



PRESSURE SENSOR 4117/4117R  
TIDE SENSOR 5217/5217R  
WAVE AND TIDE SENSOR 5218/5218R

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2 <sup>nd</sup> Edition	05 September 2003	New version including general updates in text. Rebranded, Frame Work 3 update, please refer Product change notification AADI Document ID:DA-50009-01, Date: 09 December 2011 (ref Appendix 6 ).
3 <sup>rd</sup> Edition	14 January 2014	New property “Installation Depth” added for Tide sensors, effective version 8.1.1

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## Introduction

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### Purpose and scope

This document is intended to give the reader knowledge of how to operate and maintain the Aanderaa Pressure Sensor 4117/4117R, Tide Sensor 5217/5217R and Wave and Tide Sensor 5218/5218R. These sensors are described in a single manual since the measurement principle and the sensor housing is the same for all sensors. Tide Sensor 5217 and Wave and Tide Sensor 5218 have extended capabilities compared to Pressure Sensor 4117.

It also aims to give insight into how the sensor works and how the pressure measurement can be converted to depth.

With this revision Aanderaa is releasing a new firmware version to accommodate higher security and future expansion. Both the Smart Sensor Terminal and the AADI Real Time protocols are updated in this version of the Smart Sensor firmware.

AADI Smart Sensors utilize common communication protocols at the RS-232 and RS-422 interface where the Smart Sensor Terminal protocol is a simple ASCII command string based protocol and the AADI Real Time is an XML based protocol. The common updates of these protocols are called framework 3, and is released August 2012 for most of the AADI smart sensors. (See Appendix 6 )

Pressure Sensor 4117, Tide Sensor 5217 and Wave & Tide Sensor 5218 is designed to fit directly on the top-end plate of SeaGuard or in a string system connected to SmartGuard or SeaGuard String logger using AiCaP. The sensor can also be used as stand-alone sensor using RS-232. Pressure Sensor 4117R, Tide Sensor 5217R and Wave & Tide Sensor 5218R are only RS-422 output and are intended for stand-alone use with longer cables than can be used with the RS-232 version.

### Document overview

Chapter 1 Short description of the sensors and lists the sensor properties

Chapter 2 Describes the measurement principles and the sensor output parameters

Chapter 3 Equations for calculating the sensor power consumption

Chapter 4 Common sensor installation and usage considerations

Chapter 5 SeaGuard applications; how to install and perform sensor configuration

Chapter 6 Sensor configuration using AADI Real-time Collector

Chapter 7 Procedure for Smart Sensor Terminal communication setup

Chapter 8 Recommended maintenance procedures and sensor calibration

Appendix 1 Mechanical design of the sensor

Appendix 2 Construction of the sensor

Appendix 3 How to calculate engineering data from measured raw data

Appendix 4 Wave Theory Primer regarding how wave parameters are calculated in the sensor

Appendix 5 Sensor power and communication cables

Appendix 6 Product Change Notification: Framework 3

### Applicable documents

DID 50388	Assembly Drawing
V-8700	Sensor Cable 3855, Sensor to PC, Rs-232, laboratory use
V10501	Sensor Cable 4865, Sensor to PC, RS-232, field use
V-10488	Sensor Cable 4799, Sensor to PC, RS-422, field use
V-10331	Sensor Cable 4762, Sensor to free end, RS-232
V-10328	Sensor Cable 4763, Sensor to free end, RS-422
V-10388	Sensor Cable 4793, for remote sensor used on SeaGuard
Form 764	Test & Specification Sheet for 4117/4117R, 5217/5217R, 5218/5218R
Form 765	Calibration Certificate for 4117/4117R, 5217/5217R, 5218/5218R
D362	Data Sheet for Pressure Sensor 4117/4117R
D405	Data Sheet for Tide Sensor 5217/5217R
D407	Data Sheet for Wave and Tide Sensor 5218/5218R
TD 277	Calculation of current drain for the Pressure Sensor, Tide Sensor and Wave and Tide Sensor.

### Abbreviations

<b>ADC</b>	Analog to Digital Converter
<b>AiCaP</b>	Aanderaa Protocol: Automated idle Line CANbus Protocol
<b>ASCII</b>	American Standard Code for Information Interchange
<b>CAN</b>	Controller Area Network - sometimes referred to as CANbus
<b>DSP</b>	Digital Signal Processor
<b>EPROM</b>	Erasable Programmable Read Only Memory
<b>HCL</b>	Hydrochloric acid (Muriatic acid)
<b>MSB</b>	Most significant bit
<b>RTC</b>	Real Time Clock
<b>UART</b>	Universal Asynchronous Receiver and Transmitter
<b>UNESCO</b>	The United Nations Educational, Scientific and Cultural Organization
<b>USB</b>	Universal Serial Bus
<b>WTS</b>	Wave and Tide Sensor

## CHAPTER 1 Short description and specifications

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In most measuring systems used in the sea, pressure is a vital parameter to derive other parameters like the water density and the speed of sound. For deep water moorings the pressure can be used to determine the actual depth of the instrument. For fixed installations on the seabed the pressure can be used for deriving the water level and wave parameters.

The Pressure sensor, Tide sensor and the Wave and Tide sensor are compact yet intelligent sensors designed for use on Aanderaa SeaGuard and SmartGuard as well as in other measuring systems. These sensors measure the absolute pressure based on a silicon piezoresistive bridge. The pressure measurements are sampled and temperature compensated by an advanced Digital Signal Processor. A temperature thermistor is located next to the pressure bridge, *Figure 1-1*.

Since all calibration and raw data are stored inside the sensor, the parameters can be presented directly in engineering units without any external calculations.

The output formats of the 4117, 5217, and 5218 are AiCaP and RS-232, while the output format of the 4117R, 5217R, and 5218R are RS-422. The sensors can be used in polled operation when set to Smart Sensor Terminal mode.

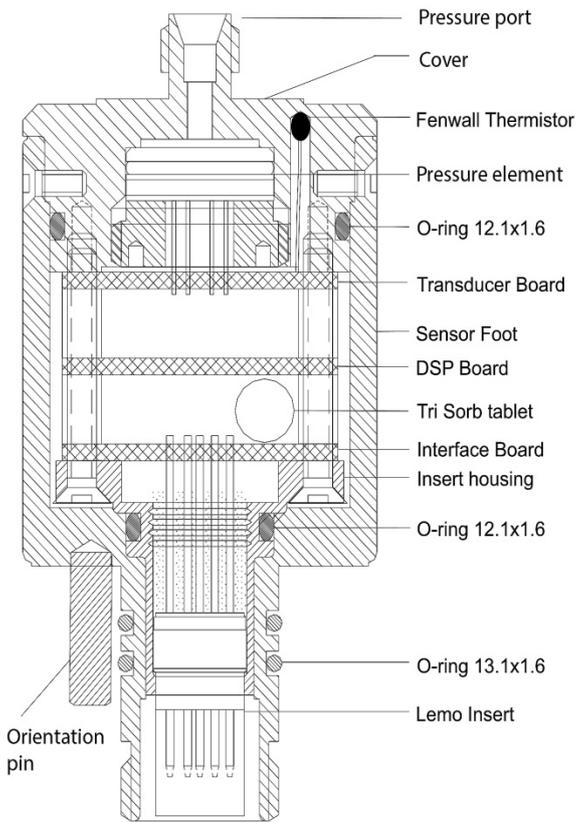
The 4117, 5217, and 5218 version fits directly on to the top end plate of Aanderaa SeaGuard Platform. The sensor is then used in AiCaP mode. When used with SmartGuard both AiCaP and RS-232 mode can be used. The sensors may also be used as a stand-alone RS-232 sensor for other applications.

The R-versions (4117R, 5217R, and 5218R) cannot be used on a SeaGuard platform. This sensor is for use with SmartGuard or as stand-alone RS-422 sensor on longer cables.

The first letter in the product number gives the maximum deployment depth for the sensor, refer datasheet for more info.

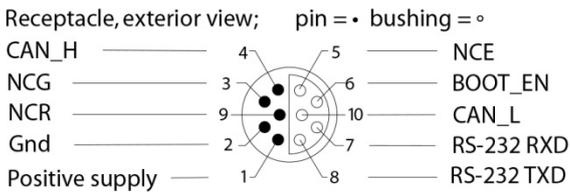
### **IMPORTANT!**

***A 4117, 5217, and 5218 sensor cannot be made into an R-version, and a 4117R, 5217R, and 5218R sensor cannot be made into a AiCaP or RS-232 sensor after delivery.***



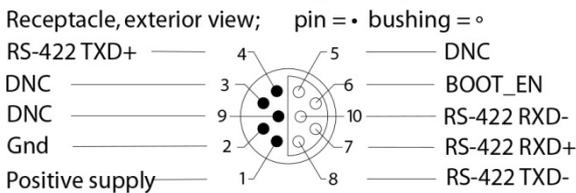
**Figure 1-1 Illustration of sensor**

**PIN CONFIGURATION 4117, 5217, 5218**



**Figure 1-2 Pin Configuration for 4117, 5217 and 5218 with AiCaP and RS-232**

**PIN CONFIGURATION 4117R, 5217R, 5218R**



**Figure 1-3 Pin Configuration for 4117R, 5217R and 5218R with RS-422**

## 1.1 Pin Configuration

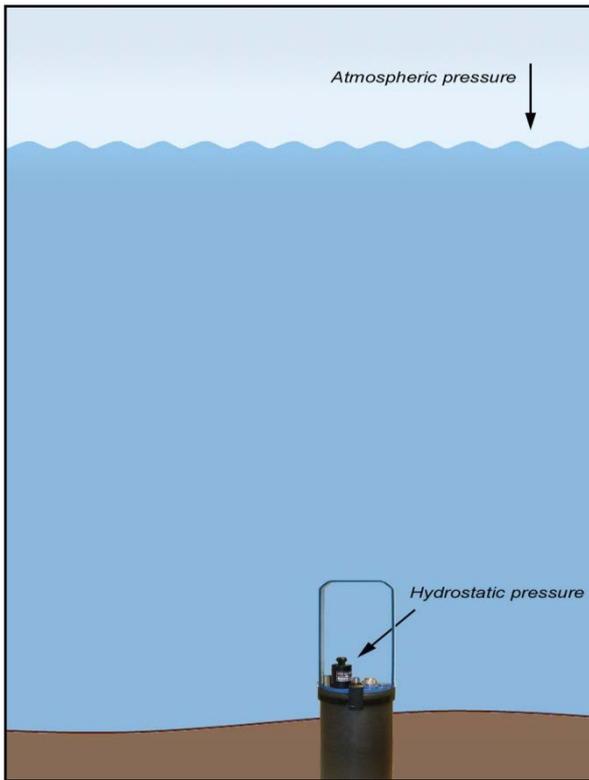
The Pressure Sensor 4117, Tide Sensor 5217 and Wave & Tide Sensor 5218 pin configuration is given in *Figure 1-2*. Pressure Sensor 4117R, Tide Sensor 5217R and Wave & Tide Sensor 5218R pin configuration is given in *Figure 1-3*. A description of the receptacle notation is given in Table 1–1.

**Table 1-1 Description of the Pin Configuration**

Signal	Description
CAN_H	CANbus line (dominant high)
NCG	Node Communication Ground
NCR	Node Communication Request
Gnd	Ground
Positive supply	6-14V positive supply.
NCE	Node Communication Enable
BOOT_EN	Boot Load Enable (do not connect)
CAN_L	CANbus line (dominant low)
RS-232 RXD	RS-232 Receive line
RS-232 TXD	RS-232 Transmit line
RS-422 TXD+	RS-422 Transmit signal+ (non-inverting output)
RS-422 TXD-	RS-422 Transmit signal- (inverting output)
RS-422 RXD+	RS-422 Receive signal+ (non-inverting input)
RS-422 RXD-	RS-422 Receive signal- (inverting output)
DNC	Do Not Connect

## 1.2 Pressure measurements for sensors 4117/4117R, 5217/5217R, 5218/5218R

These sensors measure the absolute pressure at the installation depth. The 4117 sensor is a momentary / instantaneous pressure measurement; the pressure is sampled at an update interval (output interval) from 1 second to 255 minutes (user configurable). The absolute pressure measured by the sensor is comprised by the weight of the water column above the sensor (hydrostatic pressure), plus the atmospheric pressure at the sea surface.



If the variation in the measured hydrostatic pressure is dominated by surface waves and ocean swell, the Tide sensor 5217/5217R and Wave & Tide sensor 5218/5218R provide time averaged measurements, to compensate for the dynamic water pressure variations seen by the instrument at depth due to vertical movement of the sea surface.

The sample set used to filter out waves is separate from that used to calculate wave statistics. Refer chapter 1.3 for a description of the Tide sensor, and 1.4 for a description of the Wave & Tide sensor

The main objective of the temperature reading is to temperature-compensate the pressure reading. AADI offers other sensors designed to measure the water temperature more accurately if required.

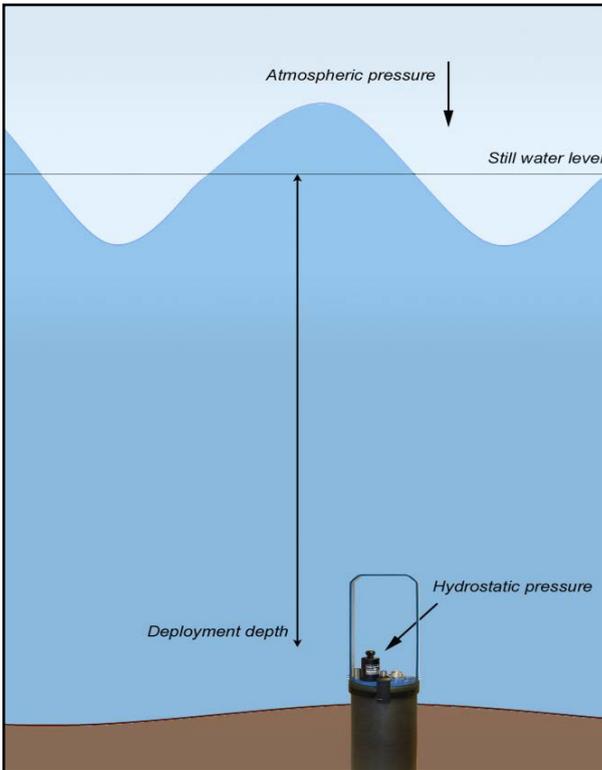
**Figure 1-4 Illustration of the pressure measurement situation.**

## 1.3 Tide measurements for sensors 5217/5217R, 5218/5218R

Tide pressure measurements are an average of the sampled pressure time series measured over a user defined time interval of 10 seconds to 8 minutes (user configurable average base), which filters out all but the longest or low frequency dynamic variations of the water surface. The default sample rate is 2 Hz; the user can enable a higher frequency sampling rate of 4 Hz.

The sensor update or output interval is user set from 1 second to 255 minutes. The tide parameter output value will be sent as 0 in the beginning until the sensor has performed enough samples to satisfy the average base and calculate the output value, refer chapter 2.4.

*Note! The tide calculations are always based on the latest samples in time, so even though you specify a longer averaging time, e.g. 8 minutes averaging, the computed value for tide will be calculated from a running sample set and a new value sent as an output message at the 1s to 255minute interval according to your settings for the output interval.*



**Figure 1-5 Illustration of the tide measurement situation.**

*calculate the tide level more accurately.*

If  $P_{atm}$  can be measured at the site the tide level can be calculated more accurately by means of post processing. The user of an R-version sensor can update the property  $P_{atm}$  on request.  $P_{atm}$  will not be presented together with the measured data.

**1.4 Wave measurements for sensor 5218/5218R**

The wave measurements are calculated independent from tide and you may choose from 256, 512, 1024 or 2048 samples performed at a default rate of 2 Hz or a higher sample rate of 4 Hz (both settings are user configurable). The pressure time series used to calculate wave statistics are therefore measured over a time period of 64 seconds to 17 minutes (measuring time is the product of sample set size and sample frequency). The wave parameters are calculated according to the linear wave theory, refer Appendix 4.

The sensor measures the pressure at the installation depth. The tide pressure is the average of the measured hydrostatic pressure, refer Eq. 1-1:

$$P = \rho gh + P_{atm} \quad \text{Eq. 1-1}$$

Where  $P$  is the measured averaged pressure,  $\rho$  is the water density<sup>1</sup>,  $g$  is the local acceleration due to gravity, and  $h$  is the height of the water column.

The tide level above the sensor deployment depth is calculated from Eq. 1-2:

$$h = \frac{P - P_{atm}}{\rho g} - h_0 \quad \text{Eq. 1-2}$$

Where  $h_0$  is the Installation Depth

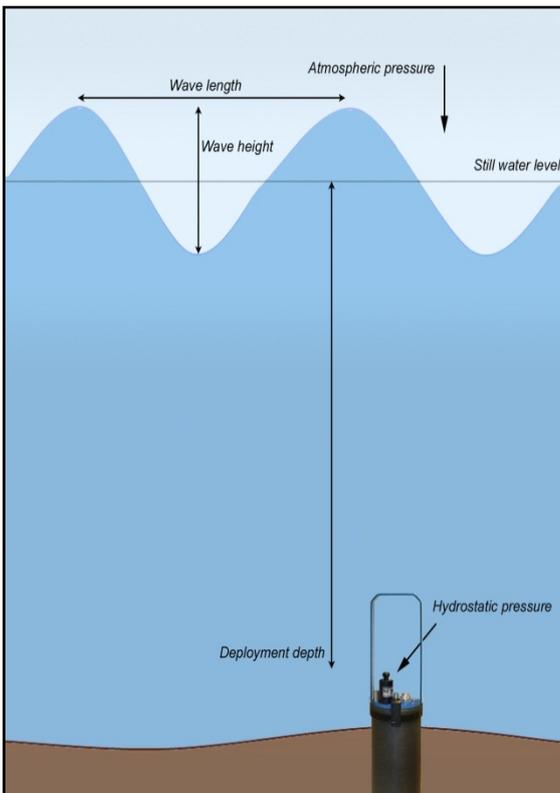
*Note!  $P_{atm}$ , and  $g$  are sensor properties that must be set by the user prior to deployment. The water density,  $\rho$ , is calculated from the measured water temperature and the salinity<sup>2</sup> of the water. Pressure is set to 0. Salinity is set by the user. If you can find precise values for the input parameters at the deployment site, the sensor will*

<sup>1</sup> Equation of state 1980 UNESCO polynomial implementation. Density calculated with pressure = 0.

<sup>2</sup> IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14

The wave parameter output values will be 0 in the beginning of the recording until the sensor has performed enough samples needed to calculate the wave statistics. When the sensor has sampled the required pressure samples, all output parameters will be calculated and updated for each output interval. This means that the first non-zero output from the sensor will be the smaller of the sample sets, i.e. tide pressure followed by wave statistics.

*Note! The wave calculations are always based on the latest sample values in the time series. The first set of calculated parameters is presented sometime after the measurements start (at least 64 seconds), but the update interval is according to your settings for the output interval.*



**Figure 1-6 Illustration of the wave measurement situation.**

$P_{atm}$ , and  $g$  are sensor properties that must be set by the user prior to deployment. The water density,  $\rho$ <sup>3</sup>, is calculated from the measured water temperature and the salinity<sup>4</sup> of the water. Pressure is set to 0. The salinity is configured by the user. If you can find precise values for the input parameters at the deployment site, the sensor will calculate the tide more accurately.

The Distance to seafloor is the distance between the sensor and the sea floor. This distance must be set by the user so that the sensor software selects the correct transfer function in the wave calculations.

If the distance is longer than 50m, you can still type 50 m since the measurement data will be processed using a “deep water”-transfer function, refer Appendix 4.

If the wave measurements are calculated from 2048 samples, the software splits the sampled pressure points into two sets of 1024 samples in each set and calculates two wave spectrums.

Next, the two power spectrums are averaged and the sensor presents a single wave spectrum of 512 frequency components. This procedure increases the statistical reliability of the spectral estimates.

<sup>3</sup> Equation of state 1980 UNESCO polynomial implementation. Density calculated with pressure = 0.

<sup>4</sup> IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14

### 1.5 User accessible sensor properties

All configuration settings that determine the behavior of the sensor are called properties and are stored in a persistent memory block (flash). One property can contain several data elements of equal type (Boolean, character, integer etc.). The different properties also have different access levels.

Table 1–2 lists all user accessible properties for the Pressure sensor.

The user accessible properties of the Tide sensor are the properties of the pressure sensor plus the properties listed in Table 1–3.

The user accessible properties of the Wave and Tide sensor are the properties of the pressure sensor plus the properties listed in Table 1–4.

Some properties of the ‘AiCaP’ sensor will not be applicable/visible when the sensor is connected to a SeaGuard instrument, as these properties will be controlled by the instrument, refer Table 1-2.

#### 1.5.1 Sensor properties for Pressure sensor 4117/4117R

**Table 1-2 Sensor properties for Pressure sensor, FC = Factory Configuration, UM = User Maintenance, SC = System Configuration, DS = Deployment Setting. ENUM=Enumeration, INT =Integer, BOOL=Boolean(‘yes’/‘no’)**

Property	Type	No of elements	Use	Configuration Category	Access Protection RS232/422 applications
<i>Product Name</i>	String	31	AADI Product name	FC	Read Only
<i>Product Number</i>	String	6	AADI Product number		
<i>Serial Number</i>	INT	1	Serial Number		
<i>SW ID</i>	String	11	Unique identifier for internal firmware		
<i>SW Version</i>	INT	3	Software version (Major, Minor, Built)		
<i>HW ID X</i>	String	19	Hardware Identifier, X =1..3		
<i>HW Version X</i>	String	9	Hardware Identifier, X =1..3		
<i>System Control</i>	INT	3	For AADI service personnel only		
<i>Production Date</i>	String	31	AADI production date, format YYYY-MM-DD		
<i>Last Service</i>	String	31	Last service date, format YYYY-MM-DD, empty by default		
<i>Last Calibration</i>	String	31	Last calibration date, format YYYY-MM-DD		
<i>Calibration Interval</i>	INT	1	Recommended calibration interval in days		

<i>Interval</i>	Float	1	Set the output interval in seconds	DS	No		
<i>Location</i>	String	31	User setting for location				
<i>Geographic Position</i>	String	31	User setting for geographic position				
<i>Vertical Position</i>	Float	1	User setting for describing sensor position				
<i>Reference</i>	String	31	User setting for describing sensor reference				
<i>Enable Temperature</i>	BOOL	1	Controls inclusion of Temperature in the output string	SC	Low		
<i>Enable Rawdata</i>	BOOL	1	Controls inclusion of raw data in the output string				
<i>Mode</i>	ENUM	1	Sets the sensor operation mode (AiCaP, Smart Sensor Terminal, AADI Real-Time, Smart Sensor Terminal FW2)				
<i>Enable Sleep</i>	BOOL	1	Enable sleep mode				
<i>Enable Polled Mode</i>	BOOL	1	Enable polled mode for Smart Sensor Terminal Mode. When set to 'no' the sensor will sample at the interval given by the <i>Interval</i> property. When set to 'yes' the sensor will wait for a <i>Do Sample</i> command.				
<i>Enable Text</i>	BOOL	1	Controls the insertion of descriptive text, i.e. parameter names				
<i>Enable Decimalformat</i>	BOOL	1	Controls the use of decimal format in the output string				
<i>Node Description</i>	String	31	User text for describing node, placement etc			UM	High
<i>Owner</i>	String	31	User setting for owner				
<i>Interface</i>	ENUM	1	Factory use only, RS232 for standard version, RS422 for R-version				
<i>Baudrate</i>	ENUM	1	RS232 baudrate: 4800, 9600, 57600, or 115200. Default baudrate is 9600 <sup>5</sup>				
<i>Flow Control</i>	ENUM	1	RS232 flow control: 'None' or 'Xon/Xoff'				
<i>Enable Comm Indicator</i>	BOOL	1	Enable communication sleep ('%') and communication ready ('!') indicators				
<i>Comm TimeOut</i>	ENUM	1	Time communication is active (Always On, 10 s, 20 s, 30 s, 1min, 2 min, 5 min, 10 min)				
<i>PT coeffs 0</i>	Float	4	Pressure calibration coefficients				
<i>PT coeffs 1</i>	Float	4	Pressure calibration coefficients				
<i>PT coeffs 2</i>	Float	4	Pressure calibration coefficients				
<i>PT coeffs 3</i>	Float	4	Pressure calibration coefficients				
<i>PT coeffs 4</i>	Float	4	Pressure calibration coefficients				
<i>Temp coeffs</i>	Float	4	Temperature calibration coefficients				

<sup>5</sup> Baud rates lower than 9600 may limit the sampling frequency

### 1.5.2 Additional sensor properties for Tide Sensor 5217/5217R

Most user accessible properties of the Tide sensor are the same properties as for the Pressure sensor, refer Table 1-2. Additional sensor properties are listed in Table 1–3.

**Table 1-3 Additional sensor properties for Tide sensor, SC = System Configuration, DS = Deployment Setting. ENUM=Enumeration, INT =Integer, BOOL=Boolean('yes'/'no')**

Property	Type	No of elements	Use	Configuration Category	Access Protection R5232/422 applications
<i>Air Pressure</i>	Float	1	Nominal air pressure	DS	No
<i>Local gravity</i>	Float	1	Set the local gravity		
<i>Salinity</i>	Float	1	Set the salinity at the deployment site		
<i>Installation Depth</i>	Float	1	Installation depth in meter relative to chosen datum, by default set to zero = instrument referred	DS	Low
<i>Enable Tide</i>	BOOL	1	Enable Tide output parameters	SC	Low
<i>Tidal Average Period</i>	ENUM	1	Set the averaging interval for the tide measurements (10 s, 20 s, 30 s, 40 s, 50 s, 1 min, 2 min, 3 min, 4 min, 5 min, 6 min, 7 min, 8 min)		
<i>Enable high sample rate</i>	BOOL	1	Set the sample rate to 4 Hz		

### 1.5.3 Additional sensor properties for Wave and Tide Sensor 5218/5218R

The user accessible properties of the Wave and Tide sensor are the same properties as for the Pressure sensor, refer Table 1-2. Additional sensor properties are listed in Table 1-4.

**Table 1-4 Additional sensor properties for Wave and Tide sensor, SC = System Configuration, DS = Deployment Setting. ENUM=Enumeration, INT =Integer, BOOL=Boolean('yes'/'no')**

Property	Type	No of elements	Use	Configuration Category	Access Protection RS232/422 applications
<i>Air Pressure</i>	Float	1	Nominal air pressure	DS	No
<i>Local gravity</i>	Float	1	Set the local gravity		
<i>Salinity</i>	Float	1	Set the salinity at the deployment site		
<i>Distance to seafloor</i>	Float	1	Set the distance between the sensor and the seafloor		
<i>Installation Depth</i>	Float	1	Installation depth in meter relative to chosen datum, by default set to zero = instrument referred	DS	Low
<i>Enable Wave</i>	BOOL	1	Enable Wave output parameters	SC	Low
<i>Number of samples</i>	ENUM	1	Set the number of samples: (256, 512, 1024, 2048)		
<i>Enable Tide</i>	BOOL	1	Enable Tide output parameters		
<i>Tidal Average Period</i>	ENUM	1	Set the averaging interval for the tide measurements (10 s, 20 s, 30 s, 40 s, 50 s, 1 min, 2 min, 3 min, 4 min, 5 min, 6 min, 7 min, 8 min)		
<i>Enable high sample rate</i>	BOOL	1	Set the sample rate to 4 Hz	UM	High
<i>Enable Spectrum</i>	BOOL	1	Controls inclusion of spectrum elements in the output string.		
<i>Enable Pressure Series</i>	BOOL	1	Controls inclusion of the measured hydrostatic pressure in the output string.		

### 1.6 Specifications

For product specifications refer Datasheet D362 for 4117/4117R, D405 for 5217/5217R, and D407 for 5218/5218R on our web site <http://www.aanderaa.com> or contact [aanderaa.info@xylem.com](mailto:aanderaa.info@xylem.com)

You will always find the latest version of our documentation on the web.

Customers can register to obtain a username and password necessary to gain access to product manuals, technical notes and software. Please contact [aanderaa.info@xyleminc.com](mailto:aanderaa.info@xyleminc.com) for guidance.

## **1.7 Manufacturing and Quality Control**

Aanderaa Data Instruments products have a record for proven reliability. With over 40 years experience producing instruments for use in demanding environments around the globe, you can count on our reputation of delivering the most reliable products available.

We are an ISO 9001 Certified Manufacturer. As a company we are guided by three underlying principles: quality, service, and commitment. We take these principles seriously, as they form the foundation upon which we provide lasting value to our customers.

## CHAPTER 2 Measurement Principles and Parameters

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The Pressure Sensor 4117/4117R, Tide Sensor 5217/5217R and Wave and Tide Sensor 5218/5218R measure raw data of Pressure and Temperature. The pressure measurement is based on a piezoresistive bridge. This bridge consists of 4 resistors implemented on a silicon diaphragm. One side of the diaphragm is exposed to the water pressure, while the other is facing a zero atmosphere vacuum chamber. When the diaphragm is flexed by the hydrostatic pressure the resistance of the resistors will change. By applying a constant voltage over the bridge, a voltage that varies with the pressure is generated. This voltage is sampled by a high resolution analog to digital converter (ADC) controlled by a digital signal processor (DSP). A thermistor sensing the water temperature is also sampled by this ADC. Engineering data are calculated by software in the sensor (Sensor Firmware) based on these raw data and referred to sets of calibration coefficients stored in the sensor.

All pressure transducers have a temperature drift. By calibrating the sensor at different temperatures, this drift can be determined. The DSP stores the data from the calibration and is thus able to temperature-compensate sampled pressure data, as well as to convert the data into linearly calibrated data in engineering units.

All calibration coefficients and settings are stored in the DSP flash-memory. These properties can be displayed and changed using the RS-232 or RS-422 port (see Chapter 7 for how to communicate with the sensor).

The Sensors can be logged directly by a PC (via the RS-232/RS-422 protocol) and by most PLC's DCP's i/o devices, data loggers and systems.

### 2.1 Sensor Integrated Firmware

The firmware's main task is to sample raw data, compute calibrated temperature compensated and linearized pressure, and present the result at the different interfaces.

All calibration coefficients and settings are called sensor properties, and are stored in the DSP flash-memory. These properties can be displayed and changed using the RS-232/RS-422 port (see Chapter 7 for how to communicate with the sensor).

## 2.2 Calculated parameters

Based on the measured parameters described above the sensor software in the Tide sensor 5217 and in the Wave and Tide sensor 5218 calculates additional parameters; refer Table 2-1.

Refer Appendix 4 for a primer describing the calculation of wave parameters.

**Table 2-1 Calculated Sensor parameters.**

Parameter	Unit	Pressure sensor 4117/4117R	Tide sensor 5217/5217R	Wave and Tide sensor 5218/5218R
Pressure	kPa	x	x	x
Temperature	°C	x	x	x
Tide pressure	kPa		x	x
Tide level	m		x	x
Significant wave height	m			x
Maximum wave height	m			x
Mean period	s			x
Peak period	s			x
Energy wave period	s			x
Mean zero crossing period	s			x
Steepness	-			x
Irregularity of sea-state	-			x
Cut-off frequency	Hz			x
Pressure Series	kPa			x
Last Pressure Sample Index	-			x
Spectrum	m <sup>2</sup>			x

## 2.3 Status codes

Status codes indicate the status of parameters and properties, refer Table 2-2 and Table 2-3 .

**Table 2-2 Status code common**

StatusCode (Common)	Number	Description
OK	0	All data OK.
Error, corrupt configuration	3	Internal storage of settings is corrupt.
Warning, watchdog detected	16	Reset generated by software
Warning, reset detected	17	Reset generated by reset command or power loss/low voltage
Parameter warning	18	Data set contains parameter(s) that is not reliable

**Table 2-3 Status code parameter warning**

StatusCode (Parameter Warning)	Number	Description
Warning, reduced quality	83	
Warning, not ready	84	e.g. too few samples to perform calculation

Each data set has a common status code. If the common status code is Parameter warning (18), then one or more of the parameters will have a Parameter Warning status code.

In RS-232, RS-422 and Polled operation errors and warnings will be indicated with a \* in front of the parameter name when the property *Enable Text* is enabled.

In AiCaP mode, the Status Codes will be collected by the SeaGuard Platform or SmartGuard and can be presented in SeaGuard Studio or Data Studio. The status codes will be shown in the *Status* column under the Data List tag. Recordings containing warnings are marked with blue text. Recordings containing errors are marked with red text. The status field will have a *Common* status code. The *Common* status code indicates whether there exist problems within the data set. By right clicking the *Status* field, details and the status codes for each parameter will be shown.

In addition to the listed status codes from the sensor, the SeaGuard platform and SmartGuard logs status codes for communication errors.

*Error, corrupt configuration (3) indicates internal flash error. Parts of the sensor configuration are lost. Contact AADI Service department for new setting file for the specific sensor with further instructions.*

## 2.4 Startup delay for calculated wave and tide parameters

The calculations of wave and tide parameters require a number of pressure samples, which will take some time for the sensor to perform due to the *Number of samples* and the *Tidal Average Period* set by the user. The value of the output parameter will be 0 until the required samples are available, and the parameter will get a status code: *Warning Not Ready*.

Once the sensor has performed the required number of samples, wave and tide parameters will be calculated for every output interval based on the most recent samples in the pressure time series. The pressure time series are updated according to the sampling rate.

Tide parameters will be calculated after *Tidal Average Period* in seconds.

Wave parameters will be calculated after  $\frac{\text{Number of samples}}{\text{Sampling rate}}$  seconds.

The sampling rate is by default 2 Hz, but you can enable high sampling rate of 4 Hz, refer Table 1-3 and Table 1-4.

*Note! The pressure time series is cleared: after sensor power up, the Reset and Start command, and a change in the properties Interval, Enable high sample rate, Tidal Average Period, Enable Tide, Enable Spectrum, Enable Wave and Number of samples.*

Example:

A tide sensor set to a *Tidal Average Period* of '40 s' and a sample rate of 4 Hz will require  $40 \cdot 4 = 160$  pressure points before calculating a tide parameter value. If the *Interval* setting is 2 seconds the sensor will measure  $2 \cdot 4 = 8$  pressure points before the next calculation.

If the *Interval* setting is 60 seconds all 160 pressure points in the series will be measured, which takes 40 s. The sensor will enter sleep mode for 20 seconds before it has to start sampling data.

## CHAPTER 3 Current drain

---

The sensors current drain depends on several property settings and the configuration of output parameters.

Assumptions to the presented current drain:

- **Enable Sleep** is set to **Yes**
- **Comm TimeOut** is given another input than **Always On**
- **Enable Pressure Series** is set to **No** (Wave and Tide sensor only)
- **Enable Spectrum** is set to **No** (Wave and Tide sensor only)

Other factors that influence the current drain:

- The total number of enabled output parameters.

*Note!*

*Refer TD277 for a spread sheet calculating the current drain.*

*The current drain will increase when the sensor is connected to a lower voltage power supply (less than 9V)*

### 3.1 Pressure sensor 4117/4117R

The pressure sensor current drain depends on the output interval (S), and the sensor operation mode, refer to Table 3-1 for current drain in each mode.

**Table 3-1 Power consumption of the Pressure Sensor 5217/5217R when the assumptions stated in the beginning of Chapter 3 are true.**

Operation Mode	Current drain@9V
AiCaP	0.4 mA + (5.4/S) mA
RS-232	0.4 mA + (24/S) mA
RS-422	1.1 mA + (22/S) mA

### 3.2 Tide sensor 5217/5217R

The sensor current drain depends on the sampling interval, the output interval (S), the tidal averaging period (T), and the sampling frequency (Fs) refer to Table 3-2 for current drain in each mode.

*Note! If **Enable Tide** is **No** (Tide output parameter are disabled), then the sensor power consumption is similar to the power consumption of the Pressure sensor 4117/4117R, refer chapter 3.1.*

**Table 3-2 Power consumption of the Tide Sensor 5217/5217R when Enable Tide is Yes, and the assumptions stated in the beginning of Chapter 3 are true.**

Operation Mode	Current drain@9V	
	T/S ≤ 1	T/S > 1
AiCaP	0.4 mA + (2.2*Fs*T/S) mA	<b>Fs = 2 Hz:</b> 4.65 mA + (1.5/S) mA
		<b>Fs = 4 Hz:</b> 9.2 mA + (1.5/S) mA
RS-232	0.4 mA + (2.5*Fs*T/S) mA	<b>Fs = 2 Hz:</b> 5.5 mA + (13/S) mA
		<b>Fs = 4 Hz:</b> 10 mA + (13/S) mA
RS-422	1.1 mA + (2.4*Fs*T/S) mA	<b>Fs = 2 Hz:</b> 5.5 mA + (13/S) mA
		<b>Fs = 4 Hz:</b> 10 mA + (13/S) mA

### 3.3 Wave and Tide sensor 5218/5218R

The sensor current drain depends on the sampling interval (Fs), the output interval (S), the number of samples for wave calculations (N), and the tidal averaging period (T), refer to **Table 3-3** for current drain in each mode.

*Note!*

If **Enable Wave** and **Enable Tide** are **No** but **Enable Tide** is **YES** (Wave and Tide output parameter are disabled), then the sensor power consumption is similar to the power consumption of the Pressure sensor 4117/4117R, refer chapter 3.1

If **Enable Wave** is **No** (Wave output parameters are disabled), then the sensor power consumption is similar to the power consumption of the Tide Sensor, refer chapter 3.2

**IMPORTANT!** If both **Enable Wave** and **Enable Tide** are **Yes** (both Wave and Tide output parameter are enabled), then the correct power consumption will be the greater of the consumption given in Table 3-2 and Table 3-3.

**Table 3-3 Power consumption of the Wave Sensor 5218/5218R when **Enable Wave** is **Yes**, **Enable Tide** is **No**, and the assumptions stated in the beginning of Chapter 3 are true. If both Wave and Tide output parameters are enabled, the correct power consumption will be the greater of the consumption given in Table 3-2 and Table 3-3.**

Operation Mode	Current drain@9V	
	$N/(F_s * S) \leq 1$	$N/(F_s * S) > 1$
AiCaP	0.4 mA + (2.2*N/S) mA	<b>Fs = 2 Hz:</b> 4.65 mA + (6.5/S) mA
		<b>Fs = 4 Hz:</b> 9.2 mA + (5.0/S) mA
RS-232	0.4 mA + (2.5*N/S) mA	<b>Fs = 2 Hz:</b> 5.5 mA + (28/S) mA
		<b>Fs = 4 Hz:</b> 10 mA + (28/S) mA
RS-422	1.1 mA + (2.4*N/S) mA	<b>Fs = 2 Hz:</b> 5.5 mA + (28/S) mA
		<b>Fs = 4 Hz:</b> 10 mA + (28/S) mA

## CHAPTER 4 Installation and deployment considerations

Please refer Table 4-1 for the most important installation and deployment considerations.

**Table 4-1 Installation considerations for the Pressure, Tide and Wave and Tide sensors.**

Description	Measurement Parameters:		
	Pressure/ Temperature	Tide	Wave
<b>Install the sensor with the top up</b>	x	x	x
<b>Install the sensor in a fixed installation</b>		x	x
<b>The deployment depth must be at least 1 meter below the water surface (at the lowest tide level)</b>			x
<b>We recommend that the deployment depth is less than 15 m</b>			x

Install the sensor with top up because the pressure inlet is filled with silicone oil. The sensor is calibrated for top-up installations; other positions will produce a small zero offset.

Valid measurements of tide and wave parameters require a fixed installation on a vertically stable structure to avoid movements of the sensor due to water conditions or settling.

For wave measurements the sensor should at all times be deployed at least 1 meter below the water surface to ensure valid measurements. Low water levels require more internal calculations. If the water level becomes less than 0.25 meters, the water level will be set to 0.25 meters.

The data quality of the wave measurements is reduced with increasing installation depth due to wave attenuation, refer Appendix 4. The pressure variations generated by waves are damped, and the cut off frequency reduces the frequency range in the wave spectrum. At depths larger than 20 meters the dampening is difficult to compensate for because of a weak signal. The frequency range is also very limited.

If the Wave and Tide sensor or the Tide sensor is attached to a floating device the sensor cannot measure tide, but can compute draft of the structure.

If the Wave and Tide sensor is attached to a very large floating device so that the sensor will be relatively steady in relation to the mean sea level, then the sensor can measure waves with reduced quality. Such a large floating device can be e.g. a floating fish farming facility or oil rig. We recommend installation on the sea floor or attached to a fixed pillar. Installation on a string is not recommended because there will always be some movement of the string/sensor.

**IMPORTANT! Do not deploy the sensor deeper than the pressure rating of the pressure element.**

## CHAPTER 5 Installation on SeaGuard

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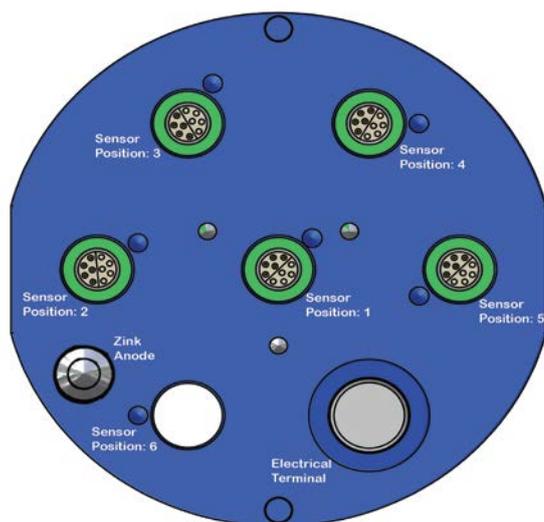
Pressure sensor 4117, Tide sensor 5217, and Wave and Tide sensor 5218 are equipped with a CANbus interface supporting the Aanderaa AiCaP (Automated idle line CANbus Protocol). This standard ensures easy plug and play connection to all Aanderaa SeaGuard and SmartGuard data loggers.

When connected to a AiCaP network the sensor will report its capabilities and specifications to the data logger at power up. The data logger assembles the information and provides the user with the possibility to configure the instrument based on the present node. The solution provides for great flexibility in both use and design of the different elements within the system.

*Note! This chapter describes the installation and the SeaGuard Configuration of the Pressure sensor, Tide sensor and the Wave and Tide sensor. Refer TD262a for a thorough description of configuring the SeaGuard Instrument, and to perform Node Identification, more Deployment settings, Recorder settings, and to view/edit sensor calibration coefficients.*

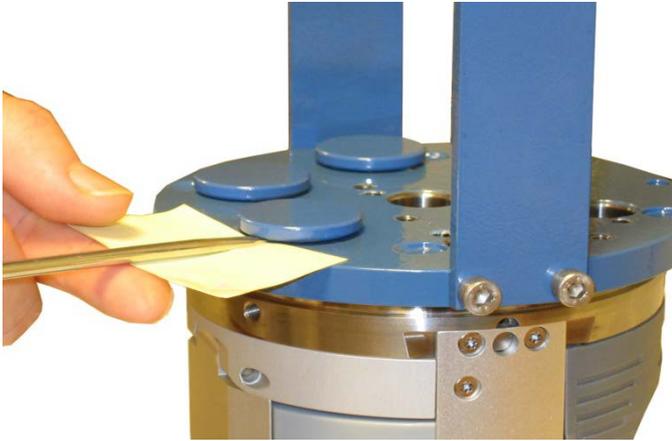
### 5.1 Installation on SeaGuard platform

The Pressure Sensor 4117, Tide Sensor 5217, and Wave and Tide Sensor 5218 can easily be installed on Aanderaa SeaGuard data loggers. We recommend that you install the sensor in sensor position 2, refer *Figure 5-1*. Sensor 4117/5217/5218 can also be installed in position 3, 4, 5 or 6. If mounted in position 6 you will need to use a patch cable to connect the sensor to the HUB card, refer TD262a SeaGuard Platform Operating Manual. If placed next to the Conductivity sensor, the cell factor calibration performed on the Conductivity sensor might be influenced.



**Figure 5-1** Illustration of the SeaGuard Top-end plate.

All sensor and sealing plugs except for the center position are secured by means of a setscrew in the side of the top end plate. Start by unscrewing the setscrew for the wanted position (the setscrew will stop when sufficiently extracted). Pull out the sealing plug (or sensor) by inserting a screwdriver in the slot between the plug and the top end plate, see *Figure 5-2*.



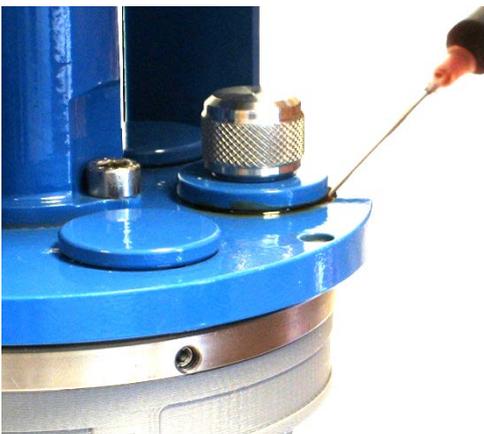
**Figure 5-2 Removal of sealing plug. Use a small piece of paper/cardboard to protect the lacquer of the top-end plate**

Make sure that the bore surface in the sensor mounting hole is clean and smooth and check also that the O-rings at the sensor foot are free from dust and particles and greased with silicon grease. Align the orientation pin in the sensor foot with the orientation hole in the top end plate, and carefully insert the sensor.

When fully seated on the top end plate, tighten the set screw with only moderate force.

*Note! Always replace O-rings when connecting to a sensor or a sealing plug.*

Apply Tectyl 506 (included in maintenance kit) in the slit between the Sensor and the top end plate, refer *Figure 5-3*. This will prevent crevice corrosion of the top end plate.



**Figure 5-3 Apply Tectyl in the slit between the Sensor and the top end plate. (Example showing tectyl around an electrical terminal).**

## 5.2 Sensor Cable

### AiCaP/RS-232:

Sensor Cable 4793 is used for remote sensor connection on SeaGuard, See Appendix 5, Figure A 12. If sensor used as 6<sup>th</sup> sensor or top-end plate us Patch Cable 4999, See Appendix 5, Figure A 13. A watertight free end cable 4762 and non-watertight free end cable 3880 is available for connection to third party datalogger, See Appendix 5, Figure A 9 and Figure A 11. For set up and configuration use Sensor Cable 3885 or 4865. 3885 is for laboratory use only, See Appendix 5, Figure A 6 and Figure A 7.

For sensor connection to AADI SmartGuard use cable 5245 or 5236, for further information contact [aanderaa.info@xylem.com](mailto:aanderaa.info@xylem.com)

### RS-422:

A watertight free end cable 4763 and non-watertight free end cable 3880 is available for connection to third party data logger, See Appendix 5, Figure A 10 and Figure A 11. For set up and configuration use Sensor Cable 4799, See Appendix 5, Figure A 8.

## 5.3 Sensor Configuration Pressure sensor 4117

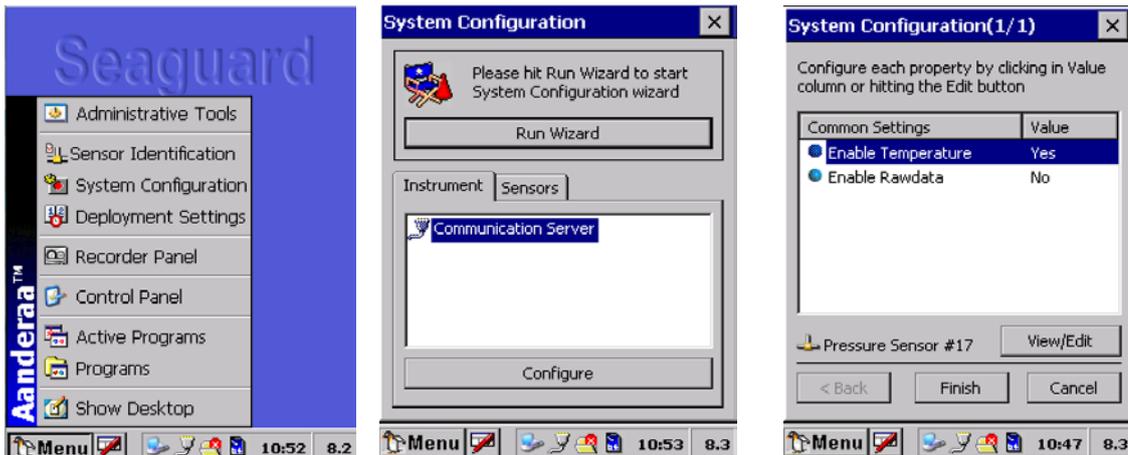
*Note! Refer to Table 1-2 for a description of the sensor settings and the input parameters.*

### 5.3.1 System Configuration

After installing the sensor turn power on and open the **System Configuration** from the **Menu** button. Select the folder labeled **Sensors**. Select the newly installed **Pressure sensor** which should appear in the list of **Sensors**, and tap **Configure** in the lower part of the window, refer *Figure 5-4*

The **System Configuration** holds a list of output parameters that can be enabled/disabled by the user. Enabled properties (**Yes**) are stored in the data logger

- **Enable Temperature** in engineering units.
- **Enable Raw data**, refer chapter 2.2



**Figure 5-4 System configuration**

To enable/disable a parameter:

Select the output parameter from the list, press **View/Edit** in the lower part of the window, and change the setting by clicking the box (box is now checked), press **Save** to save and close the window.

We recommend that you enable all parameters in case of later use. The memory card storage capacity is normally not a limitation for the SeaGuard. Raw data can be used e.g. to control calibration coefficients and perform quality control on the data.

The **System Configuration** holds output parameters which can be enabled/disabled by the user, refer *Figure 5-4*

Select the property, and press **View/Edit** to set the value. Tap **OK** to return to the **System Configuration** display, refer *Figure 5-4*. Press **Finish** to store the settings when complete.

### 5.3.2 Deployment Settings

The **Deployment Settings** hold a list of user defined inputs: **location**, **geographic position**, **vertical position** and **reference**. To add information to one of these properties, select the property, press **View/Edit** and with the keyboard panel enter the text or numbers. Press **OK** and **Finish** storing the information.

### 5.3.3 User maintenance

Node Description, User Information and calibration coefficients are found in **User Maintenance**

Open **Administrative Tools** from the **Menu** button Select **User Maintenance** and then **Pressure Sensor** from the **sensor list**. Refer *Figure 5-5*. In **User Maintenance** you find properties that are password protected, and are set/alterd by the 'advanced user', **note! the password is: 1000** The properties in user maintenance are therefore not changed during normal operation. The user maintenance holds three submenus:

- **Node Descriptions**
- **Owner**
- **Calibration Coefficients**

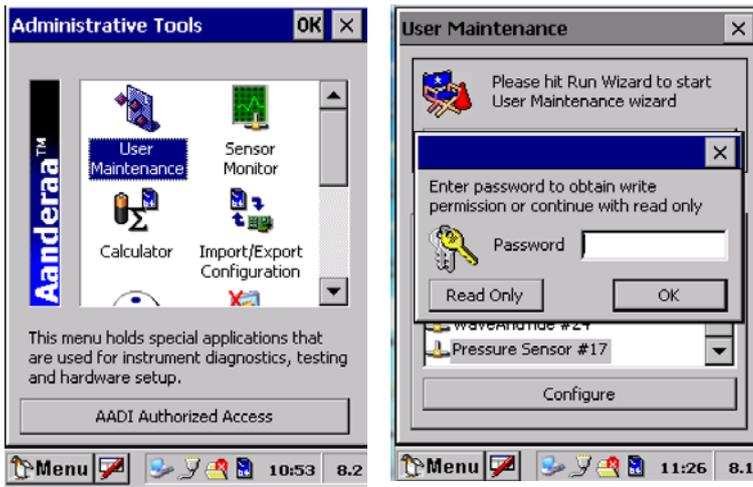
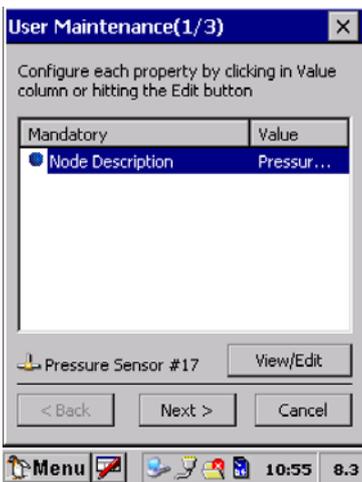


Figure 5-5 User Maintenance.

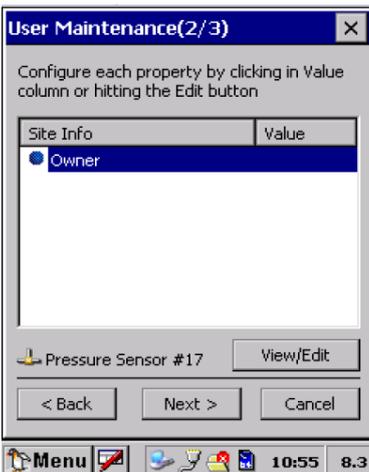


Select the **Node Description** property, press **View/Edit** in the lower part of the window, and change the setting. Press **Save** to store the setting when completed.

**Node Description** is a user entered text describing the sensor, placement etc. If using for example a SeaGuard sensor string with multiple sensors connected; renaming the sensor can facilitate analyzing data. The text is by default set to the product name followed by product model and serial number, e.g. *Pressure Sensor 4117#52*.

Press **Next>** to continue with the next submenu.

Figure 5-6 Node Description



The second submenu is the **Owner** property, press **View/Edit** in the lower part of the window, and change the text. Press **Save** to store the setting when completed.

**Owner** is a user entered text describing the sensor owner, name and address etc. If using. The text is by default empty

Press **Next>** to continue with the next submenu.

Figure 5-7 Owner

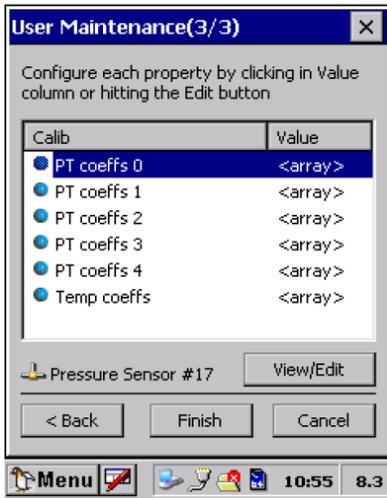


Figure 5-8 Calibration Coefficients

The third submenu is the **Calibration Coefficients** property. For each calibration property to be set, you must first select the property then press **View/Edit** and type the correct value. Press **Save** to store the settings.

Press **Finish** > to complete and exit and store the changes made

Always press **Finish** to complete, exit and store the changes made in the Pressure Sensor User Maintenance. Selecting **Cancel** or clicking on the 'X' in the top right corner to close the screen exits the menu without saving any of the changes.

### 5.4 Sensor Configuration Tide sensor 5217

Note! Refer to Table 1-3 for a description of the sensor settings and the input parameters.

#### 5.4.1 System configuration

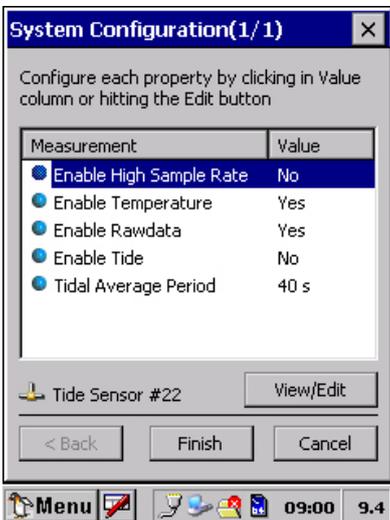


Figure 5-9 System Configuration; measurement settings.

Open the **System Configuration** from the **Menu** button. Select the **Tide Sensor** from the list of sensors, and tap **Configure** in the lower part of the window.

The **System Configuration** holds output parameters which can be set by the user, refer **Figure 5-9**.

Select the property, and press **View/Edit** to set the value. Tap **OK** to return to list.

Press **Finish** to store the measurement configuration or **Cancel** to continue without storing.

For property **Enable High Sample Rate**, if you select **No** the sampling rate will be 2Hz. If **Yes** the sampling rate will be 4Hz

For property **Enable Temperature** and **Enable Rawdata**. If set to **Yes** the parameter will be included in the dataset, if set to **No** the data will not be stored or displayed.

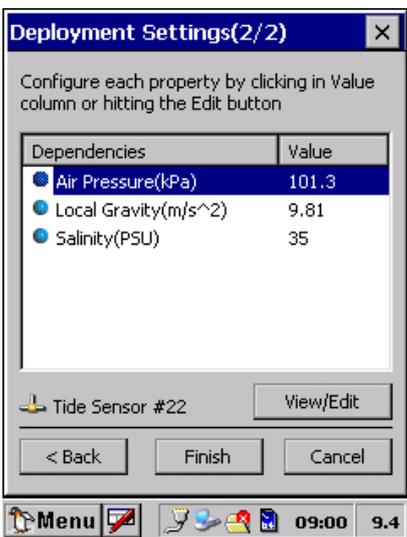
For property **Enable Tide**. The sensor will act as a Pressure Sensor if set to **No**. Select **Yes** if you want to output Tide data.

Property *Tidal Average Period* will select the averaging interval for the tide measurements, select a period from 10 seconds to 8 minutes from the drop down menu.

### 5.4.2 Deployment settings

Open the *Deployment Settings* from the *Menu* button. Select the *Tide Sensor* from the list of sensors, and tap *Configure* in the lower part of the window.

The *Deployment Settings(1/2)* holds a list of user defined input: owner, location, geographic position, vertical position and reference. To add information to one of these properties, select the property, press *View/Edit* and with the keyboard panel enter the text or numbers. Press *OK* and *Finish* storing the information.



The *Deployment Settings(2/2)* holds a list of fixed parameters that must be valid at the deployment site (refer chapter 1.3 and 1.4 for a short description):

- Atmospheric Pressure
- Local Gravity Acceleration
- Salinity

Type the value in the input field using keypad panel. The parameters are used in calculating the tide parameters.

At delivery, these parameters are set to 101.3 kPa (Ambient Air Pressure), 9.81 m/s<sup>2</sup> (Local Gravity), 35.0 psu (Salinity).

Figure 5-10 Deployment Settings; fixed settings.

### 5.4.3 User maintenance

The *User Maintenance* holds Node Description, Interface settings, and calibration coefficients.

See chapter 5.3.3 for details since this is identical to Pressure Sensor 4117 User Maintenance.

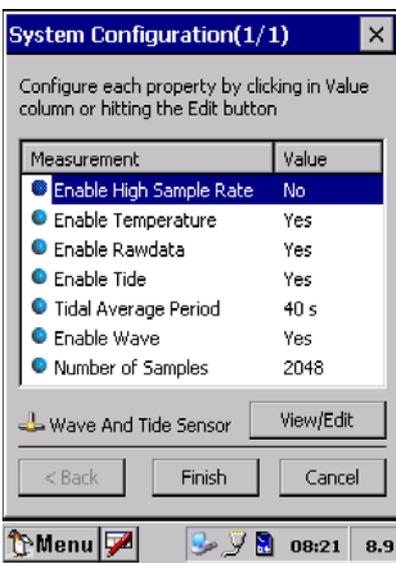
### 5.5 Sensor Configuration Wave and Tide sensor 5218

Note! Refer Table 1-4 for a description of the sensor settings and the input parameters.

#### 5.5.1 System configuration

Open the **System Configuration** from the **Menu** button. Select the **Wave and Tide Sensor** from the list of sensors, and tap **Configure** in the lower part of the window.

The **System Configuration** holds output parameters which can be set by the user, refer *Figure 5-11*:



Select the property, and press **View/Edit** to set the value. Tap **OK** to return to list.

Press **Finish** to store the measurement configuration or **Cancel** to continue without storing.

For property **Enable High Sample Rate**, if you select **No** the sampling rate will be 2Hz. If **Yes** the sampling rate will be 4Hz.

For property **Enable Temperature** and **Enable Rawdata**. If set to **Yes** the parameter will be included in the dataset, if set to **No** the data will not be stored or displayed.

**Figure 5-11 System Configuration; measurement settings.**

For property **Enable Tide** and **Enable Wave**. The sensor will act as a Pressure Sensor if both are set to **No**. If Enable Tide is set to **Yes** and Enable Wave is set to no it will act a Tide Sensor. If both are set to Yes it will record all available parameters for pressure, tide and wave.

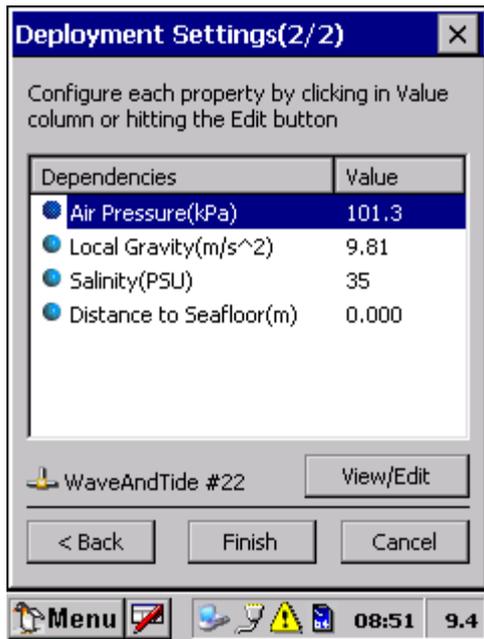
For property **Tidal Average Period** will select the averaging interval for the tide measurements, select a period from 10 seconds to 8 minutes from the drop down menu

For property **Number of Samples** select the number of samples desired in one wave measurement from the drop down menu.

### 5.5.2 Deployment settings

Open the **Deployment Settings** from the **Menu** button. Select the **Wave and Tide Sensor** from the list of sensors, and tap **Configure** in the lower part of the window.

The **Deployment Settings(1/2)** holds a list of user defined input: owner, location, geographic position, vertical position and reference.



The **Deployment Settings(2/2)** holds a list of fixed parameters that must be valid at the deployment site (refer chapter 1.3 and 1.4 for a short description):

- Ambient Air Pressure
- Local Gravity
- Salinity
- Distance to Seafloor

Type the value in the input field using keypad panel. The parameters are used in calculating the wave and tide parameters.

At delivery, these parameters are set to 101.3 kPa (Ambient Air Pressure), 9.81 m/s<sup>2</sup> (Local Gravity), 35.0 psu (Salinity), and 0 m (Distance to Seafloor).

**Figure 5-12**Deployment Settings; fixed settings.

Press **Finish** to store the settings when complete.

### 5.5.3 User Maintenance

Open **Administrative Tools** from the **Menu** button Select **User Maintenance** and then **Wave and Tide Sensor** from the **sensor list**. Refer **Figure 5-13**.. In **User Maintenance** you find properties that are password protected, and are set/alterd by the 'advanced user', **note! the password is: 1000** The properties in user maintenance are therefore not changed during normal operation. The user maintenance holds four submenus:

- **Node Descriptions**
- **Owner**
- **Pressure Series and Wave Spectrum**
- **Calibration Coefficients**

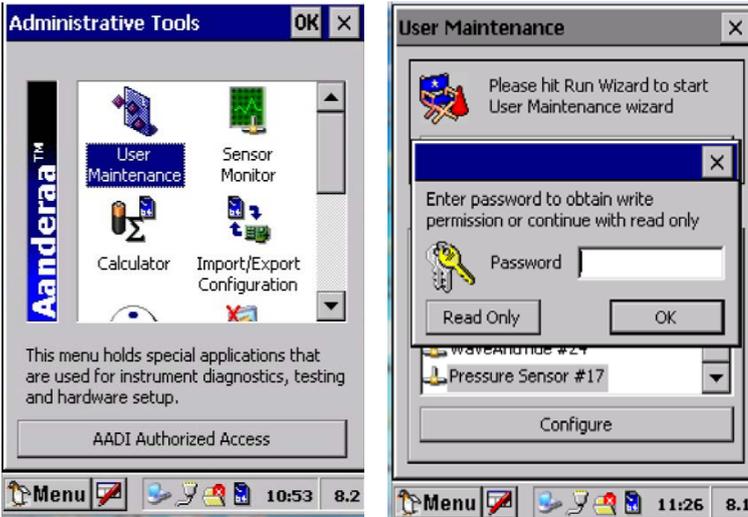
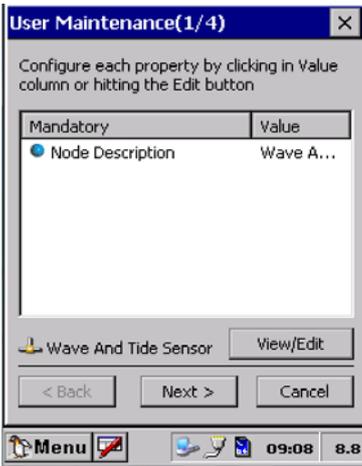


Figure 5-13 User Maintenance.

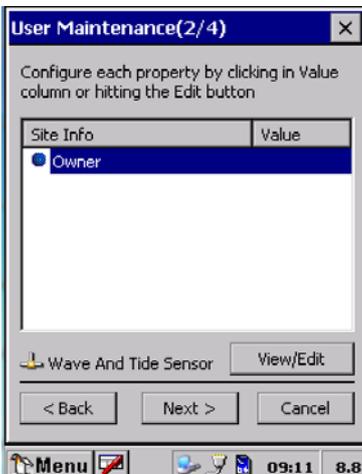


Select the **Node Description** property, press **View/Edit** in the lower part of the window, and change the setting. Press **Save** to store the setting when completed.

**Node Description** is a user entered text describing the sensor, placement etc. If using for example a SeaGuard sensor string with multiple sensors connected; renaming the sensor can facilitate analyzing data. The text is by default set to the product name followed by product model and serial number, e.g. *Wave and Tide Sensor 5218#52*.

Press **Next>** to continue with the next submenu.

Figure 5-14 Node Description

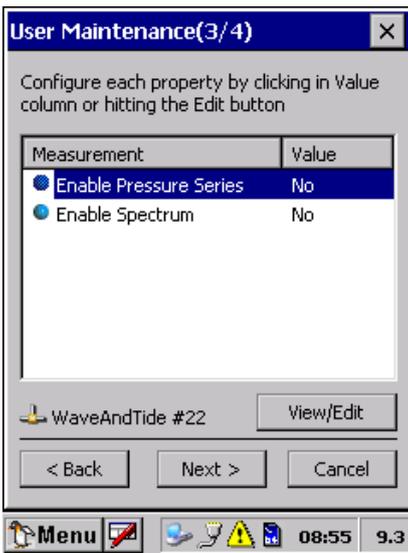


The second submenu is the **Owner** property, press **View/Edit** in the lower part of the window, and change the text. Press **OK** to store the setting when completed.

**Owner** is a user entered text describing the sensor owner, name and address etc. If using. The text is by default empty

Press **Next>** to continue with the next submenu.

Figure 5-15 Owner



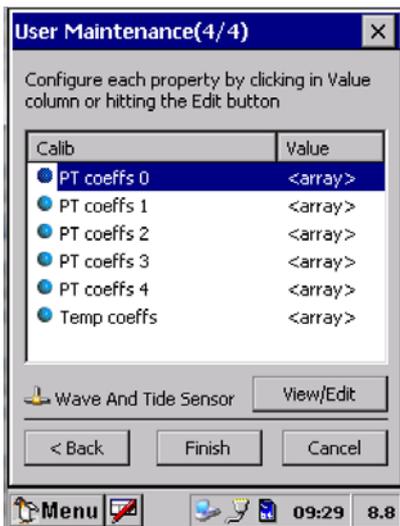
The third submenu is the *Enable Pressure Series and Enable Spectrum* property, press *View/Edit* in the lower part of the window, and enable or disable the property in the box. Press *OK* to store the setting when completed.

These properties are by default disabled

Press *Next>* to continue with the next submenu.

*NOTE! The Pressure time series/spectrum parameter holds a large amount of data, hence occupies a large part of the storage capacity. Pressure time series/spectrum should only be recorded in special occasions.*

**Figure 5-16 Enable Pressure Series and Spectrum.**



The fourth submenu is the *Calibration Coefficients* property. For each calibration property to be set, you must first select the property then press *View/Edit* and type the correct value. Press *Save* to store the settings.

Press *Finish >* to complete and exit and store the changes made

**Figure 5-17 Calibration Coefficients.**

Always press *Finish* to complete, exit and store the changes made in the Pressure Sensor User Maintenance. Selecting *Cancel* or clicking on the 'X' in the top right corner to close the screen exits the menu without saving any of the changes.

## CHAPTER 6 Sensor configuration using AADI Real-Time Collector

The sensors that are updated with Sensor Framework version 3 can be configured as stand-alone sensors using AADI Real-Time Collector.

Open the sensor connection as described in TD268 AADI Real-Time collector operating manual.

When the connection is established you can start and stop recordings or configure the device, refer Figure 6-1 . Open Device Configuration and press *Get Current Configuration*. Check *Include User Maintenance* to view maintenance settings. **The password is 1000.**

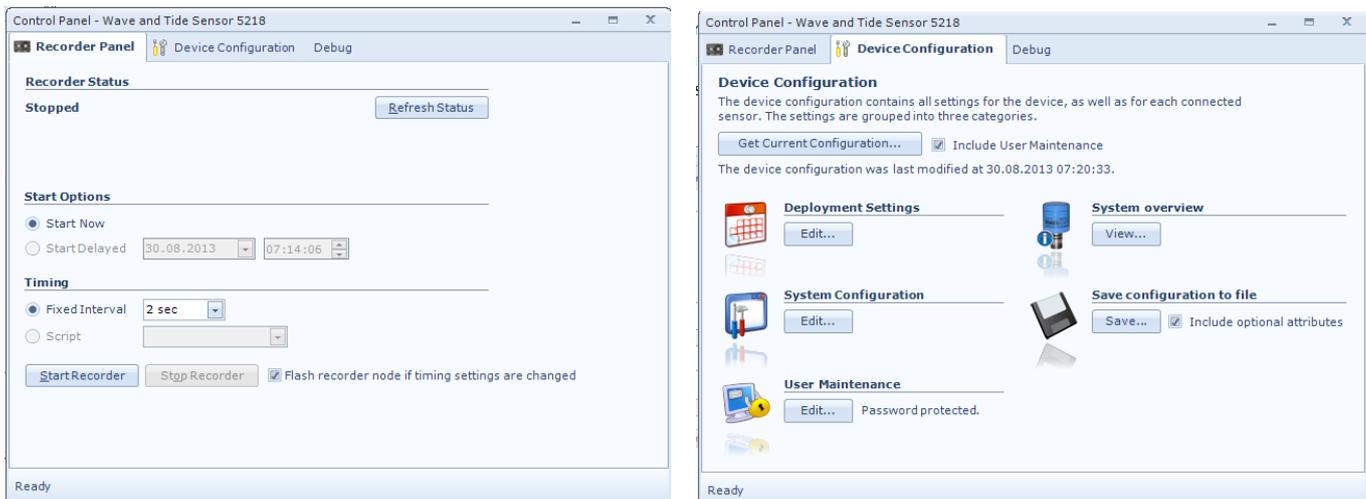


Figure 6-1 AADI Real-Time Collector screen views

User accessible sensor properties are found in Deployment settings, System Configuration and User Maintenance. Refer Table 1-2, Table 1-3 and Table 1-4 in chapter 1 for an overview of the properties and the chapter 1 text for a description of sensor properties. To edit the configuration, click in the value-field and enter new value. Press *Next* to update sensor flash and store changes.

Figure 6-2, Figure 6-3, Figure 6-4 and Figure 6-5 present screen views of AADI Real-Time Collector.

**Note! These screen shots might show minor discrepancies compared to screen shots taken from your sensor due to sensor updates.**

Deployment Settings

**Wave And Tide Sensor #327**  
 Wave And Tide Sensor (5218, Version 8)  
 Serial No: 327

**Common Settings**

Property	Value
Interval (s)	2.000000E+00

**Site Info**

Property	Value
Location	
Geographic Position	60.31115,5.3494
Vertical Position	
Reference	

**Dependencies**

Property	Value
Air Pressure (kPa)	1.013000E+02
Local Gravity (m/s^2)	9.809999E+00
Salinity (PSU)	3.500000E+01
Distance to Seafloor (m)	0.000000E+00

< Back   Next >   Cancel

Figure 6-2 Sensor deployment settings

System Configuration

**Wave And Tide Sensor #327**  
 Wave And Tide Sensor (5218, Version 8)  
 Serial No: 327

**Common Settings**

Property	Value
Mode	AADI Real-Time
Enable Sleep	<input checked="" type="checkbox"/>

**Terminal Protocol**

Property	Value
Enable Polled Mode	<input type="checkbox"/>
Enable Text	<input checked="" type="checkbox"/>
Enable Decimalformat	<input type="checkbox"/>

**Measurement**

Property	Value
Enable High Sample Rate	<input checked="" type="checkbox"/>
Enable Temperature	<input checked="" type="checkbox"/>
Enable Rawdata	<input type="checkbox"/>
Enable Tide	<input checked="" type="checkbox"/>
Tidal Average Period	40 s
Enable Wave	<input checked="" type="checkbox"/>
Number of Samples	256

< Back   Next >   Cancel

Figure 6-3 Sensor system configuration

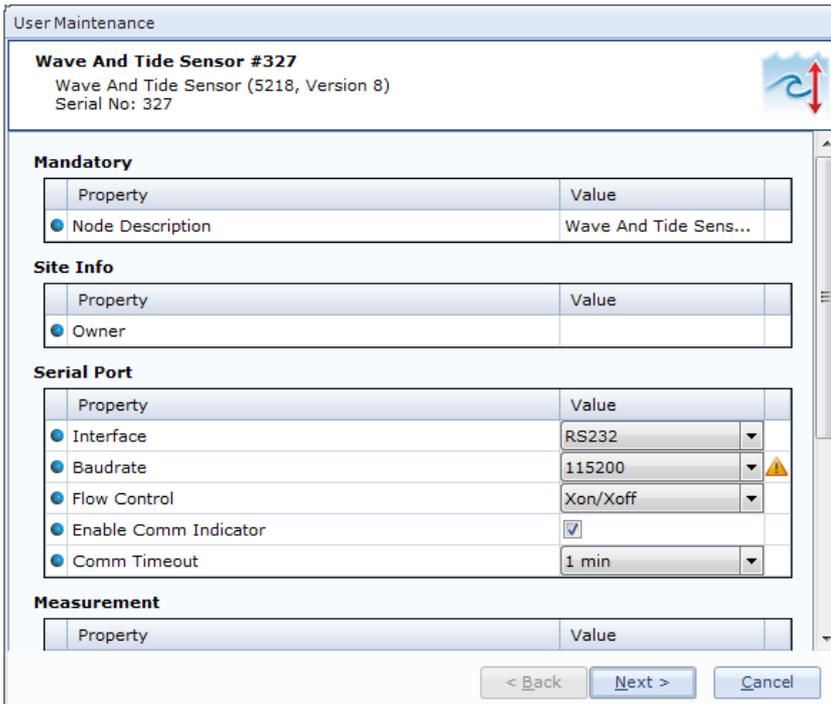


Figure 6-4 Sensor user maintenance part 1

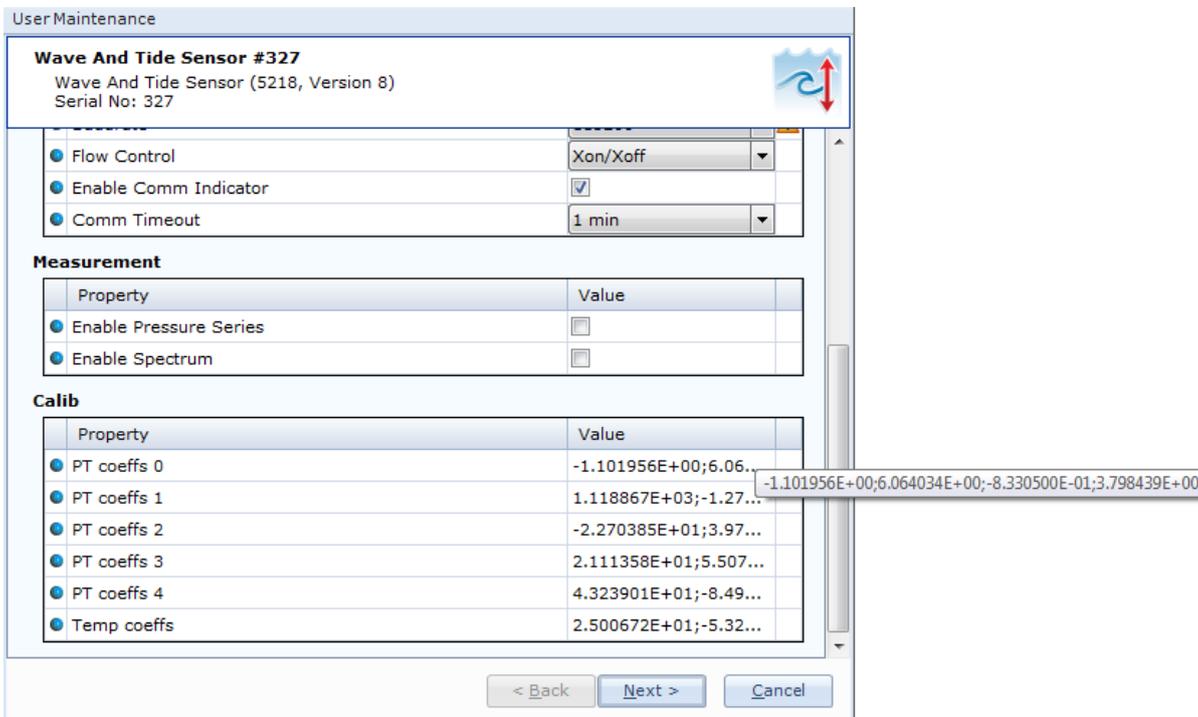


Figure 6-5 Sensor user maintenance part 2

The screenshot displays the 'Wave and Tide Sensor 5218' interface. On the left, there are control panels for 'Connection', 'Stylesheet', 'View Settings', and 'Virtual Sensors'. The main area is titled 'All Recorder Groups' and shows 'Wave And Tide Sensor #327 (Wave And Tide Sensor / 5218-327)'. It contains several data sections:

- Device information:** A table with three columns: Device Metadata, Message information, and Static System Parameters.
- Data Record:** A table with one column: Record information.
- System data:** A section for system-related information.
- Sensor data:** A table with two columns: Wave And Tide Sensor #327 and CTD Virtual Sensor.

Device information		
Device Metadata	Message information	Static System Parameters
Device ID: 5218-327	Message timestamp: 2013-08-30T08:27:53.721Z	Geographic Position: 60.31115,5.3494
Description: Wave And Tide Sensor #327	Time Received: 2013-08-30T08:27:53.7217597Z	
Product Number: 5218	Time Correction:	
Product Name: Wave And Tide Sensor	Status Code: 0	
Serial Number: 327		
Device Type: Sensor		
Device Session ID: 5218-327-8.0.1-0-26		
Protocol Version: 6		

Data Record	
Record information	
Record Number: 178	
Timestamp: 2013-08-30T08:27:53.721Z	
Data Session ID: 5218-327-8.0.1-0-26-30-2	
Group ID:	

Sensor data	
Wave And Tide Sensor #327	CTD Virtual Sensor
Pressure: 100.119 kPa	Depth: -0.117 m
Temperature: 26.868 DegC	
Tide Pressure: 100.092 kPa	
Tide Level: -0.120 m	
Sign. Height: 0.025 m	
Max Height: 0.044 m	
Mean Period: 0.697 s	
Peak Period: 0.600 s	
Energy Period: 0.949 s	
Mean Zero Crossing: 0.672 s	
Steepness: 0.034	
Irregularity: 0.065	
CutOff Freq High: 1.765625 Hz	

Figure 6-6 Data visualization

Figure 6-6 showing real-time data from sensor obtained via the data visualization tool in Real-time Collector. This data can either be displayed in the text viewer as shown in figure 6-6 or in graphs by using the graph viewer. For more info on this feature refer to TD268 AADI Real-Time collector operating manual.

## CHAPTER 7 Connection to PC

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This chapter describes how to connect and communicate with the Pressure Sensor 4117, Tide Sensor 5217 and Wave and Tide Sensor 5218 using the RS-232 Smart Sensor Terminal protocol. Sensor configuration is described in chapter 4 and 5.

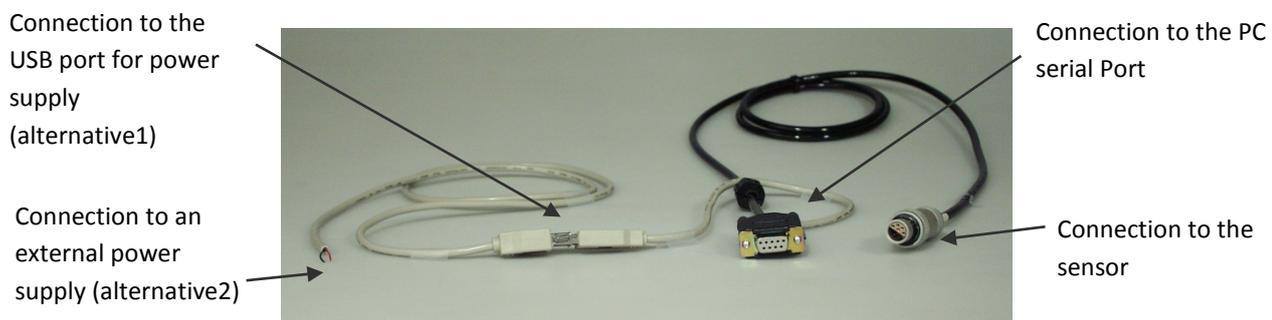
Sensor Cable 3855 (1.5m) is not intended for in water use, it is for sensor setup in an office environment only, for laboratory or in water use Sensor Cable 4865 to connect pressure Sensor 4117/5217/5218 to a PC.

*Note! The connector on Sensor Cable 3855 is made of Aluminum, due to risk of corrosion it is not recommended for use in saltwater. Same pin configuration as Cable 4865.*

Either connect the additional USB plug in a USB port for providing power to the sensor (the USB port normally gives 5V power), or connect the USB plug to an included extension of the USB and connect to external power (5-14V), refer Figure 7-1.

*Note! If power cannot be obtained from an USB port a practical solution is to use a 9V alkaline battery (6LF22) to set the sensor up or log data in the laboratory.*

Sensor Cable 4865 is also available in other lengths. The cable has a titanium plug, and can be used in applications that require a direct connection to a PC in RS-232 operations.



**Figure 7-1 Sensor Cable 3855.**

See Appendix 5 for illustrations of all available cables.

## 7.1 Operation mode: AiCaP and Smart Sensor Terminal

### 7.1.1 AiCaP sensors

'AiCaP' sensors can be used either with AiCaP protocol or Smart Sensor Terminal protocol. At delivery, the sensor is configured with 'AiCaP' mode. Ensure that the sensor is configured for AiCaP mode when used in SeaGuard applications or SmartGuard with AiCaP connection. If the sensor is set in another mode it will not be detected by the logger. Refer Table 1-2 (page 14) for *Mode* property settings.

The sensor must be configured to Smart Sensor Terminal mode before it can be used in RS-232 operations. Refer to chapter 7.2 for serial communications setup and chapter 7.4 for scripting.

Procedure to configure the sensor to Smart Sensor Terminal mode from AiCaP:

1. Disconnect the sensor from the SeaGuard or SmartGuard Platform.
2. Connect the sensor to a PC using e.g. cable 3855/4865.
3. Open a terminal emulation program on your PC, copy and paste or write a text file in an ordinary text editor the command lines and save this file. This file can then be sent to the sensor in one operation. The first line in the example below is a user comment line that is disregarded by the Sensor. Strings starting with either `//` or `;` are ignored by the software, and do not produce any errors nor are they acknowledged by the sensor.
4. Set the *Mode* property to [Smart Sensor Terminal](#), refer Table 1-2. Followed by sending the *Save* and *Reset* commands to Save the configuration and reset the sensor.

Example:

```
//Press Enter to start communicating with the sensor, refer chapter 7.2.2.
↵ //press Enter
Stop ↵ //Wait for ack #. Repeat if necessary
Set Passkey(1) ↵
Set Mode(Smart Sensor Terminal) ↵ //wait for ack #
Save ↵ // wait for ack #
Reset ↵ // the sensor will restart with new settings
```

Procedure to configure the sensor to AiCaP mode from Smart Sensor Terminal:

1. Connect the sensor to a PC using e.g. cable 3855.
2. Set the *Mode* property to [AiCaP](#), refer Table 1-2. Save the configuration and reset the sensor.
3. Mount the sensor to the SeaGuard or SmartGuard Platform, refer *Figure 5-1.*

### 7.1.2 R-version sensors

The R-version sensor supports only RS-422 and Polled operations. These sensors cannot be used in SeaGuard applications.

Sensors with RS-422 output must use a cable designed for RS-422 communication when connected to the PC. If your PC does not support RS-422, you can buy an expansion card or you can use an RS-232 port and an RS-232/RS-422 converter. AADI can provide such a cable: sensor cable 4799 to PC (with RS-232/RS-422 converted included).

*Note! It is possible to receive data from the 'R' sensor using sensor cable 3855 to PC, but it is not possible to transmit commands to the sensor when connected to cable 3855.*

### 7.1.3 RS-422 transmission line

RS-422 has differential transmission lines with twisted pairs. The sensor signals are less influenced by external noise than a sensor with RS-232 serial communication, which makes it possible to communicate using longer cables (in RS-422 operations).

RS-422 has one balanced signal pair for the transmitted signal, TXD (also called TXD+ and TXD-) and one balanced signal pair for the received signal, RXD (also called RXD+ and RXD-).

RxD+ and TxD+ are often named B and called non-inverting input and output, respectively.

RxD- and TxD- are often named A and called inverting input and output, respectively.

The EIA standard uses the notation A and B as described above; many manufacturers of signal converters uses the opposite naming (A for non-inverting input/output, and B on inverting input/output) which is not correct.

*Note! Always ensure which signal is non-inverting and which is inverting.*

Figure 7-2 illustrates the balanced signals of an RS-422 line during transmission of a byte. The non-inverting signal is called TXD+ while the inverting signal is called TXD-.

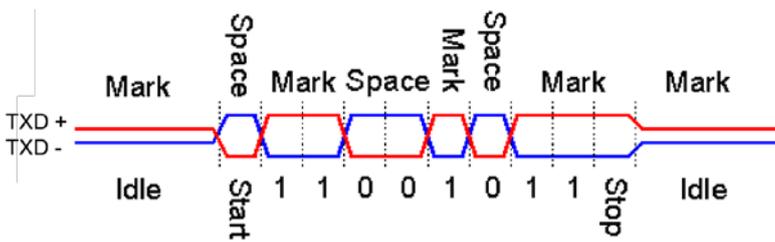


Figure 7-2 Example of a RS-422 signal

### 7.1.4 Polled mode

Sensors set to Smart Sensor Terminal mode can be used in Polled operation with third party hardware, where the sensor presents measurement data on user request only.

The Pressure sensor:

- The **Do Sample** command updates pressure and temperature measurements.
- The **Do Output** command presents the last set of measured data.

Tide sensor and Wave and Tide sensor:

- The **Do Sample** command starts a calculation and presents one set of output data.
- The **Do Output** command presents the last set of calculated data.

The Tide Sensor and the Wave and Tide sensor are sampling continuously (if tide or wave is enabled) to ensure that there is a complete pressure time series ready at all times for calculation of output parameters. The temperature measurement is updated at sensor power up, clearing of the pressure series and at a 10 min interval.

After sensor start up or clearing of the pressure series some time will elapse before the required number of pressure samples are available, hence wave and tide parameters cannot be calculated. The parameters will be set to 0 and there will be a status code "Not ready". Refer chapter 2.4 for details and information about when the pressure series are cleared.

Procedure to configure the sensor to Polled operations from RS-422:

1. Connect the sensor to a PC. Use e.g. cable 4799 if connecting to the PC RS-232 serial port.
2. Set the **Enable Polled Mode** property to **yes**. Save the configuration and reset the sensor.

Example: //Press Enter to start communicating with the sensor, refer chapter 7.2.2.

```
↵ //press Enter
Stop ↵//Wait for ack #. Repeat if necessary
Set Passkey(1) ↵
Set Enable Polled Mode(yes) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
```

### 7.1.5 Description of user configurable properties

The **Node Description** property is a user defined text that describes the sensor or the location of the sensor.

The **Mode** property is used to set the sensor operation mode of the sensor. Set the **mode** property to **AiCaP, Smart Sensor Terminal, AADI Real-Time, Smart Sensor Terminal FW2** to enable the different sensor operations. *Note! The mode **Smart Sensor Terminal FW2** brings the sensor into an operation mode with output string that is compatible with AADI framework 2. 'AiCaP' sensors will be set to RS-232 operation if configured to RS-422 communication interface. An R-sensor will be set to RS-422 operation if configured to AiCaP or RS-232 communication interface.*

Set the **Enable Text** to **Yes** for the sensor to output a detailed text string (including the output parameter name and engineering unit names) with the measurements, or **No** to output the measured values without the descriptive text.

Set the **Enable Decimalformat** to **Yes** to output the measured values in decimal format. Set the property to **No** (default) to output the values in exponential format (higher resolution in the output parameter value). Example of decimal format: the presented value is e.g. 0.0025. Example of exponential format: the presented value is e.g. 2.500000E-03.

Set the **Enable Sleep** to **Yes** (default) for the sensor to go to sleep between recordings, or **No** for the sensor to stay continuously switched *on* between recordings (consumes more power).

*Note! After receiving input at the RS-232 or RS-422 interface or as **Polled** input, **Comm TimeOut** will decide when the sensor is allowed to re-enter sleep mode. In **AiCaP** mode the sensor will always enter sleep mode between recordings/calculations. Setting **No** is not recommended for battery operation as the current drain will rise by up to 9mA continuous. The accuracy of the temperature readings will also be reduced and may not meet published accuracy specification with this setting due to internal self-heating.*

The **Interval** property describes the output interval in seconds (stand-alone sensor). The value must be a float between 1 and 15300. The sensor provides a set of measured/calculated data for every output interval. When configured to **non-polled** mode the sensor can be used in systems with one-way communication. In **Polled** operation the sensor will present data only on request (the internal interval timer is disabled). In **AiCaP** mode the interval is controlled by the SeaGuard or SmartGuard instrument (minimum 2 seconds).

*Note! For 5218/5218R Wave and Tide sensor with pressure series and/or spectrum enabled, the interval will automatically be extended to 1 min if the interval setting is less than 60 seconds.*

The **Vertical Position** property is a user defined value that describes the sensor installation depth. The information is not used in calculation of parameters.

Set the **Enable Temperature** and **Enable Rawdata** to **Yes** to include these parameters in the output string. The raw data readings are values directly from the 24 bit ADC.

The **Comm TimeOut** property controls how long the sensor will wait for the next command before it shuts down the transceiver (indicated by the communication sleep indicator '%'). In this time period the sensor is not allowed to enter communication sleep. If set to **Always On**, the sensor will not need a wakeup character and is always ready to read incoming commands. This setting will not allow the sensor to enter communication sleep, and is not recommended for battery operation. In **AiCaP** mode the setting is overridden to 1 minute when configured using the RS232 line.

**PT coeffs 0,1,2,3,4** and **Temp coeffs** holds the calibration data needed to convert from raw data to engineering values. The sensors are calibrated at delivery; if these settings are lost AADI Service Department will provide the calibration data.

### 7.1.6 Additional configuration of the Tide Sensor and Wave and Tide Sensor

Set the **Enable Tide** to **Yes** to include this parameter in the output string.

Set the **Tidal Average Period** in seconds (default is 40 seconds). The minimum averaging time is 10 seconds; the maximum averaging time is 8 minutes, refer chapter 1.3.

Set the **Air Pressure**, **Local gravity** and **Salinity** at the deployment site. These properties are used in calculations of the tide parameters and wave parameters, refer Table 1-2, Table 1-3 and Table 1-4. At delivery, these parameters are set to 101.3 kPa (Ambient Air Pressure), 9.81 m/s<sup>2</sup> (Local Gravity), 35.0 psu (Salinity). Air pressure variations of 5 kPa gives approximately 50 cm variation in the tide level parameter. The equation for calculating the water density is only accurate for salinity values between 2 and 42.

The **Installation Depth** property can be used for referring the Tide Level to a chosen datum (reference level). Set this property to the distance in meters from the datum to where the sensor is installed.

Set the **Enable high sample rate** to **Yes** to sample at 4 Hz rate. The factory setting is **No** (which means 2 Hz sampling rate).

Set the **Enable Wave** to **Yes** to include these parameters in the output string (Wave and Tide Sensor).

Set the **Number of Samples** to be collected for wave calculations, refer chapter 1.3 (Wave and Tide Sensor). Wave parameters are calculated with better accuracy if the number of pressure samples is high. If you select 2048 samples, the sensor averages two frequency spectrums each of 1024 samples.

Set the property **Enable Spectrum** to **Yes** to present the spectrum elements in the output string. The spectrum is presented as the value of each frequency component in the wave spectrum. Spectral components outside of the calculated *cut-off* frequencies are set to 0. When in **Smart Sensor Terminal** mode the XML output format can be access when in **Polled** mode or when in **AADI Real-Time** mode using Aanderaa's Real-Time Data Collector software XML Output is enabled and the spectrum info length, freq. resolution etc are shown, refer chapter 7.2.10 XML Commands (Wave and Tide Sensor) Table 1-4; Table 7-2 and Appendix 4 *Note! When the Wave & Tide sensor is connected to a SeaGuard instrument we recommend that you enable wave spectrum and/or pressure time series only for short deployments due to current drain and memory usage. The output update interval will be at least 10 seconds for AiCaP applications, and at least 1 minute for RS232/RS422 operation.*

Set the property **Enable Pressure Series** to **Yes** to present the Pressure Time Series and Last Pressure Sample Index. The Pressure Time Series is the sample set used for the spectrum and wave calculation. (Wave and Tide Sensor only).

Set the **Distance to seafloor** as the distance between the sensor and the seafloor in meters. The value is used in wave calculations. For values below 50 meters, you can set the value to 50 meters. Set the property to 0 (default) if the sensor is deployed on the seabed (Wave and Tide Sensor).

### 7.2 Smart Sensor Terminal communication setup

Most terminal programs can be used for *Smart Sensor Terminal* communication with the sensor when connected to a PC, e.g. Teraterm. A copy of Teraterm is included on the CD following the sensor. Copy the content of the zip file to the Program File folder on your PC. Start the teraterm.exe file and the terminal program will start up with standard sensor setup.

The following Smart Sensor Terminal setup should be used:

- 9600 Baud
- 8 Data bits
- 1 Stop bit
- No Parity
- Xon/Xoff Flow Control

*IMPORTANT! The terminal program must send a Line Feed after each Carriage Return.*

RS-232/RS-422 operation:

When connected, you will get measurement data according to the output interval stored in the flash memory. If the measurement interval is set to zero, you can type the command *Reset* to get the operation mode and a single set of measurement data.

#### 7.2.1 Polled Mode:

Type a command to retrieve data/information from the sensor, refer e.g. chapter 7.1.4, chapter 7.2.6 and chapter 7.2.10 for a description of available commands.

#### 7.2.2 Sensor startup

When property *Enable Text* is set to *Yes*, *StartupInfo* is displayed at sensor power up or after reset. *StartupInfo* contains this information about product number, serial number, current mode setting, Protocol version for Smart Sensor Terminal operation and Config Version.

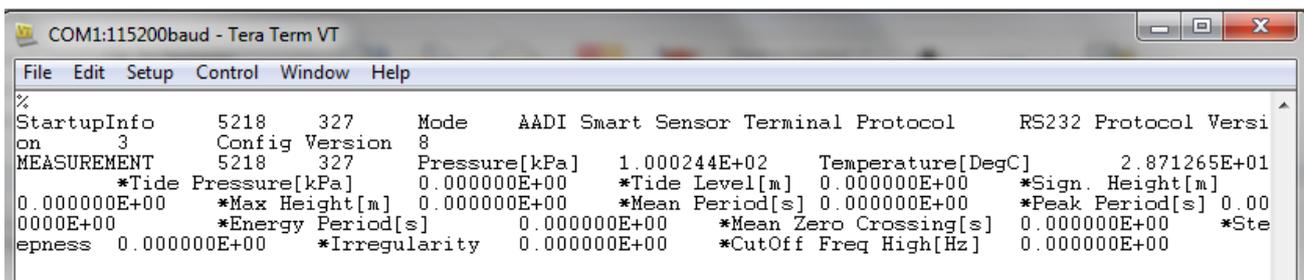


Figure 7-3 Sensor Startup Information

When used in *Smart Sensor Terminal* mode the sensor will always start by doing a sample that will be presented within 2 seconds from powering the sensor. This does not apply for Polled operations. Please note that some of the parameters starts with a \*. This indicates that the parameter cannot be calculated because the required number of pressure samples is not available.

In order to minimize the current drain the sensor normally enters a power down mode after each sampling; the sensor can be awakened by any characters on the Smart Sensor Terminal input, and will stay awake for a time set by the *Comm TimeOut* property after receiving the last character.

If the property *Comm TimeOut* is set to other than '*Always On*' the serial interface will not be activated after power-up (or the Reset command). Any character will activate the serial interface, but a Carriage Return (CR or CR+LF), '/' or ';' are often preferred since these character do not interfere with the command syntax. The serial interface will then be active until a period of input inactivity specified by the *Comm TimeOut* value (10 s,20 s,30 s,1 min,2 min,5 min,10 min). The Communication Sleep Indicator, '%', will be transmitted when the serial communication is deactivated, and the Communication Ready Indicator, '!' is outputted subsequent to activation. When *Comm TimeOut* is set to '*Always On*' the communication (and microprocessor) will be kept active all time.

The Communication Sleep Indicator '%' and the Communication Ready Indicator '!' are not followed by Carriage Return and Line Feed.

The character '%' indicates that communication with the sensor is not possible (shut-down); refer third line in the screen dump presented in Figure 7-4. In this mode the electronics requires up to 500 ms start up time.

Any character will cause the electronics to return to normal operation; when the sensor has responded with the character '!', new commands may be entered.

When communicating with the sensor, you must start by pressing *Enter*. The sensor will respond in two ways (*Comm TimeOut* is 1 minute by default in the following description):

- If the sensor is ready for communication, it will not send any response indicator. The sensor will stay awake and ready to receive commands for 1 minute (controlled by the *Comm TimeOut*) since the last command.
- If the sensor is in sleep mode and not ready for communication, the sensor will send a 'communication ready' indicator (!) when awakened (within 500ms). The sensor will then be ready for communication.

The 'communication sleep indicator '%' and the 'communication ready' indicator '!' are not followed by Carriage Return and Line Feed.

### 7.2.3 Smart Sensor Terminal protocol

All inputs to the sensor are given as commands with the following format:

- *MainCmd SubCmd* or *MainCmd Property(Value., Value)*

Description of ASCII coded communication rules:

- The main command, *MainCmd*, is followed by an optional subcommand (*SubCmd*) or sensor property (*Property*).

- The **MainCmd** and the **SubCmd/Property** must be separated with the space ‘ ’ character.
- When entering new settings the **Property** is followed by a parenthesis containing comma-separated values.
- The command string must be terminated by Carriage Return and Line Feed (ASCII code 13 & 10).
- The command string is not case sensitive (UPPER/lower-case).
- The ENUM property settings are case sensitive. E.g. “**Set Mode(AiCaP)**” Here AICAP will result in argument error. Refer Table 1-2
- A valid command string is acknowledged with the character ‘#’ while character ‘\*’ indicates an error. Both are followed by Carriage Return/ Line Feed (CRLF).
- For most errors a short error message is also given subsequent to the error indicator.
- There are also special commands with short names and dedicated tasks, as **save**, **reset**, and **help**.
- All names and numbers are separated by tabulator spacing (ASCII code 9).
- The string is terminated by Carriage Return and Line Feed (ASCII code 13 & 10).

*Note! Losing power during the flashing process can cause corruption of vital settings, such as coefficients, serial number, model number etc. If losing settings, contact AADI Service department for new setting file for the specific sensor with further instructions.*

**7.2.4 Passkey for write protection**

To avoid accidental change, most of the properties are write-protected. There are four levels of access protection, refer Table 7-1.

A special property called **Passkey** must be set according to the protection level before changing the value of properties that are write-protected, refer Table 1-2. After a period of inactivity at the serial input, the access level will revert to default. This period corresponds to the **Comm TimeOut** setting, or 1 minutes if the **Comm TimeOut** is set to **Always On**.

**Table 7-1 Access protection levels**

Output	Passkey	Description
No		No Passkey needed for changing property
Low	1	The Passkey must be set to 1 prior to changing property
High	1000	The Passkey must be set to 1000 prior to changing property This Passkey value also give read access to factory properties that usually are hidden
Read Only		The user have only read access

## 7.2.5 Save and Reset

When the required properties are set, you should send a **Save** command to make sure that the new configuration is saved internally in the flash memory. The sensor always reads the configuration from the internal flash memory after reset and power up. The **Save** command takes about 20 seconds to complete (indicated with the character '#').

Always send a **Reset** command when a new configuration has been saved (or switch the power OFF and then back ON), or else calculated parameters may be corrupt. This forces the sensor to start up with the new configuration input. If the **Enable Sleep** property is set to **Yes** and the **Comm TimeOut** property is not set to **Always On** the sensor enters sleep mode after reset.

At startup/reset the sensor performs measurements according to the interval setting if the mode is **Smart Sensor Terminal**, refer Figure 7-4. If **Enable Text** is set to **Yes**, the **Startup Info** is presented.

If the **Save** command is executed the new setting will be stored in the internal Flash memory.

Property changes will be lost when the sensor is reset or loses power unless you type the **Save** command.

```

COM1:115200baud - Tera Term VT
File Edit Setup Control Window Help
reset
#
%
StartupInfo      5218      327      Mode      AADI Smart Sensor Terminal Protocol      RS232 Protocol Versi
on              3        Config Version 8
MEASUREMENT     5218      327      Pressure[kPa] 1.001195E+02      Temperature[DegC]    2.876778E+01
    *Tide Pressure[kPa] 0.000000E+00      *Tide Level[m] 0.000000E+00      *Sign. Height[m]
0.000000E+00      *Max Height[m] 0.000000E+00      *Mean Period[s] 0.000000E+00      *Peak Period[s] 0.00
0000E+00      *Energy Period[s] 0.000000E+00      *Mean Zero Crossing[s] 0.000000E+00      *Ste
epness 0.000000E+00      *Irregularity 0.000000E+00      *CutOff Freq High[Hz] 0.000000E+00

!
stop
#
set passkey(1)
#
set enable text(no)
#
save
#
reset
#
%5218 327      1.001198E+02      2.872962E+01      0.000000E+00      0.000000E+00      0.000000E+00      0.00
0000E+00      0.000000E+00      0.000000E+00      0.000000E+00      0.000000E+00      0.000000E+00      0.00
0000E+00      0.000000E+00

```

Figure 7-4 Sensor start up after reset.

### 7.2.6 Available commands

Available commands and properties for the sensors are given in Table 7-2 and Table 1-2 respectively.

**Table 7-2 Available RS-232/RS-422 commands.**

Command	Description
Start	Start a measurement sequence according to current configuration
Stop	Stop a measurement sequence
Do Sample	Calculates and presents a new single set of measurement data. (used in polled mode.)
Do Output	Presents the last set of calculated measurement data.
Get <i>ConfigXML</i>	Outputs information about the configuration in XML format
Get <i>DataXML</i>	Outputs information about available(enabled) parameters in XML format
Get <i>Property</i>	Output Property value (refer Table 1-2)
Get All	Output all property values
Set <i>Property(Value,.. Value)</i>	Set Property to Value,.. Value
Set <i>Passkey(Value)</i>	Set passkey to change access level
Save	Store current settings
Load	Reloads previous stored settings
Reset	Resets the sensor with last saved new configuration
Help	Print help information
;	Comment string, following characters are ignored
//	Comment string, following characters are ignored

### 7.2.7 The Get command

The **Get** command is used to read the value/values of a property and to read the latest value of a parameter.

The command name **Get** followed by a **Property** returns a string in the following format:

*Property ProductNo SerialNo Value, ..Value*

The string starts with the name of the property, the product number and serial number of the sensor, and finally the value of the property, refer example in Figure 7-5.

The command name **Get** followed by a parameter returns the name and unit of the parameter, the product and serial number of the sensor, and finally the latest parameter reading, refer example in Figure 7-5.

A special version, **Get All**, reads out all available properties in the sensor. Some properties are passkey protected and will not be shown without first writing the passkey. Refer chapter 1.5 for properties and chapter 5.4 for passkey.



Figure 7-5 Examples of the Get command.

### 7.2.8 The Set command

The **Set** command is used for changing a property. The corresponding **Get** command can be used to verify the new setting, refer example in Figure 7-6.

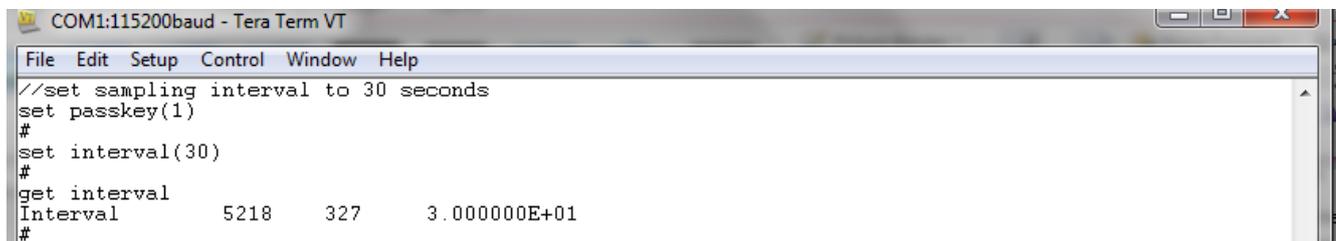


Figure 7-6 Example of the Set command.

Use the **Save** command to permanently store the new property value.

The **Mode** property will require a **Reset** before the change is executed. All other property changes will be executed immediately.

Some property changes will automatically restart the collection of pressure samples, refer chapter 2.4.

Some properties are passkey protected and will not be accessible without first writing the passkey. If the passkey is needed you get the error message: "ERROR PROTECED PROPERTY". Refer chapter 1.5 for properties and chapter 7.2.4 for passkey.

### 7.2.9 Formatting the output string

The property called **Enable Text** controls the presentation of measured data. When the property is set to **Yes** the output string includes the descriptive parameter name with engineering units of measure. When the property is set to **No**, the output parameters are presented without descriptive parameter names and engineering units; the parameter order is the same, refer Figure 7-4 for an example.

The property called **Enable DecimalFormat** controls the format of the output values, either as decimal numbers (**Yes**), or in exponential format (**No**). Refer Figure 7-7 for an example.

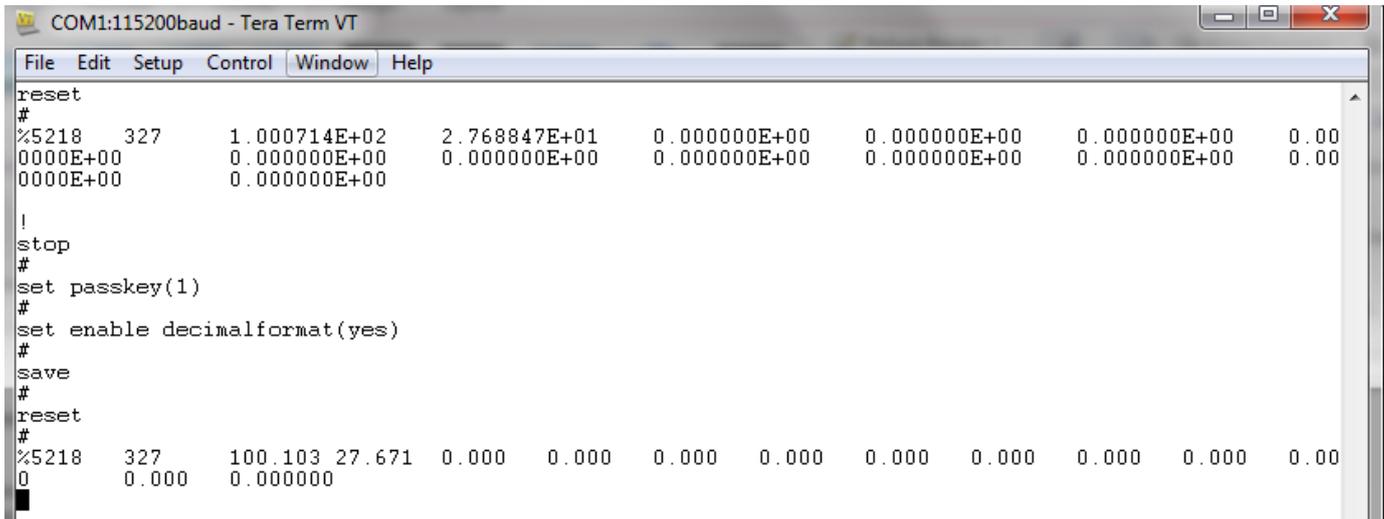


Figure 7-7 Example of output string: decimal/exponential format.

The property setting affects the presentation of measured values in the output string, not in the sensors response to the **Get** command (which is always in exponential format).

### 7.2.10 XML commands

The **Get ConfigXML** command outputs all available sensor properties in XML-format.

The **Get DataXML** command outputs all available sensor parameters in XML-format.

The **XML-output** is a general format shared by all Aanderaa smart sensors; the output from different types of smart sensors can be read and present e.g. in a general smart sensor setup program. Refer Table 7-2

### 7.3 Examples of Smart Sensor Terminal communication

Use a terminal program e.g. Teraterm or Hyperterminal, refer chapter 7.2 for communication setup.

In the following examples the sensor update interval is 5 seconds. They illustrate several configuration changes. The command **Stop** is recommended to avoid output strings while configuring the sensor.

Example 1: Enable Rawdata

```
//Press Enter to start communicating with the sensor, refer chapter 7.2.2.
↵ //press Enter
Stop ↵//Wait for ack #. Repeat if necessary
Set Passkey(1) ↵
Set Enable Rawdata(yes) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
```

Example 2: Change Number of Samples to 2048

```
//Press Enter to start communicating with the sensor, refer chapter 7.2.2.
↵ //press Enter
Stop ↵// Stop current measurement. Wait for ack #. Repeat if necessary.
Set Passkey(1) ↵//wait for ack #
Set Number of Sample(2048) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
```

Example 3: Disable wave measurement

```
//Press Enter to start communicating with the sensor, refer chapter 7.2.2.
↵ //press Enter
Stop ↵// Stop current measurement. Wait for ack #. Repeat if necessary.
Set Passkey(1) ↵//wait for ack #
Set Enable Wave(no) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
```

Example 4: Set Comm TimeOut to 20 sec

```
//Press Enter to start communicating with the sensor, refer chapter 7.2.2.
↵ //press Enter
Stop ↵// Stop current measurement. Wait for ack #. Repeat if necessary.
Set Passkey(1000) ↵//wait for ack #
Set Comm TimeOut(20 s) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
```

Example 5: Set Tidal Average Period to 1 min

```
//Press Enter to start communicating with the sensor, refer chapter 7.2.2.
↵ //press Enter
Stop ↵// Stop current measurement. Wait for ack #. Repeat if necessary.
Set Passkey(1) ↵//wait for ack #
Set Tidal Average Period(1 min) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
```

#### 7.4 Scripting -sending a string of commands

Often it may be usefully to include more than one command in a text file. For example the instructions below can be written in an ordinary text editor and saved as a text file, which can be sent to the sensor.

Example of text file:

```
// Set sampling interval to 30 seconds
Stop ↵// Stop current measurement. Wait for ack #. Repeat if necessary.
Set Passkey(1) ↵//wait for ack #
Set Interval(30) ↵//wait for ack #
Save ↵// wait for ack #
Reset ↵// the sensor will restart with new settings
Get All ↵
```

**Note! The last line, *Get All*, reads out available properties for the sensor.**

The first line is a comment line that is disregarded by the sensor. Strings starting with either ‘//’ or ‘;’ are ignored by the software, and do not produce errors or acknowledgements.

Always press Enter before sensing a script file, refer chapter 7.2.2.

## **CHAPTER 8 Quality assurance, maintenance, calibration**

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Aanderaa Instruments' established routines and quality checks throughout the production process are based on a relentless QC program of continuous monitoring to maintain the highest standards of reliability.

In order to assure the quality of this sensor, critical properties are tested and documented during production. A special form, named "Test and Specification Sheet" (refer chapter 8.3 for examples) lists the required tests and the result of these tests and checkpoints.

### **8.1 Maintenance**

The Pressure sensor, Tide sensor, and Wave and Tide sensor requires modest maintenance. For deployments where the water contains high concentrations of sediment or where the organic fouling is extensive it is important to check that the pressure port is not clogged. Unscrew the pressure port cap, inspect the holes of the cap and clean it if necessary. Before replacing the pressure port cap, inspect that there is silicon oil in the pressure port.

To avoid clogging the pressure port is filled with high viscous silicon oil. After long time use this oil may vanish. If no oil can be seen in the pressure port we recommend that the sensor is returned to the factory for refilling.

The sensor housing is easily cleaned if exposed to a vinegar solution (5%) over night. Carefully remove barnacles and similar fouling the next day.

#### **8.1.1 Maintenance procedure prior to every deployment**

- Inspect the O-rings.
- Make sure that the surfaces of the O-ring seating's are clean and smooth.
- Replace O-rings if necessary.
- Lubricate the O-ring with silicon grease.

### **8.2 Calibration**

Each sensor is calibrated using highly accurate instruments that are traceable to international standards.

For most versions of the sensor this involves 5 pressure points at 4 different temperatures.

From this calibration the 20 calibration coefficients are calculated and stored in each sensor.

### 8.3 Example of Test & Specification sheet and Calibration certificate



# TEST & SPECIFICATIONS

Form No. 764, Dec 2005

**Layout No:**  
**Circuit Diagram No:**  
**Program Version:** 4.2.1

**Product:** Wave and Tide Sensor 5218R  
**Serial No:** 27

#### 1. Visual and Mechanical Checks:

- 1.1. Soldering quality
- 1.2. Visual surface
- 1.3. Galvanic isolation between housing and electronics

#### 2. Voltages and Current Drain performance:

2.1. DSP IO voltage, Tp3 ( 3.3±0.07V )	3.28	V
2.2. DSP core voltage, Tp2 ( 1.9±0.04V )	1.91	V
2.3. Analog voltage, Tp7 (3.3±0.15V )	3.35	V

#### RS232 / RS422

2.4. RS232 Average current at 2Hz( Max: 6mA / 7mA )	3.79	mA
2.5. RS232 Peak current ( Max: 50mA )	31.12	mA
2.6. RS232 Sleep current ( Max: 400µA / 1100µA )		µA
2.7. AiCaP Average current at 2 Hz ( Max: 6mA )		mA
2.8. AiCaP Peak current ( Max: 50mA )		mA
2.9. AiCaP Sleep current ( Max: 400µA )		µA

#### 3. Electronic performance test:

3.1. Raw data pressure reading at air pressure (-500000 to +1000000)	605099	LSB
3.2. Raw data temp. reading in room temperature (6500000 to 10000000)	8564967	LSB
3.3. Noise on pressure raw data ( Max: 400LSB )	127	LSB
3.4. Noise on temperature raw data (Max: 5000 LSB )	520	LSB

Date: 31 Jul 2013

Sign:

*Lene Magnussen*  
 Lene Magnussen, Production Engineer

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

Figure 8-1 Example of Test and Specification Sheet.



# CALIBRATION CERTIFICATE

Form No. 765, Oct 2008

**Certificate No:** 5218\_27\_41500  
**Range:** 0-400 kPa

**Product:** Wave and Tide Sensor 5218R  
**Serial No:** 27  
**Calibration Date:** 14 Aug 2013

This is to certify that this product has been calibrated using the following instruments:

Calibration Bath model FNT                    321-1-40  
 Pressure Controller PPC3 10M                Serial: 673  
 ASL Digital Thermometer model F250      Serial: 6792/06

**Parameter: Temperature**

**Calibration points and readings:**

Temperature (°C)	0.98	13.95	26.99	39.99
Reading (LSB)	12251976.77	10184700.17	8021015.03	6057902.16

**Giving these coefficients**

Index	0	1	2	3
TempCoef	2.47323E01	-5.12022E01	8.01822E00	-1.91647E01

**Parameter: Pressure**

**Giving these coefficients**

Index	0	1	2	3
R1Coef0	1.81362E01	3.58064E00	-2.53511E-01	1.36888E00
R1Coef1	1.13475E03	-1.25197E02	1.99698E01	-4.33252E01
R1Coef2	-2.13844E01	1.39107E01	1.66381E01	-3.57935E01
R1Coef3	3.03291E01	1.60961E01	-7.60110E01	1.90096E02
R1Coef4	3.38603E01	-3.96332E01	1.08305E02	-2.83762E02

Date: 14 Aug 2013

Sign:

Tor-Ove Kvalvaag, Calibration Engineer

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Figure 8-2 Example of Calibration Certificate.

## Appendix 1 Mechanical design of the sensors

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**Figure A 1 Sensor Housing**

Sensors 4117/4117R, 5217/5217R and 5218/5218R are housed in a cylinder of ABS/PC, Sensor Fott and Pressure port is made of Titanium.

The sensor foot holds the electrical connector and O-rings for bulk head mounting. The pressure port at the other end is equipped with a Swagelok™  $\frac{1}{8}$  inch compression fitting, allowing easy connection to calibration and test equipment.

In order to avoid clogging and internal corrosion, the pressure inlet is filled with high viscous silicon oil to isolate the pressure element from Seawater.

## Appendix 2 Sensor construction

The sensor is designed to measure the pressure differential produced by a head of water above the instrument and an absolute reference pressure. The pressure element is based on a piezoresistive bridge. This bridge consists of 4 resistors implemented on a silicon diaphragm. One side of the diaphragm is exposed to the water pressure, while the low pressure side faces a vacuum chamber.

When the diaphragm is flexed by the pressure the resistance of the bridge circuit will change. By applying a constant voltage over the bridge, a voltage that varies with the pressure is generated. This voltage is sampled by a high resolution analogue to digital converter (ADC) controlled by a digital signal processor (DSP). A thermistor sensing the water temperature is also incorporated in the sensor and sampled by the ADC.

All pressure transducers have a temperature drift. By calibrating the sensor at different temperatures, the drift can be estimated. The DSP stores the data from the calibration and are thus able to temperature compensate sampled pressure data, as well as convert the data to linear calibrated data in engineering units.

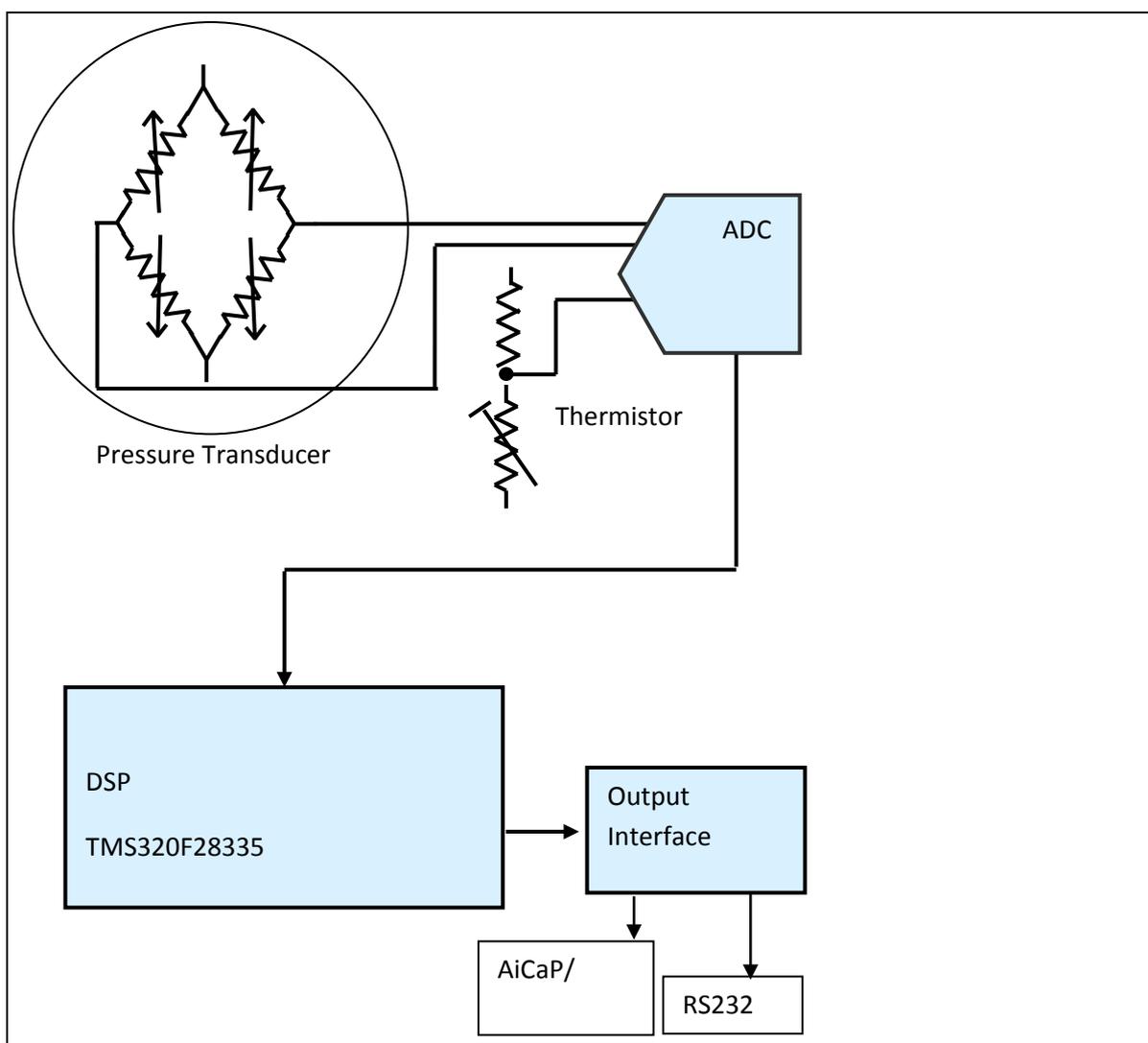


Figure A 2 Functional Diagram

## Appendix 3 Calculating engineering values from raw data

Sensor calibration coefficients, Temp coeffs, PT coeffs 0, PT coeffs 1, PT coeffs 2, PT coeffs 3 and PT coeffs 4 are stored inside the sensor. The coefficients are available as output from the sensor, refer Table 1-2 and Figure A3.

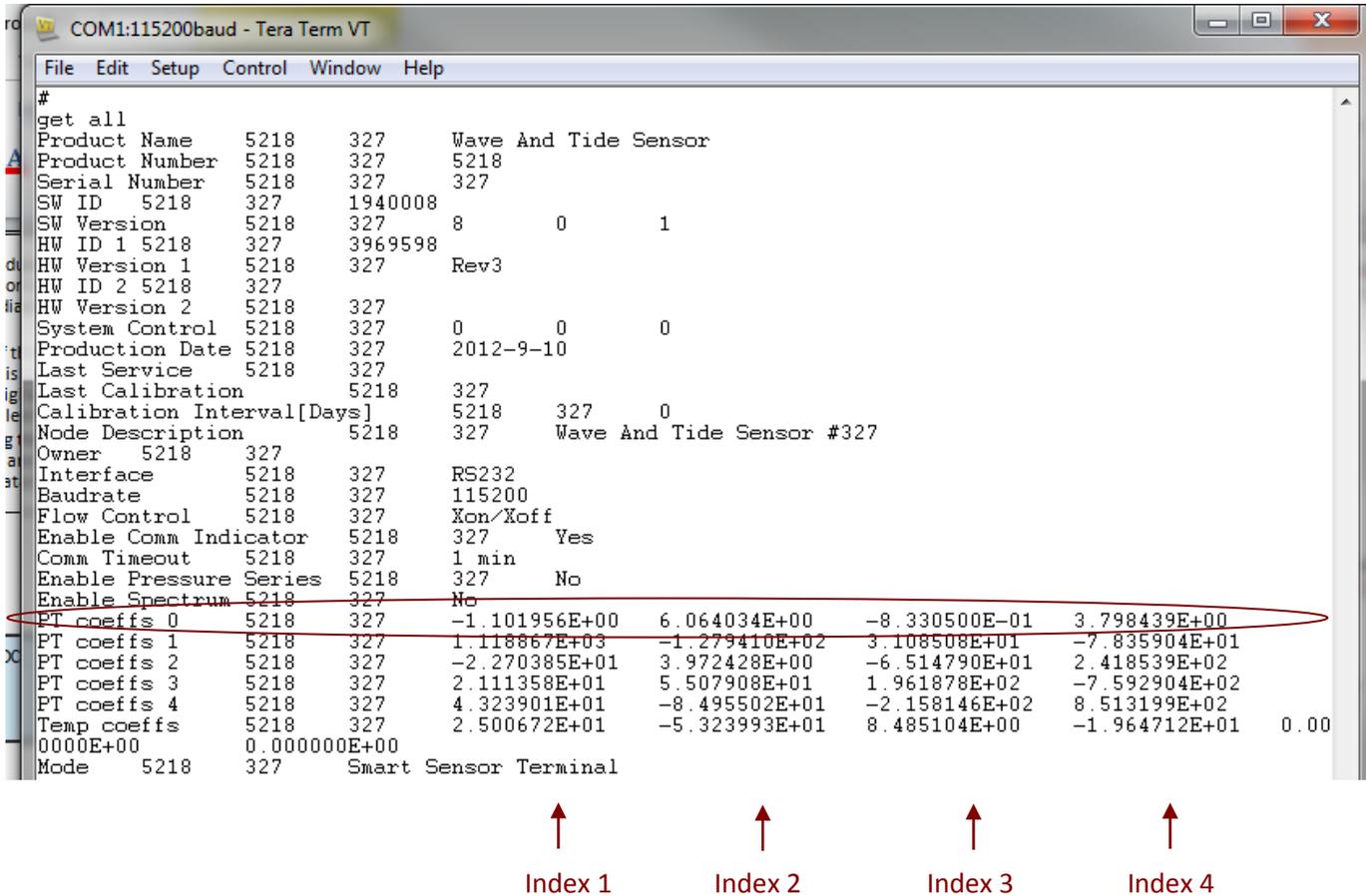


Figure A 3 Sensor calibration coefficients properties are available as sensor output.

Each coefficient holds a set of 4 values, e.g. PT coeffs 0<sub>1</sub>, PT coeffs 0<sub>2</sub>, PT coeffs 0<sub>3</sub>, PT coeffs 0<sub>4</sub>.

The engineering data are calculated from the raw sensor readings and these calibration coefficients using the following equations:

### Temperature:

Temperature = TempCoeffs<sub>0</sub> + TempCoeffs<sub>1</sub>·T<sub>Norm</sub> + TempCoeffs<sub>2</sub>·T<sub>Norm</sub><sup>2</sup> + TempCoeffs<sub>3</sub>·T<sub>Norm</sub><sup>3</sup>, where

$$T_{Raw} = \text{RawdataTemp}$$

$$T_{Norm} = \frac{T_{Raw}}{8388608} - 1$$

**Pressure:**

$$\text{Pressure} = C_0 + C_1 \cdot P_{\text{Norm}} + C_2 \cdot P_{\text{Norm}}^2 + C_3 \cdot P_{\text{Norm}}^3 + C_4 \cdot P_{\text{Norm}}^4$$

where

$$P_{\text{Raw}} = \text{RawdataPressure}$$

$$P_{\text{Norm}} = \frac{P_{\text{Raw}}}{8388608}$$

$$C_0 = \text{PTCoeffs0}_0 + \text{PTCoeffs0}_1 \cdot T_{\text{Norm}} + \text{PTCoeffs0}_2 \cdot T_{\text{Norm}}^2 + \text{PTCoeffs0}_3 \cdot T_{\text{Norm}}^3$$

$$C_1 = \text{PTCoeffs1}_0 + \text{PTCoeffs1}_1 \cdot T_{\text{Norm}} + \text{PTCoeffs1}_2 \cdot T_{\text{Norm}}^2 + \text{PTCoeffs1}_3 \cdot T_{\text{Norm}}^3$$

$$C_2 = \text{PTCoeffs2}_0 + \text{PTCoeffs2}_1 \cdot T_{\text{Norm}} + \text{PTCoeffs2}_2 \cdot T_{\text{Norm}}^2 + \text{PTCoeffs2}_3 \cdot T_{\text{Norm}}^3$$

$$C_3 = \text{PTCoeffs3}_0 + \text{PTCoeffs3}_1 \cdot T_{\text{Norm}} + \text{PTCoeffs3}_2 \cdot T_{\text{Norm}}^2 + \text{PTCoeffs3}_3 \cdot T_{\text{Norm}}^3$$

## Appendix 4: Calculations of wave parameters (5218/5218R)

---

Raw Wave data are simply the pressure measured at the location of the instrument.

The pressure changes according to changes in distance between the surface and the instrument. As the distance increases, the pressure increases. As the distance decreases, the pressure decreases.

The wave parameters are calculated from wave records containing  $2^N$  samples where  $N = 8, 9, 10, 11$ . The pressure is sampled at either 2 or 4 Hz so that the duration of the wave records ranges from 64 seconds to 17 min (1024 seconds)

### Processing of raw data

In general, the measured water pressure consists of a hydrostatic and dynamic components:  $P = (\rho gh + P_{atm}) + P_{dyn}$

The dynamic part is due to surface wave motion. To reveal the dynamic pressure, the measured time series are pre-processed in a two-step manner:

First, the contribution from the atmospheric pressure,  $P_{atm}$ , to the absolute pressure is subtracted from the samples. In AiCaP CANbus mode, the sensor uses the fixed atmospheric pressure set by the user in *Sensor Configuration*, refer chapter 5. In RS232/RS422 the atmospheric *Air Pressure* is a property that must be set by the user, refer e.g. chapter 6.

Second, the hydrostatic pressure is calculated by subtracting the atmospheric pressure from the time series samples. The hydrostatic pressure is used to calculate the deployment depth.

### Calculation of Wave Spectrum:

The dynamic pressure time series are used to calculate the wave spectrum. This involves Fourier transformation of the time series using a Fast Fourier Transform (FFT) algorithm and scaling of the power spectrum to compensate for the damping of the dynamic pressure.

### Power Spectrum Scaling:

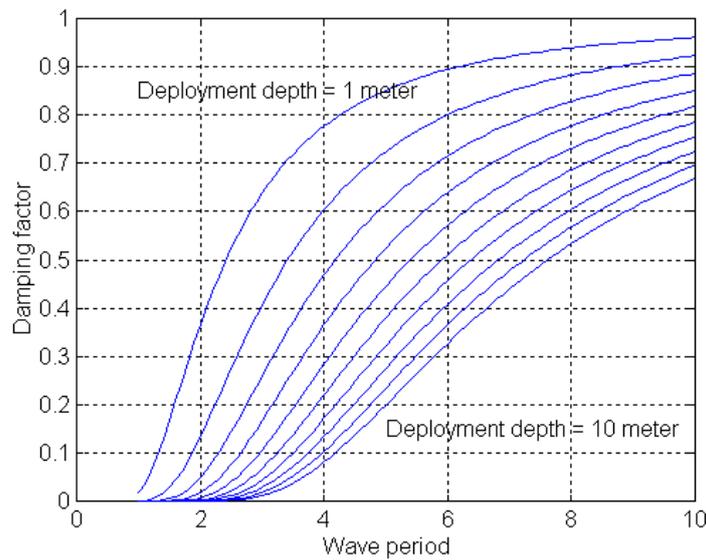
The wave motion at the sea surface causes a dynamic pressure that can be measured using a pressure sensor deployed somewhere between the seabed and the sea surface. The magnitude of the observed dynamic pressure depends on the surface wave period and the sensor deployment depth.

The deeper the sensor is deployed the more the dynamic pressure is damped. The shorter the surface wave period the faster the damping of the dynamic pressure. Hence, the power spectrum must be scaled to correct for the

difference between the true dynamic pressure and the observed dynamic pressure before the wave parameters can be calculated.

The damping of the dynamic pressure can be described by the Linear Wave Theory (sometimes known as the Airy Wave Theory). Figure A 4 illustrates the damping of the dynamic pressure as a function of the wave period in [m] and of the deployment depth. A small damping factor means that the dynamic pressure is significantly damped, while less damped when the damping factor is larger; as the damping factor approaches 1, the observed dynamic pressure approaches the true dynamic pressure.

To compensate for the damping of the dynamic pressure, the power spectrum is multiplied with a transfer function that is the inverse of the function describing the damping of the dynamic pressure.



**Figure A 4 Damping of the dynamic pressure in deep water as a factor of wave period and deployment depth.**

**Linear Wave Theory:**

The Linear Wave Theory provides a number of equations that can be applied to compute wave properties as e.g. significant wave height, mean zero crossing and mean wave period.

**Wave Spectrum:**

The magnitude of one frequency component of the power spectrum is proportional to the square of the amplitude of the signal with the very same frequency. That is, if the wave is a pure sine wave with amplitude  $a$ , the magnitude of the spectrum component with the same frequency as the sine wave, is  $a^2$ . The wave energy is given as:

$$E = \frac{\rho g H^2}{8} = \frac{\rho g a^2}{2}$$

where  $\rho$  is the medium density,  $g$  is the gravitational coefficient and  $H$  is the wave height. The wave spectrum calculated by the WTS are scaled in this manner.

**Spectral Moments:**

A number of *spectral moments* are calculated based on the wave spectrum. Next, these spectral moments are used to compute wave parameters. The spectral moments are defined as follow:

$$m_n = \sum_{i=0}^N f_i^n S(f_i)$$

where  $f_i$  is a specific frequency and  $S(f_i)$  is the wave spectrum component at that frequency. Hence, the moment of order zero,  $m_0$ , is found by summing the wave spectrum components from zero frequency up to the cut-off frequency.

Based on the above considerations and the definition of the spectral moments, the moment of order zero is equal to:

$$m_0 = \sum_{i=0}^N \frac{a_i^2}{2}$$

Assuming that  $X$  is a simple sinusoidal wave with amplitude  $a$ , the sampled values  $X_i$  are:

$$X_i = a \sin(y_i)$$

The variance,  $\sigma$ , of  $X$  is:

$$\sigma^2 = E(X_i - \mu)^2 = E(a \cdot \sin(y_i))^2 = \frac{a^2}{2}$$

where  $E$  denotes the expectation and  $\mu$  is the average of  $X$  ( $\mu = 0$  for an ideal sine wave). The wave motion can be modelled as a superposition of simple sinusoidal waves. Hence, the individual spectral components in the wave spectrum can be seen as the variance of individual sinusoidal waves with different frequencies. The zero order spectral moment,  $m_0$ , which then is the sum of the variances of the individual spectral components, can be seen as the total variance of the wave record.

### Cut-off Frequency:

The WTS is applicable for studies of waves with wave period as small as 1 second without aliasing, according to the Nyquist theorem. However, the dynamic pressure caused by waves with short wave period is damped rapidly with depth, see Figure A , hence the WTS calculates a cut-off frequency based on the deployment depth as measured by the pressure sensor<sup>6</sup>:

$$f_{Cut-Off} = 0.282 \cdot \sqrt{\frac{g}{d}}$$

where  $g$  is the gravitational coefficient and  $d$  the deployment depth.

### Calculation of Wave parameters

The sea conditions can be described by a number of wave parameters, like e.g.

- Significant Wave Height
- Maximum Wave Height
- Mean Zero Crossing
- Peak Wave Period
- Mean Wave period
- Energy Wave Period
- Irregularity
- Wave Steepness

These parameters are provided by the WTS, and will be described below. For more information regarding the wave parameters, see the '*Guide to Wave Analysis and Forecasting*', World Meteorological Organization (WMO) report number 702.

<sup>6</sup> IEEE Journal of Oceanic Engineering, VOL 26, No2, April 2001, p 171-180

**Significant Wave Height:**

Originally, Significant Wave Height,  $\bar{H}_{1/3}$ , was defined as the average height of the 1/3 highest waves in a wave record.  $\bar{H}_{1/3}$  should roughly approximate to visually observed wave heights.

The wave energy for a superposition of sinusoidal waves is given as:

$$E = \frac{\rho g}{8} \sum_{i=0}^N H_i^2 = \rho g \sum_{i=0}^N \frac{a_i^2}{2}$$

Comparing this equation with the expression for the moment of zero order,  $m_0$ , it is easily seen that an expression for the wave height can be estimated.

For historical reasons a parameter that corresponds close to  $\bar{H}_{1/3}$  has been defined:

$$H_{m_0} = 4\sqrt{m_0}$$

Note that both  $\bar{H}_{1/3}$  and  $H_{m_0}$  are called Significant Wave Height. The parameter provided by the WTS is  $H_{m_0}$ .

**Maximum Wave Height:**

The expected Maximum Wave Height is estimated based on the statistical distribution of the wave height parameter. Assuming that the sea surface can be modelled as a narrow-banded Gaussian Process, the standard model is a wave amplitude distribution based on the Rayleigh's distribution. This yields the following estimate of the Maximum Wave Height:

$$H_{Max} = C_1 \sqrt{\ln(R_{MD})} = \sqrt{0.5 \cdot \ln(R_{MD})}$$

where  $C_1$  is a scaling parameter and  $R_{MD}$  is equal to the ratio of the *Mean Wave Period* and the *Duration of wave record* (the number of waves in the wave record). The WTS uses the above expression for calculation of the maximum wave height.

**NOTE!** *The assumptions regarding the scale parameter,  $C_1$ , and the statistical distribution will influence the estimate of the maximum wave height.*

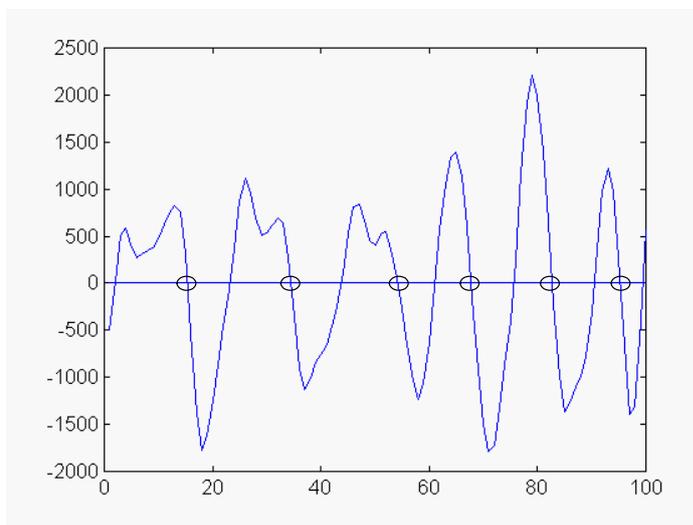
**Mean Zero Crossing Period:**

The Mean Zero Crossing Period is originally directly computed from the wave records. It is defined as the record length divided by the number of down-crossings (or up-crossings) in the record.

The Mean Zero Crossing Period is defined as:

$$T_{m02} = \sqrt{\frac{m_0}{m_2}}$$

According to WMO, the wave period  $T_{m02}$  is sensitive to the cut-off frequency in the calculations of the spectral moments. Refer to NOTE on page 71.



**Figure A 5 Part of a wave record. Zero down-crossings are circled.**

**Peak Wave Period:**

The Peak Wave Period,  $T_{wp}$ , is equal to the inverse of the frequency of the peak of the wave spectrum:

$$T_{wp} = \frac{1}{f_{wp}}$$

where  $f_{wp}$  is the frequency of the peak of the wave spectrum. Hence, the Peak Wave Period is the period of the wave that dominates the wave motion, assuming that the wave motion can be modelled as a superposition of waves. Refer NOTE on page 71.

**Mean Wave Period:**

The Mean Wave Period is defined as:

$$T_{m01} = \frac{m_0}{m_1} = \frac{\sum_i S(f_i)}{\sum_i f_i S(f_i)}$$

From this equation it can be seen that the mean wave period,  $T_{m01}$ , is the inverse of the weighted average frequency of the spectrum and hence a measure of the average period of the wave motion. Refer NOTE on page 71.

**Energy Wave Period:**

The Energy Wave Period is defined as:

$$T_{m-10} = \frac{m_{-1}}{m_0}$$

The Energy Wave period is used in calculations of the wave power in [kW/m] of wave fronts. The wave power is given as:

$$J = 0.49 \cdot H_{m0}^2 \cdot T_{m-10}$$

Refer NOTE on page 71.

**Regularity:**

When studying the wave parameters provided e.g. by the WTS, note that the motion of the sea surface caused by the waves is a random process.

Significant wave height is for example a measure of the average wave height. The height of many, if not most, of the waves in a record will differ from the significant wave height. The more irregular the sea state, the broader the wave spectrum. A measure of the peakedness of the spectrum, and correspondingly of the regularity of the sea is:

$$Q_p = \frac{2}{m_0^2} \int_0^{\infty} f \cdot S^2(f) df \approx \frac{2}{m_0^2} \sum_0^N f_i \cdot S^2(f_i)$$

Generally, a calm sea gives a narrow/peaked spectrum and a high  $Q_p$  factor; an irregular sea will give a broader spectrum and a lower  $Q_p$  value.

**Wave Steepness:**

Wave Steepness is generally defined as:

$$\xi = \frac{H}{\lambda}$$

where H is wave height. Replacing wavelength with wave period using the equation given by the linear wave theory the wave steepness becomes:

$$\xi = \frac{2\pi H}{gT^2}$$

The WTS uses  $H_{m0}$  and  $T_{m01}$  for wave height and wave period.

According to Stokes theory, waves cannot attain heights of more than 1/7 of the wavelength without breaking.

*Note! Additional information about the four parameters Mean Zero Crossing Period, Peak Wave Period, Mean Wave Period and Energy Wave Period: If the pressure variations caused by the waves are smaller than what can be measured by the pressure sensor, the estimated wave periods will approach  $1/f_{cut-off}$ . This will happen e.g. if the instrument is deployed too deep to monitor the current sea state.*

**Spectrum and pressure series**

The spectrum is presented as the value of each frequency component in the wave spectrum. Spectre components outside of the calculated *cut-off* frequencies are set to 0. The first frequency component in the spectrum is 0 Hz.

**Table A 1 Access protection levels**

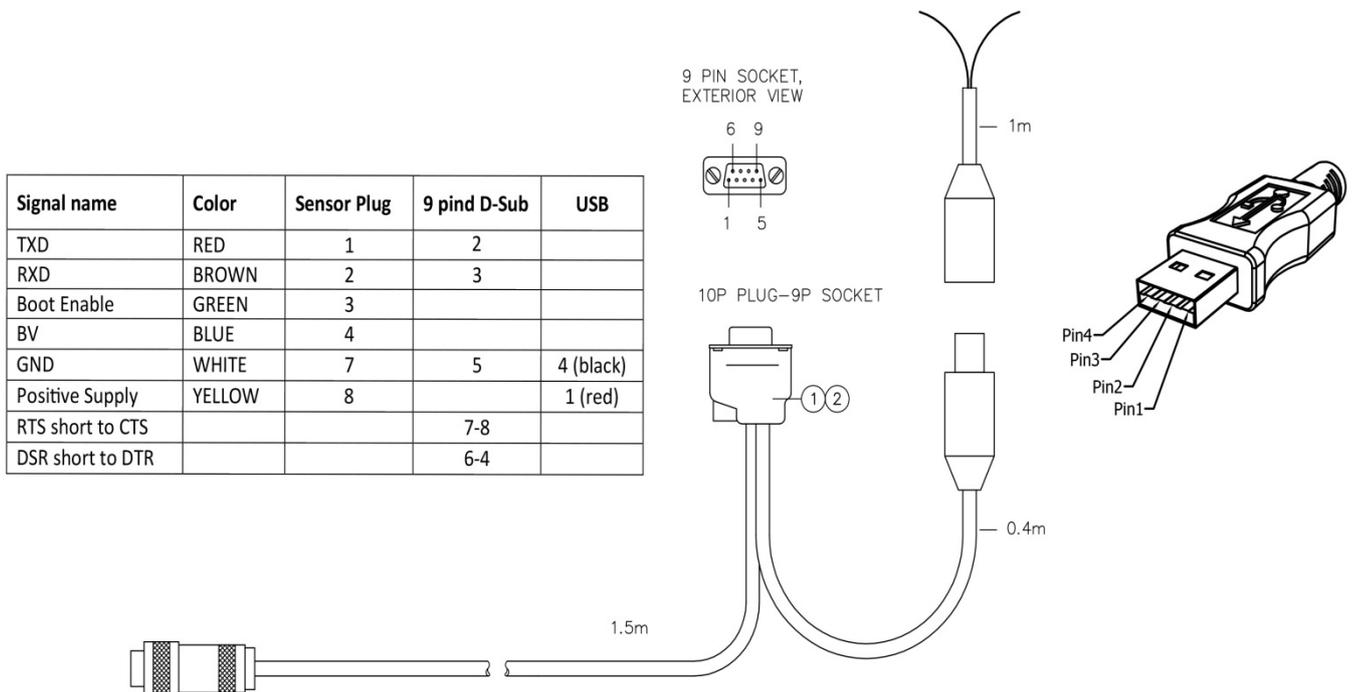
Number of Samples	Number of freq. components	Resolution at 2 Hz sampling	Resolution at 4 Hz sampling
256	128	0.0078125 Hz	0.015625 Hz
512	256	0.00390625 Hz	0.0078125 Hz
1024/2048	512	0.001953125 Hz	0.00390625 Hz

The pressure series can be used as raw data input for e.g. other spectra or wave calculations. The Last Pressure Sample Index parameter is the index of the last element in the pressure series. It tells how many continuous samples the sensor has collected. Depending on the recording Interval setting there can be overlap between the pressure series. The parameter makes it easy to remove duplicated data (overlap) and generate continuous pressure samplings at 2 or 4 Hz. Continuous pressure samplings can be used for e.g. tsunami warning systems. If samplings are not performed during the entire recording interval, the Last Pressure Sample Index will be reset for each recording and the value will be the Number of Samples setting plus a few samples in the beginning that are not used.

## Appendix 5 Illustrations

Figure no.	Description	For use with	
		4117/5217/5218	4117R/5217R/5218R
Figure A 6	Set up and configuration Cable 3855, RS-232	X	
Figure A 7	Set up and configuration Cable 4865, RS-232	X	
Figure A 8	Set up and configuration Cable 4799, RS-422		X
Figure A 9	Free end Cable 4762, Rs-232	X	X
Figure A 10	Free end Cable 4763, Rs-422		X
Figure A 11	Free end Cable 3880	X	X
Figure A 12	Remote Sensor Cable 4793, AiCaP	X	
Figure A 13	Patch Cable 4999, AiCaP	X	

**Table A 2 Access protection levels**



**Figure A 6 Set up and configuration cable 3855, for laboratory use.**

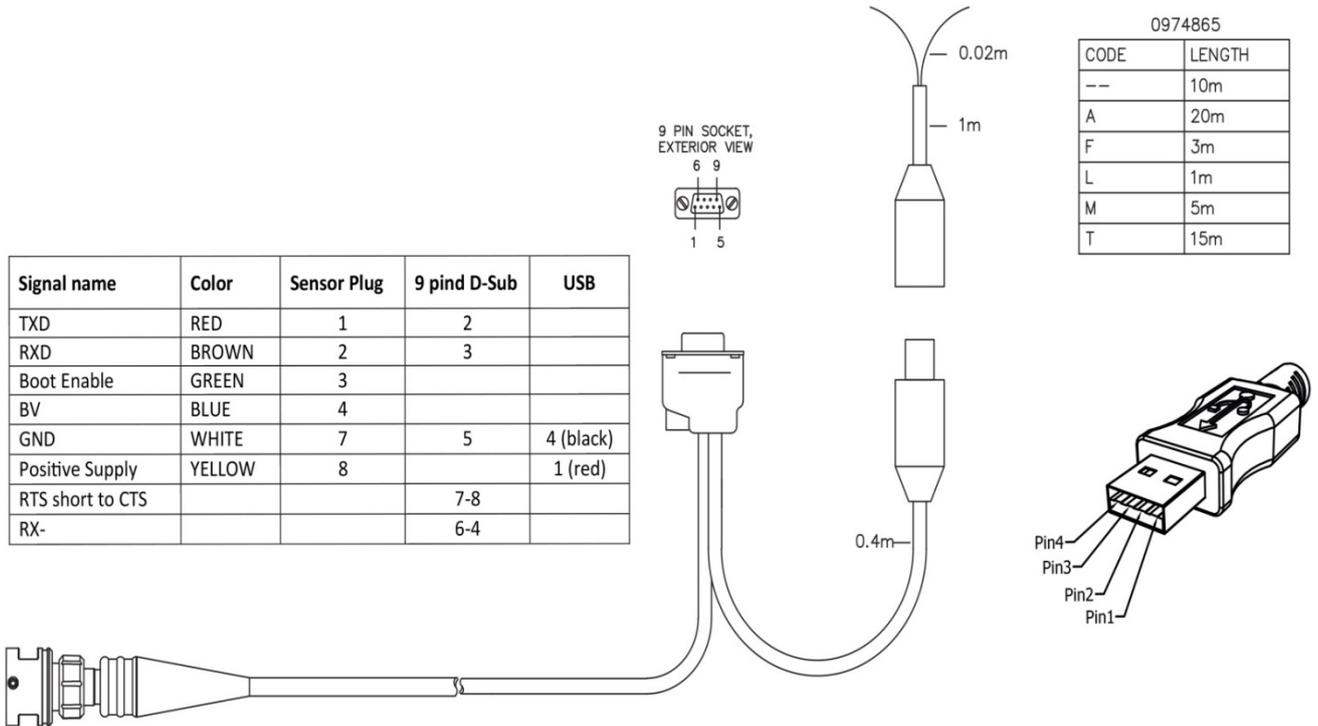


Figure A 7 Set up and configuration cable 4865, RS-232 for field use.

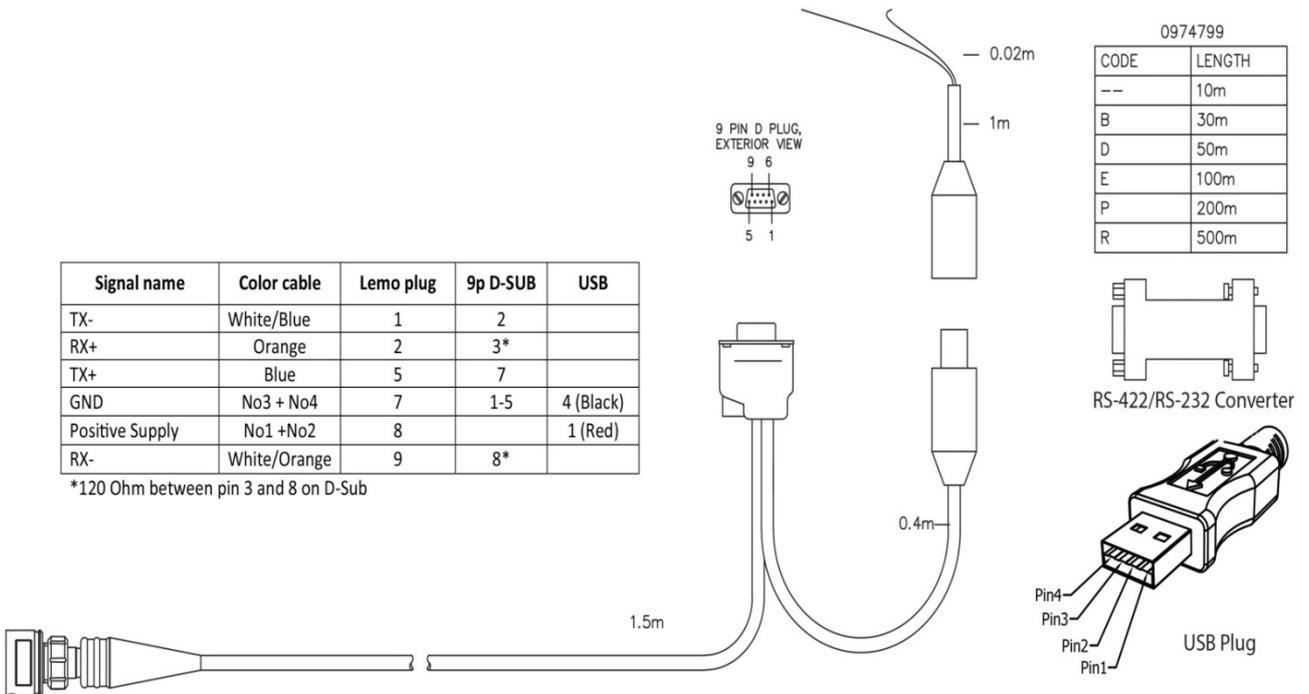
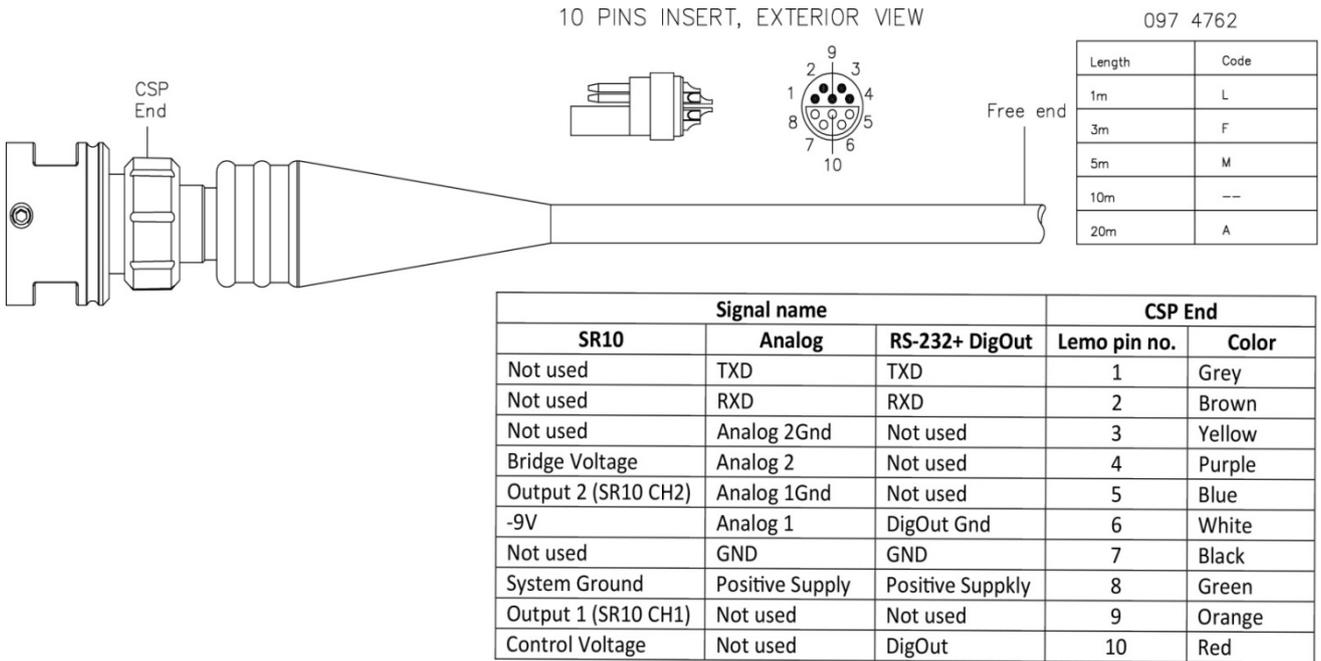
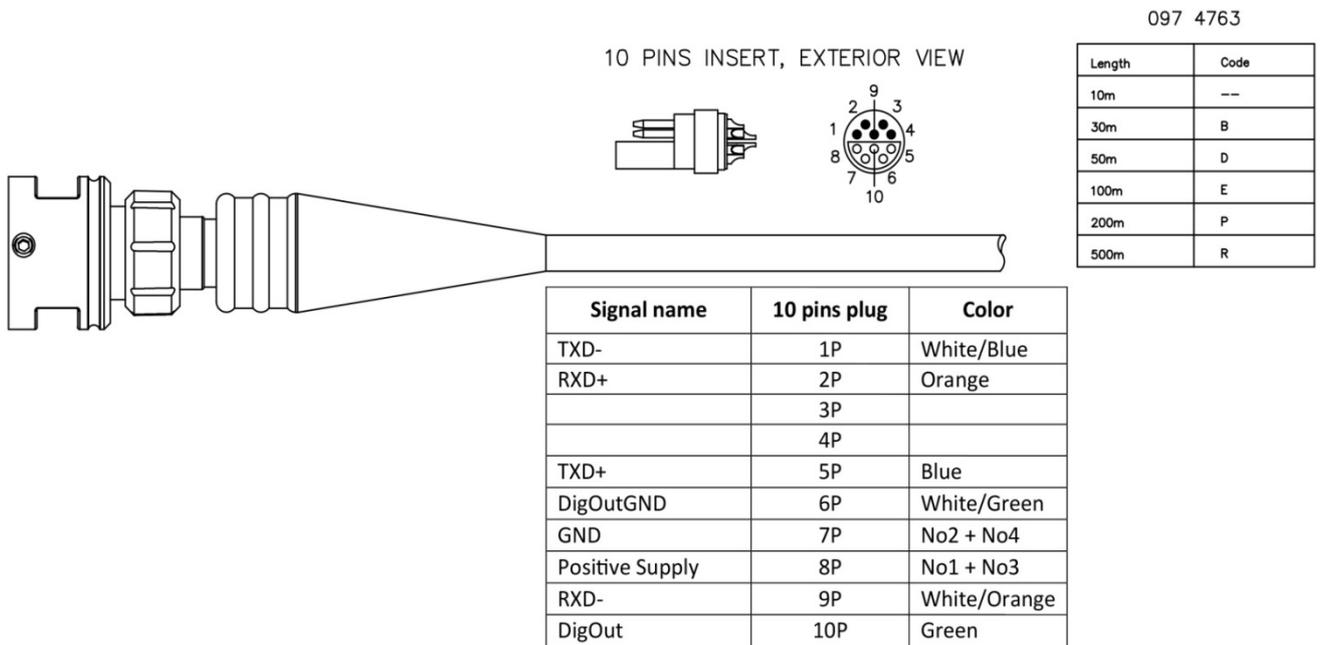


Figure A 8 Set up and configuration cable 4799, RS-422 for field use.



**Figure A 9 Drawing Free end Cable 4762, RS-232**

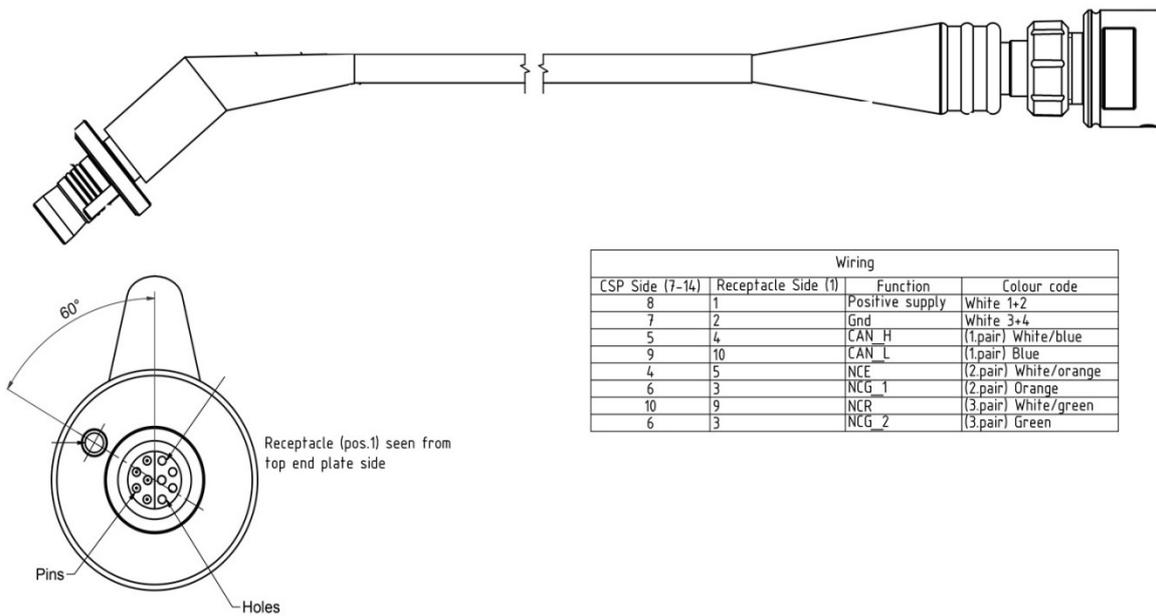


**Figure A 10 Drawing Free end Cable 4763, RS-422**



Signal name	Color	10P Insert Plug
Control Voltage	GREEN	10
TXD	BLUE	1
RXD	VIOLET	2
BV	GREY	4
GND	WHITE	7
Positive Supply	BLACK	8

Figure A 11 Drawing Free end Cable 3880



Wiring			
CSP Side (7-14)	Receptacle Side (1)	Function	Colour code
8	1	Positive supply	White 1+2
7	2	Gnd	White 3+4
5	4	CAN H	(1.pair) White/blue
9	10	CAN L	(1.pair) Blue
4	5	NCE	(2.pair) White/orange
6	3	NCG 1	(2.pair) Orange
10	9	NCR	(3.pair) White/green
6	3	NCG 2	(3.pair) Green

Figure A 12 Drawing Remote Sensor Cable 4793, AiCaP

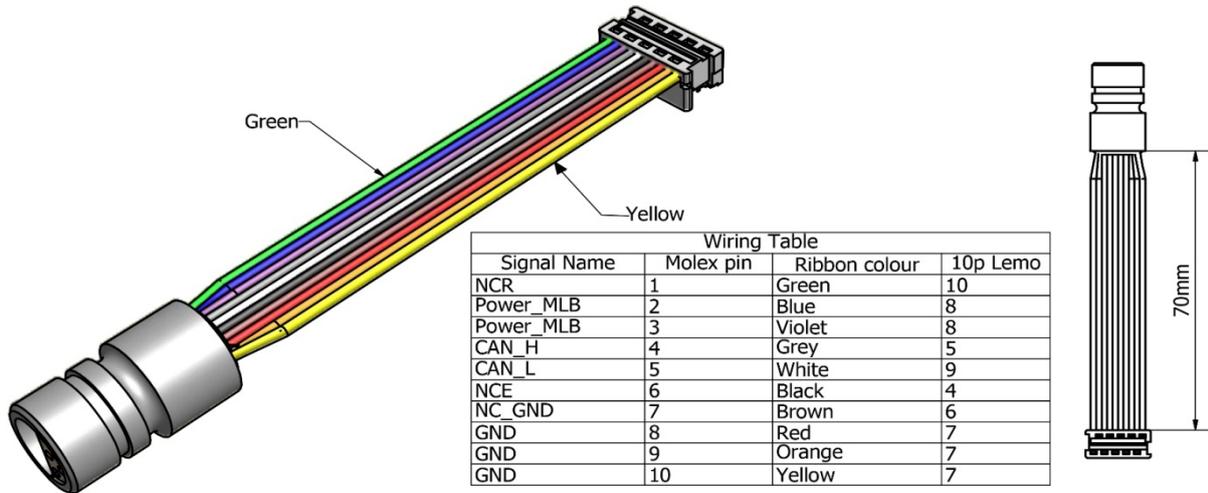


Figure A 13 Drawing Patch Cable 4999, AiCaP

## Appendix 6 Product change notification: Frame Work3

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Copy of content in Product Change Notification Document ID: DA-50009-01 of date 09 December 2011:

### Product(s) Affected:

Product Number	Product Name	From Serial No.
4050	Temperature Sensor	300
4060	Temperature Sensor	500
4017	Pressure Sensor	700
4117	Pressure Sensor	600
4319(A/B)	Conductivity Sensor	800
4330(F/A)	Oxygen Optode	1000
4420	ZPulse® Doppler Current Sensor	500
4520	ZPulse® Doppler Current Sensor	600
4117(R)	Pressure Sensor	600
5217(R)	Tide Sensor	600
5218(R)	Wave and Tide Sensor	600
4830	ZPulse® Doppler Current Sensor	100
4835	Oxygen Optode	300
4930	ZPulse® Doppler Current Sensor	100
4880(R)	Temperature Sensor	200
4930	ZPulse® Doppler Current Sensor	100

### General Change Description:

Most of AADI's Smart Sensors utilized common communication protocols for use at the RS232 and RS422 interface. Two protocols are available; Smart Sensor Terminal protocol and the AADI Real Time protocol, where the Smart Sensor Terminal protocol is a simple ASCII command string based protocol and the AADI Real Time is an XML based protocol. To accommodate for higher security and future expansions both protocols will be updated when releasing Sensor Framework version 3 (common software for the above sensors). This notification aim is to give an overview of the changes in the Smart Sensor Terminal protocol. Please refer to the equipment specific Operating Manuals for further details and to Technical Description TD267a for updates in the AADI Real Time protocol.

### Specific Changes:

1. Input command line termination is changed from line feed (LF) with optional carriage return to line feed and mandatory carriage return (LF+CR).
2. 'Do Stop' and 'Do Start' command changed to 'Stop' and 'Start'
3. All units in output string changed from '(' and ')' type parenthesis to '[' and ']' type, example [hPa].
4. The Sleep indicator ('%') and the Wakeup indicator ('#') is replaced by a Communication Sleep ('%') indicator and a Communication Ready ('!') indicator. A property called 'Enable Comm Indicator' can be used for enabling/disabling of these characters.
5. Polled mode is no longer enabled by setting the interval to zero (Set Interval(0) is now illegal). A property called Enable Polled Mode is now used for controlling polled/non-polled mode.
6. The 'Output' property is substituted by a 'Mode' property for changing the operation mode, for example; 'Set Mode(Smart Sensor Terminal)'. Specific properties control the formatting of the output string, for example 'Set Enable Text(no)'.  
7. The startup notification (at power up) is changed from 'Mode <Mode name>' to the following format: 'StartupInfo <Product No.> <Serial no.> Mode <Protocol Name> Version <Version No.> Config Version <Version No.>', for example; 'StartupInfo 4330 83 Mode AADI Smart Sensor Terminal Protocol RS232 Protocol Version 3 Config Version 6'
8. The startup notification will be switched off when the 'Enable Text' property is set to 'no'.
9. A '\*' will precede the parameter name if an error status related to the specific parameter occur. This applies for example to the tide parameter of the Wave an Tide Sensor before the sample base is complete : '\*Tide Pressure[kPa] 0.000000E+00'

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