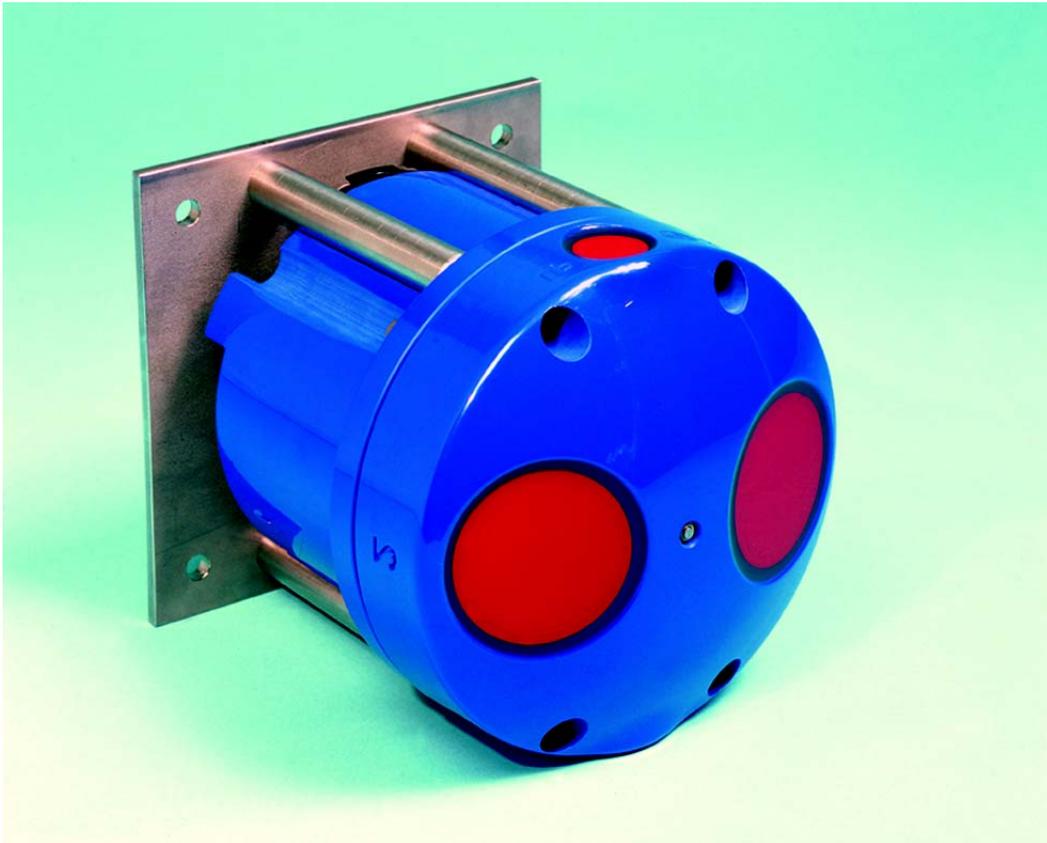


H-ADFM™ Velocity Profiler

Operation, Maintenance, & Software Manual



TELEDYNE ISCO

A Teledyne Technologies Company

Part #69-7303-001 of Assembly #60-7304-004
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Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Teledyne Isco recommends that you read this manual completely before placing the equipment in service.

Although Teledyne Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or e-mail the Teledyne Isco Technical Service Department for assistance. Simple difficulties can often be diagnosed over the phone.

If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Teledyne Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Teledyne Isco is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

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About this manual:

 **DANGER**

DANGER – limited to the most extreme situations to identify an imminent hazard, which if not avoided, will result in death or serious injury.

 **WARNING**

Warnings identify a potentially hazardous condition, which if not avoided, could result in death or serious injury.

 **CAUTION**

Cautions identify a potential hazard, which if not avoided, may result in minor or moderate injury. This category can also warn you of unsafe practices, or conditions that may cause property damage.

 **Note**

Notes contain useful information that may help you in deciding which settings to choose.

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Section 1 Introduction

1.1 System Overview

The Horizontal Acoustic Doppler Flow Meter (H-ADFM) from Teledyne Isco, Inc. leverages the exceptional velocity profiling capability of the ChannelMaster horizontal ADCP manufactured by Teledyne RDI, Inc. The H-ADFM system consists of the ChannelMaster instrument and an Isco-designed Flow Computer that accurately measure depth and velocity and calculate flow rates. Each component is described in more detail below.

1.1.1 ChannelMaster H-ADCP

The H-ADFM is a Horizontal Acoustic Doppler Current Profiler (H-ADCP). It is available in 300kHz, 600kHz, and 1200kHz configurations. The instrument houses three transducers: two for velocity measurement and one for water depth measurement. It also houses pressure, temperature, and pitch and roll sensors. The pitch and roll sensors are used to ensure that the instrument is installed in the correct orientation, as this is crucial for proper operation. The ChannelMaster measures velocity vectors at various points along its velocity beam axis along with the range to the water surface, and transmits that data to the Flow Computer.

1.1.2 Software

The
WinHADFM

1.2 Installation Overview

Teledyne Isco recommends installing the H-ADFM system in the following order:

1. Physical installation
2. Wiring installation
3. Station file configuration
4. Programming and testing

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Section 2 Physical Installation

Physical installation of the H-ADFM consists of installing the ChannelMaster in the channel to be measured and installing the Flow Computer nearby.

2.1 ChannelMaster Installation

For instructions on how to mount the ChannelMaster, refer to the ChannelMaster Quick Start Guide and/or the ChannelMaster Operation Manual provided with the ChannelMaster documentation.

 Note

Proper orientation (pitch, roll, and heading) of the ChannelMaster is essential for reliable ChannelMaster operation. WinHADFM provides a function for checking the pitch and roll of the ChannelMaster. See Section 5 for more details.

2.2 Flow Computer Installation

The specific arrangement of components in an H-ADFM flow monitoring system can vary greatly, and depends to a large extent on the physical parameters of the monitoring location. However, the distance between the Flow Computer and the ChannelMaster is significant because the standard ChannelMaster I/O cable is 75 feet long. If the ChannelMaster and the Flow Computer are more than 75 feet apart, RS-422 communication should be used and additional user-supplied wiring will be required.

A minimum clearance of two inches (50mm) should be provided on the top and on both sides of the Flow Computer, with the minimum clearance increased to six inches (150 mm) on the bottom of the enclosure to provide access for cable entry. The enclosure may be installed in any orientation; however, readability of the display will suffer if the enclosure is not oriented vertically.

The Flow Computer is packaged in a NEMA 4X enclosure with power supply and terminal strips for field wiring connections.

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Section 3 Wiring Installation

All field wiring connections to the ChannelMaster H-ADCP are made using the supplied I/O cable. Field wiring to the Flow Computer is connected to the terminal block marked TB2. Each position within TB2 is marked with its function rather than a terminal number, for ease of connection in the field.

3.1 ChannelMaster I/O Cable

The ChannelMaster I/O cable provides both power and communications connections to the ChannelMaster through a single underwater-style rubberized connector. Power supply and communications functions are broken out at the other end of the cable into separate cables using molded “Y” junctions. The power supply cable terminates in individual DC+ and DC– wires with alligator clamps for quick connection to a 12V battery. The communications cable is terminated in a standard 9-pin Female D-sub connector. The same I/O cable is used for both RS-232 and RS-422 communications.

3.2 Power Supply

The H-ADFM (ChannelMaster and Flow Computer) requires +10 to +18 VDC, unregulated, for full operation. Typical power consumption will be approximately 4.5 watts (370 mA at 12VDC). Connect the ChannelMaster DC power supply leads to the DC power supply or batteries. Teledyne Isco suggests cutting off the alligator clamps and hard-wiring the I/O cable power supply leads to the DC power source for better reliability in permanent or semi-permanent applications. Also connect DC power to the DC power supply terminals (or to the J6 connector), marked DC+ and DC–, on the Flow Computer.

3.3 Analog Data Output

The H-ADFM Flow Computer can be equipped with up to three independent analog channels, each capable of driving up to a 600 ohm load. Analog outputs on these channels are generated using DGH Corporation Model 3251 current output modules. These modules act as 4-wire transmitters (i.e. the DGH module provides power to the analog loop). Each analog output is electrically isolated from the remainder of the Flow Computer circuitry. Analog output channels are designated as Flow (QA+, QA–), Depth (DA+, DA–), and Velocity (VA+, VA–). Connect each analog output channel to the appropriate external loads/devices, consistent with standard current loop wiring practices for 4-wire transmitters, and ensure that the total load for each loop does not exceed 600 ohms.

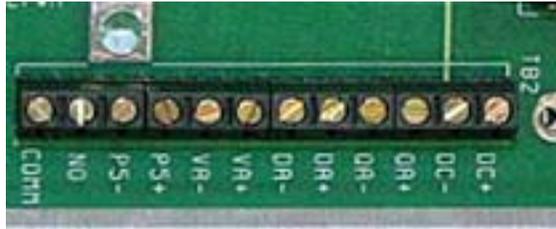


Figure 3-1 Analog Output Terminal Block

3.4 Totalizer Pulse Output

The H-ADFM Flow Computer computes incremental volume and outputs digital pulses based on a user-specified volume increment. The totalized volume is also displayed on the LCD screen and is reset with each power cycle or when the unit receives new settings. The pulse outputs can be connected to an external device to keep track of totalized output over multiple power cycles. Pulse outputs are available as either +5VDC pulses (P5+, P5-) or as dry contact closures (NO, COMM). The +5VDC pulse, if used, can source a maximum current of 15mA. Dry contact closures are provided by a solid-state relay rated at 3-60VDC, 0.02 - 1.0 amps.

3.5 Communications

3.5.1 RS-232

H-ADFM Flow Computers configured for RS-232 communication will include a short RS-232 cable extending from the J1 terminal inside the Flow Computer enclosure. This cable terminates in a 9-pin male D-sub connector. The ChannelMaster communications cable connects directly to this connector.

3.5.2 RS-422

H-ADFM Flow Computers configured for RS-422 communication will include an RS-232 to RS-422 converter inside the Flow Computer enclosure, as shown in Figure 3-2.

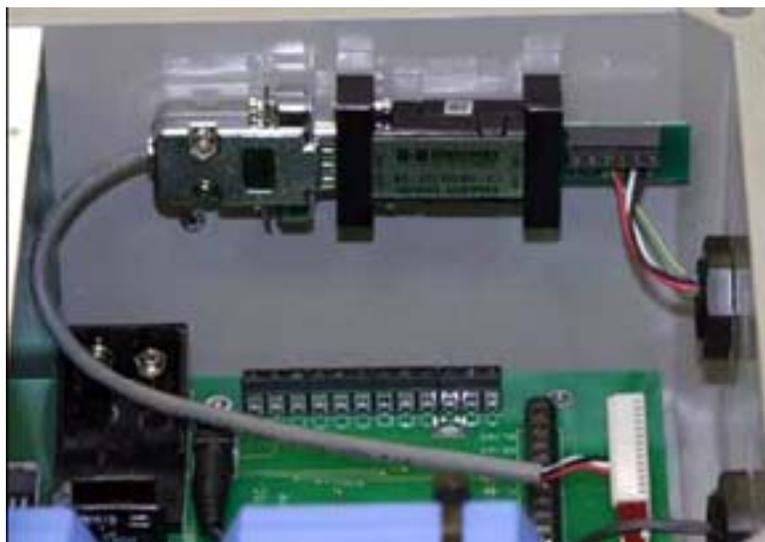


Figure 3-2 RS-422 Configuration

A short cable will extend from the RS-422 side of the converter to the exterior of the Flow Computer enclosure. This cable will terminate in a 9-pin male D-sub connector. The ChannelMaster communications cable connects directly to this connector.

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Section 4 Software Installation and Station File Configuration

4.1 Introduction

WinHADFM is the primary program used to configure and operate an H-ADFM system. System configuration information is saved in a station file (*.hstn). Station files may (optionally) be grouped as desired. The station file is also used to display collected data. Station files, and associated data files, are stored in the following directory path:

C:\WinHADFM\SITES\<>groupname>\<stationname>

WinHADFM will automatically scan this path for valid station files and display a list of stations sorted by group each time the program is started.

Note

WinHADFM will automatically select and display information for the first station in the station file list when the program is started. Ensure that you select the desired station file before entering configuration changes or programming the Flow Computer and ChannelMaster.

Two other software programs may at times be required:

- DGH Utility software is used to configure and test the analog output signal generator modules incorporated into the Flow Computer. Installation of this program is strongly recommended.
- The Basic-X download utility is used to flash updated firmware into the Flow Computer. Installation of this program is optional and only required if updated firmware for the Flow Computer becomes available.

4.2 Installing the Software

Before configuring the H-ADFM station file, you must install Win-HADFM and the DGH Utility Software 2000. These programs will run on computers with Windows 95 and newer operating systems.

Note

The Basic-X Download Utility will also be required if updates to the firmware in the Flow Computer are required.

Installing WinHADFM – To install Win-HADFM, simply double-click the WinHADFM Setup program and follow the installer's prompts.

Installing the DGH Utility Software 2000 – To install the DGH Utility Software 2000 setup file, simply double-click the Setup program and follow the installer’s prompts. The version currently distributed with the H-ADFM is V2_0_2_1.

Installing the Basic-X Download Utility software – To install the Basic-X Download Utility software simply double click the Basic-X setup program and follow the installer’s prompts. The version currently distributed with the H-ADFM is V2_10.

4.3 Configuring the System Settings

To create a new station file, click the new station icon in the upper left corner of the Win-HADFM window. You will now have a configuration window divided into three tabs: System, Channel, and Velocity Model. The system tab window is divided into the following seven sections:

- Site
- Display Units
- 4-20 Output
- Totalizer
- Communications
- Graphics Preferences
- Flow Computer Settings

4.3.1 Site

The Site section contains information about the installation site. Multiple configurations can be saved and used later. Sites can also be arranged in groups.

Site Name – Enter the name of the specific installation site.

Group – Enter the name of the group that this site belongs to. A group name is not necessary.

Location – Enter the physical location of the site.

4.3.2 Display Units

The Display Units section contains pull-down menus for flow, velocity, stage, volume, and temperature. The unit types you set here determine not only the units displayed on the LCD display of the Flow Computer, but also the units used to set the analog output spans, the Totalizer Pulse increments, and the channel dimensions. The unit indicators next to the input fields for these parameters will change to reflect your choices in the unit window.

The units selected for stage also determine the units for the channel dimensions in the Channel tab. Selecting an English measurement (e.g. inches) for stage will require the channel to be dimensioned in English units (inches). Selecting a metric measurement (e.g. meters) will require you to dimension the channel in metric units (meters).

<input checked="" type="checkbox"/> Note

If the unit selected for stage is modified after channel dimensions have been entered, those dimensions will be re-scaled accordingly.

Table 4-1 lists the units available for each measurement.

Table 4-1 User-Selectable Units of Measure	
Measurement	Available Units
Flow	MGD, Gallons per minute, Cubic meters per second, Liters per second, Cubic feet per second, Million liters per day
Velocity	Meters per second, Feet per second, Millimeters per second, Centimeters per second
Stage	Inches, Centimeters, Millimeters, Meters
Volume	Liters, Cubic meters, Megaliters, Gallons, Cubic feet, KGallons, Million Gallons, Acre Feet
Temperature	Degrees Fahrenheit, Degrees Celsius

4.3.3 4-20 mA Output

The 4-20 Output section of the System tab allows you to set the relationship between the digital and analog signals of the Flow Computer. The Flow Computer generates an analog signal that ranges from 4mA to 20mA. Therefore, a signal of 4mA will represent the low-limit of the H-ADFM's analog output and a 20mA signal will represent the high-limit of that output. Values between these limits are determined by linear interpolation.

For example, if you set the low limit for flow at zero GPM (outputs 4mA) and the high limit at 500GPM (outputs 20mA), then a 250GPM flow will result in an analog signal of 12mA $[250/500(20-4)+4]$. The resolution of this analog representation of the digital data is .01mA.

Note

Ensure adequate margins when setting the high/low limits; otherwise, data will be clipped. This can happen because measurements from the Flow Computer that are less than the specified low-limit will result in an analog output of 4mA, and values that exceed the high-limit will result in a 20mA output. There is no indication that the measurements have exceeded the limits, resulting in ambiguous data.

Note

In the case of bad or missing velocity or stage data from the ChannelMaster, the H-ADFM Flow Computer will output a specific user-defined signal level: by default, 3.9 mA for bad data, or 3.6 mA when no data is received from the ChannelMaster. However, these output values do not apply to clipped data (data that exceeds the high/low-limits set in the span section).

4.3.4 Totalizer

The Flow Computer is capable of sending out a pulse of user-defined length (50 milliseconds by default), when the measured volume increases by the amount specified in the Totalizer Pulse field. The units for this value are the same as the units specified for Volume in the Units section.

Note

The built-in totalizer uses volatile memory and will reset to zero when power is disconnected or when new configuration settings are sent to the Flow Computer.

Note

Setting the Totalizer Pulse value too small will cause the Flow Computer to stop responding to data from the ChannelMaster.

4.3.5 Communications

The Communications drop-down list allows you to select the Com port your computer uses for its serial connection.

4.3.6 Graphic Preferences

Click the Graphics Preferences button to bring up a new dialog box where you can specify which graphs and data types to display when viewing data.

4.3.7 Flow Computer Settings

Click the Flow Computer Settings button to bring up a new dialog box where you can specify what analog value(s) to output in the case of bad or missing data, how many consecutive bad readings are allowed before the flow computer switches to the appropriate analog output value(s), how long the flow computer will wait for data from the ChannelMaster before timing out, the duration of the totalizer pulse, and what smoothing parameters (if any) are used for data display and output.

Smoothing

Smoothing multiplies a portion of the current reading by the previous reading:

$$R = TCF * M + (1 - TCF) * P$$

where:

M is the current measured value from the instrument.

P is the previous output value.

R is the new output data value.

Note that R becomes the P for the next reading. Also, a TCF of 1.0 means that no smoothing will be performed (this is the default). The smoothing time constant (TC) is calculated from the TCF and sample interval, and is displayed for the user's information.

Big Step

The Flow Computer is designed to respond quickly when large changes in flow rate occur rapidly. The smoothing specified by the TCF value is ignored and the new output data value equals the current measured output when the change in flow rate exceeds the specified percentage of the analog output span. The Big Step value is that percentage, entered as a decimal fraction of the analog output span for flow rate. The corresponding flow rate change is displayed for the user's information.

Zero Screen

All instruments become less precise when reading values very near to zero. The Flow Computer is designed to output a zero reading when the flow rate is very low. The Zero Screen value is

the user-selected percentage, entered as a decimal, of the analog output span for flow rate below which the output will always be forced to zero.

4.3.8 Calculation Settings

Calculated flow rates are not stored in H-ADFM download data files. Flow data displayed in the WinHADFM software is re-calculated each time it is displayed. This dialog box displays the geometry and velocity model settings in effect at various times. New entries in this table are created automatically each time the Flow Computer is programmed. Entries can be created, modified, or removed as desired by the user to evaluate the effects of changes to the geometry and velocity models on flow calculation. Changes to these settings will normally be made only by experienced users.

Note

Calculation setting entries store the channel geometry settings in effect at the time the entry was created. Channel geometry settings cannot be edited once created. If you wish to change the channel geometry settings in use for a given time period, you must configure the station file for the desired geometry settings, create the calculation settings entry, then (if necessary) return the geometry settings to their correct values.

Note

Calculation settings are currently not sorted by date/time. The user must ensure that all calculation setting entries are arranged in proper date/time sequence.

4.4 Configuring the Channel Dimensions

Use the Channel tab to specify the channel cross-section dimensions used in the flow calculations. The Channel tab consists of a display window that shows a graphic representation of the channel cross-section you define, as well as input fields for the channel type and the specific dimensional inputs required for each type. Five types of channel-dimensioning schemes can be used:

- Rectangular channels
- Circular channels
- Trapezoidal channels
- Multi-Point channels
- Polynomial

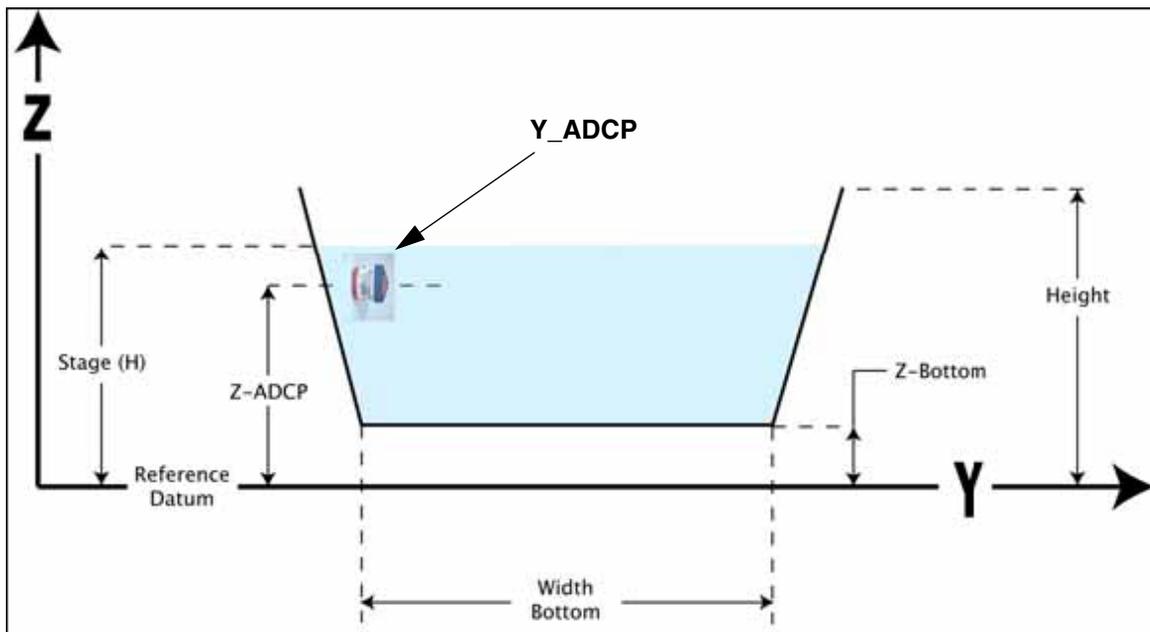


Figure 4-1 Channel Dimensions

4.4.1 Mounting Orientation

The mounting orientation specifies which side of the channel the instrument is mounted on with respect to the flow direction. The screen view of flow faces downstream. WinHADFM software and the H-ADFM follow the USGS convention of looking downstream to determine which side of the channel is the left bank and which is the right bank. Top and Bottom mounting orientations assume that the ChannelMaster is installed with beam 1 facing upstream (into the flow).

4.4.2 Rectangular Channels

The Rectangular Channel scheme allows you to define a simple rectangular channel by entering values for the bottom width and the height. Entries are required for mounting orientation, Y-ADCP, Z-ADCP, and Z-Bottom. Y-ADCP is the distance between the ChannelMaster and the wall of the channel. Z-ADCP is the height of the ChannelMaster depth beam ceramic above the reference datum. Z-Bottom is the height of the channel bottom above the reference datum. Therefore, if the channel bottom is used as the reference datum, the Z-Bottom value will be zero.

The mounting orientation specifies which side of the channel the instrument is mounted on with respect to the flow direction. Flow direction in the graphic window is away from you, into the screen.

Table 4-2 describes the fields used to define a rectangular channel.

Table 4-2 Rectangular Channel Fields	
Field	Description
Z-ADCP	Z-ADCP is the height (in units selected for stage in the System tab) of the H-ADFM above the reference datum. This value is determined when the H-ADFM is installed and configured. Z-ADCP is marked by a blue line in the display window.
Reference Datum	The reference datum is a user-specified line located at or below the channel bottom. The reference datum is always Z = zero for the coordinate system used to define the channel cross section, regardless of where it is at in relation to the channel.
Z-Bottom	Z-Bottom is the distance between the reference datum and the bottom of the channel. This value is zero if the channel bottom and the reference datum are the same (i.e. Z = zero).
Width	The Width is the width of the channel at depth = Z-Bottom. Use the units shown below the channel-drawing window.
Y-ADCP	The distance between the ChannelMaster and the wall of the Channel. This is used by the ChannelMaster to calculate the distance across the channel at the instrument mounting height.
Height	Height is the distance from the top of the channel to the reference datum. This is an absolute value because it is referenced to the local coordinate system. Therefore, if your reference datum is 5 feet below the channel bottom (i.e. Z-Bottom = 5), and the channel is 10 feet deep, the Height would be 15 feet. See Figure 4-1 for further clarification.
Mounting Orientation	Determines the orientation of the ChannelMaster with respect to the flow direction (into the screen). If the orientation is not specified correctly, velocity values will be reversed.

4.4.3 Circular Channels

The circular channel scheme allows you to define a simple circular channel by entering values for the diameter and Z-ADCP.

Note

Care must be taken when installing the ChannelMaster in a circular channel to ensure that the ultrasonic depth sensor (up-looking beam) can properly measure water depth. Depending on the installation, the curved wall above the ChannelMaster may interfere with this measurement.

Table 4-3 describes the fields used to define a circular channel.

Field	Description
Z-ADCP	Z-ADCP is the height (in units selected for stage in the System tab) of the H-ADFM above the reference datum. This value is determined when the H-ADFM is installed and configured. Z-ADCP is marked by a blue line in the display window.
Reference Datum	The reference datum is a user-specified line located at or below the channel bottom. The reference datum is always $Z = \text{zero}$ for the coordinate system used to define the channel cross section, regardless of where it is at in relation to the channel.
Diameter	Diameter is the diameter of the circular channel, set in the units specified in the System tab.
Y-ADCP	The distance between the ChannelMaster and the wall of the Channel. This is used by the ChannelMaster to calculate bin positions across the channel at instrument height.
Mounting Orientation	Determines the orientation of the ChannelMaster with respect to the flow direction (into the screen). If the orientation is not specified correctly, negative velocity values will be recorded.

4.4.4 Trapezoidal Channels

Use the Trapezoidal scheme for channels with sloping sides. Values must be entered for the Height, Bottom Width, and sidewall slope. The sidewall slope (rise/run) is unit-less and cannot be set to zero. Z-Bottom specifies the height of the channel bottom above the reference datum. Therefore, if the reference datum is located at the channel bottom, the Z-Bottom value will be zero.

Note

The Height and Width-Bottom fields are not measured in similar ways. The Height dimension is the distance between the top of the channel and the reference datum. The Width-Bottom dimension is the actual width of the channel bottom.

The subtle difference here is that the Height is referenced to the origin of the local coordinate system ($Z = \text{zero}$), making it an absolute dimension. Width-Bottom, on the other hand, is not referenced to the origin, making it a relative dimension.

Table 4-4 describes the fields used to define a trapezoidal channel.

Table 4-4 Trapezoidal Channel Fields

Field	Description
Z-ADCP	Z-ADCP is the height (in units selected for stage in the System tab) of the H-ADFM above the reference datum. This value is determined when the H-ADFM is installed and configured. Z-ADCP is marked by a blue line in the display window.
Reference Datum	The reference datum is a user-specified line located at or below the channel bottom. The reference datum is always Z = zero for the coordinate system used to define the channel cross section, regardless of where it is at in relation to the channel.
Z-Bottom	Z-Bottom is the distance between the reference datum and the bottom of the channel. This value is zero if the channel bottom and the reference datum are the same (i.e. Z = zero).
Width	The Width is the width of the channel bottom. Use the units shown below the channel-drawing window. Unlike the Height value, the Width-Bottom value is not in reference to the local coordinate system.
Y-ADCP	The distance between the ChannelMaster and the wall of the Channel. This is used by the ChannelMaster to calculate the distance across at instrument height.
Height	Height is the distance from the top of the channel to the reference datum. This is an absolute coordinate because it is referenced to the local coordinate system. Therefore, if your reference datum is 5 feet below the channel bottom (i.e. Z-Bottom = 5), and the channel is 10 feet deep, the Height would be 15 feet. See Figure %% for further clarification.
Mounting Orientation	Determines the orientation of the ChannelMaster with respect to the flow direction (into the screen). If the orientation is not specified correctly, negative velocity values will be recorded.
Slope	Slope is the inclination of the channel walls. It is specified as a ratio (rise over run) and cannot be set to zero. This value is dimensionless.

4.4.5 Multi-Point Channels

This option allows you to specify a channel shape as a series of Y, Z coordinates. Y refers to the horizontal dimension and Z refers to the vertical dimension relative to the reference datum. When entering the coordinates, the following rules must be followed:

- Each Y value must be greater than the Y value that precedes it, so that the points are arranged in order left to right. The first Y value should be zero (the left bank of the channel should be used as the Y axis reference point).
- Side channels are not allowed (see below).
- The channel must slope downwards to a minimum Z value, and then slope back upwards. It is acceptable, but not required, to use zero as the minimum Z value.
- The final Z value should equal the first Z value.

4.4.6 Polynomial Channel

Cross-sectional area of a channel can be defined as a function of water depth by a polynomial equation as follows:

$$\text{Area} = A1 + A2 * H + A3 * H^2$$

where:

H = Water depth relative to the reference datum Z = 0

A1, A2, A3 = polynomial coefficients

Please consult Teledyne Isco if you wish to use the Polynomial Channel and require assistance in developing a polynomial channel model.

4.5 Configuring the Velocity Model

Channel configurations and velocity profile distributions in channels where the H-ADFM will typically be used will be much more variable than channels where a standard vertically oriented ADFM would be used. The H-ADFM uses an Index Velocity and a Velocity Model to calculate flow rates from channel geometry, stage, and velocity profile information. Accuracy of an H-ADFM system can only be assured if suitable calibration measurements are taken and used to develop a site-specific velocity model. Calibration measurements and the velocity model should span the entire range of stage and velocity conditions experienced at the site for greatest flow measurement reliability.

The ChannelMaster Index Velocity V_i is a straight (not weighted) average of the individual velocities for each bin in the specified index range.

WinHADFM and the H-ADFM Flow Computer have three velocity models to choose from: Linear Regression, Power-Law Regression, and Compound Linear Regression. The selected model is used to calculate the average velocity and flow rate from the index velocity.

The following variables are used in the velocity models:

Table 4-5 Velocity Model Variables

Variable	Description
$V=$	The final computed average velocity.
$V_i=$	The index velocity, computed as an average of the velocity bins specified in the Index Range fields.
$V_c=$	The critical velocity used in the Compound Linear Regression velocity model. When this average velocity is reached or exceeded, the second equation in the model is used.
H=	The stage, or water height, in the units specified in the Units section of the System tab. See Figure 4-1 for more information.
$A, B_n=$	Any user-designed coefficient used in the velocity calculation.

Note

For more information about determining the site-specific regression coefficients, please refer to the following application notes:

http://www.adcp.com/pdfs/channelmaster_checkpoint13.pdf

http://www.adcp.com/pdfs/channel_streampro_imperial.pdf

4.5.1 Linear Regression Model

The Linear Regression model calculates the average velocity V at time t . B_1 , B_2 , and B_3 are site-specific regression coefficients. These will have been determined by the user using independent calibration data when the H-ADFM was installed and configured.

In cases where the effect of stage on the velocity model is insignificant, the linear regression equation may be reduced to a one-parameter linear regression such as $V=B_1+B_2V_1$. This is achieved by entering zero in the B_3 field.

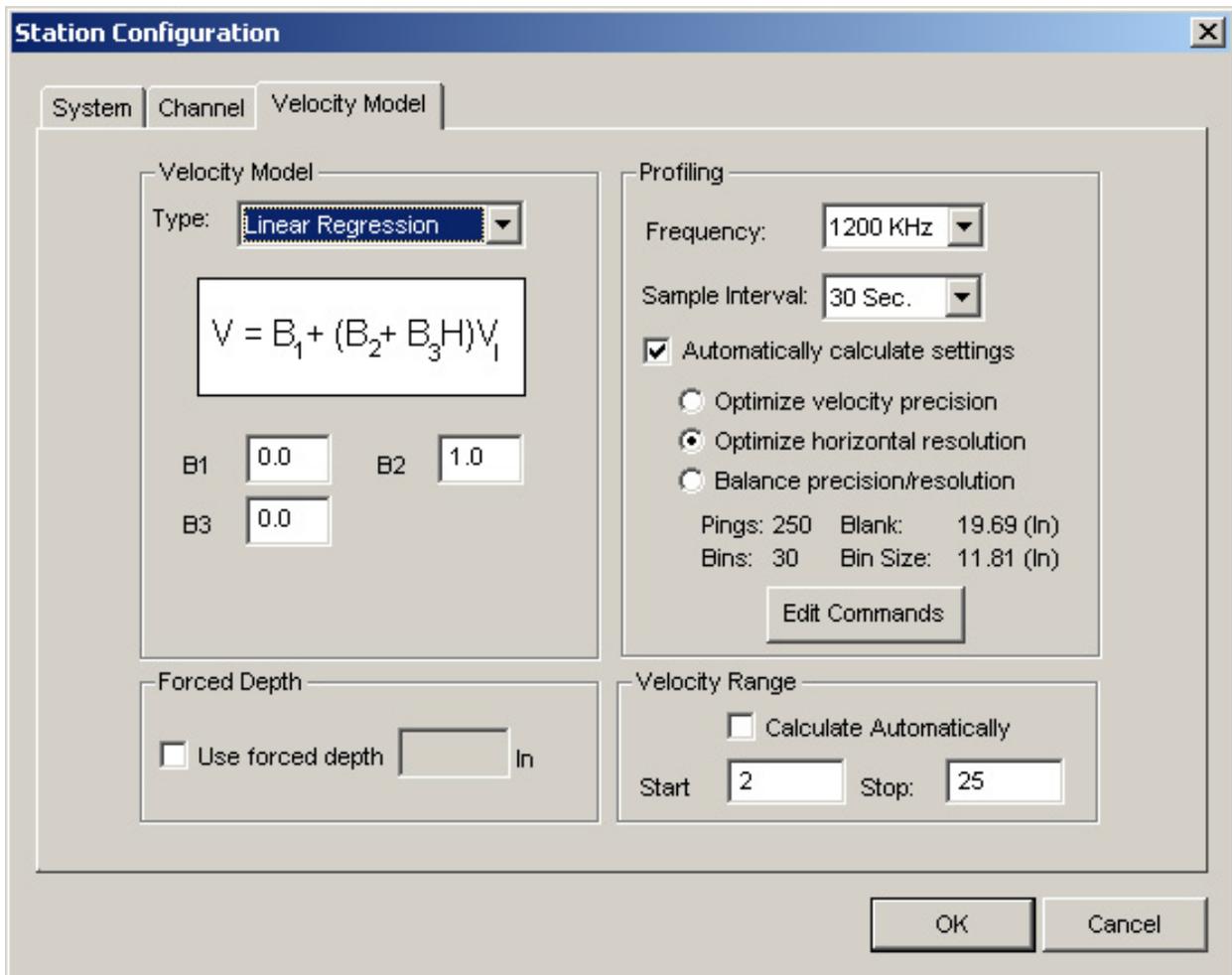


Figure 4-2 Linear Regression Model

4.5.2 Power-Law Regression Model

The Power-Law Regression model calculates average velocity V at time t and uses site-specific regression coefficients (a , B). These will have been determined by the user using independent calibration data when the H-ADFM was installed and configured.

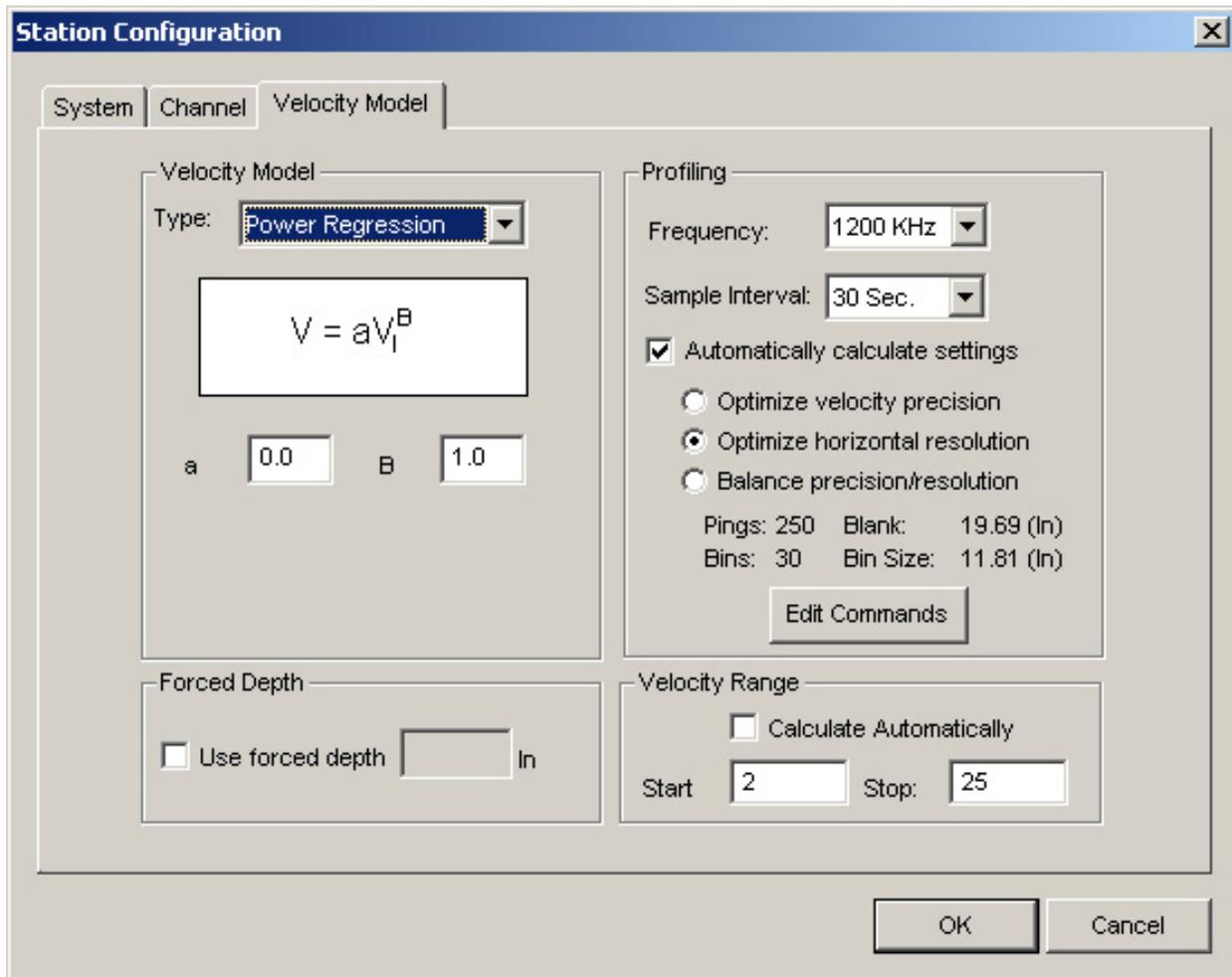


Figure 4-3 Power-Law Regression Model

4.5.3 Compound Linear-Regression Model

The Compound Linear-Regression model calculates mean velocity and is used when extreme hydraulic conditions prevent the use of the standard linear regression model. The critical velocity V_c determines the velocity at which the second equation is used for velocity calculation. V_c must be set in the units specified for velocity in the Units section of the System tab.

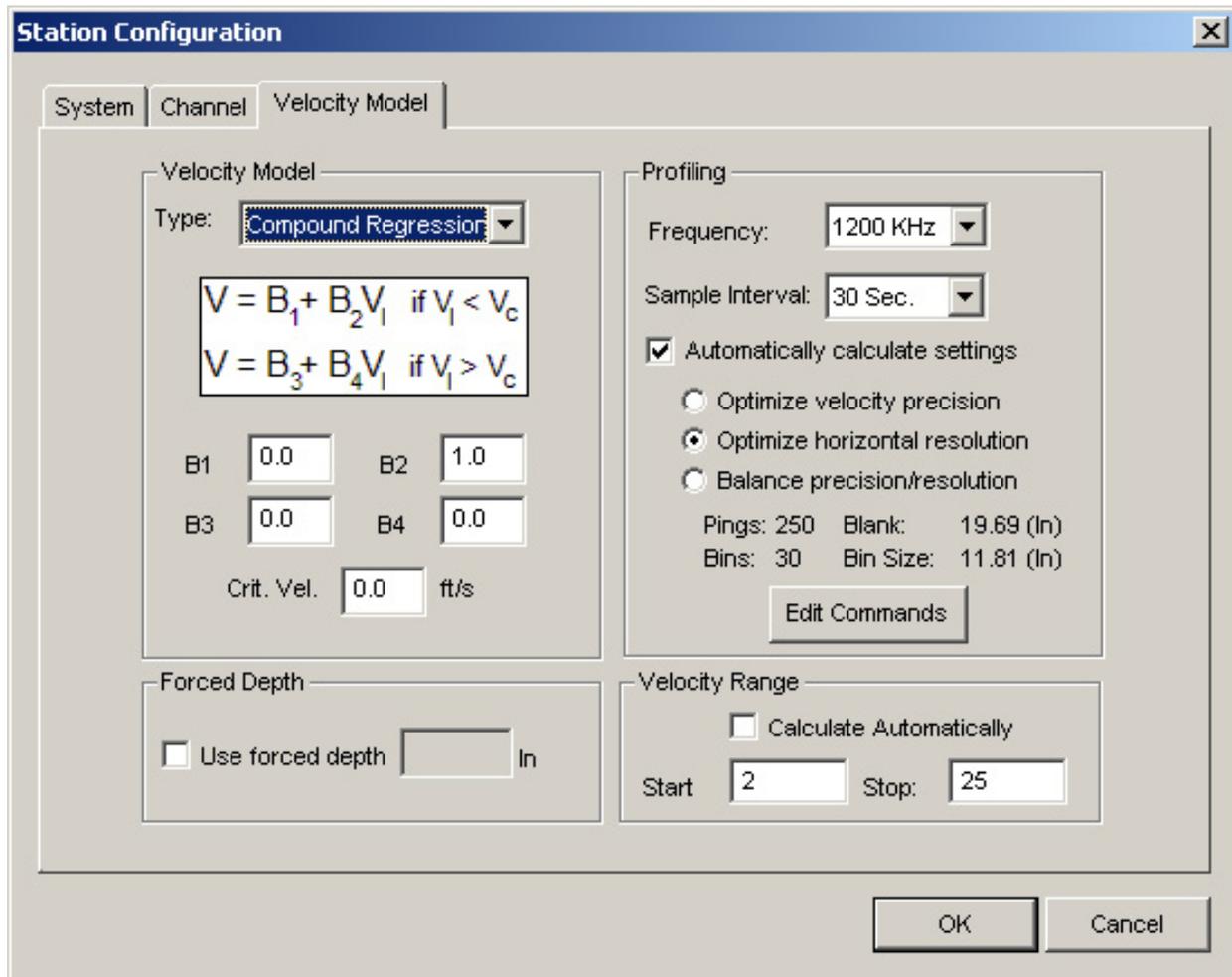


Figure 4-4 Compound Linear-Regression Model

4.5.4 Forced Depth

Water depth (stage) measurement is not always possible in some applications, notably in circular pipes (or other channel shapes) which always flow full, and/or applications in which a top or bottom mounting orientation is used. A constant stage is assumed in these types of applications by selecting Forced Depth and entering the desired stage (in user-defined units). The H-ADFM will calculate area and flow rate based on the stage, channel geometry, and measured velocity profile data.

4.5.5 Profiling

Accurate velocity profile measurement requires that several parameters be properly programmed within the ChannelMaster. WinHADFM has been developed to streamline and simplify the selection of proper values for those parameters based on the channel geometry and the settings in this section.

System Frequency – Proper settings for some velocity profiling parameters depend on the ChannelMaster frequency of operation. Select from 1200 khz, 600 khz, or 300 khz as appropriate for your application. WinHADFM will confirm this selection whenever it connects to the ChannelMaster.

Sample Interval – Select the desired update interval.

Automatically Calculate Settings – Select this checkbox to allow WinHADFM to automatically calculate velocity profiling parameter settings.

Optimization strategy – The H-ADFM flow computer can process data using a maximum of 30 velocity profile bins. Velocity profile data will have the greatest precision when a small number of larger bins are used.

Velocity profile data will have the greatest resolution and the smallest dead zones adjacent to the ChannelMaster and the far side of the channel when a large number of smaller bins are used. A balance between better precision and better resolution is obtained by using a moderate number of medium sized bins.

Select from:

- Optimize velocity precision (10 bins)
- Optimize horizontal resolution (30 bins)
- Balance precision/resolution (20 bins)

Edit Commands – Clicking this button will bring up a new dialog box listing the commands that will be sent to the ChannelMaster when it is programmed. Teledyne Isco normally recommends using the default values generated by WinHADFM. Please contact Teledyne Isco if you wish to override the default command settings and require assistance or additional information.

4.5.6 Velocity Range

WinHADFM will automatically select a range of velocity profile bins to use in calculating the index velocity V_i based on the channel geometry and the profiling settings. The bin number range selected by the program is shown when the “Calculate Automatically” checkbox is selected. Channel configuration, hydraulic conditions, and/or calibration measurement results may dictate using a different range of velocity profile bins to calculate the index velocity. Manually select the desired index velocity bin range by deselecting the “Calculate Automatically” checkbox and entering the desired first and last bin numbers in the appropriate fields. The index velocity is the average velocity for all bins in the index velocity range.

H-ADFM™ Velocity Profiler

Section 5 Programming and Testing the H-ADFM

5.1 Overview

After installing the H-ADFM and configuring a station file, you must program and test the H-ADFM. This is done using Win-HADFM and the DGH Utility 2000 software. Programming and testing should be performed in the following order:

1. Verify the DGH Module calibration.
2. Program the H-ADFM Flow Computer.
3. Program the ChannelMaster.

5.2 Connecting the H-ADFM Flow Computer to a PC

WinHADFM and the DGH Utility software communicate with the ChannelMaster and Flow Computer through the PC's serial port using a standard RS-232 serial cable (9-pin M-F straight through, **not** null-modem or crossover). Connect the cable to the appropriate port P1-P5 on the Flow Computer as shown in the photo below.

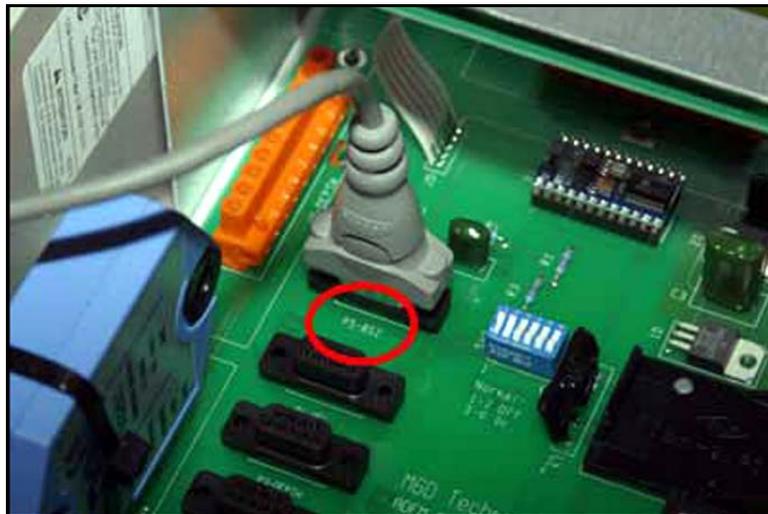


Figure 5-1 Connecting the H-ADFM to a PC

5.3 Verifying the DGH Module Calibration

The DGH Signal Generator Modules are configured at the factory, but it is a good idea to verify that the calibration is correct for each installation. To perform the verification, you will need a PC with the DGH Utility Software 2000 installed and the appropriate serial cable. Follow the steps below to verify correct calibration. This procedure must be performed for each of the three output channels.

1. Plug one end of the serial cable into your PC's serial port. Plug the other end into the connector on the Flow Com-

puter's electronics board that corresponds to the output channel being verified (P2-flow, P3-depth, or P4-velocity).

2. Set the DIP switches (SW2) to the following:

Table 5-1 DIP Switch (SW2) Settings for DGH Verification

Switch	Setting
1	N/A
2	On
3	N/A
4	On/Off, turn off if testing flow channel.
5	On/Off, turn off if testing depth channel.
6	On/Off, turn off if testing velocity channel.

3. Launch the DGH Utility Software 2000 program.
4. From the Tools menu, select “Evaluation Screen” then select “D3000/D4000 Series Module.”
5. Set the parameters as shown in Figure 5-2.

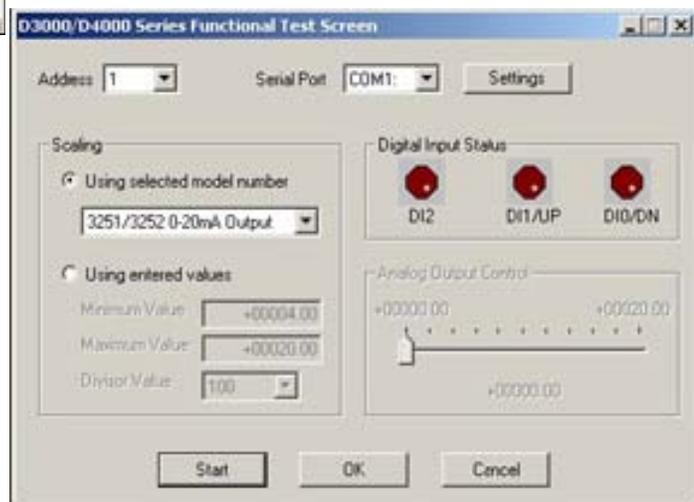
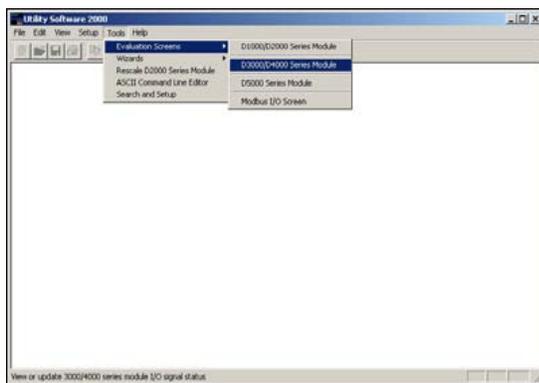


Figure 5-2 DGH Test Settings

6. Click Start.
7. Set the Analog Output Control slider to 4mA. (Clicking beside the slider will cause it to move in increments of 4 mA.)
8. Measure the output at the receiving device (whatever the analog output channel is connected to).
9. Repeat steps 7 and 8 as desired for other output values between 4 and 20 mA. Repeat steps 1-8 for each additional output channel. If required, follow the procedure provided in Appendix A to recalibrate the DGH Module(s).

5.4 Programming the Flow Computer

The Flow Computer is the portion of the H-ADFM system that computes average velocity and flow rate from the depth range and velocity profile information collection by the ChannelMaster. The Flow Computer must be reprogrammed after all configuration changes to the WinHADFM station file (except changes to the Graphics Preferences and Calculation Settings). This ensures that the Flow Computer is using the correct parameters for velocity and flow computations.

The firmware version in the Flow Computer must be compatible with the WinHADFM software version to ensure successful programming. Mismatches between the Flow Computer firmware and the WinHADFM software are annunciated either as messages on the Flow Computer display or as message boxes in the WinHADFM software. The Flow Computer firmware version is displayed briefly on its LCD display when it is powered on or reset. Teledyne Isco recommends always upgrading to the latest Flow Computer firmware version and WinHADFM software versions to ensure proper and reliable H-ADFM system operation.

Note

WinHADFM will automatically select and display information for the first station in the station file list when the program is started. Ensure that you select the desired station file before entering configuration changes or programming the Flow Computer and ChannelMaster.

To program the flow computer:

1. Set DIP switch SW2-3 to the OFF position. This disables the Flow Computer from receiving data from the ChannelMaster. Programming the Flow Computer may fail and the Flow Computer may lock up if data is received from the ChannelMaster while programming is in progress. If the Flow Computer locks up, reset it by removing all power for at least 10 seconds, then reapply power. The Flow Computer should return to normal operation.
2. Plug the RS-232 comms cable from the computer into the P5-BS2 port on the Flow Computer.
3. Select “Program Flow Computer” from the main Station Information dialog. A dialog box will appear showing the

status of the programming process. Ensure that programming completes successfully.

4. Remove the RS-232 comms cable from the P5-BS2 port on the Flow Computer.
5. Set DIP switch SW2-3 to the ON position. This enables the Flow Computer to receive data from the ChannelMaster.

5.5 Programming the ChannelMaster

The ChannelMaster is the component in the H-ADFM system which measures the depth range (depth of water over the ChannelMaster) and collects velocity profile information to use in calculating average velocity and flow rates. WinHADFM provides the following functions for operating the ChannelMaster H-ADCP:

- Wakeup
- System Test
- Zero Pressure
- Check Orientation
- Download Data
- Erase Data
- Set Time
- Sleep
- Program

Selecting “Program ChannelMaster” from the main station window will bring up the ChannelMaster Communications dialog and automatically establish communications with the ChannelMaster. A wakeup message and the results of each action will be displayed in the dialog. A log file containing a record of each ChannelMaster communications session will automatically be created.

Note

WinHADFM will automatically select and display information for the first station in the station file list when the program is started. Ensure that you select the desired station file before entering configuration changes or programming the Flow Computer and ChannelMaster.

5.5.1 Wakeup

WinHADFM will automatically wake up the ChannelMaster when entering the ChannelMaster Communications dialog. Select this function if the automatic wakeup is not successful or if you need to wake up the ChannelMaster at any other time when using this dialog.

5.5.2 System Test

Selecting System Test will run a series of informational and diagnostic tests on the ChannelMaster hardware. System Test should be run after initial installation to document initial conditions and periodically thereafter.

5.5.3 Zero Pressure

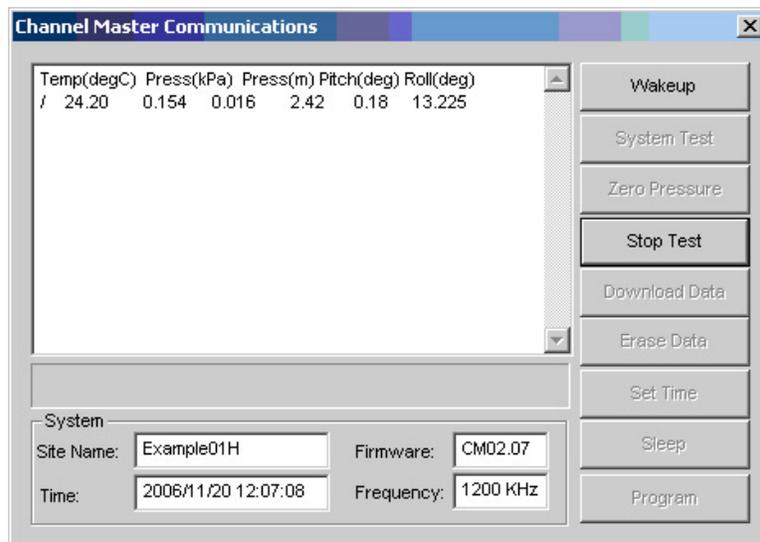
The ChannelMaster contains an integral pressure sensor. Select this command to zero the pressure sensor to atmospheric conditions. You will be prompted to confirm this selection to avoid inadvertently setting the zero when the sensor is submerged.

Note

The pressure sensor must not be submerged when this command is executed or it will not read depth range correctly. If the pressure sensor is zero-adjusted when submerged you will need to remove the ChannelMaster from the channel, re-zero it, and reinstall it before it will again read correctly.

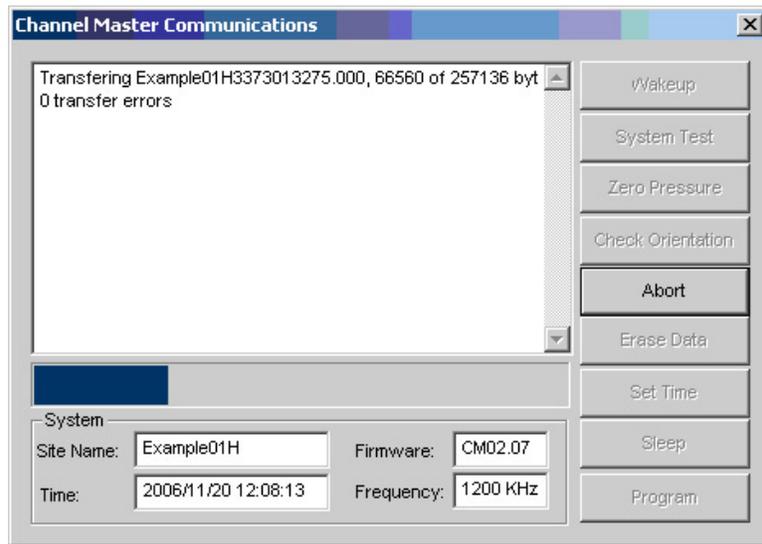
5.5.4 Check Orientation

When this command is selected, the ChannelMaster will display temperature, pressure depth, pitch, and roll data. The button text will also change to “Stop Test” as soon as this function is entered. Orientation data (sensor temperature, pressure depth, pitch and roll, and supply voltage) will be continuously updated until you select “Stop Test”.



5.5.5 Download Data

Selecting this command will download all data currently stored on the ChannelMaster’s internal recorder to your computer. You will be asked if you want to erase the recorder at the end of the download process. Teledyne Isco suggests erasing the recorder at this time to expedite subsequent downloads and avoid generating overlapping data files.



5.5.6 Erase Data

All data currently stored on the ChannelMaster's internal recorder will be erased when you select this command. You will be prompted to confirm this selection to avoid inadvertently losing stored data.

5.5.7 Set Time

The ChannelMaster contains an internal real-time clock, and all recorded data is time-stamped. Selecting Set Time will bring up a dialog box for adjusting the time setting in the ChannelMaster. The Set Time dialog allows synchronizing the ChannelMaster clock to the computer clock including a time zone offset as appropriate.



5.5.8 Sleep

Use this command to suspend normal operation of the ChannelMaster and conserve battery power. The ChannelMaster will NOT record or output data when put to sleep, and cannot be programmed to automatically exit sleep mode.

5.5.9 Program

Selecting this command will program the ChannelMaster with the current station file configuration and deploy it (cause it to start taking readings). Programming the ChannelMaster will also save the current station file configuration to the list of calculation settings.

The ChannelMaster **must** be reprogrammed after making changes to the channel geometry and dimensions, Z-ADCP, or Profiling parameters in the station file. Teledyne Isco recommends reprogramming the ChannelMaster after any changes to the station configuration.

WinHADFM will ask you if you want to monitor data collection in real time after you program the ChannelMaster. This allows you to quickly observe and verify proper ChannelMaster operation. Selecting “Yes” will bring up a window showing data as it is received from the ChannelMaster. Data will be depicted in both graphical and tabular formats. Close the window to exit real-time data collection mode.

5.6 Listen Realtime

You can monitor ChannelMaster operation and collect real-time data without interrupting normal operation of the ChannelMaster by selecting the “Listen Realtime” function from the main station window. Data will be depicted in both graphical and tabular formats (Figure 5-3). Close the window to exit real-time data collection.

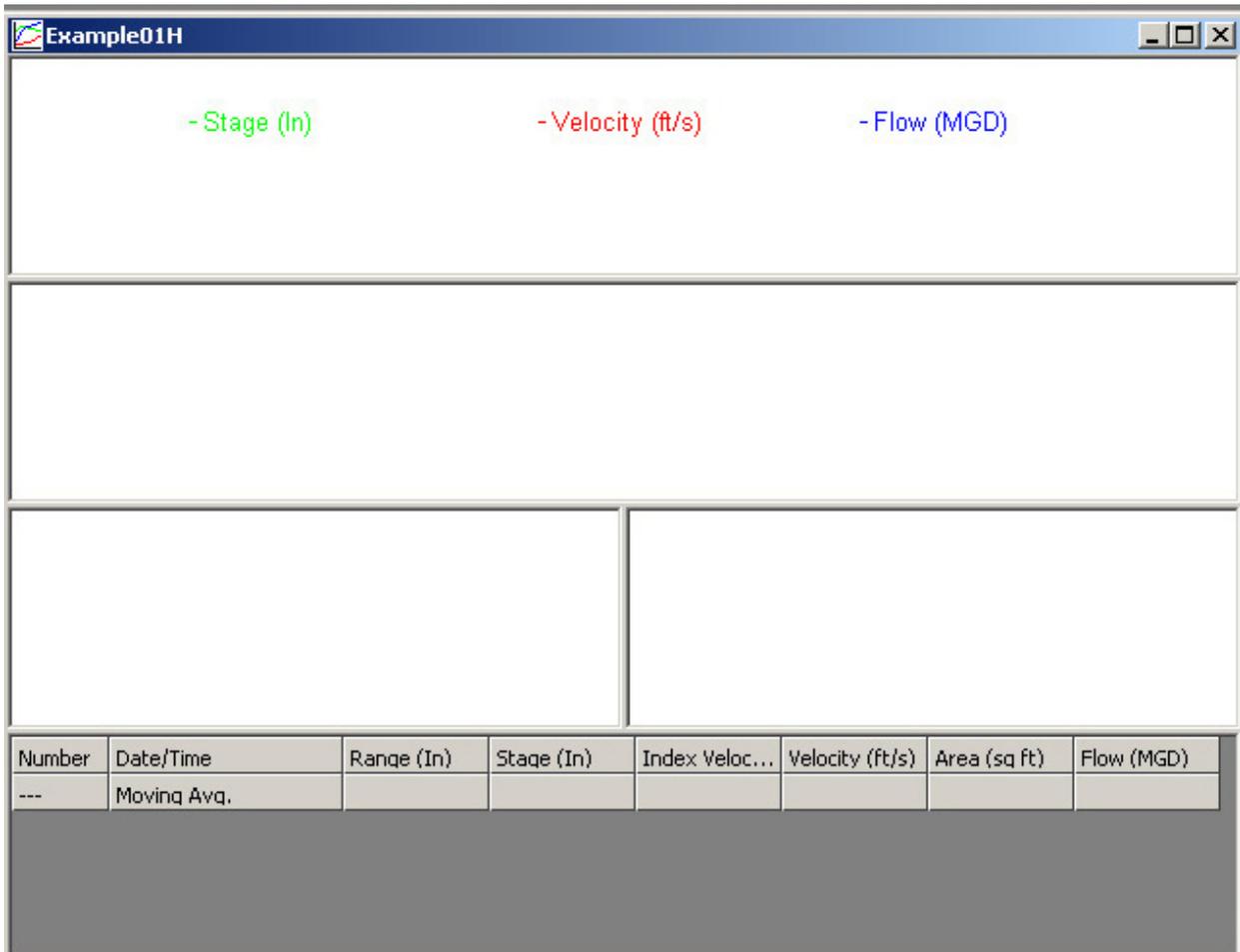


Figure 5-3 Listen Realtime data window

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Section 6 Reviewing Collected Data

All data collected by the WinHADFM software by downloading from the ChannelMaster or while listening to ChannelMaster in real-time mode is stored on the computer in the following path:

C:\WinHADFM\SITES\<>groupname>\<stationname>

A list of available data files for a station is displayed in the main station window. Selecting a data file from the list will display statistical information about the data within that file.

Note

Changes to the calculation settings in the station file may invalidate the stored statistical information. That information may be updated by viewing the data file or by clicking the refresh button below the list of data files.

6.1 Refresh

Selecting “Refresh” from the main station window will update the stored statistical information for every available data file. This information is displayed whenever a file is selected from the list. This statistical information should be refreshed every time changes are made to the calculations settings for the station file, or when data files are manually added to the site data directory.

6.2 View Data

Selecting “View Data” will open a window depicting the contents of the data file in both graphical and tabular formats. The data display window is configurable in both content and the size of each display area. Standard display components include a hydrograph, velocity vector graph, velocity beam data, and a tabular view. Data can also be copied from the tabular display area and pasted into a spreadsheet.

6.2.1 Configuring the Data Display

Contents of the data display window may be changed by selecting “Graphics Preferences” on the System tab of the Station Configuration dialog. Different display configurations can be used for each station file.

6.2.2 Resizing Display Areas

The data display is divided into individual panes for each display type. The space allocated to each graphical or tabular area can be adjusted by clicking on and moving the dividers. Display area sizing is not saved in by the program.

6.2.3 Hydrograph

This graphical display area is used to show all time-series data stored in the selected data file. The hydrograph includes traces for stage, average velocity, and flow rate. Stage is the water level above the reference datum, and is calculated from the measured range to water surface using the Z-ADCP value(s) saved in the calculation settings dialog. Average velocity is calculated from index velocity using the velocity model settings saved in the calculation settings dialog. Flow rate is calculated from stage and average velocity using the channel geometry configuration saved with the calculation settings entries. The date/time stamp of the recorded data is used to determine the entry in the calculation settings dialog in effect for that data.

 **Note**

Calculation setting entries store the channel geometry settings in effect at the time the entry was created. Channel geometry settings cannot be edited once created. If you wish to change the channel geometry settings in use for a given time period you must configure the station file for the desired geometry settings, create the calculations settings entry, then (if necessary) return the geometry settings to their correct values.

 **Note**

Calculation settings are currently not sorted by date/time. The user must ensure that all calculation setting entries are arranged in proper date/time sequence.

A dashed vertical position marker is included in the hydrograph (see Figure 6-1). Data in the remaining graphical display areas and in the tabular display is synchronized to the ensemble indicated by the position marker in the hydrograph. Clicking in the hydrograph will move the position marker and synchronize the remaining display areas to the selected ensemble.

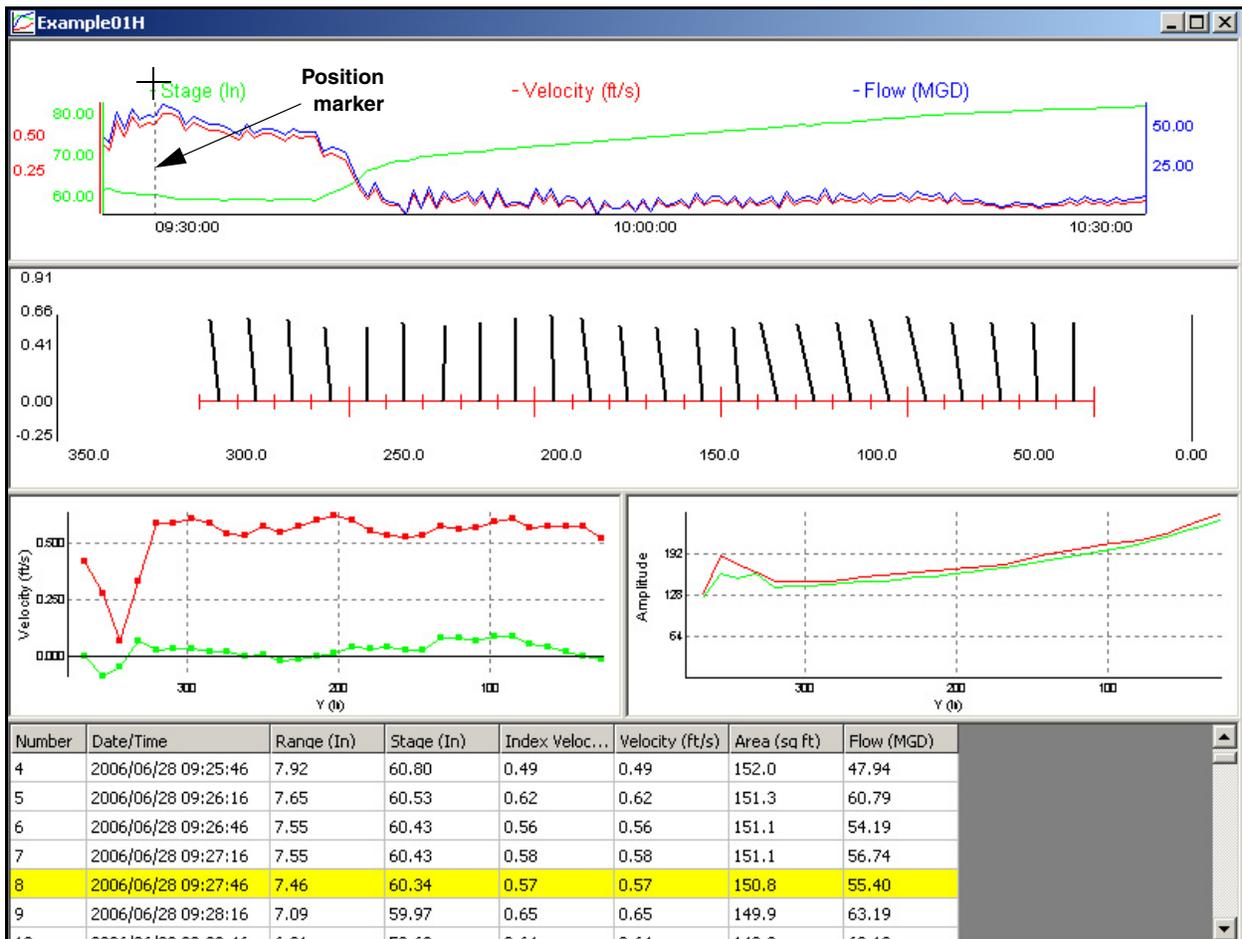


Figure 6-1 Data display

6.2.4 Velocity Distribution Whisker Graph

This graphical display area is used to display the current ensemble's measured velocity vector for each velocity bin within the index velocity range. Bins outside of the index velocity range are not displayed. Data is plotted from a bird's-eye perspective, with the right bank on the right side of the graph and the left bank on the left side, and downstream (positive flow) to the top of the graph. The horizontal axis scaling indicates the distance from the channel bank, either left or right depending on mounting orientation. Tick marks are provided along the horizontal axis to indicate bin positions, with a larger tick mark every 5 bins. The length of a whisker indicates the magnitude of the velocity vector for that bin. The angle of a whisker with respect to vertical indicates the direction of the velocity vector for that bin.

6.2.5 Beam Graphs

These graphical display areas are used to show the current ensemble's velocity beam data for all velocity bins. Available data will typically be limited to velocity vectors and amplitude. The velocity vector beam graph contains traces for longitudinal

(along the axis of the channel) and transverse (perpendicular to the axis of the channel) velocities. Distorted vectors will likely be present in bins located close to the channel wall(s).

The amplitude beam graph contains traces for each velocity beam. Sufficient amplitude above the background noise level is required to ensure that the velocity beam data is valid. Velocity beam amplitudes will typically be distorted in bins located close to the channel wall(s).

6.2.6 Tabular Display

The tabular display area is used to show data from the selected file in tabular format. The highlighted ensemble corresponds to the position marker in the hydrograph display. Beam graphs and the whisker graph are synchronized to the current ensemble. Data can be copied from the tabular display and pasted into a spreadsheet for further manipulation by simply clicking and dragging within the tabular display area. Standard Windows keyboard shortcuts can also be used to select the desired range of cells.

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Appendix A Current Loop Calibration

The current loop calibration procedure calibrates the analog output signal of the DGH modules. A calibrated ammeter and a PC with the DGH 2000 software installed are required to perform this procedure. Follow the steps below for each analog output channel:

1. Start the DGH Utility Software 2000.
2. From the Tools menu, select ASCII Command Line Editor.
3. Click the Settings tab and ensure that the baud rate matches that of the DGH module (see the setup to change this).
4. Click the Open button in the Settings window.
5. Connect the serial cable to the appropriate DB9 connector.
6. Set the DIP switches (SW2) to the following settings:

Table A-1 DIP Switch (SW2) Settings for DGH Calibration

Switch	Normal Setting	Test Setting
1	Off	N/A
2	Off	On
3	On	N/A
4	On	On/Off, turn off if testing flow channel.
5	On	On/Off, turn off if testing depth channel.
6	Off	On/Off, turn off if testing velocity channel.

Table A-2 SW2 DIP Switch Functions

Switch	On Function	Off Function
1	Enables microprocessor programming (Off for normal operation).	Disables microprocessor programming.
2	Forces DGH module to default communication settings (300 baud). (Off for normal operation.)	Forces DGH to use configured communication settings (2400 baud).
3	Enables microprocessor input.	Isolates microprocessor from input. (On for normal operation.)
4	Enables microprocessor/DGH module communication.	Isolates DGH module from microprocessor. (On for normal operation.)
5	Enables microprocessor/DGH module communication.	Isolates DGH module from microprocessor. (On for normal operation.)
6	Enables microprocessor/DGH module communication.	Isolates DGH module from microprocessor. (On for normal operation.)

Perform the following calibration sequences for each output channel (P2, P3, and P4).

1. Enter the `$1AO+00004.00` command in the command line and click Transmit. If successfully sent, the unit will respond with an asterisk (*).
2. Measure the current output using a calibrated ammeter or the receiving device.
3. If the output is not 4mA, enter the write-enable command by typing `$1WE`. This allows data to be written to the DGH Module.
4. Next, tell the unit what the measured output was by entering the `$1TMN+0000X.XX` command, where `0000X.XX` is the actual measured output value.
5. Measure the new output value. If the new value is not 4.0mA, repeat steps 3 and 4 until the measured output is 4.0mA.
6. Enter the `$1AO+00020.00` command in the command line and click Transmit. If successfully sent, the unit will respond with an asterisk (*).
7. Measure the current output using a calibrated ammeter or the receiving device.
8. If the output is not 20mA, enter the write-enable command by typing `$1WE`. This allows data to be written to the DGH Module.
9. Next, tell the unit what the measured output was by entering the `$1TMX+000XX.XX` command, where `000XX.XX` is the actual measured output value.
10. Measure the new output value. If the new value is not 20mA, repeat steps 3 and 4 until the measured output is 20mA.
11. Recheck the zero-scale value.

 **Note**

Remember to return the DIP switch settings to their normal positions prior to operation. Failure to do so will result in improper operation.

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Teledyne Isco One Year Limited Warranty*

Factory Service for Teledyne Isco Flow Meters, Waste Water Samplers, and Syringe Pumps

This warranty exclusively covers Teledyne Isco instruments, providing a one-year limited warranty covering parts and labor.

Any instrument that fails during the warranty period due to faulty parts or workmanship will be repaired at the factory at no charge to the customer. Teledyne Isco's exclusive liability is limited to repair or replacement of defective instruments. Teledyne Isco is not liable for consequential damages.

Teledyne Isco will pay surface transportation charges both ways within the 48 contiguous United States if the instrument proves to be defective within 30 days of shipment. Throughout the remainder of the warranty period, the customer will pay to return the instrument to Teledyne Isco, and Teledyne Isco will pay surface transportation to return the repaired instrument to the customer. Teledyne Isco will not pay air freight or customer's packing and crating charges. This warranty does not cover loss, damage, or defects resulting from transportation between the customer's facility and the repair facility.

The warranty for any instrument is the one in effect on date of shipment. The warranty period begins on the shipping date, unless Teledyne Isco agrees in writing to a different date.

Excluded from this warranty are normal wear; expendable items such as charts, ribbon, lamps, tubing, and glassware; fittings and wetted parts of valves; and damage due to corrosion, misuse, accident, or lack of proper maintenance. This warranty does not cover products not sold under the Teledyne Isco trademark or for which any other warranty is specifically stated.

No item may be returned for warranty service without a return authorization number issued by Teledyne Isco.

This warranty is expressly in lieu of all other warranties and obligations and Teledyne Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose.

The warrantor is Teledyne Isco, Inc. 4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to the USA and countries where Teledyne Isco Inc. does not have an authorized dealer. Customers in countries outside the USA, where Teledyne Isco has an authorized dealer, should contact their Teledyne Isco dealer for warranty service.**

Before returning any instrument for repair, please call, fax, or e-mail the Teledyne Isco Service Department for instructions. Many problems can often be diagnosed and corrected over the phone, or by e-mail, without returning the instrument to the factory.

Instruments needing factory repair should be packed carefully, and shipped to the attention of the service department. Small, non-fragile items can be sent by insured parcel post. **PLEASE BE SURE TO ENCLOSE A NOTE EXPLAINING THE PROBLEM.**

Shipping Address: Teledyne Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln, NE 68504 USA

Mailing Address: Teledyne Isco, Inc.
PO Box 82531
Lincoln, NE 68501 USA

Phone: Repair service: (800) 775-2965 (lab instruments)
(866) 298-6174 (samplers & flow meters)
Sales & General Information: (800) 228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: IscoService@teledyne.com



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