Sarasota 200 Ultrasonic Flowmeter Handbook

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SARASOTA 200 ULTRASONIC MULTIPATH OPEN CHANNEL FLOWMETER HANDBOOK

Issue 1.1

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Issue Information

Further copies of this handbook may be obtained from the sales department of Thermo Electron at the address given below.

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NOTICE

Read this manual before working with the product. For personal and system safety, and optimum product performance, make sure you thoroughly understand the contents before installing, using or maintaining this product.

For equipment service, please contact Thermo Electron.

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1 INTRODUCTION

1.1 Applications

The Sarasota 200 is a velocity x area open channel flowmeter which uses the ultrasonic “time of flight”, also known as the “transit time” method. It is similar to the larger Sarasota 2000 but with fewer ultrasonic velocity paths (up to 4) and just one water channel.

Unlike traditional methods of open channel flow measurement which use weirs or flumes, the transit time method creates no obstruction and assumes no relation between level and flow. It will correctly determine flow throughout its designed range by measuring water velocity and cross section area (see Section 1.2).

The method is tolerant of backwater effects caused by tides, downstream confluence or blockages. Unlike a weir or flume it does not drown out at high flow conditions.

The method employs the transmission of ultrasonic “beams” which can be affected by factors which impede or deflect them. For this reason the method should not be used in situations of:

- Aerated water
- Weed growth between the transducers (unless it is regularly cut)
- High levels of suspended solids (greater than 2000 mg/l) *
- <u>Gradients</u> of salinity (the actual value of salinity is, however, unimportant**)
- <u>Gradients</u> of temperature (the actual temperature is, however, unimportant**)

* In relatively small channels (up to 5 metres) the method is more tolerant of suspended solids and therefore is often used in sewage applications.

** Provided the velocity of sound in water (VOS) remains within the range 1350 to 1650 m/s

Though described as an open channel method, the flowmeter may be used in closed conduits, including those which run full. In the latter case, the cross section area is defined by the conduit geometry without the need to measure water level.

Suitable applications include water flow measurement of:

- Rivers
- Canals
- Aqueducts
- Irrigation conduits
- Sewage discharges
- Sewage works
- Industrial discharges
- Power generation

Note that although the flowmeter is most often used for open channels or part filled conduits, it is often used for conduits which always run full. Under these circumstances it is not necessary to have a depth input but steps need to be taken to ensure that the flowmeter always takes the conduit as full. This is done via the fixed level input PC screen. The conduit shape must still be entered.

1.2 Principle of operation

1.2.1 The Standard

The Sarasota 200 is an ultrasonic “transit time” flowmeter which complies with the International Standard ISO 6416. The UK standard BS 3680 part 3E is identical. The transit time method belongs to the general category of velocity x area methods. A full description of the method and its applications is to be found in the Standard. A brief summary is given below.

1.2.2 Velocity x area method

Velocity x area methods require a means of determining the water velocity and the cross section area. The product of the two determines the flow rate in a manner which is not dependent on factors influencing the level, for example downstream constrictions, tidally affected water level etc.

Assuming the shape of the channel cross section is stable, determination of the area becomes a matter of measuring water level. This may be done by a variety of methods.

1.2.3 Water level

Water level is required in order to determine the cross section area in an open channel. Though a single level measurement may be used, it is common to use more than one and to average them. This has the advantage of a more representative level, particularly if the measurements are made at different positions, for example on either side of the channel. Another advantage is that flow may still be computed even if a level sensor fails.

Level may be determined by using one or more ultrasonic transducers in the water facing upwards. The time taken for a pulse of sound to return to the transducer after being reflected from the surface is converted into level using the velocity of sound in water as measured by the water velocity paths (see Section 1.2.4). There is a minimum depth of water required above the transducer for it to carry out a measurement. This is given in Appendix 2: Specification.

Water level may also be provided by external auxiliary depth gauges via 4-20 mA signals, for example pressure transmitters, downward facing ultrasonic devices and float systems with shaft encoders.

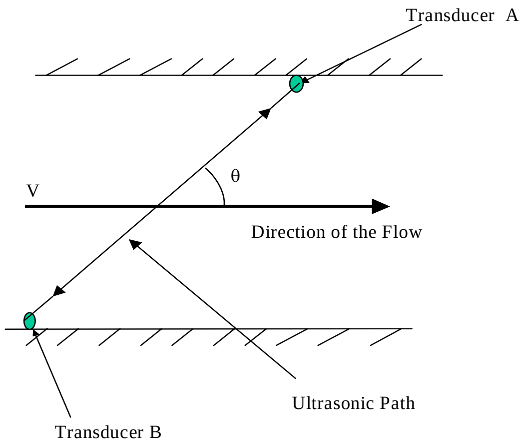
1.2.4 Water velocity

In the transit time method, water velocity is determined at a number of heights within the body of water by measurement of time taken for pulses of ultrasound to travel across the channel at an angle to the flow direction.

Transducers are mounted in the water at or near the sides of the channel with each pair usually at the same height and aligned so that each one can transmit a “beam” of ultrasound towards its partner. The ultrasonic “path” between the transducer pairs must be at an angle (usually about 45^{o}) to the flow direction.

Each transducer acts as a transmitter and receiver and is connected to a processing unit, which measures the transit time and the time difference.

The mean water velocity at the height of each path is determined from these timing measurements, based on pre-determined geometrical measurements (length of the path and the angle to the flow direction).



It may be shown that the water velocity at the height of the path AB is:

$$v = L \text{ x } (T_{AB} - T_{BA}) / (T_{AB} \text{ x } T_{BA} \text{ x } 2\cos\theta)$$

Where

T_{AB} = Transit time from transducer A to B
T_{BA} = Transit time from transducer B to A
L = Path length (distance between transducer A and transducer B)
θ = the angle between the “path” and the direction of flow.

1.2.5 Flow determination

The flow is determined by combining the water velocity measurements at the height of each path with the cross section area defined by the water level and the shape of the channel. The channel shape need not be the same as the projected width between the transducers. For example if the transducers are mounted on piles inset from the channel sides. For the purposes of flow determination the cross section area is divided into horizontal slices determined by the channel bed, the heights of the paths themselves and the water surface level.

The channel flow is the sum of the flows in each slice determined by the path velocity or velocities and the area of the slice. The bottom slice is defined by the bed (which is assumed not to move) and the top slice by the water surface (the level of which is measured by the flowmeter). The slice widths may be determined by the projected width between the transducers or by a separate table defining the cross section shape. The latter method is used by the Sarasota 200.

There are 2 methods, mid section and mean section.

1.2.5.1 Mid section method

In the mid section method, the slice boundaries are defined by lines mid way between the paths. The slice velocity is taken as that determined by the ultrasonic path within the slice and the slice area as the product of the slice height and the (average) width. The upper boundary of the top slice is the water surface. At the bottom, an additional slice is defined between the bed and a line half way between the bed and the bottom path. This bottom slice has a weighting factor, K, normally between 0.4 and 0.8 to allow for the slow moving water near the bed. To reduce the uncertainty of this factor, the bottom path should be positioned as close to the bed as practical.

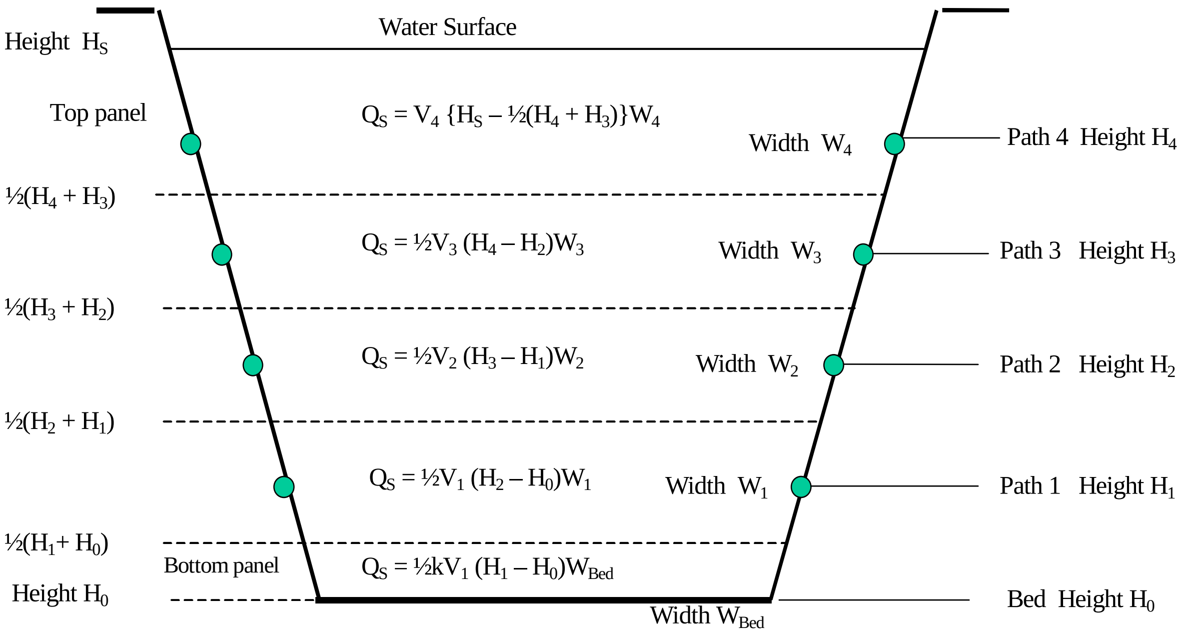


Illustration of the mid section method for 4 paths

1.2.5.2 Mean section method

In the mean section method, the slice boundaries are defined by the path heights themselves. The slice velocity is taken as the mean of the upper and lower paths which define the slice boundaries. The upper boundary of the top slice is the water surface.

The velocity of the water surface, Vs, is given by:-

$Vs = V_4 + (V_4-V_3) \times Ks(Hs-H_4)/(H_4-H_3)$

Where Ks is a multiplying factor normally between 0 and 1 to allow for the projection of velocity to the water surface

Vs is limited to a value of $V_4 + (V_4-V_3)$ in the event of $(Hs-H_4)$ being greater than (H_4-H_3)

The lower boundary of the bottom slice is the bed. This bottom slice has a weighting factor, K_B, normally between 0.4 and 0.8 to allow for the slow moving water near the bed.

The mean section method is superior in cases where the paths are not near the slice centres, but the mid section method handles the top slice better. The more paths that are deployed, the less the differences matter.

The mean section method is illustrated in the following diagram:

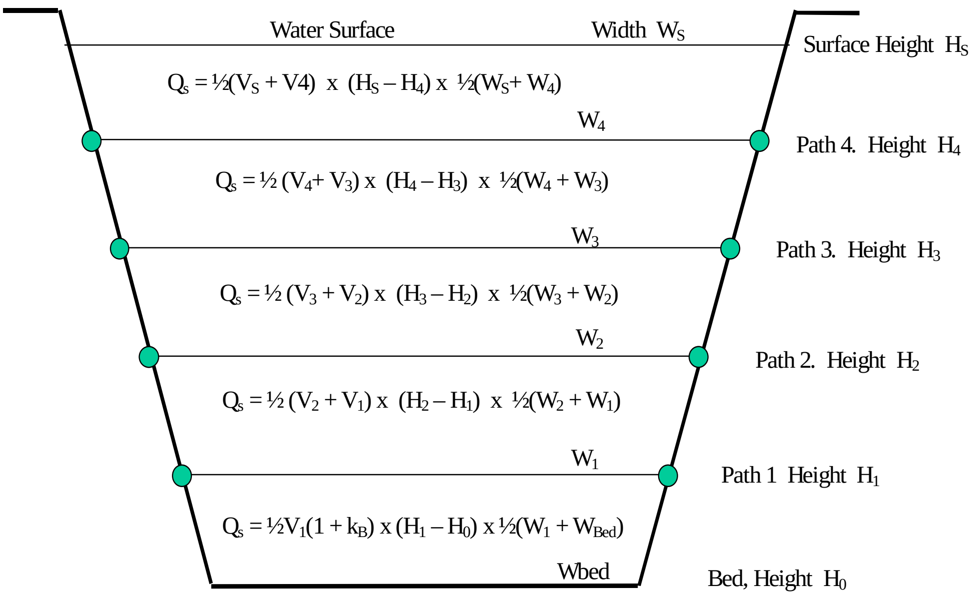


Illustration of the mean section method for 4 paths

1.2.5.3 Closed conduits

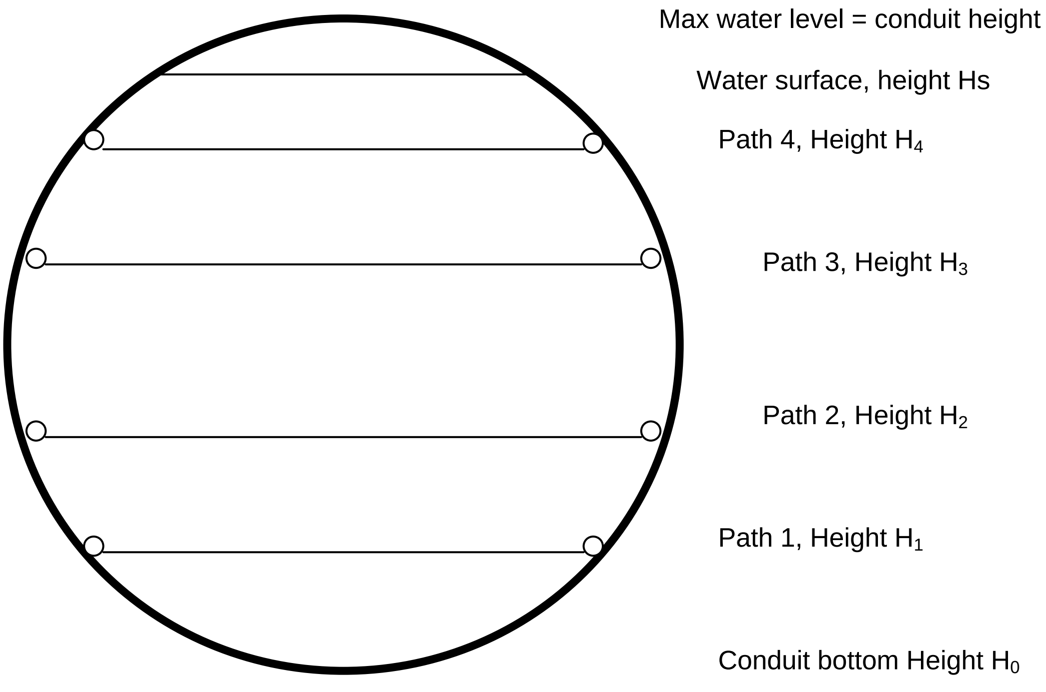
ISO 6416 is mainly concerned with open channels. The mean section method is also used for closed conduits which may be always full or sometimes full and sometimes part full. The Standard IEC 41 is often quoted in connection with flow in full pipes. In fact that Standard describes methods of testing turbines and pumps. The ultrasonic method appears as an appendix as a method of measuring flow as a means of testing. ISO 6416 remains the only specific standard concerned entirely with the ultrasonic method.

The illustration below shows the application of the method as applied to closed conduits, using paths at 4 heights.

The values of Qs are derived from the same formulae as given in 1.2.5.2. Of course, the difference $V_4 – V_3$ will generally be negative in this case so the projected surface velocity will be lower than V_4.

The method of projection to obtain the surface velocity ensures progressive transition between the part full and full conduit conditions.

In practice, the slice areas are normally derived from the conduit shape rather than the path geometry. This is the correct treatment and is used by the Sarasota 2000 and 200.



1.2.6 Path configurations

The simplest arrangement is to have a number of paths "in line" above each other. This would be suitable for a channel of regular cross section shape, which is straight for a long distance compared with its width (5 to 10 times).

Other configurations are often used in other circumstances. For example:

- Crossed paths where there is uncertainty about the flow direction
- Sloping paths where the depth is greater on one side compared with the other
- Transducers inset from the banks
- Reflected paths where transducers are on one side only and reflectors "bounce" the sound pulses back from the far side. This method saves cable but increases path lengths and is very sensitive to misalignment.

The Sarasota 200 flowmeter is capable of being configured for these and other situations.
For more complex configurations requiring more than 4 paths or compound channels, the Sarasota 2000 offers more flexibility. Examples are:

- Multiple sets of paths for compound channel shapes
- V configuration used to divide the width because of size or uneven profile
- Multiple channels

Please consult Thermo Electron's local representative for examples and advice.

1.2.7 Transducer frequency

Transducers are manufactured with characteristic frequencies. These are in the range 1 MHz to 250 kHz. For propagation reasons, the greater the path lengths the lower the frequency and the larger the transducer. As a guide, path lengths below 10 metres would use 1MHz transducers, 5 to 80 metres 500 kHz, 50 to 200 metres 250 kHz. These figures are for guidance and the selection may be influenced by other factors relating to the application. Where there is overlap, lower frequency transducers may be used to improve penetration in conditions of high suspended solids provided there is sufficient depth and velocity.

Please consult Thermo Electron's local representative for advice.

1.2.8 Minimum depth of water

In order to avoid reflections from the bed or surface causing distortion of the ultrasonic signals, a minimum height of water is necessary above each path. This depends on the transducer frequency and the path length.

$$H_{min} = 27 \sqrt{(L / f)}$$

Where:

H_{min} is the minimum height of water above the path, in metres
L is the path length, in metres
f is the transducer frequency, in Hertz

A similar restriction applies to the channel bed, particularly if it is smooth and reflects rather than absorbs an acoustic signal. The minimum depth of water is therefore usually 2 x H_{min}

1.2.9 Performance estimates

ISO 6416 describes how to estimate the uncertainty of measurement in any particular installation. Please consult Thermo Electron's local representative for advice on this.

1.3 Implementation of the principles of operation in the Sarasota 200

The principles described in Section 1.2 are used by the Sarasota 200 subject to certain rules as listed below. See also Appendix 1: GAFA Screens that describe in detail how the flowmeter is programmed via a PC.

Flow

- There is a choice of mean or mid section method of flow calculation.
- The channel cross section shape is entered as a height/width table independent from the path lengths and angles. (For rectangular or trapezoidal channels it is only necessary to enter 2 points to define the channel.) The separate table allows the path velocities to be applied to more accurate slice areas since the defined shape is used rather than a fixed width for each slice as specified in the Standard.
- Where no path velocity is available, for example at low water height, flow may be inferred from water level. This is done via a flow estimation table, which may be derived empirically or by calculation.

Velocity

- The upstream velocity transducers are connected as shown in section 2.
- Path numbering is from the bottom.
- Paths are automatically brought into operation according to the water level and the programmed minimum water cover.
- Paths entered as being at the same height are taken as crossed, otherwise they are separate.
- Separate paths may be "normal" with transducers on each side or "reflected" with transducers on one side only. The latter method saves cable but is not recommended because of the increased path lengths and sensitivity to alignment.
- The velocities calculated by a pair of paths comprising a crossed path are averaged and the average velocity used for the slice. The velocity calculated by a separate path is used alone for the slice.
- When a velocity path fails, the slice boundaries automatically adjust to use only the working paths.
- A failed path will show on the status indicated. The path status is a percentage of the "instantaneous" transducer firings which result in successful reception. If this figure drops below 12% the path is considered to have failed during the corresponding instantaneous cycle time and is discarded for that cycle. This could be the result of a fault, misalignment or obstruction.
- Only valid velocity paths which are in the water and covered by sufficient water to be operating are used for the status indication.
- Each path may have a multiplying factor ("X Factor") assigned to it. This will normally be 1 but may be different in exceptional circumstances for calibration purposes. An example of when this might be is when the transducers are not exactly at the channel edges.
- Transducers in each velocity path may be set to operate simultaneously (the norm) or sequentially. Simultaneous operation allows more measurements in a given time but there is a small possibility of confusing a signal reflected back to the firing transducer with one received from the opposite transducer.

Water level

- Levels are combined in the following algorithm:
  Only non-faulty measurements are used.
  Highest and/or lowest are discarded until 3 remain.
  The one furthest from the others is discarded leaving 2.
  The remaining 2 measurements are averaged for arbitrated level if within an acceptable band defined via the PC GAFA software.
  If they are not within the acceptable band, level determination fails and flow cannot be calculated.
  If only 1 level measurement is installed or only 1 remains after arbitration, it is used as the arbitrated level.
  If not OK, level fails and flow cannot be calculated.
- Levels defined as valid but rejected by the algorithm will be indicated on the level status.
- Where the flowmeter is installed in a closed conduit which always runs full, the channel shape is entered in the usual way but there is no need for a level measurement. The flowmeter is programmed with a fixed level input corresponding to the top of the conduit.

Transducer and bed levels

All heights may be set to a fixed datum (local or national) or relative to mean bed level. The former requires a height for the bed and avoids re-entering all path and level transducer heights in the event of a change to the bed.

General

- “Instantaneous” means the average over the cycle time scale. This defaults to 10 seconds for fast response suitable for small channels. It may be set to 1 minute for smoother averaging where the rate of change of flow conditions is slower.
- The average period is the time over which measurements are averaged for the purpose of output or logged data. The average period cannot be shorter than the cycle time.
- At the data logging intervals, the averaged values of the selected data are stored.
- Analogue inputs will normally be linear. However, non linear characteristics may be entered via the PC, see Appendix 1
- When operating on a 12 volt source, for example from a solar panel, power saving is possible by using intermittent operation. Power consumption in normal and intermittent modes is quoted in the Appendix 2: Specification.

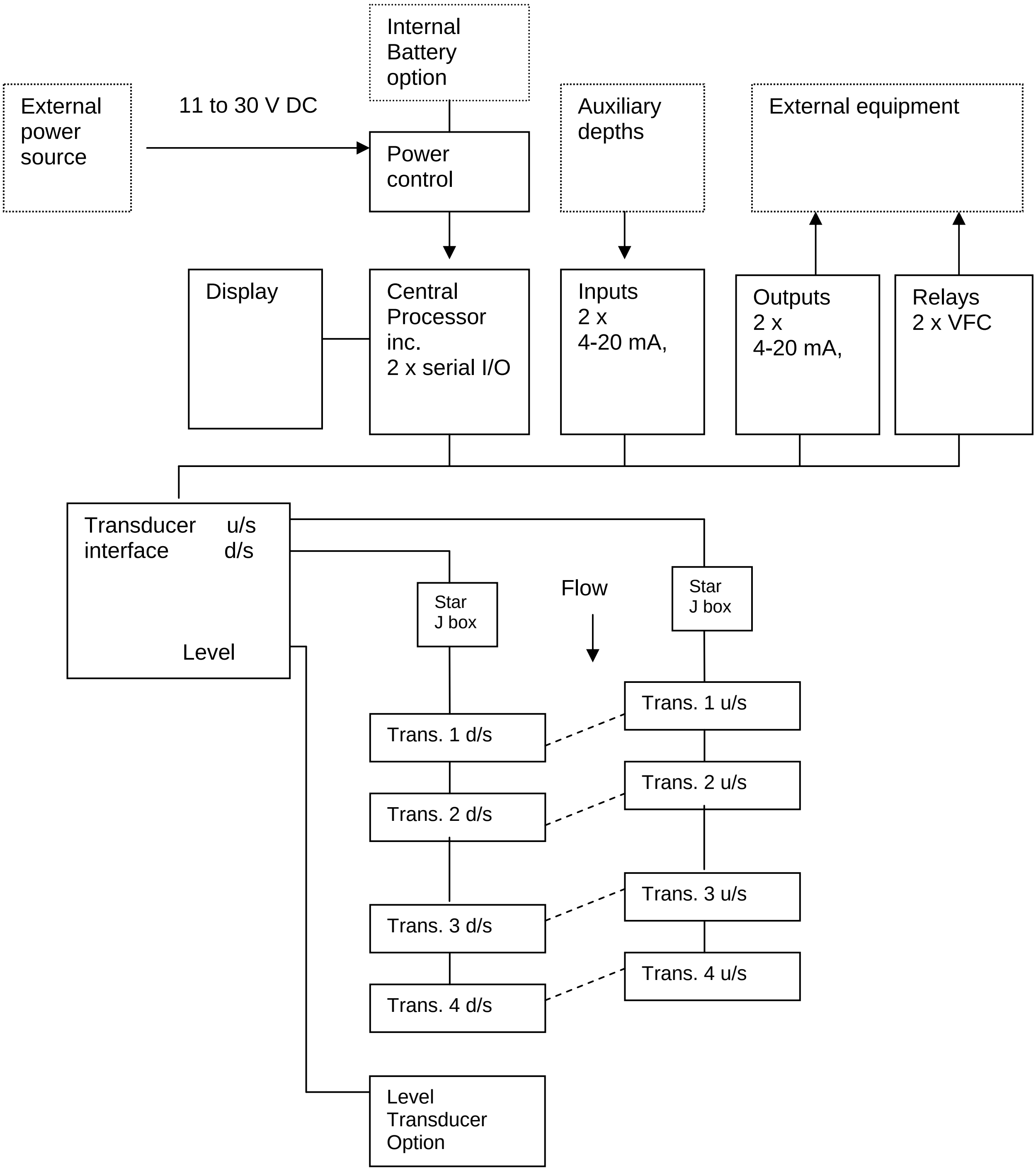
2 SYSTEM COMPONENTS

2.1 Flowmeter system overview

- The Sarasota 200 is an ultrasonic multi-path flowmeter, which complies with ISO6416.
- It employs state of the art technology to achieve excellent performance in conditions which have previously been outside the scope of this type of instrument.
- Smart transducer technology incorporating drive and receiver circuits optimises signal to noise ratio and minimises losses. The smart circuits are located inside the transducer housings except for the 1 MHz transducers. In that case they are in sealed in-line housings known as Tboxes.
- Automatic adjustment of receiver gain and transducer drive voltage (HT).
- Low power consumption and intermittent modes make mains free operation feasible.
- Multi-path operation, (up to 4) with multi-drop facility made possible by smart transducer addressing to save cable.
- Multiple water level inputs, subject to a maximum of 4 overall:
  - up to 4 ultrasonic level transducers
  - up to 2 auxiliary level gauges (via 4-20 mA inputs.)
- Up to 2 analogue 4-20 mA outputs
- System fault relay (volt free contacts)
- 2 programmable relays, 1 volt free contact, 1 high speed solid state. Programmable, for example for alarms, status, totaliser pulses.
- Two serial ports. RS232 for PC, RS232 for modem.
- Internal data logger, 1 Mbyte capacity, programmable.
- Water temperature measurement at each smart transducer (except 1 MHz transducers)

2.2 Family tree

The schematic diagram below is an illustration of a four path system.



2.3 Flowmeter contents and options

2.3.1 Flowmeter layout

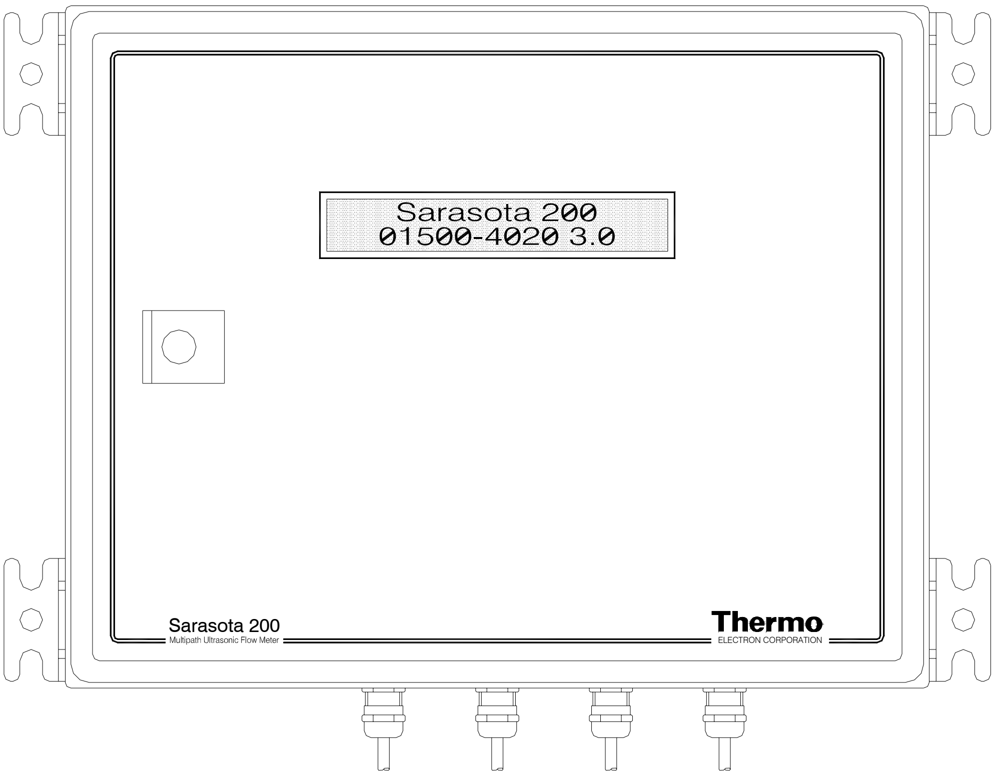


Fig 1 Sarasota 200 Flowmeter. Front panel view

This view of the Sarasota 200 shows:

- the LCD display (see section 2.3.2.3)
- the cable entry glands at the bottom
- the wall mounting brackets (see Appendix 2 for mounting dimensions)

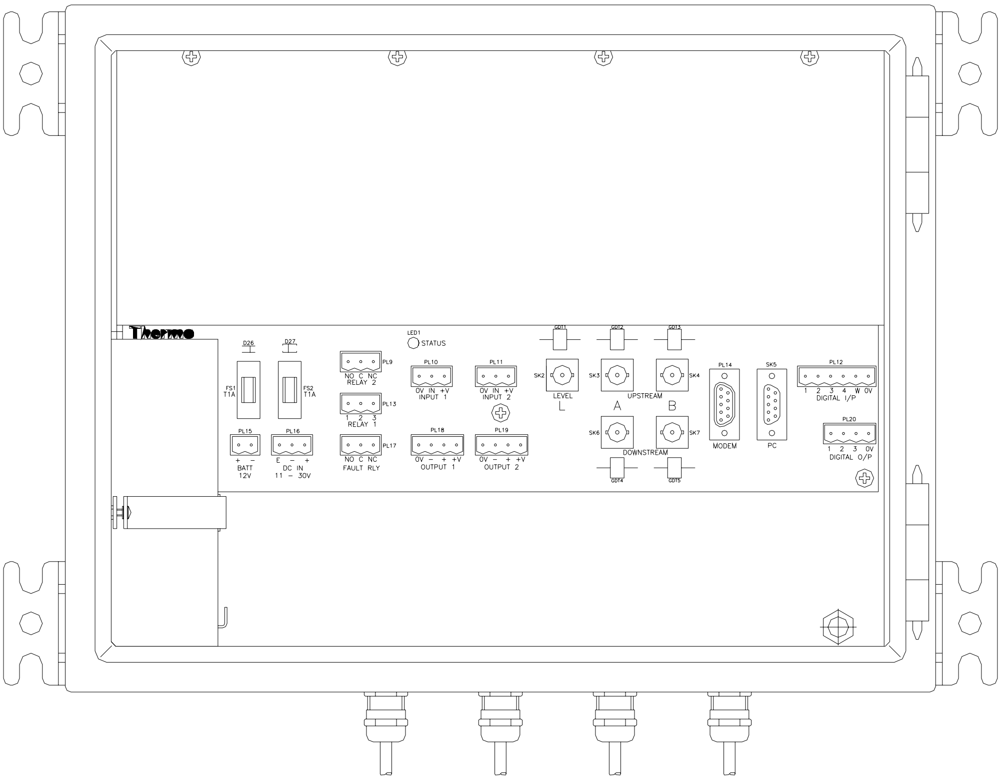


Fig 2 Sarasota 200 with lid open showing internal components

This view shows the connection panel protruding from the protective cover and the internal battery in the bottom left corner.

The connection panel is part of the mother board which contains the input, output and power management functions. It supports the main processor (CPU) card and the transducer interface (TIF) card which plug in beneath the protective cover. The connection panel is shown on a larger scale in Fig 3.

The internal battery allows operation to continue when the external power source has failed. This is an optional facility which may only be fitted for certain external power sources. See section 2.3.2.1.1

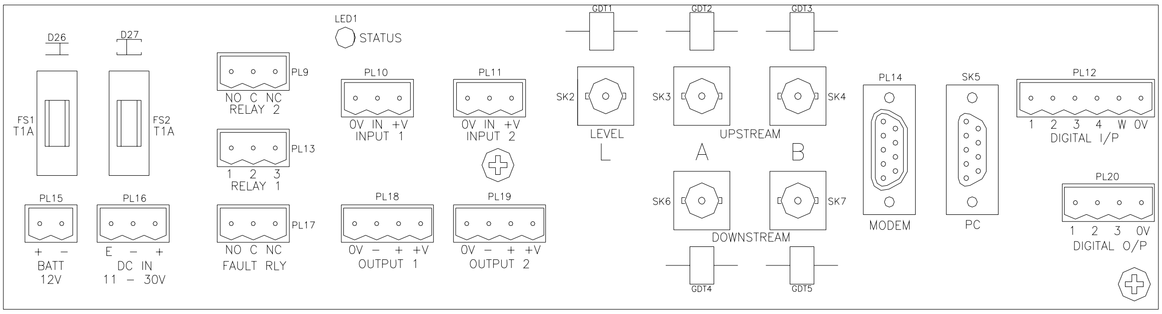


Fig 3. Connection panel - enlarged view.

This panel is where all the connections are made and where the power fuses are located. Before making any connections the external power source and the internal battery (if fitted) should be unplugged. The connections are in groups from left to right:

Power connections. See section 2.3.2.1.1

- PL15 – BATT. 2 pin plug for connection to the internal 12volt battery if one is to be fitted.
- PL16 – DC IN. 3 pin plug for connection to the external dc supply.
- Fuses FS1 and FS2

Relay connections. See Specification, Appendix 2

- PL9 – RELAY 2 - VFC, 3 pins, NC, Common and NO
- PL13 – RELAY 1 - SOLID STATE, 3 pins. See Appendix 2
- PL17 – FAULT RLY, 3 pins, NC, Common and NO

Status LED

Inputs See section 2.3.2.1.3

- PL10 – INP 1. 3 pin plug, 4-20 mA
- PL11- INP 2. 3 pin plug, 4-20 mA

Outputs See section 2.3.2.1.4

- PL18 – OUT 1. 4 pin plug, 4-20 mA
- PL19 – OUT2. 4 pin plug, 4-20 mA

Ultrasonic transducer connections. See section 2.3.2.1.2

- SK2 – LEVEL (L). BNC coaxial socket for ultrasonic water level transducer(s) if fitted.
- SK3 – UPSTREAM (A). BNC coaxial socket for upstream velocity transducer(s)
- SK6 – DOWNSTREAM (A). BNC coaxial socket for downstream velocity transducer(s)
- SK4 – UPSTREAM (B). BNC coaxial socket for upstream crossed path velocity transducer(s) if fitted.
- SK7 – DOWNSTREAM (B). BNC coaxial socket for downstream crossed path velocity transducer(s) if fitted.

Communications See section 2.3.2.1.7
SK5 – PC. 9 way D socket for RS232 serial link to PC
PL14 – MODEM. 9 way D plug for RS232 serial link to modem.
Digital See section 2.3.2.1.6
PL12, External connection W to 0V to wake up if in intermittent (external control) mode.
PL12 1 to 4 and PL20 – not used.

2.3.2 Internal components

The enclosure houses the following components

- Mother board with power connections, connectors for transducers and peripheral devices.
- Internal battery option.
- Transducer interface card
- Central processor card, with data storage, input/output and communications circuits
- LCD display

2.3.2.1 Mother board

2.3.2.1.1 Power supply and internal battery option

The power supply input is 11 to 30 Volts DC (see specification in Appendix 2)

For operation from an AC source, an external adapter is required.

If the DC input is 15 Volts or more, the internal battery option may be fitted to allow operation to continue in the event of power failure. The internal battery is automatically charged by the power supply when external power is being supplied.

Power consumption and the period of operation from the internal battery option depend on the mode of operation and are given in the specification.

The fuse values are both T1A.

2.3.2.1.2. Transducer connections

For an in-line configuration of velocity paths there will be 2 star junction boxes, 1 for each transducer array. The coaxial cable from the upstream star box terminates at SK3. The coaxial cable from the downstream star box terminates at SK6.

For a crossed configuration of velocity paths there will be 4 star junction boxes, 1 for each transducer array. The coaxial cable from the upstream left star box terminates at SK3 and the downstream right at SK6. The coaxial cable from the upstream right star box terminates at SK4 and the downstream left at SK7.

If an upward facing depth transducer is being used, the coaxial cable from it terminates at SK2.

2.3.2.1.3. Depth input signals

These will normally be from auxiliary depth gauges via 4-20 mA. Common examples are pressure transmitters and downward facing ultrasonic devices. The Sarasota 200 can accept up to 2 inputs of this type via PL10 and PL11. The power for the 4-20 mA loop can come from the Sarasota 200 or from the external device.

Pin	Signal name	Connect for internal loop power	Connect for external loop power	Comment
1	0V	N/C	4-20mA -	Applies to INP 1 on PL10 and INP2 on PL11
2	IN	4-20mA -	4-20mA +	
3	+V	4-20mA +	N/C	

2.3.2.1.4. Output signal connections (Analogue)

There are 2 analogue output connectors, OUT1 PL18 and OUT2 PL19. The functions to be output and their ranges are programmable. The power for the 4-20 mA loop can be internal, from the Sarasota 200 in which case the outputs are not isolated, or from the external device in which case they are isolated.

Pin	Signal name	Connect for internal loop power	Connect for external loop power	Comment
1	0V	4-20mA -		Applies to OUT1 PL18 and OUT2 PL19
2	-	4-20mA +	4-20mA -	
3	+	Link 3 – 4	4-20mA +	
4	+V			

2.3.2.1.5. Relay connections

There are 3 relay connections

PL17 System fault relay. This relay has Normally Open (NO), Normally Closed (NC) and Common (C) contacts. It operates when there is a fault which prevents flow being calculated. This will occur when no velocity path is functioning or when no depth is functioning.

PL13 Relay 1. Solid state relay, see Appendix 1, Screens. Although relay 1 may be programmed for any of the available functions, its faster switching rate makes it particularly suited for a pulsed output to an external totaliser. See appendix 2 Specification.

PL9 Relay 2. Programmable, see Appendix 1, Screens. This relay has Normally Open (NO), Normally Closed (NC) and Common (C) contacts.

For example, relay 2 could be programmed as a high flow alarm to switch on at a high flow and off again at a lower value (hysteresis).

2.3.2.1.6. Digital signal connections

When in intermittent mode under external control (see Appendix 1, screens), the external controlling device must apply a connection between W and OV of PL12 to switch the Sarasota 200 on.

PL12 - 1 to 4 and PL20 – not used at present.

2.3.2.1.7 Serial communications connections

Serial communications are controlled by the CPU (see 2.3.2.2). It has 2 ports and connections are made via SK5 and PL14 on the mother board as follows:

- **SK5 - RS232** via 9 way D connector (female). See Fig 3. This port is used for connection to a PC for setting up, diagnostics and downloading logged data.
- **PL14 - RS232** via 9 way D connector (male). See Fig 3. This port is used for connection to a modem for remote access for programme alterations, diagnostics and downloading logged data.

Pin (F)	Signal	Comment
2	TxD	SK5 – RS232, PC connection 9 way female D connector
3	RxD	
5	0V	

Pin (M)	Signal	Comment
1	CD	PL14 RS232, Modem connection 9 way male D connector
2	RxD	
3	TxD	
4	DTR	
5	0V	
7	RTS	
8	CTS	
9	RI	

2.3.2.2 Central processor (CPU)

The central processor carries out the control and timing functions, stores and runs the operating program and stores the data logs.
It controls the two serial i/o ports, see 2.3.2.1.7.
The CPU card plugs into the mother board by removing the cover.
There are no operator settable links on the CPU.

2.3.2.3 LCD display

The LCD has 2 lines of 20 characters to display measurements, computed results and diagnostic information. (see Section 2.5).
The LCD card is located on the opening lid of the enclosure.

2.3.2.4 Transducer interface card (TIF)

The flowmeter has a single TIF which plugs into the mother board by removing the cover. The transducer connections are made via internal cables to the mother board.
The jumper links on the card should not be altered. When a TIF is changed during service, the replacement must have the same links set.

2.3.2.5 AC Power adapter module

The adapter is an external module. It allows the Sarasota 200 to be operated from AC mains electricity between 90 and 264 Volts and between 47 and 63 Hz.

2.4 Ultrasonic transducers

Each velocity path requires two transducers and each ultrasonic depth requires one.
The transducers are available in a number of frequencies. See Section 1.2.7 for frequency selection. The frequency of the ultrasonic depth transducer, if used, is not normally critical.
1 MHz is usually used if the velocity transducer frequency is 1 MHz or 500 kHz otherwise.

The diameter of the transducer is different for different frequencies. This is to maintain the angular spread of the beam, which is a function of frequency and diameter.

The transducers for the Sarasota 200 are “smart”, with local circuits for the drive voltage (HT) generation and the receiver amplifier built in to minimise losses and optimise signal-to-noise ratio. In the case of the 1 MHz transducers the size of the transducer is limited and the local circuit is separated from the transducer in a potted in-line housing called a “Tbox”,

Transducers are wired to the flowmeter using the multi-drop method, via “star” junction boxes in each transducer array. Up to 4 transducers may be joined together in this way.

The maximum capacity with multi-drop is 4 paths and 4 ultrasonic depths. (Auxiliary depths may also be used via 4-20 mA inputs).

The transducers connected to each star box must be pre-programmed with different addresses from 1 to 4 to enable each one to be operated separately by the flowmeter. Specialist equipment is necessary to programme the transducers and it is usual for them to be supplied with specified addresses.

2.4.1 1 MHz transducers

For use with path lengths up to 10 metres. In cases where serious attenuation is anticipated (for example, sewage) it is recommended that the use be restricted to 5 metres and a lower frequency be used above that. Of course the lower frequency requires a greater depth of water in which to operate and this must be taken into account (see Section 1).

An in-line Tbox is fitted in line with each transducer.
The co-axial cable from the T box must be connected to a star box or extended to run directly to the flowmeter. Coaxial cables to the flowmeter enclosure are usually made up on site. Cables may be supplied to length with made up ends if specified with the order. However this often makes the installation more difficult where there is the need to pull cables through ducts.

2.4.2 1 MHz intrinsically safe (IS) transducers

1 MHz transducers are available for use in hazardous areas which have atmospheres with a risk of explosion. The IS specification is given in Appendix 2, specification. The transducer is internally different from the standard one and a special barrier is wired between it and its Tbox. The transducer and connecting cable can be used in the hazardous area but the barrier and all other electronic parts must be located in safe areas.

2.4.3 500 kHz transducers

For use with path lengths above 10 metres. In cases where serious attenuation is anticipated (for example, sewage) it is recommended that 500 kHz transducer be used above 5 metres. At the upper end, they may normally be used up to 80 metres. For cases where serious attenuation is anticipated, lower frequency transducers should be used for paths above 50 metres.

The 500 kHz transducers have the HT and signal amplifiers built in. They are connected directly to the flowmeter or via star boxes. If ultrasonic depth transducer(s) are being used, it is usual to use 500 kHz frequency when that frequency is being used for water velocity measurement.

The transducers are supplied with 5 metres of cable which is connected to a star box or extended to run directly to the flowmeter. Coaxial cables to the flowmeter enclosure are usually made up on site. Cables may be supplied to length if so ordered with made-up ends. However, this often makes the installation more difficult where there is the need to pull cables through ducts.

The 500 kHz transducer also has a temperature sensor built in allowing water temperature at each transducer to be recorded by the Sarasota 200.

2.4.4 Lower frequency transducers

Consult Thermo Electron's local representative about low frequency transducers for path lengths above 80 metres or where conditions might attenuate higher frequency signals.

If ultrasonic depth transducer(s) are being used, it is usual to use 500 kHz frequency when lower frequency transducers are being used for water velocity measurement.

2.4.5 Maximum cable lengths

Item	From	To	Max length	Comment
1	500 kHz transducer (velocity or depth)	Flowmeter	300 m	Direct connection
2	1 MHz TBox (velocity or depth)	Flowmeter	300 m	Direct connection
3	Star box	Flowmeter	300 m	Multi-drop (but see depth options items 6 & 7)
4	500 kHz transducer	Star box	5 m	Multi-drop (but see depth option item 6)
5	1 MHz	Tbox	1.5 m std.	Longer separations may be supplied. Consult factory.
6	Tbox	Star box	5 m	Multi-drop (but see depth option item 7)
7	500 kHz depth transducer	Star box	50 m	Multi-drop depth option (star box max 5 m from flowmeter)
8	1 MHz depth TBox	Star box	50 m	Multi-drop depth option (star box max 5 m from flowmeter)
9	1 MHz IS	Barrier		Consult factory
10	Barrier	Tbox	1 m	

2.5 Controls and displays

Fig 1 shows the layout of the front panel. It contains the liquid crystal display (LCD).

Electronic access to the flowmeter is by means of a (laptop) PC via the serial connector locally or remotely via a modem. This allows the operator to:-

- programme the flowmeter with site data. For example. path lengths, angles, heights
- set up the inputs and outputs (including simulation for test purposes)
- set up the relay functions and values on which they switch
- set up the information to be displayed cyclically on the flowmeter LCD
- display ultrasonic waveforms
- display measurements and results
- display diagnostic data
- download stored data

The information being displayed cycles through items selected from a menu on a PC screen.

2.6 Software & firmware

There are 2 types of software:

- The internal pre-loaded operating software, normally called "firmware"
- The PC software for communicating with the flowmeter, called "GAFA"

2.6.1 Operating firmware

The flowmeter is supplied with the operating firmware already loaded. It would not normally be necessary to re-load the firmware. In the event that new firmware is to be loaded, Thermo Electron's local representative will provide the procedure or carry out the operation. Alternatively upgrades may be loaded remotely by Thermo engineers via a modem.

2.6.2 "GAFA" PC software

GAFA software runs on a PC under Windows. This allows communication with the flowmeter:-

- Via the RS232 PC port on the mother board
- Remotely via a modem connected to the RS232 MODEM port on the mother board

See Appendix 1: GAFA Screens.

2.7 Documentation

In addition to the hardware described above, and possible peripheral equipment, the following documentation may also be supplied:

- A copy of this manual (additional paper or electronic copies may be supplied)
- Site specific data (Appendix A4: Site Data). Configuration and program data completed by installation and commissioning engineers.
- Site specific drawings – transducer mounts, site layout, civil details (if part of contract)
- Certificate of conformity (specific test sheets available on request)
- Certificate of approval for Quality Management System
- On site calibration certificate (if included in the installation contract)

3 PERIPHERAL EQUIPMENT

3.1 Additional items

A number of additional items will be required to complete a flowmeter system. These may include:-

- Hardware to be installed in the channel on which to mount the transducers.
- Auxiliary depth gauge(s)
- Kiosk to house the flowmeter
- Communications equipment – for example modems, telemetry outstations, GSM modems.
- Power supplies, for example solar power systems.

plus, often, some civil work for cable ducts, supporting piles etc.

The additional items are often supplied and installed by Thermo Electron’s local representative as part of the contract, in which case details will be included in Appendix 4: Site Data Book.

3.2 Transducer mounting hardware

Thermo Electron has extensive experience of transducer mounting system design and maintains a comprehensive computerised library. Please consult Thermo Electron’s local representative for a quotation to design and supply a suitable system.

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4 INSTALLATION

4.1 Safety

SAFETY NOTICE
The installation of the Sarasota 200 flowmeter may involve a number of steps which require special skills, training and special equipment. Examples include: • **Electrical installation** • **Working on construction sites** • **Working near water (may be deep or fast flowing)** • **Lifting equipment** • **Working at height** • **Working from boats** • **Confined space working** **It is recommended that prior to the installation the installer should write a method statement detailing:** • **The scope and purpose of the work,** • **The steps in the operation,** • **Interaction with others,** • **The personnel to be involved,** • **Their qualifications for the work,** • **Protective clothing and equipment,** • **Machinery, tools etc.** • **Emergency contacts and procedures.** **A risk assessment should be carried out and both the method statement and risk assessment should be approved by the person responsible for Health and Safety on the site.** **Thermo Electron Corporation accepts no responsibility for the safety of personnel other than its own employees in the installation and commissioning of the Sarasota 200 flowmeter and accessories supplied.**

4.2 General

It is usually necessary for some preparatory work to be carried out prior to installation of the flowmeter system. This work is often performed under a separate contract and typically includes:-

- Installation of supporting structures for transducer mounts, for example, piles in a river, brackets on concrete channel walls.
- Installation of ducts or cable tray for the interconnecting cables.
- Installation of a suitable housing for the flowmeter and peripheral equipment. This could be an existing building or a kiosk.
- Provision of a power supply.
- Provision of a PSTN connection.

The installation of the equipment on site follows the above. It is normal practice to carry out a risk assessment and to write a method statement to be agreed by the client before starting work. The installation work is often restricted to times when suitable site conditions apply.

It is recommended that the installer of the flowmeter should inspect the preparatory work prior to mobilising resources for the installation.

4.3 Unpacking and laying out

If site and general assembly drawings were specified as part of the supply contract they will normally have been supplied and accepted prior to delivery of the equipment. The drawings will be a useful guide to checking the inventory of equipment delivered.

The equipment supplied should be carefully unpacked and checked for content and damage.

The transducers may have been supplied in rack assemblies ready to be fixed to the supporting structure. There will normally be two or four racks (for in-line or crossed paths). In large channels or those with complex shapes, there may be more than two racks, for example, in a stepped channel with a low level channel and a wider high one.

If the racks have not been assembled, this may be carried out on site according to the assembly drawings.

It is important to check that sufficient cable has been supplied for connecting transducers and that suitable fixings for all the items have been supplied or separately procured.

4.4 Installing transducer assemblies

WARNING – Installing transducer racks may involve working near deep or contaminated water and/or in confined spaces. Appropriate precautions and suitably qualified personnel should be used.

The transducer rack assemblies should be installed in their prepared positions according to the drawings and method statements.

Care must be taken not to damage the coaxial cables during this operation.

See Section 2.4 for transducer and junction box configuration.

Depth gauge transducers or transmitters may be fitted to one or more of the transducer racks or have a separate fitting.

4.5 Connecting transducers to flowmeter

Cables for the ultrasonic transducers should be labelled for identification, cut and pulled through the ducts or attached to trays and run back to the flowmeter. Connectors should be fitted to each end according to the instructions supplied with the connectors.

Where 1 MHz transducers are being installed, the connections are via the transducer boxes (see Section 2.4.1) which are fitted at the rack assemblies.

Cables for depth gauges other than Sarasota ultrasonic transducers should also be pulled back to the flowmeter. Generally, if the depth gauge is a pressure transmitter, the attached cable will be supplied long enough for this purpose without joining. Care must be taken to ensure that the transducer vent, which is part of the cable, is open to the atmosphere and in no danger of becoming blocked or submerged in water.

The transducer cables are to be terminated at the flowmeter end and plugged in to the flowmeter connection panel as shown in Section 2.3.1.

Ultrasonic path numbers are as shown, numbered from the lowest path. If 2 paths are at the same height the firmware will take them as crossed for the purposes of slice allocation and flow calculation (see 1.2.5).

4.6 Transducer alignment

At this stage it is usual practice to align the transducers. Each transducer should point at its partner to within $\pm 1^{o}$. The method used will vary according to the conditions.

- Pre-set alignment derived from construction drawings.
- Visual methods involving pointers and sighting arrangements.
- Low power laser methods.

If the transducers are in the water, only the first of these may be possible and final adjustment should then be carried out by adjustments to maximise signals during commissioning.

4.7 Output connections

Output signals should be wired to the peripheral devices according to the connection tables given in section 2.3. In some cases standard cables will have been provided, eg RS232, or pre-made cables will have been ordered as part of the contract.

Note For compliance with EMC emissions control, I/O cables should be screened and the screen connected to a 0V pin. Where the connector is a 'D' type connector, the screen may alternatively be connected to the connector body if metal.

4.8 Power Connection

Connection should be made to the external power source according to local or national regulations. The flowmeter is supplied with a standard 11 to 30 volt DC input with an optional external mains convertor for connection to an AC source in the range 90 to 264 volt AC, 47 to 63 Hertz. This may be connected to the power outlet via a plug or, more usually via a switched spur. This work should be carried out by a person with the appropriate qualifications.

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5 COMMISSIONING

5.1 Site dimensions

If this information is not already available, it will be necessary to carry out a dimensional survey of the installed transducers and the channel in order to programme the flowmeter. It will be necessary to determine the following:-

- length, angle and the heights of each path,
- average cross section profile, if different from that defined by the paths,
- mean bed level (MBL),
- height offset of the level transducers and,
- relationship between the local heights and a fixed datum if not working with respect to MBL.

This manual does not cover surveying techniques. However, for small sites physical measurements are easily carried out by means of a tape measure. Angles may be determined by triangulation.

5.2 Powering up

Check that the flowmeter has been connected up correctly and the cards are plugged in securely.

Load the GAFA software into a PC and plug in to the PC serial port.

Switch on the power source.

The LCD will be activated though the display may be meaningless at this stage.

5.3 Programming

The flowmeter should be programmed via the PC as described in Appendix 1: GAFA Screens. The programme details should be recorded to become part of Appendix 4: Site Data.

Appendix 4: Site Data is a useful checklist covering all programmed data, some of which may not be required for any particular site.

5.4 Setting up

5.4.1 Velocity paths

Select “Manual” and set the gain and voltage for each path to obtain a clean waveform and detection point.

5.4.2 Ultrasonic levels

Select “Manual” and set the gain and voltage for each level to obtain a clean waveform and detection point.

5.4.3 Auxiliary levels – analogue input

Set the input range. This allows the input to be linearised, but most level devices will be sufficiently linear and only need 2 points to define the input. On the table, define 4 mA as the minimum, 20 mA as the maximum and enter the depth offset (level above datum).

5.5 Outputs

The outputs are selected from analogue and relays.

Analogue outputs may be forced to a value of mA which may be entered via the PC. See "Loop Test", Appendix 1, A1.4.1.2. This is a valuable tool for setting up the link to peripheral equipment. The forced values may be confirmed by a calibrated multi-meter.

Correspondence between the displayed selected parameter value and the output should be checked. It is possible to force the outputs by temporarily changing the set-up, for example changing the level datum will affect not only the apparent level measurement but also the flow.

Alarm thresholds may be altered to check relay operation.

Alarm outputs may be checked by a calibrated multi-meter and verified as being received by the destination device.

6 CALIBRATION/VERIFICATION

Flowmeters of this type do not normally require calibration. Exceptions are where there are significant unmeasured areas, for example, behind transducers, or where local conditions might create atypical velocity profiles and a small number of velocity paths are deployed. See Section 1: Introduction and Appendix 3: References.

However, it is normal to carry out periodic checks to verify the overall performance of the flow determination.

Whether for calibration or verification purposes, the comparison method to be used will be the same and will depend on the site.

Reference is made to ISO 748 for details of methods. See Appendix 3: References.

The most common method used is by current metering using a calibrated rotating element or electromagnetic current meter. Recently the use of an acoustic Doppler profiler (ADP) has become more common for this purpose. This has enabled the checking process to become much quicker and, where high flows in rivers are concerned, safer too.

Care should be taken to use repeated checks and to minimise the experimental uncertainties which could otherwise be greater than the uncertainty of the ultrasonic flowmeter.

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7 MAINTENANCE

There is little maintenance as such relating to the flowmeter itself. However, the river or channel must be kept free of weed, silt and other obstructions to avoid interruption of the ultrasonic paths or changing the cross section area which would affect the accuracy of flow determination.

Periodic checks on the functioning of the flowmeter and verification of the flow as calculated are recommended.

7.1 Channel maintenance

7.1.1 Weed

- If weed tends to grow in the channel, it must be kept cut.
- Weed must be kept clear from between the transducer arrays where it may stop the passage of sound between the transducers.
- Weed should also be controlled on the approach to the gauged section and immediately downstream of it where its presence could distort the velocity profile.

The user must decide on the seasonal cutting regime to suit the channel.

7.1.2 Profile

Periodically the channel shape should be checked to determine whether it has changed since the flowmeter was programmed. It is particularly important to check the bed where silt might have been deposited or scouring could have occurred.

Changes may be required to the programmed channel shape or mean bed level.

In serious cases, it may be necessary to dredge the channel, taking care not to damage the transducers.

The user must decide on the checking regime to suit the channel.

7.1.3 Debris

Under high flow conditions it is not uncommon for debris to be washed along the channel. Whilst the design of the transducer supports should be such as to minimise the risk of snagging this debris, separate deflectors or devices intended to capture it may be employed.

If the channel is prone to this phenomenon, the user must instigate an appropriate debris-clearing regime.

7.2 Flowmeter maintenance

There are no parts requiring maintenance except that the transducers should be checked occasionally for a build-up of surface coating, for example by grease, and for misalignment caused by physical shocks. These checks may be carried out along with the channel maintenance.

Normally it is possible to obtain advance warning of problems by checking the signal quality. This may be done on site or remotely via GAFA (Appendix 1: GAFA Screens).

7.3 Routine checks

7.3.1 Remote

Remote checks of operation of all velocity paths and depths are easily carried out via GAFA. It is recommended that a monthly routine should be set up to handle this.

If the flowmeter is fitted with the relay option, one of the relays may be programmed to initiate an early warning call via a telemetry outstation.

7.3.2 On site

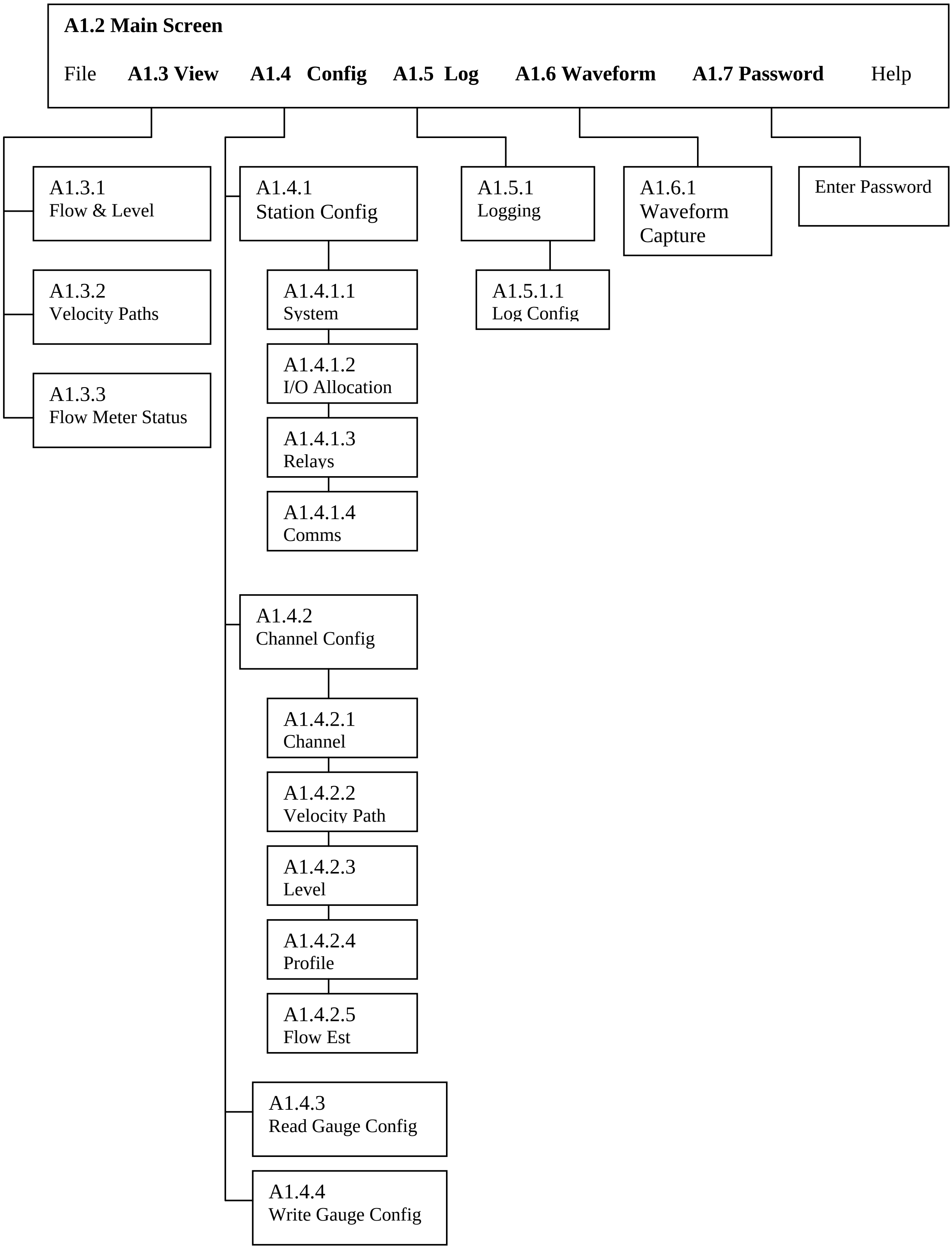
It is recommended that regular checks be made on site. These should include:

- A visual observation of the equipment in the channel and the flowmeter.
- A functional check of the operation of the paths, levels and outputs.
- A check on the operation of the internal battery.
- A verification of calculated flow by a comparison method, see Section 6: Calibration

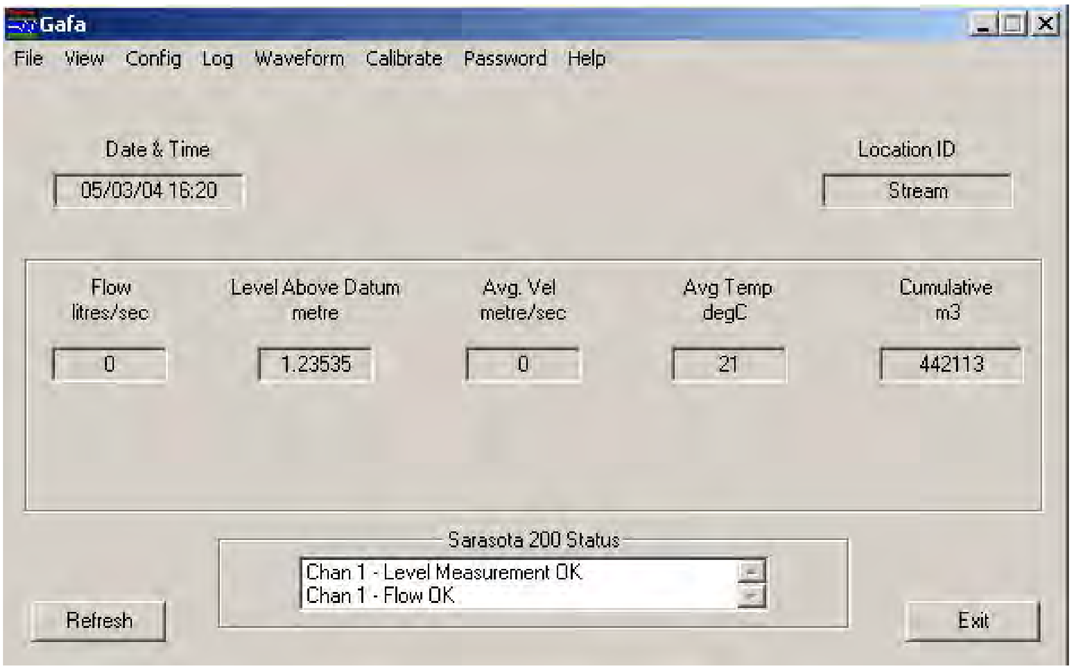
Any corrective work should be taken at the time if possible or reported for subsequent action.

APPENDIX 1 “GAFA” PC SOFTWARE

A1.1 Screen organisation chart



A1.2 Main Screen

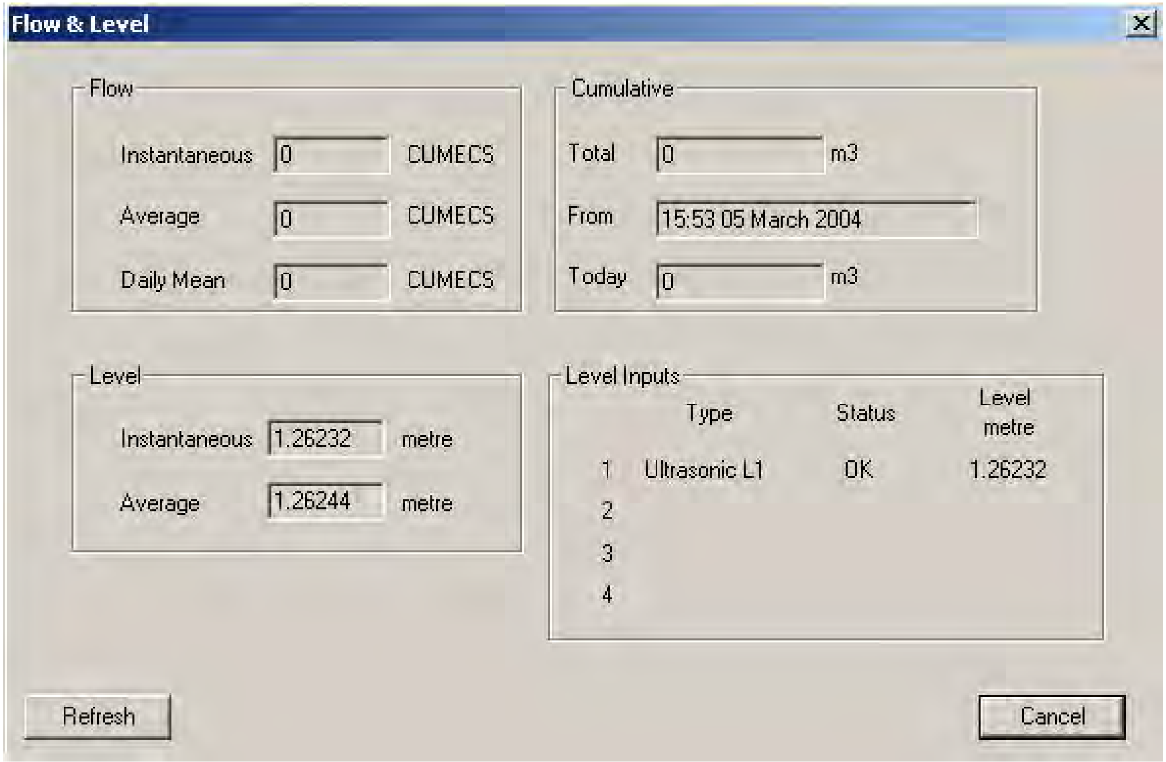


Notes

- This is the main screen showing current measurements and status.
- Measurements displayed on this screen are subject to averaging as set up on the "Station Configuration - System" screen A1.4.1.1.
- Cumulative volume is the total volume passed since last reset via the "Station Configuration – System" screen A1.4.1.1.
- If more than 1 level input is used, the Level displayed on this screen is the combination subject to the arbitration rules given in section 1 of this manual.
- Average temperature is taken from all sensors with transducers that are in the water. Transducers above the water are not included. Temperature is measured by sensors in the transducer smart electronic circuits. For 1 MHz transducers this will often not be water temperature since the circuits are in Tboxes which may be out of the water. Individual temperatures may be viewed on the "Velocity Paths" screen A1.3.2.
- Data presented on the screen is automatically refreshed every 30 seconds.
- Click on "Refresh" to update immediately.
- Click on menu bar across the top of the screen to obtain drop down menus for other screens.
- Pressing Escape on the PC keyboard when in other screens causes a return to the previous screen.

A1.3 "View" Screens

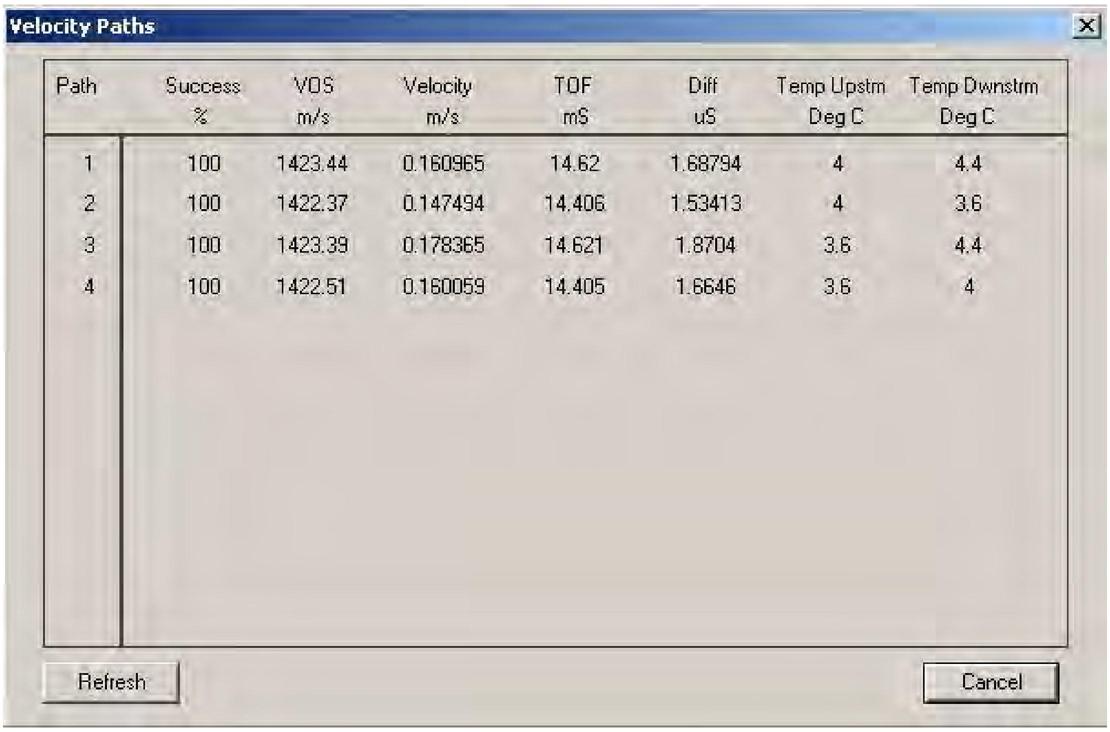
A1.3.1 (View) Flow and Level



Notes

- "Instantaneous" data is based on the measurement cycle of 10 seconds or 1 minute as set on the "Station Configuration – System" screen A1.4.1.1.
- "Average" is based on the period set on the "Station Configuration – System" screen A1.4.1.1.
- "Daily Mean" is the flow for the previous 24 hour period to the DMD time as set on the "Station Configuration – System" screen A1.4.1.1. The Daily Mean value will only change at the set time.
- "Cumulative Total" volume is from the date indicated as set via the "Station Configuration – System" screen A1.4.1.1.
- "Cumulative, Today" is from the DMD time to the present time.
- "Level Inputs" are the instantaneous separate inputs used to calculate the average level.
- Click on "Refresh" to update the display.
- Click on X or Cancel or press the escape key to return to the Main screen.

A1.3.2 (View) Velocity Paths

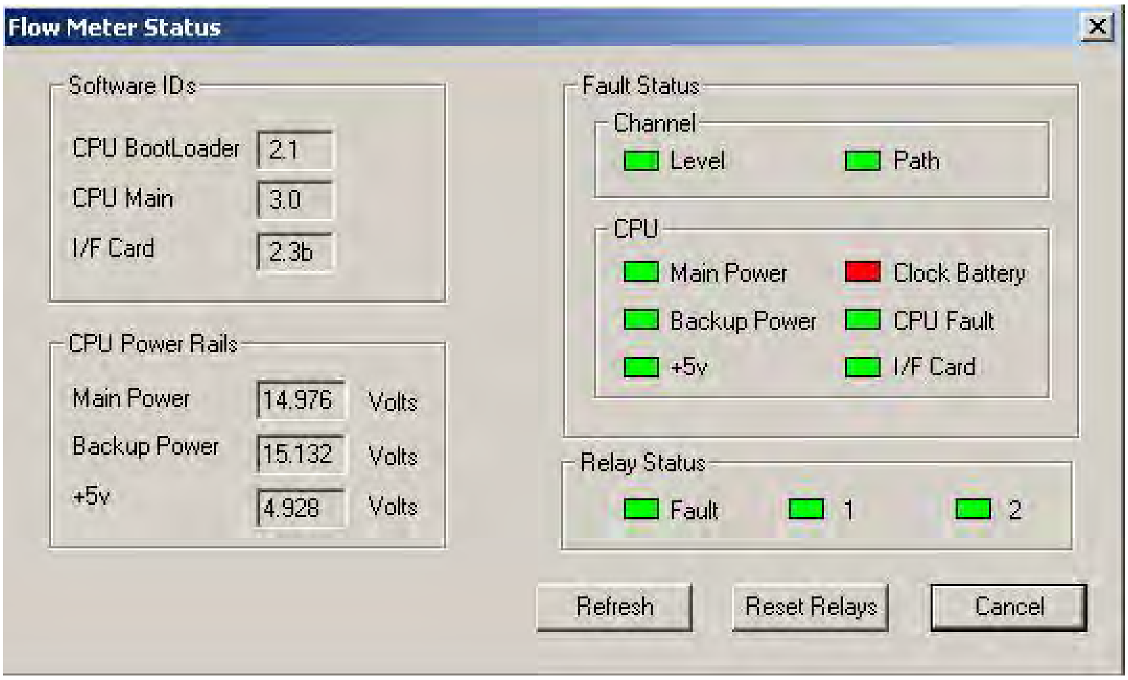


Path	Success %	VOS m/s	Velocity m/s	TOF mS	Diff uS	Temp Upstm Deg C	Temp Dwnstrm Deg C
1	100	1423.44	0.160965	14.62	1.68794	4	4.4
2	100	1422.37	0.147494	14.406	1.53413	4	3.6
3	100	1423.39	0.178365	14.621	1.8704	3.6	4.4
4	100	1422.51	0.160059	14.405	1.6646	3.6	4

Notes

- “Success” indicates the proportion of “flights” of sound pulses resulting in acceptable signals received.
- “VOS” is the velocity of sound measured by each path. It is the path length divided by the transit time.
- “Velocity” is the water velocity calculated for each path. (see Section 1 of the manual)
- “TOF” is the ultrasonic time of flight or transit time
- “Diff” is the difference in transit times between the upstream and downstream directions.
- “Temp” is the temperature measured by sensors in the transducer smart electronics. This will be water temperature for transducers other than 1 MHz immersed in water.
- Click on “Refresh” to update the displayed data.
- Click on X or Cancel or press the escape key to return to the Main screen.

A1.3.3 (View) Flow Meter Status



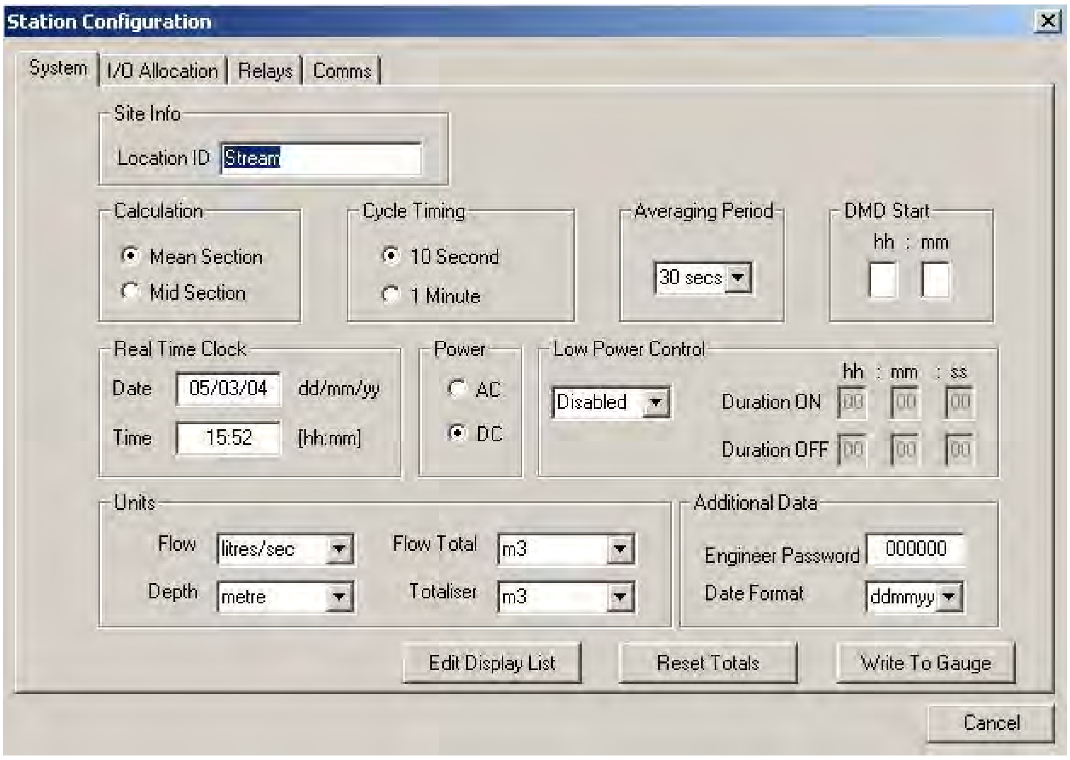
Notes

- "Software IDs" are the issue numbers of the software loaded on the system cards
- "CPU Power Rails" show the values of the internal supply voltages.
- "Status" conditions are red for a fault and green for OK.
- For "Channel" status, "Level" is red if all the levels are faulty and "Path" if all the paths are faulty. These are "fatal" conditions that could prevent flow being calculated. Under these conditions, a flow figure could still be estimated using the flow estimation table, See A1.4.2.5
- "Relay Status" indications depend on conditions as set on the "Station Configuration – Relay" screen.
- Click on "Refresh" to update displayed data.
- Relays may be reset on this screen or alternatively on the "Station Configuration - Relays" screen A1.4.1.3.
- Click on X or Cancel or press the escape key to return to the Main screen.

A1.4 Configuration screens

A1.4.1 Station Configuration

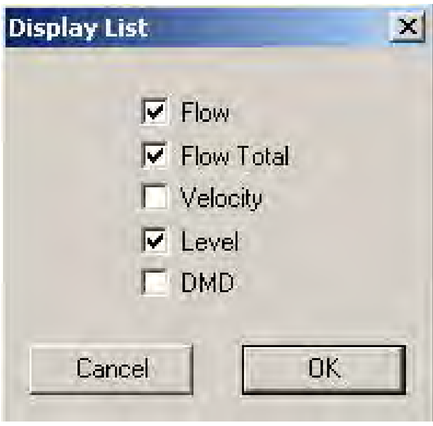
A1.4.1.1 System



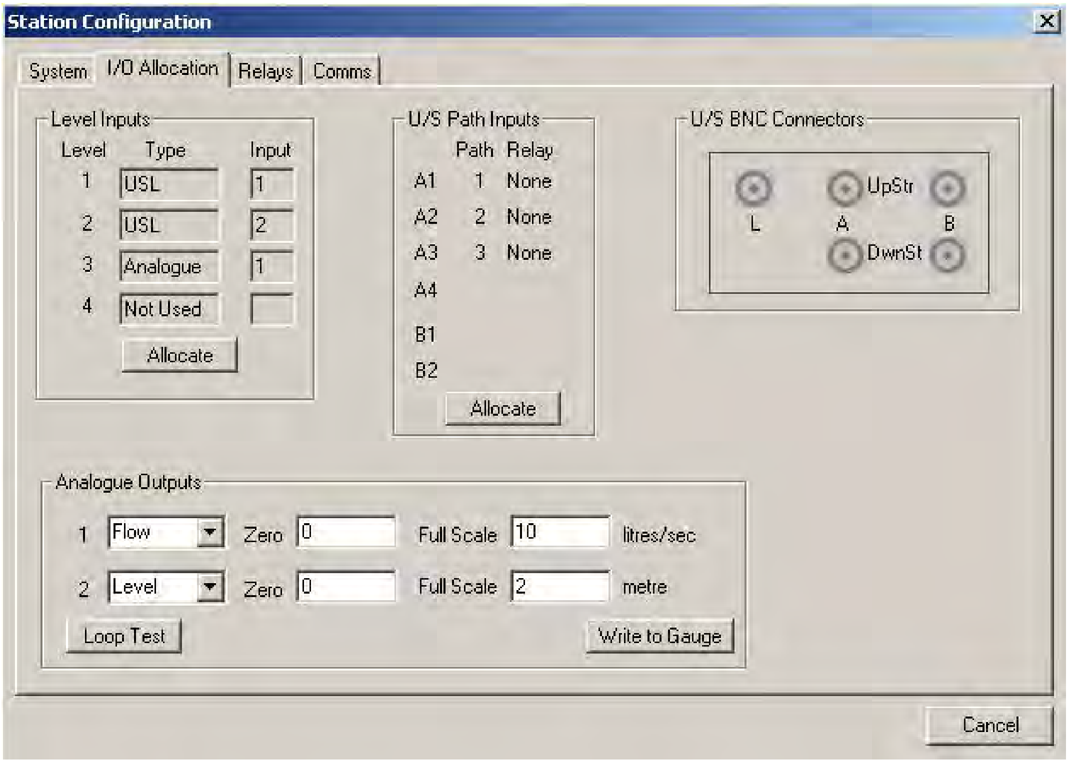
Notes

This screen is used to

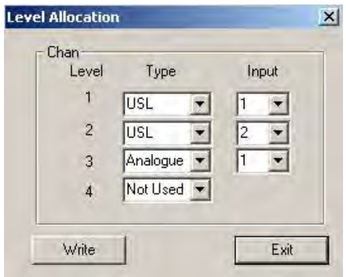
- Set the site name or number if used (ID)
- Select the flow calculation method (See section 1 of the manual.)
- Select the measuring cycle time (default 10 seconds)
- Set the averaging period. This is a rolling average, updated at each measuring cycle.
- Set the time of day for the Daily Mean Discharge (daily mean flow) calculation.
- Set the date and time
- Select the power source (used by the power supply alarm threshold circuits).
- Select low power control (if required) via external interrupt or internal timer.
- Select the units of measurement.
- Select the items to be displayed on the LCD by clicking on "Edit Display List" (see picture, right)
- "Reset Totals" clears the cumulative flow total.
- Write selection to Sarasota 200 by clicking "Write to Gauge".
- Additional data is for changing the password (See A1.7) and altering the date format.
- Click on X or press the escape key to return to the Main screen.



A1.4.1.2 (Station configuration) I/O Allocation



Notes - Level Inputs



- Click on “Allocate” to get pop up screen (right)
- Up to 4 levels in total may be selected
- For each one, select a type :

  Not Used if none allocated to that level input

  USL for an ultrasonic upward facing transducer. For this selection, a multi-drop address between 1 and 4 must be specified via the Input drop down. If there is only 1 USL, use Input 1 on the drop down.

  Analogue for 4-20 mA auxiliary depth inputs. For this selection, input 1 or 2 must be selected on the drop down.

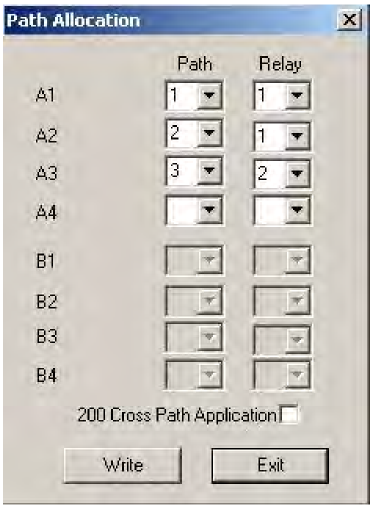
  Fixed for a channel where the depth does not change, e.g a full pipe.

- Click on “Write” to confirm selected levels to the Sarasota 200.
- Click on “Exit” to abandon selection.
- See “Channel Configuration – Level” A1.4.2.3 to set up the selected levels.

Notes – U/S Path Inputs

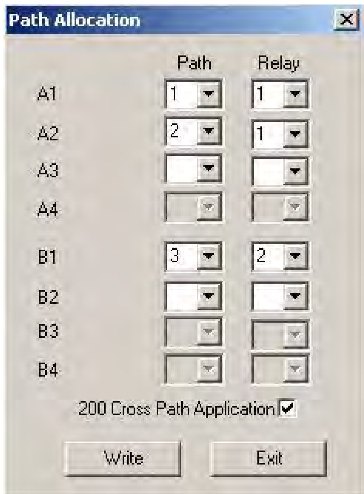
- Click on "Allocate" to get pop up screens (right)
- Up to 4 velocity paths in total may be selected

- If the "200 Cross Path Application" is not ticked, the paths will be allocated to an in-line configuration using connectors A only.
- Paths, numbering from the bottom, shall be allocated to A connectors (upstream and downstream) via addresses 1 to 4



- If the "200 Cross Path Application" is checked (right), the allowable configurations are:
  - up to 2 paths allocated to A and 2 to B
  - up to 3 paths allocated to A and 1 to B

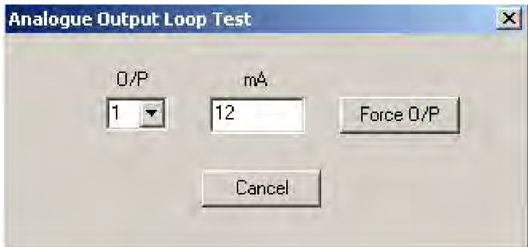
- A relay may be selected for any path or paths. The relay will then operate in the event of a fault on any of the paths for which the relay is selected
- Click on "Write" to confirm selected levels to the Sarasota 200.
- Click on "Exit" to abandon selection.
- See "Channel Configuration – Velocity Paths" (A1.4.2.2) to set up the selected paths.



Notes – Analogue Outputs

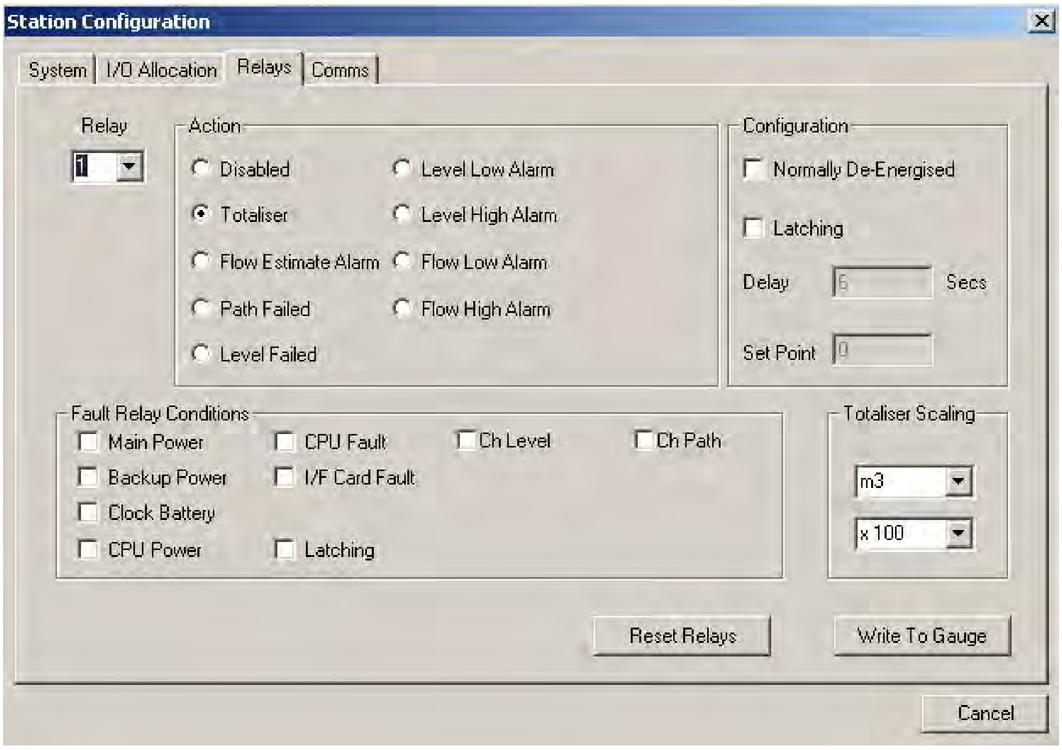
- There are 2 analogue (4-20 mA) outputs.
- Click on each one to get the drop down and allocate to functions:
  - Flow
  - Level
  - Velocity
  - DMD
- Ranges are set up on this screen for the functions selected by entering numbers for "Zero" and "Full Scale"

- Click on "Write" to confirm selected analogue outputs to the Sarasota 200.



- Click on "Loop Test" to obtain pop up (right).
- Select output 1 or 2 and the value of mA to be applied to the output for test purposes. Before using loop test, the analogue output must be set to "None" on the drop down menu.

A1.4.1.3 (Station configuration) – Relays



Notes

Relay 1 or 2.

- Select and allocate an "Action". For each action, certain parts of the "Configuration" box are enabled and should be set up.

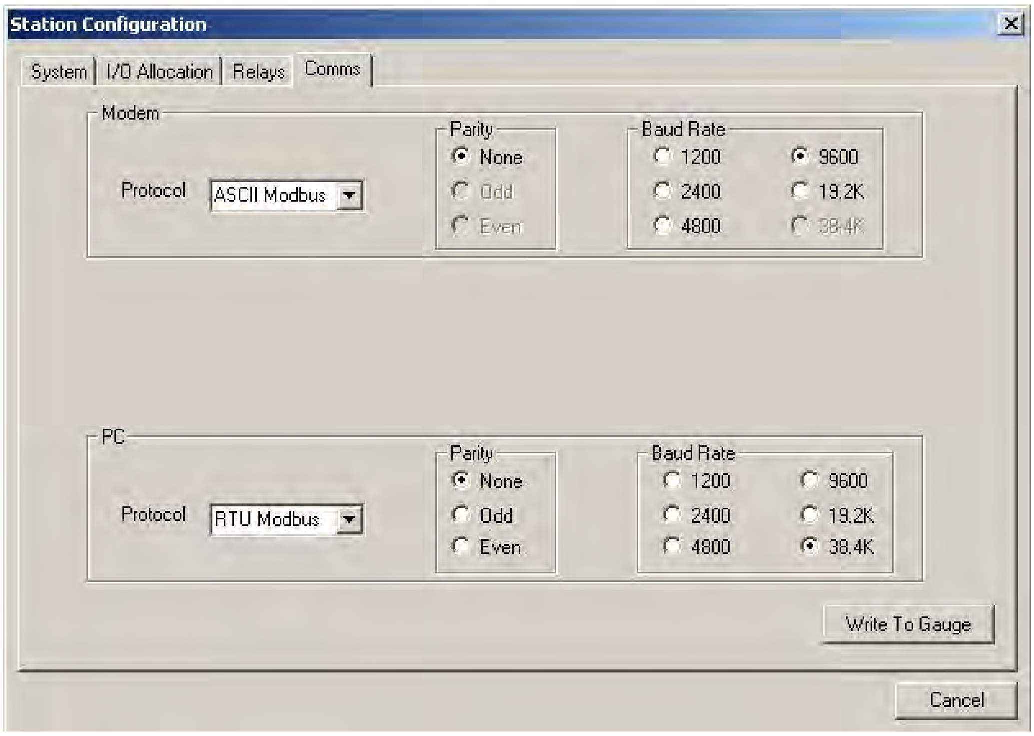
  Totaliser. When this is selected, the "Totaliser Scaling" box is enabled to allow the totaliser pulses to be scaled. Note that relay 1 is a solid state relay and is more suitable for this action than relay 2. See the Specification in Appendix 2 of the manual.
  Flow Estimate Alarm. If selected, this is actioned when the flow estimation table is being used in place of the normal transit time measurements.
  Path Failed. If selected, this is actioned for failure of any of the paths which have been selected via the I/O Allocation screen A1.4.1.2.
  Level Failed. If selected, this is actioned when all the levels fail.
  Level Low Alarm. Define the low level threshold to operate the relay selected.
  Level High Alarm. Define the high level threshold to operate the relay selected.
  Flow Low Alarm. Define the low flow threshold to operate the relay selected.
  Flow High Alarm. Define the high flow threshold to operate the relay selected.

Fault Relay.

- Set the conditions, any one of which will cause the fault relay to operate.

- Click on "Reset Relays" to clear all the relays which have been set to "Latching".
- Click on "Write To Gauge" to confirm selections to the Sarasota 200 or "Cancel" to abandon.

A1.4.1.4 (Station Configuration) - Comms

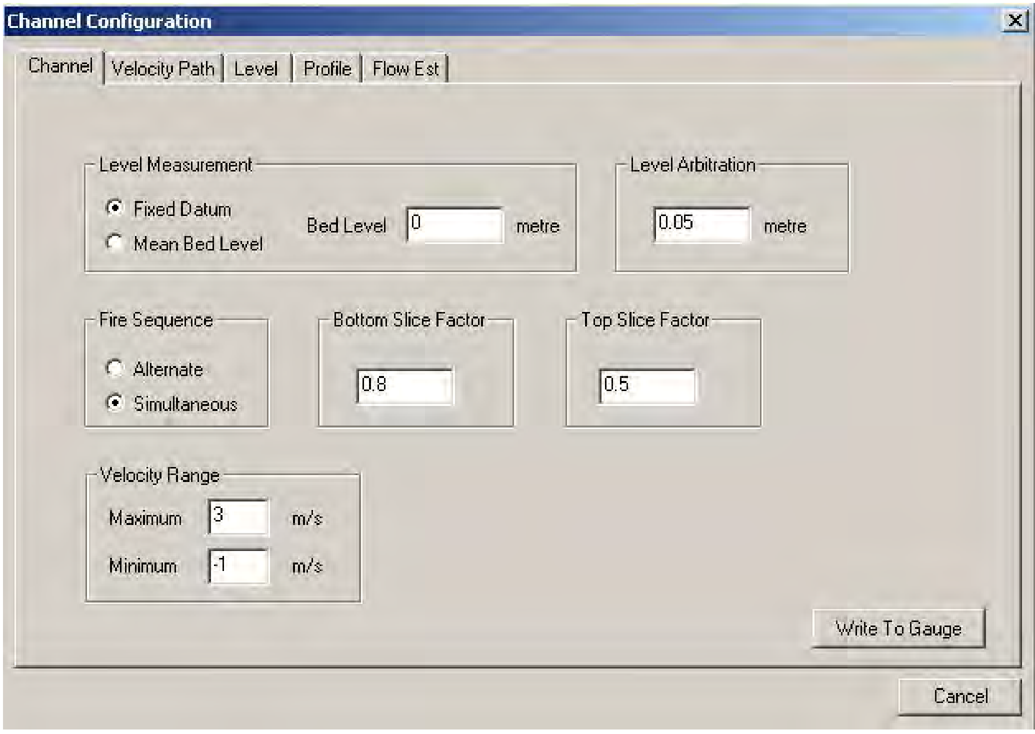


Notes

- Use this screen to set up the serial ports.
- Click on "Write To Gauge" to confirm selections to the Sarasota 200 or "Cancel" to abandon.
- When the modem comms configuration is changed, the dial-up connection will be lost and it will be necessary to re-dial to re-establish comms.

A1.4.2 Channel Configuration

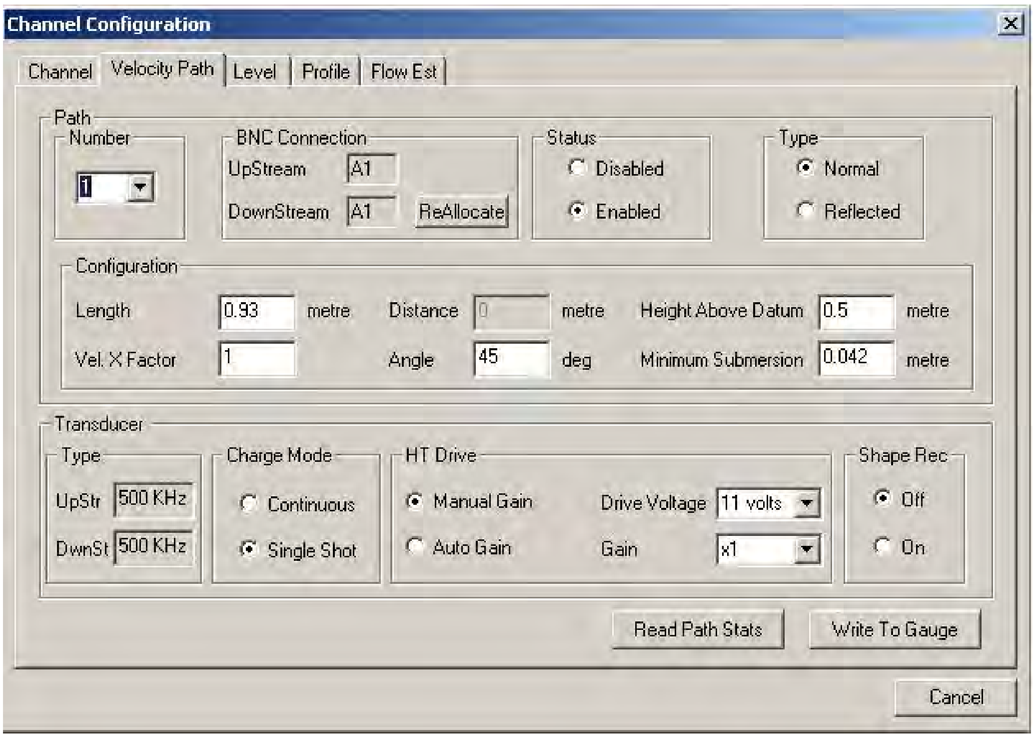
A1.4.2.1 (Channel Configuration) Channel



Notes

- If a “Fixed Datum” is used, the height of the bed of the channel must be specified relative to the fixed datum via this screen. Also all path heights and depth offsets must be specified relative to the fixed datum via the “Channel Configuration – Velocity Path” and “Channel Configuration – Level” screens A1.4.2.2 and A1.4.2.3.
- If the “Mean Bed Level” datum is used, the Sarasota 200 sets the “Bed Level” to zero. All path heights and depth offsets must be specified relative to the Mean Bed Level via “Channel Configuration – Velocity Path” and “Channel Configuration – Level” screens A1.4.2.2 and A1.4.2.3.
- “Level Arbitration” is the allowable difference between individual level measurements.
- “Fire Sequence” is normally Simultaneous. “Alternate” should only be used if there is a risk of reflections from a transducer being confused with signals being transmitted by its partner. “Alternate” will slow the operation.
- The top and bottom slice factors are entered via this screen. Refer to Section 1 of this manual.
- The maximum and minimum water velocities are entered via this screen. If any path measures a velocity outside the specified range it is considered faulty and excluded from the flow calculation.
- Click on “Write To Gauge” to confirm selections to the Sarasota 200 or “Cancel” to abandon.

A1.4.2.2 (Channel Configuration) – Velocity Path



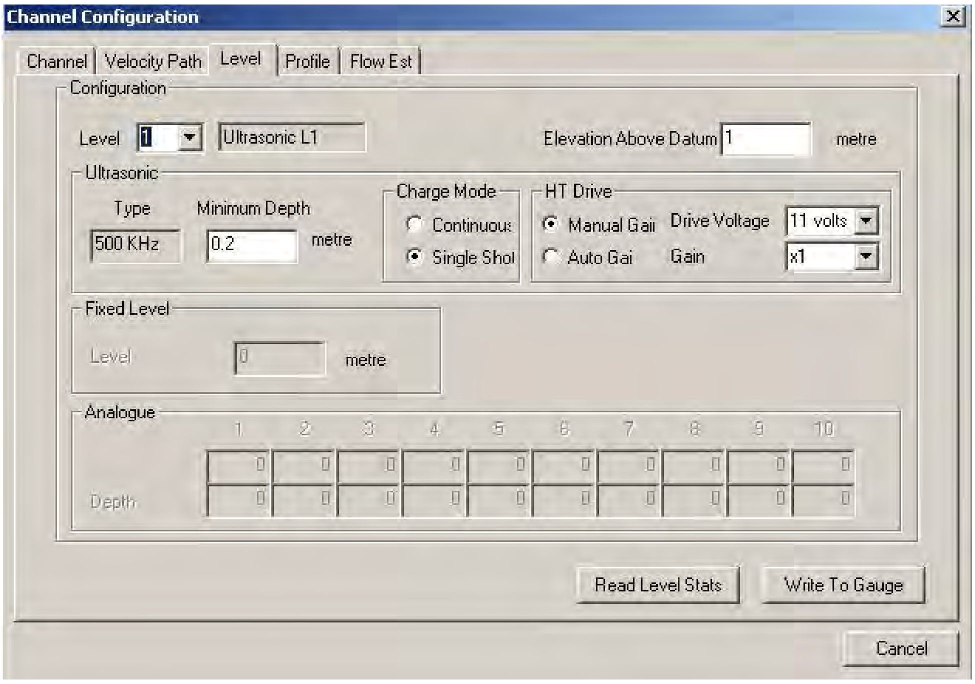
Notes

- Enter the “Path Number” to be configured.
- The “BNC Connection” will be as entered on “Station Configuration – I/O Allocation” A1.4.1.2.
- By clicking on “ReAllocate”, the transducers may be re-allocated to paths for diagnostic purposes. See the pop-up screen, right. For example, transducer 1 upstream may be paired with transducer 2 downstream. This may help diagnose whether a transducer is faulty or obstructed.
- A path may be “Disabled” if an intermittent fault is causing confusion.
- A “Normal” path operates directly between a pair of transducers. Alternatively, select “Reflected” if the ultrasonic path goes via a reflector on the far side of the channel.
- Path Length and Height must be entered on this screen.
- The X factor is a multiplier, normally 1 but may be different for special calibration reasons.
- Angle to flow is for “Normal” paths only.
- The “Distance” along the channel between the upstream and downstream transducer is used only for reflected paths. In this case, no Angle is required.
- Minimum submersion is the water height above a path required to allow it to operate. A value will be offered by the Sarasota 200 according to calculations as defined in Section 1, but may be changed, for example if the water surface is likely to be rough.

- The “Transducer Type” is identified by the Sarasota 200 and is for information only.
- The normal transducer “Charge Mode” is “Single Shot” which consumes minimum power. “Continuous” may be used for single path operation for convenience during setting-up.
- The “HT Drive” is usually set to “Manual” for setting up in which case the “Drive Voltage” and “Gain” are set manually. The effect of changing them is observed via the Waveform Capture Screen. Once set up, “Auto Gain” may be selected.
- “Shape Recognition” is used to reject distorted signals. It may be switched off for diagnostic purposes.
- Click on “Read Path Stats” to view the autogain statistics. This is for diagnostic purposes.

- Click on “Write To Gauge” to confirm selections to the Sarasota 200 or “Cancel” to abandon.

A1.4.2.3 (Channel Configuration) – Level

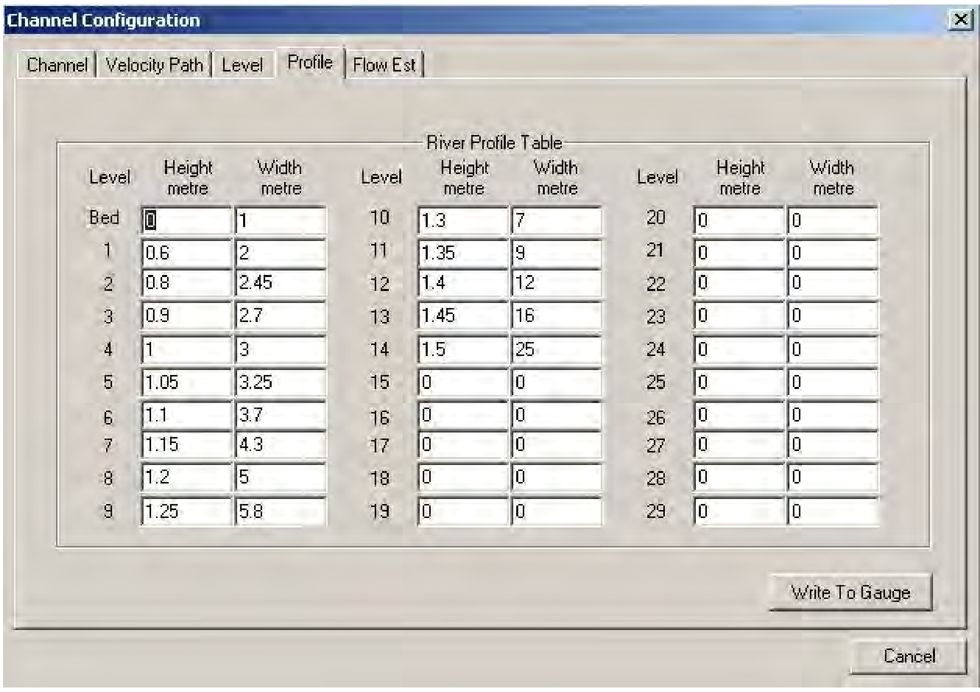


Notes

- Enter the "Level" number to be configured. This will be as entered on "Station Configuration – I/O Allocation" A1.4.1.2.
- "Elevation above Datum" is the offset to be applied to this level, e.g. the height of a pressure transmitter.
- If the Level is Ultrasonic (upward facing) the "Ultrasonic" panel on the screen is enabled and must be completed in the same way as for the Velocity paths on the previous screen.
- If the channel is closed and full, the channel height is entered as "Fixed Level".
- If the Level is via an analogue input, the mA/Depth table may be entered. If the relationship is linear, it is only necessary to enter 2 values. If it is non linear, intermediate values may be entered.
- For Ultrasonic Levels, "Read Level Stats" is similar to that for velocity paths on the previous screen.

- Click on "Write To Gauge" to confirm selections to the Sarasota 200 or "Cancel" to abandon.

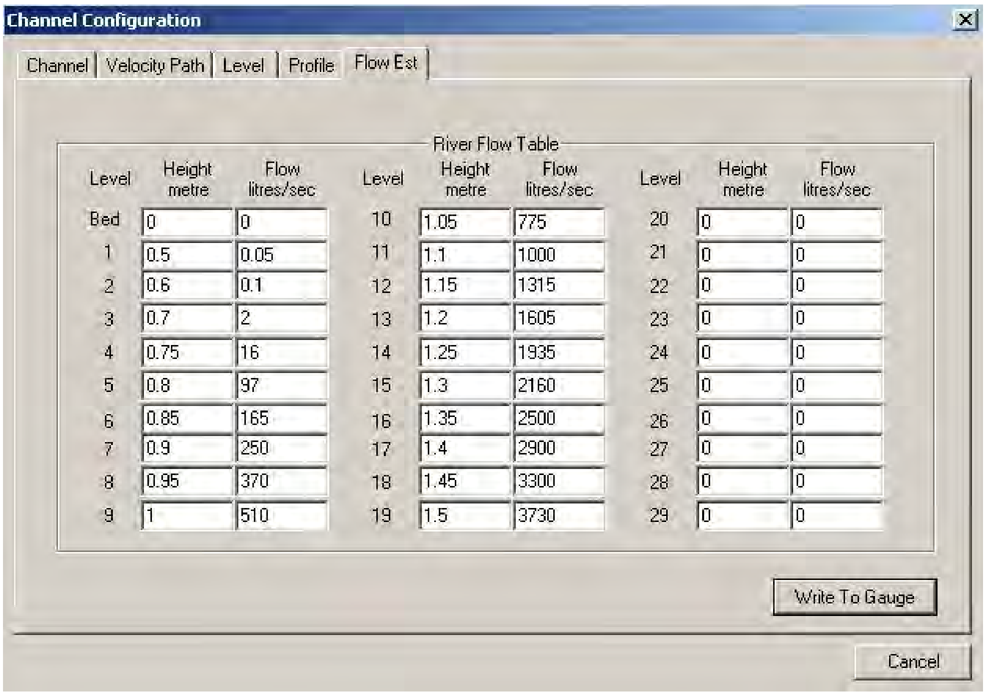
A1.4.2.4 (Channel Configuration) – Profile



Notes
- This table defines the cross section shape of the channel.
- It is entered as a series of widths against heights above datum.
- The Sarasota 200 will interpolate between the entered values.
- For channels with straight sides (even if not vertical), it is only necessary to enter 2 points, the width at the bottom and at the top.
- It is important to enter a width for a height greater than or equal to the maximum water level because the cross section area of the channel will only be calculated up to the highest defined width.

- Click on “Write To Gauge” to confirm selections to the Sarasota 200 or “Cancel” to abandon.

A1.4.2.5 (Channel Configuration) – Flow Est.



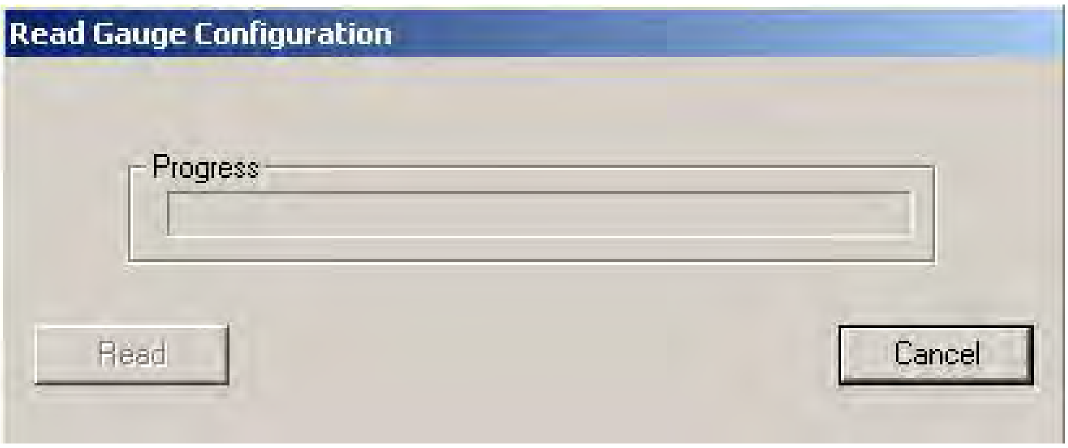
Level	Height metre	Flow litres/sec	Level	Height metre	Flow litres/sec	Level	Height metre	Flow litres/sec
Bed	0	0	10	1.05	775	20	0	0
1	0.5	0.05	11	1.1	1000	21	0	0
2	0.6	0.1	12	1.15	1315	22	0	0
3	0.7	2	13	1.2	1605	23	0	0
4	0.75	16	14	1.25	1935	24	0	0
5	0.8	97	15	1.3	2160	25	0	0
6	0.85	165	16	1.35	2500	26	0	0
7	0.9	250	17	1.4	2900	27	0	0
8	0.95	370	18	1.45	3300	28	0	0
9	1	510	19	1.5	3730	29	0	0

Notes

- The table defines an estimate of the flow as a function of water level which will apply when the velocity paths do not operate.
- It is entered as a series of flow values against heights above datum.
- The Sarasota 200 will interpolate between the entered values.
- The usual reason for using a flow estimation table is when the water level can go below the minimum required for the lowest velocity path to operate.
- It may also be used when all velocity transducers have failed, for example when water becomes aerated under extreme storm conditions.
- The relationship must be determined by calculation or experiment or by reference to historical records.

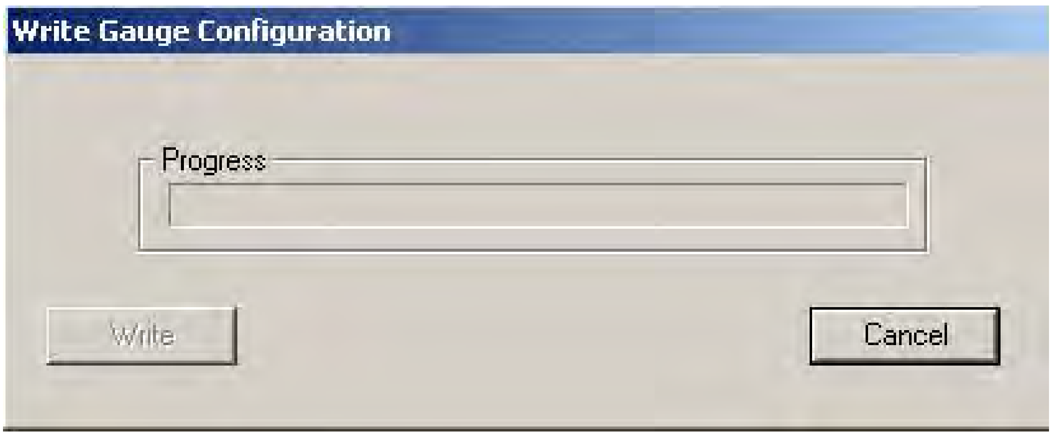
- Click on “Write To Gauge” to confirm selections to the Sarasota 200 or “Cancel” to abandon.

A1.4.3 Read Gauge Configuration



Notes
- Click on “Read” to retrieve configuration data from Sarasota 200.
- A “Save As” screen will appear. Enter a file name with a .cfg type (config.) and a PC location in which to store it.
- Subsequently, to view or print file:
  - Run GAFA off line
  - Click on “File” on the Main screen
- -“Open” the config file previously saved.

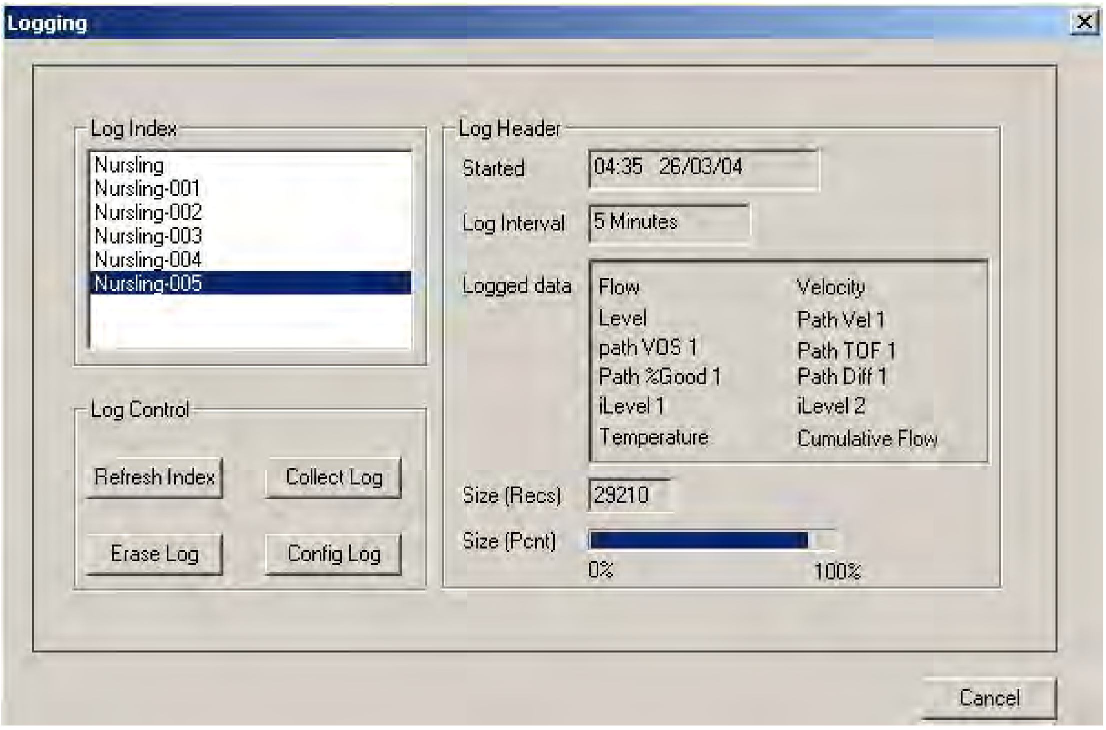
A1.4.4 Write Gauge Configuration



Notes
- Click on “Write”.
- An “Open” screen will appear. Enter the name of the required .cfg file and its location in the pc.
- “Write” to the Sarasota 200 to load the config file.

A1.5 Log

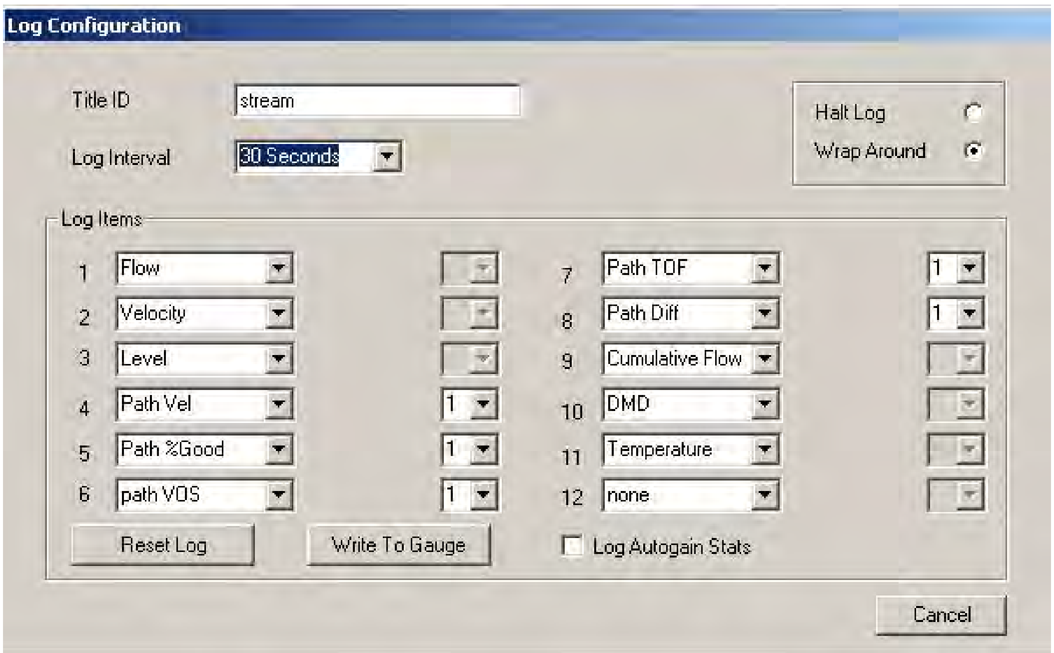
A1.5.1 Logging



Notes

- The Log Index is a list of pages of the records or “Logs” in the Sarasota 200
- There are 8 pages available. Logging will automatically continue on the following pages until the whole log memory is full at which point it will stop or wrap round. See A1.5.1.1
- .As an example, 12 variables at 15 minute logging intervals will fill the memory in 210 days.
- The “Log Header” shows the details of the highlighted Log page
- The Log Size indicates the number of record samples and the proportion of the page occupied by the highlighted Log.
- “Refresh Index” causes the latest status of the selected Log to be displayed. This will be changing if the Sarasota 200 is operating.
- Clicking “Collect Log” brings up a “Save As” screen to allow the Log to be saved to the computer memory as a comma separated variable (.txt) file.
- The saved file may be imported into a spread sheet.
- “Erase Log” clears all the Logs.
- “Config Log” allows up to 12 parameters to be selected for logging via the “Log Configuration” screen A1.5.1.1.

A1.5.1.1 Log Configuration

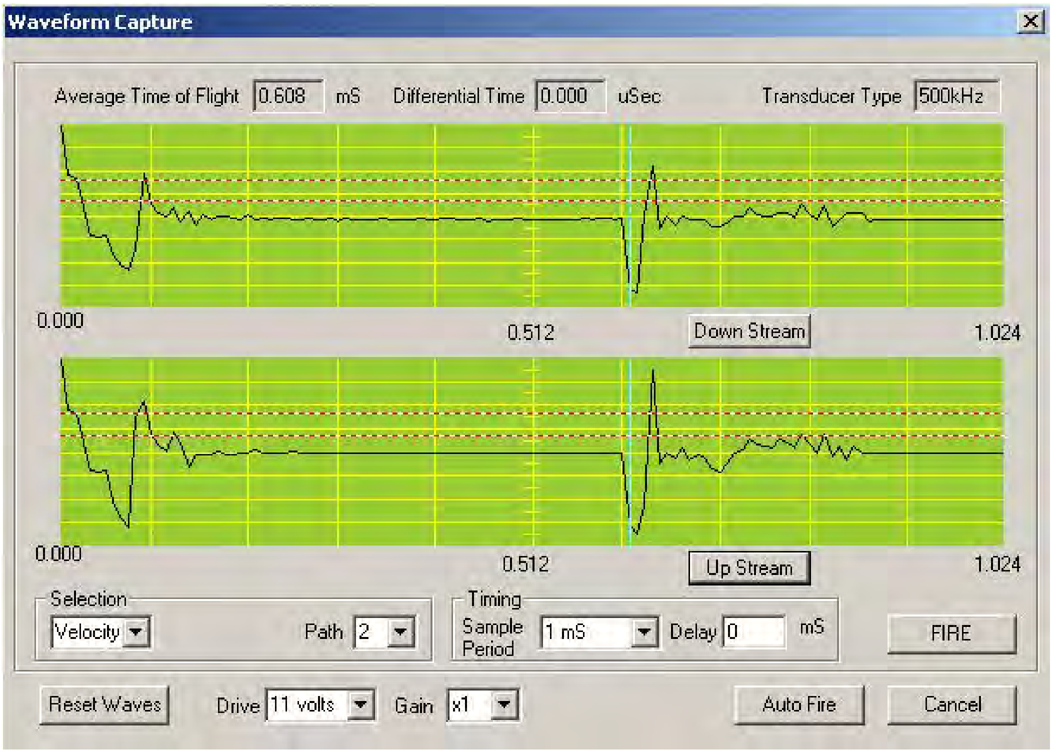


Notes

- Title ID allows a Log name to be entered
- Log Interval is the period between taking samples of the averaged data. Averaging is defined in the Station Configuration screen.
- Select "Halt Log" to stop when the Log memory is full or "Wrap Around" for the most recent records to over write the oldest when full.
- As an example, 12 variables at 15 minute logging intervals will fill the memory in 210 days.
- Select up to 12 Items for Logging
- "Reset Log" clears the log to allow a new one to be defined.
- Autogain Stats may be logged for a path for diagnostic purposes. If selected, a path number will be requested.
- "Write to Gauge" sends the Log configuration to the Sarasota 200 to start the log.

A1.6 Waveform

A1.6.1 Waveform Capture



Notes (General)

- Ultrasonic waveforms may be displayed via this screen
- The transducer type is as identified by the Sarasota 200. If "None" the transducer has not been recognised and a fault exists.
- Once "Fired" the waveform will show the "fire" pulse at time zero and the receive pulse at a time equal to the time of flight (TOF) or transit time provided the sample period that has been selected is long enough.
- If the selected path has not previously operated, the default sample period is 256 microseconds and the delay zero. These may be changed via the "Timing" box on the screen.
- If the selected path has been observed previously, the sample and delay times will be as previously selected.

To Observe Waveforms

- The path number and type (i.e. velocity or depth) must be selected from the “Selection” screen box.
- To observe the transducer “fire” signal in detail, select a sample period of 1 ms and a delay of 0 ms. Click on “Fire” and the fire signal will be displayed after approximately 10 seconds.
- To observe the receive signal, (right), first note the path TOF for the selected path. This may be found on the “(View) Velocity Paths” screen A1.3.2.

- Set the Delay to slightly less than the TOF and Sample Period to 1 ms.
- Alternatively estimate the TOF as the path length divided by the velocity of sound in water (VOS).
- To expand the waveform, the “zoom” facility may be used. Double click on the waveform in an area of interest.
- 2 vertical lines will appear which define the viewing area to be zoomed in to.
- Click and drag the viewing lines
- Double click in the area between the viewing lines to zoom in.
- It may be necessary to enter a longer Delay time in conjunction with zoom to avoid losing display resolution.

- If the viewing conditions are set up on the Down Stream waveform, click on the “Up Stream” box to replicate the conditions.
- The blue vertical lines show the time that the signal has been received and accepted.
- If there is no blue line the signal has not been accepted.
- “Reset Waves” reverts to the initial view with no zoom.
- “Fire” gets another sample
- “Auto Fire” gets a new sample every 5 seconds.
- “Drive” and “Gain may be altered from this screen rather than returning to the Channel Config screen A1.4.2.2. It is best to set the operation to manual and to turn off shape recognition via the Config screen beforehand. Set to Auto again via A1.4.2.2 if required once finished with waveform viewing.

- Ultrasonic Level waveforms are displayed in a similar fashion but only 1 waveform is displayed for each level transducer.

A1.7 Password

Notes

- The password is actually a 6 digit number.
- The password is set at the factory to 999999
- The Sarasota 200 may be viewed without entering a password but no data may be written to it without the password having been entered.
- Entering the password via the above screen allows unrestricted access for viewing and writing.
- Once unrestricted access has been obtained, the password may be changed via the “Config Station – System” screen A1.4.1.1.
- Once unrestricted access has been obtained, the above screen will not be displayed.
- If the password becomes lost, consult the supplier for an unlocking code.
- If no password protection is required, the password should be set to 000000.

APPENDIX 2 SPECIFICATION

A2.1 Enclosure

Size	Height	300 mm
	Width	380 mm
	Depth	155 mm
Wall mounting centres	Width	410 mm
	Height	240 mm
Weight	9 kg	Includes battery.

Environment

IP rating	65
Operating temperature	-10 to +50 ^{o}C
Storage temperature	-10 to +70 ^{o}C
Humidity	85% condensing

A2.2 Power supply

A2.2.1 DC Supply

Voltage	11 to 30 Volts
Fuses FS1, FS2	20 mm T1A

Power consumption for 4 path flowmeter typically 0.25A @12 V when on continuously, 0.02A in sleep mode.

Intermittent modes may be set up by defining on and off times or an external input by shorting W to 0V on the digital input PL11. Average consumption is then defined by the on/off ratio.

For example, for a 4 path flowmeter on 12 volt supply, “On” time 2 minutes, “off” time 13 minutes in a 15 minute cycle, average current = 0.051A.

A2.2.2 AC power adapter module

Input Voltage	90 to 264 Volts AC
AC Frequency	47 to 63 Hz
Output Voltage	16 V DC

The AC adapter should be connected to an AC power source via a 1A fused spur or plug.

A2.2.3 Internal battery option

Internal battery capacity	12 V, 3.2AH

The internal battery may be fitted if the DC input exceeds 15 Volts. This includes the case when the AC adapter is being used. The battery allows the Sarasota 200 to operate when the external power supply fails. The time for which it will operate depends on the mode (see A2.2.1) and the state of charge of the battery. In continuous mode with a fully charged battery the operating time will be 12 hours.

When the external supply is restored, the internal battery re-charges. In the worst case the battery will fully charge in 12 hours.

A2.3 Electronics

Timer resolution

10^{-9} s

Logging capacity

1 Mbyte

4-20 mA outputs

Resolution 12 bits
Maximum load when loop power internally sourced 600 ohms
Minimum voltage when loop power externally sourced 3.5 volts

4-20 mA inputs

Resolution 12 bits
Input impedance 200 ohms

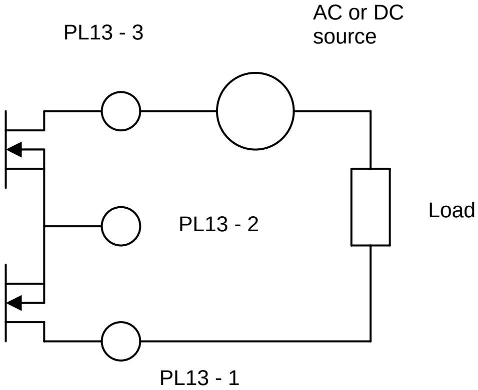
Serial

RS232 Baud rates	PL14, MODEM	1200, 2400, 4800, 9600, 19200
	SK5, PC	1200, 2400, 4800, 9600, 19200, 38400

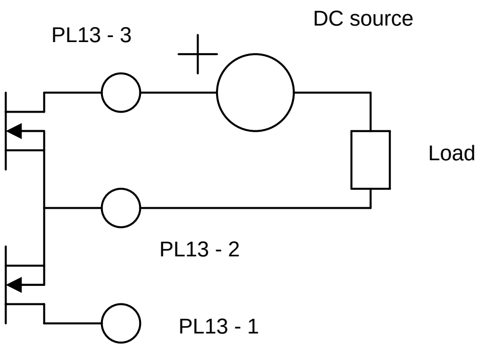
Relays

Fault relay
Type – **change over** (NO & NC)
Contact rating 0.3 A at 125 V AC or 1A @ 30 V DC
Guaranteed operations 10^5 (depends on load and voltage)
Relay 2
Type – **change over** (NO & NC)
Contact rating 5 A at 250 V AC or 30 V DC
Guaranteed operations 10^5 (depends on load and voltage)
Relay 1
Type - **Solid State Relay**
(For full spec. and test conditions, see IR data sheet PD10031C)
For connection options A,B,C see the diagrams which follow.

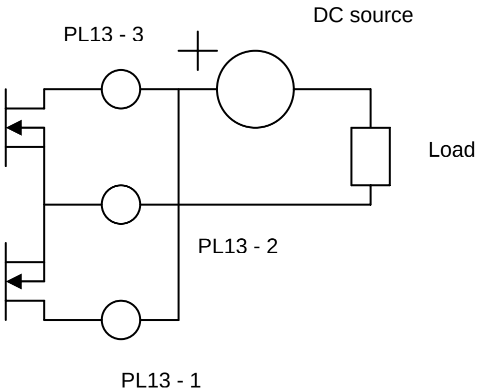
Max voltage DC or AC peak	+/- 400V
Max load current @ 40°C	A connection – 140 mA (AC or DC)
	B connection – 150 mA (DC)
	C connection – 210 mA (DC)
Max on-state resistance @ 25°C	A connection – 27 ohms
	B connection – 14 ohms
	C connection – 7 ohms
Min off state resistance	10^{10} ohms
Max switching rate limited to	1 Hz



“A” connection



“B” connection



“C” connection

Diagram of Solid State Relay connections

A2.4 Transducers

A2.4.1 1 MHz

Size	37 mm dia, 37 mm length. Consult Thermo for alternative shape and size.
Frequency tolerance	2%
(matched pairs available for close tolerance requirements)	
Immersion pressure	max 15 bar.
Operating temperature range	- 20°C to +50 °C
Safe area use	standard.
Hazardous area use	Alternative transducers plus barriers Transducer EEx ia IIB T4 (-20°C $\leq T_A \leq$ 40°C) Barrier EEx ia IIB (-20°C $\leq T_A \leq$ 40°C) Consult Thermo Electron's local representative

A2.4.2 500 kHz

Size	50 mm dia, 75 mm length
Frequency tolerance	2%
Immersion pressure	max 2 bar.
Operating temperature range	- 20°C to +50 °C
Safe area use	standard.

A2.4.3 Other frequencies

Consult Thermo Electron's local representative

A2.4.4 Transducer cable

URM76 with additional outer polypropylene sheath for continuous immersion.
Overall diameter 8mm.

A2.5 GAFA software

PC requirement

Minimum 486 with 8Mbyte RAM free
Operating under Windows 95, 98, 2000, XP

APPENDIX 3 REFERENCES

BS 3680: Part 3E: 1993
Measurement of liquid flow in open channels – measurement of discharge by the ultrasonic (acoustic) method.

This is identical to:-

ISO6416: 1992 (E)

In the near future a revised, dual numbered version will be published as:-

BS ISO 6416

BS ISO 748: 1997
Measurement of liquid flow in open channels – velocity area methods.

This is identical to:-

ISO 748

This includes check gauging by current metering. The standard was formerly numbered as BS 3680 part 3A.

CEI/IEC 41: 1991

Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump turbines

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APPENDIX 4 SITE DATA BOOK

A4.1 Model and serial number

Sarasota 200
Serial Number……………

A4.2 Site and customer

Site name:
River or channel:
Customer name:
Customer reference:
Sales Order reference number:
Thermo Electron site reference number:

A4.3 General description

Number of paths:
Configuration:
Number and frequency of transducers:
Number and type of levels:
Number and type of outputs:
Power source:
Internal battery fitted?:
Other comments:

A4.4 Software issue

Software issue:
Date:
Special features:

A4.5 Cards fitted

Part No.	**Type**	**Serial Number**	**Address**	**Comments**
01550-3009	Mother board			
01500-3029	CPU			
01500-3039	TIF			
01550-3029	Display			

A4.6 Programmed data

Fill in the table below or attach GAFA configuration print out.

Screen No.	Data type	Programmed data
	Password	
	Measurement units	
	Real time clock	
	Station configuration	
	Path allocation	
	Flow calculation method	
	Output configuration	
	Analogue output config'n	
	Test output config'n	
	Auxiliary input allocation	
	Relay configuration	
	Fault relay config'n	
	Other relays config'n	
	Relay U/S path allocation	
	Serial Port 1 (PC) config'n	
	Serial Port 2 (Modem) config'n	
	Power management	
	Data logging	
	Channel config'n	
	Level allocation	
	Analogue input config'n	
	U/S level config'n	
	Transducer setup (level)	
	Waveform capture (level)	
	U/S path config'n (vel)	
	Transducer setup (vel)	
	Waveform capture (vel)	
	Path constants	
	Transducer re-allocation	
	Channel profile edit	
	Flow table edit	

A4.7 Schedule of drawings

(Drawings to be enclosed)

Drawing Number	Title	Issue	Date

A4.8 Test certificates

(Enclose the following as appropriate)

Type	Certificate No	Date	Comment
Declaration of conformances			
In house test schedules			
Safety certificates			
On site test schedules			
Calibration certificates			
Other			

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APPENDIX 5

INTRINSICALLY SAFE TRANSDUCERS AND INTERFACE UNIT

A5.1 Introduction.

The Sarasota 200 Intrinsically safe system comprises a Transducer Type No: 01500-IST and an Interface Unit Type No: 01500-ISI. These two items are certified as a single entity and are intended for use with each other.

The transducer is dimensionally identical to the standard 1 MHz unit and is mounted in the same manner on a rack assembly which is positioned to propagate ultrasound in the hazardous area. It has additional energy limiting components potted in the housing adjacent to the piezo ceramic disc to prevent excessive voltages being generated from mechanical impact under fault conditions. It is labelled with specifications and manufacturers data.

The Interface unit is contained in a surface mounting enclosure with terminal block connections. It contains components to prevent the transfer of excessive energy from the safe area to the hazardous area where ignition may be caused. The unit is mounted remote from the transducer in the safe area and is labelled with specifications and manufacturers data.

The maximum permissible cable length between the transducer and interface is 100 meters

The general installation instructions as contained in the main body of the manual apply but for the IS system additional precautions and instructions apply.

A5.2 Installation guidelines for Hazardous Areas.

The Sarasota 200 IS Transducer and Interface Unit has been designed such that it will not give rise to physical injury when handled properly. Neither item produces excessive surface temperature and they do not emit infra red, electromagnetic or ionising radiation.

Before starting installation work ensure all power connections are isolated and precautions taken to prevent power being restored while work is taking place. Hazardous area installations forbid the use of tools or equipment which could produce an explosion hazard by causing a spark or imposing excessive mechanical stress.

Each item must be installed in a manner to avoid exposure to thermal or mechanically induced stresses and in addition neither item should be exposed to chemically aggressive substances beyond the expected levels in a sewage treatment installation or aqueous industrial outflows. The Sarasota 200 IS Transducer and Interface is not intended to be exposed to significant conditions of dust build up.

In cases where impact or other mechanical forces may be expected appropriate methods of protection must be used. Details of permissible installation conditions (ambient temperature, maximum surface temperature and gas groups) are provided on the labels affixed. This equipment must only be installed in hazardous areas appropriate to the method of protection.

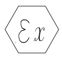
A5.3 Marking.

The Sarasota 200 IS Transducer and Interface unit are marked for use in hazardous areas in accordance with the ATEX Directive. The transducer is considered as part of the interface. Each item is marked as follows:

IS Transducer: [Epsilon x] II 2 G EEx ib IIB T4 Installed in the hazardous area
Intrinsically safe protection: ib. Apparatus Group II, Area Category 2 G, Gas Group IIB, T4 Surface temperature class at an ambient temperature of 40 Deg C

IS Interface: [Epsilon x] II (2) G [EEx ib] IIB Installed in the safe area
Intrinsically safe protection: ib. Apparatus Group II, Area Category 2 G, Gas Group IIB, T4 Surface temperature class at an ambient temperature of 40 Deg C

[Epsilon x] is marked on the label as shown below.



A5.4 Maintenance.

The Sarasota 200 IS Transducer and Interface is maintenance free and in the event of a fault condition developing cannot be serviced. No repair should be attempted to installed items, faulty assemblies should be replaced with an identical replacement