8510MA0036 REV. 04

8510 Series Flowmeter
Technical Reference Manual

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Division of ADS LLC
An IDEX Fluid and Metering Business

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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 and 200 kHz

- **Analog Inputs**
  Number 4 (2-Path & 4-Path Versions) or 8 (10-Path Version)
  Load resistance 100 Ω
  Power supply +24 V d.c.

- **Analog Outputs**
  Number 4 (2-Path & 4-Path Versions) or 8 (10-Path Version)
  Type Isolated
  Maximum load 600Ω

- **Digital Outputs**
  Number 3
  Type RS-232; RS-232/RS-485 (User Selectable); Ethernet
  Protocol ModBus Slave

- **Relays (Optional)**
  Number 6
  Type SPDT

- **Internal Data Logging**
  Memory Supplied 4Gb (minimum) via SDHC Class 4 Card

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 Explosionproof 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 (2-Path and 4-Path Versions) or 8 (10-Path Version), and the total number of paths allocated among the Sections is limited to 2, 4, or 10 depending on the version purchased.

The electronic unit provides up to four (4) or eight (8) 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 inserted 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. A 4GB SDHC memory card will store over 10 years of data logging at a 1 minute interval.

The flowmeter is fitted with an LCD touch screen display, which can offer a range of flow, velocity, path, and level data displays, depending on the configuration of the flowmeter. Parameter entry can be performed through the use of an integrated numeric entry pad.

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/million	
	Vapors of Ketones & Esters must not be present		

Characteristic frequency: 1MHz , 500 kHz and 200 kHz using standard electronic filters.

Maximum Transmit Voltage:

Standard systems,	1300 VDC peak.
Flameproof protected transducers	1300 VDC peak.

Electronic Unit

Standard Model

Power supply: Electronic Unit — 90 to 250 V a.c. 47 to 63 Hz or 100 to 300 V d.c. without adjustment.

Power consumption:

Standard unit	10 Watts,	20 VA. (with a.c. power supply)
With relays	25 Watts,	40 VA. (with a.c. power supply)

Contact Accusonic for details of Models suitable for 12 V or 24 V d.c. 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
For higher altitudes, contact Accusonic.

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 in total, allocated between all the Sections).

Length	(Standard range)	0.7 to 50 ft	0.2 to 15 m
	(Extended ranges)	5 to 300 ft	1.5 to 90 m

Permanent Data Display — LCD Touchscreen (320 x 240 Pixel)
Character height 9 mm

Level inputs: 4 (2-Path & 4-Path Versions) or 8 (10-Path Version)		
useable input range with standard 100Ω load	4 -20 mA,	(0.4 - 2.0 V)
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 (2-Path & 4-Path Versions) or 8 (10-Path Version)		
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 VDC.	

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 d.c, L/R = 40 ms
Isolation 2000 V a.c.

Integral Data Logger

104 different variables (all logged).
Interval selectable between 1 second and 24 hours
Capacity of main memory: 4GB minimum

Transducer Cable

Unbalanced mode: Coaxial RG59 A/U. A 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.
Maximum length between Transducers and Electronic unit: 1600 ft (500m)
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

EMC Directive, Immunity (Cont):

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 flow meter 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 2-2.

- 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. 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 2-2.

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 milli seconds 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, 9 different display screens are available, one for each variable as follows:
Flow & Level, Temperature & Volume, Velocities & VSounds, Signal Gains & Detection Method, Signal to Noise Ratio & Signal Gain %, Travel Times, Time Differences, Envelope Travel Times, and Analog Inputs.
Screens 0-1 and 0-2 are related to observing section data. Screens 1-1 through 1-6 are for viewing acoustic path measurements and diagnostics, Screen 1-7 is for diagnostic purposes concerned with the various Level inputs. 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 inserted using 6 different parameter menus (displayed on 7 screens). These parameter screens are numbered 2-1 through 2-7. The flowmeter parameters are accessed by touching the **SETUP** button on the left side of the display. These parameter menus are: SYSTEM, SECTION, PATH, LEVEL, OUTPUT, and RELAY.
For instructions on how to insert 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 located on the left side of the display:

MEASURE: To put the flowmeter into the “Measure” mode. Screen 1-1 (Path Velocity) screen will be displayed when touching this button at any time. To access Screen 0-1 (Section Flow), press the **LEFT** arrow button.
SETUP: To set the flowmeter parameters and store in non-volatile memory. The **UP** or **DOWN** arrow button will allow parameter entry for the different parameter menus.
LOGGING: To enable and disable data logger and choose the logging interval.
SCOPE: To view the processed acoustic signals for each path.
SYSTEM: To set the flowmeter date/time, choose RS-232/RS-485 or TCP/IP Modbus, set password and enable password protection, set Ethernet IP/Gateway/Subnet, or update firmware.
HISTORY: To view error log history

Connection of a PC for use with “Accuflow” Flowmeter Interface

A PC may be connected to the 9 pin “RS232/Modem” or the “RS-232” socket (when RS-232 is selected in the System Menu), for use with special Accusonic PC based programs. There are a series of jumpers on the DSP board that can be set for use with a standard 9 pin serial cable or for use with a “Null Modem” cable (or standard serial cable with a “Null Modem adapter”) to interconnect between this socket and a PC’s serial port. Either the cable or adapter can be purchased at a PC supply or electronics store. See below for the jumper positions on the DSP board:

RS232 Port: Set JP10 & JP11 to Pins 1-2 for standard serial cable
Set JP10 & JP11 to Pins 2-3 for “Null Modem” serial cable

RS232/Modem Port: Set JP12 & JP13 to Pins 1-2 for standard serial cable
Set JP12 & JP13 to Pins 2-3 for “Null Modem” serial cable

RS232 signals: 9600 baud, 8 data bits, No parity, 1 Stop bit, No hand-shaking protocol.
The connections on the 9 pin D socket are:
Pin 2. Data into the 8510 unit.
Pin 3 Data out from the 8510 unit
Pin 5 Common, connected to ground in the 8510 unit.

Optional High Speed Modem

A High Speed Modem can be supplied with the 8510. A separate dedicated com-port (RS-232/Modem) is available for connection to the modem. Data transfer (send or receive) at line speeds of 19200, 14400, 12000, 9600, 7200, 4800 and 2400 baud. Auto-negotiating line speed connections at 19200, 14400, 12000, 9600, 7200, 4800 and 2400 baud using:
Fall Forward/Fallback handshaking (based on line signal quality) per EIA/TIA-P2330.
Lightning Surge Protection tested to IEEE C62.41-1991 and IEEE C62.45-1992.

Integral Data Logger

The integral data logger can be configured to log at a chosen interval (all variables will be logged), using the supplied SDHC memory card. 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 using the Accuflow Interface. The logger is fully protected against data loss in the event of power failure.

Chapter 3

Flow Computation

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.

Flow Computation Algorithms

In "Compound" Mode

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:

1. Zero flow if the Level (or depth of water) is below a user defined value.
2. 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.
3. 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.
4. 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.
5. Surcharged Integration, when the pipe is surcharged. A user-selectable choice of two methods is available:
   "Pipe" as described for "Pipe" mode involving parameters of path weights and pipe area;
   "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.

In 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.

In 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).

In 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:

1. 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.
2. Intermediate panel bounded on the top and bottom by consecutive operating paths that are not at the same elevation.
3. 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.

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

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.

In 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

In "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:

1. The number of good paths must be equal to or greater than the Section parameter *Min good Paths*.
2. 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 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

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.

Physical Installation

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 out-doors, it should be protected by a sun shield on the top and the south facing side.

Electrical Installation

Caution *when drilling conduit holes, protect the circuit cards in the unit.*

Note. In order 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**.

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:

- a.c. or d.c. 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.

Check that the input voltage is within the voltage ratings for the electronics and heater (if equipped) as specified on the flowmeter's label, Figure 4-1, 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 4-1. Be sure to follow appropriate local codes and practices, and to attach a proper earth ground to the instrument.

For low voltage d.c. power, observe the correct polarity.
For d.c. power 100 to 300 V d.c. the low potential side of the supply should be connected to the "N" terminal.

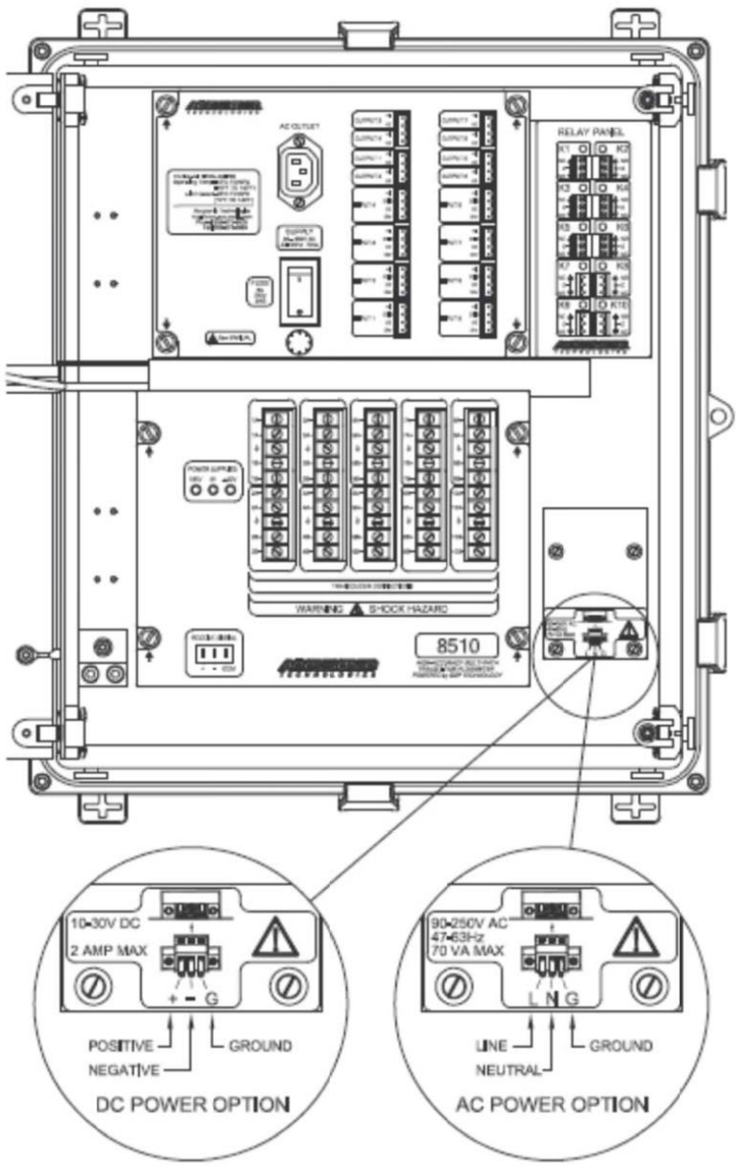


Figure 4-1 Location of Power Line Connections

Transducer Wiring

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 4-2. Trim the cables, strip back 2 inches of outer sheathing from each, pull inner conductors back from inside the outer braid, and solder spade lugs to the conductor and shield of each cable as shown in Figure 4-3.

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 or with any metal parts on the flowmeter console.

Caution

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

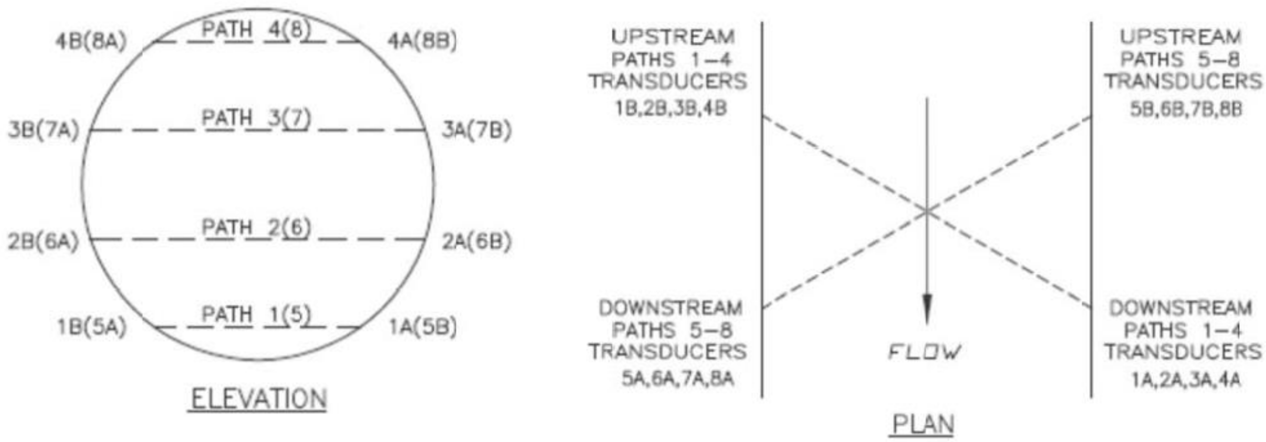


Figure 4-2 Transducer Numbering - Simple Pipe

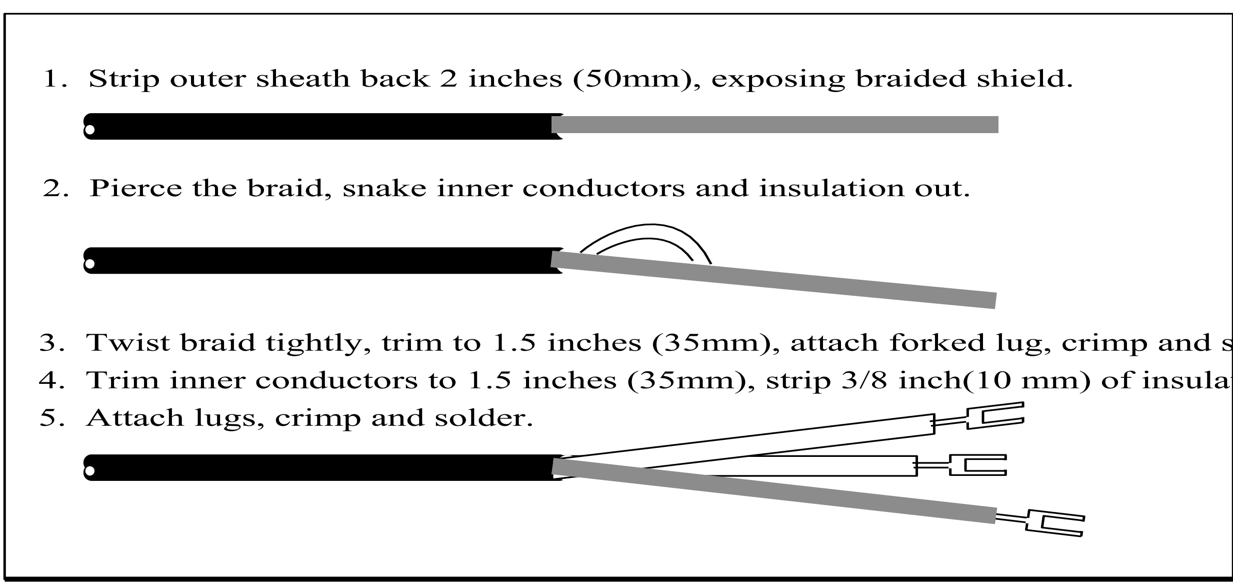


Figure 4-3 Stripping and Terminating the Transducer Cable

Transducer and Cabling Checkout

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

There are three steps to verify the transducer cabling and transducers:

1. Verify that there is infinite resistance across each transducer with cable attached.
2. Verify that there is infinite resistance across each transducer, if required.
3. Verify continuity in the cabling.

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.

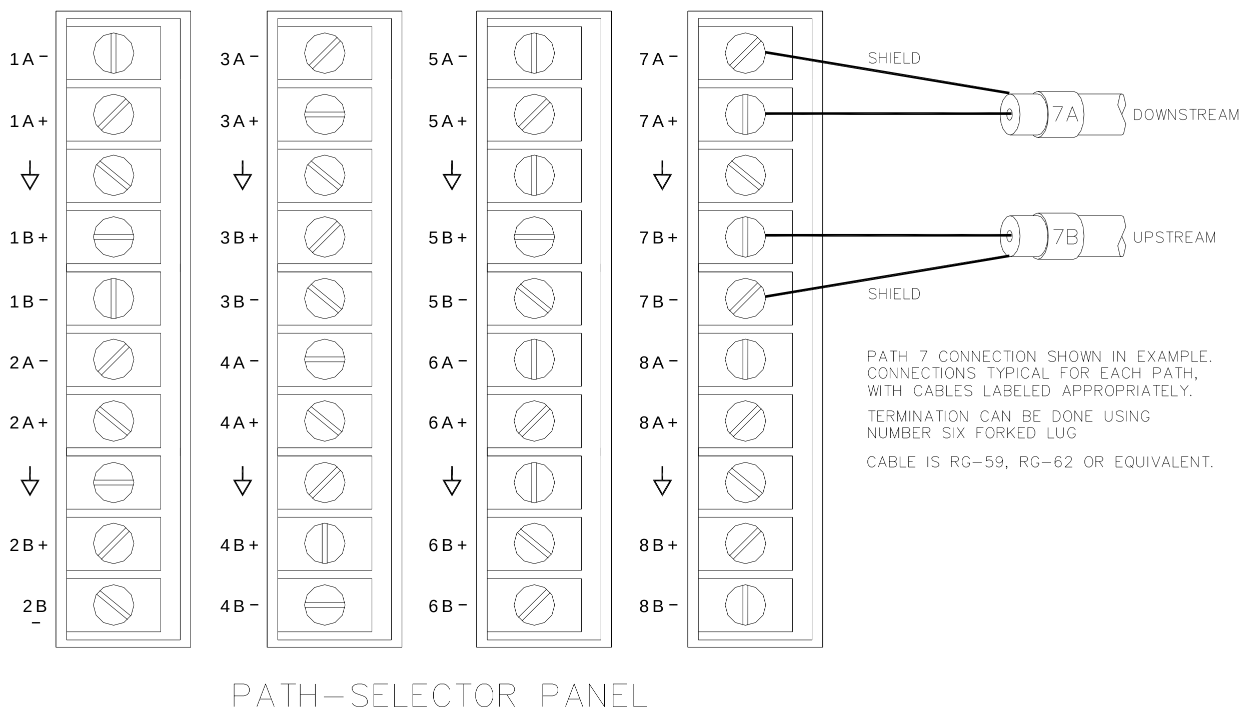
The transducers are now ready to be terminated to the flowmeter.

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 Figures 4-4A or 4-4B.

Coaxial Cable (unbalanced cables)

Connect cables as shown in figure 4-4A
Configure jumpers for on Path-Selector Backplane as shown in figure 4-4A.



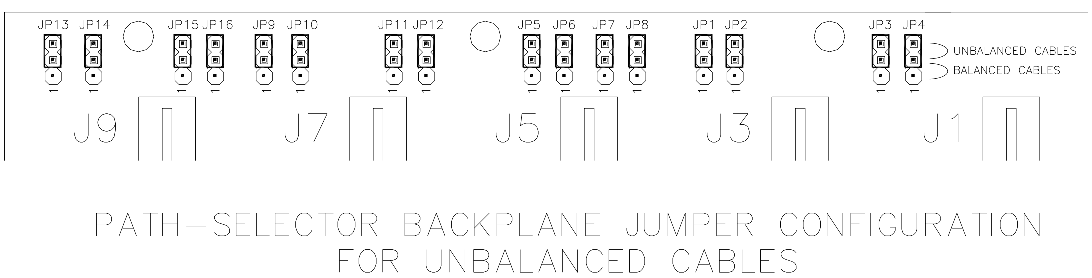


Figure 4-4A Unbalanced Connections

Twin Axial Cable (balanced cables)

Connect cables as shown in figure 4-4B.

Configure jumpers on Path-Selector Backplane as shown in figure 4-4B.

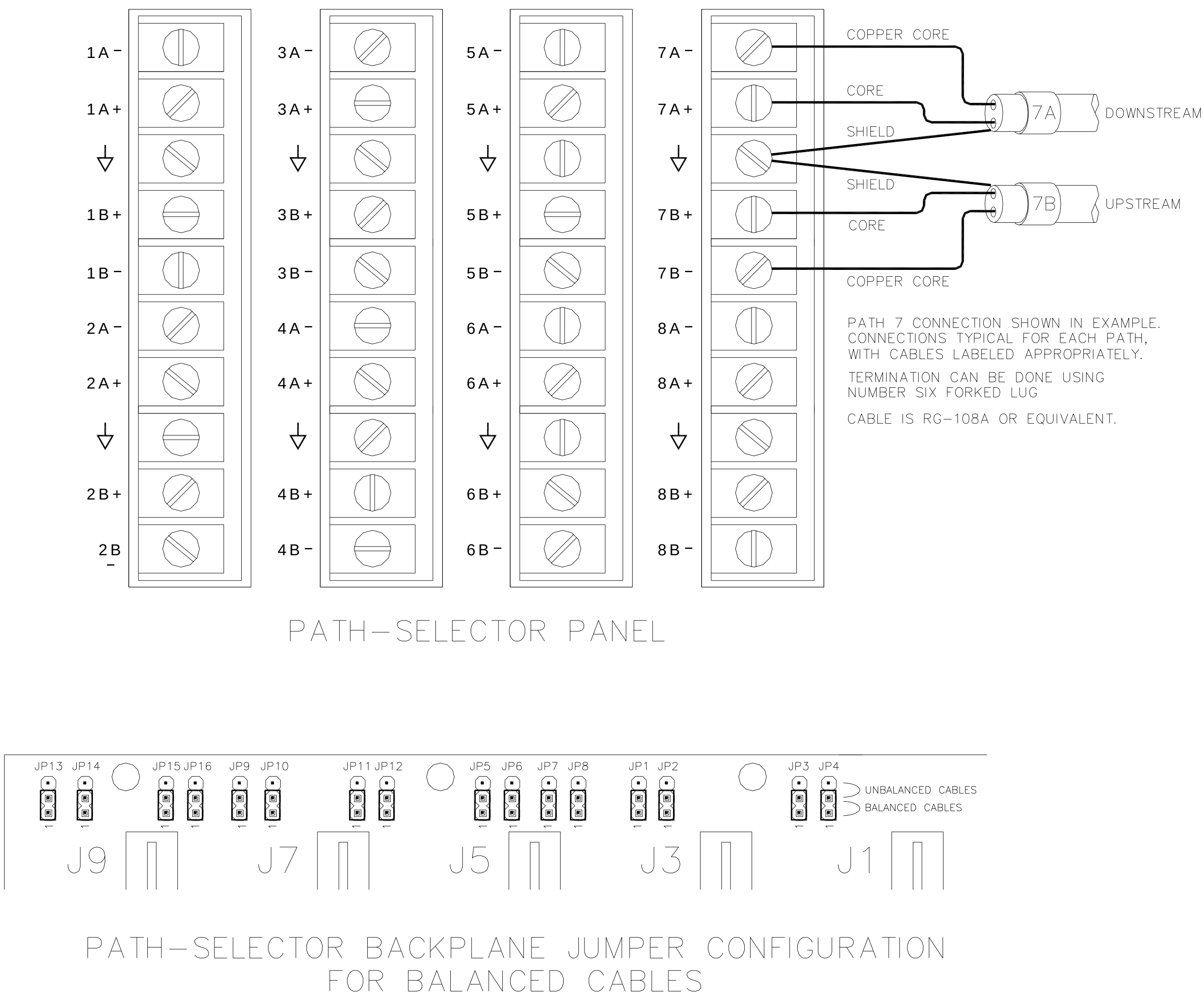


Figure 4-4B Balanced Connections

Connecting the Analog 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 terminal strip.

On most systems the terminal strip for the level inputs is located on the extreme right hand end of the connector panel shown in Figure 4-6.

Input impedance for each channel is 100 ohms.
For typical connection configurations see Figure 4-5.

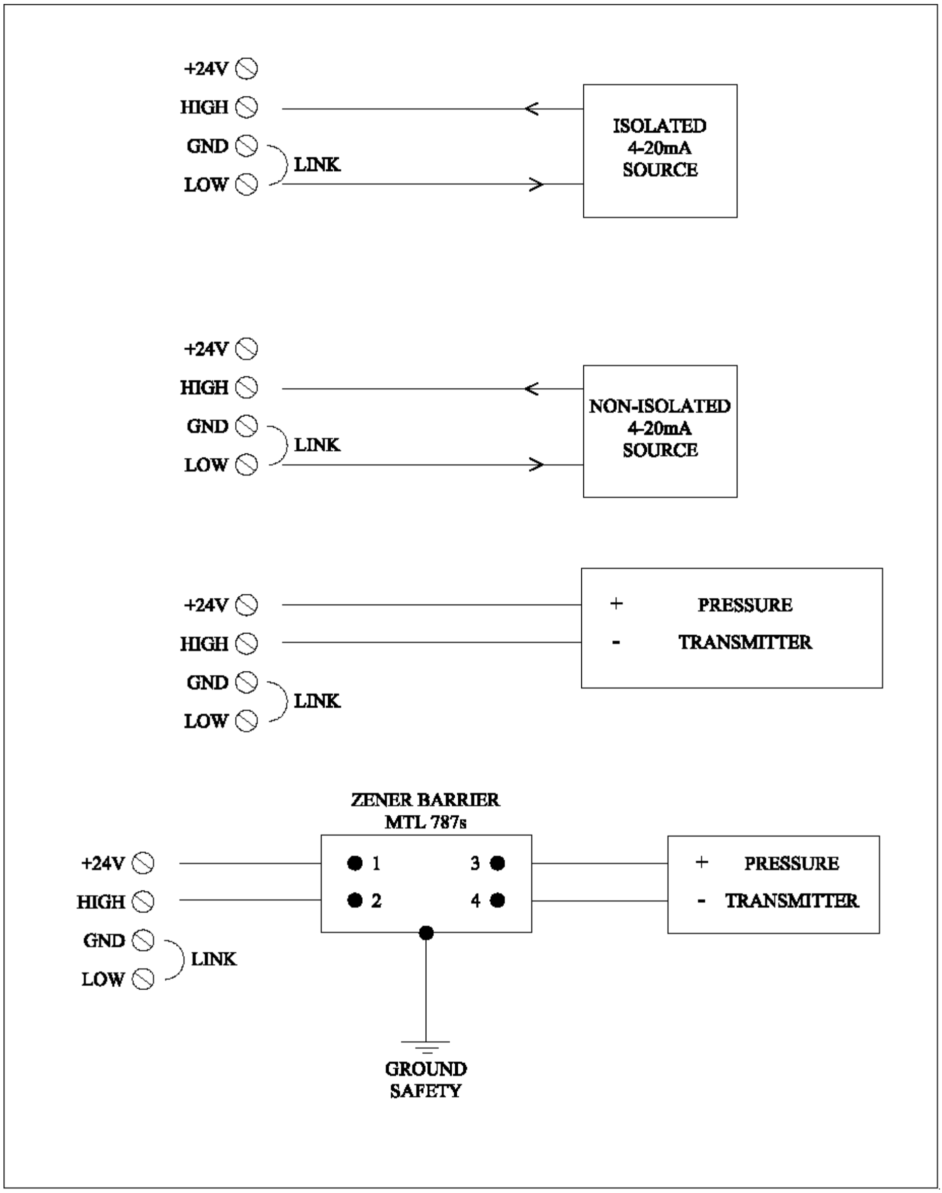


Figure 4-5 Typical Analog Level Connection

Connecting the Analog Outputs

Connect to the 4-20mA terminals as indicated in Figure 4-6

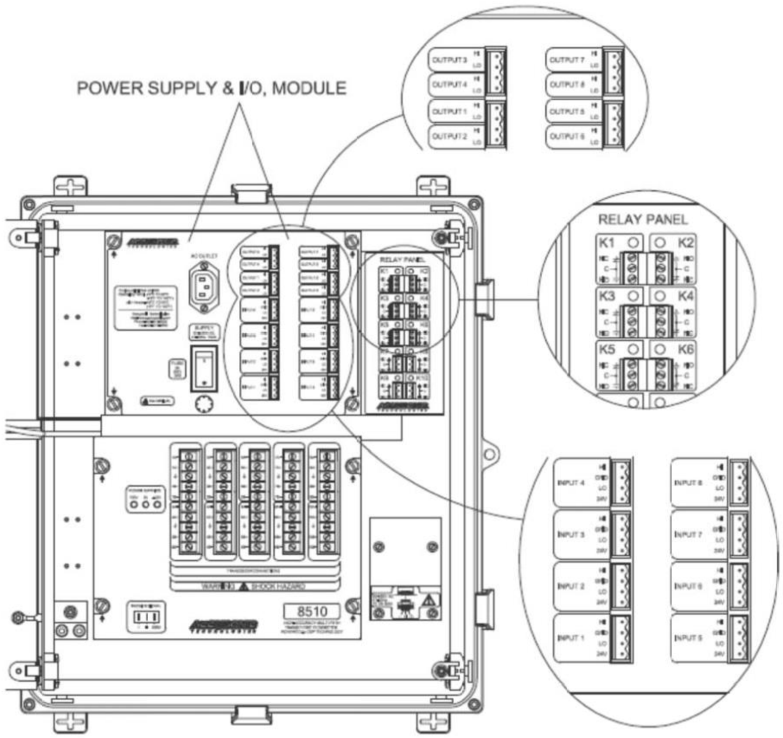


Figure 4-6 Location of the Analog Output, Level Input, Relays, RS232 Connections and Optional Modem Connection

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 4-6. 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 can be connected to the socket marked *"RS232/Modem"* or *"RS232"* (if RS232 is chosen in the system tab). The PC should be a ModBus Master PC, running a ModBus testing program, or running Accuflow.

There are a series of jumpers on the DSP board that can be set for use with a standard 9 pin serial cable or for use with a "Null Modem" cable (or standard serial cable with a "Null Modem adapter") to interconnect between this socket and a PC's serial port. Either the cable or adapter can be purchased at a PC supply or electronics store. See below and Figure 4-7 for the jumper positions on the DSP board:

RS232 Port: Set JP10 & JP11 to Pins 1-2 for standard serial cable
Set JP10 & JP11 to Pins 2-3 for "Null Modem" serial cable

RS232/Modem Port: Set JP12 & JP13 to Pins 1-2 for standard serial cable
Set JP12 & JP13 to Pins 2-3 for "Null Modem" serial cable

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.

Alternatively, a PC may be connected to the socket marked *"USB 2.0"* for use with special Accusonic programs such as "Accuflow Flowmeter Interface".

Connecting a Modem

For remote access to the flowmeter from an office, via a telephone and modem link, connect a user supplied Modem to the port labeled "RS232/Modem".

The equipment required at the office consists of a suitable telephone connection, V.32 modem and a PC running the Accusonic program "Accuflow Flowmeter Interface".

DSP Connection Detail

Figure 4-7 below shows the various connections and jumper positions for the DSP board located behind the touchscreen display on the console's swing panel.

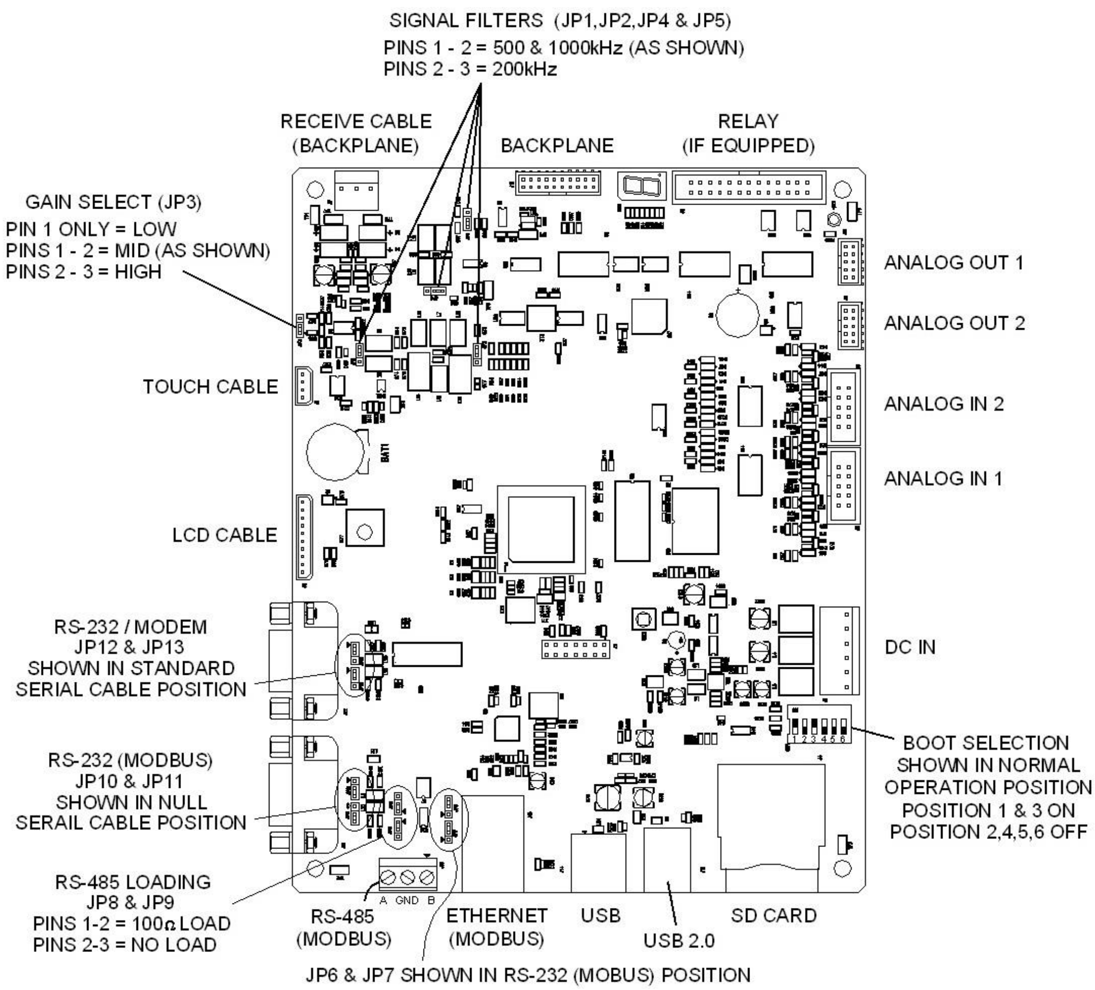


Figure 4-7 DSP Connection Detail

Chapter 5
Initial Setup, 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 Flow. Commands and control parameters are entered into the flowmeter using menus shown on the display. To cause the menus to appear, press the **SETUP** button. 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 menus

Seven buttons are used to navigate through the various menu options and to move through lists of parameters. The main navigation buttons are the four arrow shaped buttons at the bottom of the display. When the numeric value of the parameter is touched, a numeric entry pad will be displayed. The value can be changed and then the **EN** button can be pressed to set the value. Pressing the **MEASURE** button when in any menu or screen, returns the flowmeter to the Measure mode. When in Measurement mode, the four arrow buttons can be used to navigate through the various variable screens. 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). If the flowmeter is left in any menu, it will automatically return to the Measure mode and store any changed parameters, after a delay of approximately 60 seconds.

Other button operations

- When the flowmeter is in normal measurement mode (Screen 0-1), pressing the **UP** or **DOWN** arrow will allow a user to view the section variables screens. To access the path variables, press the **MEASURE** button and then the **UP** and **DOWN** arrows enable you to select alternative display screens. To go back to the main measurement screen, press the **LEFT** button. Pressing the **SETUP** button allows access to the following parameters:

SYSTEM PARAMETERS:	One list of basic system parameters.
SECTION PARAMETERS:	Up to five parallel lists, one for each flowmeter section.
PATH PARAMETERS:	Up to ten parallel lists, one for each path.
LEVEL PARAMETERS:	Up to eight parallel lists, one for each analog Level input.
OUTPUT PARAMETERS:	Up to eight parallel lists, two for each analog output.
RELAY PARAMETERS:	Up to 16 parallel lists, one for each Relay.

Parameter Data Entry

All parameters are entered using the same method. If the current value of the displayed parameters are correct, move to the next page (either **UP** or **DOWN** arrows). Once a parameter value has been pressed, the entry pad will be displayed. The symbols available on the entry pad are:

Numbers 0 through 9, . (decimal point), - (negative), EN (enter), <- (delete), C (clear)

An example of the method of data entry follows:

Action	**LCD Display shows**	**Comments**
Press **SETUP**	SYSTEM PARAMETERS	Measurements cease.
Press ↓	SECTION PARAMETERS	Pressing the first column number allows for selecting specific section with ↑↓
Press **Path Enable** value	Entry Pad	Press **EN** without typing a number to ESC
Press **15**	Entry Pad	15 will be shown in the Entry Pad
Press **EN**	SECTION PARAMETERS	15 will now be shown as Path Enable value Paths 1 – 4 now enabled
Press ↓**,** (**D**) twice	PATH PARAMETERS	Pressing the first column number allows for selecting specific section with ↑↓
Press **LENGTH** value	Entry Pad	Press **EN** without typing a number to ESC
Press **5.25**	Entry Pad	5.25 will be shown in the Entry Pad
Press **EN**	PATH PARAMETERS	5.25 will be shown as Path Length value

To return to the flowmeter to “Measure“ mode:

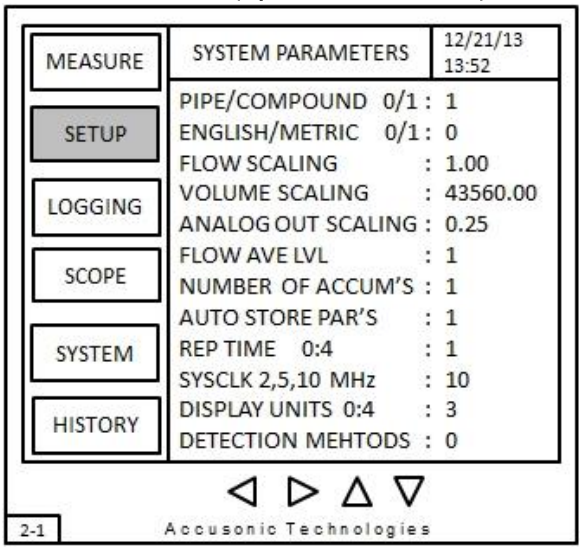
Press **MEASURE**	PATH VARIABLES	
Press ←	SECTION FLOW SCREEN	If ← is not pressed, the flowmeter will Time-out and default to the SECTION FLOW SCREEN (0-1)

Typical Parameter List – As Seen on Display

Note: The parameter list is visible by pressing the **SETUP** button. Press the **UP** or **DOWN** arrow to navigate through the various parameters. After selecting a parameter to be changed, a numeric entry pad will appear and will be displayed similar to a calculator. Press the various numeric buttons to enter a specific value, verify the entry pad's displayed value; then press **EN** to store the value. If a parameter has been selected in error, press the EN button without pressing any number value to ESC. The LEFT arrow acts as a backspace function and the C button will clear the keypad's numerical value.

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

Screen 2-1 (System Parameters)

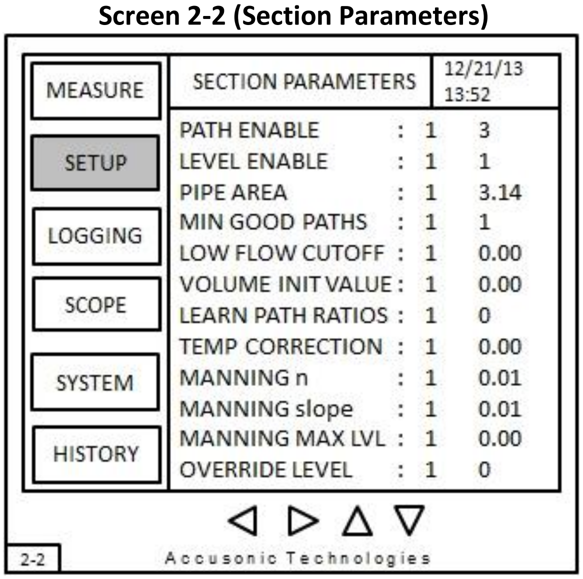


Screen Description

To change a given parameter on this screen, press the number after the colon. This will bring up the numeric entry pad. Press the desired value, verify the value displayed on the top line of the entry pad, and press EN to store.

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

Screen 2-2 (Section Parameters)

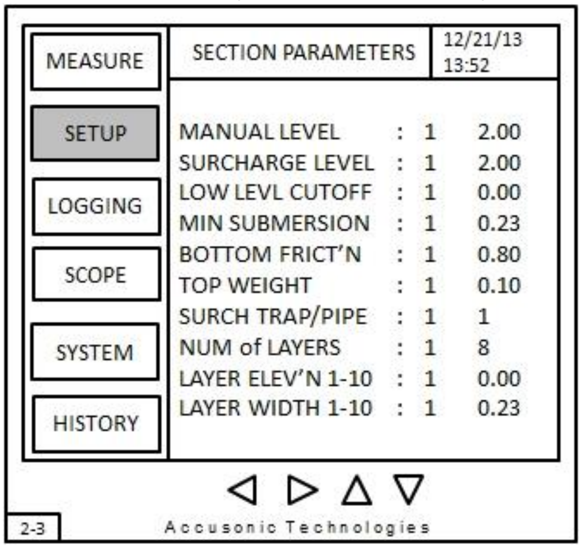


Screen Description

There are two columns of numbers in this screen. The first column after the colon defines the Section Number. To view the current parameter for each section, press the number in the first column which will underline the number. Pressing the UP or DOWN arrow will change the Section number as well as the parameter value in the last column.

To change a given parameter for a given section, press the number in the last column when the desired section number is displayed (this will bring up the numeric entry pad). Enter the desired value, verify the value displayed on the top line of the entry pad, and press EN to store.

Screen 2-3 (Section Parameters)

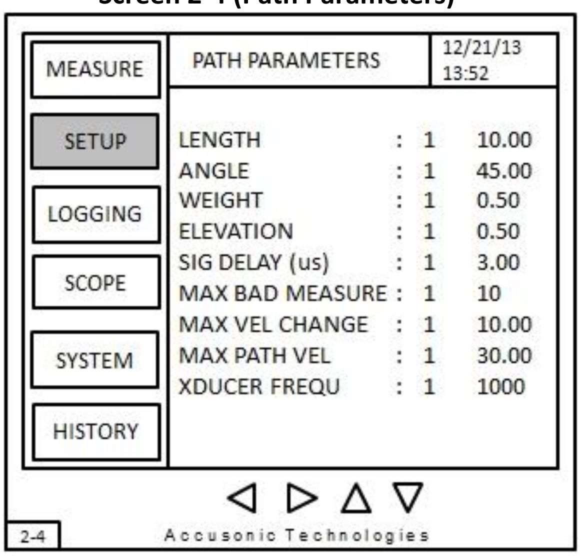


Screen Description

The parameter entry is as described for Screen 2-2.

NOTE: The Layer Elevation and Layer Width Parameters are not listed by Section Number. Layers 1-10 are assigned to SECTION 1; Layers 11-20 are assigned to SECTION 2; Layers 21-30 are assigned to SECTION 3; Layers 31-40 are assigned to SECTION 4; and Layers 41-50 are assigned to SECTION 5.

Screen 2-4 (Path Parameters)

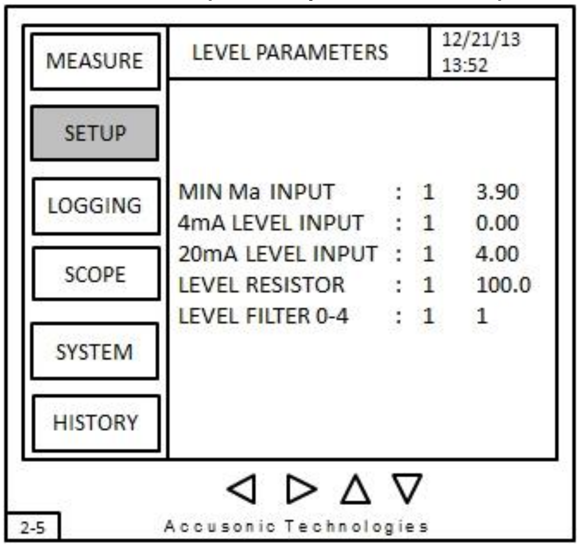


Screen Description

There are two columns of numbers in this screen. The first column after the colon defines the Path Number. To view the current parameter for each section, press the number in the first column which will underline the number. Pressing the UP or DOWN arrow will change the Path number as well as the parameter value in the last column.

To change a given parameter for a given path, press the number in the last column when the desired path number is displayed (this will bring up the numeric entry pad). Enter the desired value, verify the value displayed on the top line of the entry pad, and press EN to store.

Screen 2-5 (Level Input Parameters)

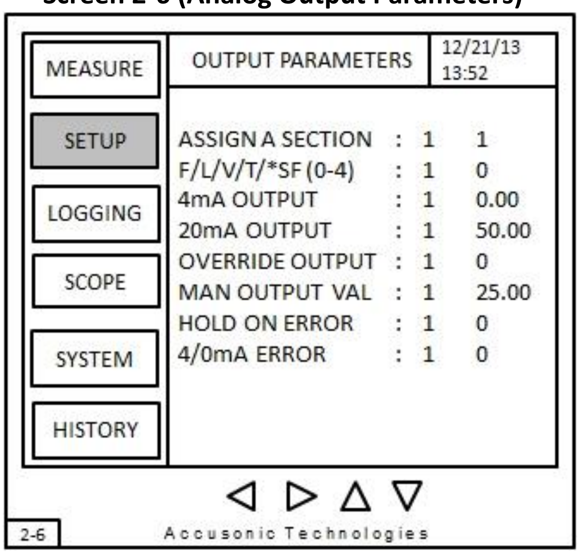


Screen Description

There are two columns of numbers in this screen. The first column after the colon defines the Level Input Number. To view the current parameter for each input, press the number in the first column which will underline the number. Pressing the UP or DOWN arrow will change the Level Input number as well as the parameter value in the last column.

To change a given parameter for a given input, press the number in the last column when the desired input number is displayed (this will bring up the numeric entry pad). Enter the desired value, verify the value displayed on the top line of the entry pad, and press EN to store.

Screen 2-6 (Analog Output Parameters)

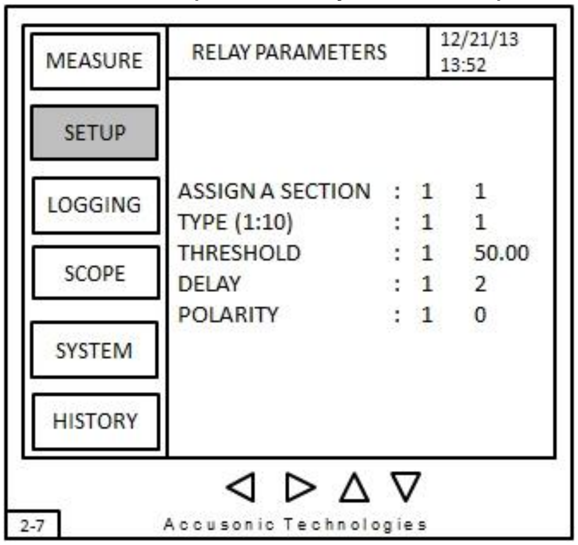


Screen Description

There are two columns of numbers in this screen. The first column after the colon defines the Analog Output Number. To view the current parameter for each output, press the number in the first column which will underline the number. Pressing the UP or DOWN arrow will change the output number as well as the parameter value in the last column.

To change a given parameter for a given output, press the number in the last column when the desired output number is displayed (this will bring up the numeric entry pad). Enter the desired value, verify the value displayed on the top line of the entry pad, and press EN to store.

Screen 2-7 (Alarm Relay Parameters)

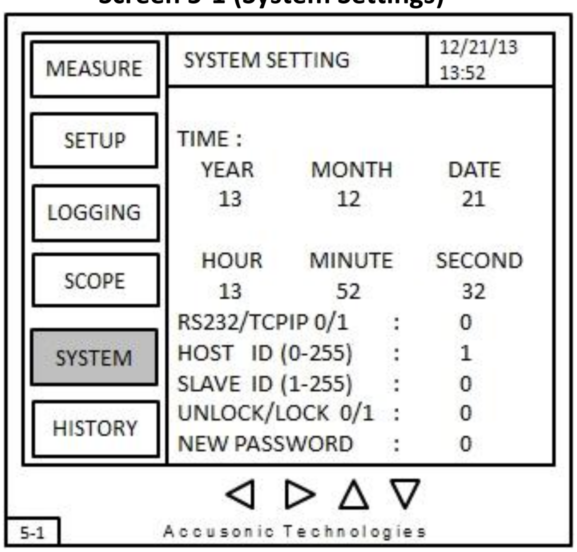


Screen Description

There are two columns of numbers in this screen. The first column after the colon defines the Alarm Relay Number. To view the current parameter for each relay, press the number in the first column which will underline the number. Pressing the UP or DOWN arrow will change the Alarm Relay number as well as the parameter value in the last column.

To change a given parameter for a given relay, press the number in the last column when the desired relay number is displayed (this will bring up the numeric entry pad). Enter the desired value, verify the value displayed on the top line of the entry pad, and press EN to store.

Screen 5-1 (System Settings)



Screen Description

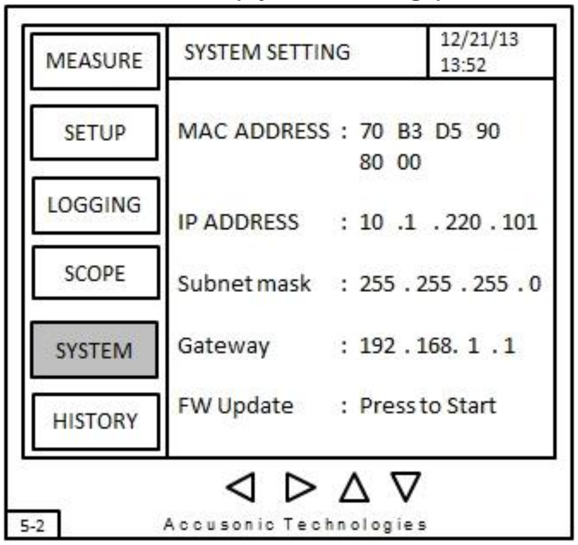
The first System Settings page allows a user to set the current date and time.

Also selectable in this screen is to define what protocol will be used for the MODBUS output. Select RS232 (0) to define the data to be sent via the RS232/RS485 port on the DSP board, or select TCPIP (1) to define the data to be sent via the Ethernet port on the DSP board.

NOTE: To Select RS232 or RS485, there are two shunt jumpers (JP6 & JP7) that must be set appropriately.

JP6 & JP7 PINS 1-2 = RS-485 (two wire)
JP6 & JP7 PINS 2-3 = RS-232 (9-pin)

Screen 5-2 (System Settings)



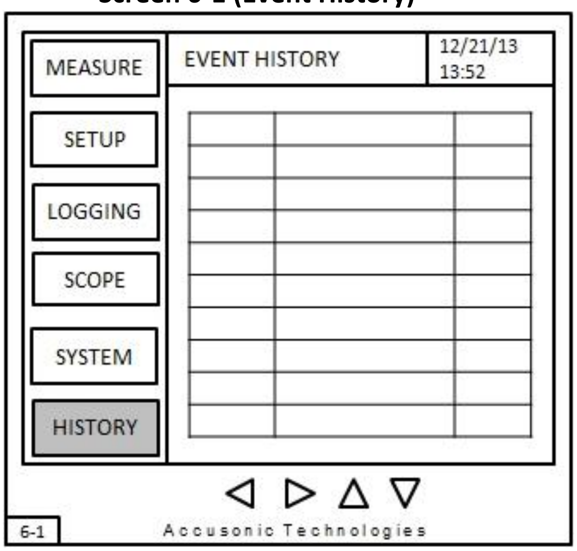
Screen Description

The second System Settings page allows a user to set the IP Address, Subnet Mask, and Gateway when TCP/IP has been selected on Screen 5-1.

The MAC address has been factory set and cannot be changed.

Also available on this screen is the ability for a user to update the firmware of the flowmeter from an SD card. The file needed to perform this firmware upgrade must be received from Accusonic and loaded to the SD card from a PC. Prior to removing the SD card, the data logging function must be STOPPED in order to remove the integral SD card.

Screen 6-1 (Event History)



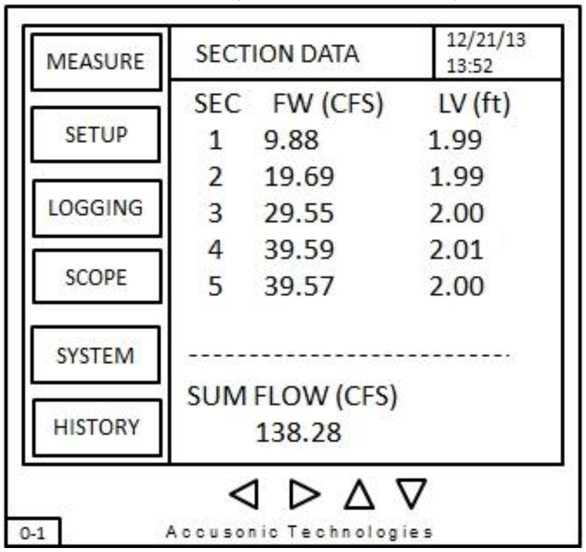
Screen Description

The HISTORY button will display any failures for a given path or section.

Display of Variables

Variables are displayed only when the flowmeter is in "Measure" mode. Immediately after power up, the flowmeter will enter the "Measure" mode, and display the Section Flow Data Screen (0-1). The **UP** and **DOWN** arrow buttons allow for viewing the Section Variables. Pressing the **MEASURE** button on the left side of the display will show the Path Variables. Once in the Path Variables screen, pressing the **UP** and **DOWN** arrow buttons allow for viewing all the Path Variables.

Screen 0-1 (Section Variables)



Screen Description

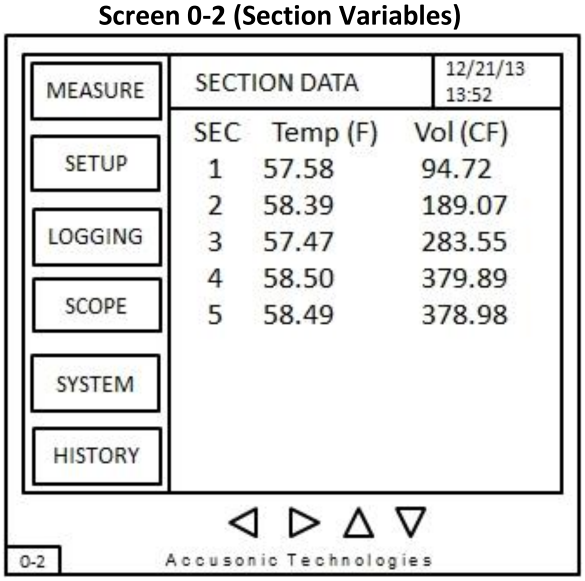
Home screen shows Section Flow and Level data. This is the default measurement screen. This screen can be accessed from the Path Variables screens by pressing the LEFT arrow button.

The first column defines the Section number.
The second column defines the Section Flow (cfs).
The third column defines the Section Water Level (ft).

The SUM FLOW (CFS) value shows the total of all the Section Flowrates.

NOTE: Any Sections that are not in use will display 0 for both flow and level.

Screen 0-2 (Section Variables)



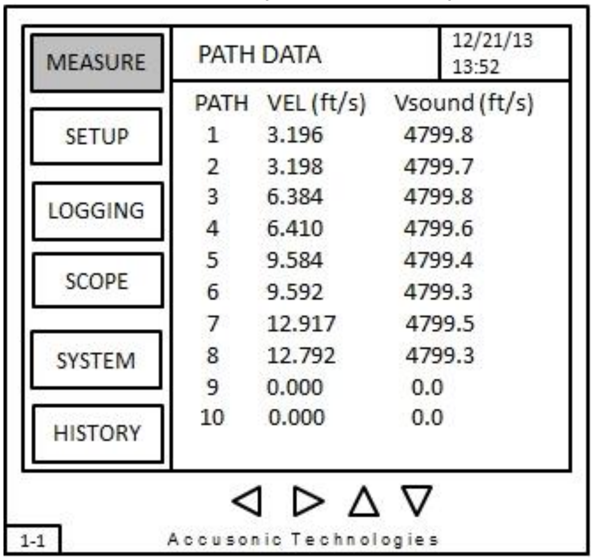
Screen Description

Temperature and Volume screen. Accessed by pressing DOWN arrow button from Screen 0-1 (Home).

The first column defines the Section number.
The second column defines the Section Temperature (°F).
The third column defines the Section Volume (CF).

NOTE: Any Sections that are not in use will display 0 for both Temperature and Volume.

Screen 1-1 (Path Variables)



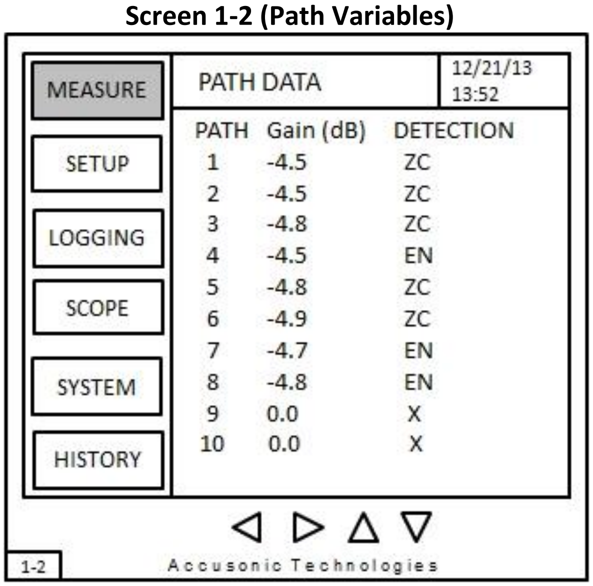
Screen Description

Path Variables can be accessed by pressing the MEASURE button on the left side of the display (after the MEASURE button has been pressed, it will highlight the button as shown). Screen 1-1 will be shown when pressing the MEASURE button from any Menu.

The first column defines the Path number.
The second column defines the Path Velocity (ft/sec).
The third column defines the Path Velocity of Sound value (ft/sec).

NOTE: Any paths that are not in use will be shown as 0.

Screen 1-2 (Path Variables)



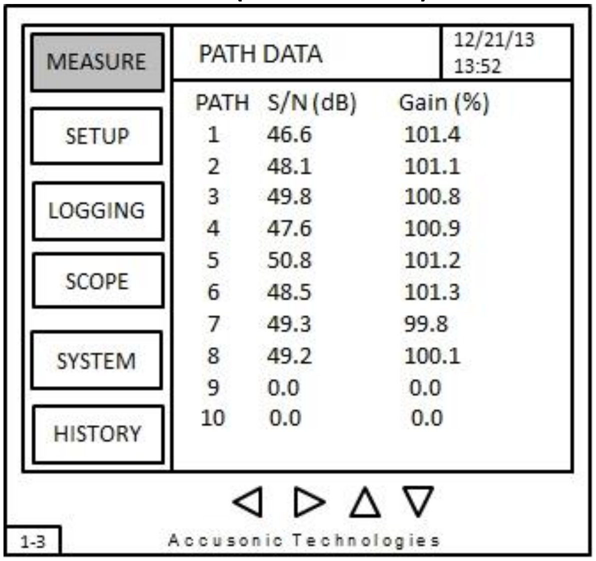
Screen Description

Path variable screens (1-2 through 1-6) can be accessed by pressing the UP or DOWN arrow after the MEASURE button has been pressed.

The first column defines the Path number.
The second column defines the Path Signal Strength (dB).
The third column defines the Path Detection Method.

NOTE: Any paths that are not in use will be shown as 0.0 for the gain value. The detection method for the paths in use (ZC) denotes Zero Crossing detection. (E) denotes Envelope detection and (X) indicates a path failure or a path not in use.

Screen 1-3 (Path Variables)



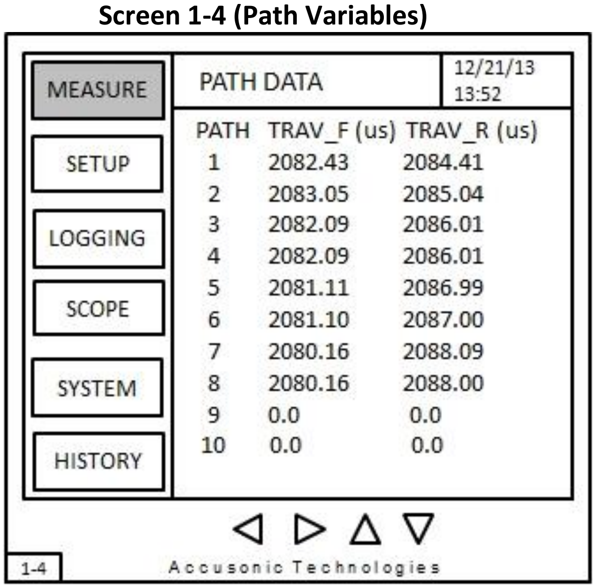
Screen Description

Path variable screens (1-2 through 1-6) can be accessed by pressing the UP or DOWN arrow after the MEASURE button has been pressed.

The first column defines the Path number.
The second column defines the Path Signal-to-Noise Ratio (dB).
The third column defines the Path Gain Percent.

NOTE: Any paths that are not in use will be shown as 0.

Screen 1-4 (Path Variables)



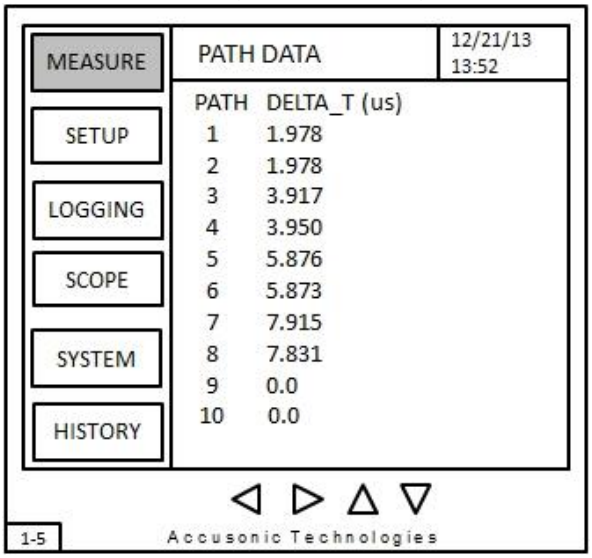
Screen Description

Path variable screens (1-2 through 1-6) can be accessed by pressing the UP or DOWN arrow after the MEASURE button has been pressed.

The first column defines the Path number.
The second column defines the Path Forward Travel Time (µs).
The third column defines the Path Reverse Travel Time (µs).

NOTE: Any paths that are not in use will be shown as 0.

Screen 1-5 (Path Variables)



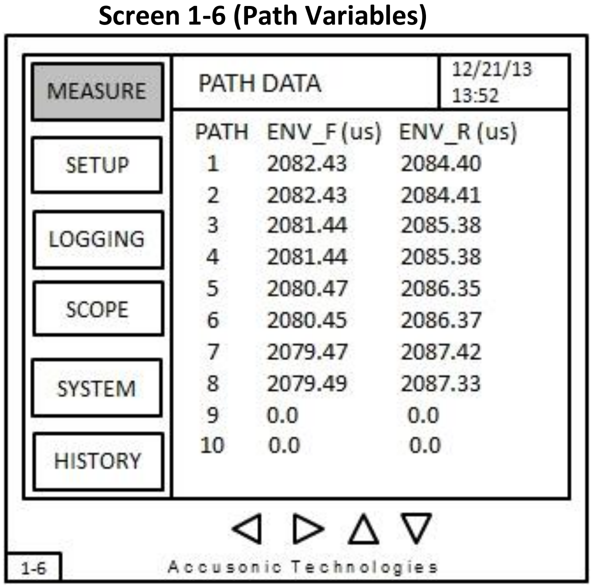
Screen Description

Path variable screens (1-2 through 1-6) can be accessed by pressing the UP or DOWN arrow after the MEASURE button has been pressed.

The first column defines the Path number.
The second column defines the Path Travel Time Difference (µs).

NOTE: Any paths that are not in use will be shown as 0.

Screen 1-6 (Path Variables)



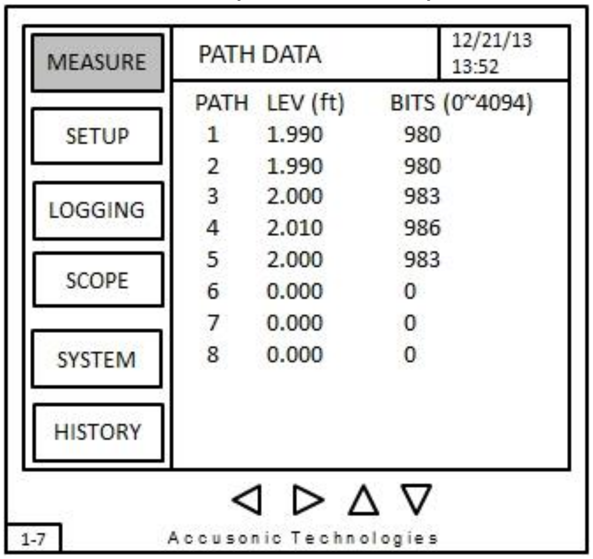
Screen Description

Path variable screens (1-2 through 1-6) can be accessed by pressing the UP or DOWN arrow after the MEASURE button has been pressed.

The first column defines the Path number.
The second column defines the Path Forward Envelope Travel Time (µs).
The third column defines the Path Reverse Envelope Travel Time (µs).

NOTE: Any paths that are not in use will be shown as 0.

Screen 1-7 (Level Variables)



Screen Description

Level variable screen (1-7) can be accessed by pressing the UP or DOWN arrow after the MEASURE button has been pressed.

The first column defines the Level Input number.
The second column defines the value of the Level Input device (ft).
The third column defines the bits for each Lvel Input; bits are scaled so that an input of 0VDC = 0 bits and an input of 5VDC = 4094 bits.

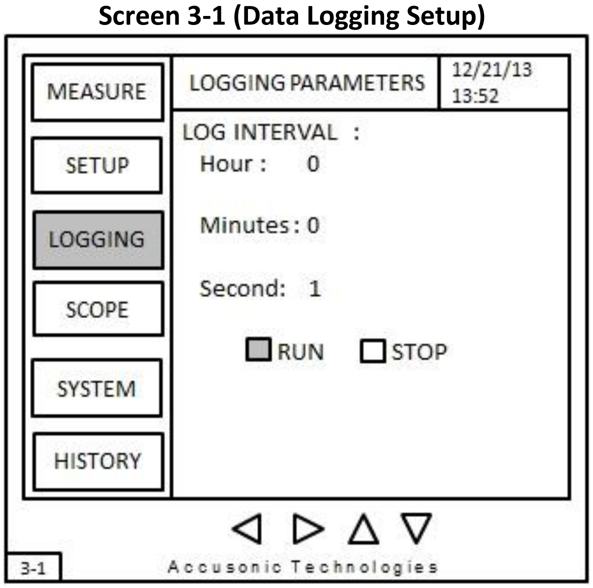
NOTE: Any level inputs that are not in use will be shown as 0.

Operation of Integral Data Logging

The integral Data Logger may be configured to store all the variables at any user selectable interval. It can be setup through the display (by pressing the **LOGGING** button), or the AccuFlow Windows® interface. The data may be retrieved only through use of AccuFlow.

Operation through AccuFlow is described in Chapter 6. The Setup screen via the display is shown below:

Screen 3-1 (Data Logging Setup)



Screen Description

The Data Logging interval can be selected by pressing the LOGGING button on the left side of the display.

Pressing the number after Hour, Minutes, or Second will bring up the numeric keypad. Press the desired number and hit EN to store the desired value.

Once the interval has been selected, press the box in front of RUN as shown. This will begin the data logging.

If the Data Logging interval needs to be changed after the logging has already been enabled, press the box in front of STOP. Now the interval can be changed and then select RUN to re-start the data logger.

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 Flowmeter 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.

A wizard interface is provided to make common tasks easier by providing step-by-step instructions. From the wizard the user can load in the last used configuration, open an existing configuration, look at previously logged data graphically, connect to a flowmeter and begin measurements, or setup flowmeter parameters through use of the setup wizard.

The main application window provides the user with the ability to setup system and flowmeter parameters, control the flowmeter measurement mode, display graphical data, manage data logging operations, and use a variety of flowmeter diagnostics.

Wizard Interface

The wizard interface provides step-by-step instructions to the user to accomplish ordinary tasks. Each step will consist of a dialog window that will "ask" the user for information about what is required, or about setup parameter information. Every step has an available help button, and pressing F1 will bring up context sensitive help on the specific step. The main wizard interface provides buttons for the following tasks:

Receive Parameters from Flowmeter

When this button is selected, the application in the PC will connect with the flowmeter and request its parameters. After having successfully received the parameters, the user is given the option of saving them in a file.

Send Parameters to Flowmeter

When this button 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 created using the wizard. Any parameters the flowmeter had stored will be overwritten.

Setup Wizard

The setup wizard provides step-by-step instructions to setup all the parameters necessary to operate a flowmeter. The setup procedure is broken down into the following steps, each of which has its own dialog window:

Firmware Version Window

In this setup wizard window, the user inputs the firmware version of the flowmeter that is being interfaced. Inputting the correct firmware version will ensure proper parameter transfer.

Sections Window

In this setup wizard window the user enters the number of sections that the flowmeter will be measuring. A section is any single pipe, conduit, channel, river, etc. where flow is to be measured. So if there are two pipes, there are two sections. In addition, the user will enter the type of section, open channel, pipe, or compound. An open channel is a section that is never full, a river or canal, for example. A pipe is a section that is always full, like a water main. A compound section can be full at some times, but not full at others. Sewers are usually compound sections.

Units of Measure

In the measurement wizard window, the user selects the units in which flow and volume are to be measured and reported. Standard choices are provided for flow and volume, but the define buttons give the user the option of defining units that are not on the list. After selecting the define button, the user is asked for a unit name, and a scale factor. The unit name will be displayed on graphs and future menu choices, and is added to the list of standard units. The scale factor is a value by which the flow or volume measurements are to be multiplied in order to convert the measurements to the desired units. The flowmeter measures flow in cubic feet per second (CFS) and volume in cubic feet when English units are chosen, and measures flow in m^3/s and volume in m^3 when metric units are chosen. The scale factors must be chosen to convert from these units. For example, To convert the flow measurement units to $m^3/hour$, the scale factor is 3600. This factor essentially converts seconds to hours.
In addition, the flow averaging period is entered. The flow averaging period is the amount of time that the flow measurements will be averaged over.

Path Enable Window

In the path enable wizard window, the user will assign paths to a section by using the path checkboxes. At least on path must be enabled to move on. Then the low flow cutoff may be entered. If the absolute value of the computed flowrate is below the low flow cutoff, the flow is set to zero.
If the section always runs full (pipe mode), then the window will also ask for the section’s shape and size, as well as the minimum number of good paths and whether learn path ratios should be on. The minimum number of good paths is the number of good path measurements which must be present to calculate flow. The contribution to the flow calculation from any failed paths will be provided by the replacement routine. The default is 4.
Learn path ratios enables a “learning” run that records information that is used in the case of path failures. In the event of one or more paths failing, a routine is implemented which enables flow to be computed from the remaining good paths. The contributions towards the flow measurement from the failed paths is replaced by a figure generated from the remaining good paths, weighted by the historic flow contribution ratios for all the paths. A table of time-averaged historic flow components is recorded during commissioning, involving about 1000 readings. The record is made automatically by the flowmeter in what is termed a “learning” run. The “learning” routine is implemented by checking the Learn Path Ratios checkbox. The learning run may be stopped by unchecking the checkbox, or allowing the flowmeter to complete the 1000 readings.

If the section does not always run full (open channel or compound), bottom friction and top weighting coefficients are to be entered. The bottom weighting and top weighting coefficients are used to extrapolate the velocities from the lowest and highest paths to the section bottom and/or top (or water surface).

Section Shape

For sections that do not always run full (open channel or compound), the section shape is requested. The section shape window gives two choices, round and other. Round is for circular pipes (they are assumed to be perfectly circular). Other is for sections that cannot be described so easily.

Round
After selecting round for the section shape, the wizard asks for the radius of the pipe. This should be the inner radius. When “Round” is selected, all layer data are automatically computed by the wizard.

Other
After selecting “other” for the section shape, the wizard asks for the number of layers, their elevations and widths. The layers describe the size and shape of the section. These should be available from the survey data taken at installation.

Flow Calculation When Level is Surcharged
For compound sections only, the flow calculation method when the level is surcharged is requested. In this wizard window, the user selects the integration method to be used when the section is surcharged (running full). For more information about integration methods, please see Chapter 3. The default for round pipes is pipe integration. For other shapes, the default is trapezoidal integration.

Level Input Enable Window
For sections that do not always run full (open channel or compound), the level input enable window is displayed. In this wizard window, the user enables the analog inputs for level (stage) measurements by selecting the appropriate checkbox for the section. For pipe and compound sections, the user is also asked for the level at which the section is surcharged (full). The user should also enter the level below which flow is defined as zero. There is also an option to enter a manual value for the level input, overriding the analog inputs. If override analog level input is checked, an entry box becomes visible for a manually entered value. The value entered will override all flowmeter calculated level values, and the flowrate will be calculated on the basis of the manually entered level. This option may be used for testing purposes.

Level Input Setup
For sections that do not always run full (open channel or compound), the level input setup is requested. In this window the user enters the level values for 4 and 20 mA. For these values the user should enter the elevation of the water surface at which the analog input is 4.0 or 20.0 mA. For example, if at 10.0 feet, the analog input is 20.0 mA, enter 10.0 for “Level at 20 mA”. This value may be in the range of -50 to 50. Also the level filtering period should be entered. This is the period, in measurement cycles, that the level inputs will be averaged over. For example, if the measurement update rate (repetition rate) is 2 seconds, and the level filtering period is 15 cycles, then the averaging period is approximately 30 seconds. The tabs at the top of the “notebook” window can be clicked to switch from one input to another.

Manning Parameters
For sections that do not always run full (open channel or compound), the Manning equation parameters are requested. In this wizard window, the user is asked if they wish to use the Manning formula, and if so, for the parameters necessary. For more information on the Manning formula, see Chapter 3.

Path Setup
This window prompts the user for path parameters. The path length, angle, and elevation should be available from the survey data. The transducer model number should also be available in the as built data. If a new transducer model number needs to be added, select the “add to list” button. After that, a transducer model number, frequency, and signal delay must be entered. Elevations are not required for sections that always run full, and are not displayed.

Output Setup
In the output setup window, the user can define what section a given 4- 20 mA analog output is assigned to, what type of data is output, the output range and the output under error conditions. An output can be assigned to any

active section, and can reflect flow, level, average velocity, temperature, or total flow data. In the 4 mA boxes the user should enter the value of the variable chosen for the analog output for which an output of 4.0 mA is desired. For example, if flow has been chosen for output, and the units are m^3/s, enter -1.5 if it desired to have a 4.0 mA output at -1.5 m^3/s. 4.0 mA is the lowest valid output. A similar procedure should be used for the 20 mA entry. It is acceptable for the 4 mA output to represent a variable value that is either greater than or less than that of the 20 mA output

Under conditions where the chosen variable is below the selected range, 4 mA will be output. Under conditions where the chosen variable is over the selected range, 20 mA will be output. If a fault occurs, the output will either be held at the last known good value, or be set to 4 mA, depending on the choice made in the "On Error" box. There is also an option to enter a manual value for the analog output, overriding the calculated outputs. If override analog output is checked, an entry box becomes visible for a manually entered value. The value entered will override all flowmeter calculated values, and the output current will be calculated on the basis of the manually entered value. This option may be used for testing purposes.

Relay Setup

In the relay setup window, the user can define what section a given relay is assigned to, what function the relay has, the threshold value, the polarity, and the delay before operation. Relays can be used as indicators that the section flow is over a threshold value, the section level is over a threshold, the sum of all the section flows is over a threshold, the section has failed, path substitution is active (pipe mode only), or as a section or sum of sections volume totalizer. For those functions that require it, the threshold value is entered in the appropriate units. The user can also define what polarity the relay is to be when operated. The delay before operation is in measurement cycles, so that if the measurement update rate (repetition rate) is 2 seconds, and the delay is 3 cycles, then the delay is approximately 6 seconds.

Open Setup

This choice allows the user to open a previously saved configuration file. A standard open file dialog box is shown, from which the user can select the desired file. Once the file is loaded, it can be used for flowmeter measurements, or can be modified.

Review Historical Data

The review historical data option allows the user to view graphs of previously logged data. When the button is selected, a flowmeter ID and data range window is displayed. In this window, the user selects the ID of the desired flowmeter. The start and stop date calendars will automatically update to show the full range of logged data for that flowmeter. The user can use the calendars to select a smaller range by clicking the arrows at the top of the calendars to change the month, and by clicking the desired date. The time is selected by using the list boxes below the calendars.

Once the ID and date/time range are selected, the user can choose which graph to be viewed. The *view data by variable* graph will display either flow or level for multiple sections. For example, in the view by variable graph, the user can graph flow for sections 1 through 4. Then they can select level for those sections. Flow and level cannot be graphed together on this view, however. The *view data by section* graph allows the user to look at flow, level and velocity for an individual section. Because there can be up to 10 velocity data curves in a section, the velocity graph is separate from the *flow/level* graph. If only one graph is selected, it will appear as a full page. If both flow/level and velocity are selected, they will share the screen. Please see "using graphs" for more information about their features.

Connect / Measure

If Connect / Measure is chosen, the application will connect to the flowmeter, and upload its parameters. The uploaded parameters will be used in building the graph. After parameter loading, measurements will begin, and the graph will start to display data. Initially, there is a delay in acquiring the data, and graph options are disabled.

They are re-enabled when the initial acquire period is complete. Please see "using graphs" for more information about their features.

File Menu

The file menu provides access to basic file management operations.

File / New

File / New starts the setup wizard in order to allow the user to create a new configuration file. The configuration initially contains only the default values.

File / Open

Choosing File / Open opens an existing configuration file. When this menu choice is selected, the standard windows *open file* dialog box will appear with the current directory and *.cfg configuration files selected as defaults. Making a selection in this dialog and selecting OK will load in the selected configuration file. This will overwrite any previously loaded configuration. Once the file is loaded, it can be used for flowmeter measurements, or can be modified.

File / Save

This allows the user to save the currently loaded configuration file, while giving it a new name. An existing file name may be chosen, or a new name created. Choosing File / Save As opens the standard *save file* dialog box which is similar to the *open file* box described above.

File / Print

The File Print item allows the user to print the contents of the configuration file. This can be useful for record keeping. The print uses the Windows default printer, unless it is changed using the Setup button.

File / Exit

This item exits the flowmeter program.

Configure Menu

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

Communications

The communications configure menu allows the user to make modifications to the communications setup. The flowmeter has particular communications formats, which are reflected in the defaults provided here. In most cases, the only two parameters that should require modification are the Comm. port number and the maximum consecutive communication errors.

Comm Port

The user chooses the communications port that is connected to the flowmeter.

Maximum Consecutive Communication Errors

This allows the user to enter the maximum consecutive number of communication errors that are to be tolerated without declaring a failure. The default is 3. A single communication error may take up to 10 seconds to confirm.

Dial Modem

The dial modem selection allows the user to choose a modem and a phone number, and establish a modem connection. After dial modem is selected, the user must choose a modem to use from the provided list. If "None" is chosen, that serial comm. port will be used directly with no modem, otherwise, the selected modem will be used. If a modem is selected, the next dialog requests a phone number to dial. The user can select a number from the list, or add one by clicking on "Add phone number". If the user wishes to configure the modem, click on "Set up modem". This will display the standard Windows95 modem properties dialog. Beware that these settings apply to all programs, not just AccuFlow. Once the phone number is entered, the modem will attempt a connection. It will retry 3 times, waiting one minute in between attempts. The connection attempt can be canceled at any time.

Hang Up Modem

The hang-up modem selection allows the user to break the existing modem connection and hang up the phone.

Get Flowmeter Version

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.

System

The system configure menu allows the user to make modifications to the currently loaded configuration in the areas of section type, number of sections, measurement units, flowmeter RS-232 enabling, and other general parameters. For definitions of these parameters, please see the parameter definition section in Chapter 7.

Section

The Section configure menu allows the user to make modifications to the currently loaded configuration in the section parameter area. For definitions of section parameters, please see the parameter definition section in Chapter 7. From the section menu, the path, level, and relay setup windows can be accessed.

Path

The path setup window allows the user to make modifications to the currently loaded configuration in the path parameter area. For definitions of path parameters, please see the parameter definition section of this manual in Chapter 7.

Level Inputs

The level inputs setup window allows the user to make modifications to the currently loaded configuration in the level analog input area. For definitions of level parameters, please see the parameter definition section of this manual in Chapter 7.

Analog Outputs

The analog outputs configure menu allows the user to make modifications to the currently loaded configuration in the analog output area. For definitions of analog output parameters, please see the parameter definition section of this manual in Chapter 7.

Relay Setup

The relay setup configure menu allows the user to make modifications to the currently loaded configuration in the relay area. For definitions of relay parameters, please see the parameter definition section of this manual in Chapter 7.

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.

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

When *send 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 created using the wizard. Any parameters the flowmeter had stored will be overwritten.

When *Connect / Measure* is chosen, the application will connect to the flowmeter, and upload its parameters. The uploaded parameters will be used in building the graph. After parameter loading, measurements will begin, and the graph will start to display data. Initially, there is a delay in acquiring the data, and graph options are disabled. They are re-enabled when the initial acquire period is complete. Please see using graphs for more information about their features.

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 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.

The *Review Historical Data* option allows the user to view graphs of previously logged data. This function is the same as described in the wizard interface section.

Diagnostics Menu

The diagnostics menu allows the user to test the flowmeter system, and to view detailed path variables that are not ordinarily used. The diagnostics menu has the following choices:

Comm Port Test

If the Comm. port item is chosen, a window to test the Comm. port is opened. The comm. port test tests the function of the port on the PC. It does not test the flowmeter communications. Before testing the port, the user must put a wrap-around connector that connects the transmit and receive lines on the desired port. When the test port button is selected, the port will output patterns and read them back. It will compare the patterns to make sure that they are the same. If they are, it will display a good status in the memo box. If they do not match, it will display the expected pattern, and the actual pattern received. If there is no response in one second, it will display a “no response” message.

The port menu item in the Comm. port test window can be used to configure and open the port. The Configure menu choice allows the user to set the desired port, the baud rate, number of data bits, parity, stop bits and flow control. These are set up initially to work with the flowmeter, and usually should not require modification. The *Open menu* choice opens the desired port for communications. This must be done or a “no response” error will occur.

Path Variables

The path variables window allows the user to look at all the data coming from the flowmeter in tabular form. It is displayed as a multiple tab notebook. Each tab contains the variables for a given section. In addition, there is a settings tab that allows the user to choose only those variables and paths required. The user may choose to have the table continuously updated, or to pause the updates.

Before beginning measurements, the user is asked if the data are required to be logged. If so, the data logging menu is displayed. The data logging menu allows the user to enable and setup data logging to the PC. Checking enabled will allow data to be saved to the PC. The name of the data to be saved can have a maximum of 8 characters. This name is actually the sub-directory name where the data files will be stored. The data can be scheduled for every reading (about one every three seconds), or a set interval. The data recorded at the set interval, i.e. 15 minutes, will be the current value of the data, not an average. Once the setup is complete, clicking OK, will cause the measurements to begin.

This window is also used to display data log data. All of the variables below remain 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.

The variables displayed are section, path and level variables, and are as follow:

Section

Section variables are flow, average level, section volume, average velocity, temperature, integration method, and section status. The status indicates if the section is full, has failed, has invoked path substitution because a path has failed, or is on a “learning” run.

Path

Path variables are velocity, gain (dB or %), signal-to-noise ratio, travel time, time difference, envelope time, path status (out of the water, failed, velocity error), and path detection method.

Level

Level variables are level and level status (good, greater than maximum layer height, below minimum level).

Scope Mode

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.

Single Sweep

When this button is clicked, the "oscilloscope" contacts the flowmeter and obtains the waveform to be displayed. 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 contacts the flowmeter and obtains waveforms.

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.

Mouse Control

When the mouse is moved into a graph that has a waveform displayed, a slidebar appears. It will follow the mouse until the mouse is clicked or the mouse exits the graph area. When the slidebar is visible, it's coordinates are displayed on the panel above the graph in engineering units (time and volts). Each graph can have its slidebar moved and set independently.

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 displayed. Waveform displays the actual received signal. Envelope displays the envelope of the received waveform 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.

Erase

Clicking the erase button clears both graphs.

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.

DataLogging Menu

The DataLogging menu allows the user to retrieve data logs stored in the flowmeter. The DataLogging menu has the following choices:

Data Log Setup

Choosing DataLogging/Data Log Setup from the main menu allows the user to set up the interval for data logging to the integral 4GB (min) SDHC Card. The maximum interval is 24 hours.

Retrieve Logged Data

Choosing DataLogging/Retrieve Logged Data from the main menu allows the user to retrieve data that has been logged at the flowmeter. This capability is optional, and requires the flowmeter to have the data logging memory card.

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.

Next, choose a data name. This name has a maximum of 8 characters, and cannot have spaces or special characters. Now click on "Retrieve Data". Each data block takes about 45 seconds to retrieve. 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.

Once the data is retrieved, it is stored in the data_log directory in a sub-directory with the name you provided. Flow, level and velocity are stored in section sub-directories, and can be viewed in "Review Historical Data." Section volume and temperature are also stored in the section sub-directories. The sum of flows and sum of volumes are stored in the "S" file, path data is stored in "P" files, and level data is stored in the "L" file. The file names will contain the date and the above code. For example, if the data log began on May 25, 1997, the data for path 1 (VSound, gains, times) will be stored in a file named "05297PO". All files are comma delimited text that can be imported into spreadsheets.

Logged Data Directory Structure

```
Data Log
 └── User Name Entered
      ├── Sect 1
      │    ├── mmddyyQ1 - Date,Flow1,Level1
      │    ├── mmddyyV1 - date,velocity 1 - 10
      │    └── mmddyyT1 - date,volume1,temperature1
      ├── Sect 2
      │    ├── mmddyyQ2 - Date,Flow2,Level2
      │    ├── mmddyyV2 - date,velocity 1 - 10
      │    └── mmddyyT2 - date,volume2,temperature2
      ├── Sect 3
      │    ├── mmddyyQ3 - Date,Flow3,Level3
      │    ├── mmddyyV3 - date,velocity 1 - 10
      │    └── mmddyyT3 - date,volume3,temperature3
      ├── Sect 4
      │    ├── mmddyyQ4 - Date,Flow4,Level4
      │    ├── mmddyyV4 - date,velocity 1 - 10
      │    └── mmddyyT4 - date, volume4,temperature4
      ├── mmddyyS - date, flowSum,volumeSum
      ├── mmddyyL - date, level1 - 4, bits1 - 4
      ├── mmddyyE - date, PathError,SectionError,LevelError
      ├── mmddyyP0 - date, Vsound1,dB1,Gain%1,S/N1,Tenv1,Travel1,Delta1
      ├── mmddyyP1 - date, Vsound2,dB2,Gain%2,S/N2,Tenv2,Travel2,Delta2
      ├── mmddyyP2 - date, Vsound3,dB3,Gain%3,S/N3,Tenv3,Travel3,Delta3
      ├── mmddyyP3 - date, Vsound4,dB4,Gain%4,S/N4,Tenv4,Travel4,Delta4
      ├── mmddyyP4 - date, Vsound5,dB5,Gain%5,S/N5,Tenv5,Travel5,Delta5
      ├── mmddyyP5 - date, Vsound6,dB6,Gain%6,S/N6,Tenv6,Travel6,Delta6
      ├── mmddyyP6 - date, Vsound7,dB7,Gain%7,S/N7,Tenv7,Travel7,Delta7
      ├── mmddyyP7 - date, Vsound8,dB8,Gain%8,S/N8,Tenv8,Travel8,Delta8
      ├── mmddyyP8 - date, Vsound9,dB9,Gain%9,S/N9,Tenv9,Travel9,Delta9
      └── mmddyyP9 - date, Vsound10,dB10,Gain%10,S/N10,Tenv10,Travel10,Delta10
```

Shown above is the sub-directory tree structure that is created to store the data downloaded from the datalog board. The number and types of files may differ slightly from site to site depending on the current system configuration. The top of the tree (Data_Log) is found in the sub-directory where the Accuflow software has been installed. The first branch below Data_Log (labeled ID above) will be the name entered as part of the download process. The file naming convention used is based on the start date of the specific data that is downloaded. For example if the datalog operation began on April 1, 1999 the mmddyy portion of the names shown above will be replaced with "040199". Note that the name is based on when the data collection started and not when it is downloaded. The last one or two characters in each filename (shown above in bold) indicate the type of data stored in each file.

The data type designators indicate the following:

- **Qn** indicates flowrate and level data for section n where n indicates the section number 1 through 4.
- **Vn** indicates the velocity data for section n. the velocity data file will store the velocity data for all paths in the system and not just the section. For example a 4- section system with 2 paths in each section (total of 8 paths) will store the velocity data for all 8 paths in each section meter sub-directory.
- **Tn** indicates the volume and temperature data for section n
- **S** indicates the system flowrate and volume that is simply the sum of the section flowrate and volume data.
- **L** indicates the level measurement data for each of the active level measurement inputs. This data consists of two parts, the first part contains the level data for each of the active level inputs scaled in engineering units (feet, meters, …). The second part contains the raw binary value as read from the A/D for each of the active level inputs.
- **E** contains the path error, section error and level error values. These values are the decimal equivalents of system

Pn contains the path data for path n. This data consists of:
the velocity of sound determined by the velocity measurement travel times
the gain required to obtain a useable signal level
the percentage of the full scale A/D resolution that the received signal achieved
the signal to noise ratio measured
average of the forward and reverse travel times measured when the path is operating in the envelope detect mode
average of the forward and reverse travel times measured when the path is operating in the zero crossing detect mode
difference between the forward and reverse travel time measurements, calculated as Trev – Tfwd

Display Retrieved Log

Choosing DataLogging/Display Retrieved Log from the main menu allows the user to display data log data that has been retrieved from the flowmeter. The data will be displayed in a tabular format, one measurement, or record, at a time.

Initially, a dialog to choose the data log ID and desired date/time appears. Once you have chosen an ID, the data log is scanned to determine its range. You can then choose a record to begin with, by entering a date and time. The default is the first record.

After choosing OK, the data is displayed in a table. To change to different records, use the record number spinner at the bottom of the screen.

Using Graphs

On the *view by variable* graph, the user can select which variable by selecting either the flow or the level button, and then select the section number(s) by using the buttons numbered 1 through 4. Multiple sections may be selected. The numbers below the section number buttons reflect the value of flow or level at the slidebar. The slidebar is the yellow vertical line that can be used as a marker for data points. It can be moved left or right by clicking and dragging the circular "knob" at the top of the slidebar. Notice that the numeric data changes as the slidebar is moved.

On the *view by section* graph, the user can select the section by clicking the radio buttons in the bottom right corner. Flow, level and velocity 1 through 10 are selected with the buttons on the bottom of the window. Slidebar operation is the same as in the *view by variable* graph, except that both graph panes are updated. If just velocities are selected, that graph will be expanded to the full window. Likewise, if only flow and/or level are selected their graph will be expanded. Otherwise, the window is split into two graph panes.

On the *settings* notebook tab, the user can select scaling options. They are normally automatically scaled based on the input value for historical data, or the maximum expected input for real-time data.
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. All parameters are defined in Chapter 7.

Variables provide a view of measurements when the flowmeter is in normal "Measure" mode.
Chapter 7 contains definitions of the variables.

Chapter 7

User Defined Parameters

Note: The System, Section, Path, Input, and Output parameters can be accessed by pressing the SETUP button on the left hand side of the touchscreen display.

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

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: 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 Millions of gallons/day: (MGD)	set to 0.646
For Metric units,	Flow in m^3/s	set to 1.0
	Flow in Mega litres/day (MLD)	set to 86.4
	Flow in l/s	set to 1000
	Flow in m^3/ hour	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:	Acre feet	set to 43560
	Flow in MGD:	Million gals	set to 86400
For Metric units,	Flow in m^3/s	1000m^3	set to 1000
	Flow in MLD	Mega litres	set to 86400
	Flow in l/s	m^3	set to 1000
	Flow in m^3/ hour	1000m^3	set to 3600000

ANALOG OUT SCALING — A factory set parameter. Set to 1.0 for non-isolated, or 0.5 for isolated outputs and 0.25 for the 8510.

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.
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.
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, (metres) set to 1.
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 **Esc** then the **Reset** (or **#**) key is pressed, or if there is a temporary loss of power.
DATA to SERIAL {0 : 3}	To select the outputting of data to RS232 serial ports. set to 0, for no serial data outputs. set to 1, for data output to the "Hand-held terminal" port, see page 5-10. set to 2, for data output to the optional Com 3 RS232 port in "Argus" format set to 3, for data output to the optional Com 3 RS232 port in "Drax" format
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.** For the 10MHz setting, link JP50 on the DSP card must be towards the center of the card. For other settings, the link must be away from center.
DISPLAY UNITS 0 : 4	Selects the characters to indicate the units of the variables displayed on the optional Liquid Crystal 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 omit the units in the display.

DETECTION METHODS Set to 0, "AUTOMATIC" to enable the flowmeter to use the optimum signal detection method for the conditions. The normal setting.
Set to 1, "FIRST NEG" to force the flowmeter to use only detection of the "first negative" edge of the received signal. (Use only if the water known to be clean and without aeration)
Set to 2, "ENVELOPE" to force the flowmeter to use only detection of the "envelope" of the received signal. (For use if water is always aerated)

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 set to zero.
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 For each section, a 10 bit binary number must be entered as a decimal value and has to be set in order to define which paths are to be allocated to the section. e.g.

For paths 1,2 to be used, the number is set to 3.
For paths 1,2,3,4 to be used, set to 15.
For paths 1,2,3,4,5,6,7,8 to be used, set to 255.
For paths 5,6,7,8 to be used, set to 240.

For custom path configurations, the table below can be used to calculate the decimal value for any configuration

Path #	1	2	3	4	5	6	7	8	9	10
Value	1	2	4	8	16	32	64	128	256	512

Each Path has a corresponding decimal value. Each individual path value for a given section should be summed to calculate the Path Enable value, e.g. to enable Path 3 & 4 = 4 + 8 = **12**.

For any Section not in use, set the path enable value to 0 which will turn the unused sections off.

LEVEL ENABLE C This parameter is ignored if the system is in "Pipe" mode.
For each section, a 4 bit binary number must be entered as a decimal value and has to be set in order to define which of the analog level inputs apply to the section.
A maximum of two inputs can be allocated to any section. e.g.
For analog level input #1 only to be used, the number is set to 1.
For analog level inputs #1 & #2 to be used, the number is set to 3.
For analog level inputs #3 & #4 to be used, the number is set to 12.

For custom level configurations, the table below can be used to calculate the decimal value for any configuration

Input #	1	2	3	4	5	6	7	8
Value	1	2	4	8	16	32	64	128

Each Level Input has a corresponding decimal value. Each individual Level Input value for a given section should be summed to calculate the Level Enable value, e.g. to enable Level 1 & 2 = 1 + 2 = **3**. To enable Level 3 & 4 = 4 + 8 = **12**.

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 page 3-5.
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.
Range 1 to 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 page 3-5 Pipe Mode).
The parameter will reset to 0, and the table frozen after 1000 readings.
Warning: all paths must be good & 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: *LEVEL MANUAL*: set 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. In narrow conduits set to 0.
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. Note that 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

1. *The layer elevations must be in strict height order. Layers 1-10 (Section 1); Layers 11-20 (Section 2); Layers 21-30 (Section 3); Layers 31-40 (Section 4); Layers 41-50 (Section 5)*
2. *Two layers cannot be given the same elevation.*
3. *Data entered in layers having numbers higher than the parameter NUM of LAYERS will be ignored*
4. *For a Round Pipe, the layer configuration given on pages 5-4 or 7-14 is recommended*
5. *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 integ'n, 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 page 3-1.
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 any given transducer type, this value should be set to 3μs. 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.
Set to 1 for the relay to be normally energized.
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** button on the left hand side of the touchscreen display.

TIME	Allows a user to set the current date and time. Press the value to be changed to bring up the entry pad.
RS232/TCPIP 0/1	Allows a user to select the protocol to be used for the Modbus Slave output. Set to 0 for the RS-232 / RS-485 user selectable port (jumpers JP6 & JP7 on the DSP board; Pins 1-2 = RS-485; Pins 2-3 = RS-232). Set to 1 for the TCP/IP port.
HOST ID (0-255)	If a “Master” 8510 flowmeter is used to communicate with “Slave” 8510 flowmmeters, use the following settings: “Master” 8510 — Set to 0. “Slave” 8510 — Set to values beginning at 1 for “Slave” 8510 #1. For a “stand-alone” unit, this value should be set to 1.
SLAVE ID (1-255)	In a “Master / Slave” configuration described above, the following describes this function: “Master” 8510 — Set to a specific “Slave” 8510 ID to view its specific parameters and variables. “Slave” 8510 — This addresses each “Slave” 8510 to allow the “Master” 8510 to communicate to each “Slave” 8510 at a centralized location. For a “Stand-alone” unit, this value should be set to 1.
UNLOCK/LOCK 0/1	Set to 0 to disable password protection. Set to 1 to enable password protection.
NEW PASSWORD	Allows for setting the password when UNLOCK/LOCK is set to 1.
MAC ADDRESS	Allows a user to view the MAC address of the flowmeter. Factory set.
IP ADDRESS	Allows a user to set a specific IP address for the TCP/IP Modbus Slave output.
Subnet Mask	Allows a user to set a specific Subnet Mask for the TCP/IP Modbus Slave output.
Gateway	Allows a user to set a specific Subnet Mask for the TCP/IP Modbus Slave output.
FW Update	Allows a user to update the 8510 firmware from the integral SDHC memory card. Please note that the firmware files must be received from Accusonic and then loaded to an SDHC card by the user to use this functionality. The data logging function should be STOP’d in the LOGGING page prior to performing the firmware update.

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. A separate screen has to be selected for each type of variable. The Path Variables can be accessed by pressing the **MEASURE** button on the left hand side of the touchscreen display. Pressing the **UP** or **DOWN** arrow will allow the user to change which variables are displayed. Pressing the **LEFT** arrow button (while viewing the Path Variables) will return a user to the Section Flow Data screen (0-1) displaying the Section 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 metres/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 $\log_{10}$ [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 (μs), 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 The time-averaged value of each individual Level input, in terms of the elevation of the water
CHNL surface above the site datum.
BITS 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 screen 1-7.

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 table below 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 on page 7-4

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
Multipath Flowmeter Systems Theory and Operating Principle

Multiple-Path Transit-Time Flowmeters Principle of Operation

About Accusonic

Accusonic, a division of ADS LLC, designs and manufactures multi-path transit-time flow measurement systems which are renowned for their precise accuracy and reliability in difficult operating environments. Accusonic flowmeters can be found in hydroelectric and thermal power plants, water and wastewater treatment facilities, sewage collection systems, and other types of water conveyance pipelines and channels. Since 1967, Accusonic has installed thousands of systems worldwide, and offers a full range of services including installation and startup, system verification, turbine performance testing services, and field training.

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.

ACCUSONIC®

TRANSIT-TIME OPERATING PRINCIPLE

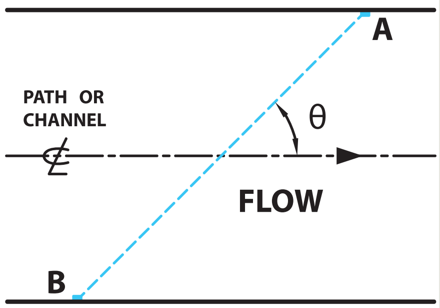


Figure 1 Acoustic Path Layout

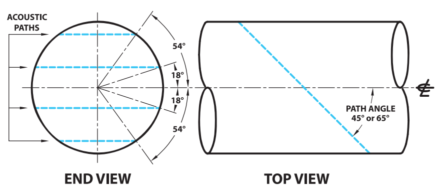


Figure 2 Typical full-pipe pipeline placement (using the Gauss-Chebyshev integration method)

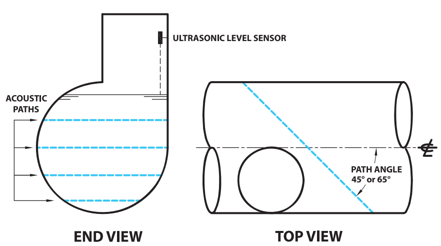


Figure 3 Typical partially full pipe

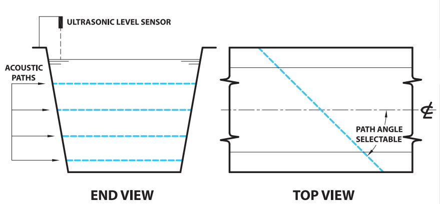


Figure 4 Typical open channel path placement

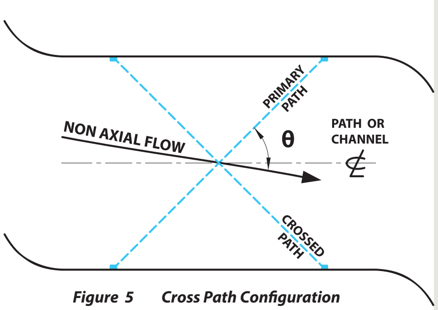


Figure 5 Cross Path Configuration

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 (see Figures 1 & 2). 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 (see Figures 2, 3, & 4). Velocities for these paths are then integrated so that flow is measured according to the following equations:

1. For pipes:

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

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)

2. For open channels and partially full pipes: When more than one path is submerged:

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

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

For 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 (see Figure 5).

3. For 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 / MEASUREMENT UNCERTAINTY

For pipeline flow measurement using a 4-path flowmeter, the accuracy of the rate indication and totalization of flow is specified to be ± 0.5 percent of actual flow. This is for all flows with velocity above 1 foot per second and up to maximum flow, provided the flowmeter 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. Sources of error for pipeline flow measurement are:

- **Path Length Measurement**
- **Path Angle Measurement**
- **Travel Time Measurement**
- **Radius Measurement (or area for non-circular conduits)**
- **Velocity Profile Integration Error**

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

2. 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 ±0.1° (±6') of the true centerline. *(CONTINUED ON THE BACK PAGE)*

PRINCIPLE OF OPERATION

As for paths nominally at 45°, the flow measurement uncertainty due to path angle measurement error would be:

$E_{ø} = (1-(\cos 45.10/\cos 45.00)) = 0.0017$ 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.

3. 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:

$E_T = 0.0001$ or .01%

4. 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:

$E_R = (1 - (1/1.002)^2) = 0.004$ or 0.4%

5. 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:

$E_I = 0.002$ or 0.2%

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

$E_Q = (E_L^2 + E_q^2 + E_T^2 + E_R^2 + E_i^2)^{1/2} = 0.0049$ @ 0.005 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 Table 1.

TABLE 1

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

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.

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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.

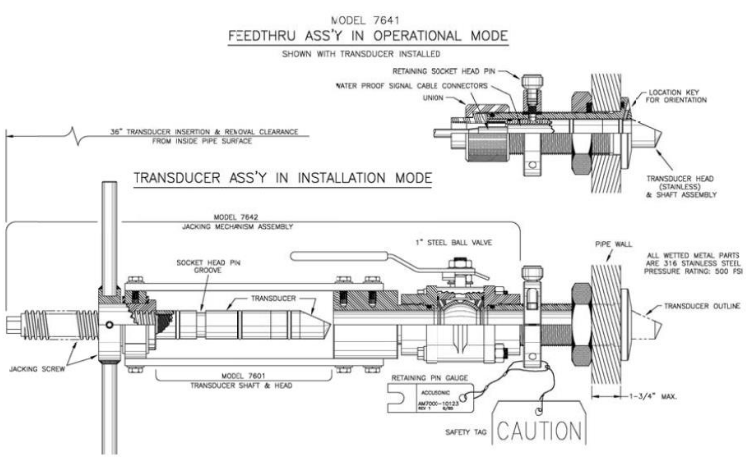
Signal deterioration

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* on page 7-11 in Chapter 7.

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* on page 4-4 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.*



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 pages B-19 and B-20.

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 15. 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

1. Verify the following safety conditions are met below. See Figure 10-1 on page B-15.

   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-16. 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-16. 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-15 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-15. 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-15)

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.

Notes

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. 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.

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

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 again to Figure 10-1 on page B-15 and verify that the following safety conditions are met:

    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.

    If any of these conditions is 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.

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-15.

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 a component 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

1. Verify the following three safety conditions are met below. See Figure 10-3 on page B-17.

   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.

   If any of these conditions is not met, STOP WORK on the transducer immediately and contact Accusonic for advice.

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-17.

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-18. 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.

Notes

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. 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.

Notes

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

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-17.

This completes removal and assembly of the 7600 Series transducer.

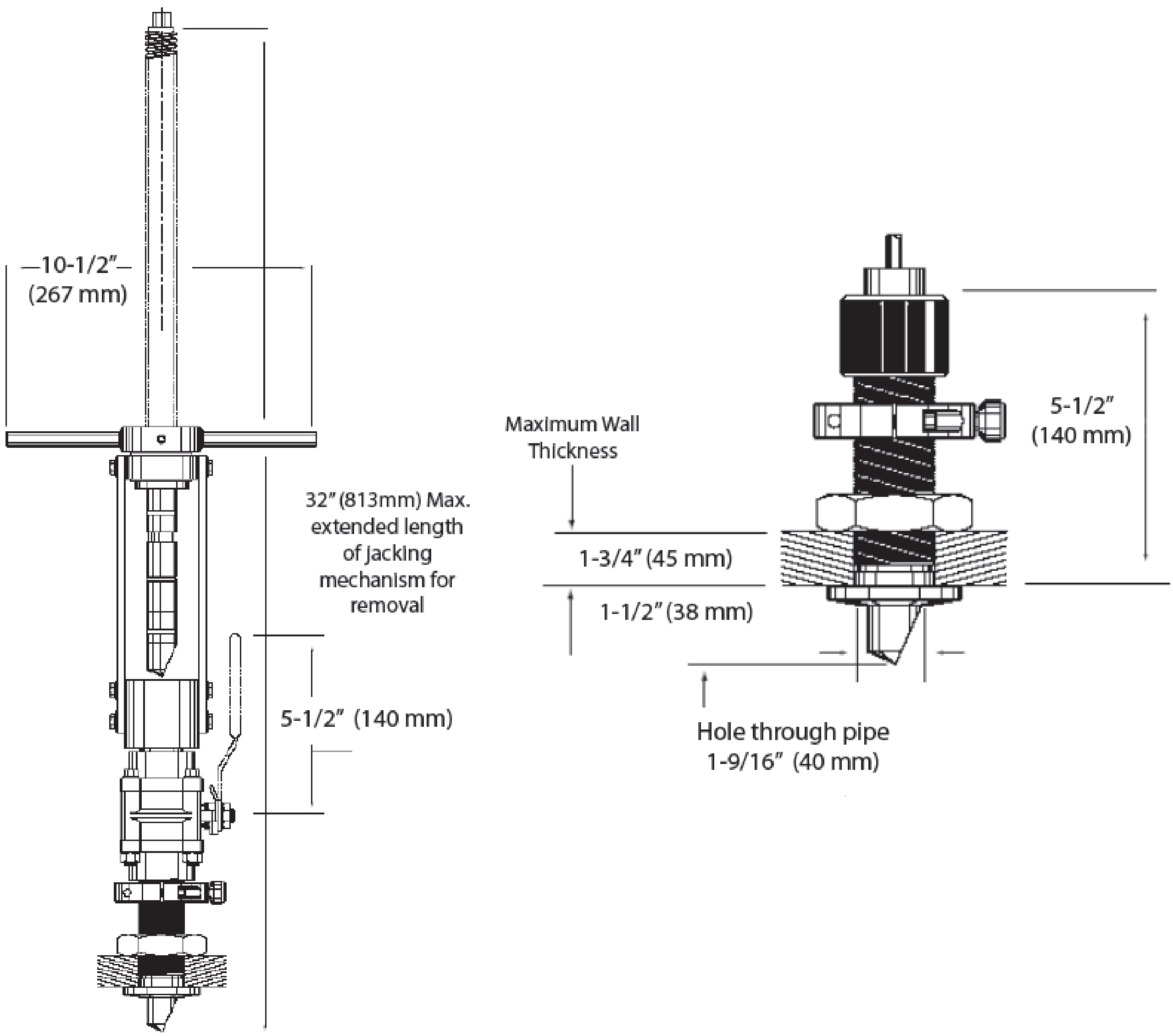


Figure 10-1 7601 Transducer Installed

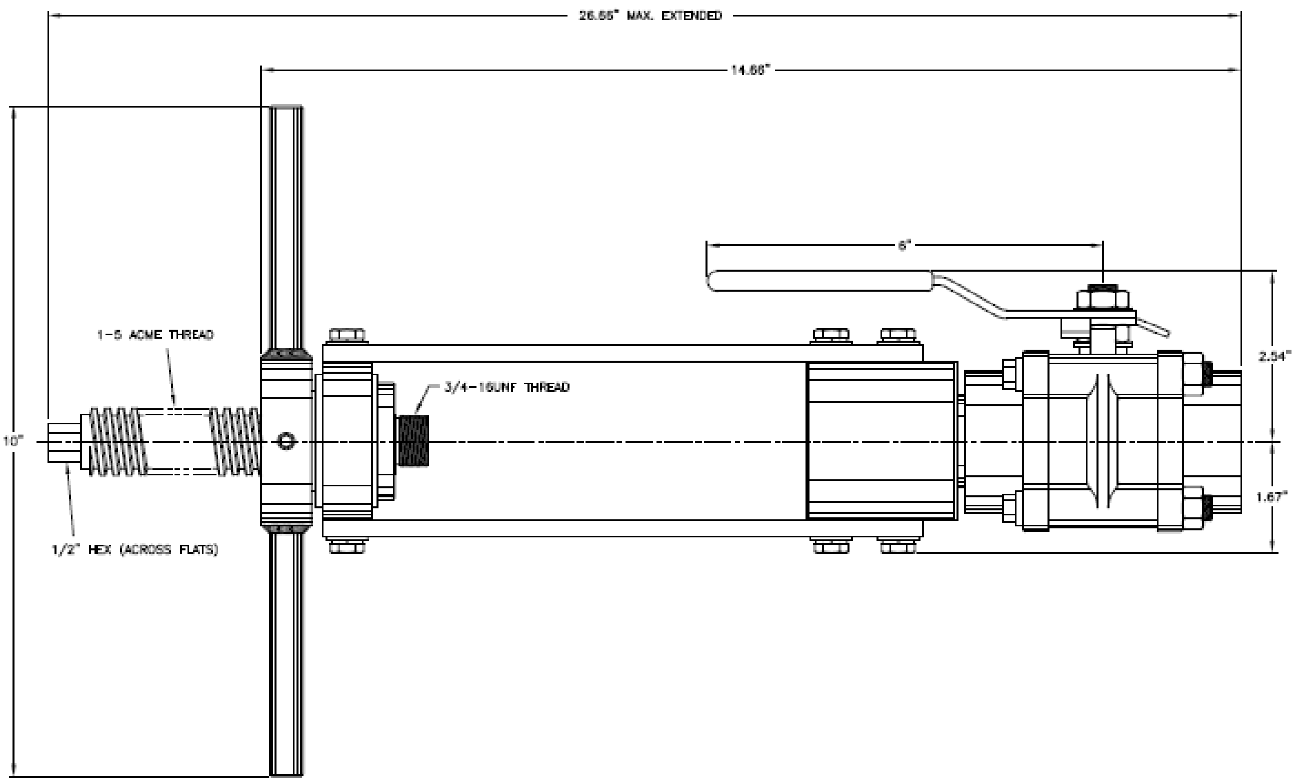


Figure 10-2 7642 Transducer Extraction Tool (uninstalled)

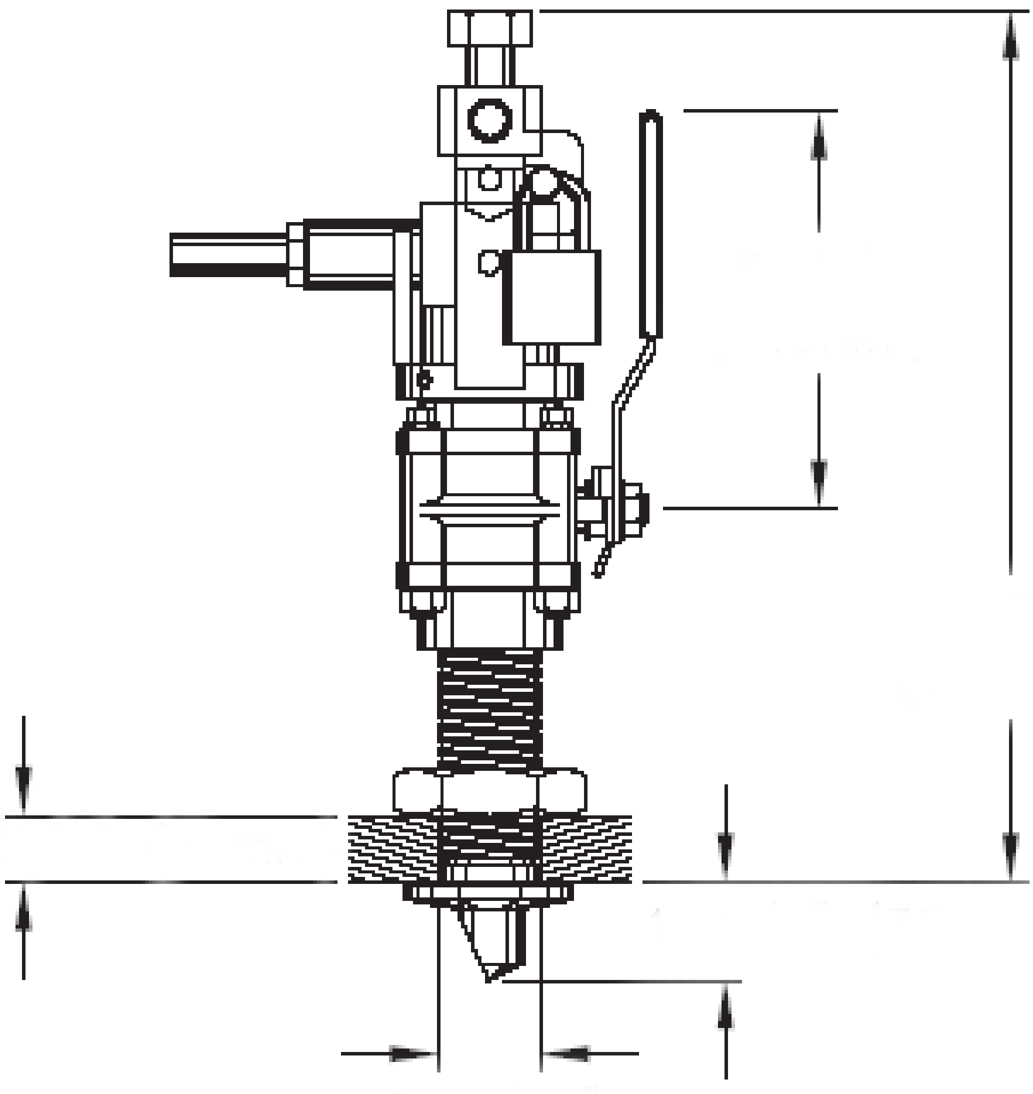


Figure 10-3 7600 Transducer

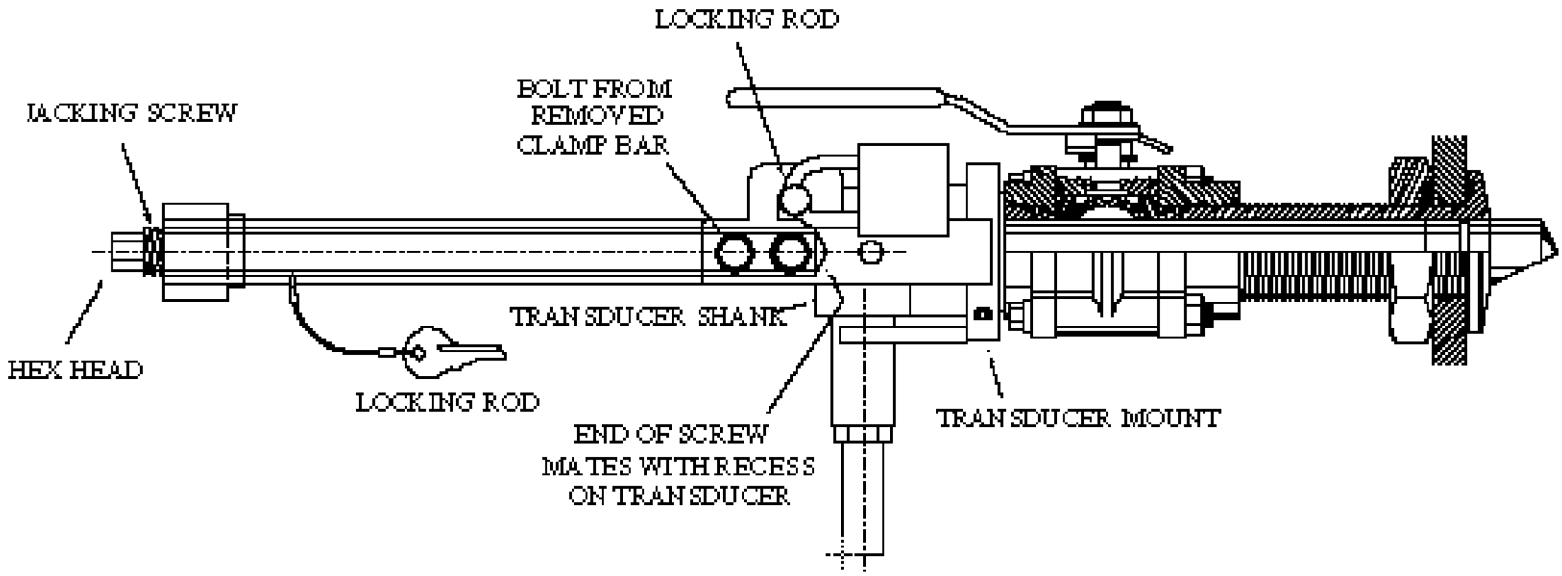


Figure 10-4 7600 Transducer Assembly with Extraction Tool Installed

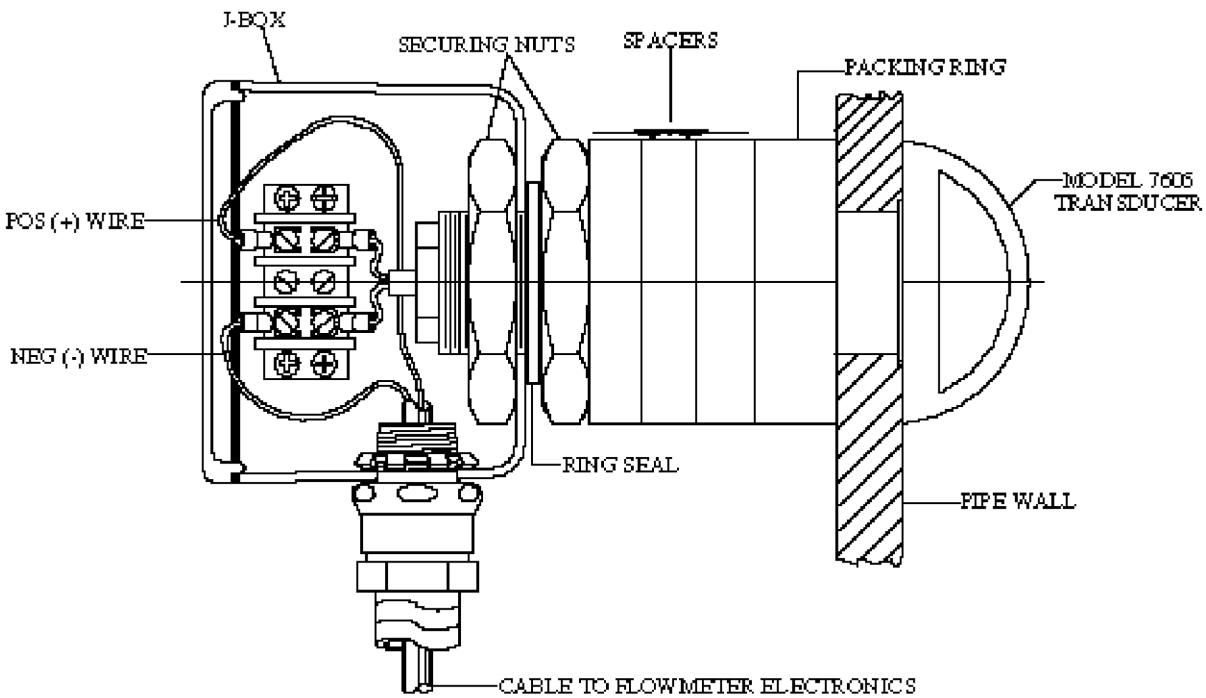


Figure 10-5 Model 7605 Stainless Steel Transducer

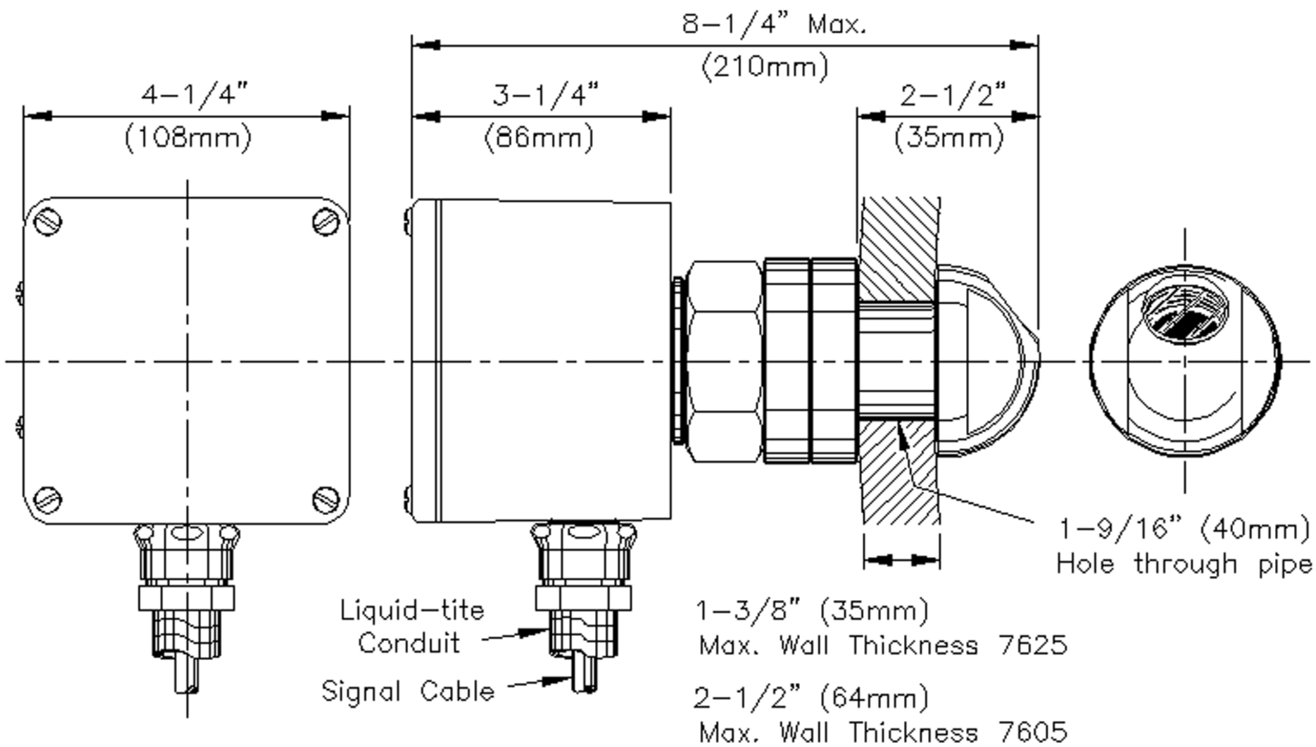


Figure 10-6 Model 7625 PVC Transducer

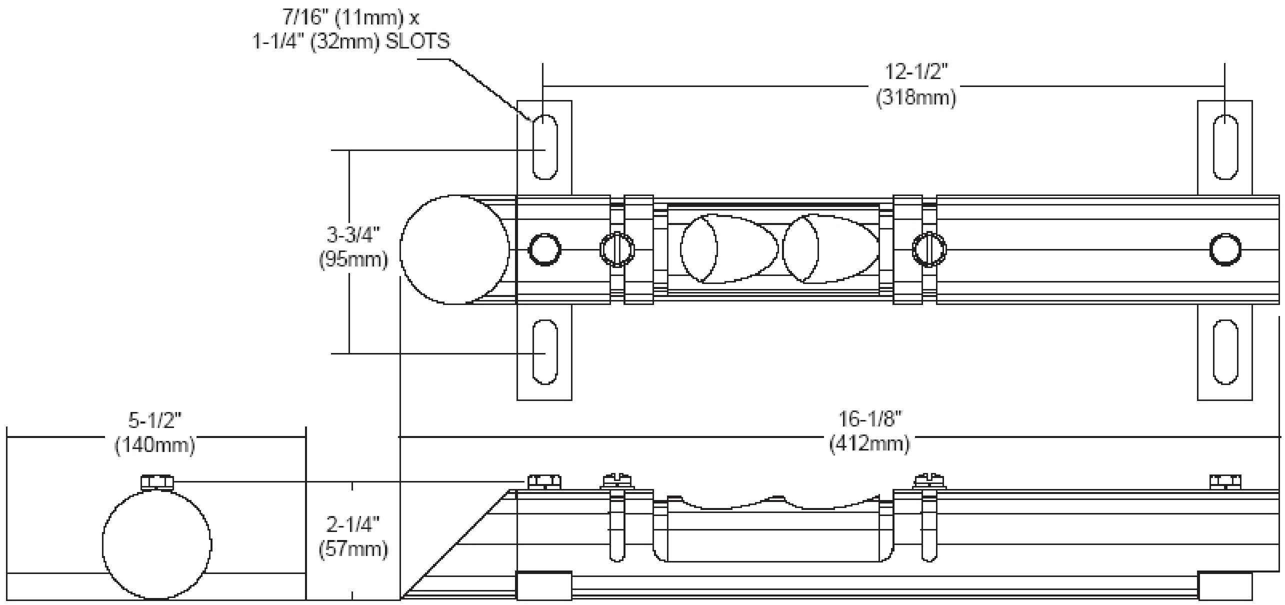


Figure 10-7 Model 7630/34 Internal Mount Transducer

Appendix C
ModBus Mapping Guide

Address	Variable	Notes
30001	Flow Section1	32-bit Float
30003	Flow Section2	32-bit Float
30005	Flow Section3	32-bit Float
30007	Flow Section4	32-bit Float
30009	Flow Section5	32-bit Float
30011	Volume Section1	32-bit Float
30013	Volume Section2	32-bit Float
30015	Volume Section3	32-bit Float
30017	Volume Section4	32-bit Float
30019	Volume Section5	32-bit Float
30021	Temperature Section1	32-bit Float
30023	Temperature Section2	32-bit Float
30025	Temperature Section3	32-bit Float
30027	Temperature Section4	32-bit Float
30029	Temperature Section5	32-bit Float
30031	Level Section1	32-bit Float
30033	Level Section2	32-bit Float
30035	Level Section3	32-bit Float
30037	Level Section4	32-bit Float
30039	Level Section5	32-bit Float
30041	Status Section1	32-bit integer
30043	Status Section2	32-bit integer
30045	Status Section3	32-bit integer
30047	Status Section4	32-bit integer
30049	Status Section5	32-bit integer
30051	Total Flow	32-bit Float
30053	Total Volume	32-bit Float

Address	Variable	Notes
30055	Velocity path1	32-bit Float
30057	Velocity path2	32-bit Float
30059	Velocity path3	32-bit Float
30061	Velocity path4	32-bit Float
30063	Velocity path5	32-bit Float
30065	Velocity path6	32-bit Float
30067	Velocity path7	32-bit Float
30069	Velocity path8	32-bit Float
30071	Velocity path9	32-bit Float
30073	Velocity path10	32-bit Float
30075	Velocity of Sound path1	32-bit Float
30077	Velocity of Sound path2	32-bit Float
30079	Velocity of Sound path3	32-bit Float
30081	Velocity of Sound path4	32-bit Float
30083	Velocity of Sound path5	32-bit Float
30085	Velocity of Sound path6	32-bit Float
30087	Velocity of Sound path7	32-bit Float
30089	Velocity of Sound path8	32-bit Float
30091	Velocity of Sound path9	32-bit Float
30093	Velocity of Sound path10	32-bit Float
30095	Gain(db) path1	32-bit Float
30097	Gain(db) path2	32-bit Float
30099	Gain(db) path3	32-bit Float
30101	Gain(db) path4	32-bit Float
30103	Gain(db) path5	32-bit Float
30105	Gain(db) path6	32-bit Float
30107	Gain(db) path7	32-bit Float
30109	Gain(db) path8	32-bit Float
30111	Gain(db) path9	32-bit Float
30113	Gain(db) path10	32-bit Float
30115	Gain(%S) path1	32-bit Float
30117	Gain(%S) path2	32-bit Float
30119	Gain(%S) path3	32-bit Float
30121	Gain(%S) path4	32-bit Float
30123	Gain(%S) path5	32-bit Float
30125	Gain(%S) path6	32-bit Float
30127	Gain(%S) path7	32-bit Float
30129	Gain(%S) path8	32-bit Float
30131	Gain(%S) path9	32-bit Float
30133	Gain(%S) path10	32-bit Float

Address	Variable	Notes
30135	Signal to Noise Path 1	32-bit Float
30137	Signal to Noise Path2	32-bit Float
30139	Signal to Noise Path3	32-bit Float
30141	Signal to Noise Path4	32-bit Float
30143	Signal to Noise Path5	32-bit Float
30145	Signal to Noise Path6	32-bit Float
30147	Signal to Noise Path7	32-bit Float
30149	Signal to Noise Path8	32-bit Float
30151	Signal to Noise Path9	32-bit Float
30153	Signal to Noise Path10	32-bit Float
30155	Envelope Fwd Time Path 1	32-bit Float
30157	Envelope Fwd Time Path 2	32-bit Float
30159	Envelope Fwd Time Path 3	32-bit Float
30161	Envelope Fwd Time Path 4	32-bit Float
30163	Envelope Fwd Time Path 5	32-bit Float
30165	Envelope Fwd Time Path 6	32-bit Float
30167	Envelope Fwd Time Path 7	32-bit Float
30169	Envelope Fwd Time Path 8	32-bit Float
30171	Envelope Fwd Time Path 9	32-bit Float
30173	Envelope Fwd Time Path 10	32-bit Float
30175	Envelope Rev Time Path 1	32-bit Float
30177	Envelope Rev Time Path 2	32-bit Float
30179	Envelope Rev Time Path 3	32-bit Float
30181	Envelope Rev Time Path 4	32-bit Float
30183	Envelope Rev Time Path 5	32-bit Float
30185	Envelope Rev Time Path 6	32-bit Float
30187	Envelope Rev Time Path 7	32-bit Float
30189	Envelope Rev Time Path 8	32-bit Float
30191	Envelope Rev Time Path 9	32-bit Float
30193	Envelope Rev Time Path 10	32-bit Float
30195	Zero-Crossing Fwd Time Path 1	32-bit Float
30197	Zero-Crossing Fwd Time Path 2	32-bit Float
30199	Zero-Crossing Fwd Time Path 3	32-bit Float
30201	Zero-Crossing Fwd Time Path 4	32-bit Float
30203	Zero-Crossing Fwd Time Path 5	32-bit Float
30205	Zero-Crossing Fwd Time Path 6	32-bit Float
30207	Zero-Crossing Fwd Time Path 7	32-bit Float
30209	Zero-Crossing Fwd Time Path 8	32-bit Float
30211	Zero-Crossing Fwd Time Path 9	32-bit Float
30213	Zero-Crossing Fwd Time Path 10	32-bit Float

Address	Variable	Notes
30215	Zero-Crossing Rev Time Path 1	32-bit Float
30217	Zero-Crossing Rev Time Path 2	32-bit Float
30219	Zero-Crossing Rev Time Path 3	32-bit Float
30221	Zero-Crossing Rev Time Path 4	32-bit Float
30223	Zero-Crossing Rev Time Path 5	32-bit Float
30225	Zero-Crossing Rev Time Path 6	32-bit Float
30227	Zero-Crossing Rev Time Path 7	32-bit Float
30229	Zero-Crossing Rev Time Path 8	32-bit Float
30231	Zero-Crossing Rev Time Path 9	32-bit Float
30233	Zero-Crossing Rev Time Path 10	32-bit Float
30235	Travel Time Difference Path 1	32-bit Float
30237	Travel Time Difference Path 2	32-bit Float
30239	Travel Time Difference Path 3	32-bit Float
30241	Travel Time Difference Path 4	32-bit Float
30243	Travel Time Difference Path 5	32-bit Float
30245	Travel Time Difference Path 6	32-bit Float
30247	Travel Time Difference Path 7	32-bit Float
30249	Travel Time Difference Path 8	32-bit Float
30251	Travel Time Difference Path 9	32-bit Float
30253	Travel Time Difference Path 10	32-bit Float
30255	Status Path1	32-bit integer
30257	Status Path2	32-bit integer
30259	Status Path3	32-bit integer
30261	Status Path4	32-bit integer
30263	Status Path5	32-bit integer
30265	Status Path6	32-bit integer
30267	Status Path7	32-bit integer
30269	Status Path8	32-bit integer
30271	Status Path9	32-bit integer
30273	Status Path10	32-bit integer
30275	Scaled Level Channel1	32-bit Float
30277	Scaled Level Channel2	32-bit Float
30279	Scaled Level Channel3	32-bit Float
30281	Scaled Level Channel4	32-bit Float
30283	Scaled Level Channel5	32-bit Float
30285	Scaled Level Channel6	32-bit Float
30287	Scaled Level Channel7	32-bit Float
30289	Scaled Level Channel8	32-bit Float

Address	Variable	Notes
30291	Unscaled Level Channel1	32-bit integer
30293	Unscaled Level Channel2	32-bit integer
30295	Unscaled Level Channel3	32-bit integer
30297	Unscaled Level Channel4	32-bit integer
30299	Unscaled Level Channel5	32-bit integer
30301	Unscaled Level Channel6	32-bit integer
30303	Unscaled Level Channel7	32-bit integer
30305	Unscaled Level Channel8	32-bit integer
30307	Status Level1	32-bit integer
30309	Status Level2	32-bit integer
30311	Status Level3	32-bit integer
30313	Status Level4	32-bit integer
30315	Status Level5	32-bit integer
30317	Status Level6	32-bit integer
30319	Status Level7	32-bit integer
30321	Status Level8	32-bit integer

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