1.0 INTRODUCTION

Climatronics' heated sonic anemometer is designed as a stand-alone sensor to provide accurate measurements of wind speed and wind direction. An internal fluxgate compass is available as an option. The unit has no moving parts and is ideally suited for use wherever reliable, maintenance free operation over a wide operating range under adverse operating conditions is required. The anemometer is equipped with thermostatically controlled heaters for ice-free operation.

Please see the configuration table on the last page of this manual. Compare it to the serial label on your sensor for your exact configuration.

1.1 SPECIFICATIONS

PERFORMANCE:

WS Range: 0-145 mph (0-65 m/s)
Accuracy: **WS** 1.1 mph (0.5 m/s) or ± 5%
WD ± 5° @ wind speeds > 5 mph (2.2 m/s)
Resolution: .22 mph (0.1 m/s)

ELECTRICAL:

Measurement Format: Two orthogonal axis North-South and East-West
Measurement Rate: Approx. 2 Hz each axis
Operating Frequency: 40 kHz
Signal Output: RS232C or RS485 @19.2 K baud (see section 5.0)
Power Requirements: 6 - 15 Vdc: 100 mA draw@ 12 Vdc (sensor)
24 Vac, 6A (heaters)

PHYSICAL:

Size: 9.25 inches (20.3 cm) x 4 inches (10.15 cm) dia.
Weight: 3.0 lb. (1.4 kg.)
Mounting: MS3106F18-1S Connector

2.0 INSTALLATION

Be sure to mount the sensor in a clear, open area to minimize any turbulent effects caused by local obstructions (e.g., trees, buildings, etc.). The sensor is typically installed on Climatronics P/N 102286 pre-wired sensor mount. The keyway in the connector on the base of the sensor is matched to the keyway on the mount.

Attach the sensor to the 102286 mount by inserting the sensor into the mating connector on the mount and screwing the collar onto the sensor connector.

If your sensor is not equipped with a fluxgate compass you will need to align the posts with the black marks towards either True North or Magnetic North depending on your application.

Loosen the set screws in the end of the Nu-Rail fitting that secures the pipe that the sensor is mounted on, rotate the sensor to North, then retighten the set screws.

The connector keyways assure correct alignment if the sensor is removed and re-installed at any time.

Please refer to Figures 1 and 2 for reference.

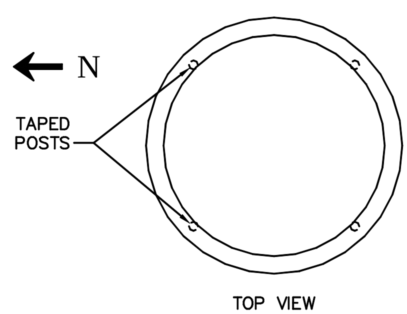

Figure 1

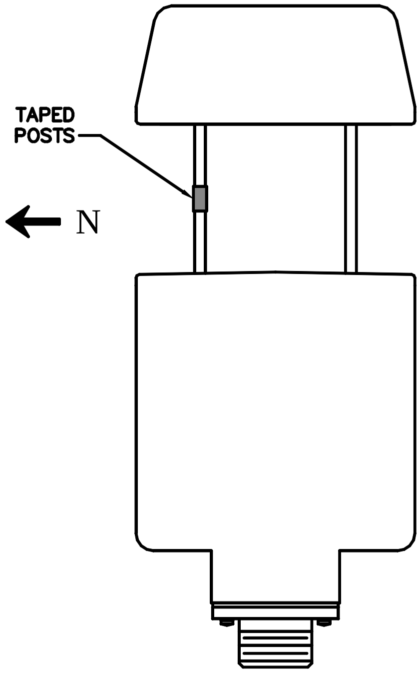

Figure 2

3.0 INPUT/OUTPUT CONNECTIONS

The sensors' pin designations are as follows:

PIN	FUNCTION
A	Ground
B	7 - 36 Vdc
C	Not Used
D	WS analog (option)
E	WD analog (option)
F	Heater Control
G	RS232 Receive Data or RS485B (+)
H	RS232 Trans. Data or RS485A (-)
I	Heater 24 V
J	Heater 24 V

4.0 USER DEFINED OPTIONS

Fluxgate Compass

An internal fluxgate compass is available with the Sonic Weather Station.

Note: *The wind direction output will be relative to magnetic north if the fluxgate compass is selected.*

5.0 USER INTERFACE

The output of the Sonic is a serial data stream. Typically the output is set for 19.2k baud (N/8/1) and outputs the data string approximately once per second. The data is easily viewed and can be displayed and captured using Climatronics WeatherView Software or Windows HyperTerminal that is supplied on most Windows operating systems. To find HyperTerminal click Start, Programs, Accessories, Communications, HyperTerminal. An ***example*** of the output format is shown below:

01+H0012 02+006.8 03+063.2 CR/LF

The first parameter is the serial number of the sensor (H0012), the second parameter is the wind speed and the third parameter is the wind direction. All parameters have fixed decimal points with leading zeroes.

Note: The optional wind tracker output is a special hex data string that cannot be viewed as shown in the above example.

Please refer to your specific sensor configuration for output ranges.

6.0 THEORY OF OPERATION

6.1 Winds

Climatronics' sonic anemometer operates on the principal that the speed of the wind effects the time it takes for sound to travel from one point to a second point. If the sound is traveling in the direction of the wind then the transit time is decreased. If the sound is traveling in a direction opposite the wind then the transit time is increased. This principal is well known and is the basis of most sonic anemometers. In mathematical terms:

$$t_1 = d / (c + u)$$
$$t_2 = d / (c - u)$$

where t_1= transit time from 1 to 2
t_2= transit time from 2 to 1
d= distance between 1 and 2
c= speed of sound
u= wind speed

If the equations are solved for $c+u$ and $c-u$ and the difference taken:

$$c+u-(c-u)=d/t_1-d/t_2$$
$$u=d/2*(1/t_1-1/t_2)$$

There are many ways to implement a sonic anemometer based on this equation and in fact most, if not all sonic anemometers operate according to this principal. It is important to note that the equation for wind speed is independent of the speed of sound. This is important because the speed of sound is not a constant but is very dependent upon air temperature, changing from 360 m/s at +50 °C to 300 m/s at -50 °C. Note that this change of 60 m/s is as great as the range of most sonic anemometers. The speed of sound is also affected by humidity and pressure, however their effect is small compared to the effect of temperature. It is interesting to note in passing that the equations can also be solved for the speed of sound and the air temperature can be determined from the speed of sound.

The relationship between the speed of sound in air and the air temperature can be described by the following equation:

$$c = 20.06\sqrt{T+273} \qquad T\text{=temp °C}$$

The equation for u above does not account for any delays in the electronics nor for any effect temperature might have on these delays. Because of this the path length d is generally made on the order of 10 cm or more. The longer the path length the less significant the other time delays. These design considerations and others lead to the sonic anemometers with which we are all familiar. Transducers are supported on long thin arms in an array to measure the components of the wind. The supports and the transducers are as slender as possible to minimize their effects on the wind field. These traditional sonic anemometers can be designed to measure one, two or three components of the wind.

Sonic anemometers of this type are generally accurate, exhibit high resolution, output temperature as well as wind speed and direction and are very responsive. They also are usually delicate, require extensive software to correct for transducer shadowing, and are expensive. Sonic anemometers of this type are generally used for research.

Climatronics' goal in developing a sonic anemometer was to design a unit that could replace cup and vane and propeller anemometers in terms of cost and accuracy and at the same time be more rugged. We also wanted an anemometer that could be kept ice-free at reasonable power levels and without expensive components to transmit heat to the rotating parts such as the cups. Size was determined in part because it was desirable that it have the same overall dimensions as Climatronics' TACMET sensor for purposes of interchangeability. All of these considerations dictate that the transducers will be close together resulting in a short path length. The short path length requires that all system delays be accounted for.

If the equations for the transit time above are rewritten to include the delays in the system then we have:

$$t_1 = d/(c+u) + t_1'$$

$$t_2 = d/(c-u) + t_2'$$

t_1'= delays due to transducers and electronics
t_2'= delays due to transducers and electronics

$$t_1-t_2 = d/(c+u)+t_1'-d/(c-u)-t_2'$$

if $t_1' = t_2'$

$$t_1-t_2 = d/(c+u)-d/(c-u)$$

rearranging terms

$$u = -(t_1-t_2)*(c^2-u^2)/2d$$

At first this expression looks difficult to evaluate. It is required to measure the temperature to assign a value to c and the expression c^2-u^2 contains the variable we are trying to solve for. The advantage is that it is possible to measure (t_1-t_2) with greater accuracy then it is to measure either t_1 or t_2. The correction required due to the variation of the speed of sound with temperature is also readily accomplished. Note that the term (c^2-u^2) varies by ± 20% over the range of 0 to 50 m/s and -50 to +50 °C. Note also that if c is corrected for temperature and u is set equal to zero then the term c^2-u^2 is in error by less then 3% from 0 to 50 m/s.

Where the greatest accuracy is required the equation can be solved for *u* and then this value of *u* can be substituted back into the equation to solve for a more accurate value of *u*. The design that has evolved consists of two tapered cylinders separated from each other by approximately 10 cm. All of the transducers are mounted in the upper cylinder pointing down. Sound is transmitted toward the lower cylinder and reflected back towards the upper cylinder as shown:

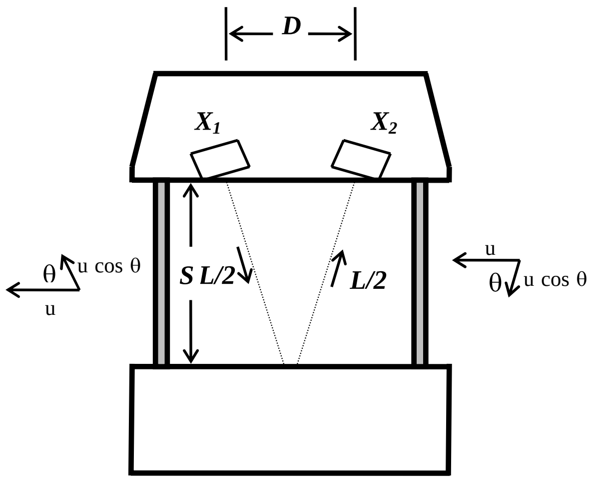

Figure 3

The transmission time is affected only by the horizontal component of the wind. Transducers are used as both transmitters and receivers. In this way the close match required for $t_1' = t_2'$ is achieved. Temperature is also measured but is not corrected for solar radiation errors. This temperature measurement is suitable for speed of sound corrections but not for most meteorological purposes. When more accurate temperature information is required a multi-plate shield is added to the unit.

Wind tunnel tests have shown that the airflow between the upper and lower housing is not greatly affected by the housings themselves through tilt angles in excess of ± 20 degrees. In this sense the sensor has an almost cosine response similar to a propeller anemometers.

6.2 Fluxgate Compass

The P/N 102294 internal compass is low power and compact, and is a complete compass or magnetic sensor module that integrates easily into the Sonic. The internal compass uses two magneto-inductive sensors, which change inductance with different applied magnetic field strengths, to sense magnetic fields.

The Sonic microprocessor measures the output of the internal compass and then corrects the wind direction data for the orientation of the sensor. The output of the Sonic wind direction is relative to magnetic North when a compass has been specified.

7.0 CALIBRATION

The sensor requires a wind tunnel for calibration. Climatronics can provide NIST traceable calibration in our wind tunnel. A portable Zero Wind Test Fixture, P/N 501506 is available for purchase. Please contact the factory for further details.

8.0 MAINTENANCE

Because the sensor has no moving parts to wear out, periodic maintenance is not required. In extremely corrosive environments, the condition of the connector used to mount the sensor should be checked. There are no adjustments or user repairable parts located inside the sensor.

Terminal Commands

RS232/RS485 Terminal Mode Commands

Terminal mode is activated by entering three carriage return characters within a 2 second period. Terminal mode times-out after 2 minutes of inactivity.

Successful entry into Terminal Mode will return the prompt:

Command (HE for Help, QU to Quit):

HE - Display Help Menu

HE	Display the Help menu Command: HE<cr> HE - This Help Menu BV - Battery Voltage Printout Toggle On/Off CV - Compass Heading Printout Toggle On/Off MD - Set Magnetic Declination OI - Set Output Interval QU - Quit command mode and save any changes SA - SDI Address SB - Set Baud rate SP - Sign-on Prompt Toggle On/Off ST - Set Serial Trigger Address SU - Set Speed Units TU - Set Temperature Units VN - Display Firmware Version Number

SU - Wind Speed Units

Read or Set the serial port's output Units for Wind Speed

COMMAND	RESULT
SU<cr>	Report Units setting
SU0<cr>	M/S
SU1<cr>	MPH
SU2<cr>	Knots
SU3<cr>	KPH

TU - Temperature Units

Read or Set the serial port's output Units for Temperature

COMMAND	RESULT
TU<cr>	Report Units setting
TU0<cr>	Fahrenheit
TU1<cr>	Celsius

SB - Serial Baud Rate

Read or Set the serial port’s Baud Rate
Note: This command is not supported by SDI-12 or Tracker Output.
SDI-12 is fixed at 1200 baud.
CAMEO/ALOHA and Tracker output are fixed at 9600bBaud.

COMMAND	RESULT
SB<cr>	Report Baud Rate setting
SB1<cr>	1200 baud
SB2<cr>	2400 baud
SB3<cr>	4800 baud
SB4<cr>	9600 baud
SB5<cr>	19200 baud

Note: Baud rate changes take effect after cycling power to the sensor.

BV - Toggle Battery Voltage Printout in data string

Read or Set the Battery Voltage output option for the serial port

COMMAND	RESULT
BV<cr>	Report option setting
BV0<cr>	Battery Voltage printout Disabled (Default)
BV1<cr>	Battery Voltage printout Enabled

CV - Toggle Compass Heading Printout in data string

Read or Set the Compass Heading output option for the serial port

COMMAND	RESULT
CV<cr>	Report option setting
CV0<cr>	Compass Heading printout Disabled (Default)
CV1<cr>	Compass Heading printout Enabled

MD - Magnetic Declination

Read or Set the Magnetic Declination

COMMAND	RESULT
MD<cr>	Report Magnetic Declination setting
MDXX.X<cr>	Set Declination to XX.X Degrees

Note: West declination values are entered and reported as negative values.

ST - Serial Trigger

Read or Set the Serial Trigger character string (Poll command)

COMMAND	RESULT
ST<cr>	Report Serial Trigger string setting
ST XXXXXX<cr>	Set Serial Trigger

VN - Software Version Number

Report the current Software Version Number

COMMAND	RESULT
VN<cr>	Report current Software Version

OI - Output Interval

Read or Set the Output Interval for the serial port

Note: This command is not supported by SDI-12, CAMEO/ALOHA, or Tracker Output.

COMMAND	RESULT
OI<cr>	Report Output Interval setting
OI1<cr>	Sensor Output every 1 second (Default)
OI2<cr>	Sensor Output every 2 seconds
OI3<cr>	Sensor Output every 5 seconds
OI4<cr>	Sensor Output every 15 seconds
OI5<cr>	Sensor Output every 30 seconds
OI6<cr>	Sensor Output every 60 seconds

SP - Sign-On Prompt

Read or Set the Sign-On Prompt output option at power-up for the serial port

COMMAND	RESULT
SP<cr>	Report option setting
SP0<cr>	Sign-On Prompt Disabled (Default)
SP1<cr>	Sign-On Prompt Enabled

QU - Quit

Exit the command mode and query to save any changes.

Command (HE for Help, QU to Quit): QU<cr>

To save changes type 'Y' : N<cr>

No changes were made

Restarting

102729 SONIC Options Configuration Guide

Base Part Number	**102729-**		
Serial Output Options	RS232		A
	RS485		B
Baud / Output Options	1200		1
	2400		2
	4800		3
	9600		4
	19200		5
	485 Tracker		6
	NMEA		7
Analog Options	None		C0
	0 - 1 Volt		C1
	0 - 5 Volt		C2
	0 - 2.5 Volt		C3
	1 - 5 Volt		C4
Averaging Options	Instantaneous		F
	Running Avg		G
	Reserved		H
	Reserved		J
Speed Units	MPH	0 to 145	1
	M/S	0 to 65	2
	Knots	0 to 125	3
	Kilometers/Hr	0 to 234	4
	MPH	0 to 100	5
	M/S	0 to 50	6
	Knots	0 to 100	7
	MPH	0 to 25	8
Compass Option	None		K
	11709 Micromag2		L

Table 1

Climatronics Corporation
140 Wilbur Place Bohemia, NY 11716 (631) 567-7300
www.climatronics.com

Revision	Description	Date	Approved
-	Released to Production	03/26/07	D.A.