TD 222 OPERATING MANUAL

CONDUCTIVITY SENSOR

3919/4019/4120

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Introduction

Purpose and scope

This document is intended to give the reader knowledge of how to operate and maintain the AADI Aanderaa Conductivity Sensor 3919/4019.

It also aims to give insight in how the sensor works and how the conductivity measurement of water can be used to determine other important seawater properties.

Document Overview

This document starts by giving a short description of the Conductivity Sensors 3919 and 4019. CHAPTER 2 and CHAPTER 3 describe configuration and configuration of sensor 3919 using the setup software 4040 and the RS 232 communication via HyperTerminal. Installation of the sensor 3919/4019 on Aanderaa Current meters is described in CHAPTER 4, while Maintenance, Calibration, Mechanical design and Theory of Operation are discussed in CHAPTER 5 and in the Appendix.

Applicable Documents

V-8875	Assembly Drawing
V-8699	Sensor Cable 3854
V-9357	Sensor Cable for RDCP 600 Internalbus 4054
V-8700	Sensor Cable 3855
Form 669	Test & Specification Sheet, Conductivity Sensor 3919/4019
Form 668	Calibration Certificate, Conductivity Sensor 3919/4019
D344	Data sheet, Conductivity Sensor 3919, 4119, 4120
D354	Data Sheet, Conductivity Sensors 4019A/4019B

References

[1] Fofonoff, Journal of Physical Oceanography JGR, Vol 90 No. C2, pp 3332-3342, March 20, 1985

Abbreviations

ADC Analogue to Digital Converter
ASCII American Standard Code for Infor

CAN	Controller Area Network - sometimes
DAC	Digital to Analogue Converter
DSP	Digital Signal Processor
EPROM	Erasable Programmable Re
HCL	Hydrochloric acid (Muriatic acid)
MSB	Most significant bit
PSU	Practical Salinity Unit
RTC	Real Time Clock
SR10	This signal corresponds to the digital signal obtained when the contents of a 10-bit shift register are clocked out in serial format. This signal is used when the parameter to be measured is digital, e.g. a frequency or a number of pulses.
UART	Universal Asynchronous Transmitter and Receiver
UNESCO	- the United Nations Educational, Scientific and Cultural Organization
USB	Universal Serial Bus

Figure 0 - 1 Conductivity sensor 3919 connected to an RCM 9 MkII

CHAPTER 1 Short Description and Specifications

Description

Specific conductivity is a property that describes how well a material can conduct an electrical current. For seawater this property is mostly dependent on the inorganic dissolved solids and the temperature of the water.

Salinity is defined as the concentration of these dissolved solids, and by measuring conductivity and temperature it is thus possible to determine the salinity of the water. Other important properties of seawater are again dependent on the salinity. Among these are the density and the speed of sound.

For freshwater the conductivity can be used as a quality indicator. Increased conductivity of a stream will often indicate increased pollution, and increased conductivity of groundwater might indicate seawater intrusion.

The Conductivity Sensor 3919/4019 is based on an inductive principle. This provides for stable measurement without electrodes that are easily fouled in the field.

Two versions of the Conductivity Sensors are available, A and B. 3919B and 4019B have enhanced accuracy compared to 3919A and 4019A. Additionally, sensor 3919 is available in two depth ratings, 6000m and 2000m (Intermediate Water).

The Conductivity Sensor 3919 outputs data in both RS-232 and Aanderaa SR10 format. On the RS-232 output the Conductivity in mS/cm as well as Temperature, Salinity, Density and Speed of sound may be presented. One of the SR10 outputs can be configured to present Conductivity, Salinity, Density or Speed of sound, while the other SR10 output presents the temperature measurement. The user may configure the range on both SR10 outputs. This offers a possibility to zoom in on the range of interest.

The RDCP 600 Internalbus is used for communication between the Conductivity Sensor 4019 and the RDCP 600.

The sensors are designed to operate down to 6000 meters.

The 3919 version fits directly on to the Top End Plate of Aanderaa Recording Current Meters (RCM 9, RCM 11) as well as on the RDCP 600. The sensor can also be used as Stand-Alone RS232 sensor for other applications.

The 4019 version fits directly on the Top End Plate of RDCP 600. The 4019 model is only for use on RDCP 600.

Specifications for Conductivity Sensor 3919/4019

Refer to Datasheet D344/D354, available on AADI web site or contact info@aadi.no

You will find the latest versions of our documents on the web.

CHAPTER 2 Setup software, Conductivity Sensor 3919

The Conductivity Sensor 4019 is a smart sensor. No setup is necessary to operate the sensor. CHAPTER 2 *Setup software, Conductivity Sensor 3919* is therefore not relevant for our 4019 customer.

The Conductivity Sensor 3919 may output RS-232, SR10 or analogue data. The RS-232 port is also used for configuration of the sensor. This may be done by use of a terminal program (refer CHAPTER 3), however we recommend using the Conductivity Setup Program 4040 described here.

First, check that your system supports the requirements given below. Then install the Conductivity Setup Program 4040 as described in *Installation* below, and connect the Conductivity Sensor to your PC using cable 3855 (refer to Figure 2-1). Now you may start the program and select the COM port to which you have connected the sensor, refer to Figure 2-3.

Parameters and units are shown in Table 2-1, and instructions to the different configuration possibilities, RS232, SR10 (Aanderaa signal) or Analogue Output, are given on page 13 to 16.

System requirements

- 600 MHz or faster Pentium or compatible
- 100 Mb of free HD space
- MS Windows98 or later versions
- 64 Mb of RAM
- SVGA (640x480) colour display or better
- Local CD-ROM Drive

Installation

A CD-ROM is delivered together with the sensor. Here you will find this manual and installation setup for the Conductivity Setup Program 4040.

Installation procedure:

- Insert the CD-ROM and open the Windows explorer or similar.
- Go to 4040 Installer/Installer/setup.exe and double-click on the setup.exe icon.
- Follow the installation instruction in the setup guide that appears.
- If you answer yes to all the questions, the program will be installed in the folder *C:\ProgramFiles\Aanderaa\ConductivitySetupProgram4040* and icons will be added to the START menu.

Connection to PC

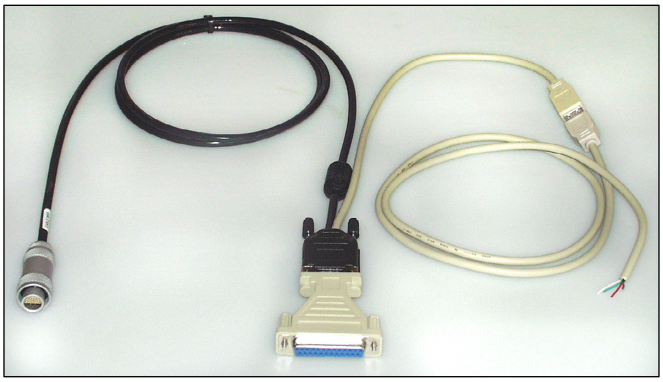


Figure 2-1 Sensor Cable 3855

A 1.5 meter cable, Sensor Cable 3855, is used for connection between the Sensor and the PC. By using a Cable Coupler 3472 and a standard Connecting Cable 3282 this connection can be extended to 15 meters.

The 10-pin receptacle in the Conductivity Sensor's foot mates with an Aanderaa 3216A plug (Figure 2-2).

This cable has a watertight 10-pin plug at the sensor end, and a 9 pin D-Sub plug at the PC-end. An additional USB plug is used for providing power to the sensor. Power may also be connected to an included extension to the USB plug.

A drawing of Sensor Cable 3855 is given in Figure 2-2:

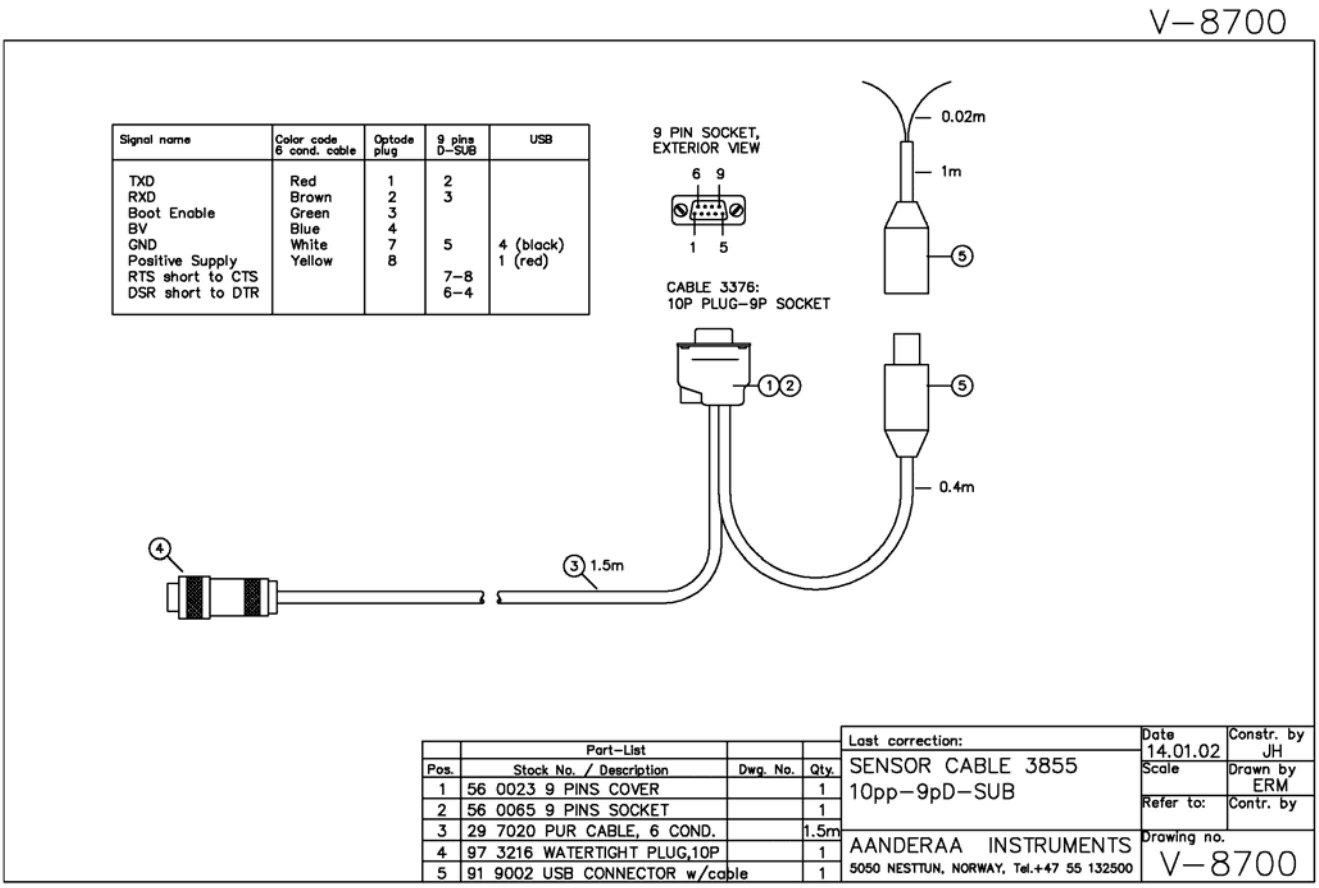


Figure 2-2 Sensor Cable 3855

Configuration of sensor using setup programme 4040

Connect the sensor to the sensor end of cable 3855, ref Figure 2-1, and connect the PC end of the cable to your computers COM port. Start setup program 4040, and select the chosen COM port from the drop down list (refer to Figure 2-3). When the correct COM port has been selected, to which the sensor is connected, the current sensor settings are read into the program automatically.

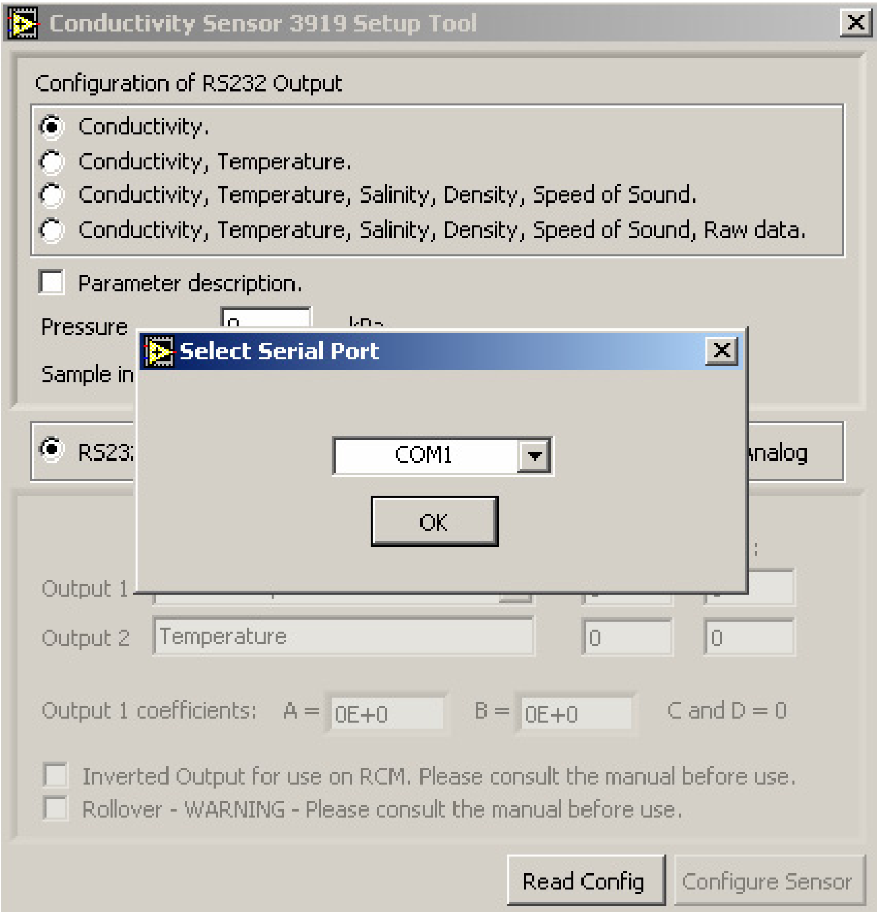


Figure 2-3 The Conductivity Setup Program 4040

At start up of setup programme 4040, the button *Configure Sensor* is disabled, since the sensor settings are as shown in the software window (the sensor settings has been read from the sensor into the setup programme).

Refer to page 13 to 16 for RS232/SR10/Analogue configuration. When setup has been completed, press the *Configure Sensor* button in the lower, right part of the window to store your settings.

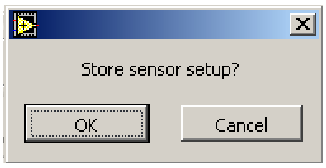


Figure 2-4 Storing configuration settings

A button with *Store Sensor setup?* will appear. Click *OK*, and a button with *Sensor setup stored* appears. Click *OK*.

When the new parameters are stored, the button *Configure Sensor* will be disabled. This means that the present configuration in the setup tool is now the same as in the sensor. If a setting is changed, the *Configure Sensor* button will be enabled.

To load the last stored sensor settings (from the sensor) click the *Read Sensor* button.

Parameters and units

The parameters and units are shown in Table 2-1:

Table 2-1 Parameters and units

Parameter	Unit
Pressure	kPa
Interval	sec
Conductivity	mS/cm
Temperature	deg. C
Salinity	PSU
Density	kg/m^3
Sound Speed	m/s

Configuration of RS-232 Output

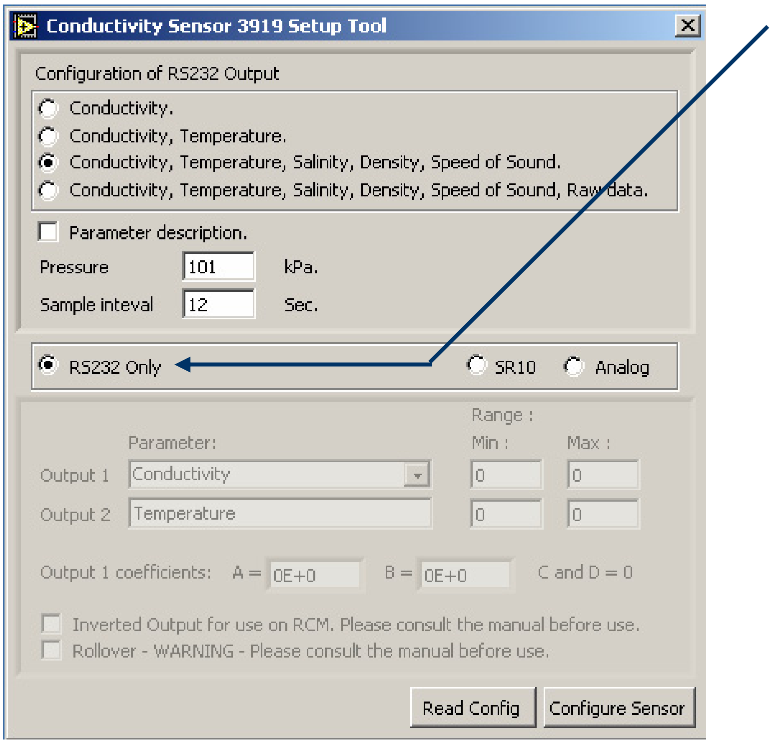


Figure 2-5 Configuration of RS232 Output

To configure the RS-232 output, check *RS232 Only* as shown in Figure 2-5.

You may now choose the desired combination of parameters, i.e. *Conductivity, Temperature, Salinity, Density, Speed of Sound*, as shown in Figure 2-5.

Insert the *Pressure* setting and the *Sample interval* that you want.

If you check the option *Parameter description*, the output will include parameter information. The output string will then start with the word MEASUREMENT followed by the sensor's product number and serial number.

Example of output string:

MEASUREMENT 3919 104 Conductivity: 56.853 Temperature: 34.563
Salinity: 30.805 Density: 1021.195 Soundspeed: 1567.15[1)]

1) *Pressure property set to 10000 kPa*

If you uncheck *Parameter description* the output string will become:

3919 104 56.853 34.563 30.805 1021.195 1567.15

NOTE! In RS232, you can not change the parameter setting or range in output 1 and output 2

When setup has been completed, press the *Configure Sensor* button in the lower, right part of the window to store your settings, refer to page 12.

Configuration of SR10 Output

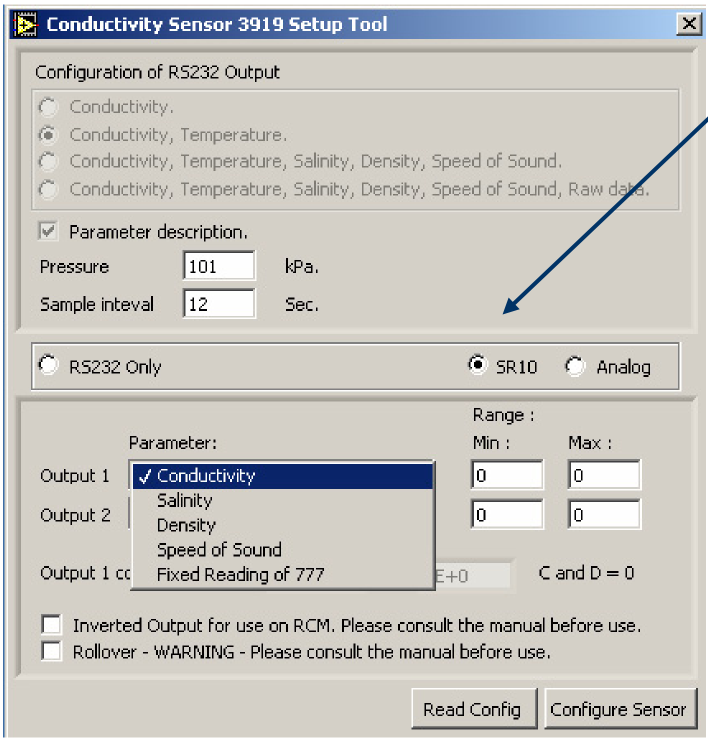


Figure 2-6 Configuration of SR10 Output, Output 1

To configure SR10 Output, check the *SR10* option. The upper parameter choices will now be disabled and turn grey.

Note! When selecting SR10 output, you will also get RS-232 output. However, you will only get two output channels and the Parameter description *will always be checked, as shown in Figure 2-6.*

As Output 1 you may choose between *Conductivity, Salinity, Density, Speed of Sound* and a *Fixed Reading of 777* which may be used for testing. Output 2 is always *Temperature*.

Example of output string:

MEASUREMENT 3919 104 Conductivity: 56.853 Temperature: 34.563
Salinity: 30.805 Density: 1021.195 Soundspeed: 1567.15 1)

1) *Pressure property set to 10000 kPa*

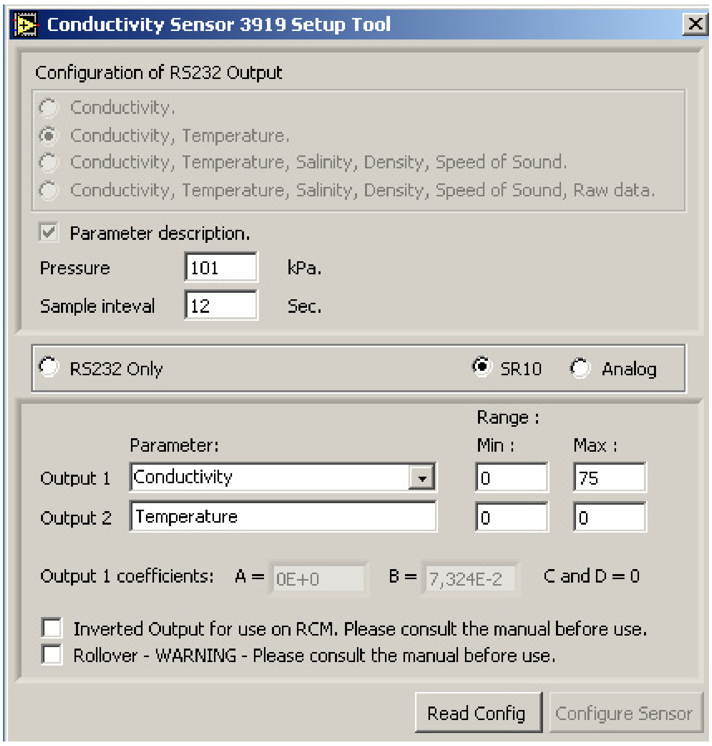


Figure 2-7 Configuration of SR10 Output

Set the range of the output parameters.

The output 1 coefficients are calculated based on the parameter range. The coefficients are automatically updated when the range has been set. The coefficients for Conductivity may be used for the test with seawater loop, refer to page 32.

An option called *Rollover*, may also be used. Selecting *Rollove*r the SR10 reading will take zero as the next value when the reading passes the upper SR10 limit and vice versa continue at 1023 when the reading passes the lower SR10 limit.

By allowing Rollover, you can set a shorter range than without the rollover feature, and achieve a better resolution for your measurements. It should however be used with caution since the user has to determine which range interval the reading actually is in.

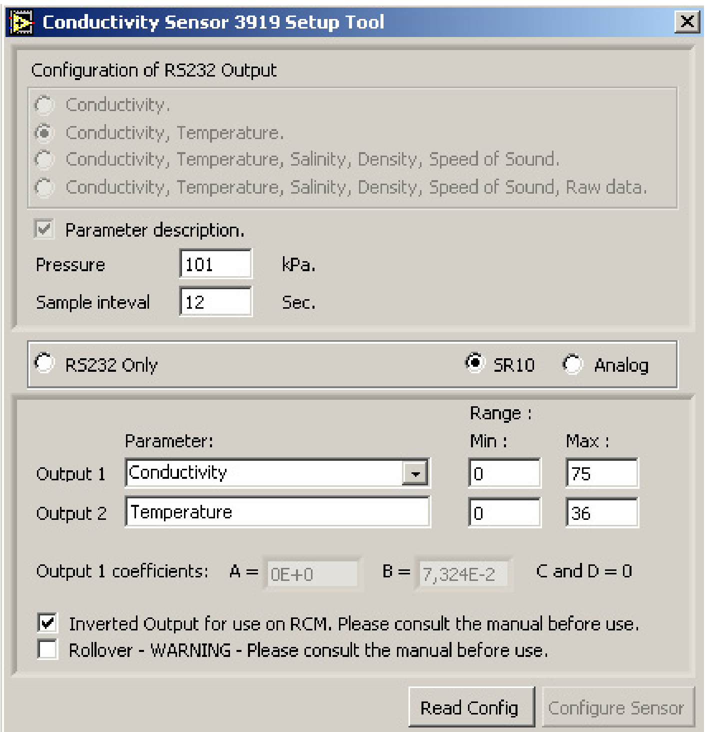


Figure 2-8 Configuration of SR10 Output, Output 1

If choosing *Conductivity* as *Output 1* and your sensor is connected to Channel 5 on RCM 9/11, check *Inverted Output*. If you chose another parameter like *Salinity*, the *Inverted Output* choice becomes unavailable.

Then set the range of Output 2 (Temperature).

Press the *Configure Sensor* button to store your settings, refer to page 12.

Fixed reading for test purposes

When setting the output 1 parameter to Fixed Reading of 777, the SR10 reading should be raw data reading of 777. This verifies that the sensor is actually sending SR10 data, and that there are communication between the sensor and the data storage unit.

Test procedure:

1. Configure the sensor with Fixed Reading of 777
2. Connect the sensor to your systems datalogger (e.g. an AADI RCM)
3. Perform one measurement
4. Read stored data to verify a raw data reading of 777.

Configuration of Analogue Output

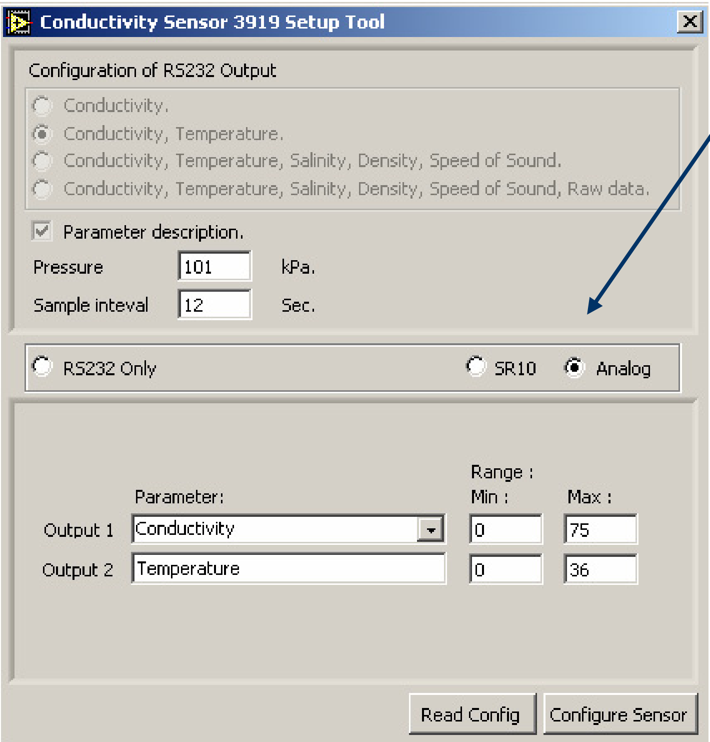


Figure 2-9 Configuration of Analogue Output

For analogue output, select *Analog*.

Note! When configuring Analogue Output, you will also get RS-232 output. However, you will only get two output channels and the Parameter description *will always be checked.*

As Output 1 you may choose between *Conductivity, Salinity, Density, Speed of Sound* and two *Fixed Readings* of 4V/16.8mA and 1V/17.2mA which may be used for testing. Output 2 is always *Temperature*.

When one of the fixed readings are chosen for output 1, output 2 is automatically set to the other of the two fixed readings!

Set the range of the output parameters (not an option if fixed readings are chosen).

Example of output string:

MEASUREMENT 3919 104 Conductivity: 56.853 Temperature: 34.563
Salinity: 30.805 Density: 1021.195 Soundspeed: 1567.15[1)]

[1)] *Pressure property set to 10000 kPa*

Press the *Configure Sensor* button to store your settings, refer to page 12.

Fixed reading for test purposes

When setting the output 1 parameter to one of the fixed readings, the analogue reading should be according to the input. A fixed reading of 4V/16.8mA gives a higher reading than 1V/7.2mA. This verifies that the sensor is actually sending analogue data, and that there are communication between the sensor and the data storage unit.

Test procedure:

1. Configure the sensor with output 1 parameter to a Fixed Reading of e.g. 4V/16.8mA
2. Connect the sensor to your receiver system
3. Perform one measurement
4. Read the received data: Output 1 and output 2 should give a Voltage/Current reading corresponding to the configuration

Error management

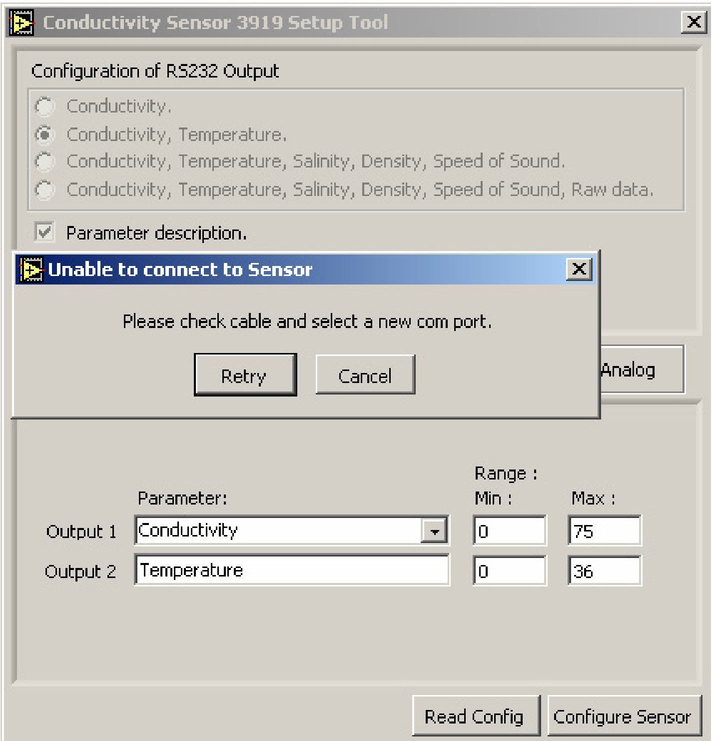


Figure 2-10 Error Management

If the box *Unable to connect to Sensor* appears, you have lost connection with the sensor.

Check that both the USB and the serial connectors are connected to your computer. If you have more than one COM port, check that you are using the correct COM port.

Then click *Retry*.

NOTE! If the software is suddenly not responding during configuration, disconnect and reconnect the sensor.

CHAPTER 3 RS-232 communication, Conductivity Sensor 3919

The Conductivity Sensor 4019 uses the RDCP 600 Internalbus. CHAPTER 3 is therefore not relevant for our 4019 customer.

The software's main tasks are to balance the conductance loop, sample the temperature and calculate the resulting conductivity.

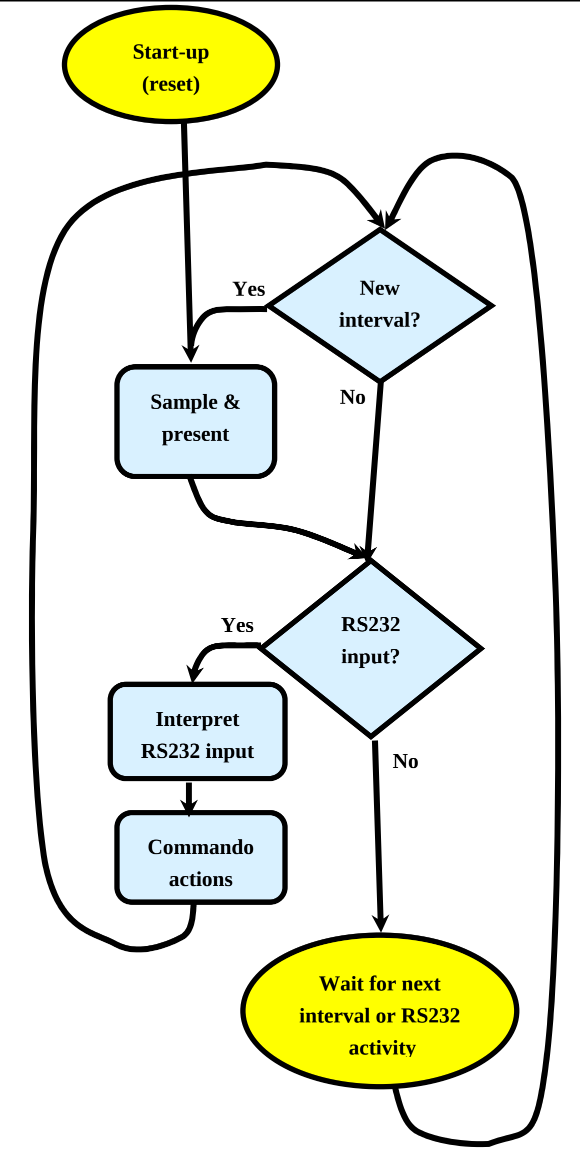


Figure 3-1 Software, Operation Sequence

All properties that can be changed for each individual sensor, i.e. calibration coefficients, are called sensor properties.

These properties can be displayed and changed using the RS-232 port (see RS-232 Protocol for how to communicate with the sensor).

When powered up; the Conductivity Sensor will take one sample and present the result.

After this, and after each following sample, the RS-232 input buffer is checked for 100 milliseconds.

If the buffer contains any characters the timeout is increased to 1 second and the software starts interpreting the RS-232 input.

If the input buffer is empty the sensor will continue to sample and present data accordingly to the setting of the *Interval* property.

If the *Interval* is set to zero the user can initiate a new sample by use of a Do_Sample command.

After approximately 40 seconds without any valid command inputs the sensor will enter a sleep mode until the next interval starts or a command is entered. A wakeup character is then required before entering a new command (see RS-232 Protocol for details).

When the Conductivity Sensor is connected to a RCM 9 or other Aanderaa Instrument or Logger, the power to the sensor is switched on by the Control Voltage becoming active (initiated by the RCM 9).

The sensor will then take one sample at the start of the recording interval and present this at the SR10 output.

When the logger is finished reading the SR10/VR22 sensors, the Control Voltage is turned off and the Conductivity Sensor is powered down.

Calculation

The software calculates the specific conductivity and temperature in engineering values based on the sampled raw-data and a set of stored (*flashed*) coefficients.

The conductivity is presented in mS/cm and the temperature in degrees centigrade.

Based on these parameters and a user selectable pressure (KPa) setting the software also calculates the salinity (PSU), the density of the water (Kg/m^3), and the speed of sound (m/s).

These calculations are made according to the UNESCO International Equation of State, IES 80, Unesco 27 [1].

RS-232 Protocol

The RS-232 protocol describes how to communicate with the sensor.

For connection to a Personal computer (PC) the 1.5-meter Sensor Cable 3855 can be used.

Most terminal programs, such as the HyperTerminal*) by Hilgraeve Inc (included in Microsoft's operating systems), can be used for manual communication.

The following RS-232 setup should be used:

9600 Baud

8 Data bits

1 Stop bit

No Parity

Xon/Xoff Handshake

**) Note! The options "Send line ends with line feeds" and "Echo line ends with line feeds" in the HyperTerminal ASCII setup must be selected.*

All communication is ASCII coded with following syntax rules:

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

  MainCmd_SubCm or MainCmd_Property(Value.., Value)

- The main command (*MainCmd*) is followed by an optional subcommand (*SubCmd*) or sensor property (*Property*).
- The *MainCmd* and the *SubCmd/Property* must be separated with the underscore character '_' or a space ' ' character.
- When entering new settings the *Property* is followed by parentheses containing comma-separated values.
- The command string must be terminated by a Line Feed character (ASCII code10). Termination with Carriage Return followed by Line Feed is also allowed.
- The command string is not case sensitive (UPPER/lower-case)

- A valid command string is acknowledged with the character '#' while the character '*' indicates an error. Both are followed by Carriage Return/Line Feed (*CRLF*). For most errors a short error message is also given subsequent to the error indicator.

The following main commands are available in the Conductivity Sensor:

Command	Meaning
Do_*Subcmd*	Execute *Subcmd*
Get_*Property*	Output *Property* value
Get_All	Output all property values
Set_Property(*Value,..Value*)	Set *Property* to *Value,.. Value*
Save	Store current settings
Load	Load stored settings
Help	Print help information
;	Comment string, following characters are ignored
//	Comment string, following characters are ignored

The Table 3-1 and Table 3-2 describes the available subcommands and properties.

Table 3-1 Available Subcommands

Subcommand	Function	Write Protection
Sample	Execute a conductivity sample and presents the result	

Table 3-2 Properties

Properties	Type	No. of elements	Use	Write Protection
Protect	Int	1	Protection of property read and write access	No
TempCoef	Float	6	Curve fitting coefficients for the temperature measurement	High
R0Coef0	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 0	High
R0Coef1	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 0	High
R0Coef2	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 0	High

R0Coef3	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 0	High
R0Coef4	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 0	High
R1Coef0	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef1	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef2	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef3	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef4	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef5	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef6	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef7	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef8	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
R1Coef9	Float	4	Temperature Coefficients for Loop reading to Conductance, Range 1	High
CellCoef	Float	4	Curve fitting coefficients for the conductivity measurement	Yes
Pressure	Float	1	Pressure setting in kPa	Yes
Interval	Int	1	Sampling Interval in seconds.	No
Output	Char	1	Output setting	Yes
SR10CondLim	Float	2	SR10 range limits for Conductivity	Yes
SR10TempLim	Float	2	SR10 range limits for Temperature	Yes
SR10SalLim	Float	2	SR10 range limits for Salinity	Yes
SR10DensLim	Float	2	SR10 range limits for Density	Yes
SR10SoundLim	Float	2	SR10 range limits for Sound Velocity	Yes
AnCoef	Float	2	Offset and Slope coefficient for data to Analogue Adaptor	Yes

A property may contain one or more equal elements of the type Character, Integer or Float. The Character type is stored as an 8-bit bit word and may be signed (value –128 to 127) or unsigned (0-256).

The Integer type is stored as a 16-bit word and may be signed (value –32768 to 32767) and un-signed (0 to 65535). The Float consists of 32-bit and has a range from 1.19209290e–38 to 3.4028235e+38.

The *Get* command is used for reading the value/values of a property.

The command name Get, is followed by *_Property* and returns a string on following format:

Property ProductNo SerialNo Value, ..Value

#

The string starts with the name of the property (*Property*), continues with the product number and serial number of the sensor, and finally the value or values of the property.

All names and numbers are separated by tabulator spacing (ASCII code 9). The string is terminated by Carriage Return and Line Feed (ASCII code 13 & 10).

Example:

Get_Interval

Returns: Interval 3919 116 30

#

A special version, *Get_All*, reads out all available properties in the sensor.

The *Set* command is used for changing a property.

Example:

Set_Interval(30)

Returns: #

Float values may be entered on normal decimal form or exponential form, either with ‘e’ or ‘E’ leading the exponent. Extra “Space” characters in front or after a value are allowed.

When one or more properties are changed, the sensor will start using the new properties. If the *Save* command is executed the new setting will be stored in the internal EEPROM. If a *Load* is executed instead, the previous stored setting will be reloaded.

To avoid accidental change, most of the properties are write-protected. There are three level of write protection:

- No: The user can change the value of properties.
- Yes: A special property called *Protection* must be set to 1 before changing the value of properties.

- High: The user cannot change the property.

The *Protection* property always returns to zero after power up or execution of the *Load* or *Save* command.

The *Do_Sample* command or an interval initiated measurement result in one output string containing the obtained data.

Output Control

A property called *Output* controls the presentation of the measured data.

When set to a negative value the *Output* property enables either the SR10 outputs or the I2C output to the Analogue Adaptor

Table 3-3 Output property

Output	Data presented on the SR10 output, Ch. 2[1)]	Unit	Data presented on the SR10 output, Ch. 3	Unit	Remark
-1	Conductivity	mS/cm	Temperature	Deg.C	Inverted output [2)], No roll over
-2	Conductivity	mS/cm	Temperature	Deg.C	No roll over
-3	Salinity	PSU	Temperature	Deg.C	No roll over
-4	Density	Kg/m^3	Temperature	Deg.C	No roll over
-5	Sound Speed	m/s	Temperature	Deg.C	No roll over
-11	Conductivity	mS/cm	Temperature	Deg.C	Inverted output [2)], Roll over
-12	Conductivity	mS/cm	Temperature	Deg.C	Roll over
-13	Salinity	PSU	Temperature	Deg.C	Roll over
-14	Density	Kg/m^3	Temperature	Deg.C	Roll over
-15	Sound Speed	m/s	Temperature	Deg.C	Roll over

[1)] *Channel 1 not used*

[2)] *Inverted output on Conductivity channel, used when connected to Conductivity Channel 5 on RCM9/11*

Each of the SR10 parameters also has a property that determines the range that is used at the SR10 output. The SR10CondLim, SR10TempLim, SR10SalLim, SR10DensLim, SR10SoundLim respectively controls the range of the Conductivity, Salinity, Density and Sound Speed. These properties must be set to the desired range limits for the SR10 output.

Example of configuring the SR10 to output conductivity with a range from 20 to 40mS/cm:

```
Set_Protect(1)

Set_Output(-3)

Set_SR10CondLim(20,40)

Save
```

Result: The range of conductivity reading presented at the SR10 output is set to 20 to 40mS/cm.

For the *Output* values –11 to –14 the SR10 reading will roll over when the limit of the range is exceeded. For the above example this means that the SR10 reading will start at zero again when the reading passes 40 mS/cm (vice versa at the low limit). This feature makes it possible to reduce the drawback of the limited resolution of the SR10. It should however be used with caution since the user has to determine which range interval the reading actually is in.

When equipped with the Analogue Adaptor 3966 the readings are converted to 0-5 Volt or 4-20 mA. Table 3-4 show the possible configuration for the data.

Table 3-4 Possible configuration for the data presented to the analogue adaptor

Output	Data presented to the analogue adaptor output 1	Unit	Data presented to the analogue adaptor output 2	Unit
-101	Conductivity	mS/cm	Temperature	Deg.C
-102	Salinity	PSU	Temperature	Deg.C
-103	Density	Kg/m^3	Temperature	Deg.C
-104	Sound Speed	m/s	Temperature	Deg.C
-110	Test, fixed reading 4V/16.8mA		Test, fixed reading 1V/7.2mA	
-111	Test, fixed reading 1V/7.2mA		Test, fixed reading 4V/16.8mA	

The selection between voltage and current output is done by dip-switches at the Analogue Adaptor board.

All measurements are also presented at the RS232 port when the analogue or the SR10 output is enabled. After the first sample, additional information on setting and scaling coefficients are presented:

Example:

```
MEASUREMENT      3919     21    Conductivity:...

SR10 Conductivity      0 use A:= 2.000000E+01 B:= 3.222656E-02

SR10 Temperature     855 use A:=-5.000000E+00 B:= 3.906250E-02
```

When the *Output* property is set to zero or higher it controls the RS-232 output string. For values less than 100 the string will contain text describing the output values. The string then starts with the leading word, MEASUREMENT followed by the sensor's product number and serial number:

MEASUREMENT 3919 104 Conductivity: 56.853 Temperature: 34.563 Salinity: 30.805 Density: 1021.195 Soundspeed:1567.15[1)]

[1)] *Pressure property set to 10000 kPa*

The output property also controls the number of parameter that are presented, refer Table 3-5:

Table 3-5 Parameters to be presented

Output	Conductivity	Temp	Salinity	Density	Speed of sound	Internal Raw data	Description text
<0	X	X					X
0	X						X
1	X	X					X
2	X	X	X	X	X		X
3	X	X	X	X	X	X	X
100	X						
101	X	X					
102	X	X	X	X	X		
103	X	X	X	X	X	X	

When the *Output* is higher than 100 the lead word and the text describing the different parameters are suppressed:

3919 104 56.853 34.563 30.805 1021.195 1567.15

All words and numbers are followed by a tabulator spacing (ASCII code 9). The string is terminated by Carriage Return and Line Feed (ASCII code 13 & 10).

Scripting

Often it may be usefully to collect more than one command in a text file e.g. the following text can be written in an ordinary text editor and saved as a text file.

```
// Set sampling interval to 30 seconds

Set_Protect(1)

Set_Interval(30)

Save

Get_All
```

This file can then be sent to the sensor in one operation. The first line is a comment line that is disregarded by the Conductivity Sensor. Strings starting with either '//' or ';' are ignored by the software, and do not produce any errors or acknowledge.

Sleep

After approximately 40 second without any RS232 input the Conductivity Sensor will enter a sleep mode. The character '%' indicates this.

In this mode the electronics requires approximately 3 ms start up time.

Any character will cause the electronics to return to the normal operation.

After the Conductivity Sensor has responded with the character '#', new commands may be entered.

When sending text file the sensor can be awakened by sending a string of comment leads characters:

```
//////////////////////////////////////////////////////////////

// Wake up test

Get_All
```

The Sensor will then wake and be ready before the next string appears.

The sleep indicator '%' and the wake up indicator '#' are not followed by Carriage Return and Line Feed.

CHAPTER 4 3919/4019 Installation on Recording Instruments

The Conductivity Sensor 3919 and 4019 can easily be installed on Aanderaa Recording Instruments with 16mm boreholes in the top-end plate (3919: RCM 9 MkII, RCM 9 LW, RCM 9 IW, RCM 11, 3919/4019: RDCP 600).

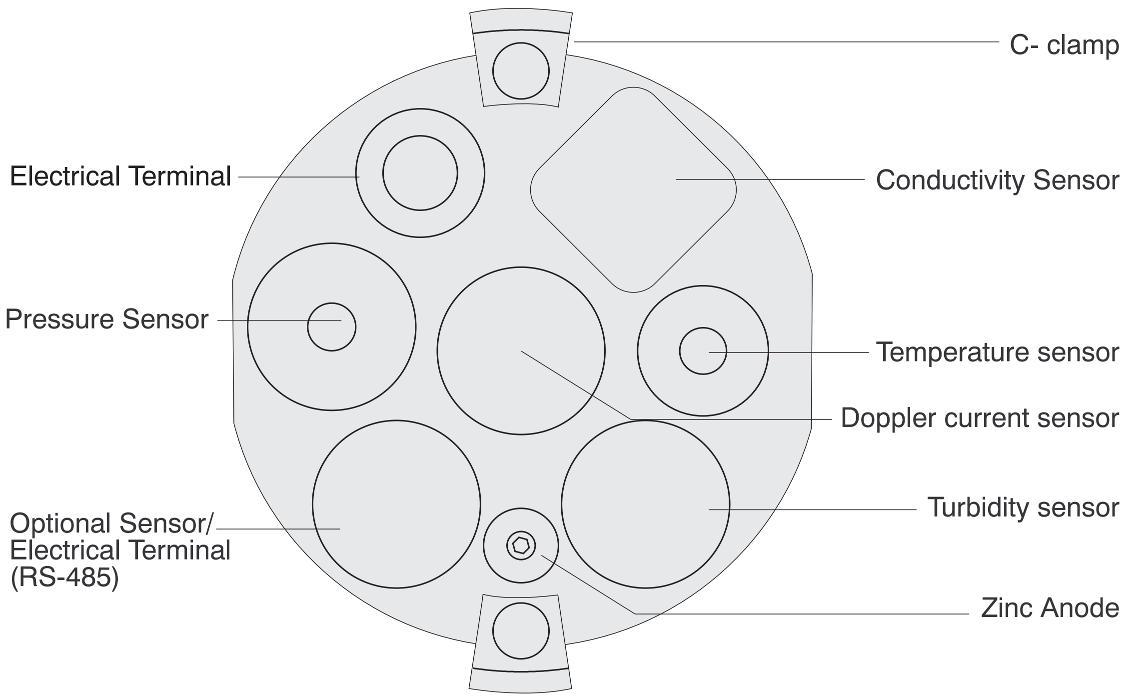


Figure 4-1 Illustration of top end plate of RCM 9/RCM11/RDCP 600. Note! The sensors may be placed differently than illustrated here. (The Electrical Terminal RS-485 is an option for RDCP 600 only.)

The best position for the conductivity sensor will on most instruments be next to the temperature sensor, on the opposite side of the zinc anode, refer to Figure 4-1.

Before installing the Sensor the borehole in the top plate of the instrument should be inspected. The surface in the hole must be smooth without any scratches. Check also that the O-rings at the Sensor foot are free from dust and particles and greased with silicon grease.

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

A small stainless steel ball is used for orientating the Sensor. Place the orientation ball in the dimple next to the hole in the top end plate, and install the Conductivity Sensor in the hole of the top end plate. Secure the Sensor with a nut on the inside of the top end plate. Apply Tectyl 506 (included in recommended spares) in the slit between the Sensor and the top end plate. This will prevent crevice corrosion of the top end plate.

The Conductivity Sensor is equipped with two orientation holes in the foot. For installation on RCM 9/RCM 11 the hole that is at an angle of 8 degrees from the centre line must be used.

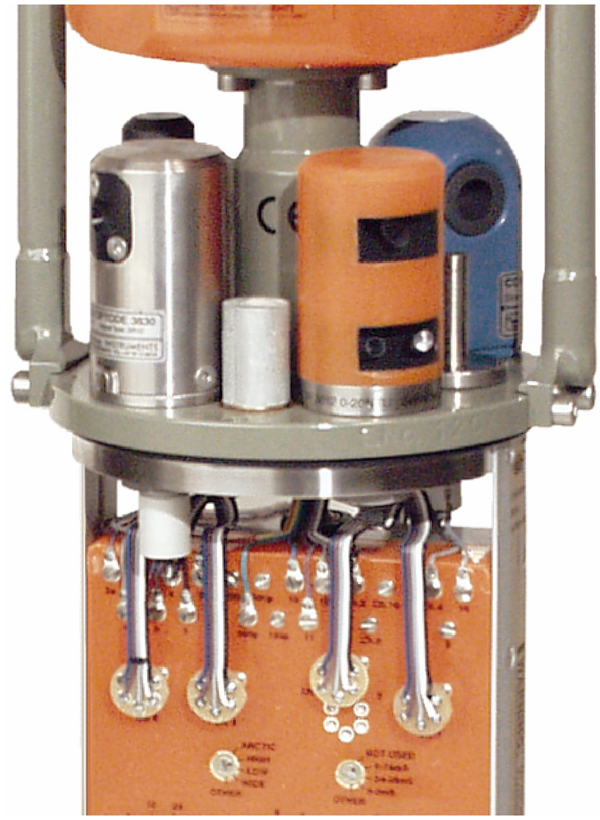


Figure 4-2: Conductivity Sensor on RCM 9 MkII

The Sensor can now be connected to the main board of the instrument by use of Sensor Cable 3854, refer to Figure 4-4 and Figure 4-5 below. Insert the 10-pin plug into the receptacle of the Sensor, and then connect the 5-pin plug into a free channel on the Electronic Board.

Note! If you have an old RCM with Electronic Board 3623 the Conductivity Sensor 3919 must not be connected to the input channel labelled "CONDUCTIVITY CHANNEL 5". This was used for the previous conductivity sensors. We recommend using channel 7 on Board 3623.

For newer RCM 9 and 11 instruments equipped with Electronic Board 3970 two connections are available for the Conductivity Sensor, in channel 5. Note that the upper receptacle should be used for Conductivity Sensor 3919, while the lower receptacle is for previous conductivity sensors. When using channel 5, you must select "Inverted input" when configuring the conductivity sensor, refer to CHAPTER 2 or CHAPTER 3.

For more details on installing the Conductivity Sensor 3919 at RCMs with old or new Electronic Boards, please request Technical Note 278: "Conductivity Sensor 3919 – Installation at RCM MKII / RCM 11".

For installation on RDCP 600, the Conductivity Sensor 3919 must be connected to one of the optional channels: channel 4, 5 or 6 on the sensor board, using Cable 3854. The sensor model 4019 must be connected to the sensor board with sensor cable 4054, refer to Figure 4-6 and Figure 4-7

For best accuracy the sensor should be recalibrated after installation on the instrument (refer to Calibration on page 31).

The pin configurations for Conductivity Sensor 3919 and 4019 are given in Figure 4-3.

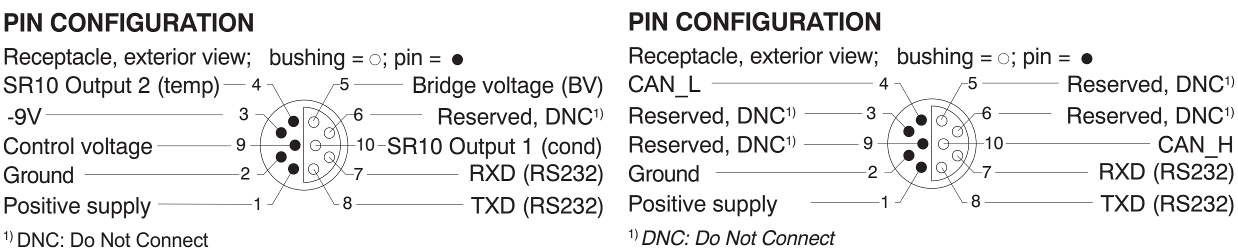
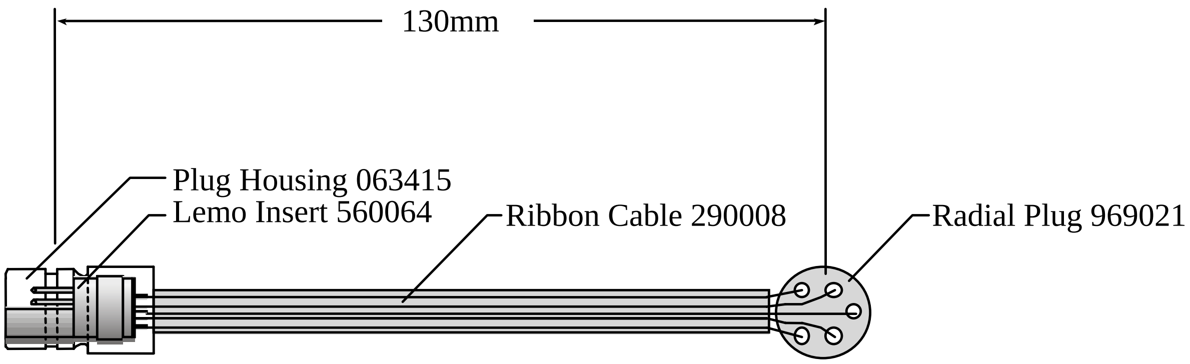


Figure 4-3 Pin configuration (receptacles) of Conductivity Sensor 3919 (to the left) and 4019 (to the right).

Sensor cables for Conductivity Sensor 3919

A short cable called Sensor Cable 3854 is used for connection between the 3919 Sensor and Aanderaa Current meters and RDCP 600 (Figure 4-4 and Figure 4-5).

Figure 4-4 Sensor Cable 3854



Signal Name	Colour	Sensor Plug	Cell Plug
BV	Blue	4	1
Control Voltage	Violet	10	2
Positive Supply	Grey	8	3
-9V	White	6	4
SR10	Black	9	5

SENSOR CABLE 3854 10pp – Radial Plug (V8699A)

Figure 4-5 Sensor Cable 3854

Sensor cables for Conductivity Sensor 4019

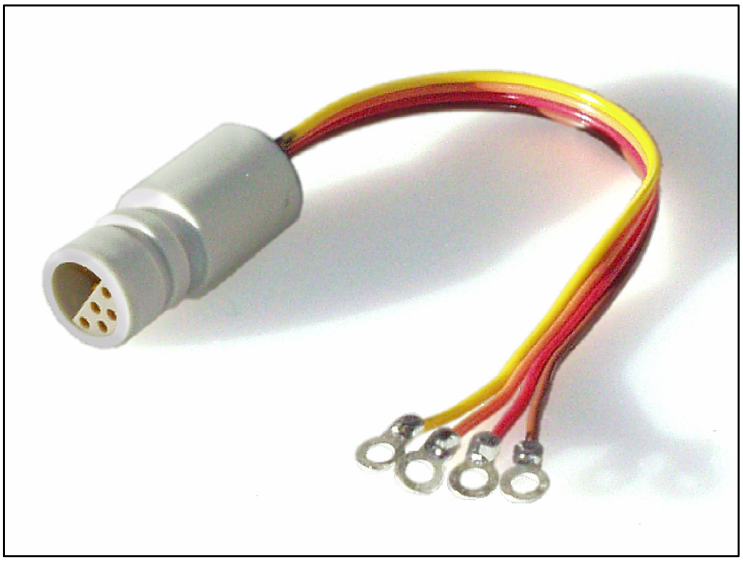
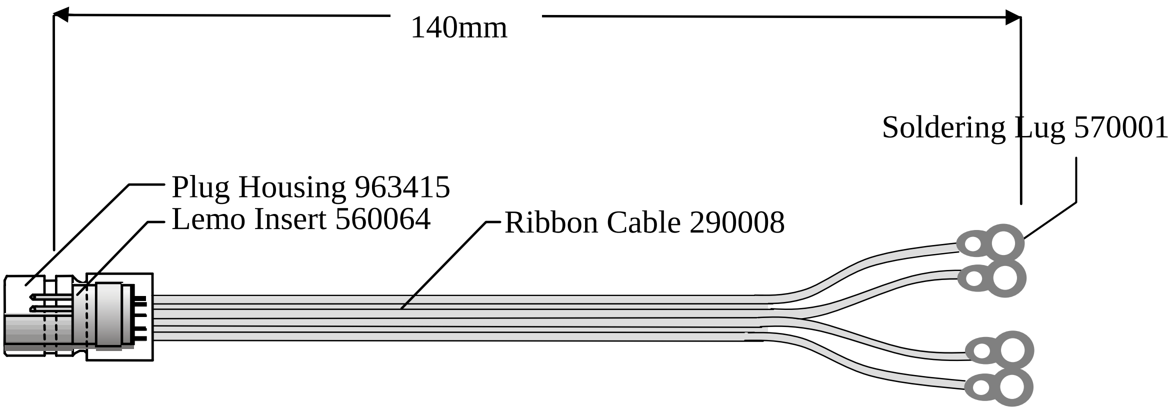


Figure 4-6 Sensor Cable 4054

A short cable called Sensor Cable 4054 is used for connection between the Conductivity Sensor 4019 and RDCP (Sensor board 3942).



Signal Name	Colour	Sensor Plug	Sensor Board 3942
Positive Supply	Red	4	T 10
Gnd	Brown	10	T 9
CAN_L	Yellow	8	T 12
CAN_H	Orange	6	T 11

SENSOR CABLE 4054 10pp – (V9357)

Figure 4-7 Sensor Cable 4054

CHAPTER 5 Quality Assurance, Maintenance and Calibration

Aanderaa Instruments have Proven Reliability. With over 30 years of producing instruments for the scientific community around the world, you can count on our reputation for designing the most reliable products available.

We are guided by three underlying principles: quality, service, and commitment. We take these principles seriously, for they form the foundation upon which we provide lasting value to our customers. Our unmatched quality is based on a relentless program of continuous monitoring to maintain the highest standards of reliability.

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

For performance check please refer to *Test of Conductivity sensor 3919 with resistor loop* on page 32.

Maintenance

Compared to conductivity measurements with electrodes, the inductive principle of the 3919 is less sensitive to fouling. However when used in the upper water region, fouling in the bore of the Sensor is usually what limits the long term accuracy of the Sensor. To avoid this the Sensor must be cleaned regularly depending on the local fouling conditions, and the required accuracy. The Sensor can also be painted with anti-fouling paint to extend the deployment period.

The ceramic hosing will tolerate most cleaning agents. Often 30% Hydrochloric acid (HCL) (Muriatic acid) will be useful for removing barnacles and similar fouling.

Be sure to follow the safety precaution for such acids.

Calibration

Each conductivity Sensor is linearized and temperature compensated by use of precision resistor loops. The temperature measurement is also calibrated in the same process. Each Sensor is then calibrated in a seawater bath with a reference sensor.

The reference sensor is calibrated against I.A.P.O. standard seawater using a National Ocean Technology Center's Model 5YA2-2 Laboratory Salinometer.

Even though most of the conductance of the seawater loop is determined by the water inside the center bore of the Sensor, large objects closer than 0.25m to the Sensor will influence the measurement.

To obtain optimum accuracy the Sensor should be calibrated in the geometrical configuration it is to be used in. This can be achieved by placing the instrument in a stirred seawater-bath (minimum 0.5m diameter x 0.6m depth) with stable salinity and temperature.

The conductivity of the water must be measured by use of a reference i.e. Autosal 8400. This calibration only involves a correction of the sensitivity of the Sensor. A "one point" calibration is therefore sufficient.

An internal setting in the Conductivity Sensor called *CellCoef* describes the relationship between the conductance (mS) in the seawater loop measured by the Sensor and the specific conductivity (mS/cm). A corrected *CellCoef* can be calculated using the following formula:

$$CellCoef_c = CellCoef \frac{C_{Ref}}{C_{Read}}$$

where:

CellCoef uncorrected Sensor factor

C_{Ref} reference reading (mS/cm)

C_{Read} uncorrected conductivity reading (mS/cm)

Test of Conductivity sensor 3919 with resistor loop

- Use Resistor Set 3719
- Recommended recording interval > 30 sec
- The sensor and resistor loop should be stabilized in room temperature for one hour
- Connect the Resistor 3719 to the Conductivity sensor while the sensor is connected to the recording instrument. The instrument must be switched *on*. Perform one measurement, wait until readings are updated on the DSU, and check that the reading (on the DSU) matches the value given in Table 5-1.

To calculate the conductance use the formula below:

$$Conductance = \frac{ACoef + N \cdot BCoef}{CellCoef} \text{ (mS)}$$

where

N is SR10 raw data reading
Cell Coef and the A and B coefficients (*ACoef* and *Bcoef*) are found in the Calibration Certificate page 2 for the range 0 to 75. Use A and B from Output 1 (Conductivity).

If the SR10 range is changed after calibration, the A and B coefficients for the new range must be used (the *Cell Coef* is always the same for each sensor). If configuring the sensor using the RS-232 port, A and B are presented when the SR10 output is enabled (refer to CHAPTER 3 Output Control). If using the Conductivity Setup Program 4040 to setup the sensor, the coefficients are easily found, refer to page 14.

To verify the conductivity sensor, the readings, in mS, shall be within the values listed in Table 5-1 for resistor set 3719.

Table 5-1 Loop resistance test; readings

Loop Resistance (ohm)	Loop conductance (mS)
70	14.29 ± 0.08
150	6.67 ± 0.08
680	1.47 ± 0.08
2000	0.50 ± 0.08

Test of Conductivity sensor 4019 with resistor loop

- Use Resistor Set 3719
- The sensor and resistor loop should be stabilized in room temperature for one hour
- Connect the Resistor 3719 to the Conductivity sensor while the sensor is connected to the RDCP 600. The RDCP 600 must be switched *on*. Open the RDCP 600 menu, and choose *Diagnostics* from the submenu. Next, choose the *Conductivity 4019* icon, press single sample, wait until readings are updated, and check that the reading listed are within the range given in Table 5-2.

A)

B)

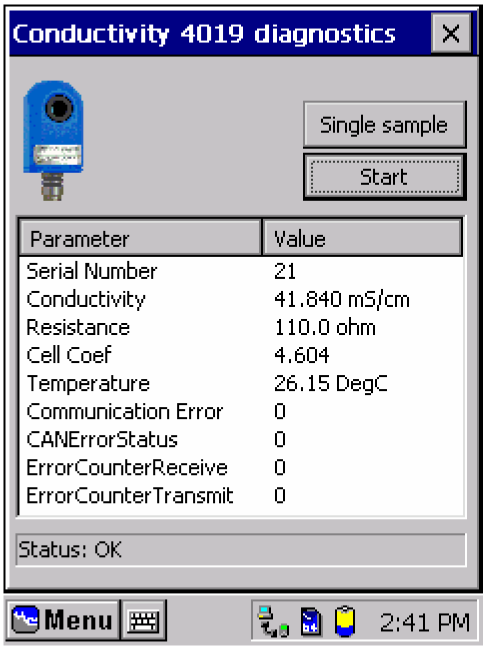


Figure 5-1 A) Conductivity Sensor 4019 with resistor set 3719, B) Example of RDCP 600 Reading

Table 5-2 Loop resistance and RDCP 600 Readings

Loop Resistance (ohm)	Reading Interval (ohm)
70	<69, 71>
150	<148, 152>
680	<645, 719 >
2000	<1724, 2380>

Appendix 1 Mechanical Design

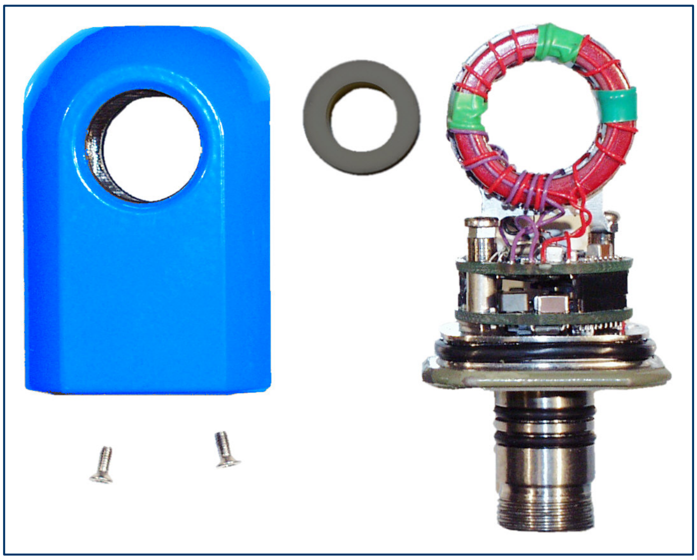


Figure A 1 Conductivity Sensor 3919 Internal Components

The Conductivity Sensor 3919/4019 is housed in titanium housing with a bore tube made of silicon nitride. This provides for a compact and stable pressure protection for the internal magnetic cores and the electronics. The non-conductance and low temperature expansion coefficient of the silicon nitride tube are features that ensure accurate conductivity measurement.

The titanium foot holds the electrical connector and O-rings for bulk head mounting.

Do not open the Sensor. The photo is for information only and shows the internal components.

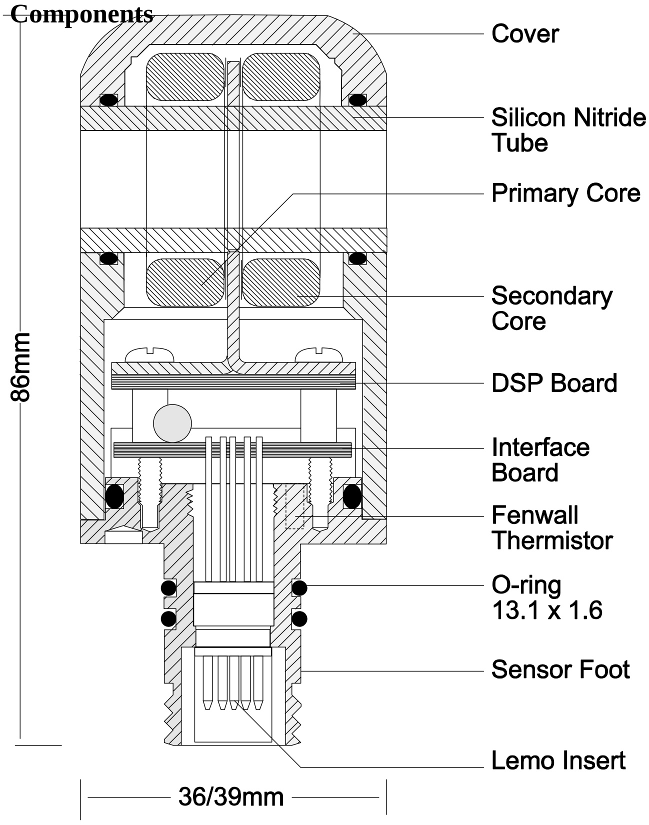


Figure A 2 Drawing of Conductivity Sensor 3919/4019 (V8875A)

Appendix 2 Theory of Operation

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

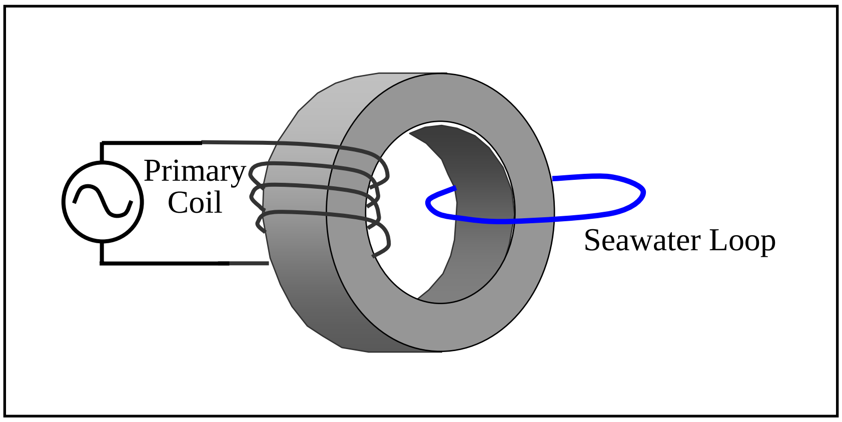


Figure A 3 Transmitter Transformer

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.

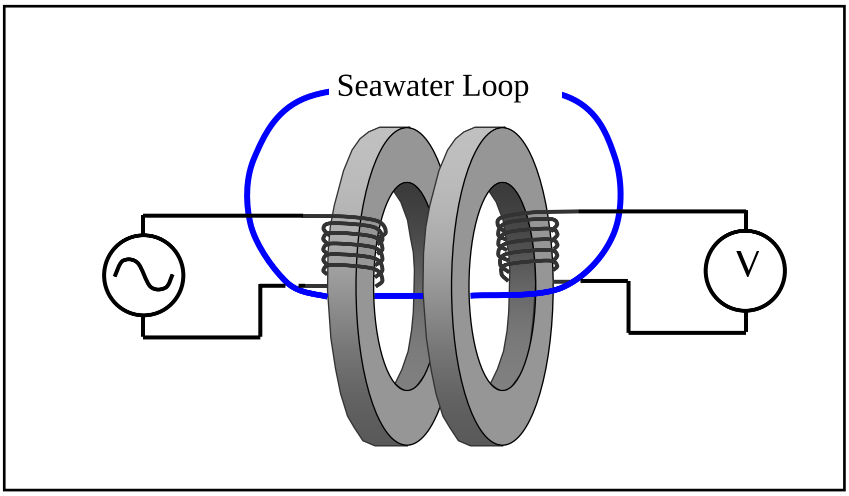


Figure A 4 Transmitter and Receiver Transformer

A second transformer, called the receiver transformer is used for sensing the current in the seawater loop.

The voltage from this transformer relates directly to the conductivity in the seawater loop.

This voltage will however also be dependent on transformer properties such as core permeability etc.

To minimize this dependency the Conductivity Sensor utilizes a special balancing method.

By introducing a coil called the compensating loop that works contrary to the seawater loop, it is possible to balance the Sensor so that the current in this loop equals the current in the seawater loop.

The voltage from the receiver coil will then be zero, and the conductance in the compensation loop will equal the conductance in the seawater loop.

In the Conductivity Sensor 3919/4019 the current in this compensation loop is controlled by a precise digital to analogue converter (DAC).

The primary compensation coil is used as a source for the compensation current.

To obtain impedances that are more adequate for the electronics to work with the compensation loop also has more than one winding.

An advanced Digital Signal Processor (DSP) controls the balancing of the Sensor.

When a sample is taken, the DSP generates the frequency for the transmitter.

The DAC is set to the midpoint and the signal from the receiver is analysed.

Depending on the phase of this signal, the DSP adjusts the DAC.

This is repeated for each approximation step so that the Sensor is balanced.

The value on the DAC will then reflect the conductance in the seawater loop.

To improve the accuracy this value is compensated for temperature drift and linearized.

By use of internal calibration coefficients that reflects the geometry of each Sensor the conductance measurement can be converted to specific conductivity.

The result is presented either as the Aanderaa SR10 or on RS232 format.

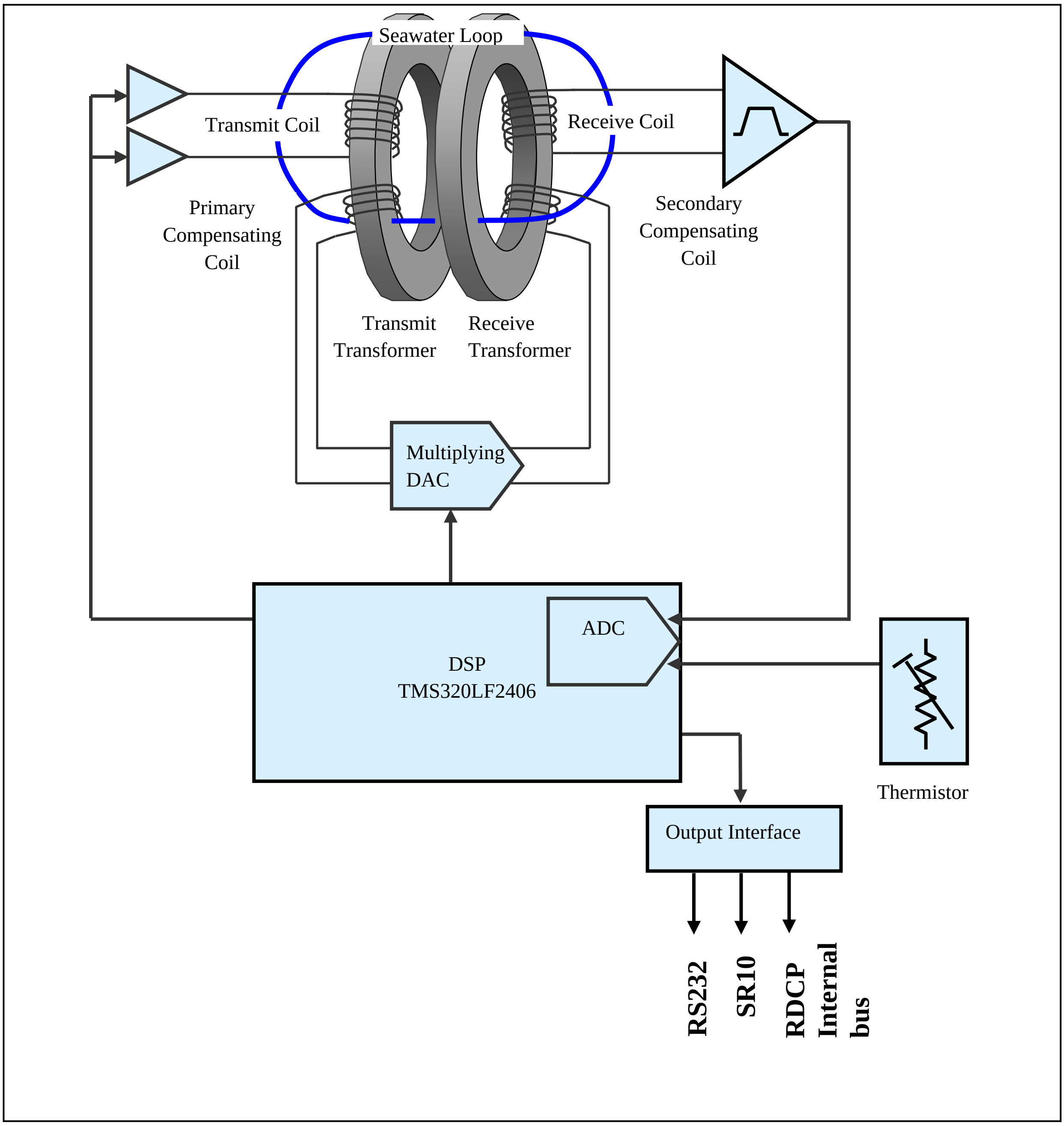


Figure A 5 Functional Diagram

Appendix 3 Conversion of Analogue Signals for Conductivity Sensor 4120

The Conductivity Sensor 4120 is a unit consisting of the Conductivity Sensor 3919 and Analogue Adaptor 3966. The Analogue Adaptor 3966 converts the signals from the Conductivity Sensor 3919 to either 0 to 5V or 4 to 20mA signals.

Table A1 gives the range, accuracy and resolution of the Analogue Adaptor 3966 when used with Conductivity Sensor 3919.

Table A1 Output specifications for the analogue signal

Parameter	**Output**	**Calibrated Range**	**Factory default Range**	**Accuracy**	**Resolution**
Conductivity	0 - 5V	0 to 75 mS/cm	0-75 mS/cm	±0.075 mS/cm	0.02 mS/cm
	4 - 20mA			±0.15 mS/cm	0.04 mS/cm
Salinity	0 - 5V	2-42 PSU	20-40 PSU	±0.15 PSU	0.01 PSU
	4 - 20mA			±0.15 PSU	0.02 PSU
Temperature	0 - 5V	0 - 36°C[1]	5 to35°C	±0.1°C	±0.01°C
	4 - 20mA			±0.15°C	±0.02°C

[1] The full temperature range of the analogue output is -5 to 40°C; however the accuracy outside the 0 to 36°C range may be reduced compared to the specified accuracy.

Conversion Calculations

From voltage (V_{out}) to temperature (°C): .... $T = \frac{V_{out} \cdot (T_{L1} - T_{L0})}{5} - T_{L0}$

From voltage (V_{out}) to Conductivity (mS/cm): .... $C = \frac{V_{out} \cdot (C_{L1} - C_{L0})}{5} - C_{L0}$

From voltage (V_{out}) to Salinity (PSU): .... $S = \frac{V_{out} \cdot (S_{L1} - S_{L0})}{5} - S_{L0}$

From current (I_{out}) to temperature (°C): .... $T = \frac{(I_{out} - 4) \cdot (T_{L1} - T_{L0})}{16} - T_{L0}$

From current (I_{out}) to Conductivity (mS/cm): .... $C = \frac{(I_{out} - 4) \cdot (C_{L1} - C_{L0})}{16} - C_{L0}$

From current (I_{out}) to Salinity (PSU): .... $S = \frac{(I_{out} - 4) \cdot (S_{L1} - S_{L0})}{16} - S_{L0}$

T_{L0}, T_{L1} are the lower and upper range limits for temperature, stored in the configuration property called $SR10TempLim_{0-1.}$

C_{L0}, C_{L1} are the lower and upper range limits for conductivity, stored in the configuration property called $SR10CondLim_{0-1.}$

S_{L0}, S_{L1} are the lower and upper range limits for salinity, stored in the configuration property called $SR10SalLim_{0-1.}$