1.0 INTRODUCTION

Climatronics' TACMET II weather station is designed as a stand-alone weather station to provide accurate measurements of wind speed, wind direction, temperature and relative humidity. A barometric pressure sensor and an internal fluxgate compass are available as options. 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 unit is built with a metal housing and filtering on all input and output lines to offer some protection from electromagnetic interference. ***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) ± 5%
WD ± 5° @ wind speeds > 5 mph (2.2 m/s)
Resolution: .22 mph (0.1 m/s)
Temperature:
Range: -22 to 131°F (-30 to +55°C)
Accuracy: ± 0.9°F (± 0.5°C) (sensor element)
Relative Humidity:
Range: 0 to 100%
Accuracy: ± 3%
MTBF: 80,000 hours

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

PHYSICAL:

Size: 12 inches (30.5 cm) X 4 inches (10.15 cm) dia.
Weight: 4.0 lb. (1.8 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, P/N 102621 or P/N 102564 pre-wired sensor mounts. The keyway in the connector on the base of the sensor is matched to the keyway on either 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. Attach the sensor to the 102621 QuickMount or 102564 Handle Mount by inserting the sensor into the top of the mount, attaching the latch springs to the clips on the bottom of the sensor and snapping them down to lock the sensor in place. It may be necessary to rotate the sensor 180° to allow the keyway to seat properly.

If your sensor is not equipped with a fluxgate compass, align the posts with the black marks towards either True North or Magnetic North depending on your application. (All hand-held sensors are provided with a compass.)
On the 102286 mount, 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.
On the 102621 mount, loosen the set screws in the bottom of the mount that attach it to your vertical ¾ inch pipe, 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.

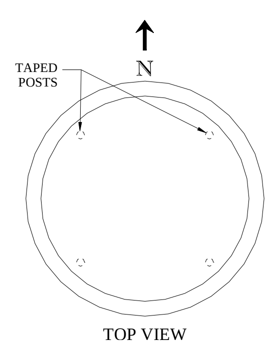

Figure 1

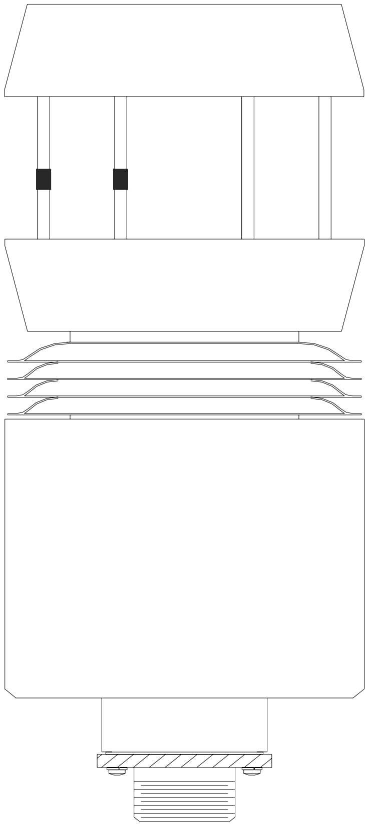

Figure 2

3.0 INPUT/OUTPUT CONNECTIONS

The sensors' pin designations are as follows:

PIN	FUNCTION
A	Power Ground
B	6.0 - 15 Vdc
C	N/C
D	N/C
E	N/C
F	N/C
G	Receive Data RS232C (RS485)
H	Transmit Data RS232C (RS485)
I	N/C
J	N/C

4.0 USER DEFINED OPTIONS

Barometric Pressure
Four barometric pressure sensors are available:

Sensor	Accuracy
Analog Pressure 1	± 2.75 mbar (.08 inHg)
Analog Pressure 2	± 1.5 mbar (.04 inHg)
Digital Pressure	± 0.65 mbar (.02 inHg)
Digital Pressure	± 0.40 mbar (.01 inHg)

Fluxgate Compass
An internal fluxgate compass is available with the TACMET II 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 TACMET II 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 04+022.2
05+015.1 06+30.26CR/LF

The first parameter is the serial number of the sensor (H0012), the second parameter is the wind speed, the third parameter is the wind direction, the fourth parameter is the temperature, the fifth parameter is the relative humidity and the sixth parameter is the optional barometric pressure.

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:

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

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:

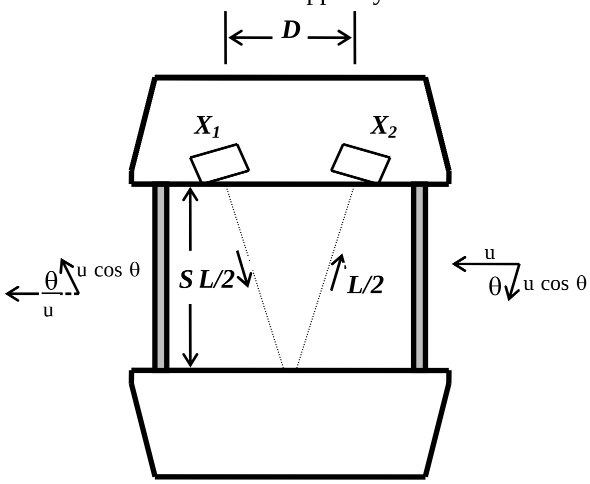

Figure 3

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 Temperature/Humidity

The temperature sensor in the P/N 102304 TACMET II uses a precision single-element Thermistor. This provides a highly accurate and stable temperature reading. The resistance value is 10K ohms at 25°C. This allows the TACMET II to directly interface with the temperature sensor without additional electronics; sensor compensation is handled through software.

The relative humidity sensor is a capacitive element sensor. It has a linear voltage output, which allows it to be connected directly to the TACMET II microprocessor. The humidity sensor element's construction provides excellent resistance to wetting, dust, dirt, oils, and common environmental chemicals. A heavy contaminant layer of dirt will slow down the sensor’s response time because it will take longer for water vapor to equilibrate in the sensor.

6.3 Barometric Pressure

There are four barometers available for use in the P/N 102304 TACMET II. This section describes each one briefly. The part number configuration should be checked to verify which barometer is included with the TACMET II being used.

The P/N 102297 is a state–of–the–art, monolithic, signal conditioned, piezoresistive silicon pressure sensor. This sensor provides an accurate, high level analog output signal that is proportional to applied pressure. The basic accuracy of the P/N 102297G0 barometer is ±2.75 hPa (0.08 inHg). The P/N 102297G1 version includes a software temperature correction to improve the overall barometer accuracy to ±1.5 hPa (0.04 inHg)..

The P/N 102298 barometer consists of a resonator and pressure sensitive diaphragm micro-machined from single-crystal silicon, thus achieving the highest level of performance stability. The sensor has a serial output that is read by the TACMET II microprocessor. The accuracy of the sensor is ±0.65 hPa (0.02 inHg).

The P/N 102555 barometer uses proven silicon sensor technology with microprocessor-based signal compensation, eliminating the need to insulate or temperature-regulate the barometer. The P/N 102555 has a pressure range of 500 to 1200 hPa. The P/N 102555 has a TTL output that lowers the power consumption of the barometer to 33 mW. The accuracy of the sensor is ±0.4 hPa (0.01 inHg).

6.4 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 TACMET II. The internal compass uses two magneto-inductive sensors, which change inductance with different applied magnetic field strengths, to sense magnetic fields.

The TACMET II 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 TACMET II 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 the sensor does not require periodic maintenance. 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.

102304 TACMET II Options Configuration Guide

Base Part Number	**102304-**		
Body Paint Options *	CARC Green		A
	CARC Tan		B
	CLEAR ANODIZE		C
	(reserved)		D
	(reserved)		E
	(reserved)		F
Shield Paint Options *	CARC Green		1
	CARC Tan		2
	CARC White		3
	(C body paint option only) GLOSS WHITE		4
Serial Output Options	RS232		G
	102295 (RS422/485)		H
Baud / Output Options	1200		1
	2400		2
	4800		3
	9600		4
	19200		5
	(requires option H) 485 Tracker		6
	NMEA		7
Averaging Options	Instantaneous		J
	Running Avg		K
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-A	0 to 100	5
	M/S-A	0 to 50	6
	Knots-A	0 to 100	7
Temperature Units	Degrees F	-22 to +131	1
	Degrees C	-30 to +55	2
Pressure Options		None	XX
102297G0 Sensor (± 0.08 inHg, 17.71-32.45 InHg)		InHg Output	L1
102297G0 Sensor (± 2.75 hPa, 600-1100 Millibars)		Millibar Output	L2
102297G1 Sensor (± 0.04 inHg, 17.71-32.45 InHg)		InHg Output	M1
102297G1 Sensor (± 1.50 hPa, 600-1100 Millibars)		Millibar Output	M2
102298 Sensor (± 0.02 inHg, 17.71-32.45 InHg)		InHg Output	N1
102298 Sensor (± 0.65 hPa, 600-1100 Millibars)		Millibar Output	N2
102555 Sensor (± 0.01 inHg, 17.71-32.45 InHg)		InHg Output	S1
102555 Sensor (± 0.4 hPa, 600-1100 Millibars)		Millibar Output	S2
Compass Option	None		X
	102294		P
EMI Shielding Options	Hardened EMI		1

*** COLORS**
FINISHED PER MIL-DTL-64159, COLOR CARC GREEN 383, 34094
FINISHED PER MIL-DTL-64159, COLOR CARC TAN 686A, 33446
FINISHED PER MIL-DTL-64159, COLOR CARC AIRCRAFT WHITE, 37875

Table 1

Climatronics Corporation
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www.climatronics.com

Revision	Description	Date	Approved
E	Released to Production	5/18/04	D.A.
F	See ECN 5420	3/24/05	D.A.
G	See ECN 5525	11/17/05	D.A.
H	See ECN 5550	3/9/06	D.A.