VALEPORT LIMITED

miniSVS Sound Velocity Sensors

Operating Manual

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CHAPTER	DESCRIPTION	PAGE

1 INTRODUCTION

The Valeport miniSVS Sound Velocity Sensor has been designed with the objective of providing high resolution, high accuracy sound velocity data in the most compact package possible. The basic principle of Valeport's Sound Velocity technology is "time of flight"; that is to say, the sound velocity is calculated from the time taken for a single pulse of sound to travel a known distance.

The miniSVS therefore consists of a single circuit board controlling all sampling, processing and communications functions, and a sensor comprising a ceramic transducer, a signal reflector, and spacer rods to control the path length. The two are connected by a single coaxial cable. A titanium housing may be fitted, which provides waterproof protection to a depth in excess of 6000m.

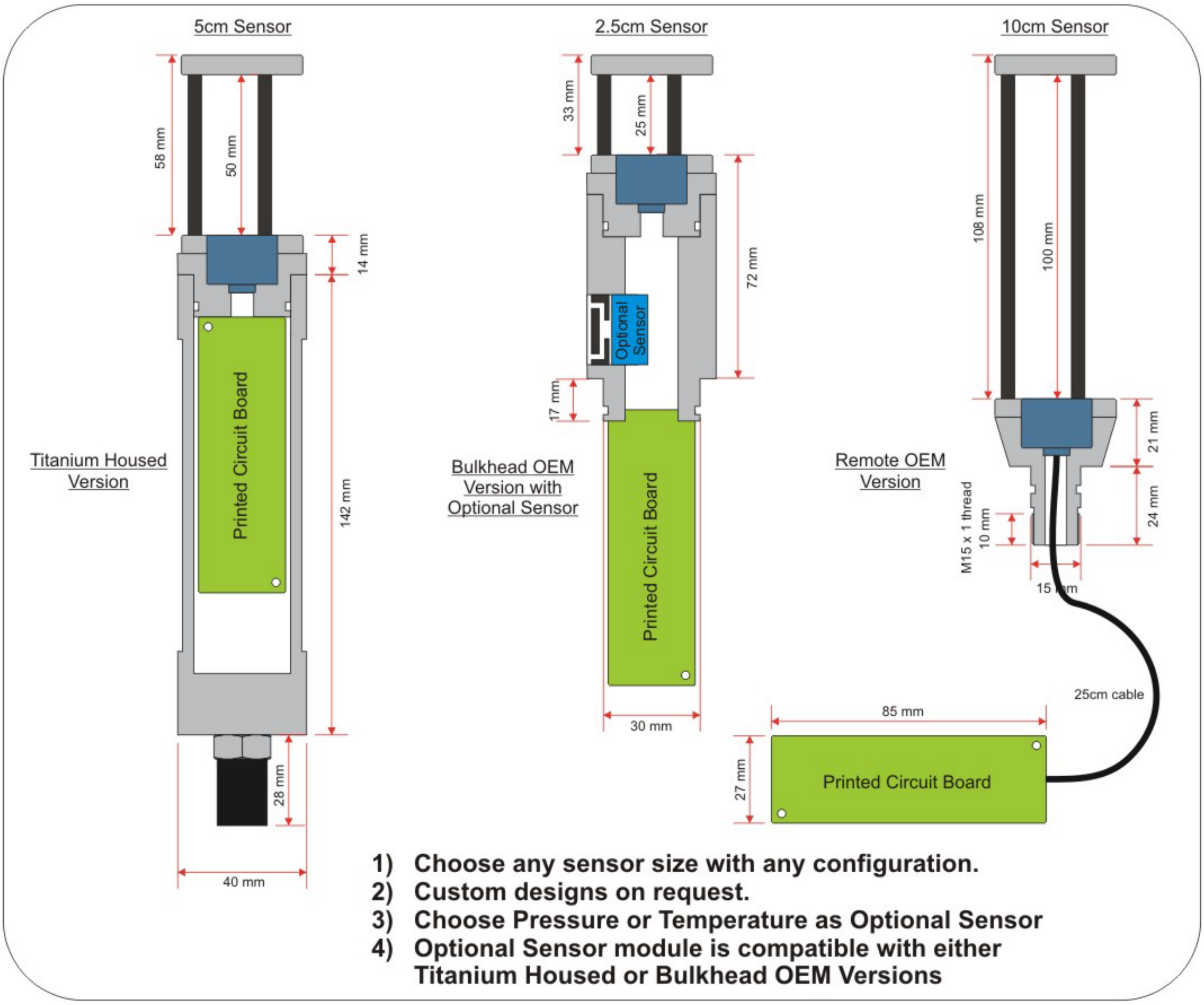
Optionally, a strain gauge pressure sensor may be added to the miniSVS, enabling sound velocity profiles to be obtained. This configuration is used in the SoundBar 2 Digital Bar Checker, where a 100dBar range transducer is used, but the miniSVS may be fitted with a selection of different range transducers up to 6000dBar. The pressure option also uses a secondary pcb.

As an alternative option, the miniSVS may be fitted with a PRT temperature sensor.

> Note that the miniSVS may have either the pressure or temperature sensor fitted as an option, but not both

2 SPECIFICATIONS

Dimensions: Dependent on type supplied. See diagram below



Connections:

Internal Co-axial connector to sensor (J3)

5 – way Harwin (power and comms) (J1)

NB: J2 is for Valeport calibration and setup purposes – not for use by customer.

External Standard is Subconn type MCBH6F in Titanium

Alternatives may be supplied on request

Wiring Information is in Section 4

Materials:

Main bulkhead	Titanium
Space Rods	Carbon Composite
Reflector Assembly	Titanium
SV Transducer	Ceramic transducer behind polycarbonate window.
Signal cable	3mm co-ax cable, nominal 25cm length. Push fit connector.
Pressure Transducer	Stainless steel diaphragm with acetal protective cover.
Temperature sensor	PRT in titanium housing with polyurethane backing.

Power:

- Requires 8 – 29V DC input
- miniSVS draws approximately 20mA at 12vDC
- miniSVS with pressure draws approximately 30mA at 12vDC
- miniSVS with temperature draws approximately 22mA at 12vDC

Output:

Data output is user selectable from RS232, or RS485. 8 data bits, 1 stop bit, no parity, no flow control.

Baud rate is factory set to 19200. User may choose between 2400, 4800, 9600, 19200 or 38400. (Note that fast data rates may not be possible with low baud rates).

Signal Frequency:

Single sound pulse of 2.5MHz frequency.

Update Rate:

Selected by command – Single output or continuous output at one of the following rates: 1Hz, 2Hz, 4Hz, 8Hz, 16Hz (50mm or 25mm sensors without pressure option only), or as fast as possible.

The fastest rate possible is determined by the path length of the sensor, and whether or not a pressure or temperature sensor is fitted:

Sensor length	SV only	SV + P	SV + T
25mm	22Hz	20Hz	18Hz
50mm	16Hz	15Hz	13Hz
100mm	11Hz	10Hz	9Hz

Performance:

Sensor	Resolution	Range	Signal Stability	Calibration Accuracy	Overall Accuracy
25mm	0.001m/sec	1400 – 1600m/s	±0.01m/s	±0.085m/s	±0.095m/s
50mm	0.001m/sec	1400 – 1600m/s	±0.006m/s	±0.054m/s	±0.06m/s
100mm	0.001m/sec	1400 – 1600m/s	±0.003m/s	±0.027m/s	±0.03m/s
Pressure	0.01% FS	0 to 100, 500, 1000 or 6000 dBar			±0.05%FS (over 10°C to 40°C)
Temp.	0.001°C	-5 to +35°C (others available)			±0.01°C

Certain features of the sensor package are designed specifically to enable high quality data to be delivered:

Carbon Composite Rods:	The carbon composite material used for the sensor spacer rods has been specifically selected to provide 3 features: a) Excellent corrosion resistance b) Very high strength c) Virtually zero coefficient of thermal expansion This last point is particularly important; accurate sound velocity measurement relies on measuring the time taken for a pulse of sound to travel a known distance. The material selected does not measurably expand over the operating temperatures of the instrument, ensuring the highest possible accuracy at all times.
Size:	The longer the path length used, the higher the accuracy that can be achieved. It has been found that a signal stability of ±10mm/sec can be achieved with a sensor path length of 25mm (overall 50mm path for reflected signal), falling to ±3mm/sec for a 100mm path (overall 200mm path for reflected signal).
Digital Sampling Technique:	***Enables a timing resolution of 1/100th of a nanosecond, equivalent to about 0.5mm/sec speed of sound on a 25mm path sensor, or 0.125mm/sec on a 100mm sensor. In practice, the output is restricted to 1mm/sec resolution.*** Allows data output at increased rates (in excess of 20Hz for a 25mm sensor). Linear sensor performance allows easy calibration.

3 DATA REQUESTS AND OUTPUT FORMATS

The miniSVS has 3 different sampling modes, and a selection of data output formats. Each mode is available with each output format.

3.1 SAMPLING MODES

- Single [data on request]
- Multiple at defined data rates [free running]
- Multiple as fast as possible [free running]

3.2 DATA FORMATS (SOUND VELOCITY ONLY)

Valeport standard format:

<space>1234567<cr><lf>

where 1234567 is the speed of sound in mm/sec [i.e. 1234.567 m/sec]

Alternative format #1:

<space>1234.567<cr><lf>

where 1234.567 is the speed of sound in m/sec.

Alternative format #2:

<space>1234.56<cr><lf>

where 1234.56 is the speed of sound in m/sec.

Alternative format #3 (SBE format):

TTT.TTTT,CC.CCCCC,SSSS.SSSS,VVVVV.VVV <cr><lf>

This format mimics the SBE output format, where:-

TTT.TTTT	is temperature value
CC.CCCCC	is conductivity value
SSSS.SSSS	is salinity value
VVVVV.VVV	is sound velocity in m/s

In this format, the miniSVS will substitute zeroes for parameters it cannot measure. Leading zeroes are replaced with spaces.

3.3 DATA FORMATS (SOUND VELOCITY & PRESSURE)

Pressure data format is dependent on sensor range, and may be any of the following. Pressure value is in dBar (abs), and leading zeroes are included, so it is a fixed length string:

PPPP.P (e.g. 1234.5 dBar)
PPP.PP (e.g. 123.45 dBar)
PP.PPP (e.g. 12.345 dBar)

In the examples below, the pressure data, whichever range is used, is expressed as *{pressure}*

Valeport standard format:
<space>*{pressure}*<space>1234567<cr><lf>
where 1234567 is the speed of sound in mm/sec [i.e. 1234.567 m/sec]

Alternative format #1:
<space>*{pressure}*<space>1234.567<cr><lf>
where 1234.567 is the speed of sound in m/sec.

Alternative format #2:
<space>*{pressure}*<space>1234.56<cr><lf>
where 1234.56 is the speed of sound in m/sec.

Alternative format #3 (SBE format):
TTT.TTTT,CC.CCCCC,SSSS.SSSS,VVVVV.VVV <cr><lf>
This format mimics the SBE output format, where:-

TTT.TTTT	is temperature value
CC.CCCCC	is conductivity value
PPPPP.PPP	is pressure value (fixed length string)
SSSS.SSSS	is salinity value
VVVVV.VVV	is sound velocity in m/s

The miniSVS will substitute zeroes for parameters it cannot measure.

3.4 DATA FORMATS (SOUND VELOCITY & TEMPERATURE)

Temperature data format is fixed to a 5 digit string with 3 decimal places. Temperature value is in °C and leading zeroes are included; it is signed only if negative. Examples:

21.456
02.769
-01.174

In the examples below, the temperature data is expressed as *{temperature}*

<u>Valeport standard format:</u>
<space>*{temperature}*<space>1234567<cr><lf>
where 1234567 is the speed of sound in mm/sec [i.e. 1234.567 m/sec]

<u>Alternative format #1:</u>
<space>*{temperature}*<space>1234.567<cr><lf>
where 1234.567 is the speed of sound in m/sec.

<u>Alternative format #2:</u>
<space>*{temperature}*<space>1234.56<cr><lf>
where 1234.56 is the speed of sound in m/sec.

<u>Alternative format #3 (SBE format):</u>
TTT.TTTT,CC.CCCCC,SSSS.SSSS,VVVVV.VVV <cr><lf>
This format mimics the SBE output format, where:-

TTT.TTTT	is temperature value
CC.CCCCC	is conductivity value
PPPPP.PPP	is pressure value (fixed length string)
SSSS.SSSS	is salinity value
VVVVV.VVV	is sound velocity in m/s

The miniSVS will substitute zeroes for parameters it cannot measure.

3.5 POWER UP

There are two power up modes. The unit will either immediately begin running in the previous sample mode, or will immediately send a '>' character, and wait for a command. There needs to be a delay of at least 500ms before sending the first command. In both cases, the data format will be the format that was previously used.

3.6 STOP COMMAND

The unit can be stopped at any time by sending the '#' character. The unit returns a '>', and waits for a further command.

3.7 COMMAND ECHOES

Each command character is immediately echoed back

<Enter> is echoed back as <cr><lf>

3.8 SAMPLING COMMANDS

S<enter>	Demands a single reading to be taken and data transmitted
M<enter>	Unit free runs at fastest data update rate
M1<enter>	Unit free runs at 1 Hz
M2<enter>	Unit free runs at 2 Hz
M4<enter>	Unit free runs at 4 Hz
M8<enter>	Unit free runs at 8 Hz
M16<enter>	Unit free runs at 16 Hz (if possible)

3.9 DATA FORMAT COMMANDS

#082;off	Sets data format to standard Valeport mode (sound speed in mm/sec)
#082;3	Sets data format to alternative mode #1 (sound speed in m/sec to 3 decimal places)
#082;2	Sets data format to alternative mode #2 (sound speed in m/sec to 2 decimal places)
#082;csv	Sets data format to alternative mode #3 (comma separated variable), mimicking SBE output format.

3.10 PRESSURE FORMAT COMMANDS

#083;0	Turns pressure sensor off and unit reverts to SV only operation mode
#083;1	Sets pressure data format to 1 decimal place
#083;2	Sets pressure data format to 2 decimal places
#083;3	Sets pressure data format to 3 decimal places

3.11 PRESSURE TARE COMMANDS

#011;on	Turns Tare mode on (i.e. unit subtracts fixed value from pressure data)
#011;off	Turns Tare mode off (i.e. unit outputs pressure as read)
#009;	Unit takes single pressure reading to use as Tare value.
#009;0	Sets Tare value to zero (i.e. removes tare)

#009;{value}	User input value to use as Tare in units of 0.001dBar (i.e. 9000 = 9dBar)

3.12 POWER UP MODE COMMANDS

#091;off	Unit waits for command on power up.
#091;on	Unit immediately begins sampling on power up.

3.13 OTHER COMMANDS

#059;{baud_rate}<cr> *e.g. #059;19200*	Sets the units baud rate. Options are 2400,4800,9600,19200,38400
#031;raw	Sets data output to raw format (time of flight in 100ths of nanoseconds)
#031;cal	Sets data output to calibrated format (sound velocity in mm/sec). Unit always starts in cal mode from power on.
#102;ON or OFF	Turns RS485 communications mode ON or OFF. RS485 communications are half-duplex only. Note: only set unit to RS485 mode if a suitable RS485 communications system is in place. Standard PC communications via RS232 will no longer be possible in this mode.
#001;nn	Sets RS485 address (01 to 99)
#005;ON or OFF	Turns Address mode ON or OFF
#026;{xxxx}	Sets data separator for Valeport mode. Default is <space>, separator may be up to 4 characters.

4 WIRING INFORMATION

This section contains wiring information for all sensor configurations, and includes several different connector types. Be sure to confirm that you are looking at the appropriate information.
Wiring colours are correct at the time the manual was printed. However, it is advised that continuity checks are performed prior to all terminations.

OEM Systems:

Supplied with a short test lead to enable configuration and testing:

FCI 5 way connector	Wire Colour	Function	9 Way D Type Connector	4mm Banana Plugs
1	Green	Signal / Power GND	5 (Linked to 1,6,8,9)	Black Plug, Green Wire, connected inside 9 way D type
2	Yellow	RS232 Tx (Out of sensor) or RS485A	2	
3	Blue	RS232 Rx (Into sensor) or RS485B	3	
4	Red	+V		Red Plug, Red Wire, connected inside 9 way D type
5 (marked with arrow)		N/C		

Housed systems (standard Subconn connector):

Systems are supplied with a short (50cm) lead for splicing or testing

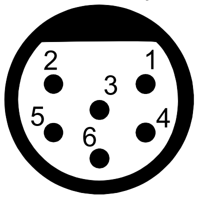
Subconn 6 pin male line (MCIL6M)		Function	9 Way D Type	4mm Banana Plugs	
Pin	Wire Colour		Pin	Pin	Wire colour
1	Black	RS232 GND	5 (Link to 1,6,8,9)		
2	White	RS232 Tx (Out of sensor) or RS485A	2		
3	Red	RS232 Rx (Into sensor) or RS485B	3		
4	Green	+V		Red Plug	Red, linked to Green inside D type
5	Orange	N/C			
6 (Link to pin 1 in sensor)	Blue	Power GND		Black Plug	Black, linked to Brown inside D type

Housed systems (Impulse IE55-12-CCP connector, optional fit only):

Systems are supplied with a free end lead for splicing

Impulse 6 pin male bulkhead		Function
Pin	Wire Colour	
1	Green	RS232 Rx (in to sensor)RS485A
2	Yellow	Power & RS232 Ground
3	Blue	9 – 28vDC input
4	Red	RS232 Tx (out of sensor)RS485B
5		N/C
6		N/C

View onto bulkhead connector pins



NB: RS232 and Power grounds must be linked.

Impulse 6 pin female line		Function
Pin	Wire Colour	
1	Yellow	RS232 Rx (in to sensor)RS485A
2	White	Power & RS232 Ground
3	Red	9 – 28vDC input
4	Brown	RS232 Tx (out of sensor)RS485B
5	Orange	N/C
6	Blue	N/C
	Screen	N/C

NB: Do not connect screen.

APPENDIX 1: FAQ'S

Why is the data different from my old CTD data?

Quite simply, the Valeport SV sensor is more accurate than anything else that has previously been available. The CTD formulae (Chen & Millero, Del Grosso etc.) all have errors in them – they were after all based on observed data taken over 30 years ago using the best technology available at the time. The Valeport SV sensor simply highlights those errors. This does raise an interesting point – if it is more important to you that your data is consistent with old data, rather than accurate in its own right, then you are possibly better off using a CTD (we would suggest a Valeport CTD, naturally).

How is it so accurate?

Several reasons. Primarily, we use an advanced digital signal processing technique that removes virtually all noise from the data, tells us the precise moment that the sound pulse is both transmitted and received, and allows us to measure the time of flight with a resolution of 1/100th of a nanosecond (10^{-11} seconds). Secondly, we have developed a carbon composite material that doesn't expand or contract with temperature, so our "known distance" is a constant. Technically, the material will expand and contract minutely, but over the operating temperatures of the probe, it is an almost immeasurably small amount, and any change is included in our overall error budget. Finally, our calibration method removes virtually all of the error sources associated with other techniques.

But don't you just calibrate it against Chen & Millero?

No we don't – that would defeat the purpose. While the seawater formulae (Chen & Millero, Del Grosso etc.) have inherent errors that are accepted as being at best ±0.25m/s, we use a different formula to calibrate the sensor. Del Grosso also published a formula for speed of sound in pure water (with Mader, 1972), which is much more accurate. In pure water, the only variable that can affect sound velocity is temperature (assuming that you are at atmospheric pressure in a laboratory environment), rather than both temperature and Salinity with the sweater equations. The Del Grosso & Mader formula therefore has an error of just ±0.015m/s. By calibrating against this rather against the error-filled seawater equations, we can achieve significantly better performance.

Is a pure water calibration valid?

Absolutely – the purpose of a calibration is just to compare (and adjust) the sensor output against a known standard – it doesn't really matter what that standard is, as long it is precisely defined. Our standard happens to be pure water because it is the most accurately defined standard available.

How often does it need calibrating?

The SV sensor itself is remarkable stable. Since the entire timing system is digital, it is not subject to the drift that analogue components often exhibit over time. The only part of the system that can drift with time is the timing crystal itself. This is typically less than ±0.005m/s in the first year, and less than ±0.002m/s in subsequent years. We quite confidently say that the SV sensor should remain within specification for several years. However, the temperature and pressure sensors (if fitted) do exhibit greater drift with time. It is our experience that in the majority of cases, performance can be maintained by recalibrating at 2-yearly intervals. However, we are aware that many operators' own QA requirements state annual recalibration, and it is true that most instruments are returned to us on a yearly basis.

What is the response time?

Virtually instant – the sound pulse takes a matter of microseconds, and the measurement is made using just one pulse.

The sensor outputs zero sometimes – why is that?

The sensor outputs zero when it doesn't record the returning sound pulse within the expected time frame (a time frame that equates to 1400 – 1600m/s in terms of sound velocity). The most common occurrence of a zero value is when the sensor is in air, but it can also happen if the probe has been dropped into a soft bed and is covered in mud or sediment. This will normally wash off during the up-cast. It can also happen if the sensor has been deployed for some time without cleaning, and there is significant growth on the sensor.