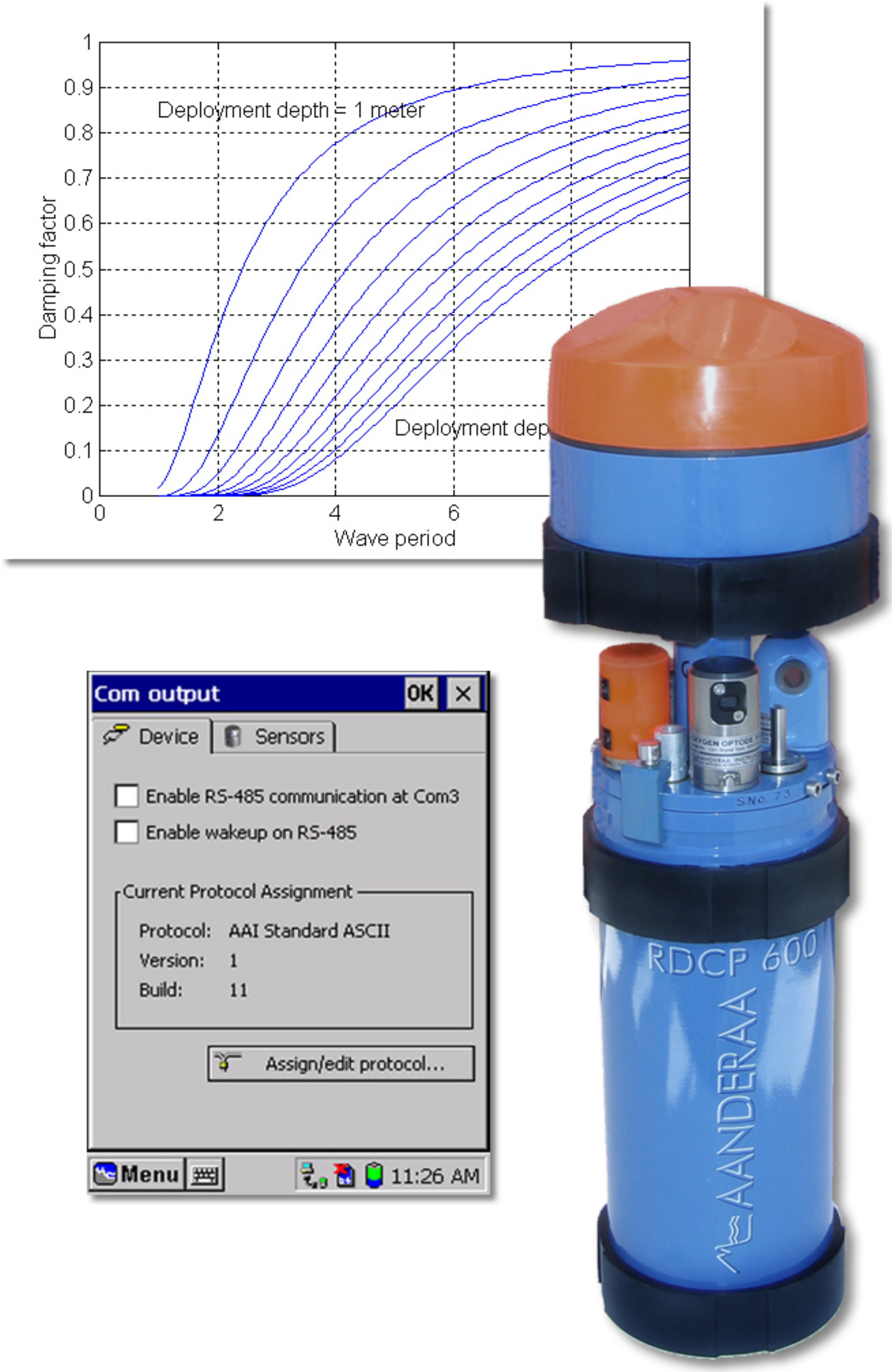
TD 220c RDCP PRIMER



AANDERAA DATA INSTRUMENTS

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Contact information:

Aanderaa Data Instruments AS
PO BOX 34, Slåtthaug
5851 Bergen, NORWAY

Visiting address:
Nesttunbrekken 97
5221 Nesttun, Norway

TEL: +47 55 604800
FAX: +47 55 604801

E-MAIL: info@aadi.no

WEB: http://www.aadi.no

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INTRODUCTION

Purpose and scope

The RDCP Primer covers information about Real-Time Communication protocols, The theoretical background for the Instrument, Technical specifications, Information about Sensors, Calibration, Mooring frames, and Batteries. Some additional illustrations are given in the end of the Primer.

References

- RDCP600 Deployment Guide, TD220a
- RDCP600 Studio, TD220b

Abbreviations

AAI SP	AAI Standard RS-232/485 based protocol
ASCII	American Standard Code for Information Interchange
CF card	Compact Flash Card
LCD	Liquid Crystal Display
MIPS	Millions of Instructions Per Second
MMC	Multi Media Card
PDC-4	Pulse Duration Code 4 seconds
RDCP	Recording Doppler Current Profiler

Definition of terms

<CRLF>	Carriage Return Line Feed. These are the two ASCII character values 0x0D and 0x0A
<TAB>	Tabulator character (ASCII number 0x09)
0xNNNN..NNN	A number denoted with 0x is a hexadecimal integer

CHAPTER 1 Theoretical Primer

The Doppler Technique

This chapter gives a basic and simplified theoretical background to modern Doppler Current Profilers with a focus on the RDCP600.

The Doppler Principle

Doppler current profilers measure water velocity using a principle of physics discovered by Christian Johann Doppler (1842). Doppler's principle relates the change in frequency of a source to the relative velocities of the source and the observer. Doppler stated his principle in the article, '*Concerning the coloured light of double stars and some other constellations in the heavens*' while working in Prague. The Doppler principle can be simply described using a water-wave analogy.

A stationary observer is watching a series of waves passing at a rate of one wave per second (analogous to a transmit frequency of 1 Hz). When the observer is boating towards the wave source at a rate of 2 wavelengths per second he notices the passage of 3 waves each second. Consequently, he senses that the rate of the passing waves is 3 Hz, although the wave source is still emitting waves at 1 Hz.

Knowing the exact source frequency, f_s, the speed of sound, c, the velocities of the observer, v_O, and the source, v_S, the Doppler shifted frequency, f_D, can be calculated:

$$f_D = f_s \left(\frac{c + v_o}{c - v_s} \right) \qquad \textbf{Eq. 1}$$

The signs indicate that the source and observer move towards each other.

Doppler shifts using acoustic scatterers

A Doppler current profiler applies the Doppler principle by acting both as source and receiver while bouncing short pulses of acoustic energy off small particles, plankton and air bubbles (in this context called scatterers) that are mostly present in the sea. When the scatterers move towards the source, the sound (if it could be perceived by the scatterers) shifts to a higher frequency. Part of this Doppler-shifted sound is backscattered towards the source, as if the scatterers were the sound source. In this case the sound is shifted one time as perceived by the scatterers and a second time as perceived by the current profiler transducers. Assuming that the velocity of the observer and of the source is much smaller than the speed of sound, $v_O << c$ and $v_s << c$ the resulting equation for the Doppler Shift is:

$$\Delta f = 2 f_S \frac{v_O}{c} \qquad \textbf{Eq. 2}$$

Example:
With a 600 kHz transducer and scatterers moving with 1 cm/s, the Doppler shift is:

$$\Delta f = 2 \cdot 600e^3 Hz \frac{0.01 \;\; m/s}{1500 \;\; m/s} = 8 \;\; Hz$$

Geometry of Doppler Current Profilers

Doppler Current Profilers usually consist of 3 or 4 transducers acting both as transmitters and receivers. The transducers are oriented 90° in azimuth from each other and with a 20 - 30° angle to the vertical mounted on a sylindrical shaped hosing containing the electronics. This configuration of beams is the so-called ‘Janus’ configuration, named after the Greek God, Janus, who could simultaneously look forwards and backwards. The configuration is particularly good for rejecting errors in horizontal velocity caused by instrument tilting since the two opposing beams allow vertical velocity components to cancel when computing horizontal velocity. Also, pitch and roll cause velocity errors proportional to the sine of the pitch and roll. The four beams allow for estimation of two perpendicular horizontal velocities and two vertical velocities. The direction of the vertical current is defined as positive upwards. Actually, the fourth beam is redundant but allows for an evaluation of whether the assumption of horizontal homogenity (as described below) is reasonable, comparing the four vertical velocity estimates.

Functioning of Doppler Current Profilers

The four transducers transmit short pulses (pings) of acoustic energy along narrow beams, ensonifying a water volume determined by the distance along the beam, the width of the beam and the pulse duration.

Due to the presence of scatterers in the water, a fraction of the transmitted energy is backscattered towards the instrument at succesive times after transmission representing succesively increasing distances from the transducers.

The frequency of the backscattered signals are Doppler shifted proportional to the average radial (alongbeam) relative velocity between the scatterers and the transducers.

The backscattered signals are used for calculation of the current speed and direction. For this technique to be valid, some assumptions must be fulfilled:

1. The scatterers must float ambiently with the water currents.

2. The water motions must be of a large scale compared to the separation of the beams (horizontal homogenity of the water).

3. The water motions must be of a large scale compared to the length of the transmitted puls (vertical homogenity of the water).

The first assumption is critical since the water movement is represented by the movement of the scatterers in the water volume. It is essential that the scatterers do not move by themselves differently from the water current.

The other assumtions are less critical. The calculated water current and speed from two pairs of beams are averaged into representing a water column just above the instrument. Thus the instrument provides a 3-dimentional velocity vector at specified cells (specified distances from the instrument) of the water column. The RDCP 600 is equipped with a Compass Tilt sensor, hence the vector can be referenced to earth.

Processing

An RDCP 600 transmits a single tone burst of duration T_p. The returned signal is compared to the transmitted pulse at a fixed time lag T_L (correlation).

The weaker the correlation the noisier the data, which means less precision in the velocity estimate.

The standard deviation, σ, of an ensemble of pings is:

$$\sigma = \frac{A}{f_S\sqrt{D \cdot P_L}}\frac{1}{\sqrt{N_p}} \qquad \textbf{Eq. 3}$$

where N_p is the number of pings, D is the cell size, P_L is the pulselength. The pulselength is usually set equal to the cell size. The constant, A, is system dependent and thus semi-empirical.

Signal bandwidth and Velocity uncertainty

The primary function of a Doppler current meter is to measure the frequency shift, or change of phase with time, of the backscattered signals. The returned signals have a spectrum of a certain bandwidth centred around f_D, the Doppler frequency.

Two main factors for this 'spectral spread' or 'spectral broadening' can be identified. One is the finite duration of the transmitted pulse. The spectrum bandwidth is of the order of the reciprocal of the length of the transmit pulse. The other is due to the cloud-like nature of the scatterers in the water.

Other sources of spectral broadening include the acoustic beam width and turbulence.

The beam width can broaden the spectrum because the relative angles of the velocity and the beam differ from one side of the beam to the other which cause the Doppler shifts to differ.

Paradoxically, very narrow beams decrease the residence time of the scatterers while moving through a cell. If the residence time is short compared to the transmit pulse duration, the spectral width will increase.

These last two effects are, however, proportional to the current velocity and are thus usually small for deployed instruments. It is believed that the precision of the frequency estimate is mostly affected by the nature of the scatterers within the scattering volumes.

The measured spectral width is therefore an indicator of velocity uncertainty. As the signal-to-noise ratio decreases near the end of the profile, the spectral width increases which translates directly into velocity uncertainty.

RDCP600 processing –ARMA model

The RDCP uses an Auto Regressive Moving Average (ARMA) model to estimate spectral properties of the backscattered signal.

The ARMA spectral estimation technique belongs to a family of spectral estimators called parametric models. They differ from non-parametric models, such as FFT, in that the Power Spectrum Density (PSD) is derived from the parametric model rather than from the time series itself.

The motivation for using parametric models of random processes is the ability to achieve better power spectrum estimation based on the model than that produced by classical spectral estimators. The models rely on some pre-knowledge about the process from which the data samples are taken. This information is used to construct a model that approximates the process that generated the observed time sequence.

The degree of improvement in resolution and spectral fidelity is determined by the appropriateness of the selected model, and the ability to fit the measured data with a limited set of model parameters.

Backscatter, Doppler based, current measurements produce random data with a known degree of randomness.

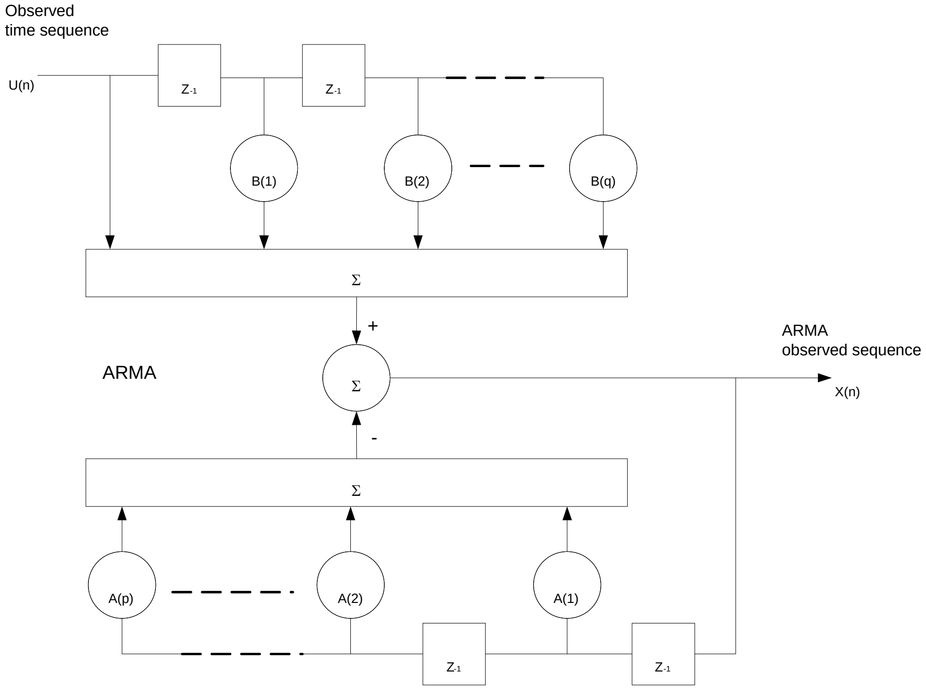
It is therefore possible to derive a parametric model that approximates these data. The model is fixed for the specific process, but the parameters of the model are derived for each set of data.

After having derived the actual parameters for a specific data set, the resulting transfer function is analysed, and key features such as resonance frequencies and phase shifts are used to calculate the major frequency content of the data set.

The processing power needed for ARMA processing increases rapidly as the number of model parameters increase. The

complexity of the model is therefore limited by the ability of the Digital Signal Processor (DSP) to perform these calculations in real-time.

The RDCP 600 employs a modern, low power DSP, capable of 400 million multiplications each second. This processing power, just recently available in low power systems, has opened up for rather sophisticated parametric models with a high degree of spectral resolution and accuracy.



Limitations

Physical and technical limitations of a Doppler Current Profiler:

- ❑ Precision in the estimation of the Doppler frequency.
- ❑ Influence of Acoustic Side lobes.
- ❑ Measurement Range.
- ❑ Blanking Distance.
- ❑ Random and Systematic errors.

The precision in the estimation of the Doppler frequency has been discussed previously. The other limitations are discussed in the following.

Influence of Acoustic Side lobes

Typically, the beam pattern of an acoustic transducer has one main lobe and a number of lower energy side lobes to both sides of the main lobe. A theoretical beam pattern (-30° to +30°) for a plane circular piston is given in **Error! Reference source not found.**, for illustration. It must be emphasized that the beam pattern for the RDCP 600 transducers differs from the illustration (Note: The beam pattern in **Error! Reference source not found.** is not representative for the RDCP 600).

The illustration has been derived from a plane circular piston of

$$ka = \frac{2 \cdot \pi}{\lambda} \cdot a = 20$$

where k is the wave number, λ is the wave length, and a is the radius of the piston. $ka = 20$ has been chosen for this example.

The main lobe is centred around 0°, the first set of side lobes are seen at approximately ±15° and the second set of side lobes at approximately ±25°. The level of the maximum signal in the first side lobe is approximately 17 dB lower than the maximum signal in the main lobe. The higher the *ka*-value, the narrower the main lobe, and the side lobes appear closer to the main lobe.

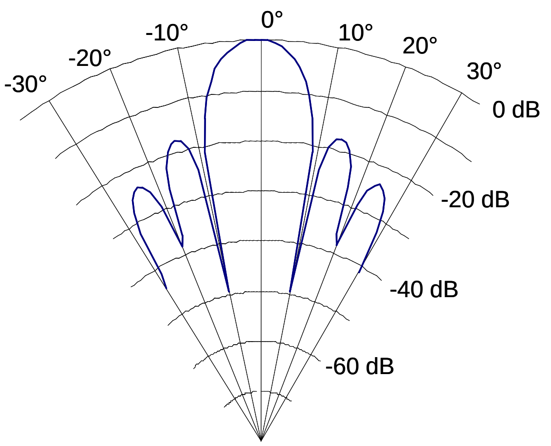


Figure A 1 Example of a theoretically derived beam pattern of a plane circular piston (ka = 20 has been chosen for the example).

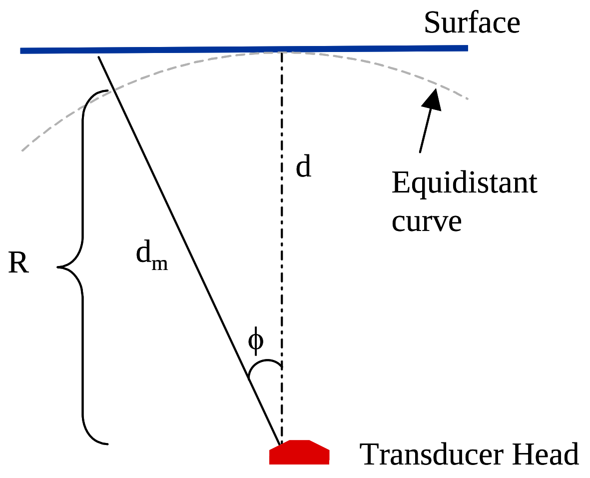
The RDCP 600 transducers are tilted 25° off the vertical axis. Hence, the distance to the surface/bottom along the vertical axis is shorter than along the main lobe axis.

As a result, strong signals backscattered off the surface/bottom originating from the pressure field outside the main lobe arrive at the same time as the backscattered signal from the main lobe pressure field and may obscure these cells.

An illustration of the 'good range', *R*, and obscure range near the surface is given in **Error! Reference source not found.**.

Here, the distance to the surface along the vertical axis is denoted *d* and the distance along the main lobe axis is denoted d_m. The blue solid line indicates the surface, and the grey dotted curve indicates the equidistant curve from the transducer.

The cells at a distance from the transducer greater than *R* may be obscure, while the cells at a distance from the transducer smaller than *R* are inside a good measurement range.



NOTE! The surface and the bottom are strong scatterers.

The expected good range is stated as

$$R = d \cdot \cos(\phi)$$

where *d* is the vertical distance from the transducers to the surface and ϕ is the beam angle relative to the vertical. Thus, for a 25° beam angle about 10% of the water volume closest to the surface may hold inaccurate data.

Figure A 2 Illustration of the good measurement range, R.

Measurement Range

The total measurement range depends on the source level i.e. the transmitted power, the transducer efficiency and the frequency. At 600 kHz, the transducers are relatively small and their efficiency is limited by non-linear behaviour and cavitations. Hence for linear wave propagation, the transmitted power of a small transducer is limited. An increased pulse length may increase the range by a small amount.

Blanking Distance

After transmitting an acoustic pulse, the transducers and electronics must rest a short time for the transducers to ring out before being able to act as a microphone and receive the very weak (compared to the transmitted pulse) reflected acoustic signals.

The ringing of the transducers depends on transducer size, frequency and the material embedding the transducers.

About half a millisecond of ringing corresponds to a 1 m blanking distance assuming a sound speed in water of 1500 m/s. The actual distance to the first measured depth cell depends on the factors listed below:

- ❑ Blanking distance
- ❑ Speed of sound
- ❑ Cell size
- ❑ Transmit Frequency
- ❑ Transducer Beam angle
- ❑ Column Set-up

Random and Systematic Errors

Two types of errors contribute to velocity uncertainty; random and systematic (bias) errors. Random errors can be averaged out while systematic errors cannot.

Random errors are reduced by the square root of the number of samples in one record.

Random errors depend on a number of factors:

- ❑ The shorter the pulse length, the greater the random error for a given frequency.
- ❑ The lower the frequency, the greater the random error for a given pulse length.
- ❑ The lower the signal-to-noise ratio, the greater the random error.
- ❑ When the beam angle approaches vertical, the measured horizontal component approaches zero, causing the random error to approach infinity.

Bias errors are non-random and can therefore not be reduced by data averaging. Fortunately, these errors are in general small, typically ~0.5 cm/s. The expression for the standard deviation is already shown in Eq. 3, page 8.

The sources of random error include:

- ❑ Pulse Length
- ❑ Transmit Frequency
- ❑ Signal/Noise Ratio
- ❑ Beam Angle

Beam Separation

The separation of the 4 transducer beams poses a limit to the vertical and horizontal scales of motion that can be resolved. With increasing distance from the transducer the sampling volume (cell volume) and the distance between the 4 cells at the same distance from the transducer increase. Thus, a short period velocity fluctuation resolved in close range may not be resolved in the end of range where the horizontal distance between the cells is greater.

Echo intensity and backscatters

A 600 kHz transducer transmits sound waves with a wavelength of a couple of millimetres. These waves may bounce off small planktons, particles or air-bubbles that have an acoustic impedance difference to the medium itself, the water. Bubbles, however, are compressible and take energy from the sound waves and thus often limit the range. Bubble clouds exist e.g. in the surface wave break zone or in the wake of ships.

The main limitation for obtaining good data is poor backscatter. If the scatterers are comprised of large zooplankton moving independently of the water current, a very critical *assumption* is violated and data may be obscured.

If the scatterers are too few the backscattered energy is very low and self-noise may corrupt the signal. The backscattered energy, or the *Echo Intensity,* is measured by the instrument relative to the maximum intensity.

Echo intensity can be used not only as a quality parameter but also to record temporal and spatial abundance of plankton. The Sonar equation has to be employed and biological 'ground proof' needs to be taken.

An estimate of the relative backscatter, R_B $[dBm^{-1}]$, can be calculated as:

$$R_B = EI + 20\log_{10}(d_s) + 2\cdot\alpha\cdot d_s$$

where EI is the echo intensity, d_s is the distance to the scatterers along the beam, and α is the sound absorption.

The other two terms in the equation are the volume attenuation by beam spreading, $20\log_{10}(d_s)$ and a decay of the signal due to sound absorption, $2\cdot\alpha\cdot d_s$.

To calculate absolute backscatter several factors like

- Signal power
- Noise level
- Transducer efficiency
- Effective diameter

have to be included.

Beam Spreading:

Beam spreading is a geometric cause for echo attenuation as a function of range. It can be found that inside the RDCP 600s measurement range the amplitude is inversely proportional to the distance squared, i.e. $\sim\frac{1}{d_T{}^2}$ (in linear units) where d_T is the distance from the transducers.

The decay in amplitude may be understood as the result of the transducers intersecting only a fraction of the reflected energy.

Sound absorption:

Absorption involves a process of conversion of acoustic energy to heat and thereby represents a true loss of energy to the medium in which propagation is taking place.

An often used model for calculation of the absorption, α, is the Francois-Garrison model which is a refinement of the Fisher-Simmons model. The Francois-Garrison model is valid in low temperature environments.

References

- Francois, R.E., Garrison, G.R., 1982. Sound absorption based on ocean measurements. Part II: Boric acid contribution and equation for total absorption. J. Acoust. Soc. Am. 72 1879-1890
- Simpson, M.R., 2001, Discharge measurements using a broadband acoustic Doppler current profiler. United States Geological Survey, Open-file-report 01-1
- Urick, R.J., 1983, Principles of underwater sound. (3rd edition): McGraw-Hill, San Francisco, USA

Optional Feature: Wave Software

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 = 7, 8,..,12. The pressure is sampled at a 2Hz rate so that the duration of the wave records ranges from 64 seconds (approx. 1 min) to 2048 seconds (approx. 34 min).

Processing of Raw data

In general, the water pressure is equal to the atmospheric pressure + the hydrostatic pressure due to the weight of the water + a dynamic part 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 to the absolute pressure is subtracted from the samples. If the atmospheric pressure is available as a sensor parameter this value is used. Else, the fixed atmospheric pressure from the *Site Settings* is used.

Second, the hydrostatic pressure is calculated and subtracted 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 by use of 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 is the dynamic pressure 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 3 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.

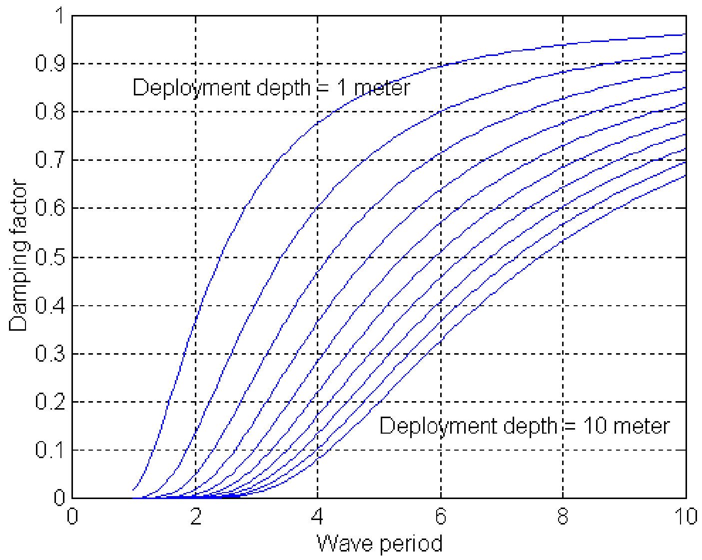


Figure A 3 Damping of the dynamic pressure in deep water as a factor of wave period and deployment depth.

Intermediate Water or Deep Water:

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. For all the wave properties the theory gives a set of equations. Which equation to apply for a given wave property depends on whether the deployment is at deep or intermediate water.

According to Krogstad and Arntsen[1] the sea is to be considered as deep if

$$\frac{d}{\lambda} > 1/2$$

where d is water depth and λ is the wave length.

[1] http://www.bygg.ntnu.no/~oivarn/hercules_ntnu/LWTcourse/index.htm

A typical wavelength is tens to hundreds of meter long.

Two different transfer functions are used to compensate for the damping of the dynamic pressure, one for the deep water deployment and one for intermediate water deployment. The RDCP 600 assumes that the sea is deep if the absolute water depth is greater than 50 meters.

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 ρ is the medium density, g is 9.81 m/s^2 and H is the wave height. The wave spectrums calculated by the RDCP 600 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_o, 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, σ, 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 μ is the average of X (μ =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 looked on 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 looked on as the total variance of the wave record.

Cut-off Frequency:
The RDCP 600 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 3, hence the RDCP 600 calculates a cut-off frequency based on the deployment depth as measured by the pressure sensor[2]:

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

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
- Regularity
- Wave Steepness

These parameters are provided by the RDCP 600, and will be described in the following. For more information regarding the wave parameters, see the '*Guide to Wave Analysis and Forecasting*', World Meteorological Organization (WMO) report number 702.

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

[2] IEEE Journal of Oceanic Engineering, VOL 26, No2, April 2001, p 171-180

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:

$$H_{m0} = 4\sqrt{m_0}$$

Note that both $\bar{H}_{1/3}$ and H_{m0} are called Significant Wave Height. The parameter provided by the RDCP 600 is H_{m0}.

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 RDCP 600 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 21.

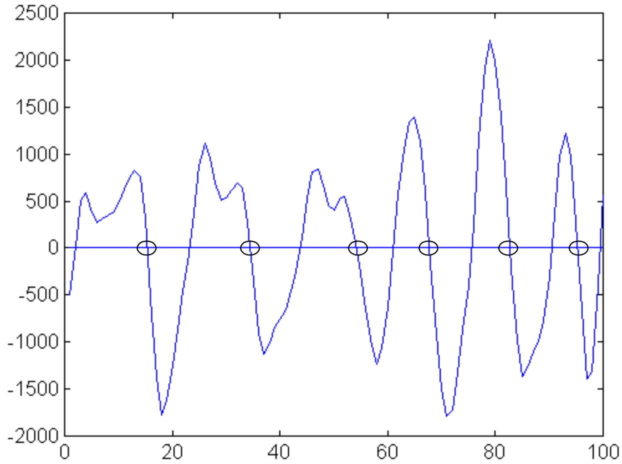


Figure A 4 Part of a wave record. Zero down-crossings are circled.

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 to NOTE on page 21.

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 to NOTE on page 21.

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 to NOTE on page 21.

Regularity:

When studying the wave parameters provided e.g. by the RDCP 600, 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 is, 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 peaked spectrum and a high Q_p factor and an irregular sea will give a broader spectrum and a lower Q_p value.

AR Wave Period:

The AR period is calculated using an auto regressive spectral estimation algorithm. The algorithm is applied to raw data –that is without compensation for the damping of the pressure variations.

As discussed earlier, wave components with short wave lengths are damped more than wave components with longer wave periods. Because of that, the AR period will often be larger than the other wave period estimates. Thus, the AR period will, together with one of the conventional wave parameters give a picture of the span of wave periods of the waves that constitutes the current sea state.

If the AR wave period is almost similar to the other wave period estimates, the sea is probably very regular.

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 RDCP 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/$f_{Cut\text{-}Off}$. This will happen e.g. if the instrument is deployed too deep to monitor the current sea state.*

CHAPTER 2 Sensors and Data Sheets

The standard sensors of the RDCP 600 are:

- Transceiver Head
- Compass and Tilt sensor

The optional sensors of the RDCP 600 are:

- Conductivity sensor 3919/4019
- Temperature sensor 4050
- Pressure sensor 4017
- Quartz Pressure sensor 3187
- Turbidity sensor 3612/4705
- Oxygen Optode 3830
- Oxygen Optode 3835

Transceiver Head

The transceiver head comprises a cylindrically shaped housing with the transceiver electronics inside and an acoustic transducer head with four piezoceramic acoustic transducers. The transducers are placed 90° apart around the top of the head with a 25° slant angle. An illustration of the Transceiver Head is given in

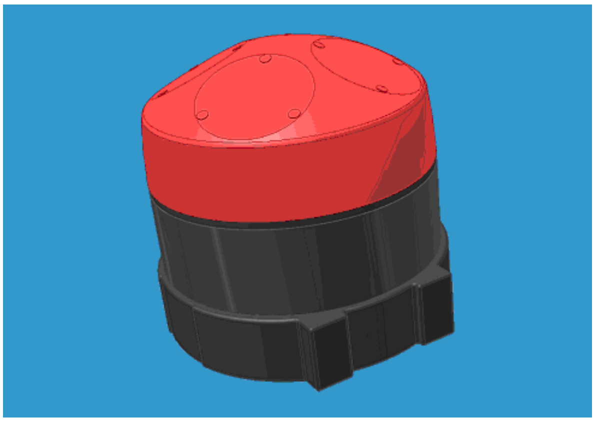


Figure A 5.

The transducer head is moulded in a polyurethane material.

The RDCP utilizes the well-known Doppler Shift principle as the basis for its current speed measurements. All four transducers transmit a 600 kHz acoustic pulse simultaneously, where the pulse length normally is equal to the selected cell size. As the sound pulse propagates through the water column, a portion of the energy is reflected by small particles or air bubbles in the water.

Figure A 5 Transceiver Head RDCP

The transducers pick up the back-scattered energy from the water column.

The signal from the transducers are amplified and filtered by the receiver electronics and sampled through an AD-converter. The sampled signal data is processed by a Digital Signal Processor on the RDCP main board to find the Doppler shift for all the cells in the column.

Compass Tilt sensor 3777

The compass sensor is a solid-state compass with no moving parts. The sensor measures the earth magnetic field and the tilt (pitch and roll). The compass direction (heading) is calculated based on these measurements. The heading direction is the angle between *magnetic* north and the direction of the sensor.

A micro-controller measures the earth magnetic field in 3 axes, where these three axis (*x,y,z*) are orthogonal (90°) to each other.

An additional measurement of tilt-x and tilt-y is performed, and knowing the tilt, the heading can be mathematically calculated from the 3-axes magnetic field, and the tilt. The results are presented on either RS-232 or CAN bus.

The output is heading, pitch and roll.

A unique power optimisation design gives an average current consumption below 250uA when the compass measures heading and tilt every second. In sleep, the average current consumption is below 70uA.

Specifications:

Temp range: -5 to +35° C

Heading accuracy: ± 4° for 0-35° tilt

Tilt (Pitch, roll) accuracy: ± 1.5°

Compass Connections

The Terminal arrangement for the Compass Tilt Sensor is illustrated in **Error! Reference source not found.**. The Terminal signals are listed in Table A 1.

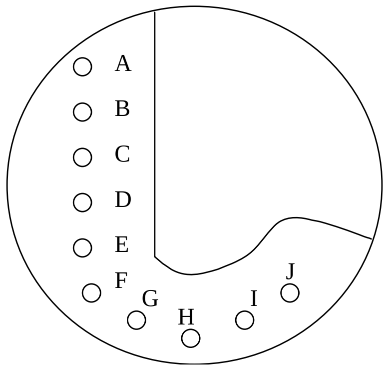


Figure A 6 Illustration of terminal arrangement for the Compass Tilt Sensor.

Table A 1 Terminal Signals, Compass Tilt Sensor

Terminal	Function
A	RS-232c TX
B	RS-232c RX
C	BOOT pin
D	Canbus (CAN_L)
E	Canbus (CAN_H)
F	SR10:CV

Terminal	Function
G	SR10: BV
H	SR10: System Ground Power: V + (7-14 V)
I	SR10: -9V Power: Gnd
J	SR10: Output

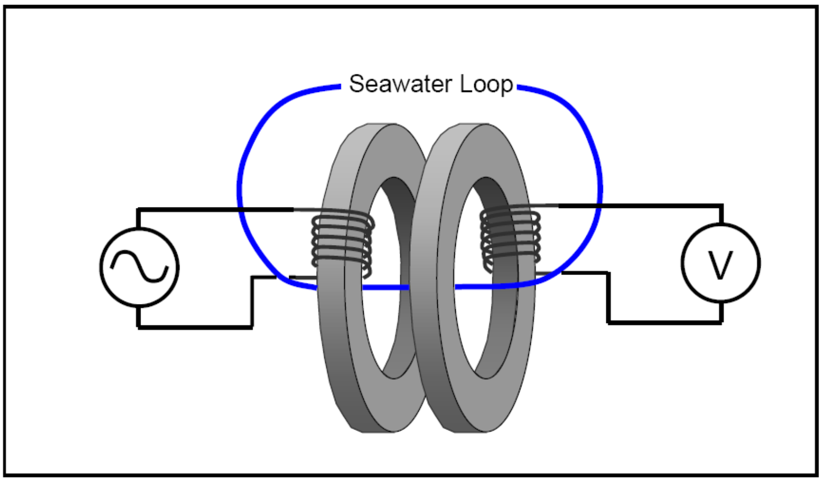
NOTE! Both terminal H and I have two functions. If the Compass Tilt sensor is connected to SR10 output, then the line starting with SR10: *yields, else the line starting with* Power: *yields.*

Conductivity sensor 3919/4019 (Depth capacity of 6000m)

The Conductivity Sensor 3919/4019 measures the conductivity of seawater.

The Conductivity Sensor 3919/4019 is based on an inductive principle. This means setting up an alternating magnetic field produces the electrical current in water. The magnetic field induces a current to flow through the hole of the sensor.

The magnetic field is generated using a ring transformer. Since the core centre is open to the water, the water acts as a coil of one turn in the transformer. A second transformer is used for sensing the current in the seawater loop. The voltage from this transformer relates directly to the conductivity in the seawater.



A digital-signal-processor calculates the conductivity based on measured values and a set of stored calibrated coefficients. The result is presented either as Aanderaa SR10 (3919) or CANBus (4019). Both models have the RS-232 interface.

The model 3919 must be connected to either channel 4, 5 or 6 on sensorboard, while the model 4019 must be connected to CANBus on sensorboard .

NOTE! Conductivity sensor 3919 also has temperature as a second parameter and this can be connected to channel 2 instead of the Temperature sensor.

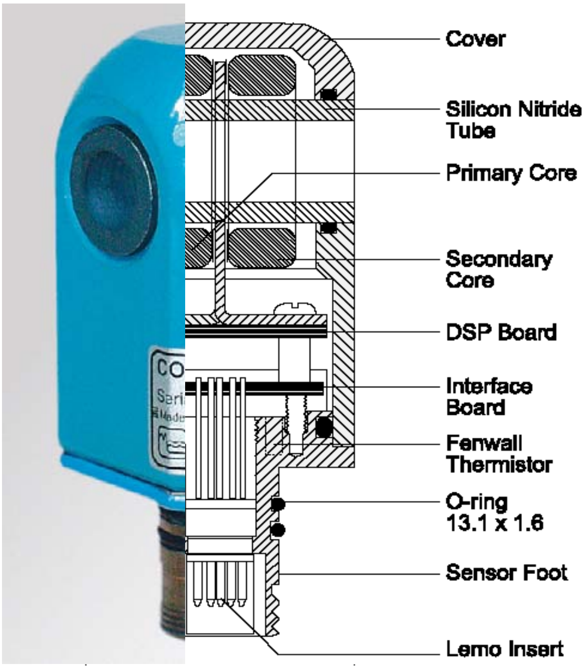


Figure A 7 Drawing of Conductivity Sensor

The calibration of the sensor may be affected by the geometry of the sensor surroundings, and should therefore be done with the sensor installed on the instrument (See operation manual Conductivity Sensor TD222).

Small scars in the epoxy coating on sensor or parts near the cell may also affect the calibration. If the sensor is removed, seal the installation bore with a 16 mm sealing plug. For correct installation, a steel ball must be mounted between sensor and top-end plate for correct orientation.

Pressure Sensor 4017 (Depth capacity of 6000m)

The sensing element in the Pressure Sensor 4017 is the STS Sensor Technik Sirnach, Type TD15 sensor; a picture of the Pressure sensor 4017 is given in figure a 28. The sensor is shaped as a small cylinder, moulded in titan. The sensor is connected to the electronic board by a molex plug. To prevent internal corrosion, the sensor tube is filled with silicone oil. Available ranges are 0 -700 kPa, 0 - 3500 kPa, 0 - 7000 kPa, 0 – 20 MPa and 0 - 60 MPa. The sensor measures the absolute pressure by means of the Piezoresistive Bridge. The output voltage from the bridge is amplified to give a VR 22 output signal.

NOTE! Pressure sensor 4017 also has temperature as a second parameter and this can be connected to channel 2 instead of the Temperature sensor.

Quartz Pressure sensor 3187

The RDCP uses a high precision quarts pressure sensor from Pressure Systems. This sensor has a frequency output inverse proportional to the pressure applied. Precise thermal compensation is provided via an integrated quartz temperature sensor used to measure the operating temperature of the transducer. A dedicated micro-controller in the sensor board measures both the pressure and temperature frequency. A sample of pressure measurement takes approximately 130ms.

The Quartz Pressure Sensor 3187B: 0-700 kPa covers most wave applications. Please contact Aanderaa Instruments for additional ranges; a picture of the Quartz Pressure sensor is given in TD220a *Deployment Guide*.

Specifications:

- Resolution: 0.001 % of full scale
- Repeatability ±0.01 % of full scale
- Calibration Accuracy 0.02 % of full scale

Turbidity Sensor 3612 (Depth capacity of 2000m)

This sensor measures the turbidity of the water by means of back-scattered infrared light. This measurement is known to have good correlation to the amount of suspended matters and can be used to monitor sediments, algae, or particle pollution. An illustration of the turbidity sensor is given in Figure A 8,a picture of the Turbidity sensor 3612 is given in A 28

Two light emitting diodes and one photodiode are pointing towards a common centre at an angle of 15°. Once every measuring cycle the light emitting diodes send out light and the reflected light from particles in the water is picked up by the photodiode.

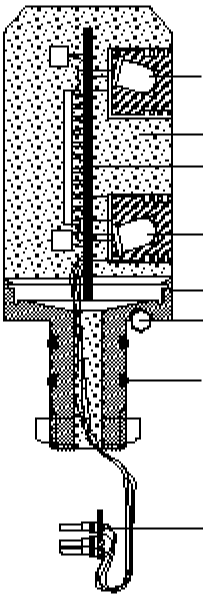


Figure A 8 Turbidity Sensor 3612

A micro-controller generates 2 kHz pulses, which are amplified and fed to infrared diodes sending light into the water.

The photodiode converts the backscattered light from the particles in the water to electronic signals. These signals from the photodiode are amplified and compared with a reference signal. The frequency of the transmitted signal is used in the filtering process of the received signal. The output of the filter process is fed to a micro-controller that gives an SR10 output signal.

The sensor is shaped as a small cylinder moulded in polyurethane material. It is also furnished with a 16 mm stud for fastening the sensor to the top end plate. The sensor plugs directly to the electronic board inside the instrument by molex plug. If the sensor is removed, a 16 mm sealing plug must be installed.

Oxygen Optode 3830 (Depth capacity of 6000m)

The Oxygen Optode 3830 is based on the ability of selected substances to act as dynamic fluorescence quenchers. The fluorescent indicator is a special platinum porphyrin complex embedded in a gas permeable foil that is exposed to the surrounding water. A black optical isolation coating protects the complex from sunlight and fluorescent particles in the water. This sensing foil is attached to a sapphire window providing optical access for the measuring system from inside a watertight titanium housing.

The foil is excited by modulated blue light, and the phase of a returned red light is measured. By linearizing and temperature compensating, with an incorporated Temperature sensor, the absolute O_2 concentration can be determined.

The Optode outputs data in both RS-232 and Aanderaa SR10 format. On the RS-232 output both the absolute oxygen content in micro molar (µM) and the relative air saturation in % are available. The SR10 output can be configured to present oxygen content in µM, by default, or air saturation by connecting the sensor to a PC. A picture of the Oxygen Optode 3830 is given in9.

Oxygen Optode 3835 (Depth capacity of 300m)

This sensor utilizes lifetime-based optical fluorescence sensor technology to provide an extremely stable, precise and low maintenance dissolved oxygen sensor.

The Optode outputs data in both RS-232 and Aanderaa SR10 format. A picture of the Oxygen Optode 3835 is shown in figure A 29

CHAPTER 3 Real-Time Communication Protocols

Real-Time transfer of data from the RDCP 600 can be done using either RS-232, RS-485 or PDC-4. In addition, the user can configure the RDCP 600 using the RS-232 or RS-485 protocol, but not by using the PDC-4. The first two sub chapters describe the RS-232 and RS-485 protocol stack and specific RDCP communication. Then follows a sub chapter regarding Real-Time output using PDC-4.

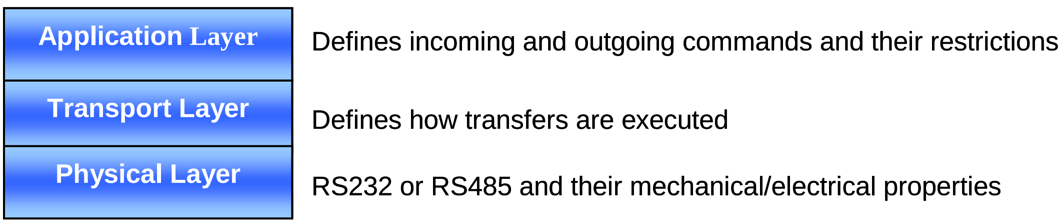
Aanderaa Instruments Standard RS-232-RS-485 Protocol Stack

This Protocol is not terminal based, i.e. it is not suitable for use with the Windows program ‘HyperTerminal’. To get a feeling of how the RS-system works, however, HyperTerminal can be useful, refer to page 46. In order to display real-time data using RS 232 or RS-485 you need software that can handle the Protocol and communicate with the RDCP. For this we recommend that you use the AAIRdcpCOMServer 4027.

AAIRdcpCOMServer 4027 is an ActiveX software component that can be included in the third party software that is to communicate with the RDCP. ActiveX was developed to significantly reduce the development time and to ease interfacing of Aanderaa equipment and is suitable for those who write Windows based programs that interface Aanderaa equipment. The AAIRdcpCOMServer 4027 may be utilized in most development environments which support ActiveX and produce Win32 based applications. Typical targets are MS Visual C++, MS Visual Basic and several Borland products.

The Protocol Stack

The protocol consists of a 3 level stack. The bottom layer is the Physical layer, which defines the electrical signals as well as the electrical and mechanical connections to the instrument, depending on which physical layer is used (RS-232 or RS-485). The second layer is the Transport layer, which defines how transfers are executed, in which sequence and how you can detect errors during transfer. The upper level is the Application layer of the protocol and defines the commands that can be executed and received. The Application layer will also set restrictions on when certain commands can be sent and which parameters are allowed at that time. Specifics for the application- and physical layer are instrument dependent and can be found in the next sub chapter, refer to page 35.



The Physical Layer

The physical implementation of this protocol is intended for use on RS-232 and RS-485. It is however possible to use this protocol on any system that can transfer one byte at the time over a communication line using a duplex communication scheme.

This Aanderaa standard protocol is intended for direct and transparent link point-to-point communication, and not as multi drop. The Aanderaa standard protocol does not give any means of addressing single instruments/sensors.

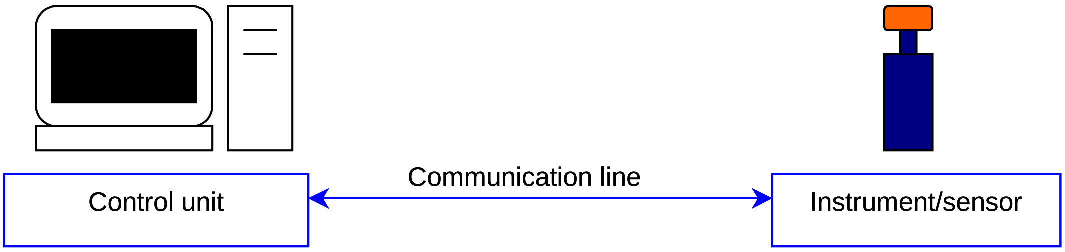


Figure A 9 The Aanderaa standard Protocol for RS-232 and RS-485 communication is intended for point-to-point communication.

The Transport Layer

Four characters are dedicated to flow control in the transport layer. These characters are:

- '#', which is used to indicate an OK acknowledge
- '*' is used to indicate an Error acknowledge
- The 'CR' and 'LF' characters are used to indicate the end of commands or acknowledges.
- The 'CR' character is also used as the wakeup character.

A command is built up from a sequence of characters; the instrument executes commands followed by a <CRLF> immediately after receiving the commands.

When transmitting a command with no data returned and with data returned, the sequences will be as shown in Figure A 10 and Figure A 11, respectively:

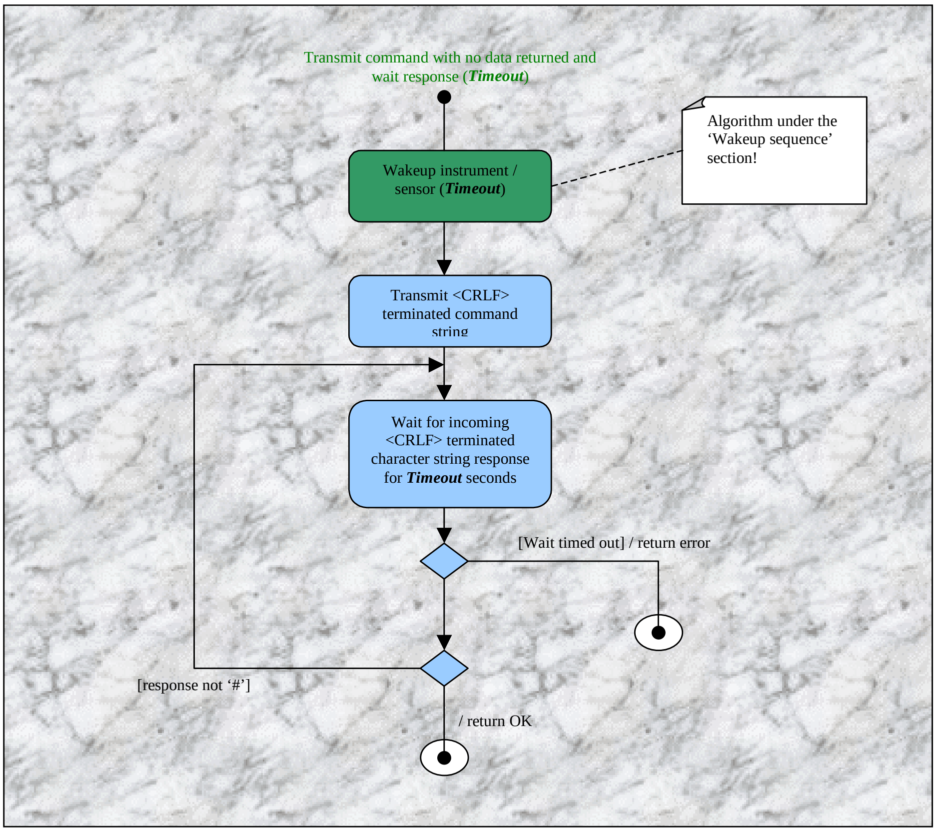


Figure A 10 Transmitting a command with no data returned

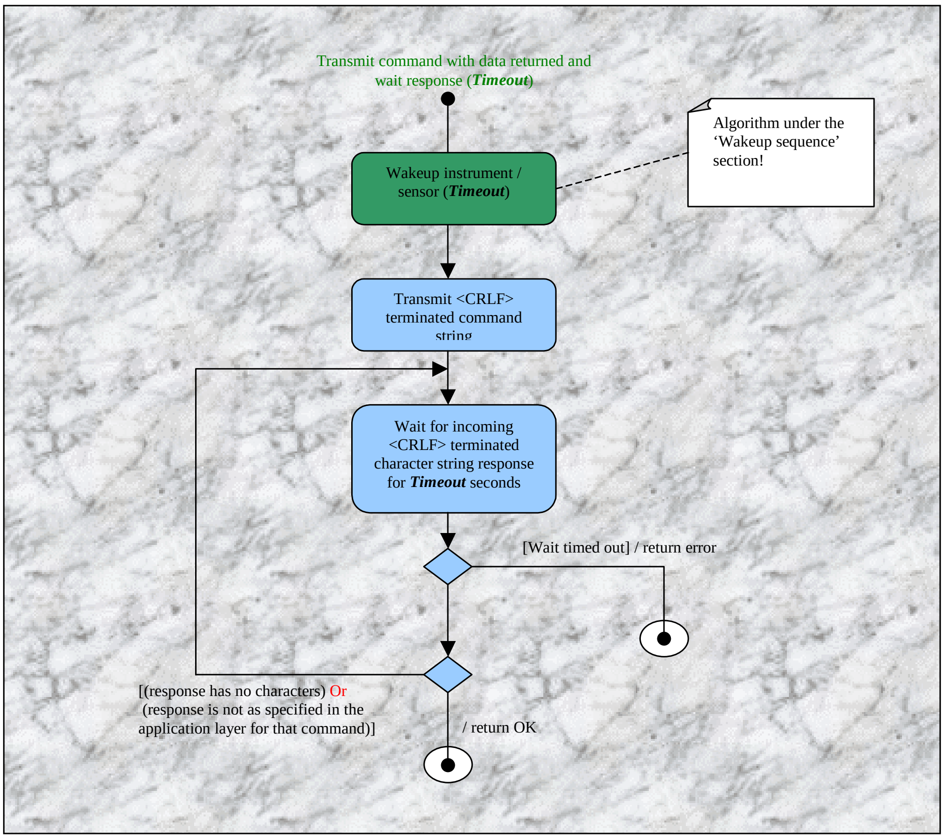


Figure A 11 Transmitting a command with data returned

Wakeup sequence: During a recording session the instrument can go into idle mode. Once the instrument has entered its idle mode it can no longer receive characters. It is therefore necessary to get the instrument out of its idle mode before any further communication is possible. The following flow chart describes this protocols wakeup sequence:

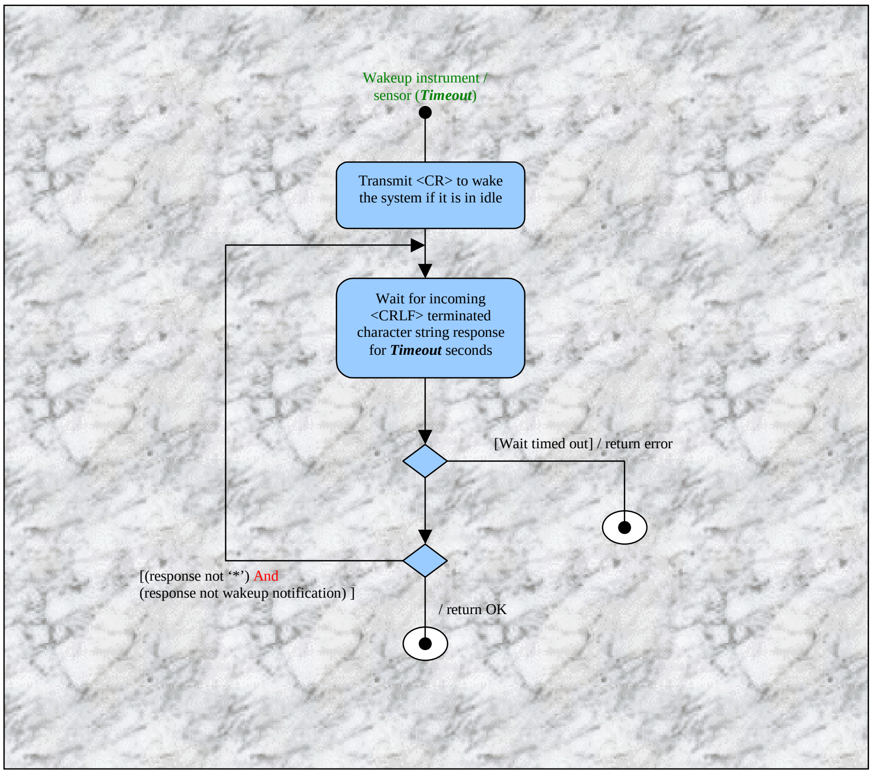


Figure A 12 Wakeup sequence

The *connection sequence* is used when it becomes necessary to connect to the instrument. The sequence is shown in Figure A 13.

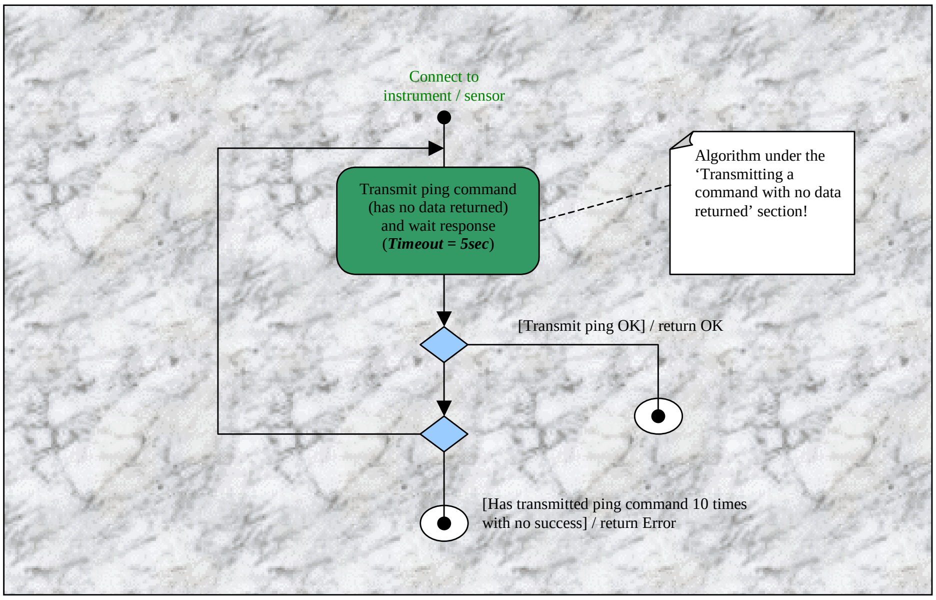


Figure A 13 Connection sequence

Receiving a command: When the instrument sends a command to the control unit, the control unit will collect characters until the <CRLF> character set is received (or the buffer overflows, in which case this error must be handled by the control unit depending on the type of unit).

There are two ways the control unit can receive a command: the control unit can send a command which results in a response from the instrument, or the instrument can send data, notification or commands to the control system without any influence on the control unit.

The application layer will decide how the response should be interpreted and which of the two response types has occurred. In both cases the algorithms transmitting data, waking up the instrument, connecting to the instrument etc. will listen for incoming strings to see if this is the expected response.

The Application Layer

An outgoing command is defined as sent to the instrument. The command starts with a string that identifies the command. The string is immediately followed by a parenthesis enclosing a comma-separated list of parameters:

command(param1, param2,…, paramN)

To execute the command the <CRLF> character set must be sent to the instrument/sensor.

An ingoing command is defined as sent from the instrument. This is usually incoming data or notifications from the instrument, but it can also be a command to the control unit. An incoming command starts out by identifying the command/response/notification, followed by an identification of the instrument/sensor, the serial number of the instrument (sno), and a list of arguments; all <TAB> separated:

command<TAB>instrument_sensor<TAB>sno<TAB>param1<TAB>param2<TAB>…<TAB>paramN

The command ends with the <CRLF> character set.

Aanderaa Instruments Standard RS-232-RS-485 RDCP 600 Applications

Start up notification

At application start up the following message is sent from the Instrument:

ready_rdcp<TAB>RDCP600<*TAB*><sno><*TAB*><Year><*TAB*><Month><*TAB*><Day><*TAB*><Hour><*TAB*><Minute><*TAB*><Second>

Set Commands: no data returned

IMPORTANT! For all commands except 'Set_output_com1' and 'Set_output_com3': all parameters must be entered into the commands; even if one or more parameters are not changed or have an influence on the configuration.

Table A 2 Set Commands: description, parameters and examples

Command RS-232 Port: RS-485 Port:	 *Set_output_com1(parameter1, parameter2, ..., parameterN)* *Set_output_com3(parameter1, parameter2, ..., parameterN)*
Action:	Sets the output parameters. Returns *<*CRLF*> at failure and #<*CRLF*> at success.
Selectable parameters:	*reference, temperature, conductivity, channel4, channel5, channel6, compasstilt, pressure, depth, salinity, soundspeed, batteryvoltage, wave, pingcount, velocities, beamvelocities, signalstrength, standarddeviation, wavetimeseries, wavespectrum, pulseattenuation.*
Examples:	*Set_output_com1(reference, temperature, pressure)* selects reference, temperature and pressure. *Set_output_com1(all)* selects all parameters listed above. *Set_output_com1(disable)* disables all parameters.
Command:	*Set_property_site(property1, property2, ...propertyN)*
Action:	Sets the site parameters. Returns *<*CRLF*> at failure and #<*CRLF*> at success.
Parameters:	UpSideDown: type *1* for downwards looking instrument, and *0* for an upward looking Mcorrection: type the magnetic correction using float number InstallationDepth: type the depth in meters using float number

	FixedTemp: type the fixed temperature in °C using float number FixedConductivity: type the fixed conductivity in mS/cm using float number FixedPitch: type the fixed Pitch value in degrees using float number FixedRoll: type the fixed Roll value in degrees using float number FixedHeading: type the fixed Heading in °M using float number FixedPressure: type the fixed pressure in kPa using float number FixedAirPressure: type the fixed air pressure in kPa using float number FixedSpeedOfSound: type the fixed speed of sound in m/s using float number LocalGravity: type the local gravity in m/s^2 using float number LocationName: type a string for the location name SiteResponsible: type a string with the site responsible Altitude: type a string for altitude Latitude: type a string for latitude Longitude: type a string for longitude
Example:	*Set_property_site(0, 0.0, 20.0, 7.0, 30.0, 0.0, 0.0, 0.0, 300.0, 101.3, 1500.0, 9.8, Bergen, Aanderaa, 0, 60°24', 05°18')*
Command:	*Set_property_profile(profileProperty1, ..., profilePropertyN)*
Action:	Sets the profile parameters. Returns *<*CRLF*>* at failure and #<*CRLF*> at success.
Parameters:	UseDefaultPulseLength: type *1* for auto setting (equal to cell size) and *0* to override auto setting UseRectangularCoodinates: type *1* for rectangular and *0* for polar UseSensorDerivedSpeedOfSound: type *1* for sensor derived and *0* for fixed reading UseSurfaceCell: type *1* for surface cell and *0* for no surface cell PulsType: type *auto* for automatic attenuation, *0dB* for no attenuation, *-3dB, -6dB, -12dB* for attenuation settings PowerLevel: type *off, low* or *high* for the power level PulseLength: type the pulse length in meters using float number CompTiltSource: type *internal* for reading from internal compass sensor; type *can* for reading from an external sensor using CANBus interface; type *fixed* for fixed reading.

	SurfaceCellSize: type the surface cell size in meters using float number Col0SurfaceRef: type *1* for surface referred column and *0* for instrument referred Col0CellOverlap: type cell overlap from 0.0 to 0.9 (0-90% overlap) in float number Col0StartFirstCell: type the distance to first cell in meters using float number Col0NumOfCells: type number of cells in the column using integer number Col0CellSize: type the cell size in meters using float number *Continue with the same parameters for the next column until the last column:* Col1…, Col2…, ColNCellSize *Note! If the parameters of this command exceed its legal limits, it will return an error (*<CRLF>). There is such a limit on pulse length vs. power level and ping rate. If the power level is low, the pulse length and ping rate can be higher and longer than if the power level is high. Using a shorter pulse length will allow a faster ping rate. Because the ping rate is controlled by Set_Property_Interval, changing these settings may result in reduced thresholds for pulse length parameter of Set_Property_Profile (See also the input parameter limitations on pages 43-46).*
Example:	*Set_property_profile(0, 1, 1, 0, auto, low, 2, internal, 0.0, 1, 0.5, 3, 10, 2)*
Command:	*Set_property_interval(intervalProperty1, .., intervalPropertyN)*
Action:	Sets the timing parameters. Returns *<*CRLF*> at failure and #<*CRLF*> at success.
Parameters:	NumOfPings: type number of pings in integer number PingMode: type *spread* or *burst* RecordingInterval: type the record interval in seconds using integer number OnlyRecordPartOfDay: type *1* for recording part of day and *0* for recording all of the day PartOfDayStartTime: type start time in *hh:mm:ss* PartOfDayRecordingPeriod: type period in minutes using integer number PressureTimingMode: type *instance* for pressure update at recording, *continuous* for continuous update or *custom* for customer specific update PressureCustomUpdateInterval: type customer specific update in seconds using integer number *Note! If the parameters of this command exceed its legal limits, it will return an error (*<CTRL>). The thresholds for resulting ping rate can change for different settings of Set_Property_Profile (See Set_Property_Profile).*
Examples:	*Set_property_interval(300, burst, 600, 1, 14:00:00, 180, instance, 0.0)*

Command:	*Set_property_wave(waveProperty1, .., wavePropertyN)*
Action:	Sets the wave parameters. Returns *<CRLF> at failure and #<CRLF> at success.
Parameters:	WaveActive: type *1* for wave parameters and *0* for no wave parameters SamplesInWaveRec: type the number of samples in integer number ApproxDistFromSeabedToSurface: type the distance in meters using integer number
Examples:	*Set_property_wave(1, 2048, 10)* for wave parameters *Set_property_wave(0)* for no wave parameters
Command:	*Set_property_profile_active(status)*
Action:	Decides if the current speed profiling should be active or inactive. Returns *<CRLF> at failure and #<CRLF> at success.
Parameters:	Status: Type *active* for current speed profiling and *inactive* for no profiling
Example:	*Set_property_profile_active(active)*
Command:	*Set_property_system_time(Date&time)*
Action:	Sets the system time on the RDCP. Returns *<CRLF> at failure and #<CRLF> at success.
Parameters:	Type Date and Time using comma separated integer numbers: *Year, Month, Day, Hour, Minute, Second.*
Example:	*Set_property_system_time(2004, 07, 09, 14, 10, 56)*

Get Commands: return of data

NOTE! Every response to the Get commands starts with a repeat of the command followed by an identification of the instrument including serial number.

Table A 3 Get Commands: Description and examples

Command:	*Get_property_site()*
Action:	Get site configuration. Returns *<CRLF> at failure and the site properties at success
Output:	property_site<*TAB*>RDCP600<TAB><sno><TAB><property1><TAB><property2><TAB>….<TAB><PropertyN><CRLF> *NOTE! Refer to Table A 2 for site properties, list order, and parameter unit*

Command:	*Get_property_profile()*
Action:	Get profile configuration. Returns *<*CRLF*> at failure and the profile properties at success
Output:	This command provides 3 output sequences: property_profile_blankingdistances<*TAB*>RDCP600<TAB><sno><*TAB*><Min.transducer><*TAB*><Min.transducerhighpower><*TAB*><Min.surface><*CRLF*> property_profile_activity<*TAB*>RDCP600<TAB><Sno><*TAB*><Status><*CRLF*> property_profile<*TAB*>RDCP600<TAB><sno><TAB><profileProperty1><TAB><profileProperty2><TAB>….<TAB><profilePropertyN><CRLF> *NOTE! Refer to Table A 2 for site properties, list order, and parameter unit* *IMPORTANT!* ColumnCount *is an additional parameter to the once listed in Table A 2 and is located as parameter number 10.*
Command:	*Get_property_interval()*
Action:	Get timing configuration. Returns *<*CRLF*> at failure and the timing properties at success
Output:	property_interval<*TAB*>RDCP600<TAB><sno><*TAB*><intervalProperty1><TAB><intervalProperty2><Tab>…<Tab><intervalPropertyN>< CRLF> *NOTE! Refer to Table A 2 for interval properties, list order, and parameter unit* *IMPORTANT!* PressureIntegrationTime *is an additional parameter to the once listed in Table A 2, which is represented as an integer of the time in seconds.*
Command:	*Get_property_wave()*
Action:	Get wave configuration. Returns *<*CRLF*> at failure or if wave is not installed. Returns the wave properties at success
Output:	property_wave<*TAB*>RDCP600<TAB><sno><*TAB*><*TAB*><waveProperty1><TAB><waveProperty2><Tab>…<Tab><wavePropertyN><CRLF> *NOTE! Refer to Table A 2 for site properties, list order, and parameter unit*
Command:	*Get_status_recorder()*
Action:	Get recorder status. Returns *<*CRLF*> at failure and the recorder status at success
Output:	status_recorder<*TAB*>RDCP600<TAB><sno><*TAB*><status><TAB><year><TAB><Month><TAB>…<TAB><Seconds><CRLF> *NOTE! Refer to the last two commands in Table A 2 for status properties and list order for date and time*

Command RS-232: RS-485:	 *Get_output_com1()* *Get_output_com3()*
Action:	Get parameters output on com1 for RS-232 or com3 for RS-485. Returns *<*CRLF*> at failure and the parameter output at success
Output RS-232: RS-485:	 property_output_com1<*TAB*>RDCP600<TAB><sno><*TAB*><parameter1><TAB><parameter2><TAB>…<TAB><parameterN><*CRLF*> property_output_com3<*TAB*>RDCP600<TAB><sno><*TAB*><parameter1><TAB><parameter2><TAB>…<TAB><parameterN><*CRLF*> *NOTE! Refer to Table A 2 for a listing of the properties*

Do Commands

Note! All Commands except 'do_system_reset' and 'do_system_sleep' have no data returned.

Table A 4 Do Commands: Description

Command:	*Do_recording_start()*
Action:	Starts recording. Returns *<*CRLF*> at failure and #<*CRLF*> when and if the recording has started.
Command:	*Do_recording_start(Y, M, D, h, m, s)*
Action:	Starts recording at date=D/M-Y time=hh:mm:ss. Returns *<*CRLF*> at failure and #<*CRLF*> when and if the recording has started.
Command:	*Do_recording_stop()*
Action:	Stops recording. Returns *<*CRLF*> at failure and #<*CRLF*> when and if the recording has stopped.
Command:	*Do_system_reset()*
Action:	Resets the system. Returns *<*CRLF*> at failure. If the system is successfully reset the start notification will be returned when the application is up and running.
Command:	*Do_system_sleep()*
Action:	Requests that the system go to sleep. Returns *<*CRLF*> at failure. Returns the message:

	‘suspend_rdcp<*TAB*>RDCP600<TAB><sno><*CRLF*>’ when and if the system is preparing to sleep. To wake the system from sleep, send any character and wait for the message: ‘resume_rdcp<*TAB*>RDCP600<TAB><sno><*CRLF*>’
Command:	*Do_ping_communication()*
Action:	Poll the communication system to see if it is ready. If it is ready, it will respond with #<*CRLF*>. This can be used successfully to wake up the system from idle the idle state is unknown. This is typical the first time an application on the control unit tries to connect to the system. After the connection has been made and the recorder status is known the control unit can follow the sleep status through the sleep/wakeup notifications
Command:	*Do_update_last_airpressure(Pressure)*
Action:	Updates the air pressure used to find the relative pressure from the absolute pressure. The input pressure must be in kPa using float number. To use this pressure, the pressure compensation in the hydrostatic pressure configuration must be set to RS-232. Returns *<*CRLF*> at failure and Returns #<*CRLF*> if success.
Command:	*Do_system_store_registry()*
Action:	Stores, to persistent memory (flash), the parameters currently located in RDCP RAM
Command:	*Do_storage_card_erase()*
Action:	Erases the storage card currently used in the RDCP if it is present. The storage card can be either MMC or CF. (the recording must be stopped before erasing)

Sleep, wakeup notification

Table A 5 Notifications: Description

Notification	*resume_rdcp<TAB>RDCP600<TAB><sno>*
Explanation	Sent each time the system wakes up from idle
Notification	*suspend_rdcp<TAB>RDCP600<TAB><sno>*
Explanation	Sent each time the system is about to enter idle mode

Data notification from the system

NOTE! Notifications regarding data, time series and wave spectrum will be sent from the system at each recording instance (at the end of the recording interval) if the respective feedback has been enabled and if at least one record has been collected by the instrument.

Table A 6 Notifications: description

Notification	*rdcp_data_record*<*TAB*> RDCP600 <*TAB*> sno<*TAB*>Year <*TAB*> Month <*TAB*> Day <*TAB*> Hour <*TAB*> Minute <*TAB*> Second <*TAB*> DataCount <*TAB*> DataType0 <*TAB*> ProfileColumn0 <*TAB*> ProfileCell0 <*TAB*> ErrorCode0 <*TAB*> Data0 <*TAB*>…<*TAB*> DataTypeN <*TAB*> ProfileColumnN <*TAB*> ProfileCellN <*TAB*> ErrorCodeN <*TAB*> DataN <CRLF>
Explanation	For parameters that are not organized into columns and cells, the column and cell parameters will be –1. For parameters that are organized into columns and cells, the column and cell parameters will be the zero based index into the columns and cells of the profile. If a column is transducer referenced, then Cell index 0 will be the closest one to the transducer within that column. If a column is surface referenced, then Cell index 0 will be closest to the surface within that column. ‘*DataType*’ is one or more parameters from the following list: reference, temperature, conductivity, channel4, channel5, channel6, pitch, roll, heading, pressureabs, pressurerel, batteryvoltage, depth, salinity, soundspeed, pingcount, signwaveheight, peakwaveperiod, meanzerocrossingperiod, maxwaveheight, meanwaveperiod, energywaveperiod, steepness, irregularityofsea, speed beam1, speed beam2, speed beam3, speed beam4, signalstrength, standarddeviation, north, east, speed, dir, z, surf.speed beam1, surf.speed beam2, surf.speed beam3, surf.speed beam4, surf.signalstrength, surf.standarddeviation, surf.north, surf.east, surf.speed, surf.dir, surf.z, pulse attenuation, ar wave period Error code is either: *0* (representing status unknown), *1* (representing Status OK), *2* (representing Status error), and *3* (representing Status out of range)
Notification	rdcp_data_timeseries<*TAB*> *R*DCP600 <*TAB*> sno <*TAB*> Year <*TAB*> Month <*TAB*> Day <*TAB*> Hour <*TAB*> Minute <*TAB*> Second <*TAB*> DataCount <*TAB*> DataPoint0 <*TAB*> DataPoint1 <*TAB*> DataPoint2 <*TAB*>… <*TAB*> DataPointN <*TAB*> <*CRLF*>
Notification	rdcp_data_spectrum<*TAB*> RDCP600 <*TAB*> sno <*TAB*> Year <*TAB*> Month <*TAB*> Day <*TAB*> Hour <*TAB*> Minute <*TAB*> Second <*TAB*> DataCount <*TAB*> DataPoint0 <*TAB*> DataPoint1 <*TAB*> DataPoint2 <*TAB*>… <*TAB*> DataPointN <*TAB*> <*CRLF*>

How to change instrument settings

NOTE! Instrument settings can not be changed during recordings. Always stop recordings before changing settings!

To change instrument settings, follow the outlined procedure:

1) Control that the instrument is not recording. If recording, stop the recordings!
2) Update all required settings.
3) Store new settings in the registry (to flash), so that they are available after a reset.
4) Reset the instrument (using the reset command) and wait for it to restart.
5) Control the changed settings to confirm a successful configuration.
6) If the recorder was initially recording, the recording can now be restarted.

Site Limitations

Selectable instrument depths, in meters: 5; 6; 7; 8; 9; 10; 12; 15; 20; 25; 30; 35; 40; 45; 50; 55; 60; 65; 70; 75; 80; 85; 90; 95; 100; 150; 200; 300; 400; 500; 600; 700; 800; 900; 1000; 1500; 2000

Profile Limitations

If *UseDefaultPingSetup* is set to *0* (false), the pulse length can be changed. The pulse length can be from 1.0m to 5.0m in steps of 0.1m. The default pulse length is set as the shortest cell used in all the columns.

If the instrument is deployed up side down, surface referenced columns are not allowed, neither is the surface cell.

At least one column or a surface cell must be present in the configuration. If the configuration is not using any profile columns it should rather disable the profile sensor by using the *set_property_profile_active(inactive)* command.

The cell sizes ranges from 1.0m to 10.0m in steps of 0.1m.

If setting up a surface referred column, the minimum distance from the sea surface to the nearest cell is:

$$MinStartFirstCell = \frac{PulseLength}{2} + MinBlankingDistSurface$$

If setting up a transducer referred column, the minimum distance from the instrument to the nearest cell is:

$$MinStartFirstCell = \begin{cases} \frac{PulseLength}{2} + MinBlankingDistTransducerHP; & if\ Highpower \\ \frac{PulseLength}{2} + MinBlankningDistTransducerLP; & if\ Lowpower \end{cases}$$

If the *use surface cell* is set to *0* (false), the *surface cell size* must be 0.0.

Timing Limitations

Selectable numbers of pings in one record are: 100; 150; 200; 250; 300; 400; 500; 600; 800; 1000; 1200; 1500; 2000; 2500; 3000

NOTE! More pings imply higher memory consumption. Therefore the maximum number of pings depends on the profile settings, which also consumes more or less memory depending on the total number of cells.

If the pressure is updated at the recording instance only, the custom update interval must be set to *0* (false).

Selectable custom set pressure update intervals are (in seconds): 40; 50; 60; 70; 80; 90; 100; 110; 120; 130; 140; 150; 160; 170; 180; 190; 200; 210; 220; 230; 240; 250; 260; 270; 280; 290; 300

The minimum recording interval allowed in seconds is given by *IMin* below, however, the selectable recording intervals in seconds are: 30; 60; 120; 180; 300; 600; 900; 1200; 1800; 3600; 5400; 7200; 9000; 10800; 14400; 21600; 28800 if above or equal to the minimum recording interval.

The minimum recording interval, IMin, is calculated as follows in the 4 steps below (*IMin* is given in step 4):

1. $\rho_0 = (Tc + Tp + Ts + Tf + Tdsp + Tsa) \cdot 1.05$

where

$$Tc_1 = \begin{cases} \frac{PulseLength}{750} \cdot 72000 - 50, & if \quad PowerLevel = High \\ \frac{PulseLength}{750} \cdot 45000 - 50, & if \quad PowerLevel = Low \\ 25, & if \quad PowerLevel = Off \end{cases}$$

$$Tc = \begin{cases} 25, & if \quad Tc_1 < 25 \\ Tc_1, & if \quad Tc_1 \geq 25 \end{cases}$$

$$Tp = \frac{PulseLength}{750} \cdot 1000$$

$$Ts = D \cdot \frac{1.15}{750} \cdot 1000$$

$$Tf = 1.2 \cdot D + 4$$

$$Tdsp = 0.86 \cdot CellSize \cdot TNC + 0.05 \cdot TNC + 6$$

$$Tsa = 7.0 \cdot TNC + 90$$

$$mp = \begin{cases} 250, & if \quad PowerLevel \neq High \\ \max\left(\frac{1000 \cdot Pulselength}{5}, 250\right), & if \quad Powerlevel = High \quad and \quad Pulselength > 0.5 \end{cases}$$

2. $$\rho = \begin{cases} \frac{mp}{1000}, \rho_0 < mp \\ \frac{\rho_0}{1000}, \rho_0 \geq mp \end{cases}$$

3. $$P = \begin{cases} ceil(\rho), \rho > 1 \\ \frac{ceil(\rho \cdot 100)}{100}, \rho \leq 1 \end{cases}$$

4. $$IMin = ceil[(P) \cdot iPings]$$

iPings: number of pings

D: Total extent of all the profile columns in meters.

TNC: Total number of cells in the system.

IMin: Minimum recording interval in seconds.

max: max(a,b) returns a if a>b and b if b>a.

The parameters *PartOfDayStartTime* and *PartOfDayRecordingPeriod* are only valid if *OnlyRecordPartOfDay* is set to *1* (true). The *PartOfDayStartTime* must be rounded to the nearest hour. Selectable recording periods are, in hours: 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23. The recording period must, however, be longer or equal to the recording interval.

Wave Limitations

Selectable number of samples in calculating the wave parameter is: 128; 256; 512; 1024; 2048; 4096

The parameter *ApproximateDistanceFromSeabedToSurface* must be between 0m and 2000m.

Wave parameters can be selected if the wave software is available and installed on the instrument. To check if the software is installed on the system use the *get_property_wave()* command; if an error is returned then wave is not installed on the instrument. If the wave configuration is returned then wave software is installed and wave parameters are available on the system.

Testing of the RS-system

Note! The software HyperTerminal is only suitable for testing of the system.

- Set up the RDCP to use RS-232 or RS-485 depending on what is to be tested. Set the communication protocol to AAI Standard ASCII and 38400 bps.
- Connect the RDCP to your PC. When using RS-485 you need a RS-485/RS-232 converter.
- Open HyperTerminal and enter the following information: Connect using: COM1, Bits per second: 38400, Bits: 8, Parity: None, Stop bits: 1 and Flow control: Xon/Xoff.
- Start the RDCP recorder.
- In the HyperTerminal window the 'Start up notification' (refer to page 35) should appear and you may enter commands according to the protocol.

PDC-4

PDC-4 is a binary 10-bit code with duration of 4 seconds, providing real-time output of data. In order to transfer data via Aanderaa UHF/VHF radio systems the signals must be of PDC-4 format. The PDC-4 code can not be used to configure the RDCP 600; PDC-4 real-time output must be configured before deploying the RDCP 600.

General description

Traditionally this code has been used by Aanderaa Instruments because most of the environmental parameters that we wish to measure vary relatively slowly. For this reason, it was not necessary to measure such parameters rapidly or to transmit measurements at high data-rates. A few seconds are usually available for each measurement. Such low rates permit the use of simple measurement systems, and allow data to be sent by simple methods via long cables, through water in the form of acoustic pulses, and in the form of radio signals through the atmosphere. The field measurement systems manufactured by Aanderaa Instruments has taken advantage of this fact by operating relatively slowly and by transmitting data by means of a special code known as PDC-4 (Pulse Duration Code of 4 seconds).

The PDC-4 signal is used only by products developed by Aanderaa Instruments. It is a 10-bit binary code with a four second duration. This binary code consists of a series of 10 short or long pulses. A binary 1 is transmitted as a short 28 milliseconds (ms) pulse, while binary 0 is a long 83 ms pulse. The ten pulses that make up each measurement are sent in the course of 1.66 seconds. These are followed by a 2.5 second pause before the next 10-bit binary word begins. Sending a short synchronization pulse marks the completion of a measurement series of several 10-bit words.

To convert this signal to one that the rest of the computer world understands various products have been produced that can accept and then convert it to RS-232 signals. The most used of these products is the Deck Unit 3127.

This product works by accepting PDC-4 signals from e.g. an RDCP 600, which converts and sends out each measured parameter as 10 pulses every 4th second.

The unit collects the 10 pulses, converts them to a number between 0 and 1023 and sends them out via the RS-232 output port before it is ready to accept 10 new pulses from the RDCP 600.

When the RDCP 600 has measured all the sensor parameters it sends a message to the Deck Unit stating that it has completed its measuring cycle. The Deck Unit then sends out a “line shift” command through the RS-232 output port.

Below is an example of data sent out of a Deck Unit 3127:

0657 0064 0237 0427 0619
0657 1023 1023 1023 1023

This example shows two data sets and is from an instrument with five channels and a reference reading of 657.

Using the calibration coefficients the data is converted by software in the computer to engineering units e.g. m/s, Deg.C, hPa.

Calculation of Engineering Units

In order to link the PDC-4 raw data readings to the actual parameters measured and provide output in engineering units, coefficients must be inserted into a formula that also takes the raw data reading as input:

$$F = A + B \cdot N + C \cdot N^2 + D \cdot N^3.$$

F = Reading in engineering units
A, B, C and *D* = Coefficients

N = Raw data reading, with range of 0-1023 for 10-bit sensors. 10-bit sensors occupy one channel each.

The depth and pressure parameters are however 20-bit sensors providing higher resolutions; they will occupy two adjacent channels each. The first incoming channel contains the most significant word (MSW) and the following channel contains the least significant word (LSW). For a 20-bit sensor the range is of 0-1048575 and the raw data readings to be put into the formula to the left is given by:

$$N = MSW \cdot 1024 + LSW,$$

where *MSW* is the raw data reading in the MSW channel and *LSW* is the raw data reading in the LSW channel.

Examples of RDCP 600 applications with use of PDC-4 signals

If the RDCP 600 is configured to output data in PDC-4 format several applications are possible. A few examples are shown in Figure A 6, Figure A 15 and Figure A 16.

In all cases it is vital that the Galvanic Isolator 3945 is applied, as an interface between the RDCP 600 and a device with PDC-4 input. The Galvanic Isolator 3945 is needed to adapt the signal levels from the RDCP 600 to the PDC-4 receiving equipment. It will also convert the 24-48V DC input to 12V DC which can supply equipment connected to the output side with power.

Note that the cable transferring PDC-4 signals from the RDCP 600 to the Galvanic Isolator 3945 must be connected to connector 3 of the galvanic isolator. The cable transferring PDC-4 signals from the galvanic isolator must be connected to connector 1 of the galvanic isolator.

shows a communication setup with use of a UHF radio system continuously transferring and receiving the PDC-4 signals, and the Deck Unit 3127 converting the signals to RS-232C format.

In Figure A 15 a second environmental station is connected, the Datalogger 3660, which is also able to send signals in PDC-4 format. The Cascade Coupler 3596 then makes it possible to combine the PDC-4 output signals from both stations and send data over the same line as one message. In such configurations the RDCP 600 must always be connected to ‘PDC-4 input 1’ of the cascade coupler and serve as a master for the system.

In Figure A 16 the Computing Unit 3015 converts the PDC-4 raw data into data in engineering units. The data can be reached using a GSM modem, the GSM Communication Unit 3743. A GSM antenna sends the signals to a PC where the data can be displayed.

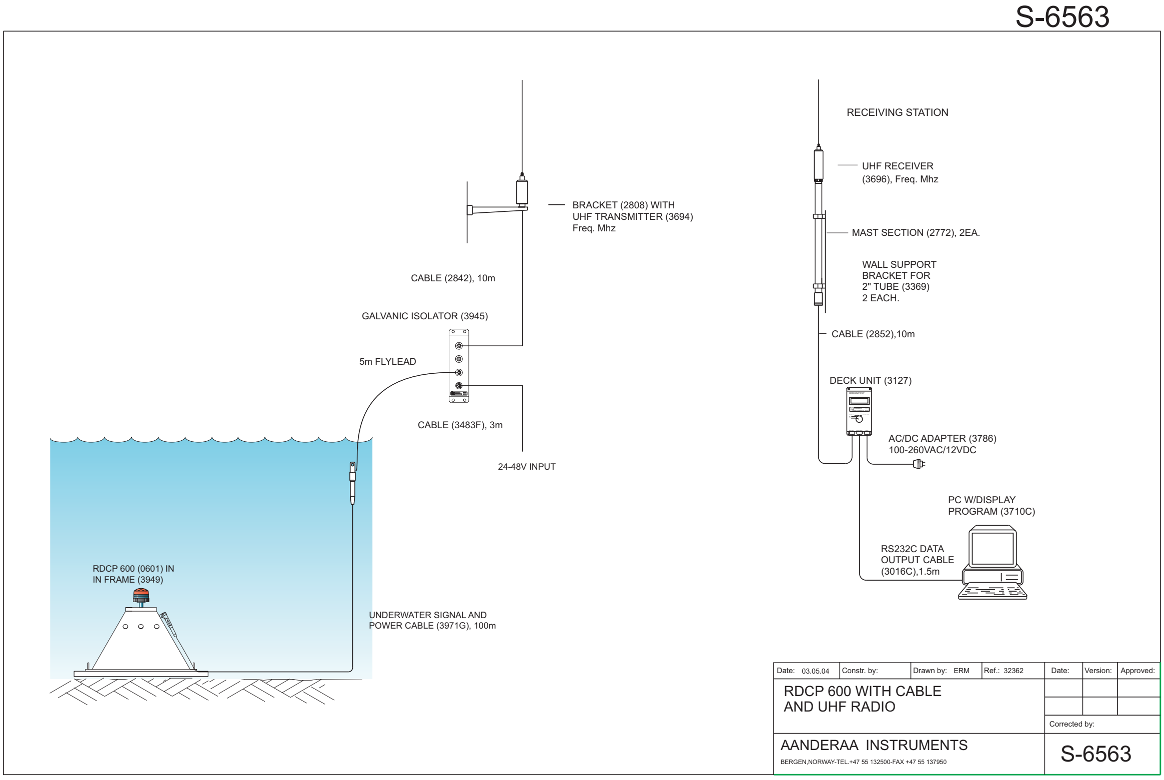


Figure A 14 RDCP 600 with cable and UHF radio. The Galvanic Isolator 3945 is needed to adapt the signal levels from the RDCP 600 to the PDC-4 receiving equipment.

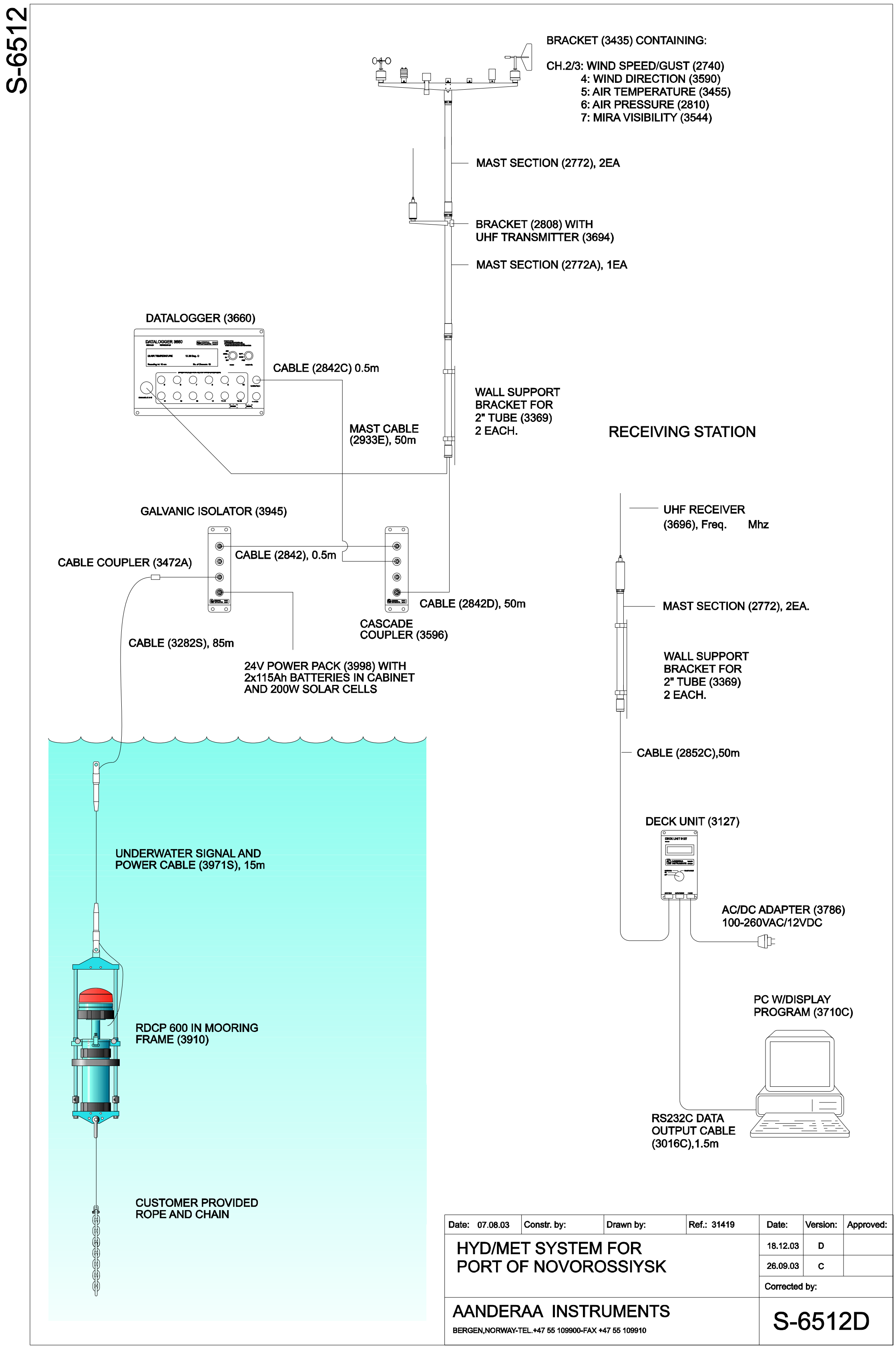


Figure A 15 RDCP 600 combined with the Datalogger 3660 and with use of the Cascade Coupler 3596.

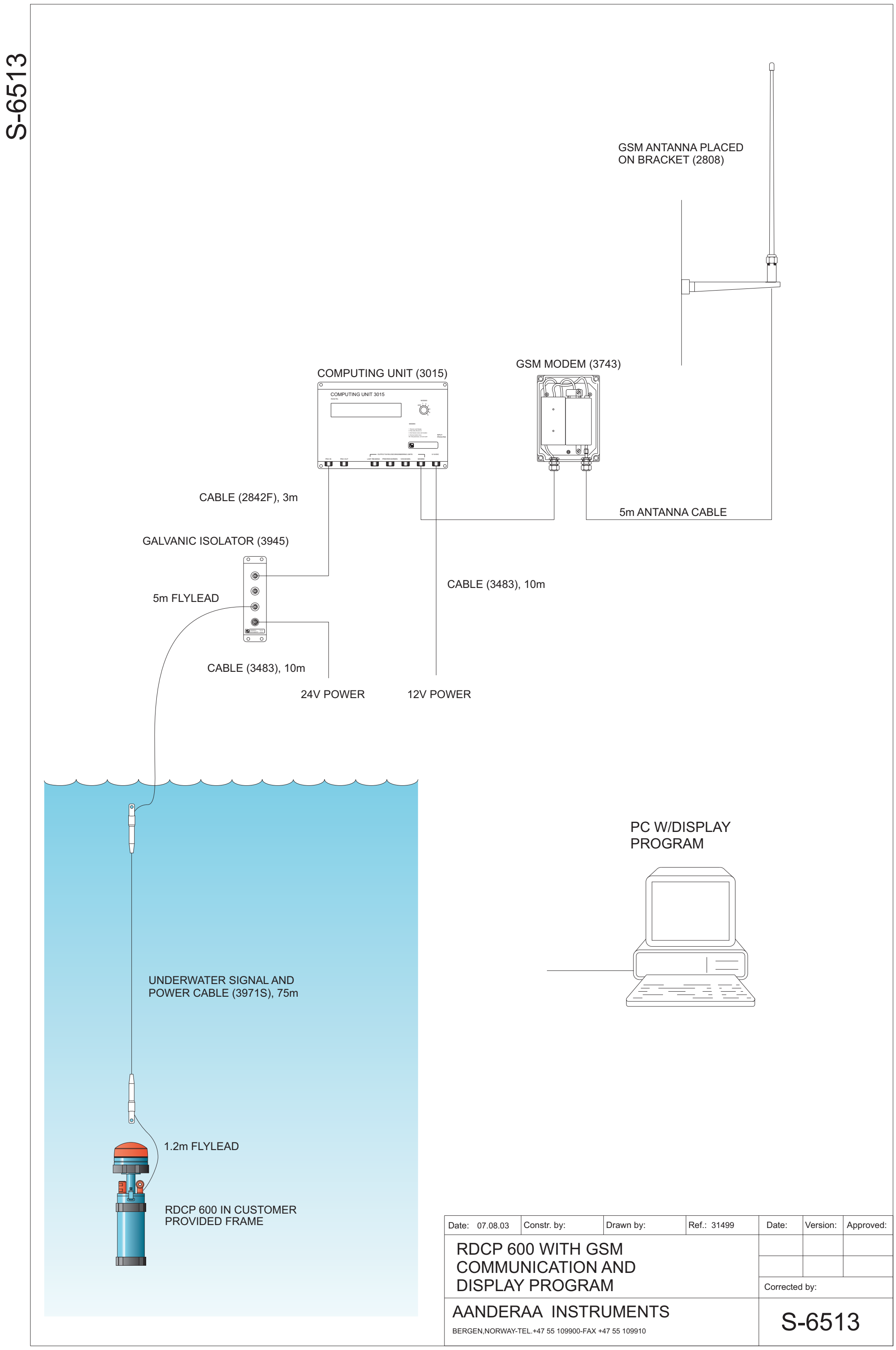


Figure A 16 RDCP 600 with the Computing Unit 3015 and a GSM communication system.

CHAPTER 4 Calibration

General

Each RDCP 600 is calibrated at the factory prior to shipment. Normally it does not have to be recalibrated for several years unless changes have been made to the instrument, i.e. replacement of defective sensors. However, to ensure maximum accuracy, the calibration should be checked once a year. The calibration procedures described in this chapter are those in use by the manufacturer.

During calibration, instruments are connected to a printer through the electrical terminal on the top end plate for direct read-out of the measured parameters. The relationship between sensor raw data readings, *N*, and the various quantities in physical units, is given as a polynomial of third degree. For some users and some applications, a simpler, linear relation would be preferable. The coefficients A, B, C and D of the polynomial are therefore given in a form that also covers the best linear fit to the sensor characteristic.

$$A + B \cdot N + C \cdot N^2 + D \cdot N^3$$

where *N* is the sensor raw data reading.

Current Speed, Direction and Instrument Tilt

Calibration of the *Compass Tilt sensor* is an extensive process that must be performed by the manufacturer only.

The part of the Transceiver Head that measures *current speed* does not have to be recalibrated (please refer to Technical Note 236: Calibration Accuracy for Aanderaa DCS Products).

Temperature

The ISO-curve type thermistor used in this sensor has well defined characteristics where the coefficients C and D in the Polynomial, given in subchapter *General*, make no significant difference to the individual sensor.

Thus factory calibration of individual sensors is restricted to measurements at two different temperatures from which the values of A and B are calculated. These measurements are performed with the instruments immersed in a temperature stabilized bath which is stirred to avoid temperature gradients.

The temperature is measured by a platinum thermometer (Automatic Systems Laboratories, model F25), which is often controlled against a reference.
During calibration, the instrument must be allowed sufficient time for proper temperature stabilization. This is indicated by a steady temperature reading in one hour.

Conductivity

The conductivity sensor is best calibrated using a sea-water bath of known conductivity.

Calibration at the factory is performed by the use of a reference conductivity sensor. The reading of this sensor is used to calculate the conductivity of the bath. The reference sensor is checked once a year against water samples.

A resistor-set-loop 3919 (supplied with the sensor) can be used as a quick check of the sensor performance. The correct readings of the sensor with these 4 loops are shown in the calibration sheet accompanying the sensor.

Pressure sensor (for measurement of depth)

The pressure sensor is a linear sensor. Calibration is performed using deadweight testers covering the range from 0 to 200 kg/cm^2. Several readings are taken throughout the range (5-6 points) to determine the coefficients in the Polynomial given in page 52. The sensor is only accepted if all the readings are within the accuracy limits as compared to the linear characteristics.

Quartz pressure sensor (for surface referred columns)

Calibration of the Quartz Pressure Sensor is an extensive process that must be performed by the manufacturer only.

Turbidity

Each sensor is calibrated prior to delivery and a calibration sheet, Form 501, is enclosed. This calibration is valid for years provided the acrylic material covering the LEDs are kept clean and transparent. If recalibration should be necessary, this must be done at the factory. During calibration the sensor is submerged in six different formazine solutions with known turbidity and connected to a Sensor Scanning Unit or a Datalogger. These units give a raw data reading for each of the six solutions and based on the readings a set of calibration coefficients are calculated. See Calibration Sheet, Form 501, following each sensor.

Oxygen Optode

Each sensor is calibrated prior to delivery and is valid for years unless the Sensing Foil is punctured or severely fouled. In general, the Oxygen Optode demands very little maintenance. Some of the features of the Oxygen Optode are:

- Long term stability.
- Rugged construction.
- Less affected by fouling.
- No consumption of oxygen.
- Connects directly to Aanderaa instruments.
- Operates as stand-alone in RS-232 mode.

Recalibration should be carried out if the reading in air does not show 100% ± 4% (or equivalent raw data reading as given in the sensors calibration Sheet, Form 533 supplied with the sensor) or when the sensing foil has been replaced due to damage of the original sensing foil. Please refer to the Operating Manual of the Oxygen Optode, TD 218 for calibration procedure and procedure for replacing the sensing foil.

A Sensing Foil Kit no. 3853 consists of the items listed in Table A 7.

Table A 7 Sensing Foil Kit 3853

Part. No	Description	Pieces
962203	Sensing Foil packed in aluminium foil	2
642710	Hex countersink screw 3 x 6mm Din 7991 A4	2
913015	2mm Hex Key	1
Form No. 621	Calibration Sheet for Sensing Foil (each batch of foils is calibrated)	

IMPORTANT! Always recalibrate the Oxygen Sensor after the Sensing Foil has been replaced.

CHAPTER 5 Mooring Frames

There are two in-line mooring frames available for RDCP 600, shown in Figure A 17 to Figure A 19, and two bottom mooring frames for fixed installations, refer Figure A 20 and Figure A 21.

NOTE! We recommend protection rods on the in-line mooring frames

Figure A 17 In-Line Frame 3910

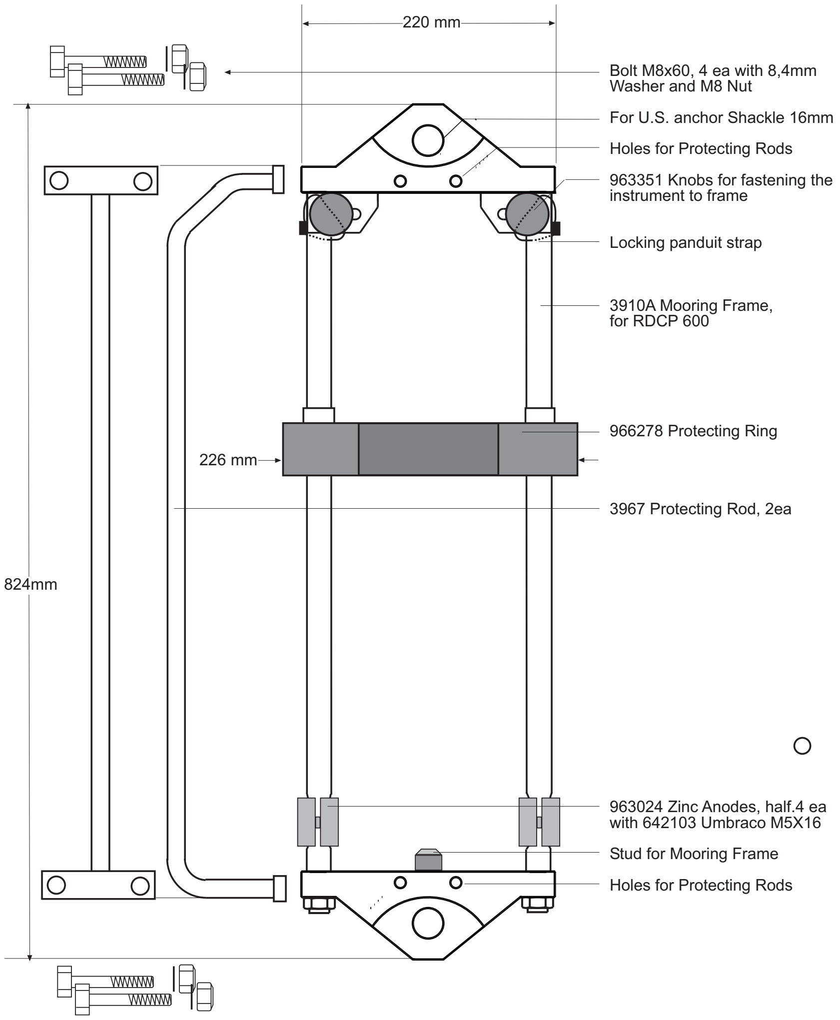


Figure A 18 Illustration of In-Line Frame 3910A with a set of Protecting rods 3967 (optional)

In-line mooring frame 3910 has been updated: new in-line frame 3910A has minor corrections compared to 3910 and is illustrated with a drawing in Figure A 18. Frame 3910A is slightly longer than 3910, the outer diameter is the same.

Figure A 19 Extended in-line mooring frame 4110 for RDCP600 and a short external battery case.

NOTE! The external battery case gives you more battery capacity. Please refer brochure B 146 for more information about available battery cases and battery packs.

Figure A 20 Bottom Mount Frame 3448

The RDCP600 can be mounted in three levels in the Bottom mooring frame 3448: In the lowest level, the entire instrument is below the Gimbal ring. In the highest level, the entire top-end plate (with sensors) is above the Gimbal Ring.

- Dimensions, HxD: 650x1400mm
- Weight in air: 55kg
- The empty frame floats in water

Refer Technical Note TN 294 for more information about the frame, optional accessories and installations procedures.

Figure A 21 Trawl Resistant Bottom Mount Frame

The Trawl Resistant Bottom Mount Frame is a recently designed bottom frame. The frame has got acoustic release and a pop up buoy.

- Frame length: 1900 mm
- Frame width: 1550 mm
- Frame height: 650 mm
- Frame weight: TBA

CHAPTER 6 Batteries

Five Aanderaa designed batteries exist, four of them are shown in the figures below.

Figure A 22 1. Lithium Battery 3908

Figure A 23 3. Alkaline Battery 3988

Figure A 24 4. Rechargeable External Battery 4021

1. The 35 Ah 7V non-magnetic Lithium Battery (part no. 3908) is available for deployment applications using low or high power setting.

2. The 15 Ah 9V Alkaline Battery (part no. 3988) should only be used for testing of the RDCP 600 as it is magnetic and will affect the compass.

3. The rechargeable external lead/acid 28 Ah 12V battery (part no. 4021) is shown in Figure A 24. It has a depth capacity of 100 m.

4. For long-term deployment the **150 Ah 7.6V Lithium Battery (part no. 3999)** is available.

For battery consumption calculator consult factory.

CHAPTER 7 Mechanical Hardware and Illustrations

Pressure Case

The pressure case shown in Figure A 26 consists of an OSNISIL copper alloy tube (95% Cu, 3.5% Ni and 0.9% Si). The lower end plate, made of non-magnetic acid proof stainless steel (57.2% Fe, 17.5% Cr, 12.5% Ni, 2.7% Mo and maximum 0.06% C) is furnished with an O-ring and press fitted to the pressure tube. The lower end of the pressure case is fitted with a rubber base. At the top end of the pressure tube there is machined a circular groove into which the clamps grip, thus holding the top-end plate seated in the pressure case.

The pressure case of this instrument is furnished with a blue (RAL 5007) epoxy coating applied by an electrostatic powder process. This coating performs well in seawater and will protect the covered parts from corrosion. However, the O-ring seats are not epoxy coated but nickel-plated. The corrosion of these surfaces is inhibited by the use of a sacrificial zinc anode fitted to the top end plate. Some sensors are encapsulated in a titan housing for protection against corrosion.

Top-End Plate

The top end plate, made of the same non-magnetic acid proof steel alloy as the bottom end plate, is seen in Figure A 26. All external and internal parts of the instrument are fastened to the top end plate, so that the instrument can be removed from the pressure case as one unit. The sealing between the top end plate and the pressure tube is obtained by an O-ring. All top end plates are bored to accommodate an optional sensor. When a sensor is not installed, the 16 mm sealing plug 3625 must be installed instead.

IMPORTANT!

The Conductivity sensor must stay plugged in where it was last calibrated.

To get enough space for all standard and optional sensors, the Temperature sensor and the Electrical Terminal must be plugged in as shown in Figure A 26.

Please refer to TD220a Deployment Guide for connection/disconnection of sensors!

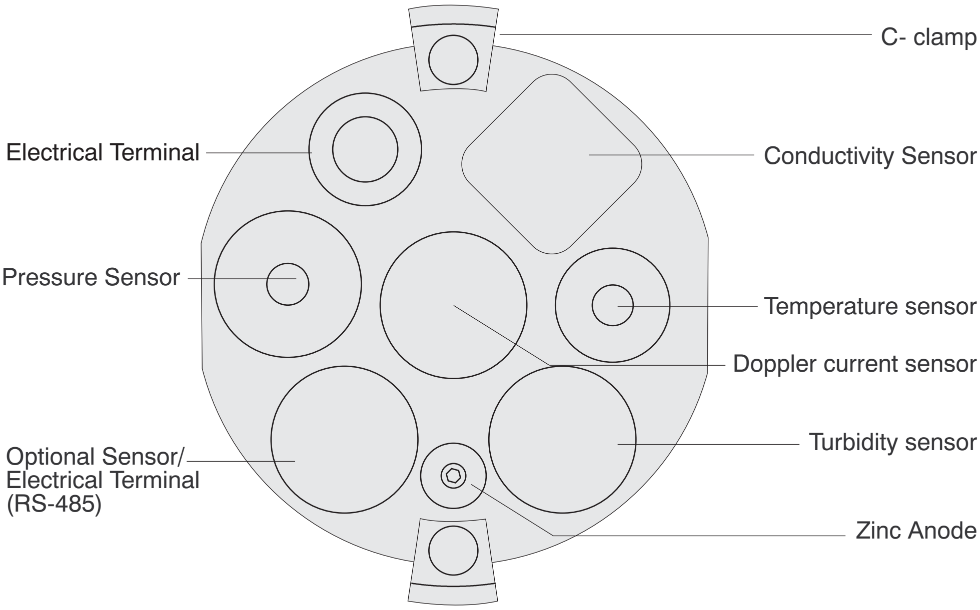


Figure A 25 Illustration of Top End Plate for RDCP 600. Note: The sensors can be placed different than illustrated here.

Pictures and Illustrations

Figure no.	Description
Figure A 26	RDCP 600 inside Pressure Case.
Figure A 27	RDCP Rear View, Battery off
Figure A 28	A selection of sensors
Figure A 29	Main Board

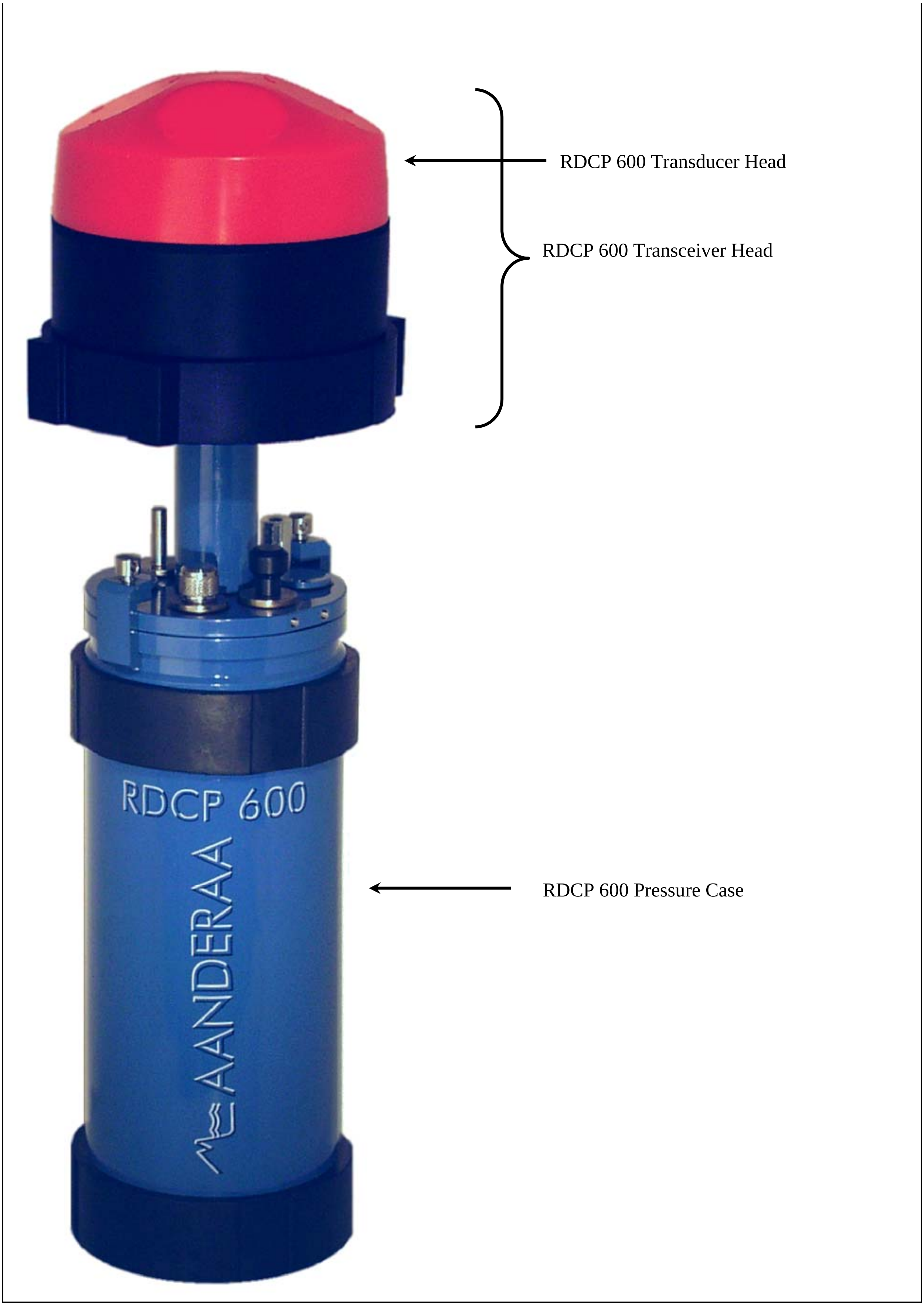


Figure A 26 RDCP 600 inside Pressure Case.

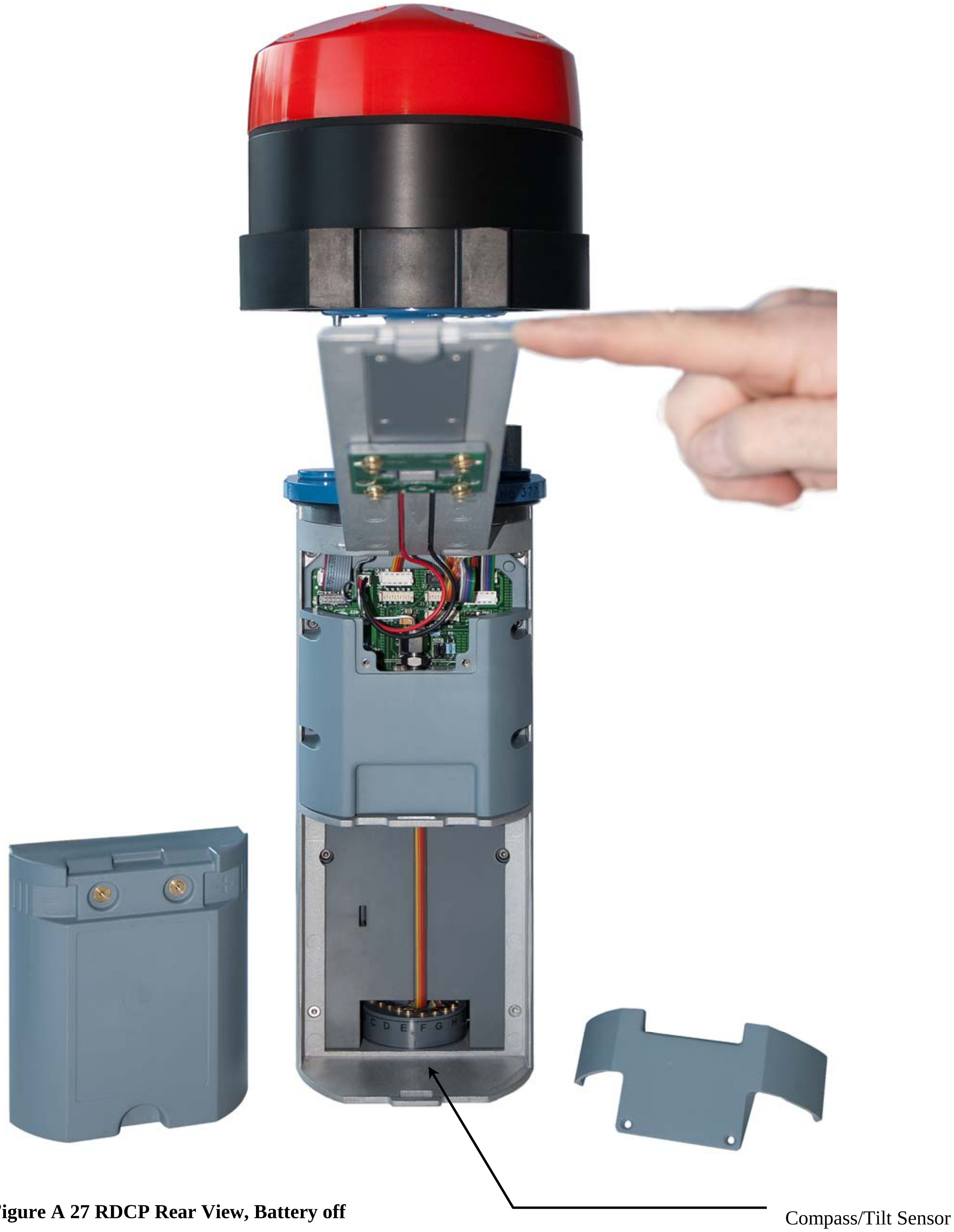


Figure A 27 RDCP Rear View, Battery off

Sensors from left: Pressure sensor 4017, Turbidity sensor 4705, Conductivity sensor 3919/4019, Turbidity sensor 3612, Temperature sensor 4050, Oxygen Optode 3830, , Oxygen Optode 3835, Quartz Pressure sensor 3187.

Figure A 28 A selection of sensors

Figure A 29 Main Board :