TD 259 OPERATING MANUAL

Recording Current Meter

RCM 9 LW, RCM 9 IW and RCM 11

AADI AANDERAA
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INTRODUCTION

This manual describes the Recording Current Meter, RCM 9 LW (Light Weight), RCM 9 IW (Intermediate Water) and RCM 11. RCM 11 is a high pressure version with depth capacity of 6000 m, RCM 9 IW has a depth rating of 2000 m while RCM 9 LW has a depth rating of 300m. RCM 9 LW weights only 4.5 kg without frame. The instruments are combining well proven components, items and parts with up to date technology. The instruments feature RCM Doppler Current Sensors as well as sensors for Instrument Tilt, Signal Strength, Temperature, Pressure, Oxygen, Conductivity and Turbidity measurements. The instruments can be used in the sea, in oceans, in lakes and in rivers. A special Arctic Temperature range makes it well suited for use in Polar Regions.

The use of RCM 9 LW / RCM 9 IW / RCM 11 instrument requires practical insight in several fields such as mooring, deployment and recovery of instruments, operation and maintenance, sensor calibration, data processing and interpretation. It is our intention by this manual to give sufficient background information and documentation for the user to ensure successful operation of the instruments.

Among the advantages of the RCM 9 LW, RCM 9 IW and RCM 11 are their ease of deployment and that they have no moving parts. The current is measured in the area from 0.4 to 2.2 meters from the instrument, which minimizes the effect of marine fouling and local turbulence. The instruments are equipped with a watertight receptacle that enables external triggering and testing of a fully assembled instrument as well as real-time data acquisition via cable.

Some of the illustrations and tables include stock identification numbers, which should always be quoted when ordering spare parts. The inside of the pressure case is similar for the RCM 9 LW, RCM 9 IW and the RCM 11. The differences between the RCM 9 LW, RCM 9 IW and RCM 11 are the physical dimensions/weight and pressure capability for the instrument. All three instruments are described in this document.

Applicable Documents

- Operating Manual, Oxygen Optode 3830, 3930, 3975, 3835, 4130, 4175, TD 218
- Operating Manual, Conductivity Sensor 3919, TD222
- Operating Manual, Pressure Sensor 4017, TD 258
- Operating Manual, Data Reading Program 5059, Technical Description TD 208
- Operating Manual, Data Storage Unit, Technical Description TD 145
- Data Sheet, Test Unit 3731 for RCM 9 and RCM 11, D320
- Calibration Accuracy for Aanderaa DCS Products, Technical Note 236

Abbreviations

ADC	Analog to Digital Converter
ASCII	American Standard Code for Information Interchange
DCS	Doppler Current Sensor
EEPROM	Electrically Erasable Programmable Read-Only Memory
IW	Intermediate Water
LED	Light Emitting Diode
LSB	Least Significant Bit
LW	Light Weight
Mk II	Mark II
MSB	Most Significant Bit
PDC-4	Pulse Duration Code 4 seconds
RCM	Recording Current Meter
RTC	Real Time Clock
DSU	Data Storage Unit
GMT	Greenwich Mean Time

INTERNAL VIEW OF RCM 9 IW

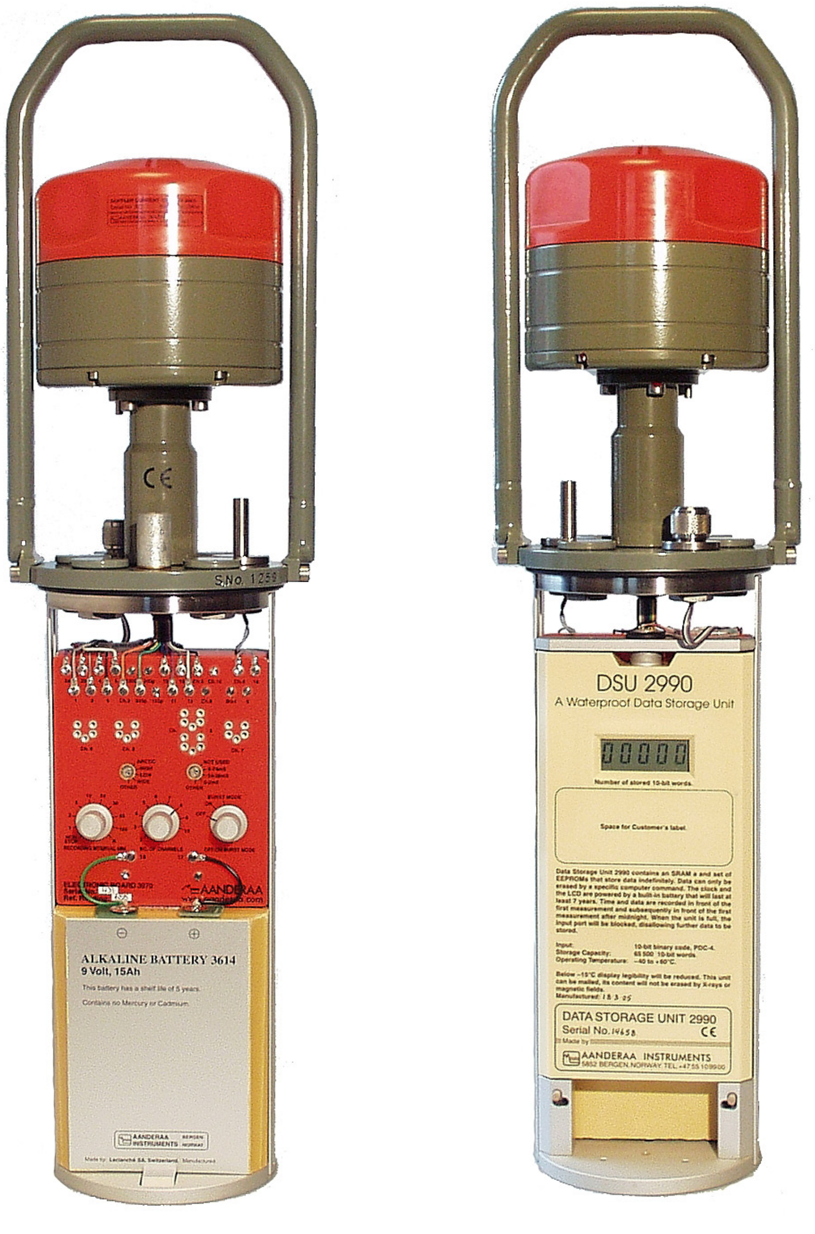


Figure 0 - 1 Internal view of RCM 9 Intermediate Water. Front view with Sensor board, and rear view with the DSU. The internal view of the RCM 9 Light Weight and RCM 11 is similar to the RCM 9 IW; the outer parts are different: Top-end plate, handle and DCS (refer Figure 1-3).

CHAPTER 1 Short Description and Specifications

Description

The Recording Current Meter 9 LW, RCM 9 IW and RCM 11 are self-recording current meters intended to be moored to measure and record the vector averaged speed, direction, temperature, conductivity, turbidity and oxygen of ocean currents as well as the instruments deployment depth, instrument tilt and signal strength.

The RCM Doppler Current Sensor sends out a selected number of pings (600, 300 or 150 pings) during each recording interval. The pings are normally distributed equally in time over the whole measuring interval but it is also possible to select a Burst Mode where the pings are distributed during the last minute of the measuring interval.

Among the advantages of the RCM 9 LW, RCM 9 IW and RCM 11 are their ease of deployment and that there are no moving parts. The DCS measures the horizontal current in an area of 0.4 to 2.2 meters from the instrument, see Figure 1-2, which minimizes the effect of marine fouling and local turbulence. The instrument is equipped with a watertight receptacle that enables external triggering and powering of the instrument as well as real-time data acquisition via cable.

The illustrations in Figure 1-1 show 2 typical ways of mooring the instrument. U-anchoring is suitable for shallow waters, while I-anchoring can be used for all depths, provided that the depth capability of the release device or current meter is not exceeded. For U-anchoring a piece of heavy chain can be used as an anchoring weight rather than a solid weight because it is easier to hoist off the bottom.

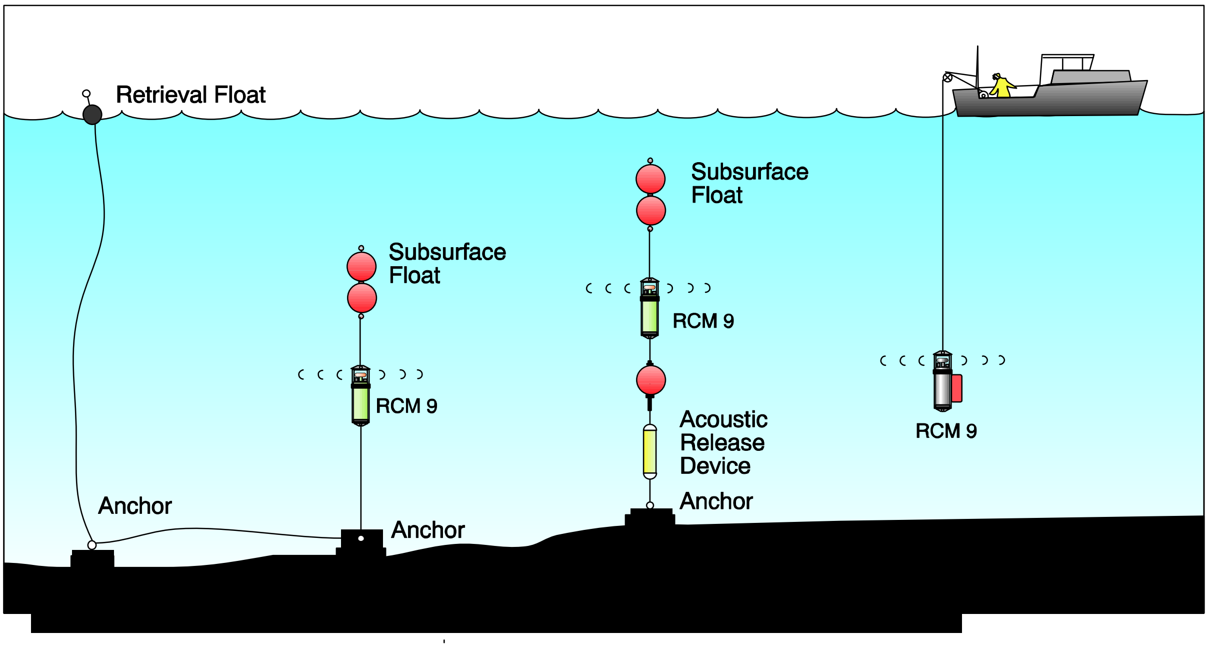


Figure 1-1 Different types of anchoring and usage illustrated with an RCM 9. U-anchoring to the left, I-anchoring in the middle, and Direct reading to the right (RCM 9 with anti-spin vane).

The instrument can also be used for profiling due to its compact design, low drag force and easy handling. The instrument can be lowered into the sea from a small boat using a simple winch. Data can be stored internally and read after retrieval or be read in real-time on deck by use of a wire cable. Figure 3-1 shows how the RCM 9 LW / RCM 9 IW / RCM 11 can be used for measurements close to the seabed. The instrument with mooring frame is then fastened with two base brackets to a concrete block or similar.

The instrument records data internally in a removable and reusable solid-state Data Storage Unit, DSU 2990, the standard data storage device for all Aanderaa recording instruments.

A built-in quartz clock triggers the measuring cycle at regular, programmable intervals.

Standard sensors are:

- Current speed and direction Sensor
- Water Temperature Sensor
- Signal strength
- Instrument Tilt

Optional sensors are:

- Conductivity Sensor
- Pressure Sensor
- Turbidity Sensor
- Oxygen Sensor

The reference is a fixed reading that serves as a control of the performance of the instrument and to identify data series from individual instruments. The temperature is measured by a thermistor fitted into a stud on the top end plate, which extends into the water. The conductivity is measured by an electrodeless induction type conductivity sensor and the turbidity is measured by use of back-scattered infrared light. The instrument depth is calculated from pressure measurements taken by a piezo resistive bridge. The current speed and the current direction are measured with the RCM Doppler Current Sensor, DCS 3820 for RCM 9 IW and RCM 11, and model DCS 4220 for the RCM 9 LW.

The measurements are compensated for tilt and referred to magnetic North by using an internal Hall-effect compass. A microprocessor computes vector averaged speed and direction over the last sampling interval.

Figure 1-3 shows the complete recording current meter, RCM 9 LW / RCM 9 IW / RCM 11. It consists of the instrument with the mooring frame. The recording unit is always installed in the frame when deployed.

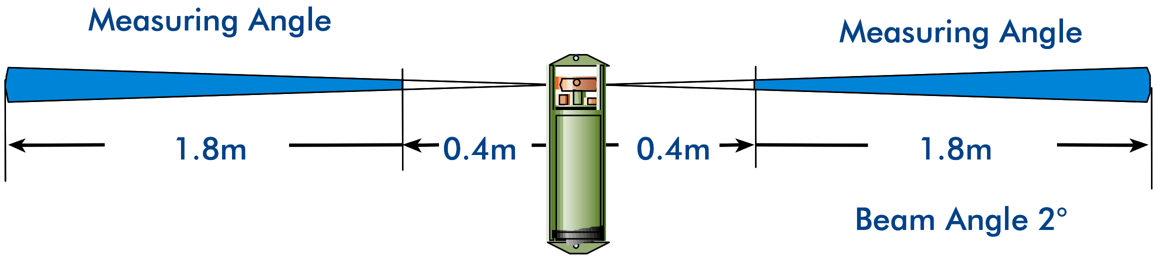


Figure 1-2 Measuring area of the RCM 9 LW/ RCM 9 IW / RCM 11. Illustrated with a RCM 9 IW.

The frame allows for easy installation and removal of the instrument without disassembling the mooring line (remove the instrument from its frame). The frame of the RCM 9 IW / RCM 11 is furnished with a Protecting Ring to shield the sensors on the top end plate, see Figure A 10 and Figure A 12. The frame can also be equipped with additional protecting rods (no. 3783 for RCM 9 IW / RCM 11) installed 90° on the frame rods. As the instrument operates under a tilt of up to 35° from vertical, it has a variety of in-line mooring applications in combination with surface or sub-surface floats. The instrument is held to the frame by two handles, which facilitates easy installation and removal of the recording unit. The RCM 9 LW frame does not have a Protecting Ring, but the instrument can be fitted in an RCM9 IW frame, if necessary (optional –contact factory).

Figure A 8 shows the assembled RCM 9 LW, Figure A 7 the assembled RCM 9 IW, and Figure A 9 the assembled RCM 11. All external and internal parts are fastened to the top end plate, and the instrument can be lifted out of the pressure case in one piece after removing the two C-clamps.

All external parts of the RCM 9 IW and the RCM 11 are protected from corrosion by a durable olive green epoxy coating. Further corrosion protection is ensured by the use of a sacrificial zinc anode, fitted to the top end plate

The RCM 9 LW DCS and the Sealing plugs are made of POM, all other external parts of the RCM 9 LW are made of thermoplastic or Titanium coated in black epoxy. Since the RCM 9 LW top end plate is made in Titanium, the LW version is not equipped with a zink anode. An illustration of the assembled RCM 9 LW in mooring frame is given in Figure A 11.

In order to withstand the pressure of up to 60 MPa, the thickness of the top and bottom end plates of the RCM 11 has been increased to 30 mm, and the electronics of the DCS is encapsulated in titan. Two O-rings connected to the RCM 11, one on the top end plate and one on the bottom end plate, are located in circular grooves to give proper sealing against the inside of the pressure case. The RCM 11 bottom end plate is press fitted to the tube. As the inside height of the RCM 11 is the same as for the RCM 9 IW, the pressure tube is made 14 mm longer to compensate for the increased thickness of the end plates, and the groove for the C-clamp is reduced to two small grooves to obtain better mechanical strength. The RCM 11 Top end plate, seen in Figure A 6, requires specially designed fastening nuts for all items penetrating the Top end plate.

The top end plate on the RCM 9 LW, RCM 9 IW and RCM 11 is furnished with a handle for carrying the unit. The top end plate also has an electrical terminal. This terminal can be used for real-time data reading, checking the performance of the instrument, as well as remote triggering. A digital display unit e.g. Deck Unit 3127 or Computing Unit 3015, can be connected to display data. By use of the PDC-4/RS232C Deck Unit 3127, the output signal can also be read by a personal computer via the same terminal.

Figure 1-3 Complete Recording Current Meter, RCM 9 LW (left), RCM LW (middle) and RCM 11 (right).

CHAPTER 2 Deployment Guide

Figure 2-1 shows the Electronic Board of the RCM 9 LW / RCM 9 IW / RCM 11 recording unit. The electronics is hermetically encapsulated in a board. This chapter guides you through the set up of the control switches and terminals to achieve your deployment configuration.

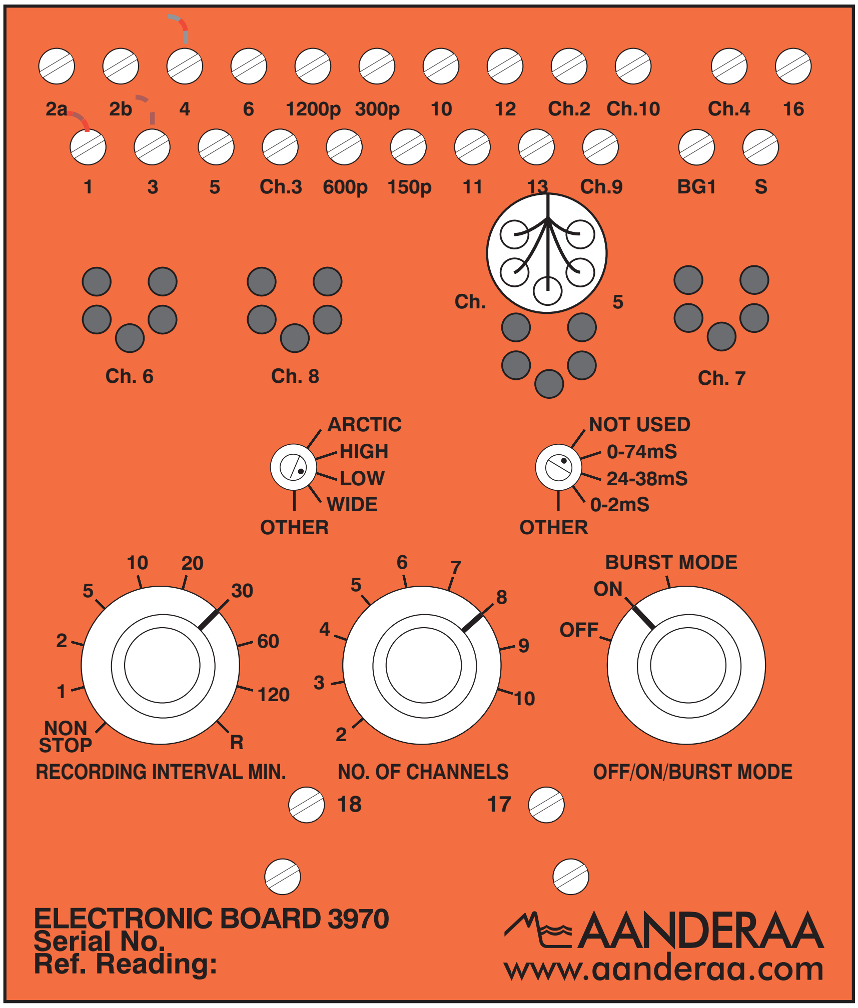


Figure 2-1 Drawing of Electronic Board 3970

Control switches

The control switches for the instrument are embedded in the electronic board. The control switches are:

- Recording Interval Minutes
- No. of Channels
- Off/On/ Burst Mode
- Temperature range
- Conductivity measurement range for conductivity sensor 3619

OFF/ON/BURST MODE switch

OFF:	When the switch is turned to *Off* the instrument is not powered.
ON:	When the switch is turned to *On* the instrument is powered, and will operate in Normal Mode (Spread Mode).
BURST MODE:	When the switch is turned to *Burst Mode*, the instrument is powered, and will operate in Burst Mode.

When the instrument is powered, the clock is reset. The instrument then comes to rest awaiting the next triggering pulse from the clock to arrive after which another measuring cycle is carried out.

NO. OF CHANNELS switch

Turn the switch to indicate the number of channels applied in your deployment. *REMEMBER! One channel, channel no. 1, is always for reference value.*

NOTE! If your deployment does not require all standard and optional sensors, we recommend you to connect the sensors at a lowest possible channel number to achieve longer deployment time (due to storage capacity) or faster recording interval. Always connect the conductivity sensor is the sensor position where it was last calibrated for valid calibration values.

RECORDING INTERVAL MIN.

NON STOP:	When the switch is turned to *NON STOP*, the recording goes on continuously until the power is switched off. The ping rate is automatically taken as twice the customer-set ping rate, with a limit of max 600 pings to be used in the signal processing. This feature improves the standard deviation of the measurements. One recording interval takes, in seconds, 4 x number of channels + 2. E.g. with a seven channel deployment, one recording interval takes (4 x 7) seconds + 2 seconds = 30 seconds.

1,2,5…60, 120: When the switch is turned to either one of the numbers around the switch, the measurement interval is that number in minutes. E.g. if the switch is turned to 10, the measurement interval is set to 10 minutes.

R: When the switch is turned to *R* the instrument will ping continuously. As a remote signal is given the instrument first reads out the measurements from the last 600 pings of the DCS, and then proceeds by reading successively the other sensors. The ping rate in this configuration is the selected ping rate divided by 10 minutes.

Temperature range

When the temperature sensor is connected to the instrument (always use Channel 4), the temperature range must be set to either *ARCTIC, HIGH, LOW or WIDE*, depending on the deployment conditions. The black spot indicates which range that has been set.

Example: in Figure 2-1 the Temperature range is set to *WIDE*.

If the temperature sensor is not connected to the instrument, and one other sensor is plugged into channel 4, always set the temperature range to *OTHER*.

Conductivity range

For the Conductivity Sensor 3919 the conductivity range is pre set to 0-75 mS. For better accuracy, the measurement range can be set to a shorter interval between 0 and 75 mS, e.g 25 – 50 mS; this is done on the sensor using the software 4040 (or a hyperterminal), prior to connecting the sensor to the instrument.

Example: Using full range, 0 – 75 mS gives you an resolution of 75/1024 ≈ 0.075 mS, while zooming down to a shorter range of 25 - 50 mS will give you a resolution of 25/1024 ≈ 0.025 mS; your sensor provides you with better data.

Connect the sensor to your PC using Sensor Cable 3855. In the 4040 program, use the RS-232 protocol to set the properties to the desired range limits for SR10 output, please refer TD 222 Operating Manual Conductivity Sensor 3919.

If using the old Conductivity Cell 3619 (channel 5, lower cell), the conductivity range must be set to either 0-74 mS, 24-38 mS or 0-2 mS on the sensor board.

If the customer makes a customer-specific range when using the Conductivity Cell 3619, the setting *OTHER* must be chosen.

If one other sensor is connected to channel 5, use *NOT USED*.

Terminal signals

The electronic board also consists of several terminals. The terminals are used as described in this chapter.

Battery connection

The battery is connected to terminal signal no. 17 and 18, which is the positive and negative battery voltage, respectively. Please refer to Table 3-1 for battery capacity.

Ping setting

The terminal signals named *150p*, *300p*, *600p and 1200p* are used to set the ping rate of the Doppler Current Sensor. The default ping setting from the factory is 600p e.g. 600 pings per interval. If the deployment requires 150 pings or 300 pings, disconnect the cable connected to terminal 600p, and connect it to either 150p or 300p terminal instead. The 1200p terminal is an option that is not available for the current DCS version, but that will be available in future versions of the sensor.

Fewer pings per interval reduce the battery consumption; hence the instrument can be deployed for a longer time. Please note that the standard deviation of the measurements will increase as the number of pings is reduced.

In the *NON STOP* recording interval, the ping rate is automatically doubled based on the customers ping setting. This is a feature that will improve the standard deviation of the measurement.

In *Normal mode* the selected number of pings (600, 300 or 150 pings) is equally distributed through the whole sampling interval. This gives a ping frequency of number of pings divided by sampling interval in seconds. In normal mode the measurement is an average of the whole sampling interval.

In *Burst mode* the selected number of pings (600, 300 or 150 pings) is distributed through the last minute of the sampling interval, which gives a ping frequency of number of pings divided by 60 seconds. In Burst mode the measurement is an average of the last minute of the sampling interval. The Burst Mode alternative was developed to avoid that the ping frequency would equal any wave frequency; this could lead to incorrect measurements. When the instrument is moored near the sea surface, Burst Mode will thus reduce the influence the waves may have on current measurements. Burst Mode can also be power-saving if you want to do recordings only at a specific time (minute) during an interval. For non-stop measurements and for 1-minute measurement interval, the choice of ping mode is irrelevant.

If a movement other than the sea current influences the instrument it is recommended to use a ping frequency at least 4 times the frequency of the movement; this movement can either be caused by waves or movement in the mooring (strumming).

Instrument Tilt

Instrument Tilt can be measured by strapping a cable (which is part of the wire harness for multiplexing DCS kit 3983, included in recommended spares and accessories) from *ch.3* to one available channel.

If strapped to either of the *channels 4, 9 or 10* attach the cable to the terminal screw in both ends.

If strapped to either of the *channels 5, 6, 7 or 8*, a connector with a complete cell plug must be used in the channel 5 - 8 end.

The wire harness for multiplexing DCS kit is delivered with the instruments spare part kit.

NOTE! Channel 5 upper cell plug is inverted; please refer chapter *Channel 5 reading of other parameters than conductivity* on page 32.

Signal Strength

Signal strength can be measured by strapping a cable (which is part of the wire harness for multiplexing DCS kit 3983) from *ch.2* to one available channel.

If strapped to either of the *channels 4, 9 or 10* attach the cable to the terminal screw in both ends.

If strapped to either of the *channels 5, 6, 7 or 8*, a connector with a complete cell plug must be used in the channel 5 - 8 end.

The wire harness for multiplexing DCS kit is delivered with the instruments spare part kit.

NOTE! Channel 5 upper cell plug is inverted; please refer chapter *Channel 5 reading of other parameters than conductivity* on page 32.

Other terminals

A list of all the terminal signals is given in Table 2-1.

- The electrical terminal, 3622, is connected to terminal no. 1, 2a, 5 and 6.
- The DSU plug is connected to terminal no. 1, 2b, 3 and 4.
- The standard and optional sensors are connected to the terminal signals named ch.2, ch.3, .., ch.10.
- The Bridge Voltage is given in Terminal 16, and the Bridge Ground is given in Terminal BG1.
- Terminals no. 10, 11, 12 and 13 are connected to the Doppler Current Sensor
- Terminal S is used for Aanderaa internal test only.

Table 2-1 List of Terminal Signals

Terminal no.	Description
BG1	Bridge Ground
S	*Aanderaa internal test only*
Ch.2	Connection for sensor, e.g. Current Speed
Ch.3	Connection for sensor, e.g. Current Direction
Ch.4	Connection for sensor, e.g. Temperature
Ch.5	Connection for sensor, e.g. Conductivity
Ch.6	Connection for sensor, e.g. Pressure
Ch.7	Connection for sensor, e.g. Turbidity
Ch.8	Connection for sensor, e.g. Oxygen Optode
Ch.9	Connection for sensor, e.g. Instrument Tilt
Ch.10	Connection for sensor, e.g. Signal Strength
1	System Ground
2a	Control Voltage
2b	Control Voltage, DSU
3	- 9 Volt
4	PDC-4 to DSU
5	PDC-4
6	- 9 Volt Input
10	Bridge Voltage
11	Control Voltage
12	System Ground
13	- 9 Volt
16	Bridge Voltage
17	Battery, Positive
18	Battery, Negative
150p	Ping rate at 150
300p	Ping rate at 300
600p	Ping rate at 600
1200p	*Not available*

CHAPTER 3 Operating Instructions

Receiving a new instrument and taking it into use

The RCM 9 LW instrument is shipped in a wooden box, while the RCM 9 IW / RCM 11 instrument is shipped in a plywood box, also containing the Mooring frame. The RCM 9 LW / RCM 9 IW / RCM 11 is equipped with battery when shipped and the DSU clock is set to GMT. The only preparation needed prior to use, is to select temperature and conductivity range, to set the desired sampling interval and to select the correct number of channels to be read. Before doing so, check the unit for possible shipping damage. If everything looks OK, prepare the instrument for deployment as follows:

1. Remove the two C-clamps at the top end plate and lift the unit out of the pressure case.

2. Set the recording interval switch as required.

3. Check that the temperature and conductivity range selector switches are set to the required ranges.

4. Place the *NO. OF CHANNELS* Selector Switch to the number of the highest channel, which is connected to a sensor.

5. Place the *OFF/ON/BURST MODE* switch to *ON* for normal mode (spread mode) or to *BURST MODE* for burst mode operation.

   The instrument starts immediately, and the DSU records time information and one measurement cycle of the selected channels. At the end of the cycle, the DSU display will show 6 words for the time information plus the number for the selected sensor channels. The clock in the DSU is set to GMT at the factory. The clock can be set in the Data Reading Program 5059.

6. Slide the instrument down into the pressure case. Ensure that the O-ring is correctly seated in its groove in the top end plate. Tighten the C-clamps until the top end plate rests against the edge of the pressure case. Do not overtight as this will damage the clamps.

7. Ensure that a protective cap is fitted to the electrical terminal. The instrument can now be fastened to the mooring frame. If used, fit additional protecting rods and deploy the instrument.

8. When the RCM 9 IW / RCM 11 is used for direct reading or profiling, the stabilizing Frame Vane Plate 3681 should be installed. The Vane is fastened to the Mooring frame 3824. For RCM 9 LW used in direct reading or profiling, contact factory.

If additional sensors are to be connected to the instrument, or if some sensors are to be disconnected, please follow the procedure described in pages 21 to 26.

The battery is connected to terminal signals 17 (positive voltage) and 18 (negative voltage).

IMPORTANT! The instrument should not be installed closer to the surface than 0.75 m and not closer to the bottom than 0.5 m to avoid reflections from the surface and the bottom.

Ensure that the protective cap is fitted to the electronic terminal.

Retrieval of the instrument and removing the DSU

When an instrument is retrieved after a period of recording, it should first be rinsed in fresh water and dried. The unit can then be opened. After opening, the following procedure is recommended (read the whole procedure before stopping the instrument):

1. Wait until the instrument starts again and finishes the recording cycle (observe the DSU display).
2. Set the *OFF/ON/BURST MODE* selector switch to *OFF*.
3. Write down the time for the last recording
4. Remove the DSU from the recording unit by releasing the 2 snap-on locks at the lower end of the instrument. Pull the DSU out and press down to release it from the connector on the top. Refer to chapter 4 for reading of the DSU.

Mooring

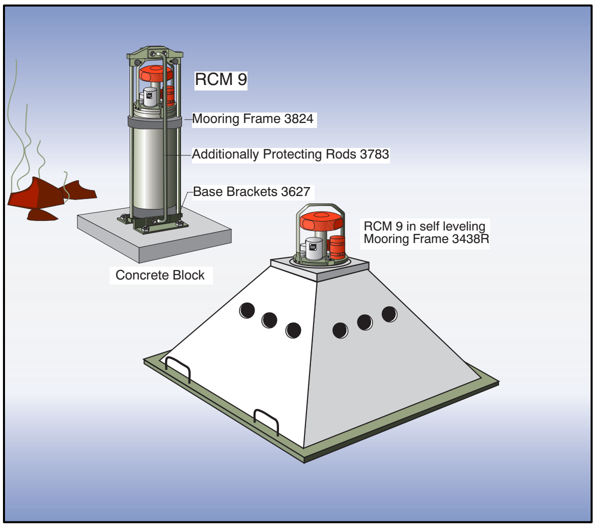


Figure 3-1 RCM 9 IW in bottom frame.

The Mooring Frame, model 3824 for RCM 9 IW / RCM 11 illustrated in Figure 3-1, and model 4044 for RCM 9 LW, facilitates easy installation and removal of the instrument without disassembly of the mooring line. The mooring frame is fastened to the mooring line by using two shackles. The instrument is held in place by two knobs, which are easily removed, even under water. The 3824 frame is made of stainless steel and has a breaking load of more than 8000 kilograms. Two additional protecting rods, no. 3783 for the RCM 9 IW / RCM 11 to protect the instrument and the DCS further e.g. against strokes in the deployment/retrieving situation, are also available. These rods are installed 90° on the frame after the instrument has been fastened to the frame.

The mooring frame 3824/4044 is typically used in in-line applications.

The mooring frame is also conveniently used when deployment on the seabed is required. For this application, the frame is furnished with two base brackets and placed on a concrete block or similar.

A self-leveling Mooring Frame, model 3438R for RCM 9 IW / RCM 11, is also available. See illustration in Figure 3-1.

A Vane Plate model 3681 is recommended for profiling applications where the instrument is physically moved up/down in the sea between measurements. The Vane Plate will slow down the rotation of the RCM 9 IW / RCM 11, which is necessary for the mechanical compass to function properly.

RCM 9 LW is mainly intended for inline mooring use, as it weighs only 4.5 kg (without frame).

IMPORTANT! Make sure that no mooring- or mounting parts are covering the Doppler Current Sensor and the Turbidity Sensor as these sensors must have line of sight to their measurement volumes.

Make sure that no other instrument or other parts of the mounting are causing turbulence around the Recording Current Meter.

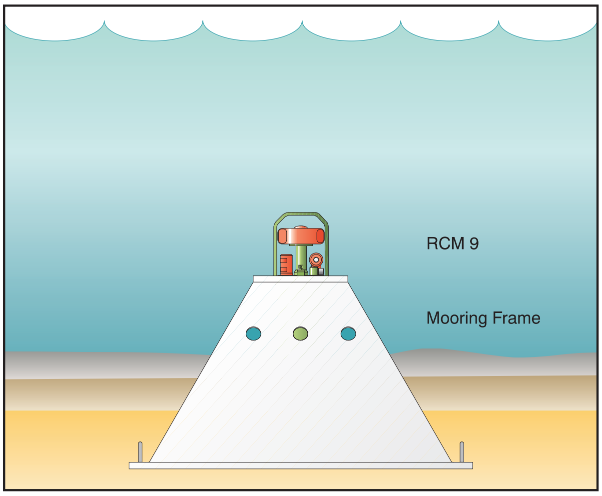
Make sure that there are no magnetic fields nearby the instrument.

Mounting

The instrument may be deployed using:

- A fixed bottom frame mooring.
- An in-line string mooring.
- A downward facing buoy.

The fixed bottom frame mooring is typically used in fixed deployment situations i.e. for harbor surveillance systems.



The bottom mounted frame supports extended battery capacity in the form of external battery package or external power by means of a cable to the shore.

Figure 3-2 Fixed bottom mooring frame

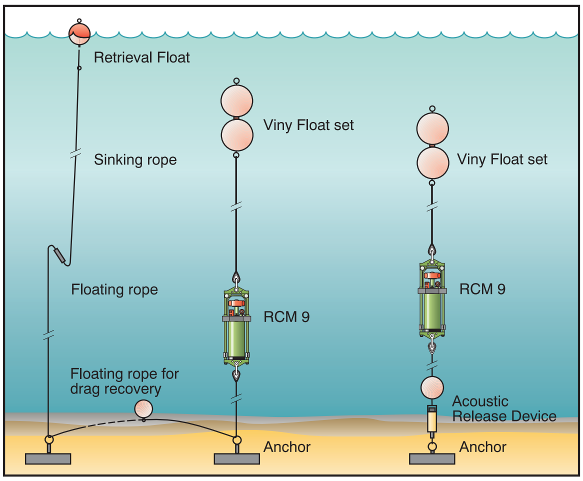


Figure 3-3 In-line mooring frame

The in-line frame may be pre-installed in the mooring string, allowing the instrument to be inserted into the frame just-in-time by means of two hand-operated screws.

For long-term deployments a separate special battery container may be used to prolong the deployment period.

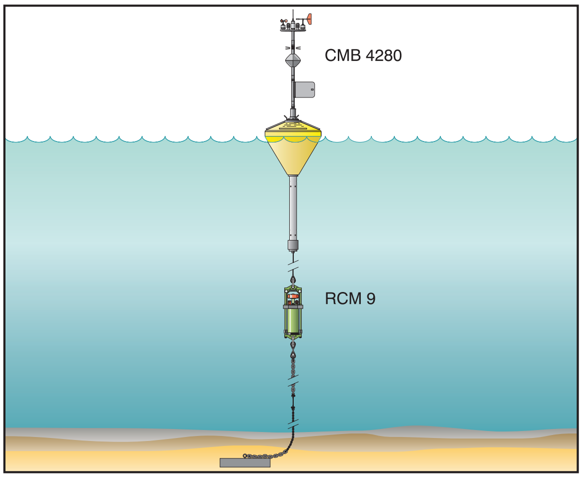


Figure 3-4 RCM 9 in Buoy Mounting

The RCM 9 LW/RCM 9 IW/ RCM 11 may also be used in a Buoy application.

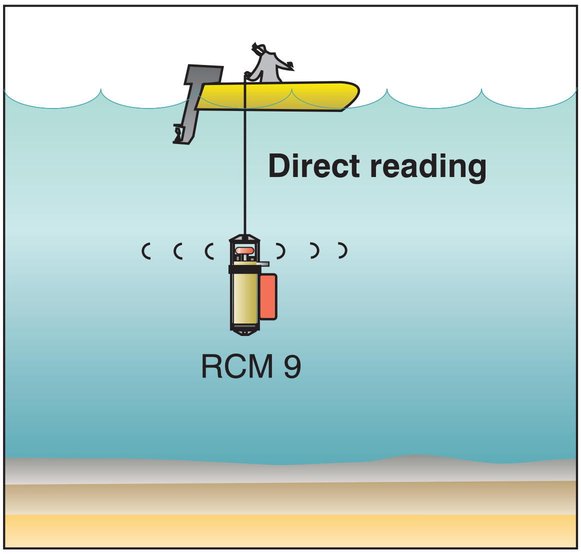


Figure 3-5 Direct Reading, red vane

Alternatively, the RCM 9 LW/RCM 9 IW/ RCM 11 may simply be moored using a small boat.

Deploying the Fixed Bottom Mooring Frame for long-term deployment

This mooring frame is applicable for port installation and marine transportation. A boat equipped with a winch is needed when installing the RCM 9 LW / RCM 9 IW / RCM 11 in a mooring frame. An illustration of the RCM deployed in a fixed mooring frame is given in Figure 3-2.

The mooring frame should be mounted to a concrete foundation of 110 x 110 x 30cm = 363000cm^3 = 363 liter.

The weight of concrete is approximately 2.4kg per litre giving a total weight of approximately 871kg.

If a concrete foundation is used, lower the instrument using a wire fastened to the block and not the instrument itself.

If a concrete foundation is not used, the instrument can be lowered to the seabed using the underwater signal/ Power cable or a rope. When the RCM 9 LW / RCM 9 IW / RCM 11 is in place, give out the rest of the cable and bring ashore.

Make sure that the cable rests on the bottom and is not stretched as the boat moves to the shore.

In general, the cable must be secured to the concrete block, the seabed, and in the brake water zone to the ground.

When a concrete block is used, laying the cable should be done from land.

In the brake water zone, the best way to protect the cable is to thread it through a durable plastic tube that is bolted to the ground.

On the seabed, place sand bags or concrete blocks over the cable at strategic places to secure it to the bottom.

In harsh environment it may be necessary to bury the entire cable in the bottom.

During operation, it is recommended to use a diver to ensure that the instrument and cable are safely installed on the seabed.

Deploying the In-line frame

Illustration of the RCM deployed in an in-line mooring frame is given in Figure 3-3.

In Figure 3-3 a mooring string is connected to a Viny Float set in one end and an anchor in the other end.

The anchor must be of suitable size and weight to keep the instrument in one position.

The instrument and optionally other sensors are connected to the mooring string at desired depths.

For convenience a frame can be connected to the mooring string, and the RCM 9 LW / RCM 9 IW / RCM 11 can be placed into the frame at deployment.

Several in-line frame systems can be linked together using a floating rope or a sink rope between two anchors.

Also, a bottom anchor can be connected to a two-parted string of floating rope and sinking rope with a retrieval float at the upper end to ease the retrieval of the system.

Deploying the Downward Facing Buoy

An illustration of the RCM deployed using a buoy is given in Figure 3-4. An anchor chain with an anchor at the end is mounted to the buoy cable to keep the instrument in one position.

The anchor dimension and weight must be suitable to match the conditions at the location.

We recommend an anchor of about 450kg for deployments in rough conditions.

Prepare the anchoring equipment and the length of the mooring line according to the deployment depth.

Lower the anchor and chains gently until the anchor rests on the bottom.

1. Let the buoy go overboard.
2. Be careful not to harm the super-structure in this operation.

The equipment is now waiting for the buoy to be triggered.

When the buoy is triggered the data are stored in the Data Storage Unit.

Deploying from a small boat

Figure 3-5 shows direct reading using a small boat. When applying this mooring alternative we recommend that you attach a vane to the RCM in order to prevent spinning.

Connection and disconnection of sensors

An illustration of the Top end plate with all standard and optional sensors connected to it is given in Figure A 6, (page 57). Except for the borehole for the Zink Anode (RCM 9 IW only), the 7 sensor boreholes in the top end plate are all equal in diameter, allowing the user to connect a sensor in a user-optimal location. However, there are some restrictions:

Temperature sensor and the Electrical terminal: If all standard and optional sensors are to be connected, the Temperature sensor and the Electrical terminal must be plugged in as shown in Figure A 6 (page 57). This is necessary to achieve enough space to the rest of the sensors, since the distance between the center of one of these two boreholes to a neighboring borehole is shorter than between two other neighboring boreholes.

Channel 5 lower receptacle: is for the old Conductivity Cell 3619 only.

NOTE! If channel 5 is used for other sensors than the conductivity sensor 3619, use upper plug.

Conductivity sensor 3919, Pressure sensor, Turbidity sensor and Oxygen optode: Theses sensors should preferably be plugged in the channel where it was last calibrated for optimal performance. Note that the Pressure Sensor 3815 must not be connected to channel 5.

If your deployment does not require all standard and optional sensors, we recommend that you connect the sensors at a lowest possible channel number to achieve longer deployment time (due to storage capacity) or faster recording interval.

An illustration of the Electronic Board with a DCS, Temperature sensor and Conductivity sensor is given in Figure 3-6.

Procedure for connecting a sensor

Please follow the listed procedure for connecting a sensor:

1. Remove the instrument from the pressure case by releasing the two c-clamps at the top end plate and lift up the instrument.
2. Unscrew the correct sealing plug at the top end plate.
3. Clean the borehole.
4. Inspect the O-ring of the new sensor.
5. Connect and tighten the new sensor. Align the steel ball for correct orientation of the sensor.
6. Plug the electronic cable into the correct channel at the electronic board
   - If the new sensor is a *Doppler Current Sensor*, it must be connected to channel 2 and 3 for current speed and direction respectively.
   - If the new sensor is a *Temperature Sensor*, it must be connected to channel 4 due to options regarding temperature range.
   - If the new sensor is connected to channel 4 though it is not a Temperature sensor, set the temperature range to *Other*.
   - If the new sensor is the old *Conductivity Cell 3619*, it must be connected to channel 5 lower cell.
   - If the new sensor is connected to channel 5 though it is not the Conductivity Cell 3619, use the upper cell of channel 5 and set the conductivity measurement range to *NOT USED*. See also page 32.
   - For *Temperature- and Conductivity* range settings and other deployment configurations please refer to the Deployment Guide in CHAPTER 2.
7. Put the instrument back into the pressure case and tighten the c-clamps.

IMPORTANT! Make sure that the sensors and the c-clamps are well tightened to ensure that no water will infuse the system. Do not overtight as this will damage the sensors and the clamps.

New features: Instrument Tilt and Signal Strength

Instrument Tilt: Instrument Tilt can be measured by strapping a cable (which is part of the wire harness for multiplexing DCS kit 3983, included in recommended spares and accessories) from *ch.3* to one available channel. If strapped to either of the *channels 4*, *9 or 10* attach the cable to the terminal screw in both ends.

If strapped to either of the *channels 5*, *6*, *7 or 8*, a connector with a complete cell plug must be used in the channel 5 - 8 end.

NOTE! Channel 5 upper cell plug is inverted; please refer chapter *Channel 5 reading of other parameters than conductivity* on page 32.

Signal Strength: Signal strength can be measured by strapping a cable (which is part of the wire harness for multiplexing DCS kit 3983, included in recommended spares and accessories) from *ch.2* to one available channel. If strapped to either of the *channels 4*, *9 or 10* attach the cable to the terminal screw in both ends.

If strapped to either of the *channels 5*, *6*, *7 or 8*, a connector with a complete cell plug must be used in the channel 5 - 8 end.

NOTE! Channel 5 upper cell plug is inverted; please refer chapter *Channel 5 reading of other parameters than conductivity* on page 32.

Procedure for disconnecting a sensor

Please follow the listed procedure for disconnecting a sensor:

1. Remove the instrument from the pressure case by releasing the two c-clamps at the top end plate and lift up the instrument.
2. Unplug the electronic cable from the correct channel.
3. Unscrew the correct sensor from the top end plate.
4. Clean the borehole.
5. Inspect the O-ring of the sealing plug.
6. Seal the borehole at the top end plate with the sealing plug.
7. Put the instrument back into the pressure case and tighten the c-clamps.

IMPORTANT! Make sure that the sealing plug and the c-clamps are well tightened to ensure that no water will infuse the system. Do not overtight as this will damage the sensors and the clamps.

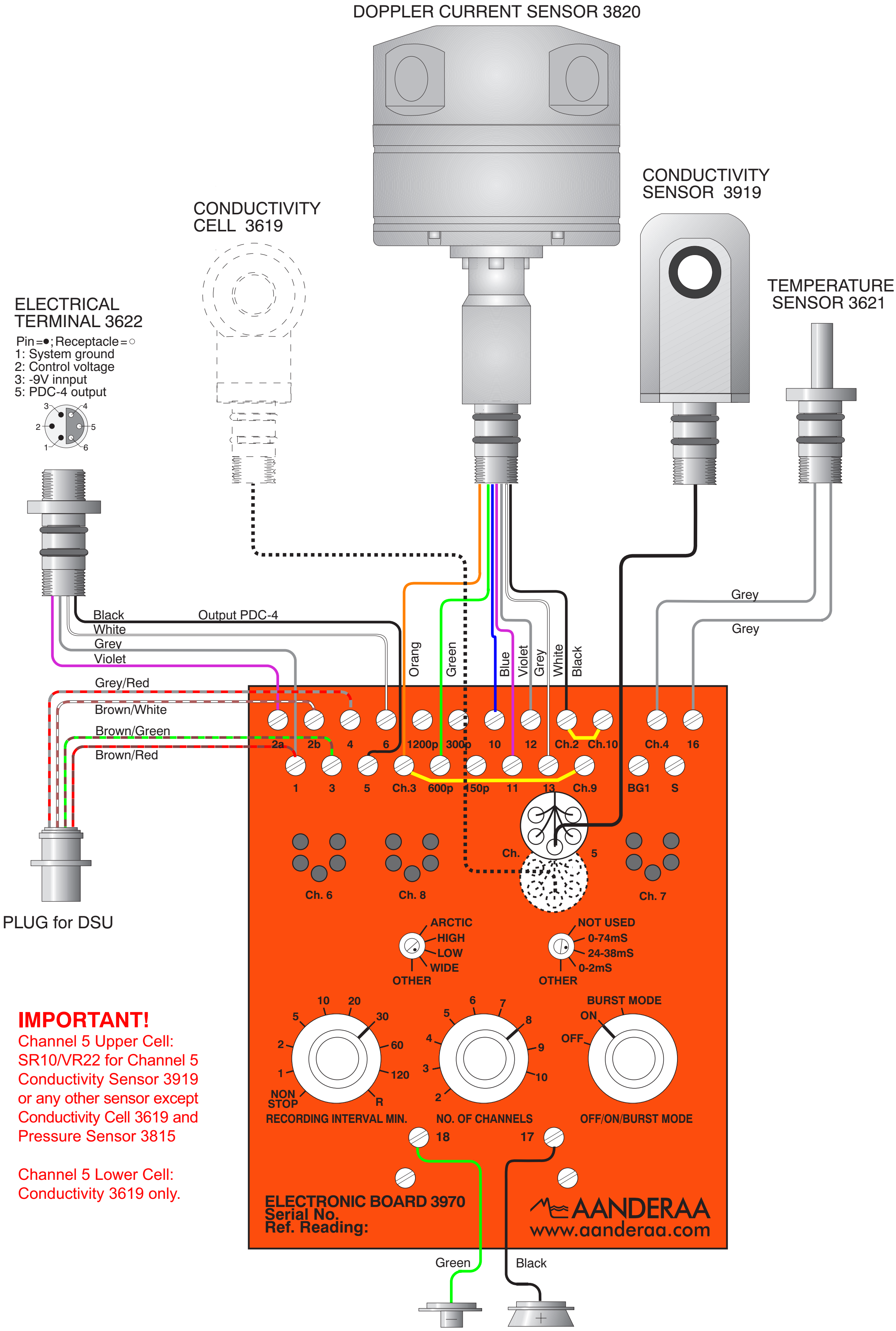


Figure 3-6 Illustration of Electronic Board with a selection of sensors connected to it.

Battery Consumption

Alkaline Battery

The correct battery for the RCM 9 LW / RCM 9 IW / RCM 11 is Alkaline Battery 3614 designed by Aanderaa Instruments AS. It consists of 6 ea 1.5 V D-cell alkaline batteries molded into a block of polyurethane foam. It measures 37 x 106 x 130 mm and is equipped with standard PP9 battery type button connectors on the top. The capacity is 15Ah (nominal capacity 12.5Ah, 220W down to 6.0V at 4.0°C) at 9 volts sufficient for 1 year operation at one hour interval or 92 days at ten minutes interval. A battery voltage above 6.7V is necessary for the DSU to function properly.

Lithium Batteries

A heavy duty 7V Lithium battery is available for long term deployment applications. The battery consists of 6 ea D-cells with a total capacity of 30 Ah. The part no is 3677.

NOTE! For extra long deployment period we recommend our Lithium Battery part no. 3677.

Examples of Battery Consumption

Table 3-1 show how many days the RCM 9 LW, RCM 9 IW and RCM 11 can operate using the 3614 and 3677 battery, and how many records that can be stored; in these examples, a deployment of 600 pings has been used. The values are based on a RCM 9 LW / RCM 9 IW / RCM 11 instrument deployed with standard sensors; however, the optional Conductivity sensor and the Pressure sensor are both very low battery consumers and will not influence the Battery Capacity significantly. The Oxygen Optode, on the other hand, consumes more battery during operation, and will reduce the number of deployment days by approximately 15 %.

The Data Storage Unit DSU model 2990 can store 65000 words and the 2990E model can store 262000 words. The Recording Current Meter stores a 10-bit word per measurement sample per channel. As seen in Table 3-1, using a sampling interval of 30 minutes and less, the number of deployment days is limited by the storage capacity of the DSU 2990, not by the battery capacity. Therefore, to get full credit for the battery capacity we recommend the 2990E model for use in the RCM 9 LW / RCM 9 IW / RCM 11. For extra long deployment period we recommend our Lithium Battery part no. 3677 which has a capacity of 30Ah. When installing a battery always check that the battery terminals are well seated and that the batteries are well connected.

IMPORTANT! Continuous operation of 7 channels takes half a minute

To get full credit for the battery capacity we recommend the 2990E model for use in the RCM 9 LW / RCM 9 IW/ RCM 11

Table 3-1 RCM 9 LW/ RCM 9 IW/ RCM 11 –Examples of Battery Duration and Storage Capacity at a deployment of 600 pings.

RCM 9 LW/ RCM 9 IW/ RCM 11 (7 Channels)						
Sampling Interval	3614 Alkaline Battery (12.5 – 15 Ah)				3677 Battery (30 Ah)	
	DSU 2990		DSU 2990E		DSU 2990E	
Minutes	Days	Words	Days	Words	Days	Words
1	7	65.500	10	100.866	24	242.070
2	13	65.500	20	100.926	47	237.168
5	33	65.500	48	97.062	115	232.536
10	65	65.500	92	93.294	220	223.086
20	129	65.500	170	86.706	395	201.456
30	192	65.500	235	80.376	540	184.686
60	370	64.386	370	64.386	850	147.906
120	530	47.706	530	47.706	1200	108.006

CHAPTER 4 Data Recovery

Reading of DSU and Data Processing

Stored data is read by connecting the Data Storage Unit, DSU 2990, via a DSU Reader 2995, to the RS-232C port of a computer, see Figure 4-1. A suitable program must control the read-out process. The operating manual for the DSU Reader, Technical Description No. 145, provides the user with sufficient information to write a user specific read-out program.

The DSU Reader 2995 converts the 0 to -5V serial signals associated with the DSU to dual-polarity signals in accordance with the RS-232C standard. In addition it supplies the -6V control voltage for powering the DSU during the read-out process. The DSU is connected to the DSU Reader 2995 by a standard Connecting Cable 2842C. A computer interfacing cable, 3016C, with a 6-pin 2828 Plug at one end and a 9-pin D-connector at the other, connects the DSU Reader to the PC's serial input port. The DSU will examine bytes received from the computer and execute the command routines. In case of an invalid command, it will return to the stand-by mode. Altogether eleven command codes are valid for communication with the DSU. Beside the commands for controlling the data read-out, which will not erase the stored data, commands are also given for display and setting the real-time clock and for erasing the content of the DSU. With the exception of the *ERASE* command, all commands are single characters.

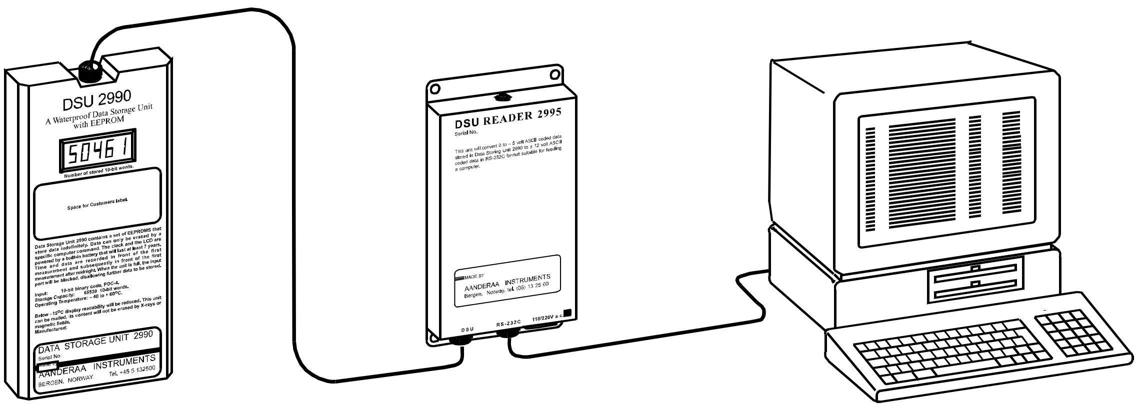


Figure 4-1 Data Reading

Data Reading Program 5059

The Data Reading Program DRP 5059 is a Win32 based program. Emphasize has been put on ease of use together with versatile, graphical user interface and system flexibility. Minimum requirements are:

- Pentium 166 Processor (recommended)
- 6MB RAM for Windows 95 and 98, 32MB RAM for Windows NT
- 10MB Hard Disk

DRP 5059 can also be used with Windows ©95 or more recent operating systems.

The DRP 5059 replaces older versions of the Aanderaa Instruments Data Reading programs. It is a component based program, built using a large set of independent binary components that become a part of your operating system instead of building the application into one huge executable file. As such, each component becomes available to any application that can make use of it.

The advantage of using this technique is that only one copy of the component resides on your disk although several applications may use it. This yields less chance for bugs or errors and it improves productivity through reuse of programming effort. An example of such a component is the *AAICOMServer* used to set up the serial (COM) ports and download the DSU. Used in the Display Program 3710, it has proven its reliability. Perhaps the most important feature is the possibility to design your own custom analysis tool components.

The DRP 5059 incorporates a special hook-in mechanism for *ActiveX* components. The hook-in interface provides your *ActiveX* component with access to the database and to a window in which you can show the analysis result.

In most cases, you will probably be satisfied with the tools shipped with the program from the factory. These tools comprise graphing features, statistical analysis and signal analysis. Analyze the exported ASCII files from the database in other products such as Microsoft Excel.

The Data Reading Program 5059 is a multi-document application.

A document always links to a measurement session.

A measurement session usually consists of the data that is stored in a single Data Storage Unit (DSU).

A DSU connects to a document via a COM port. Several documents can be open at the same time. Each document uses a separate COM port, so to work with two DSUs at the same time two COM ports must be available.

The COM port is, however only needed during the actual DSU download (reading) session and not while working with a previously downloaded DSU file or an imported ASCII file.

The Data Reading Program 5059 is a new, multifunction handling and data processing program. It contains:

- A Template Library of standard instruments
- Stations and sensors from Aanderaa Instruments
- A Custom Library to store customers' own product specifications
- Tooling section for different data handling functions as well as a faster data transfer mode.

Two sample **.dsu* files, located in the samples directory, allow for experimenting with the program without having to download a DSU item. To download a complete version of the Data Reading Program 5059, see our web pages on the Internet. The program grants a 30 day trial period during which time all functionality is available. After the trial period the program reverts into a non-licensed, limited capability version. By purchasing a license key from the manufacturer, or one of our representatives, the full functionality will be retained. The size of this file is 3253KB.

NOTE! Please refer to the Data Reading Program 5059 User Manual, TD 208.

Data stored on the DSU can be erased from the DRP 5059.

Channel 5 reading of other parameters than conductivity

The Conductivity Sensor 3919 and the Conductivity Cell 3619 reports values from 1023 – 0, which is oppositely than the other sensors (the other sensors read from 0 – 1023). Channel 5 on the electronic board has therefore been implemented to read from 1023 – 0 as well. Hence, if another sensor than the Conductivity Sensor 3919 or the Conductivity Cell 3619 is connected to channel 5 (see Procedure for connecting a sensor on page 25) the readings must be corrected as described here:

1. Create a virtual channel in Data Reading Program 5059.
2. Let the calculated raw data reading, N, for the virtual channel be 1023 minus channel 5 reading:

   $$N = 1023 - channel\ \ 5\ \ reading$$

CHAPTER 5 Maintenance

General

The RCM 9 LW / RCM 9 IW / RCM 11 requires a minimum of maintenance. Apart from keeping the outside of the instrument clean, changing pressure case o-ring, zinc anode and corroded parts, only the following yearly maintenance is required:

Yearly maintenance

- Refill silicone oil in the pressure sensor by using a hypodermic syringe. Use silicone oil of 60000 centistoke e.g. Dow Corning Silicone Oil DC200, Aanderaa part no 260017. Take care not to puncture the membrane inside the sensor.
- Corroded parts should be replaced by new when necessary. Always fill crevices between metal surfaces and threaded screw holes with Tectyl 506 to avoid crevice corrosion. You may also use Tectyl around sensors and sealing plugs for easy cleaning after deployment.
- Check the calibration according to Appendix 2 of this manual.

Replacement of parts

The *Doppler Current Sensor*, the *Turbidity Sensor*, the *Pressure Sensor 4017* and the *Oxygen Optode* are calibrated separately and can be changed without influencing the instrument performance. The Calibration of one of these sensors is valid regardless of which RCM 9 LW / RCM 9 IW / RCM 11 it is installed in. This allows for factory supply of calibrated sensors for installation by the customer.

The *Temperature Sensor*, the *Pressure Sensor 3815* and the *Conductivity Sensor* must be calibrated when connected to the instrument for optimum performance. If a new Electronic Board is installed, these sensors should be re-calibrated before deployment.

An *Electronic Board* can be ordered and installed without any adjustments or re-calibration of the Doppler Current Sensor, the Turbidity Sensor, the pressure sensor 4017 and the Oxygen Sensor.

Factory service

Factory service is offered for maintenance, repair or calibration of instruments or parts. When returning instruments or parts for service, use the *Instrument Service Order* form no 135. Normal turn-around time is three to four weeks, but on request the service department will make every possible effort to meet customers' requirements.

Spare Parts and Accessories

The manufacturer always keeps a stock of spare parts, accessories and consumable parts for quick delivery. Orders may be placed by fax, telephone or mail. See Table 5-1 for RCM 9 LW / RCM 9 IW / RCM 11 spare part list.

The Oxygen Sensor 3830 is optional and demands very little maintenance. A Sensing Foil Kit no. 3853 is supplied with the sensor (refer to page 48).

Table 5-1 Recommended Spare Parts for RCM 9 LW, RCM 9 IW and RCM 11

Part. No	Description	RCM 9 LW	RCM 9 IW	RCM 11
3625B	Sealing Plug for Top end plate	x		
963384	Pressure Inlet for Pressure Sensors (Protection)	x	x	x
4132	Handle for RCM 9LW	x		
3625	Sealing Plug for Top end plate		x	x
4032	Handle for RCM 9IW		x	
3824	Mooring Frame for RCM 9IW and RCM 11, 8 ton brake load		x	x
3965	Handle for RCM 11			x

Tools kit for Doppler Instruments

Tools kit for all AADI Aanderaa Doppler instruments, part no. 3986, can be ordered from the factory and consists of the parts given in Table 5-2.

Table 5-2 Tools kit for RCM 9 IW, RCM 9 LW, and RCM 11, part no. 3986

Part. No	Description	Pieces
1913002A	Allan key, nv 4mm (for 3620)	1
1913022	Allan key, nv 3mm	1
1913003	Wrench for C-clamp, dor 4/sd-5”	1
1913018	19mm nv Wrench	1
1913015	Allan key, nv 2mm	1
1913009	Allan key, nv 2.5mm	1
1913033	24mm nv Wrench	1

Maintenance Kit

Maintenance kit for RCM 9 IW, RCM 9 LW, and RCM 11 can be ordered from the factory and consists of the parts given in Table 5-3 and Table 5-4, and Table 5-5 respectively.

Table 5-3 Maintenance kit for RCM 9 IW, part no. 3813

Part. No	Description	Pieces
3738	O-ring grease, 10ml	1
642103	Umbraco screw, M5 x 16	4
642122	Umbraco screw, M4 x 25mm	1
7972577	Tectyl 506	1
7972579	Repair lacquer, jotun green	1
7972579A	Repair lacquer, jotun blue	1
680037	Panduit sta-strap plt4i-co	4
865000	O-Ring, SOR 72	1
862006	O-Ring, rm0131-16	2
863013	O-ring rm0216-24	1
963024	Zinc Anode (Half) for Frame	4
963352	Zinc Anode, Mod-9/11	1

Table 5-4 Maintenance kit for RCM 9 LW, part no. 3813B

Part. No	Description	Pieces
3738	O-ring grease, 10ml	1
7972577	Tectyl 506	1
865000	O-Ring, SOR 72	1
862006	O-Ring, rm0131-16	2
863013	O-ring rm0216-24	1
7972579B	Repair lacquer, jotun black	1

Table 5-5 Maintenance kit for RCM 11, part no. 3813A

Part. No	Description	Pieces
3738	O-ring grease, 10ml	1
7972577	Tectyl 506	1
7972579	Repair lacquer, jotun green	1
862006	O-Ring, rm0131-16	2
863013	O-ring rm0216-24	1
642103	Umbraco screw, M5 x 16	4
642122	Umbraco screw, M4 x 25mm	1
963024	Zinc Anode (Half) for Frame	4
963352	Zinc Anode, Mod-9/11	1
865001	O-Ring, SOR 71	1
680037	Panduit sta-strap plt4i-co	4

Appendix 1 Theory of Operation

The measuring system used in this instrument is a self-balancing bridge system that processes its 10 sensor channels sequentially. The sensor forms one half of the bridge and the other half is a 10-step approximation network. The system carries out the same process for all sensors. The bridge and sensors act together as described below.

All power and signals are referred to positive ground to maintain compatibility with former Aanderaa equipment.

The output code is the PDC-4 code (see Figure A 2). This code is chosen because it is simple, compact and well suited for telemetering. Data are stored in the Data Storage Unit, DSU 2990. Computer compatibility is taken care of when reading the DSU via the DSU Reader 2995. The PDC-4 coded information is then converted to ASCII coded RS-232C signals.

The VR22 and SR10 sensor signals

The RCM 9 LW / RCM 9 IW / RCM 11 uses sensors with analog output signal of type VR22 and digital output signal of type SR10[1]. These signal forms allow simple sensor design, offer high accuracy over a wide temperature range at low power consumption, and permit analog and digital sensors to be interchanged.

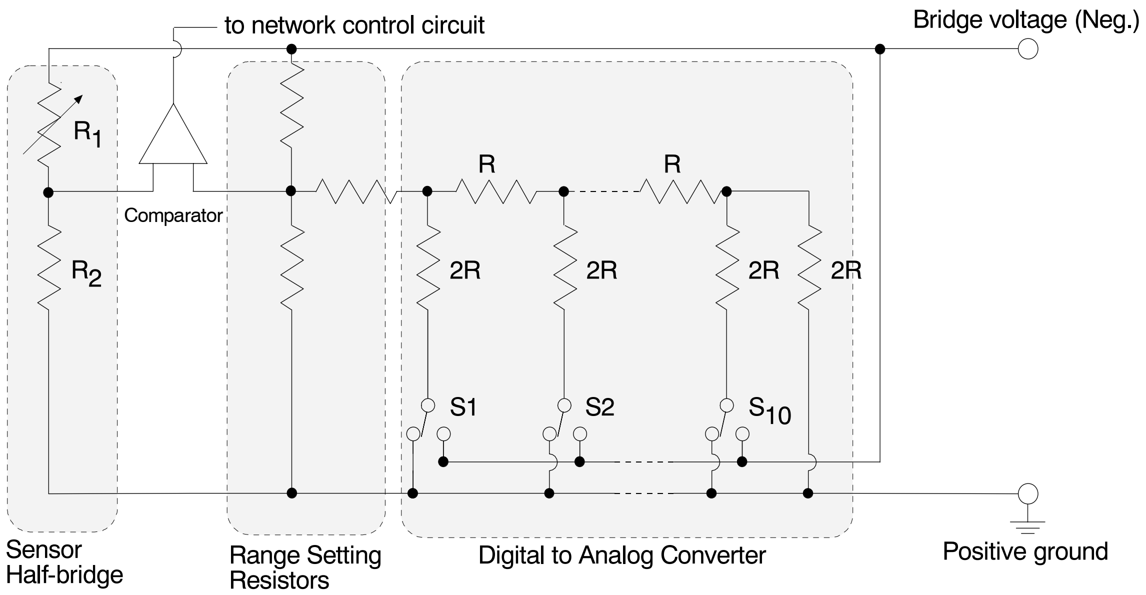


Figure A 1 VR22 / SR10 Measuring Circuit

[1] *Except for the temperature sensor and the conductivity cell where the ranges are selectable*

When reading an analog VR22 signal, the sensor acts as the left half of a Wheatstone measuring bridge, and an R-2R network inside the electronic board as the other half of the bridge, see Figure A 1. The bridge is balanced successively in 10 binary steps by setting the switches S1, S2...S10.

This cycle forms a 10 bit binary word that represents the ratio between the resistors in the half bridge of the sensor. By equipping the sensor bridge with one resistor that varies along with the parameter that needs to be measured, e.g. temperature, a simple sensor is made. Since such sensing resistors usually have a relatively small change of resistance in the measuring range, the output range of VR22 sensors is set to be 1/22'nd of the applied Bridge Voltage varying ± 1/44'th around the middle.

The Bridge Voltage is applied as a pulse for each step in the approximation cycle. By using these pulses to clock out the content of a ten bit shift register, a ten bit digital word can be read on the same input as for the VR22 signal. This means that a sensor with the digital output called SR10 and sensors with analog VR22 output can be connected to the same input channel without any reconfiguration of the electronic board.

By reading all input channels sequentially the sensor signals can be multiplexed and read by the same input circuit. The Bridge Voltage is applied to all sensors in a sequence of ten pulses. This sequence takes 4 seconds and is repeated for each input channel to be read. The reading cycle is initiated by a Control Voltage, which is used for activation of the output of digital sensors. The Control Voltage is *on* during the entire reading cycle, see Figure A 2.

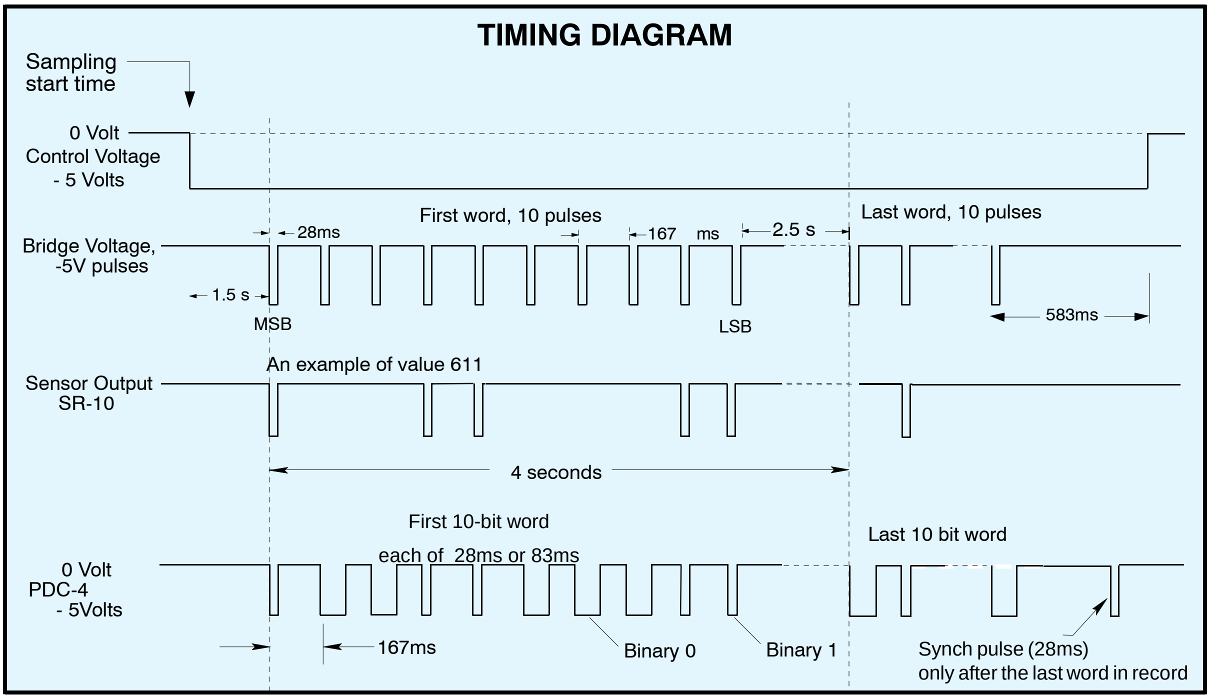


Figure A 2 Timing Diagram

Electronic Board

The Electronic Board 3970 shown in Figure 2-1 contains the main electronic circuitry of the instrument. It comprises a printed circuit board with screw terminals, 4 receptacles for sensor connection, temperature and conductivity range selectors and three control switches. This design makes the component a solid board, which will not be affected by a harsh environment. The electrical functions of the board can be divided into six main functions or circuits:

1. Voltage regulator and bridge voltage generator.
2. Multiplexer and sensor input circuits.
3. Comparator and bridge balancing circuits.
4. Control circuits and micro-processor.
5. Circuits for output pulses and remote start.
6. Quartz Clock.

The voltage regulators and bridge voltage generator provide all required operating voltages. Ten -5 volt pulses of 28 milliseconds duration are generated for each of the sensor channels and supplied to all channels simultaneously. The multiplexer switches each of the sensor channels to the comparator and bridge balancing circuit. The microprocessor and control circuit initiate and control the various operations of the board. The output signal circuit generates the PDC-4 coded output pulses as described on pages 37 and 38. It also initiates triggering of the instrument when a positive pulse of 5 to 8 volts is applied to the output terminal. The pulse should be 50 milliseconds or more.

The quartz clock triggers the instrument at preset intervals. The intervals can be set to 1, 2, 5, 10, 20, 30, 60 or 120 minutes by a rotary switch embedded in the board. The switch also has a position for *NON STOP* (Continuous) operation and a position for *R* (Remote start only). The remote start feature is useful during calibration or checking of the instrument, as it will respond only to the remote start signal.

For other time intervals remote triggering will only be executed if there is enough time to perform a measuring cycle before the clock triggers the instrument. A complete measurement cycle of 10 channels takes 4 x 10 seconds plus 2 seconds = 42 seconds. When either the internal interval clock or the external signal has triggered the instrument, the Electronic Board will initiate the sensor reading by turning the Control voltage to *ON* for all sensors. After 1.5 seconds the first 10 Bridge Voltage pulses are sent out and the first sensor channel is read (Reference reading). The reading is converted to PDC-4 and stored in the Data Storing Unit. The Electronic Board then continues in the same manner until the selected number of channel is read.

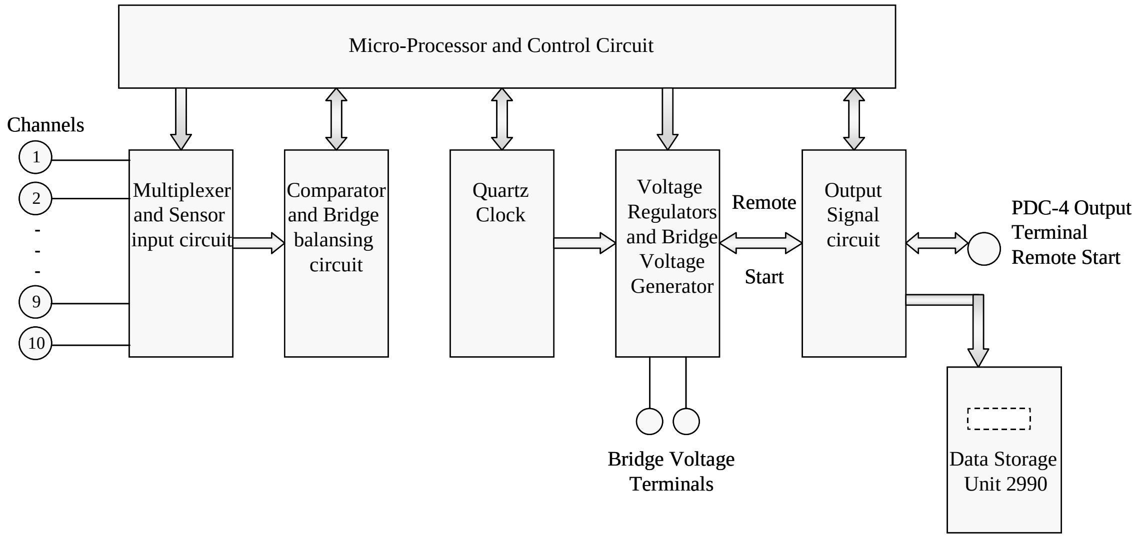


Figure A 3 Block diagram for the Electronic Board

After finishing the reading cycle the Control Voltage and most of the Electronic Board are turned off, awaiting the next trigger signal. The Electronic Board controls the ping rate of the Doppler Current Sensor. The user can specify the instrument to ping 150, 300 or 600 times per measurement interval. The instrument can either operate in normal mode with ping distribution over the entire measuring interval, or in burst mode with pings distributed over the last minute of the measuring interval. The instruments *OFF/ON/BURST MODE* switch is both a power switch and an operating mode selector.

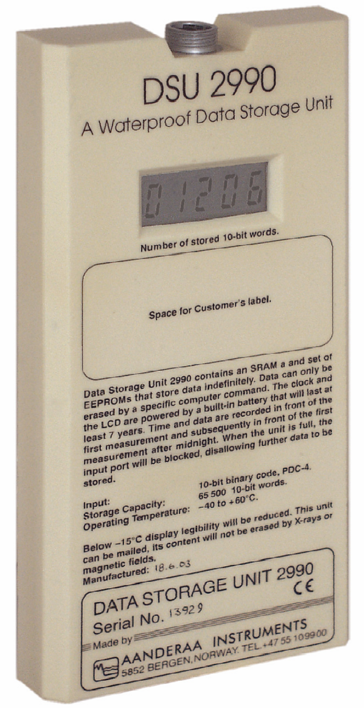
A small temperature range selector switch is embedded in the board. Four ranges can be selected: *ARCTIC*, *LOW*, *HIGH*, or *WIDE* range. See specifications on page 53 for actual ranges in degrees Celsius.

A similar switch for selecting the conductivity ranges is also embedded in the board, these ranges are however only valid for the old Conductivity Cell 3619. Two standard ranges are available, *0 - 74 mS*, *24 - 38 mS*, and an optional *0 - 2 mS* (3619N) plus a fourth position, OTHER, for a customer specified range. If the old Conductivity Cell 3619 is not connected to the instrument, use the fifth position called *NOT USED*, refer page 15.

In addition the board has a *NO. OF CHANNELS* switch; the instrument operates normally with 8 channels (reference and 7 parameters), but has also two channels for e.g. instrument tilt and signal strength.

Data Storage Unit

The Data Storage Unit, DSU, shown in Figure A 4, is in the form of a solid board molded in low-density polyurethane. It contains a set of EEPROMs for storage of data. On the top there is a 6-pin receptacle for the input/output of data. A 5-digit liquid crystal display indicates the total number of data words stored. When reading the data, the display number is counted down, and the display will therefore always show the number of words left to be read.



The DSU is furnished with a built-in, presentable, real-time quartz clock enabling time information to be recorded. Within a temperature range of -10 to + 45°C the accuracy of the clock is ± 2 s/day. A time record consists of six 10-bit words. The first is a fixed binary reading equal to 7, followed by 5 words indicating year, month, day, hour and minute.

Time information is recorded for the first measurement taken, and subsequently every day (24 hours) at the time of the first measurement after midnight. The clock features automatic leap year compensation.

The DSU exists as two models, the DSU 2990 model storing 65500 10-bit data words and the DSU 2990E model storing 262000 data words. The input port will be blocked when full, disallowing further storage of data.

Figure A 4 Data Storage Unit, DSU 2990

When the instrument is turned *ON* the DSU is powered by the instrument's battery. When disconnected, a built-in battery (Lithium AA cell, 3.4 volts, 1.9 Ah) will provide power for the display and the clock. The power consumption is 30 µA, and the battery lasts at least 7 years. For reading of stored data, setting the real-time clock and erasing data from the DSU, please refer to the Operating Manual of the DSU, TD 145.

PDC-4/RS-232 Converter 3818 for RCM 9 LW/ 9 IW/ RCM 11

The PDC-4 / RS-232 Converter is designed to fit into the RCM 9 LW/ RCM 9 IW / RCM 11 pressure case, and provides the RS-232C output signal to the 6-pin receptacle on the top-end plate (see Figure 3-6). The RS-232C output signal is galvanic separated from the supply power of the RCM 9 LW/ RCM 9 IW/ RCM 11.

The 10-bit input signals are tested and only data, which is in accordance with specifications, is routed to the RS-232C terminals on the converter. This feature will reject any possible noise signals and only high quality data is presented

Figure 5-1 PDC-4/RS-232 Converter

Specifications

Input Signal: Aanderaa10-bit binary code, PDC-4 from El. board on RCM 9 LW/ RCM 9 IW/ RCM 11

Output Signals: RS-232C asynchronous code. ASCII characters at 1200 baud, 8 data bits, no parity and 2 stop bits.

Operating Temperature: -15 to +50°C
Electrical Connection: 6 terminals

Current Consumption: Quiescent < 5 µA, 19 mA average when operating

Supply Voltage: Powered from RCM 9 LW/ RCM 9 IW/ RCM 11, 9V

Size: 71 X 38 X 25cm

Net Weight: 200 grams

Warranty: Two years against faulty materials and workmanship

Serial Setting:

1200 baud, 8 data bits, no parity and 2 stop bits.

SERIAL OUTPUT FORMAT

<table>
<tr><th colspan="8">One Data Word, 7 Characters</th></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>Fault / Synch</td></tr>
<tr><td colspan="4" rowspan="4">READING
(any number from 0000 to 1023)</td><td>Space</td><td>Space</td><td>Null</td><td>No fault, no Synch</td></tr>
<tr><td>Space</td><td>CR</td><td>LF</td><td>No fault, Synch</td></tr>
<tr><td>*</td><td>Space</td><td>Null</td><td>Fault, no Synch</td></tr>
<tr><td>*</td><td>CR</td><td>LF</td><td>Fault, Synch</td></tr>
</table>

Appendix 2 Calibration

General

Each RCM 9 LW / RCM 9 IW/ RCM 11 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 or change of sensor range. 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 third degree polynomial. 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 Tilt sensor and the Compass in the DCS is an extensive process that must be performed by the manufacturer only. The part of the DCS that measures current speed does not have to be calibrated[2].

In the algorithms for calculating the current speed from the measurements, a parameter for sound speed in water is pre set to 1500 m/s.

If the correct sound speed in water differs from this value, the calculated sound speed should be corrected. A procedure for correcting the current speed is given in the following. The 5059 DSU reader software will calculate the corrected speed in a separate virtual channel; the user may set the correct sound speed as a parameter, or a new sound speed can be calculated based on measurements of temperature, conductivity and depth.

Procedure for correcting current speed

The currents in two orthogonal directions are given by the Doppler shift of the transmitted sound. Since both the transmitted frequency and the measurement of the back-scattered frequency are based on a common crystal oscillator, the correlation between the actual current and the measurements are fixed. According to the equation for the Doppler effect.

[2] ref. Technical Note 236: Calibration Accuracy for Aanderaa DCS Products

$$f_s = 2\frac{C_{sea}}{C_{sound}} f_T$$

where f_s is the change in frequency between the transmitted and the reflected sound wave, f_T is the frequency of the transmitted sound wave, C_{sea} is the current speed of the water and C_{sound} is the speed of sound in the water.

During calculation of the RCM Doppler Current Sensor, the speed of sound is set to 1500 m/s. This sound speed is correct within ± 2% when the values of the following parameters are in the given range:

Temperature : between +5 to +22 °C

Salinity : between 34 to 37 ppt

Depth : less than 100 m

To obtain a greater accuracy for wider operating conditions, the current speed can be corrected for variations of the speed of sound by the following equation:

$$C_{sea,c} = \frac{C_{sea,m} \cdot C_{sound}}{1500}$$

where

$C_{sea,c}$ is the corrected current speed of the water

$C_{sea,m}$ is the measured, or the uncorrected, current speed of the water,

C_{sound} is the actual speed of sound, which is[3]:

$$C_{sound} = 1449.05 + 4.57 \cdot T - 5.21 \cdot 10^{-2} \cdot T^2 + 2.3 \cdot 10^{-4} \cdot T^3 + \{1.333 - 1.26 \cdot 10^{-2} \cdot T + 9 \cdot 10^{-5} \cdot T^2\} \cdot (S - 35) + 1.63 \cdot 10^{-2} \cdot D_m + 1.8 \cdot 10^{-7} \cdot D_m{}^2$$

where

T = water temperature [°C]

S = Salinity [ppt]

D_m = Depth [m]

[3] Coppen, Journal of Acoustical Society of America. 69, 862 (1981)

Calibration coefficients for Instrument Tilt and Signal strength

The B coefficient in the polynomial for Instrument Tilt and Signal strength are:

Instrument Tilt: $B = 4.3988 \cdot 10^{-2}$

Resulting polynomial: $B \cdot N$ *[deg]*

Signal strength: $B = -3.9100 \cdot 10^{-2}$

Resulting polynomial: $B \cdot N$ *[dB]*

NOTE! The A, C and D coefficients of the polynomial are zero for both Instrument Tilt and Signal Strength

Temperature

The ISO-curve type thermistor used in this sensor has well defined characteristics where the coefficients C and D in the polynomial on page 43 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 frequently checked against an Equiphase Cell (Trademark of Trans-sonic, Inc., Burlington, Massachusetts.) establishing the triple point of water (0.0098 °C).

During calibration, the instrument must be allowed sufficient time for proper temperature stabilization. This is indicated by a steady temperature reading for about four or five samples (2 minute sampling interval).

Conductivity

The conductivity sensor is best calibrated using a seawater 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 (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.

Refer operating manual for Conductivity sensor 3919, TD 222, for calibration procedure.

Calculation of Salinity

The 5059 DSU reader software will calculate the salinity in a separate virtual channel. The salinity calculations will appear in the engineering units file as a separate column. The equations used are presented below.

Input parameters:

Conductivity, *CND* : [mS/cm]

Temperatur, *T* : [°C] (ref. IPTS-68)

Pressure, *P* : [dbar]

Output parameters:

Salinity, *Sal* : [PPT] (ref PSS-78)

Equations

Calculation of the Salinity can be made from the following algorithms:

$$Sal = S = \sum_{j=0}^{5} a_j \left(R_T\right)^{j/2} + \frac{T-15}{1+k(T-15)} \sum_{j=0}^{5} b_j \left(R_T\right)^{j/2}$$

where

$a_0 = 0.0080$ $b_0 = 0.0005$ $k = 0.0162$

$a_1 = -0.1692$ $b_1 = -0.0056$

$a_2 = 25.3851$ $b_2 = -0.0066$

$a_3 = 14.0941$ $b_3 = -0.0375$

$a_4 = -7.0261$ $b_4 = 0.0636$

$a_5 = 2.7081$ $b_1 = -0.0144$

and $R_T = \dfrac{R}{R_P r_T}$

where $R = \frac{CND(S,T,P)}{CND(35,15,0)} = \frac{CND(S,T,P)}{42.914[mS/cm]}$; R = Relative Conductivity.

R = 1 when T = 15°C, P = 0 dbar, Sal = 35 PPT (Conversion from conductivity in mS/cm to relative conductivity R)

and $$R_P = 1 + \frac{P \cdot (A_1 + A_2 \cdot P + A_3 \cdot P^2)}{1 + B_1 \cdot T + B_2 \cdot T^2 + B_3 \cdot R + B_4 \cdot R \cdot T}$$

and $$r_T = c_0 + c_1 \cdot T + c_2 \cdot T^2 + c_3 \cdot T^3 + c_4 \cdot T^4$$

where

$A_1 = 2.070 \cdot 10^{-5}$	$B_1 = 3.426 \cdot 10^{-2}$	$c_0 = 6.766097 \cdot 10^{-1}$
$A_2 = -6.370 \cdot 10^{-10}$	$B_2 = 4.464 \cdot 10^{-4}$	$c_1 = 2.00564 \cdot 10^{-2}$
$A_3 = 3.989 \cdot 10^{-15}$	$B_3 = 4.215 \cdot 10^{-1}$	$c_2 = 1.104259 \cdot 10^{-4}$
	$B_4 = -3.107 \cdot 10^{-3}$	$c_3 = -6.9698 \cdot 10^{-7}$
		$c_4 = 1.0031 \cdot 10^{-9}$

REFERENCES : Also located in Unesco report No. 37 1981 practical salinity scale 1978 : E.L. Lewis IEEE Ocean eng. Jan 1980.

Pressure

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 43. The sensor is only accepted if all the readings are within the accuracy limits as compared to the linear characteristics.

Pressure Sensor 4017 is calibrated prior to delivery.

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 232C 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 1.

Table A 1 Sensing Foil Kit 3853

Part. No	Description	Pieces
962203	Sensing Foil packed in aluminum 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.

Appendix 3 Specifications for RCM 9 LW, RCM 9 IW and RCM 11

General Specifications, RCM 9 LW / RCM 9 IW/ RCM 11	
No of channels is selectable from 2 to 10 channels	
Ch. 1 Reference is a fixed reading to check the RCM's performance and to identify individual instruments	
Ch. 2 and 3 Current Speed and Direction	
Speed Sensor Type:	Doppler Current Sensor 4220/3820
Range:	0 to 300cm/s
Resolution:	0.3cm/s
Absolute Accuracy: Relative Accuracy: Statistic precision:	± 0.15m/s ± 1% of reading 0.45cm/s (standard deviation)
Direction Sensor:	Magnetic compass, Hall effect type
Resolution	0.35°
Accuracy	± 5° for 0 to 15° tilt ± 7.5° for 15 to 35° tilt
Acoustic Frequency:	2MHz
Power:	25W in 1ms pulses
Beam Angle:	± 1° (main lobe)
Installation Distance: (to the DCS Head)	Minimum 0.5m from bottom Minimum 0.75m from surface
Ch. 4 Temperature	
Sensor Type:	Thermistor (Fenwall GB32JM19)
Resolution:	0.1% of selected range
Accuracy:	± 0.05°C
Response Time (63%):	12 seconds
Selectable Ranges: Wide: Low[1)]: High[1)]: Arctic[1)]:	 -0.6°C to 32.8°C -2.7° to 21.7°C +9.8° to 36.6°C -3.0°C to 5.9°C
Ch. 9 and Ch. 10[2)] Signal Strength and Instrument Tilt	
External Triggering:	A positive 5V pulse to the electrical terminal, output pin, will trigger one measurement cycle
Recording Interval:	1, 2, 5, 10, 20, 30, 60, and 120min Continuous (4s x no of ch. +2s) and Remote start only
Recording System:	Data Storage Unit 2990 or 2990E Data Storage in EEPROM
Storage Capacity: DSU 2990: DSU 2990E:	 9000 records (7 ch) (2 months at 10 minutes interval) 36100 records (7 ch) (8 months at 10 minutes interval)
Battery: Alkaline 3614: or Lithium 3677:	 9V, 15Ah (nominal 12.5Ah 20W down to 6V at 4°C) 7.2V 30Ah
Average Current Consumption (mA):	0.50 + (50 divided by the recording interval in minutes)
Warranty: Two years against faulty materials and workmanship. For subsurface cables: contact factory	

1) RCM 9LW: Available on request/ RCM 9 IW and RCM 11: Standard

2) We recommend you to use the lowest available channel number

Individual specifications, RCM 9 LW
(DCS 4220 Head)

Depth Capacity:	300m
Dimensions:	H: 595mm OD: 128mm
Weight (in air): With frame	Net Gross 9 kg 11.5 kg
Packing:	Woodybox: 900x350x330mm
External Materials:	POM, Titanium, Stainless acid proof Steel, Durotong DT322 polyurethane
Accessories: Included: Optional:	 Recommended spares and accessories Alkaline Battery 3614 Data Storage Unit DSU 2990 Data Reading Program 5059 In-line mooring frame 4044 DCS Test Unit 3731 PDC-4/RS-232 Converter 3818 Maintenance Kit 3813 Bottom mooring frame 3438R

Individual specifications, RCM 9 IW
(DCS 3820 Head)

Depth Capacity:	2000m
Dimensions:	H: 595mm OD: 128mm
Weight (in air): With frame	Net Gross 23.2 kg 32.7 kg
Packing:	Plywood case: 890x270x240mm
External Materials:	Stainless acid proof steel, Titanium, OSNISIL, Durotong DT322 polyurethane
Accessories: Included: Optional:	 Recommended spares and accessories Alkaline Battery 3614 In-line Mooring frame 3824 Protecting Ring 966278 Data Storage Unit DSU 2990 Data Reading Program 5059 Base Brackets 3627 (2) for Frame Additional Protecting Rods 3783 Vane Plate 3681 DCS Test Unit 3731 PDC-4/RS-232 Converter 3818 Maintenance Kit 3813 Bottom Mooring frame 3438R

Individual specifications, RCM 11
(DCS 3820 Head)

Depth Capacity:	6000m	
Dimensions:	H: 595mm OD: 128mm	
Weight (in air):	Net	Gross
With frame	26.5 kg	37.5 kg
Packing:	Plywood case: 890x270x240mm	
External Materials:	Stainless acid proof steel, Titanium, OSNISIL, Durotong DT322 polyurethane	
Accessories:		
Included:	Recommended spares and accessories Alkaline Battery 3614 In-line Mooring frame 3824 Protecting Ring 966278 Base Brackets 3627 (2) for Frame	
Optional:	Data Storage Unit DSU 2990 Data Reading Program 5059 Additional Protecting Rods 3783 Vane Plate 3681 DCS Test Unit 3731 PDC-4/RS-232 Converter 3818 Maintenance Kit 3813 Bottom Mooring frame 3438R	

Pin Configuration, RCM 9 LW, RCM 9 IW and RCM 11

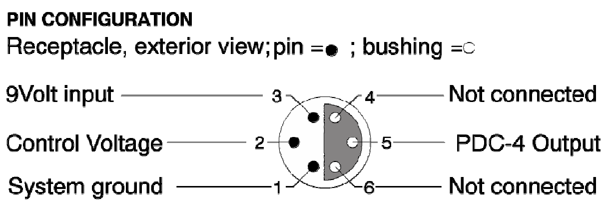


Figure A 5 Pin configuration for RCM 9 LW, RCM 9 IW and RCM 11

Appendix 4 Sensors and Data Sheets

The standard sensors of the RCM 9 LW are:

- Doppler Current Sensor, DCS 4220
- Temperature sensor 3621
- Signal Strength
- Instrument Tilt

The standard sensors of the RCM 9 IW/ RCM 11 are:

- Doppler Current Sensor, DCS 3820
- Temperature sensor 3621
- Signal Strength
- Instrument Tilt

The optional sensors of the RCM 9 LW, RCM 9 IW and RCM 11 are:

- Conductivity sensor 3919
- Pressure sensor 3815, 4017
- Turbidity sensor 3612
- Oxygen Optode 3830
- Oxygen Optode 3835

Information about the standard sensors is given below; for information about the optional sensors please refer the information supplied with the sensors. Pictures of all the sensors are shown in Figure A 13.

Doppler Current Sensor 4220 (Depth capacity of 300 m, RCM 9 LW)

The DCS 4220 housing is made in POM (polyoxymethylene). The depth capacity is 300m. Except for these parameters, the description of the DCS 4220 is similar to the description of DCS 3820, refer next section.

Doppler Current Sensor 3820 (Depth capacity of 6000 m, RCM 9 IW/ RCM 11)

This disk-shaped sensor with an OD of 120 mm, is 100 mm thick and has a 10-pin receptacle at its lower end; a picture of the DCS 3820 is given in Figure A 13. The sensor is fastened to the instrument by an 86 mm high sensor outlet. Four piezoceramic acoustic transducers are placed 90° apart around the circumference of the sensor body, which is molded in a polyurethane material.

The sensor utilizes the well-known Doppler Shift principle as the basis for its current speed measurements. The sensor normally transmits a preset number of acoustic pulses (pings) of 2 MHz into the water in sequence in every measurement interval. As the sound propagates, a portion of the energy is reflected by small particles or air bubbles in the water. The back-scattered energy from the area 0.4 to 2.2 meters from the sensor is picked up by the transducers and analyzed to find any change in frequency. The signal from the transducers are amplified and filtered by the receiver electronics and sampled through an AD-converter. A Digital Signal Processor on the RCM main board processes the sampled signal data to find the Doppler shift.

The sensor output is the Aanderaa standard SR10. A low frequency acoustic transducer for data transmission is molded into the top of the sensor.

A unique DCS Test Unit 3731 is available for checking that the vital parts of the Doppler Current Sensor are working correctly (not for calibration purposes). Please refer page 54.

Temperature sensor 3621 (Depth capacity of 6000 m)

The temperature sensing thermistor is housed in a stainless steel stud, fitted to the top end plate by a 16 mm stem and extends into the water. A picture of the Temperature sensor is given in Figure A 13. The thermistor, Fenwall GB 32JM19, is molded into the stud with polyurethane. The time constant for the temperature to reach 63% of a step change in temperature is about 12 seconds. Together with a set of resistors the thermistor forms a half-bridge. The output voltage does not cover full range and therefore range reducing resistors are used. The values of these resistors vary with the temperature range chosen by the temperature range selector switch located on the main electronic board.

Four ranges are available:

- *High range*, covering the temperature range from 9.81°C to 36.66°C
- *Low range*, covering the temperature range from -2.70°C to 21.77°C
- *Wide range*, covering the temperature range from -0.64°C to 32.87°C
- *Arctic range*, covering the temperature range from –3.01°C to 5.92°C

The instrument raw data reading N is a function of the thermistor resistance R_T as well as the range reducing resistors R_1 and R_2.

For Low, High and Wide temperature range, the Raw Data is expressed as:

$$RAW\ DATA(N) = \left\{ \frac{R_1 R_2 \left(R_T + 953 + 40K\right) + 20K\left(R_T + 953\right)\cdot\left(R_1 + 2R_2\right)}{2R_1 R_2 \left(R_T + 953 + 30K\right) + 60K\left(R_T + 953\right)\cdot\left(R_1 + R_2\right)} - \frac{1}{2} \right\} \cdot 22 \cdot 1024 + 512$$

For Arctic temperature range, the Raw Data is expressed as:

$$RAW\ DATA(N) = \left\{ \frac{R_2\left(R_1 + R_T + 953\right)}{R_1\left(R_T + 953\right) + R_2\left(R_1 + R_{T+}953\right)} - \frac{1}{2} \right\} \cdot 22 \cdot 1024 + 512 \,.$$

Test Unit 3731

Using the acoustic Doppler principle to measure current has many advantages over the mechanical rotor. The simple function-testing, however that could be done before by spinning the rotor, has not yet been possible on the Doppler based type. The Test Unit 3731 is designed to fulfill this purpose for the Aanderaa Doppler Current Sensors 3820/4220 installed on the RCM 9, and the stand-alone sensor DCS 4100.

The test unit consists of a ring with 4 test transducers. They are suspended by mechanical springs, enabling each test transducer to be pressed against the DCS transducers. Each test transducer has a piezoelectric disk at the end facing the DCS transducers. The test unit is placed over the DCS with each test transducer placed in its outer position. To release the transducers, pull and turn. Then adjust each test transducer so that the surface of the test makes good contact with the DCS transducer. To achieve the best possible contact, moisten the surface of the transducers.

The disks will pick up some of the energy transmitted by the 'ping' from the Doppler Current Sensor. This energy is then used to start the oscillation of a crystal with a resonant frequency slightly different to the acoustic frequency of the DCS. When the DCS is supposed to receive the scattered echo from the 'ping', the crystal is still oscillating and thus transmitting a weak signal back to the DCS via the same piezoelectric disk.

Two of the test transducers have crystals with slightly higher frequency than the frequency transmitted by the DCS, and the other two, have a slightly lower frequency. The high frequency corresponds to the frequency received when the current is flowing towards the DCS transducer, and the low frequency to a current flowing away.

The frequency shift corresponds to a current of about 2 m/s, and since this is applied on both axis the test unit will simulate a current speed of about 2.83 m/s. The direction of the simulated current will be right between the middle of the two low frequency test transducers. This direction is marked by a slot in the ring.

The DCS for 3500, 3620, 3900A, 4100A should give stable current raw data readings between 540 and 590 and between 940 and 990 for DCS 3820, 3920, 3900, 4100 and 4220. Multiplying the raw data from the direction channel by 0.3516 gives direction in degrees. This angle should correspond to the direction of the slot in the ring, with respect to Magnetic North.

By turning the Test Unit 180 degrees on the DCS, the reading should be repeated but in the opposite direction. By turning the DCS and the test unit together, the direction reading should turn accordingly.

The DCS Test Unit is designed only for checking that the vital parts of the Doppler Current Sensor are working correctly, and not for calibration purposes. The Doppler calculation is fixed and the compass and the tilt sensor are factory calibrated.

By tilting the DCS in any direction the current speed reading should increase (approximately 8% at 30 degrees).

Please refer to Data Sheet D320 for more information about the Test Unit 3731.

Appendix 5 Mechanical Hardware and Illustrations

Pressure case

The pressure case shown in Figure A 14 for RCM 9 IW and in Figure A 15 for RCM 11 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 these two instruments are furnished with an olive green epoxy coating applied by an electrostatic powder process. This coating performs well in sea-water 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.

The pressure case for RCM 9 LW is made of durable thermoplastic.

Top end Plate

RCM 9 IW: The top end plate, made of the same non-magnetic acid proof steel alloy as the bottom end plate, is seen in Figure A 6. 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. The electrical terminal, part number 3622 is fitted to the top end plate and mates with plug 2828Ti.

RCM 11: the top end plate is thicker than the RCM 9 IW top end plate, else the description is similar to the one given for RCM 9 IW. As a consequence of thicker top end plate, the nuts for connecting the sensors and the C-clamps for tightening the top end plate to the pressure case are somewhat different.

RCM 9 LW: The top end plate is made in Titanium, else the description is similar to the one given for RCM 9 IW. Sealing plug 3445 must be used if a sensor is disconnected from the instrument.

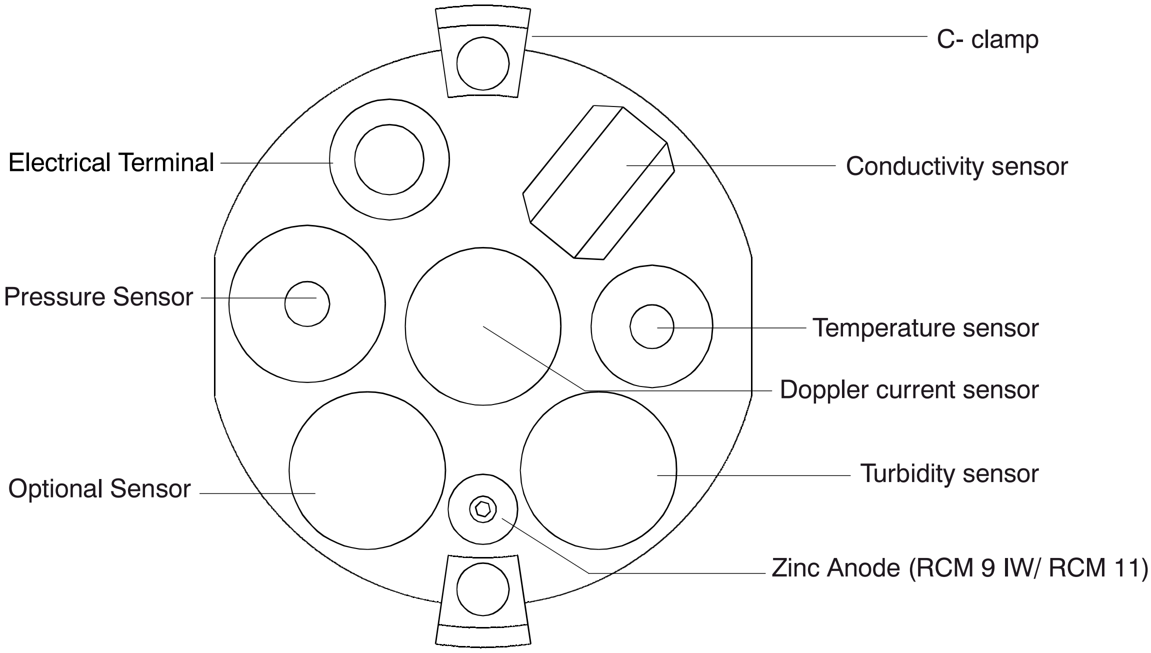


Figure A 6 Illustration of Top End Plate for RCM 9 LW/RCM 9 IW/ RCM 11. Note: The sensors can be placed different than illustrated here.

IMPORTANT! The Conductivity sensor must stay plugged in where it has been calibrated.

To leave enough space for all standard and optional sensors to be connected, the Temperature sensor and the Electrical Terminal must be plugged in as shown in Figure A 6.

Please refer to CHAPTER 3, page 21 for connection/disconnection of sensors!

Pictures

Figure no.	Description
Figure A 7	RCM 9 IW in pressure case
Figure A 8	RCM 9 LW in pressure case
Figure A 9	RCM 11 in pressure case
Figure A 10	RCM 9 IW in mooring frame
Figure A 11	RCM 9 LW in mooring frame
Figure A 12	RCM 11 in mooring frame
Figure A 13	Sensors

Figure A 7 RCM 9 IW in pressure case

Figure A 8 RCM 9 LW in pressure case

Figure A 9 RCM 11 in pressure case

Figure A 10 RCM 9 IW in mooring frame

Figure A 11 RCM 9 LW in mooring frame

Figure A 12 RCM 11 in mooring frame

Doppler Current Sensor 4220

Doppler Current Sensor 3820

Oxygen Optode 3830

Oxygen Optode 3835

Turbidity Sensor 3612

Pressure Sensor 4017

Temperature Sensor 3612

Conductivity Sensor 3919

Figure A 13 Sensors

Illustrations

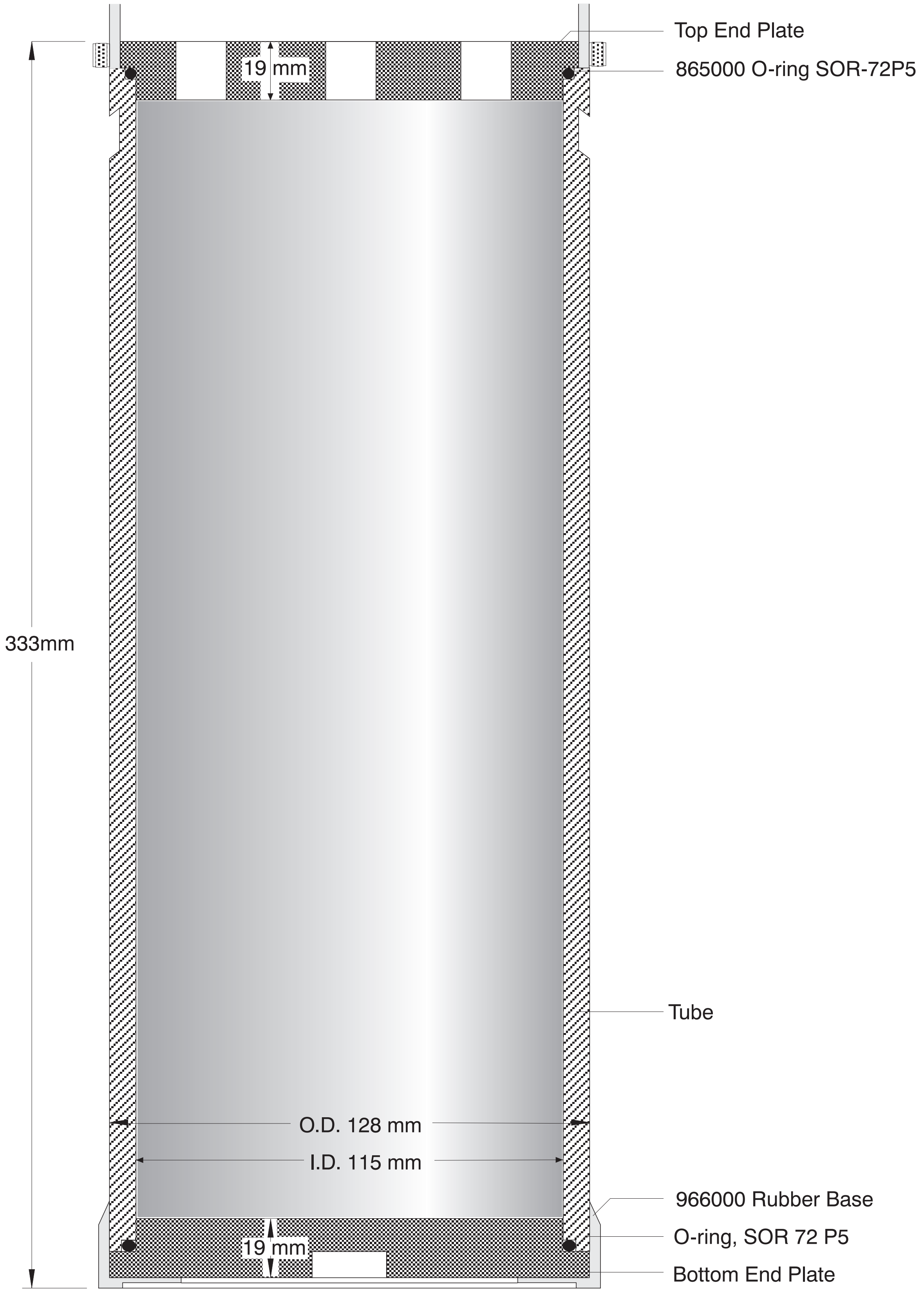


Figure A 14 RCM 9 IW Pressure case

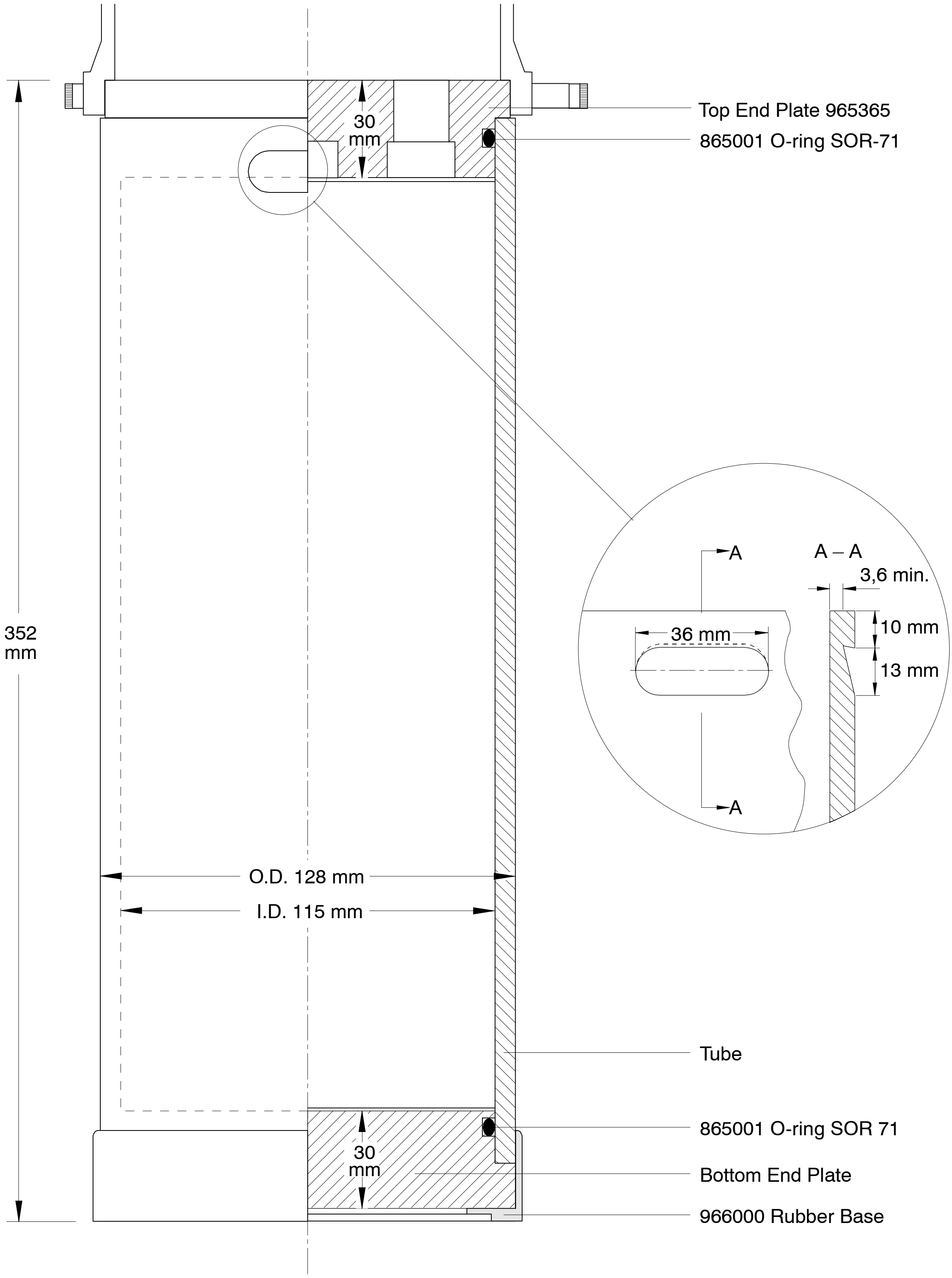


Figure A 15 RCM 11 Pressure case

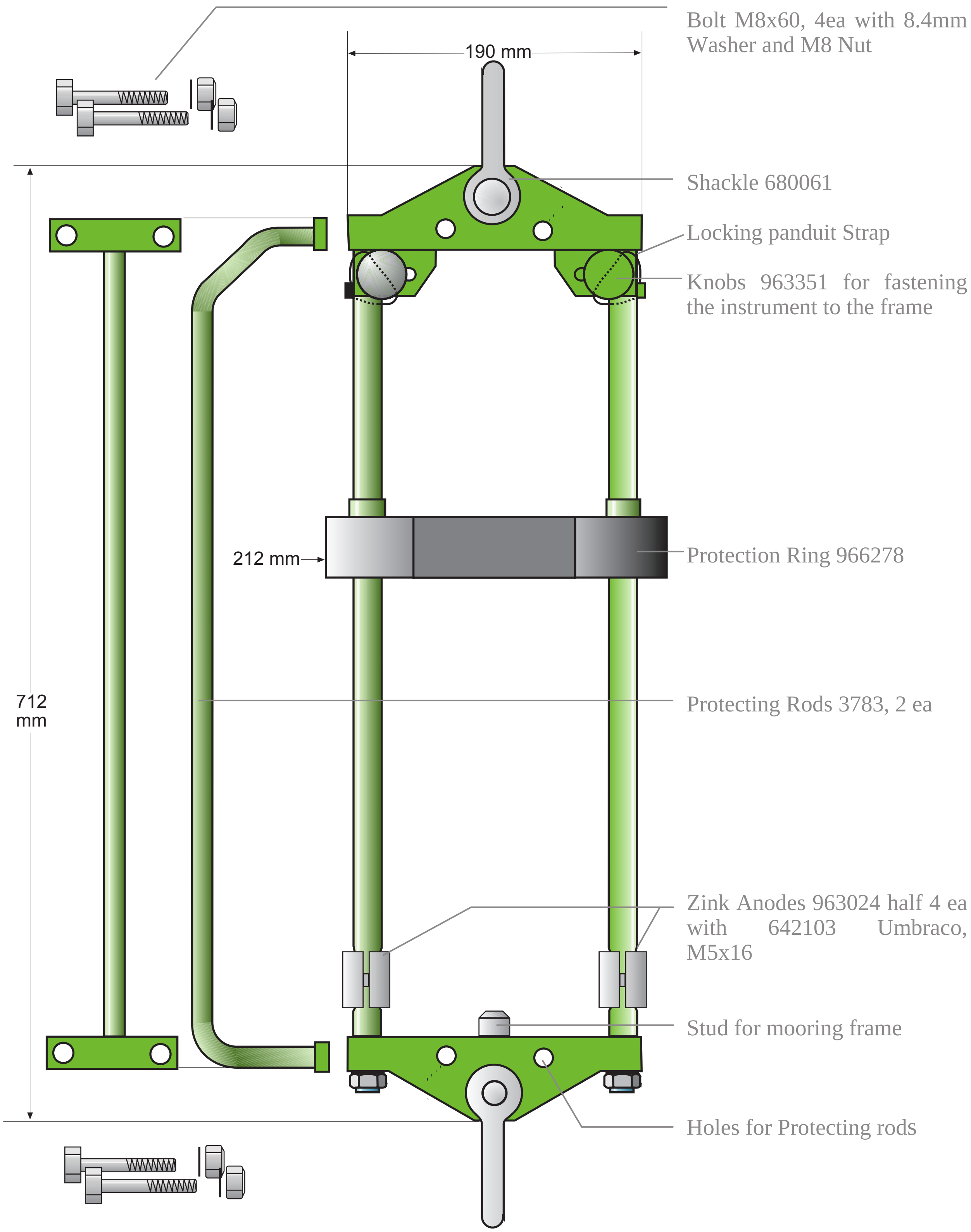


Figure A 16 RCM 9 IW/ RCM 11 mooring frame 3824

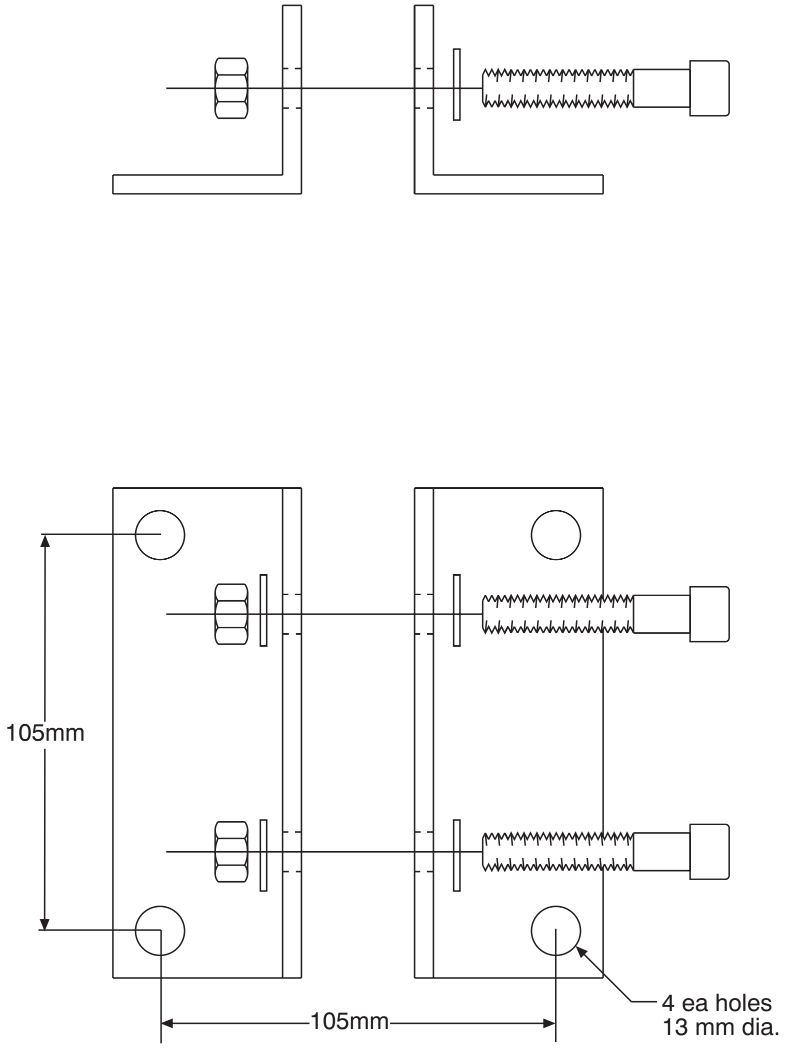


Figure A 17 Base Brackets 3627 (optional)