

# Research Constant Temperature Anemometer

Model IFA 300

## *A revolution in thermal anemometry*

- SMARTTUNE™ automatic bridge optimization technology
- High frequency response (with no tuning)
- Windows-based software
- Built-in signal conditioner and thermocouple circuit
- Optional constant current anemometer
- Fully computer controlled
- Ultra-low-noise circuits
- Optional integrated calibration system

**The IFA 300 is a state-of-the-art research anemometer capable of meeting the most demanding measurement requirements. Whether your application involves measurement of high speed flows, measurement of very low turbulence intensities, fast temperature measurement, or the use of a high power bridge, the IFA 300 can do it all. It represents the depth of design capability and an understanding of the dynamics of constant temperature anemometry which TSI has developed over the past thirty years of building exceptional anemometry products. Examine the many features of this anemometer and we are sure you will agree that no other system can compare in performance or value.**



## SMARTTUNE\* Bridge Optimization

Research thermal anemometry has been an effective tool for fluid mechanics researchers for many years, but the requirement for precise manual frequency response tuning of the anemometer/sensor circuit has made accurate measurement an art form and has restricted some applications. With the effective implementation of TSI's SMARTTUNE bridge optimization circuitry, the IFA 300 represents the greatest single advance in thermal anemometry technology in over thirty years.

SMARTTUNE technology eliminates the controls normally used to optimize frequency response, while maintaining stability. This allows the anemometer to stay optimally tuned over its entire operating range. You only need tell the computer whether the sensor is a film or a wire and the rest is automatic. For the first time, turbulence measurements are possible with a thermal anemometer in applications where the mean velocity changes rapidly over a wide range, such as a

blow-down wind tunnel, thanks to the self-optimizing SMARTTUNE bridge circuit.

SMARTTUNE technology eliminates the need for a special 1:1 bridge to achieve high frequency responses, with the IFA 300, the confusion over a multiplicity of inputs and settings is eliminated. You only need a single input jack to handle any sensor, under any conditions.

## The System

The IFA 300 utilizes the latest in surface mount electronics to provide a reliable, compact system. From the rugged cabinet to the easily installed channel modules, the system is designed to provide many years of trouble-free operation. The signal conditioner and anemometer bridge functions are built on a single board, with up to eight channels available in a single 19-inch rack mount. Automated overheat ratio control and SMARTTUNE bridge optimization further simplify the overall package by eliminating the numerous potentiometer adjustments previously required for each channel. A built-in thermocouple circuit in

\*Patent applied for.

each cabinet simplifies temperature measurement. Control for the Model 1129 Automated Calibrator and signal conditioning for a pressure transducer are included in each cabinet. The overall result is an elegant, compact system—simple to use, very reliable, with superior specifications.

## The Anemometer/Signal Conditioner

Each anemometer/signal conditioner in the IFA 300 is mounted on a single circuit board so installation and trouble shooting are quick and easy. Each board is fully electrically shielded, eliminating the possibility of interference. This integrated design, together with SMARTTUNE technology, allows high frequency response, a maximum probe current of 1.6 A, and equivalent amplifier input noise of only  $1.7 \text{ nV}/\sqrt{\text{Hz}}$ , specifications unmatched in the industry!

The signal conditioner section features a voltage offset of up to ten volts in 10 mV steps and up to 1000x gain. Both functions are fully computer-controlled and allow the user nearly infinite flexibility in managing the dynamics of the ana-

log signal before digitizing. This can be critical when making measurements at very low turbulence intensities.

## Data Acquisition and Analysis

The IFA 300 is designed for complete computer control. System operating functions, such as control of the overheat ratios and signal conditioner settings, are handled via an RS232 interface, while the high speed analog data from the anemometer output is managed with a high speed A/D converter mounted inside the computer.

Each system is supplied with a copy of TSI's THERMALPRO™ software. This software integrates all control and data acquisition functions, while providing complete data analysis.

Should you decide to use your own software for acquisition and analysis, you will find the IFA 300 straightforward to control using standard RS232 commands. This is a major advantage over other anemometer designs having specialized software controls with proprietary algorithms.

## Options

While the basic IFA 300 system can handle up to eight anemometer channels in one cabinet, a total of sixteen anemometers can be monitored and controlled by THERMALPRO software with the addition of a second cabinet (and the appropriate digitizer). You can also operate this flexible package as two separate systems with the purchase of a second copy of THERMALPRO software and a second A/D converter.

In cases where there is a need for rapid-response temperature measurement, a fine hot wire sensor can be operated at a very low current, resulting in a high-frequency-response resistance thermometer. Frequency response from this circuit can easily exceed one kilohertz when a very small diameter sensor, such as our P.5 wire sensor, is used.



## IFA 300 Specifications

<b>Amplifier drift</b>	0.3 $\mu\text{V}/^\circ\text{C}$
<b>Amplifier input noise</b>	1.7 $\text{nV}/\sqrt{\text{Hz}}$ and 1.5 $\text{pA}/\sqrt{\text{Hz}}$
<b>Frequency response</b>	>250 kHz (without tuning)
<b>Resistance measurement</b>	0.1% $\pm$ 0.01 ohms
<b>Operating resistance</b>	2 to 80 ohms
<b>Maximum probe current</b>	800 mA (1.6 A with high power setting)
<b>Cable length</b>	5 m or 30 m; RG-58 A/U (other lengths available on request)
<b>Output</b>	Bridge voltage to 11.5 volts
<b>Size</b>	17.8 cm $\times$ 48 cm $\times$ 41 cm (7 in. $\times$ 19 in. $\times$ 16 in.); standard 19-inch rack mount
<b>Number of channels</b>	Up to eight per cabinet; sixteen channels supported by standard software
<b>Input power</b>	100/120/220/240 VAC, 50-60 Hz, no switching required
<b>Temperature measurement</b>	Thermocouple circuit built-in for type-T thermocouple
<b>Signal conditioning</b>	
<b>Offset</b>	0 to 10 V in 10 mV steps, 0.15 % accuracy
<b>Gain</b>	1 to 1000 (1.0 MHz maximum bandwidth), 0.15 % accuracy
<b>Low pass filters</b>	Linear phase, 12 Hz to 1 MHz; 13 settings; -60 dB/decade
<b>High pass filters</b>	0.1, 1, 10 Hz; -60 dB/decade
<b>Output (analog)</b>	-5 to +5 V
<b>Accessories included</b>	One 5-meter probe cable per channel, one 2-meter output cable per channel (plus 2 extra per system), one Model 1340 thermocouple, one Model 1341 thermocouple cable, one BNC shorting cap (coaxial), one BNC "T" connector, power cable(s), one 4-meter (12 ft) RS232 cable, one shorting probe for single-sensor probe supports and one for dual-sensor probe supports, software, and instruction manual

## To Order

All components for single channel operation, except the digitizer, are included in the basic IFA 300 package. Up to seven additional

channels can be installed in the cabinet by TSI. Up to eight more channels can be added using a second cabinet. Constant current

temperature modules can be substituted for the constant temperature anemometer modules.

<b>Specify</b>	<b>IFA 300</b>	<b>Single-channel Research CTA w/Data Analysis Software</b> —Includes cabinet for up to eight channels of anemometer/signal conditioner, one Model 183150 anemometer/signal conditioner module, one copy of THERMALPRO software and all necessary interface cables. <b>Note: the Multichannel Digitizer is not included. This must be purchased separately.</b>
	<b>183150</b>	<b>SMARTTUNE CTA Module w/Signal Conditioner</b> —Order one for each channel needed after the first (included in basic IFA 300). Maximum of eight per cabinet and sixteen per system.
	<b>183102</b>	<b>Cabinet</b> —Allows addition of eight channels to IFA 300, for a total of sixteen.

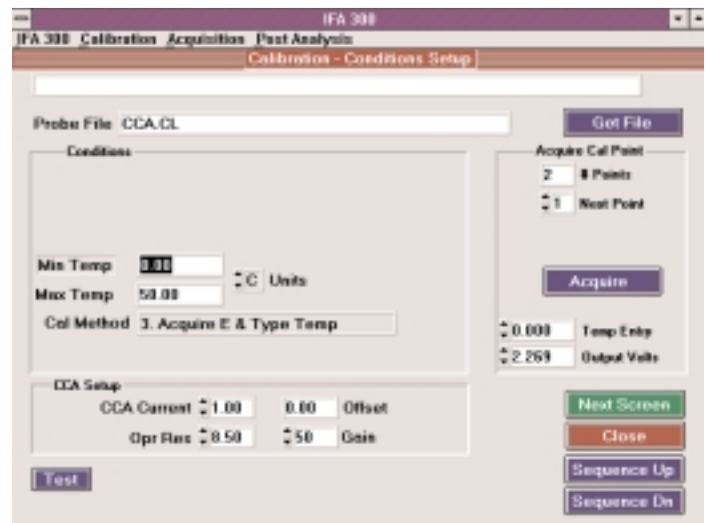
**Example:** To select a system with three anemometer channels and one temperature channel, order the following: (1) IFA 300, (2) 183150, and (1) 183145. **Note: digitizer and probes must be purchased separately**

## Model 183145 Temperature Module

This circuit supplies the sensing current and signal conditioning needed to use a fine wire sensor as a resistance thermometer. While the built-in thermocouple circuit is adequate to compensate for normal variations in tunnel temperatures, if higher frequency temperature variations are present, a faster sensor is required. It is for such applications that the Model 183145 is used.

The frequency attainable depends directly on the diameter of the sensor selected. For example, the 3 dB point for a 4 $\mu$ m tungsten wire is about 700 Hz at 10 m/s. The maximum frequency increases with higher velocities or smaller diameter wires.

A wide range of computer-controlled current settings, low pass filters, gain settings, and offsets are provided to optimize the system for the sensor and the flow conditions. The temperature module plugs into a standard anemometer slot in the IFA 300.



## Specifications

<b>Low pass filters (Hz)</b>	10, 20, 50, 100, 200, 500, 1K, 2K, 5K, 10K at -60dB per decade
<b>High pass filters (Hz)</b>	None, 0.1, 1, 10 at -60dB per decade
<b>Offset</b>	1 to 10 volts in 10 mv steps
<b>Gain</b>	1 to 1000
<b>Output (analog)</b>	-5 to +5 V

## To Order

<b>Specify</b>	<b>183145</b>	<b>Temperature Module w/Signal Conditioner</b> —Used for fast response temperature measurement.
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# Analog-to-Digital Converters

## Models ADCWIN-16 and ADCWIN-4

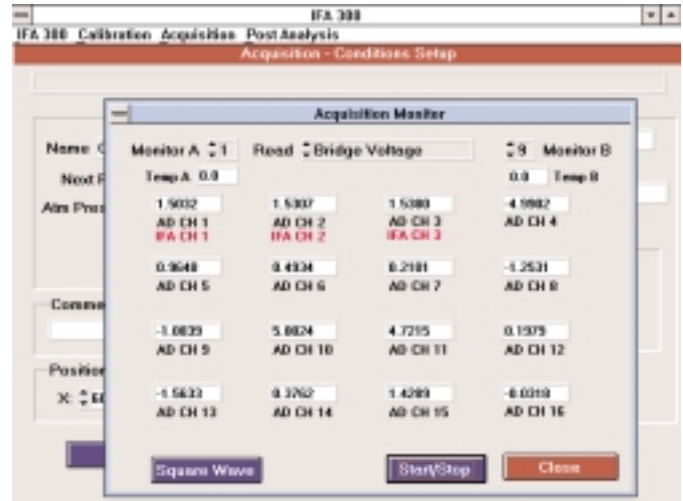
- High digitization rate
- Operates with 486 or higher computers
- True simultaneous sample and hold
- Integrated with THERMALPRO software
- Four- and sixteen-channel versions available

The ADCWIN-16 and ADCWIN-4 Analog to Digital (A/D) Converters match the capabilities of the IFA 300 anemometer, ensuring that information acquired by the anemometer is not lost in the digitization process. They are ideally suited for the specialized requirements of thermal anemometer signals. To make use of all the information in the analog anemometer output signal, they digitize the signal at a rate that ensures that no frequency information is lost or aliased. They also digitize the signal with sufficient resolution to detect small fluctuations in velocity and they simultaneously sample several anemometer signals in order to calculate valid crosscorrelation statistics.

### ADCWIN-16

This digitizer offers the capability for simultaneous sampling of up to sixteen individual anemometer signals, the maximum number allowed in the IFA 300. The throughput rate of the card is one megasample per second for four or more channels (250 kilosamples per channel for four channels). One channel can be sampled at 714 kilosamples per second. Adding channels reduces the effective digitization rate for each channel. The card allows the user to select from a number of preset digitization rates. Large continuous data blocks can be written directly to high memory.

The ADCWIN-16 card features full 12-bit resolution, spanning a ten-volt input range. When used with the voltage offset and gain from the anemometer, this allows fluctuations in even the quietest flows to be measured accurately. The card is inserted into a 16-bit slot in your 486 or higher personal



computer. Drivers for the card are included with THERMALPRO software and all digitization rate control is performed through the software.

### ADCWIN-4

The ADCWIN-4 Analog-to-Digital Converter has the same operating characteristics and specifications as the ADCWIN-16 but offers only four input channels.

### ADCTRIG

In addition to the BNC connections to the anemometer modules, the ADCTRIG also provides an input for an external switch to trigger data acquisition.

### Specifications

<b>Computer connection</b>	Requires full-length 16-bit ISA (AT) slot
<b>Number of input channels</b>	16 (ADCWIN-16) or 4 (ADCWIN-4)
<b>Resolution</b>	12 bit, 1 in 4096
<b>Input range</b>	-5 to +5 V
<b>Sample rates per channel</b>	1 Hz to 200 kHz in a 1, 2, 5, 10 sequence; also 250, 294.1, 416.7, 500, 714.3 kHz
<b>Data throughput rate</b>	714.3 kHz (single channel); 833.4 kHz (2 channels); 882.3 kHz (3 channels); 1 MHz (4 or more channels)
<b>Accessories included</b>	One ribbon cable and adapter for BNC (coaxial) input board

### To Order

<b>Specify</b>	<b>ADCWIN-16</b>	12 bit A/D, 1 MHz throughput, 16 channels
	<b>ADCWIN-4</b>	12 bit A/D, 1 MHz throughput, 4 channels
	<b>ADCTRIG</b>	BNC input board with external trigger

**Note:** A/D converters are not included with IFA 300 systems. They must be ordered separately.

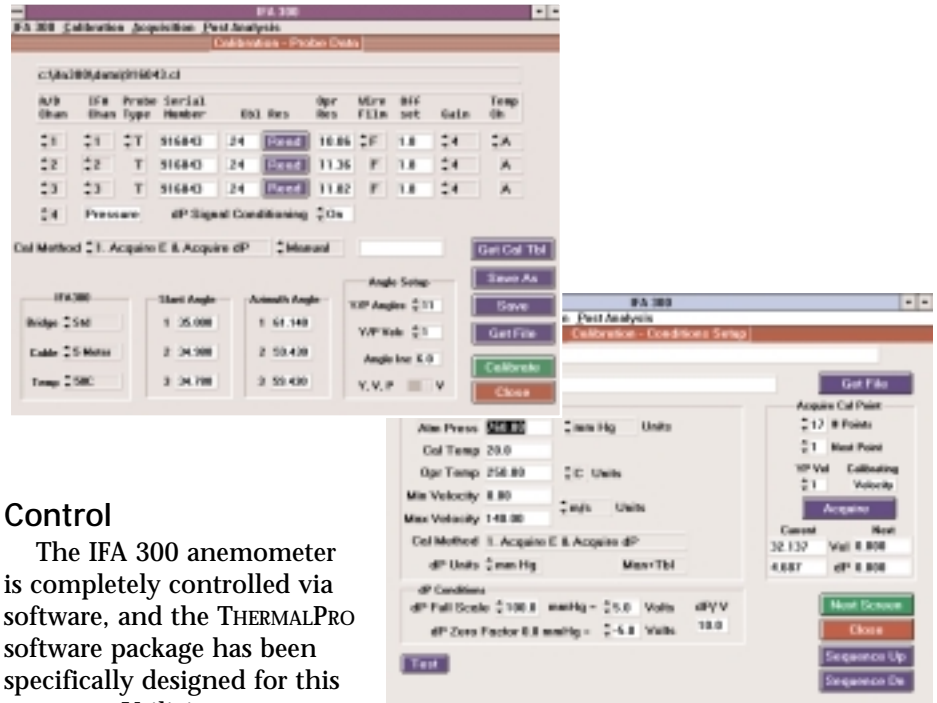
# THERMALPRO™ Software

- Comprehensive data acquisition and analysis for thermal anemometry
- Operates under Windows™
- Gives results in fluid mechanics terms
- Analyzes data from one-, two-, or three-sensor probes
- Controls TSI's Automated Calibrator
- Controls TSI traverses

THERMALPRO software gives you complete control over the operation of your IFA 300 Research Constant Temperature Anemometer. It also offers the ability to acquire and analyze data from other analog sources, including TSI's earlier 1050 and IFA 100 series anemometers and anemometer systems from other manufacturers.

Almost any application requirements you could have for the IFA 300 have been anticipated and provided for. You can use a single integrated package to handle all of your needs. THERMALPRO software operates under Windows, using the familiar LabWindows CVI™ development language.

THERMALPRO software functions can be divided into four discrete sections: control, calibration, acquisition, and analysis. Each is discussed here.



## Control

The IFA 300 anemometer is completely controlled via software, and the THERMALPRO software package has been specifically designed for this purpose. Utilizing a standard serial interface, THERMALPRO software and the IFA 300 communicate to set and monitor key operating parameters for up to sixteen anemometer channels. Easy-to-use set-up screens allow the user to set operating resistance, offset and gain, and high and low pass filters, and to choose film or wire sensors for each channel.

With the IFA 300's SMARTTUNE bridge optimization technology, bridge frequency response tuning using hardware or software is unnecessary. For other anemometers with less sophisticated controls, only limited parts of the control section are usable.

## Calibration

A major step in any thermal anemometry measurement involves calibrating the probe in the measurement environment over the velocity range of interest. This can be quite simple, as for single sensor probes used in air, or very complex, as when multiple sensor probes are used in a non-isotropic environment. Both manual and automated methods are used for sensor calibrations, which can be performed by

TSI or on-site by the user. THERMALPRO software allows the user complete flexibility in choosing how to obtain and input calibration data.

The preferred calibration method for many users is to calibrate their probes in the test environment immediately prior to the actual measurement. Traditionally, this has been difficult and time-consuming, especially with multiple-sensor probes. When THERMALPRO software is used with the IFA 300 and the Automated Calibrator, the entire process can be completed easily and quickly. Once instructed, the software automatically handles calibrator set-up, records velocity from the calibrator's pressure transducer, and changes the calibrator velocity. Even complex yaw and pitch calibrations for two- and three-component probes require minimal operator interaction. Provisions are also made for users to enter data manually or in a partially automated mode. If you have TSI perform the calibration, the calibration data is provided on a diskette, and easily integrated with the THERMALPRO software.

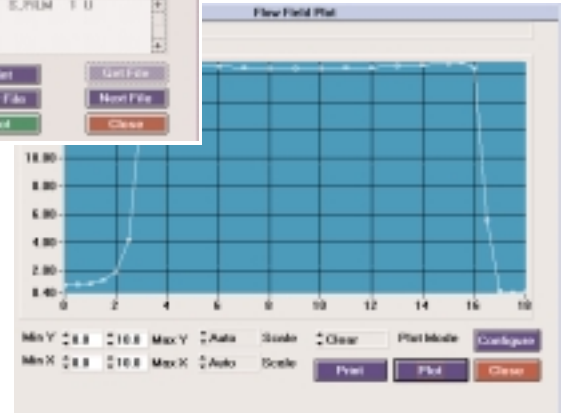
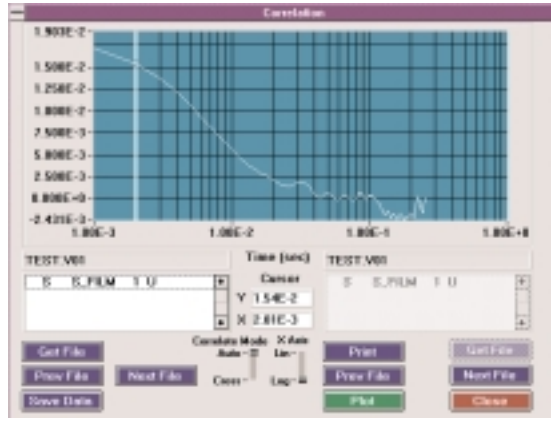
## Data Acquisition

Acquisition of analog data from the IFA 300 is handled by an A/D converter, such as the ADCWIN-4 or ADCWIN-16, described earlier. THERMALPRO software gives you full control over the digitizing rate and other key operating parameters for these cards, and their drivers are integrated into the software.

Data acquisition also allows collecting supplementary data such as pressure, temperature, and location. Temperature and pressure transducers can be accommodated by acquiring data through the A/D converter and using the calibration function to interpret the data. Sensor position can be input manually or by using a TSI computer-controlled traverse, where THERMALPRO software directs probe movement according to a customer-created matrix. In either case, probe location, along with other key measurement parameters, are recorded in the file header for later use in plotting data.

## Data Analysis

The section of greatest interest to most users is data analysis. The ability of the software to display the data in meaningful terms is of interest. But more important, it is here that interpretation of the input data takes place and key analysis algorithms are implemented. TSI has spent considerable effort to ensure that THERMALPRO software gives com-



plete answers in fluid mechanics terms. All key flow parameters can be shown, in units of measure you select, with near real-time graphical displays of the velocity time-history and probability distribution. Mean velocity and turbulence intensity are also displayed immediately and all data can be saved for future analysis.

Post-processing gives complete statistics, including mean velocity, turbulence intensity, standard deviation, skewness, flatness, and normal stress for one-, two-, and three-component probes, and shear stress, correlation coefficient and flow direction angle for two- and three-component probes. In addition, power spectrum, autocorrelation, and crosscorrelation can be calculated and displayed.

The key algorithm used for three sensor probe analysis is based on work done by Fingerson\* at TSI, with further refinement by Lekakis\*\* and Walter.<sup>†</sup> These equations represent the latest refinements in deriving velocity from complex three-sensor probe geometries. Combined with the software data handling capabilities, even the most difficult analysis tasks become routine. All results can be stored in ASCII text files for easy additional analysis or plotting using third-party software.

## Specifications

### Functions controlled

### Number of channels

### Minimum computer requirements

All anemometer operating functions, data collection and analysis

Up to 16

PC-compatible 486 computer or higher with AT bus; 12 MB RAM; one serial port (in addition to mouse port); Microsoft™ mouse or equivalent; available 16-bit ISA (AT) slot (for A/D board); math co-processor; VGA graphics; DOS 6 or higher; MS Windows 3.1 or Windows for Workgroups 3.11

### External signals

External analog signals such as pressure and temperature can be acquired and analyzed

## To Order

### Specify THERMALPRO Software

Thermal Anemometry Data Acquisition and Analysis Software for Windows

**Note:** One copy of THERMALPRO software is included with each IFA 300. Contact TSI for advice regarding use of THERMALPRO software with other anemometer systems.

\*Fingerson LM (1968) Practical extensions of anemometer techniques. *Advances in Hot-Wire Anemometry*: 203-218

\*\*Lekakis IC; Adrian RJ; Jones BJ (1989) Measurement of velocity vectors with orthogonal and nonorthogonal triple-sensor probes. *Experiments in Fluids* 7, 221-240

<sup>†</sup>Walter J (1995) Ph.D. Thesis, University of Iowa Hydraulics Laboratory