter contrast threshold Koschmieder's Law is modified to become

$$V_R = \frac{3.00}{\beta}$$

This simple law accounts for both the extinction of light by the atmosphere and the addition of air light by the same atmosphere - for a black target viewed against the horizon sky. Thus, the strict definition of daytime visual range implies the limiting distance at which a black target can be discerned against the horizon sky.

6.2.2 Night-time Visual Range

Night-time visual range refers to the distance at which an observer can see lights through the atmosphere at night. Allard gave the formula for the distance at which lights of intensity **I** can be seen at night in 1876.
Allard's Law is expressed as:

$$E_t = \frac{Ie^{-\beta V}}{V^2}$$

Where Et is the observer's illuminance threshold and β is the atmospheric extinction coefficient.

In addition to the extinction of light by the atmosphere, this formula accounts for the decrease of light from the point sources of light as the inverse square of the distance.

This formula for calculating night-time visual range has a significant mathematical difference from the formula derived from Koschmieder's law. Where the latter has a single algebraic relation between visibility and extinction coefficient, the former has a transcendental relation between the two quantities. Thus, the solution can only be found by an iterative numerical procedure or from a prepared table of values.

6.2.3 Meteorological Optical Range

Meteorological Optical Range (MOR) is the length of the path in the atmosphere required to reduce the luminous flux in a collimated beam from an incandescent lamp at a colour temperature of 2700°K to 0.05 of its original value. That is, the length of the path is the atmosphere for which the regular transmittance is 0.05.

For practical purposes one may calculate MOR in the same manner as Daytime Visual Range; i.e. MOR is given by the relation:

$$MOR = \frac{3.00}{\beta}$$

The use of MOR satisfies the requirements of a meteorologist since it yields a one-to-one correlation with atmospheric transmittance. A change from day to night does not produce, by itself, a change in the visibility.

6.3 Extinction Coefficient Calibration

The calibration of the prototype sensor was carried out at the Weather Test Facility (WTF) of the Air Force Geophysical Laboratory which is located at the Otis Air National Guard Base (ANGB) on Cape Cod, Massachusetts, USA. The calibration was made by comparison of atmospheric extinction coefficient measurements with those of standard FAA approved transmissometers. Comparisons were made over an extremely wide range of fog and haze situations.

The calibration of each duplicate Present Weather Sensor is traceable back to the measurements made with the prototype instrument at the AFGL Weather Facility. This "primary" calibration is transferred to other instruments of the same type using a "primary reference standard" whose "equivalent extinction coefficient" was established at the time of the primary calibration. A secondary reference standard similar in construction to the primary standard can be furnished with each instrument so that the sensor calibration can be periodically checked. The secondary reference standard has received its value of equivalent extinction coefficient by a comparison with the primary reference standard. This determines the calibration constant for the secondary reference standard.

6.4 Theory of Forward Scatter Meters

6.4.1 Optical Sensor Configuration

The visibility measurement capability of the VPF-700 series of sensors derives from its forward scatter meter (FSM) configuration. Unlike a transmissometer, which measures the total atmospheric extinction coefficient, a FSM measures only an angular portion of the atmospheric scattering coefficient, that is, the scattering in a narrow range of angles around a central forward scatter angle.

The application of the standard universally accepted formulae for the calculation of daytime and night-time visibility requires that the total atmospheric extinction coefficient be measured, not the angular scattering coefficient. Thus, it is necessary to show that a measurement of the angular scattering coefficient, under certain strict conditions, can be related to the total atmospheric extinction coefficient (EXCO). Where EXCO includes both scattering and absorption of radiation at all angles from 0 to 180 degrees and by all atmospheric constituents be they suspended aerosols, precipitation or molecules of air.

The first step in that conversion process is to demonstrate that the total atmospheric scattering coefficient and total atmospheric extinction coefficient are synonymous for all practical purposes.

Assumption (1): The visibility measurements are restricted to less than 100 kilometers. (Rayleigh scattering by air molecules does not contribute significantly to atmospheric attenuation of visible light for visibility less than 100 kilometres).

Assumption (2): Absorption by fog, natural aerosols and precipitation contributes a negligible amount of attenuation compared to their scattering for visible and near visible radiation.

Given the above reasonable assumptions, the total scattering coefficient can be equated to the total extinction coefficient.

The next step in the process requires equating the angular scattering coefficient as measured by a FSM with the total scattering coefficient. That transition requires restrictions to be placed on the physical configuration of a FSM and on the wavelengths of radiation employed.

6.4.2 **Visibility in Fog & Haze**

The angular scattering coefficient can be separated into two components, a phase function Φ (θ) and the total scattering coefficient σ as follows:

$$\sigma(\theta) = \Phi(\theta)\sigma$$

To replace the total scattering coefficient by the angular scattering coefficient, as required for valid measurements with a FSM, it is obvious that the phase function must be a constant for all environmental conditions in which visibility measurements are of interest (usually all weather conditions).

During WWII, British scientists discovered a natural phenomenon that allowed substitution of the angular scattering coefficient for the total scattering coefficient. In the scattering angle region between 35 to 55 degrees, they found very little change in the phase function for all classes of fogs and hazes. It was given the code name "Loofah". (See: W.E.K. Middleton, Vision through Atmosphere, University of Toronto Press). Much post-WWII work has substantiated the existence of this phenomenon.

Many FSMs employ a 35-degree scattering angle configuration since this angle provides more scattered light, hence more signal, than do greater "Loofah" angles. (The phase function has an inverse dependence with increasing scattering angle, its value being largest at smaller angles).

Whatever central angle is chosen for the FSM configuration, there is no simple way of providing an absolute calibration for the FSM. Calibration of a FSM must be accomplished by a comparison of measurements with an instrument that measures the atmospheric extinction coefficient directly. A transmissometer is such an instrument. Only one FSM of a given type, usually the prototype, need be calibrated against a well-maintained visible light transmissometer. The calibration of the prototype sensor is transferred to a calibration reference standard, which then serves as the primary reference standard for calibration of all other FSMs of an identical configuration. The primary standard for a given FSM is not a reliable reference standard for FSMS with any other size, central angle, types of optics or light source.

Well-maintained transmissometers that are available for calibration purposes are airport type transmissometers, dedicated to the measurement of visual range in heavy haze and fog. Such transmissometers prove to be accurate calibration references only over a limited range of visibilities, namely 1/2B to 20B, where B is the baseline of the transmissometer. A typical airport transmissometer has a baseline in the neighbourhood of 100 meters. Thus, its range of valid measurements extends from 50 meters to 2000 meters. This range encompasses only two environmental conditions, fog and very heavy haze.

To assure that the fog calibration of HSS sensors remains valid for lighter haze conditions and clear air, extensive use has been made of visual observations and televisiometer measurements. Proper targets for such observations must satisfy the conditions required by daytime visual range formulae; i.e., large, dark objects silhouetted against the horizon sky with no cloud cover present. A minor wavelength dependence effect is present for haze measurements, which is discussed later.

6.4.3 **Visibility During Precipitation**

It is highly desirous that the fog/haze calibration of a FSM carries over to various forms of precipitation. For this condition to be satisfied requires that the measurements of a fog/haze calibrated FSM give identical results to a transmissometer in snow and rain.

Forward scatter meters configured for a central scattering angle of 35 degrees and calibrated against transmissometers in fog/haze environments will overestimate the visibility in snow and underestimate the visibility in rain. To find out if there is a common "Loofah" angle for fog, haze, snow and rain HSS FSMs with central scattering angles other than 35 degrees have been operated for several years comparing their measurements with those of transmissometers in all types of weather. The results indicate that with a scattering angle near 45 degrees, a fog/haze calibration will remain valid for snow.

There is no common "Loofah" angle that allows transmissometer measurements in rain to agree with those of a FSM. The best result that can be achieved is a minimisation of the difference between the readings of a FSM in rain verses those of transmissometer. Since FSMs give higher EXCOs in rain than transmissometers (i.e. the corresponding visibilities are lower) the difference is a fail-safe error if one accepts the transmissometer readings as the "true" value.

Disagreement between FSMs and transmissometers in rain has two root causes:

(1) The phase function for scattering by rain is dramatically different from that of fog, haze and snow: (the phase function has a highly forward-directed diffraction component that accounts for one-half of the light energy scattered by a raindrop) and,

(2) The receiver of a transmissometer is unable to distinguish between un-scattered light and diffracted light and treats both as un-scattered radiation. As a result, transmissometer measurements underestimate the total extinction coefficient.

There are two schools of thought regarding which sensor type gives the more valid visibility measurement in rain, FSMs or transmissometers. One school believes the eye performs the same function as the transmissometer receiver, hence the transmissometer readings give the correct extinction coefficient. The second school counters with the opinion that while the first argument may be valid for point light sources, it is certainly not valid for non-self-luminous objects, especially for the theoretical black target used in the definition of daytime visual range. In the second case, the target contrast is reduced by the air light that results from light scattered by the raindrop at all angles. There is no light emanating from a black target to be diffracted toward the eye.

6.4.4 Transmissometer Equivalent EXCO

A BIRAL present weather sensor can satisfy either school of opinion using its unique measurement techniques. For those that believe that the FSM measurements characterise the true extinction coefficient in rain, the total EXCO value normally provided by the sensors is always available. For the other school who believe that the true extinction coefficient in rain is that measured by transmissometers, the BIRAL present weather sensors can provide the Transmissometer Equivalent EXCO, (TEXCO).

The Transmissometer Equivalent EXCO is arrived at by the following steps:

(1) The sensor must first determine that the precipitation is rain not snow or other form of frozen precipitation.

(2) Separate the total EXCO into its components: EVENTS EXCO and EXCO MINUS EVENTS. (This step is essential to remove the fog or haze component from EXCO).

(3) Using an empirically determined relationship, convert the FSM EVENTS EXCO to TRANSMISSOMETER EVENTS EXCO.

(4) Restore the EXCO-EVENTS component (i.e. non-rain component of EXCO) to arrive at TEXCO.

(5) Output EXCO, EXCO-EVENTS and TEXCO.

6.4.5 **Wavelength Dependence of FSM Measurements**

Measurements by forward scatter meters and transmissometers in fog have no wavelength dependence on the radiation employed by their light sources. This fact is easily confirmed by the observation that fog is white in appearance.

Such is not the case with haze that has a decidedly blue cast in appearance. The transition to fog from haze is not a gradual affair. Middleton points to an abrupt transition in wavelength dependence at an extinction coefficient of 4 km^{-1}. This he takes to be the transition point from haze to fog. Above 4 km^{-1}, there is no variation of the extinction coefficient with wavelength. Below 4 km^{-1}, there is a distinct variation. Angstrom demonstrated that this wavelength variation of extinction in haze is due to aerosol scattering and has a wavelength dependence of:

$$\sigma(\lambda) = const \frac{1}{\lambda^{1.3}}$$

Others have shown this variation to be generally applicable for the spectral range from visible to near-infrared wavelengths of 1.0 micron and for visibilities extending to 100 kilometres.

BIRAL FSMs operate at a wavelength of 0.88 microns because of the high powered IREDs available at that wavelength compared with LED's operating in the visible spectral region at the peak of the eye response (0.55 microns). The variation with wavelength in haze implies that if two FSMS, one operating at 0.88 micron and one at 0.55 micron are calibrated against a visible light transmissometer in fog then their measurement in haze will differ by the amount:

$$\sigma(0.88) = \left(\frac{0.55}{0.88}\right)^{1.3} \sigma(0.55)$$

$$= 0.54\sigma(0.55)$$

In fog and haze, the visible light transmissometer will measure the total scattering coefficient σ (.55). A visible light FSM might also give σ (.55) in haze, but it does not because it measures the angular scattering coefficient not the total scattering coefficient.

Atmospheric aerosol models show, in addition to the wavelength dependence, a slight wavelength dependence of the phase functions as well. For the two wavelengths of interest in the above example, the phase functions in fog and haze are as follows:

$$\Phi_{FOG}(0.55) = \Phi_{FOG}(0.88) = 0.13$$

$$\Phi_{HAZE}(0.55) = \Phi_{HAZE}(0.88) = 0.22$$

Thus, a FSM operating at 0.88 micron and calibrated in fog will show a phase function difference in haze by the amount:

$$\Phi_{HAZE}(0.88) = \frac{0.22}{0.13}\Phi_{FOG}(0.88)$$

$$= 1.7\Phi_{FOG}(0.88)$$

For a FSM operating at 0.88 microns, the two wavelength dependent components of the angular scattering coefficient are in the opposite direction and nearly offset one another. The net result is that a calibration made in fog will be applicable to haze situations.

Such is not the case for a FSM operating at 0.55 microns. At that wavelength there is no spectral difference between FSM and a visible light transmissometer. The total scattering coefficient portion of the angular scattering function will remain unchanged, but the phase function will jump in the transition from fog to haze. Larger than "true" extinction coefficients will result with the subsequent underestimation of the true visual range in haze.

6.5 Precipitation Measurements

An automated present weather sensor must be capable of determining the type, intensity and quantity of precipitation in addition to the visibility. In the case of the VPF700 series of sensors these precipitation parameters are established by a combination of several methods.

6.5.1 **Identification:**

The type of precipitation is established by one of two independent techniques. In one of the techniques, the ratio of the back scatter atmospheric extinction coefficient (BACK SCATTER EXCO) to the forward scatter atmospheric extinction coefficient (FORWARD SCATTER EXCO) is determined. A ratio greater than a specific value indicates snow while a ratio lower than a specific value indicates rain. In the second the size and velocity distributions of the precipitation particle are used to determine the type of precipitation. These two techniques are intended to complement one another. However, under some circumstances one of the techniques is programmed to override the other. The particular circumstance under which the one is programmed to veto the other has been established by several years of empirical observations.

6.5.2 **Precipitation Recognition Matrix**

The VPF-700 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 Matrix. This figure portrays a 16 x 21-matrix array of particle sizes and velocities. Sizes are arranged in columns and velocities in rows.

The Marshall-Palmer model for raindrop size-distribution and the Gunn-Kinzer measured velocities for raindrops in stagnant air were used to construct the matrix scales. If rainfall behaved in the exact manner of the Marshall-Palmer and Gunn-Kinzer models all raindrop measurements would fall in the data bins along the diagonal of the Precipitation Recognition Matrix. In practice, several factors tend to disperse the size/velocity relationship from the idealised characterisations.

(1) The Marshall-Palmer size distribution for raindrops is only a best-fit approximation,

(2) Winds and wind gusts can perturb the velocity/size relationship,

(3) The shape of the sample volume can significantly influence the velocity/size characteristics of particles. (i.e. Particles falling through a portion of the sample volume other than the centre, or falling in other than a vertical direction because of wind, will exhibit slightly different velocity/size characteristics depending upon the shape of the sample volume and the direction of the wind).

For the foregoing reasons, one expects raindrop counts to show up in some off-diagonal bins of the Precipitation Recognition Matrix as shown in the schematic illustration given in Figure 6-3 - Precipitation Matrix. Indeed, this conjecture is substantiated in practice. This diagram shows a schematic portrayal of the use of the Precipitation Matrix to identify different kinds of precipitation. The locations of various forms of precipitation, which are schematically illustrated in the matrix, are also borne out in practice.

6.5.3 Signal Processing

A functional block diagram of the VPF700 series of sensors is shown in Figure 6-4 - VPF730 Sensor Functional Block Diagram. Those components of the sensor housed in the transmitter and receivers are shown enclosed in one dashed line. Those components housed in the power/control system are shown enclosed in the other dashed line.

When a particle of precipitation passes through the sample volume, light from the LED source, which is housed in the transmitter section of the sensor head, is scattered into the receiver section where it is sensed by the photo detector. Because the LED source is modulated at a 2 kHz frequency, the detector and amplifier chain generates an AC signal whose amplitude is proportionally to the size of the particle and whose duration is inversely proportional to its velocity.

6.5.4 Quantity and Intensity

Typically a sampling time interval of one minute is employed in automated present weather sensors. When rain is identified the quantity of water falling in the one-minute sampling time interval is determined from the number and size of the raindrops passing through the sample volume. The intensity is established by a comparison of the quantity of rainfall in one minute with the rate of fall intensity scale published in the Federal Meteorological Handbook (see Precipitation Measurements, paragraph 7.3.4). Other reporting codes and intensities may also be provided to conform to local standards, to determine the system in use please consult the calibration data supplied with the sensor. When snow is identified the intensity is established on the basis of the visual range. For other forms of frozen precipitation, the intensity is established on the basis of the equivalent water content rate of fall.

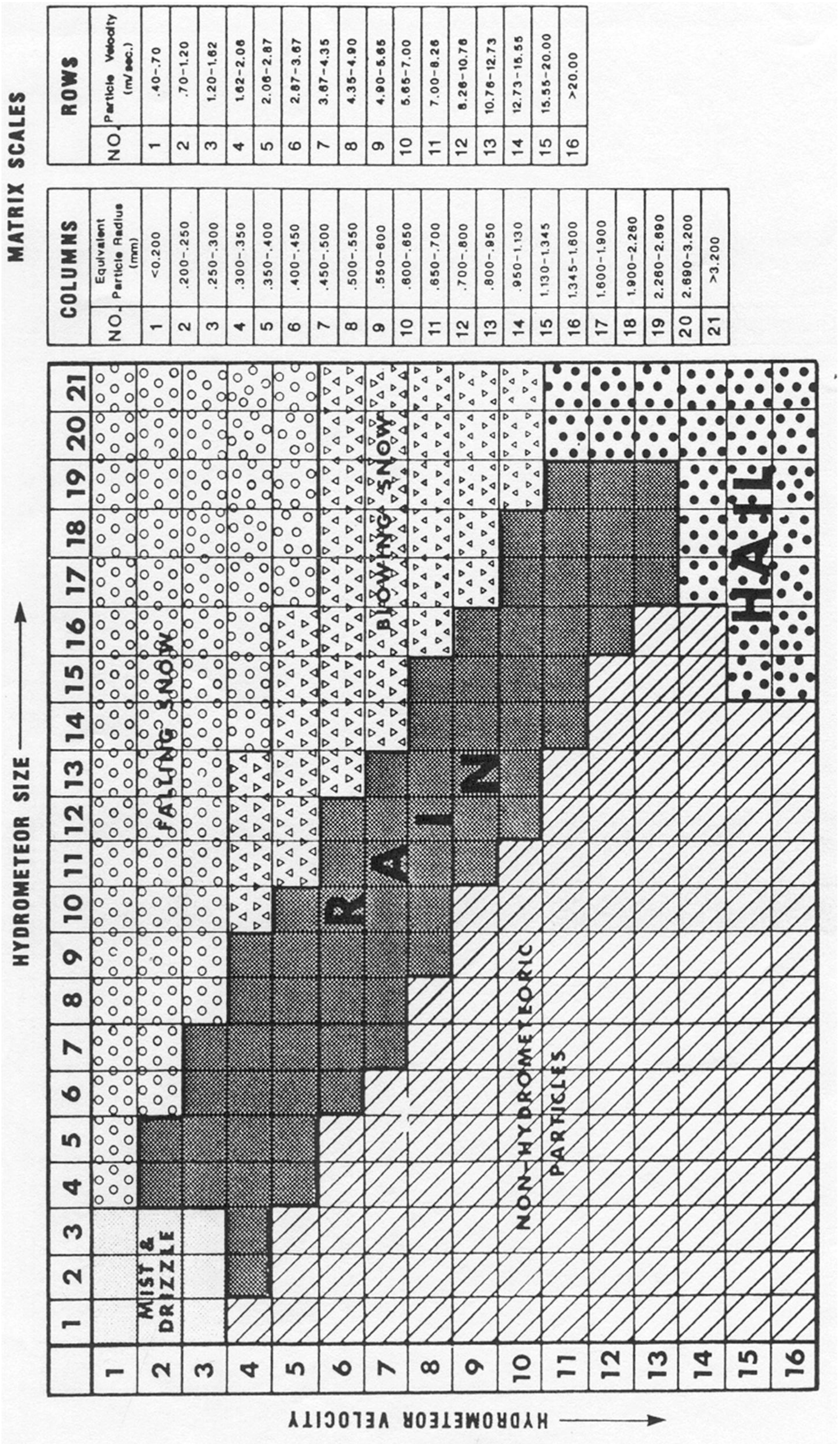


Figure 6-3 - Precipitation Matrix
General size/velocity characteristics of various types of precipitation displayed on the precipitation recognition matrix.

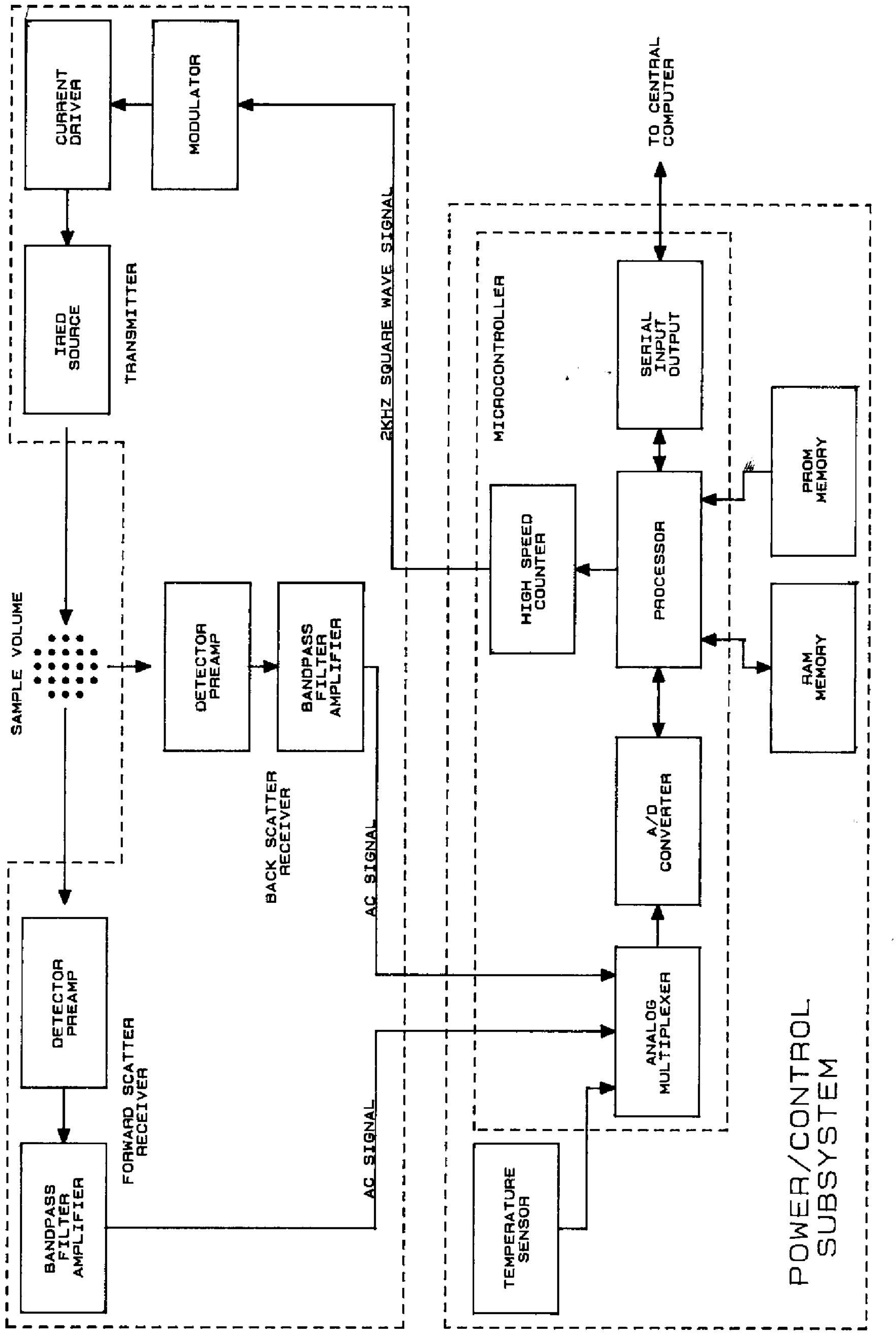


Figure 6-4 - VPF730 Sensor Functional Block Diagram.

7 PRODUCT OVERVIEW

7.1 VPF700 Series of Present Weather Sensors

7.1.1 Available Sensor Models

There are three models in the VPF700 series of present weather sensors, the VPF710, the VPF730 and the VPF750. They use the same basic opto-mechanical and electronic components and have an optical transmitter and forward scatter receiver. The VPF730 and VPF750 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 these models are as follows:

Sensor Model	Capability
VPF710	Visibility

Sensor Model	Capability
VPF730	Visibility Precipitation type identification

This model has an extra backscatter receiver for:

Rain rate
Snowfall rate
Precipitation accumulation

VPF750 Visibility
Precipitation type identification

This model has an extra precipitation sensor and an extra high accuracy temperature and humidity sensor for:

50 weather codes (from WMO Code Table 4680), including:

- Past Weather
- Freezing Rain
- Ice Pellets

7.1.2 Instrument Components

Each sensor has been engineered and manufactured with high-reliability components to provide accurate measurements under all weather conditions. Its rugged anodised, salt-brazed aluminium construction is intended to serve you in the severest of environmental conditions throughout the long life of the instrument.

A VPF700 series sensor system consists of the major components listed below:

Item	QUANTITY
Basic Sensor assembly incorporating: transmitter, receiver and electronics housing.	1
Stainless steel mounting U-bolt kit for fixing to a pole.	1
Cable Assemblies.	As Required
Operation and Maintenance Manual.	1

The VPF750 has, in addition:

Item	QUANTITY
Precipitation Sensor.	1
High quality temperature and humidity sensors within a radiation shield.	1

7.1.3 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 consist of 15W heaters per hood on all versions.

Advanced Self-Test and Monitoring

In addition to the standard self-test transmitter window monitoring the sensors can have the optional receiver window monitoring to provide warning of additional contamination build-up. This option includes monitoring of the receiver sensitivities.

Single Cable for both Power and Data

The sensor can be supplied with a single cable connector to carry both the power and data. This can only be supplied for DC sensors with RS232 data configuration.

Customer Specified Cable Lengths

The data and power cables can be supplied at any length (up to 25m), as specified by the customer.

Note: For RS232 data configuration, cable lengths above 6m will not work reliably at high baud rates. It is strongly recommended that baud rates no higher than 4800 are used for cable lengths up to 25m.

Analog Inputs for Weather Station Integration

The sensors can be supplied with three analog inputs designed for connection to other instruments in a weather station system. The data from these inputs is integrated into the standard VPF700 data output message; see paragraph 2.3.1, Weather Station Module.

7.1.4 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.

Ambient Light Sensor

An ambient light sensor can be supplied as part of the VPF700 system. This provides measurements of the ambient light intensity up to 40,000 Cd/m^2, with its output integrated into the standard VPF700 data output string. See paragraph 2.3.2, Ambient Light Sensor for models VPF710 and 730, and paragraph 2.4, Data Output Message VPF750.

External High Accuracy Temperature and Humidity Sensor
Supplied as standard on the VPF750. Not applicable to the VPF710. When fitted to the VPF730 it enables Dust, Smoke and Mist to be identified, distinguishing these from Haze and Fog.

7.2 Sensor Features

The VPF710 sensor is a visibility sensor. The VPF730 and VPF750 are both visibility and present weather sensors. All these sensors 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 (not VPF710) 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 high reliability 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 of 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 VPF700 sensors have a number of distinctive physical features:

Compactness:

Each 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.

7.2.1 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 (not VPF710).

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

7.3 Present Weather Measurements

7.3.1 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.

(2) Those suspended particles that are classed as obstructions to vision; namely, mist, fog, haze, dust and smoke.

7.3.2 Overview

These sensors utilise microprocessor technology to perform automatic visibility, precipitation (not VPF710) and temperature measurements. Both DC versions and mains driven versions of each sensor are available. Patented techniques are employed to identify precipitation and to determine the presence of fog during episodes of precipitation.

7.3.3 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 (FG) is indicated in the output message. If the MOR is between 1 and 10 km, then haze (HZ) is indicated in the output message. If MOR is greater than 10 km, no obstruction to vision is indicated.

Visibility Measurements

Function	Details
Meteorological Optical Range	10 metres to 75km (30 feet to 46 miles)
Atmospheric Extinction Coefficient (EXCO)	$300km^{-1}$ to $0.04km^{-1}$
Accuracy	± 2% at 2 km ± 10% at 16 km ± 20% 16 to 30 km
Obstruction to vision	(1) Identifies Fog or Haze (precipitation absent) (2) Identifies Fog in presence of precipitation

Table 7-1 - Measurement Capabilities of the VPF700 Series of Sensors

Precipitation/Obstruction to Vision Measurements (VPF730 and VPF750)

Function	Details
(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).
Identification/Intensity	Drizzle: Slight/Moderate/Heavy Rain: Slight/Moderate/Heavy Snow: Slight/Moderate/Heavy Hail
Precipitation rate	Rain – Up to 500 mm/hr (20 in/hr) Snow – Rain Equivalent up to 500 mm/hr (20 in/hr)
Obstruction to vision	Haze Fog

Table 7-2 - Additional Measurement Capabilities of the VPF730 and VPF750

Additional Precipitation/Obstruction to Vision Measurements (VPF750)

Function	Details
Identification/Intensity Non-Freezing	Drizzle and Rain: Slight/Moderate/Heavy
Identification/Intensity Freezing	Freezing Fog Freezing Drizzle Slight/Moderate/Heavy Freezing Rain Slight/Moderate/Heavy Rain (Drizzle) and Snow Slight/Moderate/Heavy Ice Pellets Slight/Moderate/Heavy Snow Grains Ice Crystals Hail
Obstruction to Vision	Smoke (HZ) Dust (DU Mist (BR)

Table 7-3 - Additional Precipitation/Obstruction to Vision (VPF750)

Past Weather Determination (VPF750)

Function	Time Constraints
Fog	In last hour but not at time of observation
Precipitation	In last hour but not at time of observation
Drizzle	In last hour but not at time of observation
Rain	In last hour but not at time of observation
Snow	In last hour but not at time of observation
Freezing Drizzle or Rain	In last hour but not at time of observation
Fog	In patches Becomming thinner in last hour No appreciable change in last hour Begun or becomming thicker in last hour
Rain showers	Slight/Moderate/Heavy
Snow Showers	Slight/Moderate/Heavy

Table 7-4 - Past Weather determination Types (VPF750)

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.

7.3.4 Precipitation Measurements

The VPF730 and VPF750 sensors identify three forms of precipitation, namely drizzle, rain and snow together with a wide variety of frozen forms of these (VPF750 only). 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.

Intensity of precipitation may be defined differently from one country to another. In 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 unless fog is present. In classifying precipitation intensity, the sensor utilises the precise definitions given in the Federal Meteorological Handbook. These definitions are given in the tables below (Table 7-5).

<u>Note:</u> *If a sensor is intended for installation in a country where the definitions of precipitation intensity differ from the U.S. 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.*

Drizzle

Slight	A trace to 0.01 inches (0.3 mm)/hour.
Moderate	0.01 inches (0.3) to 0.02 inches (0.5 mm)/hour.
Heavy	More than 0.02 inches (0.5 mm)/hour.

Rain

Slight	A trace of 0.10 inches (2.5 mm)/hour.
Moderate	0.10 to 0.30 inches (2.6 to 7.6 mm)/hour.
Heavy	More than 0.30 inches (7.6 mm)/hour.

Snow

Slight	Visibility equal to or greater than 5/8 statute miles, 0.55 nautical miles, or 1,000 meters.
Moderate	Visibility 5/16 to 1/2 statute miles, 0.25 to 0.5 nautical miles, or 500 to 900 meters.
Heavy	Visibility equal to or less than 1/4 statute miles, 0.2 nautical miles, or 400 meters.

Frozen Precipitation (other than snow)

Slight	A trace to 0.10 inches (2.5 mm) water equivalent/hour.
Moderate	0.10 to 0.30 inches (2.6 to 7.6 mm) water equivalent/hour.
Heavy	More than 0.30 inches (7.6 mm) water equivalent/hour.

Table 7-5 - US Precipitation Intensity Definitions
(Based on Federal Meteorological Handbook No. 1 Part B.1.)

The following present weather codes, from WMO Table 4680 are used on the VPF700 series of sensors:

VPF710 – Visibility only, no weather codes

VPF730 – Compressed message only:

00	No significant weather observed, or not ready
04	Haze or Smoke or Dust
10	Mist (If optional high accuracy temperature / humidity sensor fitted)
30	Fog
40	Indeterminate precipitation type
51	Slight Drizzle
52	Moderate Drizzle
53	Heavy Drizzle
61	Slight Rain
62	Moderate Rain
63	Heavy Rain
71	Slight Snow
72	Moderate Snow
73	Heavy Snow
89	Hail

VPF750:

XX	Sensor not ready
00	No significant weather observed
04	Haze or Smoke or Dust
10	Mist
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
25	Freezing Drizzle or Freezing Rain in last hour but not at time of observation
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
53 Heavy Drizzle
54 Freezing Slight Drizzle
55 Freezing Moderate Drizzle
56 Freezing Heavy Drizzle
57 Drizzle and Rain, Slight
58 Drizzle and Rain, Moderate or Heavy
61 Slight Rain
62 Moderate Rain
63 Heavy Rain
64 Freezing Slight Rain
65 Freezing Moderate Rain
66 Freezing Heavy Rain
67 Rain and Snow, Slight
68 Rain and Snow, Moderate or Heavy
71 Slight Snow
72 Moderate Snow
73 Heavy Snow
74 Ice Pellets, Slight
75 Ice Pellets, Moderate
76 Ice Pellets, Heavy
77 Snow Grains
78 Ice Crystals
81 Rain Showers, Slight
82 Rain Showers, Moderate
83 Rain Showers, Heavy
85 Snow Showers, Slight
86 Snow Showers, Moderate
87 Snow Showers, Heavy
89 Hail

7.4 Sensor Specifications

The specifications for all versions of the VPF700 series of sensors 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 VPF710 visibility sensor, disregard those portions of the specification pertaining to precipitation measurements.

Atmospheric Extinction Coefficient (EXCO) and Precipitation Measurements

Function	Details
Meteorological Optical Range (MOR)	10m to 75km
Measures:	Atmospheric Extinction Coefficient (EXCO), reductions in visibility caused by: fog, haze, smoke, sand, drizzle, rain, snow and general precipitation
Measurement Accuracy at 16 km	± 10%
Measurement Accuracy at 2 km	± 2%
Measurement Time Constant	30 seconds

Stability of EXCO Zero Setting

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

Precipitation Measurements (Not VPF710)

Function	Details
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)	~ 500mm/hr (20 in/hr)
Rain Rate Accuracy	± 10%

Maintenance

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

VPF750 Specific Temperature and Humidity Measurements

Function		Details
Humidity:	Type Range Accuracy Response Time	Capacitive 0 to 100% Relative Humidity ± 2 % Relative Humidity < 20 seconds
Temperature:	Type Range Accuracy 10°C to 40°C Accuracy <10°C, >40°C Response Time	PT 100 Class B -30°C to 70°C ± 0.2 °C ± 0.2 °C ±0.0073°C/°C < 20 seconds

Table 7-6 - Sensor Specifications

7.4.1 Instrument Characteristics

Physical

Function		Details
Scattering Angle Coverage		39° to 51°
Sample Volume		400 cm^3
Weight	DC Sensors Mains Powered Sensors	5.6Kg 6.8Kg
Length		0.75 m

Light Source

Function	**Details**
Type	IRED
Central Wavelength	0.85µm
Bandwidth	0.04µm
Lifetime	>10 years
Modulation Frequency	2000 Hz

Detector

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

Power Requirements

Function	**Details**
Basic Sensor	3.5 W
De-Icing Heaters (Optional)	**VPF710:** 30W (17W for 12V DC Version) **VPF730:** 45W (25W for 12V DC Version) **VPF750:** 45W
No-Dew Window Heaters	**VPF710:** 1.7 W **VPF730 and VPF750:** 2.5 W
VPF750 Additional Sensors: Precipitation Sensor Temperature and Humidity Sensor Ambient Light Sensor	 17W 0.2W 2.0W (17W with optional hood heater)

Environmental

Function	Details
Operating Temperature Range	-50°C to +60°C
Altitude	0 to 20,000 ft
Precipitation	All weather
Humidity	0 to 100%
Protection Rating	IP66
CE Certified	√
EMC Compliant	EN61326-1997,1998.2001
RoHS and WEE Compliance	√

Table 7-7 - Instrument Characteristics

7.4.2 Digital Communication Interface

Communication Protocols

Function	Details
Interface Type	RS232C, (Full Duplex)
Optional	RS422 or RS485

Parameters:

Function	Details
Baud Rates	1200 Baud to 57K6 Baud, selectable
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None
Message Termination	CR-LF
Message Check Sum:	Selectable

Function	Details
Reporting Interval	Programmable (Response to poll, or Automatic at programmable intervals: e.g., 30 seconds to several minutes; 1 minute typical)
Message Content:	• Instrument Identification Number (Programmable) • Reporting Interval (seconds) • Meteorological Optical Range (Kilometres) • Precipitation Type • Obstruction to Vision (Fog, Haze, None) • Precipitation Amount (One Minute Interval) • Temperature • Remote Self-Test & Monitoring Flags • Date and time tags

Table 7-8 - Digital Communication Interface Specifications

7.4.3 Sensor Remote Self-Test Capabilities

Standard Self-Test and Monitoring

- Optical Source Power
- Transmitter Window Contamination
- Power Supply Voltages
- Non-Volatile Memory Check Sum Test
- EPROM Check-Sum Test
- Restart Occurrence
- Sensor Sample Interrupt Verification
- RAM Read/Write Verification
- Register Read/Write Verification
- A/D Control Signal Test
- A/D Conversion Accuracy Check
- Input Voltage Check (Battery Check on DC Powered Sensors Only)
- Forward-Scatter Background Illumination Level
- Back-Scatter Background Illumination Level

Advanced Self-Test and Monitoring

- Optical Source Power
- Forward-Scatter Receiver Sensitivity
- Back-Scatter Receiver Sensitivity
- Transmitter Window Contamination

- Forward-Scatter Receiver Window Contamination
- Back-Scatter Receiver Window Contamination
- Power Supply Voltages
- Non-Volatile Memory Check Sum Test
- EPROM Check-Sum Test
- Restart Occurrence
- Sensor Sample Interrupt Verification
- RAM Read/Write Verification
- Register Read/Write Verification
- A/D Control Signal Test
- A/D Conversion Accuracy Check
- Input Voltage Check (Battery Check on DC Powered Sensors Only)
- Forward-Scatter Background Illumination Level
- Back-Scatter Background Illumination Level

Standard Self-Test and Monitoring is a Standard Feature on the VPF700 Series of sensors.

Advanced Self-Test and Monitoring is an Optional Accessory on the VPF700 Series of sensors

.

7.5 VPF700 Series of Sensors - Dimensions

The model shown is the VPF730 (and VPF750). The VPF710 is identical except that the Back Scatter Head is not fitted.

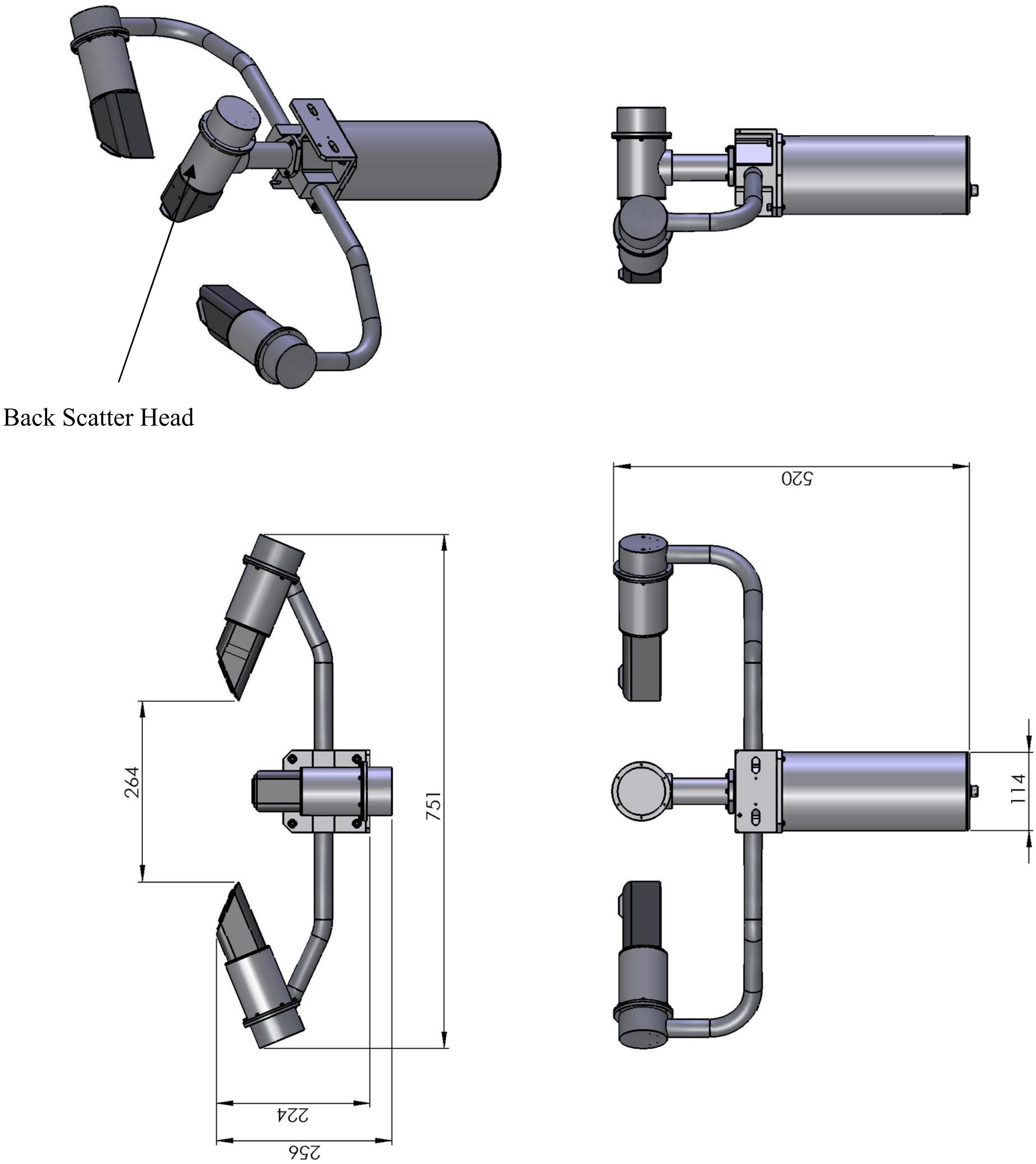


Figure 7-1 - VPF730 Model Dimensions (mm)
(VPF750) is identical)

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