Ultrasonic Wind Sensors
WAS425

USER'S GUIDE

U428en-1.1
March 2000

VAISALA

PUBLISHED BY

Vaisala Oyj
P.O. Box 26
FIN-00421 Helsinki
Finland

Phone (int.): (+358 9) 894 91
Fax: (+358 9) 894 9227

Visit our Internet pages at http://www.vaisala.com/

Table of Contents

CHAPTER 1

GENERAL INFORMATION 5

About This Manual 5

Safety 5

ESD Protection 6

Version Information 7

Getting Help 7

Warranty 8

CHAPTER 2

INTRODUCTION 9

Differences Between Models 10

Measuring Principle 11

Modes 12

CHAPTER 3

INSTALLATION 13

Unpacking 13

Location 13

Mounting 14

Mounting Procedure on a 1-inch IPS Vertical Pipe 15

Mounting Procedure on the Vaisala Sensor Arm WAC425 16

Wind Direction Alignment Procedures 16

CHAPTER 4

POWERING AND CABLE PINOUTS 21

Power Supplies 21

Cable Pinouts 22

CHAPTER 5

OPERATION AND PROGRAMMING 23

RS-232 Mode 24

Configuration Menu 24
Operation Mode 25
Handar RS232 26
Coast Angle Command 26
Heater Control Command 27
Identify Command 27
Measurement Command 27
Measurement Unit Change Command 29
NMEA Standard 29
NMEA Extended 30
WAT11 31
Wind Speed Units 32
Average Interval 32
Averaging Method 33
Scalar Averaging 33
Vector Averaging 33
Output Interval 33
Sensor ID Character 34
Wind Direction Coast Threshold 34
Head Orientation 35
Baud Rate 35
Parity 36
Data Bits 36
Save Configuration 36
Do Zero Speed Calibration 36
Resume Operation 37
Analog Mode 37
Wind Speed 37
Wind Direction 39
Missing Readings 40
Serial Outputs 40
Analog Output 41

CHAPTER 6
MAINTENANCE 43
Periodic Testing 43
Bird Spikes 45
Sensor Failure 45

CHAPTER 7
TECHNICAL DATA 47
Block Diagram 47
Specifications 48
Accessories and Spare Parts 49

List of Figures

Figure 1 Model WAS425A Ultrasonic Wind Sensor 9
Figure 2 Details of the WAS425 Ultrasonic Wind Sensor 14
Figure 3 A Sketch of Magnetic Declination 17
Figure 4 Getting in Line with the Sensor 18
Figure 5 The Correctly Aligned WAS425 Ultrasonic Wind Sensor 19
Figure 6 WAS425 as an Analog Wind Speed Sensor 38
Figure 7 WAS425 as an Analog Wind Direction Sensor 39
Figure 8 Margin Verifier 45
Figure 9 WAS425 Block Diagram 47

List of Tables

Table 1 Manual Revisions 7
Table 2 WAS425 Ultrasonic Wind Sensor Modes 12
Table 3 Sensor Cable Pinouts 22
Table 4 Handar RS232 Polling Commands 26
Table 5 RS-232 19-character Fixed Length Output Message 28
Table 6 Consecutive Measurements of Wind Direction 35
Table 7 Available Accessories 49
Table 8 Available Spare Parts 49

This page intentionally left blank.

CHAPTER 1

GENERAL INFORMATION

About This Manual

This manual provides all the information for installing, operating and maintaining the WAS425 Ultrasonic Wind Sensors, models WAS425A and WAS425AH.

The manual begins with introduction to operational principles of the Ultrasonic Wind Sensors. An installation chapter introduces the basic installation options of the sensor. The later chapters include more detailed information on operating the sensors and guidelines for maintenance. The last chapter includes technical information

Safety

Throughout the manual, important safety considerations are highlighted as follows:

WARNING	Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.

CAUTION	Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.

NOTE	Note highlights important information on using the product.

ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects inside the equipment housing.

To make sure you are not delivering high static voltages yourself:

- Handle ESD sensitive components on a properly grounded and protected ESD workbench. When this is not possible, ground yourself to the equipment chassis before touching the boards. Ground yourself with a wrist strap and a resistive connection cord. When neither of the above is possible, touch a conductive part of the equipment chassis with your other hand before touching the boards.
- Always hold the boards by the edges and avoid touching the component contacts.

Version Information

Table 1 Manual Revisions

Manual Code	Description
U428en-1.1	Applicable to Models WAS425A and WAS425AH firmware versions 1.04

Getting Help

Contact Vaisala technical support:

E-mail helpdesk@vaisala.com
Telephone +358 9 8949 789
Fax +358 9 8949 790

Warranty

Vaisala hereby represents and warrants all Products manufactured by Vaisala and sold hereunder to be free from defects in workmanship or material during a period of twelve (12) months from the date of delivery save for products for which a special warranty is given. If any Product proves however to be defective in workmanship or material within the period herein provided Vaisala undertakes to the exclusion of any other remedy to repair or at its own option replace the defective Product or part thereof free of charge and otherwise on the same conditions as for the original Product or part without extension to original warranty time. Defective parts replaced in accordance with this clause shall be placed at the disposal of Vaisala.

Vaisala also warrants the quality of all repair and service works performed by its employees to products sold by it. In case the repair or service works should appear inadequate or faulty and should this cause malfunction or non function of the product to which the service was performed Vaisala shall at its free option either repair or have repaired or replace the product in question. The working hours used by employees of Vaisala for such repair or replacement shall be free of charge to the client. This service warranty shall be valid for a period of six (6) months from the date the service measures were completed.

This warranty is however subject to following conditions:

a) A substantiated written claim as to any alleged defects shall have been received by Vaisala within thirty (30) days after the defect or fault became known or occurred, and

b) The allegedly defective Product or part shall, should Vaisala so require, be sent to the works of Vaisala or to such other place as Vaisala may indicate in writing, freight and insurance prepaid and properly packed and labelled, unless Vaisala agrees to inspect and repair the Product or replace it on site.

This warranty does not however apply when the defect has been caused through

a) normal wear and tear or accident;

b) misuse or other unsuitable or unauthorized use of the Product or negligence or error in storing, maintaining or in handling the Product or any equipment thereof;

c) wrong installation or assembly or failure to service the Product or otherwise follow Vaisala's service instructions including any repairs or installation or assembly or service made by unauthorized personnel not approved by Vaisala or replacements with parts not manufactured or supplied by Vaisala;

d) modifications or changes of the Product as well as any adding to it without Vaisala's prior authorization;

e) other factors depending on the Customer or a third party.

Notwithstanding the aforesaid Vaisala's liability under this clause shall not apply to any defects arising out of materials, designs or instructions provided by the Customer.

This warranty is expressly in lieu of and excludes all other conditions, warranties and liabilities, express or implied, whether under law, statute or otherwise, including without limitation ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE and all other obligations and liabilities of Vaisala or its representatives with respect to any defect or deficiency applicable to or resulting directly or indirectly from the Products supplied hereunder, which obligations and liabilities are hereby expressly cancelled and waived. Vaisala's liability shall under no circumstances exceed the invoice price of any Product for which a warranty claim is made, nor shall Vaisala in any circumstances be liable for lost profits or other consequential loss whether direct or indirect or for special damages.

CHAPTER 2
INTRODUCTION

Chapter 2 describes the features of the WAS425 Ultrasonic Wind Sensors.

The WAS425A and WAS425AH Ultrasonic Wind Sensors determine wind speed and wind direction. The difference between sensors is that model WAS425AH has heating, as model WAS425A is unheated. The sensor is shown in Figure 1 below.

0003-009

Figure 1 Model WAS425A Ultrasonic Wind Sensor

This User's Guide uses the expression "WAS425" to mean the WAS425A and WAS425AH models for almost all instances since they are the same except for that Model WAS425AH has a built-in heater. When needed, the User's Guide explicitly notes the differences between the two models.

The joint sensor features are:

- Communication with a wide range of data acquisition systems using:
  - Digital output for RS-232 serial data interface
  - Analog outputs
- No moving parts
- Power-on self-tests of RAM and ROM
- Contamination and corrosion resistance since exposed surfaces are stainless steel and anodized aluminum
- Simple alignment to true north.

Differences Between Models

The model WAS425A is not heated. Below freezing, there is the possibility that snow and/or ice accumulation on the ultrasonic transducers will cause missing readings.

The heated version WAS425AH uses 36 VDC to power the heater elements. The elements have a built-in thermostat to switch the heaters on when the transducer head needs it. Model WAS425AH can use any source of 36 VDC for its heater.

Measuring Principle

The WAS425 Ultrasonic Wind Sensor has an on-board microcontroller that captures and processes data and performs serial communications.

The wind sensor has an array of three equally spaced ultrasonic transducers in a horizontal plane. The sensor measures transit time, the time that it takes the ultrasound to travel from one transducer to another. The transit time is measured in both directions.

Transit time depends on the wind velocity along the ultrasonic path. For zero wind velocity, both the forward and reverse transit times are the same. With wind along the sound path, the up-wind transit time increases and the down-wind transit time decreases.

The microcontroller's microprocessor computes the wind speed from the transit times using the formula:

$$V_W = 0.5 \cdot L \cdot (1/t_f - 1/t_r) \quad (1)$$

where:

V_w	=	Wind velocity
L	=	The distance between two transducers
t_f	=	The transit time in the forward direction
t_r	=	The transit time in the reverse direction.

Measuring the six transmit times allows Vw to be computed for each of the three ultrasonic paths, which are offset to each other by 120°. The computed wind speeds are independent of altitude, temperature, and humidity because they cancel out with the six measurements even though the velocity of sound affects individual transit times.

Bad readings, which can happen when a large raindrop or ice pellet hits a transducer, are eliminated by a proprietary

signal processing technique. The one Vw that is most affected by turbulence error is eliminated so wind speed and wind direction are calculated from the best two vectors.

Modes

There are two output modes from WAS425 but only one mode can be in operation at a time. The sensor was designed to have the cables, and jumpers on the cable's pins, determine the operational mode, allowing the factory to permanently seal the sensor from the elements.

Table 2 below summarizes the operational modes of the ultrasonic wind sensor. Chapter 5 on page 23 gives complete details.

Table 2 WAS425 Ultrasonic Wind Sensor Modes

Mode	Description	Power (mA)
RS-232	The sensor is free running, taking continuous readings. Data strings are transmitted either continuously or they are transmitted in response to a polling command.	15
Analog	When power is first turned on, it takes about two seconds for the sensor to initialize and stabilize. The measurement takes 0.35 second, during which the sensor synthesizes the analog outputs of wind speed and wind direction. Every second, it repeats the cycle until power is turned off.	15

CHAPTER 3

INSTALLATION

This chapter describes the installation of the WAS425 Ultrasonic Wind Sensor.

Unpacking

The ultrasonic wind sensor comes in a custom shipping container. Carefully remove the sensor from the container and save the container and all the packing. You should use this custom container whenever you transport the wind sensor.

CAUTION	Never move the WAS425 Ultrasonic Wind Sensor until it is in its custom shipping container. Otherwise, you will void the warranty.

Location

Install the WAS425 Ultrasonic Wind Sensor in a location that is free from the turbulence caused by nearby objects, such as trees or buildings. Ideally, the sensor should be higher than any other object within a 300 m horizontal radius.

WARNING To protect personnel (and the wind sensor), a lightning rod must be installed with the tip several feet above the wind sensor. The rod must be properly grounded, compliant with all local applicable safety regulations.

Mounting

Install the sensor vertically with the arms facing up. The bird spikes discourage birds from either sitting on the sensor arms or building a nest in the cradle of the sensor. The sensor can be mounted by using the 1" adapter or Vaisala sensor arm WAC425.

1. **Bird spikes**
2. **Sensor body**
3. **3/16 inch Hex-socket bolt**
4. **Adapter**
5. **Clamp**

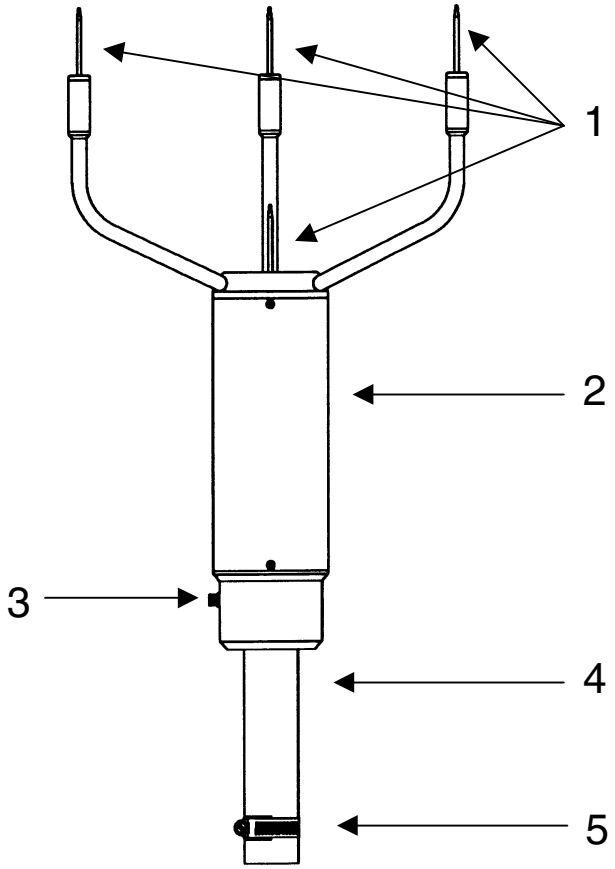


Figure 2 Details of the WAS425 Ultrasonic Wind Sensor

If the bird spikes are not sufficient to keep animals away from the sensor arms, the sensor may also be mounted arms down. This installation method requires the use of a sensor arm WAC425. The sensor arm protects the cable connector from rain. Do not use the 1" adapter for installation when mounting the sensor arms down.

Mounting Procedure on a 1-inch IPS Vertical Pipe

Use the following procedure to mount the sensor to a vertical 1-inch International Pipe Standards (IPS) pipe, see Figure 2 on page 14 for details.

Do the following:

1. Remove the hex-socket bolt shown in Figure 2 on page 14 (use 3/16-inch Allen key).
2. Separate the adapter from the sensor body.
3. Connect the cable to the sensor, routing it through the adapter.
4. Attach the adapter to the sensor body and tighten the hex-socket bolt.
5. Run the cable out of the adapter's slot between the sensor and the clamp.
6. Place the sensor on the pipe and slightly tighten the clamp's bolt (use wrench or medium-sized slotted-tip screwdriver).
7. Perform Wind Direction Alignment Procedures as explained on page 16.

Mounting Procedure on the Vaisala Sensor Arm WAC425.

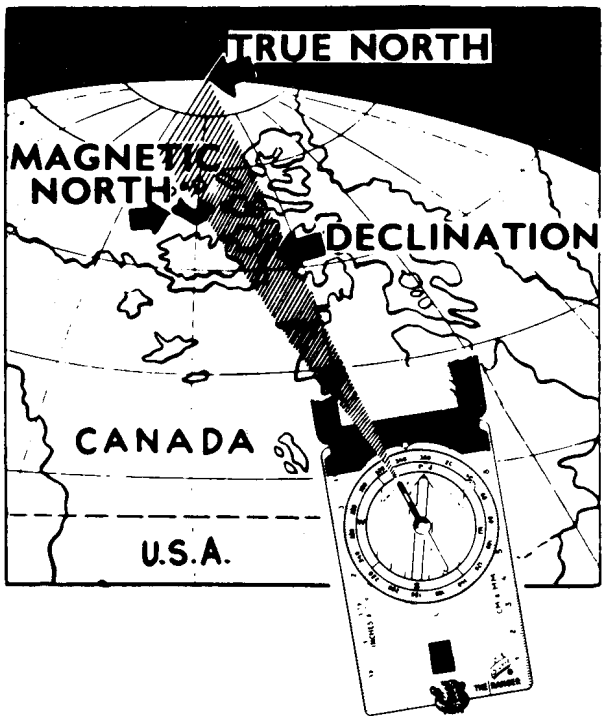
1. Remove the hex-socket bolt, if still attached to the sensor body, shown in Figure 2 on page 14 (use 3/16-inch Allen key).
2. Pull the cable through the horizontal pipe of the sensor arm so that the cable connector remains inside the vertical pipe.
3. Connect the cable to the sensor.
4. Attach the sensor to the vertical pipe of the sensor arm. Insert the hex-socket bolt.
5. Use the clamps to attach the sensor arm to a 60 mm diameter tube.

Wind Direction Alignment Procedures

One transducer arm is permanently marked with "N " for north and a second transducer arm is permanently marked with "S " for south.

NOTE	You might find the alignment procedure easier if you mark (e.g., with paint or colored tape) the sensor body to indicate north and south so that you can see it from the ground.

Wind direction can be referenced to either true north, which uses the earth’s geographic meridians, or magnetic north, which is read with a magnetic compass. The magnetic declination is the difference in degrees between true north and magnetic north, see Figure 3 on page 17 for the idea.



0003-011

Figure 3 A Sketch of Magnetic Declination

NOTE	Your source for magnetic declination must be current because declination changes over time.

The following steps aim the wind sensor when using the 1" adapter for mounting.

1. Use the compass to determine that the ultrasonic wind sensor's N-S transducer heads are exactly in line with the compass. If not, move left or right until the N-S heads are exactly in line with the compass. For right position see Figure 4 on page 18.
2. If the alignment is not correct, lower the tower.
3. Loosen the clamp at the bottom of the sensor's adapter and rotate the sensor so that the heads marked with "N" and with "S" are exactly aligned to north and south when the tower is erected. Tighten the clamp.

4. Raise the tower to the vertical position. Figure 5 on page 19 shows the correct alignment.

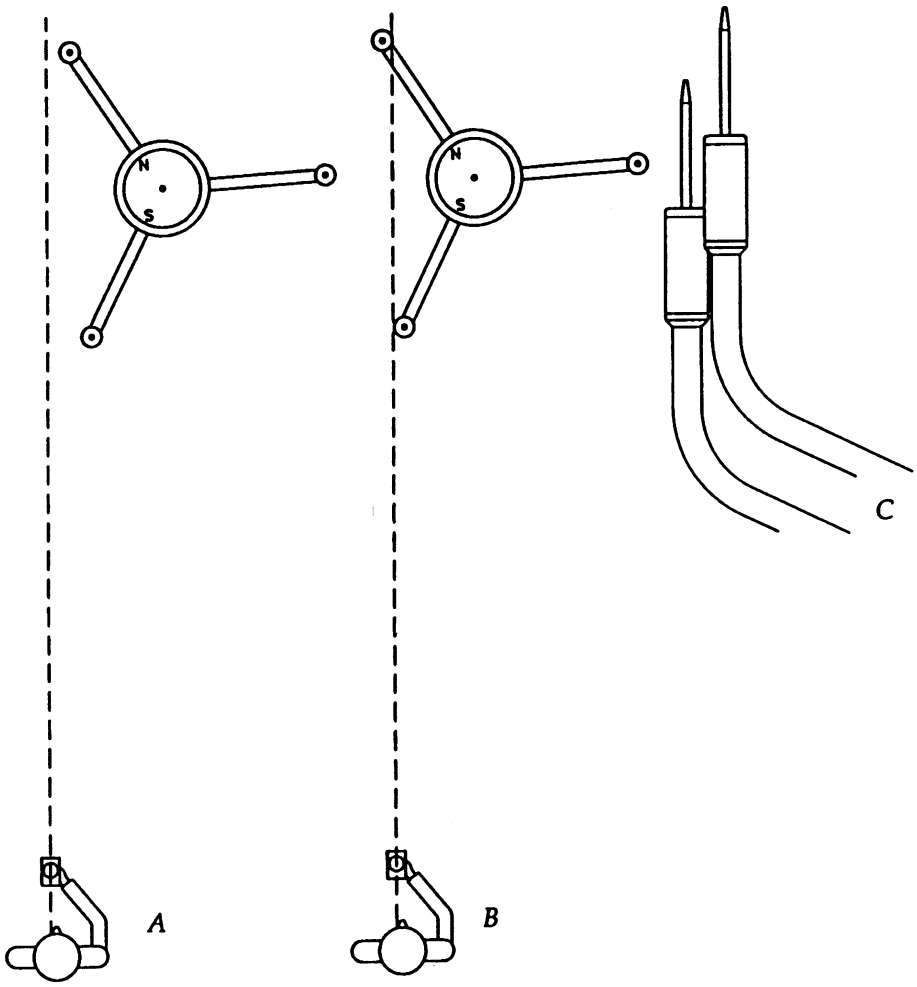
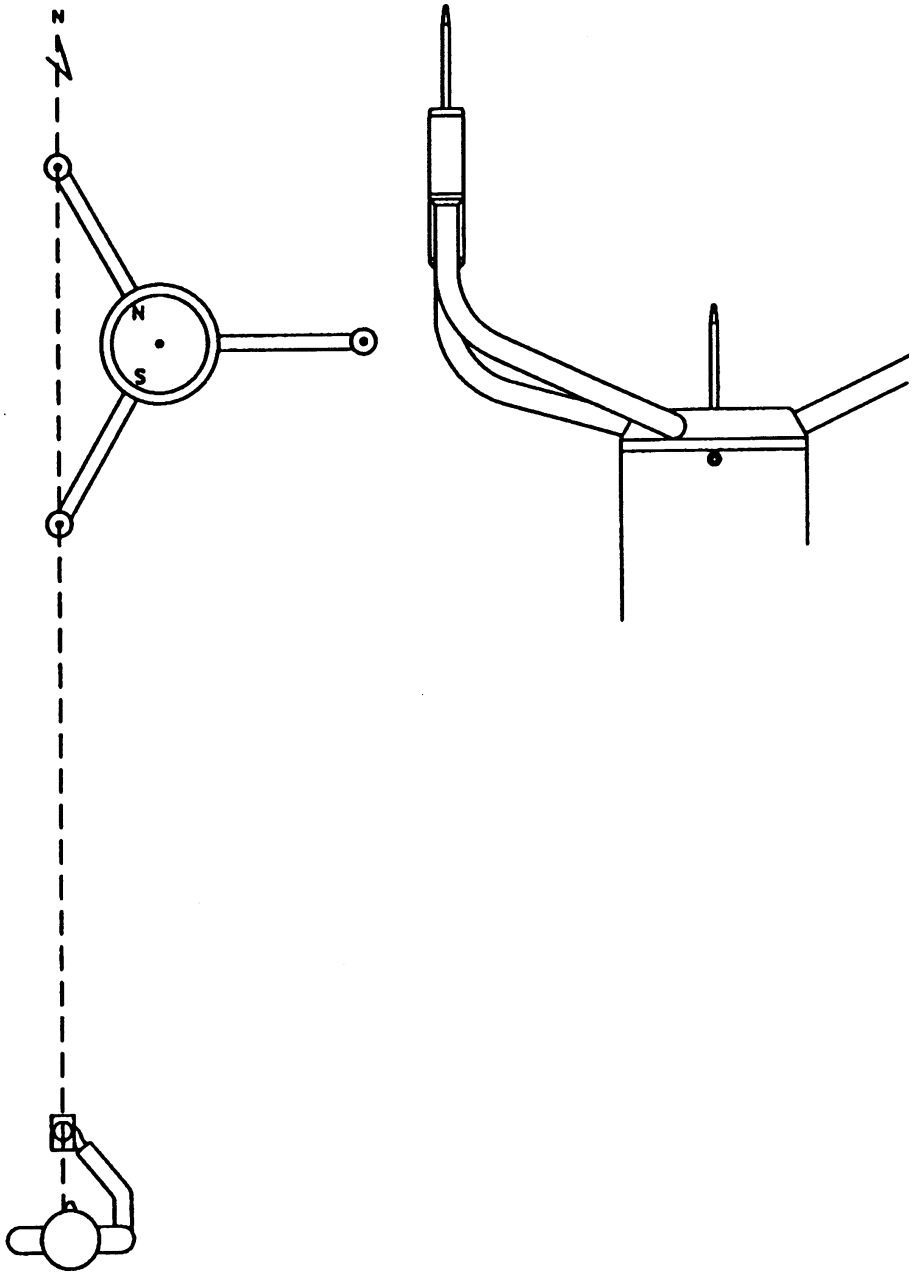


Figure 4 Getting in Line with the Sensor

In Figure 4 above the installer is too far to the left in case A. The installer is in line with the sensor in case B. Case C shows the sensor's appearance when the installer is in the correct position but the sensor is not correctly aligned.



0003-013

Figure 5 The Correctly Aligned WAS425 Ultrasonic Wind Sensor

The following steps aim the wind sensor when using the WAC425 sensor arm for mounting.

1. Use the compass to determine if the horizontal pipe of the sensor arm is aligned to north and south. The sensor end should face to north.
2. If the alignment is not correct, lower the tower.
3. Loosen the clamps which attach the sensor arm to the mast. Rotate the arm so that the alignment is correct.
4. Raise the tower to the vertical position. Figure 5 on page 19 shows the correct alignment.

CHAPTER 4

POWERING AND CABLE PINOUTS

The ultrasonic wind sensor is capable of operating in two modes:

- RS-232 serial
- Analog

However, the sensor can only be in one mode at a time. Because it is important to keep the sensor sealed against the elements, the sensor was designed to have the cables and jumpers at the cable's pins to determine the operational mode.

Table 3 on page 22 lists the sensor cable pin outs.

Power Supplies

You can use any 12 VDC power supply with the unheated model WAS425A Ultrasonic Wind Sensor, as long as it meets all applicable safety regulations. Typically, the power supply is a fused 12 V battery with either a solar panel charger or a trickle charger.

The heated ultrasonic wind sensor, model WAS425AH, requires +12 VDC for the sensor and +36 VDC for the heater.

CAUTION The WAS425AH heated Ultrasonic Wind Sensor is intended to be operated while pin 16 is connected to a +36 VDC source. If you are operating WAS425AH when pin 16 is not connected to +36 VDC, you have to ground pin 16. Never float pin 16 on WAS425AH because the sensor will not report accurate readings.

Cable Pinouts

The cable connector pin designations are listed in Table 3 below.

Table 3 Sensor Cable Pinouts

Pin at sensor	Description
1	GROUND for +12 VDC
2	GROUND
3	GROUND for +36 VDC
4	Not used
5	Analog jumper (factory installed within cable) Analog signal = jumper between pins 5 and 7 RS-232 = no jumper to pin 5.
6	RS-232 jumper (factory installed within cable) RS-232 = jumper between pins 6 and 7 Analog signal = no jumper to pin 6.
7	GROUND
8	GROUND for RS-232 / Analog outputs
9	RS-232 data out of sensor
10	RS-232 data into sensor
11	+12 VDC supply
12	Analog wind direction reference voltage into sensor (+1 … +4 VDC)
13	Analog wind direction voltage out of sensor
14	Analog wind speed frequency out of sensor
15	Analog wind speed voltage out of sensor
16	+36 VDC supply (WAS425AH only)

CHAPTER 5
OPERATION AND PROGRAMMING

There are two different output modes from the WAS425 Ultrasonic Wind Sensor but it can be in only one mode at a time. The sensor was designed to have the cables and jumpers at the cable pins to determine the operational mode. This allows the factory to permanently seal the sensor from the elements.

The two output modes are:

1. RS-232 serial communications mode

   RS-232 serial communications mode can be used in polled or in autosending mode. The data can be collected by any computer or data logger that has a RS-232 port. Refer to section RS-232 Mode on page 24 for detailed information.

2. Analog output mode

   The analog output data free runs as long as power is applied. Any data logger that is capable of connecting to an analog wind sensor can collect the data. Both wind speed and direction are represented by voltage outputs. There is also a frequency output for representing the wind speed. Refer to section Analog Mode on page 37 for detailed information.

RS-232 Mode

You can use any computer or data logger that has a RS-232 port to collect the sensor data by using the RS-232 commands. The communication speed, parity, and number of data bits for the serial line are user-selectable. The sensor can be set to transmit data messages at predefined intervals (autosending) or it responds to a polling string which is specific to a selected output message format. Various operational parameters can be set through a terminal connection.

NOTE Since the serial line settings may not be known for a device, the settings are held as constant for the first five seconds after powering up the sensor. During this time the sensor responds to commands issued with settings 9600 bit/s, 8 databits, parity “none”, 1 stopbit.

Configuration Menu

The configuration menu can be opened by typing `open` or `open <id>`, where `<id>` is the identification character of the sensor. If the sensor has been running for more than five seconds, use the currently active baud rate and other communication settings. There is a short timeout in typing in the characters, therefore type the `open` command followed by `<enter>` relatively fast.

The `open` command displays the following menu:

```
VAISALA WAS425 Ultrasonic Anemometer
Firmware Version v6.00

1.  Operation Mode: WAT11
2.  Wind Speed Units: Meters/Second
3.  Average Interval (seconds): 3
4.  Averaging Method: Vector
5.  Output Interval (seconds, 0 for polled): 0
6.  Sensor ID Character: A
7.  Wind Direction Coast Threshold (speed
    units): 1.0
8.  Head Orientation: Up
9.  Baud Rate: 9600b
10. Parity: None
11. Data Bits: 8
12. Save Configuration
13. Do Zero Speed Calibration
14. Resume Operation

Enter Function Number:
```

Each configuration parameter is displayed together with the currently active setting. The configuration parameters can be changed by selecting the number of the parameter followed by **Enter**. After modifying parameters, type 12 for storing the new parameter values and 14 to exit the configuration menu and to return to the measurement mode.

Operation Mode

First parameter selects the message format and polling commands for the sensor. The available options are:

```
1 Handar RS232
2 NMEA Standard
3 NMEA Extended
4 WAT11
```

Handar RS232

When the sensor is in the Handar RS232 mode, it responds to polling commands which are used for requesting data from the sensor. Some operational settings can also be changed instantaneously without accessing the configuration menu. Table 4 below summarizes these commands.

Table 4 Handar RS232 Polling Commands

Command	Name	Page
Cx.x	Coast angle	26
Hx	Heater control	27
I	Identify	27
Wx	Measurement	27
Ux	Measurement unit change	29

Coast Angle Command

The Coast angle command is Cx.x where x.x is the coast wind speed threshold.

x.x has a range of 0.0 to 9.9 units of measurement (e.g., m/s)

When the measured wind speed drops below the coast wind speed, the calculations use the last wind direction angle that occurred while the wind speed was at or above the direction coast wind speed.

Example:

```
C9.9
```

sets the coast wind speed at 9.9 units.

Heater Control Command

The Heater control command is Hx where:

x = 0 to disable the heater
x = 1 to enable the heater (default)

Example:

```
H0
```

The WAS425AH sensor turns the heaters off.

Identify Command

The Identify command is I.

Example:

```
I
VAISALA WAS425A/AH 600
```

VAISALA WAS425A/AH is the vendor and model number, 600 is version 6.00 of the models WAS425A/AH.

Measurement Command

The Measurement command is Wx where x is the time for averaging wind speed and wind direction.

x has a range of 1 to 9.

Example:

```
W5
•W5P1200013.2TDE•
```

The interpretation of the output message is described in the Table 5 on page 28.

Table 5 RS-232 19-character Fixed Length Output Message

Character position	Message
1	“• ” 02H (<STX>, start of transmission)
2	“W”
3	“5” for 5-second running average
4	“P” for “pass” “F” for “fail”
5	Wind direction (most significant digit)
6	Wind direction (middle digit)
7	Wind direction (least significant digit)
8	Wind speed (most significant digit)
9	Wind speed (next digit)
10	Wind speed (next digit)
11	Wind speed (least significant digit)
12	“.” (dot character)
13	Wind speed (tenths digit)
14	“M” for miles per hour “K” for knots “L” for kilometers per hour “T” for meters per second
15	Check sum (most significant digit) (See note)
16	Check sum (least significant digit)
17	“• ” 03H (<ETX>, end of transmission)
18	[CR] (carriage return)
19	[LF] (line feed)

NOTE Check sum is calculated of 13 characters from position 2 through 14. The accumulator initializes at 0 with the addition of the byte value. The check sum has a range of 0H…FFH.

Measurement Unit Change Command

The Measurement unit change command is Ux where:

x = 0 for miles per hour, [mph]
x = 1 for knots (default), [knot]
x = 2 for kilometers per hour, [km/h]
x = 3 for meters per second, [m/s]

Example:

```
U3
```

Sets meters per second for wind speed.

NMEA Standard

The standard variable length comma separated MWV wind message is defined by NMEA 0183 V2.20 as follows:

$WIMWV,<dir>,<ref>,<spd>,<uni>,<sta>*<chk><cr><lf>

where:

$WIMWV	=	Fixed text
<dir>	=	Wind angle, 0 to 359 degrees
<ref>	=	Reference; R=Relative, T=True
<spd>	=	Wind speed
<uni>	=	Wind speed units; K = kmph [km/h], M = mps [m/s], N = kt
<sta>	=	Status; A = Data Valid, V = Invalid Data
*	=	Fixed text
<chk>	=	Chksum (8-bit XOR, excluding $ and *)
<cr>	=	Carriage return code, ASCII 0DH
<lf>	=	Line feed code, ASCII 0AH

NOTE	When the NMEA Standard message format is selected, the sensor must have a non-zero output interval setting (parameter 5 in the configuration menu) since no polling command is defined for this message type.

NMEA Extended

Vaisala extension to the standard MWV wind message is defined as follows:

$P<id>MWV,<dir>,<ref>,<spd>,<uni>,<sta>*<chk><cr><lf>

where:

$P	=	Fixed text
<id>	=	Is the data ID; A … Z
MWV	=	Fixed text
<dir>	=	Wind angle, 0 to 359 degrees
<ref>	=	Reference; R=Relative, T=True
<spd>	=	Wind speed
<uni>	=	Wind speed units; K = kmph [km/h], M = mps [m/s], N = kt
<sta>	=	Status; A = Data Valid, V = Invalid Data
*	=	Fixed text
<chk>	=	Chksum (8-bit XOR, excluding $ and *)
<cr>	=	Carriage return code, ASCII 0DH
<lf>	=	Line feed code, ASCII 0AH

In NMEA Extended the polling can be done using the following command:

```
$WIP<id>Q,*<chk><cr><lf>
```

where:

$WIP	=	Fixed text
<id>	=	Is the data ID; A … Z
Q	=	Fixed text
*	=	Fixed text
<chk>	=	Chksum (8-bit XOR, excluding $ and *)
<cr>	=	Carriage return code, ASCII 0DH
<lf>	=	Line feed code, ASCII 0AH

NOTE When using the sensor in NMEA Extended mode, you can either set the output interval to zero (parameter 5 in the configuration menu) to enable polling or use some fixed output interval.

WAT11

WAT11-message fixed length format is defined as follows:

<stx><id><spd><dir>

where:

<stx>	=	Start of text character (1 digit)
<id>	=	Sensor identification character, e.g. "A" (1 digit)
<spd>	=	Wind speed (in m/s) multiplied by 10, e.g. 045 is 4.5 m/s (3 digits)
<dir>	=	Wind direction with two octal numbers for 6 bit binary data, e.g. $45_8 = 37_{10}$ corresponds to 37/64*360 = 208 degrees

WAT11-polling command is defined as follows:

```
<esc><id>
```

where:

<esc>	=	Escape character ASCII 27H
<id>	=	Sensor ID, e.g., "A"

Wind Speed Units

There are four wind speed units available:

1. Miles/hour
2. Knots
3. Kilometers/hour
4. Meters/second

NOTE When the operation mode is WAT11 (selected from configuration parameter 1) the only option for wind speed unit is meters/second. This is because the WAT11 message does not contain wind speed unit information.

Average Interval

The averaging interval can be selected as full seconds between 1 and 9 seconds. For WAS425 sensor the time between each consecutive wind direction measurement is one second. Each wind direction measurement taken over the preceding averaging interval is summed and the sum is divided by the number of measurements.

The same averaging interval is used for both average wind speed and average wind direction.

The sensor computes a true running average. If the data aquisition system requests data before the initial averaging interval completes, the sensor returns the best possible running average.

Averaging Method

This setting affects to the wind speed and direction calculation. The available options are

```
1.  Scalar
2.  Vector
```

Scalar Averaging

When scalar averaging is selected, the wind direction is a circular function with a discontinuity at due north, where 360° is equal to 0°. For example, 359° + 5° equals + 4° and 0° - 5° equals 355°.

The microprocessor translates this circular function to a linear function so that 359° + 5° is translated to 364° and 0° - 5° translates to - 5°.

To calculate the scalar average wind direction, each translated wind direction measurement taken over the preceding averaging interval is summed and the sum is divided by the number of measurements.

Vector Averaging

Each x velocity and y velocity measurement over the averaging interval is added and then divided by the number of measurements. The resultant average x velocity and average y velocity are converted to polar direction and magnitude, returning as average direction in degrees and speed in the chosen units.

Output Interval

The output interval can be selected as full seconds between 1 and 9 seconds. This setting is independent of the averaging interval (configuration parameter 3, see section Average Interval on page 32). Regardless of the length of

the output interval the last measurement sample before transmission is always the last sample of the averaging window. Therefore the transmitted data is always based on the latest measurements.

If the output interval is set to zero (0), polling is used in data acquisition.

NOTE	If the operating mode (configuration parameter 1) is NMEA Standard, there must be a non-zero setting for output interval since polling is not supported in NMEA Standard mode.

Sensor ID Character

The sensor ID character must be a single capital letter from A to Z. No numbers or small letters are accepted. After an ID is defined for a sensor, the configuration menu can be opened by typing `open <id>`. This is useful if several sensors are sharing the same communication line. When running the NMEA Extended mode or the WAT11 mode, the sensor ID is a part of the polling string.

Wind Direction Coast Threshold

At very low wind speeds, the measured wind direction is meaningless. Therefore, you specify a direction coast speed. When the measured wind speed drops below the direction coast speed, the calculations use the last wind direction that occurred while the wind speed was at or above the direction coast speed to average wind direction. You can specify a direction coast speed of between 0.0 and 9.9 units of measurement. Use 0.0 if coasting is not required.

For example, you made direction coast speed = 2.0. Consecutive measurements are as presented in Table 6 on page 35.

Table 6 Consecutive Measurements of Wind Direction

Measured wind speed	Measured wind direction	Wind direction used for averaging
3.5	350	350
2.5	340	340
2.2	340	340
1.9	175	340 (coasting)
1.2	045	340 (coasting)
2.1	345	345

NOTE The wind direction coast threshold can be set to a non-zero value only when the averaging method (configuration parameter 4) is set to scalar averaging.

Head Orientation

The sensor can be installed either transducers up or transducers down. The wind direction calculation requires that the installation position is configured correctly to the sensor.

Baud Rate

The available options are

```
1.  1200b
2.  2400b
3.  4800b
4.  9600b
5.  19200b
```

The new bit rate setting is activated as soon as the configuration changes are saved (selection 12) and operation resumed (selection 14).

NOTE	For the first 5 seconds after powering up the sensor, the serial line parameters are 9600b, 8, N, 1.

Parity

The available options are

1. None
2. Odd
3. Even

Data Bits

The available options are 7 or 8 databits.

Save Configuration

After adjusting one of the configuration parameters, apply this function to save the new settings.

Do Zero Speed Calibration

The zero speed calibration is done to all sensors in factory before delivery. There is no reason to perform this tuning periodically. Instead, use the margin verifier for periodic testing as described in section Periodic Testing on page 43.Do the zero speed calibration only after possible firmware update or if the periodic test indicates too high wind speeds.

For doing the zero speed calibration, remove the bird spikes and install the verifier as described in Figure 8 on page 45. Select zero speed calibration from the configuration menu and wait until the sensor resumes to normal operation. Check that the sensor passes the periodic test.

CAUTION	Do not perform the zero speed calibration unless the margin verifier is mounted on the sensor. Use this function only if there is reason to suspect that the sensor characteristics have changed.

Resume Operation

After opening the configuration menu, return to the current mode of operation by selecting "Resume Operation". This selection terminates the configuration dialog.

NOTE	Changes to the configuration will not be saved automatically, the command "Save Configuration" needs to be executed.

Analog Mode

The WAS425 Ultrasonic Wind Sensor can be used as a conventional wind set that gives instantaneous readings. Sensor is normally powered down. When power is first turned on, it takes about two seconds for the sensor to initialize and stabilize. It then takes a 0.35-second measurement and synthesizes the analog outputs of wind speed and wind direction. Every second, it repeats the cycle until power is turned off.

Wind Speed

The factory sets the analog mode wind speed unit to miles per hour. This is the only option available for analog mode.

The wind speed output at pin 14 is a 0 to 12 V pulsed output with frequency proportional to wind speed. Every mile per hour adds 5 Hz to the frequency (in SI units, a change of

0.894 m/s adds 10 Hz to the frequency). You need a frequency counter to count this output in Hz and the calculation that scales the result to appropriate units.

The wind speed output at pin 15 is a voltage that varies linearly from 0 VDC at 0 mph to 1 VDC at 125 mph.(in SI units the voltage varies linearly from 0 VDC at 0 m/s to 1 VDC at 55.88 m/s.)

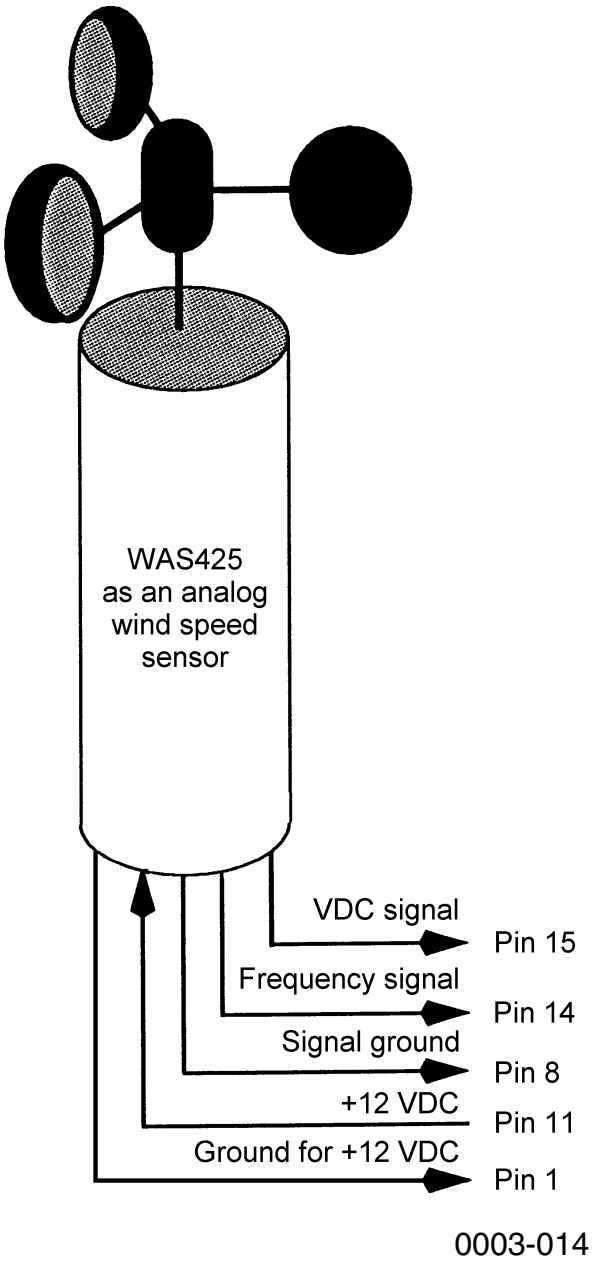


Figure 6 WAS425 as an Analog Wind Speed Sensor

NOTE	The wind speed voltage output cannot be used simultaneously with the frequency output. If the voltage output pin 15 is used, the frequency output pin 14 must be connected to ground, see Figure 6 on page 38.

Wind Direction

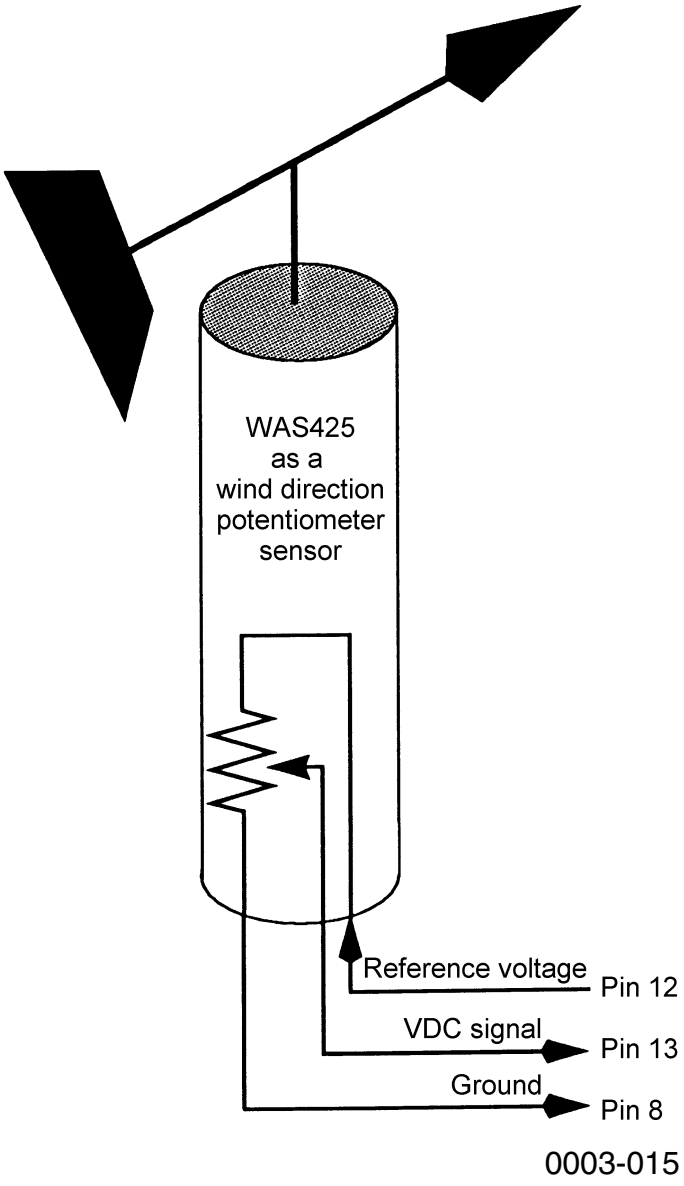


Figure 7 WAS425 as an Analog Wind Direction Sensor

The wind direction sensor appears as a conventional potentiometer-type sensor. The DC reference voltage that inputs the sensor at pin 12 produces a voltage that represents the position of wind. The reference voltage must be in the range of 1.0 to 4.0 VDC. The output at pin 13 is 0 VDC at zero degrees and increases to the maximum input voltage at 359 degrees. See Figure 7 on page 39 for the pinouts.

Missing Readings

When the WAS425 sensor detects that the received signal amplitude is below the safe level, the sensor will report "missing ".

However, the data logger has to handle the missing readings properly. Missing readings must be excluded from averages and from gust-algorithms.

The received signal amplitude can fall below the safe level due to:

1. A receiver malfunction (e.g. failed transmitter or receiver circuit).
2. An obstruction of a signal path (e.g. a wind-blown plastic bag stuck between any of the three transducers).

Serial Outputs

For serial data messages, the format of a missing reading depends on the Operation Mode setting (configuration parameter 1).

For the NMEA Standard and the NMEA Extended format, the wind speed and direction readings will simply be missing from the message string.

If WAT11 message is selected, the missing wind speed and direction are displayed as slashes (/).

If the Handar RS232 message is used, the wind speed is set to 999.9 for a missing reading.

Analog Output

For analog outputs, the wind speed is set to 125 mph when a reading is missing.

This page intentionally left blank.

CHAPTER 6

MAINTENANCE

Periodic Testing

Section Measuring Principle on page 11 explains that the sensor measures the time it takes for an ultrasonic signal to travel from transmitter to receiver. The accuracy of the sensor is, therefore, dependent on the accuracy of two factors:

1. The distance between the ultrasonic transmitter and receiver. This requires a measurement of the transducer arm trueness.
2. The time-of-flight measurement circuit, which uses a crystal oscillator for its time reference.

NOTE	Since the same crystal oscillator is used by the communications circuit for the bit rate generator, if you use the RS-232 operational modes and the oscillator loses accuracy, the sensor stops communicating and is useless.

If you use the RS-232 operational modes, there is periodic testing to detect slow deterioration of the sensor before it significantly affects accuracy. Perform the test either in the field or in the laboratory. The periodic test uses the margin verifier, which is a small echo-free chamber with built-in 10

dB sonic attenuators in each of the three sonic paths. The margin verifier is shown in Figure 8 on page 45.

This test verifies the following:

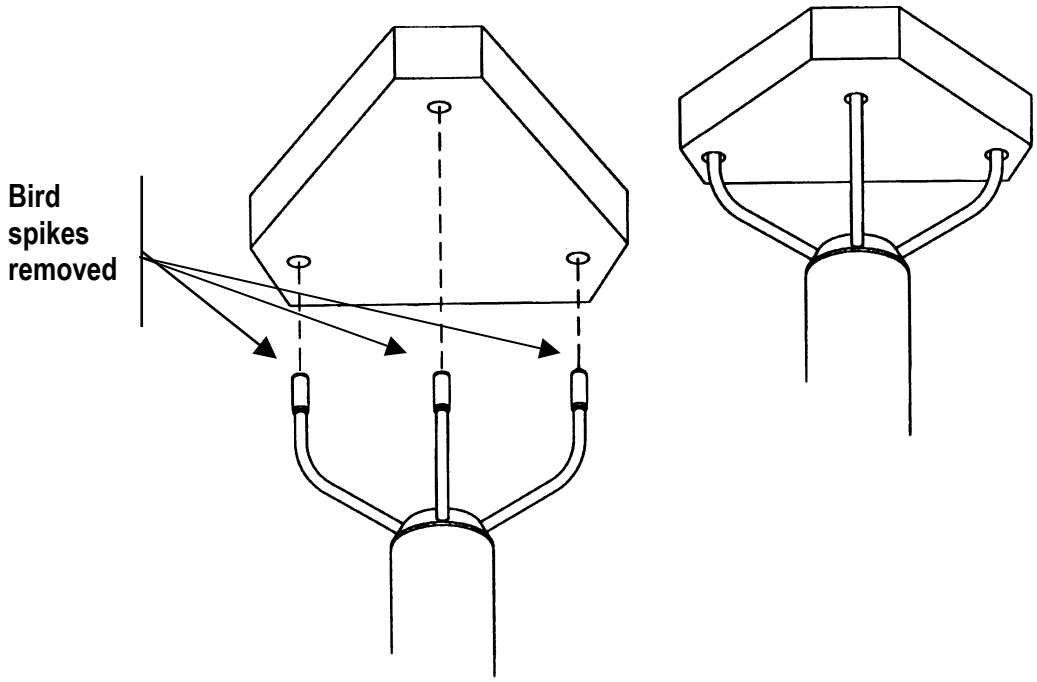
- Transducer arm trueness, since the verifier can not be put into place if an arm is bent.
- Transmitter output power.
- Transmitter and receiver transducer efficiency.
- Receiver sensitivity.
- Acoustic crosstalk from any transmitter to any receiver.
- Electric crosstalk.
- Automatic gain threshold detectors.

This test gives a very high confidence that the sensor will work at high wind speeds since the signal-to-noise ratio decreases as wind speed increases. Because, as wind speed increases, turbulence increases acoustic noise. At the same time, acoustic lenses that form around the transducers (because of air pressure gradients) reduce the received signal.

Since the margin verifier decreases the signal-to-noise ratio to a level that is slightly lower than what it would be with the highest wind speed that the sensor's specification's allows, a zero wind speed reading with the verifier in place indicates accurate readings at high wind speeds.

The test consists of the following steps:

1. Remove the bird spikes by unscrewing them.
2. Slip the margin verifier over the three transducers (see Figure 8 on page 45).
3. The sensor must read less than 0.5 miles per hour (0.22 m/s) with the margin verifier in place.



0003-016

Figure 8 Margin Verifier

Bird Spikes

The only replaceable part is the bird spike, which screws in. It is designed to break off with enough material left to unscrew its threaded base with a pair of pliers.

Sensor Failure

If the sensor fails, replace it with a known good unit.

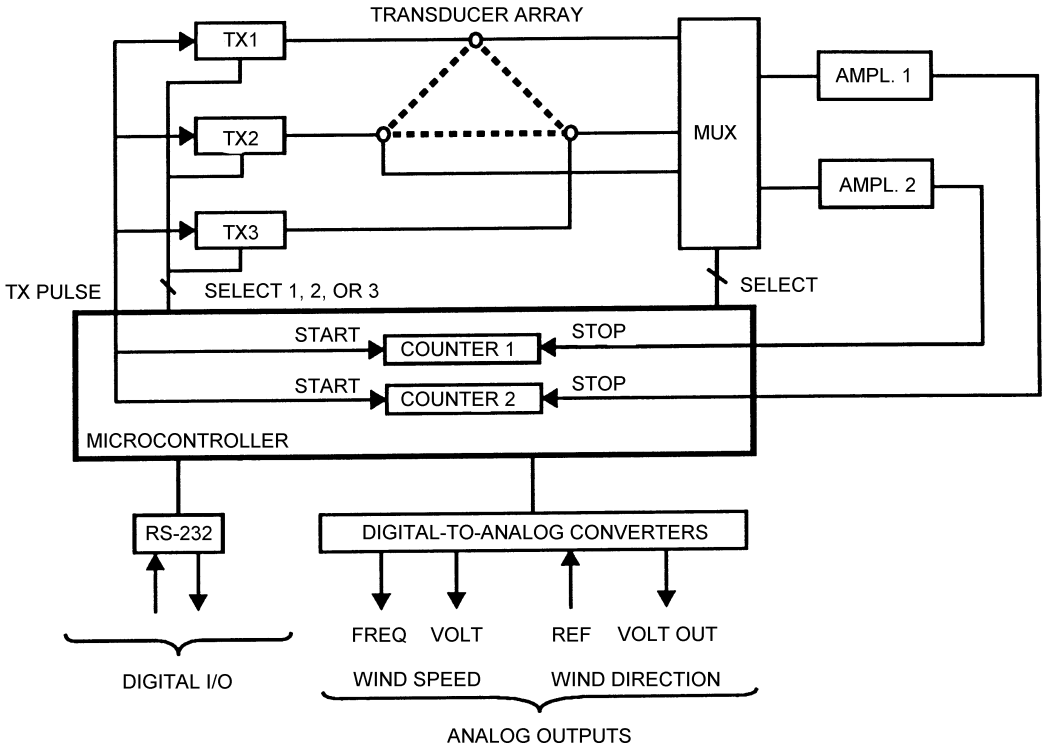
This page intentionally left blank.

CHAPTER 7

TECHNICAL DATA

Block Diagram

The block diagram for the ultrasonic wind sensors is presented in Figure 9 below.



0003-017

Figure 9 WAS425 Block Diagram

Specifications

Type		Ultrasonic 100 kHz Fully compensated for temperature, humidity, and altitude.
Range	Operating: Survival:	0 … 65 m/s 0 … 130 m/s
Response characteristics		Maximum reading rate: 1 per second Sonic measurement time: 0.2 second Signal processing time: 0.15 second Response time: 0.35 second
Accuracy	Wind speed: Wind direction:	± 0.135 m/s or ± 3 % of reading, whichever is greater; for readings up to 50 m/s ± 5 % of reading for readings of 50 m/s or greater ± 2 degrees
Resolution	Wind speed: Wind direction:	0.1 m/s 1 degree
Power	Operating: Heating:	10…15 VDC, 15 mA (analog) 10…15 VDC, 15 mA (RS-232) 36 VDC ± 10 %, 0.7 A
Heater	WAS425AH only	Thermostatically controlled heaters in the transducer heads prevent freezing rain or snow build up.
Output		
RS-232		Four different message formats, either polled or regular transmission. Bit rate adjustable from 1200 to 19200 bits/s.
Analog Wind Speed		
	frequency: voltage:	10 Hz/ 0.894 m/s (0 to 625 Hz at 0 to 55.88 m/s) 10 mV/0.558 (0 to 1.0 volt at 0 to 55.88 m/s)
Analog Wind Direction		
	simulated potentiometer: reference voltage:	(0 to Vref at 0 to 359°) 1.0 … 4.0 VDC, for 5.0 VDC reference an additional -2° error occurs for angles greater than 291°
Available averages:		1 to 9 seconds (RS-232)
Delay distance		Virtually zero
Starting threshold		Virtually zero
Dead band	Wind direction:	None
Operating temperature		WAS425A: - 40° C to +50° C WAS425AH: - 50° C to +50° C
Dimensions		27.9 cm wide x 24.3 cm deep x 53.3 cm high
Weight		0.7 Kg
Mean time between failure (MTBF)		26 years calculated per the standard assumptions of MIL-HDBK-217, Revision E.

Accessories and Spare Parts

Table 7 Available Accessories

Accessories	Order code
Sensor support arm	WAC425
RS232 cable	ZZ45203
Analog cable	ZZ45204
Margin verifier unit	425mvu

Table 8 Available Spare Parts

Spare part name	Order code
Bird spike set	425bird
3/16" mounting bolt and Allen key	425bolt
AMP connector kit	425con

Contact your local Vaisala representative for a complete list of accessories and components.