FLUID MECHANICS

Thermal Anemometry

IFA 300

Constant Temperature Anemometer System

Operation Manual

P/N 1990746, Revision D
December 2010

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IFA 300

Constant Temperature
Anemometer System

Operation Manual

CE

Manual History

The following is a manual history of the IFA 300 Constant Temperature Anemometer System (Part Number 1990746).

Revision	Date
Preliminary	December 1994
Preliminary 1	June 1995
Preliminary 2	November 1995
Preliminary 3	January 1996
Final	July 1996
A	May 1997
	July 2000
B	August 2000
C	November 2007
D	December 2010

- In preliminary 1 a caution statement was added to Chapter 3.
- In preliminary 2 minor formatting and revisions were made to entire manual.
- In preliminary 3 “EC Declaration of Conformity” was added to the front of the manual.
- In the final version, the entire manual was revised and TSI’s “Limitation of Warranty and Liability” on page iii was updated.
- In revision A, several updates were made throughout the manual to comply with the EC Safety Directives as well as extensive changes to the appendixes.
- In July 2000, some minor grammatical corrections were made.
- In revision B, TSI’s Limitation of Warranty and Liability was updated.
- In revision C, the entire manual was reformatted and Chapters 5 and 7 were updated and Appendixes were added.
- In revision D, In Chapter 5, Windows 7 32-bit operating system and instructions for installing PowerDAQ for Windows 7 were added. Corrected part number for ThermalPro software in packing list. Added Windows 7 operating system where applicable.

Warranty

Part Number 1990746 / Revision D / December 2010

Address TSI Incorporated / 500 Cardigan Road / Shoreview, MN 55126 / USA

Phone No. 1-800-874-2811 (USA) or (651) 490-2811

Fax No. (651) 490-3824

E-mail Address fluid@tsi.com

Limitation of Warranty and Liability
(effective July 2000)

Seller warrants the goods sold hereunder, under normal use and service as described in the operator's manual, shall be free from defects in workmanship and material for (12) months, or the length of time specified in the operator's manual, from the date of shipment to the customer. This warranty period is inclusive of any statutory warranty. This limited warranty is subject to the following exclusions:

a. Hot-wire or hot-film sensors used with research anemometers, and certain other components when indicated in specifications, are warranted for 90 days from the date of shipment.

b. Parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment.

c. Seller does not provide any warranty on finished goods manufactured by others or on any fuses, batteries or other consumable materials. Only the original manufacturer's warranty applies.

d. Unless specifically authorized in a separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, goods which are incorporated into other products or equipment, or which are modified by any person other than Seller.

The foregoing is IN LIEU OF all other warranties and is subject to the LIMITATIONS stated herein. **NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE**.

TO THE EXTENT PERMITTED BY LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF SELLER'S LIABILITY FOR ANY AND ALL LOSSES, INJURIES, OR DAMAGES CONCERNING THE GOODS (INCLUDING CLAIMS BASED ON CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) SHALL BE THE RETURN OF GOODS TO SELLER AND THE REFUND OF THE PURCHASE PRICE, OR, AT THE OPTION OF SELLER, THE REPAIR OR REPLACEMENT OF THE GOODS. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY SPECIAL, CONSEQUENTIAL OR INCIDENTAL DAMAGES. SELLER SHALL NOT BE RESPONSIBLE FOR INSTALLATION, DISMANTLING OR REINSTALLATION COSTS OR CHARGES. No Action, regardless of form, may be brought against Seller more than 12 months after a cause of action has accrued. The goods returned under warranty to Seller's factory shall be at Buyer's risk of loss, and will be returned, if at all, at Seller's risk of loss.

Buyer and all users are deemed to have accepted this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of Seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended, modified or its terms waived, except by writing signed by an Officer of Seller.

Service Policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI Customer Service at 1-800-874-2811 (USA) or (651) 490-2811.

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TSI Incorporated

500 Cardigan Road, Shoreview, MN 55126 USA
tel 651 490 2811 **toll free** 800 874 2811 **fax** 651 490 3824 **web** www.tsi.com

EC Declaration of Conformity

This instrument meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility and Directive 73/23/EEC for Electrical equipment designed for use within certain voltage limits. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 50082-1:1992
EN 50081-1:1992
EN 61010-1:1993

Contents

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About This Manual

Purpose

This is an instruction manual for the operation and handling of the IFA 300 Constant Current Anemometer System.

Manufacturer's Declaration of Conformity

TSI Incorporated hereby certifies that, to the best of its knowledge and belief,

- The instrument documented in this manual meets the essential requirements and is in conformity with the relevant EC Directive(s)
- The CE Marking has been affixed on the instrument

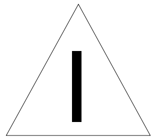
Safety Labels

This section acquaints you with the advisory and identification labels on the instrument and used in this manual to reinforce the safety features built into the design of the instrument.

Caution

Caution
Caution means ***be careful***. It means if you do not follow the procedures prescribed in this manual you may do something that might result in equipment damage, or you might have to take something apart and start over again. It also indicates that important information about the operation and maintenance of this instrument is included.

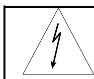
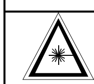
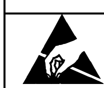
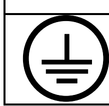
Warning



W A R N I N G
Warning means that unsafe use of the instrument could result in serious injury to you or cause irrevocable damage to the instrument. Follow the procedures prescribed in this manual to use the instrument safely.

Caution or Warning Symbols

The following symbols may accompany cautions and warnings to indicate the nature and consequences of hazards:

	Warns you that uninsulated voltage within the instrument may have sufficient magnitude to cause electric shock. Therefore, it is dangerous to make any contact with any part inside the instrument.
	Warns you that the instrument contains a laser and that important information about its safe operation and maintenance is included. Therefore, you should read the manual carefully to avoid any exposure to hazardous laser radiation.
	Warns you that the instrument is susceptible to electro-static dissipation (ESD) and ESD protection procedures should be followed to avoid damage.
	Indicates the connector is connected to earth ground and cabinet ground.

Getting Help

To report damaged or missing parts, for service information or technical or application questions and to ship equipment for repairs, contact:

TSI Incorporated
500 Cardigan Road
Shoreview, MN 55126 USA

Telephone:	1-800-874-2811 (USA)
	(651) 490-2811
Fax:	(651) 490-3824
E-mail Address:	fluid@tsi.com

Submitting Comments

TSI values your comments and suggestions on this manual. Please use the comment sheet, on the last page of this manual, to send us your opinion on the manual's usability, to suggest specific improvements, or to report any technical errors.

If the comment sheet has already been used, mail or fax your comments on another sheet of paper to:

TSI Incorporated
500 Cardigan Road
Shoreview, MN 55126
Fax: (651) 490-3824
E-mail Address: fluid@tsi.com

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PART 1

Hardware

This part gives information on the IFA 300 Constant Temperature Anemometer System hardware. It is divided into the following sections:

- **Chapter 1: System Overview**
  Gives an overview of the IFA 300 System.

- **Chapter 2: Unpacking and Checking**
  Gives the packing list for the IFA 300 System and discusses what you should do if the system was damaged in transit or if parts are missing.

- **Chapter 3: Installing the IFA 300 System**
  Gives information on how to install and set up the IFA 300 System.

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CHAPTER 1

System Overview

This chapter gives you an overview of the IFA 300 Constant Temperature Anemometer System. It discusses the components of the system and briefly explains its operation and applications.

Description

The System is a fully-integrated, thermal anemometer-based system that measures mean and fluctuating velocity components in air, water, and other fluids. It also measures turbulence and makes localized temperature measurements.

System Components

As shown in Figure 1-1, the IFA 300 Constant Temperature System includes:

- ❑ Anemometer (1 to 16 channels)
- ❑ Thermocouple for temperature measurement
- ❑ Data acquisition and analysis software and an A/D converter board installed in a user-supplied computer.

The following components, ordered separately, complete the system:

- ❑ Probes with sensors
- ❑ Probe supports

IFA 300 Anemometer

The IFA 300 System is a constant temperature anemometer, expandable to 16 channels. It provides up to 300 kHz frequency response, depending on the sensor used. Each module is designed with a built-in thermocouple circuit for measuring fluid temperature and for making temperature corrections. All operations, including setup, calibration, and data acquisition are software-controlled via an RS-232 interface.

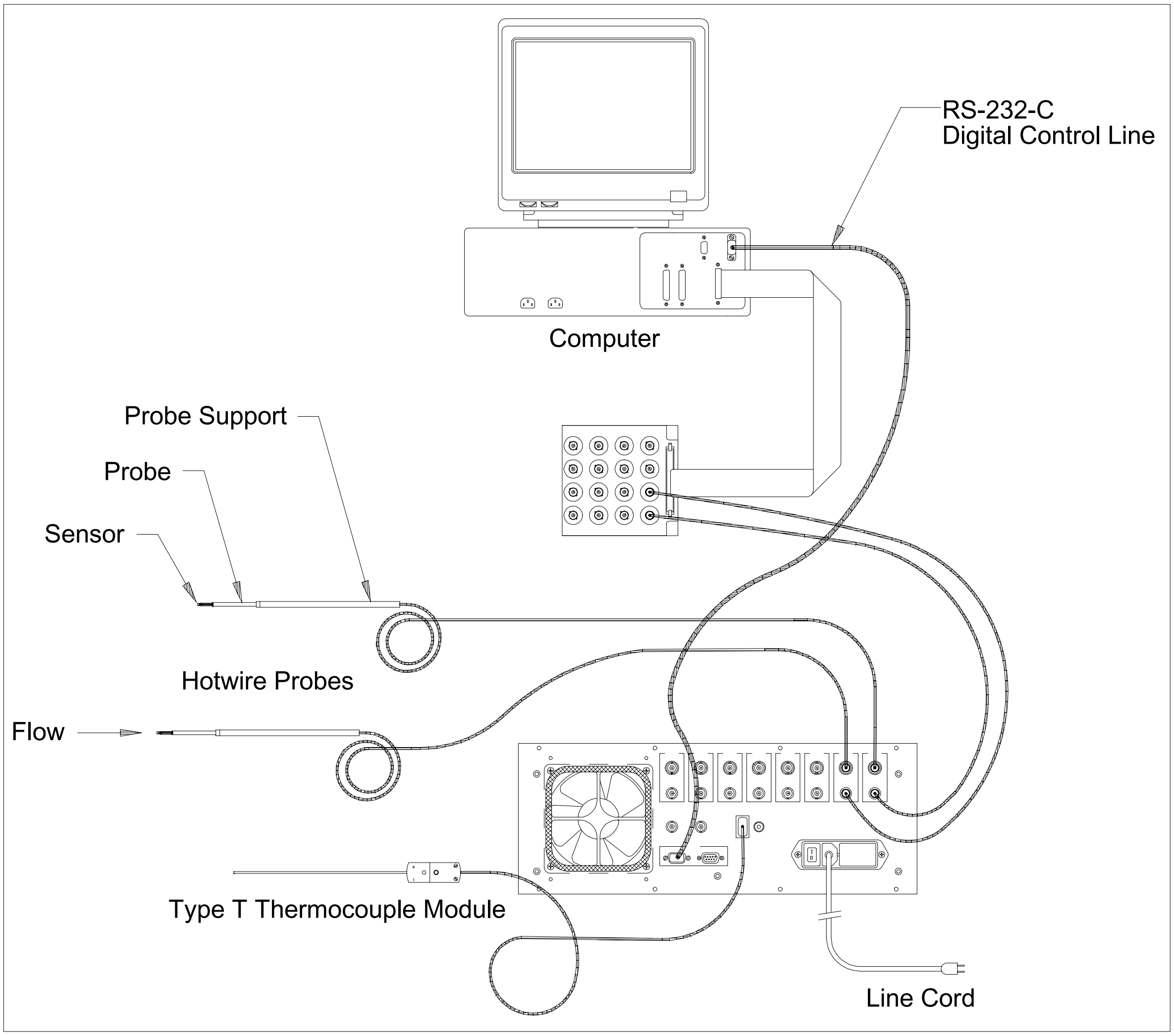

Figure 1-1
Overview of the IFA 300 Constant Temperature Anemometer System

IFA 300 Data Acquisition and Analysis Software and A/D Converter Board

The data acquisition and analysis software runs as a stand-alone program under Microsoft® Windows XP® and Windows® 7 operating systems (32-bit only). The software selects the channel, measures cable and sensor resistances, sets sensor operate resistance, measures fluid temperature, switches between standby and run modes, and sets signal conditioner offset and gain.

®Microsoft and Windows XP are trademarks of the Microsoft Corporation.

The A/D converter board plugs directly into your Windows XP/7 compatible computer. The software controls the A/D converter, selecting the sampling rate and the sample block size and performs all the calibration, acquisition, and analysis functions.

How the System Works

A constant-temperature anemometer is a bridge and amplifier circuit that controls a tiny wire or film sensor at constant temperature. As a fluid flow passes over the heated sensor, the amplifier senses the bridge off-balance and adjusts the voltage to the top of the bridge, keeping the bridge in balance. The voltage on top of the bridge can then be related to the velocity of the flow. The bridge voltage is sensitive to temperature as well as velocity and so the built-in thermocouple circuit can be attached to a thermocouple that can measure the fluid temperature. This temperature reading can then be used by the software to correct the results to minimize the effect of temperature.

Each IFA 300 cabinet is a constant temperature anemometer, configured for one to eight channels of anemometry, with built-in signal conditioning and with a thermocouple circuit for measuring fluid temperature. Two cabinets may be daisy-chained to form a 16-channel system.

Each IFA 300 unit contains one microprocessor system board. This board controls all functions and settings of the anemometer and signal conditioner via an address and data bus. An RS-232-C interface is used to send commands from the computer to the microprocessor. On the microprocessor board is a thermocouple circuit, which can be used to measure temperature. A 12-bit analog-to-digital converter on the microprocessor board can be used to send the temperature data through the RS-232-C interface, or the analog signal output, on the back panel, can be used to directly input the data to the analog-to-digital converter board installed in the computer.

A BNC connector on the back panel, labeled “Selected Bridge,” can be used to observe the bridge voltage of a single channel. However, this output should be used for observation purposes only; for collecting data use the appropriate channel BNC output connector.

Each channel of anemometry contains a single bridge circuit and signal conditioner. The bridge circuit includes the SMARTTUNE™ technology that automatically optimizes the frequency response and prevents oscillations. The back panel includes an input BNC connector for each channel labeled “Channel x Probe” (for x = 1 to 8), and another BNC connector labeled “Output Voltage” for the voltage after the signal conditioner. The front panel LEDs indicate configuration and status of each sensor. Refer to Chapter 3 for details on the back and front panel connectors and indicators.

The block diagram (Figure 1-2) shows the basic circuit of the constant temperature bridge. As in most constant temperature anemometer systems, a Wheatstone bridge configuration is used to maintain the sensor at a given operating resistance. In most applications, the standard bridge with a 10Ω resistor above the sensor is used. For higher power applications using custom probes, the standard bridge with 2Ω above the sensor can be used.

Since the IFA 300 bridge uses the SMARTTUNE™ technology, the bridge does not require tuning for frequency response regardless of the type of sensor used or the length of the cable. SMARTTUNE constantly monitors the bridge voltage and feeds a signal back to the amplifier circuit, maintaining the frequency response based on the operating temperature and sensor type. It also prevents oscillations which may damage the sensor. To check frequency response, a square wave test is available.

SMARTTUNE is a trademark of TSI Incorporated.

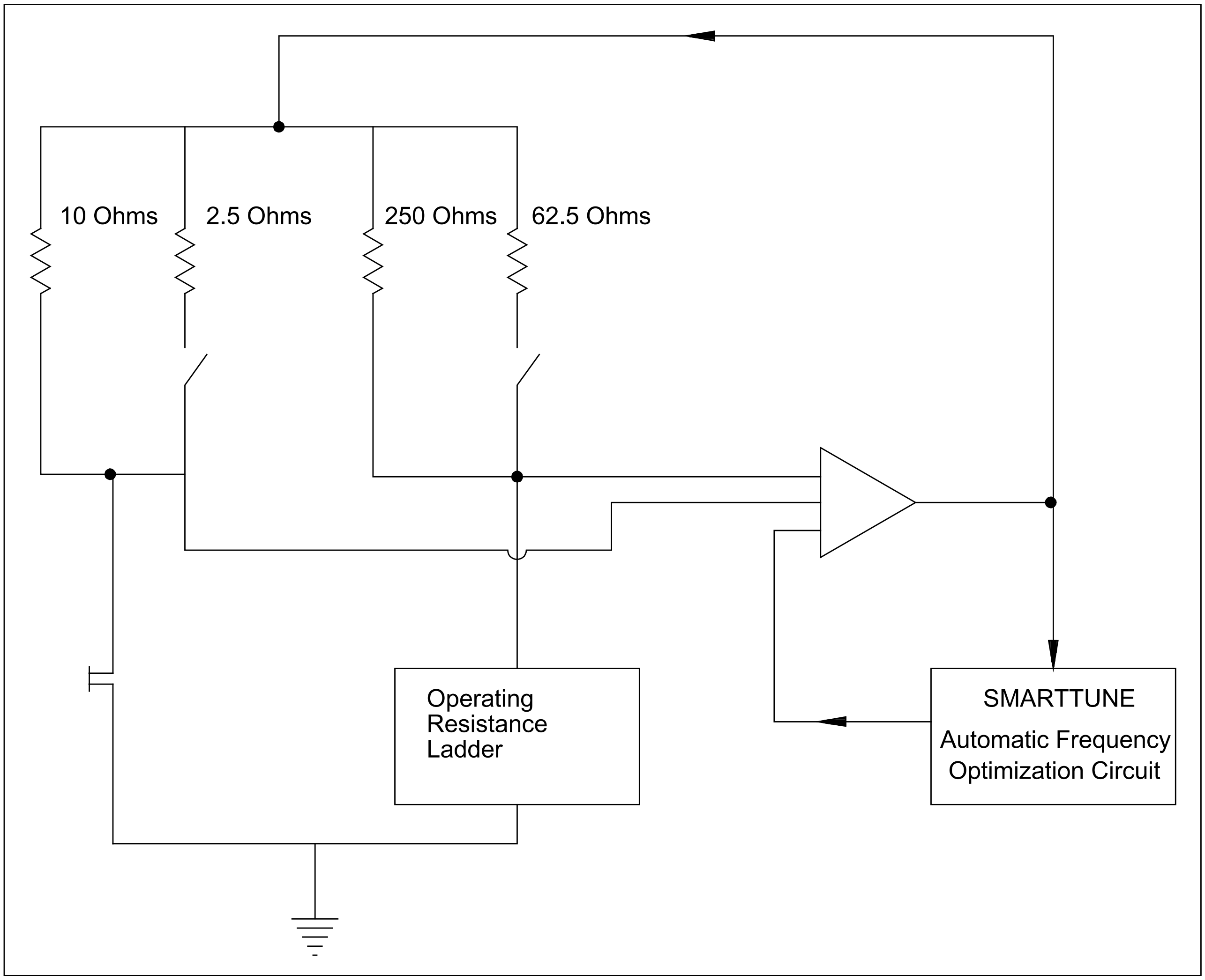

Figure 1-2
Basic Circuit of the Constant Temperature Bridge

The signal conditioners (Figure 1-3) in the IFA 300 provide settings for filtering and increasing the bridge voltage gain to use the entire ±5V signal range. High-pass filters available are .1 Hz, 1 Hz, and 10 Hz. These filters are used when only velocity fluctuation measurements are needed since mean voltage information and thus actual velocity is removed from the signal. Offset settings available are 0 to 10 V in 10 mV steps. Offset and gain can be used to utilize entire ±5V signal range. Offset must be used when actual bridge voltage is greater than 5 volts. Gains available are 1 to 1000. Low-pass filters allow the removal of high frequency signals which are out of the range of interest and to eliminate aliasing. Thirteen low-pass filter settings are available from 10 Hz to 1 MHz.

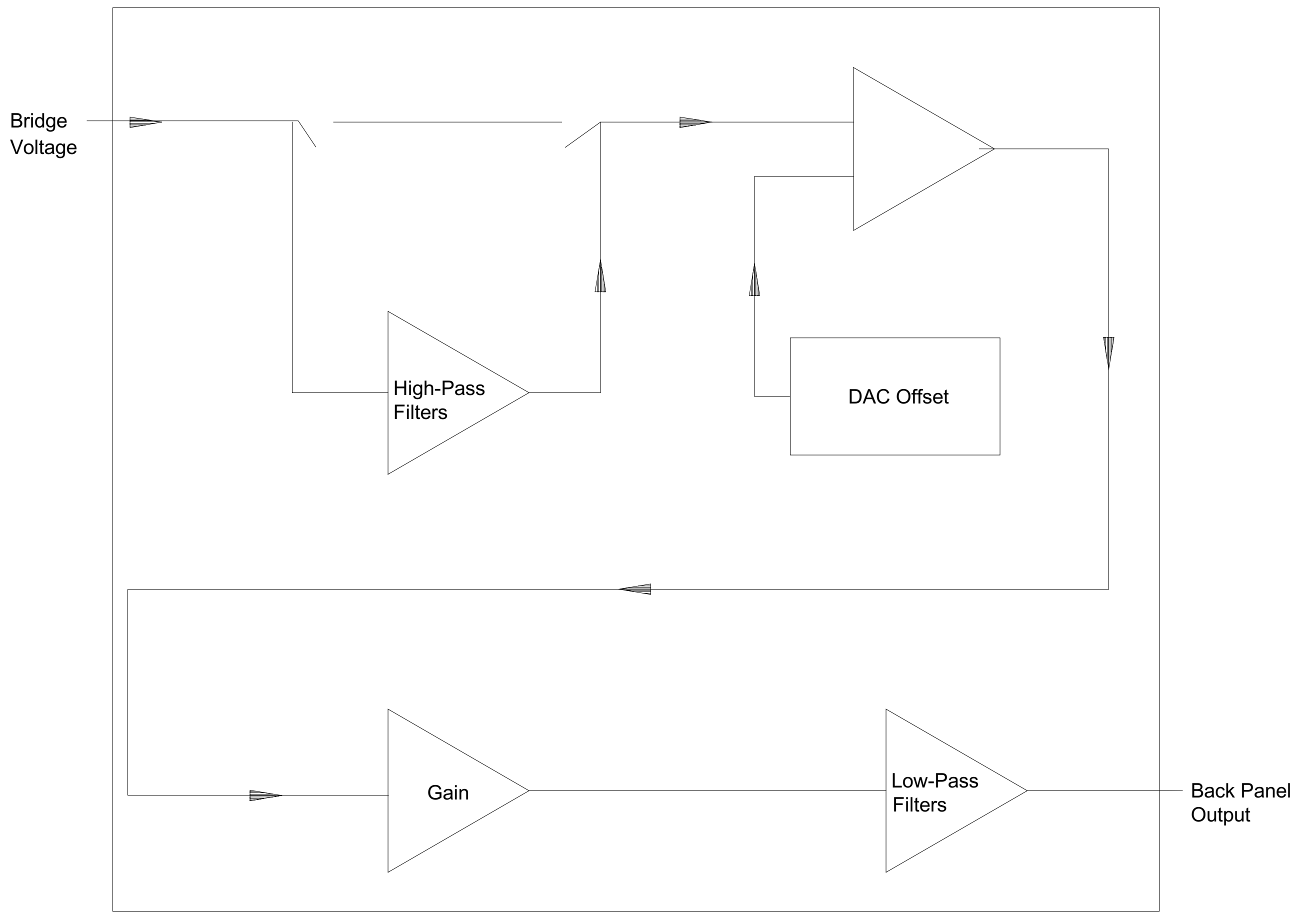

Figure 1-3
Signal Conditioner Circuit

Figure 1-4 gives a functional overview of the IFA 300 Constant Temperature Anemometer.

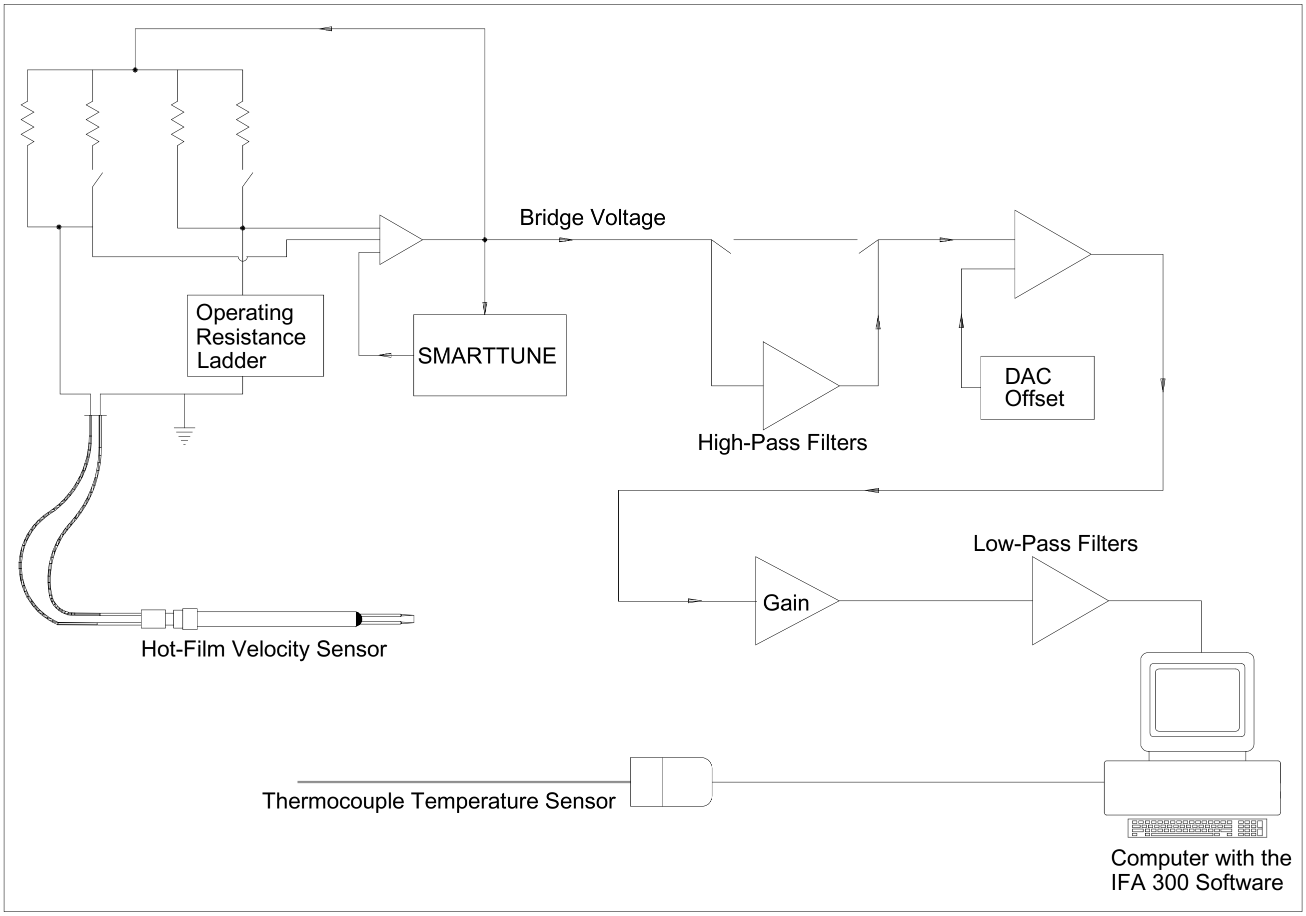

Figure 1-4
Functional Overview of the IFA 300 System

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CHAPTER 2

Unpacking and Checking

This chapter gives the packing list for the Model IFA 300 Constant Temperature Anemometer System. It also discusses what you should do if the system was damaged in transit or if parts are missing.

Unpacking

The IFA 300 System is shipped in more than one box. Carefully unpack the case, making sure the components arrived in good condition. If there are signs of damage, contact the nearest TSI sales office or representative at TSI. See "Service Policy" on page iii, at the beginning of this manual, for further details.

Checking the Packing List

Compare all the components you received with those listed in Table 2-1. If any parts are missing, contact TSI. See, "Getting Help" in the *About This Manual* section for the address and phone number.

Table 2-1
Packing List for the IFA 300 Constant Temperature Anemometer System

Qty	Description	Part Number
1	IFA 300 System with one channel, includes:	183101
	1 IFA 300 cabinet with microprocessor	183100
	1 IFA 300 anemometer channel	183151
	1 IFA 300 accessory kit including:	193181
	3 2-meter coaxial cable	101144
	1 12-ft, 9-pin RS-232-C cable	1303236
	1 Model 10114-5M output cable assembly	101146
	1 Model 1340-cable assembly	134000
	1 Power supply cord	1303053
	1 Subminiature-type T thermocouple probe	134100
	1 Single channel shorting probe	121000
	1 Dual-channel shorting probe	124000
	1 BNC cap connector with chain	1302186
	1 BNC T-connector	1302562
	1 IFA 300 THERMALPRO™ software	THERPRO32U
	1 Operation manual	1990746
1	4-channel A/D converter board ADCPCI-4	962112
1	Shielded ribbon cable	962114
1	4-channel connector board	962115
Optional:		
1	8-channel A/D converter board ADCPCI-8	962113
1	Shielded ribbon cable	962114
1	8-channel connector board	962116
Each IFA 300 add-on channel includes:		183150
1	IFA 300 anemometer channel	183151
1	5-meter probe cable	101146
1	2-meter output cable	101144

CHAPTER 3

Installing the IFA 300 System

This chapter gives information on how to install and set up the IFA 300 System.

To set up the system you need to perform the following steps:

Step 1. Install and configure the Model ADCPCI-4 or the Model ADCPCI-8 A/D Converter Board in the computer

Step 2. Install the connector board and use it to connect the signal cables from the IFA 300 to the A/D converter

Step 3. Connect the probe(s)

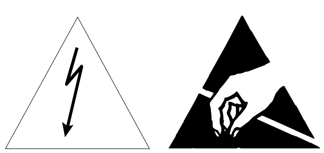
Step 4. Connect the thermocouple(s)

Step 1: Installing the A/D Converter Board

Installing the converter board involves the following substeps:

A. Unpacking the board from the anti-static container

B. Installing the board in the computer



Caution
Do ***not*** install or remove the boards with the computer power turned on. Doing so would expose you to electrical shock. Also, to avoid any damage to the computer, be sure to follow the ESD protection procedures.

A: Unpacking the Board

The A/D converter contains integrated circuits that can be damaged by static electricity. TSI recommends that you follow electrostatic discharge (ESD) protection procedures when handling these interface boards:

- ❑ Leave the board in the static-shielding container until you have taken the anti-static precautionary measures described below and are ready to actually install the board in your computer.
- ❑ Wear a grounded, static-discharging wrist strap connected to the computer frame or other grounded work station.
- ❑ Handle the board by the edges only. Do *not* touch edge connectors or exposed circuitry.
- ❑ Use only a table top with a grounded static-dissipative surface.

Follow these steps to unpack the board:

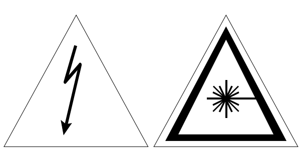
1. Remove the A/D converter board from the outer shipping carton and place it on a table top with a grounded static-dissipative surface.

2. Wearing a grounded, static-discharging wrist strap, remove the board from the anti-static wrap.

3. Inspect the board for signs of damage. If there are signs of damage, place the board back in the anti-static bag and ship it to TSI.

B: Installing the A/D Converter Boards

To install the A/D Converter Board, follow these steps:



W A R N I N G
Do *not* install or remove the board with the computer power turned on. Doing so will expose you to electrical shock. Also, to avoid any damage to the computer, be sure to follow the ESD protection procedures described earlier.

1. Make sure the computer and all the attached equipment are turned off.

2. Following the directions given in your computer's operations manual, remove the computer's cover.

3. Select any available expansion slot that can accommodate a full-length board. Locate the screw behind the slot you have selected and remove the screw holding the metal adapter plate. Save the screw for later use.

4. With the appropriate ESD protection described earlier, apply even pressure to the board and slide the board's edge connector into its socket. Make sure the board's metal tab fits securely into the slot at the back of the computer's chassis.

5. Secure the board's metal support bracket to the computer's chassis with the screw retained in step 3.

6. Replace the top cover on the computer and tighten the retaining screws.

7. If installing a second board, connect the Host board to the Worker board by the ribbon cable as shown in Figure 3-1. Of course, a second connector board must also be used.

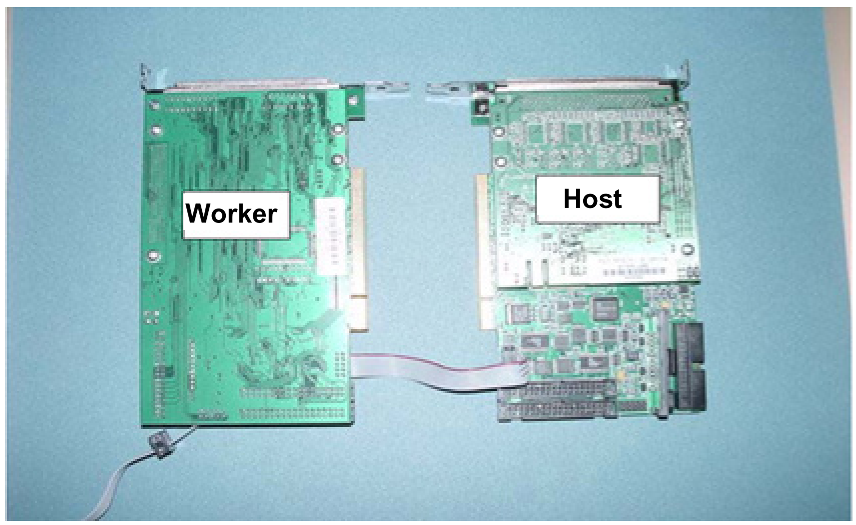


Figure 3-1
Connecting the Host Board to the Worker Board

Step 2: Installing the Connector Board

This step involves the following substeps:

A. Installing the connector board

B. Making all the appropriate connections

Note: *The IFA 300 THERMALPRO software assumes that the RS-232-C cable is connected to the Com1 serial port of your computer. If your setup differs, you need to indicate in the THERMALPRO Configuration screen which COM port the IFA 300 is connected to. See Part 2 of this manual for details on how to use the IFA 300 Installation program.*

Before proceeding with the installation, review Figure 3-2 to get acquainted with the connectors on the back panel of the IFA 300 Anemometer.

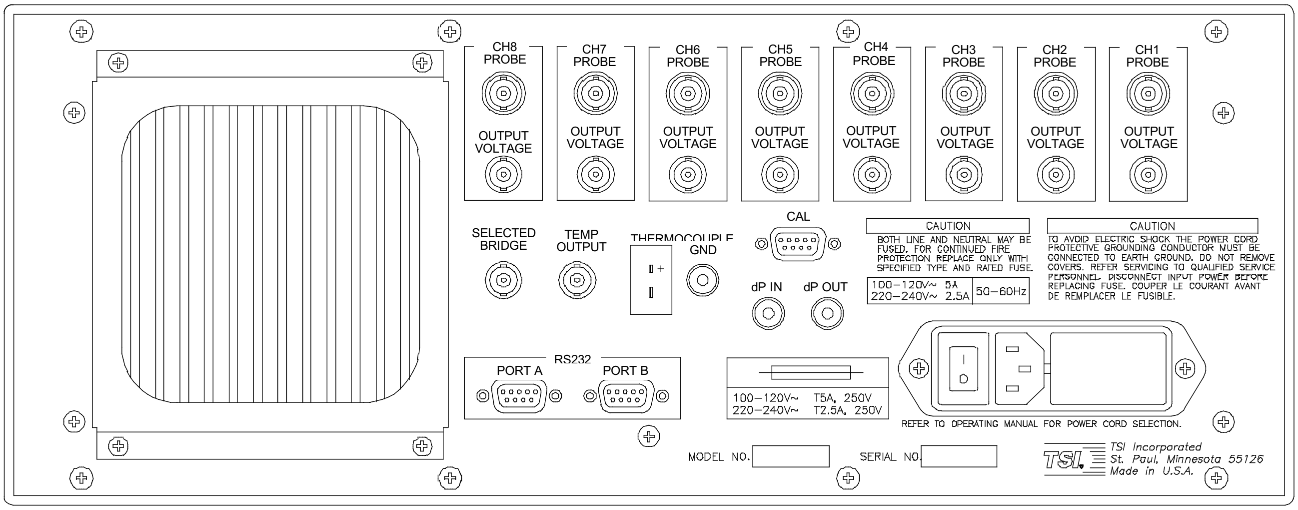


Figure 3-2
Back Panel of the IFA 300 Constant Temperature Anemometer

Installing the Connector Board and Connecting the Computer

The Connector Board (p/n 2615228) connects the IFA 300 Anemometer to the interface card in the computer using a ribbon cable.

The 8 Channel BNC Connector Board (2615228) is used with the 4 or 8 Channel PCI A/D Boards and is also used for internal or external triggering of the A/D Board.

Board Configuration

The 8 Channel BNC Connector Board (shown in Figure 3-3) does not have jumpers or switches that need to be set for internal or external triggering.

The two sets of jumpers on the BNC Connector Board will be used to add functionality in the future. These do not need to be used.

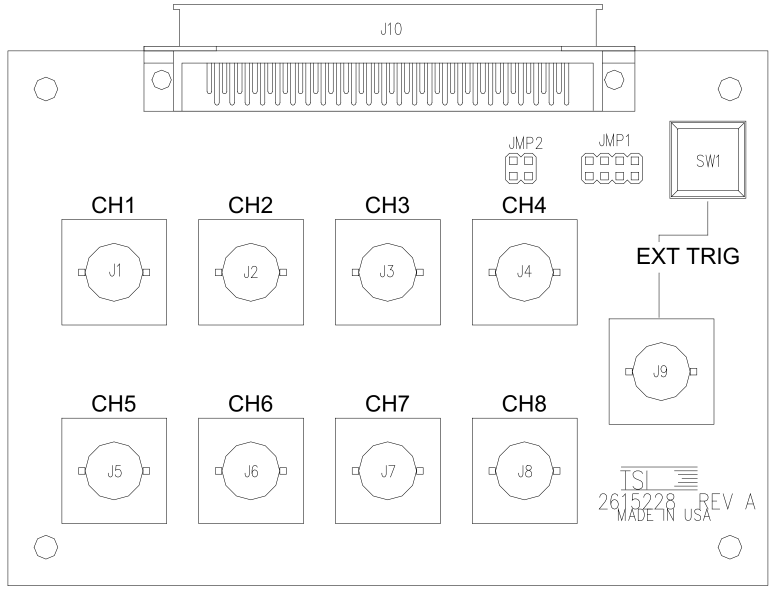


Figure 3-3
Sketch of BNC Connector Board (2615228) showing connectors for Probe Output Voltage Signals and External Triggering

Installing the Connector Board

The Connector Board comes with Velcro pads on the back. If you prefer, you can use the Velcro pads to adhere the Connector Board to one side of the IFA 300 or to the side of your computer. To do this:

1. Pull out the four Velcro pads from their mates on the back of the Connector Board.
2. Peel the protective backing from these pads. Stick the pads on the side of the IFA 300, taking care to place them on locations that match their mates.
3. Using the Velcro pads, adhere the Connector Board to the side of the IFA 300.

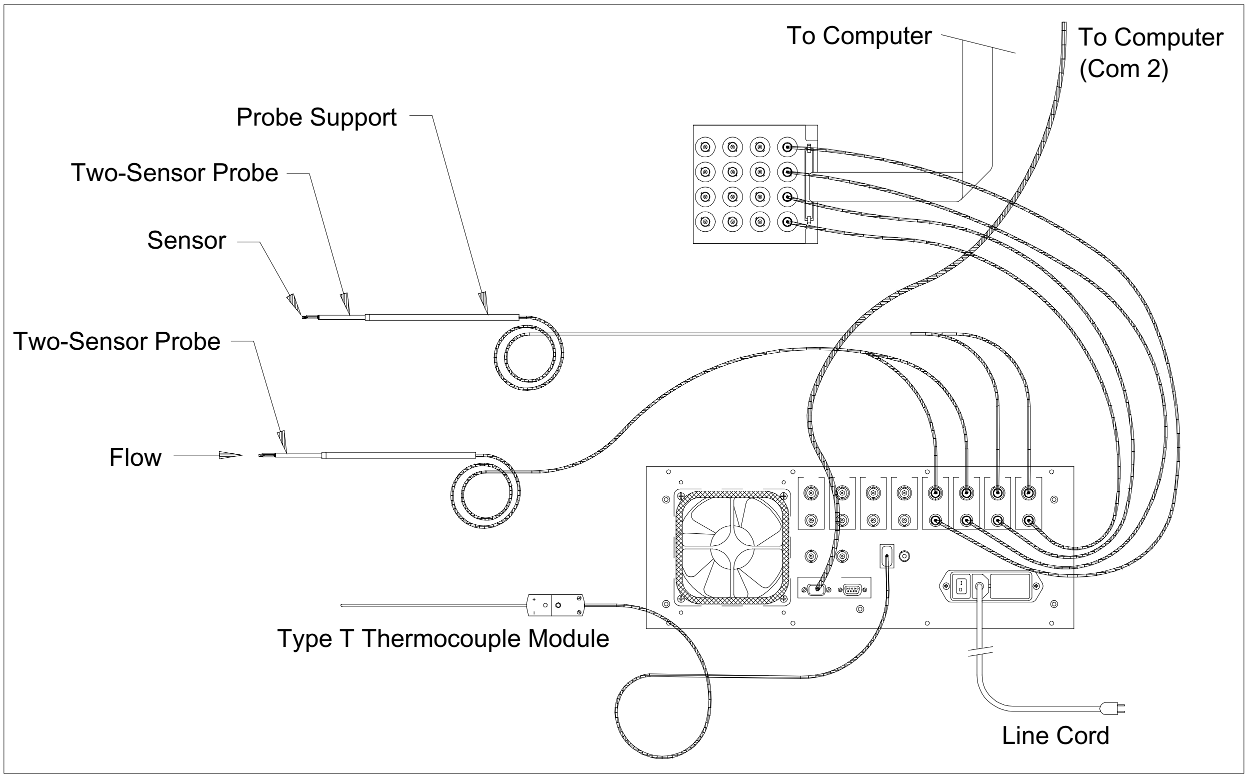


Figure 3-4
Connecting a Four-Channel Model IFA 300 System

Making the Connections

Refer to Figures 3-2 through 3-5 as you make the following connections.

Caution
Use only the 5-meter or the 30-meter cable supplied by TSI to connect the IFA 300 to the probe.

1. Connect the 50-pin/ribbon cable from **J1** (50-pin connector) on the connector board to the A/D converter board slot on the back of the computer.
2. Connect the 2-meter BNC/coaxial cable from **CH1** on connector board to **Channel 1 Output Voltage** on the back of the IFA 300.
3. Repeat step 2 for the number of channels that your system is configured for.

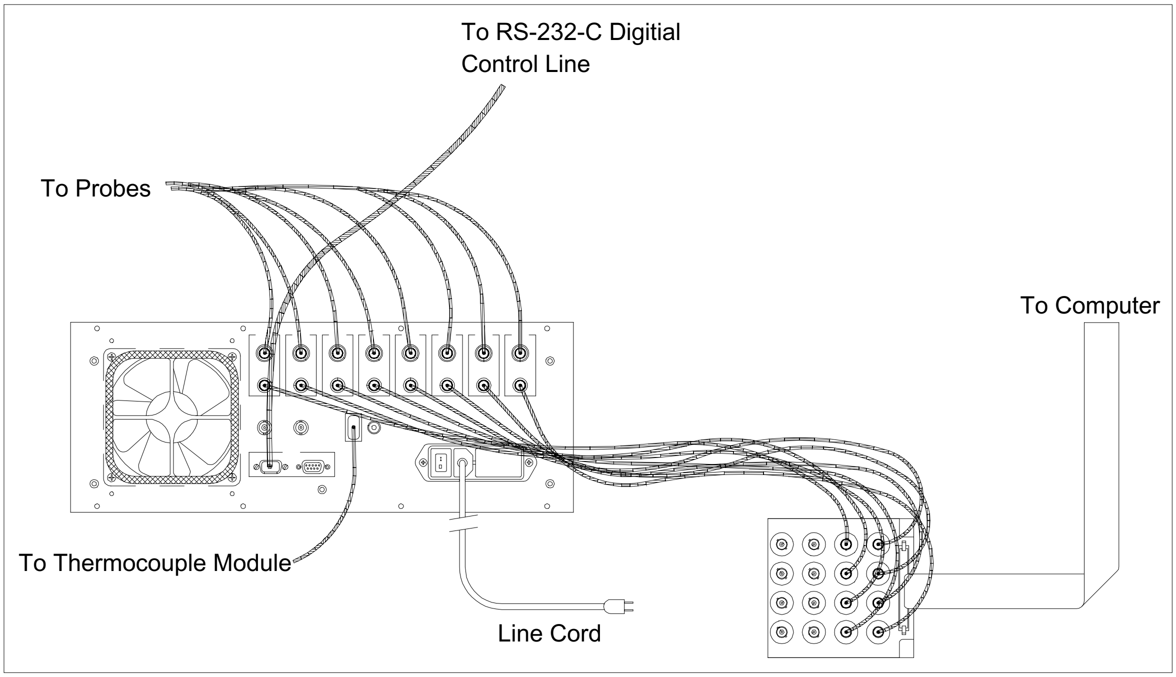


Figure 3-5
Connecting an Eight-Channel Model IFA 300 System

4. Connect the 4-meter, 9-pin RS-232-C cable from the serial port (Com2) on the back of the computer to **Port A** on the back of the IFA 300.

5. Connect the line cord to the appropriate power source.

Step 3: Connecting the Probe(s)

Depending on your application and your system configuration, use the 5-meter coaxial probe cables to attach the appropriate number of probes to the connectors labeled **Channel 1** through **8** on the back of the IFA 300 Anemometer.

Step 4: Connecting the Thermocouple

Depending on your application and your system configuration, attach the thermocouple cable to the connector labeled **Temp Probe** on the back of the IFA 300 Anemometer.

Next Step

Once all the hardware has been installed, the next step is to install the software. Refer to Part 2 of this manual for details on how to install and use the software.

PART 2
THERMALPRO™ Software

This part gives information on the IFA 300 THERMALPRO software. It is divided into the following sections:

- **Chapter 4: Overview of IFA 300 THERMALPRO Software**
  Briefly acquaints you with IFA 300's features and capabilities.

- **Chapter 5: Installing IFA 300 THERMALPRO Software**
  Shows you how to install the software and get started.

- **Chapter 6: Quick Guide to IFA 300 THERMALPRO Software**
  Gives an overview of the software to help you acquire data and measure velocity as quickly as possible.

- **Chapter 7: IFA 300 THERMALPRO Software Reference Guide**
  Gives detailed descriptions of each task you can perform.

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CHAPTER 4

Overview of IFA 300 THERMALPRO Software

This chapter gives you an overview of the IFA 300 THERMALPRO software.

Overview

The IFA 300 THERMALPRO™ software allows you to control the IFA 300 Constant Temperature Anemometer and the A/D converter board through an RS-232-C interface. You can use the software to

- Select the anemometer channels to be used
- Measure the resistance of a probe cable or sensor
- Set the sensor operating resistance
- Measure fluid temperature, in either Celsius or Fahrenheit units, using the built-in thermocouple circuit
- Switch between "standby" and "run" modes
- Set the "offset," "gain," and low pass filter values for the signal conditioner
- Select sampling rate and sample block size for the A/D converter
- Make corrections for fluid temperature drift and atmospheric pressure
- Use yaw coefficients for *x*-sensor analysis and yaw and pitch coefficients for triple-sensor analysis
- Measure velocity in meters/sec, feet/sec, or feet/minute
- Enter atmospheric pressure in mm Hg, in. Hg, in. H_2O, mm H_2O, or Pascals.
- Enter differential pressure in mmHg, in. Hg, or Pascals
- Enter probe position for plotting the data, in mm or inches.

Functions

Through the IFA 300 software you can calibrate probes, acquire data, and analyze the collected data.

Calibration

The calibration program allows you to:

- ❑ Calibrate single-sensor, *x*-sensor and triple-sensor probes easily.
- ❑ Store calibration information as a file on disk.
- ❑ Calibrate by acquiring analog signals from a differential pressure transducer, or by typing in reference velocity or pressure values.
- ❑ Verify calibration data on screen and create a polynomial curve fit.
- ❑ Use calibration files supplied on disks by TSI, with the probes (*optional*).

Acquisition

Using the acquisition program you can:

- ❑ Display each data batch immediately on screen as a time-history display and as a probability distribution (histogram) display.
- ❑ Display mean velocity, turbulence intensity and temperature immediately.
- ❑ Store data on disk for further analysis.

Post Analysis

The post analysis program of the IFA 300 software allows you to:

- ❑ Calculate and display complete statistical results for one-, two- and three-component probes. The program calculates the mean velocity, normal stress, standard deviation, turbulence intensity, skewness coefficient and flatness coefficient for single-sensor, *x*-sensor, and triple-sensor probes. In addition, it calculates shear stress, correlation coefficient and direction angle for *x*-sensor and triple-sensor probes.

- Display time history and histograms of stored data. Store time history information in an ASCII text file.
- Calculate and display power spectral density, auto-correlation, and cross-correlation.
- Write the statistical results for multiple statistics files to an ASCII text file and plot on screen velocity, statistics *vs* probe position. You can also use this file with spreadsheet or plotting programs to plot flow-fields.

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CHAPTER 5

Installing the IFA 300 THERMALPRO Software

This chapter specifies the hardware and software requirements to run the IFA 300 THERMALPRO software and tells you how to install it on your personal computer.

Installing the IFA 300 Software

IFA 300 software comes on a single CD. Before installing the software make sure you have the following hardware and software.

What You Need

- A Windows® XP/7 (32-bit only) computer.
- A minimum of 512 MB of RAM is recommended
- One available serial port for IFA 300 control and an additional serial port for traverse control
- One available PCI slot for each A/D converter board

Installing the Software

To install the IFA 300 software and the software for the A/D Converter Board (the PowerDAQ™ program) on your hard disk, perform the following steps:

1. Turn on your computer and allow it to boot.
2. Log into the Windows operating system.

Note: *It is important to install the PowerDAQ™ software before installing the IFA 300 software. The PowerDAQ software can be installed from the TSI THERMALPRO CD or from a UEI PowerDAQ CD.*

3. Insert the THERMALPRO software CD in CD drive. Click on **My Computer** on your desktop (or otherwise find the CD drive).

™PowerDAQ is a trademark of United Electronic Industries, Inc

a. Double-click on the CD drive and then double-click on the PowerDAQ Install folder.

b. **For Windows XP operating system users**:
Double-click **Windows XP** folder and then double-click on the install program called **PowerDAQ3_6_0.exe** to extract the software suite (this is version 3.6.0, but a later version is okay).

For Windows 7 operating system users:
Double-click **Windows 7** folder. Right-click **PowerDAQ3_7_0.exe**, select the "Run As Administrator" option, and run the installation.

c. Click **Next** to start the installation.

d. Click to accept license terms and click **Next**.

e. Click **Typical** to select the most common installation and then click **Install** and click **Finish** to exit.

f. A message will ask if you wish to restart your computer. You do not have to restart until after THERMALPRO is installed.

4. Return to the THERMALPRO CD and double-click the THERMALPRO Install folder and double-click the setup.exe program. The next screen shows the default directories. Click **Next** if you choose to accept these locations and then **Next** again. Click **Next** again and then **Finish** and restart. After the restart, you are ready to run the program.

5. If you are installing on a second computer that will not be used for data acquisition (but only for analysis, for example), you should still install the PowerDAQ software for THERMALPRO software to operate properly. In this case, after installation, go to the Configure screen (under the IFA 300 menu), and select **Select/None** under the Data Acq Brd selector. Also set the Time Out to 0.10 seconds after the IFA Comport selector. This allows the program to move from screen to screen more quickly without waiting for serial communications.

Display Options for IFA 300 Software

The following display options have proven to work with the IFA 300 THERMALPRO software:

800 x 600	This display will fill up the monitor screen.
1280 x 768 works well	Higher resolution is a personal preference.

The screen resolution can be changed by right-clicking on the desktop, selecting properties, then settings. Some options with large fonts will not work well.

Troubleshooting if the A/D Board is not Working

The PowerDAQ software includes a utility program called SimpleTest.exe that can be used to test the PowerDAQ A/D board. A typical installation will find this program in: C:\Program Files\UEI\PowerDAQ\Applications or from the Start Menu, select **Programs**, then **PowerDAQ**, then **Simple Test** and the utility's dialog box appears. Click the **Analog In** tab and the following panel appears.

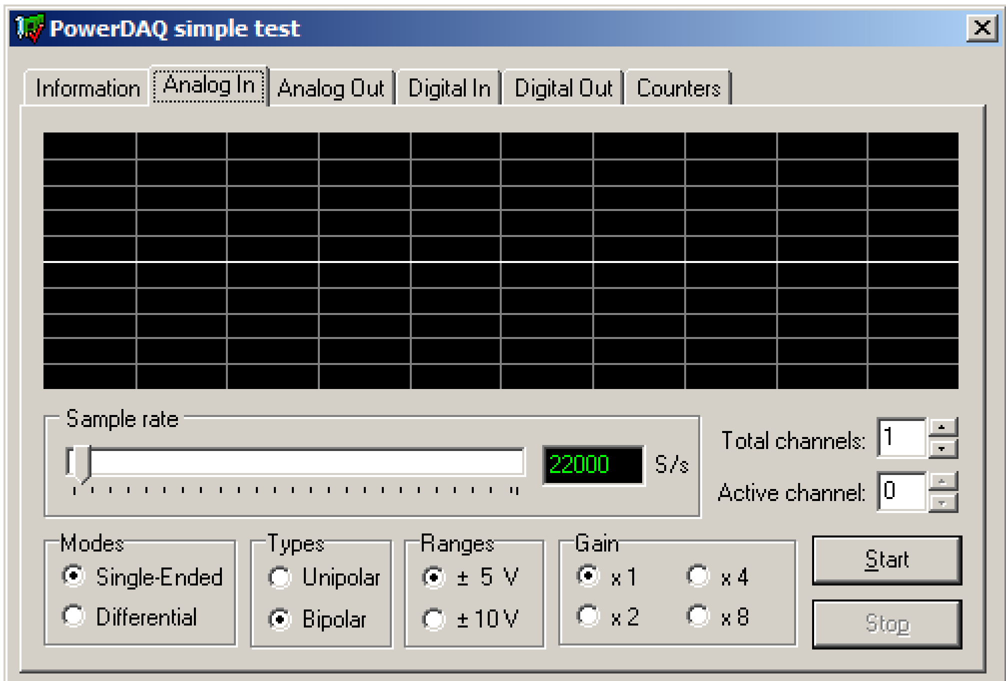

Figure 5-1
PowerDAQ Simple Test Screen

Set the active channel to 0 (this is channel 1 in THERMALPRO software). Note that at the I/O level channels 0 through 7 are mapped to Channels 1 through 8 in the THERMALPRO software. Click the **Start** button and the trace will reflect the voltage input much like an oscilloscope. With nothing attached, the trace will be a horizontal line at the midpoint on the vertical scale (look closely for it to be overlaid upon the white line). If you attach the output channel of an IFA 300 (during "standby" mode) to the active channel of the PowerDAQ board, the trace will go to the bottom of the screen (at –5 volts). You can also attach any DC voltage from –5 volts to +5 volts to verify operation.

IFA Configuration Panel

Start your Windows program and double-click on the IFA 300 icon. Select **IFA 300** from the main menu and **Configure** from the pull-down menu that appears. The IFA configuration panel shown in Figure 5-2 appears.

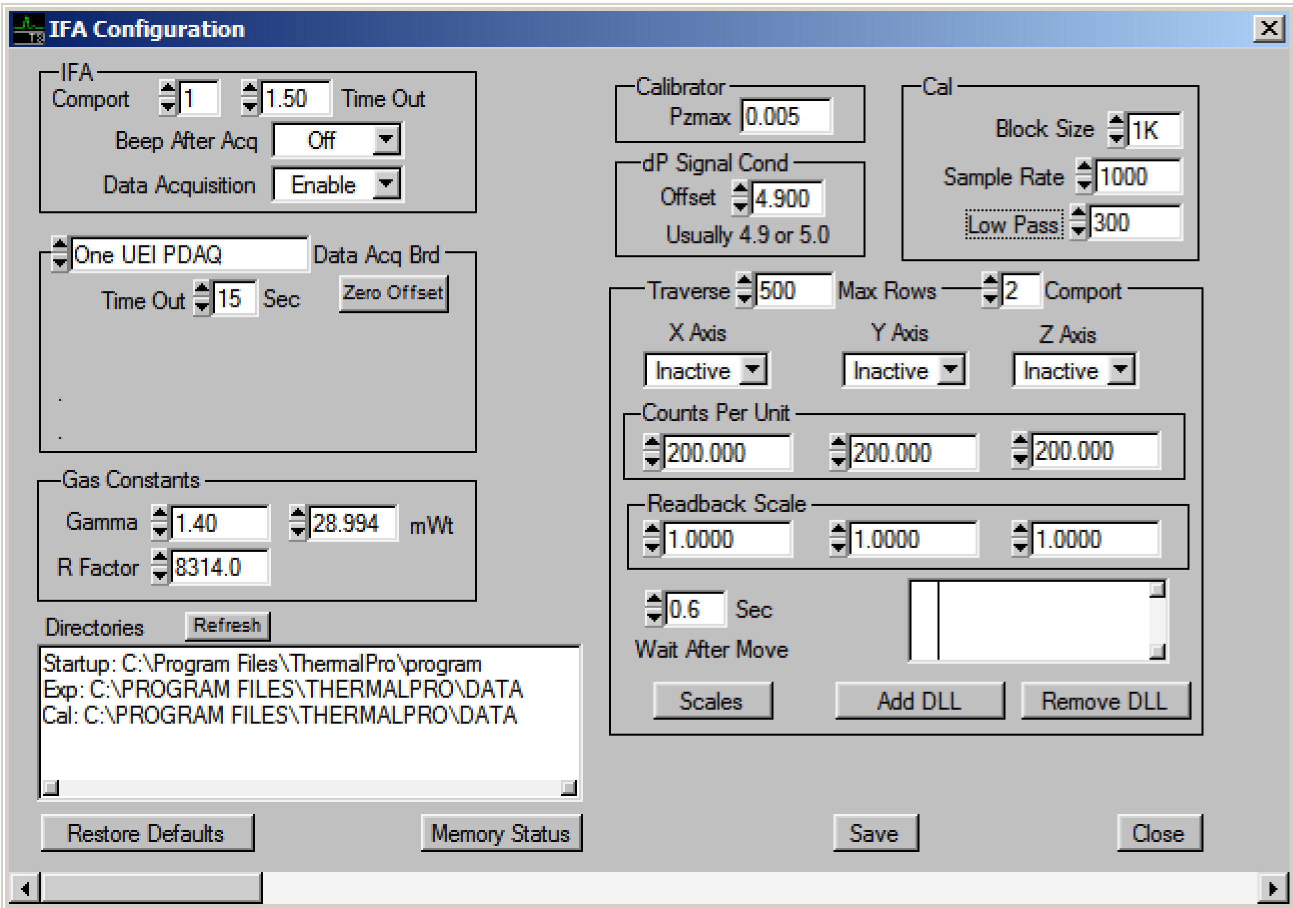

Figure 5-2
IFA Configuration Panel

The two areas in the upper-left part of the panel, labeled “IFA” and “Data Acq Brd” are the areas of interest at this time.
IFA Comport is usually set at 1, but can be set differently as desired. Time Out is usually set at 1.5 seconds.

Normally set Data Acq Brd to One UEI PDAQ unless you are using two boards. Then set to Two UEI PDAQs. A unique feature has been added that increases the accuracy of data acquisition. You can short the inputs on the Data Acquisition connector board with a shorting cap and acquire data. This value is stored in a file and while taking data this zero value is always subtracted. To accomplish this task, simply click on the **Zero Offset** control and follow the directions on the screen. If you have sufficient shorting caps, all channels can be measured at one time. Otherwise, channels can be measured one at a time.

If you are installing on a computer that will only be used for analysis and not for acquisition, Time Out can be set to 0.1 seconds to minimize the time for the software to cycle through the screens. Also Data Acq Brd can be set to select/none so that the software will not try to communicate with a data acquisition board.

The gas constants identified in the IFA Configuration Panel relate to air. If you will be calibrating and measuring in a gas other than air, you may change these values. You may leave these values unchanged when calibrating and measuring in a liquid, as differential pressure will not be used to determine velocity.

The Calibrator setting for Pzmax is only for the Model 1129 Automated Air Velocity Calibrator. This setting should be 0.005. The dP Signal Cond Offset should normally be at 4.900 volts. Some very early IFA 300 Anemometers have an offset of 5.0 volts and can be accommodated.

The Cal values identify the block size, sample rate, and low-pass filter value used for each data point obtained during calibration. Block Size of 1K, Sample Rate of 1000 per second and Low Pass filter setting of 300 are default and usually are adequate.

The traverse settings should be left in an “Inactive” state, unless a traverse system will be used. Several traverse models can be operated within the THERMALPRO software. Contact TSI for details.

Click on **Close** to exit the IFA Configuration Panel without saving any changes, or **Save** to exit and save any changes made.

Starting the Program

Once you have installed the program, you are now ready to run your experiment and collect and analyze the data.

Start the IFA 300 software by double-clicking the IFA 300 icon from Windows. The first screen should display a line near the top that says:

```
1 IFA300 Cabinet with x Channels
```

where x is the number of anemometer channels in the cabinet. If an incorrect number is displayed, it may be that the serial (com port) is not properly connected, or that the serial port is not properly identified in the IFA300.cfg file. Select **IFA 300** from the main menu and then **Configure**. Check the com port value in the upper-left portion of the IFA Configuration Panel. The default value is 1.

You may need to change it if a different com port is used on your computer.

For a quick overview of how to acquire data and measure velocity, see Chapter 6.

For detailed, step-by-step information on how to use the calibration, acquisition and post-analysis programs, see Chapter 7.

See the next section, "IFA 300 Diagnostics" if you need to perform diagnostics on individual IFA 300 channels.

Note: *The IFA 300 software uses menu bars, pop-up panels, and keyboard and mouse controls for selecting and entering parameters that are common to all software. If you are not familiar with these controls or not sure how to use certain features, see Appendix C.*

IFA 300 Diagnostics

The IFA 300 Communications screen, accessed from the main menu bar, is used to communicate with individual IFA 300 channels for diagnostic purposes or to set up and run one or more channels manually. Before using this screen to operate a sensor, note that you must set certain controls; you must select a probe sensor type (film or wire), you must set proper cable and operate resistance, and you must measure the probe resistance.

Select **IFA 300** from the main menu and then **Communications.** The screen shown in Figure 5-3 appears. Enter values for the parameters listed in Table 5-1. When you are done, press **Close** to get out of the Diagnostics program.

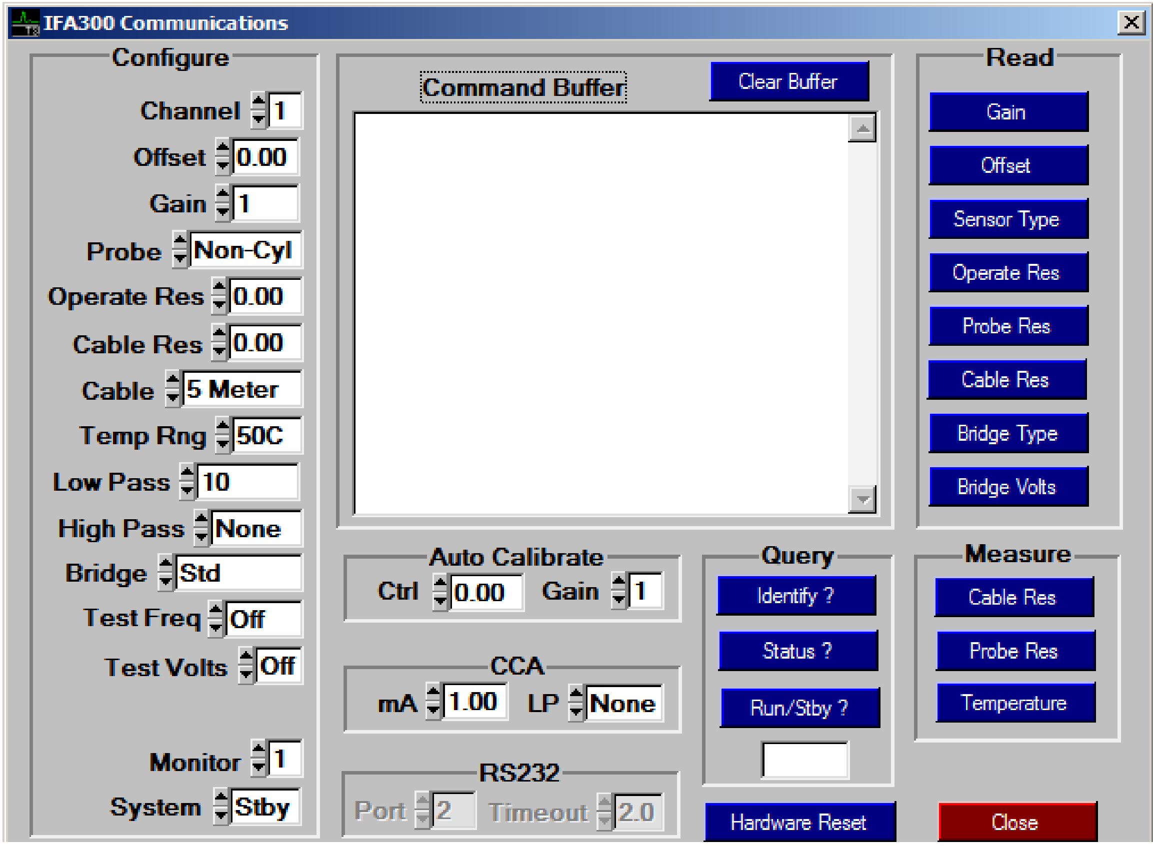

Figure 5-3
IFA 300 Diagnostics Screen

Table 5-1
IFA 300 Diagnostics Screen Parameters

Parameter	Description	Possible Values
Configure		
Channel	Select an IFA 300 channel.	Depends on the number of anemometers installed in your system. A single IFA 300 unit occupies channels 1 through 8 and if the system has a second unit, there can be channels up to 16. Default is channel 1.
Offset	Set the signal conditioner offset for a selected channel.	Can be set from 0 to 10.00 volts in 0.01 volt increments. Default is -0.00 volts.
Gain	Set the signal conditioner gain for a selected channel.	Can be set to the following values: 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 12; 14; 16; 18; 20; 25; 30; 40; 50; 60; 70; 80; 90; 100; 120; 140; 160; 180; 200; 250; 300; 350; 400; 500; 600; 700; 800; 900; 1,000
Probe	Enter the sensor type.	Wire, Film, Noncylindrical.
Operate Res	Enter the operating resistance (in ohms) listed on the probe box label.	Sum of Cable Resistance and Operate Resistance can be from 1.5 to 80.00 ohms.

Parameter	Description	Possible Values
Cable Res	Type in or measure the resistance (in ohms) of the probe cable and probe support. If you choose to measure the resistance: **a.** Insert shorting probe into probe support (See Appendix D) **b.** Click on **Measure Cable Res**. The results are displayed in the Cable Res box. **c.** Replace the shorting probe with the probe that is to be operated. ***Note:*** *Be sure to include the probe support resistance if used.*	Usually about 0.3 ohms for a 5 meter cable and about 1.8 ohms for a 30 meter cable. Default is 0.3 ohms.
Cable	Sets the selected anemometer to be tuned for either standard probe cable length.	Select 5 meter or 30 meter cable. Default is 5 meter.
Temp Rng	Sets the temperature range of the thermocouple circuit in cabinet A or cabinet B.	Range is 0 to 50 degrees C or 0 to 200 degrees C. Default is 0 to 50 C.
Low Pass	The Low Pass filter removes high frequency fluctuations from the output voltage.	Possible values are None; 10; 100; 300; 1,000; 2,000; 5,000; 10,000; 20,000; 50,000; 100,000; 200,000; 500,000; or 1,000,000 Hz.
High Pass	The High Pass filter removes low frequency fluctuations and therefore also removes the DC component from the bridge voltage.	Set to None; 0.1; 1.0; or 10 Hz. Default is None.
Bridge	Select Standard or High Power bridge for chosen channel.	Select Std or High Pwr. Standard bridge has 10 ohms in leg above sensor and High Power bridge has 2 ohms above sensor. High power bridge is only used for sensors that require high current to reach operating resistance. Default is Standard.
Test Freq	Use to select frequency of square wave input for frequency response test.	Set to Off, 1.02; 4.06; 8.19; 16.4; or 32.8 kHz.
Test Volts	Use to select amplitude of square wave input for frequency response test.	Set to Off, 1.0, 2.5, or 5.0. This input amplitude is in volts, but is attenuated so that the impulse to the bridge is quite small. If either Frequency or Amplitude is OFF, the square wave input is off.
Monitor	Use this control to set the channel for the “Selected Bridge” connector on the IFA 300 back panel. This output is the bridge voltage for channels 1 through 8 (or channels 9 through 16 on the second cabinet if installed).	The Selected Bridge connector is typically used to monitor any selected channel with an oscilloscope for square wave test, etc. This output is not affected by the signal conditioner (offset, gain or filters). Default is channel 1.
System	Sets selected bridge to Run or Standby	Stby or Run
Auto Calibrate		
Ctrl	Sets a control voltage used by the model 1129 Auto Calibrator.	This signal can be set from 0 to 10 volts in 0.01 volt steps. Default is 0.0 volts.

Parameter	Description	Possible Values
Gain	Sets the gain of the signal conditioner used with a differential pressure transducer. This allows pressure transducers with 0 to 10 volt output to be used with the A/D converter that has an input of -5 to +5 volts.	The calibrator signal conditioner can be used with pressure transducers that have a 0 to 10 volt output. First a gain of X1 or X10 is applied and then a fixed offset of 5 volts is applied. Default is X1.
CCA		
mA	Sets the current in the CCA module. Use only if you have an optional model 183145 temperature module.	Possible values are: 0.25; 0.3; 0.4; 0.5; 0.6; 0.8; 1.0; 1.2; 1.5; 1.9; 2.5; and 3.0 mA.
LP	Sets the low pass filter on a CCA module.	Possible values are: None (off); 10; 20; 50; 100; 200; 500; 1000; 2000; 5000; and 10000 Hz.
Query		
Status?	This command displays and clears error messages from the error queue.	The error queue is last in first out.
Run/Standby?	Checks to see if the current channel is in run or standby.	Answer is displayed in the box below the control.
Read		
Gain	This command reads the gain of the current channel from the microprocessor memory.	
Offset	This command reads the offset of the current channel from the microprocessor memory.	
Sensor Type	This command reads the sensor type of the current channel from the microprocessor memory.	W for wire sensor or F for film sensor. This choice is made on the left side of this screen.
Operate Res	This command reads the probe operate resistance of the current channel from the microprocessor memory.	This value can be entered on the left side of this screen.
Probe Res	This command reads the sensor cold resistance of the current channel from the microprocessor memory.	This value will be correct only if the correct value has been measured by the microprocessor.
Cable Res	This command reads the cable resistance of the current channel from the microprocessor memory.	This value will be correct only if the correct value has been measured or typed in. When the system is turned on, the default value of 0.3 ohms will be in memory.
Bridge Type	Detects if the current channel has a constant temperature bridge (standard CTA) or a constant current bridge (CCA which is used for making fast temperature measurements.	If a CTA is detected a 1 is returned and if a CCA is detected a 0 is returned.
Bridge Volts	Click to read the bridge voltage of the current channel. This voltage is read by a 10 bit A/D converter in the microprocessor that is independent of the A/D board used for data acquisition.	If the channel is on standby, the bridge voltage will be about 0.035 volts. If in run it may be about 1 volt at zero velocity (depending on sensor type and operate resistance).

Parameter	Description	Possible Values
Measure		
Cable Res	Click to measure the resistance of a probe cable or probe cable plus probe support attached to the current channel. Be certain that you have removed the probe and have shorted the cable or support.	Usually about 0.3 ohms for a 5 meter cable and about 1.8 ohms for a 30 meter cable. If used, a probe support will add a small resistance to the cable resistance.
Probe Res	Click to measure the cold resistance of a sensor attached to the current channel. The displayed value has the cable resistance subtracted.	The IFA 300 can measure up to 80.00 ohms, including the cable resistance.
Temperature	Click to read the temperature from the thermocouple of the current channel.	O to 50°C or 0 to 200°C depending on the range selected.
Other Command Buttons		
Hardware Reset	Initializes the IFA 300 microprocessors.	All parameters are set to default values.
Close	Click to return to the main screen.	

CHAPTER 6

Quick Guide to IFA 300 THERMALPRO Software

This chapter is a quick guide to using the IFA 300 software. Its goal is to help you acquire and measure velocity as quickly as possible.

See Chapter 7 for detailed information on each program in the IFA 300 software.

Figure 6-1 gives an overview of the various screens and options in the IFA 300 software.

Quick Guide

The following steps assume you have calibrated your probe and have a calibration file on the system.

1. Make sure your IFA 300 system is up and running and the software is loaded.
2. Select **Acquisition** from the main menu and then **Probe Table.**
3. Use **Get File** option to name a new data file or recall an existing file.
4. Use the **Get Probe** option to set up the probe table, if you are setting up a new file or modifying an old one.

   Edit the data in each line as necessary. Check to make sure the operating resistance value for the probe matches the label on the probe box and the cable resistance value is correct.
5. Click on **Next Screen** to get to the Acquisition-Conditions Setup Screen. While moving to the next screen, the system is setting all parameters for the selected channels, including setting sensors to run at correct operate resistance and setting signal conditioner offset and gain, etc.

   Select desired units, enter atmospheric pressure, sample rate, sample size and acquisition mode.
6. Select **Acquire** to move to the real-time screen (unless in the Write Only Mode). Click on **Trigger** to acquire data.

7. You may drag the vertical red cursors to display the time between events. The square on the left vertical bar may be used to measure a velocity. Click the square to the velocity point you wish to measure. The velocity is displayed in the box labeled "Crs" to the right of the histogram.

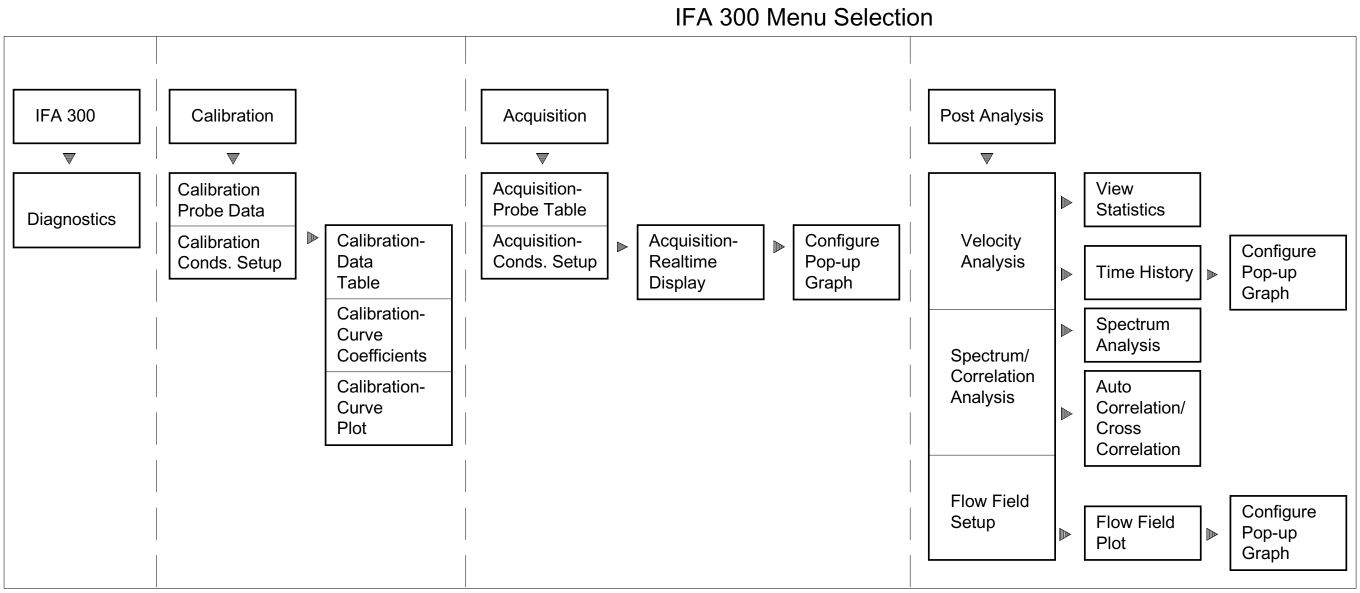

Figure 6-1
Overview of the IFA 300 Software Screens and Options

CHAPTER 7

IFA 300 ThermalPro Software Reference Guide

This chapter gives detailed descriptions of how to use the following IFA 300 programs:

- Calibration Program
- Data Acquisition Program
- Post Analysis Program

Using the Calibration Program

The calibration program is used to calibrate single sensor, *x*-sensor, or triple-sensor probes, either by acquiring data or by entering data on the screen.

A calibration generates a relationship between the bridge voltage and a reference velocity.

The calibration data is curve fit with a fourth-order polynomial as a default, but other curve fitting options are available. All calibration data is stored in a file that is typically named by the serial number of the probe, and has an extension of .CL. This calibration file is used by the Acquisition program to convert raw data into velocity data.

The calibration program has three screens that must be setup before calibrating a probe: Calibration-Probe Data, Calibration-Conditions SetUp, and Calibration-Autocalibration Table. Before you calibrate a probe you must enter various parameters into the Probe Data and Calibration SetUp screens as described below.

Note: *Do* not *calibrate a probe without moving from the Probe Data screen to the Conditions Setup screen using the* **[Calibrate]** *control or the IFA 300 will not be set up properly.*

The following steps assume that you have attached a probe to the IFA 300 unit and have the probe in a nozzle or wind tunnel that is suitable for calibration. See Appendix D for information on how to set up the probe for calibration.

Follow these steps to calibrate a probe:

1. Select **Calibration** from the main menu and then **Probe Data**. The screen shown in Figure 7-1 appears.

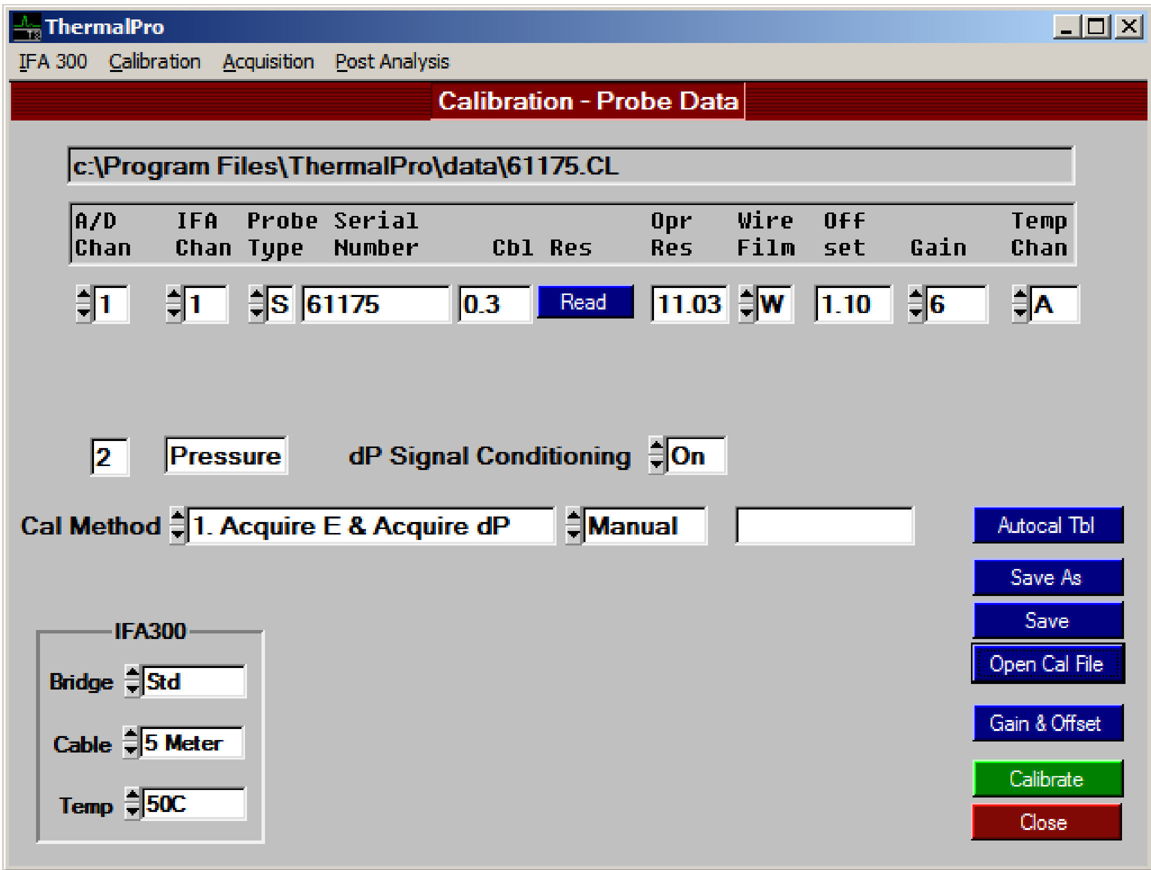

Figure 7-1
Calibration-Probe Data Screen

2. Click on **Open Cal File** option and select one of the following three options:

   - ❑ If you are recalibrating a probe, select the appropriate calibration file from the pop-up file list. Click on **OK**. If you are not making any changes to the Probe Data or Conditions Setup parameters, skip to step 5.
   - ❑ If you would like to use an existing calibration file for a new probe, select the file from the list and click on **OK**. Click on **Save As.** Type in new filename. (The filename is usually the probe serial number). Click on **OK** again. Make any

changes—usually at least the operating resistance of the sensor—and then calibrate as described later in this section.

If you are *not* making any changes to the Probe Data parameters, skip to step 5.

- ❑ If you are calibrating a probe from scratch, type in new filename in the **Open Cal File** pop-up screen. (The filename is usually the probe serial number). Click on **OK** and follow the rest of the steps below.

  The filename is displayed in the serial number box and also in the command line with an extension of .CL.

- ❑ If you are calibrating a dual-sensor probe, it is a good practice to click on **Get File** and then select the "x_film.cl" file or another existing x-probe calibration. This will set up the Calibration-Probe Data screen for two channels. You may then make parameter changes as needed (see step **3**). Then you may **Save As** your probe's serial number. Similarly, for a triple-sensor probe, start with the "t_film.cl" file, modify as necessary, and then **Save As** that probe's serial number.

  Note: *If you made minor changes to the Probe Data or Conditions Setup parameters, but do* not *wish to recalibrate the probe, you can save the changes you've made by clicking on* ***Save*** *before exiting the Calibration program.*

3. Enter or alter the parameters on the Calibration-Probe Data screen according to instructions in Table 7-1.

Table 7-1
Probe Data Parameters

Parameter	**Description**	**Possible Values**
A/D Chan	Select the A/D channel of the A/D converter board that is connected to the "output voltage" (on back of IFA 300) of the probe you wish to calibrate.	Values range from 1 to 16 channels, depending on the A/D board that is installed
IFA Chan	Select the corresponding IFA 300 channel assigned to each A/D channel.	The IFA 300 system can have up to 16 channels.
Probe Type	Select the type of probe being used.	*S* indicates a single-sensor probe *X* indicates an *x*-probe *T* indicates a *triple*-probe
Serial #	The filename you entered earlier, using the Get File command. The filename format is the serial number of the probe with the extension .CL. This file will contain all the calibration information you enter in this program.	Up to 8 alpha-numeric characters. The extension (.CL) will be added automatically. ***Note:*** *This parameter can be changed only by entering a different serial number or name after clicking on the* ***Save As*** *button.*

Parameter	Description	Possible Values
Cable Resistance	Type in or measure the resistance (in ohms) of the probe cable and probe support. If you choose to measure the resistance: **a.** Insert shorting probe into probe support (See Appendix D) ***Note:*** *Be sure to have the probe support attached to the probe cable when measuring cable resistance.* **b.** Click on **Read**. The results are displayed in the Cable Resistance box. **c.** Replace the shorting probe with the probe that is being calibrated.	Usually less than 0.5 ohms.
Opr Resistance	Enter the operating resistance (in ohms) listed on the probe box label.	Sum of Cable Resistance and Opr. Resistance can be up to 80 ohms but is typically 6 to 12 ohms.
Wire Film	Enter the sensor type.	W—Wire, F—Film, N—Noncylindrical film.
Offset	Enter the offset value for the signal conditioner. For more information about offset and gain, refer to Appendix F, "Determining Offset and Gain Settings for a Hot-Wire Probe."	0 to 10 volts in steps of 0.01. An offset value of approximately 1.8V is appropriate for "—*20*" film Sensors and about 1.2V for "—T1.5" wire Sensors
Gain	Select the gain for the signal conditioner. For more information about offset and gain, refer to Appendix F, "Determining Offset and Gain Settings for a Hot-Wire Probe."	1, 2, 3, 4, 5, 6, 7, 8, 9, 10 ,12, 14, 16, 18, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 500, 600, 700, 800, 900, 1000 A value of approximately 5 is appropriate for "—*20*" film sensors and about 6 for "—T1.5" wire sensors
Temp. Chan.	The temperature channel. Select a temperature sensor to correct all probes for fluid temperature changes. Each IFA 300 unit has one thermocouple circuit.	Set Temperature Channel to A if you have one IFA 300 system and you are using the thermocouple for temperature measurement. If you have a larger system (more than eight channels) which requires you to connect two IFA 300 units together in series, you may select channel B to read a thermocouple attached to the second IFA 300 cabinet. If you select **Ext**, the program prompts you to enter the temperature manually.

4. Click on **Cal Method.** Select the calibration method. See Table 7-2 for a list of choices.

Table 7-2
Calibration Methods

1. Acquire E & Acquire dP	Use this method if you have a pressure transducer with an analog voltage output. The output voltage E (or voltages for multi-sensor probes) and the analog output from a pressure transducer are acquired by the A/D system in a block of 1k (1024 points) for each calibration point. The averaged voltage and differential pressure are put into a data table along with the velocity calculated (using compressible gas equations; see Appendix G) from each acquired differential pressure. ***Note***: *If you select Method 1: Acquire E and Acquire dP, an additional line of data appears just above the Cal Method data line. The additional line identifies the next available A/D channel, specifies "Pressure" as the IFA Channel and gives you the choice of turning on or off the dP signal conditioner within the IFA 300. The dP signal conditioner is explained in Table 7-7. If you choose Method 1, connect a coaxial cable from the dP Out port on the back of the IFA 300 to the A/D channel identified on the screen (Channel 2 when calibrating a single-sensor probe, Channel 3 when calibrating a dual-sensor probe, and Channel 4 when calibrating a triple-sensor probe). Connect your pressure transducer output cable to the dP In port on the back of the IFA 300 cabinet.*
2. Acquire E & Type dP	Use this method if you have a pressure transducer with a display but no analog voltage output. The output voltage E (or voltages for multi-sensor probes) is acquired by the A/D system in a block of 1k (1024 points) for each calibration point. You enter the differential pressure for each calibration point. The averaged voltage value and the differential pressure value for each velocity point are inserted into a data table along with the velocity calculated from each differential pressure.

3. Acquire E & Type Velocity	Use this method if you have an independent measurement of velocity in your calibration flow. The output voltage E (or voltages for multi-sensor probes) is acquired by the A/D system in a block of 1k (1024 points) for each calibration point. You type in velocity for each calibration point. The averaged voltage and velocity are inserted into the data table by the software.
4. Type E & Type dP	Use this method if the calibration data for your probe is in the form of bridge voltage vs. differential pressure. You type in this information in the data table and the software calculates the velocity for each differential pressure value.
5. Type E & Type Vel.	Use this method if the calibration data for your probe is in the form of bridge voltage vs. velocity.

5. Next to the Cal Method window is a window indicating how the software will be prompted to step through the calibration points. See Table 7-3 for a list of choices.

Table 7-3
Calibration Points

Choices	Description
Manual	Using the mouse, you will manually prompt the software to acquire data and move to the next calibration point.
Man + Tbl	You will manually prompt the software to acquire data for each calibration point. In addition, the "next Vel" (next velocity) and "next dP" values will be given to help guide you through a calibration. ***Note:*** *You must select a calibration table to use this function. To do so, click on the **Autocal Tbl** button. A list of calibration tables appear. Select a table of your choice and click on **OK**. You may view a table by clicking on **Calibration** and then **Autocalibration Table** in the menu bar at the top of the screen (you may do this without exiting the Probe Data screen). To view a file, click on **Get Table** in the Autocalibration Table Editor screen. Choose a file to view and click on **OK**.* ***IMPORTANT*** *If you are using any calibration equipment other than TSI Model 1127, 1128, or 1129 Calibrators, it will be necessary for the values in the "Nz" column to be "1". Values "2" and "3" in the "Nz" column refer to nozzles provided with the TSI calibrators, Model 1127, 1128, and 1129. If you are using calibration equipment other than TSI Models 1127, 1128, or 1129 Calibrators, do not use autocalibration table which have values "2" and "3" in the "Nz" column. If the given calibration tables do not suit your calibration requirements, you may create a new table. Refer to the section in this chapter entitled "Autocalibration Table Screen" for information about creating a new table.* You may exit the Autocalibration Table Editor screen by clicking on **Close**. You may now select the table you viewed by clicking on **Autocal Tbl** in the Calibration-Probe Data screen. The file name of the calibration table you selected will appear in the window next to the Get Cal Tbl button.
Auto	To be used in conjunction with Method 1:Acquire E and Acquire dP. This mode is designed to operate exclusively with the TSI Model 1129 Automated Air Velocity Calibrator. This mode automatically steps through a velocity calibration. It establishes and measures a sequence of air velocities according to the Autocalibration Table selected. If you are using a Model 1129, you may refer to instructions in that manual for further details about this calibration mode.

6. In the lower-left portion of the Calibration Probe Data screen, you will see a box with the heading "IFA 300." There are a few parameters to set, but most applications use the default values. See Table 7-4 for a list of parameter choices.

Table 7-4
Parameter Choices

Parameter	**Choices**
Bridge	**Std** (default) Used for the vast majority of gas and liquid measurement applications. The "standard" 10:1 Wheatstone bridge circuitry is selected. **High Pwr** The High Power 1:1 bridge is used for rare applications where extra power is needed to operate the anemometer. Large, homemade sensors and certain liquid flow measurement applications are examples.
Cable	**5 meter** (default) **30 meter** Select the cable length you are using for probe cables.
Temp	**50°C** (default) **200°C** Select the temperature range of the thermocouple you are using. Standard thermocouples supplied by TSI are T-type, 0° to 50°C range.

Note: *Remember to save this information before proceeding with a calibration if you have made any changes to data in the Probe Data screen. Press **Save** if you wish to keep the filename, or **Save As** if you wish to create a new filename. Probe serial numbers are often used as calibration filenames.*

7. Click on **Calibrate**. The Conditions Setup screen appears (Figure 7-2).

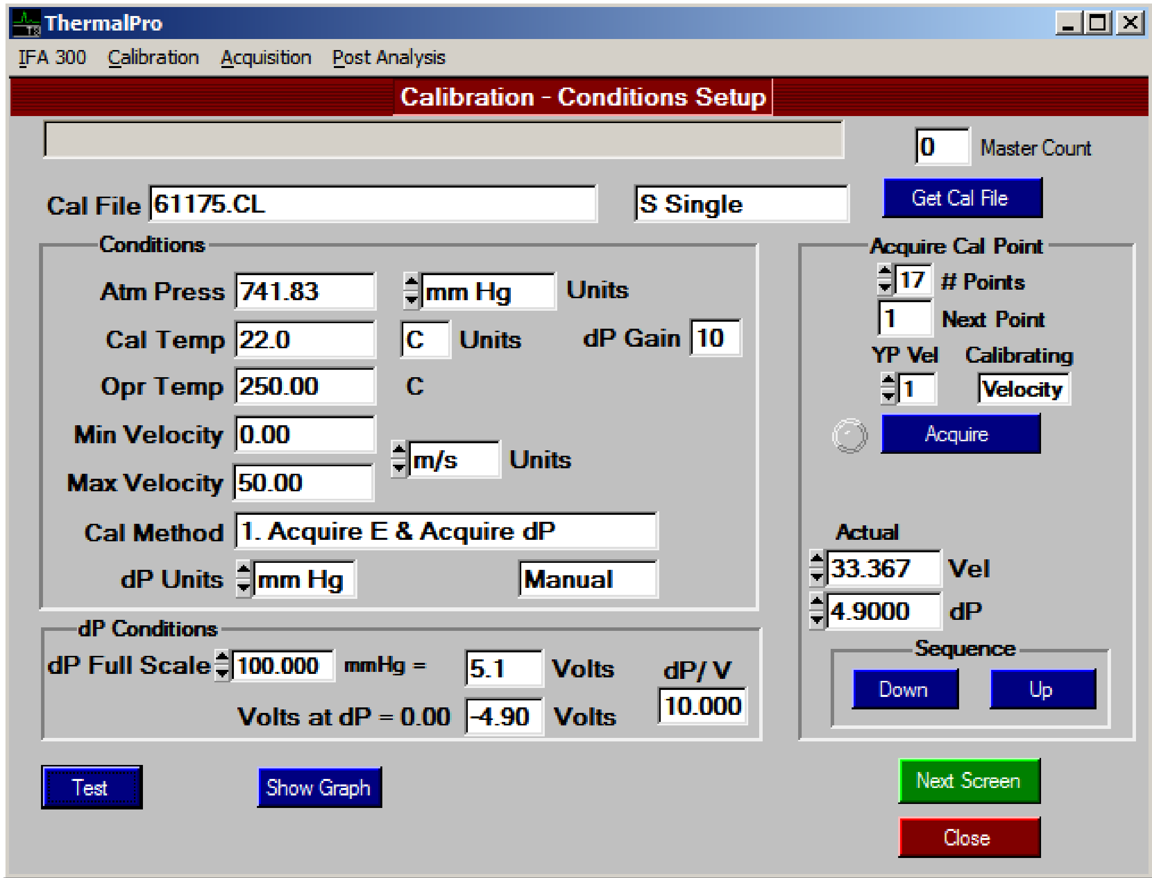

Figure 7-2
Conditions Setup Screen

At this point, the bridge parameters have been sent to the IFA 300 and the sensor(s) to be calibrated will be in the run mode. In the Calibration-Conditions Setup screen, the filename of the probe to be calibrated is displayed in the **Probe File** window.

8. Select the desired parameters and measurement units in the Conditions Setup screen. Refer to Table 7-5 for detailed explanations.

Table 7-5
Calibration—Conditions Setup Parameters

Parameter	**Description**	**Possible Values**
Atm Pressure	The barometric or atmospheric pressure. This value must be entered before calibration. If you don't have a barometer, enter a value that is typical for the altitude at which you are located. Click on **Units** to specify mmHg, in-Hg, or kPa	Standard values for sea level are: 760 mmHg, 29.921 in Hg, 101.325 kPa.
Cal Temp	Bridge voltage values are corrected to this temperature. Click on **Units** to specify either Celsius or Fahrenheit units.	This value is usually 20°C or 68°F.
Opr Temp	The sensor's operating temperature taken from the label on the probe box. ***Note:*** *Always specify in Celsius even if you have specified temperature units in Fahrenheit.*	Usually 250°C for air calibrations and 66.7°C for water probes.
Min. Velocity	The minimum velocity value your calibration will include. May be zero velocity, but other values will be accepted.	0.00 or any other non-negative value less than max. velocity.
Max. Velocity	The maximum velocity you expect the probe to encounter. Click on **Units** to specify m/s, ft/s, or ft/min	
Cal Method	The calibration method that you selected in the previous screen is displayed. Can only be changed in the previous screen.	
dP Units	Units of measure for the differential pressure. ***Note:*** *This parameter is used only in Calibration Methods 1, 2, and 4, described later in this section.*	

Parameter	**Description**	**Possible Values**
# Points	The number of velocity points that you will acquire in your calibration, including the minimum velocity point. ***Note:*** *If you choose calibration procedure "Manual + Tbl" or "Auto," this number will be determined by the autocalibration table you selected. If you chose calibration procedure "Manual + Tbl" or "Auto," do not change this value in this screen. If you want to use a different number of calibration points, return to the Calibration-Probe Data screen and select another autocalibration table or create a new one and designate the number of calibration points you would like to use (see section in this chapter entitled, "Autocalibration Table Screen."* Table 7-6 shows a sample file that you can build using either Lotus® or Quattro® software programs. This matrix charts velocity points versus differential pressure. As can be seen from the chart, the velocity points are spaced out so that the calibration fits nicely with a fourth-order polynomial. For your convenience, this file, called IFA300\DATA\VELCHART.WK1, is included with the IFA 300 software. To use the chart, type in: ❑ Maximum expected velocity in meters/sec into cell B1 ❑ Temperature in degrees Celsius into cell B2 ❑ Atmospheric pressure into cell B3 ***Note:*** *As long as the actual velocity (or differential pressure) is input into the calibration, it is not important to set the velocity in your flow exactly at each velocity point listed in the matrix.*	About 17 points work very well, but as few as 8 points will also work if they are spaced properly.

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Table 7-6
Sample Velocity Chart to Generate in a Spreadsheet Program

A	B	C	D	E	F	G
1	Max Vel;oc	**50** m/s		Act Vel	Delta P	Delta-P
2	Temp	**20** Deg C		M/S	mmHg	inH2O
3	Bar.Press	**760** mm Hg	1	0.000	0	0
4			2	1.581	0.0113	0.0060
5			3	1.991	0.0179	0.0096
6			4	2.506	0.0284	0.0152
7			5	3.155	0.0451	0.0241
8			6	3.972	0.0714	0.0381
9			7	5.000	0.1132	0.0605
10			8	6.295	0.1794	0.0958
11			9	7.924	0.2843	0.1519
12			10	9.976	0.4505	0.2407
13			11	12.559	0.7141	0.3815
14			12	15.811	1.1317	0.6046
15			13	19.905	1.7937	0.9582
16			14	25.059	2.8428	1.5186
17			15	31.548	4.5055	2.4069
18			16	39.716	7.1407	3.8147
19			17	50.000	11.3173	6.0458

9. If you selected **Method 1: Acquire E & Acquire dP** calibration method, specify the values for the pressure transducer parameters, listed in Table 7-7.

Table 7-7
dP Conditions Setup

Parameter	Explanation
dP Full Scale	Enter the full scale pressure range of your pressure transducer (in units of mmHg).
dP Full Scale x mmHg = 5.10 volts dP Zero Factor 0.0 mmHG = –4.90 volts	If the dP Signal Conditioning was switched to "ON" in the Calibration-Probe Data Screen, the dP Full Scale and dP Zero Factor values will be fixed at 5.10 volts and –4.90 volts, respectively. The program assumes your pressure transducer has a 0–10 volts span. The dP signal conditioner in the IFA 300 subtracts 4.9 volts from the dP signal input. Thus "dP Out" on the back of the IFA 300 is 4.9 volts less than "dP In." This provides a voltage signal to the PowerDAQ A/D converter board. The reason for the 4.9 volt offset is that the system can read the zero dP output without going below the –5 volt limit. If there are small fluctuations, the system will average the signal without clipping the signal. If the dP Signal Conditioning was switched to "OFF" in the Calibration-Probe Data screen, you may enter any values between –5 volts and +5 volts (in 0.1-volt resolution) for the dP Full Scale and dP Zero Factor values.
dP/V	Calculated by the program. Cannot enter a value.

10. Depending on which calibration method you chose in the previous screen, select one of the following sets of instructions:

Method 1: Acquire E and Acquire dP

a. Position your probe in the calibration flow.

b. Set the flow and differential pressure in your experiment to zero.

c. Click on **Acquire.**

The system acquires the first data point and increments the Next Point field to 2.

d. Increase the differential pressure in your experiment to the next value on your chart. If you chose "Manual + Tbl" calibration procedure, each subsequent velocity and dP values appear under the heading "Next" alongside the current values as you click on **Acquire**. This helps guide you through your calibration.

e. Repeat steps (c) and (d) until you've acquired all of the points you had specified in the **# Points** box.

After the last data point is acquired, a pop-up message, "Calibration Data Set Complete" appears. Click on **OK.**

f. Click on **Next Screen.** The Calibration-Data Table screen appears (Figure 7-3). Go to Step 11 to continue with the calibration process.

Method 2: Acquire E and Type dP

a. Position your probe in the calibration flow.

b. Set the flow and differential pressure in your experiment to zero (or your minimum designated velocity).

c. Enter 0 (or the dP associated with the designated minimum velocity) in the dP box.

d. Click on **Acquire.**

The system acquires the first data point and increments the **Next Point** field to 2.

e. Increase the differential pressure to the next value on your chart.

f. Enter the next value for the differential pressure in the dP box and click on **Acquire**. Repeat steps (e) and (f) until you've acquired all of the points you had specified in the **# Points** box.

Note: *Type the dP value for a given point before the voltage is acquired.*

After the last data point is acquired, a pop-up message, "Calibration Data Set Complete" appears. If your calibration was error-free, click on **OK**. However, if you missed a point, or mistakenly typed in an incorrect dP value, you may step back to that point by clicking on the "sequence" **Up** or **Down** buttons. Be sure to adjust the flow in your calibration device to match the point(s) you are repeating.

g. Click on **Next Screen.** The Calibration-Data Table screen appears (Figure 7-3). Go to step 11 to continue with the calibration process.

Method 3: Acquire E and Type Velocity

a. Position your probe in the calibration flow.

b. Set the flow and differential pressure in your experiment to zero (or your minimum designated velocity).

c. Enter 0 (or your minimum designated velocity) in the Vel box.

d. Click on **Acquire.**

The system acquires the first data point and increments the **Next Point** field to 2.

e. Increase the velocity to the next value on your chart.

f. Enter the next value for the velocity in the **Vel** box and click on **OK**.

Repeat steps (e) and (f). until you've acquired all of the points you had specified in the **# Points** box.

Note: *Type the velocity value for a given point before the voltage is acquired.*

After the last data point is acquired, a pop-up message, "Calibration Data Set Complete" appears. If your calibration was error-free, click on **OK**. However, if you missed a point, or mistakenly typed in an incorrect velocity value, you may step back to that point by clicking on the "sequence" **Up** or **Down** buttons. Be sure to adjust the flow in your calibration device to match the point(s) you are repeating.

g. Click on **Next Screen.** The Calibration-Data Table screen appears (Figure 7-3). Go to step 11 to continue with the calibration process.

Method 4: Type E and Type dP

a. Click on **Acquire.**

Note: *You typically use this method to manually enter data for probes that were previously calibrated.*

b. The message "Use the View Results Screen to Enter Cal Data" appears. Click on **OK**.

c. Exit the Calibration-Conditions SetUp screen by clicking on **Close**.

d. From the main menu click on **Calibration** and then **Conditions Setup**. Make sure all the calibration conditions are correct (including the number of calibration points you will be entering) and then click on **Next Screen**.

e. The Calibration Data Table screen appears (Figure 7-3).

The data table displays a table with columns for bridge voltage, differential pressure, actual velocity (which is calculated from the differential pressure) and temperature.

In the following steps you enter the values for the bridge voltage and differential pressure one point at a time.

f. Move the cursor to the first line. Click on **Edit Line.**

g. Enter values for E1 (and E2 and E3 as appropriate) in the boxes at bottom of the screen. Enter differential pressure in the dP box.

h. Click on **Save Line.**

The data is saved, velocity for that point is calculated and the cursor moves down to the next line.

i. Repeat steps (g) and (h) until you've entered data for the number of points you had specified in the **# Points** box.

j. Go to step 11 and continue with the calibration process.

Method 5: Type E and Type Velocity

a. Click on **Acquire.**

Note: *You typically use this method to manually enter data for probes that were previously calibrated.*

b. The message "Use the View Results Screen to Enter Cal Data" appears. Click on **OK**.

c. Exit the Calibration-Conditions SetUp screen by clicking on **Close**.

d. From the main menu click on **Calibration** and then **Conditions Setup**. Make sure all the calibration conditions are correct (including the number of calibration points you will be entering) and then click on **Next Screen**.

e. The Calibration Data Table screen appears (Figure 7-3).

The data table displays a table with columns for bridge voltage, actual velocity, and temperature.

In the following steps you enter the values for the bridge voltage and velocity one point at a time.

f. Move the cursor to the first line. Click on **Edit Line.**

g. Enter values for E1 (and E2 and E3 as appropriate) in the boxes at bottom of the screen. Enter velocity in the Act. Velocity box.

h. Click on **Save Line.**

The data is saved and the cursor moves down to the next line.

i. Repeat steps (g) and (h) until you've entered data for the number of points you had specified in the **# Points** box.

j. Go to step 11 and continue with the calibration process.

Note about "Test" button:

There is a button in the lower-left corner of the Calibration-Conditions SetUp screen labeled "Test." You may click on this button at any time during setup or calibration to get a real-time display of output voltages or bridge voltages for all channels in your IFA 300 system. Voltages are displayed in each of 16 A/D channel locations. Active channels are indicated in blue lettering if the IFA channel is in "Standby" mode (sensor not *on), and red lettering if the IFA channel is in "Run" mode (sensor* is *on). Inactive channels will have random values in the display. Choose to display either Output Voltage or Bridge Voltage by clicking on the arrows of the display at the top, marked "Read." Click on* ***Stop/Start*** *to freeze the display and to let it return to continuous updating.*

The "Square Wave" button injects a square wave into the bridge circuit as a way of testing frequency response of the system. The injected square wave simulates a repeated step-change in velocity. You may view the output of any channel on an oscilloscope to test the frequency responses of the system. To do so, connect a coaxial cable from the "SELECTED BRIDGE" connector on the back of the IFA 300 to an oscilloscope. You may select a channel's signal to view by choosing one of Channel 1 through 8 from "Monitor A" (if you have one IFA 300 cabinet operating) in the upper-left port of the Acquisition Monitor screen. If you have two IFA 300 cabinets operating, you may choose to view any one of Channels 9 through 16 from "Monitor B" in the upper-right port of the screen. Click on ***Square Wave*** *again to turn off the square wave signal. Click on* ***Close*** *to exit the Acquisition Monitor screen.*

Note about "Show Graph" button:

Next to the "Test" button is a button labeled "Show Graph." This control displays a small graph that displays a form of the calibration curve as calibration points are acquired. The vertical axis is Output Voltage (from –5 volts to +5 volts) and the horizontal axis is velocity. Use this graph to make sure that the data is reasonable during calibration and that the system is working properly.

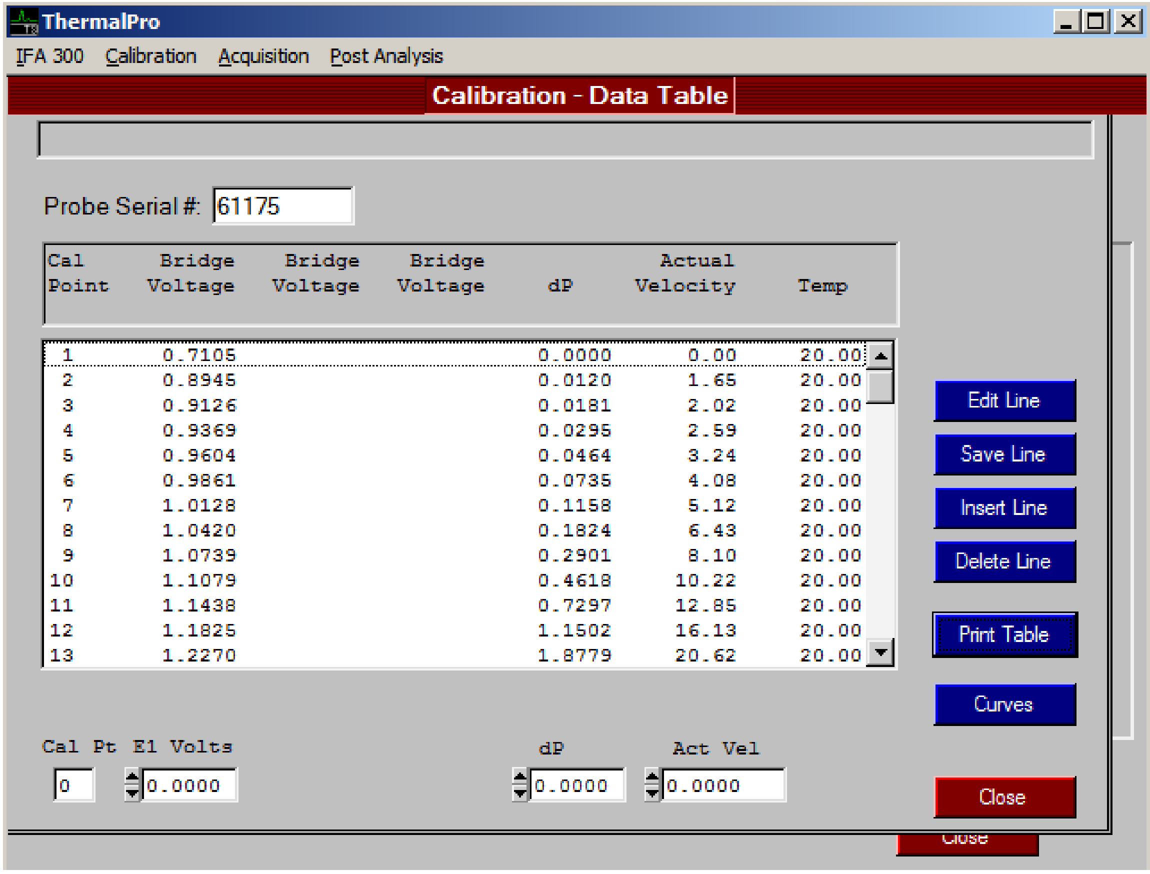

Figure 7-3
Calibration-Data Table Screen

11. Click on **Curves** to calculate the polynomial curve fit, and to generate the calibration curve.

The Calibration-Curve Fit screen appears (Figure 7-4). This screen displays the velocity vs. bridge voltage curve, the polynomial coefficients, and the mean square error as a measure of how well the curve fits the calibration points.

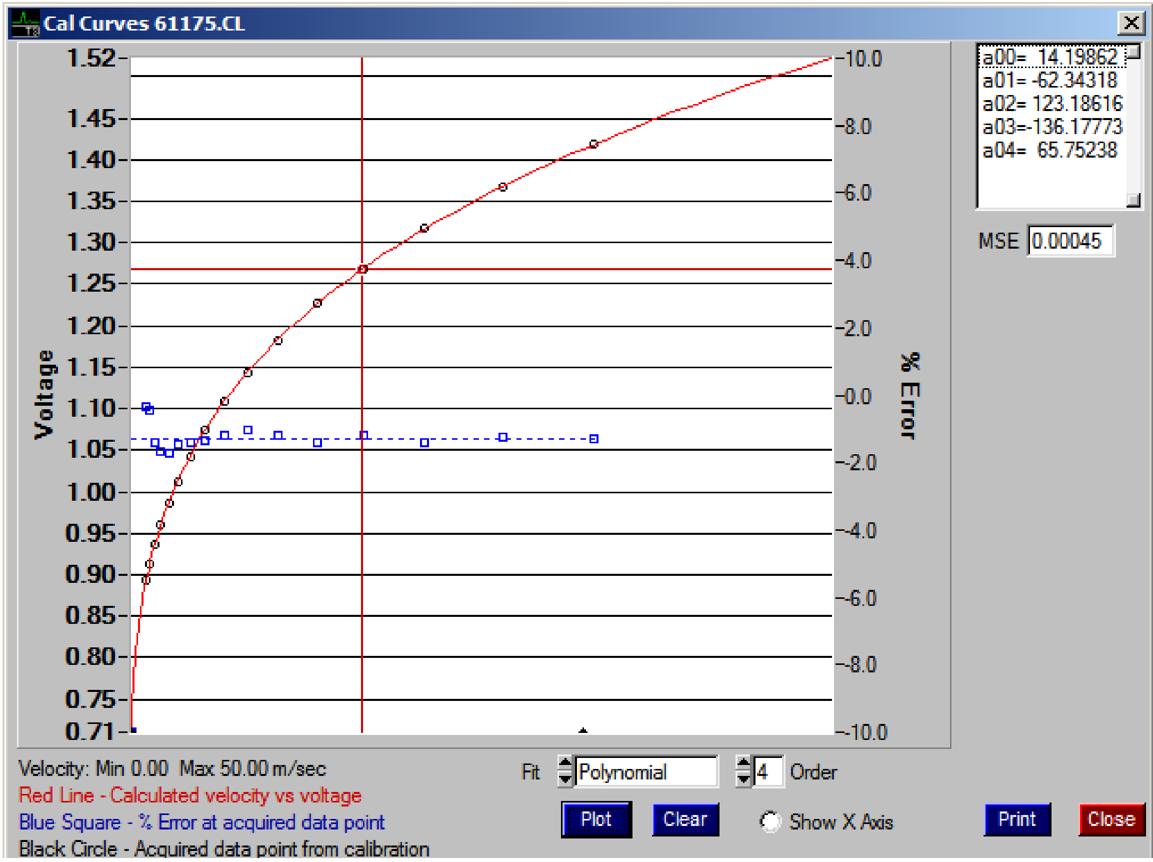

Figure 7-4
Calibration-Curve Fit Screen

12. Observe the graph.

If the points on the graph are plotted correctly and the graph looks good (that is, the graph smoothly increases monotonically as in Figure 7-4), the calibration process is complete and you can proceed to acquiring data with the calibrated probe. See "Using the Data Acquisition Program" next, for details.

If a point on the graph does not look good, you may need to edit one or more data points or repeat the calibration procedure. Go to step 12.

Appearing in the upper-right corner of the Calibration-Curve Fit screen are coefficients representing the calibration curve shown, according to the following equation:

$$\text{Velocity} = K + AE + BE^2 + CE^3 + DE^4$$

where E = Bridge Voltage.

13. Exit to the Data Table screen by clicking on **Close** in the Curve Fit screen. Edit the erroneous point using the **Edit Line** option. Make the change and click on **Save Line**. Click on **Curves** to return to the Curve Fit screen. Observe the graph. Repeat this step if necessary.

Note about Curve Fit options:

The default curve fit is a 4^{th} order polynomial as described above. This fit works well for most calibrations; however, several options have been added. For a given calibration file, you can experiment with different options to see which works best. In addition to the polynomial, the "TSI" fit, Cubic spline, and King's Law can be selected.

Polynomial

For the polynomial fit you can change the order from 1 to 9. Of course, the 1^{st} order is linear and is not practical. The best choice depends somewhat on the number of data points—the more the data points, the higher the order.

TSI

Bridge voltage squared is fairly linear with the square root of velocity, so this fit does a polynomial fit of bridge voltage squared vs the square root of velocity. A customer favorite.

Cubic Spline

This is a standard mathematical curve fit that forces the fit to go through each point. If there is scatter in the data, the curve won't be smooth.

King's Law

King's Law uses the following equation.

$E^2 = A + B * V^{1/n}$

Where E is bridge voltage, A, B and n are constants, and V is velocity. This is a form of a heat transfer equation for the heat loss from the sensor to the fluid. This fit gives a reasonable curve with only a few points. Whichever plot was selected last before the screen is closed, will be saved in the calibration file.

Autocalibration Table Screen

Select this screen under **Calibration** in the pull-down menu. Selecting this screen allows you to view, modify, or create new "autocalibration" tables. If you have a Model 1129 Autocalibrator, the table determines each velocity that will be set up during the calibration. If you have a manual calibrator, or even if you are calibrating in a wind tunnel using a pitot tube, you can use a table to display target differential pressure for each calibration point. Autocalibration tables contain velocity vs. dP data to use for calibrating hot-wire and hot-film probes.

To view an existing autocalibration table, click on **Table Editor** and then click on **Open** (see Figure 7-5). You may choose from the list of files that appears. Files with the extension .ctb are autocalibration tables. As you examine given files, first note the column to the extreme right with the heading "Nz." If this column contains a number other than 1, do ***not*** use this table unless you have a TSI Model 1127, 1128, or 1129 Calibrator. Tables with 1 in the "Nz" column are generalized tables calculated from compressibility gas equations and may be used with pitot tubes, well designed wind tunnels, open jets, etc.

If you have a TSI Model 1127, 1128, or 1129 Calibrator, the "Nz" column identifies the secondary nozzle to install at the base of the flow settling chamber. The velocity through the secondary nozzle (which is displayed in the column headed "Ctrl") is higher than the velocity emerging from the Calibrator (displayed in the column headed "Exit"). The displayed velocities are in units of m/s. When the value 1 is in the "Nz" column, the exit velocity is the control velocity, so the two columns headed "Exit" and "Ctrl" are identical.

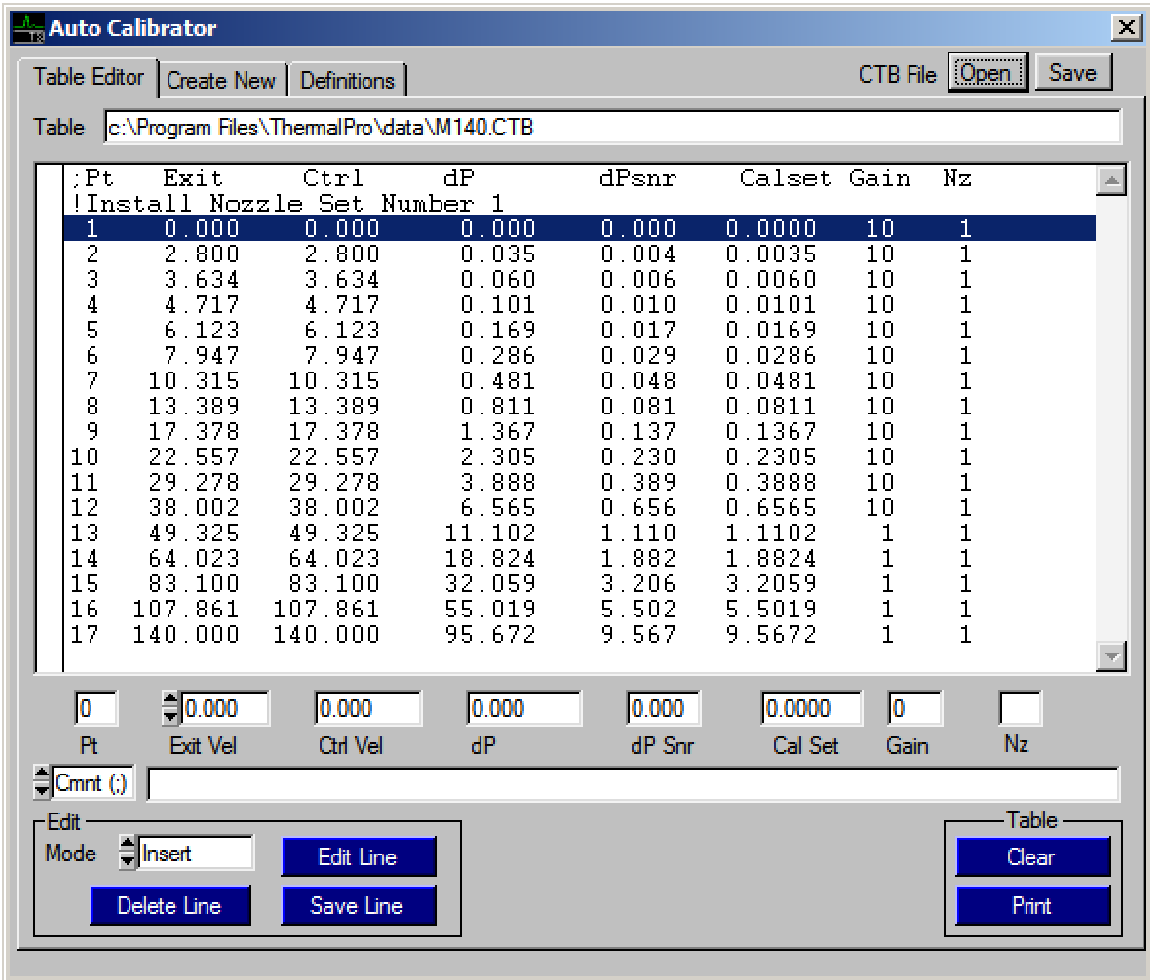

Figure 7-5
Autocalibration Table Editor Screen

The other data shown in this table is explained in Table 7-8.

Table 7-8
Autocalibration Parameters

Parameter	**Explanation**
dP	This is the differential pressure (units are mmHg) that is associated with each velocity value. Ranges from 0.001 mmHg at 0.469 m/s to approximately 600 mmHg at 300 m/s.
dP Snr	Pressure signal (in volts) associated with the dP value. The value in this column is determined by parameters established in the “dP Conditions” portion of the Create New Calibration screen.

Parameter	Explanation
Calset	Used for TSI Model 1129 Automated Air Velocity Calibrator. This is the voltage signal sent to the automatic valve in the Model 1129 Calibrator to establish the given velocity. ***WARNING TO MODEL 1129 CALIBRATOR USERS:*** *Do **not** change these values. The Model 1129 Calibrator is an extremely sensitive device. Altering the given Calset values could disable the Calibrator.*
Gain	This will be either 10 or 1, depending on dP Snr. For dP Snr <0.9 volts, the gain will be 10. This augments the dP signal to increase the resolution by utilizing a greater portion of the -5 to +5 volts signal going into the A/D converter.

You may modify a given or saved table by using the edit commands.

To edit a line:

1. Click on the line you wish to edit.
2. Click on **Edit Line**. The data for this line will appear in the labeled boxes below the table.
3. You may edit any of the data by highlighting the data in the labeled box below the table.
4. Click on **Save Line** to save the edited information.
5. Click on **Save** to keep the filename, or **Save As** to save under a new name. The extension, .ctb, will be added automatically.

C a u t i o n

Use the edit option with care. We do ***not*** recommend editing data unless you understand the relationship between velocity and differential pressure.

To delete a line:

1. Click on the line you wish to delete.
2. Click on **Delete Line**. The highlighted line disappears. Lines following the deleted line are renumbered.
3. Click on **Save** to keep the filename, or **Save As** to save under a new name. The extension, .ctb, will be added automatically.

To create a new table:

1. Click on the **Table Editor** tab and click on **Clear** to clear the current table. Make sure that the Edit Mode is in the "Overwrite" position. Then click on the **Create New** tab".
2. Determine and enter the following parameters. dP Full Scale (usually 10, 100 or 1000 mm Hg. Voltage range will be – 4.9 volts to 5.1 volts if using the signal conditioner on the IFA 300.
3. The "Conditions" are what the autocalibration table will use as "standard" conditions. It is recommended to leave these at 760 mmHg and 20°C.
4. For "Nozzle Set," choose 1 unless you have a TSI Model 1127, 1128 or 1129 Calibrator. If you have one of these calibrators, you may select 1, 2, or 3. Refer to the calibrator manual to help you determine the best nozzle set for your calibration.
5. You can type in the Max Exit Velocity and the Max dP will be calculated and displayed. You can also type in a dP value and the Exit Velocity will be calculated and displayed. These calculations will change if the Nozzle number is changed. This can help to determine the range of your calibration table.
6. Set the "Max. Velocity" and "Min. Velocity" (usually zero) values for your calibration.
7. Select the number of calibration points you wish to use. It is a good practice to use at least 11, and preferably at least 17 calibration points.
8. Click on **Calculate** and then click the **Table Editor** tab to view the table.
9. Click on **Save** and enter a file name to save the table.

You may exit the Autocalibration Table Editor screen by clicking on the **X** box**.**

See "Using the Data Acquisition Program" next, for details on the next step.

Using the Data Acquisition Program

Use the Data Acquisition program to

- ❑ Acquire data that can be saved in raw data files for further analysis
- ❑ Display the graphic results immediately after acquiring the data. These graphics are plotted as velocity vs. time (time

history) and as velocity vs. probability distribution (histogram). Mean velocity, turbulence intensity, and temperature are also displayed.

To use the Data Acquisition program, perform the following steps:

1. Select **Acquisition** from the main menu, then select **Probe Table** option.

   The probe tables from the last used data file appears. Select one of the following options:

   - ❑ If you would like to continue with the same filename and same probe table, review the table and Click on **Next Screen** and move on to step 7 after ensuring that the probe(s) and cables are properly attached.
   - ❑ If you would like to use the existing probe list for a new data file, Click on **Rename.** Type in a new filename. Click on **OK.** Review the Probe Table (Figure 7-6). If you are *not* making any changes to the Probe Data Table parameters, click on **Next Screen** and move on to step 7.
   - ❑ If you are creating a new probe table, continue with step 2.

2. Click on **Get File**. Type in a new filename to establish a name for a series of raw data files. The name can be up to eight alpha-numeric characters. The system adds an extension of .R????, where ???? starts at 0001 and increments as additional files are acquired.

   Click on **OK** to confirm the experiment name.

3. With the cursor bar on the first row in the probe table, click on **Add Probe**. Double-click on the probe number you would like to select as the first probe.

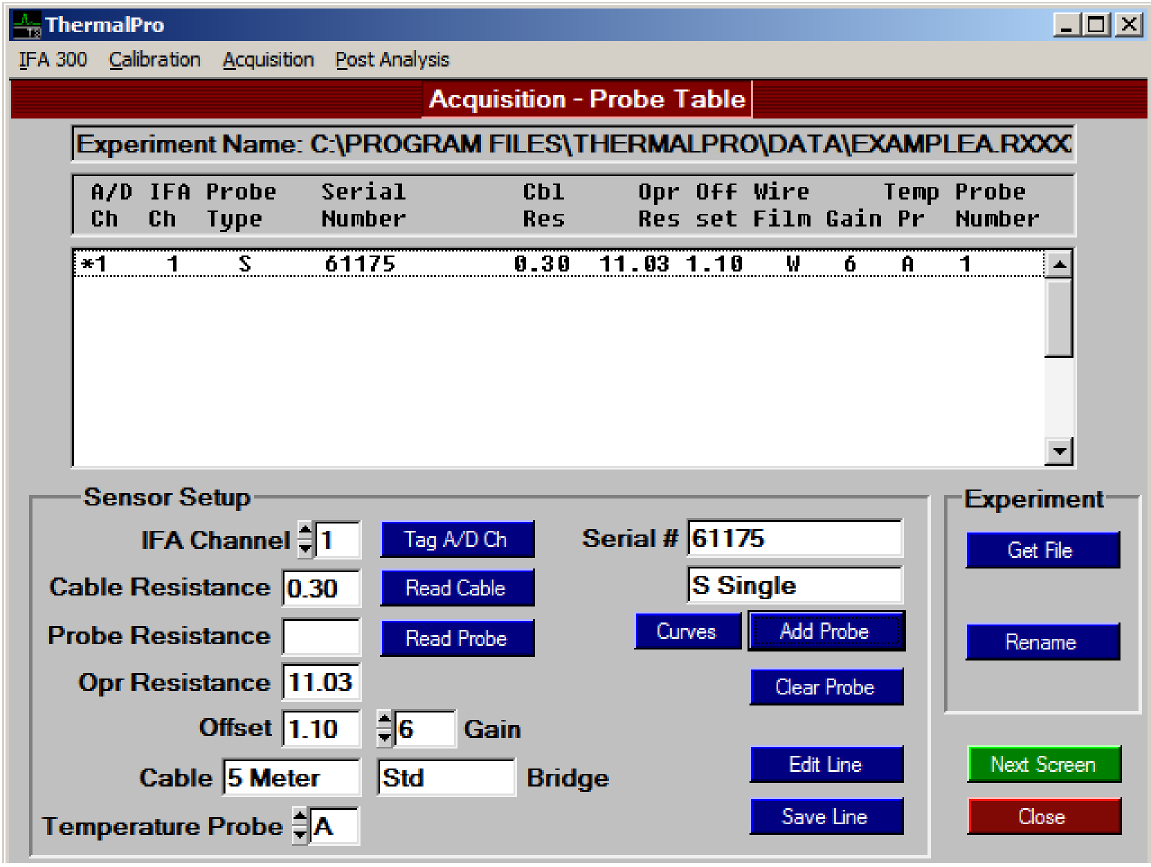

Figure 7-6
Data Acquisition Program: Probe Table Screen

4. Press **Edit Line** (or double click on the line in the probe table**)** and make changes, if any, to the parameters listed in Edit Probe Table (Table 7-9) then click on **Save Line**.

   Note: *Each time you make any changes after using the Edit Line command, make sure you press **Save Line**, before moving to the next line or to another screen.*

To add more probes, move the cursor bar to the next row and select **Add Probe** as before. Then press **Edit Line** and **Save Line** as needed to modify parameters.

Table 7-9
Edit Probe Table Parameters

Parameter	Description	Possible Values
A/D Ch	Indicates the channel for the analog to digital (A/D) Data Acquisition Board.	Table has a range of 1 to 16. Channel must be tagged with an asterisk (*) to be active. Click on **Tag A/D Ch** control to tag or untag a channel with cursor bar on the line to be modified.
IFA Ch	Indicates IFA 300 channel. Assigned by the system but can be modified here.	The IFA 300 system can have up to 16 channels.
Probe Type	Type of probe(s) being used. Probe type is established in the calibration file and cannot be changed in this screen.	*S* indicates a single sensor probe *X* indicates an x-probe (two sensor) *T* indicates a triple sensor probe *C* indicates a thermocouple probe (usually used when sampling the analog output of the built in thermocouple circuit). *K* indicates a temperature signal from an (optional) Constant Current channel. *P* indicates a pitot probe (or differential pressure signal). The system will calculate velocity from this signal. *G* indicates a general probe type that can be any linear or non-linear analog signal. No pressure or temperature corrections will be made.
Serial Number	The serial number of the probe. Used to name the file containing calibration information. Can be changed only in the Calibration program. Entered in the table with the Add Probe control.	The filename format is the serial number with the extension ".CL".
Cbl Res	The resistance (in ohms) of the probe cable. Assumes that probe support resistance is also included. Generally read from the Calibration File but can be modified here.	Usually about 0.3 ohms for a 5 meter cable and about 1.8 ohms for a 30 meter cable.
Opr Res	The operating resistance in ohms. Generally read from the Calibration File but can be modified here.	The sum of cable resistance and the operating resistance. Cannot be higher than 80 ohms.
Offset	The offset value for the signal conditioner. Read from the Calibration File but can be modified here.	0 to 10 volts in steps of 0.01
WireFilm	The sensor type. For display only; can be changed only in the Calibration program.	W—Wire Sensor F—Film Sensor N—Noncylindrical Film
Gain	The gain for the signal conditioner. Read from the Calibration File but can be modified here. For most applications a gain below 10 is appropriate.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10,12, 14, 16, 18, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 500, 600, 700, 800, 900, 1000

Parameter	Description	Possible Values
Temp. Pr	The temperature channel. Used to select a temperature sensor to correct each probe for fluid temperature changes. Each 8-channel IFA 300 cabinet has one thermocouple circuit. Channel can be changed on this screen. For example, all probes can be corrected using one thermocouple attached to temperature channel A.	Ext, A, B, Probe# 1 through 16 or Off. If Ext is selected, the software program prompts you to input the temperature manually. If A or B is selected, temperature will be read once per data file on the serial port (RS232) from cabinet A or B. If a probe# is selected, then temperature correction will be done point by point using a temperature probe that is attached to an A/D channel. If Off is selected, no temperature correction will be made.
Probe Number	Calculated by the program and used to keep track of statistical results.	1 through 16. Note that a multi-sensor probe will have 1 line on the probe table for each sensor but all lines have the same probe number.
Probe Resistance	Select Read Probe to measure the probe resistance. *Probe resistance can be read on this screen, but is **not** shown on the Probe Table.*	If there is a cable resistance indicated, this will be subtracted from the measured resistance.
Cable	Indicator to show if calibration had been done with 5 meter or 30 meter probe cable Can be changed only in the Calibration program.	5 m or 30 m
Bridge	Indicator to show if calibration had been done with standard or high power bridge. Can be changed only in the Calibration program.	Std or High Pwr

5. When all parameters are changed, press **Save Line.**

Repeat steps 3 to 5 for additional probes.

6. When all the changes are made and saved, select **Next Screen**.

This command sends information from the probe table to the IFA 300, setting up each anemometer channel including setting probes to run. This command also saves the current information into the MASTER.AQ file, and into the raw data file header for future reference. The Conditions Setup (Figure 7-7) screen appears.

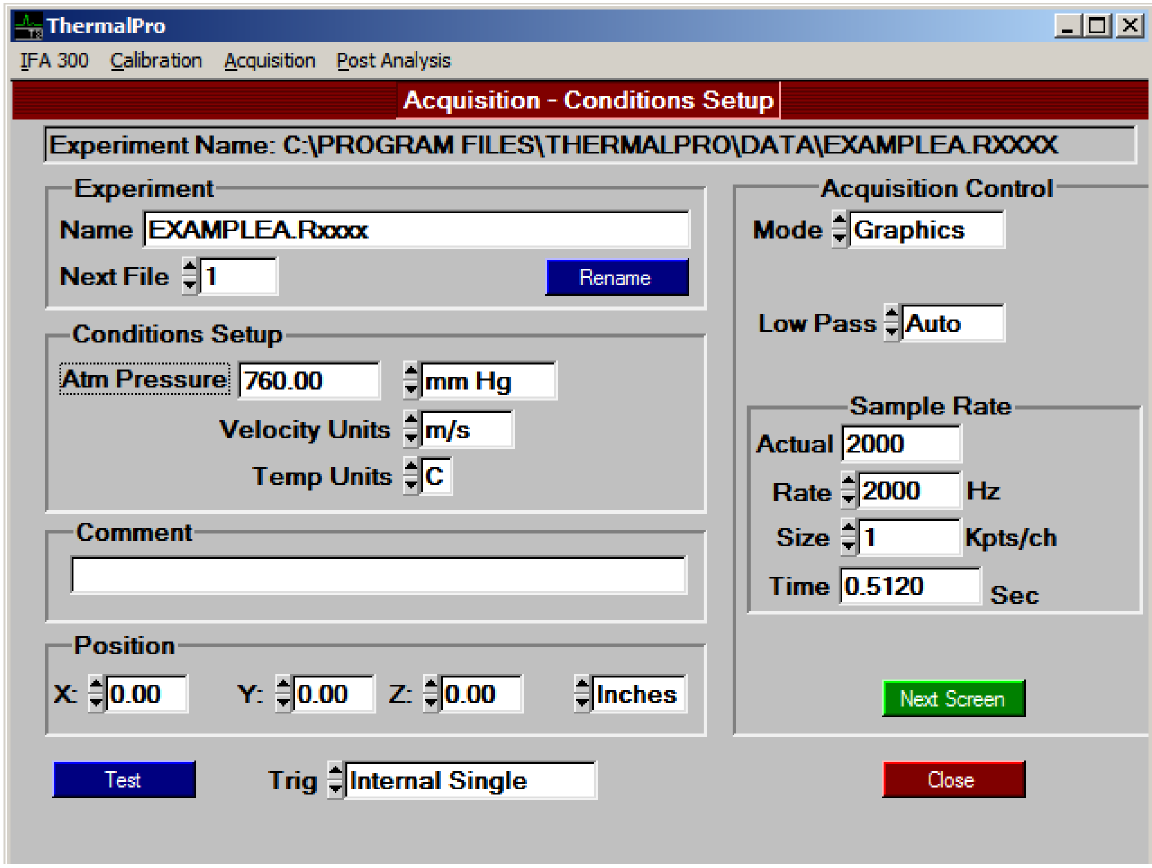

Figure 7-7
Data Acquisition Program: Conditions Setup Screen

7. At this stage all active anemometer channels are in run. If you wish, you can click the Test control which brings up a screen that displays voltages on all A/D channels. For more information on this screen, see "Note About 'Test' Button" earlier in this chapter at the end of step 10 of the section entitled "Using the Calibration Program."

8. Make changes, if any, to the Experiment Setup (Table 7-10) parameters and the Data Acquisition parameters (Table 7-11).

Caution
While in run mode, do ***not*** disconnect or connect any probe cables. The IFA 300's bridge is active during run mode, and you risk damage to the probe and IFA 300.

Table 7-10
Experiment Setup Parameters

Parameter	Description	Possible Values
Exp Name	The experiment name where raw data for an experiment will be stored. Filename has an extension of .R0001 which is the first file in a sequence.	Up to eight alpha-numeric characters. Can be renamed by selecting the **Rename** control.
Next File #	The number of the next file where raw data will be stored. The system increments it by one after each data point is acquired.	File numbers range from 0001 to 9999. If you would like to change the next point to be taken, you can change the number here.
Atm pressure	The atmospheric pressure (or absolute static pressure in a pressurized system). This value must be entered before collecting data. If you don't have a barometer, enter a value that is typical for the altitude at which you are located.	Standard values for sea level are: 760 mmHg 29.921 in Hg 101.325 kPa.
Velocity Units	Units of velocity. These units can be selected regardless of the units specified in the calibration file.	Specify: meters/second feet/second feet/minute
Temp Units	Units of temperature measurement. These units can be selected regardless of the units specified in the calibration file.	Specify in either C or F for Celsius or Fahrenheit units.
Comment	Use this to enter comments you may want to make. These are stored in the raw data file header.	Saves up to 79 characters. 40 are displayed in this window.
Pos X: Y: Z:	(*Optional*) The position coordinates that can be entered before each file is collected. These values can be used later by the plotting program. If using a traverse control system, the positions will be entered automatically.	Units can be either inches or millimeters.

Table 7-11
Data Acquisition Parameters

Parameter	Description	Possible Values
Acquisition Control Mode	The data acquisition modes. Data can be acquired directly from the Acquisition – Conditions Setup screen (Write Only Mode) or from the Real-time Display Screen (Graphics Mode)	***Write Only*** Data is acquired and stored as in the Display and Write mode and the real time display screen is not used. In this mode, the Acquire button is labeled “Acquire”. ***Graphics*** From the Acquisition–Conditions Setup screen, click on **Next Screen** to access the Graphics (Real-time Display Screen). Note that Low Pass Filter, and Sample rate and Block Size can be selected from either screen. Data is acquired and the results are displayed as real-time graphs for up to 4 channels. Data is acquired when you click on **Trigger** in the Display Graph screen. In either mode, as each data point is acquired, data is stored in a raw data file with an extension of .R0001 and subsequent files are incremented up to a maximum of .R9999. For each binary raw data file (R file) another file is saved with a similar extension with T substituted for R. This file contains various setting, Temperature data and information about the calibration file for each probe.
Trigger Control (Trig)		**Internal Single** A single batch of data will be acquired each time the Acquire button is selected. **Internal Continuous** A series of batches are acquired when the Trigger button is selected and continue until the stop button is selected. The file extension is incremented for each batch. **External** Data can be collected from a hardware switch closure on the BNC connector board that is connected to the Data Acquisition board. This can be accomplished by pressing the pushbutton switch or by a switch closure attached to the EXT TRIG BNC connector. The procedure is to select **External Trigger**, click on **Arm** after which the system waits for the external trigger. For more information, see External Trigger in Chapter 7.
Low Pass Filter	The Low Pass filters on each anemometer can be set from this screen. These filters can remove unwanted high frequency noise, and avoid aliasing problems.	Possible Low Pass filter settings are 10 Hz, 100 Hz, 300 Hz, 1 kHz, 2, 5, 10, 20, 50, 100, 200, 500 kHz, and 1 MHz. If None is selected, there will be no Low Pass filter. If Auto Sample Rate is selected, the optimum filter will be selected depending on sample rate. The criteria is that the filter setting will be less than or equal to one half the sampling rate.
Sample Rate	The sample rate in Hz.	Select from a range of 1 Hz to 500 kHz in a 1, 2, 5, 10, 20 sequence. In addition 600 Hz, and 4, 40, 133, 150, 177, 250, 277.777, 416.666, and 850 kHz can be selected. If set to Auto, the sampling rate will be set to about twice the Low Pass Filter setting. ***Note:*** *One channel can be sampled at 850 kHz, two channels at 416.666 kHz, three channels at 277.777 kHz. The total throughput for 4 or more channels is 1 MHz.*

Parameter	Description	Possible Values
Sample Size	The number of samples, in kilopoints per channel, that will be acquired for each IFA 300 channel. Each Kpt is 1024 samples.	The block size can be an integer in a binary progression from 1 to 4096 (1, 2, 4, 8, 16, 32, 64,........4096. The maximum block size you can use will depend on the amount of memory in your computer.
Sample Time	The sample time in seconds. Calculated from the values you specify for the Sample Rate and Sample Size parameters.	$\frac{(\text{Sample Size}) \times 1024}{\text{Sample Rate, Hz}}$

9. Once you have made all the changes, you are ready to take data. If you selected the Write Only mode, data is taken each time you click on **Trigger**.

   Otherwise, click on **Next Screen** and the Real-time Display screen appears (Figure 7-8) and a data file is taken each time you click on **Trigger**.

   Table 7-13 shows the available options on the Real-time Display screen.

   Use the Graph A Probe # control to select the probe number to be displayed in the upper graph. Then select **Graph B Probe #**, **Graph C Probe #**, and **Graph D Probe #** controls to select the probe number to be displayed in the lower graphs.

   If you are using only one single sensor probe, select probe number one for the upper graph and select **Off** for the lower graphs.

   If you are using a multi-sensor probe, you may wish to select probe number one for more than one graph and then use the "Configure Graph" control to set up one graph for the *u*-component and the others for the *v*-component or *w*-component or some other combination.

   The time scale of the time history graphs depend on the sample rate you selected on the Conditions Setup Screen. Since the graph displays the first 1024 points, the time for the entire graph is [1024/sample rate in Hz]. This time is displayed under each time history graph. The delta time is the time between the two vertical cursors. This can be used to determine the time between two events in the time history. The 1/dT (1/delta time) can be used to easily determine the approximate frequency of a periodic flow. Drag the cursors to the desired position with the mouse.

   Note: *When you zoom in or out on a graph, notice that the time, dT, and 1/dT values do not change immediately. However, once you move the vertical cursors after zooming in or out, the dT and 1/dT values will be correct for the zoomed view.*

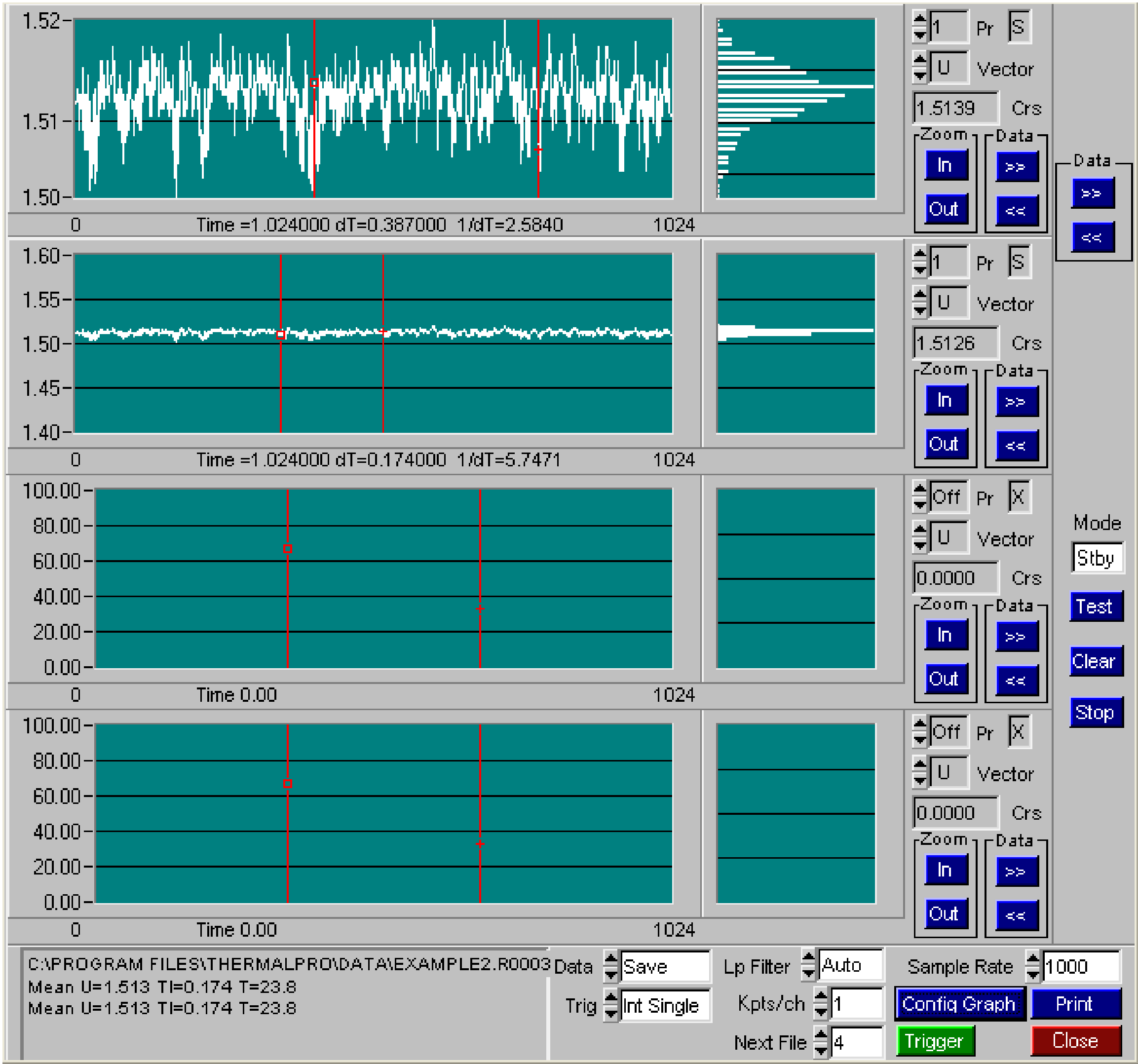

Figure 7-8
Real-time Display Screen

The left cursor on each graph has an additional function. Its square symbol can be aligned with the graph and its vertical position is displayed in the window labeled “Crs” to the right of each graph. Note that the cursors will snap to the closest point, making it easy to find a minimum or maximum.

Table 7-12
Controls and Options to Edit the Real-time Screen Display

Parameter	Description	Possible Values
Next File	Displays the numeric portion of the extension of the current velocity file.	0000 to 9999
Sample Rate	This mirrors the control on the Condition Setup screen. You can change the Sample Rate in this screen without reverting back to the Acquisition-Conditions Setup screen.	Select from a range of 1 Hz to 500 kHz in a 1 - 2 - 5 sequence. In addition 600 Hz, and 133, 150, 177, 250, 277.777, 416.666, and 850 kHz can be selected
Test	This mirrors the control on the Condition Setup screen.	
Configure Graph	A pop-up set of options that allow you to change the configuration of the graph. See later table for details.	
Print	Sends the screen to the printer selected in the Windows "Printers and Faxes" panel.	
Graph Scroll Control	If the current velocity file has more than a 1k block (1024 points), the right or left arrow control in a block labeled Data can be used to scroll through 1k blocks of sampled data.	Graph A, Graph B, Graph C, Graph D or A, B, C, D. Individual graphs can be scrolled, or graphs A, B, and C can be scrolled together with the arrow controls on the upper right of the screen.
Data Save/Overwrite	If **Save** is selected, the file extension is incremented. This is the default condition. Data Overwrite is usually used with Trigger Internal Continuous so that the graph updates continuously. When you stop the Trigger Continuous (using the spacebar or mouse), the program returns to the acquisition mode you specified in the Acquisition-Setup screen.	If **Overwrite** is selected, data is written to a file with the extension of ._R0 and overwritten with each sample.
Trigger	Triggers a new sample that is stored as a raw data file with the next File Index (file extension number).	
Close	Close screen and return to Conditions-Setup screen.	
Graph A Controls *(upper right)*		
Pr (Probe number)	Select the probe number to be displayed on graph A. The probe type of the current probe is displayed in a small box. ***Note***: *If you select an inactive probe number, you will get a series of pop-up error messages. Click on* ***OK*** *to each until they are gone, and then select an active probe number.*	1 through 16. Note that these are probe numbers and not channel numbers. For example, to view 3 vectors from a triple probe, select probe #1 for all three graphs.

Parameter	Description	Possible Values
Vector	Select the velocity component of the current probe **U** - to display U component **V** - to display V component of x or triple probe **W** - to display W component of triple probe **Ut** - to display total velocity for x or triple probe **Th** - to display the angle that the total vector makes with the X axis (for x or triple-probe) **T** - to display the time history of temperature if temperature is sampled on an A/D channel	
Crs (cursor display)	This box displays the amplitude (velocity) at the location of the left cursor. The cursor will snap to the closest point when moved with the mouse and can be used to find a local minimum or maximum velocity.	
Zoom In or Out	Zoom In expands the data between cursors to fill up the graph. This can be repeated several times to see details in a smaller time period. ***Note:*** *When you zoom in or out on a graph, notice that the time, dT, and 1/dT values do not change immediately. However, once you move the vertical cursors after zooming in or out, the dT and 1/dT values will be correct for the zoomed view.*	
Graph B Controls *(center right)*		
Pr (Probe number)	Select the probe number to be displayed on graph B.	Off and 1 through 16
	Other controls are similar to those for graph A	
Graph C Controls *(lower right)*		
Pr (Probe number)	Select the probe number to be displayed on graph C.	Off and 1 through 16
	Other controls are similar to those for graph A	

10. To change how the results are displayed, click on **Configure Graph.** Use the options, listed in Table 7-13 to make changes to the display.

Note: *The last saved configuration of this screen is saved in a file named IFA300GR.*CFG *and is recalled the next time the screen is used.*

Table 7-13
"Configure Graph" Control Options

Parameter	Description	Possible Values
Mode	Selects the graph modes.	**Clear** The screen is erased before the next set of data points are plotted. **Overwrite** New data is written over the old screen.
Scale	Scales the graph vertically.	**Auto** Automatically scales vertical axis to accommodate varying velocity results. **Manual** Lets you manually enter minimum and maximum velocity values to be used for scaling the graph.
Min Y Max Y	Minimum and Maximum velocity values for the graph to plot (used in Manual scaling only).	Can be any value within the range of the velocity calibration, **Max Y** must be greater than **Min Y.**
Close	Discards any changes you made and returns you to the real-time screen.	
Save	Saves the changes you have made and returns you to the real-time screen.	

External Trigger

For External Triggering, an additional BNC Connection must be made. A BNC cable should be attached between your trigger output and the BNC Connector labeled "EXT TRIG" on the BNC Connector Board.

The EXT TRIG signal at the BNC connector is normally high (at about +5 volts). Your device should bring this logic level signal to ground until the point in time at which you would like to start capture. THERMALPRO should be "Armed" and waiting for a trigger, and capture occurs on the next rising edge. If you use the pushbutton switch on the connector board, capture starts when you release the pushbutton. If you use a relay or other contact switch, best results are obtained with the contacts normally closed, thus pulling the internal ~5V to ground. Opening the contacts allows the voltage to go high, thus triggering a capture. It is best to operate with a signal that is normally low (at ground), rather than one that is normally high (at ~5V).

Switching noise is to be avoided. If the contacts do not open/close cleanly or the trigger signal generating device cannot produce a trigger signal with a clean low-to-high transition, THERMALPRO will become unstable, even to the point of freezing the entire PC. There must only be one low-to-high transition per capture, and no other transitions until THERMALPRO software is ready for another capture.

Note: *A "switch debouncing" circuit is recommended for user devices that generate a reset signal by a mechanical switch. Another means of eliminating switching noise is to use optical type switches. We point out that the "Ext Trig" button on the TSI connector board could occasionally generate switching noise and cause the PC to hang up. This is a result of it being a mechanical contact switch.*

The procedure for using an external trigger with THERMALPRO software is described below.

1. From the Acquisition-Conditions Setup screen, change the Trig Source selection box to "External".
2. For Mode "Graphics", go on to the next screen (Real-time Data Acquisition) by pressing **Next Screen**.
3. The "Acquire" button on the new screen should now be labeled "Arm". If it is not, check that the Trigger Switch is set to "Extern" on this screen.
4. Choose **Discard** or **Save** the Data as desired.
5. Press the **Arm** button once before the first triggering event. Triggering events will activate the trigger provided the processing of the prior event has been completed. The "Arm" button changes to "Stop".
6. To stop the external trigger mode, click **Stop** once immediately after the last trigger event. If you miss the 3-second window after the last external trigger event, manually trigger with the push button and click **Stop**.
7. For Mode "Write Only" the "Acquire" button will change to "Arm" and a new switch appears to "Stop" external triggering mode.
8. Press **Arm** once before the first triggering event. Triggering events will activate the trigger provided the processing of the prior event has been completed.
9. To stop the external trigger mode, click **Stop** once immediately after the last trigger event. If you miss the 3 second window after the last external trigger event, manually trigger with the push button and click **Stop**.

Using the Post Analysis Program

The post-analysis program allows you to calculate and display velocity statistics, time history, spectrum, autocorrelations and crosscorrelations and also to generate plots of statistical data and display flow field plots.

The following section describes how to use the Velocity, and Spectrum Analysis and Flow Field Options of the Post Analysis program.

Using the Velocity Option

The following steps outline how to use the Velocity option in the Post-Analysis program:

1. Select **Post Analysis** from the main menu and then **Velocity Analysis.** The screen shown in Figure 7-9 appears.

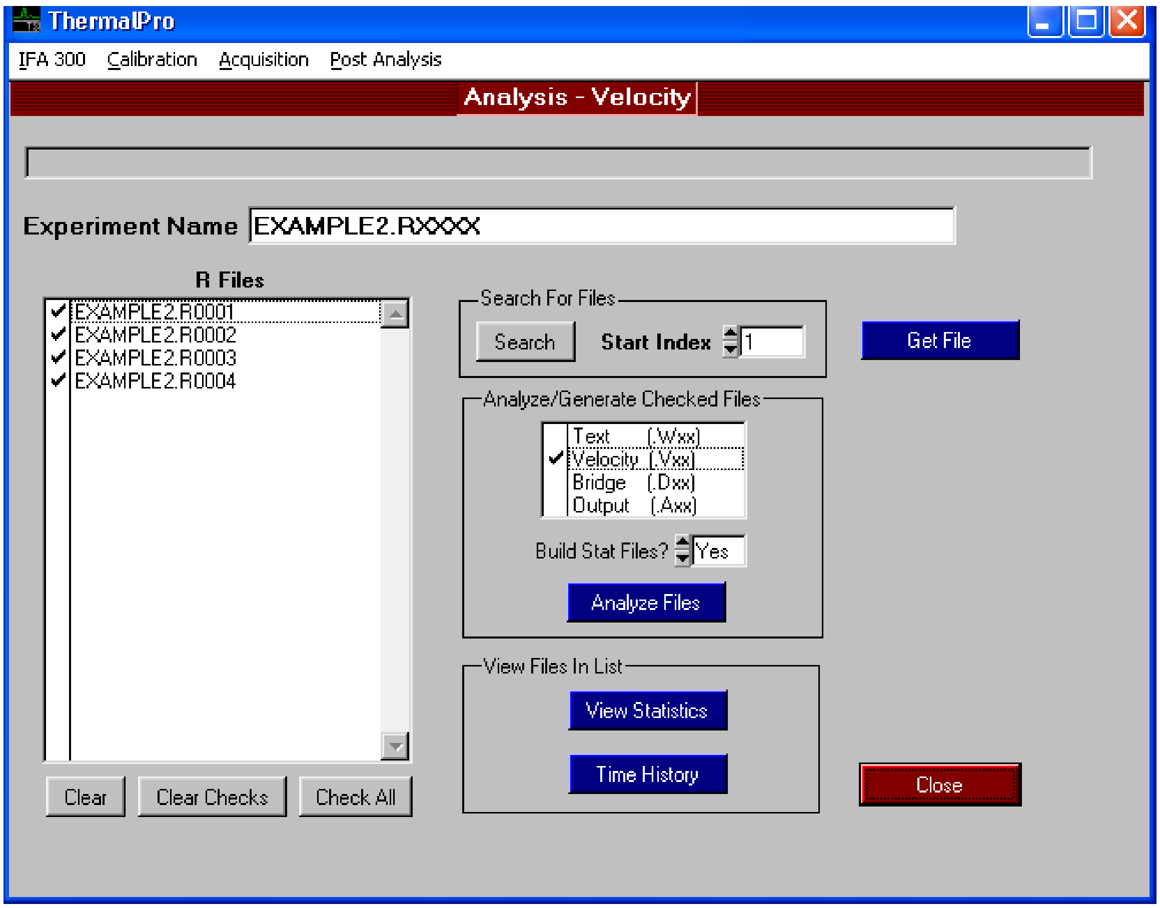

Figure 7-9
Post Analysis-Velocity Screen

2. If the file that you wish to analyze is not current, click on **Get File** option and select the file from the pop-up list to analyze or view and click **OK**. If there is a sequence of files, usually select the first file in the sequence. Next click **Search** and the sequence or group of files will appear in the "R files" table. If you only want files starting with a number, you can change the Start Index to show the first file of interest, before clicking on Search. Once you have a file list, the files with a check mark

will be analyzed when clicking **Analyze Files**. These check marks can be cleared or checked with the **Clear Checks** or **Check All** buttons or files can be individually checked or cleared by clicking on the filename. The entire list can be cleared with the **Clear** button.

3. If you are looking at a file that you have previously analyzed, go to step 5 or step 6.

Analyze and Generate Files	Indicate one of the following: **Velocity File** *(this is the default)* Creates velocity data and statistics files with extensions *.V* and *.S* when you click on the Analyze File option. The velocity file is in a binary format and the statistics file is in text form. **Velocity & Text File** In addition to the velocity and statistics file mentioned above, this option also creates a velocity file in text form, with an extension of *.W*. This file contains the velocity time history and can be exported to spreadsheet and graphics programs for further analysis. **Output Voltage File** Creates a file with signal conditioned output voltages with extensions of ***.A*.** **Output Voltage and Text File** In addition to the output voltage file mentioned above, this option also creates an output voltage file in text form with an extension of *.B*. This file contains the Output Voltage time history and can be exported to spreadsheet and graphics programs for further analysis. **Bridge Voltage File** Creates a file with calculated bridge voltages with extensions of **.D***. **Bridge Voltage and Text File** In addition to the bridge voltage file mentioned above, this option also creates a bridge voltage file in text form with an extension of *.E*. This file contains the bridge voltage time history and can be exported to spreadsheet and graphics programs for further analysis. Usually the Bridge voltage files and the output files are not useful except for troubleshooting the system.

4. Select **Analyze File** option.

   This will calculate the selected files from the raw data files and the calibration files.

   Once the velocity and statistics files have been generated, you can exit the Post Analysis program and return later or proceed with step 5 to view statistics or step 6 to view a time history or perform both steps.

5. Select **View Statistics** option.

The Velocity Analysis-Statistics screen appears (Figure 7-10).

This screen can be used to view or print statistics for any probe in a current velocity file. The table on the screen lists the probes associated with the velocity file. The filename with the extension, the position of the probe, the temperature recorded by the thermocouple module and the velocity magnitude are also displayed.

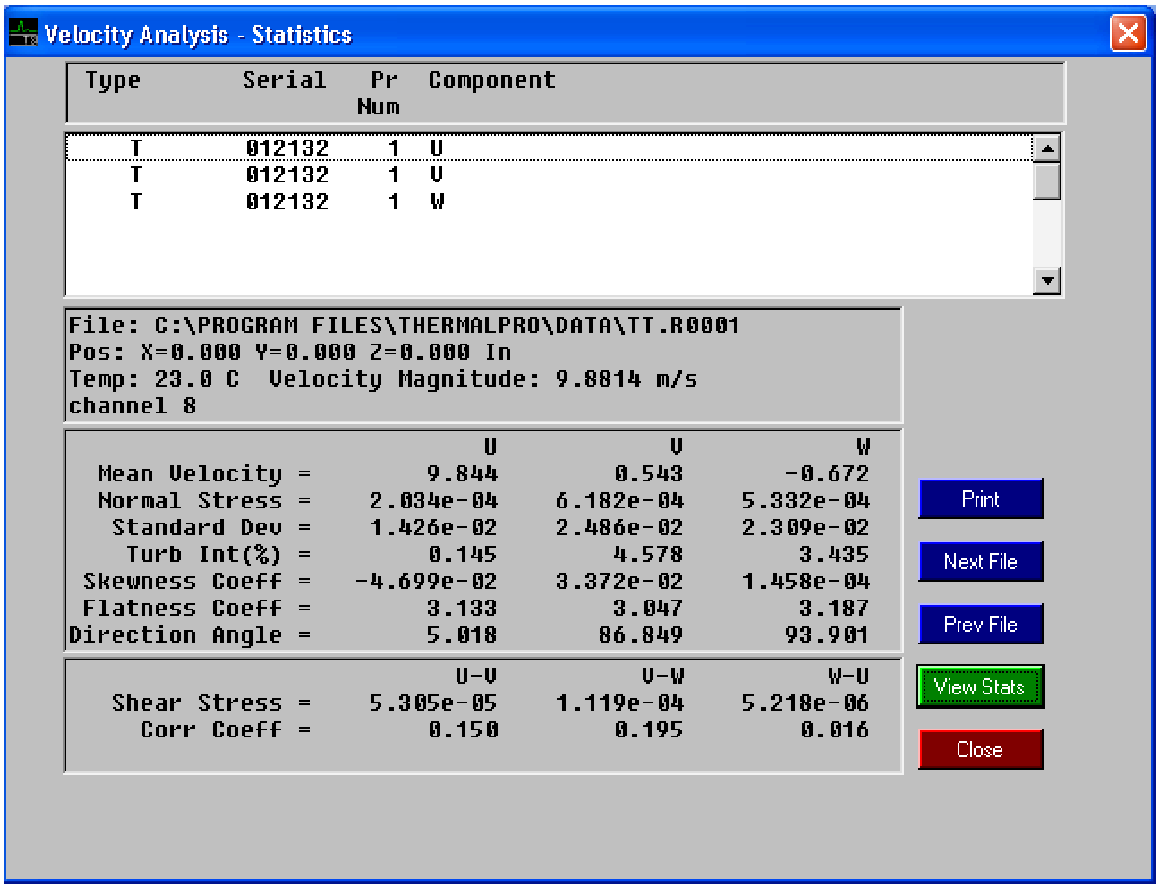

Figure 7-10
Velocity Analysis Statistics Screen

Table 7-14 lists the options and controls used in the Velocity Analysis-Statistics screen.

Table 7-14
Options and Controls in the Velocity Analysis-Statistics Screen

View Statistics	Click to list the statistics for the selected probe. See Appendix E for details on how the statistics are compiled.
Next File	Click to view statistics for the next file in the selected sequence.
Prev File	Click to view statistics for the previous file in the selected sequence.
View Stats	Refreshes the screen after selecting a new probe in the list.
Print	Click to send statistics to the printer.
Close	Click to return to the Analysis-Velocity screen.

6. Select **Time History** option from the Analysis-Velocity screen.

The Time History screen (Figure 7-11) appears. This screen is similar to the Real-time Display screen in the Acquisition Program, except that it is used to view *existing* velocity files. Table 7-15 lists the controls used in this screen in place of the trigger controls.

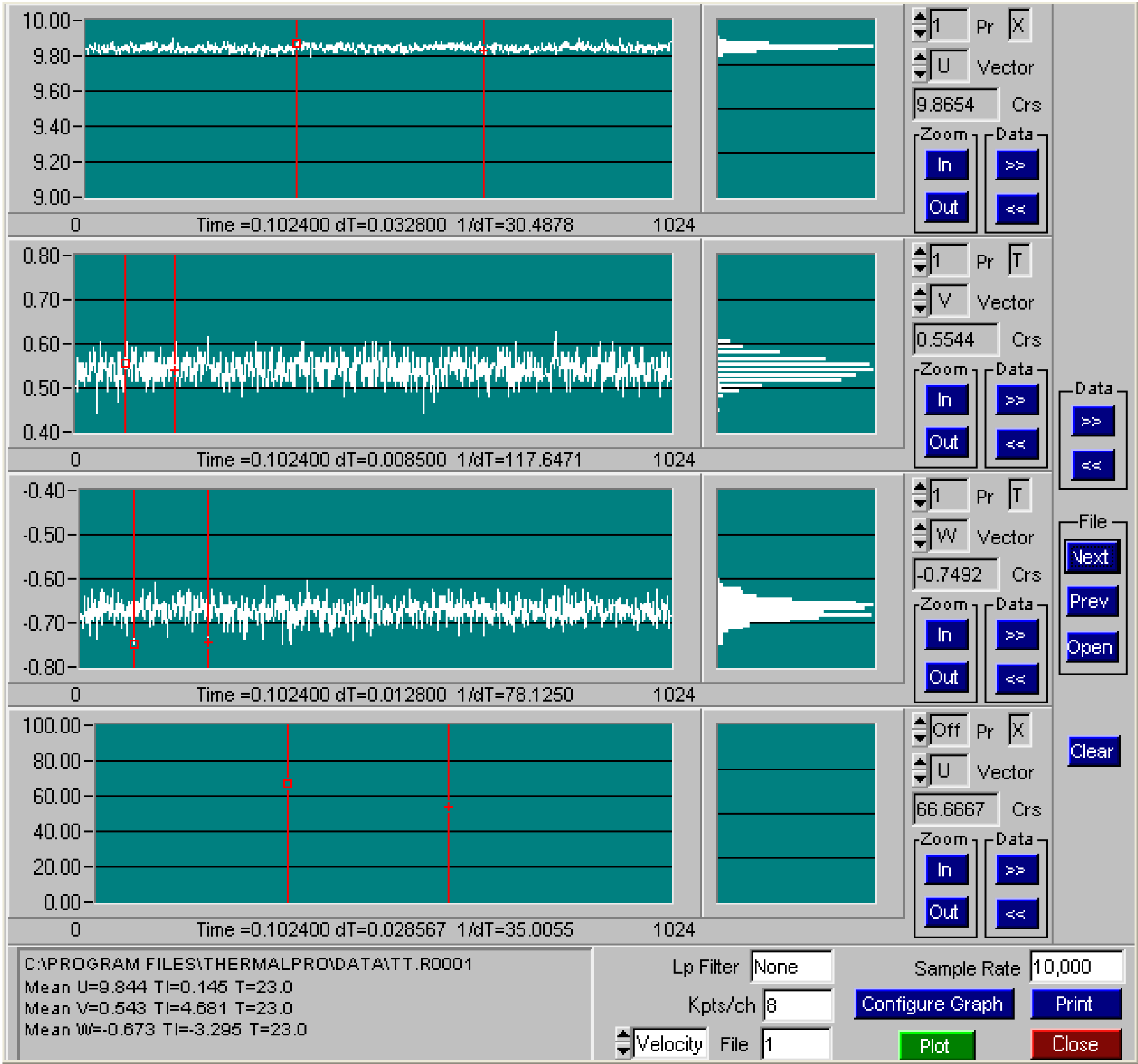

Figure 7-11
Time History Screen

Table 7-15
Time History Screen Options

Parameter	Description	Possible Values
File	Displays the numeric portion of the extension of the current velocity file.	0000 to 9999
Prev File/Next File	Click these controls to increment the file number up or down	
Open	Use this control to select a new file name	Any velocity file that has been analyzed
Configure Graph	A pop-up set of options that allow you to change the configuration of the graph. See table in Acquisition section for details.	
Clear	Click to clear the display.	

Parameter	Description	Possible Values
Print	Sends the screen to the graphics printer that is identified in the Windows Print Manager.	
Graph Scroll Control	If the current velocity file has more than a 1k block (1024 points), the right or left arrow control can be used make the graph display the next or previous 1k block	Individual graphs can be scrolled, or graphs A, B, C, and D can be scrolled together.
Velocity/Bridge/ Output	This control will usually be in the Velocity position, to display the velocity time history, but can be used to have the display show the bridge voltage or output voltage time history.	Velocity Bridge Output
Plot	Replots the data on the graph.	
Close	Close screen and return to Analysis-Velocity screen.	
Graph A Controls *(upper right)*		
Pr (Probe number)	Select probe number to be displayed on graph A. The probe type of the current probe is displayed in a small box.	1 through 16. Note that these are probe numbers and not channel numbers. For example, to view 3 vectors from a triple probe, select same probe # for all three graphs.
Vector	Select the velocity component of the current probe **U** - to display U component **V** - to display V component of x or triple probe **W** - to display W component of triple probe **Ut** - to display total velocity for x or triple probe **Th** - to display the angle that the total vector makes with the X axis (for x or triple probe) **T** - to display the time history of temperature if temperature is sampled on an A/D channel	
Crs (cursor display)	This box displays the amplitude (velocity) at the location of the left cursor. The cursor will snap to the closest point when moved with the mouse and can be used to find a local minimum or maximum velocity.	
Zoom In or Out	Zoom In will expand the data between cursors to fill up the graph. This can be repeated several times to see details in a smaller time period. ***Note:*** *When you zoom in or out on a graph, notice that the time, dT, and 1/dT values do not change immediately. However, once you move the vertical cursors after zooming in or out, the dT and 1/dT values will be correct for the zoomed view.*	
Graph B Controls *(center right)*		
Pr (Probe number)	Select the probe number to be displayed on graph B.	Off and 1 through 16
	Other controls are similar to those for graph A	

Parameter	Description	Possible Values
Graph C Controls *(lower right)*		
Pr (Probe number)	Select the probe number to be displayed on graph C.	Off and 1 through 16
	Other controls are similar to those for graph A	
Time= *(just below each graph)*	The time (in seconds) for the block of 1024 points.	
dT=	The delta time or the time between cursors. Drag the cursors with the mouse.	
1/dT=	The frequency of a fluctuation if the cursors are lined up with one cycle in a periodic flow.	
Primary Statistics. Mean U= TI= T= Mean V= T1= T= Mean W= T1= T= Mean th=	The mean velocity, turbulence intensity, and temperature values for Graphs A, B and C. The angle theta (th) can be plotted for *x*-probes or triple-probes. This is the angle between the total velocity (V_t) and the *x* axis.	**U,V,W** = Mean Velocity **TI** = Turbulence Intensity **T** = Temperature

Using the Spectrum Analysis Option

The following steps outline how to use the Spectrum Analysis option in the Post-Analysis program:

1. Select **Post Analysis** from the main menu and then **Spectrum/Correlation.** The screen shown in Figure 7-12 appears.
2. Click on **Get File**.

   Select **Velocity File** from the pop-up list.

   To perform spectrum analysis, go to step 3 and for autocorrelation or crosscorrelation, go to step 4.

*Turbulence Intensity = (Standard Deviation/Mean) × 100 (%)

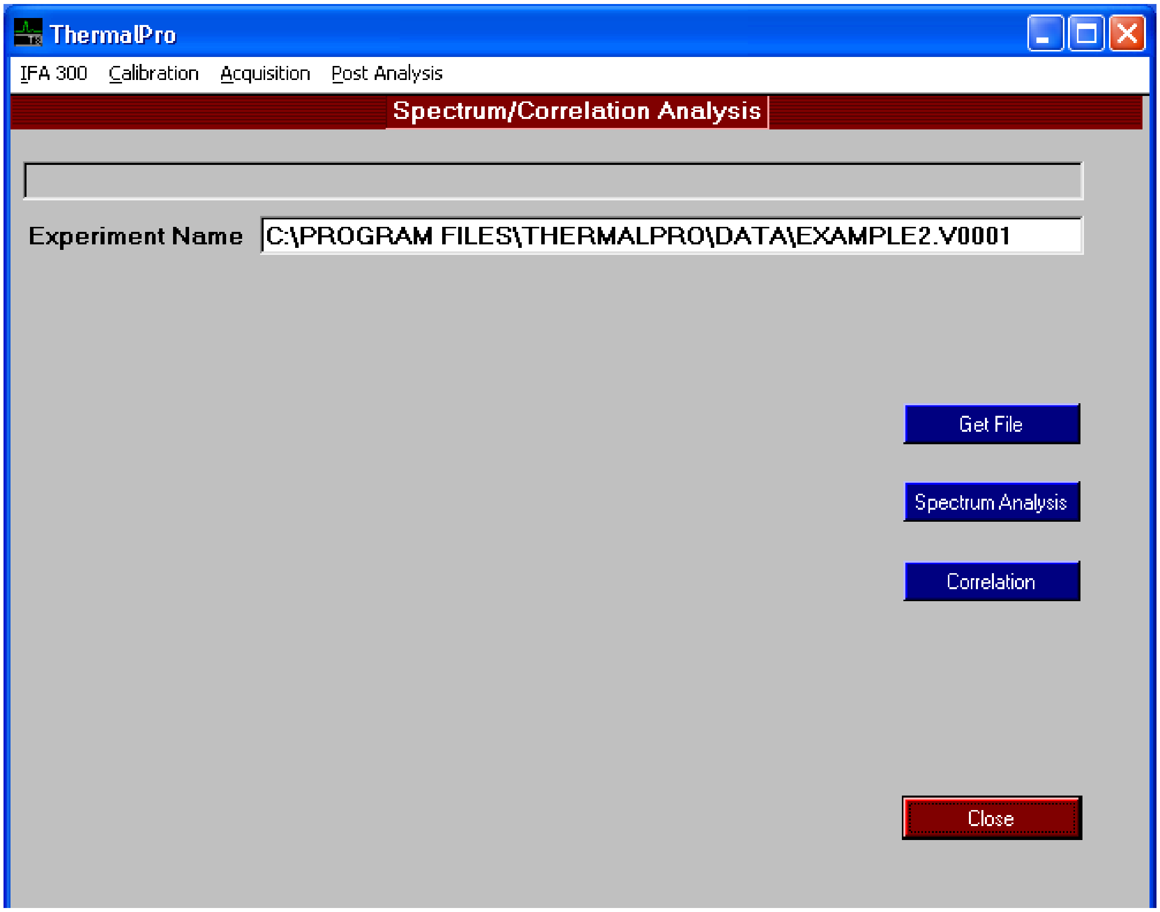

Figure 7-12
Spectrum/Correlation Analysis Screen

3. Click on **Spectrum Analysis**. The Spectrum Analysis screen appears (Figure 7-13).

   Click on **Plot** to display the power spectrum of the current probe in the velocity file. Displayed is the power spectral density in units of velocity squared per Hz plotted as a function of frequency in Hz. The scales are auto-ranged and can be set to any combination of log or linear scale.

   Table 7-16 lists the options and controls available on this screen.

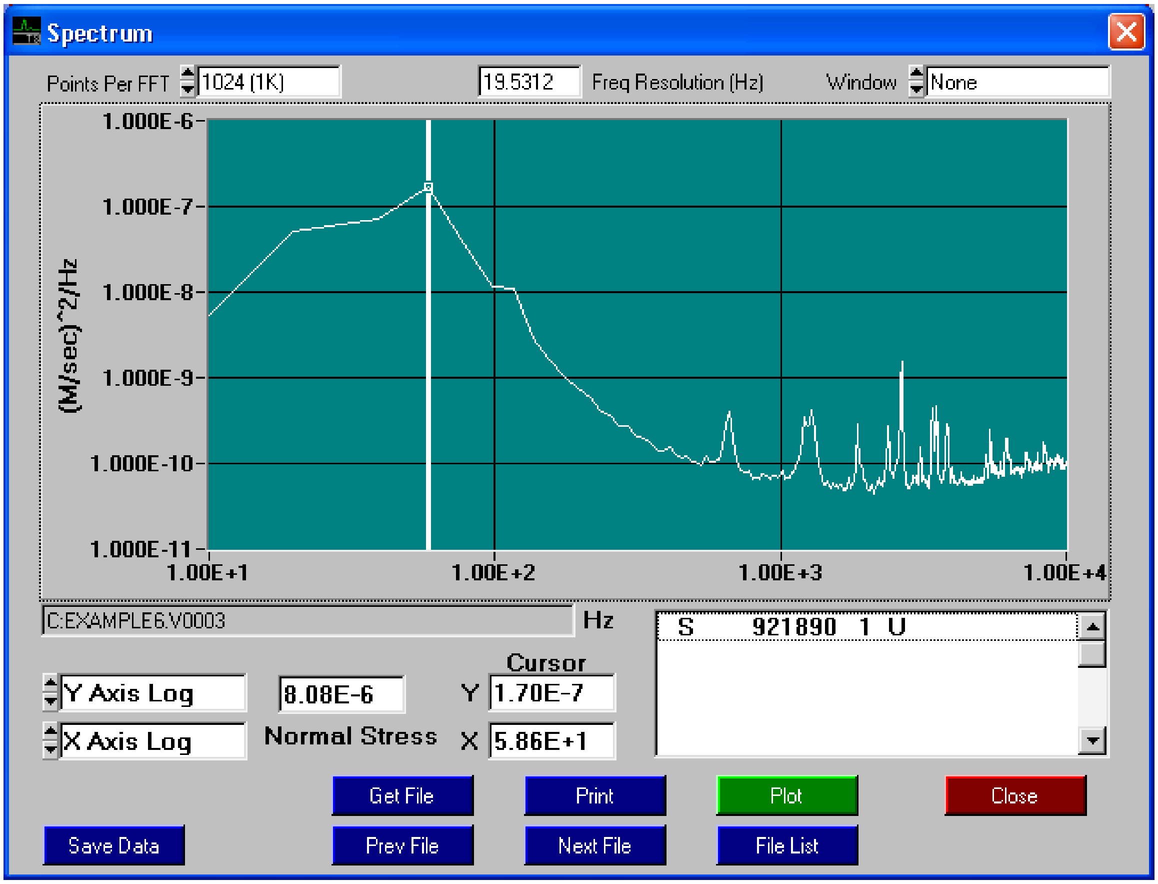

Figure 7-13
Spectrum Analysis Screen

Table 7-16
Options and Controls in the Spectrum Screen

Option/Control	**Description**
Get File	Click to select a new velocity file. The selected file is displayed in the box just above the probe list.
Print	Click to send screen to the graphics printer.
Plot	Click to draw or redraw the graph on the screen.
Points per FFT	Choose the block size to use in the calculation. This value cannot be larger than the acquired data block. If the value is smaller than the data block, the FFT is calculated for each segment and the FFT's are averaged.
Window	Windows can be applied to the calculations to reduce the end effects of the data blocks. Select a window and click on **Plot** to view the effect.
Prev File/Next File	Click these controls to increment the file number up or down.

Option/Control	Description
Vert Axis	Configures the vertical axis as linear or log.
Horiz Axis	Configures the horizontal axis as linear or log.
Normal Stress	This parameter is displayed. Normal Stress is the square of standard deviation.
Highlight Bar	Double-click to select another probe within the current velocity file.
Save Data	Click to name a file on which Spectrum data can be saved as a text file, with an extension of .X****
File List	Can be used to create multiple text files for a series of data files. After selecting the files to be created (with check marks), click **Go** to calculate and save the files.
Cursor	The cursor can be dragged with the mouse. The cursor windows indicate the *x* and *y* locations of the square symbol on the cursor.
Points per FFT	The FFT can usually be performed on the entire data file (up to block size of 256K) or the file can be broken up into segments of 256 to 256K in which case the FFT is done on each segment after which the results are ensemble averaged.
Frequency Resolution	The frequency resolution displays the resolution in Hz depending on the Points per FFT.
Normal Stress	This display is the Normal Stress of the velocity file and represents the area under the Spectrum plot.
Close	Click to discard any changes made in the screen and return to the previous screen.

4. Click on **Correlation**. The Correlation screen appears (Figure 7-14). This screen allows you to perform autocorrelation on velocity data files. You can also do crosscorrelation of two velocity signals from the same data file or from different data files.

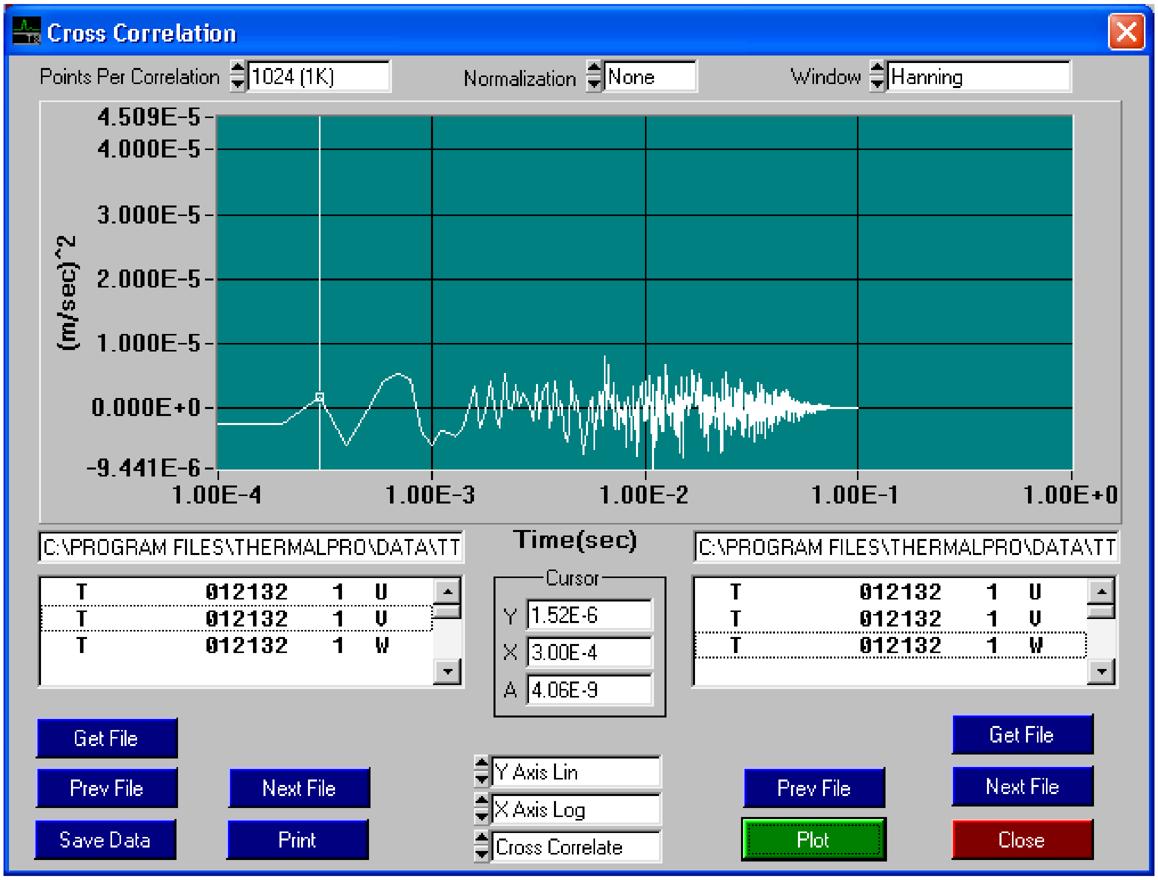

Figure 7-14
Correlation Screen

Table 7-17 lists the options and controls available on this screen.

Table 7-17
Options and Controls in the Correlation Screen

Option/Control	**Description**
Get File *(Left)*	Click to select velocity file to use for autocorrelation or for first signal in crosscorrelation.
Get File *(Right)*	Click to select the second signal for crosscorrelation, cross power spectrum, or coherence. ***Note:*** *This control is not active in Auto-correlation mode.*
Points per Correlation	The Correlation can usually be performed on the entire data file (up to block size of 256K) or the file can be broken up into segments of 256 to 256K in which case the FFT is done on each segment after which the results are ensemble averaged.
Normalization	If normalization is selected, the data vertical axis is normalized about zero.

Option/Control	Description
Window	Windows can be applied to the calculations to reduce the end effects of the data blocks. Select a window and click on **Plot** to view the effect.
Print	Click to send screen to the printer.
Plot	Click to draw or redraw the graph on the screen.
Save Data	Click to name a file on which data can be saved as a text file.
Cursor	The cursor can be dragged with the mouse. The cursor windows indicate the *x* and *y* locations of the square symbol on the cursor.
Close	Click to discard any changes made in the screen and return to the previous screen.
Y Axis	Selects linear or log scale for the y-axis.
X Axis	Selects linear or log scale for the *x*-axis.
Correlate Mode	Selects autocorrelation, crosscorrelation, cross power spectrum, or coherence mode.
Highlight Bar	Double click on probe list to select another probe within the current velocity file.

Using the Flow Field Plotting Option

The following steps outline how to use the Flow Field Plotting option in the Post-Analysis program:

1. Select **Post Analysis** from the main menu and then **Flow Field** from the pull-down menu**.** The screen shown in Figure 7-15 appears.

   This screen is used to build a plot file (named *.PLT) which is a chart with the filename(s) of the data files that you will plot, the first and last file number in the sequence, the number and type of probe to be plotted and any comment you may have included. A .PRN file (named *.PRN) is also created. This text file contains all statistics and position data for the selected probe and file sequences.

   Using an example to help you follow the rest of the steps, let us assume that we have acquired raw data files EXP.R0001 through EXP.R0011, and used the Statistics program to create velocity files EXP.V0001 through EXP.V0011 and statistics files EXP.S0001 through EXP.S0011. Now, we would like to plot the mean velocity vs. position.

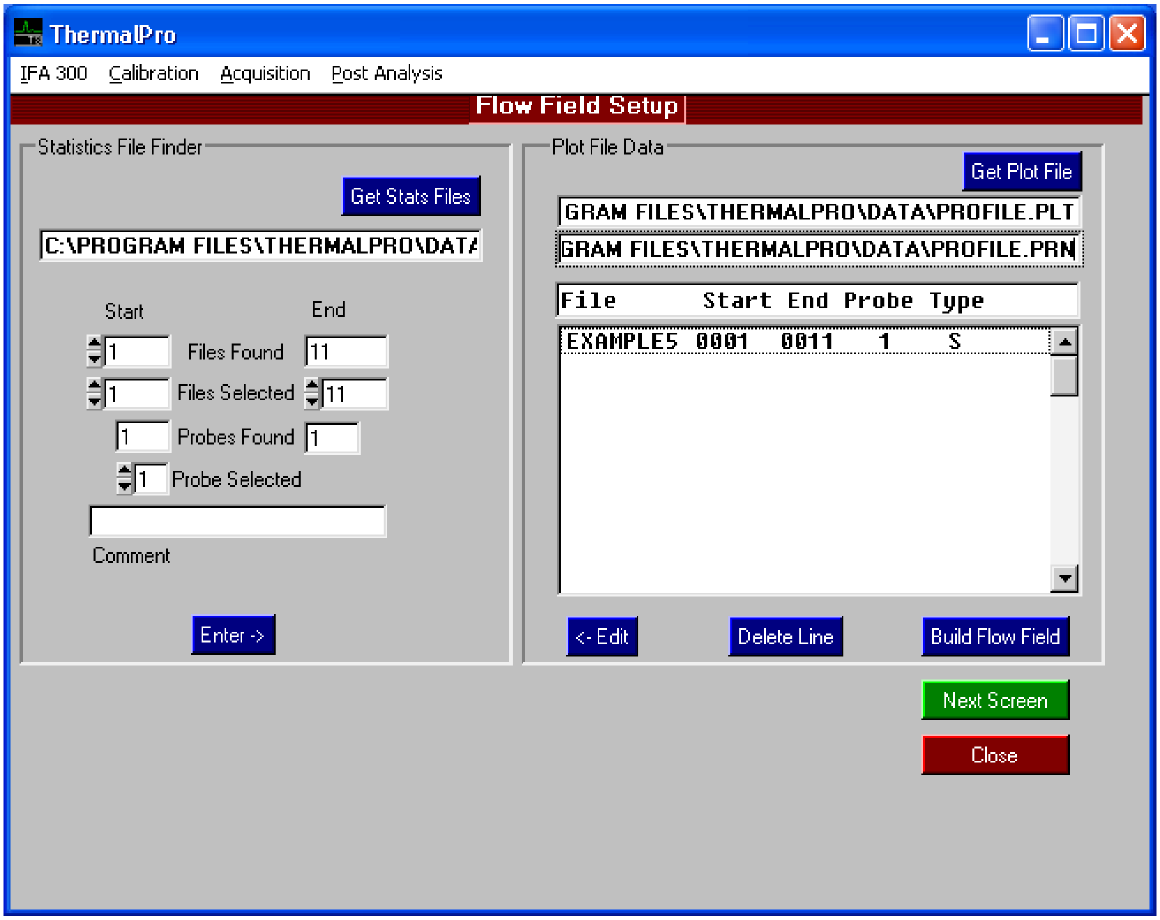

Figure 7-15
Flow Field Setup Screen

2. Select one of the following options:

If you have already created plot files, click on **Get Plot File**. Select the previously-created plot file, and then proceed to the Flow Field Plot screen by clicking on **Next Screen.**

If you are starting from scratch, click on **Get Stats Files**. Select the first file in the sequence. In our example it is EXP.S0001. Table 7-18 lists the displayed parameters and the selections you can make.

Table 7-18
Plot File Parameters

Parameter	**Description**
Files Found	Indicates the first and the last file number in the sequence.
Files Selected	Enter first and the last file number in the sequence, if you need to select only part of the sequence.

Parameter	Description
Probes Found	Displays the number of probes found.
Probe Selected	Select Probe Number if the file has data for more than one probe.
Comment	Enter any comments (up to 50 characters) in this line.

3. Click **Enter Line** to enter data in the Plot File Data chart.

   Repeat steps 2 and 3 to append the plot file with additional files.

4. Click on **Build Flow Field** and enter a plot filename in the pop-up screen. Click on **OK**. Another pop-up screen appears. Click **OK** again. This saves the PRN file with the same name as the plot file (but with a different extension).

5. Click on **Next Screen** to proceed to the Flow Field Plot screen (Figure 7-16).

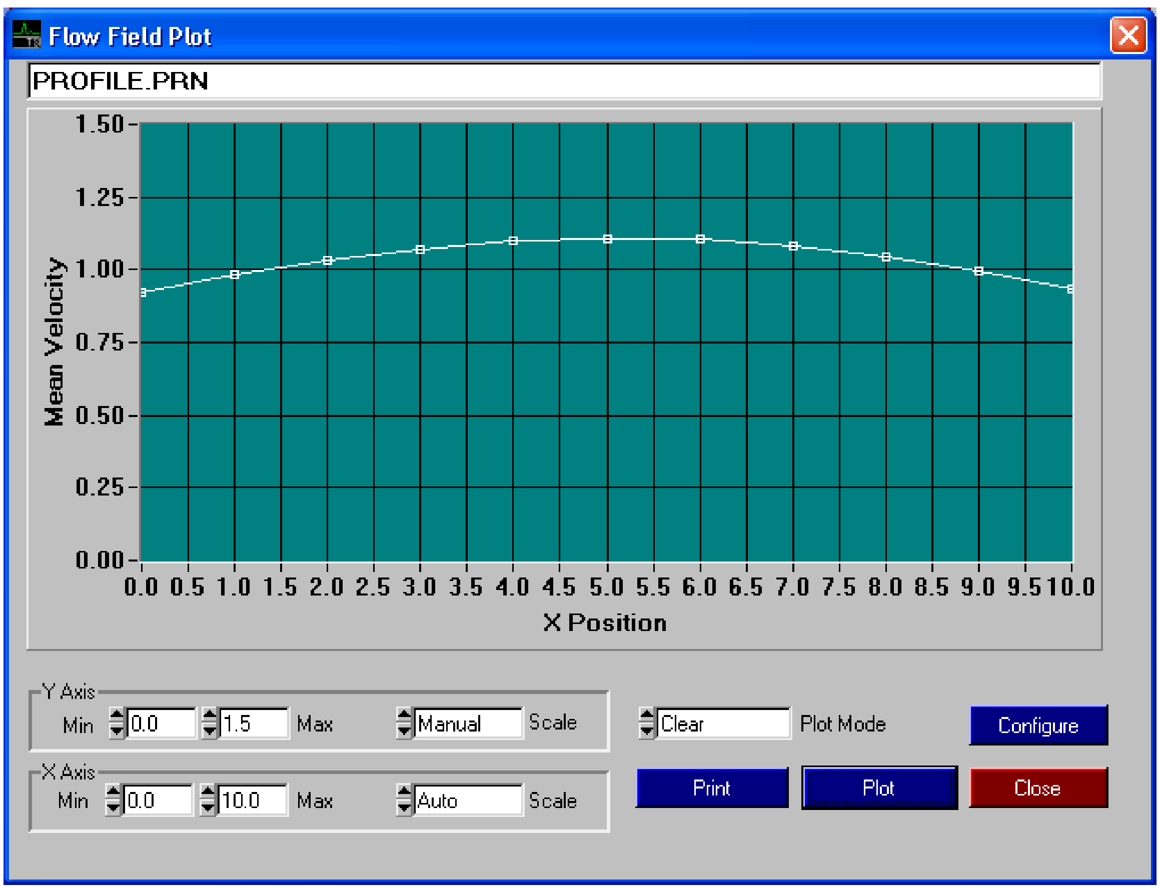

Figure 7-16
Flow Field Plot Screen

6. Click on **Plot** to write the plot to screen. Table 7-19 lists the options that you can select to format the graph.

Table 7-19
Options and Controls on the Flow Field Plot Screen

Scale	Select **Auto** or **Manual** for the *x*- and the *y*-axes.
Min/Max	Enter **Minimum** and **Maximum** values, if you have selected Manual scale for the *x*- or *y*-axis.
Plot Mode	Select **Clear** to plot only one statistical parameter on the screen. Select **Overwrite** to add parameters to your graph.
Print	Select to send plot to a graphics printer
Plot	Select to replot the current graph
configure	Select to access additional parameters listed in Table 7-20.

Table 7-20
Additional Options in the Configure Flow Field Plot Screen

Mode	Select **Symbol & Line, Symbol Only,** or **Line Only**.
Type	Select **Dimensional** or **Normalize** for either or both axis.
View	Choose ***u, v*** or ***w*** component, if you have a multi-sensor probe.
Axis 1 Scale Stat	Select the position axis to be either the horizontal or the vertical axis. ***Note:*** *When you change from horizontal to vertical, Axis 2 is automatically changed.* Select **linear** or **log** Select **X, Y, Z, or Mean Velocity** to be plotted on Axis 1.
Axis 2 Scale Stat	This axis will be opposite axis 1. Select **linear** or **log.** Select a statistic, from the following list, to be plotted against the position axis. Mean Velocity Normal Stress Standard Deviation Turbulence Intensity (%) Skewness Coefficient Flatness Coefficient Direction Angle (degrees) - x or triple probe only Shear Stress - x or triple probe only Correlation Coefficient - x or triple probe only

APPENDIX A

Specifications

This appendix lists the specifications—which are subject to change—for the IFA 300 System.

Table A-1
Specifications of the IFA 300 System

Number of channels	One to eight in first cabinet and up to eight in second cabinet.
Amplifier drift	0.3 μV/°C
Amplifier input noise	1.7 nV/√Hz and 1.5 pA√Hz
Frequency response	260 kHz (3.8 μm) diameter tungsten wire, 100 m/s velocity
Maximum probe current	0.8 A (1.6 A with high power bridge)
Maximum bridge voltage	12 VDC
Signal conditioner Offset Gain	 0 to 10 V in 0.01 volt steps 0.15% accuracy 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 ,12, 14, 16, 18, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 500, 600, 700, 800, 900, 1000 1.5 MHz maximum bandwidth 0.15% accuracy
Output range, after signal conditioner	-5 to +5 VDC
Analog output impedance	50 Ω
Resistance measurement	0.1% ±0.01 Ω
Sensor operating resistance	From 1.5 Ω to 80 Ω in 0.01 Ω steps.

Analog-to-digital converter Resolution Sampling rate	 12-bit Select from a range of 1 to 500,000 samples per second (Hz) in a 1, 2, 5, 10, 20 sequence. In addition, 600, 4,000, 40,000, 250,000, 277,777, 416,666, and 714,285 Hz can be selected. ***Note:*** *One channel can be sampled at 714,285 Hz, two channels at 416,666 Hz, three channels at 277,777 Hz. All sampling rates are on a per channel basis. The total throughput for 4 or more channels can be 1 MHz.*
Low pass filters	Linear phase, 12 Hz to 1 MHz; 13 settings; -60 dB/decade
High pass filters	0.1, 1, 10 Hz; -60 dB/decade
Cable length	5 m or 30 m; RG-58 A/U (other lengths available with factory setup)
Size	17.8 cm × 48 cm × 41 cm (7 in. × 19 in. × 16 in.); standard 19-inch rack mount
Input power	100/110/220/240 VAC, 50-60 Hz
Temperature measurement	Built-in thermocouple circuit in each cabinet.
Operating temperature	0° to 40°C
Sample/Hold	True simultaneous sample/hold.
Computer requirements	Windows XP/7 (32-bit only) computer with available PCI slot for data acquisition board and at least one available serial (com) port.

APPENDIX B

RS-232-C Commands

RS-232-C commands are used to control the IFA 300 parameters and also to transfer information such as the data rate back to the computer. This appendix gives you the following types of information on the RS-232-C commands.

- ❑ Format of RS-232-C Commands and Responses
- ❑ Rules and Conventions
- ❑ Command Examples
- ❑ Error Codes
- ❑ IFA 300 Commands

You need this information only if you are writing your own communications software.

Format of RS-232-C Commands and Responses

Figure B-1 shows the structure of the RS-232-C commands and responses.

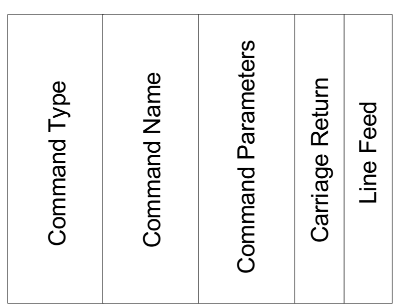

Figure B-1
Command and Response Structure

Command Type	The type of command.
Command Name	The name of the command.
Command Parameters	The parameters, if any, for the command.
Carriage Return	Represented by the ASCII character (C_r).

Line Feed	The end delimiter, which is indicated by the ASCII character (L_f).

Here is an example of an RS-232-C command:

CONF	:ROP	5.12
Command Type	Command Name	Parameter

This command, CONF:ROP 5.12 CONFigures the Resistance OPerating to 5.12 ohms.

Rules and Conventions

The following lists the rules and conventions for the RS-232 commands:

- Upper or lower case characters are allowed.

  Example, GAIN? or gain?.
- Items in brackets <> are mandatory for the command.
- Items with question marks only return values.
- Commands that do not have a channel listed should be preceded with a INST:NSEL <*channel*> command.
- Valid channel numbers are 1–16 with 1–8 in the IFA 300 with Port A connected to a host computer and 9–16 in the IFA 300 with its Port A daisy chained to Port B.
- Multiple commands in one command string are supported; however, they must be of the same command type. Command name strings must be separated by a semicolon and a colon. If the command requires parameters, the parameters must have a space separating the argument from the command. If channels 9 and above are used, a multiple command string cannot be used on these channels. However, they can still be used on channels 1–8.
- The maximum size of a command string is 80 characters including the <cr><lf> characters and the terminating NULL character.

Command Examples

The following lists examples of valid and invalid commands followed by an example communication session using a set of the IFA 300 commands.

Examples of Valid Multiple Command Strings

The following are examples of valid commands. Each of the processed commands returns a <cr>and an <lf> character. Since these are valid commands, three sets of <cr><lf> characters are returned for each of the command strings.

Command:

```
CONF:GAIN 25;:OFFS 3.55;:RES 8.02<cr>
```

Response:

```
<cr><lf>
<cr><lf>
<cr><lf>
```

Command:

```
READ:GAIN?;:OFFS?;:RES?;:PROB?<cr>
```

Response:

```
1<cr><lf>
0.00<cr><lf>
5.00<cr><lf>
W<cr><lf>
```

Example of an Invalid Multiple Command String

The following is an example of invalid command strings. Here only one set of <cr><lf> characters is returned. This indicates that the first command was processed properly and the status error flag was set to an error code caused by the incorrect second command syntax (a missing colon before the command) and command processing was stopped after the first invalid command in the string. See Error Codes for definitions of errors.

Command:

```
INST:NSEL 3;GAIN 25<cr>
```

Response:

```
<cr><lf>
ERRORS 1<cr><lf>
```

Example of a Communication Session

Following is an example of a typical communications session that occurs when the system is being used. It illustrates the order in which the IFA 300 commands are sent.

Step 1: After the software starts up, initialize the system by sending:

INST:IFA?
INST:CNUM?
*STAT?

Step 2: Set up the channel(s)

For a single channel:

INST:NSEL 1
CONF:RCBL 0.31
MEAS:RMES
*OPC?
READ:RMES?
INST:NSEL 1
CONF:HPWR 0
CONF:CABL 0
CONF:PROB F
CONF:GAIN 4
CONF:RCBL 0.31
CONF:ROP 9.08
CONF:OFFS 1.80
CONF:TEMP 0
INIT:STAR 1
INIT:STAT? 1

For two channels:

```
INST:NSEL 1
CONF:RCBL 0.31
INST:NSEL 2
CONF:RCBL 0.30
MEAS:RMES
*OPC?
INST:NSEL 1
CONF:HPWR 0
CONF:CABL 0
CONF:PROB F
CONF:GAIN 4
CONF:RCBL 0.31
CONF:ROP 9.08
CONF:OFFS 1.80
CONF:TEMP 0
INST:NSEL 2
CONF:HPWR 0
CONF:CABL 0
CONF:PROB W
CONF:GAIN 5
CONF:RCBL 0.30
CONF:ROP 11.03
CONF:OFFS 1.10
INIT:STAR 1
INIT:STAT? 1
*STAT?
INIT:STAR 2
INIT:STAT? 2
*STAT?
```

Step 3: With the probe running, set the low-pass filter when ready to acquire data:

For one channel:

```
INST:NSEL 1
OUTP:FILT 1KHZ
```

For two channels:

```
INST:NSEL 1
OUTP:FILT 1KHZ
INST:NSEL 2
OUTP:FILT 1KHZ
```

Step 4: To stop acquiring data and to shut down:

```
ABOR
```

Error Codes

The following gives a list of returned error codes:

-100	INST Base command syntax error.
-101	Channel number is not valid.
-102	Attempt to access board not installed.
-110	CONF Base command syntax error.
-111	Set gain on channel failed.
-112	Set offset voltage failed.
-113	Set probe type failed.
-114	Set of resistor value failed.
-115	Set cable length failed.
-116	Set hi power bridge failed.
-117	Setting overheat ratio failed.
-120	READ Base command syntax error.
-121	Read of 8-bit a/d produced an invalid number.
-122	Xmit of last temp value failed.
-130	MEAS Base command syntax error.
-131	Measure resistance failed.
-132	Measure temp with 12-bit failed.
-140	INIT Base command syntax error.
-141	Missing channel number on command line.
-142	Channel already is already in run mode.
-143	Stop a channel that is not running.
-144	High-power bridge is selected with a wire probe type. This is not allowed.
-150	TEST Base command syntax error.
-151	Processing test command failed.
-160	STAT Base command syntax error.
-170	OUTP Base command syntax error.

-171	Set high pass filter failed.
-172	Set low pass filter failed.
-173	Invalid channel.
-300	Invalid command received. Second level command syntax error.
-301	No anemometer boards detected at power on.
-303	A channel is indicating a FAULT condition.
-304	An invalid channel was read at power on.

Command Descriptions

The following lists the various IFA 300 commands.

System Commands

The following lists the system commands.

Command	Description
*RST	Sets a relay that causes the 68HC16Z1 micro-controller to go into reset processing. The unit comes back in a first-time power on condition with all default settings.
*IDN?	Reads the firmware version number and model number.
INST:IFA?	Tests for subsequent IFA 300 unit daisy chained on the serial port. Command must be sent to talk to the second unit. Returns 1 if second IFA 300 is present, 0 if not.
INST:CNUM?	Returns the number of total channels.
INST:NSEL <channel>	Makes the selected channel current.
OUTP:VOLT <channel>	Routes the selected channel bridge voltage for monitoring the output BNC **Selected Bridge** on the back panel of the IFA 300. There is no filtering or signal conditioning on this signal.
*OPC?	Queries Operation Complete status.
*STAT?	Reads error code queue.

Bridge Commands

The following lists the bridge commands.

Command	Description
CONF:RCBL <decimal value>	Sets the cable resistance used by the IFA 300 for calculating the bridge resistance to set on each channel and to find the cold resistance of the each probe after measuring.

Command	Description
MEAS:RCBL	Measures cable resistance. Global unless followed by channel number. The IFA 300 assumes there is a shorting cap at the end of the cable and makes a resistance measurement. This value is stored for each channel. This value must be in place in the IFA 300 prior to setting the operating resistance. If it is not measured by the IFA 300, you should set it manually using the CONF:RCBL command.
READ:RCBL?	Reads the cable resistance of the selected channel.
CONF:RMES <value>	Manually sets the measured resistance for the selected channel. Use this command if you want to use the resistance reading from an external meter.
MEAS:RMES	Starts the resistance measurement sequence. Global unless followed by channel number. The last resistance settings for the channels is not changed. This takes about 3 seconds and measures all channels installed. It is important that you do not change the channel number during this operation. Use the *OPC? command to find when the routine is completed. The routine sets the channel number to 1 and sets the bridge voltage output BNC to channel 1 when finished. If just one channel needs to be measured, an optional channel number may be included in the MEAS:RMES <channel> command and the command measures the resistance only on the given <channel>. This does not change the selected channel number. To read the measured resistance first use the INST:NSEL <channel> command.
READ:RMES?	Reads the measured resistance value for the current channel. If a measured resistance is run before this command, that measured resistance value is returned or else a zero is returned. This value is up to two decimal places.
CONF:ROP <value>	Tells the IFA 300 firmware the operating resistance of the probe.
READ:ROP?	Reads the operating resistance for the current channel as set by the host computer.
READ:ANEM?	Reads the anemometer type for the selected channel. This is set in hardware and can only be read. Constant Temperature Anemometer (CTA) is 1 and Constant Current Anemometer is 0.
CONF:PROB <"W," "F," "N">	Tells the IFA 300 what type of probe is used on each channel. This is needed in the over-heat-ratio routine in the IFA 300 firmware.
READ:PROB?	Returns "W" for wire, "F" for film, and "N" for non-cylindrical sensor. Default: WIRE
CONF:HPWR <0 or 1>	Turns "ON" the high power bridge with a <1> and off with a <0>. The high power bridge cannot be "ON" during a resistance measure or with a WIRE type Probe. If it is "ON" during resistance measure, the IFA 300 turns it "OFF" and the resistance measure but will NOT turn it back on until the command is resent.

Command	Description
CONF:CABL <0 or 20>	Tells the anemometer the length of the cable that is connected to the probe. Zero is default (5 meters) and 20 is for 30 meters.
INIT:STAR <channel>	Starts run mode on a channel if a cable resistance, an operating resistance and a measured resistance were set. Make sure the sensor type has been set with the CONF:PROB command.
INIT:STOP <channel>	Takes channel out of run mode and puts in standby.
INIT:STAT? <channel>	Returns 1 for run mode and 0 for standby.
ABOR	Places all channels in STOP mode.
CONF:OVHT< hex value 0 - FF>	Sets the over heat relays. The relays are normally set with the ratio of operating resistance/measured resistance. This is done in the firmware of the IFA 300. You cannot go into run mode unless both measured (probe) resistance and operating resistance are set in the IFA 300—you get an error code.
READ:OVHT	Reads the over-heat-ratio calculated by Rop/Rcold. It can be read while in run mode only. These ratios are cleared after stop mode and must be recalculated each time before going into the run mode.
READ:BDGV?	Reads the bridge voltage on the selected channel. A 10-bit A/D conversion is done. The returned value is the 10-bit conversion converted to ASCII. The bridge voltage range is adjusted by the firmware to span a 12-volt range with a 5-volt A/D converter input range, so the voltage read by this command is equal to the (bit value * 2.4). To read bridge voltage from a channel, select the channel number then send the read bridge voltage command. The command is processed in the IFA 300 with the channel selected.

Signal Conditioner Commands

The following table lists the signal conditioner commands.

Command	Description
CONF:GAIN <value>	Sets the gain of the signal from the bridge output on the back panel. Only valid settings are allowed. Valid gain settings are: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 500, 600, 700, 800, 900, 1000.
CONF:OFFS <value>	Sets the offset voltage for the channel selected. This is in the form of 0–10.24 volts in .01v steps.

Command	Description
READ:GAIN?	Returns the gain setting for that channel. See valid gain settings above.
READ:OFFS?	Reads the last offset value set on channel. Returns a ASCII value using two decimal places.
OUTP:FILT <value>	Sets the low-pass filter value on channel selected. The <value> must be an ASCII string corresponding to a valid filter setting. Valid Low-Pass Filter Settings: (Frequency in Hertz) 10HZ, 100HZ, 300HZ, 1KHZ, 2KHZ, 5KHZ, 10KHZ, 20KHZ, 50KHZ, 100KHZ, 200KHZ, 500KHZ, 1MHZ, BVSC. Enter these as ASCII strings to set the proper filter. If no filtering is needed, then enter BVSC which will disable the filters. Example: OUTP:FILT 5KHZ Sets the 5 kHz filter on.
OUTP:HPAS <value>	Sets the high-pass filter value on the selected channel. The <value> must be an ASCII string corresponding to a valid filter setting. Valid high-pass filter settings: (Frequency in Hertz) 10HZ, 1HZ, .1HZ, BVSC. Enter these as ASCII strings to set the proper filter. If no filtering is needed, then enter BVSC which will disable the filters.

Temperature Commands

The following table lists the temperature commands.

Command	Description
CONF:TEMP <0, 1>	Sets the temperature range used by the thermocouple to measure the temperature of the flow. 0 = 0–50°C and 1 = 0–200°C.
MEAS:TEMP <A or B>	(*Optional)* If channel is blank or A, the IFA 300 reads the temperature of the thermocouple in the first box, calculates the temperature, and saves this value in RAM. Adding the optional “B” does a measure temperature using the A/D in box “B” if more than one IFA 300 is connected together.
READ:TEMP? <A, or B>	(*Optional)* If channel is blank or A, reads the last value measured using the MEAS:TEMP command that was stored in RAM. Adding the optional “B” reads the last measured temperature from unit (B) in the IFA 300 RS-232 daisy chain.

APPENDIX C

Line Voltages and Fuses

This appendix gives information on line voltages and fuses. The IFA 300 can operate on several AC line voltages (100, 110, 220, or 230 volts). The IFA 300 automatically senses the line voltage and sets itself. The fuse selection, however, should match the line voltage. Table C-1 lists the fuses for each line voltage.

Table C-1
Matching the Fuse to the Line Voltage

Line Voltage (VAC)	**Fuse Rating (A/V)**
100–110	5.0/250
220–230	2.5/250

Checking and Changing Fuses

Before installing the IFA 300, make sure the fuse is compatible with your site. The IFA 300 works with both North American and European-style fuses. The 110-volt model comes with the American-style fuse and the 240-volt model is equipped with the European-style fuse. If you need to change the fuse from North American (Figure C-1) to the European style (Figure C-2), follow these steps:

1. Disconnect the power from the IFA 300 and remove the line cord.
2. Lift off the fuse on the back panel of the IFA 300 cover using a small-blade screwdriver or similar tool.

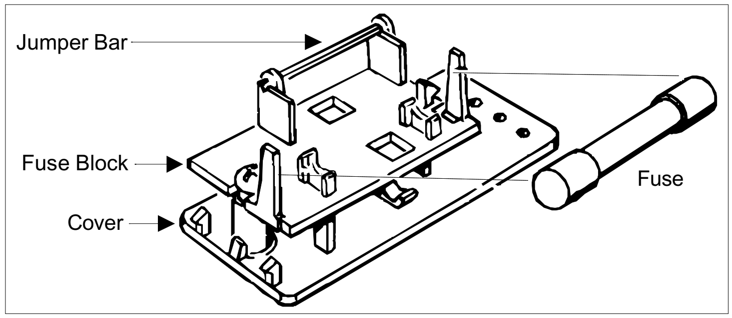

Figure C-1
North American–Fusing Arrangement

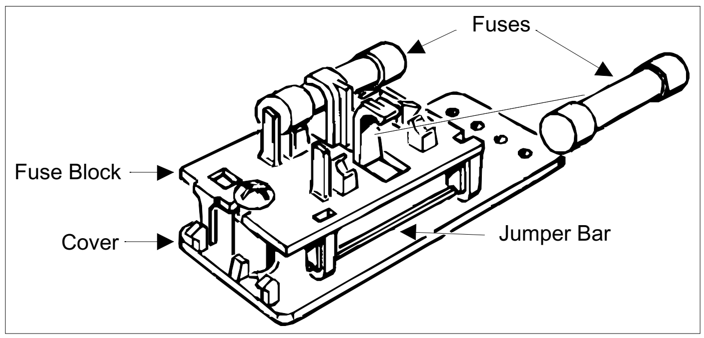

Figure C-2
European–Fusing Arrangement

3. Loosen the screw on the fuse block two turns.
4. Remove the fuse block (Figure C-3) by sliding it up and away from the screw. Lift the block from the pedestal.

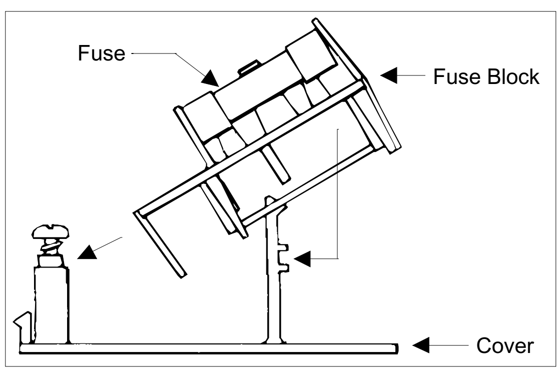

Figure C-3
Fuse Block/Cover Assembly

5. Change the fuses. Two European fuses are required. Invert the fuse block and slide it back onto the screw and the pedestal.

6. Tighten the screw and replace the fuse module cover. The fuse that enters the housing first is the active one.

Replacing Faulty Fuses

The IFA 300 uses a 5-amp (250 volt) fuse. To replace a faulty fuse, follow these steps:

1. Disconnect the power from the IFA 300 and remove the line cord.
2. Lift off the fuse on the back panel of the IFA 300 using a small-blade screwdriver or similar tool.
3. Replace the fuses.

   Note: *Two European-style fuses are required for 220–230V operation.*

4. Replace the fuse module cover.

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APPENDIX D

Calibration Setup

This appendix describes how to set up the IFA 300 system for calibration.

Calibration Overview

To calibrate a probe, you need a calibration nozzle or flow tunnel, or some other means of setting the probe in a steady flow, with known velocity, that can be changed from zero velocity to the maximum velocity of interest. A pressure transducer or manometer is normally used to measure the differential pressure across a nozzle or across the taps of a Pitot probe that is positioned in the flow near the probe to be calibrated. In this way the velocity is determined, and a correspondence to the IFA 300 bridge voltage is developed.

Bernoulli's equation is used to determine the air velocity from differential pressure and with a density correction taking into consideration the atmospheric pressure and the ambient temperature.

If the pressure transducer has an analog output, this output can be attached to an A/D channel of the Data Acquisition Board, in the IFA 300 system. (See "Cal Method 1" in Chapter 7 for details). If the pressure transducer does not have an analog output, but has a readout display, the differential pressure can be typed into the IFA 300 software. (See "Cal Method 2" in Chapter 7 for details.) If you have other means of determining velocity, the velocity can be typed in directly in the IFA 300 software. (See "Cal Method 3" in Chapter 7 for details.)

If you do not have calibration facilities, contact TSI. TSI sells several calibrators, or we can calibrate the probe and supply the calibration files on floppy disks. You can then copy these calibration files to the `C:\Program Files\ThermalPro\Data` directory and proceed to the Data Acquisition part of the IFA 300 software program.

Mounting the Probe

When calibrating a single sensor probe you must mount the probe in the calibration nozzle or wind tunnel so that the sensor is perpendicular to the flow. The flow can be parallel or perpendicular to the sensor needle supports. However, for best results, orient the probe the same as it will be in your experiment (after calibration).

X-sensor probes should be calibrated with the flow at 45° to each sensor and parallel to the sensor needle supports. For calibrations and experiments with very low velocities (below 1 meter/sec), it is best to have your calibration flow and your experimental flow vertically upwards. This minimizes the effect of free convection from the heated sensor(s).

Figure D-1 illustrates the various parts of a probe and acquaints you with the nomenclature used with these probes.

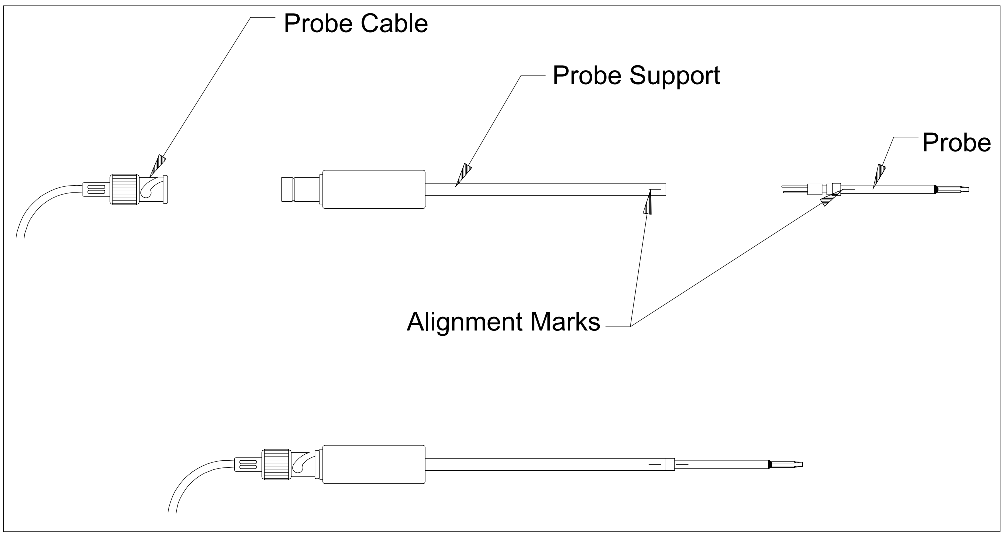

Figure D-1
Probe Components

If you need to measure cable resistance, you can do one of the following:

- ❑ If you have a probe with a probe support, install a shorting probe as shown in Figure D-2
- ❑ If you have a one-piece probe (no probe support), you can short the cable with a BNC shorting cap, as shown in Figures D-3 and D-4. Figure D-3 shows a straight connector and Figure D-4 shows a T-connector. In both figures, View (A) shows an unassembled probe and View (B) shows an assembled probe.

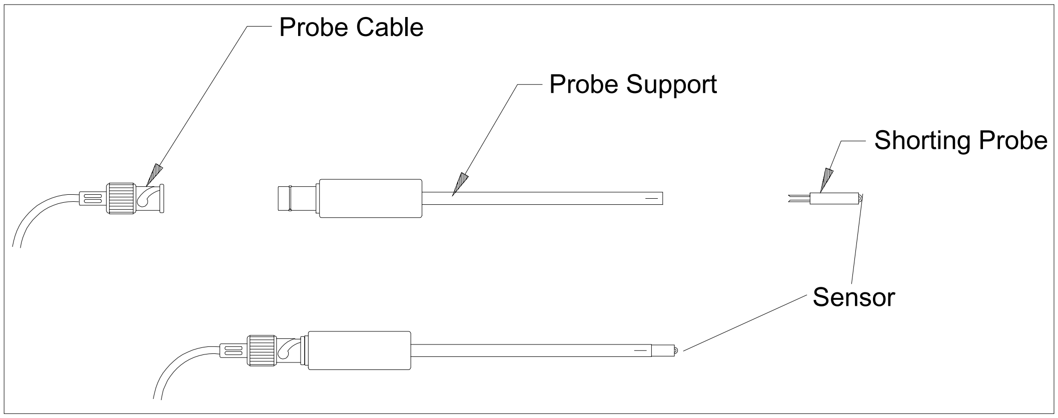

Figure D-2
Installing a Shorting Probe

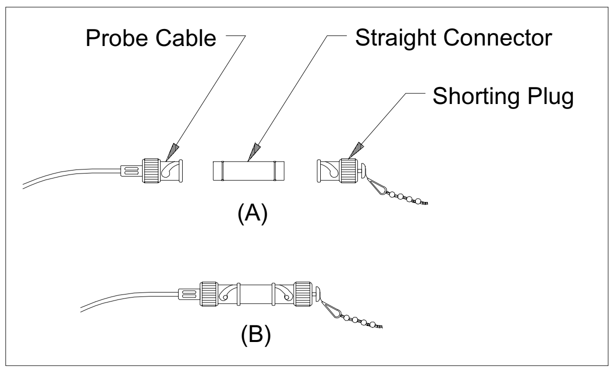

Figure D-3
Installing a Shorting Plug with a Straight Connector

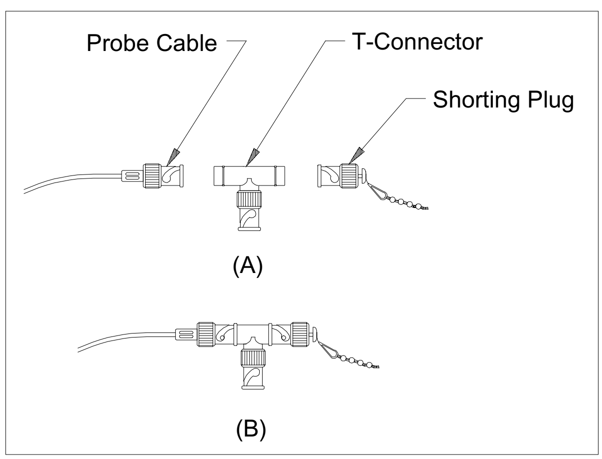

Figure D-4
Installing a Shorting Plug with a T-Connector

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APPENDIX E

Computational Algorithms for Statistics

This appendix explains the algorithms and equations used in computing the statistics for the IFA 300 system. It discusses the following topics:

- Concept of Effective Velocity
- Converting Voltage to Effective Velocity
- Various Data Analysis Procedures

The last part of this section lists the nomenclature used in these computations.

Concept of Effective Velocity

To define a relationship between output voltage and velocity that is independent of orientation, we use the concept of effective velocity. If we were to calibrate a sensor in the normal manner, and then use that sensor in a flow of unknown direction, the indicated velocity would be less than the actual velocity, unless the velocity was still normal to the sensor. We call this the “indicated velocity” or the “effective velocity.” It is sometimes also referred to as “cooling velocity.” If we use two sensors on a probe, and assume that the velocity is in the plane of the sensors, which are at 45 degrees to each other, and if we have a calibration for each sensor of output voltage vs. effective velocity, we can learn much about the flow's magnitude and direction.

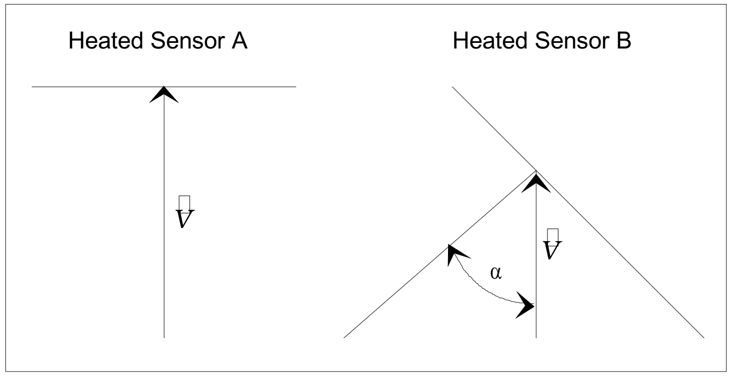

Figure E-1
Illustration of the Effective Velocity

Following is a description of the algorithms that are used to calculate the results.

The outputs from heated sensors A and B are different, since the velocity that is "effective" in cooling each sensor is different.

Sensor A: The effective velocity in cooling the sensor is $\hat{V}$.
Sensor B. The effective velocity in cooling the sensor is $\hat{V}$ cos α.

***Note**: Although the relationship between voltage and effective velocity remains the same, the relationship between effective velocity and the flow velocity components needs to be known.*

The example given above is referred to as the Cosine law, where

$$V_{eff} = \hat{V} \cos \alpha$$

A more accurate description of the directional sensitivity of inclined sensors is given by Jorgensen's equation:

$$V_{eff}^2 = \hat{V}^2 \left[\cos^2 \alpha + k^2 \sin^2 \alpha\right],$$

which can be rewritten in terms of velocity vectors with respect to sensor geometry:

$$V_{eff}^2 = U_N^2 + k^2 * U_T^2$$

Converting Voltage to Effective Velocity

The basic output of the anemometer is called the bridge voltage or raw voltage, E_b. For all probe types, the procedure is to convert the bridge voltage to effective velocity. For single sensor probes, effective velocity and velocity are synonymous. This voltage is usually signal conditioned to best use the resolution of the A/D converter:

$$E_o = (E_b - \text{Offset}) \times \text{Gain}$$

Gain and offset are selected such that E_o will nearly fill the -5V to +5V input of the A/D. Then the A/D creates a 12 bit binary count, B, as follows:

$$B = 4095\frac{(E_o + 5)}{10}$$

The deconditioned voltage, E_b, is then back-calculated:

$$E_b = \frac{[(B \times 10/4095) - 5]}{\text{Gain}} + \text{Offset}$$

The temperature corrected voltage, E, is then calculated as follows:

$$E = E_b \times \sqrt{\frac{(T_s - T_c)}{(T_s - T_e)}}$$

E is now corrected to be equivalent to the bridge voltage in the calibration file and in the lookup file.

The basic calibration is a curve fit of the effective velocity, V_{eff}, as a function of the bridge voltage, E, where:

$$V_{eff} = K + A \times E + B \times E^2 + C \times E^3 + D \times E^4$$

Then density correction is applied as follows:

$$V_{eff(cor)} = \frac{P_c}{P} \times V_{eff}$$

Where:

P_c = Atmospheric Pressure during calibration
P = Atmospheric Pressure during test
V_{eff} = Effective Velocity from look-up table
$V_{eff(cor)}$ = Density corrected, effective velocity

If results in “standard” velocity are desired, the above density correction can be made using a standard value for P.

The temperature and density corrections are derived from a form of “King’s Law” as follows:

$$\frac{E_b^2}{(T_s - T)} = A' + B' \times (P \times V_{eff})^{1/N}$$

However, the polynomial gives us a better curve fit than the King's Law equation.

Data Analysis Procedures

From the calibration, the relationship between anemometer output voltage and effective velocity has been established (see “Concept of Effective Velocity” earlier in this appendix). This section deals specifically with analyses of single, cross-wire, and triple sensors to yield statistical parameters. Refer to the nomenclature, at the end of this appendix, for explanations of the mathematical terms used here.

Single-Sensor Analysis

Single-Sensor analysis makes the assumption that the velocity is normal to the sensor axis and at the same orientation relative to the needle supports during both calibration and measurement.

$$V_{eff} = \hat{V}$$

Note: *Assume that the probe is operated with the same orientation as it was during calibration.*

Cross-Wire Sensor Analysis

Cross-Wire (or *x*-Sensor) analysis makes the assumption that the velocity is in the plane of the two sensors. The ideal direction is at 45 degrees to each sensor (plus or minus about 30 degrees) and stays within the quadrant used during calibration.

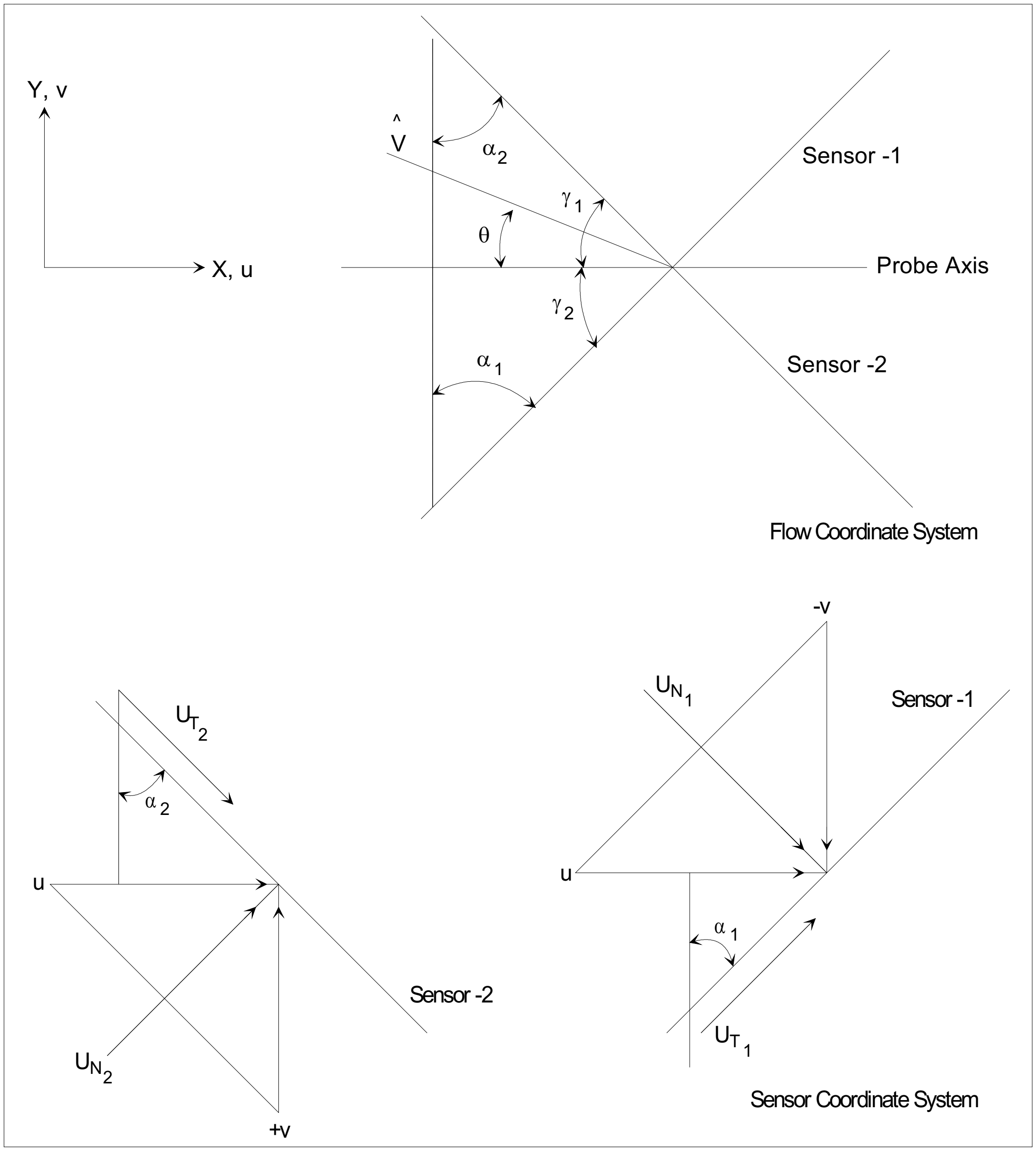

Figure E-2
Flow Coordinate System

The sensor inclination angle (slant) is the angle measured in the plane of the needles made by a sensor with the normal to the probe axis. The nominal slant angle for a cross-wire sensor probe is 45 degrees.

Note: *Sensors No. 1 and No. 2 (from Figure E-2) are designated by subscripts "1" and "2" in the following mathematical analysis.*

Referring to Jorgensen's equation and rewriting it for the two sensors in a cross-wire sensor probe (Figure E-2) we obtain:

$$V_{eff}^2 = \hat{V}^2 \left[\cos^2 \alpha + k^2 \sin^2 \alpha\right],$$

or (1)

$$V_{eff1}^2 = U_{N1}^2 + k_1^2 * U_{T1}^2$$

And since $U_{N1} = U_{T2}$ and $U_{T1} = U_{N2}$

$$V_{eff2}^2 = U_{N2}^2 + k_2^2 * U_{T2}^2 = U_{T1}^2 + k_2^2 * U_{N1}^2$$

$$U_{N1}^2 = \frac{V_{eff1}^2 - k_1^2 * V_{eff2}^2}{1 - k_1^2 * k_2^2}$$

$$U_{T1}^2 = \frac{V_{eff2}^2 - k_2^2 * V_{eff1}^2}{1 - k_1^2 * k_2^2}$$

$$U = \frac{U_{T1} + U_{N1}}{\sqrt{2}}$$

$$V = \frac{U_{T1} - U_{N1}}{\sqrt{2}}$$

$$\hat{V} = (U^2 + V^2)^{1/2}$$

Hence, given a pair of cooling velocities (V_{eff1}, V_{eff2}) from a single measurement of a cross-wire sensor probe, we can compute the u and v components and also the total magnitude $\hat{V}$.

These velocity components are stored in the appropriate velocity record of the velocity file.

Building Statistics From Velocity Components

To build statistics from velocity components requires two separate steps:

Step 1. Compute the first four moments about the origin for each vector component of velocity. If any two of the vector components are components of the same probe-velocity vector, then also compute the sum of all the products of the two components.

Step 2. Compute the statistical parameters for each vector component from the associated moments. Also compute the covariances and the correlation coefficients for those pairs of vector components that represent the same probe-velocity vector.

This section discusses the two statistics construction steps in more detail; the statistical formulas are described in relation to the construction process.

Moment Computations

Each record in the velocity data file is composed of vector components that represent velocity vectors. Each velocity vector is attached to a specific probe, defined in Probe Definition Screen of the Data Acquisition program. Each velocity vector may have one or two velocity components depending upon whether the associated probe is a 1-, or 2-sensor probe.

Example

If the experiment uses two cross-wire sensor probes, then each record in the velocity file looks like the following:

u-component x-sensor probe #1	v-component x-sensor probe #1	u-component x-sensor probe #2	v-component x-sensor probe #2

There is one record for every data point collected.

The first step in building statistics is to take each velocity component from the velocity file record and add that component to its associated set of moments about the origin.

The general formula for the *k*th moment about the origin is

$$M_k(x_i,0) = \left(1/n\sum_{i=1}^{n} x^k\right),$$

where x_i is the *i*th data point in the data sequence x of length n. The term x^k is the *k*th power of x_i. The first four moments about the origin (M_1, M_2, M_3, M_4) are computed for each velocity component.

The general formula for the cross-product of two data sets is

$$cp(x,y) = \sum_{i=1}^{n} X_i Y_i,$$

where X_i and Y_i are the *i*th data points in each of the data sequences X and Y.

Four sets of moments and two cross-products are computed from the velocity file data. The two cross-products are

cp(probe #1 *u*-component, probe #1 *v*-component)
cp(probe #2 *u*-component, probe #2 *v*-component).

Statistics Computations

Each velocity component in the velocity file has the following eight statistical parameters constructed from its set of four moments about the origin:

1. velocity mean

2. normal stress (variance)

3. standard deviation

4. turbulence intensity

5. third moment about the mean

6. skewness coefficient

7. fourth moment about the mean

8. flatness coefficient.

Note: *Except for the third and fourth moments about the mean (5) and (7), all are displayed.*

For a given (fixed) velocity component of a probe, let us abbreviate the notation for the moments about the origin to M_k:

(a) The velocity mean:

$$\bar{x} = M_1$$

(b) The normal stress (variance), or, second moment about the mean:

$$\mu_2 = M_2 - M_1^2$$

(c) The third moment about the mean:

$$\mu_3 = M_3 - 3M_2M_1 + 2M_1^3$$

(d) The fourth moment about the mean:

$$\mu_4 = M_4 - 4M_3M_1 + 6M_2M_1^2 - 3M_1^4.$$

It may help to realize that $M_1 = \overline{x}$, $M_2 = \overline{x^2}$, $M_3 = \overline{x^3}$, and $M_4 = \overline{x^4}$, The other four statistical parameters are built from the computed μ_1, μ_2, μ_3 and μ_4. They are:

(a) standard deviation

$$\tau = \sqrt{\mu_2}$$

(b) turbulence intensity

$$T = \left(\frac{\tau}{\bar{x}}\right) \times 100$$

(c) skewness coefficient

$$\partial_1 = \frac{\mu_3}{\tau^3}, \text{ and}$$

(d) flatness coefficient

$$\partial_2 = \frac{\mu_4}{\tau^4}.$$

From this point on, the statistical parameters are subscripted with a component designation to indicate the component. For example, $\bar{x}_u$ and τ_u stand for the mean and standard deviation of the *u*-component for a specific probe.

Additional statistical parameters are constructed for cross-wire sensor probes.

Statistics Computation for Cross-Wire Probes

In addition to the above statistics, the following values are calculated for cross-wire (or *x*-sensor probes).

(a) The resultant two-dimensional velocity vector magnitude:

$$V_2 = \sqrt{\bar{x}_u^2 + \bar{x}_v^2}.$$

(b) The direction angle of the two-dimensional velocity vector:

$$\theta_u = \cos^{-1}\left(\frac{\bar{x}_u}{v_2}\right)$$

(c) The shear stress (covariance):

$$\mathrm{cov}(u, v) = \left(\frac{1}{n}\right)\left[cp(u, v) - n \times \bar{x}_u \times \bar{x}_v\right]$$

(d) The cross-correlation coefficient:

$$r(u,v) = \frac{\text{cov}(u,v)}{(\tau_u \times \tau_v)}$$

Nomenclature

The following is a list of the nomenclature used in the mathematical discussions in this appendix:

$\hat{V}$	Instantaneous velocity vector
V_{eff}	Effective velocity or cooling velocity
γ	Yaw angle
k	Yaw coefficient
U_N	Component of $\hat{V}$, normal to the sensor and in the plane of the sensor support needles
U_T	Component of $\hat{V}$, tangential to the sensor
u, v	Components of $\hat{V}$ in the coordinate system of x and y respectively
$\overline{u}, \overline{v}$	Mean of the components of $\hat{V}$ in the coordinate system of x and y respectively
θ	Angle formed by $\hat{V}$ with coordinate direction X
γ_1	Angle formed by normal to sensor No. 1 with the x axis
γ_2	Angle formed by normal to sensor No. 2 with the x axis
α	Sensor inclination angle
T_s	Sensor operating temperature
T_c	Fluid temperature during calibration
T_e	Fluid temperature during experiment
E_b	Raw or bridge voltage
E_o	Signal-conditioned voltage
E	Temperature-corrected bridge voltage
Gain	Gain value of signal conditioner
Offset	Offset of signal conditioner
B	Binary count from A/D converter
N	Normalized bridge voltage
P	Atmospheric pressure

APPENDIX F

Determining Offset and Gain Settings for a Hot-Wire Probe

In the THERMALPRO™ software, values selected for Offset and Gain are automatically applied to the anemometer Bridge Voltage to arrive at a value known as "Output Voltage." To achieve maximum resolution available from the A/D board, Output Voltage should fill as much of a –5 Volt DC to +5 Volt DC range as possible. Thus, the goal of applying Offset and Gain to the Bridge Voltage is to get the Output Voltage to be as close as possible to a –5 VDC to +5 VDC span.

Offset and Gain operate on Bridge Voltage in the following way:

First, the chosen Offset value is subtracted from the Bridge Voltage. Then, the difference is multiplied by the Gain:

$$[(\text{Bridge Voltage}) - (\text{Offset})] \times \text{Gain} = \text{Output Voltage}$$

Optimally, then, the Offset can be selected as:

$$\tfrac{1}{2} \times (\text{Bridge Voltage}_{max} + \text{Bridge Voltage}_{min}) = \text{Offset}$$

And Gain can be determined by:

$$[-4 \div (\text{Bridge Voltage}_{min} - \text{Offset})] \geq \text{Gain} \leq [4 \div (\text{Bridge Voltage}_{max} - \text{Offset})]$$

The THERMALPRO software allows you to enter Values between 0 and 10 volts in 0.1 volt increments for Offset and select among many integer values for Gain in the Calibration - Probe Data screen.

To determine Bridge Voltage$_{min}$ and Bridge Voltage$_{max}$ for a particular probe, you will need to take Bridge Voltage readings at zero velocity (or some other minimum air velocity) and your desired maximum velocity. To do this:

1. Click on **Probe Data Screen** from the Calibration menu bar at the top of the screen. After selecting the file for your probe (make sure all the data is correct for your probe), set the Offset to "0" and Gain to "1."
2. Click on **Calibration** and **Conditions Setup** from the main menu bar.
3. In the Calibration Setup screen, make sure the values for Atm Pressure, Cal Temp (standard ambient temperature to which you want all data to be referenced; usually 20°C), and Opr Temp are set correctly. Enter your Min Velocity and Max Velocity values in the field provided.
4. Click on Test in the Calibration Setup screen. The Acquisition Monitor appears. This screen displays voltage readings from the A/D channels connected to your computer—either Output Voltage or Bridge Voltage—as shown at the top of this screen. Set Read to "Bridge Voltage" (when Offset = 0 and Gain = 1, Bridge Voltage and Output Voltage are equal). "Active" channels (meaning a probe and sensor are properly connected and operating) are indicated in red.
5. Carefully position the probe properly above the exit nozzle of your Calibrator. Shut off all flow through the Calibrator to establish a good zero velocity. Alternatively, you may select a non-zero minimum velocity value. In that case, adjust the velocity to establish the minimum velocity value required.
6. Read and record the Bridge Voltage from the active probe channel(s). This is the Bridge Voltagemin value. For this example, let us say that the Bridge Voltagemin value is 1.100 volts.
7. Adjust velocity to establish the maximum velocity value required. Read and record the Bridge Voltage from the active probe channel(s). This is the Bridge Voltagemax value. Let us say that the Bridge Voltagemax value is 2.500 volts.
8. Calculate the Offset value desired using the following equation:

   $\frac{1}{2} \times (\text{Bridge Voltage}_{max} + \text{Bridge Voltage}_{min}) = \text{Offset}$

   Example: $\frac{1}{2} \times (2.500 + 1.100) = 1.800$ volts

   Now calculate the Gain:

   $[-4 \div (\text{Bridge Voltage}_{min} - \text{Offset})] \geq \text{Gain} \leq [4 \div (\text{Bridge Voltage}_{max} - \text{Offset})]$

   Example:
   $[-4 \div (1.100 - 1.800)] \geq \text{Gain} \leq [4 \div (2.500 - 1.800)]$

   $-4 \div (-.7) \geq \text{Gain} \leq 4 \div 0.7$

   $5.7 \geq \text{Gain} \leq 5.7$

   Choose Gain = 5

9. Return to the Calibration–Probe Data screen. You can now enter the Offset value you calculated. Finally, select the appropriate Gain setting from the available integer values.

You are now ready to proceed with your calibration.

Note: *You will need to obtain new Offset and Gain values:*

- ❑ *For each sensor of every probe*
- ❑ *For each calibration range*
- ❑ *For each different sensor operating temperature used*
- ❑ *For each sensor that has been repaired or replaced*
- ❑ *If there has been substantial change in the sensor data due to sensor drift.*

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APPENDIX G

Relating Velocity to Differential Pressure

THERMALPro software uses compressible gas equations to calculate air velocity. The velocity is calculated using differential pressure as well as absolute (barometric) pressure, temperature, and certain air properties such as gas constant and ratio of specific heats as follows:

P	Absolute pressure
Δp	Differential pressure (same units as P)
T	Stagnation temperature (°C)
γ	Ratio of specific heats (Cp/Cv) (γ = 1.399 for air)
MW	Molecular Weight (MW= 28.994 kg/kmol for air)
$\overline{R}$	Universal gas constant = 8314 (J/kmole °K)
$R = \overline{R}/MW$	Gas constant for specific gas
a	speed of sound (m/s)
a_o	speed of sound at stagnation conditions (m/s)
M	Mach number
U	velocity (m/s)

$$a_o = [\gamma \bullet R \bullet (T + 273.15)]^{1/2}$$

$$M = \left[2\frac{\left(\frac{P + \Delta p}{P}\right)^{\frac{\gamma - 1}{\gamma}} - 1}{\gamma - 1} \right]^{\frac{1}{2}} \qquad \text{(equation 1)}$$

$$a = \left(\frac{a_o^2}{1 + \left(\frac{\gamma - 1}{2} M^2\right)} \right)^{\frac{1}{2}} \qquad \text{(equation 2)}$$

$$U = M \bullet a \qquad \text{(equation 3)}$$

You may notice that these equations give the same result as Bernoulli's equation for velocities less than 50 m/s. At velocities greater than 50 m/s, the Bernoulli equation starts to introduce significant error because of compressibility effects.

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APPENDIX H

Using an Automated Traverse System with THERMALPRO software

After you have installed the THERMALPRO software in your computer, you will need to designate a Traverse Driver to control the traverse system. To designate the traverse driver, follow these steps:

1. From the THERMALPRO main menu, click on **IFA300** and then select **Configure** from the pull-down menu.
2. From the “IFA Configuration” screen, under the “Traverse” section in the bottom right side of the screen, click on **Add DLL**.
3. From the “Add Traverse DLL” screen, under the “Directories” heading:
   a. Click on **c:**.
   b. Click on the program **files\ThermalPro\trav**.

At this point, several files with extensions “.DLL” appear under the “File Names” heading.

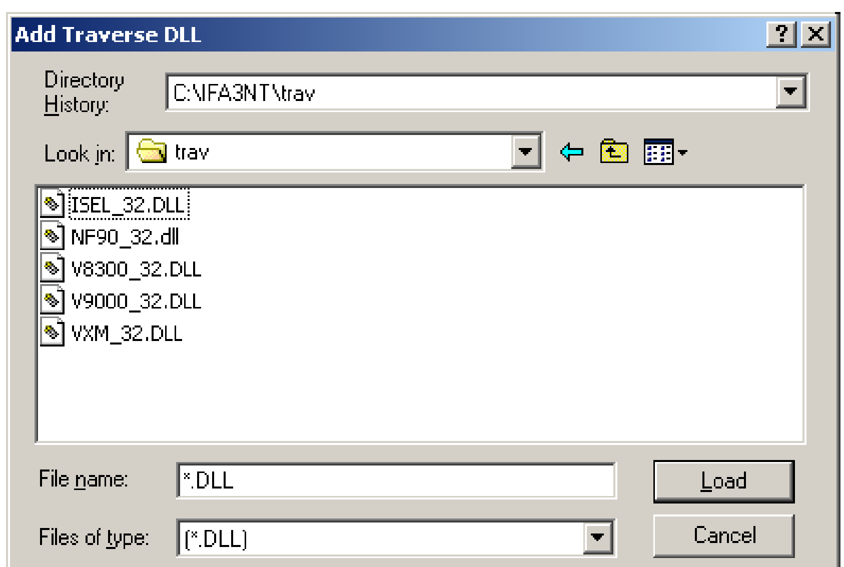

Figure H-1
Add Traverse DLL Screen

4. Select the appropriate traverse driver for your system:

ISEL_32.DLL	All ISEL traverse controllers
NF90_32.DLL	Velmex NF90 traverse controller
V8300_32.DLL	Velmex V8300 traverse controller
V9000_32.DLL	Velmex VP9000 traverse controller
VXM_32.DLL	Velmex VXM traverse controller

   Click on **Load** on the right side of the screen. The program returns to the "IFA Configuration" screen. The DLL file appears in the imbedded file screen under the "Traverse" section.

5. Be sure that the COM port for the traverse system is correctly identified in the "Traverse" area of the "IFA Configuration" screen. The designated COM port must be different than the COM Port chosen for the IFA 300 connection (under "IFA" in the upper left of the "IFA Configuration" screen). Connect the RS-232 cable from the designated serial port (COM port) on your computer to the traverse controller.

6. In the "Traverse" area of the screen, make sure that the "Counts per Unit" for the X, Y and Z axes is 200. This parameter will ensure that the traverse moves the proper distance. Set the "Readback Scale" to 5. This will ensure that the units on the Velmex VP9000 Traverse Controller display and the Traverse Control portion of the THERMALPRO software reads correctly in millimeters.

7. In the "Traverse" area of the "IFA Configuration" screen, be sure to activate the axes of the traverse that you will be using. Activate each of the axes of your choice by clicking the on-screen toggle switch into the "Active" position.

   ***Note**: When you first activate the axes of your choice, it will be necessary to exit and restart the THERMALPRO software (see step 7).*

8. While in the configure screen, set the maximum number of rows that you expect to use in your matrix up to a maximum of 9,999. When creating a matrix, the spreadsheet will always open with this number of rows and if your matrix will be small, it will be convenient to set this parameter accordingly.

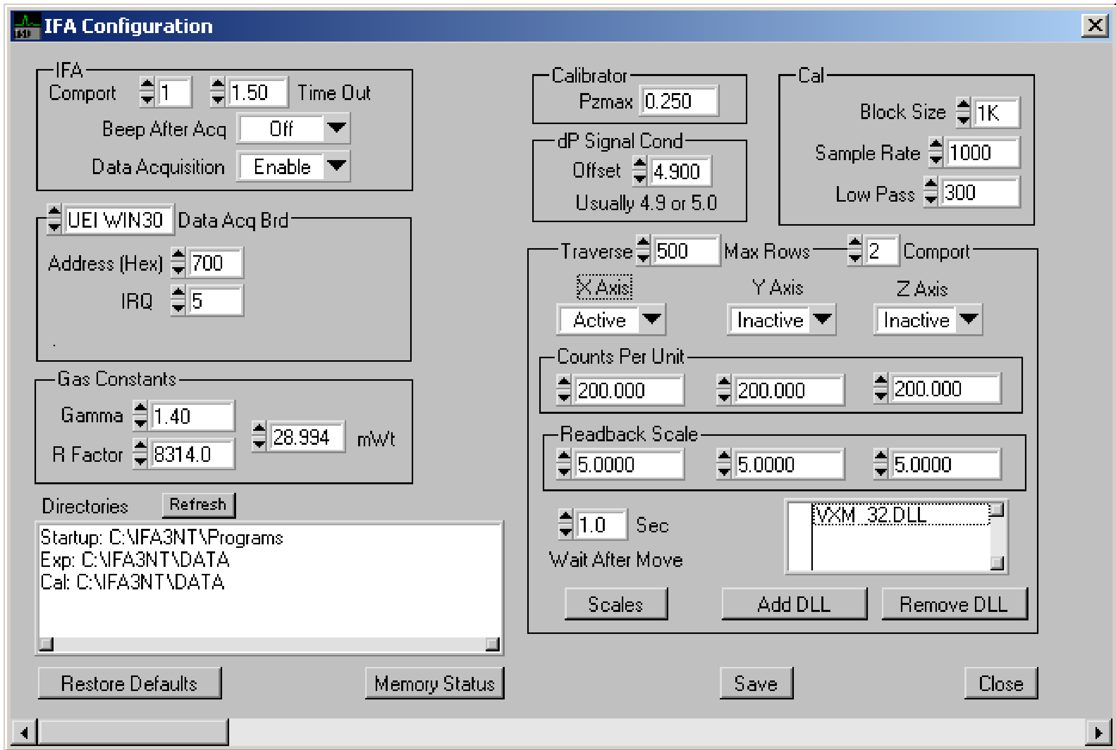

Figure H-2
IFA Configuration Screen

9. On the IFA 300 Configuration screen, click to the left of the traverse that you are configuring. If this is a new configuration, a series of messages appears while the traverse DLL is moved and loaded.

Figure H-3
Confirm Screen

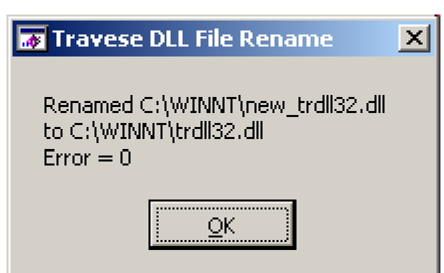

Figure H-4
Traverse DLL File Rename Screen

Figure H-5
Advice Screen

10. If you wish to skip acquisition at a point on the matrix, put an X in the No Acq column. The system renumbers the rows with no number at that row and the acquisition will not be done at that position. This would allow for a Z move before an X move, for example.

11. Be sure to select **Save** to leave the "Configuration" screen. (If you make a mistake in selecting or designating the traverse driver or any other parameter, you may choose **Close** to exit "Configuration" without saving your selections.)

Once you have designated the Traverse Driver, we recommend that you become familiar with how the traverse system works by working with the Traverse Control screen, and by creating and running at least one Traverse Matrix before using the traverse system with the thermal anemometer system for data acquisition.

Traverse Control, Manual

To enter the Traverse Control portion of the THERMALPRO software, click on **Traverse Ctrl** in the "IFA300" pull-down menu from the main menu. The "Manual Traverse" screen appears. From this screen you may control the movement of the traverse system.

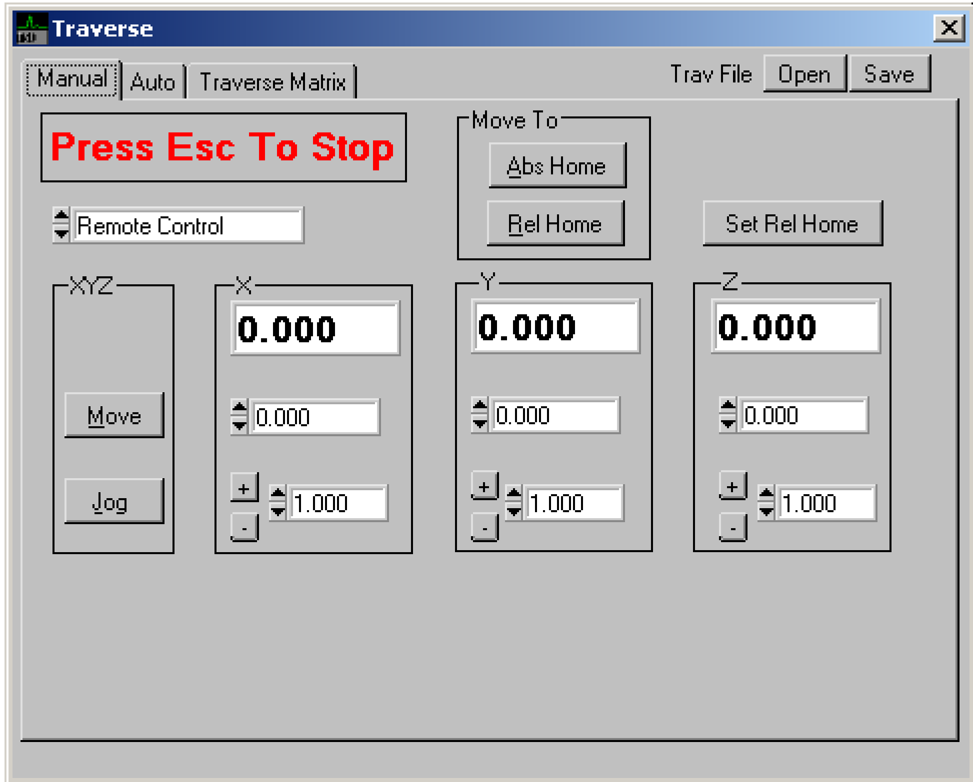

Figure H-6
Traverse Control, Manual Screen

Note: *You may press the **Escape** key at any time to stop the movement of the traverse system.*

There are a number of different ways that you can move the traverse system.

Home Control

The **Move to Abs Home** control will move all axes to their absolute home. You can manually move the system to a new home and establish this as a relative home by clicking on **Set Rel Home.** You can then move to this new relative home by selecting **Move to Rel Home**.

"Jog" Button

When you click on the **Jog** button, the traverse moves each of the active axes by the amount shown in the boxes to the right of the "Jog" button. If you did not activate an axis, the word "Off" shows up next to the axis heading in the center of the "Traverse" screen. Change the value shown in each of the boxes by whole millimeters using the up-arrow or down-arrow to the left each of the boxes. Or you may change the value displayed by double-clicking on the value and typing in a new value. You may type in decimal fractions of millimeters with a resolution of .025 mm. Negative numbers are accepted.

You may move each individual axis with the "+" and "–" buttons next to each number box. Click on the **+** button to move in the direction indicated in the number box. Click on the **–** button to move in the opposite direction.

Note: *The traverse always moves the X-axis first, then the Y-axis, then the Z-axis. This may be an extremely important consideration if you have structures you need to avoid in your test field.*

"Move" Button

Each time you move the traverse position, the final X-, Y- and Z-position will show up in large numbers in the center of the "Traverse" screen. Likewise, it will show up in the number boxes next to the "Move" button. You may enter destination coordinates in the number boxes next to the "Move" button by double-clicking on each of the numbers shown and entering new values. The traverse then moves to the designated location when you click on the **Move** button.

Note: *The exception to this rule is if you stop the traverse using the "Escape" key on your computer. When you do this, the location of where the traverse stops is correctly identified in the large numbers, but not necessarily in the number boxes next to the "Move" button. Be careful in using the "Jog" and "Move" buttons in this case as they may not be in sync with the true traverse position.*

Move to Absolute Home

Click on this button when you want to move the traverse to the "absolute" 0,0,0 position. Remember that the traverse always moves the X-axis first, then the Y-axis, then the Z-axis. You will get a message to confirm that you wish to move to the absolute home position before the traverse begins to move.

Set Relative Home

Click on this button to create a new "relative" 0,0,0 position at the current location of the traverse.

***Note**: This is **not** the same as Absolute 0,0,0, which is the Absolute Home position.*

After selecting a Relative Home, all coordinates in the large numbers and the numbers next to the “Move” button will be in relation to this Relative Home position. If you subsequently wish to return to the Relative Home position, click on the **Move to Rel Home** button.

Move to Relative Home

This button is active only after you have designated a Relative Home position. See “Set Relative Home” note above.

Click on the **Close** button to exit the traverse control screen.

Traverse Control, Auto

Click on the **Auto** button to test the traverse using a position matrix. If you don’t have an opened matrix, click **Open** and select a matrix. Then you can move through the matrix with the right/left arrows and see the x and y position on the graph. The z position will be displayed on the Thermometer-like indicator.

Click on the **Manual** button to return to the Manual screen. Click on the **Close** button to exit the traverse control screen.

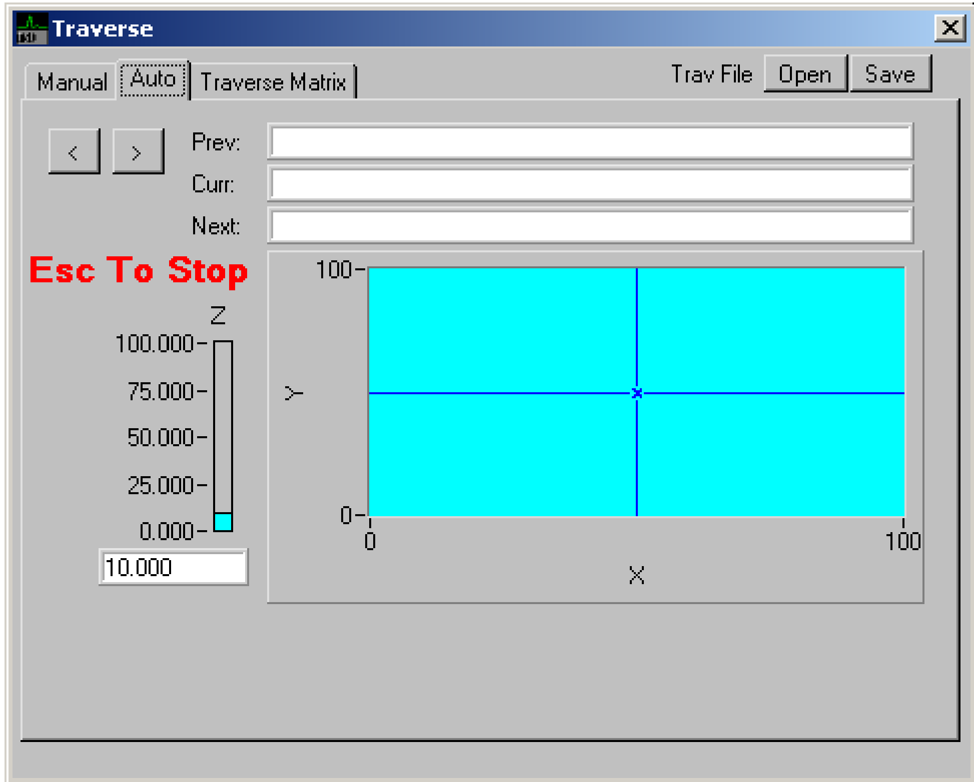

Figure H-7
Traverse Control, Auto Screen

Select a Matrix

To select a matrix, from the Traverse Control Manual or Auto screens, click on **Open** and select from the existing files. This makes the traverse file active. You can then view or edit the matrix.

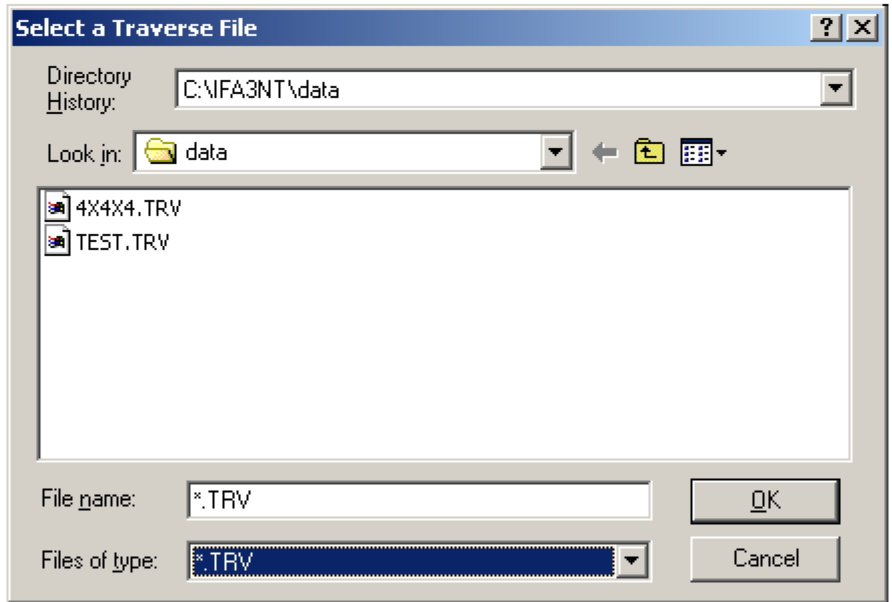

Figure H-8
Select a Traverse File Screen

Several types of files can be opened:

*.TRV	THERMALPRO Traverse File
*.CSV	Comma Separated Variable File
*.TXT	Space Separated Variable File
*.PRN	Tab Separated Variable File

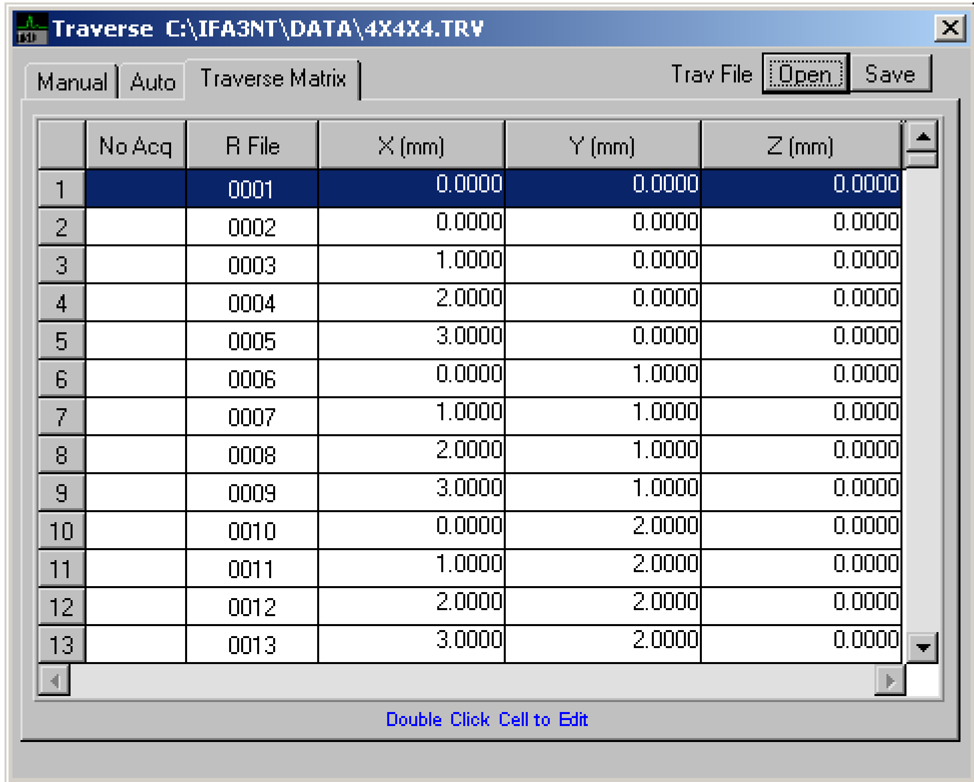

Figure H-9
Traverse Control, Traverse Matrix Screen

Creating a Matrix

You may create and save new traverse control matrixes for automatic control of the traverse (to be used for probe positioning during data collection in the “Acquisition” portion of the THERMALPRO software). Make sure that you don’t have an active matrix file. If a matrix is active, there will be a check mark by the Traverse File Active selection under the IFA 300 pull-down menu. To deactivate the matrix, simply click on the check mark and it will disappear.

To create a matrix from a blank spreadsheet, click on the **Matrix** button from the “Traverse Ctrl” auto or manual screen, A blank “Traverse Matrix” screen appears. You may enter up to 9999 coordinates to which you would like the traverse to move in sequence during data acquisition. Once you have created a matrix, click on the **Save** button. You will be asked to name the matrix.

Note: *It is strongly recommended that you test any matrix that you build before using with a hot-wire probe for data collection. This could save the grief of accidentally running the probe into a structure.*

To create a large matrix, you can use Excel® to edit or create a matrix. We suggest that you import a small matrix into Excel as a text file, space delimited, then modify it as desired. Excel will want to save it as a *.prn file space delimited. You can then rename it as a *.trv file.

***Note**: During data acquisition, when you have the traverse active and have designated a traverse control matrix, anemometer data will be captured after each line in the selected matrix. In some cases, you may wish to skip acquisition at a given position.*

To test a matrix, click the **Open** button in the "Traverse" screen and select the matrix you wish to test. Next, click on the **Auto** button from the "Traverse" screen. A screen appears which graphically shows the position and path of the traverse. The X-Y position is shown in the XY graph and the Z position is shown in the single-column bar graph to the left of the XY graph. You will initially be asked if you want the traverse to proceed to the first designated position. If so, answer "Yes". You then may step through each of the positions of the matrix using the ">" arrow to move to the next position or the "<" arrow to move to the previous position. Coordinates of the "current", "next", and "previous" position are also displayed.

***Note:** You may press the **Escape** key on your computer keyboard at any time to stop the movement of the traverse.*

Operation

To acquire a set of data files using a traverse table and a matrix, enter the Acquisition Probe Table screen with the normal procedure and continue to the next screen (Acquisition Conditions Setup). Then click the IFA 300 menu bar in the upper left of the screen and select Traverse File. Select the matrix file to use. This activates traverse control and you should see two additional controls on the screen. One is "Home Trv" which returns the traverse table to absolute home. The other is "Stop Trv" which stops the traverse table motion during a move.

Once the Traverse Control is activated, a Trigger command from the Conditions screen in Write Only mode starts a measure; move; measure; move; etc., until a file is written for each position in the matrix. The position for each data point will be written into the raw data file header and can be used for plotting in the Post Analysis-Flow Field section.

® Excel is a registered trademark of Microsoft Corporation.

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APPENDIX I

Temperature Measurements and Temperature Correction of CTA

Summary of temperature measurement and correction for constant temperature anemometer, (CTA), using the IFA 300 anemometer and THERMALPRO software.

Temperature correction of the CTA is done using the following relationship, commonly called King's Law.

$$\frac{E^2}{(T - T_o)} = A + B * V^{1/2}$$

where

E	=	bridge voltage
T	=	Temperature of fluid being measured
T_o	=	Temperature of fluid during calibration
A and B	=	constants based on calibration
V	=	fluid velocity

Bridge voltages taken during calibration are corrected to what they would be at a nominal temperature, usually 20°C. Then during acquisition, bridge voltages are also corrected to the same nominal temperature. As can be seen from the equation, the temperature correction is made directly to the bridge voltage, so it is independent on the type of curve fit that is used on the calibration data.

The THERMALPRO™ software allows for several methods of correcting the acquired data for temperature. The first two methods work well if temperature is quite stable in the fluid being measured. These methods are also used during velocity calibration using the system. With the third and fourth methods, temperature is acquired simultaneously with the CTA data so that point by point corrections can be made.

1. **External Temperature measurement.**
   Temperature can be monitored by an independent device with readout and the value simply typed into the computer screen for each data file that is acquired. In the acquisition probe table, the Temperature Probe selected should be **Ext** (for External). When acquiring data, you will be prompted to type in temperature.

2. **Thermocouple via RS-232.**
   A thermocouple can be connected to the IFA 300 cabinet and the software can retrieve the temperature via RS-232 communications automatically after each data file is acquired. The acquisition probe table should specify Temperature Probe A in the line for each velocity probe. When two IFA 300 cabinets are used, Temperature Probe B is used to specify the thermocouple that is attached to the second cabinet.

3. **Thermocouple via Analog output.**
   The thermocouple circuit in the IFA 300 has an analog output that can be acquired on a separate channel of the data acquisition board. In this case, the data array will have a temperature for each velocity in the array. This works well if the temperature is changing during the time that the block of data is acquired and if the thermocouple is fast enough to keep up with the temperature fluctuations. The output of this circuit is –5 volts to +5 volts over a range of 0 to 50 or 0 to 200°C. To use this feature, insert calibration file C50.cl into the acquisition probe table (or file C200.cl if you wish to use a range of 0 to 200). These calibration files contain the parameters to select the range in the system. Then you must attach the temperature probe number to the velocity probe by editing the velocity probe in the probe table.

4. **Temperature via CCA with Cold Wire.**
   The 183145 Temperature Module offers a faster circuit for measuring temperature, commonly called a CCA or Constant Current Anemometer. Of course, it is not an anemometer, as it us used to measure temperature and not velocity. It can be described as a fast resistance thermometer. A small hot-wire sensor is used with a circuit that has a bridge and amplifier that supplies a constant current to the wire sensor. A two-point calibration that brackets the range of expected temperature is recommended. The current should be the maximum that will not cause the wire to self-heat. In other words, increasing current increases sensitivity, but if the wire temperature is greater than the fluid temperature, the measurement is in error. A good current setting for a T1.5 wire (0.00015-in. or 3.8-micron diameter) is 1.0 mA. This wire will give a frequency response of about 800 Hertz. If this is too slow, a P.5 wire (0.00005-in. or 1.3-micron diameter) can be used to get a faster frequency response. Each wire must be calibrated individually.

As resistance is so important, you should use the same probe support, cable and CCA circuit combination while acquiring data, as were used during calibration. It is also recommended that the settings on the CCA circuit be the same as during calibration.

Note about Specifying the Temperature Probe in the Acquisition—Probe Table

Each probe in the table is assigned a probe number. These probe numbers align with the A/D channel unless one or more probes have two or three sensors. Each CTA (velocity) probe must have Temperature Probe specified in its row in the probe table where it says “Temp Pr”. To change this assignment, double-click the row that you wish to edit (or click **Edit Line**). Next select from the Temperature Probe list (Ext, A, B, 1,2,3…..16 or OFF). Then click **Save** Line). This will write the selection in the “Temp Pr” column. If “Ext” is selected, you will be prompted to type in temperature when acquiring data. If A or B are selected, the temperature from a thermocouple will be acquired via RS-232 (one value for each data block. Note that B refers to the circuit in a possible second IFA 300 cabinet. Probes 1 through 16 are specified if a temperature is acquired from an analog output such as from the thermocouple circuit in an IFA 300 cabinet or if a CCA circuit is installed in the IFA 300. If the OFF selection is used, no temperature correction will be utilized.

CCA Overview

Comparison of CCA and CTA

The CCA (constant current anemometer) schematic looks similar to a CTA (constant temperature anemometer) schematic as both have a bridge with a sensor in one leg of the bridge and another segment that has adjustable resistance.

On the CTA when we change the adjustable resistor we are setting the operating resistance of the sensor as the amplifier keeps the bridge in balance and in the process, heats the sensor.

On the CCA, when we change the resistor, we are directly changing the bridge balance but not the sensor resistance, so it is not technically correct to label the resistance adjustment "operating resistance". The amplifier then amplifies the off-balance of the bridge and the calibration is actually relating sensor resistance to fluid temperature.

CCA Calibration

Equipment

- Two baths of known temperature, which should be representative of the temperature range that will be measured.
- Probe with wire sensor. Film sensors are not fast in the uncompensated constant current mode.
- Probe support.
- Probe support stand.
- Shorting probe.
- IFA 300 system with A/D board with model 183145 CCA temperature module.

Assumptions

- The CCA is channel 3 on the IFA 300 (This can be any channel but if a system has two CTA channels and one CCA, the CCA is usually the third channel.
- IFA 300 is powered up.
- IFA software is running and at the main screen

Procedure

1. Connect the CCA probe to channel 3 on the IFA 300. Connect channel 3 output to A/D channel 3.
2. Select **Probe Data** under "Calibration" from the main menu.
3. Select **Get Cal File** to acquire CCA probe.
4. A window will appear with a list of probes. Choose the **kCCA.cl** probe by clicking on it once with the mouse and then choosing **OK**.
5. Use the **Save As** command to rename the file to match your probe.
6. Select the A/D channel display on the left side of the screen using the mouse. A window appears with a list of channels. Select **channel** 3.
7. Select the IFA channel display on the left side of the screen using the mouse. A window appears with a list of channels. Select channel 3.
8. Make sure the "Probe" display reads "K". If it does not, select the **Probe** display with the mouse. A window appears with a list of probes. Select **K**.

9. Make sure the Offset is **0**.

10. Make sure the Gain is **1**.

11. Select the current you wish to work with; usually it should not exceed 1 mA for a –T1.5 Tungsten wire sensor. For a smaller wire, try a lower current, and for a larger wire, you can increase the current. The current display is in the middle of the screen. Use the automatic step adjustment to change the current value. (You may also change it manually by clicking on the display window with the mouse. Another window will appear with a list of current values. Select the desired current by selecting it with the mouse.)

12. Click on the **Calibrate** box near the right side of the screen to start the calibration.

13. Enter the maximum and minimum temperatures you will be using in calibration. Click on **Min Temp** with the mouse and enter the value for minimum temperature. Do the same for maximum temperature.

14. ***Note:*** Before actually acquiring calibration data, you must set up a good range for output voltage (approximately 8 volts). Follow steps 15 to 17 to establish a -4 to +4 range of output voltage for the minimum to maximum temperatures to be used for calibration.

15. The output voltage is the second box under “Acquire” on the right side of the screen. With the probe in the cold bath, change the operating resistance (bottom left side of the screen) so that the output voltage is closest to 0. This is the cold bath voltage. You can use the automatic step adjustment, or click on the **Operating Resistance** display and type in a value.

16. You can usually keep the offset at zero and use the “Operate Resistance” setting to move the output up or down and the gain setting to increase or decrease the sensitivity of the output. With a typical Tungsten hot wire with 1 mA of current and a temperature span of about 100 degrees C, a gain of about 10 is typical.

17. Place the probe in the warm bath and increase the Gain, found in the lower center portion of the screen. If the cold bath voltage was negative, increase the gain until the output voltage is closest to 4.0, but just below 4.0. If the cold bath voltage was positive, increase the gain until the output voltage is closest to 4.0, but just above 4.0.

18. Place the probe back in the cold bath. Click on **Temp Entry** (the first box below the “Acquire” button) with the mouse and enter the cold bath temperature in this box.

19. Look under the heading "Acquire Cal Point" at the top right side of the screen. The **"#** Points" should be 2, and the "Next Point" should be 1. If the next point is not 1, change it to 1 by selecting the **Sequence Up** or **Sequence Down** option at the bottom right of the screen.

20. When "Next Point" reads 1, choose **Acquire**, which is a button on the right side of the screen.

21. If the temperature pop up appears, select **Disable Pop Up**, then **Return**. The "Next Point" display should now read **2**. If it does not, change it to 2 by using the "Sequence Up" or "Sequence Down" option at the bottom right of the screen.

22. Place the probe in the warm bath.

23. Click on **Temp Entry** (the first box below the "Acquire" button) with the mouse and enter the warm bath temperature.

24. Select **Acquire**. A pop-up appears reading "Temperature calibration complete". Select **OK**.

25. Select **Next Screen**, which is the green box on the lower right side of the screen.

26. You should now see the Calibration Data Table. Look in the Temperature column. Make sure the temperatures that appear on the chart correspond to the temperatures that you entered during calibration. If they are not the same, you must now enter the calibration temperatures manually. To do so, click on the line whose temperature you wish to update. Once the line is selected, click on **Edit**, which appears on the right side of the screen. Go to the temperature box on the bottom of the screen. Select it and type in the correct calibration temperature. Now save the line by clicking on **Save**, which appears on the bottom of the screen. Edit the temperature values until they correspond with the hot and cold bath temperatures.

27. Select **Curves** from the lower right side of the screen.

28. A graph appears representing the calibration data along with coefficient values, which are displayed at the top right of the screen.

29. The CCA calibration is complete. This calibration can be inserted into the probe table in the acquisition program and a time history of temperature can be acquired.

CCA Operation

Once a temperature probe is calibrated with the CCA bridge, the probe can be inserted into a probe table in the acquisition program and the output can be sampled simultaneous with the CTA outputs. Thus temperature can be measured with a response time that is very difficult with conventional methods and much faster than thermocouples.

The CCA temperature output can also be used to make point-by-point corrections to the output of one or more CTA channels. To set this up on the probe table, consider the following example:

- You have two channels of CTA and are running these two channels to make velocity measurements, and also have a CCA bridge for temperature measurements. You have calibrations for your velocity sensors and also for your CCA sensor. In your Acquisition Probe Table, you insert the velocity calibrations into the table on channels one and two. The type K probe calibration is on channel three. For probes one and two, edit and save showing probe three as the Temperature probe for probes one and two.

Then a complete time history of the three channels will be saved when data is collected. When data is analyzed, the velocity data will be corrected point-by-point based on the output of the CCA bridge. Statistics of the temperature will also be collected so that you can see the temperature time history, mean temperature, standard deviation, etc. The higher order statistics may not be meaningful as they are for velocity.

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APPENDIX J

Binary File Format

The binary formats for Raw data files (*.R*) and Velocity files (*.V*) are the same for the 16-bit version of THERMALPRO™ software (up to version 2.xx) as for the 32-bit versions (4.00 and later).

Raw Data Files (*.Rxxxx)

R files use Metrabyte format. Each sample is 16 bits wide. The upper 12 bits are the actual sample data (0 to 4095), and the lower 4 bits designate the channel (0 to15). Data appear in sequential order as a continuous loop (ch 1, ch 2 . . . ch n, ch 1, ch 2 . . . ch n, ch 1, ch 2, etc).

Example:
4 3 2 1
9 9 C 0
1 9 B 1
6 1 9 2
9 A O 0
1 9 1 1
6 1 3 2
9 9 B 0
.
.
.

The corresponding decimal data is:

Channel Number	Value (Scan1)	Value (Scan2)	Value (Scan3)
1	2460	2464	2459
2	411	401	etc.
3	1561	1555	etc.

Velocity Files (*.Vxxxx)
Output Voltage Files (*.Axxxx)
Bridge Voltage Files (*.Exxxx)

Files appear in the same sequential order as Raw Data Files, except for files with multi-channel probes where U, V, W appear in place of ch 1, ch 2, ch 3, as an example.

In C language the union data structure allows multiple data types to occupy the same memory space. The velocity files use an 8 byte union which contains a floating point velocity value and an integer channel number.

C language syntax:

```
union  _utmp
{
   double  dval;   /* one 8 byte wide double precision */
   float  fval[2];    /* two 4 byte wide floating point */
   int  ival[4];       /* four 2 byte wide integers */
} utmp;
```

Example:

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Byte Count**
C	C	U	U	F	F	F	F	F = Floating Point Data C = Channel (0 to 15) U = Unused space filled with zeros

The following fragment shows how to use the union data structure:

```
int channel;
float velocity;

/* read from the file array of doubles, index to the sample you need,
then use the union to extract the particular component */

velocity = utmp.fval[0];
channel = utmp.ival[3];

....user code here
```

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