Datasonics, Inc.

PSA-916 Sonar Altimeter
User's Manual

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PREFACE

Congratulations on purchasing a Datasonics PSA-916 Precision Sonar Altimeter.

This User Manual provides complete instructions on using and maintaining the PSA-916. Please read it prior to deploying the equipment and keep it where it can provide a reference during setup and operation of the altimeter.

CUSTOMER FEEDBACK FORM

We appreciate any suggestions you may have for making Datasonics products more useful to you and other users, including comments about the PSA-916 unit itself, the way the equipment is packaged and delivered and the quality of this User's Manual. Please use this Customer Feedback Form to identify any areas where we can make improvements. For returning this form, you will receive a complimentary gift from Datasonics

Copy this page to provide individual forms. Please reference page and figure numbers where applicable.

Customer Name:
Name of Individual Completing Form:
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Unit Serial Number
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Section 1. Overview

The PSA-916 is a microprocessor-controlled, self-contained, underwater acoustic product. It generates a narrow beam acoustic signal and measures the travel time for the signal to bounce back from the target surface. The unit provides range data in both analog and digital formats for analysis and process control.

The PSA-916 is housed in a corrosion-resistant anodized aluminum pressure case. It is O-ring-sealed and rated for operation in water depths up to 2,500 meters. The external 6-pin connector provides connections for external power source input, external key source input, analog and RS-232 output.

Figure 1-1 PSA-916 Sonar Altimeter

1.1 Applications

The Model PSA-916 with the built-in flexibility of its microprocessor design, cost-effectively meets a wide variety of sonar measurement applications with a single self-contained instrument.

The most common use of the Model PSA-916 Sonar Altimeter is for altitude measurement (height above bottom). Other uses include:

- Wave height measurement
- Obstacle avoidance
- Altitude of an ROV and other submersibles
- Surveying of shallow waters
- Sediment transport studies

Section 2. Specifications of Unit

TRANSMIT FREQUENCY:	200 kHz
TRANSMIT PULSE WIDTH:	250 microseconds
BEAM PATTERN:	14° conical
PULSE REPETITION RATE:	Selectable: Internal or External Internal - 5 pulses per second External - customer controlled rate, up to 5 pulses per second
RANGE:	100 meters full scale; 1.0 meter guaranteed minimum; 0.8 meter typical
ANALOG OUTPUT:	0 to 5 VDC
DIGITAL OUTPUT:	RS-232, baud rate 9600, 4800, 2400 or 1200, (user selectable)
RESOLUTION:	RS-232: 1 cm Analog: 2.5 cm
POWER REQUIREMENT:	6 to 24 VDC
CURRENT:	50 ma @ 15 VDC 100 MA @ 6 VDC
OPERATING DEPTH:	2,500 meters
CONNECTOR:	Part Number: Impulse XSG-6-BCL-3/4-16
MATING PIGTAIL:	Part Number: Impulse RMG-6-FS
DIMENSIONS:	2 1/4 in. OD x 9 in. long
WEIGHT:	In Air: 1.4 lbs In Water: 0.8 lbs

Table 6.1

Configuration	Standard	FSI Mode	Custom
Description of Configuration			
Key (SW 1 & 2)	Internal	External	
Serial Output (SW 1 & 2)	Every Cycle	N/A	
Gain (SW 3)	High	High	
Under Range Detection (SW 4)	Disabled	Disabled	
Baud (SW 5 & 6)	9600	9600	
FSI Mode (SW 7)	Disabled	Enabled	
Dip Switches			
SW 1	OFF	ON	
SW 2	ON	OFF	
SW 3	ON	ON	
SW 4	ON	ON	
SW 5	OFF	OFF	
SW 6	OFF	OFF	
SW 7	OFF	ON	

Configuration:

Standard _____

FSI Mode _____

Custom _____

Note: The configuration is set by the dip switches. This page describes how the unit was configured when shipped to you. Any changes to the dip switches will change the configuration. Refer to Section 3.3.

Section 3. Setup and Deployment

This section provides information on unpacking, installation and general operation of the PSA-916.

3.1 Unpacking and Disassembly

As with any sophisticated electronic equipment, Datasonics' products should be handled with a reasonable amount of care when unpacking, transporting or storing.

When shipped from the factory, the units are packed in weatherproof cartons. Every effort is made at the factory to pack the equipment so as to protect it during shipment and to minimize the effect of any mishandling.

Carefully inspect each instrument for physical damage as it is unpacked. Report any damage to the freight carrier and to the Datasonics sales office, at the number listed below. Store the shipping cartons and packing materials in a cool, dry place for later use in system transport.

The unit is shipped completely assembled and internally configured. Should an internal inspection be deemed necessary, the unit can be opened by turning the delrin closure ring counterclockwise. The transducer and electronics should slide easily from the pressure case. Caution is advised as the electronics is connected to the interface connector at the opposite end of the pressure case.

NOTE -- *A double O-ring seal is designed into the pressure case/end cap to protect the electronic components from moisture. A failure of these seals will result in the unit flooding and subsequent loss.Whenever the unit is disassembled, carefully inspect the O- rings for cracks, tears, and proper fit. Replace any damaged O-rings. The end cap O-ring grooves and housing O-ring mating faces should also be checked for tool marks or abrasions.*

Prior to reassembling the unit, clean o-rings and o-ring surfaces, apply a coat of silicone lubricant to the O-rings. Reposition the internal components in the casing and tighten the closure ring, turning it in a clockwise fashion.

WARNING *--DO NOT apply excessive torque to the closure ring. Over-tightening of the closure ring could damage the ring and make any future disassembly difficult.*

If you suspect that there are items missing, or if you suspect that there has been any damage to the equipment, contact Datasonics immediately.

3.2 Connection

The PSA-916 outputs data and receives power through a 6 pin connector. The PSA-916 is supplied with the mating pigtail and a dummy plug. Whenever the pigtail is not installed, install the dummy plug to protect the connector pins.

3.2.1 Connector Pin-out

The functional assignments of the six pin connector is as follows:

Pin Number	Pigtail Color (Impulse RMG-6-FS)	Function
1	White	External key input
2	Black	External power ground
3	Blue	RS-232 Output/Error Output*
4	Orange	Analog output
5	Green	Analog output ground
6	Red	External power (6 - 24V)

To select RS-232 Output install a jumper between JP3 pins 1 & 2. To select Error Output install a jumper between JP3 pins 2 & 3.

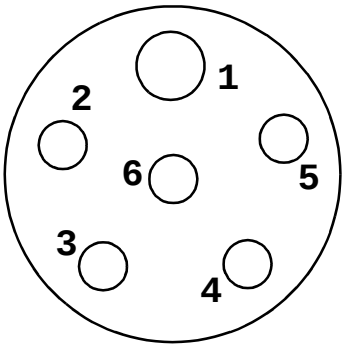

Figure 3-1 Connector view, looking at the PSA-916

3.2.2 RS-232 Output

The RS-232 output is set to the following parameters:

Baud:1200,2400,4800, or 9600 user selectable
Number of Data Bits:8
Number of Stop Bits:1
Parity:none

On power up the following banner message will be output:

"Datasonics PSA-916 V1.2"

Where the number following the V is the firmware version.

The serial output will be in the following format:

Rxx.xx<cr><lf>

where xx.xx can range from 0.80 to 99.99. If no echo was received the output will be R99.99E<cr><lf>. If an echo was missed or the value does not meet the averaging criteria then an “E” will be appended to the previous value. If under range detection is selected and the value is under range then a ‘<’ will be appended to the data.

If the unit is not functioning correctly, “E1,<cr><lf>” will be output. If this occurs see section 4.4.3.

3.2.3 Error Output

This output is useful for indicating the validity of the data whenever the analog output is the source of range output. This line will be a logic 1 (5 volts) whenever no echo was detected in the last range interrogation cycle. If averaging is enabled and the data does not meet the averaging criteria then this line will be high. Essentially this line is high whenever it would be necessary to output an E on the serial output. This line also goes high if error condition E1 occurs. If this line is low it can be assumed that the altimeter is functioning normally and the analog output is valid.

3.2.4 Analog Output

The analog output ranges from 0 VDC to 4.98 VDC, Which represents 0.00 to 99.99 meters. Note that if no echo is received, the output will go to full scale (4.98 VDC).

3.2.5 External Key

This line is used to tell the PSA-916 to take a range reading. The altimeter looks for a transition from a logic 1 (5 volts) to a logic 0 (0 volts). Once the transition is detected the altimeter will take a range reading and wait 200ms before looking for the next transition. Thus the minimum time between key pulses is 200ms. However there is no maximum limit to the time between key pulses. Note that the analog value will be valid 200ms after sending the external key.

3.3 Configuration

There are seven switches which determine the mode of operation. The different combinations are listed in the table below.

DIP SWITCHES - All dip switch changes will take affect immediately, except for the baud rate. To change baud rate the unit must be reset(i.e. cycle pwr).

Description	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
Test mode - see section 4.4	ON	ON						
External key - 200 MS min. between keys	ON	OFF						
Internal key - serial out every depth cycle	OFF	ON						
Internal key - serial out every fifth depth cycle	OFF	OFF						
More gain			ON					
Less gain			OFF					
Disable under-range detection				ON				
Under-range detection (if range is less than 0.8, then output is '0.8<')				OFF				
1200 baud (rep rate may be > 200ms)					ON	ON		
2400 baud					ON	OFF		
4800 baud					OFF	ON		
9600 baud					OFF	OFF		
RS-232 off								ON
RS-232 on								OFF
FSI mode disabled							OFF	
FSI mode enabled							ON	

3.4 Predeployment

Always test the altimeter immediately before deployment to ensure that the unit can transmit and receive acoustic signals and that the system parameters are correctly set.

NOTE: Always test the operation of each PSA-916 as a stand-alone instrument before integrating it into another system.

Datasonics recommends that an in-air test be performed followed by a short range in-water test prior to the actual deployment.

A major source of problems with acoustic equipment is that the transducer is not clean and acoustic signals are masked. We strongly recommend that prior to each deployment that the user clean the exterior of the pressure casing and transducer with fresh water and a mild detergent. Do not use glass cleaner.

To perform the in-air test:

- Turn the altimeter ON by applying power.
- Verify that the RS-232 output is 99.99E and that the analog output is 4.98V. Note that if under-range detection is enabled, verify the RS-232 output is'0.8<' and the analog output is 39.8 mv.
- If under-range detection is not enabled, tap on transducer face with finger, and verify that the RS-232 and analog output changes.

If the in-air test was successfully completed, proceed to an in-water test. Make sure the transducer is well below the keel of the boat and away from prop wash and noise. A test tank or barrel filled with water can be used provided the water depth is at least three feet.

3.5 Deployment

Once you are confident that the unit is operating properly on its own, you can then integrate it with other instrumentation used in your application.

If acoustic energy generated by other instruments is strong enough, it can adversely affect PSA-916 operation, even if the acoustic output of the other instrumentation is at different frequencies. You may have to relocate or reposition the PSA-916 to achieve reliable results.

Make sure sources of noise and turbulence such as the boat propeller and ROV truster motors are not between the altimeter and the target surface, and that they are well away from the transducer.

Securely fasten the PSA-916 to its platform, vehicle or instrument package, making sure there are no obstructions between the transducer face and the intended target. When mounting be sure the anodize is not scratched or gouged by clamps, bolts, etc.

If the unit is mounted on an underwater vehicle, be sure that the sound beam path is perpendicular to the horizontal flying position of the vehicle. Note that excessive pitch or roll motion will influence the PSA-916 range measurement. The PSA-916 radiation pattern is 14°.

Make sure the altimeter is attached to the bottom of the ROV so that it is not affected by echos from the skids.

In applications using multiple altimeters within each others range, their transmissions should be externally triggered to avoid crosstalk between the units.

The sound beam pattern is an important consideration. The pattern consists of the main beam and small side lobes stemming from it. Certain conditions may cause range errors from sidelobe reflections.

- A strong acoustic reflector close to the instrument reflects a side lobe signal before the main beam echo is received.
- When using a towed vehicle to measure depth, a steep slope reflects the side lobe before the main beam is reflected by the bottom directly below the instrument.
- The side lobe reflects off the bottom before a main beam aimed diagonally at the seabed.

3.6 Maintenance

If you exercise reasonable care, your Datasonics products should provide you with years of reliable service.

To ensure an even greater level of reliability, Datasonics recommends that you take a few preventive maintenance measures and that you contact Datasonics early in your efforts to troubleshoot an altimeter malfunction. We have found that most problems are related to the acoustic environment and can be solved with applications planning and pre-deployment testing.

The following steps will help you maintain protection against damage to the altimeter.

When you retrieve the unit at the completion of a project, follow these preventive maintenance procedures:

- Turn the unit OFF by unplugging the mating connector.
- Clean the exterior of the pressure casing and transducer with fresh water and a mild detergent. Do not use glass cleaner.

NOTE: It is important to clean the transducer face so that film does not build up on the transducer face and attenuate acoustic signals.

- Dry the unit with a cloth.
- Inspect the transducer and the exterior of the casing for signs of wear and damage.
- Clean the connector on the unit using a lint free alcohol wipe.
- Lubricate the connector o-ring mating surface with a light coat of silicone and place the protective dummy plug on the connector.
- Store the unit, in its original packing case, in a cool, dry place.

Section 4. Theory of Operation

This section describes the operation of the PSA-916. DO NOT ATTEMPT REPAIR of the PSA-916 unless you are a trained electronics technician. For help with any questions about using or maintaining the instrument, contact your local Datasonics representative, or call our headquarters at 508/563-5511.

4.1 Operating Principle

The PSA-916 Sonar altimeter determines the round trip time for a sound pulse to travel from the transducer through the water, reflecting off a surface and returning to the transducer. Since the speed of sound is known, the altimeter can determine the range utilizing this equation:

R = 1/2 (Cs)(t +/-Δ t)

Where:

Cs - the speed of sound in meters per second

t - the total round-trip travel time in seconds

R - range in meters

The nominal speed of sound is 1,500 meters per second in water, and is used by the PSA-916. Note that the speed of sound is affected by temperature, salinity, and pressure.

The Δ t factor is the jitter or the ability of the detectors to accurately determine the presence or absence of a pulse. Jitter is a function of operating frequency, system bandwidth and signal to noise ratio. In the PSA-916 Δt is approximately 5 microseconds or approximately +/-0.4 cm total distance. Since the total travel time is divided by two in the above formula, the jitter error is +/-0.2cm.

4.2 Board level description

Please refer to drawings D916-07008 and C916-06812

4.2.1 Power Supply

The input power can range from 6 to 24 volts, and is diode protected by CR1 to prevent reverse polarity. The power supply regulates the input power to 5vdc and 12vdc. VR3 regulates the 5 VDC and U6 and VR2 produce the 12 VDC. Whenever the input voltage is below 13 vdc, U6 goes into a switching mode and boosts the voltage up to 13 volts. This voltage is then regulated to 12 volts by VR2.

4.2.2 Transmitter

The microprocessor (U8) generates a key pulse. The Key pulse puts the Ultrasonic transceiver(U1) into the transmit mode for the duration of the pulse. In the transmit mode the L2-C4 tank circuit is switched to oscillator mode, and a train of 1μs pulses is output from U1 pin 7 at the oscillator frequency of 200khz. The pulse train is then input to the monostable multivibrator(U2), which stretches the pulses to 1.8 μS. The output of U2 is sent to the power MOSFET driver(U3). U3 inverts the pulses and drives MOSFET Q1. Q1 in turn drives transformer T1, Which steps up the voltage and drives the transducer. The inductance of the output of T1 and the capacitance of the transducer create a tank circuit, which resonates at 200Khz. Thus the output to the transducer is a sinusoidal 200Khz burst which lasts for the duration of the key pulse.

4.2.3 Receiver

The transmit pulse and any received echoes are input to the receiver through a transmit/receive network consisting of R28, C13, CR7 & CR8. The receive network is capacitively coupled to U1 through C9. JFET Q3 attenuates the received signal during transmit and during the first few milliseconds of the receive cycle, when the returned echoes are likely to be the strongest. Once

U1 receives the received signal, it goes through a high gain amplifier within U1. The receiver uses the same L2-C4 tank circuit as the transmitter, so the receiver and transmitter are always tuned to the same frequency. U1 also detects the received echoes. When receiving an echo or its own transmit signal U1 pulls pin 14 low.

4.2.4 Microcontroller

The microcontroller(U8) provides the system timing and computing power. U8 operates at a clock frequency of 12Mhz controlled by crystal X1. When power is applied, a power on reset pulse is generated by R16 and C17. This positive pulse initializes U8. The key pulse is output from Port 2.7, and the low going pulse generated by the receiver is input to interrupt 1 of U8. The Key input comes into interrupt 0 of U8. To generate the RS-232 output, U8 sends data to the RS-232 driver(U7). The analog output is generated by sending data to the 12 bit D to A(U4). The output of U4 is then amplified by opamp (U5). The Error output is sent out port 2.6 of U8.

4.3 Firmware Description

4.3.1 Main Program

The program generates the key pulse, which causes a 200khz burst to be transmitted as described in section 4.2.2. The transmission is detected by interrupt 1, which starts a 1µs timer. If the transmission is not detected, the program will output “E1" on the RS-232 output. The program then waits 133mS for an echo. Once an echo is received, it stops the timer, and

calculates the range. If no echo is received, the timer is stopped and the range is assumed to be 99.99 meters. If averaging is enabled this range will be run through the algorithm described in section 4.3.2. The range or averaged range is then sent to the RS-232 and Analog outputs, and the error output is set or cleared as required. If in internal Key mode the microcontroller will wait 200ms from the previous key before sending another key pulse, thus starting the whole cycle over again. If in external key mode, the microcontroller will wait for a low going pulse on the Key In input, before sending the next Key pulse.

4.3.2 Averaging Algorithm

A moving weighted average is used. Each new range is given a weight of 25%, while the previous value is given a weight of 75%. In addition if the new range differs significantly from the old range then the new range will be skipped and the old range will be used. Note that the algorithm will not skip more than two consecutive ranges. If two consecutive ranges have been skipped, than the next new range will be used. Note that if a range is skipped than an “E” is appended to the data and the error output is goes to a logic ‘1'.

4.4 **Diagnostics**

4.4.1 Analog output

The analog output can be tested by using the DIP switches to put the altimeter in test mode. The following table shows the dip switch settings and the corresponding analog output.

SW1	SW2	SW3	SW4	SW5	OUTPUT	SERIAL OUTPUT
ON	ON	ON	ON	ON	0 Volts	Analog out - 0V
ON	ON	ON	ON	OFF	1 Volt	Analog out = 1V
ON	ON	ON	OFF	ON	2 Volts	Analog out = 2V
ON	ON	ON	OFF	OFF	3 Volts	Analog out = 3V
ON	ON	OFF	ON	ON	4 Volts	Analog out = 4V
ON	ON	OFF	ON	OFF	5 Volts	Analog out = 5V
ON	ON	OFF	OFF	ON	Datasonics Use	
ON	ON	OFF	OFF	OFF	Datasonics Use	

Warning - Do not set to the "Datasonics use" position, or damage may result.

4.4.2 Test Points

TP1 Detector: normally a logic 1 (5 VDC), whenever a transmission or a received echo is detected the line goes to a logic 0 (0vdc) for the duration of the detection.

TP2 Transmit Pulse: normally a logic 1 (12 VDC). During transmit a train of 1.8us pulses at the transmit frequency.

TP3 Oscillator during Transmit cycle, and amplified output of the receiver. Note that the scope capacitance will alter the signal.

TP5 Transmitter Key: Normally 0 VDC, during transmit it is at 0.6 VDC lasting for 250us.

TP6 2.5 VDC

TP7 Analog Output

TP8 12 VDC

TP9 5 VDC

4.4.3 Error Message

If Error message E1 is continuously output, it means the receiver is unable to detect the transmission of the transmitter. Check that Jumper JP1 is installed, and that the ground wire from the end cap to J2 is connected. Otherwise the most likely source of the failure is U1 or its associated components.

Section 5. Packing List

Ref	Qty	Part No.	Manufacturer	Description
1	1	007216	Datasonics, Inc.	PSA-916, Top Assembly
2	1	RMG-6-FS	Impulse	Connector, 6 pin, pigtail
3	1	RMG-6-FSD-HP	Impulse	Connector, 6 pin, dummy
4	1	007217	Datasonics, Inc.	Manual, PSA-916

Section 6. Drawing List

Drawing Number	Description
C916-06812	Assy, Altimeter Board
D916-07008	Schematic