ACCUSONIC®

8510+IS Series Flowmeter
Technical Reference Manual
8510MA0100 A4

Accusonic, a Brand of ADS LLC.
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INTERFACES SUPPLIED (UNLESS NOTED AS OPTIONAL)

Power Supply	Voltage	90 to 250 V a.c. 47 to 63 Hz, or 100 to 300 V d.c.
Signal Filters	Transducer Frequency	1 MHz / 500 kHz
Analog Inputs	Number	4
	Load Resistance	100 Ω
	Power supply	+24 V d.c.
Analog Outputs	Number	4
	Type	Isolated
	Maximum load	750Ω
Digital Outputs	Number	3
	Type	RS-232; RS-232/RS-485 (User Selectable); Ethernet
	Protocol	ModBus RTU Slave
Relays (Optional)	Number	6
	Type	SPDT
Internal Data Logging	Memory	Supplied 8Gb (minimum) via Micro SDHC Class 4 Card

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CHAPTER 1

Flowmeter Description

The Accusonic Model 8510+ Flowmeter is designed for use in pipes, channels and sewers, ranging from 8 inches to 300 feet (0.2m to 90m) in width, and of cross section which may be circular, rectangular, trapezoidal, "horseshoe" or other defined shape.

The depth of water above the invert or bottom of the conduit may vary from zero to surcharged. The flow may be in either direction, and generally there is no assumed relation between depth and flow. Under certain conditions of low water level, a Manning type of relation between level and flow may exist. To cope with all these three possible flow conditions, and the possible temporary loss of velocity measurements, "Compound" flowmeter logic is required.

The water may range in quality from clean to raw sewage, from natural or industrial sources, having a pH in the range 3.5 to 10, temperature between 32°F and 105°F (0°C and 40°C), and a solids loading from near zero to 2000 parts per million. It is assumed that the conduit does not contain vapors of ketones or esters which might eventually reduce the integrity of the plastic housing of the transducers. In addition, the water may contain floating weed, rag, paper and plastic debris, and may deposit grease on the walls and any devices attached to the walls, especially in the region around the dry weather flow level.

Sewers may be classified as "confined spaces" as regards access: they may also contain potentially explosive atmospheres. If this is the case, the Hazardous Area Classification in USA and Canada, is typically Class I, Division 1, Gas groups C & D; elsewhere it is usually classified according to IEC codes as Zone 0 or Zone 1, Gas groups IIA & IIB.

For these applications, all transducers, cabling and other electrical equipment in the sewer and associated with it, should be installed in accordance with the appropriate National codes.
In USA installation should follow NEC Articles 500 & 501 for Explosion proof protection, or NEC Article 504 for Intrinsically Safe protection.

Elsewhere IEC 79-14, or EN 50014 & EN 50018 should be consulted.

For those conduits which are always surcharged the flowmeter may be configured in the "Pipe" mode. In this mode the level inputs are ignored, and in some cases the flowmeter may be supplied from the factory without level input circuits. For the flow computation, either the "Gaussian" (Gauss-Legendre) or "Chebyshev" (Jacobi-Gauss) multi-path integration methods can be implemented by setting the parameters describing path lengths, angles and weighting coefficients in accordance with ASME or IEC codes.

For all other conduits the "Compound" mode should be used. The flowmeter is based on the "velocity-area" method for flow determination, generally described in ISO 6416 1992, and more specifically in Appendix A of this manual.

The water velocity is determined using the multi-path ultrasonic time-of-flight method. The elevation of the water surface above the site datum is called the "Level," and the variable component of this value is input to the flow computer in analog form from one or two sensors, (typically downlooker ultrasonic units or pressure transmitters). A single arbitrated value for Level is obtained from the two inputs. The wetted cross section area is computed from the Level and parameters stored in the computer defining the shape of the conduit. The integration technique for computing the flow from the velocity data is determined automatically from the water level and from the quality of the velocity data.

When the Level is too low for any acoustic paths to operate (or if they are submerged and have failed), flow may be computed using the Manning equation. When the level is higher and ultrasonic paths are operating, a “Trapezoidal” integration method is used. When the conduit is surcharged, either the same integration algorithm may be used (modified to allow for the friction effect of the top of the conduit), or alternatively the “Pipe” mode may be used.

The flowmeter may be configured to provide determinations of flow in up to five (5) separate and dissimilar conduits or *Sections*, each with one or two analog Level inputs and a number of acoustic paths. The total number of Level inputs allocated among the Sections is limited to 4, and the total number of paths allocated among the Sections is limited to 4, 8, or 10 depending on the version purchased.

The electronic unit provides up to four (4) independent outputs in a 4-20 mA analog form, which may be differently scaled to output separately forward and reverse flow, flow over any range from reverse to forward, mean velocity, level, water temperature or sum of section flows.

Optional six (6) alarm relays may be fitted to the electronic unit to provide flow and level threshold alarms for each section or sum of sections, section status (fail) alarms, or totalizer pulses.

An LCD touch screen display of flow and diagnostic data is provided with every flowmeter. The site parameters may be entered into the flowmeter’s non-volatile memory from this touch screen display, by way of a *user-friendly* menu. Alternatively, a user supplied PC with a communications software provided with every flowmeter may be used in place of the touch screen display.

An RS232 port is provided for use with a user supplied PC which has *Accuflow* software installed. This provides a “Windows” based user friendly flowmeter configuration routine, as well as graphics showing trends from recent flow data, the received acoustic signal waveforms and other data to aid commissioning.

An integral data logger is standard, which stores all of the measured variables at a chosen interval, using non-volatile SDHC Class 4 memory card. The data log interval and turning the data logging function on or off can be accessed from the “Logging” menu. An 8GB SDHC memory card will store over 20 years of data logging at a 1 minute interval.

CHAPTER 2

General Specifications

Transducers

Temperature Range	Operating: 32°F to 105°F (0°C to 40°C) Storage: 0°F to 150°F (–18°C to 65°C)
Pressure range	Dependent on model
Water quality	pH: 3.5 to 10 Solids Loading: 0 to 2000 parts per million Vapors of Ketones & Esters must not be present
Characteristic frequency	1MHz or 500 kHz
Maximum Transmit Voltage	Standard Systems: 1100 VDC peak Flameproof protected transducers: 1100 VDC peak.

Electronic Unit

Standard Model

Power Supply	Electronic Unit: 90 to 250 Volts AC 47 to 63 Hz 100 to 300 Volts DC without adjustment
Power Consumption	Standard Unit: 10 Watts, 20 VA.(with AC power supply) With relays: 25 Watts, 40 VA. (with AC power supply)
Temperature Range	Operating: -4°F to 160°F (–20°C to 70°C) Storage: 0°F to 160°F (–18°C to 70°C)
Maximum altitude for normal operation	6500 ft. (2000 m) Contact Accusonic for higher altitudes
Dimensions (nom)	18 x 16 x 10 inches (460 x 410 x 255 mm)
Weight	30 lb (14 kg)

Enclosure protection	NEMA 4X (IP66)
Acoustic Paths	Up to 10 total, allocated between all the Sections. Length Standard range 0.7 to 50 ft. (0.2 to 15 m) Length Extended ranges 5 to 300 ft. (1.5 to 90 m)
Permanent Data Display	LCD Touchscreen: (800 x 480 pixel) Character height: 9mm
Level Inputs	4 Useable input range with standard 100Ω load: 4 -20 mA, (0.4 - 2.0V) Maximum load (optional): 150Ω (0.6 - 3V range) Maximum voltage relative to ground for operation: ± 20 V DC Maximum withstand voltage relative to ground: 240 V rms. Power supply for external transducers: +24 V DC 0.5 A max
Analog Outputs (Isolated)	4 Range: 4-20 mA Maximum load: 600Ω 24 Volts Resolution: 0.005 mA (16 bit) Linearity and Stability: 0.04% 180ppm Isolation: 2500 V rms. common mode to ground Protection: ± 50 V DC
Alarm relays **(Optional 6)**	For Flow or Level exceedance, Faults or Totalizer. Normally open contacts. 10 A carrying capacity. Switching capacity: 0.5 A, 110 V DC L/R = 40 ms Isolation 2000 V AC
Integral Data Logger	104 different variables (all logged) Interval selectable between 1 second and 24 hours Capacity of main memory: 8GB minimum

Transducer Cable

Unbalanced mode	Coaxial RG59 A/U Special double-jacketed version for underwater use
Balanced mode	Twin-axial RG108 for lengths up to 300 ft. (100 m). Twin-axial RG 22 for long lengths
Max length between transducers and electronic unit	1600 ft. (500m)

Note: Approval from Accusonic should be obtained if the cables are expected to exceed 300 ft (100m).

Conformity with EMC and Safety Standards

The Model 8510+ Flowmeter is designed and constructed in conformity with the following standards or normative documents, and with the essential requirements of the European Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC with amend. 92/31/EEC and 93/68/EEC.

Low Voltage Directive

EN 61010-1	Safety Requirements for Electrical Equipment.

EMC Directive, Immunity

EN 61326-1 (2006)	Part 2 Industrial	
IEC 61000-4-11 (2004)	Interruptions (100 ms), dips and voltage variations (+12 to -15%) on supply	
IEC 61000-4-4 (2012)	Fast transient/bursts.	2 kV common, 1 kV normal mode
IEC 61000-4-5 (2005)	High energy pulse/transient	2 kV common, 1 kV normal mode
IEC 61000-4-6 (2008)	Conducted disturbances, induced by radio frequency fields.	
	150 kHz to 80 MHz (10 V)	
IEC 61000-4-2 (2008)	Electrostatic discharge	8 kV in air, 6 kV in contact
IEC 61000-4-3 (2010)	Radiated electromagnetic field 80-1000 MHz, 10 V/m	

EMC Directive, Emission

EN 61000-3-2 (2006)	Harmonic current emitted into power source (+ A1: 2009; + A2: 2009)
EN 61000-3-3 (2008)	Voltage Fluctuation and Flicker Emission

EN 55011 (2009) Power Line Conducted Emission and Radiated Emission (+ A1: 2010)

Warning: This is a Class A (ITE) product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

FCC Compliance

To comply with the Federal Communications Commission (FCC), Accusonic Technologies provides the following information concerning the 8510+ flowmeter installation and operation.

Part 68

This equipment complies with Part 68 of the FCC Rules and the requirements adopted by the ACTA. It bears a label displaying, among other information, a product identifier in the format US:AAAEQ##TXXXX. The user must provide this information to the telephone company if requested.

The REN identifies the number of devices that may be connected to the telephone line. Excessive RENs on the telephone line may prevent devices from ringing in response to an incoming call. In most areas, the sum of the RENs should not exceed five (5.0). To determine the number of devices you may connect to a line, as determined by the total RENs, contact your telephone company. For this product the REN is part of the product identifier, the digits represented by ## are the REN without the decimal point (e.g., 03 is a REN of 0.3).

The plug and jack used to connect this equipment to the telephone network must comply with the applicable FCC Part 68 rules and the requirements adopted by the ACTA. A compliant telephone cord and modular plug is provided with this product. It is designed to be connected to a compatible modular jack that is also compliant. See installation instruction for details.

The telephone company may make changes in its facilities, equipment, operations, or procedures that could affect the operation of this equipment. If this occurs, the telephone company will provide advance notice so you can make necessary modifications to maintain uninterrupted service.

In the unlikely event that this equipment harms the telephone network, the telephone company will notify you that temporarily discontinuing telephone service may be required. Notification will occur in advance of discontinuation, or as soon as practically possible. They will also inform you of your right to file a complaint with the FCC if necessary.

This equipment may not be used on public coin phone service provided by the telephone company. Connection to party line service is subject to state tariffs.

This equipment is not field repairable. If you experience trouble with it, please refer to this manual for troubleshooting, replacement, or warranty information, or contact:

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Interface Specifications

Analog Level Input

Level is input in 4-20 mA analog form, from an external current loop source. Both terminals at the flowmeter must be within 20 volts of ground for operation. The external device should be configured to give increasing current for increasing water depth. If it is configured to give increasing current for decreasing water depth, the Level Arbitration will not operate correctly. For Level sensors requiring d.c. power, 24 Volts dc (at a total maximum current of 0.5 A) is available from the Level input terminal block. Configuration of the Level input is defined by user-defined parameters. A parameter makes allowance for alternative load resistances to be placed across the input terminals. Normally the input resistance is 100Ω. For electrical characteristics see "Electronic Unit" Specifications, page Electronic Unit2-1.

- A Level input having an electric current (in mA) less than the value set by the parameter *Min mA Input*, or more than 21.0 mA is treated as being in a "fault" state.
- Level inputs between the value set by the parameter *Min mA Input* and 20.00 mA are interpreted as elevations in feet or meters, linearly interpolated in the range from 4.00 to 20.00 mA, between the values stored under the parameters *4mA Level Input* & *20mA Level Input.*

Level Arbitration

- Applies when two Level inputs are allocated to a Section. Both inputs must be configured to give increasing current for increasing water depth. Input #1 is the lower numbered input allocated to the section.
- If input #1 is between the value set by the parameter *Min mA Input* and 19.8 mA, the value scaled by the parameters *4mA Level* and *20mA Level* is used as the arbitrated value for Level. Input #2 is ignored.
- If input #1 is below the value set by the parameter *Min mA Input*, it is rejected. If at the same time, input #2 is between the value set by the parameter *Min mA Input* and 20.0 mA, the scaled value from input #2 is used as the arbitrated value for Level.
- If inputs #1 and #2 are both below their values set by the parameters *Min mA Input*, both are rejected, and no Level value is available. The flowmeter is declared failed.
- If input #1 is above 19.8 mA, and input #2 is not rejected, then the arbitrated level is the greater of that indicated by input #1 or input #2.
- If input #1 is above 19.8 mA, and input #2 is rejected, then Level is that indicated by input #1.
- Usually input #1 reading 20mA indicates pipe full depending on surcharge level parameter value. Input #2 is usually scaled for a larger range than #1.

Analog Outputs

These are configured for 4-20mA, and may be separately allocated to give a linear representation of the flow, level, average water velocity, water temperature or sum of section flows. If desired, the outputs may be scaled to cover any range of the variable from reverse, through zero, to forward: it is necessary only to define the output by the extremes of the range (i.e., at 4mA and 20mA). Output allocation to flowmeter section, variable to be output, range, and output under fault condition, are all defined under Analog Output parameters (for definitions see Chapter 7).

Under fault conditions, the outputs will go either to 4.00 mA or be held at the last good value, depending on the choice under the parameter *Hold on Error*. On some systems a zero output can be selected.

Under conditions of under-range, an output will go to 4.00 mA.

Under conditions of over-range, an output will go to 20.00 mA.

When the flowmeter is taken out of measurement mode the output holds the last value.

For electrical characteristics see "Electronic Unit" Specifications, page 2-1.

Relay Outputs

The relays which have been installed can be allocated to any section and to any of the functions by setting the Relay Output parameters described in Chapter 7. The logical operation for the different functions is:

Threshold Exceedance

- The relay changes from its normal state when the value of the Flow or Level equals or exceeds the *Threshold* parameter for more than the number of consecutive measurement cycles defined by the *Delay* parameter.
- The relay returns to its normal state if the value of the Flow or Level falls below the *Threshold* for more than the number of consecutive measurement cycles defined by the *Delay.*
- If the section fails, the relay remains at, or immediately returns to its normal state.
- The Normal state (either energized or de-energized) can be selected by the parameter *Polarity*.
- The value of the *Threshold* can be positive or negative (–99999 to +999999).

Note: In the logic, the value -6.00 is regarded as greater than -7.00.

Status Alarms

- The relay changes from its normal state when the Fault state has been in existence for more than the number of consecutive measurement cycles defined by the *Delay* parameter.
- The relay returns to its normal state immediately if the Fault state ceases.
- The Normal state (either energized or de-energized) can be selected by the parameter *Polarity*.

Note. A fault state due to a path failure is declared when the path has failed to provide data for more than a number of consecutive measurement cycles defined by the parameter *Max Bad Measures*. If the relay *Delay* is set to a value greater than zero, the relay will not operate until after that delay, even though the fault state will have already been in existence.

- The purpose of this routine is to hide short term faults which are known to occur, and only to give alarms for permanent faults.

Totalizer Relays

- The relay changes from its normal state and returns 100 milliseconds later whenever the value for the Volume has increased by one complete unit.
- Only one operation of the relay can occur each measurement cycle.
- Only one relay can be allocated to each Section and only one to the Sum of Sections for totalizer pulses.

- In the event of power failure or the flowmeter being taken out of the Measure mode for less than one hour, the relay may operate at a rate of once per measurement cycle until the number of relay pulses has caught up with the Volume change which was computed to have occurred during the outage.

Data Display on Touch Screen LCD Display

In normal operation, four different display screens are available, and are as follows:

- Section Variables (Flow & Level & Temperature & Volume)
- Path Variables (Velocities & VSounds & Signal Gains & Detection Method & Signal to Noise Ratio)
- Path Variables (Signal Gain % & Travel Times)
- Path Variables (Time Differences & Raw Analog Input information).

For details of the displays, see the *Display of Variables* section at the end of *Chapter 5*. For definitions of the variables, see the section on *Variables* at the end of *Chapter 7*.

Parameter Insertion and Reading, Touch Screen LCD Display

Parameters describing the flowmeter configuration are entered using 6 different parameter menus (access via the Parameter Icon in the HOME screen). These parameter screens are selectable via the icons at the bottom of the display. These parameter menus are: SYSTEM (1 page), SECTION (3 pages), PATH (1 page), LEVEL (1 page), OUTPUT (1 page), and RELAY (1 page).

For instructions on how to enter the parameters, see *Chapter 5*.

For details on setting up the integral data logging, see *Chapter 5*.

For details and definitions of the parameters, see the *User Defined Parameters* section in *Chapter 7*.

There are six command buttons on the HOME page (Selectable by pressing the HOME icon):

- **Section** To put the flowmeter into the *Measure* mode. This display function will show all of the Section related variables (flow, level, temperature, and volume).
- **Path** To put the flowmeter into the *Measure* mode. This display function will show all of the *Path* related variables. A user can select from 3 different path variable displays by selecting Page 1, Page 2, or Page 3 in the vertical navigation bar on the right side of the display.
- **Parameter** To view or change the flowmeter's internal parameters. The various system, section, path, level, output, and relay parameters can be selected via the icons located on the bottom of the display.
- **Logging** To access the data logging function of the flowmeter. A user can enable or disable logging, set a logging interval, select a storage location, export internal data to a USB drive, or clear the internal data logging memory.
- **Scope** To view the processed receive signals for each acoustic path.
- **System** To view or set the System values. Page 1 allows a user to set the date/time, IP address, subnet mask, gateway, and Device ID of the unit. Page 2 allows a user to select a baud rate (9600, 19200, or 38400), Transmit Mode (Pulse Mode – standard, IS Mode, or Burst Mode), enable password protection, or update the system's software (Update HMI) or firmware (Update DSP). Page 3 displays the flowmeter's current revisions and allows a user to store or restore the flowmeter parameters to or from the flowmeter's internal memory.

Connection of a PC for use with *Accuflow* Flowmeter Interface

A PC may be connected to the 9-pin RS-232 socket or the RJ45 Ethernet socket, for use with special Accusonic PC based programs. The RS-232 connection requires a *Null-Modem* connection and the Ethernet connection requires a *Cross-Over* LAN cable or a standard LAN cable if connection via a switch or router. Either the cable or adapter can be purchased at a PC supply or electronics store.

Integral Data Logger

The integral data logger can be configured to log at a chosen interval (all variables will be logged), by selecting “Internal” memory which will use the supplied MicroSDHC memory card installed in the HMI board. The user interfaces with the logger for setting up, either using the touch screen LCD display (see Chapter 5 & 7), or via the RS232 serial port using a PC running under the Accuflow Interface (see Chapter 6). Reading the logged data can only be achieved by exporting the data to a user supplied USB Drive or by physically removing the supplied MicroSDHC memory card (a user should stop the datalogging function prior to removing the MicroSDHC memory card). A separate .csv file will be created for each calendar day containing all of the flowmeter variables for a given day. The .csv files can be opened with any version of Microsoft Excel.

CHAPTER 3

Flow Computation

Flow Computation Algorithms Overview

The Accusonic Model 8510+ Flowmeter may be configured with up to a maximum of ten acoustic paths and two inputs for Level (or water depth) in one conduit or "Section." Details of the configuration are defined by a set of parameters, the names of which appear in this document in *italics.*

Each path is characterized by parameters describing *Length* and *Angle.* For "Pipe" mode integration, a *Weight* parameter is added: for "Compound" mode *Elevation* is added. Paths are numbered in order of elevation, with the lower path numbers having lower elevations. In a Compound flowmeter, pairs of "Crossed Paths" in a section are indicated by having the same elevation. Other Path parameters include: *Max Bad Measures, Max Velocity Change, Max Path Velocity, Signal Delay* and *Transducer Frequency*

In **Pipe** mode, path transducers are energized and measurements taken for all paths which are configured.

In **Compound** mode, only those transducers submerged by an amount greater than the parameter *Min. submersion* are energized.

If a path fails to provide a good velocity value, because the signal is not found, or the velocity appears to exceed the *Max Path Velocity* parameter, then the last good velocity value is used for flow calculations until the number of consecutive failures exceeds the parameter *Max Bad Measures*. If this value is exceeded, the path is declared to have failed, and its data are then not used for flow computation, unless and until new valid data are obtained.

If the change in velocity appears to exceed the *Max Velocity Change* parameter, the computed velocity is incremented or decremented by an amount equal to the *Max Velocity Change.*

In **Pipe** mode, all Manning, Level and Layer parameters indicated by the letter "C" after their names are ignored. The conduit geometry and velocity integration are defined in terms only of Pipe Area and Path weights.

In **Compound** mode instantaneous values for velocity are averaged for paths having identical elevations, and the averaged velocity is used as the velocity at that elevation. If one of the paths has failed for more than the parameter Max Bad Measures, the good path will be used alone for providing the velocity at that elevation. Paths which do not have identical elevations will be treated as separate paths in the Trapezoidal Integration. The displayed and outputted velocities will be the individual velocities for each path. The conduit cross-section is defined in terms of up to 8 "Layers," each layer being described by an elevation and a width. The width of the conduit at any elevation is computed by linear interpolation between the layer widths above and below. The elevation and width of the channel bottom are defined by Layer #1 (see Chapter 5 for additional details). The layer elevations are independent of the path elevations. For a rectangular or trapezoidal conduit, only two layers need be defined, the first describing the channel bottom, and the second describing the top of the channel. For a closed conduit, the top-most layer elevation must be equal to or greater than the elevation of the soffit or top of the conduit (or the Surcharge Level parameter). For an open channel, the top-most layer elevation must be set above the highest possible level. The other Section parameters required for Compound Integration are: Bottom friction, Top weight and the Surcharged Integration method to be used (Surch Trap/Pipe). If "Trapezoidal" integration is chosen for the surcharged condition, certain “Pipe” mode parameters are ignored by the system, and these are indicated in Chapter 7.

Compound Modes

The flowmeter automatically chooses one of 5 integration methods, depending on the value of the Level, and on the status of any of the acoustic paths which are sufficiently submerged to operate, (i.e. those paths whose elevations are defined to be less than [Level - *Min. submersion*]. The 5 methods are:

- Zero flow if the Level (or depth of water) is below a user defined value.
- **Manning Equation** when the depth of water is too low for acoustic paths to operate, or, within-user defined limits, if none of the acoustic paths yields valid data.
- **Single Path Trapezoidal Integration** when the conduit is not surcharged and only one path (or one pair of crossed paths) is submerged, or when only one path (or one pair of crossed paths) is able to yield valid data.
- **Multi-path Trapezoidal Integration** when the conduit is not surcharged and at least two acoustic paths at different elevations (any of which may be pairs of crossed paths) yield valid data.
- **Surcharged Integration** when the pipe is surcharged. Two user-selectable methods are available: **Pipe** as described for *Pipe* mode involving parameters of path weights and pipe area; and **Surcharged Trapezoidal** where the pipe geometry and velocity integration are defined by methods similar to those used for non-surcharged trapezoidal integration.

Note: If none of the above conditions is satisfied, the flowmeter is declared to be in a *fault* state. On sites where the Manning equation is not appropriate, the facility can be inhibited by setting the parameter Manning max lvl. to a value equal to or below the parameter Layer elevation 1.

Manning Mode

The flow is computed from the variable Level and fixed parameters of channel roughness, channel slope, and dimensions of the conduit.

The flow = Flow scaling $*$ Area $*$ C $*$ n^{-1} $*$ $R^{0.667}$ $*$ $\sqrt{s}$

where:

Area = the cross-section area of fluid at the current Level, computed using layer data.

C = Manning Constant = 1.49 if English units are used, 1.00 if metric units are used.

n = the Manning coefficient of roughness.

R = Hydraulic radius, which is the Area/Wetted Perimeter.

s = Slope of the energy line. For a long pipe, the pipe slope.

Non-Surcharged Single Path Trapezoidal Integration Mode

The flow is computed from the variables Level and Water Velocity, and fixed parameters describing the conduit.

Flow = Flow scaling $*$ Area $*$ Velocity $*$ Path position coefficient.

where: Area = the cross-section area of fluid at the current Level, computed using layer data.

Path position coefficient is obtained by interpolation from the following look-up table (from ISO 6416).

Ratio of path depth below surface to depth of water above bottom	Ratio of point velocity to mean velocity in the vertical
0.1	0.846
0.2	0.863
0.3	0.882
0.4	0.908
0.5	0.937
0.6	0.979
0.7	1.039
0.8	1.154
0.9	1.424
0.95	1.65 (extrapolation)

Non-Surcharged Multi-Path Trapezoidal Integration Mode

The flow computation in this mode is performed in a series of steps, following the principles set out in ISO 6416 for the "mid-section" method. Each step consists of determining the flow over a smaller cross-sectional area or panel. The total flowrate in the conduit then becomes the sum of the individual panel flows.

There are three basic types of panel:

- *Bottom* panel which is bounded on the bottom by the bottom or bed of the conduit and on the top by the lowest operating path.
- *Intermediate* panel bounded on the top and bottom by consecutive operating paths that are not at the same elevation.
- *Top* panel bounded on the bottom by the highest operating path and on the top by the surface of the water.

Each of these panels is bounded on either side by the walls of the conduit, whose dimensions and shape are defined by the layer parameters. The actual area for each panel can therefore be a complicated computation involving the calculation of the conduit widths at the paths which bound the panel (from interpolation between the nearest layer widths), the calculation of the areas between these paths and the layer nearest them (or between the paths if there is no layer between them), and the calculation of the areas between any other layers which may lie between these paths.

The flow computation in the bottom panel is:

$$Q_{Bottom} = Area_{Bottom} * Vel_A * (1 + \text{Bottom friction}) / 2$$

where: $Area_{Bottom}$ = conduit area between the bottom (Layer #1) and the lowest good path (or pair of crossed paths)

Vel_A = Water velocity as computed from the lowest good path or pair of crossed paths

The flow in the intermediate panel above the bottom panel is:

$$Q_{Int} = Area_{Int} * (Vel_A + Vel_B) / 2$$

where: $Area_{Int}$ = conduit area between good path A and the next good path B
Vel_B = water velocity as computed from the next good path or pair of crossed paths

The flows in all the intermediate panels is computed similarly.

The flow in the uppermost panel bounded by the surface is:

$$Q_{Top} = Area_{Top} * (Vel_N + \text{Top Weight} * Vel_{Surface}) / (1 + \text{Top Weight})$$

where: $Area_{Top}$ = conduit area between the uppermost good path (or pair of crossed paths) and the water surface.

Vel_N = water velocity computed from the uppermost good path or pair of crossed paths

$Vel_{Surface}$ = an estimated water velocity at the surface from a limited algebraic extrapolation of the velocities from the uppermost good path (or pair of crossed paths) and the next good path (or pair of crossed paths) below it.

If the difference in elevation between the water surface and the uppermost good path is less than the difference in elevations between the uppermost and next lower good paths, then:

$$Vel_{Surface} = Vel_N + (Vel_N - Vel_M) * (\text{Level} - Elevation_N) / (Elevation_N - Elevation_M)$$

where $Elevation_N$ and $Elevation_M$ are the elevations of the uppermost good path and of the next lower good path.
and Vel_N and Vel_M are the water velocities from the uppermost good path (or pair of crossed paths) and of the next lower good path (or pair of crossed paths)

If the difference in elevation between the water surface and the uppermost good path is greater than the difference in elevations between the uppermost and next lower good paths, then:

$$Vel_{Surface} = Vel_N + (Vel_N - Vel_M)$$

The total Flow in the conduit is the sum of the flows in all the panels.

$$\text{Flow} = \text{Flow scaling} * (Q_{Bottom} + \sum Q_{Int} + Q_{Top})$$

Alternative Crossed Path Configuration in Open Channels

When crossed paths are installed, the flowmeter may be configured as two separate sections having identical geometry and the same level inputs. Section #1 is configured for the paths in one plane, and section #2 for those in the other plane. The *Flow Scaling* parameter is set to 0.5, and the channel flow is the sum of the section flows.

Analog outputs should be allocated to section #1 to give Level, temperature and velocity, and to SF (Sum of Flows) for Flow.

Surcharged Mode

A choice of two possible integration methods is available: **Pipe** and **Surcharged Trapezoidal**.

Surcharged Pipe Integration

See description on page 3-5 for Pipe Mode.

Surcharged Trapezoidal Integration

The flow is computed from the path velocities and the cross-section area (which is computed from the layer parameters and the *Surcharge Level* parameter).

When paths at more than one elevation are good, the Flow is computed in the same manner as for non-surcharged trapezoidal integration, except that the flow in the panel between the uppermost good path (or pair of crossed paths) and the top of the conduit or soffit is set to:

Q_{Top} = Area between uppermost good path and soffit $*$ Vel_N $*$ (1 + Bottom Friction)/2

When only one path (or pair of crossed paths) is good, the total section Flow calculation simplifies to:

The Flow = Flow scaling $*$ Area $*$ Vel_A $*$ (1 + Bottom Friction)/2

where: Area = the surcharged cross section area of conduit computed from the Layer data and the *Surcharge Level* parameter.

For multi-path installations, the value of *Bottom Friction* is usually set between 0.5 and 0.8. The lower value is used when the lowest path is very close to the bottom of the channel.

For single path installations with the path located near to the bed, the value for *Bottom Friction* should be set according to:

Channel shape	Path elevation / Surcharge Level	Bottom Friction.
Rectangular	10%	1.6
Rectangular	20%	1.4
Round	10%	1.3
Round	20%	1.1

Pipe Mode

In *Pipe* mode, the conduit is surcharged, and flow is computed by the product of average water velocity and the conduit cross-section area. The average water velocity is obtained from the sum of the path velocities, each weighted according to its position in the conduit.

The cross-section area is a fixed value defined by a single user-defined parameter, *Pipe area.*
The other user-defined parameters are: *Flow scaling* and *Weight* for each path W_n (n is the path number 1 to 10)

Flow = Flow scaling $*$ Pipe area $*$ $\sum W_n * V_n$

where V_n = velocity for path n.

Details of the method, including path configurations and weights to be used in special formulae for different pipe shapes, are described in the ASME PTC 18 or IEC Pub 41 codes for hydraulic turbine efficiency testing. The formulae and the weighting factors used in the codes differ from the more general formula used in the flowmeter. Examples of weights to be inserted in the flowmeter are given in Chapter 7, under Path Parameters.

In the event of one or more paths failing, the flowmeter is capable of calculating Flow by invoking a "Path substitution" routine. The Flow continues to be computed from those paths which remain good, however the uncertainty increases with the number of paths failed. For this routine to operate, the following two conditions must be met:

- The number of good paths must be equal to or greater than the Section parameter *Min good Paths*.
- The flowmeter must have completed the *Learn* routine.

During the *Learn* routine, which must be implemented at the pipe's normal flow (non-zero!), a table of time-averaged historic flow components ($V_n * W_n$) is recorded and stored in the flowmeter's protected memory. The "learn" routine is implemented by setting the section parameter *Learn Path Ratios* to 1, and then setting the flowmeter to run. At the end of 1000 readings, the *Learn Path Ratios* parameter will automatically reset to zero. During the learning run, the letter "L" is displayed adjacent to the section Flow value. The learning run may be curtailed at any time by manually setting the *Learn Path Ratios* parameter to 0. Repeating the learning process will erase an old table and create a new one.

In the Path Substitution routine, the contributions towards the total pipe flow from the failed paths is replaced by a figure generated from the flow contribution from the remaining good paths, weighted as appropriate by the historic flow contribution ratios for all the paths. Mathematically, the routine can be represented as:

Flow = Current Flow from Good Paths ∗ Historic Flow / Historic Flow from current good paths.

The Current Flow from Good Paths is = Pipe Area $* \sum V_n.W_n$ in which the velocity from any failed paths is set to zero.

Historic Flow is the long time-averaged flow recorded by Learn Path Ratios during flowmeter commissioning.

Historic Flow from current good paths is = Pipe Area $* \sum$ Historic $V_n.W_n$ excluding those historic flow components which apply to the paths which are currently failed.

Volume Calculation

Volume is the totalized flow and is computed as:

Volume = Flow in the displayed units ∗ Time elapsed in seconds **/** *Volume Scaling*

If the flow is positive, the count will rise to a maximum of 99 999 999, and then reset to zero and start again.

The Volume figure will be incremented or decremented depending on whether the flow is positive or negative.

If the count is small, the Volume figure will be displayed as a number with up to 4 decimal places.

The volume counts transmitted by relay closures to an external counter are designed to maintain agreement between the displayed Volume (in the flowmeter) and the count as registered by the counter.

When the flow is positive, a count is usually transmitted by the relay whenever the Volume increases by one complete unit. However, if there is a period during which the flow is negative, the Volume figure displayed in the flowmeter will decrement, but there will be no counts transmitted by the relay. If the flow should then return positive, no further counts will be transmitted until the Volume figure exceeds the value which it attained prior to the negative flow period.

In the event of the flowmeter being taken out of the Measure Mode or powered down for a period not exceeding one hour, the Volume count will be made up for the missing period. The count made up will be given by: Make-up Count = Flow existing at time of Flowmeter recovery ∗ Down time in Seconds **/** *Volume Scaling*.

Water Temperature Calculation

Water temperature for a section is computed from the average speed of sound in water, as determined from the measurements made by all the good working paths in the section.

The result is in °F if the System Parameter *English / Metric* is set to "English", and in °C if it is set to "Metric".

The Calculated Temperature is:

Temperature °F = $1.129 * 10^{-7} * c^3 - 1.46827 * 10^{-3} * c^2 + 6.450118 * c - 9559.7 +$ *Temp Correction*

Temperature °C = $5.0822 * 10^{-6} * c^3 - 2.127056 * 10^{-2} * c^2 + 29.88592 * c - 14096 +$ *Temp Correction*

where c is the average speed of sound in water, and *Temp Correction* is a Section Parameter.

These formulae apply only to fresh water at low pressure.

At 10 Bar Pressure:

The flowmeter will indicate 0.6°F (0.3°C) high at near freezing, and 1.4°F (0.8°C) high at 90°F (30°C).

At a Salinity of Sea Water (35 Parts / Thousand):

The flowmeter will indicate 19°F (10°C) high at near freezing, and 30°F (17°C) high at 90°F (30°C).

CHAPTER 4

Unpacking and Installation

Warning: After unpacking the equipment, inspect it for signs of physical or water damage. Do not apply power to damaged components. Injury or further damage may occur.

Warning: If this equipment is being installed in a wastewater environment, or where corrosive gases (e.g. chlorine, H2S, SO2) are present, these gases or other condensing vapors shall be prevented from entering the flow meter enclosure; otherwise permanent damage to the electronics will occur.

To prevent such entrance, all conduits and cables entering the enclosure shall be sealed with poured seals in accordance with the National (USA) or Canadian Electrical Safety Codes. If permanent seals are not being installed at this time, temporary seals shall be made using electricians putty or similar material. However,

Do not use RTV sealant as it gives off acetic acid vapors.

Special Notes for Installations in Potentially Flammable Atmospheres

Intrinsically Safe Installations

For installations requiring intrinsic safety, the electronic console, cabling, transducers, and other electrical equipment in the sewer and associated with it, shall be installed in accordance with the appropriate regional or national electrical codes or standards. The work shall be carried out by experienced personnel whose training has included formal instruction in the installation of electrical equipment in potentially explosive atmospheres. They shall be knowledgeable of the relevant rules and regulations for such installations with particular emphasis on "intrinsically safe" protection and installation practices.

In the USA installation should follow National Electrical Code (NEC) Article 504 for Intrinsically Safe protection.

In Canada installation should follow the Canadian Electrical Code (CEC) Part 1, CSA C22.1.
In the European Economic Community (EEC) and elsewhere, IEC 60079-14 (for installation) should be consulted.

Authorized Repair

Alteration or repairs to the flow meter shall be carried out only with appropriate authorization and only by adequately trained personnel who are fully aware of the safety issues associated with the apparatus. Following replacement, repair, modification or adjustment, the items concerned shall be inspected in accordance with manufacturer's documentation and relevant regional or national safety codes, such as IEC 60079-17 (Table 2).

North American Installations

In addition to the material provided in the General section above, the following items apply in North American Installations.

This flow meter has cable and transducer connections approved by the Canadian Standards Association for use in Class I, Division 1, Groups C & D hazardous locations. The installation interconnections shall be accomplished as described in Control Drawing 7510-BE-0118 that is included with every product shipment.

EEC Installations

In addition to the items covered in the General section above, the following items apply in EEC installations.

This flow meter has cable and transducer connections certified by Sira as meeting the criteria of the EEC ATEX Directive 94/9/EC effective 30 June 2003 for use in flammable gases and vapors with apparatus groups IIA and IIB and temperature classes from T1 through T6. The apparatus qualifies for an ambient temperature range from –20C to +50C. The IEC Codes EEx ia, Zones 0 and 1, Groups IIA and IIB, Temperature Code T6 apply.

The marking of transducer Models 7601P, 7657,and 7658 are given on drawings 7601AE0196, 7657AE0004, and 7658AE0004 that fully describe the products and their range of applicability including the certificate number Sira 03ATEX2471X.

Since the enclosures are of polymeric material, the user shall take precaution to assure that conditions that would promote the generation of static charge on the enclosure surface be avoided. A caution is provided on the product marking advising to clean with a damp cloth in order to prevent static accumulation.

The manufacturer’s local distribution centers will supply operating/installation instructions in English and any other appropriate language in use where the equipment will be installed in the EEC.

The owner of the flow meter should establish a routine for regular inspection in accordance with any relevant National Safety Codes, such as IEC 60079-17.

Installations Outside North America and EEC

For installations outside of North America and the EEC, the criteria given in the *Intrinsically Safe Installations* and *EEC Installations* above may be used.

Unpacking the Flowmeter

When the flowmeter arrives, inspect the packaging for signs of damage. If there is obvious external damage to the shipping container, request that the carrier's agent be present when the unit is unpacked. Be particularly careful not to destroy the shipping container during opening so that it may be used for future shipment of the unit.

Warning: Do not apply power to damaged components. Injury or further damage may occur.

Remove the flowmeter from the package and verify all parts against the packing list. Examine each of the components for physical damage. If a component is damaged, notify the carrier and follow the instructions for damage claims. Report any shipping problems immediately to Accusonic.

Performing the Flowmeter Installation

Proper Flowmeter Mounting

The flowmeter should be mounted on a location so the cable run from the transducers to the unit does not exceed 300 feet or 100 meters without the approval of Accusonic. In addition, the unit requires a power connection, as well as connections to any pressure transmitters and to the site process control system. The instrument should be mounted vertically and should be attached to a wall or mounting panel capable of safely supporting 50 pounds (25 kg). Use 3/8 inch (10 mm) lag screws or carriage bolts.

If an external PC is used, provide a suitable table or shelf while in use. If the cabinet is to be mounted outdoors, it should be protected by a sun shield on the top and the south facing side.

Caution! When drilling the conduit holes for the electrical installation, be sure to protect the circuit cards in the unit.

Proper Flowmeter Wiring

All wiring should be brought into the unit through customer-supplied conduit connectors. The cable entries shall be in conformity with the National Electrical Codes for Intrinsically Safe Systems.

Note. To reduce the possibility of malfunction of the processor due to electro-magnetic interference radiated from the various cables, all wiring brought into the unit should be routed to its terminals by the shortest reasonable route. **Spare cable should be looped in the conduit and trunking outside the flowmeter console, or left in a customer-supplied and installed junction box in close proximity to the flowmeter console**.

Recommended cable entries are shown in Figure 4-1. These cable entries will provide for the most direct point to point wiring and provide the required separation between the intrinsically safe and non-intrinsically safe wiring. (2 inches or 50mm). **Do not run intrinsically safe cables with non-intrinsically safe cables in the same conduit.**

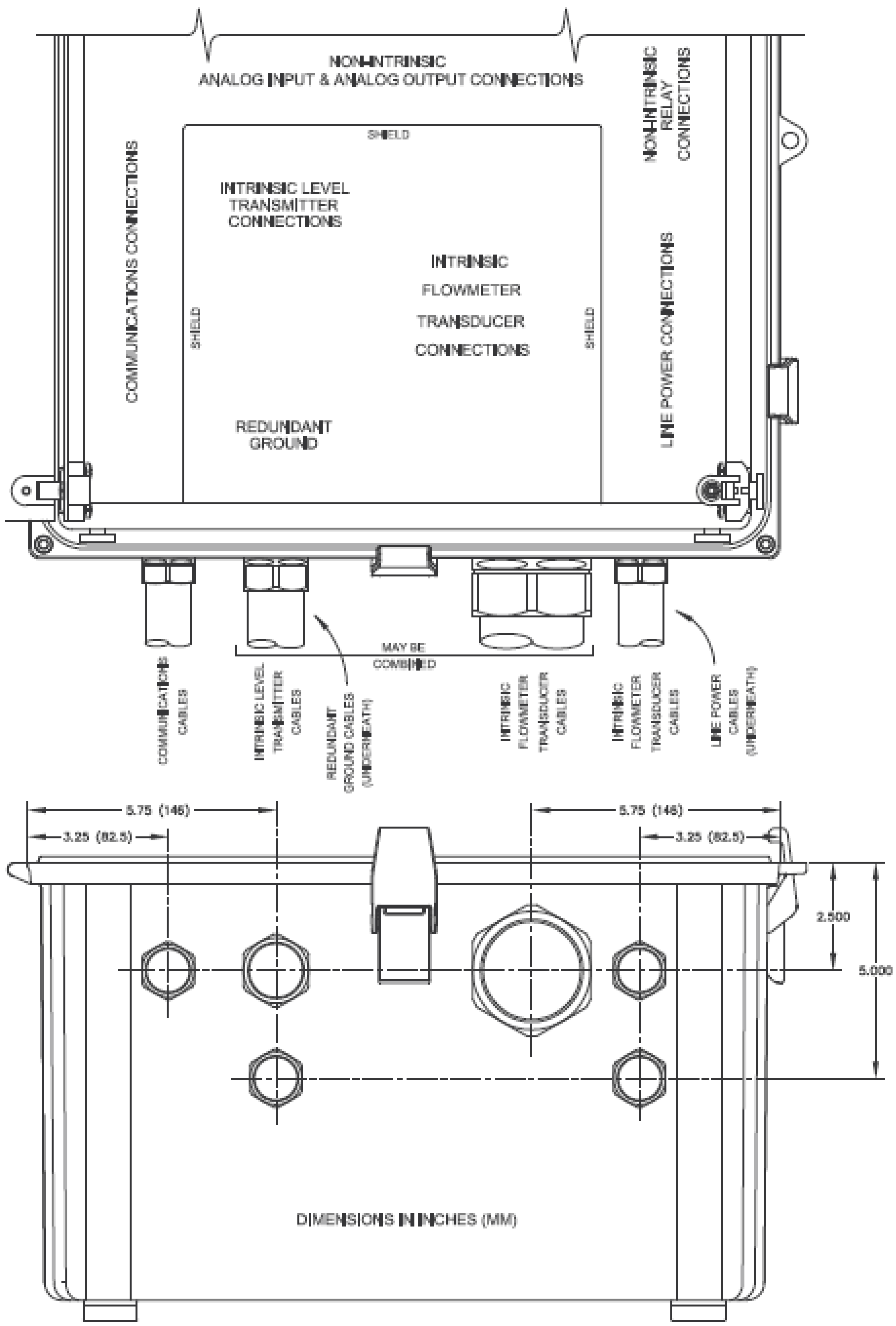


Figure 4-1 Cable Entry Locations

WARNING: DO NOT RUN INTRINSIC SAFE CABLES WITH NON-INTRINSIC SAFE CABLES IN THE SAME CONDUIT.

All wiring is brought into the flowmeter console through customer-supplied conduit and customer-supplied conduit connectors. All wiring, with the exception of the transducer cables or Accusonic supplied level measurement cables, is to be customer-supplied. This may include:

- AC or DC power supply mains to the electronic unit
- Transducer cabling (may require more than one penetration)

- Level sensor inputs, if required
- 4-20mA Analog outputs, if required
- Alarm and Totalizer relay outputs, if required
- Digital outputs, if required

Verify the input voltage is within the voltage ratings for the electronics and heater (if equipped) as specified on the flowmeter's label, Figure 4-2, prior to applying voltage to the flowmeter.

Power Wiring

Power consumption for the electronics is less than 40 VA.

Use #16 AWG or #14 AWG (1.5 mm^2 minimum).

The unit requires direct mains wiring and should be installed with a separate main power cutoff switch near the instrument, in compliance with the National Electrical Code (or IEC 60079-14 clauses).

Route power mains wiring into the unit through the appropriate feedthrough to the mains terminal block, and connect as shown in Figure 4-2. Be sure to follow appropriate local codes and practices, and to attach a proper earth ground to the instrument.

For DC power 100 to 300 V DC the low potential side of the supply should be connected to the N terminal.

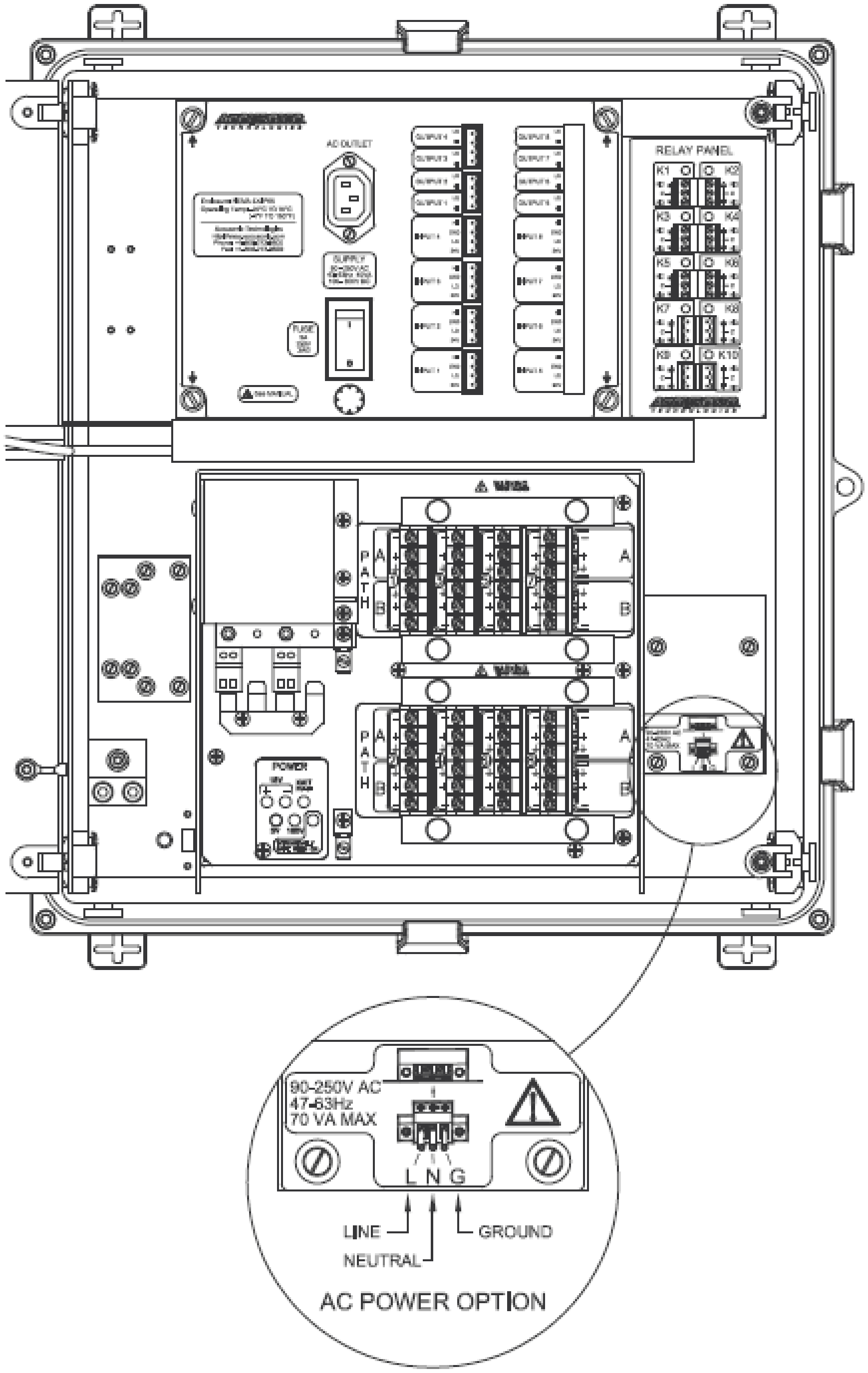


Figure 4-2 AC Power Input Connection

Earth Ground Connections

Caution. Connection to Earth Ground must be made and tested *BEFORE* any other connections (other than power) are made. Make sure all signal, computer, transducer, sensor, relay, input or output connections are disconnected at this time. Connections other than ground may result in a false ground impedance measurement. (See Figure 4-3)

Redundant ground connections are made to the various intrinsic safety ground terminal lugs. These wires are not considered intrinsically safe themselves, but rather an intrinsic safety guard. The ground wires may enter through the center of the cabinet if space permits. If space does not permit, move the ground entry point towards the left of the cabinet. Each ground circuit must be connected in such a way that disconnection of one ground circuit does not result in loss of ground to the other ground circuits.

All grounding must meet the wiring requirements of National Electrical Codes for intrinsically safe equipment.

Redundant ground cables must be insulated stranded cables #12 AWG (American Wire Gauge), or $4mm^2$ or larger. Each cable must be individually connected from a redundant ground lug to a point on the site's ground grid network.

The flowmeter transducer redundant ground lug is located next to the power supply indicators on the lower edge of the path selector module.

Be sure the cable is squeezed between the compressing copper lug plates, and NOT directly under the screw. (See figure 4-8)

The barrier block redundant ground lug for the water level inputs (if supplied) is located next to the barrier blocks in the upper left corner of the path selector module. If barrier blocks are not installed, then there may not be a barrier block redundant ground lug. Be sure the cable is squeezed between the compressing copper lug plates, and NOT directly under the screw. (See figure 4-8)

Each ground connection shall be tested to assure a ground impedance in accordance with National Electrical codes for Intrinsically Safe Circuits. When testing a ground connection, other grounds must be disconnected.

Refer to figure 4-3 for measurement details.

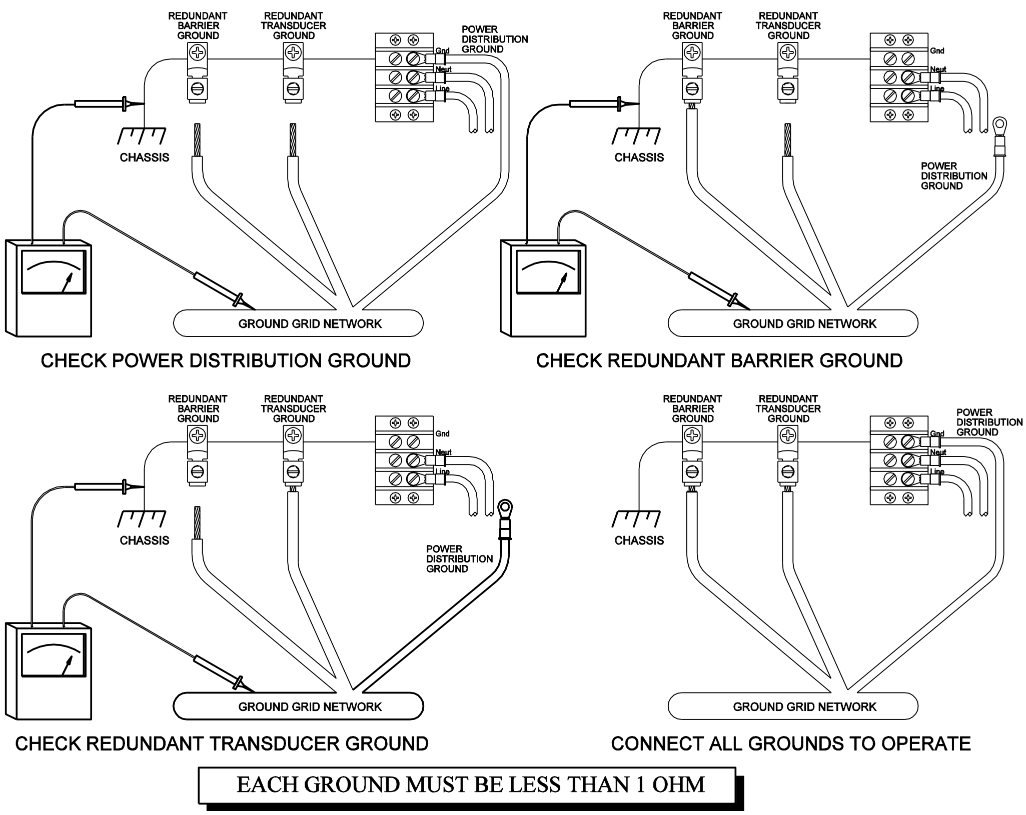


Figure 4-3 Earth Ground Connections

1. Disconnect transducer and barrier grounds. Check the power distribution ground(s).
2. Disconnect barrier and power distribution grounds. Check the transducer ground.
3. Disconnect transducer and power distribution grounds. Check the barrier ground.
4. CONNECT ALL GROUNDS PRIOR TO SYSTEM OPERATION.

Replace the relay connection assembly using three (3) screws.

Intrinsically Safe Transducer Wiring

Both intrinsically safe (IS) flowmeter transducer cables and intrinsically safe (IS) level sensor cables should enter the cabinet in the center directly under the shielded area. IS flowmeter transducer cables may occupy a common entry provided that the cable type is as specified in control drawing 7510-BE-0118

IS level sensor (pressure transmitter) cables may also occupy the same entry as the IS flowmeter transducer cables, or a separate common entry.

Note: Accusonic flowmeter transducer cables meet the requirements of drawing 7510-BE-0118.

DO NOT RUN INTRINSICALLY SAFE CABLES WITH NON-INTRINSICALLY SAFE CABLES IN THE SAME CONDUIT.

Intrinsically safe wiring from the flowmeter cabinet shall be enclosed in bonded conduit and sealed in conformity with National Electrical codes for intrinsically safe equipment.

The number of conduits installed for IS flowmeter transducer cables and IS level sensor cables is determined by the number and size of the cables. When selecting conduit, consider any future plans to upgrade the number of IS flowmeter transducers or IS level sensors.

Large systems may use 16 to 20 flowmeter transducer cables. When calculating conduit size, the Accusonic Technologies jacketed and non-jacketed transducer cables have outside diameters of 0.325 inches and 0.250 inches (8mm and 6.5mm) respectively.

Prior to pulling cables through the conduit, it is best to label each IS flowmeter transducer cable and IS level sensor cable for identification later. Refer to Figure 4-5 or the customer specific drawings at the back of this manual. Label each IS transducer cable with a path number (1-8) and position (A, B).

Note that transducer "A" is the **downstream** transducer and transducer "B" is the **upstream** transducer.

Caution: Double-check the cable numbering and verify sufficient reach before trimming.

Pull transducer cabling through the appropriate feedthrough and trim each line, leaving enough cable to reach the transducer terminal blocks at the bottom of the flowmeter console. Tag each cable with a path number and transducer letter according to the Accusonic numbering convention as shown in Figure 4-5. Trim the cables, strip back 2 inches of outer sheathing from each, pull inner conductors back from inside the outer braid, solder spade lugs to the conductor and shield of each cable as shown in Figure 4-6.

Do not connect the cables to the flowmeter yet. Leave the ends of the cables so that the conductors are not in contact with one another nor with any metal parts on the flowmeter console.

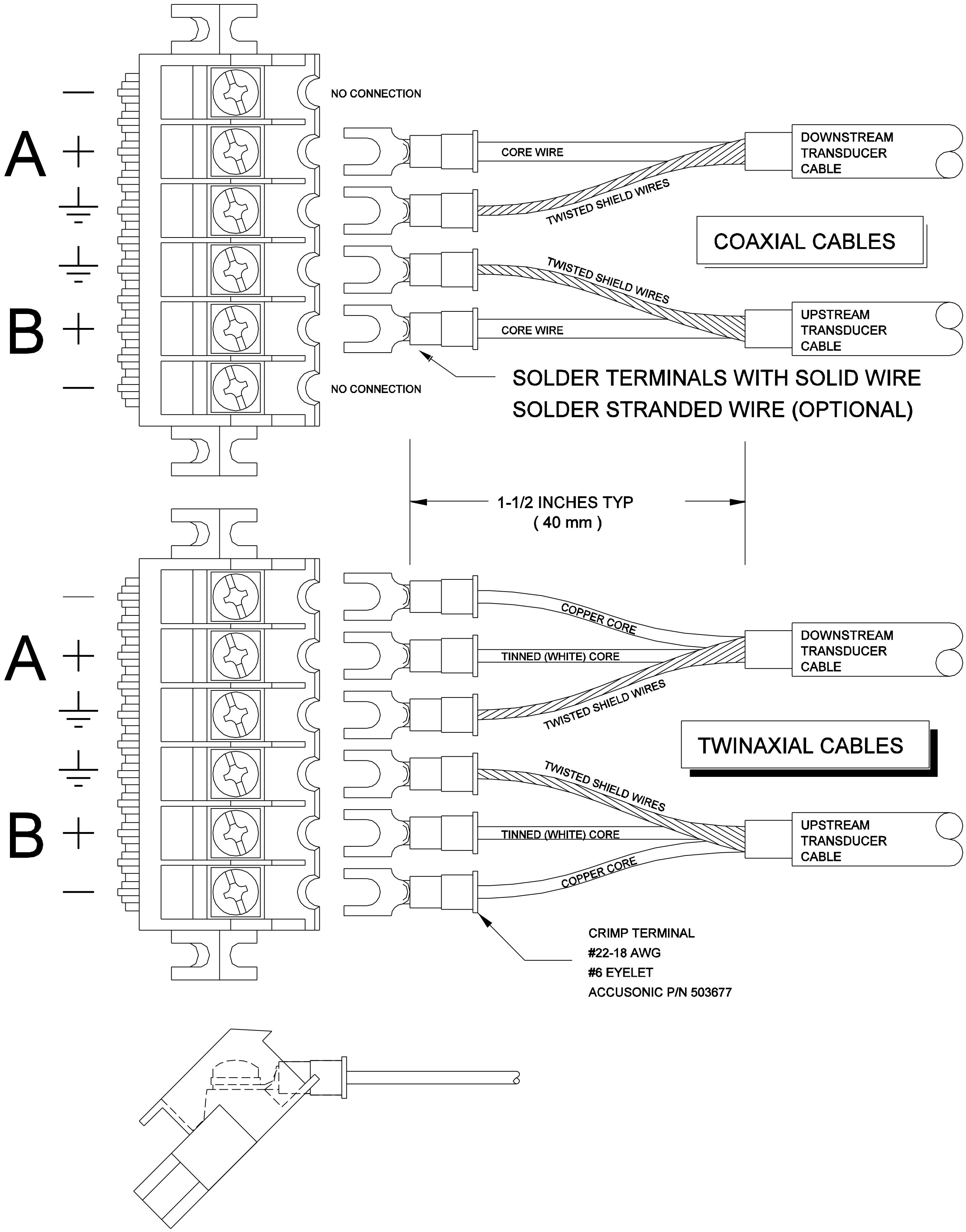


Figure 4-4 Transducer Connections

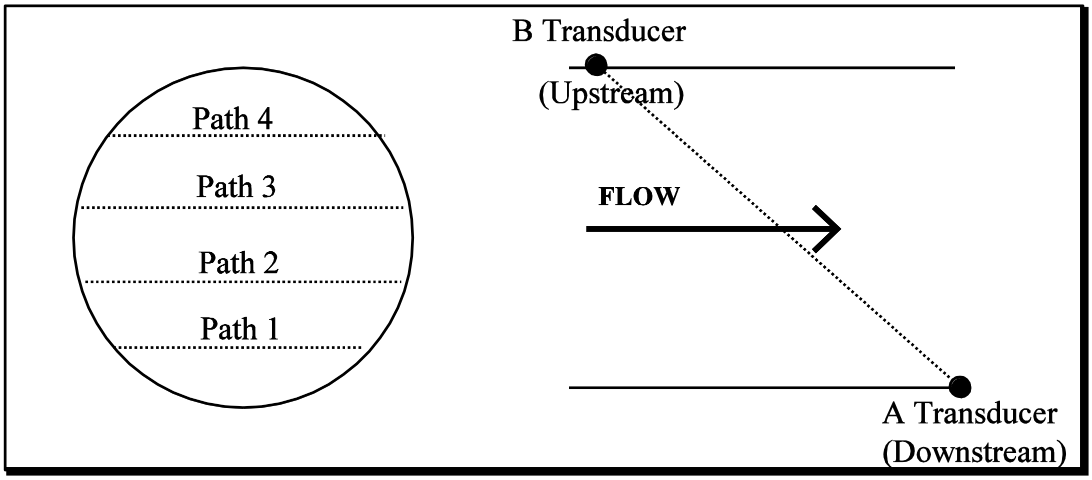


Figure 4-5 Transducer Numbering - Simple Pipe

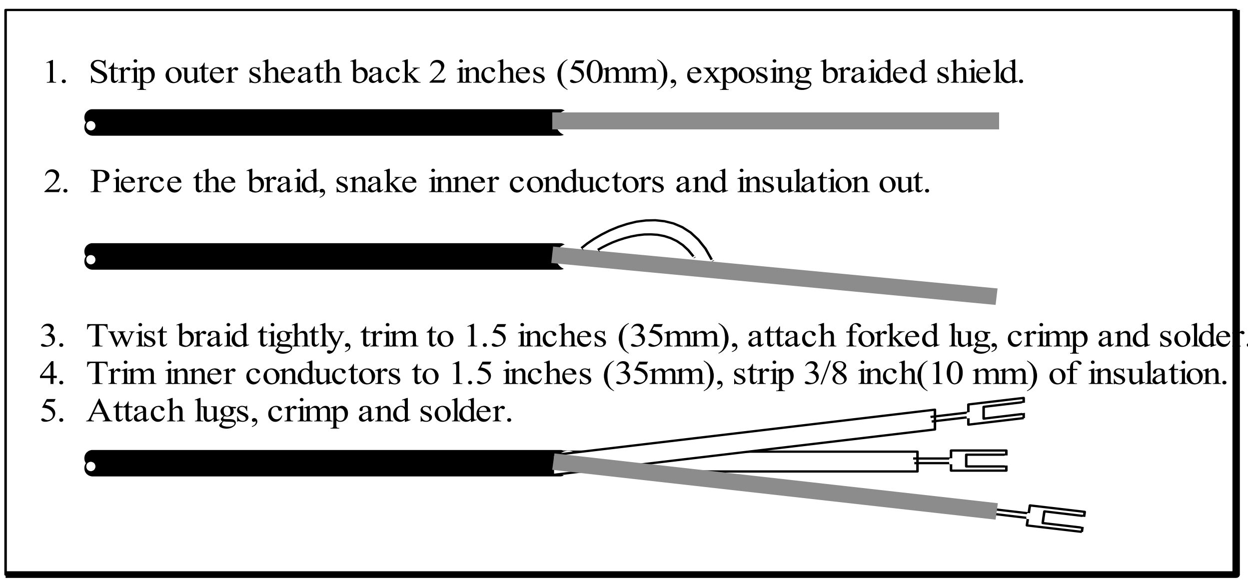


Figure 4-6 Stripping and Terminating the Transducer Cable

Transducer and Cabling Checkout

Perform the following three steps to verify the transducer cabling and transducers:

> **Note:** The transducer and cabling checkout is performed by Accusonic during the commissioning of a newly installed system.

Step 1 - Verify Resistance for Each Transducer with Cable Attached

Measure the resistance across the transducer cable using a MegOhm-meter (high voltage ohmmeter, 500V d.c. minimum) set to the highest resistance range. If the transducer cables have already been terminated to the flowmeter, remove the cables from the flowmeter prior to performing any resistance testing.

For coaxial cable, test conductor to shield, conductor to ground and shield to ground. For twin-axial cable, test conductor to conductor, each conductor to shield, each conductor to ground, and shield to ground.

Each transducer cable should measure infinite resistance for newly installed transducers and transducer cables. Contact Accusonic if any transducer measures less than 20 MΩ resistance (lower resistance values may be acceptable depending on site conditions). If the transducer and cable assemblies test infinite, proceed to Step 3.

Step 2 - Verify That There are No Internal Shorts in Any Transducer

Test transducer resistance at the transducer, with the cabling detached, if possible. This can usually be performed easily when the transducers are feedthrough type, where the outside of the pipe is accessible, and when the transducers are fitted with E/O connectors. Use a short test cable attached to the transducer's E/O connector and measure the resistance across the E/O conductors and each conductor to ground if possible.

When the transducer is not accessible, or when the cable is permanently attached to the unit, you will not be able to test the transducer alone. If there is a junction box between the flowmeter and transducers, then test the resistance at the junction box by disconnecting the cable running to the transducers from the terminal block. Follow the instructions from Step 1 to test.

This step will isolate the poor readings to either the cable or the transducer.

Step 3 - Verify Continuity and Cable Identification

Work from either end of the cable and use a partner to connect pairs together, one at a time, at the far end of the cable. For each coaxial cable, short the connector to shield and measure continuity. For each twin-axial cable, short each connector to shield and measure continuity.

The transducers are now ready to be terminated to the flowmeter.

Connecting Transducer Cabling

After verifying that all transducer cabling is sound, connect each line to the appropriate terminal on the flowmeter console, as shown in Figure 4-4.

Using the thumbscrews, remove the four (4) hold-down clamps, and unplug the terminal blocks. Attach the terminated cables to the terminal blocks as shown in Figure 4-4. Plug the terminal blocks into their respective slots, and refasten the hold-down clamps.

Intrinsically safe wiring shall be routed to stay clear of non-intrinsically safe wiring (i.e. all cables excluding grounds outside the shielded area) by a separation of 2 inches (50 mm).

In addition all intrinsically safe wiring shall stay within the shielded area. Route the cabling to assure that these separation and shielding requirements are met. Use cable ties if necessary. Refer to NEC ANSI/NFPA 70 Article 504, Par 504-30 or other applicable National Electrical codes for intrinsically safe circuits.

Connecting Intrinsically Safe Water Level Sensors

Warning: Only intrinsically safe water level transmitters may be connected to these inputs. Inputs from non-intrinsically safe circuits (such as 4-20mA signals from an electronic unit mounted in the “safe” area shall be connected to the “Non-intrinsic Analog I/O” see Figure 4-9)

The integral barrier blocks (if fitted), provide two terminals for connection to intrinsically safe current loop (4-20 ma) pressure transmitters. Connection of the pressure transmitters to these barrier blocks ensures that the electrical signals emanating from the flowmeter are restricted to intrinsically safe levels.
The signals emanating from the water level transmitter will be limited by the design of that transmitter, and certified accordingly.

No wire preparation is necessary other than stripping back the insulation, and attaching using the screw terminals provided, as shown in Figure 4-8.

Connect the POSITIVE (+) wire to terminal 3; connect the NEGATIVE (-) wire to terminal 4.

Connecting Non-Intrinsically Safe Water Level Sensors

Any level sensor providing a 4-20 mA process loop signal can be used by the flowmeter.

After installing the external level sensor according to the manufacturer’s instructions, use a twin-axial, shielded cable to connect the input to the appropriate terminals. See Figures 4-7.

On most systems the terminals for the level inputs are located in the right hand upper section of the cabinet as shown in Figure 4-9. Input impedance for each channel is 100 ohms.

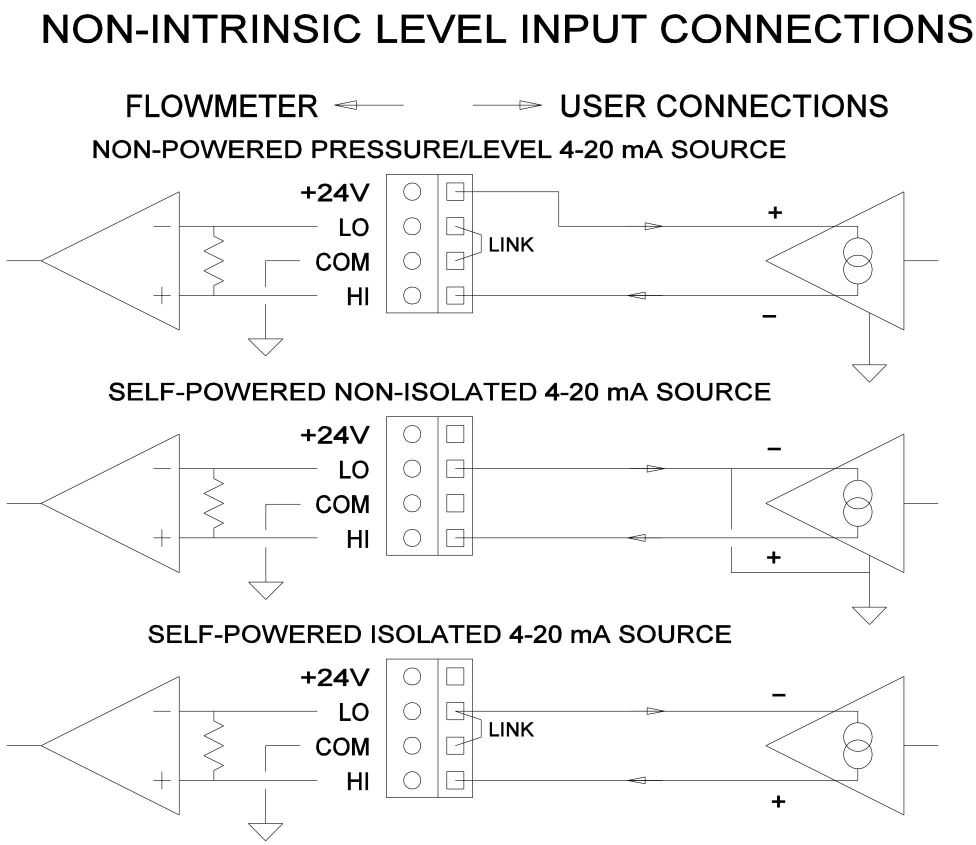


Figure 4-7 Non-Intrinsic Level Input Connections

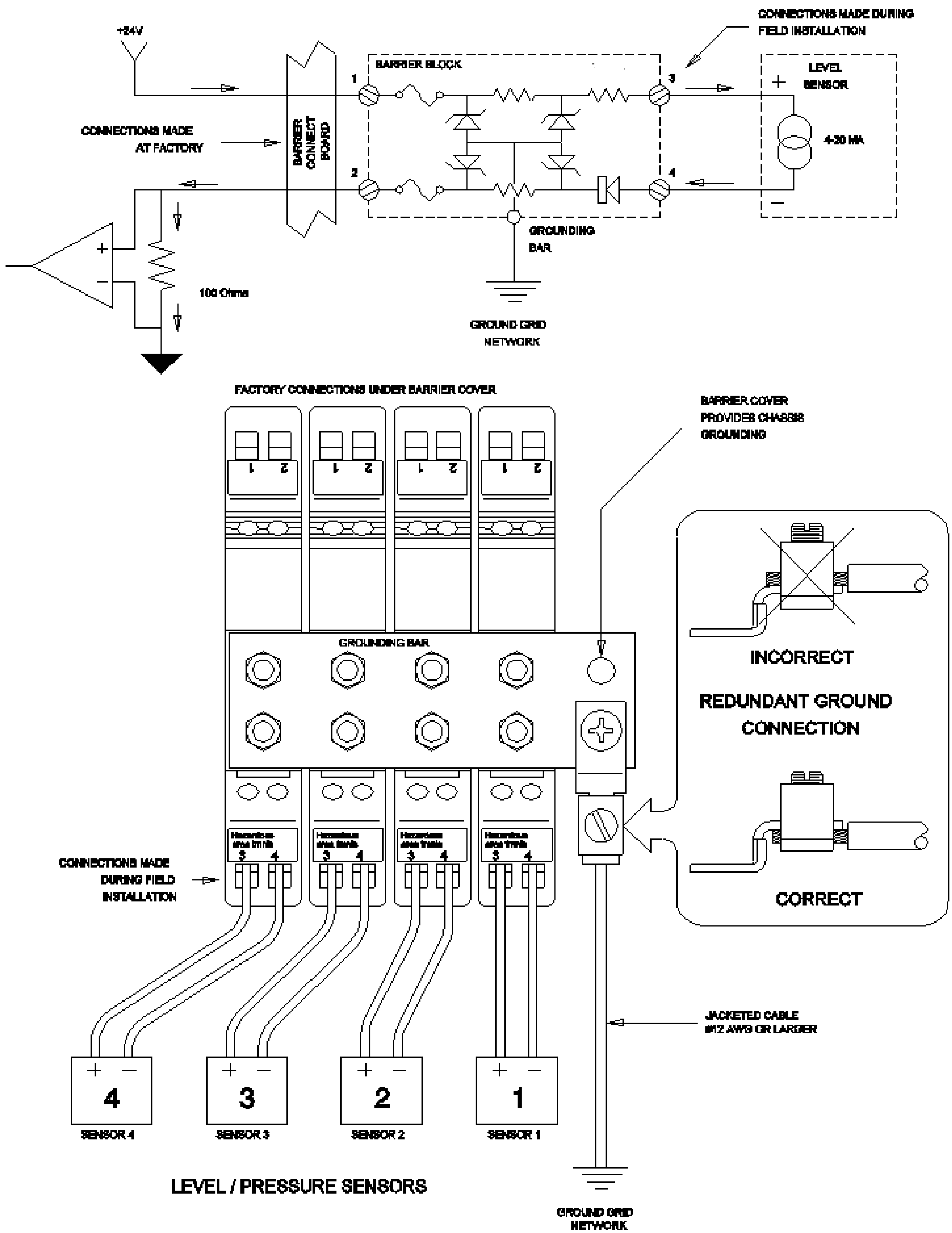


Figure 4-8 Intrinsically Safe Water Level Sensor Connections

Connecting the Analog Outputs

Connect to the 4-20mA terminals as indicated in Figure 4-9

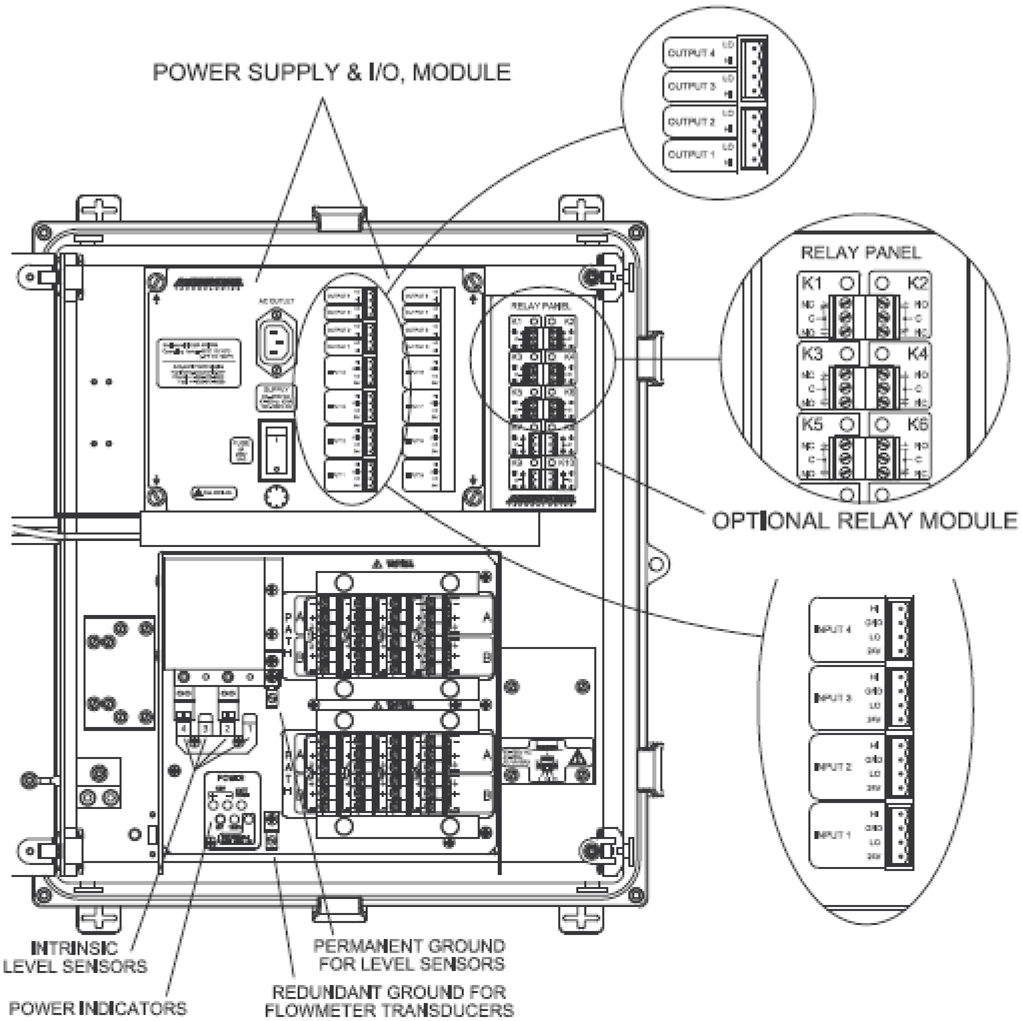


Figure 4-9 Analog Output and Relay Connection Locations

Connecting to the Relay Outputs

On most systems the terminal strip for the relays is located on the extreme right hand end of the connector panel shown in Figure 4-9. The labeling on the flowmeter and the Customer Specific drawings at the back of this manual will indicate the terminals to be used.

Connecting a PC

A PC may be connected to the 9 pin "RS-232" socket or the RJ45 "Ethernet" socket, for use with special Accusonic PC based programs. The "RS-232" connection requires a "Null-Modem" connection and the "Ethernet" connection requires a "Cross-Over" LAN cable or a standard LAN cable if connection via a switch or router. Either the cable or adapter can be purchased at a PC supply or electronics store.

If the user supplied PC does not have serial ports available, a USB to Serial adaptor can be purchased at a PC supply or electronics store. Not all USB to Serial adaptors can be used for this purpose. Contact Accusonic for recommendations when purchasing a USB to Serial adaptor.

Connecting a ModBus Master Device

For remote access to the flowmeter from a ModBus Master Device, there are three ports that can be utilized for this connection. Inside the swing panel, there are 4 external connection ports that are located vertically to the right of the DSP board. RS-232, RS-485, or Ethernet (TCP/IP) can be used with a ModBus Master Device.

RS-232:

The Device ID parameter must be set by the user in order for the Modbus Master Device to communicate with the flowmeter. The Device ID parameter can be found by accessing the System icon on the HOME page, then pressing Page 1. Additionally, the baud rate should be verified or selected by pressing Page 2 in the same menu. The unit comes factory set for 9600 baud rate.

RS-485:

The Device ID parameter must be set by the user in order for the Modbus Master Device to communicate with the flowmeter. The Device ID parameter can be found by accessing the System icon on the HOME page, then pressing Page 1. Additionally, the baud rate should be verified or selected by pressing Page 2 in the same menu. The unit comes factory set for 9600 baud rate.

Ethernet (TCP/IP):

The Device ID parameter must be set to 1 by the user in order for the Modbus Master Device to communicate with the flowmeter over TCP/IP. Additionally, the TCP/IP connection values must be set appropriately (IP Address, Subnet Mask, and Gate Way). The Device ID and TCP/IP parameters can be found by accessing the System icon on the HOME page, then pressing Page 1.

CHAPTER 5

Initial Setup and General Operations

This Chapter describes setup and operation of the flowmeter using the Touch Screen Display. The alternative method using a PC with "Accuflow" is described in Chapter 6. Chapter 7 contains definitions of each parameter and variable. *(Note: The instrument will not be damaged by entering incorrect parameters.)*

Touch Screen LCD Display, Parameters and Variables

The touch screen LCD display is used to set up the flowmeter, start measurements, and observe the measured variables and status messages. Once the flowmeter starts taking measurements, it will continue to do so at a rate defined during setup. Flow measurements can be interrupted or halted from the display. Set up the flowmeter by entering appropriate values for various parameters. Parameters define the geometry of each meter section and govern the operating modes of the flowmeter. Variables provide a view of measurements when the flowmeter is in normal "Measure" mode. At the end of this chapter typical display screens of the variables are shown.

Menus

After power-up, the flowmeter always returns to the "Measurement" mode, with the display showing a LOGIN page. IF the ADMIN LOGIN password is not known, then simply press OK to login as a GUEST. An ADMIN can view all of the measured variables and change the flowmeter's parameters. A GUEST can only view the measured variables.

The factory default ADMIN LOGIN password is "123456".

Commands and control parameters are entered into the flowmeter using menus shown on the display. To cause the menus to appear, press the **Parameters** icon in the HOME screen. Some menus display the available options, (e.g., "Pipe" or "Open Channel" mode), and you choose between them; in most cases, you need to enter data. The next section describes how to access these options.

Stepping Through the Parameters Menus

Six buttons are used to navigate through lists of parameters. The vertical navigation bar on the right side of the display will allow a user to select a specific page number when there is more than one page available. The icons at the bottom of the screen will allow a user to select which parameters to view or change. Any icon that is blue is a selectable icon and any icon that is gray shows which icon a user has currently selected. To change any parameter value, simply press on the numeric box under the parameter label. When the numeric value of the parameter is touched, a numeric entry pad will be displayed across the top of the display. The value can be changed and then any part of the screen can be touched to store the value. Any changed parameters will be stored in non-volatile memory (provided that the parameter *AUTO STORE*

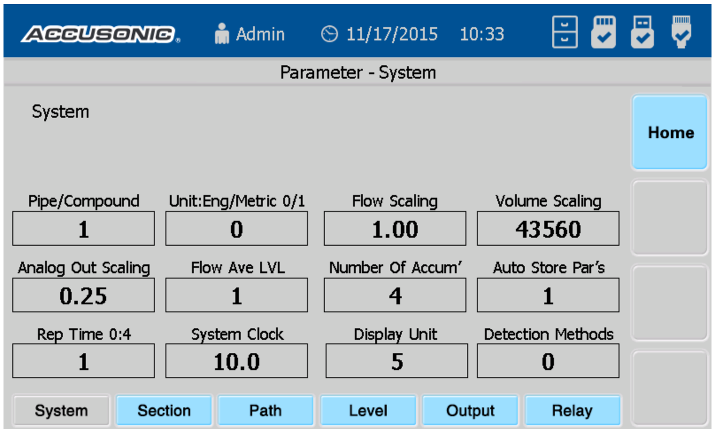
PAR'S in the System menu is set to 1). The flowmeter itself will return to Measure mode even if data is not being shown on the display (at this time any analog outputs or ModBus communications will begin to operate). In order to show the flowrates on the display, press the HOME icon in the vertical navigation bar and then select the Section icon on the HOME page.

Typical Parameter List

The parameter list is visible on the display by pressing the **Parameter** icon. Press the appropriate icon at the bottom of the display to navigate through the various parameters. After selecting a parameter to be changed, a numeric entry pad will appear and will be displayed across the top of the display. Press the various numeric buttons to enter a specific value, verify the entry pad's displayed value; then press anywhere on the display to store the value. If a parameter has been selected in error, press anywhere on the display without touching any of the keypad numbers. The ← arrow acts as a backspace function, the **C** button clears the keypad's numerical value, and the **–** is for negative numbers.

A description of each parameter can be found in Section 7 of this manual.

Systems Parameters



System Parameters

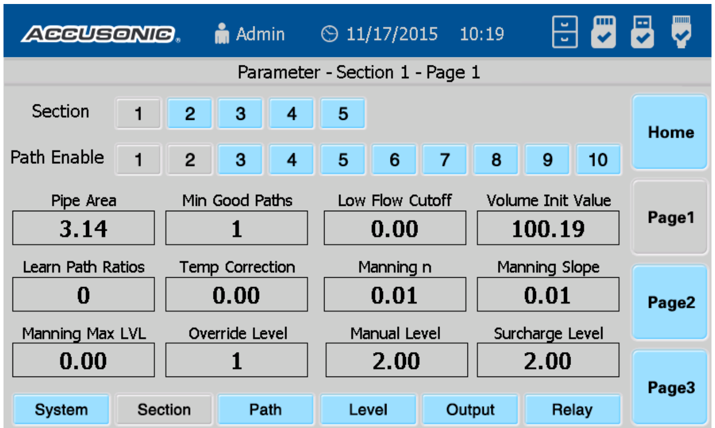
Change a parameter on this screen by pressing the number below the desired parameter label. This will bring up the numeric entry pad. Press the desired value, verify the value displayed, and press anywhere on the display to store the new value.

The Parameter icons at the bottom of the screen allow a user to switch between the various parameters.

Note: The SYSTEM PARAMETERS will apply to all Sections in use.

Section Parameters

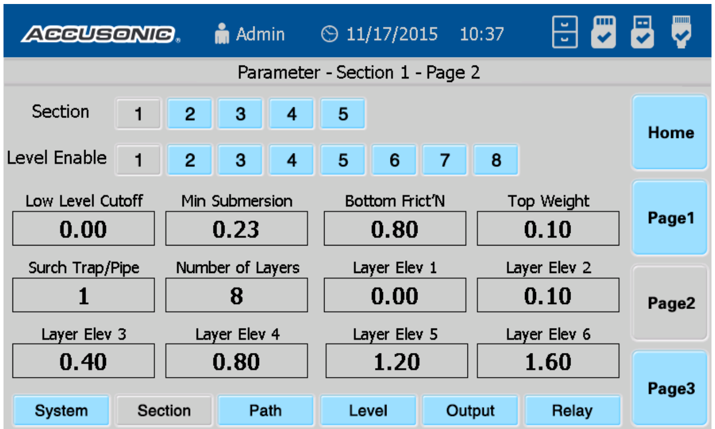
There are three *Section Parameters* screens. Refer to the following screens to view the *Section Parameters*.



Section Parameters, Page 1 of 3

This screen shows Page 1 of the Section Parameters. In this screen, Section 1 is selected and Paths 1 and 2 have been assigned to Section 1. Path numbers that are gray in color have been assigned to the chosen gray section number.

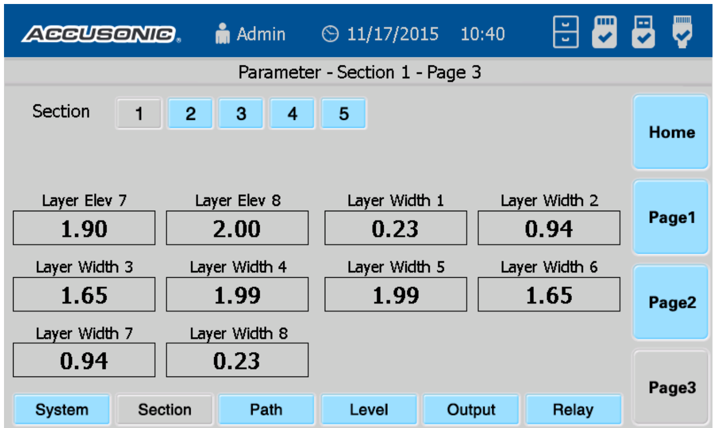
Change the assigned paths to a specific section by pressing a gray path number to deselect that path from a section which then turns blue. If a user presses a blue path number, it will assign that path to whatever section is currently selected and turn gray.



Section Parameters, Page 2 of 3

The above screen shows Page 2 of the Section Parameters. In this screen, Section 1 is selected and Level input 1 has been assigned to Section 1. Level input numbers that are gray in color have been assigned to the chosen gray section number.

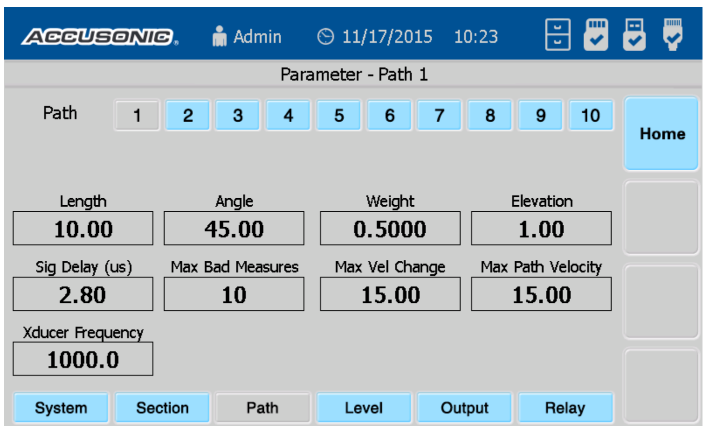
In order to change which level inputs are assigned to a specific section, if a user presses a gray level number, it will deselect that level from a section and turn blue. If a user presses a blue level number, it will assign that level input to whatever section is currently selected and turn gray.



Section Parameters, Page 3 of 3

Path Parameters

Press the Path icon at the bottom of the display to show the path specific parameters.

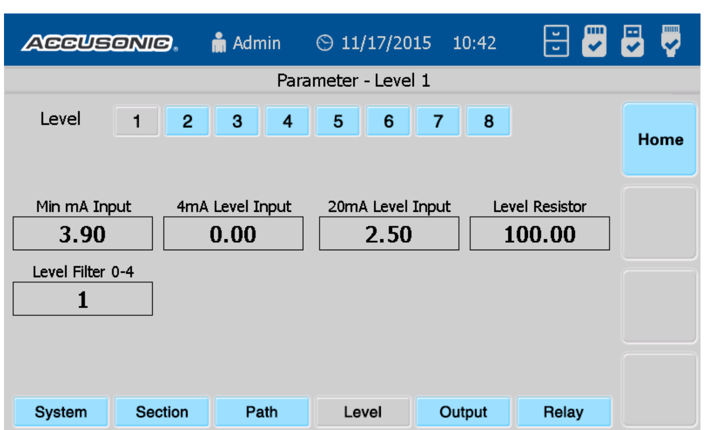


Path Parameters

This screen shows the Path 1 parameters. To switch between paths, press the desired path number to display that path's specific parameters.

Press the Level icon at the bottom of the display to switch to the Level Input parameters.

Level Input Parameters

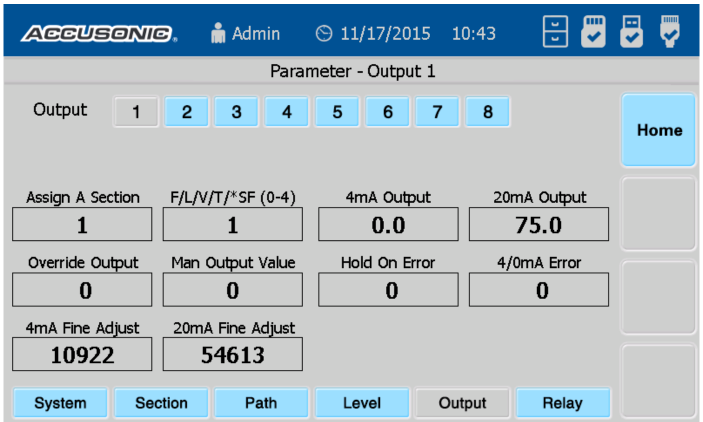


Level Input Parameters

This screen shows the Level Input 1 parameters. To switch between level inputs, press the desired level input number to display that input's specific parameters.

Press the Output icon at the bottom of the display to switch to the Analog Output parameters.

Analog Output Parameters

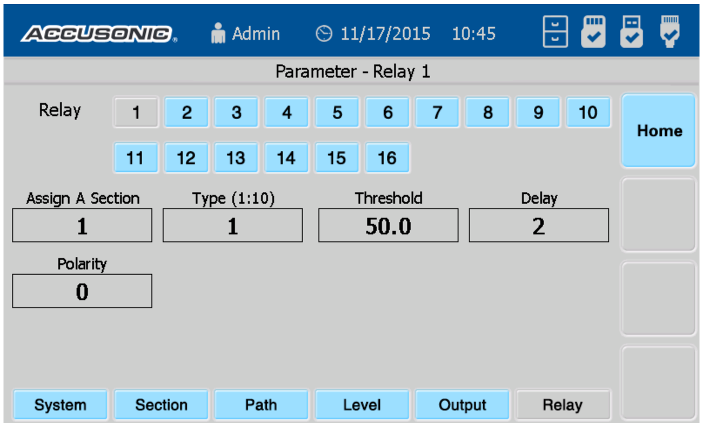


Analog Output Parameters

This screen shows the Analog Output 1 parameters. To switch between analog outputs, press the desired analog output number to display that output's specific parameters.

Press the Relay icon at the bottom of the display to switch to the Alarm Relay parameters.

Alarm Relay Parameters

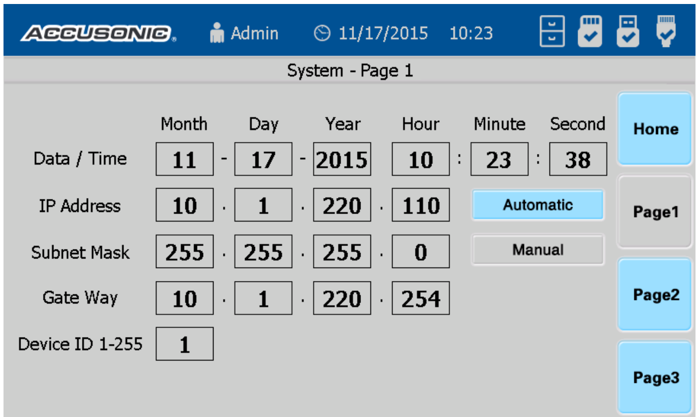


Alarm Relay Parameters

This screen shows the Alarm Relay 1 parameters. To switch between alarm relays, press the desired relay number to display that relay's specific parameters.

Press the Home icon to exit the Parameter menu.

System Settings (1 of 3)

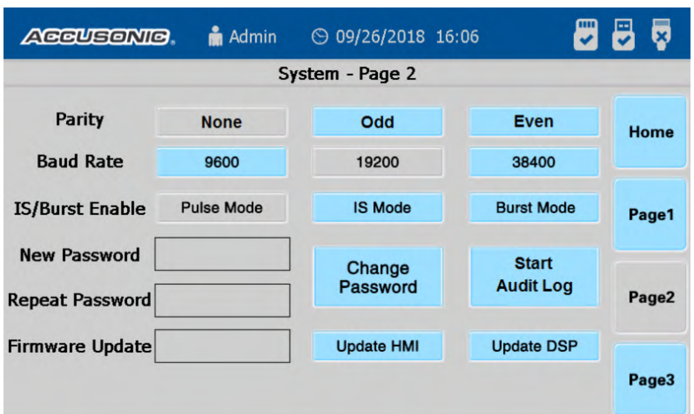


System Settings 1 of 3

This screen shows Page 1 of the System settings. To access this menu, select the Home icon in the vertical navigation bar and press the System icon.

A user can view or change the Date/Time, the Device ID, or any of the TCP/IP ModBus specific connection settings. The IP address can be configured to be set manually (as shown on the display) or Automatic.

System Settings (2 of 3)



System Settings 2 of 3

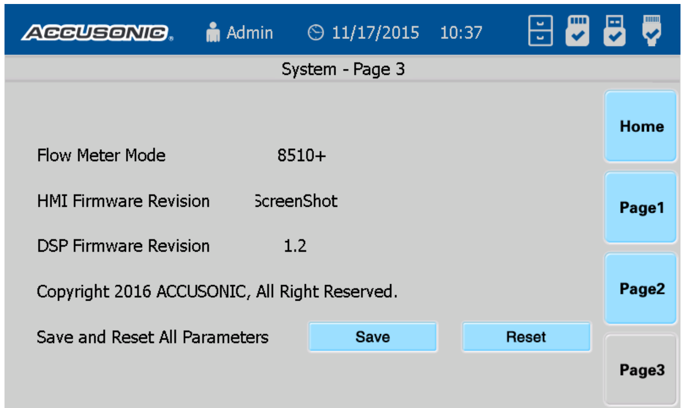
This screen shows Page 2 of the System settings.

A user can view or change the Parity and Baud Rate for the serial port interfaces (RS232 and RS485), the IS/Burst Enable (Pulse Mode standard), or set or enable password protection.

Additionally, the system software (Update HMI) or firmware (Update DSP) can be updated. The HMI or system software is updated by a USB drive with the updated program file on it. The DSP firmware is updated by using a SDHC card with the updated firmware file on it plugged directly into the DSP board.

A user can implement an audit log, this creates and maintains a text file where any operating parameters that have been changed are logged along with the date and time of day. The variable is identified by Modbus map address and will need to be looked up in Appendix C to determine the parameter name. Once started this log cannot be turned off, only copied to a USB drive for viewing.

System Settings (3 of 3)



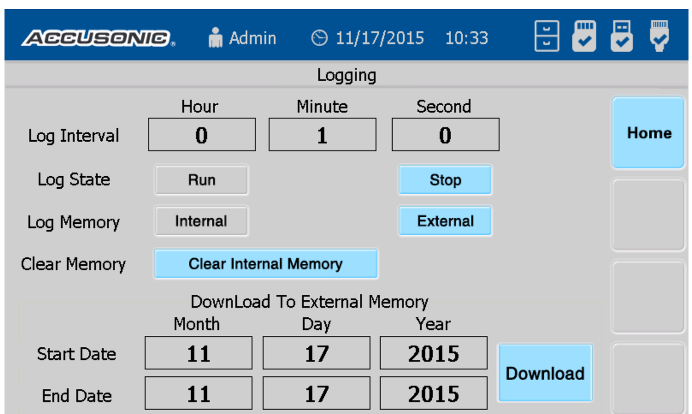
System Settings 3 of 3

This screen shows Page 3 of the System settings.

The HMI and DSP firmware revisions can be seen on this screen.

Additionally the flowmeter parameters can be stored to internal memory. The saved parameters can be used to restore the flowmeter's parameters in the event of memory loss or DSP board replacement.

Logging Parameters



Logging Parameters

This screen shows the Data Logging Parameters.

The log internal can be set using the numeric boxes under the data labels. The logging function can be set to Run or Stop as well as the location to store the logged data (Internal vs. External). Note for External data logging, a user supplied USB drive must be installed.

To export data to a user supplied USB drive, insert the USB drive, select the start and end dates, then press Download.

The icons located in the upper right hand corner of the display shows various connectivity status. Reading from left to right, the list below details the icons and what status they will show.

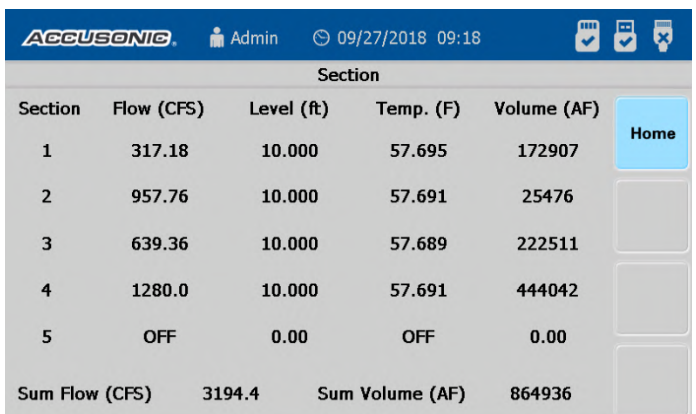
File Cabinet	This shows that the flowmeter is currently configured to log data. If this icon is not shown, then the flowmeter is not logging data.
SC Card	A ✓ displays in the icon when a MicroSD card is inserted in the HMI board. An X indicates there is no MicroSD card present.
USB Drive	A ✓ displays in the icon when a USB drive is inserted in the USB Port on the vertical connection. An X indicates if there is no USB Drive present.
Ethernet	A ✓ displays in the icon when the Ethernet port is connected. An X indicates that no Ethernet cable is plugged into the port.

NOTE: The 8510+ flowmeter writes a .csv file daily which can be opened with any version of Microsoft Excel. Each column in the .csv file will have the data variable labels in the top row located directly above the raw data.

Variables Display

Variables are displayed only when the flowmeter is in "Measure" mode and either the Section or Path icons have been pressed from the Home page.

Section Variables



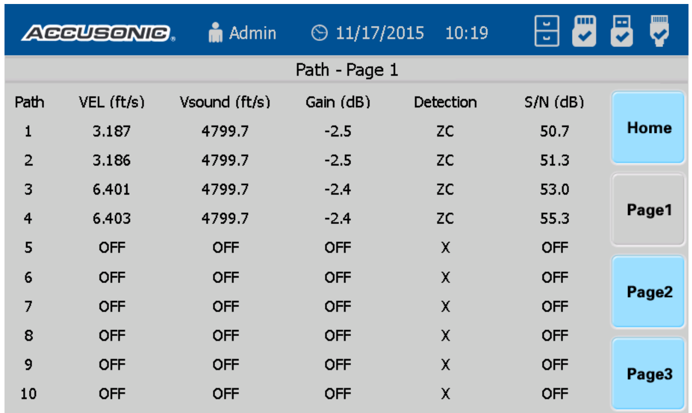
Section Variables

This screen shows the Section Variables. This screen can be accessed by pressing the Section icon on the Home page.

All of the section related variables are displayed on one page. For this display, only Sections 1 and 2 have been turned on and have acoustic paths assigned to them.

The sum of all of the individual section flowrates and volumes can be seen at the bottom of the screen.

Path Variables – 1 of 3



Path	VEL (ft/s)	Vsound (ft/s)	Gain (dB)	Detection	S/N (dB)
1	3.187	4799.7	-2.5	ZC	50.7
2	3.186	4799.7	-2.5	ZC	51.3
3	6.401	4799.7	-2.4	ZC	53.0
4	6.403	4799.7	-2.4	ZC	55.3
5	OFF	OFF	OFF	X	OFF
6	OFF	OFF	OFF	X	OFF
7	OFF	OFF	OFF	X	OFF
8	OFF	OFF	OFF	X	OFF
9	OFF	OFF	OFF	X	OFF
10	OFF	OFF	OFF	X	OFF

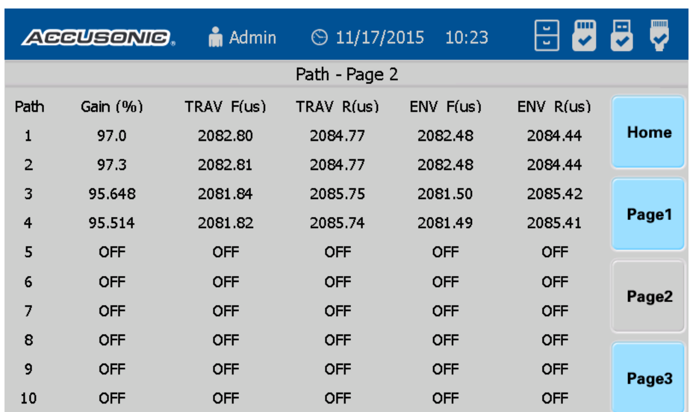
Path Variables 1 of 3

This screen shows Page 1 of the Path Variables.

The individual path Velocities, VSounds, Gains, Detection Method, and S/N ratios can be viewed.

Note: Any paths that are not assigned to a specific section will show “OFF”. Any paths that are assigned to a section, but is not turned on by the flowmeter since they are not submerged will show “OFF-L”

Path Variables – 2 of 3



Path	Gain (%)	TRAV F(us)	TRAV R(us)	ENV F(us)	ENV R(us)
1	97.0	2082.80	2084.77	2082.48	2084.44
2	97.3	2082.81	2084.77	2082.48	2084.44
3	95.648	2081.84	2085.75	2081.50	2085.42
4	95.514	2081.82	2085.74	2081.49	2085.41
5	OFF	OFF	OFF	OFF	OFF
6	OFF	OFF	OFF	OFF	OFF
7	OFF	OFF	OFF	OFF	OFF
8	OFF	OFF	OFF	OFF	OFF
9	OFF	OFF	OFF	OFF	OFF
10	OFF	OFF	OFF	OFF	OFF

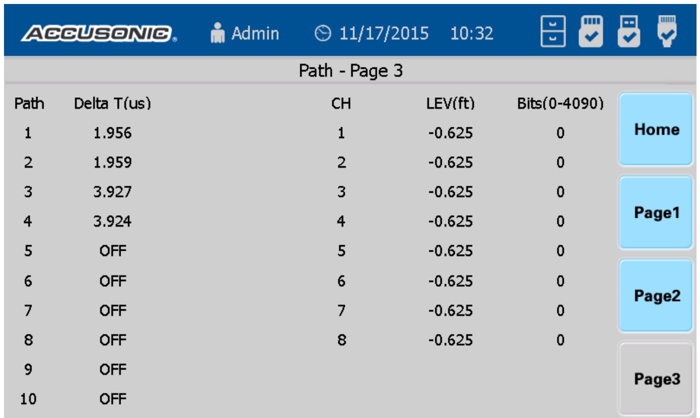
Path Variables 2 of 3

This screen shows Page 2 of the Path Variables.

The individual path Gain %, Travel Times, and Envelop Travel Times can be viewed.

Note: Any paths that are not assigned to a specific section will show “OFF”. Any paths that are assigned to a section, but is not turned on by the flowmeter since they are not submerged will show “OFF-L.”

Path Variables – 3 of 3



Path Variables 3 of 3

This screen shows Page 3 of the Path Variables.

The individual path Delta Travel Times can be viewed. Additionally the raw individual Level Input values can be viewed.

Note: Any paths that are not assigned to a specific section will show “OFF”. Any paths that are assigned to a section, but is not turned on by the flowmeter since they are not submerged will show “OFF-L.”

CHAPTER 6

Accuflow Windows Interface

This Chapter describes the alternative method of setting-up and operating the flowmeter using the Windows interface.

(Note: The instrument will not be damaged by entering incorrect parameters.)

Application Overview

The Accusonic 8510/7510 Flow meter Windows application provides a user friendly interface to the flowmeter. From the application, the user can enter and examine flowmeter parameters, control the flowmeter measurement cycle, graph real time or historical data, and conduct diagnostic tests.

The menu system provides the user the ability to setup system and flowmeter parameters, control the flowmeter measurement mode, display graphical data, and use flowmeter diagnostics.

Accuflow version 6 supports both the 7510 series of flowmeters and the new Accusonic Model 8510 series of flowmeters. Version 6 is fully 32 and 64 bit operating system compatible.

Accuflow version 6 is backward compatible in certain areas:

- Configuration files are saved in the same text format as the older versions of Accuflow making parameter translation between each of the flowmeter models, 7510, 7510+, 8510, 8510+ more flexible.
- Accuflow will still read the interim binary format files (*.acd) and automatically save them in the current (*.cfg) format.
- Data files collected by older versions can still be processed in graphical and text formats.
- Waveform files saved from scope mode in earlier versions can be processed. This feature is not required for the 8510 or 8510+ which show waveforms on the front panel touch-screen display.

Connecting a PC to Use AccuFlow

A PC may be connected to the 9 pin “RS-232” socket or the RJ45 “Ethernet” socket, for use with special Accusonic PC based programs. The “RS-232” connection requires a “Null-Modem” connection and the “Ethernet” connection requires a “Cross-Over” LAN cable or a standard LAN cable if connection via a switch or router. Either the cable or adapter can be purchased at a PC supply or electronics store. The physical connection should be made prior to launching the Accuflow program. See the Connect Command (Operate Menu) section to establish communications between Accuflow and the flowmeter.

File Menu

The file menu provides access to basic file management operations.

Load Flowmeter Command (File Menu)

This loads previously saved parameters from a disk file to the application for review or in preparation for sending the parameters to the flowmeter. This command can also be used to load a parameter file saved by Accuflow Version 4.21 or earlier.

Accuflow first looks for files with the ".cfg" extension to load, which is a text file. Optionally, changing the file type pull down on the right side of the file load dialog will allow loading the binary version ".acd" configuration file that was in use for earlier versions of Accuflow. Accuflow will read those files and automatically save the file in the current text format.

Note: This version supports both 7510 series and 8510 series flowmeter configuration files.

Save Flowmeter Command (File Menu)

Accuflow version 5 and later saves the configuration data in a binary file with the extension "acd"; e.g "this meter.acd."

Starting with Accuflow version 6.2.4 the binary format (*.acd) is not used for saving parameters. Flowmeter configurations are now saved in text file format and given the extension ".cfg," making translation of parameters between meter types more transparent.

Export Flowmeter Parameters (File Menu)

Starting with Accuflow version 5 parameter files are written to disk in a binary format for easier access by the application. This command can be used to export the parameters for a flowmeter to a text file that is formatted the same as the older '.cfg' files. The exported file can then be printed and/or reviewed to confirm the flowmeter parameters outside of Accuflow.

Import Flowmeter Parameters (File Menu)

Starting with Accuflow Version 5 flowmeter parameter files are saved in binary format for easier access by Accuflow while operating. This command can be used to translate and load ".cfg" files created by Accuflow version 4.21 or earlier. After the file has been successfully translated and loaded, a "File Save As" dialog will be displayed to allow it to be saved in the new format.

Exit (File Menu)

Use this command to end your Accuflow session. You can also use the Close command on the application Control menu or type ALT+F4 on the computer keyboard. Accuflow will prompt you to save documents with unsaved changes.

Configure Menu

The configure menu allows the user to make modifications to the currently loaded configuration. The configure menu has the following choices:

System Parameters (Configure Menu)

The system parameters configure menu allows the user to make modifications to the currently loaded configuration in the areas of section type, number of sections, measurement units, analog outputs, contact closures (relays), as well as the flowmeter's Device ID and IP address.

Note: When this dialog is opened while connected to a flowmeter, two additional command buttons will appear above the OK and Cancel buttons that will allow sending and receiving the system parameters while making changes.

System Parameter: Analog Outputs

Selecting the Configure Analog Outputs button will bring up the dialog box to configure the analog output parameters. Each analog output that is connected to a user's system can configured to: assigned to specific flowmeter section, the variable to be output, the 4mA value (in engineering units), and the 20mA value (in engineering units).

System Parameter: Contact Closures

Selecting the Configure Contact Closures button will bring up the dialog box to configure the alarm relay contact parameters. Each alarm relay contact that is connected to a user's system can be configured: Relay function, assigned to a specific flowmeter section, threshold to switch, delay time to switch (in measurement cycles), as well as the contact polarity (normally energized or de-energized).

System Parameter: 8510 More

Selecting the 8510 More displays the dialog box to allow configuring the Device ID and TCP/IP communication settings (IP address, subnet mask, and default gateway).

Section Parameters (Configure Menu)

The section parameters configure menu allows the user to make modifications to the currently loaded configuration for specific measurement sections.

When this dialog is opened while connected to a flowmeter, two additional command buttons will appear to the right of the Apply button that will allow parameters to be updated as they are changed. It is important to note that when connected to a 7510 or 7510+ all sections are updated or read when one of these buttons is selected while an 8510 or 8510+ will only update or read the current section highlighted in the section selection strip at the top of the dialog.

The 7510 or 7510+ flowmeter will allow entry for up to 4 flow sections and 4 level input channels while the 8510 or 8510+ flowmeter will allow entry for up to 5 flow sections and 8 level input channels.

Path Parameters

Selecting the Configure button in the Path Enable section of the Section Parameters dialog box will allow a user to configure the parameters for each acoustic path defined as a part of this section. The asbuilt values should be available for entry in this section. Each path can be configured: length, angle, weight, elevation, max bad measures, max velocity change, max velocity, and transducer type (the transducer type will set the signal delay and transducer frequency).

Level Input Parameters

Selecting the Configure button in the Level Enable section of the Section Parameters dialog box will allow a user to configure the parameters for each analog input defined as a part of this section. The asbuilt value should be available for entry in this section. Each available analog input can be configured: 4mA input, 20mA input, minimum mA value, resistor value (can be used to calibrate an input), and Level Filtering (averaging the input signal).

Change Flowmeter Model (Configure Menu)

Accuflow version 6 supports both the 7510/7510+ series flowmeters as well as the 8510/8510+ series flowmeters. This dialog can be launched from the **Configure** menu to change the flowmeter model without closing Accuflow.

Clicking on the down-tab on the right side of the drop-down box will show the valid list of flowmeters supported by the current version of Accuflow.

The user will be forced to choose a flowmeter type when any other menu selection is chosen.

Operate Menu

The operate menu provides the ability to connect to the flowmeter and send or receive parameters, to begin measurements, or to review historical data.

Connect (Operate Menu)

The Connect selection allows the user to choose the type of connection to the flowmeter. The two types are a direct connection which would be used for RS232 or TCP/IP or a modem connection which involves the use of a phone line. Regardless of the connection method, the physical connection between the customer supplied PC and the flowmeter should be made prior to running the connect command.

When the Direct connection type is selected, simply choose a comm port for RS232 or IP address for TCP/IP and click the Connect button. Accuflow will capture the port for communication with the flowmeter until the connection is closed, see Disconnect (Operate Menu) or the application is terminated. Note, for TCP/IP connection, the IP Address may need to be set or read via the flowmeter display prior to configuring the IP address in the Accuflow program.

When the Modem connection type is selected, a popup dialog will display the modems currently installed on the computer and allow one to be selected for this connection. Once the modem has been selected, set the Comm Port to the appropriate port for the modem and either choose the flowmeter to call or click on the Add Connection button to add a phone number to the Connect To list.

Once the selections have been made click the connect button to establish communication with the flowmeter. Regardless of the connection type chosen, once communication with the flowmeter has been established a message box will be displayed to confirm that Accuflow has connected with the flowmeter.

Disconnect (Operate Menu)

This command will break the communication link to the flowmeter. If a modem has been used for the connection then a command to hang up will be issued to the modem causing the phone connection to be terminated.

Receive Parameters (Operate Menu)

When *receive parameters* is selected, the application in the PC will request parameters from the flowmeter. After having successfully received the parameters, the user is given the option of saving them in a file.

Transmit Parameters (Operate Menu)

When *transmit parameters* is selected, the application in the PC will send the parameters contained in the PC to the flowmeter. The parameters may have been from a file that was opened or a configuration that was previously downloaded from a flowmeter. Any parameters the flowmeter had stored will be overwritten.

Path Variables (Operate Menu)

This window allows the user to look at all the data coming from the flowmeter in tabular form. Flowmeters with more than one operating section can choose to view the variables for the other sections by clicking on the radio button for that section in the Currently Viewing box. The process can be paused to allow printing the current screen or saving it to disk in the form of a bitmap file.

Before beginning measurements, a popup box will give a choice of logging the data that is displayed. If the yes option is chosen data will be logged in the same format as data that is collected from the flowmeter datalogger. See Retrieved Logged Data (Datalog menu). The destination folder for the logged data will be chosen automatically by Accuflow and will be formatted as **Data-n** where n is chosen to make the folder for this data unique. The panel at the bottom of the display indicates the current settings for the datalogging.

This window is also used to display data collected from the flowmeter datalogger. All of the information displayed is the same, but the PC is not connected to the flowmeter. The pause and resume buttons are replaced by record number and choose a new log controls. See Display Retrieved Log (View menu).

See Chapter 5 for a description of the variables that can be viewed.

Graph Data (Operate Menu)

Users familiar with previous versions of Accuflow will recognize this function as the Connect/Measure command.

Before beginning measurements, the user is asked if they wish to log data. When the data is to be logged Accuflow will automatically select a folder name and all variables will be logged using the same file naming conventions and formats used when data is collected from the flowmeter datalogger. See the Retrieve Logged Data (Datalog Menu) for the details.

Next the Data Series selection dialog will be displayed to allow selection of specific data variables to be plotted. Note that even though all data selections are allowed, if a selection is chosen that there is no current data for such as section 2 flow data when section 2 is not enabled in the flowmeter the plot will only show zero. Once the data to be plotted is chosen and the **OK** button is clicked the graph will be displayed and data will be acquired from the flowmeter for processing. Should the cancel button be clicked then the display will be cleared and no data processing will take place. Different buttons are enabled or disabled based on the running/paused state of the data acquisition process.

- The **?** button can be used to display this screen.
- The **Close** button will terminate the acquisition process and close the dialog window.
- The **Pause** button will momentarily interrupt data acquisition causing the **Print**, **Save** buttons and **Data Series** to be enabled for use.
- The **Print** button will raise a printing dialog to allow selecting a printer to print the current state of the graphs.
- The **Save** button will display a “Save As” dialog box to save a bitmap file representing the current display.
- The **Data Series** button will display the data selection dialog for adding/subtracting data to be plotted.
- The **Graph** button will interrupt the acquisition process and display a dialog to allow changing various settings of the graph.

Flowmeter Reset (Operate Menu)

This command pertains to the 7510 series flowmeter and is not available for the 8510 series and causes the computer portion of the DSP board perform a full reset which returns the CPU and associated circuitry to the same state as if the system was just powered on. If the connection to the flowmeter is via a phone line using a modem, the modem will hang-up and the connection will need to be restored manually.

Set Volume (Operate Menu)

When Set Volume is chosen, a dialog to set the individual section volumes is displayed. Check all sections that you wish to set a volume for, and enter the new volume value. When OK is clicked, the entered volume will be sent to the meter. 7510 flowmeters with Firmware versions prior to 837991 do not support this option.

Note: A 7510 or 7510+ flowmeter will allow settings for 4 sections while an 8510 will allow settings for 5 sections.

Get Flowmeter Version (Operate Menu)

When get flowmeter version is chosen, the application will attempt to connect with the flowmeter, and will ask for its version number. It will be reported to the user and stored in the current configuration. Flowmeter firmware versions prior to 837991 do not support this command, and communication failures will occur.

Set Flowmeter Clock (Operate Menu)

When *Set Flowmeter Clock* is selected, a dialog will appear for the user to enter in the desired date and time to be sent to the flowmeter. It will default to the current time according to the PC clock. After making the desired entries, click on Set Meter Clock to send it to the flowmeter. If you wish to see the date and time according to the flowmeter, click on Get Flowmeter Clock.

Show Differences (Operate Menu)

Show Differences can be used to verify that the configuration sent to the flowmeter has been received and stored properly. When show differences is chosen, the application connects with the flowmeter and requests its parameters. When they are received, they are compared to the configuration currently loaded in the PC. The parameters in the PC are shown on the left as “Local Configuration”, while the parameters on the right are the “Flowmeter Configuration”. Only those parameters that are different are shown, so that if the configurations are identical, both lists will be blank. It is common for the section volume parameters to be different, as they are updated with every measurement. Clicking on the Re-Transmit Parameters button sends the PC configuration to the flowmeter. After it has been sent, it is read back and any differences are shown again.

Scope Mode (Operate Menu) – *Only Available for 7510/7510+ Series*

Scope mode allows the user to look at the received transducer waveforms in a window that looks much like an oscilloscope. Scope mode will put the flowmeter into pipe mode, so that any selected paths will be active without regard to the water level, and will freeze the 4-20 mA analog outputs at their current values. The window displays the forward waveform in the top graph, and the reverse in the bottom graph. One path at a time may be displayed. The path to be traced may be set by using the Path Number spin control. There are a number of controls available. They are described below.

It is important to note that this mode of operation shows only the signal as processed by the DSP. A path that has failed will not display any useful information.

Single Sweep

When this button is clicked, the “oscilloscope” acquires waveform data for a single measurement and updates the scope display. Because of the volume of data, this process usually takes 3 to 4 seconds. Only one trace is taken in single sweep mode.

Continuous

When this button is clicked, the “oscilloscope” continuously acquires waveform data from the flowmeter and updates the display.

Pause

Clicking on the pause button stops the “oscilloscope from acquiring data after the latest waveform is taken. It is most commonly used to stop the continuous mode.

Zoom Level

Zoom level allows the user to control the length of the time period to be displayed. A value of 1 displays the smallest time period (usually 50 μS), or the maximum “zoom”. A value of 8 displays the longest period (usually 400 µS). After the zoom level is selected, a new waveform must be obtained by clicking either single sweep or continuous.

Display Variables

If display variables is checked, velocity, gain, time difference, and travel time will be obtained in addition to the waveform.

Waveform/Envelope

This control is used to select what kind of waveform is acquired and displayed. Waveform displays the discrete cycles in the received signal. Envelope displays the envelope of the received signal as computed by the flowmeter.

Build History

Normally, an old waveform is erased every time a new waveform is obtained and displayed. Build history allows the waveforms to display on top of each other. This can show any differences from measurement to measurement.

Restore Paths

Clicking restore paths will set the path enables and the pipe/open channel mode back to the state they were in prior to entering scope mode. The analog outputs will also become active.

Open File

A previously saved file can be opened and displayed. The variables are not active.

Save File

The currently displayed waveform is saved as a *.dat file.

Print

Print prints a copy of the scope mode window.

Flowmeter Reset

If flowmeter reset is selected, the application will attempt to connect to the flowmeter and send its reset command. A reset is the software equivalent of flipping the on/off switch.

View Menu

The view menu allows the user to view previously downloaded data and any saved waveforms (7510 / 7510+ series only).

Review Historical Data (View Menu)

Selecting this command from the will display the dialog box titled **Historical Data Selection**. First use the drop down list box to select a data set for review, what is shown is the top folder or data set name and the time span covered by this data set. Once the selection has been made, click the button corresponding to type of review or analysis to be performed.

Once the dataset has been chosen clicking on the **Plot Data** button will display the Data Selection dialog that will allow selection of the data to be plotted and whether to plot it against the left or right axis. If the

Cancel button is clicked the dialog will close and the previous **Data Set Selection** dialog will be displayed. Note that some of the check boxes are disabled (grayed out) preventing selection of that item, this means that the data represented by that check box is not available to be plotted.

Data viewed in this mode can be zoomed, press and hold the **[Shift]** key while pressing the left mouse button, a rectangle will be drawn on the chart indicating the area that will be expanded into the current view. Releasing the mouse button first will display the expanded view. Using the same technique the view can be expanded multiple times so that a data point of interest can be viewed closely. Clicking the left mouse button will cause the display to revert to the previous resolution. Once the original resolution is reached clicking the left mouse button will have no effect.

Holding the **[Ctrl]** key while pressing the left mouse button will allow the chart area to be moved or panned in any direction by moving the mouse. This can be a useful feature while in a zoomed display allowing the view of the plotted data to be moved for better presentation.

Clicking the **Data Series** button will display the data selection dialog to allow adding or subtracting a series from the displayed data. Clicking the **Data Set** button will display the first data set selection dialog.

Clicking the **Print** button will display a printer dialog to allow printing the current view (normal or zoomed) to the printer of your choice. Clicking the **Save** button will display a “Save As” dialog to allow saving a bitmap representation of the view to a diskfile.

This version of Accuflow does not limit the amount of data that is presented on the graphs; however, larger data files will take longer to load the data for display.

Display Retrieved Log (View Menu)

Choosing the Display Retrieved Log selection from the View Menu will display the Historical Data Selection dialog. The pull-down list box allows selection of the dataset to review. Once the selection is made, clicking on the Go button will display the Record Viewer as shown immediately below.

Controls are on the form to allow easy navigation; the **[<<]** and **[>>]** buttons allow seeking to the first or last record with a click of the mouse. The **[<]** and **[>]** move forward or backward one record at a time and the slider bar can be dragged to allow quickly moving to records in the middle of a large data set.

Display Saved Waveforms (View Menu)

Note: This option is only available for 7510 / 7510+ series.

This command allows viewing previously saved waveform data. See Scope Mode (Operate Menu)

Statusbar (View Menu)

This command causes the status bar to be visible or not visible.

Datalog Menu

The DataLogging menu allows the user to retrieve data logs stored in the flowmeter.

The DataLogging menu has the following choices:

Translate Logged Data (Datalog Menu)

When the 8510 flow meter is selected this menu will show just one possibility; **Translate Logged Data**. This selection will allow a Datalog file saved over time by an 8510 to be converted to the “csv” file format that can be loaded by most current spreadsheet programs.

The translation dialog will be displayed first; clicking on the **Input File** button will launch a windows open file dialog to allow selecting the file to be translated. Once the file is selected the file will be examined and the dialog will be modified. The next two buttons have been enabled for use and some information has been added to the dialog; the input filename, the path where the csv files will be written and lastly the number of records along with the starting and ending date of the data records in the file. The destination folder can be changed by clicking the **Change Destination** button to display a folder selection dialog.

This dialog allows navigation to the parent folder and then to create a new folder click on the **Make New Folder** button, this will create a windows new folder entry in the listbox portion of the dialog. Type the new folder name and press the **ENTER** key to create the folder, click on OK to close the dialog. The folder just entered now appears on the Destination Folder line. Using the mouse to push the **Begin Translation** button will popup one last dialog.

Selecting the data to be extracted is done by selecting the section(s) and path(s) and then selecting the variables that will be extracted for those sections and paths. Checking the **Log Status** box will log the operating status for the sections, paths and level measurement. Records can be filtered by time when the **Logging Interval** is set to a value other than one second which is the default. During the extraction process the time stamps will be examined for each record and a record will only be translated if the record time meets the interval requested. Note that the logging interval will not align records to a specific time of day or adjust the time stamps in any manner. In the event that the 8510 logging interval has been set to an interval that causes fewer records to be logged, records will be translated according to the longer interval. As an example the 8510 datalog has been set to log a record every minute, setting the logging interval here will only have an effect if set to an interval longer than one minute.

As the binary data is retrieved, it is stored under the [Data] folder in a folder with the name you provided. The data is stored in comma separated value files (CSV), these files are compatible to most current spreadsheet application. The file naming conventions are:

- The base name will reflect the date of the first record as *mmddyyyy*.
- A letter is appended to the name to indicate the type of data contained in the file.
- When necessary a numeric index will follow the letter designation if there is more than one file of that type.
- The file extension will be “CSV”.

As an example the file **01042012 P5.csv** indicates:

- The date of the first record in the file is January 4 2012.
- The file contains path data: sound velocity, gain, gain %... see below.
- The numeric index of 5 indicates this data is for path 5

The Data Files

There are nine (9) different data file categories that can be generated during the collection process. They are:

- Q_n files, where n indicates flow section 1 to 5 and the data consists of Date Stamp, $Section_n$ flow data, $Section_n$ level data
- T_n files, where the n indicates flow section and the data consists of Date stamp, $Section_n$ volume data, $Section_n$ Temperature data
- P_n files where the n indicates path number and the data consists of;
  Date Stamp,$Path_n$ Velocity of Sound, $Path_n$ signal gain, $Path_n$ signal %, $Path_n$ Signal to Noise,
  $Path_n$ envelope fwd time in microseconds, $Path_n$ envelope rev time in microseconds,
  $Path_n$ zero-crossing fwd time in microseconds, $Path_n$ zero-crossing rev time in microseconds,
  $Path_n$ travel time differential in nanoseconds, note this can be envelope or zero-crossing and depends on the actual detection method used for this path when this record was saved
- V files, the data consists of the Date Stamp, Path1 velocity data, …Path 10 velocity data

- S files, the data consists of the Date Stamp, Total flow data for the meter, total volume data for the meter
- L files, the data consists of Date Stamp, Level channel 1 to 4 level data, Level channel 1 to 4 raw data
- EL files, The data consists of Date Stamp, One level status word for each channel; 8 total
- EP files, The data consists of Date Stamp, One path status word for each path; 10 total
- ES files, The data consists of Date Stamp, One status word for each of 5 sections

Data Log Setup (Datalog Menu)

Choosing DataLogging/Data Log Setup from the main menu allows the user to set up the parameters for data logging at the flowmeter. This capability is optional, and requires the flowmeter to have the data logging memory card.

First choose the kind of log file you desire, main or temporary. The main file provides 192k of capacity, while the temporary provides only 16k. Typically, the temporary memory is used only for short term debugging. In addition, a measurement status can be logged with every measurement by checking “Log Status”. The parameters in use may also be recorded by checking “Log Parameters”. Normally, the log will overwrite memory when the logging memory is completely full, always keeping the most recent data. To prevent any overwriting, check “Stop logging when memory is full”. Next, choose a logging interval in hours, minutes and seconds. The maximum interval is 24 hours.

Finally, choose the sections, paths and variables you wish to log. When complete, click on “Send Setup to Meter”, and the parameters will be sent to the meter, and logging will begin. This action will start a new log file, so any previous data will be overwritten. You can also view the flowmeter setup by clicking “Get Meter Setup”.

As changes are made to the setup, the amount of memory capacity in terms of logging hours is displayed. For example, if you log section 1 flow at 1 hour intervals, the memory capacity is 98,280 hours (about 11 years). The message will say you have chosen 2 parameters because time is always logged.

Retrieve Logged Data (Datalog Menu)

This command is only available to models 7510 and 7510+ flowmeters, model 8510 flowmeters handle logged data in a different manner, see Translate Logged Data (Datalog menu).

Choosing Data Logging/Retrieve Logged Data from the main menu allows the user to retrieve data that has been logged at the flowmeter. Note that in a 7510 flowmeter this capability is optional, and requires the flowmeter to have the data logging memory card. 7510+ flowmeters include datalog capability at all times.

First, choose how much data to retrieve, the “most recent”, or “all data”. If you choose most recent, you must click on the “Retrieve Directory” button. This will provide you with the number of “blocks” available, and the number of hours of data stored in a block. Choose the number of blocks you wish to retrieve. For example, if 8 blocks are available, each with 1 week of data, and you wish to retrieve 2 weeks of data, select 2 blocks.

A block is a segment of memory 64 Kbytes long. AccuFlow calculates the number of hours in a block based on the number of parameters being logged, and the logging frequency. Since data is retrieved in blocks, the user should choose the number of blocks that is closest to the desired amount of data.

Accuflow will automatically choose a basic data name for you that is a new folder named “data-n” where the n is used to make this folder name unique. If an existing folder name is entered in place of the one chosen by Accuflow you will be given the option of appending the data to the existing files or erasing the existing files and writing new ones. Now you can click on “Retrieve Data”. Each data block will take about 45 seconds to retrieve and store. If the data is corrupted, this time can be longer. If you check for confirmations, you will be given the option of not retrieving a particular block.

Checking the **Append to Existing** will launch a dialog to assist navigating to the folder where the collected data should be appended. Accuflow will estimate which data block should contain the next record and begin downloading the data. This method will retrieve any data from the flowmeter that was logged after the last record in the existing data files.

Once the data is retrieved, it is stored under the [Data] folder in a folder with the name you provided. The data is stored in comma separated value files (CSV), these files are compatible to most current spreadsheet application. The file naming conventions are:

- The base name will reflect the date of the first record as mmddyyyy.
- A letter is appended to the name to indicate the type of data contained in the file.
- When necessary a numeric index will follow the letter designation if there is more than one file of that type.
- The file extension will be “CSV”.

As an example the file **01042012 P5.csv** indicates:

- The date of the first record in the file is January 4 2012.
- The file contains path data: sound velocity, gain, gain %... see below.
- The numeric index of 5 indicates this data is for path 5

The Data Files

There are 7 different data file categories that can be generated during the collection process. They are:

- Q_n files, where n indicates flow section 1 to 4 and the data consists of Date Stamp, $Section_n$ flow data, $Section_n$ level data
- T_n files, where the n indicates flow section and the data consists of Date stamp, $Section_n$ volume data, $Section_n$ Temperature data
- P_n files where the n indicates path number and the data consists of;
  Date Stamp,$Path_n$ Velocity of Sound, $Path_n$ signal gain, $Path_n$ signal %, $Path_n$ Signal to Noise,
  $Path_n$ envelope fwd time in microseconds, $Path_n$ envelope rev time in microseconds,
  $Path_n$ zero-crossing fwd time in microseconds, $Path_n$ zero-crossing rev time in microseconds,
  $Path_n$ travel time differential in nanoseconds, note this can be envelope or zero-crossing and depends on the actual detection method used for this path when this record was saved
- V files, the data consists of the Date Stamp, Path1 velocity data, …Path 10 velocity data
- S files, the data consists of the Date Stamp, Total flow data for the meter, total volume data for the meter
- L files, the data consists of Date Stamp, Level channel 1 to 4 level data, Level channel 1 to 4 raw data
- E files, the data consists of Date Stamp, Path status word, Section status word, level status word

Note: The 8510+ flowmeter writes a .csv file and can be opened with any version of Microsoft® Excel®. Each column will have the data variable labels in the top row located directly above the raw data. Accuflow is not necessary for viewing or downloading the data from the 8510+ flowmeter.

CHAPTER 7

User Defined Parameters

The System, Section, Path, Input, and Output parameters can be accessed from the HOME screen by pressing the Parameter icon and selecting the appropriate parameter tab on the bottom of the screen.

System Parameters

These parameters define the overall configuration of the flowmeter.

PIPE / COMPOUND 0 /1	Set to 0 (zero) to select "Pipe" mode for all sections. Set to 1 to select "Open Channel/Compound" mode
ENGLISH / METRIC 0/1	Selects the units of the Parameters and Variables of the flowmeter. For English units (feet) set to 0. For metric units (meters) set to 1.
FLOW SCALING	The flowmeter calculates flow in either English or Metric units defined by the parameter below. If English is chosen, flow will be in ft^3/s, and if Metric in m^3/s. To express flow in alternative units, the value for the Flow may be multiplied by the *FLOW SCALING* parameter. This scaled flow is output to the display, the analog outputs and RS232 ports. For English units: • Flow in ft^3/s set to 1.0 • Flow in MGD set to 0.646 For Metric units: • Flow in m^3/s set to 1.0 • Flow in MLD set to 86.4 • Flow in l/s set to 1000 • Flow in m^3/hr set to 3600
VOLUME SCALING	Sets the scaling of the totalized flow. For English units: • Flow in ft^3/s, Volume in 1000 ft^3 set to 1000 • Flow in ft^3/s, Volume in Acre-feet set to 43560 • Flow in MGD, Volume in Million gals set to 86400 For Metric units: • Flow in m^3/s, Volume in 1000m^3: set to 1000 • Flow in MLD, Volume in Mega liters set to 86400 • Flow in l/s, Volume in m^3 set to 1000 • Flow in $m^3/hr.$, Volume in 1000m^3 set to 3600000
ANALOG OUT SCALING	A factory set parameter. This value should be factory set to 0.25

FLOW AVE LVL {0 : 5}	The time over which the Flow data are averaged. Applies to the data displayed, logged and output on the analog output. • Set to 0, No time-averaging of the flow data • Set to 1, the flow data are averaged over a period of 1 minute. • Set to 2, the flow data are averaged over a period of 2 minutes. • Set to 3, the flow data are averaged over a period of 5 minutes. • Set to 4, the flow data are averaged over a period of 10 minutes. • Set to 5, the flow data are averaged over a period of 15 minutes.
NUMBER OF ACCUM's	Number of accumulations of signal waveform for each velocity measurement. Range 1 to 16. This facility can be useful for increasing the signal/noise ratio. In high velocity applications, (>10 ft./s, 3m/s)) this parameter should be set to 1, otherwise signal cancellation can occur. If the acoustic signal quality is very good, a low value may be used, (1 to 4). Under adverse noise conditions, set to 8 or more. The advantage of using a low value is that the measurement cycle is shorter, and a better "snap-shot" of the flow in the conduit is taken.
AUTO STORE PAR's	Set to 1 normally, so that changed parameters are stored in non-volatile memory whenever the system is returned to the Measure mode. If set to 0, changed parameters are used by the system but not stored. The changed parameters will be lost and the old ones asserted if the power is cycled.
REP TIME {0 : 4}	Sets the time interval between measurements. • Set to 0, the flowmeter meter will run at its maximum rate. • Set to 1, the flowmeter will take readings at 1 second intervals. • Set to 2, the flowmeter will take readings at 2 second intervals. • Set to 3, the flowmeter will take readings at 5 second intervals. • Set to 4, the flowmeter will take readings at 10 second intervals. **Note.** If the flowmeter is unable to complete the reading in the time selected, (because the path lengths are long or too many paths are selected) then the flowmeter will take the readings as quickly as possible without attempting to synchronize to any real time.
SYSCLK 2, 5, 10 MHz	Sets the sampling rate of the digitizer. • For 1MHz transducers or path lengths less than 50 ft (15m): set to 10.0 • For path lengths up to 100ft, (30m) and 500 kHz transducers set to 5.00. • For path lengths up to 300ft, (90m) and 200 kHz transducers set to 2.00. **Note.** If using 200kHz transducers, the filter jumpers on the DSP must be changed.
DISPLAY UNITS 0 : 5	Selects the characters to indicate the units of the variables displayed on the optional Liquid Crystal Display. Note this setting does not affect the flow scaling and only the labels used for the data on the display. • Set to 0 to display flow in "l/s", level in "m", Volume in Cm, Temp in °C. • set to 1 to display flow in "MLD", level in "m", Volume in ML, Temp in °C. • set to 2 to display flow in "CMS", level in "m", Volume in Cm, Temp in °C. • set to 3 to display flow in "CFS", level in "ft", Volume in CF, Temp in °F. • set to 4 to display flow in "MGD", level in "ft", Volume in MG, Temp in °F. • set to 5 to display flow in "CFS", level in "ft", Volume in AF, Temp in °F. • set to 6 to display flow in "CMH", level in "m", Volume in "Cm", Temp in °C

DETECTION METHODS	Set to 0, "AUTOMATIC" to enable the flowmeter to use the optimum signal detection method for the conditions. Used for most applications. Set to 1, "FIRST NEG" to force the flowmeter to use only detection of the "first negative" edge of the received signal. Set to 2, "ENVELOPE" to force the flowmeter to use only detection of the "envelope" of the received signal.

Section Parameters

These parameters describe each conduit and the method of flow computation. Separate lists are required for each section. For all unused sections, the parameters Path Enable and Volume Init Value must be deselected to turn the section off. All other parameters for unused sections can be ignored; their values are not used by the system. All lengths and elevations are limited to five figures (Note: only 2 decimal places are displayed). Parameters with the letters C after their names are used only in Open Channel or Compound mode.

PATH ENABLE		The path enable function can be found in the section parameters page 1 screen. Any given path can be selected to work in up to 5 different sections. Switch between sections by selecting the desired section number. To select or deselect any given path for any given section, press the desired path number. A gray tint will show that a path is assigned to a given section, a blue tint will show that a path is not assigned to a given section.
LEVEL ENABLE	**C**	The level enable function can be found in the section parameters page 2 screen. Any given level input can be selected to work in up to 5 different sections. To switch between sections, select the desired section number. To select or deselect any given level input for any given section, press the desired level input number. A gray tint will show that a level input is assigned to a given section, a blue tint will show that a level input is not assigned to a given section. For custom level configurations, the table below can be used to calculate the decimal value for any configuration. **Note:** A particular level input can be allocated to one or more sections.
PIPE AREA		"Pipe" mode only. The cross-section area of the conduit in ft^2 or m^2. This parameter is ignored in "Open Channel" or "Compound" mode.
MIN GOOD PATHS		"Pipe" mode only. The minimum number of good paths which must be present to calculate flow. The contribution to the Flow from any failed paths can be provided by the Path Substitution routine, providing that the "Learn path Ratios" routine has been correctly implemented. See Chapter 3, *Pipe Mode* for more information. If the "Learn" routine cannot be implemented, because at the time of commissioning there is insufficient flow, this parameter must be set equal to the number of paths installed. If set to number of paths installed, the flow will cease to be computed and the section fail, if any path fails.
LOW FLOW CUTOFF		Defines the range of flows which the flowmeter will declare to be zero. If set to 0.00, the flowmeter will be bi-directional, with no minimum flow. If set to a + value, all negative flows and positive flows up to the set value will

		be declared to be zero. If set to a – value, all positive flows and negative flows down to the set value will be declared to be zero. Any flow which is declared to be zero will be output on the displays and analog outputs as zero, and treated as zero flow for the computation of Volume and the computation of Sum of Section Flows.
VOLUME INIT VALUE		The current value of the Totalized Flow or Volume. The volume may be reset to any value as required, Range 0 to 999 999. For unused sections, this parameter should be set to zero, otherwise it will contribute to the Sum of Volumes.
LEARN PATH RATIOS		"Pipe" mode only. If set to 1, the "Learning" routine will be invoked, and a new path ratio table will be created automatically. (See Chapter 3, *Pipe Mode*). The parameter will reset to 0, and the table frozen after 1000 readings. **Warning: all paths must be good and flow non zero if this routine is invoked.**
TEMP CORRECTION		A constant in °F or °C which is added to the computed temperature to correct for minor variations in the water quality. Range -30 to +30. Normally set to 0.
MANNING n	**C**	The Manning coefficient of roughness. Usually between 0.01 & 0.03.
MANNING slope	**C**	The slope of the energy line in the conduit: a dimensionless number: Usually between 0.0 to 0.010.
MANNING MAX LVL	**C**	The maximum value of Level for which the Manning Formula is valid. Range: -5000 to +5000.
OVERRIDE LEVEL?	**C**	Selects whether the level is to be derived from the 4-20 mA analog level input or from a manually entered fixed value. To select the analog input, set to 0. To select the manually entered Level value. set LEVEL MANUAL to 1.
MANUAL LEVEL	**C**	A fixed Level value, representing the elevation of the water surface above the site datum. Range: -5000 to +5000
SURCHARGE LEVEL	**C**	The value of Level at and above which the section is surcharged. For an open channel site, this must be set above the highest possible Level. For a closed conduit, it is set equal to the elevation of the top of the conduit or soffit. Range: -5000 to +5000
LOW LEVL CUTOFF	**C**	Elevation of the water surface, above the site datum, below which the flowmeter will regard the flow as zero. Range -5000 to +5000
MIN SUBMERSION	**C**	The minimum submersion is the minimum distance which the water surface must be above a path for the path to be energized and used by the system to compute flow. Range: 0.0 to 5.0. Usually set to a value at least equal to the surface wave amplitude, or if the surface is smooth, set in accordance with the following: for 1 MHz transducers, 0.05√Path Length in ft, or 0.03√Path Length in m. for 500 kHz transducers, 0.07√Path Length in ft, or 0.04√Path Length in m. for 200 kHz transducers, 0.11√Path Length in ft, or 0.06√Path Length in m.
BOTTOM FRICT'N	**C**	The ratio between the assumed velocity at the conduit bottom and that at the elevation of the first good path above the bottom. Also used to compute the assumed velocity at the top of the conduit under surcharged conditions.

		Range: 0.0 to 2.0 Usually set to: 0.8 for multi-path open channels. A lower value, (0.5 min.), if the bottom path is very near the bed. A value of 1.2 to 1.8 may be appropriate for single path installations. See p 3-4
TOP WEIGHT	***C***	The weighting coefficient used to correct the extrapolated surface velocity. Usually set to 0.1. Set to 0 in narrow conduits.
SURCH TRAP / PIPE	**C**	Selects the integration method to be used when the conduit is surcharged. Set to 0 if surcharged trapezoidal mode is to be used. Set to 1 if "Pipe" mode is to be used.
NUM of LAYERS	**C**	Number of layers used for defining the conduit cross-section area. Any number between 2 and 8 layers may be defined.
LAYER ELEV'N 1	**C**	The elevation of the conduit bottom or invert relative to the site datum. Range –5000 to +5000.
LAYER ELEV'N 2	**C**	The elevation of the next layer above the bottom relative to the site datum.
LAYER ELEV'N 3	**C**	The elevation of the next layer, if required. If the conduit is closed, the elevation of the highest layer must be equal to or greater than that of the soffit or top of the conduit. If the conduit is an open channel, the elevation of the highest layer must be greater than that of the highest possible Level.
LAYER WIDTH 1	**C**	The effective width of the conduit at the bottom or invert of the conduit. Range 0.0 to 300.
LAYER WIDTH 2	**C**	The width of the next layer above the bottom..
LAYER WIDTH 3	**C**	The width of the next layer, if required.

Notes:

- The layer elevations must be in strict height order.
- Two layers cannot be given the same elevation.
- Data entered in layers having numbers higher than the parameter NUM of LAYERS will be ignored
- For a Round Pipe, the layer configuration given on page 7-11 is recommended
- The Surcharge Level parameter for a given section should not be set higher than the top layer elevation. It should be set equal to the top layer elevation or slightly less.

Path Parameters

The paths are numbered in sequence, 1 through 8, any of which can be allocated to any section. The individual paths are each described by:

LENGTH	The length between the transducer faces which are in contact with the water. Standard range: 1.0 to 50ft or 0.3 to 15m Extended range 300ft or 90m
ANGLE	The angle in degrees between the acoustic path and the center line of the conduit. Range of values: 10.00° to 80.00°
WEIGHT	The weighting constant for the path.

	Range: 0.000 to 1.000 This parameter is used only in “Pipe” mode; it is ignored in “Compound” mode. For a multi-path pipe, the sum of all the weights should be approximately 1.0. For 2-path round pipe, Chebyshev integration, set both path weights to 0.500. For 4-path round pipe, Chebyshev integration: • Paths 1 & 4 set to: 0.1382 • Paths 2 & 3 set to: 0.3618 For 8-path round pipe, Chebyshev integration: • Outer Paths, set to: 0.0691 • Inner Paths set to: 0.1809 For 4-path rectangular pipe, Gaussian integration: • Outer Paths, set to: 0.1739 • Inner Paths set to: 0.3261
ELEVATION C	“Compound” mode only. This parameter is ignored in “Pipe” mode. The elevation of the center line of the path above the site datum. In a given Section, the paths must be in the same numerical order as the elevations. Crossed paths must have identical elevations. See Chapter 3, *Flow Computation Algorithms Overview*.
SIG DELAY	The part of the signal travel time in µs, which is due to the electronic circuits, the total cable delay, and the signal travel time through the two transducer windows at either end of the path. Range: 0 to 20 µs For Model 7600, 7601, 7630, 7634, 7616, 7618, 7657, 7658, set to 6µs For Model 7612 transducer, set to 8µs For Model 7617 or 7656 transducers, set to 10µs For Model 7605 or 7625 transducers, set to 16µs These figures assume a cable run between the electronic unit and the section of about 150 ft (50 m). For longer cable runs, add 1µs for every additional 300ft (100m) of distance between electronic unit and transducers. Additionally, the actual travel time of the waveforms can be verified with an oscilloscope and the sig delay value can be adjusted accordingly.
MAX BAD MEASURES	The maximum number of consecutive measurement cycles in which no valid value of velocity on a particular path is obtained. If this value is not reached, the last good velocity value from that path is used for the Flow computation. If this value is reached, the path is declared to have failed, and its data are then not used for Flow computation, unless and until new valid data are obtained. Range: 1 to 500. Usually set to: 10.
MAX VEL CHANGE	The maximum change of water velocity between successive measurement cycles which is considered to be reasonable. If this value is exceeded, the computed velocity will change towards the new value at a rate limited by this parameter & the averaging filter. For changes which are large compared with this parameter, the displayed velocity will change in steps of about 0.3 * *Max Vel Change*.
MAX PATH VELOCITY	The maximum water velocity which is regarded as physically realistic. Values in excess of this value are regarded as erroneous.
XDUCER FREQ	The characteristic frequency (kHz) of the transducers. For Model 7600, 7601, 7605, 7625, 7630, 7657, set to 1000kHz. For Model 7616, 7617, 7618, 7634, 7656, 7658, set to 500kHz.

	For Model 7612, set to 200kHz

Level Input Parameters

Either one or two can be allocated to a section. The allocation is defined in the Section menu.

Level parameters are ignored by the system when in "Pipe" mode.

Scaling for each individual analog level input is defined by the following parameters.

MIN mA INPUT	The value of the input in mA below which it is declared to be in a fault state. The value may be in the range 0.0 to 19.0 mA.
4mA LEVEL INPUT	Elevation of the water surface above the site datum, at which the Level input is 4.0 mA. The value may be in the range –5000 to +5000.
20mA LEVEL INPUT	Elevation of the water surface, above the site datum, at which the Level input is 20.0 mA. The value may be in the range –5000 to +5000.
LEVEL RESISTOR	The value of the input resistance of the 4-20 mA Level input. The value may be in the range 150Ω to 50Ω. Standard value is 100Ω. This parameter is set at the factory to calibrate the input. This value can be changed to calibrate the input,as necessary.
LEVEL FILTER 0-4	The approximate time in units of 15 measurement cycles, over which the Level data are averaged. e.g.: if set to 0 no averaging; if set to 4 (max) averaged over 60 measurement cycles. Applies to the data displayed, used in the computation of flow, logged and output on the analog output.

Analog Output Parameters

Any number up to four analog outputs can be allocated to a section. The allocation to the section, the variable to be output and the scaling for each individual analog output are defined by the following parameters.

ASSIGN A SECTION	Defines which section the output responds to. For "sum of section" flow, set to 0. For Section 1, set to 1, etc.
F / L / V / T / *SF {0-4}	Selects the variable to be represented by the analog output. Set to 0 to output flow for the section. Set to 1 to output the arbitrated value of the level for the section. Set to 2 to output the average velocity for the section. Set to 3 to output Temperature, in °F for English or °C for metric units. Set to 4 to output the Sum of the Section Flows. **Note**. The units of velocity are either ft/s or m/s depending on the parameter English/metric. Velocity output is not affected by the Flow Scaling. The velocity is equal to the flow divided by the wetted cross section area.
4mA OUTPUT	The value of the variable, in the units specified, for which an output of 4.00 mA is

	required.
20mA OUTPUT	The value of the variable, in the units specified, for which an output of 20.00 mA is required.
OVERRIDE OUTPUT?	Selects whether the output is to be derived from the variable or from a manually entered fixed value. Normally only used during commissioning. To select the chosen Variable, (Flow, Level, Temperature etc.)set to 0 To select the manually entered MAN OUTPUT VALUE: set to 1
MAN OUTPUT VALUE	The manual figure, in the scaled units used by the flowmeter.
HOLD ON ERROR 0 / 1	Set to 0 to cause the output to go to 4mA in the event of failure. Set to 1 to cause the output to hold the last good value in the event of failure.
4/0 mA Error	Set the 8510 to 4mA or 0mA on error.
4mA FINE ADJUST	Adjust the 4mA Output (every 25 counts will change the output by 0.01mA).
20mA FINE ADJUST	Adjust the 20mA Output (every 25 counts will change the output by 0.01mA).

Relay Parameters

There are 16 separate lists, one for each relay. These describe the function, section allocation and behavior of each individual relay, if supplied.

ASSIGN A SECTION	Defines which section the relay responds to. For “sum of section” functions, set to 0.
TYPE (1 : 10) 0 = OFF	Defines the function of the relay. When a selection has been made, a code giving an indication of the function appears on the screen. **Value** / **Display Code** / **Function** Set to 0 / **OFF** / if the relay is not used. Set to 1 / SEC Q MX 1 / for the relay to operate when the section flow exceeds the threshold value in this relay’s list. Set to 2 / SEC L MX 1 / for the relay to operate when the section level exceeds the threshold value in this relay’s list. Set to 3 / PATH SUB / for the relay to operate when Path Substitution is in operation in the section. (Pipe mode only). Set to 4 / SECT FAIL / for the relay to operate when the section fails. Set to 5 / SECT VOL / for the relay to transmit section totalizer pulses. **Note** Only one relay may be allocated to each section for this function. Set to 6 / SUM Q MX 1 / for the relay to operate when the sum of section flows exceeds the threshold value in this list. Set to 7 / SUM VOL / For the relay to transmit totalizer pulses for the sum of the sections.
THRESHOLD	The value of the variable (flow or level), above which the relay will eventually operate. Range –99999 to +999999
DELAY	The number of consecutive measurement cycles for which the variable exceeds or falls below the threshold, before the relay operates.

	When used for Section Fail or Path Substitution alarms, the relay operation is delayed by a number of measurement cycles, after the onset of the alarm state. If an alarm state ceases, the relay returns to its normal state immediately. Range 1 to 999 measurement cycles.
POLARITY 0 / 1	Defines whether the relay is energized or de-energized when it operates as a result of the event . Set to 0 for the relay to be normally de-energized (Open). Set to 1 for the relay to be normally energized (Closed). **Note**. All relays are de-energized when the electronic unit is without power. **Examples:** • To configure a relay to close when the flow in section #1 is negative, set: TYPE = 1, ASSIGN A SECTION = 1, THRESHOLD = 0, DELAY = 5, POLARITY = 0 • To configure a relay to indicate if section #3 fails, or if the power is off, set: TYPE = 6, ASSIGN A SECTION = 3, THRESHOLD = 0, DELAY = 0, POLARITY = 1

System Settings

This list contains general information on the system, as well as facilities for choosing which protocol to use for the Modbus Slave output. The System Settings can be accessed by touching the system icon on the HOME page.

DATE/TIME	Allows a user to set the current date and time. Press the value to be changed to bring up the entry pad.
IP ADDRESS	Allow a user to set the flowmeter IP address for TCP/IP communications. Select Manual to manually set the IP address. Select Automatic to allow the HMI board to automatically select the available IP address on a network. The gray color shows the current selection.
SUBNET MASK	Allow a user to set the subnet mask for TCP/IP communications.
GATE WAY	Allow a user to set the gate way for TCP/IP communications.
DEVICE ID	Allow a user to set the device ID for RS-232 and RS-485 communications. For TCP/IP communications, this value must be set to 1.
BAUD RATE	Allow a user to specify the baud rate of the digital output. 9600 is the factory standard. 19200 and 38400 are the other allowable selections. The gray value will show the selected baud rate.
IS/BURST ENABLE	Allow a user to set the transmit mode. This would be factory set to IS mode. Do not change unless instructed to do so by Accusonic.
NEW PASSWORD	Allow a user to set a new password for password protection.
REPEAT PASSWORD	A user will be asked to repeat the password for password protection.
FIRMWARE UPDATE	Allow a user to update the HMI firmware and/or DSP firmware. This should not be performed unless specifically instructed to do so by Accusonic. Specific firmware files are required to perform these updates. Contact Accusonic for additional information.

Variables

All variables except average velocity are available to be displayed on the touchscreen display, as live data with the flowmeter operating in the "Measure" mode. To display the section variables, press the Section icon on the HOME page. To display the path variables, press the Path icon on the HOME page. Only 1 page is available for the section variables, and 3 pages are available for the path variables. The variable list below describes the measured variable as well as defines which screen the variable can be found:

FLOW SECT	The time-averaged value of the water flow, scaled in the required units. If the parameter Flow Scaling is set to 1, the units will be cubic ft/s or cubic meters/s. The averaging is carried out using an Infinite Impulse Response (IIR) digital filter, whose time is set by the System parameter FLOW AVE LVL (0 – 5). The Flow for each section can be found on screen 0-1. The screen number is in the lower left corner of the touchscreen display. The SUM OF SECTION FLOWS will be displayed at the bottom of this page, for a one section flowmeter, the SUM OF SECTION FLOWS will match the flow for SECTION 1.
LEVEL SECT	The arbitrated time-averaged value of the Level in each section, which is used for the calculation of flow. The averaging is carried out using an Infinite Impulse Response (IIR) digital filter, whose time is set by the parameter LEVEL FILTER. The level for each section can be found on screen 0-1.
TEMP SECT	The water temperature in each section, computed from the average velocity of sound for each good working path in that section. It is computed using the relationship for distilled water, corrected if necessary by a user defined offset; the section parameter TEMP CORRECTION. This is displayed on screen 0-2.
VOL SECT	The totalized flow for each section, scaled according to the Volume Scaling parameter. These values can be individually set or reset from the Section menus. The maximum displayed value is 999,999 after which the display goes to zero and restarts. This is displayed on screen 0-2.
VEL	The VEL is the value of the individual water velocity in feet/second or meters/second, averaged over 8 readings. A negative figure indicates reverse flow. This is displayed on screen 1-1.
Vsound	The Vsound is the computed velocity of sound for that path (used for diagnostic purposes) in feet/second or meters/second. This is displayed on screen 1-1.
GAIN	The value of the Receiver gain, nominally in dB units. Maximum value 40 Equal to: 20 x log10 [Ratio of signal voltage at A/D converter: Transducer output] 0dB indicates a signal level of 1Volt peak to peak at the transducer terminals. This is displayed on screen 1-2.
Detection	The letter E or Z indicates the signal detection method, either "Envelope" or "First Negative". The letter H indicates that the velocity reading has been "Held" The latest acoustic signal is unacceptable, and the previous value for water velocity is being used for the computation of flow. X indicates that consecutive acoustic signals for that path have been rejected for a period greater than the parameter Max Bad Measures and the path has failed or that the path is not in use. Displayed on screen 1-2.
S/N (dB)	S/N is the Signal to Noise ratio expressed in dB. Less than 12dB indicates a serious noise problem, and that the data for that path will be rejected. Displayed on screen 1-3.
Gain %	Gain % is the amplitude of the latest instantaneous signal, after amplification, expressed as a % of full signal at the detector. Normally this value will be between 95 and 105. Displayed on screen 1-3.

TRAV	The signal travel times in micro seconds (μs), Forward (left column) and Reverse (right column). The values are the total times less the Signal Delays and represent the travel times of the signals through the water. Displayed on screen 1-4.
DELTA_T	The time difference, in nano seconds (ns), between the instantaneous forward and reverse signal travel times. A negative figure indicates reverse flow. Displayed on screen 1-5.
ENV	The travel times of the overall signal envelopes for both the Forward (left column) and Reverse (right column). Note: this is used for diagnostic purposes. Displayed on screen 1-6.
LEVEL ***CHNL*** ***BITS***	The time-averaged value of each individual Level input, the elevation of the water surface above the site datum. The second 4-digit number after the Level value is the instantaneous value of analog input. It is scaled so that an input of 0.00 volts is displayed as 0, and 5.00 volts as 4094. If the input resistor fitted is the nominal 100Ω (Standard), the 4 digit number will be scaled so that: 0mA is displayed as 0, 4mA as 328, 20mA as 1638, and 50 mA as 4095. Displayed on the path variable screen 3.

Special Configurations

Occasionally, it may be necessary to configure the meter in a “non-standard” mode to meet a particular requirement. This section contains special configurations.

Using Layer Boundary Parameters to Simulate a Round Pipe

When a “compound flowmeter” is set up in a pipe, the shape of the pipe has to be described using the Layer Boundary parameters. If the pipe is round, a large number of possible ways of describing its shape in terms of trapezoidal layers can be devised.

The following table gives one possibility, which has the merits of giving very close approximations to the wetted area, with only 11 numbers to be calculated. The maximum errors occur when the stage is below 0.1 x Pipe Diameter. This is below the lowest layer and likely to be below the lowest path, and so of no relevance. At a stage of 0.05 x Pipe Diameter, the error is 4.5% of actual area. For stages between 0.1 and 0.2 x Pipe Diameter, the errors are less than 0.2%. Above 0.2 x Pipe Diameter, the errors are small.

Layer Boundary Elevation	Layer Boundary Width
Zero x Diameter	0.116 x Diameter
0.05 x Diameter	0.472 x Diameter
0.20 x Diameter	0.823 x Diameter
0.40 x Diameter	0.993 x Diameter
0.60 x Diameter	0.993 x Diameter
0.80 x Diameter	0.823 x Diameter
0.95 x Diameter	0.472 x Diameter
1.00 x Diameter	0.116 x Diameter

All Path Elevations in terms of measured distance above the channel bottom.

Separating Forward and Reverse Flows, (For Pump / Generating Plant)

For some full pipe systems, it may be desired to compute separate totalizer counts (from relay closures) and volumes for forward and reverse flows. To achieve this, two sections should be configured, using the same paths, but with slightly different section parameters. In this example, Section #1 is for forward flow, and section #2 for reverse.

Parameter	Section #1	Section #2	Comment
Path Enable	1111000000	1111000000	Both the same
Pipe Area	Actual Value	-Actual value	Section #2 will read negative
Low Flow Cutoff	0.0001 or more	-0.0001 or less	See description in **Section Parameters**.

With this configuration, Section #1 will give a positive value for all forward flows, and zero for reverse flows.

Section #2 will give a positive value for all reverse flows, and zero for forward flows.

For Compound or open channel situations, contact Accusonic.

Relay to Indicate That a Section is Good

For flowmeters which are used for automatic plant control, it is often desirable to have a relay to indicate "Section Good", rather than "Section Failed". The difference being that "Section Good" should be energized only when the section is "good", be de-energized immediately it is "bad", and allow for a delay between the section recovering and the relay becoming energized. The "Section Failed" concept does not provide this logic.

To provide this: Enable a "dummy" path in the section, (e.g. Path #10), to which nothing is connected.

Set Section parameter Min Good Paths to the minimum number required for flow calculation.

Set "dummy" path Length to 1.0, Weight to 0, Other parameters to 1 or ignore.

Set Relay parameter for desired Section, Type to 3 (Path Sub), Delay as required, Polarity to 0.

APPENDIX A

Multiple-Path Transit-Time Principles of Operation

Description

Accusonic flowmeters utilize the multiple chordal path transit-time flow measurement technique which is designed for accurate flow measurement (±0.5% of actual flowrate) in large pipes and open channels. The systems can be configured to measure flow in full pipes and conduits, pipes and conduits ranging from partially full to surcharged, and open channels. Depending upon accuracy requirements, the flowmeters can be set up to operate 1-10 acoustic paths with cross path (cross flow) correction available on flowmeters with 2 or more paths. A single console can be used to handle flow measurements in multiple pipes.

Transit-Time Operating Principles

The Accusonic flowmeter is connected via signal cables to multiple pairs of transducers mounted in a pipe or channel at specific elevations. Velocity at each elevation is determined using the transit time method in which an acoustic pulse travels downstream faster than a pulse travels upstream. A pulse of sound traveling diagonally across the flow in a downstream direction will be accelerated with the velocity of the water and, conversely, a pulse traveling diagonally upstream will be decelerated by the water velocity as in the following (Fig. 1 and Fig. 2).

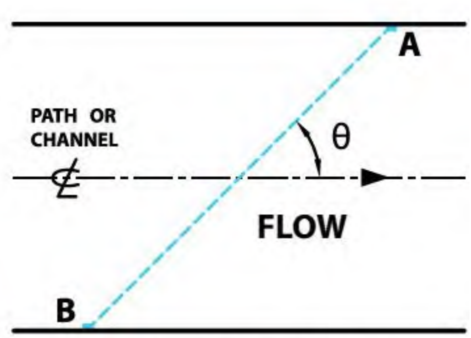


Figure 1 Acoustic Path Layout

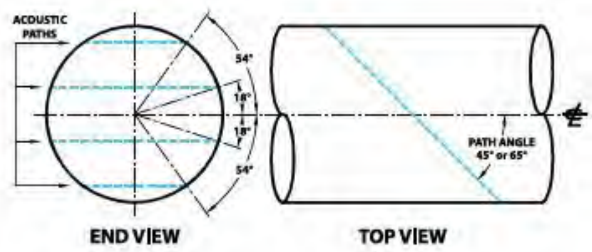


Figure 2 Typical full-pipe pipeline placement (using the Gauss-Chebyshev integration method)

This method of measurement is described as follows:

$$T1 = \frac{L}{C - V\cos Ø} \qquad T2 = \frac{L}{C + V\cos Ø}$$

Where:

T1 = Travel time of the acoustic pulse between transducer B and transducer A (Figure 1)

T2 = Travel time of the acoustic pulse between transducer A and transducer B

C = Speed of sound in water

V = Velocity of the water

Ø = Angle between the acoustic path and the direction of water flow

L = Path length between transducers

The above equations are solved for V, independent of C, yielding:

$$V = \frac{(T1 - T2)}{(T1 \times T2)} \times \frac{L}{2\cos Ø}$$

Therefore, the velocity of the water at the acoustic path can be calculated by knowing the path length (L) and path angle (Ø), and measuring the time for the acoustic pulse to travel between the transducers in the upstream and downstream directions.

Typically, four pairs of transducers are spaced in the pipe or channel to give four parallel acoustic paths (Fig.2 above, Fig. 3, and Fig. 4 following). Velocities for these paths are then integrated so that flow is measured according to the equations in the following sections.

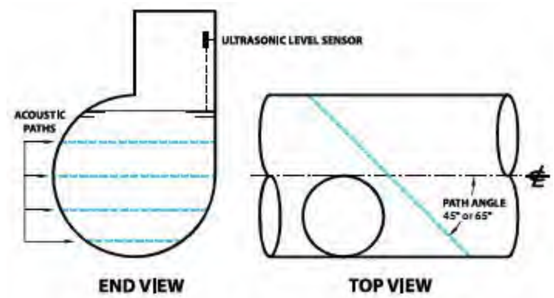


Figure 3 Typical partially full pipe

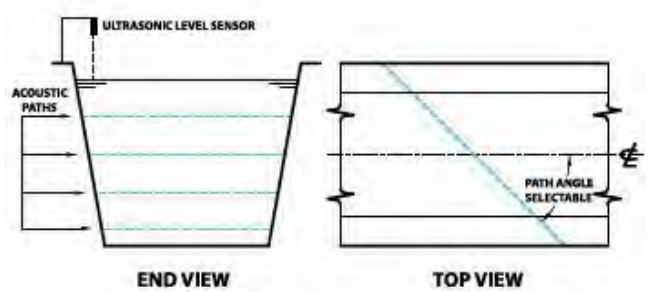


Figure 4 Typical open channel path placement

Pipe Equation

$$Q = \Pi R^2 \sum_{i=1}^{N} w_i v_i$$

Where:

Q = Flowrate

R = Pipe radius

W_i = Normalized integration weighting constant for the i^{th} path (defined by the path location)

V_i = Velocity determined by the i^{th} path

i = number of acoustic paths (1,2, 4, 8, or 18)

Open Channels and Partially Full Pipes (When More Than One Path is Submerged)

$$
\begin{aligned}
Q = {} & [A_{Bottom} * V_A * (1 + F_{Bottom}) / 2] + \\
& [\sum_{i=1}^{N} A_{i-i+1} * (V_i + V_{i+1}) / 2] + \\
& [A_{Top} * (V_N + W_{Top} * V_{Surface}) / (1 + W_{Top})]
\end{aligned}
$$

Where:

Q = flowrate

A = Cross sectional area (determined as a function of depth and channel/pipe dimension

V_A = Velocity of lowest path of lowest pair of crossed paths

F_{Bottom} = FBottom friction coefficient

V_i = FVelocity of the I path or pair of crossed paths

W_{Top} = FWeight for the surface velocity to correct for friction at the surface

$V_{Surface}$ = FSurface velocity extrapolated from the top two measured path velocities.

Pipes and Channels Where Only One Path is Submerged

$$Q = V * C * A$$

Where:

A = Cross-section area of flow (depth)

C = A correction factor to correct velocity measured as a function of the path height to depth. The correction factor is based on USGS (ISO 6416) developed velocity/depth relationships.

In cases where there is a very short (less than 5 x width or diameter) straight channel or pipe run upstream of the meter section, it is likely that the direction of flow will not be parallel to the centerline. If this is the case, a second *crossed path* at each elevation will be required to eliminate the cross-flow error (Fig. 5).

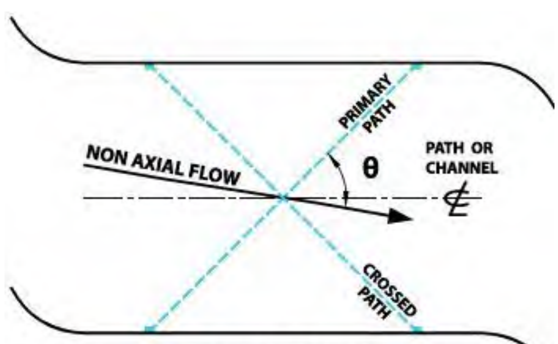


Figure 5 Cross Path Configuration

Pipes and Conduits That Range From Partially Full to Surcharged

For compound applications, Accusonic meters are designed to automatically change mode of operation from open channel to full pipe as the conduit surcharges. The method of flow calculation used is based on depth, number of paths submerged, and path locations. From the above, it can be seen that to calibrate an acoustic flowmeter, all that is required is to measure the distance between the transducers, the angle of the transducers with respect to the centerline of the pipe or channel, and the physical dimensions of the pipe or channel. The multiple chordal path acoustic method is an absolute flow measurement method that does not require calibration by comparison to another flow measurement method.

System Accuracy and Measurement Uncertainty

For pipeline flow measurement using a 4-path flowmeter, the be ± 0.5 percent of actual flow. This is for all flows with velocity above is installed according to Accusonic specifications in a section of pipe with a minimum of ten diameters of upstream straight pipe. For installations having between four and ten diameters of straight pipe upstream of the meter section, four crossed paths (eight paths total) are required to maintain an accuracy of ± 0.5 percent of flowrate.

To assure the specified accuracy, the flowmeter integrates the four velocities for each measurement plane (one for four path, two for four crossed paths) to calculate flowrate. Where crossed paths are used, the flowmeter software is designed to utilize velocity information from each plane of transducers to quantify and correct for crossflow. System accuracy is determined by assigning an expected error to each component of flow measurement and then defining the total system uncertainty (accuracy) as the square root of the sum of the squared values of the individual errors. See the sections below for additional details on the following sources of error for pipeline flow measurement:

- **Path Length Measurement**
- **Path Angle Measurement**
- **Travel Time Measurement**
- **Radius Measurement (or Area for Non-Circular Conduits)**
- **Velocity Profile Integration Error**

Path Length Measurement

Path length measurement is typically done with the pipe dewatered. Using steel tape measures in larger pipes and calipers or micrometers in smaller pipes, individual path length uncertainty is less than 0.15% (e.g., a 1/16-in (1.5mm) error in a 4-ft (1.2m) path length would result in a 0.13% error in velocity calculation). However, since there are 4 paths and the error is random, overall flow measurement uncertainty due to path length measurement error would be:

$$E_L = 1/4\ (4 \times 0.0015^2)^{1/2} = 0.00075 \text{ or } 0.075\%$$

Path Angle Measurement

Path angle measurement is typically done with the pipe dewatered using a theodolite. The theodolite is capable of measuring angles to within ±20”; however, the primary source of error is the ability to set the theodolite up on the pipe centerline. Careful set-up, according to Accusonic procedures, will assure that the theodolite is within $\pm 0.1^{o}$ (±6’) of the true centerline.

As for paths nominally at 45^{o}, the flow measurement uncertainty due to path angle measurement error would be:

$$E_{\emptyset} = (1-(\cos 45.10/\cos 45.00)) = 0.0017 \text{ or } 0.17\%$$

The above analysis assumes that there is no cross flow in the pipe (due to upstream disturbances such as elbows). This assumption is good for applications where there are at least 10 diameters of upstream straight pipe. For less available straight pipe, cross paths may maintain accuracy - see Operating Principle.

For cross path installations, the above error is reduced to the theodolite resolution.

Travel Time Measurement

Travel time measurement is dependent on the digital oscillator accuracy, oscillator frequency, and the time delays in the transducers, cable and system. A precision oscillator, accurate to within ±0.005%, is used as the conversion trigger to translate the analog received signal into digital RAM for processing by the DSP firmware. DSP techniques are then used to detect the first negative edge of the received acoustic pulse and determine the actual travel time. The flow measurement uncertainty from all timing errors is calculated to be:

$$E_T = 0.0001 \text{ or } .01\%$$

Radius Measurement

Radius measurement is typically done from the inside with the pipe dewatered. The radius is measured at several sections to account for normal pipe out-of-roundness and give an average radius through the meter section. When done according to Accusonic procedures, the radius measurement can be completed to within ±0.2% (e.g., for a 6-foot (1.8m)-diameter pipe, the radius is measured to within 1/16 in (1.5mm) or for a 10-foot (3m)-diameter pipe, the radius is measured to within 1/8 inch (3mm). The flow measurement uncertainty due to radius measurement error is:

$$E_R = (1 - (1/1.002)^2) = 0.004 \text{ or } 0.4\%$$

Velocity profile uncertainty is estimated by numerical analysis of the ability of a 4-path chordal integration to fit simulated velocity profiles. Discharge uncertainty including profile integration error is determined to be less than:

$$E_I = 0.002 \text{ or } 0.2\%$$

Therefore, the total flow measurement uncertainty for a 4-path flowmeter, installed according to specifications is:

$$E_Q = (E_L^2 + E_q^2 + E_T^2 + E_R^2 + E_i^2)^{1/2} = 0.0049 \text{ @ } 0.005 \text{ or } 0.5\%$$

For other situations such as open channel systems, 2-path systems, compound meters, etc., the accuracy would be determined through an error analysis similar to the above with the additional sources of error considered. For example, for an open channel system, there would be additional uncertainties due to level measurement and surface velocity determination.

Typical system uncertainties for various meter applications are presented in the following table:

UNCERTAINTY VALUES FOR VARIOUS FLOWMETER CONFIGURATIONS

Description	Typical Uncertainty
4-or 8-path pipeline system	±0.5% of actual flowrate
2-path pipeline system	±1.5% of actual flowrate
4-path open channel system	±2.0% of actual flowrate
2-path open channel system	±5.0% of actual flowrate

Typical System Uncertainties

PIPES:

ASME MFC-5M-2006

ASME PTC 18-2011

IEC 60041-1991

ANSI / AWWA C750-2010

OPEN CHANNELS:

ISO 6416: 2004 Part 3E

The accuracy of Accusonic multi-path flowmeters has been well proven in numerous independent laboratory and field tests conducted by the EPRI and others on a variety of large-diameter pipes.

APPENDIX B

Transducer Maintenance

Ultrasonic transducers require little maintenance. They need attention only when the signal shows signs of deterioration. The following safeguards apply:

- The connector-ends of transducers - those which lie outside of the conduit - should be protected from the weather and from vermin so as to retain electrical integrity.
- Devices not in service should be protected from the weather and extreme humidity (95% max) and stored at a temperature between -20°C and 60°C.

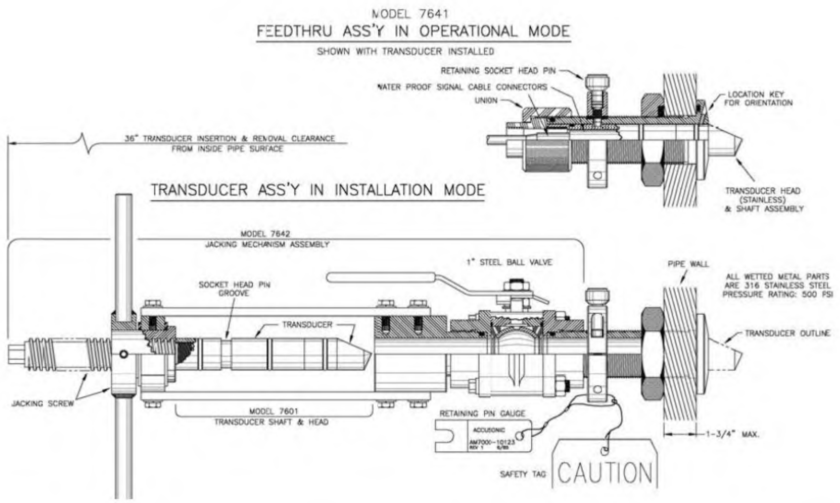
Signal Deterioration

After a period of time, the signal level of the transducer signal may deteriorate. This is usually due to the growth of algae or buildup of mineral deposits on the face of the transducer. The rate at which foreign matter builds up on a transducer face varies, depending on the ambient water conditions. Under normal water conditions, Accusonic recommends that transducer signals be checked for deterioration monthly at first, and then annually. Under severe conditions, more frequent testing may be appropriate. The simplest method is to monitor the AGC values for each path. See path variables *Gain* in Chapter 7, *Variables*.

In many cases, signal deterioration may be caused by loose, wet, frayed, or worn transducer cables or connections. When signal deterioration is observed or suspected, be sure to check the wiring before assuming that foreign matter has built up on the transducer face or that there is trouble with the transducer itself. Consult the procedures given in *Transducer and Cabling Checkout* in Chapter 4, on 4-5 to test and prove out the transducer wiring and external junctions. If signal strength drops below acceptable levels, the appropriate action to be taken depends on the type of the transducer.

For internal mount transducers (Models 7630 and 7634) - most of which are installed with dual active elements - try switching elements to see if the problem clears up. If not, the only option is to run the flowmeter with a path shut down (which degrades accuracy), switch on path substitution (which also degrades accuracy), or to dewater the pipe and clean, inspect, and possibly replace the unit.

> **Note:** When switching to a backup element in a dual-element transducer, it is necessary to change the path parameters Path length and Path angle accordingly; unless the elements on both ends of the path are changed.

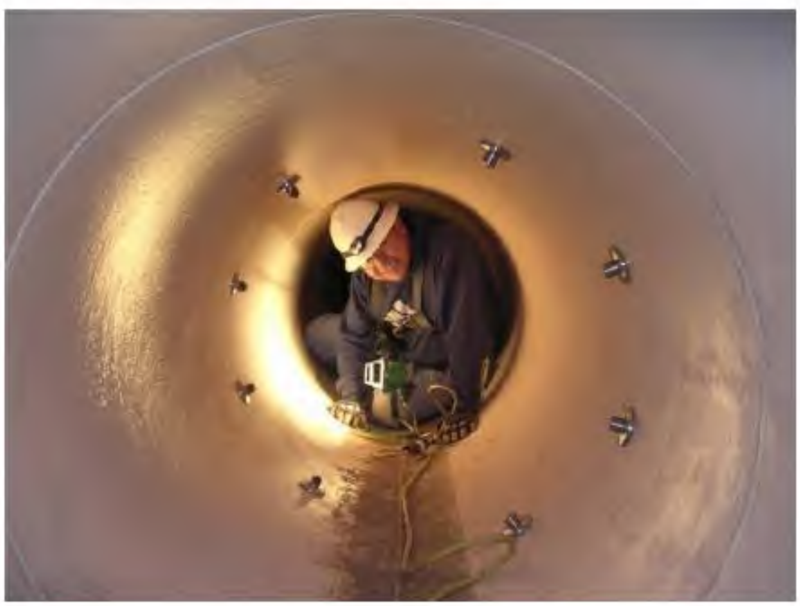

MODEL 7641
FEEDTHRU ASS'Y IN OPERATIONAL MODE
SHOWN WITH TRANSDUCER INSTALLED
RETAINING SOCKET HEAD PIN
WATER PROOF SIGNAL CABLE CONNECTORS
UNION
LOCATION KEY FOR ORIENTATION
TRANSDUCER HEAD (STAINLESS) & SHAFT ASSEMBLY
36" TRANSDUCER INSERTION & REMOVAL CLEARANCE FROM INSIDE PIPE SURFACE
TRANSDUCER ASS'Y IN INSTALLATION MODE
MODEL 7642
JACKING MECHANISM ASSEMBLY
1" STEEL BALL VALVE
PIPE WALL
ALL WETTED METAL PARTS ARE 316 STAINLESS STEEL PRESSURE RATING: 500 PSI
SOCKET HEAD PIN GROOVE
TRANSDUCER
TRANSDUCER OUTLINE
JACKING SCREW
MODEL 7601
TRANSDUCER SHAFT & HEAD
RETAINING PIN GAUGE
ACCUSONIC
AM7000-10123
1-3/4" MAX.
SAFETY TAG
CAUTION

The Model 7601/7641 is a 316 stainless steel transducer and feedthrough assembly designed for low to medium pressure, indoor or outdoor applications. The assembly allows for the removal of the entire transducer for repair, replacement, or cleaning, without dewatering the pipe.

The Model 7601/7641 assembly is installed in a dewatered pipe from the inside out. Installation is performed by accurately determining transducer locations, drilling holes in the pipe for penetration of the feedthroughs, and measuring the as-built transducer locations.

The Model 7601 Feed -Through Transducer can be cleaned in most cases using a soft bristle brush and diluted soapy water.

1. Inspect transducer, interior flange for damage.
2. Ensure that mounting hardware is in tact and secured to pipe surface.
3. Carefully scrub debris, algae build up off of transducer and mount.
4. Ensure that transducer orientation/alignment stays the same during the cleaning process.
5. Rinse with water.



For fixed-window transducers (Models 7605 and 7625) the active elements of can be replaced from outside the conduit, but cleaning of the acoustic window requires dewatering the conduit. These can be found on *Figures 10-5* and *10-6* on page B-15.

If the transducers are subjected to high temperatures (> 140°), which can occur if the pipe is dewatered and exposed to strong sunshine, the coupling grease between the transducer element and the window can deteriorate. If this occurs, or whenever the transducer element is removed for inspection or replaced, a 1/32" (1mm) layer of grease should be applied to the flat face of the transducer element. Appropriate grease obtainable from Accusonic.

For removable transducers (Models 7600, 7601, 7635, 7620), remove the unit according to the procedures recommended by Accusonic, and then clean, inspect, and possibly replace the unit.

DANGER: Removing a transducer from a pressurized pipe MUST be done in strict accordance with Accusonic procedures. Failure to do so may result in serious injury to personnel or in damage to the transducer or other equipment nearby.

Note: Transducers are position-dependent. When replacing a transducer, always verify that the replacement unit is of the same type as the unit removed. In particular, pay attention to the angle, position, and length designators (i.e., 45°,60°,65°; inner vs. outer; Short or Long) that are part of the model and serial number designators marked on the body of the unit.

Fixed-Window Transducer (Models 7605 and 7625)

7601 Series Transducers

The transducers are installed in special feedthroughs which allow for removal of the transducer without dewatering the pipe or disturbing the alignment of the unit. A special tool must be used. The following is a step-by-step procedure for removal, cleaning, and reinsertion of the transducer.

DANGER: THE TRANSDUCER IS PROBABLY UNDER CONSIDERABLE PRESSURE FROM THE LIQUID IN THE PIPE. ANY ATTEMPT TO REMOVE A TRANSDUCER IN ANY OTHER MANNER THAN OUTLINED BELOW MAY CAUSE SERIOUS INJURY TO PERSONS IN THE GENERAL AREA.

Caution: The 7601 transducers are equipped with a gauge for confirming that the locking pin is fully engaged. Measurements with the gauge and an independent test is required to confirm that the locking pin is seated. If the gauge is missing, do not proceed. Never loosen the locking pin unless the transducer removal tool supplied by Accusonic is installed in complete accordance with the procedure given below.

Caution: Always work from the side of the transducer feedthrough, so that if an error or a component failure results in the transducer blowing out of its seat, you are not in the exit trajectory. Keep the trajectory area clear of other personnel.

Warning: Read through the entire procedure below to be certain you understand it completely.

IF YOU DO NOT UNDERSTAND ANY PORTION OF THIS PROCEDURE, STOP FURTHER WORK, DO NOT CONTINUE!

Notes: Transducers are position-specific. Always reinstall a transducer in the same feedthrough position from which it was removed. When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one.

Hydrostatic pressure is pushing radially outward on the transducer at all time, including during removal and replacement of the transducer. During normal operations, the transducer is held in place against this pressure by the union nut shown in Figure 10-1 on page B-12.

When the nut is removed, then the locking pin prevents transducer movement. It is extremely important that locking pin engagement be confirmed (using the supplied gauge) before attempting to remove the union nut.

The locking rings which are installed in numbered pairs - the serial numbers are stamped on the opposite mating faces. Parts from on locking ring must not be interchanged with other units. If a ring is disassembled, it must be reassembled using a matched pair.

Tools Required

- 7601 series clearance gauge (attached to transducer fitting on the conduit)
- Model 7642 series transducer jacking mechanism (order from Accusonic)
- Medium (8 inch) crescent wrench (or 1/2 inch (13mm) open-end wrench)
- 3/8 inch hex (Allen) wrench

Perform the Maintenance

1. Verify the following safety conditions are met below. See Figure 10-1 on page B-12.
   - **Locking Pin is Fully Engaged** Check that the clearance between the shoulder of the pin and the face of the locking ring is less than the specified limit. Check this by trying to slide the u-shaped end of the clearance gauge under the pin as shown. It must not fit.
   - **Locking Ring is Tightly Installed** Check that lock washers (spacers) are installed between both sets of mating faces of the two halves of the locking ring. Verify that the hardware is tight and that the lock washers are compressed flat.
   - **Union Nut Rotates Freely** Check that the union nut turns freely and exhibits no resistance to turning caused by back pressure on the nut from the transducer behind it after it has been loosened one-half turn.

   If any one of these conditions is not met, there may be a safety hazard. Leave the union nut in place, **STOP WORK** on the transducer **IMMEDIATELY** and contact Accusonic for advice.
2. Locate the jacking screw in the jacking mechanism, shown in Figure 10-2 on page B-13. Make certain that the valve on the jacking mechanism is fully open.
3. Spin the bearing lever so that the threaded tip of the jacking screw is retracted inside the tool valve. The jacking screw should extend beyond the bearing lever about two inches (50mm) as shown in the inset of Figure 10-2 on page B-13. It may be necessary to rock the valve slightly to allow the jacking

screw clearance. Set the jacking mechanism on a clean surface (free of mud or debris), in easy reach for the following steps.

4. Slowly loosen the union nut.

> **Caution:** There should be no resistance caused by back pressure from the transducer acting upon it after it has been loosened one-half turn. If there is, or if you observe any movement of the transducer itself, STOP WORK. Immediately clear the area around the transducer of personnel and contact Accusonic for advice.

5. Gently remove the union nut from the feedthrough assembly as shown in Figure 10-1 on page B-12. At all times, be alert for any transducer movement.

> **Caution:** If, at any time before the jacking tool finally is in place, you observe that the transducer moves even slightly, STOP ALL WORK. Immediately clear the area around the transducer of personnel and contact Accusonic for advice.

6. Gently pull the E-O connector out of the body of the transducer as shown in Figure 10-1 on page B-12. Be alert for transducer movement.

7. Slowly screw the threaded collar of the jacking mechanism valve over the mating thread of the transducer feedthrough. Screw the tool on until in bottoms.

> **Note:** For the first three full turns, be sure to support the far end of the jacking tool so that it does not exert undue torque on the transducer and feedthrough assembly. Be alert for transducer movement.

8. Slowly rotate the bearing lever to advance the tip of the jacking screw into contact with the end of the transducer. This must be done by feel, since the two components meet inside the tool valve. Stop when contact is made.

9. While holding the bearing lever stationary, use a wrench to gently and slowly turn the jacking screw so that it advances into the end of the transducer and begins to engage the inside thread of the transducer.

10. Alternate between turning the bearing lever and then holding it stationary and advancing just the jacking screw to continue threading the jacking screw into the transducer. Do not force it. Continue until the screw bottoms.

> **Note:** As you screw the tool into place, it is necessary to alternately advance and back off on the bearing handle because two threads of different pitches are being taken up at the same time.

11. After the jacking screw bottoms in the transducer, back the screw off slightly so that it will be easier to separate the two later.

12. Turn the bearing lever so that the jacking screw presses the transducer unit assembly inward *slightly*, thereby releasing tension on the locking pin.

> **Note:** The locking pin should rotate easily when it is freed. If necessary, work the bearing lever forward and backward (moving the transducer slightly in and out of the feedthrough) until the pin is free.

13. Slowly loosen the transducer locking pin.

14. Rotate the bearing lever to withdraw the transducer 3/4 of an inch (20mm).

15. Tighten the locking pin firmly against the shaft of the transducer and then back it off one quarter of a turn. This prevents water leakage from around the locking pin.

16. Continue to extract the transducer just until the second O-ring on the transducer body becomes visible - about 3/4 (20mm) inch of the transducer is visible. The transducer face is now clear of the ball valve. (See Figure 10-1 on page B-12).

17. Close the jacking tool valve.

18. Continue turning the bearing lever until the transducer is entirely clear of the valve. Unscrew and remove the transducer from the jacking screw.

19. Inspect the transducer face for growth or buildup. Remove any buildup with a hard nylon scrubber (Dobie) and a mild detergent (Joy).

Note: Handle the transducer with care. Do not cut or nick the O-rings or try to remove them from the transducer.

Caution: Once a transducer face has been cleaned, do not contaminate it with grease, oil or hand or finger prints, as such film will degrade performance of the unit.

20. Screw the transducer back onto the jacking tool.

Note: Transducers are position-specific. Always reinstall a transducer in the same location from which it was removed.

Note: When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one. Make certain that an inner path transducer is replaced with an inner unit and that an outer path transducer is replaced with an outer unit.

21. Just prior to assembly, *lightly* lubricate the O-rings with an appropriate O-ring grease, Parker O-Lube or equivalent.

Warning: Do not use silicone-based grease.

22. Turning the bearing lever, advance the face of the transducer until it just reaches the valve opening.

23. Use a 1/2 inch (13mm) open face wrench on the hex end of the jacking screw to rotate the jacking screw until the alignment slot on the transducer is in alignment with the locking pin on the conduit.

Note: Hold the wrench in place during the following steps to help keep the transducer in alignment until it engages the alignment pin located on the inside end of the feedthrough.

24. Continue to turn the bearing lever, advancing the transducer into the valve housing until the middle O-ring on the transducer just slips inside the valve housing.

25. Slowly open the valve all the way.

26. Continue to ease the transducer into the mount until either it meets increased resistance or until the shoulder of the jacking screw comes flush with the bearing lever. Do not advance the jacking screw shoulder past the surface of the bearing lever.

Note: It may be necessary to rock the valve handle back and forth slightly to allow the transducer to slip through the valve.

Note: If the transducer stops prior to the fully inserted position, it is probably out of alignment. Rock the jacking screw back and forth slightly using the 1/2 inch (13mm) wrench until the unit aligns with the alignment pin and is free to advance further.

CAUTION: Use only enough pressure during insertion to overcome the back pressure from fluid in the pipe. If you try to force the transducer into place when it is misaligned, you will damage the unit, possibly jamming it in the fitting.

27. When the transducer is home, screw in the locking pin until it bottoms. Then back off the pin one quarter turn to allow the transducer to center itself in the mount.

28. Refer to Figure 10-1 on page B-12and verify that the following safety conditions are met. If any of these conditions are not met, there may be a safety hazard. Leave the tool in place. Try removing and reinserting the transducer, and rechecking the safety conditions. If that doesn't solve the problem, STOP WORK IMMEDIATELY and contact Accusonic for advice.

    - **Locking Pin is Fully Engaged** Check that the clearance between the shoulder of the pin and the face of the locking ring is less than the specified limit. Check this by trying to slide the u-shaped end of the clearance gauge under the pin as shown. It must not fit.

- **Locking Ring is Tightly Installed** Check that lock washers (spacers) are installed between both sets of mating faces of the two halves of the locking ring. Verify that the hardware is tight and that the lock washers are compressed flat.

29. Remove the jacking mechanism assembly from the transducer's feedthrough assembly.
30. Reconnect the E-O connector and screw in the union nut.

Caution: Before leaving the transducer, be certain that the locking pin is fully engaged and that the union nut and the E-O connector are installed as shown in Figure 10-1 on page B-12.

This completes removal and assembly of the 7601 Series transducer.

7600 Series Transducers

The transducers are contained in a special mount which allows for removal of the transducer without dewatering the pipe or disturbing the alignment of the unit. A special tool must be used.

The following is a step-by-step procedure for removal, cleaning, and reinsertion of the transducer.

DANGER: THE TRANSDUCER IS PROBABLY UNDER CONSIDERABLE PRESSURE FROM THE LIQUID IN THE PIPE. ANY ATTEMPT TO REMOVE A TRANSDUCER IN ANY OTHER MANNER THAN OUTLINED BELOW MAY CAUSE SERIOUS INJURY TO PERSONS IN THE GENERAL AREA.

Caution: The 7600 transducers are equipped with a padlock locking rod to prevent tampering with the transducer when the proper tool is not in place. Never unlock the padlock unless the transducer removal tool supplied by Accusonic has been installed as described in the following procedures. Never leave an unlocked transducer unattended for even a short period of time.

Caution: Always work from the side of the transducer feedthrough, so that if an error or acomponent failure results in the transducer blowing out of its seat, you are not in the exit trajectory. While working on the transducer, keep the trajectory area clear of other personnel.

Warning: Read through the entire procedure below to be certain you understand it completely. IF YOU DO NOT UNDERSTAND ANY PORTION OF THIS PROCEDURE, STOP FURTHER WORK, DO NOT CONTINUE!

Note: Transducers are position-specific. Always reinstall a transducer in the same location from which it was removed. When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one.

Tools Required

- 7661-L or 7661-S series transducer jacking mechanism (order from Accusonic)
- Medium (8 inch) crescent wrench (or a 1/2 inch (13mm) open-end wrench and a 1 inch (25mm) open-end wrench)
- Key to the transducer padlock (all padlocks shipped by Accusonic use the same key)
- 1/8 inch (3mm) hex (Allen) wrench

Perform Maintenance

1. Verify the following three safety conditions are met below. See Figure 10-3 on page B-14. If any of these conditions is not met, STOP WORK on the transducer immediately and contact Accusonic for advice.

   - **Locking Rod is Padlocked** Check that the padlock on the locking rod is locked. The locking rod should not be in contact with the transducer, and it should be free to slide back and forth.
   - **Clamp Bar is Secure** Check that the two bolts (1/2 inch (13mm) heads) holding the clamp bar are tight.
   - **Clamp Bar Jack Screw is Fully Engaged** Check that the jack screw on the clamp bar presses tightly against the shoulder of the transducer.

   Caution: If, at any time before the jacking tool is finally in place, you observe that the transducer moves even slightly, STOP ALL WORK. Immediately clear the area around the transducer of personnel and contact Accusonic for advice.

   Warning: Do not loosen any set screws on the transducer mount. They are locked in place during setup and alignment of the unit, and must not be disturbed.

2. Locate the jacking tool and retract the jacking screw so that the hex end of the screw extends 1 inch (25mm) from the tool. Set the tool on a clean surface (free of mud or debris), in easy reach for the following steps.

3. Remove the conduit clamp and gently pull the E-O connector out of the body of the transducer cable connector as shown in Figure 10-3 on page B-14.

4. Slowly loosen the clamp screw. Fluid pressure should press the transducer tightly against the screw as it turns, pushing the transducer up and out of its seat slightly. Continue loosening the screw until the transducer moves out of its seat about 1/8 inch (3mm) and the shoulder of the transducer back contacts the locking rod.

   Note: If the transducer fails to move as the screw is loosened, it may be jammed, or there may be low pressure in the conduit. Try alternately tightening and loosening the clamp screw or manually pulling on the transducer to release it. If it does not move, contact Accusonic for advice.

   Warning: Never allow more than 1/16 (1.5mm) inch clearance between the contact point of the clamp screw and the transducer. If the transducer is caught and suddenly breaks free when there is too much clearance, the resulting impact could damage the equipment or cause a safety hazard.

5. Loosen the clamp screw another full turn, retracting it completely from the transducer.

6. Unscrew the two bolts (1/2 inch (13mm) heads) holding the clamp bar and remove it.

   Caution: Always work from the side of the transducer mount, so that if an error or a component failure results in the transducer blowing out of its seat, you are not in the exit path. While working on the transducer, keep the downrange trajectory area clear of other personnel.

7. Bolt the jacking tool to the transducer mount using the clamp bar mounting holes as shown in Figure 10-4 on page B-14. Tighten all four bolts.

8. Rotate the jacking screw to advance the tip of the screw into the recess on the transducer.

9. Use a wrench to tighten the jacking screw until the transducer no longer presses on the locking rod. When pressure on the locking rod is released, the rod should slide freely from side to side.

   Note: Do not tighten the jacking screw past the point where the locking rod is freed.

10. Unlock and remove the padlock and remove the locking rod.

11. Retract the jacking screw slightly (fluid pressure should press the transducer tightly against the jacking screw), and push it out of its seat as the screw is backed off.

Note: If the transducer fails to move as the jacking screw is loosened, it may be jammed or there may be low pressure in the conduit. Try alternately tightening and loosening the jacking screw and pulling on the transducer to release it. If it does not move, contact Accusonic for advice.

Warning: Never allow more than 1/16 (1.5mm) inch clearance between the contact point of the jack and the transducer. If the transducer is caught and then suddenly breaks free when there is too much clearance, the resulting impact could damage the equipment and cause a safety hazard.

12. Continue to retract the transducer until 7 5/8 (195mm) inch of the round transducer body (not counting the square back) is exposed.

Warning: Retracting the transducer too far may allow fluid to leak from the mount.

13. Close the valve on the transducer mount.
14. Completely back off the jacking screw.
15. Grasp the transducer by the square shank and the cable connector and rotate it back and forth slightly to pull it completely out of the mount.

Note: The transducer mount has a movable collar and yoke that serve to align the transducer in the conduit. These were set, locked and sealed during installation. If the collar or yoke are loose now, the transducer will need to be realigned; contact Accusonic for advice.

16. Inspect the transducer face for growth or buildup. Remove any buildup with a hard nylon scrubber (Dobie) and mild detergent (Joy).

Note: Handle the transducer with care. Do not cut or nick the O-rings or try to remove them from the transducer. Do not bend the connector. Protect sealing surfaces from abuse.

Caution: Once the transducer face has been cleaned, do not contaminate it with grease, oil or hand or finger prints, as such film will degrade the performance of the unit.

17. Just prior to assembly, *lightly* lubricate the O-rings with an appropriate O-ring grease, Parker O-Lube or equivalent.

Warning: Do not use silicone-based grease

18. Gently slide the transducer approximately 1/2 inch (13mm) into the mount - just until it remains in place.

Note: Transducers are position-specific. Always reinstall a transducer in the same location from which it was removed.

Note: When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one. Make certain that an inner path transducer is replaced with an inner unit and that an outer path transducer is replaced with an outer unit.

Caution: Be sure that the connector shaft that extends from the transducer back is positioned so that it will engage with the saddle located on the mount as the transducer is pressed into place.

19. Tighten the jacking screw until the pointed tip engages the recess on the transducer.
20. Use a 1/2 (13mm) inch open face wrench on the hex end of the jacking screw to tighten the jacking screw and press the transducer into the mount. Stop when only 7 5/8 inches (195mm) of the round transducer body (excluding the square back) is visible above the shoulder of the mount.
21. Slowly open the valve all the way.
22. Continue to tighten the screw and press the transducer into the mount until either it meets increased resistance or until the shoulder of the jacking screw comes flush with the bearing level. Do not advance the jacking screw shoulder past the surface of the face of the jacking tool.

Note: It may be necessary to rock the valve handle back and forth slightly to allow the transducer to slip through the valve.

Note: Be sure that the connector shaft of the transducer properly seats in the alignment yoke.If necessary, rotate the transducer into alignment by pulling on the body of the cable connector.

23. When the transducer is home, reinstall the locking rod and lock the padlock. Make certain that the locking rod cannot be removed from the mount.
24. Slowly loosen the jacking screw until the shoulder of the transducer presses tightly against the locking rod.

Caution: Until the transducer is snug against the locking rod, never allow more than 1/16 inch (1.5mm) clearance between the contact point of the jack and the transducer. If the transducer is caught and suddenly breaks free when there is too much clearance, the resulting impact could damage the equipment or cause a safety hazard.

25. Loosen four bolts (1/2 inch (13mm) heads) and remove the jacking tool from the transducer mount.
26. Install the clamp bar using the same bolts; tighten both bolts.
27. Finger-tighten the clamp screw until it is snug against the recess on the transducer.
28. Tighten the clamp bar jack screw with a 1 inch (25mm) wrench until the transducer bottoms in the mount. Do not over tighten.
29. Connect the E-O connector and screw on the conduit clamp.

Caution: Before leaving the transducer, be certain that the locking rod is fully engaged and padlocked and that the E-O connector is installed as shown in Figure 10-3 on page B-14.

This completes removal and assembly of the 7600 Series transducer.

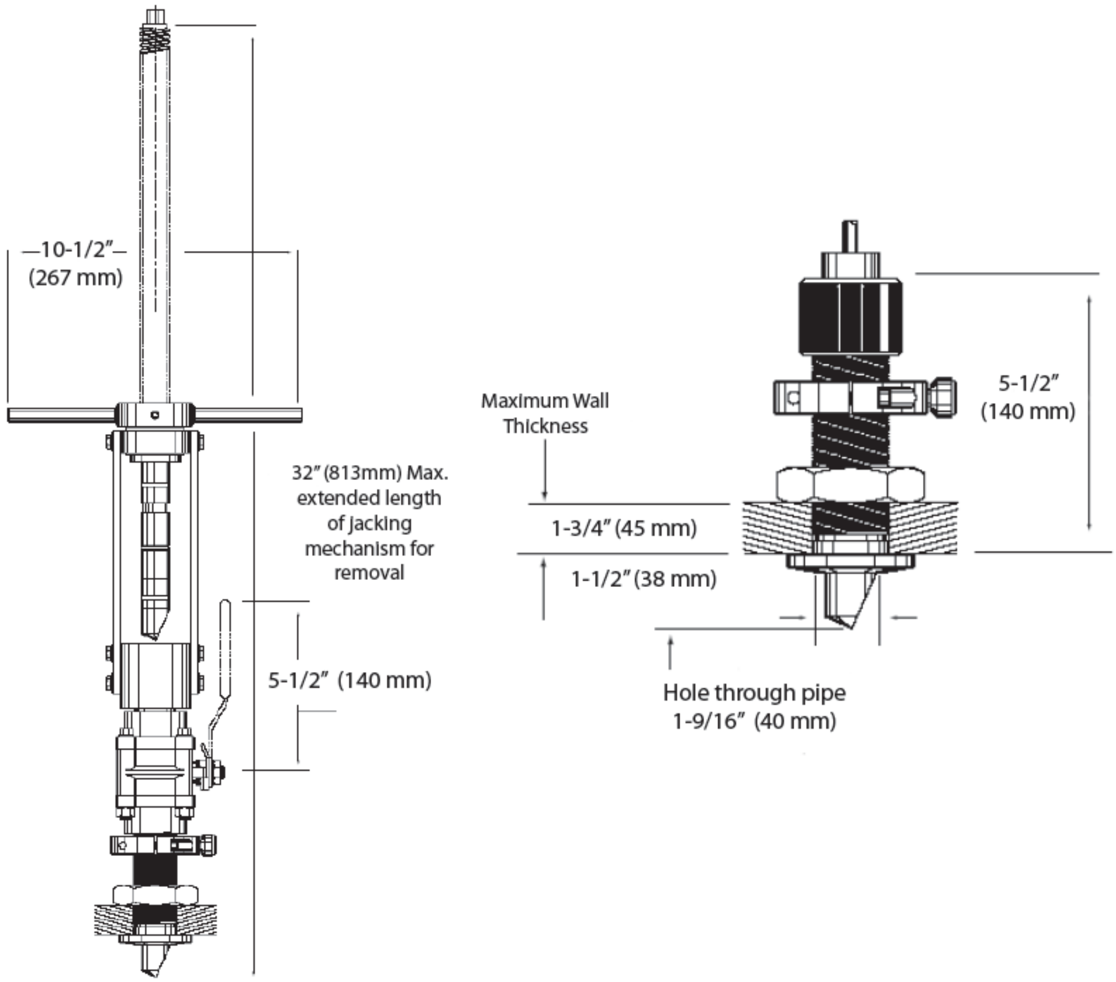


Figure 10-1 7601 Transducer Installed Error! Bookmark not defined.

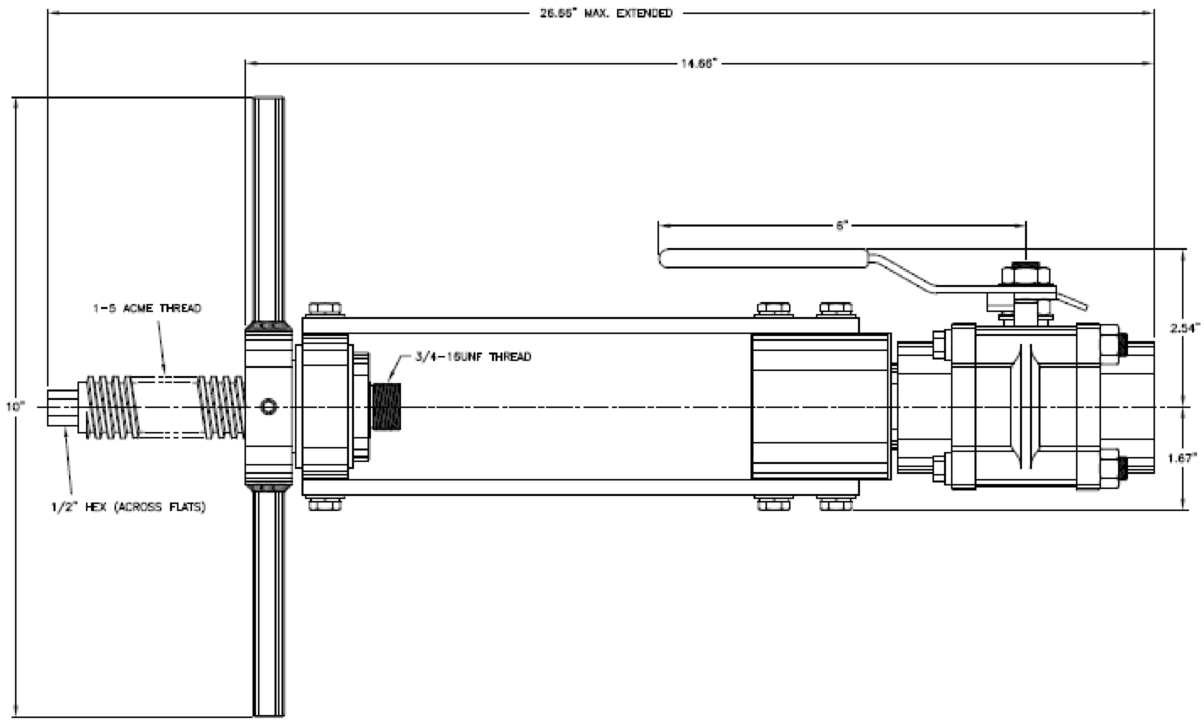


Figure 10-2 7642 Transducer Extraction Tool (Uninstalled)

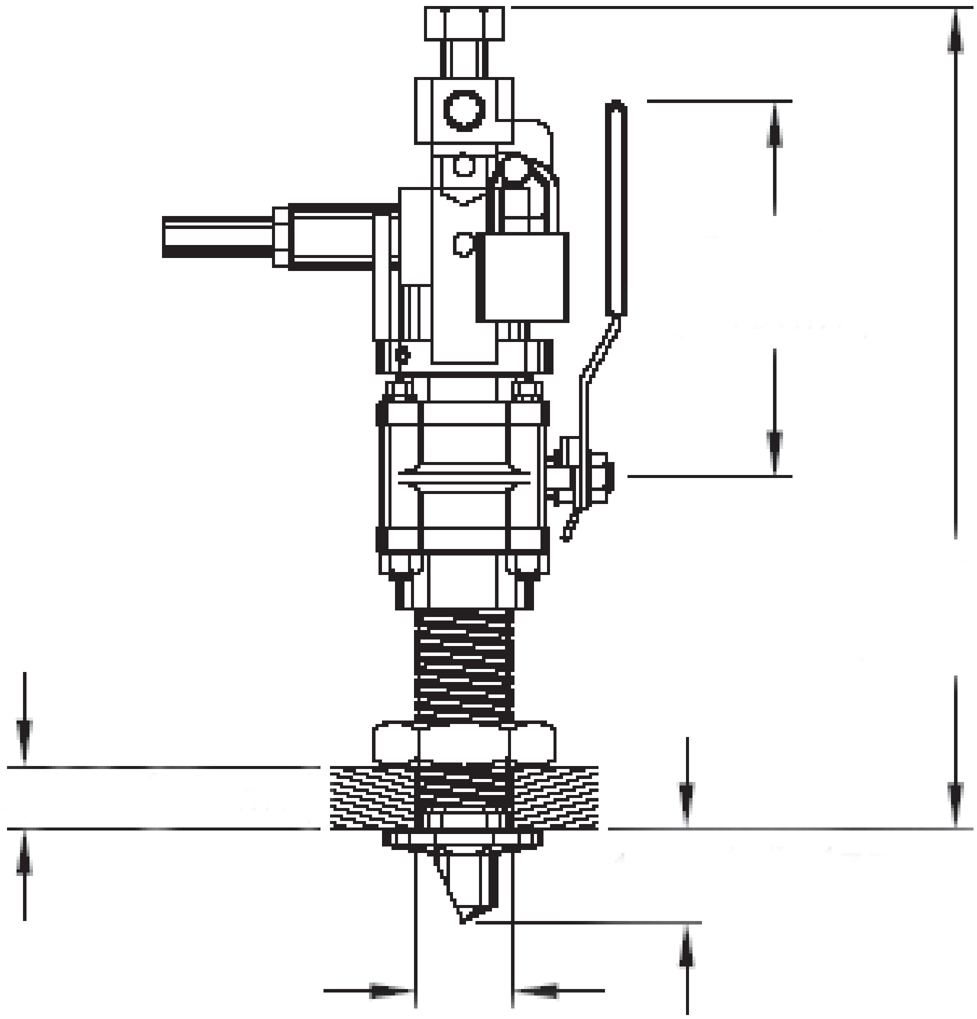


Figure 10-3 7600 Transducer

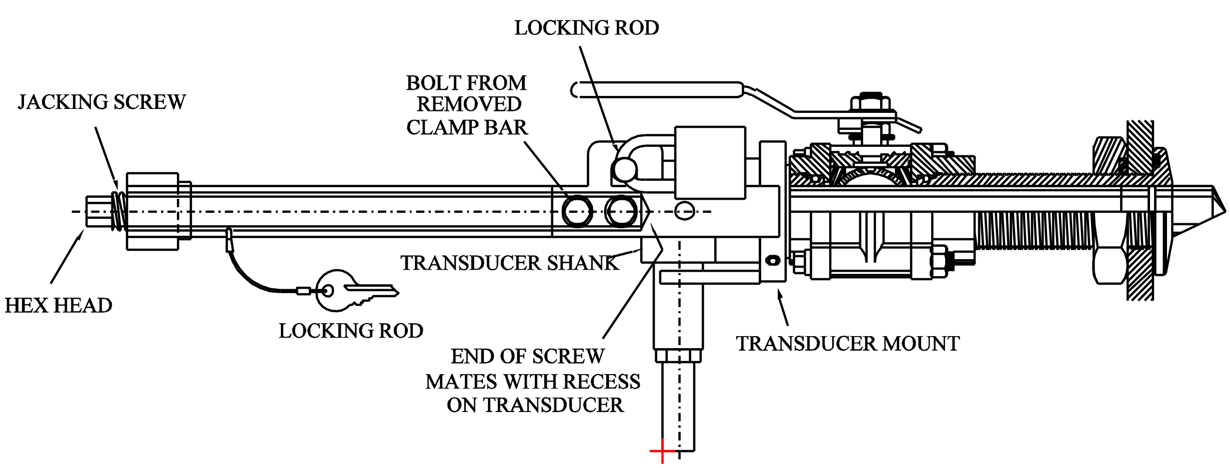


Figure 10-4 7600 Transducer Assembly with Extraction Tool Installed

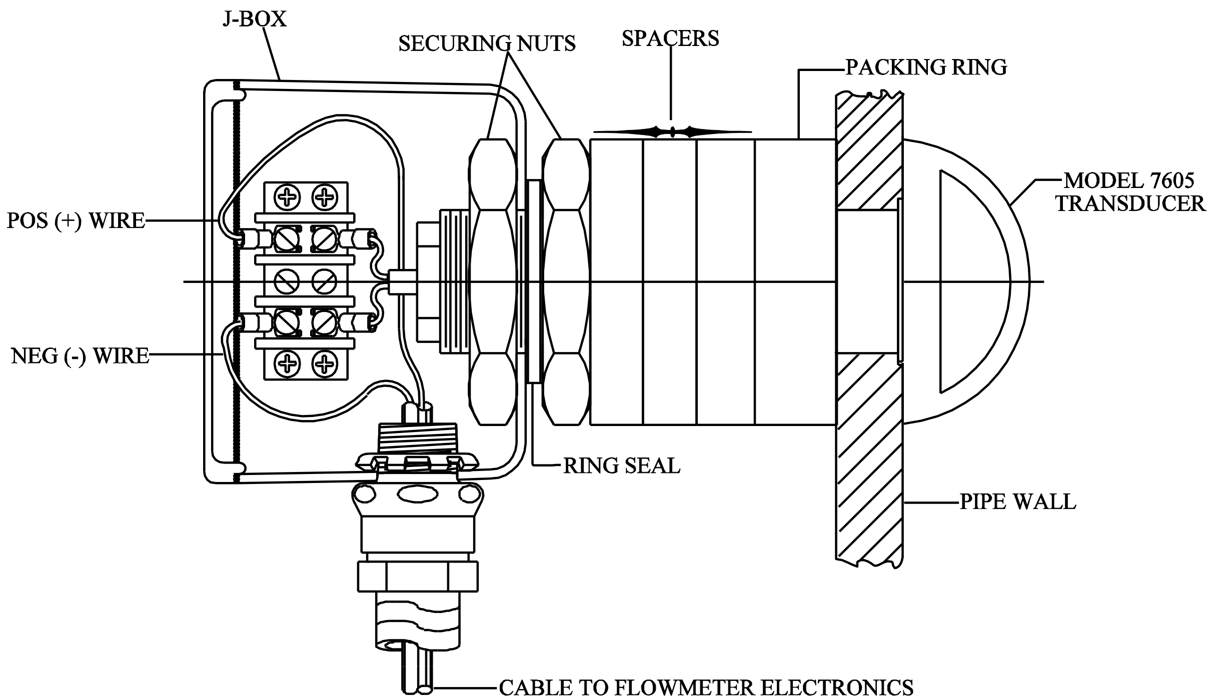


Figure 10-5 Model 7605 Stainless Steel Transducer

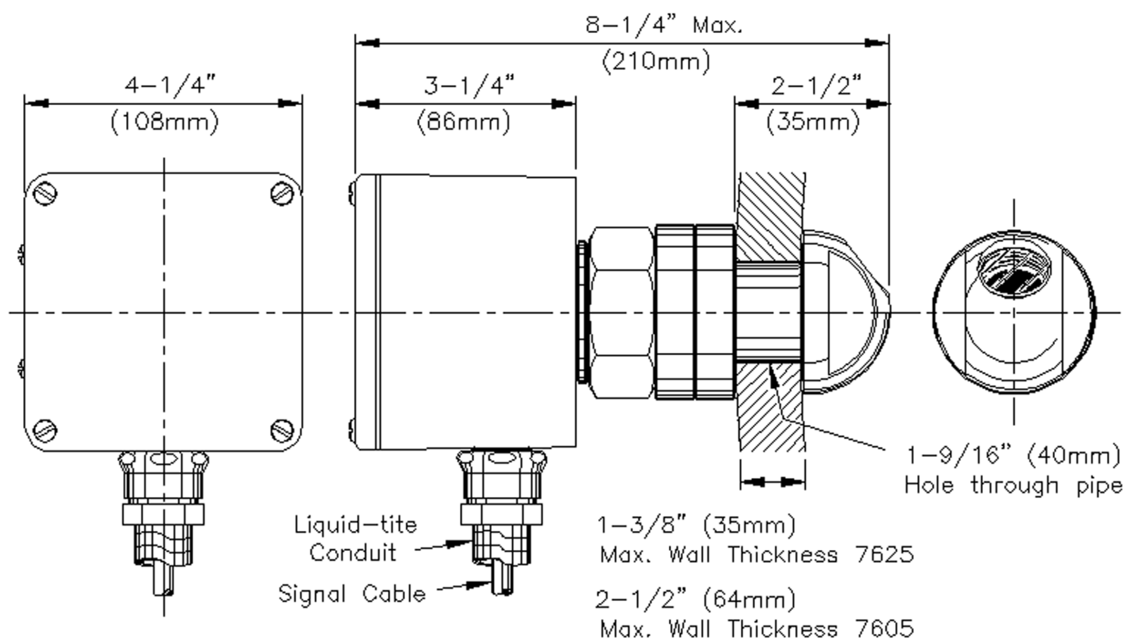


Figure 10-6 Model 7625 PVC Transducer

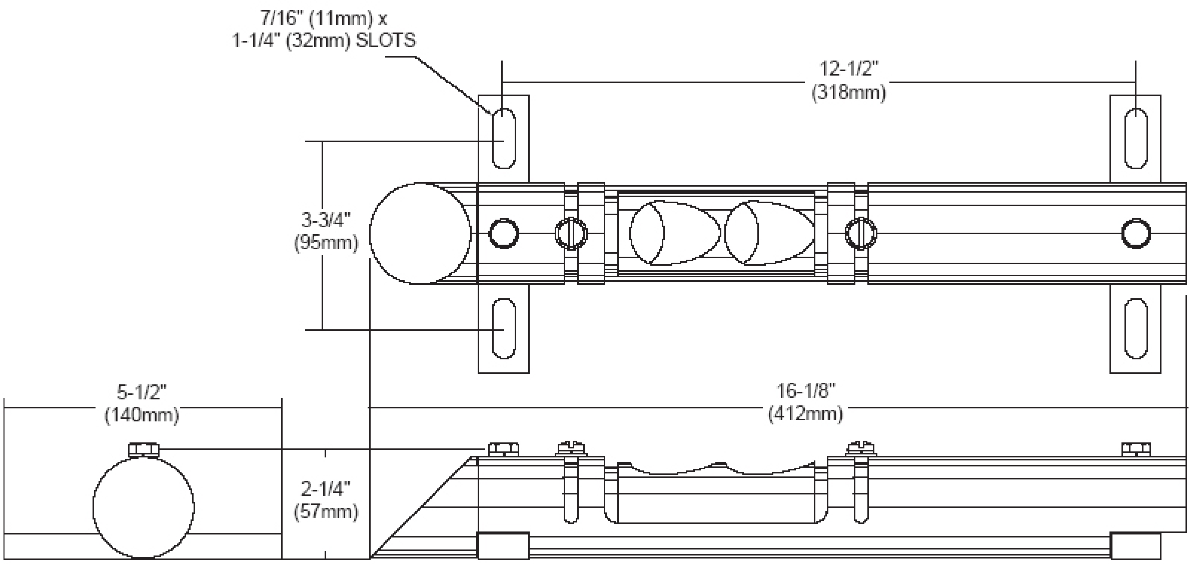


Figure 10-7 Model 7630/34 Internal Mount Transducer

APPENDIX C

Modbus Mapping Guide

Read-Only Registers

Note: The 8510+ uses the 3x register range (starting with 30001) to expose the variables (data) that result from the flow measurement process. This same data is mirrored to the 4x range (starting at 42001) and is also treated as read-only by the 8510+.

Address	Variable	Notes
30001 (42001)	Flow Section1	32-bit Float
30003 (42003)	Flow Section2	32-bit Float
30005 (42005)	Flow Section3	32-bit Float
30007 (42007)	Flow Section4	32-bit Float
30009 (42009)	Flow Section5	32-bit Float
30011 (42011)	Volume Section1	32-bit Float
30013 (42013)	Volume Section2	32-bit Float
30015 (42015)	Volume Section3	32-bit Float
30017 (42017)	Volume Section4	32-bit Float
30019 (42019)	Volume Section5	32-bit Float
30021 (42021)	Temperature Section1	32-bit Float
30023 (42023)	Temperature Section2	32-bit Float
30025 (42025)	Temperature Section3	32-bit Float
30027 (42027)	Temperature Section4	32-bit Float
30029 (42029)	Temperature Section5	32-bit Float
30031 (42031)	Level Section1	32-bit Float
30033 (42033)	Level Section2	32-bit Float
30035 (42035)	Level Section3	32-bit Float
30037 (42037)	Level Section4	32-bit Float
30039 (42039)	Level Section5	32-bit Float
30041 (42041)	Status Section1	32-bit integer
30043 (42043)	Status Section2	32-bit integer
30045 (42045)	Status Section3	32-bit integer
30047 (42047)	Status Section4	32-bit integer
30049 (42049)	Status Section5	32-bit integer

	Read-Only Registers (cont.)	
Address	**Variable**	**Notes**
30051 (42051)	Total Flow	32-bit Float
30053 (42053)	Total Volume	32-bit Float
30055 (42055)	Velocity path1	32-bit Float
30057 (42057)	Velocity path2	32-bit Float
30059 (42059)	Velocity path3	32-bit Float
30061 (42061)	Velocity path4	32-bit Float
30063 (42063)	Velocity path5	32-bit Float
30065 (42065)	Velocity path6	32-bit Float
30067 (42067)	Velocity path7	32-bit Float
30069 (42069)	Velocity path8	32-bit Float
30071 (42071)	Velocity path9	32-bit Float
30073 (42073)	Velocity path10	32-bit Float
30075 (42075)	Velocity of Sound path1	32-bit Float
30077 (42077)	Velocity of Sound path2	32-bit Float
30079 (42079)	Velocity of Sound path3	32-bit Float
30081 (42081)	Velocity of Sound path4	32-bit Float
30083 (42083)	Velocity of Sound path5	32-bit Float
30085 (42085)	Velocity of Sound path6	32-bit Float
30087 (42087)	Velocity of Sound path7	32-bit Float
30089 (42089)	Velocity of Sound path8	32-bit Float
30091 (42091)	Velocity of Sound path9	32-bit Float
30093 (42093)	Velocity of Sound path10	32-bit Float
30095 (42095)	Gain(db) path1	32-bit Float
30097 (42097)	Gain(db) path2	32-bit Float
30099 (42099)	Gain(db) path3	32-bit Float
30101 (42101)	Gain(db) path4	32-bit Float
30103 (42103)	Gain(db) path5	32-bit Float
30105 (42105)	Gain(db) path6	32-bit Float
30107 (42107)	Gain(db) path7	32-bit Float
30109 (42109)	Gain(db) path8	32-bit Float
30111 (42111)	Gain(db) path9	32-bit Float
30113 (42113)	Gain(db) path10	32-bit Float
30115 (42115)	Gain(%S) path1	32-bit Float
30117 (42117)	Gain(%S) path2	32-bit Float
30119 (42119)	Gain(%S) path3	32-bit Float
30121 (42121)	Gain(%S) path4	32-bit Float
30123 (42123)	Gain(%S) path5	32-bit Float
30125 (42125)	Gain(%S) path6	32-bit Float
30127 (42127)	Gain(%S) path7	32-bit Float

	Read-Only Registers (cont.)	
Address	**Variable**	**Notes**
30129 (42129)	Gain(%S) path8	32-bit Float
30131 (42131)	Gain(%S) path9	32-bit Float
30133 (42133)	Gain(%S) path10	32-bit Float
30135 (42135)	Signal to Noise Path 1	32-bit Float
30137 (42137)	Signal to Noise Path2	32-bit Float
30139 (42139)	Signal to Noise Path3	32-bit Float
30141 (42141)	Signal to Noise Path4	32-bit Float
30143 (42143)	Signal to Noise Path5	32-bit Float
30145 (42145)	Signal to Noise Path6	32-bit Float
30147 (42147)	Signal to Noise Path7	32-bit Float
30149 (42149)	Signal to Noise Path8	32-bit Float
30151 (42151)	Signal to Noise Path9	32-bit Float
30153 (42153)	Signal to Noise Path10	32-bit Float
30155 (42155)	Envelope Fwd Time Path 1	32-bit Float
30157 (42157)	Envelope Fwd Time Path 2	32-bit Float
30159 (42159)	Envelope Fwd Time Path 3	32-bit Float
30161 (42161)	Envelope Fwd Time Path 4	32-bit Float
30163 (42163)	Envelope Fwd Time Path 5	32-bit Float
30165 (42165)	Envelope Fwd Time Path 6	32-bit Float
30167 (42167)	Envelope Fwd Time Path 7	32-bit Float
30169 (42169)	Envelope Fwd Time Path 8	32-bit Float
30171 (42171)	Envelope Fwd Time Path 9	32-bit Float
30173 (42173)	Envelope Fwd Time Path 10	32-bit Float
30175 (42175)	Envelope Rev Time Path 1	32-bit Float
30177 (42177)	Envelope Rev Time Path 2	32-bit Float
30179 (42179)	Envelope Rev Time Path 3	32-bit Float
30181 (42181)	Envelope Rev Time Path 4	32-bit Float
30183 (42183)	Envelope Rev Time Path 5	32-bit Float
30185 (42185)	Envelope Rev Time Path 6	32-bit Float
30187 (42187)	Envelope Rev Time Path 7	32-bit Float
30189 (42189)	Envelope Rev Time Path 8	32-bit Float
30191 (42191)	Envelope Rev Time Path 9	32-bit Float
30193 (42193)	Envelope Rev Time Path 10	32-bit Float
30195 (42195)	Zero-Crossing Fwd Time Path 1	32-bit Float
30197 (42197)	Zero-Crossing Fwd Time Path 2	32-bit Float
30199 (42199)	Zero-Crossing Fwd Time Path 3	32-bit Float
30201 (42201)	Zero-Crossing Fwd Time Path 4	32-bit Float
30203 (42203)	Zero-Crossing Fwd Time Path 5	32-bit Float
30205 (42205)	Zero-Crossing Fwd Time Path 6	32-bit Float

Read-Only Registers (continued)		
Address	Variable	Notes
30207 (42207)	Zero-Crossing Fwd Time Path 7	32-bit Float
30209 (42209)	Zero-Crossing Fwd Time Path 8	32-bit Float
30211 (42211)	Zero-Crossing Fwd Time Path 9	32-bit Float
30213 (42213)	Zero-Crossing Fwd Time Path 10	32-bit Float
30215 (42215)	Zero-Crossing Rev Time Path 1	32-bit Float
30217 (42217)	Zero-Crossing Rev Time Path 2	32-bit Float
30219 (42219)	Zero-Crossing Rev Time Path 3	32-bit Float
30221 (42221)	Zero-Crossing Rev Time Path 4	32-bit Float
30223 (42223)	Zero-Crossing Rev Time Path 5	32-bit Float
30225 (42225)	Zero-Crossing Rev Time Path 6	32-bit Float
30227 (42227)	Zero-Crossing Rev Time Path 7	32-bit Float
30229 (42229)	Zero-Crossing Rev Time Path 8	32-bit Float
30231 (42231)	Zero-Crossing Rev Time Path 9	32-bit Float
30233 (42233)	Zero-Crossing Rev Time Path 10	32-bit Float
30235 (42235)	Travel Time Difference Path 1	32-bit Float
30237 (42237)	Travel Time Difference Path 2	32-bit Float
30239 (42239)	Travel Time Difference Path 3	32-bit Float
30241 (42241)	Travel Time Difference Path 4	32-bit Float
30243 (42243)	Travel Time Difference Path 5	32-bit Float
30245 (42245)	Travel Time Difference Path 6	32-bit Float
30247 (42247)	Travel Time Difference Path 7	32-bit Float
30249 (42249)	Travel Time Difference Path 8	32-bit Float
30251 (42251)	Travel Time Difference Path 9	32-bit Float
30253 (42253)	Travel Time Difference Path 10	32-bit Float
30255 (42255)	Status Path1	32-bit integer
30257 (42257)	Status Path2	32-bit integer
30259 (42259)	Status Path3	32-bit integer
30261 (42261)	Status Path4	32-bit integer
30263 (42263)	Status Path5	32-bit integer
30265 (42265)	Status Path6	32-bit integer
30267 (42267)	Status Path7	32-bit integer
30269 (42269)	Status Path8	32-bit integer
30271 (42271)	Status Path9	32-bit integer
30273 (42273)	Status Path10	32-bit integer
30275 (42275)	Scaled Level Channel1	32-bit Float
30277 (42277)	Scaled Level Channel2	32-bit Float
30279 (42279)	Scaled Level Channel3	32-bit Float
30281 (42281)	Scaled Level Channel4	32-bit Float
30283 (42283)	Scaled Level Channel5	32-bit Float

Read-Only Registers (continued)		
Address	**Variable**	**Notes**
30285 (42285)	Scaled Level Channel6	32-bit Float
30287 (42287)	Scaled Level Channel7	32-bit Float
30289 (42289)	Scaled Level Channel8	32-bit Float
30291 (42291)	Unscaled Level Channel1	32-bit integer
30293 (42293)	Unscaled Level Channel2	32-bit integer
30295 (42295)	Unscaled Level Channel3	32-bit integer
30297 (42297)	Unscaled Level Channel4	32-bit integer
30299 (42299)	Unscaled Level Channel5	32-bit integer
30301 (42301)	Unscaled Level Channel6	32-bit integer
30303 (42303)	Unscaled Level Channel7	32-bit integer
30305 (42305)	Unscaled Level Channel8	32-bit integer
30307 (42307)	Status Level1	32-bit integer
30309 (42309)	Status Level2	32-bit integer
30311 (42311)	Status Level3	32-bit integer
30313 (42313)	Status Level4	32-bit integer
30315 (42315)	Status Level5	32-bit integer
30317 (42317)	Status Level6	32-bit integer
30319 (42319)	Status Level7	32-bit integer
30321 (42321)	Status Level8	32-bit integer

Coil/Status Signals

Coil #	Variable	Notes
Coil 1	Section 1 On	Coil Status
Coil 2	Section 1 Fail	Coil Status
Coil 3	Section 1 Full	Coil Status
Coil 4	Section 2 On	Coil Status
Coil 5	Section 2 Fail	Coil Status
Coil 6	Section 2 Full	Coil Status
Coil 7	Section 3 On	Coil Status
Coil 8	Section 3 Fail	Coil Status
Coil 9	Section 3 Full	Coil Status
Coil 10	Section 4 On	Coil Status
Coil 11	Section 4 Fail	Coil Status
Coil 12	Section 4 Full	Coil Status
Coil 13	Section 5 On	Coil Status
Coil 14	Section 5 Fail	Coil Status

	Coil/Status Signals (cont.)	
Coil#	**Variable**	**Notes**
Coil 15	Section 5 Full	Coil Status
Coil 16	Path 1 Fail	Coil Status
Coil 17	Path 1 Out of Water	Coil Status
Coil 18	Path 1 Velocity Error	Coil Status
Coil 19	Path 2 Fail	Coil Status
Coil 20	Path 2 Out of Water	Coil Status
Coil 21	Path 2 Velocity Error	Coil Status
Coil 22	Path 3 Fail	Coil Status
Coil 23	Path 3 Out of Water	Coil Status
Coil 24	Path 3 Velocity Error	Coil Status
Coil 25	Path 4 Fail	Coil Status
Coil 26	Path 4 Out of water	Coil Status
Coil 27	Path 4 Velocity Error	Coil Status
Coil 28	Path 5 Fail	Coil Status
Coil 29	Path 5 Out of water	Coil Status
Coil 30	Path 5 Velocity Error	Coil Status
Coil 31	Path 6 Fail	Coil Status
Coil 32	Path 6 Out of water	Coil Status
Coil 33	Path 6 Velocity Error	Coil Status
Coil 34	Path 7 Fail	Coil Status
Coil 35	Path 7 Out of water	Coil Status
Coil 36	Path 7 Velocity Error	Coil Status
Coil 37	Path 8 Fail	Coil Status
Coil 38	Path 8 Out of Water	Coil Status
Coil 39	Path 8 Velocity Error	Coil Status
Coil 40	Path 9 Fail	Coil Status
Coil 41	Path 9 Out of Water	Coil Status
Coil 42	Path 9 Velocity Error	Coil Status
Coil 43	Path 10 Fail	Coil Status
Coil 44	Path 10 Out of Water	Coil Status
Coil 45	Path 10 Velocity Error	Coil Status
Coil 46	Level 1 < Min MA	Coil Status
Coil 47	Level 1 Fail	Coil Status
Coil 48	Level 1 > Max Layer Height	Coil Status
Coil 49	Level 1 < Low Level	Coil Status
Coil 50	Level 2 < Min MA	Coil Status
Coil 51	Level 2 Fail	Coil Status

Coil Status Signals (cont.)		
Coil #	**Variable**	**Notes**
Coil 52	Level 2 > Max Layer Height	Coil Status
Coil 53	Level 2 < Low Level	Coil Status
Coil 54	Level 3 < Min MA	Coil Status
Coil 55	Level 3 Fail	Coil Status
Coil 56	Level 3 > Max Layer Height	Coil Status
Coil 57	Level 3 < Low Level	Coil Status
Coil 58	Level 4 < Min MA	Coil Status
Coil 59	Level 4 Fail	Coil Status
Coil 60	Level 4 > Max Layer Height	Coil Status
Coil 61	Level 4 < Low Level	Coil Status
Coil 62	Level 5 < Min MA	Coil Status
Coil 63	Level 5 Fail	Coil Status
Coil 64	Level 5 > Max Layer Height	Coil Status
Coil 65	Level 5 < Low Level	Coil Status
Coil 66	Level 6 < Min MA	Coil Status
Coil 67	Level 6 Fail	Coil Status
Coil 68	Level 6 > Max Layer Height	Coil Status
Coil 69	Level 6 < Low Level	Coil Status
Coil 70	Level 7 < Min MA	Coil Status
Coil 71	Level 7 Fail	Coil Status
Coil 72	Level 7 > Max Layer Height	Coil Status
Coil 73	Level 7 < Low Level	Coil Status
Coil 74	Level 8 < Min MA	Coil Status
Coil 75	Level 8 Fail	Coil Status
Coil 76	Level 8 > Max Layer Height	Coil Status
Coil 77	Level 8 < Low Level	Coil Status

Read-Write Registers

Address	Parameter	Notes
40001	Flow Scaling	32-bit float
40003	Volume Scaling	32-bit float
40005	Rep Time	32-bit Integer
40007	System Clock	32-bit float
40009	Analog Output Scaling	32-bit float
40011	Number of Accumulates	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameter**	**Notes**
40013	English or Metric	32-bit Integer
40015	Blank	32-bit Integer
40017	Auto Store	32-bit Integer
40019	Pipe or Open Channel Mode	32-bit Integer
40021	Flow Averaging Period	32-bit Integer
40023	Display Units	32-bit Integer
40025	Detection Method	32-bit Integer
40027	DSP ID	32-bit Integer
40029	Device ID	32-bit Integer
40031	Section 1 Pipe Area	32-bit float
40033	Section 1 Bottom Friction	32-bit float
40035	Section 1 Min Submersion	32-bit float
40037	Section 1 Top Weight	32-bit float
40039	Section 1 Low Flow Cutoff	32-bit float
40041	Section 1 Temp Correction	32-bit float
40043	Section 1 Manning n	32-bit float
40045	Section 1 Manning Slope	32-bit float
40047	Section 1 Manning Max	32-bit float
40049	Section 1 Level Manual Value	32-bit float
40051	Section 1 Surcharge Level	32-bit float
40053	Section 1 Low Level Cutoff	32-bit float
40055	Section 1 Volume Initial Value	32-bit float
40057	Section 1 Layer Width 1	32-bit float
40059	Section 1 Layer Width 2	32-bit float
40061	Section 1 Layer Width 3	32-bit float
40063	Section 1 Layer Width 4	32-bit float
40065	Section 1 Layer Width 5	32-bit float
40067	Section 1 Layer Width 6	32-bit float
40069	Section 1 Layer Width 7	32-bit float
40071	Section 1 Layer Width 8	32-bit float
40073	Section 1 Layer Elevation 1	32-bit float
40075	Section 1 Layer Elevation 2	32-bit float
40077	Section 1 Layer Elevation 3	32-bit float
40079	Section 1 Layer Elevation 4	32-bit float
40081	Section 1 Layer Elevation 5	32-bit float
40083	Section 1 Layer Elevation 6	32-bit float
40085	Section 1 Layer Elevation 7	32-bit float
40087	Section 1 Layer Elevation 8	32-bit float
40089	Section 1 Path Enable	32-bit Integer

Read-Write Registers (cont.)		
Address	Parameter	Notes
40091	Section 1 Level Enable	32-bit Integer
40093	Section 1 Min Good Paths	32-bit Integer
40095	Section 1 Surcharge Trap/Pipe Int	32-bit Integer
40097	Section 1 Learn Path Ratios	32-bit Integer
40099	Section 1 Manual Level	32-bit Integer
40101	Section 1 Number of Layers	32-bit Integer
40103	Section 2 Pipe Area	32-bit float
40105	Section 2 Bottom Friction	32-bit float
40107	Section 2 Min Submersion	32-bit float
40109	Section 2 Top Weight	32-bit float
40111	Section 2 Low Flow Cutoff	32-bit float
40113	Section 2 Temp Correction	32-bit float
40115	Section 2 Manning n	32-bit float
40117	Section 2 Manning Slope	32-bit float
40119	Section 2 Manning Max	32-bit float
40121	Section 2 Level Manual Value	32-bit float
40123	Section 2 Surcharge Level	32-bit float
40125	Section 2 Low Level Cutoff	32-bit float
40127	Section 2 Volume Initial Value	32-bit float
40129	Section 2 Layer Width 1	32-bit float
40131	Section 2 Layer Width 2	32-bit float
40133	Section 2 Layer Width 3	32-bit float
40135	Section 2 Layer Width 4	32-bit float
40137	Section 2 Layer Width 5	32-bit float
40139	Section 2 Layer Width 6	32-bit float
40141	Section 2 Layer Width 7	32-bit float
40143	Section 2 Layer Width 8	32-bit float
40145	Section 2 Layer Elevation 1	32-bit float
40147	Section 2 Layer Elevation 2	32-bit float
40149	Section 2 Layer Elevation 3	32-bit float
40151	Section 2 Layer Elevation 4	32-bit float
40153	Section 2 Layer Elevation 5	32-bit float
40155	Section 2 Layer Elevation 6	32-bit float
40157	Section 2 Layer Elevation 7	32-bit float
40159	Section 2 Layer Elevation 8	32-bit float
40161	Section 2 Path Enable	32-bit Integer
40163	Section 2 Level Enable	32-bit Integer
40165	Section 2 Min Good Paths	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameters**	**Notes**
40167	Section 2 Surcharge Trap/Pipe Int	32-bit Integer
40169	Section 2 Learn Path Ratios	32-bit Integer
40171	Section 2 Manual Level	32-bit Integer
40173	Section 2 Number of Layers	32-bit Integer
40175	Section 3 Pipe Area	32-bit float
40177	Section 3 Bottom Friction	32-bit float
40179	Section 3 Min Submersion	32-bit float
40181	Section 3 Top Weight	32-bit float
40183	Section 3 Low Flow Cutoff	32-bit float
40185	Section 3 Temp Correction	32-bit float
40187	Section 3 Manning n	32-bit float
40189	Section 3 Manning Slope	32-bit float
40191	Section 3 Manning Max	32-bit float
40193	Section 3 Level Manual Value	32-bit float
40195	Section 3 Surcharge Level	32-bit float
40197	Section 3 Low Level Cutoff	32-bit float
40199	Section 3 Volume Initial Value	32-bit float
40201	Section 3 Layer Width 1	32-bit float
40203	Section 3 Layer Width 2	32-bit float
40205	Section 3 Layer Width 3	32-bit float
40207	Section 3 Layer Width 4	32-bit float
40209	Section 3 Layer Width 5	32-bit float
40211	Section 3 Layer Width 6	32-bit float
40213	Section 3 Layer Width 7	32-bit float
40215	Section 3 Layer Width 8	32-bit float
40217	Section 3 Layer Elevation 1	32-bit float
40219	Section 3 Layer Elevation 2	32-bit float
40221	Section 3 Layer Elevation 3	32-bit float
40223	Section 3 Layer Elevation 4	32-bit float
40225	Section 3 Layer Elevation 5	32-bit float
40227	Section 3 Layer Elevation 6	32-bit float
40229	Section 3 Layer Elevation 7	32-bit float
40231	Section 3 Layer Elevation 8	32-bit float
40233	Section 3 Path Enable	32-bit Integer
40235	Section 3 Level Enable	32-bit Integer
40237	Section 3 Min Good Paths	32-bit Integer
40239	Section 3 Surcharge Trap/Pipe Int	32-bit Integer
40241	Section 3 Learn Path Ratios	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameters**	**Notes**
40243	Section 3 Manual Level	32-bit Integer
40245	Section 3 Number of Layers	32-bit Integer
40247	Section 4 Pipe Area	32-bit float
40249	Section 4 Bottom Friction	32-bit float
40251	Section 4 Min Submersion	32-bit float
40253	Section 4 Top Weight	32-bit float
40255	Section 4 Low Flow Cutoff	32-bit float
40257	Section 4 Temp Correction	32-bit float
40259	Section 4 Manning n	32-bit float
40261	Section 4 Manning Slope	32-bit float
40263	Section 4 Manning Max	32-bit float
40265	Section 4 Level Manual Value	32-bit float
40267	Section 4 Surcharge Level	32-bit float
40269	Section 4 Low Level Cutoff	32-bit float
40271	Section 4 Volume Initial Value	32-bit float
40273	Section 4 Layer Width 1	32-bit float
40275	Section 4 Layer Width 2	32-bit float
40277	Section 4 Layer Width 3	32-bit float
40279	Section 4 Layer Width 4	32-bit float
40281	Section 4 Layer Width 5	32-bit float
40283	Section 4 Layer Width 6	32-bit float
40285	Section 4 Layer Width 7	32-bit float
40287	Section 4 Layer Width 8	32-bit float
40289	Section 4 Layer Elevation 1	32-bit float
40291	Section 4 Layer Elevation 2	32-bit float
40293	Section 4 Layer Elevation 3	32-bit float
40295	Section 4 Layer Elevation 4	32-bit float
40297	Section 4 Layer Elevation 5	32-bit float
40299	Section 4 Layer Elevation 6	32-bit float
40301	Section 4 Layer Elevation 7	32-bit float
40303	Section 4 Layer Elevation 8	32-bit float
40305	Section 4 Path Enable	32-bit Integer
40307	Section 4 Level Enable	32-bit Integer
40309	Section 4 Min Good Paths	32-bit Integer
40311	Section 4 Surcharge Trap/Pipe Int	32-bit Integer
40313	Section 4 Learn Path Ratios	32-bit Integer
40315	Section 4 Manual Level	32-bit Integer
40317	Section 4 Number of Layers	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameters**	**Notes**
40319	Section 5 Pipe Area	32-bit float
40321	Section 5 Bottom Friction	32-bit float
40323	Section 5 Min Submersion	32-bit float
40325	Section 5 Top Weight	32-bit float
40327	Section 5 Low Flow Cutoff	32-bit float
40329	Section 5 Temp Correction	32-bit float
40331	Section 5 Manning n	32-bit float
40333	Section 5 Manning Slope	32-bit float
40335	Section 5 Manning Max	32-bit float
40337	Section 5 Level Manual Value	32-bit float
40339	Section 5 Surcharge Level	32-bit float
40341	Section 5 Low Level Cutoff	32-bit float
40343	Section 5 Volume Initial Value	32-bit float
40345	Section 5 Layer Width 1	32-bit float
40347	Section 5 Layer Width 2	32-bit float
40349	Section 5 Layer Width 3	32-bit float
40351	Section 5 Layer Width 4	32-bit float
40353	Section 5 Layer Width 5	32-bit float
40355	Section 5 Layer Width 6	32-bit float
40357	Section 5 Layer Width 7	32-bit float
40359	Section 5 Layer Width 8	32-bit float
40361	Section 5 Layer Elevation 1	32-bit float
40363	Section 5 Layer Elevation 2	32-bit float
40365	Section 5 Layer Elevation 3	32-bit float
40367	Section 5 Layer Elevation 4	32-bit float
40369	Section 5 Layer Elevation 5	32-bit float
40371	Section 5 Layer Elevation 6	32-bit float
40373	Section 5 Layer Elevation 7	32-bit float
40375	Section 5 Layer Elevation 8	32-bit float
40377	Section 5 Path Enable	32-bit Integer
40379	Section 5 Level Enable	32-bit Integer
40381	Section 5 Min Good Paths	32-bit Integer
40383	Section 5 Surcharge Trap/Pipe Int	32-bit Integer
40385	Section 5 Learn Path Ratios	32-bit Integer
40387	Section 5 Manual Level	32-bit Integer
40389	Section 5 Number of Layers	32-bit Integer
40391	Path 1 Angle	32-bit float
40393	Path 1 Length	32-bit float
40395	Path 1 Weight	32-bit float

Read-Write Registers (cont.)		
Address	**Parameters**	**Notes**
40397	Path 1 Elevation	32-bit float
40399	Path 1 Signal Delay	32-bit float
40401	Path 1 Transducer Freq	32-bit float
40403	Path 1 Max Path Velocity	32-bit float
40405	Path 1 Max Velocity Change	32-bit float
40407	Path 1 Max Bad Measures	32-bit Integer
40409	Path 2 Angle	32-bit float
40411	Path 2 Length	32-bit float
40413	Path 2 Weight	32-bit float
40415	Path 2 Elevation	32-bit float
40417	Path 2 Signal Delay	32-bit float
40419	Path 2 Transducer Freq	32-bit float
40421	Path 2 Max Path Velocity	32-bit float
40423	Path 2 Max Velocity Change	32-bit float
40425	Path 2 Max Bad Measures	32-bit Integer
40427	Path 3 Angle	32-bit float
40429	Path 3 Length	32-bit float
40431	Path 3 Weight	32-bit float
40433	Path 3 Elevation	32-bit float
40435	Path 3 Signal Delay	32-bit float
40437	Path 3 Transducer Freq	32-bit float
40439	Path 3 Max Path Velocity	32-bit float
40441	Path 3 Max Velocity Change	32-bit float
40443	Path 3 Max Bad Measures	32-bit Integer
40445	Path 4 Angle	32-bit float
40447	Path 4 Length	32-bit float
40449	Path 4 Weight	32-bit float
40451	Path 4 Elevation	32-bit float
40453	Path 4 Signal Delay	32-bit float
40455	Path 4 Transducer Freq	32-bit float
40457	Path 4 Max Path Velocity	32-bit float
40459	Path 4 Max Velocity Change	32-bit float
40461	Path 4 Max Bad Measures	32-bit Integer
40463	Path 5 Angle	32-bit float
40465	Path 5 Length	32-bit float
40467	Path 5 Weight	32-bit float
40469	Path 5 Elevation	32-bit float
40471	Path 5 Signal Delay	32-bit float
40473	Path 5 Transducer Freq	32-bit float

Read-Write Registers (cont.)		
Address	**Parameters**	**Notes**
40475	Path 5 Max Path Velocity	32-bit float
40477	Path 5 Max Velocity Change	32-bit float
40479	Path 5 Max Bad Measures	32-bit Integer
40481	Path 6 Angle	32-bit float
40483	Path 6 Length	32-bit float
40485	Path 6 Weight	32-bit float
40487	Path 6 Elevation	32-bit float
40489	Path 6 Signal Delay	32-bit float
40491	Path 6 Transducer Freq	32-bit float
40493	Path 6 Max Path Velocity	32-bit float
40495	Path 6 Max Velocity Change	32-bit float
40497	Path 6 Max Bad Measures	32-bit Integer
40499	Path 7 Angle	32-bit float
40501	Path 7 Length	32-bit float
40503	Path 7 Weight	32-bit float
40505	Path 7 Elevation	32-bit float
40507	Path 7 Signal Delay	32-bit float
40509	Path 7 Transducer Freq	32-bit float
40511	Path 7 Max Path Velocity	32-bit float
40513	Path 7 Max Velocity Change	32-bit float
40515	Path 7 Max Bad Measures	32-bit Integer
40517	Path 8 Angle	32-bit float
40519	Path 8 Length	32-bit float
40521	Path 8 Weight	32-bit float
40523	Path 8 Elevation	32-bit float
40525	Path 8 Signal Delay	32-bit float
40527	Path 8 Transducer Freq	32-bit float
40529	Path 8 Max Path Velocity	32-bit float
40531	Path 8 Max Velocity Change	32-bit float
40533	Path 8 Max Bad Measures	32-bit Integer
40535	Path 9 Angle	32-bit float
40537	Path 9 Length	32-bit float
40539	Path 9 Weight	32-bit float
40541	Path 9 Elevation	32-bit float
40543	Path 9 Signal Delay	32-bit float
40545	Path 9 Transducer Freq	32-bit float
40547	Path 9 Max Path Velocity	32-bit float
40549	Path 9 Max Velocity Change	32-bit float
40551	Path 9 Max Bad Measures	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameters**	**Notes**
40553	Path 10 Angle	32-bit float
40555	Path 10 Length	32-bit float
40557	Path 10 Weight	32-bit float
40559	Path 10 Elevation	32-bit float
40561	Path 10 Signal Delay	32-bit float
40563	Path 10 Transducer Freq	32-bit float
40565	Path 10 Max Path Velocity	32-bit float
40567	Path 10 Max Velocity Change	32-bit float
40569	Path 10 Max Bad Measures	32-bit Integer
40571	Output 1 4mA Output	32-bit float
40573	Output 1 20mA Output	32-bit float
40575	Output 1 Manual Output Value	32-bit float
40577	Output 1 Variable	32-bit Integer
40579	Output 1 Override Output	32-bit Integer
40581	Output 1 0mA or 4mA on Error	32-bit Integer
40583	Output 1 Assign a Section	32-bit Integer
40585	Output 1 Hold On Error	32-bit Integer
40587	Output 2 4mA Output	32-bit float
40589	Output 2 20mA Output	32-bit float
40591	Output 2 Manual Output Value	32-bit float
40593	Output 2 Variable	32-bit Integer
40595	Output 2 Override Output	32-bit Integer
40597	Output 2 0mA or 4mA on Error	32-bit Integer
40599	Output 2 Assign a Section	32-bit Integer
40601	Output 2 Hold On Error	32-bit Integer
40603	Output 3 4mA Output	32-bit float
40605	Output 3 20mA Output	32-bit float
40607	Output 3 Manual Output Value	32-bit float
40609	Output 3 Variable	32-bit Integer
40611	Output 3 Override Output	32-bit Integer
40613	Output 3 0mA or 4mA on Error	32-bit Integer
40615	Output 3 Assign a Section	32-bit Integer
40617	Output 3 Hold On Error	32-bit Integer
40619	Output 4 4mA Output	32-bit float
40621	Output 4 20mA Output	32-bit float
40623	Output 4 Manual Output Value	32-bit float
40625	Output 4 Variable	32-bit Integer
40627	Output 4 Override Output	32-bit Integer
40629	Output 4 0mA or 4mA on Error	32-bit Integer

Read-Write Registers (cont.)		
Address	Parameters	Notes
40631	Output 4 Assign a Section	32-bit Integer
40633	Output 4 Hold On Error	32-bit Integer
40635	Output 5 4mA Output	32-bit float
40637	Output 5 20mA Output	32-bit float
40639	Output 5 Manual Output Value	32-bit float
40641	Output 5 Variable	32-bit Integer
40643	Output 5 Override Output	32-bit Integer
40645	Output 5 0mA or 4mA on Error	32-bit Integer
40647	Output 5 Assign a Section	32-bit Integer
40649	Output 5 Hold On Error	32-bit Integer
40651	Output 6 4mA Output	32-bit float
40653	Output 6 20mA Output	32-bit float
40655	Output 6 Manual Output Value	32-bit float
40657	Output 6 Variable	32-bit Integer
40659	Output 6 Override Output	32-bit Integer
40661	Output 6 0mA or 4mA on Error	32-bit Integer
40663	Output 6 Assign a Section	32-bit Integer
40665	Output 6 Hold On Error	32-bit Integer
40667	Output 7 4mA Output	32-bit float
40669	Output 7 20mA Output	32-bit float
40671	Output 7 Manual Output Value	32-bit float
40673	Output 7 Variable	32-bit Integer
40675	Output 7 Override Output	32-bit Integer
40677	Output 7 0mA or 4mA on Error	32-bit Integer
40679	Output 7 Assign a Section	32-bit Integer
40681	Output 7 Hold On Error	32-bit Integer
40683	Output 8 4mA Output	32-bit float
40685	Output 8 20mA Output	32-bit float
40687	Output 8 Manual Output Value	32-bit float
40689	Output 8 Variable	32-bit Integer
40691	Output 8 Override Output	32-bit Integer
40693	Output 8 0mA or 4mA on Error	32-bit Integer
40695	Output 8 Assign a Section	32-bit Integer
40697	Output 8 Hold On Error	32-bit Integer
40699	Input 1 4mA Level Input	32-bit float
40701	Input 1 20mA Level Input	32-bit float
40703	Input 1 Level Resistor	32-bit float
40705	Input 1 Min mA Input	32-bit float
40707	Input 1 Level Filter	32-bit integer

Read-Write Registers (cont.)		
Address	**Parameter**	**Notes**
40709	Input 2 4mA Level Input	32-bit float
40711	Input 2 20mA Level Input	32-bit float
40713	Input 2 Level Resistor	32-bit float
40715	Input 2 Min mA Input	32-bit float
40717	Input 2 Level Filter	32-bit integer
40719	Input 3 4mA Level Input	32-bit float
40721	Input 3 20mA Level Input	32-bit float
40723	Input 3 Level Resistor	32-bit float
40725	Input 3 Min mA Input	32-bit float
40727	Input 3 Level Filter	32-bit integer
40729	Input 4 4mA Level Input	32-bit float
40731	Input 4 20mA Level Input	32-bit float
40733	Input 4 Level Resistor	32-bit float
40735	Input 4 Min mA Input	32-bit float
40737	Input 4 Level Filter	32-bit integer
40739	Input 5 4mA Level Input	32-bit float
40741	Input 5 20mA Level Input	32-bit float
40743	Input 5 Level Resistor	32-bit float
40745	Input 5 Min mA Input	32-bit float
40747	Input 5 Level Filter	32-bit integer
40749	Input 6 4mA Level Input	32-bit float
40751	Input 6 20mA Level Input	32-bit float
40753	Input 6 Level Resistor	32-bit float
40755	Input 6 Min mA Input	32-bit float
40757	Input 6 Level Filter	32-bit integer
40759	Input 7 4mA Level Input	32-bit float
40761	Input 7 20mA Level Input	32-bit float
40763	Input 7 Level Resistor	32-bit float
40765	Input 7 Min mA Input	32-bit float
40767	Input 7 Level Filter	32-bit integer
40769	Input 8 4mA Level Input	32-bit float
40771	Input 8 20mA Level Input	32-bit float
40773	Input 8 Level Resistor	32-bit float
40775	Input 8 Min mA Input	32-bit float
40777	Input 8 Level Filter	32-bit integer
40779	Relay 1 Threshold	32-bit float
40781	Relay 1 Type	32-bit Integer
40783	Relay 1 Assign a Section	32-bit Integer
40785	Relay 1 Delay	32-bit Integer

Read-Write Registers (cont.)		
Address	Parameter	Notes
40787	Relay 1 Polarity	32-bit Integer
40789	Relay 2 Threshold	32-bit float
40791	Relay 2 Type	32-bit Integer
40793	Relay 2 Assign a Section	32-bit Integer
40795	Relay 2 Delay	32-bit Integer
40797	Relay 2 Polarity	32-bit Integer
40799	Relay 3 Threshold	32-bit float
40801	Relay 3 Type	32-bit Integer
40803	Relay 3 Assign a Section	32-bit Integer
40805	Relay 3 Delay	32-bit Integer
40807	Relay 3 Polarity	32-bit Integer
40809	Relay 4 Threshold	32-bit float
40811	Relay 4 Type	32-bit Integer
40813	Relay 4 Assign a Section	32-bit Integer
40815	Relay 4 Delay	32-bit Integer
40817	Relay 4 Polarity	32-bit Integer
40819	Relay 5 Threshold	32-bit float
40821	Relay 5 Type	32-bit Integer
40823	Relay 5 Assign a Section	32-bit Integer
40825	Relay 5 Delay	32-bit Integer
40827	Relay 5 Polarity	32-bit Integer
40829	Relay 6 Threshold	32-bit float
40831	Relay 6 Type	32-bit Integer
40833	Relay 6 Assign a Section	32-bit Integer
40835	Relay 6 Delay	32-bit Integer
40837	Relay 6 Polarity	32-bit Integer
40839	Relay 7 Threshold	32-bit float
40841	Relay 7 Type	32-bit Integer
40843	Relay 7 Assign a Section	32-bit Integer
40845	Relay 7 Delay	32-bit Integer
40847	Relay 7 Polarity	32-bit Integer
40849	Relay 8 Threshold	32-bit float
40851	Relay 8 Type	32-bit Integer
40853	Relay 8 Assign a Section	32-bit Integer
40855	Relay 8 Delay	32-bit Integer
40857	Relay 8 Polarity	32-bit Integer
40859	Relay 9 Threshold	32-bit float
40861	Relay 9 Type	32-bit Integer
40863	Relay 9 Assign a Section	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameter**	**Notes**
40865	Relay 9 Delay	32-bit Integer
40867	Relay 9 Polarity	32-bit Integer
40869	Relay 10 Threshold	32-bit float
40871	Relay 10 Type	32-bit Integer
40873	Relay 10 Assign a Section	32-bit Integer
40875	Relay 10 Delay	32-bit Integer
40877	Relay 10 Polarity	32-bit Integer
40879	Relay 11 Threshold	32-bit float
40881	Relay 11 Type	32-bit Integer
40883	Relay 11 Assign a Section	32-bit Integer
40885	Relay 11 Delay	32-bit Integer
40887	Relay 11 Polarity	32-bit Integer
40889	Relay 12 Threshold	32-bit float
40891	Relay 12 Type	32-bit Integer
40893	Relay 12 Assign a Section	32-bit Integer
40895	Relay 12 Delay	32-bit Integer
40897	Relay 12 Polarity	32-bit Integer
40899	Relay 13 Threshold	32-bit float
40901	Relay 13 Type	32-bit Integer
40903	Relay 13 Assign a Section	32-bit Integer
40905	Relay 13 Delay	32-bit Integer
40907	Relay 13 Polarity	32-bit Integer
40909	Relay 14 Threshold	32-bit float
40911	Relay 14 Type	32-bit Integer
40913	Relay 14 Assign a Section	32-bit Integer
40915	Relay 14 Delay	32-bit Integer
40917	Relay 14 Polarity	32-bit Integer
40919	Relay 15 Threshold	32-bit float
40921	Relay 15 Type	32-bit Integer
40923	Relay 15 Assign a Section	32-bit Integer
40925	Relay 15 Delay	32-bit Integer
40927	Relay 15 Polarity	32-bit Integer
40929	Relay 16 Threshold	32-bit float
40931	Relay 16 Type	32-bit Integer
40933	Relay 16 Assign a Section	32-bit Integer
40935	Relay 16 Delay	32-bit Integer
40937	Relay 16 Polarity	32-bit Integer
40939	Date Stamp	32-bit Integer
40941	Time Stamp	32-bit Integer

Read-Write Registers (cont.)		
Address	**Parameter**	**Notes**
40943	IP Address	32-bit Integer
40945	Subnet Mask	32-bit Integer
40947	Gateway	32-bit Integer
40949	Pulse or Burst Mode (0=Pulse, 1=IS,2=Burst)	32-bit Integer
40951	Baud Rate (0=9600,1=19200,2=38400)	32-bit Integer
40953	Admin Password	32-bit Integer
40955	Logging Memory Location (0=Internal,1=External)	32-bit Integer
40957	Logging Interval Hour	32-bit Integer
40959	Logging Interval Minute	32-bit Integer
40961	Logging Interval Second	32-bit Integer
40963	Data Logging Enable (0=Disable Log,1=Enable Log)	32-bit Integer
40965	Blank	32-bit Integer
40967	Output 1 Fine Adjust 4mA	32-bit Integer
40969	Output 2 Fine Adjust 4mA	32-bit Integer
40971	Output 3 Fine Adjust 4mA	32-bit Integer
40973	Output 4 Fine Adjust 4mA	32-bit Integer
40975	Output 5 Fine Adjust 4mA	32-bit Integer
40977	Output 6 Fine Adjust 4mA	32-bit Integer
40979	Output 7 Fine Adjust 4mA	32-bit Integer
40981	Output 8 Fine Adjust 4mA	32-bit Integer
40983	Output 1 Fine Adjust 20mA	32-bit Integer
40985	Output 2 Fine Adjust 20mA	32-bit Integer
40987	Output 3 Fine Adjust 20mA	32-bit Integer
40989	Output 4 Fine Adjust 20mA	32-bit Integer
40991	Output 5 Fine Adjust 20mA	32-bit Integer
40993	Output 6 Fine Adjust 20mA	32-bit Integer
40995	Output 7 Fine Adjust 20mA	32-bit Integer
40997	Output 8 Fine Adjust 20mA	32-bit Integer

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