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**A** Technical papers:
Electronic testing of frequency response for thermal anemometers', P. Freymuth and L. M. Fingerson
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# about this manual

The purpose of this instruction manual is to familiarize you with the functions, capabilities, and operation of the IFA 100 system.

## organization

This manual consists of seven chapters:

- 'Controls and functions of the IFA 100' (chapter 1) explains the features and the functions of the IFA 100, one component at a time.
- 'The flow-measurement process' (chapter 2) provides all of the system's setup and operating instructions that you must know in order to make flow measurements.
- 'General information' (chapter 3) explains the instrument's principle of operation and the system's main auxiliary equipment.
- 'Expanding the system' (chapter 4) tells you how to unpackand install the IFA 100.
- 'Remote-control interfacing' (chapter 5) gives complete instructions on installing a remote interface.
- 'Troubleshooting' (chapter 6) helps to isolate, clarify, and perform certain common system functions.
- 'Specifications' (chapter 7) gives the specifications for most important components of the system.

## formatting and typography

This instruction manual is broken down into three levels: Chapter titles appear at the top of the page in upper and lower case. Section titles appear outside the column of text on the left. Subsection titles appear above the column of text in ***bold italic***.

Step-by-step procedures are numbered in boldface type—**1, 2, 3,** etc.—set flush-left against the text margin.

Look for figure captions outside the text column on the left, along with notes and footnotes.

Use the generous margins on each page to make notes as you read the manual and set up the system.

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**help!**

To obtain assistance with this hardware, or simply to submit suggestions, please contact Customer Service:

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This section gives brief information—just enough to get you started—about unpacking, inspecting, and installing your IFA 100 System.

## Unpacking and inspection

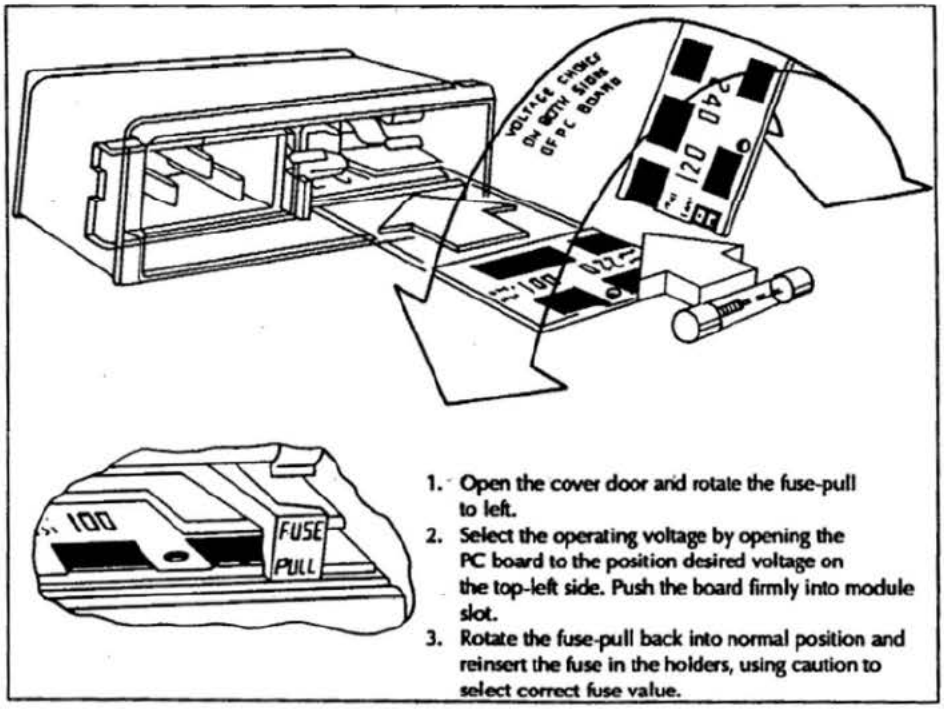
Remove the IFA 100 from its shipping container and thoroughly inspect it for shipping damage. If damage is found, notify the carrier. Then contact your nearest TSI sales office for instructions on return shipping; use the original container if possible.

Note that the IFA 100 hardware includes an accessory package that contains this instruction manual and all other accessories as listed in chapter 7, 'Specifications'. Make sure you have received all these items. If not, contact TSI's Customer Service department.

## Selecting the line voltage

The IFA 100 System consists of a MODEL 158 Master Cabinet for the first four transducer channels, and a MODEL 159 Slave Cabinet for each additional group of four channels. Both master and slave cabinets are equipped with a rear-panel module that provides a fuse holder, a PC card to switch the line voltage, and a line-cord receptacle. See figure 1 and table 1 for instructions on selecting and setting the line voltage.

[1] Selecting the line voltage




1. Open the cover door and rotate the fuse-pull to left.
2. Select the operating voltage by opening the PC board to the position desired voltage on the top-left side. Push the board firmly into module slot.
3. Rotate the fuse-pull back into normal position and reinsert the fuse in the holders, using caution to select correct fuse value.



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To operate the master and slave, use the line voltages in table 1:

TABLE 1.
Line voltages for the master and slave cabinets

| nominal (VAC) | range (VAC) | fuse (A) |
|---|---|---|
| 100 | 90 to 105 | 1 |
| 120 | 108 to 126 | 1 |
| 220 | 198 to 231 | 0.5 |
| 240 | 216 to 252 | 0.5 |

## Rack mounting

The master and slave cabinets are easily rack-mounted. Remove the rubber feet from the bottom of each cabinet and slide the cabinet into the rack. Secure it with the two screws included in the accessory package.



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# 1 Controls and functions of the IFA 100

This chapter explains the features and functions of the IFA 100. Carefully read through this section *after* you have unpacked the components of the IFA 100 and set them out in front of you. Refer to them frequently, particularly when a component's features are described.

## Model 158 and Model 159 cabinets

***Description of the cabinets***

The MODEL 158 is the master cabinet and the MODEL 159 is the slave cabinet. Both cabinets house, and provide power to, four channels of transducers and signal conditioners.

The master cabinet can control up to 16 channels by means of: (a) its front-panel keyboard (local) or via a computer (remote) through an RS-232-C interface; (b) a 4½-digit data display with channel number; (c) three warning indicators; and (d) a test signal.

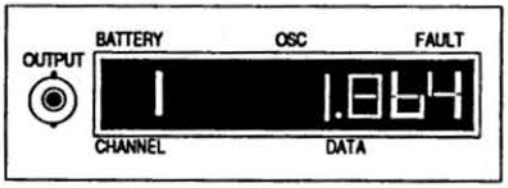
*Since the MODEL 159 has no internal microprocessor, it must rely on the MODEL 158 for control. (A ribbon cable in the back panel connects the slave to the master.)

Its microprocessor sends instructions to the transducer module and signal conditioner module;* the microprocessor also monitors such parameters as the selected bridge, sensor faults, and the overheat setting of the MODEL 150 Anemometer (in the standard, 1-bridge position).

***Front-panel controls of the Model 158 Master Cabinet***

Refer to figure 2 as you read the following descriptions.

*LED display.* The display includes two digits for channel number and 4½ digits for data. It can monitor up to 16 channels of transducers and signal conditioners. When overranged, the display flashes '99999'. When no polarity sign appears, the display is positive; the display is negative only when the negative sign (–) appears.



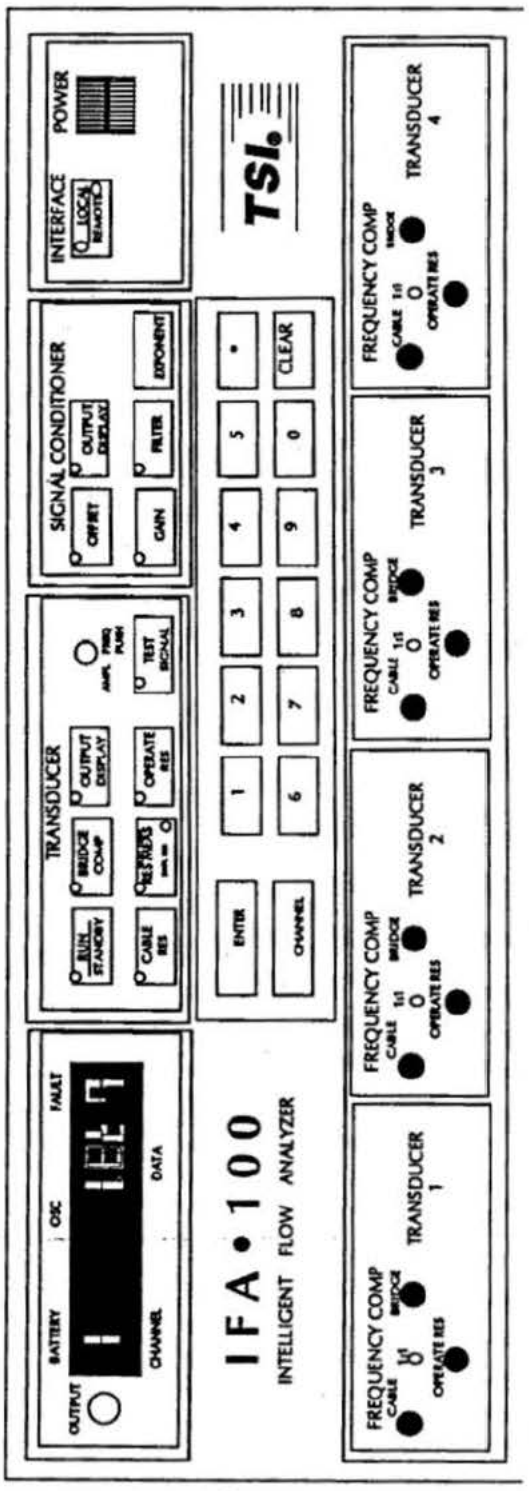

*Battery; OSC, fault (warning indicators).* The warning indicators are Battery, Osc, and Fault, listed horizontally across the top of the LED display; they are visible only when in an active warning mode.

When the Battery indicator comes on, it means that the internal battery (back-up battery) is too low to retain function values if the power were interrupted. Generally the battery holds a charge for several days.



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[2] Front panel of the master cabinet and LED display






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When the Osc indicator comes on, it means that the anemometer is oscillating or that large-scale turbulence is occurring.

When the Fault indicator comes on, it means that the anemometer probe is not connected or is damaged (resulting in an open circuit). If your transducer is a MODEL 140 Temperature Module, FAULT means either that the thermocouple is open or that the reference junction is no longer maintained at a constant temperature.

*Test signal.* The TEST SIGNAL is a square-wave signal that is applied to the bridge of the anemometer to visually optimize the frequency response of the anemometer. The amplitude and frequency of the signal are continuously variable. To adjust the amplitude, rotate the knob above the Test Signal key. To adjust the frequency, push in the knob while turning. For detailed information on square-wave testing of the frequency response, refer to Appendix A.

*Local/remote interface mode.* When power is first applied, the master starts in the Local interface mode. The system is then operated through the front-panel controls.

If you set the interface mode to Remote, the system is controlled from a remote terminal or computer via an RS-232-C interface.

*Channel.* The channel function selects one of the 16 channels. To select a channel, press Channel and then a channel number (1 through 9, or 01 through 16).

*Output connector.* The Output Connector on the front panel of the master monitors the transducer or signal conditioner output on any one of 16 channels. The Output Display of either the transducer or signal conditioner switches the output to the LED display and to the output connector.

***Back-panel controls of the Model 158 Master Cabinet***

Refer to figure 3 when reading the following descriptions of the master cabinet's back panel.

*RS-232-C connector.* The RS-232-C connector is on the upper right side of the rear panel. It is used for remote control of the master cabinet via a terminal or computer.

*Ribbon cable connector.* The ribbon cable connector is just above the power connector on the upper left side of the back panel. Use it to connect additional slave cabinets.

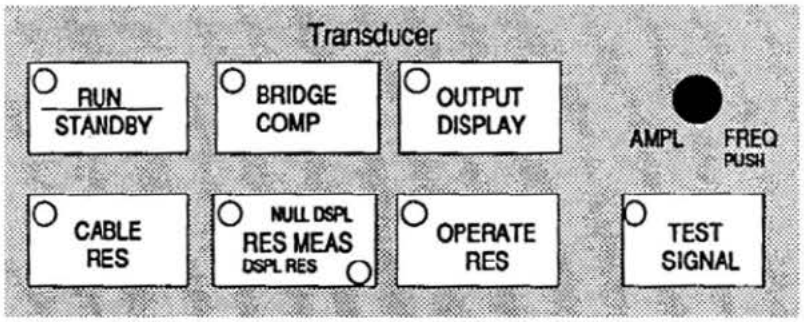


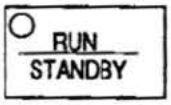
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### *Functions of the anemometer*

The seven anemometer functions (figure 4) include Run/Standby, Bridge Comp(ensation), Output Display, Cable Res(istance), Res(istance) Meas(ure), Operate Res(istance), and Test Signal. These functions may be monitored or controlled by computer or terminal via the RS-232-C interface.

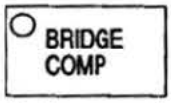
[4] Front-panel display of the anemometer's functions




Run/Standby is a dual-purpose key. When the anemometer is in the Run mode, the LED indicator is on; when the anemometer is in the Standby mode, the LED indicator is off. If the anemometer is in Run and you press the Run/Standby key, the anemometer switches to Standby (and vice versa).

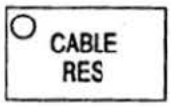
Run (Run/Standby) is the mode in which the bridge amplifier is connected to the top of the bridge and the probe is controlled at a constant temperature. Standby is an idle condition in which there is no feedback from the bridge amplifier to the top of the bridge.




Bridge Compensation (Bridge Comp) allows you to repeat frequency-response settings. It is one of the two controls that are needed to optimize the frequency response. The display range is approximately 20 to 5300. Once a given probe is optimized for maximum frequency response, press Bridge Comp to record the value from the display and repeat the bridge-compensation setting. This means that there is only one control for optimizing the frequency response (cable).




Output Display (Output Display) switches the output of the anemometer to the digital display on the front panel; on the master cabinet, it switches it to the output connector on the front panel. When the anemometer is in Run, the display is in volts; when Cable Res or Operate Res is pressed, the display is in ohms.



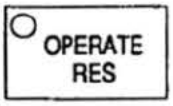

Cable Resistance (Cable Res) allows you to store the cable resistance value in memory and to use it for subsequent calculations.



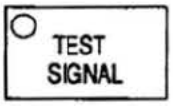
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Resistance Measure (Res Meas) measures the cable resistance or the probe resistance.




Operate Resistance (Operate Res) displays the operating resistance of the probe; use it in conjunction with the Operate Res control to set the operating resistance.



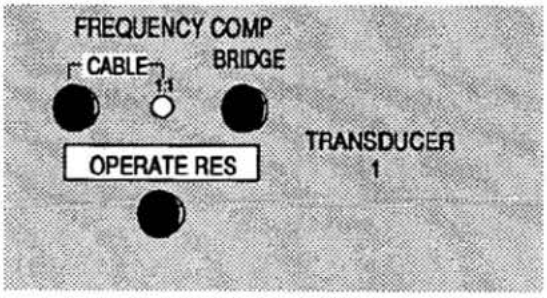

Test Signal applies a square wave to one side of the bridge so that you can see the pulse response on an oscilloscope. When pressed the first time, Test Signal activates the square-wave test signal; when pressed a second time, it deactivates the test signal. Test Signal can only be used in the Run mode to optimize the frequency response of the anemometer. When the LED is *on*, the function is on; the function is off when the LED is *off*.

The Test Signal has a dual-function control above the Test Signal key. Pushing in and turning the control allows you to adjust the frequency of the test signal from 300 hertz to 30 kilohertz; when you turn the control, you adjust the amplitude.

***Front-panel controls of the anemometer***

The front-panel controls, shown in figure 5, include the Operate Res and Frequency Compensation controls.

[5] Front-panel controls of the anemometer




*Operate Res.* The Operate Res control is used in conjunction with the Res Meas and Operate Res functions.

In the Res Meas function, the function of the Operate Res control is to null the display. In the Operate Res function, the function of Operate Res is to adjust the value of the operating resistance.

*Do not worry about breaking the knob while turning the Operate Res control.

The Operate Res control is continuously variable (no stops) and equipped with a dual-ratio drive. When the control turns easily (fine adjustment), the ratio is 36:1; when the control turns very hard* (coarse adjustment), the ratio is 6:1. Note that the fine-adjustment range is approximately one turn.



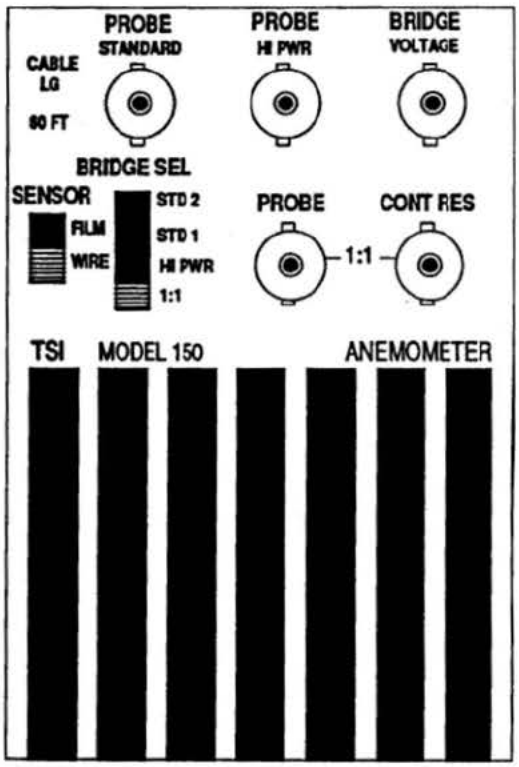
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*Frequency Comp.* The Frequency Compensation controls include cable compensation (Cable) and bridge compensation (Bridge). The Cable (1:1) control is used for the 1:1 bridge position while the Cable control (knob) is used for the remaining bridge positions. The Bridge control is common to all bridge positions.

### *Back-panel controls of the anemometer*

As illustrated in figure 6, the back panel of the anemometer contains eight connectors and switches from top left:

[6] Connections in the back panel of the anemometer




1 LED for 60-ft cable length to indicate the position of the internal switch

2 Standard probe connector

3 Hi-Pwr probe connector

4 Bridge Voltage output connector

5 Sensor switch (film/wire)

6 Bridge Selector switch (Std 1, Std 2, Hi Pwr, 1:1)

7 Probe connector for the 1:1 bridge position

8 Control Resistor (Cont Res) connector for the 1:1 bridge position

### *Internal switches*

The anemometer has only two internal switches (see 'Field installation of additional modules' in chapter 4). Channel Number selects the channel number for each anemometer module; Cable Length sets either the '15-foot' or '60-foot' position used for all bridge positions except 1:1.



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***Bridge selection***

The anemometer offers four bridge positions: Standard 1, Standard 2, High Power, and 1:1 Bridge.

*Standard 1.* The Std 1 bridge position is used for most applications in gases and low-velocity liquids.

*Standard 2.* The Std 2 bridge position is used only when the operating resistance of the probe is in the range of 20 to 99.99 ohms.

*High power.* The Hi Pwr bridge position is available for applications in high-heat-transfer liquids and for controlling large flush-mount gauges. It has a maximum probe current of 1.2 amperes and a 2-ohm upper-bridge resistor.

> ***Note for STD1, STD2, Hi-power bridges:*** *These bridges are designed to be immune from noise. Even though cables and probes tend to act as antennae in a noisy environment, the outer shield of TSI's coaxial cable is grounded and this does not allow noise to radiate through to the center signal line.*

*1:1 Bridge.* The '1:1' bridge position is used for applications that require low-noise and high-frequency response. It includes a symmetrical bridge with 20-ohm upper-bridge resistors. Two 15-foot RG58A/U cables are used for the symmetrical bridge, one for the probe and one for the control resistor in order to match impedances on both sides of the bridge. You must connect a MODEL 1306 Control Resistor to the end of the Control Res cable, one that is equal to the desired operating resistance of the probe. Due to the symmetrical bridge, the probe current is 0.3 ampere. The transducer functions applicable in the '1:1' bridge position are Run/Standby, Bridge Comp, Test Signal, and Output Display. A long tone sounds if you press any other function.

> ***Note for 1:1 bridge:*** *This bridge has been designed for very high frequency response applications. When connected to this bridge, the outer shield of the coaxial cable and probe support are not grounded, and sometimes may act as antennae picking up RF noise and EMI. If this should occur, the typical frequencies are very high (around 1 MHz) and are way beyond flow frequencies of interest. Therefore, one should set the low-pass filter setting of the Model 157 Signal Conditioner to around 400 - 500 kHz and this will effectively eliminate the noise.*

## Model 157 Signal Conditioner

***Description of the signal conditioner***

The signal conditioner is a precision instrument that is required to offset, amplify, and filter the transducer signal before transmitting it to external



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signal-processing equipment. Its features include keypad entry and digital display of the Offset, Gain, and Filter values for each channel; internal solid-state switching; computer control via an RS-232-C interface; nonvolatile function values that last for days without power; a large number of function values that last for days without power; a large number of function settings to allow for maximum utilization of the conditioner's output range; an internal-external switch to allow for inputs other than those of the transducer; and direct-current or input coupling of 0.1, 3, or 10 hertz.

***Front panel controls***

The signal conditioner's four functions are controlled from the front panel of the IFA 100 or from a computer via a RS-232-C (see figure 7).

*Offset.* Offset ranges from 0 to 9 volts in 1-volt increments. Offset is subtracted from the transducer voltage or from the external input voltage only in the DC-coupling position.

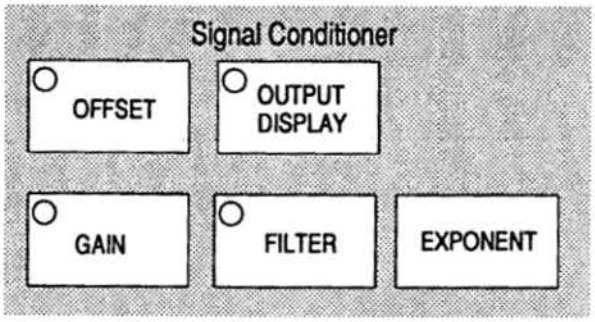
*Gain.* The Gain setting ranges from 1 to 900 (DC or AC). The setting is made up of a single-digit mantissa (1 through 9) and an exponent (0 through 2). Gain is applied after Offset.

*Filter (low-pass).* The Filter setting is the cutoff frequency from 1 hertz to 400 kilohertz; it is a third-order (–18 db/octave) Sallen-Key type. The setting is made up of a single-digit mantissa (1 through 9) and an exponent (0 through 5). The 900-kilohertz setting can be used as a no-filter position.

*Output Display (signal conditioner).* The Output Display switches the output of the signal conditioner to the digital display and to the front panel Output connector of the master cabinet

*Exponent.* Press the Exponent switch to set exponential notation for the Gain and Filter settings.

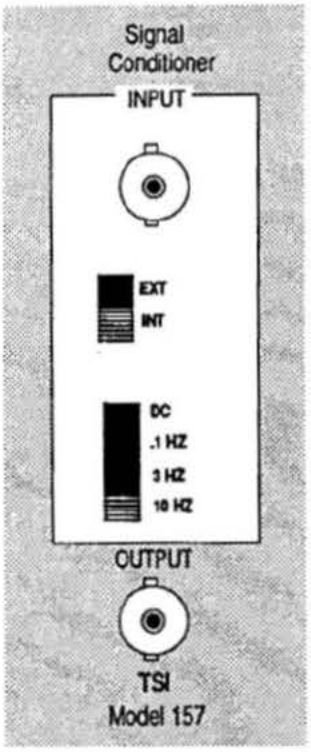
[7] Front panel of the signal conditioner






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[8] Back panel of the signal conditioner




### *Back panel controls*

The back panel, shown in figure 8, has an input connector, an internal-external switch, a four-position coupling switch, and output connector.

The Int-Ext switch (factory-set to Internal) toggles between the transducer output connector and the Input connector.

The Coupling switch (factory-set to DC) selects either DC or AC input coupling. In the AC position, the 0.1-, 3-, or 10-hertz switches select the lowest frequency of interest.



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# 2 The flow-measurement process

## Overview of the measurement process

The setup and operating procedure for the IFA 100 consists of four main steps (see figure 9):

1 Set up the back panel of all anemometer and signal conditioner switches; connect the probe and output cables.

2 Measure and enter all transducer operating parameters.

3 Tune the frequency response of the system.

4 Enter all signal conditioner functions.

This chapter provides all of the system's setup and operating instructions that you must perform in order to make flow measurements. However, it is recommended that you review the entire manual to fully utilize the features and capabilities of the IFA 100.

## Detailed instructions

***Configuring the back panel and connecting the cables***

Follow these nine steps to set up the back panel and to connect all the cables (refer to 'Configuring and operating the 1:1 bridge' later on in this chapter for detailed instructions on setting up and operating the 1:1 bridge).

1 Select the length of the probe cable with the internal slide-switch to either 5 meters [15 ft] or 20 meters [60 ft] (see figure 10). The anemometer is factory-set for 5-meter [15-ft] cables. The probe cable should be a standard RG58A/U, 50-ohm coaxial cable. When the switch is set for 20-meter [60-ft] cables, an LED on the back panel of the anemometer comes on.

   Select the sensor position, film or wire (back-panel switch).

2 Select the bridge position (back-panel switch).

   Use 1:1 Bridge for high-frequency response and low noise requirements.

   Use Std 1 bridge for most applications in gases and liquids.

   Use Std 2 bridge for probes with operating resistances greater than 20 ohms (20- to 99.99-ohm range).

   Use the Hi Pwr bridge in high-heat-transfer liquids or for controlling large flush-mount gauges. To double the bridge current for high-current applications, up to a maximum of 1.2 amperes, refer to table 12 in chapter 7.

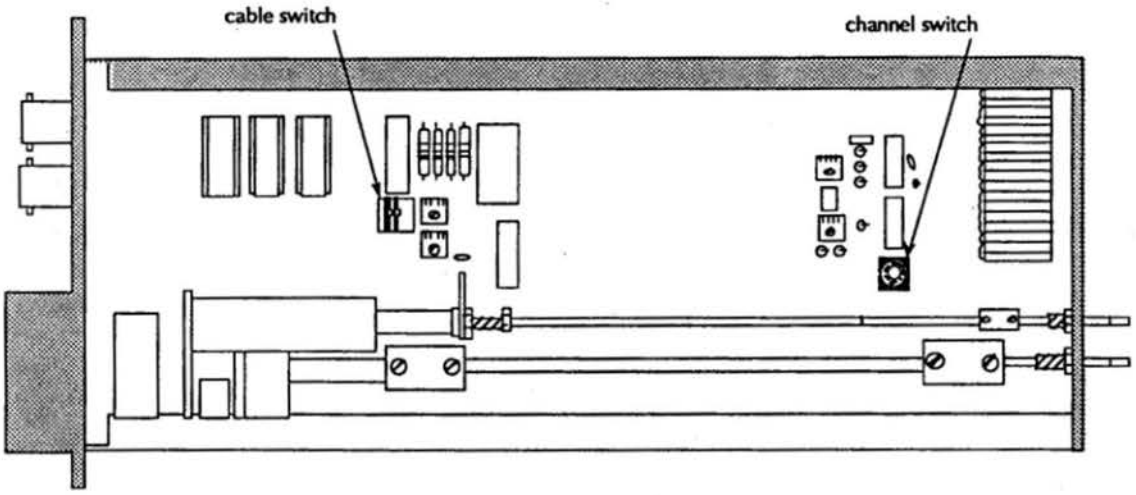


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[9] Front panel of the IFA 100

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[10] Location of the cable and channel switches




3 Set the Time Constant switch to adjust the averaging time of the front panel's digital meter. For setup and calibration, best results are obtained with switch in the *off* position. Connect either 5 meters [15 feet] or 20 meters [60 feet] of RG58A/U probe cable to the appropriate connector, 'Probe, Standard' or 'Probe, Hi Power'.

4 Set the input switch on the signal conditioner to Int and set the coupling switch to DC.

5 You may connect the 2-meter [6-ft] output cable to either the Bridge Voltage output jack or to the Signal Conditioner output jack on the rear panel of the master cabinet; both are primary output jacks. You may also use the output jack on the front panel by pressing Signal Conditioner or Transducer Output Display on the front panel.

6 If the system includes a slave cabinet, you must power it up first.

7 Plug in the power cord. Switch on the power. The Channel display shows that Channel 1 is selected by default. The fault light above the Data display comes on, indicating an open sensor. Both the LED for output display in the transducer and the 'local' LED in the interface section are also on.

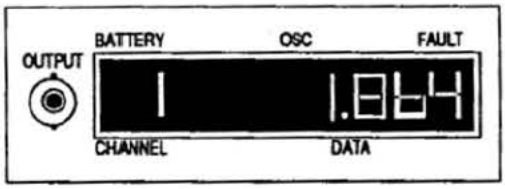
8 Connect the probe support to the end of the probe cable and connect the shorting probe into the probe support. The fault indicator above the digital display goes off when the cable is shorted.

9 Initially, the IFA 100 selects Channel 1. To change the channel number, simply touch the Channel keypad followed by the appropriate channel



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number. The channel number then appears on the front panel's digital display.




If the system has fewer than nine channels, you can select a channel by pressing Channel and then the appropriate channel number (1 through 9). If there are more than nine channels, press Channel and then enter a two-digit number (01 through 16).

Example 1: Select Channel 2 when fewer than nine channels are connected.

| *press:* | *displayed:* |
|---|---|
| CHANNEL | blank |
| 2 | 2 |

Example 2: Select Channel 2 when more than nine channels are connected.

| *press:* | *displayed:* |
|---|---|
| CHANNEL | blank |
| 0 | 0 |
| 2 | 2 |

A long tone indicates that the channel selected is not connected or that a two-digit number was entered instead of a single-digit number.

***Measuring and entering transducer parameters***

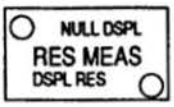
*Measuring the cable and cold-probe resistance.* All resistance measurement functions and operating parameters are displayed in the 'Data' portion of the front-panel's digital display.

The Resistance Measure (Res Meas) function is used to measure the resistance of the probe or the probe cable depending on whether a shorting probe or a sensor probe is attached to the probe cable. The resistance being measured is considered to be cable resistance if its value is less than 2.000 ohms (with shorting probe attached); it is considered to be probe resistance if the value is greater than 2.000 ohms (with sensor probe attached). The Resistance Measure is a two-step function that involves the following steps:



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*press:* *displayed:*




XXXX [LED displays null reading (1)]

Now null (adjust to zero) the display reading using the Operate Res control. Observe the polarity sign on the display. If it is negative (–), turn the Operate Res control clockwise; if it is positive (no sign), turn the Operate Res control counterclockwise. Use the coarse and fine adjustments to null the display.

Note that the Operate Res control is equipped with a dual-ratio drive. The ratio is 36:1 when the control knob turns easily in the Fine-adjustment mode; the ratio is 6:1 when the control knob turns very hard in the coarse adjustment mode. The control is continuously variable, that is, it has *no* stops. The fine-adjustment range is limited to approximately one rotation of the control knob.

Since Operate Res is a continuously variable control, two nulls can exist. When nulling the Operate Res potentiometer to zero, take care to select the correct null by turning the control in the proper direction.

For example, if the display reads a positive number and you turn the control counterclockwise, the reading decreases to zero and then, if continued, increases negatively. This zero is the real null. If you continue to turn the control counterclockwise, the reading becomes a large negative number. At some point, the control resets and the display reads a large positive number.

At the point where the control resets, the Null Display may be very close to zero. However, this is *not* the real null. For example, if by turning the Operate Res control clockwise, the potentiometer resets and the display shows a large negative number, you must continue to turn the control clockwise and increase the display reading toward the true zero reading. An incorrect setting produces a Display Resistance reading that gradually increases until it reaches 19.999 ohms, then indicates an overrange reading by flashing '99.999' on the Data display.

After nulling the display, you must

*press:* *displayed:*




XXXX [LED indicates DSPL Res (2)]

to read the Display Resistance. An LED indicates DSPL Res (display resistance), which is the probe-cable resistance or the probe resistance. The



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resistance is displayed as 'XX.XXX' in the Std 1 and Hi Pwr bridge positions, and as 'XX.XX' in the Std 2 bridge positions. The display reads both cable resistance and the sensor's cold resistance directly in ohms.

Press Enter to record the resistance value in memory.

The following table lists the change in resistance on the display as a result of how close to zero you set the null display.

TABLE 2.
Resistance change as zero is approached

| bridge position | | display | ohms |
|---|---|---|---|
| Std 1 | cable resistance | 0000 | 0.259 |
| | | 0010 | 0.261 |
| | probe resistance | 0000 | 8.500 |
| | | 0010 | 8.504 |
| Hi Pwr | cable resistance | 0000 | 0.264 |
| | | 0010 | 0.265 |
| | probe resistance | 0000 | 8.522 |
| | | 0010 | 8.531 |

Example: Measure and enter the cable resistance.

| *press:* | *displayed:* | |
|---|---|---|
| CABLE RES | XXXX | [previous value] |
| • | | |
| 2 | | . |
| 3 | | .2 |
| 4 | | .23 |
| ENTER | | .234 |
| | | .234 |



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Example: Change the value to '0.3 ohms'.

| *press:* | *displayed:* |
|---|---|
| CLEAR | blank |
| • | . |
| 3 | .3 |
| ENTER | .3 |

Note that the cable resistance range is from 0 to 1.999 ohms.

Example: Measure the cold probe resistance.

| *press:* | *displayed:* | |
|---|---|---|
| NULL DSPL RES MEAS DSPL RES | 0000 | [Adjust the Operate Res control to null the display (display should read 0000 ±0005).] |

| *press:* | *displayed:* | |
|---|---|---|
| NULL DSPL RES MEAS DSPL RES | XX.XXX | [The display reads the actual resistance of the sensor at room temperature; the cable resistance is automatically subtracted.] |

Note that for this measurement, a probe must be attached to the probe support. Handle the probe with care: it is easily damaged.

*Determining the operating resistance.* The operating resistance of the sensor can be taken from the resistance data supplied with each TSI probe or it can be calculated from the cold resistance by applying the appropriate overheat ratio (OHR).

$$\text{OHR} = \frac{\text{heated sensor resistance}}{\text{cold sensor resistance}}$$

Refer to chapter 3, 'General information', for additional information on selecting and calculating the sensor operating resistances.

The operating resistance ranges are given in chapter 7, 'Specifications'.



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Example: Set the operating resistance.

| *press:* | *displayed:* | |
|---|---|---|
| ○ OPERATE RES | XX.XXX | [The sensor cold resistance or previous Operating Resistance is displayed.] |
| | 12.000 | [Adjust the value on the display with (example) Operate Res control to the desired operating resistance (it is not necessary to press Enter).] |

Once you enter the cable resistance and set the operating resistance, the system is ready to run. To set the system to Run:

| *press:* | *displayed:* | |
|---|---|---|
| ○ RUN STANDBY | XX.XXX | [The transducer output automatically appears.] |

If you select the Output Display on the signal conditioner, the displayed signal is filtered, offset, and amplified. Use the Output Display of the transducer while you set up the system.

***Frequency-response tuning***

Note that the frequency-response tuning assures that the system allows rapid fluctuations in flow velocity. Therefore, when tuning the system, the probe should always be operated in a flow at the maximum velocity expected during measurements.

*Adjusting bridge compensation.* To activate this function,

| *press:* | *displayed:* | |
|---|---|---|
| ○ BRIDGE COMP | 70 (example) | [Current bridge compensation appears.] |

To change the setting, adjust the Bridge Comp control on the front panel to the appropriate value from Bridge Comp settings listed in table 3.

*Adjusting cable compensation.* With the IFA 100 in the Run mode, turn the Cable Comp control fully counterclockwise. Then turn the Cable Comp control clockwise until the oscillation indicator (Osc) above the display comes on.



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TABLE 3. Available settings for the Bridge Comp control

| sensor | type | standard 1 | high power | 1:1 |
|---|---|---|---|---|
| –T1.5 | wire | 35 | | 188 |
| –P2 | wire | 83 | | |
| –PI2.5 | wire | 115 | | |
| –P15 | wire | 120 | | |
| metal | clad | 775 | | |
| –10A | | 70 | 25 | |
| –10 | | 70 | 28 | |
| –20 | | 115 | 40 | 1041 |
| –60 | | 250 | 85 | |

This normally requires seven to eight full turns for a standard 5-meter [15-ft] probe cable. Turn the Cable Comp counterclockwise until Osc goes *off* (approximately ¼ to ½ turn).

Erratic operation of the Osc indicator may occur with some sensors or turbulent flows. For some sensors, the oscillation indicator may come on before Cable Comp has been turned sufficiently clockwise. Continue turning Cable Comp until the oscillation indicator goes *off* and then comes *on* again; then turn it back counterclockwise until the oscillation indicator goes off (approximately ¼ to ½ turn).

Rapid fluctuation of the bridge voltage, such as occurs in turbulent flows, can also trigger the Osc indicator. If you have difficulty, connect an oscilloscope to the front-panel output jack and observe the signal as you adjust the Cable Comp control.

*Square-wave test for optimum frequency response.* To optimize the frequency response of the system, use the Test Signal. (Refer to Appendix 1 for information on square-wave testing.) With the system in Run and an oscilloscope connected to the front-panel output jack,

*press:*

| | |
|---|---|
| TEST SIGNAL | [The test signal appears on the oscilloscope. The amplitude and frequency of the signal may require adjustment. The control is located above the Test Signal key.] |

Adjust the amplitude by turning the control knob. Adjust the frequency by pushing in and turning the control knob. Finally, adjust the frequency and amplitude of the Test Signal for ease of viewing on the oscilloscope.

You can optimize frequency response by adjusting the Cable Comp control to achieve the proper test-signal shape.



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You can also vary the Bridge control slightly, along with the Cable control, to optimize the shape of the signal displayed on the oscilloscope.

After optimizing the frequency response:

*press:*

| | |
|---|---|
| TEST SIGNAL | [Switches off the Test signal.] |

The anemometer is now ready for calibration or measurements. Refer to 'Calibration procedure' guidelines.

***Configuring the signal conditioner***

The following steps explain how to enter or read values for the Offset, Gain, and Filter functions:

*Offset.* The range of offset is from 0 to 9 volts in 1-volt increments.

To read the previous value (assuming that the previous value is '1'):

| *press:* | *displayed:* |
|---|---|
| OFFSET | 1 |

To enter a new value of '9':

| *press:* | *displayed:* |
|---|---|
| 9 | 9 |
| ENTER | 9 |

To change the value to '8':

| *press:* | *displayed:* |
|---|---|
| CLEAR | blank |
| 8 | 8 |
| ENTER | 8 |

*Gain.* The Gain on the signal conditioner is displayed with a 1-digit mantissa (range of 0 to 9) and a 2-digit exponent (0, 1, or 2).



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Example: For a gain of 10 ($1 \times 10^1$), the display reads '1 01'.

To read a previous value (assuming that the previous value is '10'):

| *press:* | *displayed:* |
|---|---|
| ○ GAIN | 1 01 |

To enter a Gain of '20':

| *press:* | *displayed:* |
|---|---|
| 2 | 2 01 |
| ENTER | 2 01 |

To change the value to '30':

| *press:* | *displayed:* |
|---|---|
| CLEAR | blank |
| 3 | 3 |
| EXPONENT | 3 00 |
| 1 | 3 01 |
| ENTER | 3 01 |

*Filter.* The filter setting of the low-pass filter also appears as a 1-digit mantissa (range of 0 to 9) and a two-digit exponent (range of 0 to 5). To read a previous value (assuming that the previous value is 1 kilohertz):

| *press:* | *displayed:* |
|---|---|
| ○ FILTER | 1 03 |



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To enter a filter value of 100 kilohertz:

| *press:* | *displayed:* |
|---|---|
| EXPONENT | 1 00 |
| 5 | 1 05 |
| ENTER | 1 05 |

To change a filter value to 20 kilohertz:

| *press:* | *displayed:* |
|---|---|
| CLEAR | blank |
| 2 | 2 |
| EXPONENT | 2 00 |
| 4 | 2 04 |
| ENTER | 2 04 |

The high-pass filter is set on the back panel to 1, 3, and 10 hertz.

*Press Output Display.* The output of the master cabinet appears on the display and is available at the slave cabinet's front-panel output connector.

The signal conditioner is now ready to operate with a transducer input. The signal conditioner is connected internally to the anemometer channel on its right (when viewed from the back of the instrument; the input switch on the rear panel is in the Int position).

All values of the signal conditioner are stored in the microprocessor's memory and are recalled each time the system is powered up.

If you hear a long tone, it means that an error has been made. Either the value is out of limits or a signal conditioner is not connected for that particular channel number.

See figure 18 for additional uses of the signal conditioner.



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### *Configuring and operating the 1:1 bridge*

Follow these 13 steps to set up and operate the 1:1 bridge:

1 With the power in the *off* position, select the '1:1' bridge position using the back-panel switch.

2 Select the type of sensor, film or wire, using the back-panel switch.

3 The internal 15-foot to 60-foot switch must be in the 15-foot position (LED on the rear panel must be *off*). See figure 10 for the location of the switch.

4 Connect the 15-foot (RG 58A/U) cables to the 1:1 probe and to the control resistor connectors.

5 Connect the MODEL 1305 Control Resistor to the control resistor cable. The value of the control resistor should equal the desired operating resistance of the probe.

6 Connect the probe support to the probe cable and then connect the probe to the probe support. Note that the probe is easily damaged: handle it with care.

7 Connect the oscilloscope to the Output jack on the front panel.

8 Plug in the power cord. Switch on the power. The LED on the back panel should be off.

The Channel display now shows that Channel 1 has been selected by default. The Fault light above the Data display should be off. The transducer Output Display and Interface Local LEDs are on.

9 Press Bridge Comp and adjust it to the value from Bridge Comp settings given below.

The Bridge Comp setting at 100 m/s of flow velocities is:

| sensor type | 1:1 bridge |
|---|---|
| T1.5 | 188 |
| –20 | 1041 |

10 Turn the 1:1 Cable control fully counterclockwise.

Turn 1:1 Cable control clockwise until the oscillation indicator comes on. Turn the Cable control counterclockwise until the oscillation indicator goes off (turn clockwise approximately 1¼ turns for a T1.5 wire probe).



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Erratic operation of the Osc indicator may occur with some sensors or turbulent flows. For some sensors, the oscillation indicator may light before the Cable Comp (1:1 control) is turned sufficiently clockwise. Continue turning the Cable Comp (1:1 control) until the oscillation indicator goes out and then comes on again; then turn it back counterclockwise until the oscillation indicator goes off (approximately ¼ to ½ turn).

Rapid fluctuation of the bridge voltage, such as occurs in turbulent flows, can also trigger the Osc indicator. If you have difficulty, connect an oscilloscope to the front-panel output jack and observe the signal as you adjust the Cable Comp (1:1 control) control.

11 Press Test Signal. Adjust the amplitude and the frequency of the test signal for ease of viewing on the oscilloscope. (Refer to Appendix A for information on square-wave testing.)

Adjust the Cable control for the desired signal shape (see Appendix A). You can also vary the Bridge control slightly along with the Cable control to optimize the shape of the signal displayed on the oscilloscope.

Switch off the Test Signal. The anemometer is now ready to take data. Next, refer to 'Configuring the signal conditioner' earlier in this chapter.

***Checklist for routine operation***

There are four main steps for routine operation:

1 Set the bridge selection.
The switch settings are on the back panel of the signal conditioner.

2 Enter the operating parameters of the transducer.
Enter and check the Cable Resistance.
Set the Operating Resistance.
Set the unit to Run.

3 Tune the Frequency Response.
Check the Bridge Comp value.

4 Set the Signal Conditioner parameters.
Adjust the proper Gain/Offset/Filter settings.



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# 3 General information

## Principle of operation

The transducer used with the IFA 100 is a small resistance element that is heated and controlled at an elevated temperature. The amount of electrical energy dissipated in the sensor is a measure of the cooling effect of the fluid flowing past the heated sensor.

The sensor is usually a fine wire (platinum, tungsten, or platinum alloy), a quartz-coated hot-film sensor (a cylinder, wedge, conical or flat surface, measuring 0.001 to 0.006 inch in diameter; or a ruggedized sensor, such as the MODEL 1266). The sensor is usually mounted on a probe and connected to the anemometer at the end of a coaxial cable (standard 15-foot length).

The cooling effect of the fluid passing over the sensor depends on both the mass flow and the temperature difference between the sensor and the fluid. The relationship between the bridge voltage and mass flow flux is given by the following equation:

$$\frac{E^2R}{(R+R_3)^2} = \left(A + B(\rho V)^{\frac{1}{2}}\right)(t_s - t_e) \qquad (1)$$

where $A,B$ = constants depending on fluid and type of sensor; functions of thermal conductivity, viscosity, and Prandtl number
$\rho$ = density of the gas or liquid
$V$ = velocity
$n$ = exponent (close to 2)
$t_s$ = operating temperature of the sensor
$t_e$ = fluid or environmental temperature
$t_s - t_e$ = typically 225°C in air and 40°C in water
$R$ = operating resistance of the sensor
$R_3$ = resistor in series with the sensor (usually 10 ohms)
$E$ = bridge

The operating resistance is set to operate the sensor at a resistance that is high enough to achieve the required operating temperature. Since the sensor is a resistor with a high-temperature coefficient, its temperature varies with resistance while the other resistors in the bridge are fixed resistors with very low temperature coefficients. If the sensor temperature is much higher than the fluid temperature, the signal is insensitive to temperature yet very sensitive to velocity; in other words, if $(t_s - t_e) = 200°C$, a change in $t_e$ represents a 1-percent temperature error. Hence, the sensor is operated at a constant temperature (constant resistance).

In practice, when the anemometer is set to Run, current flows through the bridge. The amplifier senses any off-balance and 'feeds back' more or less current until the bridge comes into balance.



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Example: If the sensor resistance is 6 ohms at room temperature and you want to operate it at 9 ohms, the operating resistance should be set to 9 ohms. The cable resistance should be measured and entered so it is subtracted from the operating resistance settings (after nulling the cable). When the circuit switches on the electrical current, flow increases through the sensor until it heats up to 9 ohms. If the velocity past the sensor increases, the sensor tends to cool, thus lowering its resistance. The amplifier senses an off-balance and feeds back a correction in the current flow to bring the sensor back to 9 ohms. The bridge voltage then changes correspondingly, showing the change in flow on the display and output.

## Selecting probes

The IFA 100 Intelligent Flow Analyzer operates almost any temperature-sensitive resistor. A wide selection of sensors, both standard and special, can be used. However, usually only one type of sensor is optimum for a given measurement. See TSI's catalog on hot-wire/hot-film anemometry probes and accessories for details on selecting probes.

The IFA 100 Intelligent Flow Analyzer is used either with hot-film sensors or hot-wires. The hot-film sensors have properties that are suitable for most applications. However, for some boundary-layer work or for very low-level turbulence measurements, fine tungsten hot-wires can have advantages both in frequency response and in signal-to-noise ratio. For work in conducting liquids such as water, the hot-film sensors must have a heavier quartz coating, which should be designated when ordering. The quartz coating does not affect frequency response until about 30 kilohertz.

## Operating resistance of the probe

The operating resistance is a predetermined resistance value obtained by heating the probe. Due to the probe's linear resistance-temperature relationship, the operating resistance determines the operating temperature of the probe. Following is a brief explanation of how a constant-resistance (temperature) anemometer controls the resistance (temperature) of the probe.

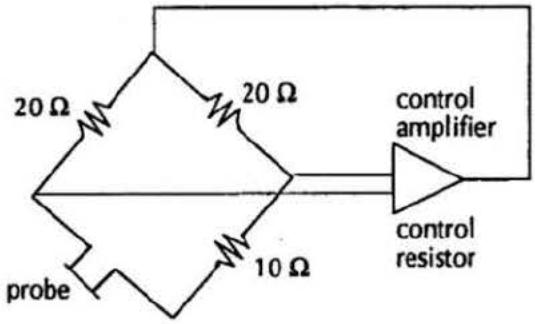
Figure 11 shows a typical anemometer circuit that includes a bridge and a control amplifier. The bridge has two fixed upper-bridge resistors, a probe, and a 10-ohm control resistor. The control amplifier regulates the current through the probe by means of the voltage at the top of the bridge. As the current through the probe increases, the heating causes the probe's resistance to increase. The control amplifier keeps the bridge balanced and in doing so, maintains the probe at a constant 10-ohm resistance (constant temperature).

The recommended operating resistance for a given probe is indicated on the label of the probe's shipping container. The label in figure 12 includes the



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[11] Typical anemometer circuit




probe resistance at 0°C, the change in resistance from 0°C to 100°C ($R_{100} - R_0$), the recommended operating resistance ($R_{op}$), and the recommended operating temperature in °C.

Table 4 shows the normal operating temperatures and temperature coefficients for various types of probes.

TABLE 4. Comparison of probes and their operating temperatures and coefficients

| probe type | fluid medium | normal operating temperature (°C) | temperature coefficient (°C) |
|---|---|---|---|
| –P2 | air | 500 | 0.003 |
| –T1.5 | air | 250 | 0.0042 |
| –PI2.5 | air | 550 | 0.0009 |
| film | air | 250 | 0.0018–0.0022 |
| film | water | 65 | 0.0018–0.0022 |

The optimum velocity sensitivity is obtained with the largest temperature difference; this also minimizes temperature sensitivity. If the resistance for ambient temperature or for a different operating temperature is needed, use the following formula (figure 12 is a graph of this relationship).

$$R_{op} = \left(\frac{R_{100} - R_o}{100}\right) T_{op} + R_o$$

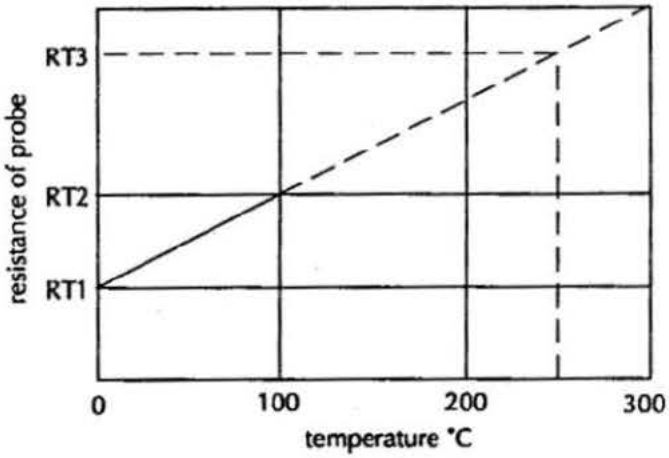
where $R_{op}$ = probe resistance at temperature (T3)
$R_o$ = probe resistance at 0°C
$R_{100}$ = probe resistance at 100°C
$T_{op}$ = ambient temperature or new operating temperature

Example 1: Given the label information in figure 13, determine the operating resistance at 250°C.

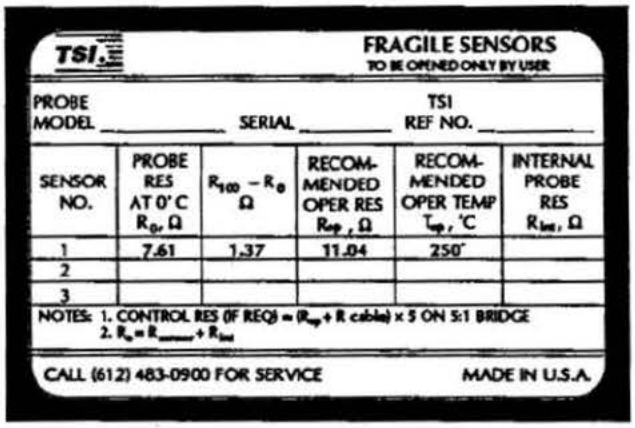


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[12] Graph of probe resistance versus temperature




[13] Probe resistance label


TSI

FRAGILE SENSORS
TO BE OPENED ONLY BY USER

PROBE MODEL _____ SERIAL _____ TSI REF NO. _____

| SENSOR NO. | PROBE RES AT 0°C $R_o$, Ω | $R_{100} - R_o$ Ω | RECOMMENDED OPER RES $R_{op}$, Ω | RECOMMENDED OPER TEMP $T_{op}$, °C | INTERNAL PROBE RES $R_{int}$, Ω |
|---|---|---|---|---|---|
| 1 | 7.61 | 1.37 | 11.04 | 250° | |
| 2 | | | | | |
| 3 | | | | | |

NOTES: 1. CONTROL RES (IF REQ'D) = ($R_{op}$ + R cable) x 5 ON 5:1 BRIDGE
2. $R_o = R_{____} + R_{int}$

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$$R_o = 7.61$$
$$R_{100} - R_o = 1.37$$
$$T_{op} = 250°C$$

$$\text{Operating resistance at } 250°C = \left(\frac{R_{100} - R_o}{100}\right) T_{op} + R_o$$
$$= \left(\frac{1.37}{100}\right) 250 + 7.61 = 11.035\Omega$$

To assure the correct operating temperature of the probe, check the probe resistance at room temperature.

Example 2: Given the label information in figure 11, calculate the resistance of the probe for room temperature.



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$$\text{probe resistance at } 20^{\circ}\text{C} = \left(\frac{1.37}{100}\right)20 + 7.61 = 7.884 \text{ ohms}$$

The operating resistance read on the display is the actual operating resistance of the probe; the cable resistance has been subtracted automatically.

The resolution of the Operate Res control is essentially infinite and can be very useful when balancing split-film probes. It is equipped with a dual-ratio drive. When the control turns easily (fine), the ratio is 36:1; when the control turns quite hard (coarse), the ratio is 6:1. The control is continuously variable (no stops) in the coarse range; the fine-adjustment range is approximately one turn.

## Determining the operating resistance of the probe

The sensor operating resistance can be taken from the resistance data supplied with each TSI probe or it can be calculated from the cold resistance by applying the appropriate overheat ratio (OHR).

$$\text{OHR} = \frac{\text{heated sensor resistance}}{\text{cold sensor resistance}}$$

Table 5 gives typical overheat ratios for commonly used sensors:

TABLE 5. Overheat ratios for common sensors

| sensor | overheat ratio | |
|---|---|---|
| | air | water |
| 4 µm tungsten wire | 1.8 | — |
| cylindrical film sensor –10 (25 µm), –20 (50 µm) | 1.5 | 1.1 |
| cylindrical film sensor –60 (150 µm) | 1.4 | 1.08 |
| noncylindrical film sensor | 1.4 | 1.08 |

Example 1: OHR = 1.8

cold sensor resistance = 5.930 W
heated sensor resistance =
= operating resistance = OHR • cold sensor resistance
= 1.8 • 5.930
= 10.67 W

## Special feature: overheat reference

The IFA 100 also provides a probe overheat reference. This feature is very useful when working in liquids.



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Note that overheat reference is a function that can be used only with the RS-232-C interface. The overheat reference value represents the imbalance of the anemometer bridge due to the overheat ratio. This off-balance relies on the Operate Res control setting and on the resistance of the probe. The resistance of the probe changes due to ambient temperature changes or to a damaged probe. As long as the Operate Res control has not been changed and the ambient temperature is constant, the overheat reference is proportional to the resistance of the probe.

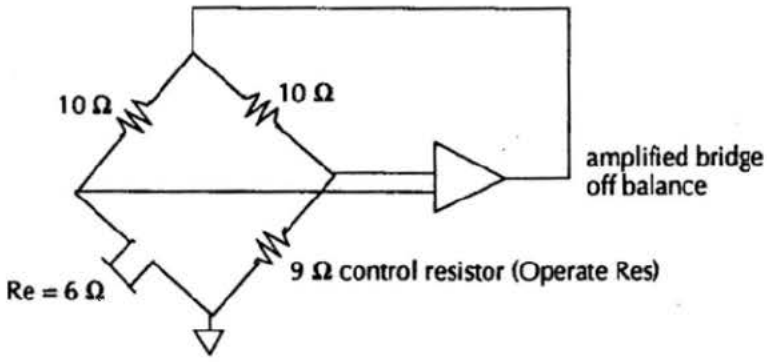
The overheat ratio is the ratio of the probe resistance at the ambient temperature (*Re*) to the probe resistance at the operating temperature (*Rp*).

$$\text{overheat ratio} = \frac{Rp}{Re}$$ : *Rp* = operate resistance (or control resistor at 1:1 Bridge position)

The overheat ratio depends on the type of probe. Normally, it is 1.8 for tungsten wires and 1.5 for hot films.

Shown below is a bridge with the following conditions:
Probe type: film
*Re* = 6 ohms (probe resistance at ambient temperature)
*Rp* = 9 ohms (probe resistance at operating temperature)

[14] Off-balance bridge with film-type probe




The off-balance of the bridge in the overheat reference function (K) is due to its ambient resistance relationship to the operating resistance of the probe. Until the probe is heated (Run) it remains at 6 Ω compared to 9 Ω on the control resistor side. This off-balance is then amplified and designated as the overheat reference.



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## Temperature compensation

You may use several techniques to take temperature into account if it varies with flow. If the temperature change is slow (ambient change), use the following techniques:

1 Measure the temperature along with the flow, and correct the flow data for the temperature difference between calibration temperature and the actual temperature (when not temperature-compensated).

These are approximate corrections only. If the temperature change is large or if the change is in fluids (where the factors 'A' or 'B' change rapidly with temperature), use a more accurate correction factor.

Multiply by $\left[\left(t_s - t_{e_2}\right)/\left(t_s - t_{e_1}\right)\right]^{\frac{1}{2}}$ for bridge-voltage corrections, where $t_{e_1}$ = new environmental temperature and $t_{e_2}$ = calibration temperature.

2 For high-frequency temperature compensation, use two anemometer systems simultaneously to operate the two sensors at different temperatures. In this case, the two equations provide two unknowns, temperature and flow, which can be solved analytically or by calibration. Additional information is given in TSI Technical Bulletin 39.*

*available on request from TSI

## Calibration procedure

The basic variable measured by a hot-film or a hot-wire sensor is the rate of heat transfer from the wire to the fluid. Since this is not generally the variable of interest, a calibration of bridge voltage versus velocity must be made. If desired, TSI can furnish calibrated probes for air or water. For other fluids, you must perform your own calibration.

### *Calibrating devices*

TSI manufactures a small calibrating device. It has a small nozzle fed by two quieting chambers in series. The MODEL 1125 Calibrator can calibrate most TSI probes for point measurements in gases.

For other calibrations in gases, a pitot or impact tube is used for reference in the flow system where the flow is smooth and turbulence levels are low. A wind tunnel or flow duct with quieting screens are sufficient to control the turbulence level. The MODEL 10180 Water Calibrator provides a uniform water jet for calibrating water probes.

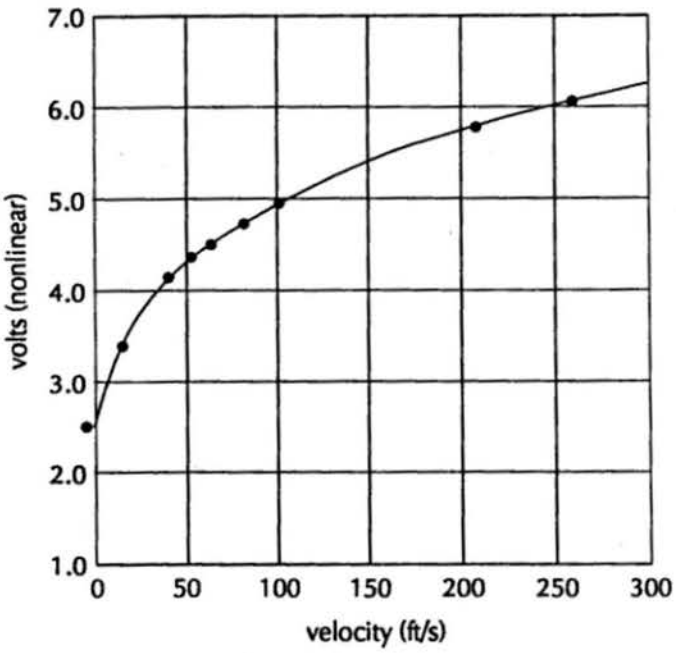
### *Velocity calibrations*

The form of the relationship between signal output and velocity or mass flow is seen in equation 1. If a calibration curve is plotted for velocity versus bridge voltage, a very nonlinear relationship results (approximately a quarter-power relation). The calibration curve has a shape like figure 15. The sensitivity is greatest at very low flowrates. In fact, it is often better that it not be



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[15] Calibration curve of velocity and bridge voltage




linearized at very low flowrates due to the increase in sensitivity with bridge voltage.

If a calibration curve of $E^2$ (bridge-voltage squared) is plotted against the square root of velocity, a nearly straight-line relationship results; as few as two points give accuracy within 5 percent. Better accuracy is obtained with more points—particularly at low velocities.

When making the calibration, record the bridge voltage in Run, the operating-resistance value, the fluid temperature and pressure, as well as the reference velocity and direction.

Calibrations with multisensor probes must be done on individual sensors operated normal to the flow stream, so the discussion of single-sensor probes given below can be extended to cover multisensor probes as well.

Since a cylindrical sensor measures the resultant velocity normal to the cylinder, it is important to orient the sensor so that the flow is perpendicular to the sensor in order to obtain a repeatable calibration.

***Repeatability***

The accuracy you can obtain depends on many factors, only a few of which can be mentioned here. The quality of the velocity reference used for calibration strongly affects accuracy. This is true as long as changes in the sensor,



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dirt accumulations, and so forth—or changes in the environment—do not affect the calibration.

The output can drift for two reasons. First, dirt accumulation affects heat transfer and accuracy. Hot-film sensors for use in gases can be cleaned by brushing with a camel's hair brush, using acetone or methanol as the solvent. (Acetone should not be used on sensors that have been insulated for use in water or mercury.) In water, if bubbles form on the quartz-coated sensor surface, brushing while the sensor is submerged generally prevents further bubble formation. Otherwise, a lower overheat should be used or else the air content of the water should be lowered. Hot-wire sensors (tungsten) are usually too fragile for brushing, but can be cleaned by dipping in a solvent or a solution of potassium dichromate in sulfuric acid. Platinum hot-wires can be cleaned by running a very high overheat to burn off the dirt.

The second cause of drift is a change in the actual cold-resistance of the sensor. This can be a problem in water measurements, even with quartz-coated sensors should the insulation on the sensor or probe legs wear through. Fine hot-wires may drift due to corrosion or other chemical effects. In general, hot-film sensors are more stable over long periods.

The accuracy of transient readings depends on the closed-loop response of the anemometer for the particular sensor and environment conditions. The IFA 100 has a frequency response up to 450 kilohertz depending on the anemometer, sensor, environment, and quality of the trim adjustment.

## Replacing sensors

The small hot-film and hot-wire sensors used with these instruments can be broken by contact with solid objects or through extreme dynamic loads. Sensors can fail due to electrolysis or to a resistance shift from prolonged exposure to some fluids.

TSI offers a sensor replacement service that provides a turnaround time of 2 to 5 days for replacing standard hot-wire and cylindrical hot-film sensors.

***Hot-wire sensors***

Tungsten hot wires can be replaced by you or by TSI. If you replace them, purchase a fixture (Model 10122-T1.5) on which a dozen tungsten wires are mounted across an open slot. The wires are platinum-coated and have a layer of copper plating on the ends that exactly defines the sensing length. To replace the wire align the supports with one of the wires in the slot (under some magnification) and attach the wires with soft solder. Instructions are included with each MODEL 10120 Repair Kit. For replacement at the factory, return the probes with the information requested below in 'Returning probes for replacement'.



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Platinum and platinum-iridium hot wires can also be furnished for replacement in the field by spot-welding. Since they are usually used in gases at elevated temperatures they should be returned to TSI for replacement unless a high-temperature bonding technique is available. Soft solder will melt if the probes are to be used in gases above 400° or 500°F. The MODEL 10170 Spot Welding Kit is recommended for spot-welding wire sensors.

***Cylindrical hot-film sensors***

If these sensors are to be used in gases, they can be replaced with the MODEL 10120 Repair Kit and MODEL 10121 Replacement Sensors. Sensors for conducting liquids should be replaced by TSI since they cannot be tested until they are mounted and insulated.

***Conical, wedge, and flat hot-film sensors***

The noncylindrical hot-film sensors are built so that the sensor becomes part of the probe structure. For this reason such probes cannot be repaired; a new one must be purchased. Fortunately these probes are more rugged and tend to last longer than the cylindrical types.

***Returning probes for replacement***

When returning a probe for repair, include the following information for fastest service:

1 The name of the individual to be contacted when returning the probe
2 The name of company and appropriate mailing address
3 The purchase order number (and proper documentation)
4 The type of sensor being returned
5 The sensor's operating fluid (air, water, etc.)
6 The sensor's operating fluid temperature, if other than ambient room temperature
7 Specify the MODEL 1305 Control Resistor if the probe is used on the 1:1 bridge.
8 Specify the overheat or operating temperature if different from standard.
9 Specify the velocity range if velocity calibration is required.

## Model 158 and 159 block diagram

Figure 15 shows a block diagram of a two-cabinet IFA 100 system (MODEL 158 and MODEL 159) with a transducer and signal conditioner module in each cabinet. These modules are controlled by the master cabinet (MODEL 158). The MODEL 159 only houses and powers the modules within it.

The signal and data lines shown are common to all modules with the selected channel switched to these lines.



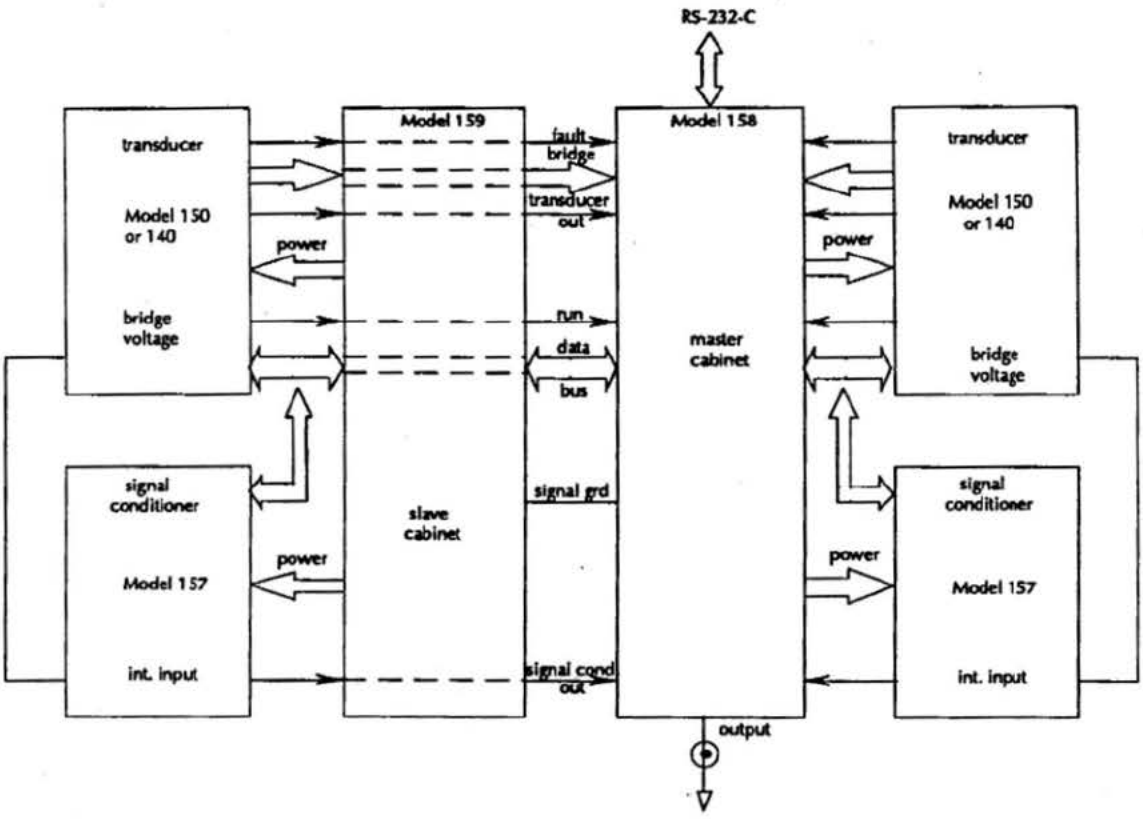
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The data bus includes four data lines, three control lines (Channel, Instruction and Load Signal Conditioner) and two anemometer lines. The data bus is required to:

1 select the channel number
2 check for the number of channels connected and their type
3 send instructions to the anemometer
4 load the function values of the signal conditioner from the battery-backup memory when the system is first powered up.

The Fault and Run line indicate the status of the transducer. The two bridge lines indicate the position of the bridge switch for a MODEL 150 Anemometer. Two lines transmit the transducer output and the signal conditioner output.

[16] Block diagram of the IFA 100 system




## Model 150 Anemometer block diagram

Figure 17 shows a block diagram of the MODEL 150 Anemometer. It includes the four bridge positions, two preamplifiers, a main amplifier/power amplifier, and a fail-safe circuit.



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The 1:1 bridge position, shown at the upper left of the diagram, contains a symmetrical bridge that has two 20-ohm upper-bridge resistors and connections for the probe and control resistor cables. It also includes a low-noise, high-frequency preamplifier.

The standard 1- and 2-bridge positions and the high-power bridge position are shown at the lower left of the diagram. The standard 1- and 2-bridge positions have a 10-ohm upper bridge resistor and a standard probe connection. The high power bridge position has a 2-ohm upper-bridge resistor and a HI PWR probe connection. All three bridge positions share the Operate Res control and the preamplifier.

The main amplifier/power-amplifier circuit is common to all four bridge positions. The input of the main amplifier is either switched to the 1:1 preamplifier or to the standard High Power preamplifier output.

The bridge compensation control, which controls the bridge impedance, is shared between the four bridge positions and switched across the upper bridge resistor.

The fail-safe circuit shown in the diagram protects against sensor failure due to operator error.

The output of the anemometer (bridge voltage) is available at the rear panel of the anemometer or at the MODEL 158 output (figure 17).

***Fail-safe circuits***

The anemometer has protection circuits to prevent accidental burnout of a probe. The anemometer automatically switches to Standby under these conditions:

1 When the IFA 100 is first powered up
2 If the line power is interrupted
3 If the probe is removed or damaged (open)
4 If the Control Resistor is removed (1:1 bridge position only)
5 When you select the Bridge Comp, Res Meas, or Operate Res keys.

If condition 3 or 4 has occurred and you have corrected the problem, press the Run/Standby key twice to make the anemometer switch to Run.

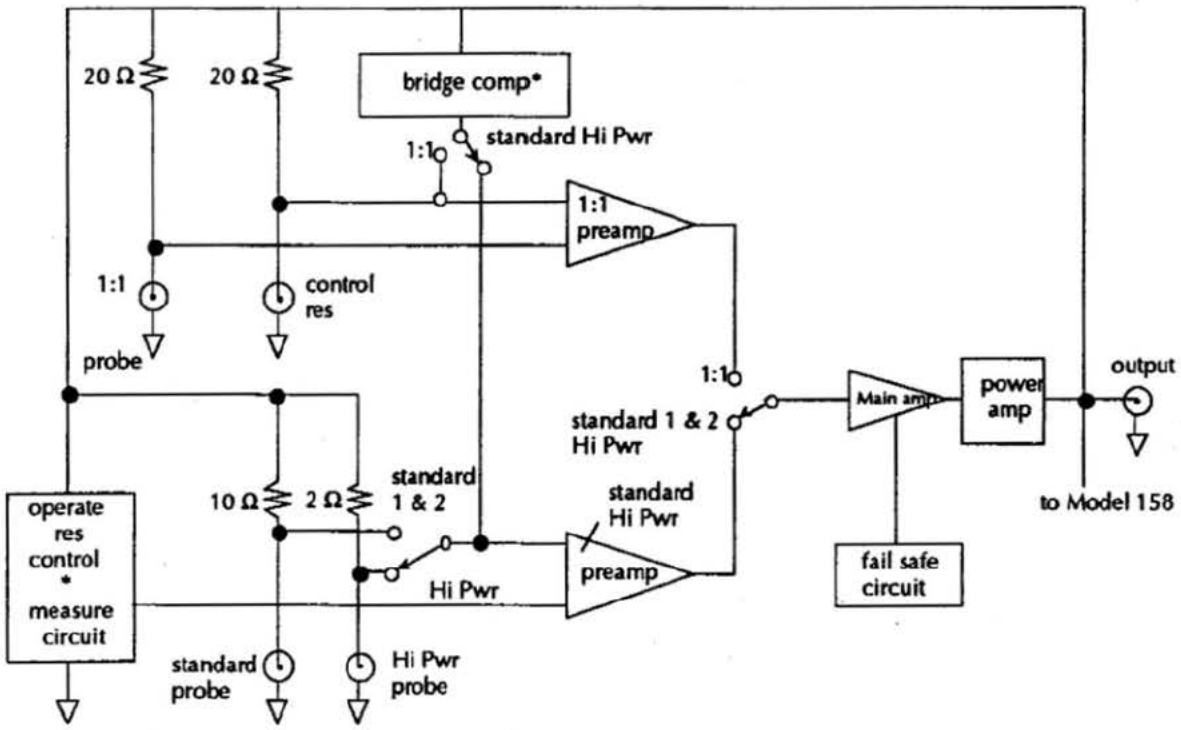
***Maximum overheat check***

In the standard 1-bridge position the overheat ratio is checked before switching to Run. A maximum overheat ratio of 2 is set at the factory (internally set on the MODEL 158). This setting relates to all channels and includes both the resistance of the probe and the cable.



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[17] Block diagram of the anemometer




*patent pending

Before switching the anemometer to Run (in the standard 1-bridge position) the overheat ratio (which includes the cable resistance) is less than 2. The maximum Operating Resistance allowed is twice the (cold) probe resistance plus the cable resistance. For example, if the cold probe resistance at ambient temperature is 8 ohms and the cable resistance is 1 ohm, the maximum Operate Resistance is (2 × 8) + 1 = 17. The acceptable overheat ratio allowed becomes 2.125.

## Model 157 Signal Conditioner block diagram

The block diagram in figure 17 includes the Internal-External switch, the Input Coupling switch, and the following sections: Offset, Gain, Filter, and Control.

The Internal-External switch selects the output of the transducer when in the Internal position. In the External position, the Input Connector (rear panel of the MODEL 157) is selected.

The Coupling switch selects either the DC position or one of the following AC positions: 0.1, 3, or 10 hertz.



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The Offset section subtracts 0 through 9 volts (in 1-volt increments) from the input voltage. The Offset can only be used in the DC-coupling position.

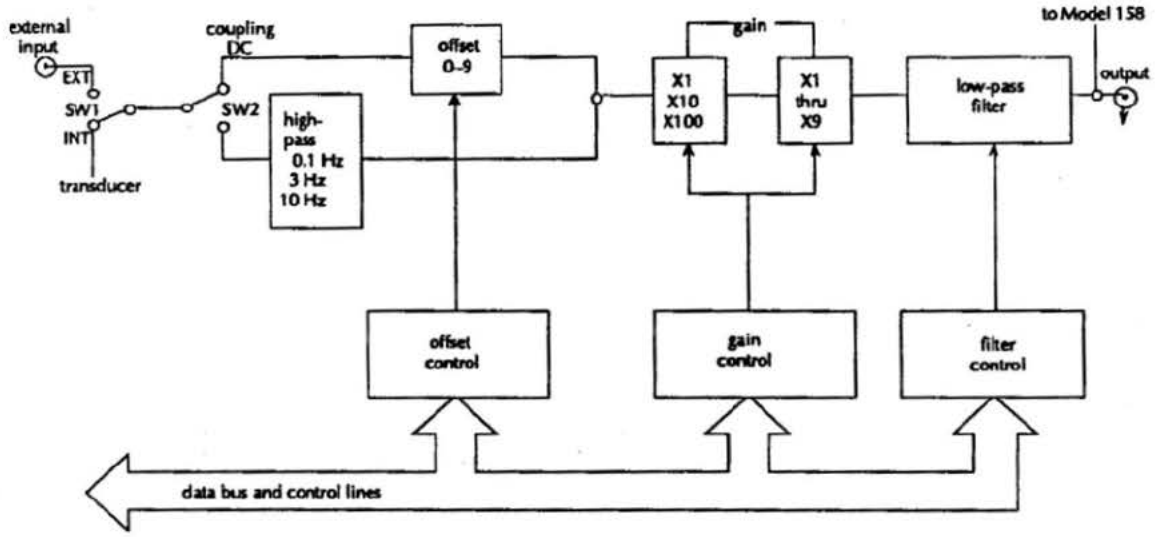
The Gain section is made up of two stages. The first stage has a gain of 1, 10, or 100; the second stage has a gain of 1 through 9, in steps of one.

The Filter (low-pass) is a third-order Sallen-Key type (–18 dB/octave roll-off) with selectable cutoff frequencies.

The Control section selects internal solid-state switches and receives information via the data bus lines which include four data lines and two control lines (Channel and Load Signal Conditioner). Each time the MODEL 158 is powered up, the MODEL 157 function values are reloaded from the battery-backup memory using these data lines.

[18] Block diagram of the master cabinet

The Signal Conditioner output is available at the rear panel or at the Output jack on the front panel of the MODEL 158.




### *Additional uses of the signal conditioner*

The output range of the signal conditioner is ±5 volts. Many wire and film sensors have a voltage span much less than the ±5 volt output range. To utilize as much of this range as possible in the DC position, you must set the Offset and Gain properly. Below is an example of how to calculate the Offset and Gain given $E_O$ and $E_M$ from the anemometer.

Given $E_O$ = 0.72 volts — $E_O$ = bridge voltage at zero flow
$E_M$ = 1.44 volts — $E_M$ = bridge voltage at maximum flow



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1 To calculate the span, follow this equation:

$$\text{span} = \frac{10}{E_M - E_O} = \frac{10}{1.44 - 0.72} = 13.89$$

2 To calculate the offset, follow this equation:

$$\text{offset} = E_M - \frac{5}{Span} = 1.44 - \frac{5}{13.89} = 1.08$$

To round off to the nearest volt:

offset = 1

3 To calculate the gain, follow this equation:

$$\text{gain} = \frac{5}{E_M - \text{Offset}} = \frac{5}{1.44 - 1} = 11.36$$

Disregard the decimal and select the nearest value equal to or less than the mantissa.

gain = 10

The gain cannot be greater than the Span in 1 above.

4 To check the range of the output voltage:

gain $(E_O - \text{Offset})$; cannot exceed –5.
10(0.72 – 1) = –2.8; negative range is within limits.

5 To check the positive range:

gain $(E_M - \text{Offset})$; cannot exceed 5.
10(1.44 – 1) = 4.4; positive range is within limits.

With an offset value of 1 and a gain of 10, the output range of the signal conditioner is –2.4 to 4.4 volts with an anemometer input of 0.72 to 1.44.



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# 4 Expanding the system

## Introduction

Chapter 4, 'Expanding the system', contains information about unpacking, inspecting, and installing additional MODEL 150 Anemometers, MODEL 157 Signal Conditioners, and MODEL 159 Slave Cabinets (when ordered separately).

## Unpacking and inspection

Carefully remove the instrument from its shipping container and thoroughly inspect it for damage. If you discover any shipping damage, contact the carrier and the nearest TSI sales office for return shipping instructions. If possible, use the original shipping container.

## Installing additional modules in the field

Follow these steps when adding MODEL 150 Anemometers or MODEL 157 Signal Conditioners to a MODEL 158 or MODEL 159 Cabinet.

***Model 150 Anemometers***

To install the MODEL 150 Anemometers in the field, follow these six steps:.

1 Select the channel number using the internal switch on the anemometer (1 through 16; see figure 19). The switch is labelled in hexadecimal (0 through 9, A through F). Channels 1 through 9 are set using switch settings 1 through 9; Channels 10 through 16 are set according to table 6:

TABLE 6. Switch settings of channels 10–16

| channel | switch setting |
|---|---|
| 10 | A |
| 11 | B |
| 12 | C |
| 13 | D |
| 14 | E |
| 15 | F |
| 16 | 0 |

The MODEL 158 and 159 have four transducer positions, labelled 1 through 4, on the front panel. The channel number and the transducer number are the same with a 4-channel system. If more than four channels are used (MODEL 158 and one or more MODEL 159 Cabinets), the transducers in the slave cabinet are assigned channels 5 through 8 for transducers labelled 1 through 4, respectively.

2 Select the cable length with the internal slide switch for either 15-foot [5-m] or 60-foot [20-m] probe cable. The anemometer is factory-set for 15-foot cables. The LED indicator on the back panel of the anemometer indicates when the switch is set for 60-foot cables.

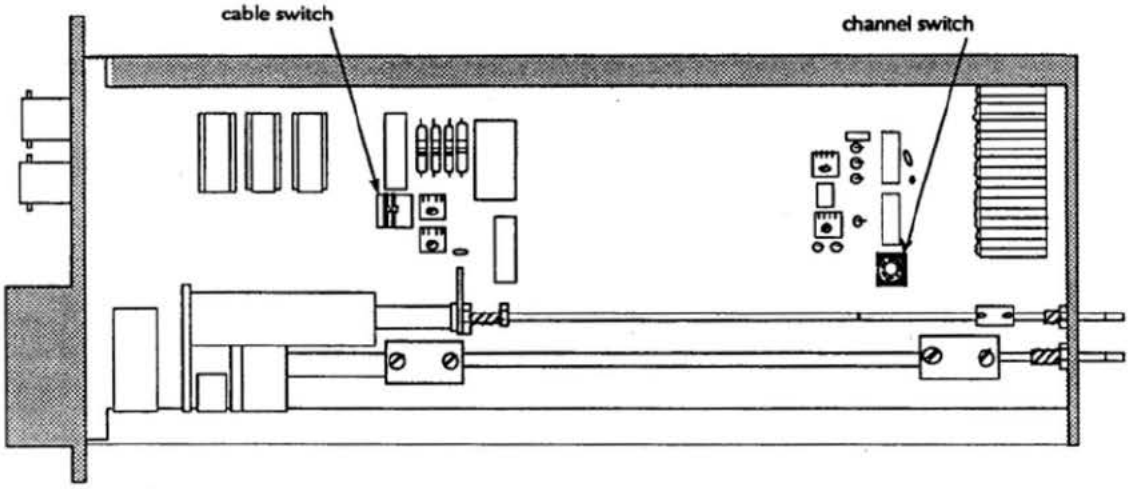


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3 Remove the blank panel on the rear of the cabinet (MODEL 158 or 159).

[19] Location of the anemometer channel switch

4 Slide the anemometer into the cabinet with the side-cover located in the slots of the guides (see figure 20 for a rear view of the cabinet).




5 Push in the module until it bottoms out on the rear rods. Secure the module with the two no. 6-32 screws provided.

6 Fasten the ⅜-inch knobs to the Cable and Bridge controls. Fasten the ½-inch knob to the Operate Res control (use the Allen wrenches provided to tighten the knobs).

### *Model 157 Signal Conditioners*

Follow these three steps to install a MODEL 157 Signal Conditioner in the field:

1 Remove the blank panel on the back of the cabinet (MODEL 158 or 159).

2 Slide the signal conditioner into the cabinet with the side-cover in the guide slots (see figure 20 for a rear view of cabinet).

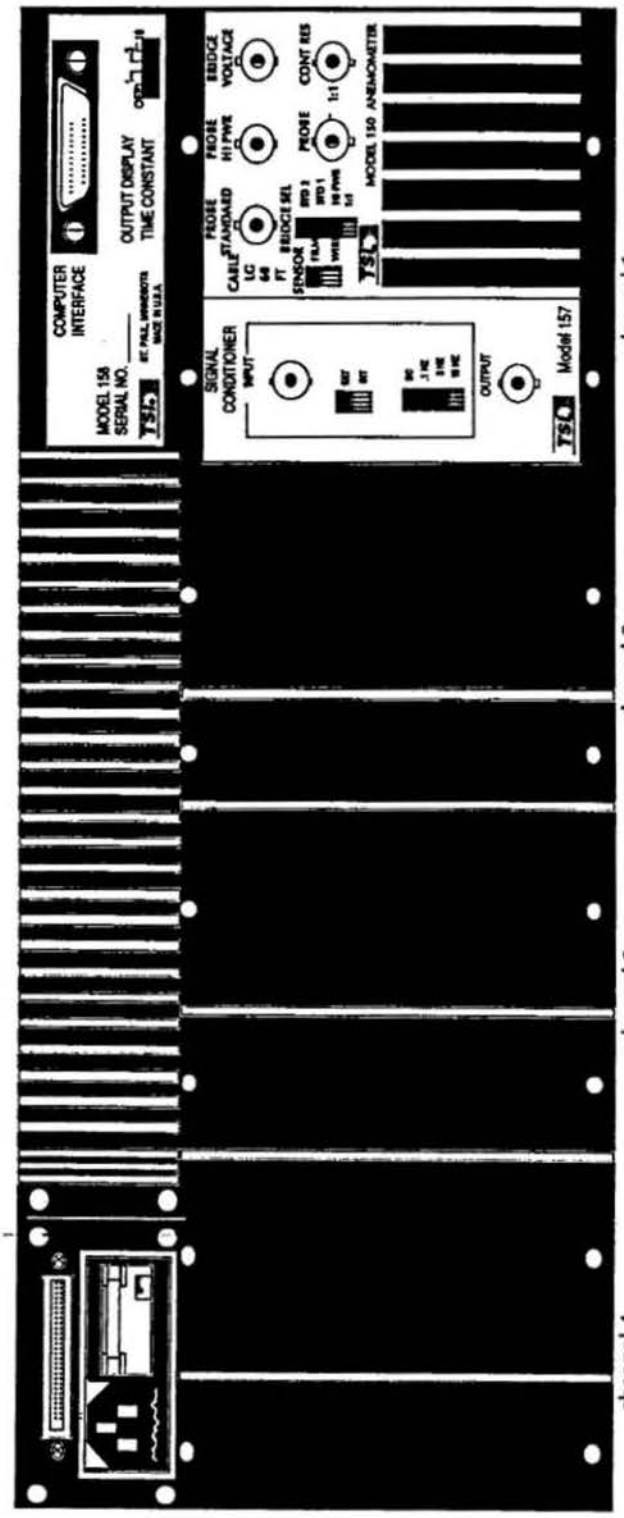
3 Push in the module until it bottoms out on the rear rods. Secure the module with the two no. 6-32 screws provided.

Note that the signal conditioner cannot be used without a transducer (MODEL 150 or 140). The signal conditioner's channel number is the same as the transducer to the right (looking from the rear of the cabinet).



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[3] Back panel of the master cabinet





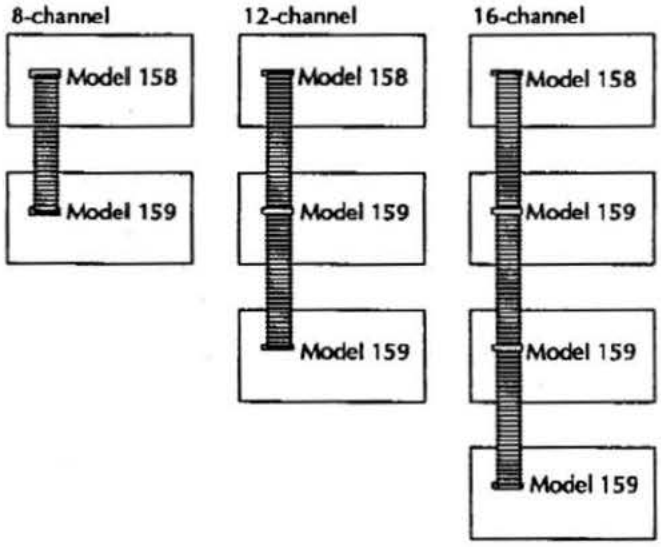

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## Expanding to five or more channels (using a Model 159 slave cabinet)

To expand to five or more channels, follow these two steps:

1 Connect the MODEL 159 to the MODEL 158 using the ribbon cable supplied with the slave cabinet. Ribbon cable connectors are in the upper left corner of each cabinet when viewed from the back (see figure 20 above the power connector). Figure 20 shows one method of connecting from the MODEL 158 to additional MODEL 159 Cabinets. You may stack the cabinets at your discretion. The anemometer modules are tagged at the back to indicate which channels (5–8, 9–12, 13–16) belong where.

[21] External connections of the master and slave cabinets




2 Install the anemometer modules and the signal conditioner modules as illustrated in figure 3.

Note that power must be applied to the MODEL 159 Slave Cabinet *before* it is applied to the MODEL 158 Master Cabinet.



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# 5 Remote-control interfacing

Before you operate the system by remote control, first set up the IFA 100 System according to the instructions in chapter 2, 'Flow measurement process'.

## RS-232-C description

The master cabinet is designed to interface directly to a terminal or computer via a serial ASCII code using the RS-232-C standard interface. The RS-232-C connector is in the upper right-hand corner of the back panel of the master cabinet. The computer or terminal must be set as follows:

baud rate : 1200
start bits : 1
data bits : 8
parity bit : none
stop bits : 1

TABLE 7.
Connections for the RS-232-C connector

| pin no. | signal |
|---|---|
| 1 | signal ground |
| 2 | data to IFA 100 |
| 3 | data to terminal |

The RS-232 standard recognizes two types of devices: data communication equipment (DCE) and data terminal equipment (DTE). In this application, the two types are differentiated by pins 2 and 3.

The IFA 100 is configured as DCE: it transmits data on pin 3 and receives data on pin 2. Using the TSI-provided cable (a nonreversing type that connects pins 2 and 3 of one end to pins 2 and 3 of the other end), the IFA 100 communicates with devices configured as DTE. If a device is configured as DCE, it is necessary to use a reversing cable (which connects pins 2 and 3 of one end to pins 3 and 2 of the other end) to establish the communication link.

In the following discussion of communications format, parentheses, spaces and quotation marks are used to make the examples more readable. They are not to be transmitted to the IFA 100.

<CR> = send or receive a carriage return
</> = send the slash key
'ACK' = receive the ACK character
_ = receive a space (underline character)



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To enter the Remote mode, send:

%<CR>

Note that remote may be entered only by an RS-232 request.

To select a channel, send:

# n<CR> or # nn<CR>

where
n = channel number (1–9 if less than 10 channels are installed)
nn = channel number (01–16 if more than 10 channels are installed)

To request a reading of current functions, send:

?<CR>

The A/D response time is approximately 2 seconds.

Command strings can include one or more characters terminated by a <CR> or a </>. The IFA 100 responds to command strings with 'ACK' <CR>. If an error occurs while the IFA 100 is servicing a command string, the IFA 100 sends <Bell> ? <CR> and aborts the remaining commands in the strings.

Command strings should not have more than one Request Reading <?>. If more than one is in the string, multiple responses—each terminated by 'ACK' <CR>—is generated.

## Signal conditioner commands

Table 8 lists the commands of the signal conditioner.

TABLE 8. Signal conditioner commands

| instrument function | character |
|---|---|
| offset | Z |
| gain | G |
| filter | F |
| output display | V |
| **numeric entry** | |
| exponent | ^ |
| clear | • |
| decimal point | . |
| enter | = |
| digits | 0–9 |

Function values for the anemometer or the signal conditioner can be read or changed from a remote terminal or computer. Shown below are examples.

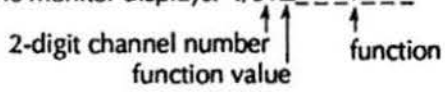


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To select the Offset function, enter: Z <CR> or </>.

To request the Offset value, enter: ? </>

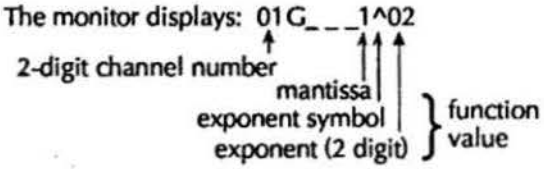
The monitor displays: ?/01Z_ _ _1_ _ _




Request Reading <?> reads the value of present function. The Select function and Request Reading may be combined to switch to a particular function and read value.

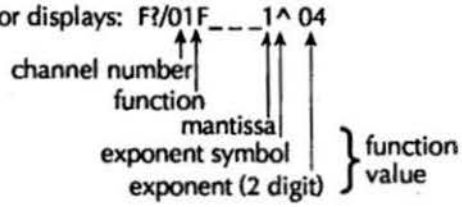
To request the Gain value, enter: G ? <CR>

The monitor displays: 01G_ _ _1^02




To request the Filter value, enter: F? </>

The monitor displays: F?/01F_ _ _1^ 04




To change the Offset value to 9, enter: Z9 = </>. The Offset of the present channel then changes to 9.

To change the Gain value to 200, enter: G2^2 = </>. Note that the mantissa and the exponent can be changed independently.

To change the Gain value to 10, enter: G1^1 = </>.

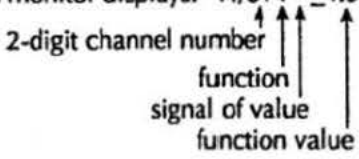
To change the Filter value to 100 kilohertz, enter: F1^5 = </>.

To request the reading of the signal conditioner's output, enter: V?</>.



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The monitor displays: V?/01V-_4.962




## Anemometer commands

Table 9 lists the anemometer's commands.

TABLE 9. Anemometer commands

| instrument functions | character |
|---|---|
| standby* | S |
| run* | R |
| bridge comp | B |
| cable res | C |
| operate res† | O |
| overheat reference** | K†† |
| test signal (ON) | T |
| test signal (OFF) | @ |
| output display | E |

*These functions respond with 'ACK''ACK' <CR>.

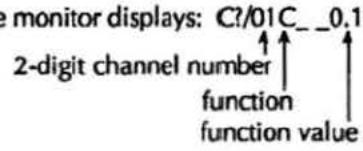
†This function must be deselected (ie, enter new selection) before you run the program. Its value may not be changed via RS-232.

**This value of Operate Res cannot be changed via RS-232.

††see 'Special features' for description

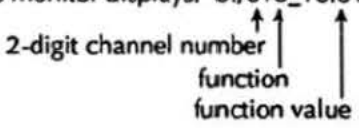
To request a reading of Cable Res, enter: C?</>.

The monitor displays: C?/01C_ _0.123




To request a reading of Operate Res, enter: O?</>.

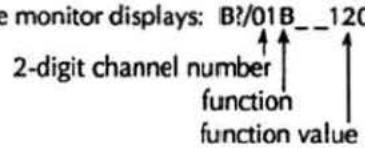
The monitor displays: O?/010_10.010




To change the value of Cable Res to 1.450, enter: C1.450 = </>.

To request reading of Bridge Comp (1200), enter: B?</>.

The monitor displays: B?/01B_ _1200






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## Master cabinet commands

Table 10 lists the master cabinet commands.

*No 'ACK' <CR> is generated in response to a numeric entry unless an instrument function is included as part of the command string.

TABLE 10. Master cabinet commands

| numeric entries* | character |
|---|---|
| clear | * |
| decimal point | . |
| enter | = |
| digits | 0–9 |

| general functions | character |
|---|---|
| channel | # |
| local | L |
| remote | % |
| request reading | ? |
| block read | <nn (nn = 2 digit channel number) |
| block load | >nn (nn = 2 digit channel number) |
| status of current channel | $ |
| disable tone in remote | \ |
| enable tone in remote | ! or | |

channel status ($)

read channel status: enter $<CR>
displayed on monitor: $

0152S@F

01 = current channel number
5 = modules type (anemometer and signal conditioner)
2 = bridge position (standard 1)
S = standby
@ = test signal (off)
F = current function (filter)

channel number: 2 digit (01–16)

module type: 1 digit (1, 2, 4, 5 or 6)
1 = anemometer
2 = temperature
4 = signal conditioner
5 = anemometer and signal conditioner
6 = temperature module and signal conditioner

bridge position: 1 digit (0–3)
0 = 1:1 bridge
1 = hi power
2 = standard 1
3 = standard 2

standby or run: (S or R)
S = standby
R = run

test signal: (T or @)
T = test signal on
@ = test signal off

current function: (one character indicating the function)



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## Block read and load

### *Block read*

To block read channel 2, enter: <02<CR>
The monitor displays: <02
02 12 22 01 0123 + _ 9995 + _ 2526 + _ 5302
Channel (02)
Filter (100 Hz)
Gain (200)
Offset (1)

Cable Res (0.123) 4 digits
Last Read Operate Res (9.995)
Last Read Res Meas (2526)
Last Read Bridge Comp (5302)

Channel number: 2 digit (01–16)
Filter: 2 digits (mantissa and exponent)
Gain: 2 digits (mantissa and exponent)
Offset: 2 digits (00–09)
Cable Res: 4 digits
Last Read Operate Res: 5 digits
Last Read Res Meas (NULL DSPL): 5 digits
Last Read Bridge Comp: 5 digits

### *Block load*

Block Load loads a string directly into the memory of the IFA 100 without changing the current channel number or function.* The functions except channel number can be in any order and all need not be present. The function characters must appear before the function value (eg, G90 means that the gain is '9' and could appear anywhere in the string). An example follows.

*The limits for the value of the functions are not checked, so it is possible to enter a value out of range.

Block load the following:
channel: 1
cable res: 1.390
offset: 3
gain: 9
filter: 20 kHz

Enter:
>Ø1C139ØZØ3G9ØF24<CR>
2-digit channel 1
cable res
4-digit cable res value
offset
2-digit offset value



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gain
gain mantissa and exponent
filter
filter mantissa and exponent

Function:
F, G, Z, or C for Filter, Gain, Offset or Cable Res, respectively.

Value:
2 digits; Offset = 00–09; Gain = Mantissa (1–9) and Exponent (0–2);
Filter = Mantissa (1–9) and Exponent (0–5) Cable Res = 4 digits



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# 6 Troubleshooting

## Bridge oscillation

An oscillation in the anemometer bridge caused by impedance mismatches is indicated by a lighted Osc lamp above the digital display meter. Oscillations can be caused by using an improper probe cable. Both the length and type of cable are important to the performance of the system. Oscillations can also be caused by improper frequency-response tuning. Refer to the procedure in 'Frequency response tuning' in chapter 3 to verify that the system has been properly tuned.

## Broken or open sensor

Open sensors are indicated by a lighted Fault lamp above the digital display meter. Disconnected probe cables or improper bridge selection also generate a Fault condition. To correct this condition, replace the probe or check for the proper probe-cable connections and switch selections.

## Inability to measure resistance in the Res Meas mode

There are two procedures for nulling the Operate Res potentiometer, but only one procedure gives a true zero reading. Be careful to use the correct procedure to null the Operate Res pot (see 'Determining the operating resistance of the probe' in chapter 3).

The Res Meas function does not work properly if you use the wrong zero setting. An incorrect setting produces a Display Resistance reading that gradually increases until it reaches 19.999 ohms and then indicates an overrange by flashing '99.999' on the display.

## IFA will not switch to Run

If the IFA will not switch to Run, follow these three steps:

1 If the sensor operating resistance is set too high, the anemometer does not switch to Run. The microprocessor checks the overheat setting by measuring the ratio of the operating resistance to the cold sensor resistance and adds it to the probe-cable resistance. The nominal overheat limit is set at an overheat ratio of 2.0. See 'Model 150 Anemometer block diagram' for a detailed description of the overheat limit check.

2 If the anemometer is improperly tuned and if very large-scale oscillations occur when the anemometer switches to Run, the anemometer immediately switches back to Standby to prevent damage to the sensor. To correct the problem, check the frequency-response tuning controls, Bridge Comp, and Cable Comp.

3 Now the anemometer will switch to run provided there is an open sensor. An open sensor is indicated by a lighted Fault lamp. Correct this problem by installing a new probe.



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## Anemometer switches from Run to Standby

The anemometer switches to Standby if:

- The power to the system is interrupted.
- The probe or probe cables are disconnected.
- The sensor is broken.
- The system goes into large-scale oscillations.
- The keys Bridge Comp, Operate Res, or Res Meas are selected on the front panel of the system.



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# 7 Specifications

## Model 158 Master Cabinet

TABLE 11. Specifications of the MODEL 158 Master Cabinet

| | |
|---|---|
| number of channels | 4 (allows control of up to 16 channels) |
| test signal specifications | |
| type of signal | square wave |
| frequency range | 0.3 to 30 kHz |
| amplitude range | 0 to 4.5 volts |
| display specifications | |
| number of digits | 4½ |
| resolution | 1 mV |
| accuracy | ±2 digits |
| sample rate | 2.5 reading/s |
| time-constant accuracy | 20% |
| temperature stability, typical | 40 ppm |
| output impedance | 100 ohm |
| accessories | |
| RS-232 cable | 6 ft [1.8 m] |
| RG 58A/U output cable | 6 ft [1.8 m] |

## Models 158 and 159 Power Supplies

TABLE 12. Voltages supplied by the MODELS 158 and 159 cabinets

| voltage | current (A) | power (W) |
|---|---|---|
| +15 | 0.2 | 3 |
| –15 | 0.2 | 3 |
| +7.5 | 0.25 | 1.9 |
| –7.5 | 0.25 | 1.9 |
| +5 | 1 | 5 |
| 4±15 | 0.6 | 36 |
| 10 | referenced | |



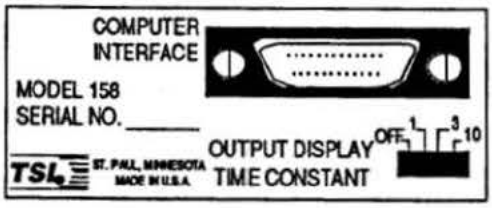
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TABLE 13. Specifications of the MODEL 159 Slave Cabinet

| | |
|---|---|
| maximum DC output power, continuous | 51 W |
| power requirements, nominal | 100, 120, 220, or 240 V<br>+5 to 10%<br>50 to 60 Hz<br>100 VA (max) |
| weight (depending on number of channels) | 12.25 to 16.8 kg<br>[27 to 37 lb] |
| dimensions (LWH) | 483 x 281 x178 mm [19 x 15 x 7 in.] |
| environmental conditions | |
| operating temperature | 0 to 50°C |
| operating altitude | 4600 m [15,000 ft] |
| storage temperature | –40 to 75°C |
| altitude | 7620 m [25,000 ft] |
| accessories | detachable power cord<br>mounting screws for rack mounting<br>(4 – no. 121-24 x 1 in.)<br>system instruction manual |
| MODEL 159 only | ribbon-cable connector for slave cabinets |

## Instrument identification

The serial number is on the back panel (see figure 22) on both models.




[22] Back label of the master and slave cabinets



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## Model 150 Anemometer

TABLE 14. Specifications of the MODEL 150 Anemometer

| | |
|---|---|
| **amplifier** | |
| typical input voltage noise | 1:1 bridge position: 1.85 nV/√Hz<br>standard and Hi Pwr bridge position: 2.5 nV √Hz |
| typical equivalent input drift | |
| 5:1 bridge | 0.35 µV/°C |
| 1:1 bridge | 0.6 µv/°C |
| maximum common mode input voltage | |
| 1:1 bridge position | 6 V |
| standard and Hi-Pwr bridge positions | 10 V |
| output impedance (resistance in series with output) | 50 ohm |
| output voltage range | 0 to 12 V |
| maximum bridge current | 1.2 A |
| amplifier gain | $>1 \times 10^6$ |
| **environmental conditions** | |
| operating temperature | 0 to 50°C |
| operating altitude | 4600 m [15,000 ft] |
| storage temperature | –40 to 75°C |
| storage or shipping altitude | 7620 m [25,000 ft] |
| **accessories** | |
| 2 - RG 58A/U probe cable | 4.57 m [15 ft] |
| 1 - RG 58A/U output cable | 1.83 m [6 ft] |
| 1 - small screwdriver | |
| 2 - shorting probes | |
| 1 - set of 2 Allen wrenches (for knobs) | |
| 1 - hardware package when the Model 150 is purchased separately | |
| 2 - knobs | ⅜ in. |
| 1 - knob | ½ in. |
| 2 - no. 6 Phillips-head screws | |
| identification | The serial number for the MODEL 150 is on the back-panel of the module. |



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## Bridge positions

TABLE 15. Resistances of the four bridge positions

| | bridge resistor (Ω) | resistance measure (Ω) operate resistance range |
|---|---|---|
| standard 1 | 10 | 3–19.999 |
| standard 2 | 10 | 20–99.99 |
| hi-power | 2 | 3–19.999 |
| 1:1 | 20 | 3–20 |

(upper limit = the value – Cable Res)

Resistance measure accuracy (15-ft probe cable):

TABLE 16. Typical repeatability of the bridge positions

| bridge position | typical repeatability (Ω) |
|---|---|
| standard 1 | 0.002 |
| standard 2 | 0.002 |
| hi-power | 0.002 |

Operating current used for resistance measure (8W probe):
Standard 1 and Standard 2 bridges: 120 μA
Hi-Pwr bridge: 220 μA
Operating resistance accuracy (15-ft probe cable):

TABLE 17. Accuracy and range of the bridge positions

| bridge position | range (W) | typical repeatability (Ω) |
|---|---|---|
| standard 1 | 3 to 19.999 | ±0.002 |
| standard 2 | 20 to 99.99 | ±0.002 |
| hi-power | 3 to 19.999 | ±0.002 |

Frequency response with 4-micrometer tungsten wire:

| | |
|---|---|
| standard bridge 1 | 150 kHz (DC) |
| 1:1 bridge | 450 kHz (DC) |

## Model 157 Signal Conditioner

TABLE 18. Specifications of the MODEL 157 Signal Conditioner

| input | | |
|---|---|---|
| voltage range | ±12 V | |
| impedance | 10 Ω | |
| typical equivalent input drift | gain (DC)<br>1 50 μV/°C<br>100 20 μV/°C | gain (AC)<br>1 20 μV/°C<br>100 5 μV/°C |
| typical equivalent input noise | 35 nV√Hz = S/N voltage ratio of 80 dB (bandwidth: 0–10 kHz; gain: 100). All other ranges exceed an 80-dB signal-to-noise ratio. | |

(continued)



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TABLE 18. Specifications of the MODEL 157 Signal Conditioner (continued)

| | |
|---|---|
| input coupling | DC or 0.1, 3, and 10 Hz, high-pass filter positions |
| accuracy | 10% |
| filter roll-off | 6 dB/octave |
| offset (DC coupling only) | |
| range | 0–9 V (1-volt increments) |
| accuracy | 0.15% |
| number of settings | 10 |
| gain (AC or DC coupling) | |
| range | 1–900 (mantissa: 1–9; exponent: 0–2) |
| accuracy | 0.15% |
| number of settings | 27 |
| filter (low-pass) | |
| range | 1 Hz–500 kHz (mantissa: 1–9; exponent: 0–5) |
| filter roll-off | 18 dB/octave |
| accuracy of cut-off frequencies | 10% |
| number of settings | 49 |
| output | |
| voltage range: ±5V | |
| impedance: 100 ohms | |
| frequency response | gain response (kHz)<br>X1 450<br>X10 400<br>X100 300<br>X900 200 |
| typical power consumption | 1 W |
| dimensions (HWD) | 127 × 38 × 346 mm (5 × 1.5 ×13.6 in.) |
| weight | 0.425 kg (15 oz.) |
| environmental conditions | |
| operating temperature | 0°C to 50°C |
| operating altitude | 4600 meters [15,000 feet] |
| storage temperature | –40°C to 75°C |
| storage or shipping altitude | 7620 meters [25,000 feet] |
| accessories | |
| 1 – 1.83 meter (6 ft) RG 58A/U output cable | |
| 1 – hardware package when Model 157 is purchased separately (2–no. 6 screws) | |
| identification | The serial number of the MODEL 157 is on the module's back panel. |



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