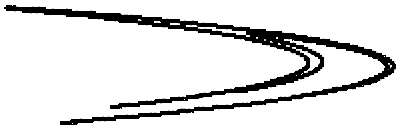

Applied Technologies, Inc.

OPERATORS MANUAL

FOR A

SONIC ANEMOMETER/THERMOMETER

MODEL # SATI/____

Prepared By:

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OPERATOR'S MANUAL

FOR A

THREE AXIS SONIC

ANEMOMETER/THERMOMETER

Revision G

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PREFACE

This new Sonic Anemometer/Thermometer incorporates many of the features from earlier models, using state-of-the-art microprocessor and surface mount technologies. Software that computes the wind velocities has been enhanced and optimized to provide a rapid response sonic anemometer/thermometer.

The electronics that operate the Sonic Anemometer/Thermometer are located in the probe array. Typically, the Sonic Anemometer/Thermometer is DC powered, however other power options are available by external adapters. The Sonic Anemometer/Thermometer is connected to a computer running a terminal emulation program, or can be connected directly to a dumb terminal. The Applied Technologies, Inc. Sonic Anemometer/Thermometer is a stable, low powered anemometer, capable of running unattended for extended periods of time.

The system may include: single, double, or triple axis probe arrays, along with several novel probe array designs. These designs reduce errors from both flow asymmetry and interference from structural members.

The system detects wind velocity components along mutually orthogonal acoustic paths, computes the wind velocity and provides an output directly in engineering units. The probe array designs of the Applied Technologies, Inc. Sonic Anemometer/Thermometer provide a true vertical velocity measurement. The "W" component is not inferred or calculated from some other instrument, but is a direct measurement that has an alignment accuracy of better than $\pm 0.1°$.

The system also provides calculations necessary to compute the sonic temperature, (in the "W" path), corrected for velocity contamination. It provides these data with excellent frequency response and makes it ideal for many aspects of basic atmospheric research.

INTRODUCTION

- **Section 1.0** is the general description of the Sonic Anemometer/Thermometer, including a summary of features and a listing of the specifications.

- **Section 2.0** is organized to familiarize the user with the theory of operation of the ultrasonic sensor technology, and how it applies to this Sonic Anemometer/Thermometer.

- **Section 3.0** describes the functional operation of the system with brief descriptions of each of the subsystems, including the sonic transducers within the probe array, and a brief description of the electronics involved.

- **Section 4.0** describes the Sonic Anemometer/Thermometer from the user's standpoint with instructions for setting up the software

- **Section 5.0** describes the software commands, includes a Table of Commands.

- **Section 6.0** describes the maintenance and setup procedures that may be required in the operation of the Sonic Anemometer/Thermometer.

- **Section 7.0** is a basic "Troubleshooting Guide" to aid in analyzing instrument operation and for tracking and isolating any problems that may occur.

1. DESCRIPTION

1.1 GENERAL

The Sonic Anemometer/Thermometer is a solid-state ultrasonic instrument capable of measuring wind velocities in three orthogonal axes (U, V, and W) and provides sonic temperature. The Sonic Anemometer/Thermometer is comprised of a probe array (containing all electronics necessary for operation), and a mounting bar. The probe array's sonic transducers are separated by 10 or 15 cm.

Sonic pulses are generated at the transducers and received by opposing transducers. Mathematics derived for these sonic pulses provide a wind velocity measurement in each of the corresponding axes and calculates a sonic temperature, which is generated from the speed of sound measurements in the "W" axis. Temperature measurements are corrected for cross-wind contamination.

The Sonic Anemometer/Thermometer uses a microprocessor-based digital electronic measurement system to control the sample rate, and compute the wind speeds and temperature. The standard data output of the Sonic Anemometer/Thermometer is 10Hz, where each output represents the average of 10 discrete measurements. The sample rate and output rate are user programmable. The wind speed from each of the axes and the temperature are presented on the computer screen, and the user can configure the Sonic Anemometer/Thermometer output to display many other parameters as well.

Calibration of the Sonic Anemometer/Thermometer requires the installation of the "Zero-Air Chamber" over the axis being calibrated. A measurement of the ambient air temperature to an accuracy of ±1°C is necessary for calibration. A calibration command is issued from the computer, and the microprocessor automatically calibrates the Sonic Anemometer/Thermometer, compensating for any electronic drift. Enter the temperature and relative humidity at the computer terminal when prompted. The correct "Zero-Air Chamber" is supplied with the instrument, in the case of the "V" probe array only, the "Zero-Air Chamber" covers all three axes simultaneously.

The software provides the capability of automatic restart in the event of power failure. It detects and displays an error in the data due to blockage of the sonic pulse, and includes some self-diagnostics and reset capability in the event of a microprocessor failure due to outside interference.

1.2 SUMMARY OF FEATURES

The Applied Technologies, Inc.'s Sonic Anemometer/Thermometer had the following features:

- Single component wind velocity
- Fast response temperature
- Extreme accuracy
- Microprocessor-based
- Solid-state digital operation
- No moving parts
- Unattended operation
- Ease of mounting
- Rugged construction
- Low power
- DC powered
- Ability to output Speed of Sound as well as temperature
- Ability to send remote commands
- Ability to provide extra output word in the data string.
- Ability to convert the horizontal velocities to wind speed and wind direction while retaining the vertical and temperature data
- Ability to output trigger pulse
- Data Quality Algorithm
- Median filter
- User adjustment to flow distortion
- User programmable sample rate, and averaging from 5 min to 200Hz.
- Variable data output rates.

1.3 SPECIFICATIONS

The Applied Technologies, Inc. Sonic Anemometer/Thermometer has the following specifications:

Measurement Range:	
Wind Velocity (V)	±15 m/sec.
Wind Velocity (Vx)	±20 m/sec
Wind Velocity (Sx, K)	±30 m/sec.
Wind Velocity (A)	±60 m/sec
Temperature	-30° to +60° C
Path Length:	
"V" Circular Probe	10 cm
"A", "Sx", "K", and "Vx" Probes	15 cm
Accuracy:	
Wind Speed	±0.03 m/sec
Orthogonality	±0.1 degrees
Temperature (Absolute)	±2° C
Sonic Temperature	±0.1° C
Resolution:	
Wind Speed	0.01 m/sec.
Wind Direction	0.1 degrees
Temperature	0.01° C
Output:	
Data Rate	10 samples / second (nominal)
Digital	Serial RS-232C compatible
BAUD Rate	9600 or 19,200
Operating Temperature Range	-30° C to +60° C
Power Requirements	+12 VDC, (+9 to +18 VDC @ 100 mA)
Probe Array:	
"A" – Non-Orthogonal	12.6cm x 22.6cm x 19.6cm
"Sx" – single axis	2.54cm x 15.9cm x 17.8cm
"Sx" – two axis	25.4cm x 25.4cm x 17.8cm
"Sx" – three axis	25.4cm x 35.6cm x 35.6cm
"K" – three axis only	25.4cm x 33.0cm x 40.6cm
"Vx" – three axis only	25.4cm x 25.4cm x 25.4cm
"V" – three axis only	17.8cm x 17.8cm x 17.8cm
Weight	<1.0 kg
Probe Mounting (all probe styles)	31.75 cm Square Tube

2. THEORY OF OPERATION

2.1 SPEED OF SOUND IN AIR

The speed of sound in still air can be measured accurately between two points a few centimeters apart by two ultrasonic transducer. The resulting speed of sound is a known function of the air temperature and composition.

The speed of sound in an ideal gas may be written

$$C = [\frac{\gamma RT}{M}]^{\frac{1}{2}}$$

where R is the universal gas constant (8314.34 mJ/mol K), T is the temperature in Kelvin, M is the molecular weight (grams/mol) of the gas, and γ is the ratio of heat capacities C_p and C_v; C_p and C_v are the specific heats at constant pressure and constant volume of the gas, respectively.

2.2 SPEED OF SOUND PRINCIPLE

The transit time of a sound signal traveling from one end of a sound path to the other, separated by distance d, can be written as follows (Schotland, 1955):

$$t = [\frac{(C^2 - V_n^2)^{\frac{1}{2}} \pm V_d}{(C^2 + V^2)}]d$$

where V is the total velocity, V_d and V_n are velocity components in the directions parallel and normal to the sound path, and C is the velocity of sound in still air.

If two transit times, t_1 and t_2 in opposite directions on the same sound path are detected, V_d can be obtained independent from V and V_n as follows:

$$V_d = \frac{d}{2}[\frac{1}{t_1} - \frac{1}{t_2}]$$

It is this principle that is used to compute the velocity of the air in the path between two opposing transducers.

2.3 CALCULATION OF THE WIND VELOCITY

In still air, t_1 and t_2 are equal. For a distance of 15 cm at 20°C, the transit time is approximately 450 µs.

If a 20 m/s wind is in the direction of the sonic pulse, the transit time t_1 will be approximately 427 µs. If the wind is opposing the sonic pulse, the transit time will be approximately 482 µs. If these two values are used in equation (3), the resultant velocity from equation (3) will be 20 m/s.

2.4 CALCULATION OF TEMPERATURE

The sonic anemometer/thermometer computes the sonic temperature of the air by first computing the speed of sound of the air:

$$C^2 = \frac{d^2}{4}[\frac{1}{t_1} + \frac{1}{t_2}]^2 + V^2$$

where V^2 is the crosswind component and t_1 and t_2 come from the "W" axis.

The calculated speed of sound of the air is substituted into the following equation for an ideal gas and solved for T_v.

$$T_v = \frac{C^2 M}{\gamma R}$$

The sonic temperature, T_v (in Kelvin), may differ from the absolute temperature by an amount equal to the water vapor content in the air measured. This difference amounts to ±1°C at 20°C and decreases as the temperature decreases.

3. FUNCTIONAL DESCRIPTION

3.1 ULTRASONIC TRANSDUCERS

The ultrasonic transducers used in the Sonic Anemometer/Thermometer are comprised of piezoelectric crystals enclosed in brass housings. The transducers are 3/8 inches in diameter, 7/8 inches long, and are attached to the probe array arms.

The transducers are acoustically isolated from the brass housing, and then sealed to prevent exposure to the outside environment. This type of assembly provides transducers that are equipped for rugged outdoor use, and can operate in most environments.

The transducer assembly is part of the probe array and should never need to be changed. If it is required, the entire probe array must be returned to the factory.

3.2 SONIC ARRAY

The probe array is a self-contained system, housing the transducers, and operating electronics. An input/output connector enables connection to a data collection computer.

The sonic probe array is machined to the specific dimensions required. The tolerance in any dimension is very tight, preserving the orthogonality to 0.1 degree in any direction. The array is a rugged sensor assembly capable of tower mounting and normal handling.

A flat surface on top of the array is provided as a leveling surface during installation. This surface is aligned to the probe array axes to less than 0.1 degrees.

All electronics necessary to the operation of the Sonic Anemometer/Thermometer are housed in the probe array. Surface mount technology has made it possible to put the electronics on a circuit card, small enough to be located in the mounting arm of the probe array. All connections to the transducers are made inside the probe array, and therefore are completely weatherproof. The electronics require DC power which is provided to the array through the cable connector.

3.3 MOUNTING BAR

A 1-1/4" square x 34" long mounting bar is provided to assist in mounting the Sonic Anemometer/Thermometer on a tower. The bar is designed to fit the connector end of the sonic array, allowing the cable to pass through the inside of the bar. Two thumbscrews are located in the end of the mounting bar, which secure the probe array to the bar.

3.4 RS-232C OUTPUT

The Sonic Anemometer/Thermometer output is formatted and scaled such that it can be read directly on a terminal. There is a choice of output modes, which can be set by way of the OPTIONS MENU. (Refer to section 5.9 for the commands). The default output mode is "VERBOSE". The other output mode is "TERSE". Examples of both are shown below. The output of the Sonic Anemometer/Thermometer can also be used by most any data recorder or computer that has a serial port.

The conditions for the serial port are: Full Duplex, 9600 baud, 7 bit ASCII, even parity and 1 stop bit. The normal output is in meters per second for velocity and degrees centigrade for temperature, but these may be changed by commands issued from the terminal or computer.

With a CRT terminal in scroll condition the data should appear as follows:

EXAMPLE: {VERBOSE} (no wind & room temperature conditions)

```
U 00.02   V 00.03   W 00.03   T 20.02
U 00.02   V 00.03   W 00.03   T 20.02
U 00.02   V 00.03   W 00.03   T 20.02
   "         "         "         "
   "         "         "         "
```

The data format has all the spaces, periods, <CR>'s and <LF>'s required to printout on a CRT terminal as shown. Therefore, there is a <CR> & <LF> at the end of each record of data, where a record is one line of the display.

It will display one record of data every 100 milliseconds, when operating at the 10 Hz data rate. The data being displayed are 1/10 of a second behind the actual measurements. This means, the first measurements taken during the first 1/10 second time period, will be displayed while the second measurements are being taken. The second measurements will be displayed while the third measurements are being taken, and so on… There are 10 measurements evenly spaced over the 10 Hz time period.

In the "TERSE' mode, the identifying letters, decimal points and some of the spaces are removed. The <CR> & <LF> are still at the end of each record for record synchronization.

EXAMPLE: {TERSE} (no wind & room temperature conditions)

```
0002 0003 0003 2002
0002 0003 0003 2002
0002 0003 0003 2002
  "    "    "    "
  "    "    "    "
```

NOTE: Refer to section 5.9 Command Tables – Options Menu – C & D for information on Binary Output.

3.5 EXTERNAL TRIGGER INPUT

External triggering is provided for customers who wish to synchronize the Sonic Anemometer/Thermometer or to provide a unique sampling rate. The customer must furnish a low going TTL pulse or low going (MARK) RS-232C pulse, at least 10 µsec wide, to a maximum of 20 Hz. This pulse ties into each system through the connector Pin 5. See Section 3.7 for pin-out of sonic connector.

In order to use the External Trigger function, it must be turned ON by way of commands issued from the terminal or computer. Refer to Section 5.9 Command Tables, Options Menu, K – External Triggering. This command is toggled ON or OFF, and by default is set to OFF. Once the External Trigger is set to ON, it will begin listening for the external trigger pulses.

When External Trigger is used, the instrument will take measurements at the rate preset by command. The digital output of this data will start appearing on the output lines approximately 50 ms after the completion of the data taking period.

3.6 EXTERNAL TRIGGER OUTPUT

An External Trigger Output is provided by the Sonic Anemometer/Thermometer on Pin 3 of the output connector. The output is an RS-232C signal (+12 to –12, High to Low). It is always present and does not require any commands to enable. It is provided to allow synchronization of several instruments, whether they be Sonics or other instruments. This output runs at the frequency determined by the Sonic acting as the "Master". If an external trigger pulse is connected to the "Master" sonic, via Pin 5, the sonic will operate at the required frequency, and the same rate will be output on Pin 3 allowing all instruments connected, to operate at the same rate.

3.7 CONNECTOR PIN-OUT

The following table describes the pin-out of the Sonic Anemometer/Thermometer.

Pin Number	Function	Description
Pin 1	*Chassis Ground*	*Chassis Ground*
Pin 2	*Spare*	*N/C*
Pin 3	*Trigger Output*	*RS-232 Signal – (+12 to –12 V High to Low)*
Pin 4	*Spare*	*N/C*
Pin 5	*Trigger Input*	*RS-232 Signal – (+12 to –12 V High to Low)*
Pin 6	*Ground*	*GROUND*
Pin 7	*Ground*	*GROUND – (RS-232 Common)*
Pin 8	*Receive Signal*	*RS-232 Signal – Connects to Transmit Out of computer*
Pin 9	*Transmit Signal*	*RS-232 Signal – Connects to Receive In of computer*
Pin 10	*External Reset*	*Floats high and requires Grounding to perform Reset*
Pin 11	*Known State*	*Floats High, requires Grounding AND the External reset or powered-up.*
Pin 12	*Vcc Input*	*+9 to +18 VDC @ 1.2 Watts*
Pin 13	*Ground*	*GROUND – (Vcc Return)*

4. OPERATION

The operation of the Sonic Anemometer/Thermometer is essentially automatic, such that no specific setup procedure is necessary for normal operation. There are, however, commands that may be entered by the operator that will set certain operating parameters. (Refer to the software section of the manual for the commands). The built-in microprocessor power-up sequence sets the system in operation when power is applied.

4.1 HARDWARE INSTALLATION

For accurate measurements, the mount should be firm with no slop or backlash. The structure to which the mounting bar is attached should be on the prevailing downwind side of the probe to minimize shadowing of the wind. For best results, the probe should also be mounted to a boom laterally from the structure at least 10 diameters or more.

Secure the probe mounting bar on the structure, feed the output cable through the mounting bar, and connect the end to the probe array. Slide the connector end of the probe array into the mounting bar, lining up the holes in the probe array with the thumbscrews in the mounting bar. Secure the array using the thumbscrews.

Orientation of the probe and the positive direction of the three axes are shown in a drawing in Appendix A.

Connect the other end of the output cable to the serial port of a computer and power source.

4.2 SOFTWARE

The Sonic Anemometer/Thermometer software is accessed by using a terminal emulation program, such as; HyperTerminal from Windows95, or any other terminal emulation program. Set the terminal to use the following settings"

Baud Rate – 9600 bps (10 Hz) or 19,200 bps (20Hz)

Parity – EVEN

Number of Data Bits – 7

Number of Stop Bits – 1

Flow Control - NONE

Once the terminal program is connected to the serial port to be used, the Sonic Anemometer/Thermometer data will be visible. Hit the {ESC} key on the keyboard while in the terminal program to access the Sonic Anemometer/Thermometer menu.

The next section describes the commands available from the Sonic Anemometer/Thermometer's Main Menu.

5. SOFTWARE COMMANDS

Hit the {ESC} key at any time from the terminal to access the Sonic Anemometer/Thermometer Main Menu. The Sonic Anemometer/Thermometer will stop operating while in Command Mode.

5.1 MAIN MENU

The main menu is the first menu available. The Seven choices on this menu are as follows:

A – OUTPUT OPTIONS

This menu allows the user to change various options for the Sonic Anemometer/Thermometer such as baud rate, parity, and type of output desired. Details for this menu can be found in Section 5.2 of this manual.

B – SAMPLING OPTIONS

This menu allows the user to change certain sampling parameters of the Sonic Anemometer/Thermometer operation, such as turning the median filter, data quality and shadow correction on and off, . Details for this menu can be found in Section 5.3 of this manual.

C – TRIGGER OPTIONS

This menu allows the user to make minor changes to the triggering of the Sonic Anemometer/Thermometer such as external triggering or character triggering on or off and setting the trigger character. More details for this menu can be found in Section 5.4 of this manual.

D – CALIBRATION

This menu is used to perform the calibration of the Sonic Anemometer/Thermometer. More details on calibrating the Sonic Anemometer/Thermometer and this menu can be found in Section 5.5 of this manual.

E – CURRENT SETTINGS

This choice will display all the current settings for the Sonic Anemometer/Thermometer. More details can be found in Section 5.6 of this manual.

F – RESET FACTORY DEFAULTS

This menu command restores the original Factory set defaults. The sonic anemometer will need to be reset in order to use the new settings.

Z – FACTORY SETTINGS

This menu choice contains factory settings. These settings should NOT be changed unless the operator is instructed to do so by Applied Technologies, Inc.'s technical support.

Ø– EXIT

This choice will return the Sonic Anemometer/Thermometer to Sampling Mode.

5.2 OUTPUT OPTIONS MENU

This menu contains all output options for the Sonic Anemometer/Thermometer. Most options can be toggled "ON" or "OFF". Refer to the Command Table in Section 5.9 of this manual for the specifics of each of the options available.

5.3 SAMPLING OPTIONS MENU

This menu contains all the configurable sampling options for the Sonic Anemometer/Thermometer. These options are toggled “ON” or “OFF”, and include Median Filter, Data Quality Algorithm, Shadow Correction and Remove RH from Temperature. Refer to the Command Table in Section 5.9 of this manual for the specifics for this menu.

5.4 TRIGGER OPTIONS MENU

This menu contains the configurable triggering options for the Sonic Anemometer/Thermometer. These options include External Triggering, Character Triggering, and setting the Trigger Character. Refer to the Command Table in Section 5.9 of this manual

5.5 CALIBRATION

This menu is for calibrating the Sonic Anemometer/Thermometer. Choose "Calibration" when required and enter the temperature, relative humidity, and axis to be calibrated from this menu. Refer to Calibrating the Sonic Anemometer/Thermometer in Section 5.10 of this manual for more details.

5.6 CURRENT SETTINGS

This menu choice will display the current settings for the Sonic Anemometer/Thermometer. This menu is provided for the user to see exactly how the Sonic Anemometer/Thermometer is currently configured.

5.7 RESET FACTORY DEFAULTS

This command allows the operator to return the system to the original factory settings.

5.8 FACTORY SETTINGS

DO NOT CHANGE THESE VALUES UNLESS THEIR EFFECTS ARE KNOW. Changing any of the values in this menu could result in inaccurate data, or could make the system inoperable. If in doubt about the settings then choose Restore Factory Settings from the Main Menu and reset the system.

5.9 COMMAND TABLES

Output Options Menu

A – BAUD Rate	This menu choice allows the user to enter a new baud rate. The system will is capable of accepting standard baud rates from 2400 to 115.2K. Baud rates below 9600 require lower output rates.
B – Parity (ON/OFF)	This menu choice allows the user to enter a new parity if desired. ON is EVEN Parity – OFF is NO Parity
C – ASCII Output (ON/OFF)	This command sets the output of the Sonic Anemometer/Thermometer to the Standard ASCII output. (VERBOSE) This is the best format for outputting the data to a display. The data should look like the following example: U 00.02 V 00.03 W 00.02 T 20.02
D – Terse Output (ON/OFF)	This command sets the output of the Sonic Anemometer/Thermometer to TERSE ASCII output. The TERSE output strips the beginning letter and decimal points from the data, to reduce the space required to store the data. The displayed data would look similar to the following example: 0002 0003 0002 2002 TERSE also applies to both ASCII and BINARY output modes.
E – Binary Output (ON/OFF)	This command sets the output of the Sonic Anemometer/Thermometer to BINARY mode. This mode changes the Standard ASCII output to binary data words. This was developed to decrease the space and time required for data logging. BINARY format is 8 bits, and NO parity. Two's compliment is used to express bipolar data as an integer. The most significant bit of the 16-Bit word is a sign bit. When this bit is 0, the number is positive, and when this bit is 1, the number is negative. **Example:** Hex Word Decimal Value 00 00 0 00 01 1 FF FF -1 7F FF 32767 80 01 -32767 09 C4 2500 *(Continues on next page)*

E – Binary Output – *(Continued)*	NOTE: The parity of the Binary Data are not affected by the parity setting of the Sonic Anemometer, however, the Power-up Diagnostic Messages, the command mode prompts, and the offset messages will be affected if the system parity is changed. These messages are always "text", regardless of the ASCII/Binary output setting. The format of the Binary Output data will look like the following example: 800055000056000057000054 09C48000… 8000 = Header (separates the data) 55 = "U" Tag 0000 = 16 Bit, 2's compliment data 56 = "V" Tag 0000 = 16 Bit, 2's compliment data 57 = "W" Tag 0000 = 16 Bit, 2's compliment data 54 = "T" Tag 09C4 = 16 Bit, 2's compliment data The Tag characters can be removed from the data string, by selecting TERSE Binary Output.
F – Break Binary Output (ON/OFF)	This command sets the output of the Sonic Anemometer/Thermometer to a BINARY output like the above command. The only difference is that the data words are separated by "Breaks". The format of the Binary Output data will look like the following example: 000C55000056000057000054 09C4000C 00 = Break 0C = Count of the number of data bytes 55 = "U" Tag 0000 = 16 Bit, 2's compliment data 56 = "V" Tag 0000 = 16 Bit, 2's compliment data 57 = "W" Tag 0000 = 16 Bit, 2's compliment data 54 = "T" Tag 09C4 = 16 Bit, 2's compliment data The Tag characters can be removed from the data string by selecting Terse Binary Output with Breaks.
G – C_s Output (ON/OFF)	This command is used to toggle the Speed of Sound "ON" and "OFF".
H – Temperature (ON/OFF)	This command toggles the display of the temperature "ON" and "OFF".

I – WS / WD (ON/OFF)	This command is used to output actual wind speed and direction and temperature rather than "U", "V", "W" and "T".
Ø– Return to Main Menu	This command will return you to the Main Menu, where other parameters can also be set, the system calibrated, or the user can return to displaying data.

Sampling Options Menu

A – Median Filter (ON/OFF)	This command is used to toggle the Median Filter "ON" and "OFF". The median filter is used to return a "median" value of ten samples, rather than averaging the samples and reporting the averaged value.
B – Data Quality Algorithm (ON/OFF)	This command is used to toggle the Data Quality Algorithm "ON" and "OFF". Data Quality is used to remove spikes caused by various external sources, such as radio frequency and acoustical interference.
C - Shadow Correction (ON/OFF)	This command toggles the Shadowing Correction "ON" and "OFF". Shadowing correction is used to correct the flow distortion caused by the wind blowing directly along the axis of one transducer.
D – Remove RH from Temp Calculation (ON/OFF)	This command is used to toggle the Relative Humidity calculation "ON" and "OFF". When the RH calculation is on, the RH is used in the equation to calculate the temperature. When toggled "OFF" this factor is removed from the calculation of the Temperature. This command has the same effect as setting the RH Value (in the Parameters Menu) equal to Zero (0).
Ø– Main Menu	Return to the Main Menu.

Trigger Options Menu

A – External Triggering (ON/OFF)	This command toggles External triggering ON and OFF. External trigger is provided for customers who wish to synchronize the Sonic Anemometer/Thermometer to other instruments. A low-going RS-232 pulse, at least 10µsec wide, must be furnished to use external trigger.

B – Character Triggering (ON/OFF)	This command toggles External Character Triggering ON and OFF. This is provided for customers who wish to synchronize the Sonic Anemometer/Thermometer to other instruments, but have no external trigger line. The Sonic will trigger on the character in the data stream chosen in the next menu.
C – Trigger Character	This command allows the user to enter the character to be used to trigger the sonic. The default character is an Asterisk (*), however any character can be used except (!); {ESC} and ^C.
Ø– Main Menu	Return to the Main Menu.

Factory Menu (Do not change these values unless their effect is know)

A – Samples per Output	This parameter is the number of high-speed samples averaged (or median size) to create the desired output. Combining this command with the next command allows adjustment of the output.
B – Ticks per Sample	This parameter sets the number of high-speed samples. 0 means 5ms "ticks"; 1 means 10ms "ticks"; 2 means 15ms "ticks". Combining this parameter with the "Samples per Output" sets the speed of the instrument. Example: 10ms "ticks" and 10 samples = 10Hz
C – Gamma for Zero RH	This parameter is used to adjust the gamma of the air with zero humidity. C^2=Gamma/Temperature. Also see Gamma Slope.
D – Gamma Slope	This command is used to change *gamma* (γ) in our equation if required. $T = \frac{C^2}{g}$ if the *gamma* is not correct, adjust the *gamma slope* to correct. $gamma = (gamma\ slope)RH + gamma\ zero$ The RH and gamma zero can also be changed if required: RH in the Parameters Menu, and gamma for zero RH in the Factory Menu.

E – RH Value	This parameter is used to set up a known general relative humidity. For example, if the system is going to be used in the tropics, the user might enter a 90 (90% Humidity). This value is required in order to calculate the virtual (Sonic) temperature. Use this command as a work-around for the Remove RH from Temp. Calculation, by setting this value to zero (Ø).
F - FD Maximum Correction	This parameter is used to set the flow distortion maximum correction. Refer to the following equation for the setting this parameter: $$NewValue = \frac{Measured}{MaximumCorrection + \left(\frac{q}{CorrectionAngle}\right)}$$
G - FD Correction Adjustment	This parameter is associated with the previous parameter. Use the previous equation in setting this parameter.
H – FD Correction Angle	This parameter is associated with the previous parameters. Use the previous equation in setting this parameter.
I – Output Spike Status	This command displays the number of samples used by the Data Quality Algorithm to get the averaged data output. If 20 samples are taken, and 3 samples thrown out, display will show 17.
J – Spike Removal Parameter	Data Quality works by comparing the current high-speed sample with an average, and then looking at this parameter to determine if the current sample has deviated too far from the average. If the deviation is larger than this value, the sample is discarded.
K – Spike Removal Reset Samples	This command is used to set the number of samples before the Data Quality Algorithm is reset. This is necessary when poor data quality occurs for an extended period of time because the values could drift too far from the average they are compared to. This value is the number of output samples that occur before a reset of the Data Quality Algorithm happens.
L – Number of Axis	This parameter is used to tell the system how many axes the probe array has, 1; 2; or 3.
Ø– Main Menu	Choose this command to return to the Main Menu.

5.10 CALIBRATING THE SONIC ANEMOMETER/THERMOMETER

The Sonic Anemometer/Thermometer is calibrated at the factory before shipping, however, it may be necessary to perform a calibration on site. Follow the steps in the next paragraph to perform calibration.

Install the Zero-Air Chamber over the axis to be calibrated, (the Zero-Air Chamber covers all axes on the "V" style sonic array). Hit {ESC} from the terminal program to bring up the Main Menu. Choose D – Calibrate. Measure the ambient temperature to within 1.0°C or better, and enter the temperature in degrees C at the prompt. After entering the Temperature, you will be prompted to enter the Relative Humidity. Enter an integer between 0 and 100, representing the percent of relative humidity. Next you will be prompted to enter the number of the axis to be calibrated.

0 = "U" Axis

1 = "V" Axis

2 = "W" Axis.

Repeat the procedure to calibrate all three axes, choosing the correct number of axis. Be sure that the Zero-Air Chamber is in place on the correct axis before beginning the calibration.

6. MAINTENANCE

The Sonic Anemometer/Thermometer is designed to run unattended, with very little maintenance required. Since there are no moving parts to contend with, maintaining the Sonic Anemometer/Thermometer is very simple. Try to keep the transducers free from dirt and ice. Check the output cable occasionally. All other required maintenance must be performed by the factory.

7. TROUBLESHOOTING

The Sonic Anemometer/Thermometer is quite reliable on its own and does not require much maintenance. Should you encounter a problem, a few basic steps can be taken to help troubleshoot the problem. Make sure that all of the cables are connected and good . If the display shows -99.99, the first indication should be that there is something blocking the axis reporting the 99.99. If a check of the axis reveals no blockage, the second indication would be that a transducer may have failed. If a further check indicates the possibility of a bad transducer, the sonic must be returned to the factory for repair. The transducers in this latest instrument are NOT field replaceable.

If the display shows a +99.99, the first indication is that the data quality algorithm has been turned on. The processor has observed some data, but discarded the complete sample when it considered the data incorrect. If this is the case, and it is a temporary problem, the instrument will continue to transmit reliable data once the situation corrects itself. The main reason for this type of condition is usually the velocity of the measurement has reached the upper limit of the instrument. In this case, the +99.99 will come-and-go as the wind speed fluctuates above or below the limit. External interference will also cause this type of symptom.

Should the +99.99 be displayed continuously, there may be several possible reasons for this error, but the first indication is that something has caused a partial blockage of a transducer. One cause of this may be a rain drop on the transducer, or something else such as bird droppings. If the cause has been removed and the problem does not cease, the instrument may have experienced a failure. Return it to the factory for repair.

CAUTION: If the instrument gets a continuous partial blockage without the problem being corrected, the data would be continually bad. To circumvent this problem, the instrument processor has a built-in reset feature that will cause the program to reset itself and try a restart. If there is

sufficient signal to continue operation, the instrument will start again and continue working until something else changes, whether it be by chance or by operator.

This reset delay time is factory set at 10 seconds, but can be changed by the operator if necessary. Check the *Factory Menu* for command Data Quality Reset Samples [G].

The Sonic Anemometer/Thermometer will report errors during Power-Up only. The errors that the sonic reports are as follows:

- FPGA Config Error – This error indicates that the Sonic failed the configuration.
- FPGA Fail – Immediately following this error will be a 2 digit Hex number != a 2 digit Hex number. The numbers can vary depending on what has failed.
- RAM Fail – Immediately following this error will be a 2 digit Hex number != a 2 digit Hex number. The numbers can vary depending on what has failed.

Any errors during Power-Up indicate something has failed internally, and the Sonic must be returned to the factory for repair.

The basic step the operator can perform is to reset the original factory settings and recalibrate the Sonic Anemometer/Thermometer. If you are still having problems after doing that, or if the Sonic Anemometer/Thermometer isn't performing up to standards, it will need to be returned to the factory for repair.

APPENDIX A

APPENDIX B