TD 213 OPERATING MANUAL
Doppler Current Sensor DCS 4100R

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Table of Contents

INTRODUCTION

Purpose and scope

This manual describes the Doppler Current Sensor DCS 4100R, the 4100R setup software, the RS 232 command system of how to set up the DCS, the specifications for the sensor as well as a few examples of applications.
The manual also gives you all necessary information on how to operate the sensor in conjunction with a common data logger device.

Applicable Documents

D359 Data sheet, Doppler Current Sensor 4100/4100R

Abbreviations

ADC	Analogue to Digital Converter
ASCII	American Standard Code for Information Interchange
DCS	Doppler Current Sensor
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.
UNESCO	- the United Nations Educational, Scientific and Cultural Organization
USB	Universal Serial Bus

CHAPTER 1 Short Description

DCS 4100/4100R has been made to replace the DCS 3900/3900R. The main difference between the two current sensors, is that the 3900/3900R had the electronics and the transducers molded into polyurethane, while the DCS4100/4100R has the electronics separated from the transducers. The DCS4100/4100R has the electronics inside a POM case fitted to the transducer part of the sensor. Service and maintenance of the DCS 4100/4100R is easier than for the old 3900/3900R.

Description of DCS 4100R

The Doppler Current Sensor 4100R is a rugged, true vector averaging sensor for measuring current speed and direction in the sea.

Features:

- High resolution output through RS-232 communication
- Customizable through the 4100R setup software or RS-232 communication
- Can operate in both polled and non-polled mode
- Up to 4 DCS 4100R can be connected in a string
- Selectable ping rates from 4 to 1200 pings per minute
- The high speed mode can output ping data 4 times a second
- Function test easily carried out with Test Unit 3731

The DCS 4100R is intended for commercial reasons as well as for research purposes. It can be used to monitor the water current in harbors, along the coast, near offshore oil platforms etc. The In-line Doppler Current Sensor DCS 4100R is a rugged and reliable sensor that offers users great flexibility to obtain accurate current measurements.

The sensor uses the Doppler Shift principle as the basis for its measurements. The sensor transmits acoustic pulses into the surrounding water. As the sound propagates, small particles or air bubbles in the water reflect a portion of the energy.

The transducers pick up the back-scattered energy from the area 0.4 to 2.2 meters from the sensor and analyzes it to find any frequency change (known as the Doppler Shift). An upward shift signifies that the particles are moving towards the sensor and vice-verse.

After reading the internal compass circuit (Hall effect compass), the sensor is able to determine the current speed and direction. The sensor will ping towards the water current. It is however also possible to set it to ping the transducers in a cylindrical sequence around the sensor. The current measurements are compensated for tilt by the use of an electrolytic tilt sensor.

The measurement accuracy is proportional to the square root of the number of pings in a measuring interval. To obtain good accuracy at short intervals e.g. 1 minute, it is possible to choose a higher ping rate. The current consumption will, however, also be greater with increasing ping rates.

The temperature is measured using a temperature dependent crystal-oscillator-circuit.

The DCS 4100R can output data using the RS232 standard.

The sensor output is set up using either the DCS 4100R RS232 command system or the 4100R setup software. The sensor can be set up to output data automatically (non-polled) or the sensor will output the data only when polled via the RS232 line.

Various system parameters can be altered using the command system listed in the table on page 3. The sensor can be set to 4 modes:

Normal, comprehensive, high speed and 3500. The differences between these modes are shown in the table Table 1-1, page 7.

When the 4100R sensor is in **3500 compatible mode**, it will act as the former version of this sensor, the DCS3500R.

Table, Available output parameters

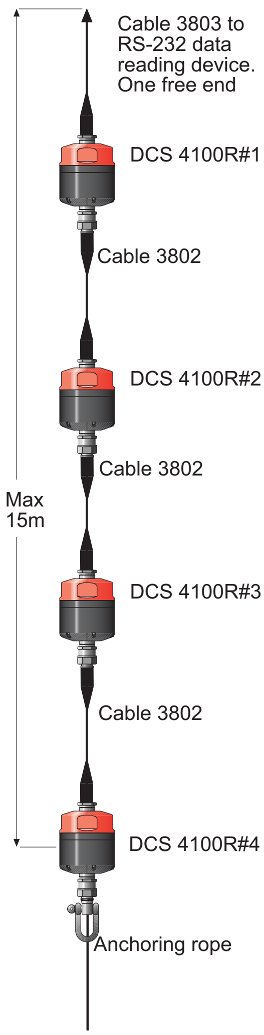
Table 1-1 Available output parameters from the DCS 4100R. R: Rectangular output P: Polar output

Available output parameters from the DCS 4100R RS232 line	**Output Mode**									
	Comprehensive				**Normal**				**High Speed**	**3500**
	Compass Compensation ON		Compass Compensation OFF		Compass Compensation ON		Compass Compensation OFF			
	R	P	R	P	R	P	R	P		
Current speed long the x-axis			•				•		•	•
Current speed long the y-axis			•				•		•	•
Current speed North	•				•					•
Current speed East	•				•					•
Absolute current speed		•		•		•		•		
Current direction ref to North		•				•				
Current direction ref to x-axis				•				•		
Signal strength	•	•	•	•						
Compass direction	•	•	•	•					•	•
Tilt along the x-axis			•	•					•	•
Tilt along the y-axis			•	•					•	•
Tilt along the North axis	•	•								
Tilt along the East axis	•	•								
Ping count	•	•	•	•						
Water temperature	•	•	•	•	•	•	•	•	•	
Time series from AD converter	*Time series are available in polled mode using a poll command*									

Table 1-2 Parameter and Parameter settings

Parameter	Settings
Ping Rate	4 to 1200 pings/min
Average Base	1 to 300 ping sets
Speed of Sound	Default = 1500m/s
Compass Compensation	On/Off
Tilt Compensation	On/Off
Upstream Compensation	On/Off
Polled Output	On/Off
Output Format	Raw/Engineering
Current Type	Polar/Rectangular
Output Mode	

Examples of Applications



DCS 4100R in a string
Up to 4 DCS 4100R can be connected in a string. Use an open ended cable, 3803, between the upper DCS and the Reading Unit. Use an interconnecting cable, 3802, between each DCS. The open end cable exposes positive supply, GND and Rx/Tx lines for 4 DCS. The recommended maximum distance between the bottom DCS and the data reading equipment connected to the open ended cable is 15 meters. Additional sensors can be connected below and between the DCS, use RS232 sensor together with DCS4100R. NOTE! The standard cables allows 11 parameters to be send to the Reading Unit, contact factory for optional cables.

DCS 4100R installed on a pier/single point
The DCS 4100R can be moored under the pier with an anchor, ref Figure 1-1. The cable from the sensor should be fastened to the pier and kept tight thus keeping the sensor horizontal and in a fixed position. Use an open ended cable, 3803, between the DCS and the Reading Unit. Maximum cable length is 500m. Additional sensors can be connected to the cable.

DCS 4100R and High speed mode
In comprehensive mode and normal mode, the DCS will collect a number of ping sets and then perform an averaging of this data. When using the highspeed mode, the DCS outputs uncompensated data from each ping set (Current speed X/Y, Compass direction, Tilt X/Y, and water temperature). This data can be output at a rate of 4 times a second.

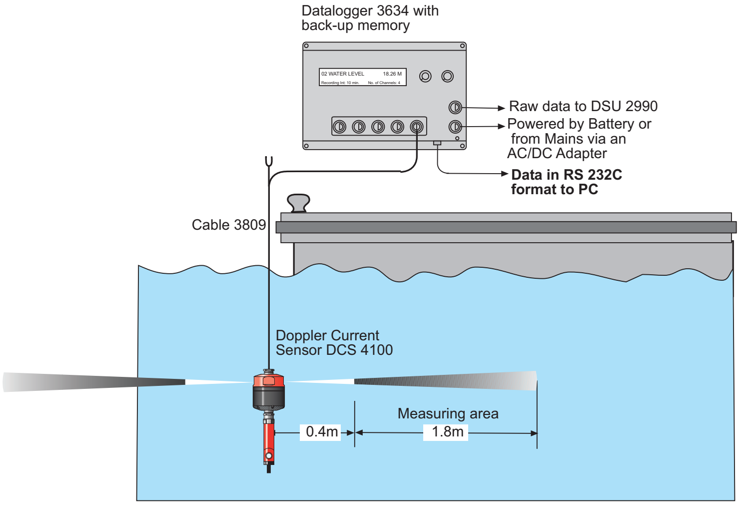


Figure 1-1 DCS 4100R installed on a pier

CHAPTER 2 4100R SETUP SOFTWARE

IMPORTANT! The command ActivateRS232Loop are runned only at startup of the 4100R Setup program. Because of that, the sensor must be powered and connected to a valid COM port before the program is started. See Programming cable on page 13.

The sensor properties are divided into three groups: "Sensor Config Properties", "Sensor Properties" and "Comp Tilt Properties". At startup, the 4100R Setup Software displays the Sensor Config Properties. To see the other properties, press one of the buttons below the list.

User Interface

The DCS 4100R uses the 3900R Setup Program user interface. Most important is the list showing the properties belonging to one of the property groups. To modify a property, select the property value, enter a new value and press the 'Press to write new settings to flash' button.

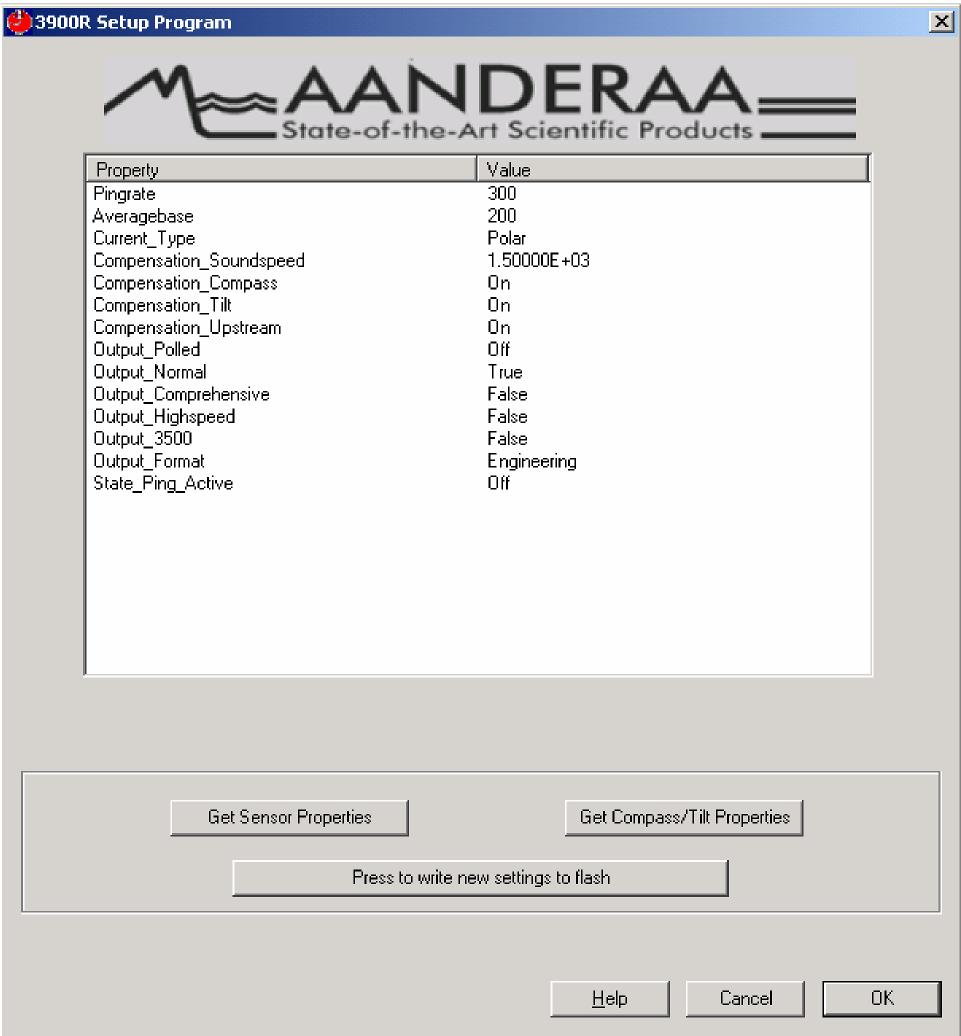
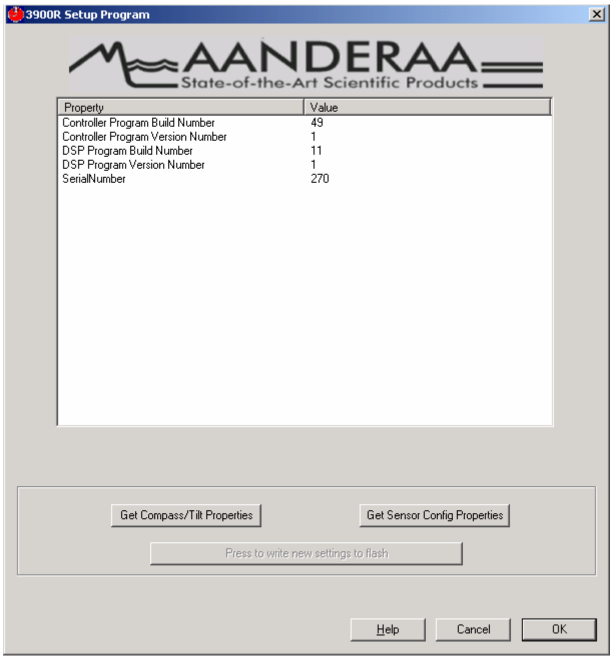


Figure 2-1 The DCS 4100R uses the DCS 3900R Setup Program. Example: The Sensor Config Properties



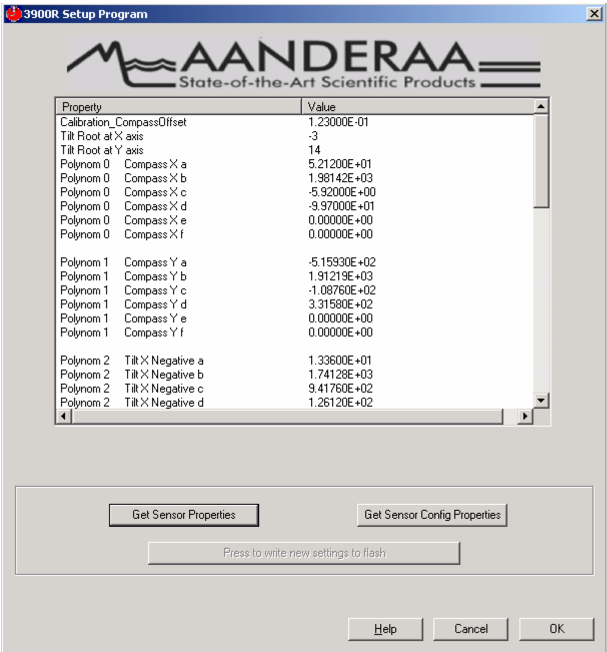


Figure 2-2The Sensor Properties and the Comp Tilt Properties

Sensor Config Properties

Properties describing the setup of the sensor. The user is free to modify these properties.

Pingrate	Set the ping rate in ping per minute. The ping rate can be between 4 and 1200 pings per minute.
Averagebase	Set the number of pings that will serve as the base for a current speed and direction measurement. If Average = 0, average since last will be used. If Average > 0, floating average will be used. The average base can vary between 1 and 300 ping sets. One ping set consists of two pings. The average-base will also affect the interval between each output in non-polled mode.
Current_Type	Sets whether the output is given in polar(speed/dir) or rectangular (north/east) format.
Compensation_Soundspeed	Sets the speed of sound in water (m/s).
Compensation_Compass	Sets whether the estimated current should be compensated for compass readings or not.
Compensation_Tilt	Sets whether the estimated current should be compensated for tilt readings or not.
Compensation_Upstream	Sets whether the DCS should sense and compensate for upstream currents (i.e. the DCS will ping towards the current flow). If this property is off, the DCS will ping its transducers in a predetermined pattern. (TR1 -> TR2 -> TR3 -> TR4 ->TR1 etc.)

Output_Polled	Sets whether the DCS results should be polled or automatically output when available. In Non-Polled mode the DCS will collect as many pings as the average base is set to.
Output_Comprehensive	The output will include the following when the DCS has this property set: Current Speed & Direction, Water Temperature, Signal Strength, Compass, Tilt and Ping count
Output_Highspeed	In this output mode the sensor will output data 4 times a second (the ping rate can be altered after setting the sensor to this output). The following parameters are output: Uncompensated current speed along the X-axis and Y-axis, compass direction, tilt X and Y, and temperature.
Output_3500	Activates backward compatibility to the previous DCS 3500 with regards on the output. It is not recommended to use this output unless backward compatibility is necessary.
Output_Format	Specifies the output format (raw/engineering) in polled and non-polled operation.
State Ping Active	Starts and stops DCS processing

Sensor Properties

Properties that identify the sensor and its software; these properties shall not normally be altered by the user.

Serial number	This property identifies the sensor. It shall not be modified by the user.
Controller Program Build Number **Controller Program Version Number** **DSP Program Build Number** **DSP Program Build Number**	Program Version Property which contains four elements. These properties identify the software and cannot be modified by the user.

Comp Tilt Properties

Properties related to the internal compass and tilt sensors; these properties shall normally not be modified by the user. The properties can be divided into:

- Calibration Polynomial
- Calibration Compass Offset
- Calibration Root Tilt

Instructions for Super User

Some of the sensor properties are protected by the Calibrate_Unlock property. Only super users are allowed to modify the protected properties.

To become a super user: press the ‘alt’ key and the ‘p’ key at the same time. This will bring up a dialog asking for a password. Enter the password and press enter. The 4100R setup software will now redraw the current list. If the current list is the Sensor Config list, the hidden properties will also be shown.

Remember to set the Calibration_Unlock property to *Unlock* before trying to modify any of the protected properties. The Calibration_Unlock property will automatically be set to *Locked* on exit.

Super users may also save/restore the compass/tilt properties to/from file.

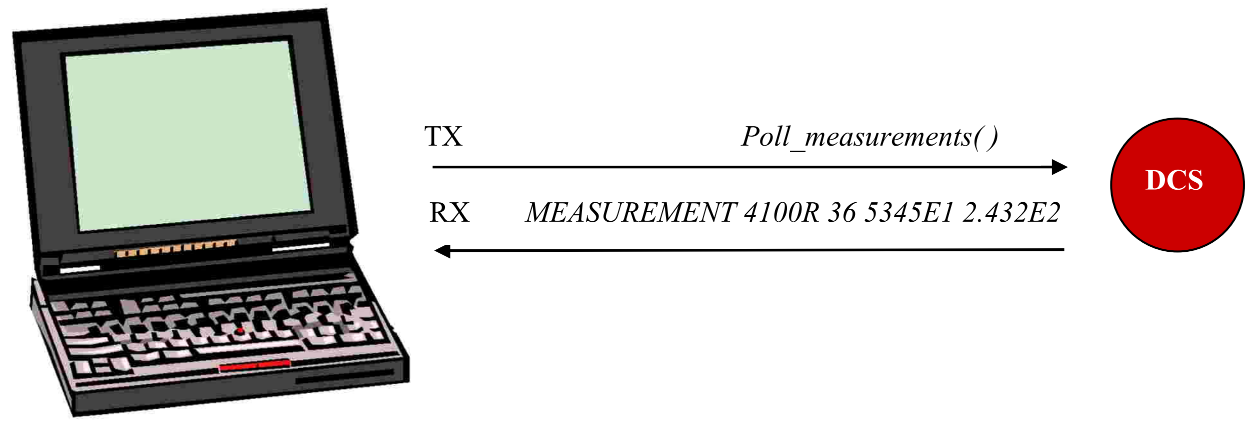
To save the properties, press the Save Props button.
To restore the properties, press the *Restore Props* button and the *Press to write new settings to flash* button.

Programming cable

Cable 3904 with 9-pin D-SUB connector to PC. Use the 12V/3A Power supply 3786. Refer Figure A 1 for illustration of the cable and for the cable pin configuration.

CHAPTER 3 DCS 4100R RS 232 Command System

DCS 4100R uses RS232 to output its measurements. The RS232 line may also be used to set up the DCS, although we recommend that you use the 4100R setup software (refer CHAPTER 2). The command system is designed for communication with automated computer software. It is however possible to enter the commands directly through a terminal software (using local echo). The commands are sent as ASCII strings to the sensor. All the available commands are listed below.



Flow Control

Each time the DCS receives a command it must return some form of acknowledge. The following acknowledges are available:

Acknowledge	**Meaning**
#<CRLF>	Command successfully executed, ready to receive a new command or poll.
***<CRLF>**	Command failed! This was due to incorrect use of the command, syntax error, error in parameter or that there is no access to this command in the current mode with the current properties.
Returned values specific for the given command.	Look at the specific commands for a closer description.

None of the commands use all of the above flow-control acknowledges. Look under the \flow control\ sections for each command type to see which acknowledge is used.

Initiating the RS232 Loop

To be able to send commands to the DCS the DCS first has wake up. To wake up the DCS, send any character and wait for acknowledge (#<CRLF>). Send the "ActivateRS232Loop()" command to the DCS within 20 seconds. The DCS is now awake and ready to receive commands from the command set. If the DCS does not receive the ActivateRS232Loop() command within 20 seconds it will perform a reset operation.

To enter sleep mode again, send the command "DeactivateRS232Loop()". To send more commands the procedure above has to be performed again.

The set commands

Structure
The set commands are used to setup the DCS. The set commands have the following structure:
Set_Subset1_Subset2_…._SubsetN([parameter1],[parameter2],…,[parameterN])<CRLF>

Subset1 to SubsetN are used to categorize the set commands. In the parameter input ',' is used to separate the parameters while '.' is used as decimal. The commands are case sensitive.

Flow control for the set command
If the set command is recognized and it is finished processing, the sensor will return a ' # ' character (ASCII 35) followed by CRLF. If the set command should fail (wrong syntax, error in the parameters, error processing) the sensor will return the ' * ' character (ASCII 42) followed by CRLF.

Available set commands

NOTE: All the Set commands, unless otherwise noted, stores data to the DCS flash memory. The flash memory cannot be overwritten more than 10000 times. This means that these commands should only be used as setup commands.

Set Commands	Meaning
Set_Property_Pingrate (integer Pingrate)	Set the ping rate in ping per minute. If Ping rate = 0, the ping is manual i.e. run the Do_Ping () poll command. The ping rate can be between 4 and 1200 pings per minute. The ping rate has a resolution of 250µs
Set_Property_Averagebase (integer Average)	Set the number of pings that will serve as the base for a current speed and direction measurement. If Average = 0, average since last will be used. If Average > 0, floating average will be used. The average base can vary between 1 and 300 ping sets. One ping set consists of two pings. The average-base will also affect the interval between each output in non-polled mode.

Set_Property_Current_Type (bool Polar/Rectangular)	Sets whether the output is given in polar (speed/dire) or rectangular (north/east) format.
Set_Property_Compensation_Sounspeed (float Soundspeed)	Sets the speed of sound in water (m/s).
Set_Property_Compensation_Compass (bool On/Off)	Sets whether the estimated current should be compensated for compass readings or not.
Set_property_Compensation_Tilt (bool On/Off)	Sets whether the estimated current should be compensated for tilt readings or not.
Set_Property_Compensation_Upstream (bool On/Off)	Sets whether the DCS should sense and compensate for upstream currents (i.e. the DCS will ping towards the current flow). If this property is off, the DCS will ping its transducers in a predetermined pattern (TR1 → TR2 → TR3 → TR4 → TR1 etc.)
Set_Property_Output_Polled (bool On/Off)	Sets whether the DCS results should be polled or automatically output when available. In Non-Polled mode the DCS will collect as many pings as the average base is set to. When the ping sets are collected the DCS will calculate and output the current values. While calculating and out putting the result, the DCS will halt the ping generator. This means that the DCS will halt for about 1 second each time it outputs data.
Set_Property_Output_Normal()	Only current speed, current direction and water temp is output (polled or non-polled)
Set_Property_Output_Comprehensive()	The output will include the following when the DCS has this property set: • Current Speed & Direction • Water Temperature • Signal Strength • Compass • Tilt • Ping count
Set_Property_Output_Highspeed()	In this output mode the sensor will output data 4 times a second (the ping rate can be altered after setting the sensor to this output). The following parameters are output: Uncompensated current speed along the X-axis and Y-axis, compass direction, tilt X and Y, and temperature. The temperature is updated every 3600 output (about 15 minute interval @ 4Hz output rate). No averaging is applied in this output mode. Setting this property will cause: Output_Highspeed = TRUE

	AverageBase = 0 Current_Type = Rectangular Compensation_Compass = Off Compensation_Tilt = Off Output_Format = Engineering Pingrate = 1200 Output_Polled = Off
Set_Property_Output_3500( ) (It is not recommended to use this output unless backward compatibility is necessary)	Activates backward compatibility to the previous DCS 3500 with regards on the output. When the non-polled property is set the DCS will operate as a DCS 3500. Setting this property will cause: Output_3500 = TRUE AverageBase = 0 Current_Type = Rectangular Compensation_Compass = On Compensation_Tilt = On Output_Format = Raw Pingrate = 600
Set_Property_Output_Format (bool Raw/Engineering)	Specifies the output format in polled and non-polled operation.
Set_State_Ping_Active (bool On/Off) (This command does not store data to the DCS flash memory. It can therefore be used during normal operation, and it is NOT considered a setup command only.)	Start and stops DCS processing

The get commands

Structure
The get commands are used to retrieve the current DCS setup. The get commands have the following structure:

Get_Subset1_Subset2_…._SubsetN([parameter1],[parameter2],…,[parameterN])<CRLF>

Subset1 to SubsetN are used to categorize the get commands. In the parameter input ',' is used to separate the parameters while '.' is used as decimal. The commands are case sensitive.

The get commands also have a returned result. The returned result has the following structure:

Subset1_Subset2_…_SubsetN<TAB>4100R<TAB>[s.no]<TAB>[retval1]<TAB>… …<TAB>[retvalN]<CRLF>

Subset1 to SubsetN are the sub setups corresponding to the set command that set these parameters. These act as an identifier for the returned result.
4100R is the DCS product number, s.no is the serial number of the DCS responding to the get command and retval1 to retvalN are the returned values.

Flow control for the get commands
If the get command is recognized and it is finished processing, the sensor will return an appropriate result for that command. The sensor will NOT respond with the ' # ' character after receiving a get command. However, if the get command fails (syntax error, error processing) the sensor will return the ' * ' character (ASCII 42) followed by CRLF.

Get Commands	Returned Values
Get_Property_Pingrate()	1) Ping rate in ping pr. Minute
Get_Property_Averagebase()	1) Number of ping sets used as average base
Get_Property_Current_Type()	1) Polar/Rectangular (current representation)
Get_Property_Compensation_Soundspeed()	1) Speed of sound in water (in m/s)
Get_Property_Compensation_Compass()	1) On / Off
Get_Property_Compensation_Tilt()	1) On / Off
Get_Property_Compensation_Upstream()	1) On / Off
Get_Property_Output_Polled()	1) On / Off
Get_Property_Output_Normal()	1) True / False
Get_Property_Output_Comprehensive()	1) True / False
Get_Property_Output_Highspeed()	1) True / False
Get_Property_Output_3500()	1) True / False
Get_Property_Output_Format()	1) Raw / Engineering
Get_Property_Processing_Active()	1) On / Off
Get_Property_Calibration_Polynomial()	1) [Compass X A] 2) [Compass X B] 3) [Compass X C] 4) [Compass X D] 5) [Compass X E] 6) [Compass X F] 7) [Compass Y A] 8) [Compass Y B] 9) [Compass Y C] 10) [Compass Y D]

	11) [Compass Y E] 12) [Compass Y F] 13) [Tilt X Negative A] 14) [Tilt X Negative B] 15) [Tilt X Negative C] 16) [Tilt X Negative D] 17) [Tilt X Negative E] 18) [Tilt X Negative F] 19) [Tilt X Positive A] 20) [Tilt X Positive B] 21) [Tilt X Positive C] 22) [Tilt X Positive D] 23) [Tilt X Positive E] 24) [Tilt X Positive F] 25) [Tilt Y Negative A] 26) [Tilt Y Negative B] 27) [Tilt Y Negative C] 28) [Tilt Y Negative D] 29) [Tilt Y Negative E] 30) [Tilt Y Negative F] 31) [Tilt Y Positive A] 32) [Tilt Y Positive B] 33) [Tilt Y Positive C] 34) [Tilt Y Positive D] 35) [Tilt Y Positive E] 36) [Tilt Y Positive F] 37) [Temperature A] 38) [Temperature B] 39) [Temperature C] 40) [Temperature D] 41) [Temperature E] 42) [Temperature F]
Get_Property_Calibration_CompassOffset()	1) [Compass Offset]
Get_Property_Calibration_RootTilt()	1) [Tilt Root at X axis] 2) [Tilt Root at Y axis]

Get_Mode()	1) [Operating mode of the DCS]
Get_Property_Program_Version()	1) Controller program build number 2) Controller program version number 3) DSP program build number 4) DSP program version number
Get_Property_SerialNumber()	1) DCS Serial number

The poll commands

Structure

The get commands are used to poll the DCS for data. The poll commands have the following structure:

Poll_Subset1_Subset2_…._SubsetN([parameter1],[parameter2],…,[parameterN])<CRLF>

Subset1 to SubsetN are used to categorize the poll commands. In the parameter input ',' is used to separate the parameters while '.' is used as decimal. The commands are case sensitive. The poll commands also have a returned result.

The returned result has the following structure:
MEASUREMENT<TAB>4100R<TAB>[s.no]<TAB>[retval1]<TAB>…<TAB>[retvalN]<CRLF>
MEASUREMENT is the identifier of the returned result.

4100R is the DCS product number, s.no is the serial number of the DCS responding to the poll command and retval1 to retvalN are the returned values.

The type of values returned will vary with the current DCS setup.

Flow control for the poll commands

If the poll command is recognized and it is finished processing, the sensor will return an appropriate result for that command. The sensor will NOT respond with the ' # ' character after receiving a poll command. However, if the poll command fails (syntax error, error processing) the sensor will return the ' * ' character (ASCII 42) followed by CRLF.

Poll Commands	**Returned Values**
Poll_Measurement() (Output is comprehensive, rectangular and compass compensation is Off)	1) Current speed X-axis, in cm/s or simulated raw data 2) Current speed Y-axis, in cm/s or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt X-axis, in degrees

	7) Tilt Y-axis, in degrees 8) Ping count
Poll_Measurement() (Output is comprehensive, rectangular and compass compensation is On)	1) Current speed North, in cm/s or simulated 2) Current speed East, in cm/s or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt North, in degrees 7) Tilt East, in degrees 8) Ping count
Poll_Measurement() (Output is comprehensive, polar and compass compensation is Off)	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in Deg referenced to the X-axis, or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt X-axis, in degrees 7) Tilt Y-axis, in degrees 8) Ping count
Poll_Measurement() (Output is comprehensive, polar and compass compensation is On))	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in DegM or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt North, in degrees 7) Tilt East, in degrees 8) Ping count
Poll_Measurement() (Output is normal, rectangular and compass compensation is Off)	1) Current speed X-axis, in cm/s or simulated raw data 2) Current speed Y-axis, in cm/s or simulated raw data. 3) Water temperature, in °C or simulated raw data
Poll_Measurement() (Output is normal, rectangular and compass compensation is On)	1) Current speed North, in cm/s or simulated raw data 2) Current speed East, in cm/s or simulated raw data. 3) Water temperature, in °C or simulated raw data
Poll_Measurement() (Output is normal and polar,	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in Deg referenced to the X-axis, or

compass compensation is Off)	simulated raw data. 3) Water temperature, in °C or simulated raw data
Poll_Measurement() (Output is normal and polar, compass compensation is On)	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in DegM or simulated raw data. 3) Water temperature, in °C or simulated raw data
Poll_Timeseries (integer TdNo)	1) First sample 2) Second sample – – – 256) Sample number 256 (last sample)

The do commands

Structure
The do commands are used to order single executions from the DCS. The do commands have the following structure:

Do_Subset1_Subset2_..._SubsetN([parameter1],[parameter2],…,[parameterN])<CRLF>

Subset1 to SubsetN are used to categorize the do commands. In the parameter input ',' is used to separate the parameters while '.' is used as decimal. The commands are case sensitive.

Flow control for the do commands
If the do command is recognized and it is finished processing, the sensor will return a ' # ' character (ASCII 35) followed by CRLF. If the do command should fail (wrong syntax, error in the parameters, error processing) the sensor will return the ' * ' character (ASCII 42) followed by CRLF.

Available do commands	Execution
Do_Ping()	When the pingrate = 0, this command will execute one ping.

The non-polled outputs

Structure
When the sensor is in one of its non-polled properties, it will output results at a given interval. The structure of the output is as follows:
MEASUREMENT<TAB>4100R<TAB>[s.no]<TAB>[retval1]<TAB>…<TAB>[retvalN]<CRLF>

MEASUREMENT is the identifier of the returned result.

4100R is the DCS product number, s.no is the serial number of the DCS performing the non-polled output and retval1 to retvalN are the output values.

Flow control for the non-polled outputs
The non-polled outputs return their values at given intervals. No special flow control is necessary.

Commands; non-polled outputs	**Return value**
Output is comprehensive, rectangular and compass compensation is Off	1) Current speed X-axis, in cm/s or simulated raw data 2) Current speed Y-axis, in cm/s or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt X-axis, in degrees 7) Tilt Y-axis, in degrees 8) Ping count
Output is comprehensive, rectangular and compass compensation is On	1) Current speed North, in cm/s or simulated raw data 2) Current speed East, in cm/s or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt North, in degrees 7) Tilt East, in degrees 8) Ping count
Output is comprehensive, polar and compass compensation is Off	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in Deg referenced to the X-axis, or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data

	5) Compass direction, in DegM 6) Tilt X-axis, in degrees 7) Tilt Y-axis, in degrees 8) Ping count
Output is comprehensive, polar and compass compensation is On	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in DegM or simulated raw data 3) Water temperature, in °C or simulated raw data 4) Signal strength, in dB1023 or raw data 5) Compass direction, in DegM 6) Tilt North, in degrees 7) Tilt East, in degrees 8) Ping count
Output is normal, rectangular and compass compensation is Off	1) Current speed X-axis, in cm/s or simulated raw data 2) Current speed Y-axis, in cm/s or simulated raw data. 3) Water temperature, in °C or simulated raw data
Output is normal, rectangular and compass compensation is On	1) Current speed North, in cm/s or simulated raw data 2) Current speed East, in cm/s or simulated raw data. 3) Water temperature, in °C or simulated raw data
Output is normal and polar, compass compensation is Off	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in Deg referenced to the X-axis, or simulated raw data. 3) Water temperature, in °C or simulated raw data
Output is normal and polar, compass compensation is On	1) Absolute current speed, in cm/s or simulated raw data 2) Current direction, in DegM or simulated raw data. 3) Water temperature, in °C or simulated raw data
Output is in highspeed mode	1) Uncompensated current speed along the X-axis in cm/s. The value is output and updated every second ping. 2) Uncompensated current speed along the Y-axis in cm/s. The value is output and updated every second ping. 3) Compass direction in degree magnetic north. The value is output and updated every second ping. 4) Tilt X in degrees. The value is output and updated every second ping. 5) Tilt Y in degrees. The value is output and updated every second ping. 6) Temperature in degrees centigrade. This value is output every second ping. It is updated every 3600 output (i.e. about 15 minute interval @ 4Hz output rate).

Output is 3500 (IT IS NOT RECOMMENDED TO USE THIS OUTPUT UNLESS BACKWARD COMPATIBILITY IS NECESSARY!)	1) Current speed along the X-axis in simulated raw data. This value is output every second ping. 2) Current speed along the Y-axis in simulated raw data. This value is output every second ping. 3) Compass direction in simulated raw data. This value is output every second ping. 4) Tilt angle along the X-axis in simulated raw data. This value is output every second ping (multiply by 45/1024 to convert to engineering units in degrees). 5) Tilt angle along the Y-axis in simulated raw data. This value is output every second ping. (multiply by 45/1024 to convert to engineering units in degrees) 6) Current Speed, North direction in simulated raw data. This value is averaged since last control volt to the sensor. The control volt has to be applied within 1000 pings since the last control volt. 7) Current Speed, East direction in simulated raw data. This value is averaged since last control volt to the sensor. The control volt has to be applied within 1000 pings since the last control volt. (All the simulated raw data in this output mode are to correspond with DCS 3500. This output mode is specialized. It has the following format: <SPACE>[retval1]<SPACE>[retval2]<SPACE> <SPACE>[retvalN]<CRLF>)

The DCS output parameters

The following parameters are output as floating average when the average-base > 0, and it is output as average since last when the average-base = 0:

- Current speed along the x-axis: When the current is flowing towards the positive of this axis, the resulting current is positive. This value is output in cm/s or raw data. To convert the raw data to cm/s, multiply the raw value with (300/1023).
- Current speed along the y-axis: When the current is flowing towards the positive of this axis, the resulting current is positive. This value is output in cm/s or raw data. To convert the raw data to cm/s, multiply the raw value with (300/1023).
- Current speed along the North-axis: When the current is flowing away from this axis, the resulting current is positive. This value is output in cm/s or raw data. To convert the raw data to cm/s, multiply the raw value with (300/1023).

- Current speed along the East-axis: When the current is flowing away from this axis, the resulting current is positive. This value is output in cm/s or raw data. To convert the raw data to cm/s, multiply the raw value with (300/1023).

- Absolute current speed. This value is output in cm/s or raw data. To convert the raw data to cm/s, multiply the raw value with (300/1023).

- Current direction: This is the current direction referenced to magnetic north. This value is output in DegM (0°-360°) or raw data. To convert the raw data to DegM, multiply the raw data with (360/1024).

The following parameters are always output as average since last:

- Signal strength: This value is output in raw data or dB1023. When raw data is output, the signal is at maximum strength when the value is 1023 and at minimum strength when the output value is 0. The value in dB1023 is calculated using Output=20*lg(RawValue/1023). This means that the signal will be 0 at maximum strength and decrease as the strength decreases (negative values are output). Signal strength between 0 and -30 dB indicates good quality measurements.

- Compass direction: This parameter is defined as the angle between the sensor positive x-axis and north. This value will be 0 when the positive x-axis point north and it will increase when the sensor is rotated to the right. This value is only output in DegX (0°-360°).

- Tilt along the x-axis: If the sensor positive x-axis is pointing to the right and the sensor is tilted to the right, this value will be positive. This value is only output as engineering values in degrees.

- Tilt along the y-axis: If the sensor positive y-axis is pointing to the right and the sensor is tilted to the right, this value will be positive. This value is only output as engineering values in degrees.

- Tilt along the North-axis: If north is to the right of the sensor and the sensor is tilted to the right this value will be positive. This value is only output as engineering values in degrees.

- Tilt along the East-axis If east is to the right of the sensor and the sensor is tilted to the right this value will be positive. This value is only output as engineering values in degrees.

The following parameters are always output as immediate values:

- Ping count: The current speed and direction is calculated using a three stage algorithm. In each stage, measurements from some of the pings are excluded based on rules in the algorithm. Ping count is the number of pings that is used to calculated the final value of the current speed and direction. The ping count should not be directly used as a quality measure.

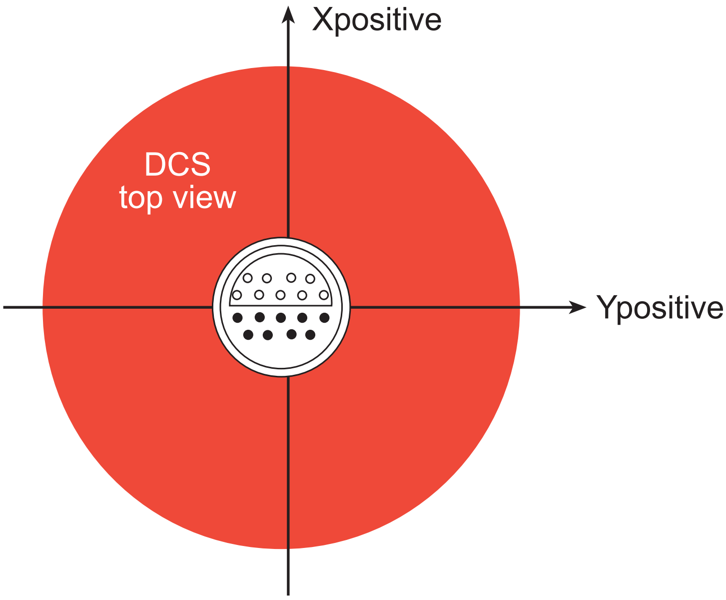
- Time series: 256 values are output. Each value has a range from 0 to 1023. These are the values that are sampled from one ping. The sampling frequency of these values is 2.10311111*105 Hz.

RS232 Setup

The DCS-4100R uses the following RS-232 setup:

Baud rate	9600 bps
Parity	None
Stop bit	2
Data bits	8
Flow control	None
Time between each incoming character (Character delay)	≥ 30 ms

DCS Axis definitions



Factory Defaults:

Ping rate	600
Average base	300
Current type	Polar
Sound speed	1500 m/s
Compensation compass	On
Compensation tilt	On
Compensation upstream	On
Output polled	On
Output type	Normal
Output format	Engineering

3500R backward compatibility

When the sensor is set to 3500R compatibility (Set_Property_Output_3500()) the output will be the same as for 3500R. The sensor will output the RS232 string at every second ping (the maximum ping rate available in this mode is 10 ping per second). Current Speed X, Current Speed Y, Compass direction, Tilt X and Tilt Y are immediate values for each ping set (1 ping set = 2 ping). Current Speed North and East are averaged values since the last control volt signal (Control volt is a pin located on the sensor plug). This means that the control volt line must be pulsed at regular intervals when in 3500R-compatibility mode. When the control volt line is pulsed, this will be indicated by a header that is output on the RS232 line (" CURX CURY COMA TILTX TILTY CURN CURE <CRLF>"). The control volt line should be pulsed within 1000 pings since the last control volt pulse.

NOTE! Even though the output is the same as for 3500R, the electrical wiring is not the same. It is not possible to use a 3500R cable on a 4100R sensor.

CHAPTER 4 Set-up examples

Example 1, External Power supply, Non-polled mode

Power supply:	External (high ping rate => large current consumption)
Output:	Non-polled (i.e. automatic output of measured parameters), comprehensive and polar.
Time between outputs:	30s
Number of collected pings:	600

If using the RS232 command system, send the following commands to achieve the above setup:

<Send a random character and wait for ' # '>

<Send the ActivateRS232Loop() command within 20seconds>

Set_Property_Averagebase(300)

Set_Property_Current_Type(Polar)

Set_Property_Compensation_Compass(On)

Set_Property_Compensation_Tilt(On)

Set_Property_Compensation_Upstream(On)

Set_Property_Output_Comprehensive()

Set_Property_Output_Format(Engineering)

Set_Property_Output_Polled(Off)

Set_Property_Pingrate(1200)

When the sensor is restarted it will transmit the following output, every 30s:

1) Absolute current speed, in cm/s.
2) Current direction, in DegM.
3) Water temperature, in °C.
4) Signal strength, in dB1023.
5) Compass direction, in DegM
6) Tilt North, in degrees
7) Tilt East, in degrees
8) Ping count

Example 2 Battery, Non-polled mode

Power supply:	Battery
Output:	Non-polled (i.e. automatic output of measured parameters), comprehensive and polar.
Time between outputs:	10 minutes
Number of collected pings:	600

If using the RS232 command system, send the following commands to achieve the above setup:

<Send a random character and wait for ' # '>

<Send the ActivateRS232Loop() command within 20 seconds>

Set_Property_Averagebase(300)

Set_Property_Current_Type(Polar)

Set_Property_Compensation_Compass(On)

Set_Property_Compensation_Tilt(On)

Set_Property_Compensation_Upstream(On)

Set_Property_Output_Comprehensive()

Set_Property_Output_Format(Engineering)

Set_Property_Output_Polled(Off)

Set_Property_Pingrate(60)

When the sensor is restarted it will transmit the following output, every 10 minutes:

1) Absolute current speed, in cm/s.
2) Current direction, in DegM.
3) Water temperature, in °C.
4) Signal strength, in dB1023.
5) Compass direction, in DegM
6) Tilt North, in degrees
7) Tilt East, in degrees
8) Ping count

Example 3 External Power Supply, Polled mode

Power supply:	External (high ping rate => large current consumption)
Output:	Polled (i.e. the computer asks for the measured parameters when it needs them), comprehensive and polar.
Time between outputs:	Each time the computer polls the sensor.
Number of collected pings:	Floating average of 600 pings.
Time between each ping:	50ms (f=20 pings per second)

If using the RS232 command system, send the following commands to achieve the above setup:

<Send a random character and wait for ' # '>

<Send the ActivateRS232Loop() command within 20 seconds>

Set_Property_Averagebase(300)

Set_Property_Current_Type(Polar)

Set_Property_Compensation_Compass(On)

Set_Property_Compensation_Tilt(On)

Set_Property_Compensation_Upstream(On)

Set_Property_Output_Comprehensive()

Set_Property_Output_Format(Engineering)

Set_Property_Output_Polled(On)

Set_Property_Pingrate(1200)

When the sensor is restarted it will transmit the below output, every time the computer activates the RS232Loop and sends the command "Poll_Measurement()" (The pinging can be halted if the computer sends the command Set_State_Ping_Active(Off) to stop it, and the command Set_State_Ping_Active(On) to start it):

Output:

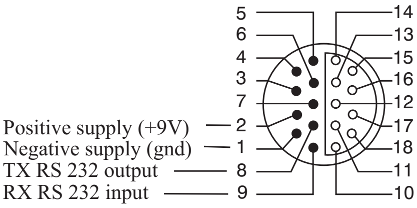
1) Absolute current speed, in cm/s.
2) Current direction, in DegM.
3) Water temperature, in °C.
4) Signal strength, in dB1023.
5) Compass direction, in DegM
6) Tilt North, in degrees
7) Tilt East, in degrees
8) Ping count

CHAPTER 5 DCS Input/Output

The RS232 Command System/ Pin configuration

PIN CONFIGURATION (Upper and Lower Receptacle)

External view. Pin= ●; Bushing=○



All connections wired through from upper to lower receptacle

Pin 9, Rx RS232 Input
This is the RS232 input to the DCS.

Pin 8, Tx RS232 Output
This is the RS232 output from the DCS.

Pin 2, Positive System (+9V)
This is the DCS positive supply voltage between + 7 to + 14V DC.

Pin 1, Negative Supply (gnd)
This is the DCS negative supply (GND referenced to + V system ground).

Pins 3, 5, 6, 10, 11, 12, 13, 14, 15
These pins are not connected to the DCS circuitry. They are however connected to the other DCS receptacle on the corresponding pins.

Pins 4, 7, 16, 17, 18
These pins are SR10 outputs used in conjunction with a Datalogger device (see 'Connection to a Datalogger device').

Cables to reading unit for the RS232 Command System

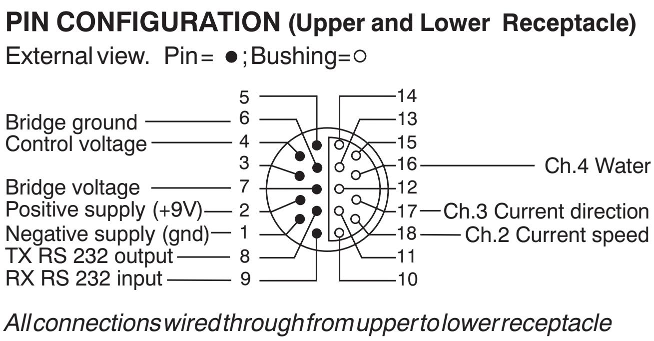
Cable 3803/3807 for connecting the upper DCS to the data reading device (maximum length between the bottom DCS and the reading device is 15 meters). Refer Figure A 2 and Figure A 3 for illustration of the cables and for the cables pin configurations.

Interconnecting cables for the RS232 Command System

Up to 4 DCS can be used in a string interconnected by 3 ea Cables 3802/3808. Refer Figure A 4 and Figure A 5 for illustration of the cables and for the cables pin configurations.

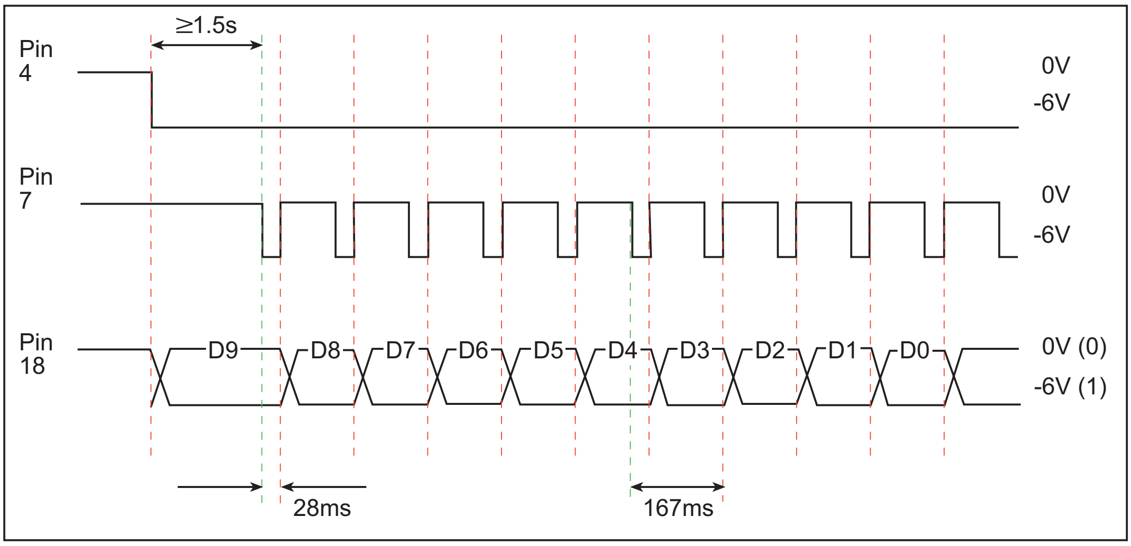
Connection to an AADI Datalogger device

DCS 4100R can be used as a DCS4 100 sensor together with an AADI Aanderaa Datalogger device for single point measurements, or in a string with just a few sensors interconnected. However, you will loose 2 channels for each sensor, due to the *TX RS 232 output* (pin 8) and the *RX RS 232 input* (pin 9) compared to using a DCS 4100 sensor. Therefore, we recommend that you use a DCS 4100 sensor for connection to an AADI Aanderaa Datalogger device.



Pin 18, Current Speed

This is an SR10 output channel. This output is used when the sensor is connected to Aanderaa standard equipment. It works together with pin 7 (Bridge Voltage) and pin 4 (Control Voltage). When the control volt input drops from 0 V to - 6V the DCS starts calculating and gives the Most Significant Bit on pin18. The Most Significant Bit will hold its state until the next time pin 7 (Bridge Voltage) goes from - 6V to 0 V. Now MSB+1 will be the output on pin 18. Each time pin 7 goes from - 6V to 0 V a new bit is clocked out on pin 18. The total output will be 10 bits. RS-232 communication cannot be used at the same time as these outputs are used to collect data. The DCS also has to be in polled mode to use this output, e.g.:



The output data is in raw data format and calibration coefficients must be applied.

Pin 17, Current Direction
This is also an SR10 output. The output values are clocked out the same way and at the same time as on pin 18 (Current Speed).

Pin 16, Water Temp
This is also an SR10 output. The output values are clocked out the same way and at the same time as on pin 18 (Current Speed).

Pin 7, Bridge voltage
(Se pin 18 for a description of this)

Pin 4, Control Voltage
(Se pin 18 for a description of this)

Pin 2, Positive System (+9V)
This is the DCS positive supply voltage between + 7 to + 14V DC.

Pin 1, Negative Supply (gnd)
This is the DCS negative supply (GND referenced to + V system ground).

Pins 3, 5, 6, 10, 11, 12, 13, 14, 15
These pins are not connected to the DCS circuitry. They are however connected to the other DCS receptacle on the corresponding pins.

Pins 8, 9
These pins are RS232 input and output, respectively (see previous section).

Cables for connecting to an AADI Datalogger device

Interconnecting Cable: 3810
Cable to Reading Unit: 3863/3809/3852

Refer Figure A 6, Figure A 7, Figure A 8 and Figure A 9 for illustration of the cables and for the cables pin configurations.

CHAPTER 6 Calculations on output data

Dependent on the settings done it may be desirable to do post processing on the data to obtain other required information, for example tilt compensation of current speed data or calculation of absolute current speed based on the rectangular current speed outputs.

Tilt compensation

Tilt Output

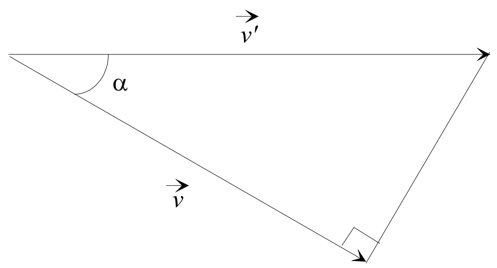
The tilt sensor reading is output if one of the following outputs is selected:

- Comprehensive output mode.
- High Speed output mode
- 3500 output mode.

The tilt compensation is disabled if the High speed output is selected or if the tilt compensation is disabled in one of the other output modes (Set_Property_Compensation_Tilt(Off)).

Calculation

The horizontal current speed can be calculated based on the tilt output and the measured current speed.



The tilt compensated current speed is calculated as follows:

$$v^1 = \frac{v_e}{\cos(\alpha)}$$

where v^1 is the compensated speed, v is the uncompensated current speed and α is the tilt angle. If compensating the Current Speed X exchange v with Current Speed X and α with the tilt X value. Similarly exchange v and α with Current Speed Y and Tilt Y, Current Speed North and Tilt North or Current Speed East and Tilt East.

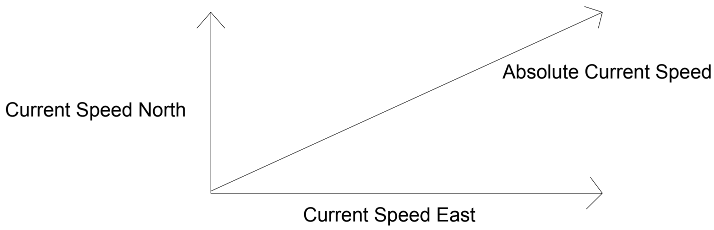
Absolute current speed and current direction

Rectangular Current Speed Output

The Current speed is output as rectangular if the Current Type is set as rectangular (Set_Property_Current_Type(Reqtangular)) or if the Highspeed (Set_Property_Output_Highspeed) or the 3500 (Set_Property_Output_3500) output mode is selected. The current speed x and current speed y is output if the compass compensation is off (Set_Property_Compensation_Compass(Off)), and the current speed north and east is output if the compass compensation is on (Set_Property_Compensation_Compass(On)).

Calculation of absolute current speed

The absolute current speed can be calculated based on the two current components, current speed x and y or current speed north and east.



The absolute current speed is calculated as follows:

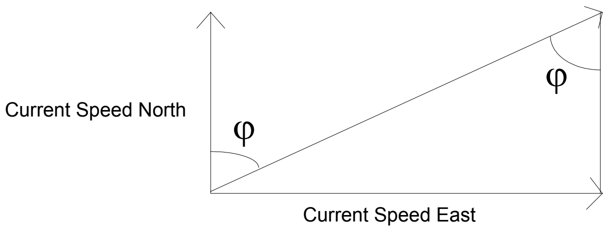
$$v = \sqrt{v^2{}_x + v^2{}_y} \text{ or } v = \sqrt{v^2{}_n + v^2{}_e}$$

Where v_x is the current speed x; v_y is the current speed y; v_n is the current speed north and v_e is the current speed east.

Calculation of current direction

The current direction can be calculated using the arctan or the arctan 2 function. These functions must be used with the following in mind: The arctan function returns an angle in radians between + π/2 and – π/2, and the arctan 2 function returns an angle between +π and -π.

Case 1: Current Speed North and East positive



$$\varphi_r = \arctan\left(\frac{v_e}{v_n}\right)$$

where v_e is current speed east and v_n is current speed north. To convert the current direction from radians to degrees multiply by $\frac{180°}{\pi}$, so that

$$\varphi_d = \varphi_r \cdot \frac{180°}{\pi}$$

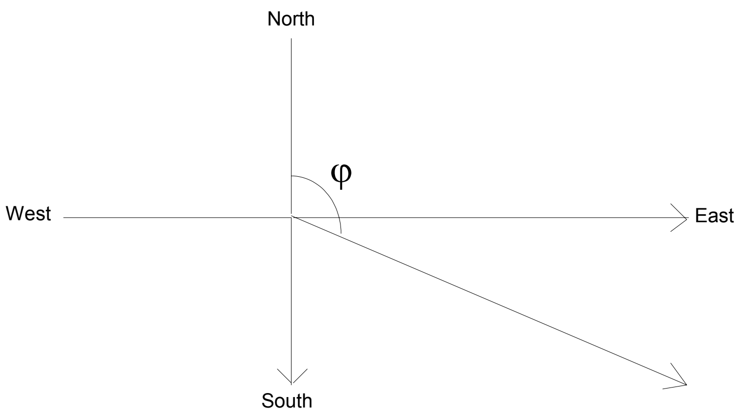
Example:

v_e = 100.0 cm/s and v_n=100.0 cm/s.

$$\varphi_r = \arctan\left(\frac{100.0}{100.0}\right) = \arctan(1) = 0.785398163$$

$$\varphi_d = \varphi_r \cdot \frac{180°}{\pi} = 0.785398163\frac{180}{\pi} = 45°$$

Case 2: Current Speed North negative and Current Speed East positive



Do the same calculation as in case 1, but add π to φ_r or 180 to φ_d.
Example:

v_n = -100.0 cm/s and v_e=100.0 cm/s.

$$\varphi_r = \arctan\left(\frac{100.0}{-100.0}\right) = \arctan(-1) + \pi = -0.785398163 = 2.35619449$$

$$\varphi_d = \varphi_r \cdot \frac{180°}{\pi} = 2.35619449\frac{180}{\pi} = 135°$$

Case 3: Current Speed North negative and Current Speed East negative
Do the same calculation as in case 1, but add π to φ_r or 180 to φ_d.

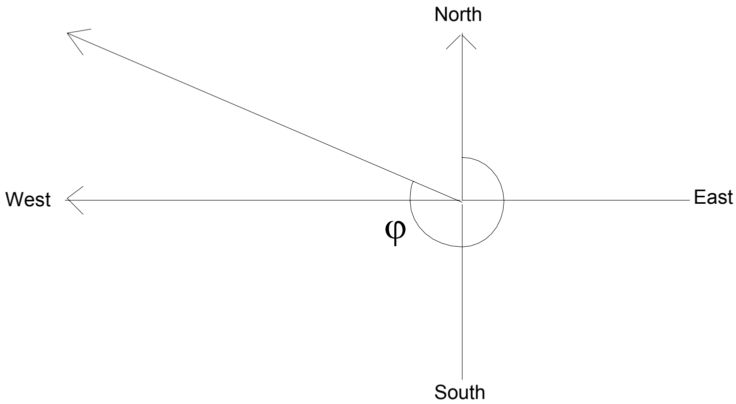
Example:

v_n = -100.0 cm/s and v_e= -100.0 cm/s.

$$\varphi_r = \arctan\left(\frac{-100.0}{-100.0}\right) = \arctan(1) + \pi = 0.785398163 = 3.926990817$$

$$\varphi_d = \varphi_r \cdot \frac{180°}{\pi} = 3.926990817\frac{180}{\pi} = 225°$$

Case 4: Current Speed North positive and Current Speed East negative



Do the same calculation as in case 1, but add 2 · π to φ_r or 360 to φ_d.

Example:

v_n = 100.0 cm/s and v_e= -100.0 cm/s.

$$\varphi_r = \arctan\left(\frac{-100.0}{100.0}\right) = \arctan(-1) + 2\pi = -0.785398163 = 5.497787144$$

$$\varphi_d = \varphi_r \cdot \frac{180°}{\pi} = 5.497787144\frac{180}{\pi} = 315°$$

Current Speed North, Current Speed East

Current Speed x,y and Compass output

Current Speed X, current Speed Y and compass data are output if the Comprehensive output (Set_Property_Output_Comprehensive()) is selected and the compass compensation is off (Set_Property_Compass_Compensation(Off)), or if the High Speed output is selected (Set_Property_Output_Highspeed()).

Calculation of Current Speed North and East

It is possible to calculate the Current Speed North and East based on the Current Speed x, Current Speed y and Compass data as follows:

$$v_n = v_x \cos(\theta) + v_y \sin(\theta)$$

$$v_e = v_x \sin(\theta) + v_y \cos(\theta)$$

where v_n is the current speed north, v_e is the current speed east, v_x is the current speed x, v_y is the current speed y and θ is the compass angle.

Conversion from simulated raw data to engineering units

Current Speed data

If the current speed, v, is output as simulated raw data the speed can be converted to engineering value as follows:

$$v_{eng} = v \frac{300cm/s}{1023}$$

If the Doppler Current Sensor has a 0-500cm/s range instead of a 0-300cm/s range use 500cm/s instead of 300cm/s.

Current Direction data and Compass direction data

If the current direction, α, or the compass direction is output as simulated raw data it can be converted to engineering value as follows:

$$\alpha_{eng} = \alpha \frac{360°}{1023}$$

Temperature data

If the temperature, T, is output as simulated raw data it can be converted to engineering value as follows:

$$T_{eng} = -10°C + \frac{53°C}{1023} T$$

Tilt data

If the tilt, β, is output as simulated raw data it can be converted to engineering value as follows:

$$\beta_{eng} = \beta \frac{45}{1023}$$

Appendix 1 Specifications and Accessories for DCS 4100R

Table A 1Specifications for DCS 4100R

Current Speed (vector averaged):	
Available ranges: P/N 4100R P/N 4100RA	 0 - 300 cm/s standard 0 - 500 cm/s on request
Resolution:	0.1% of FS
Accuracy: Absolute: Relative:	 ±0.15 cm/s ±1% of reading
Statistic precision:	0.55 cm/s (Standard deviation)
Current Direction (vector averaged):	
Range:	0-360° magnetic
Resolution:	0.35°
Accuracy:	±5° for 0-15° tilt ±7.5° for 15-35° tilt.
Temperature:	
Range:	-10 to 43°C
Resolution:	0.05°C
Accuracy:*	±0.08°C with 600pings/minutes only. Better than ±0.16°C for other ping rates.
Tilt Circuit:	
Accuracy:	±1.5°
Compass Circuit:	
Accuracy:	±3°
RS 232 Output:	9600 Baud, 8 data bit, No parity, 2 stop bits
Acoustic Frequency:	2MHz
Acoustic Power:	25W in 1ms pulses
Beam Angle:	±1° (Main lobe)
Installation distance: (to the DCS head)	Minimum 0.5m from the bottom Minimum 0.75m from the surface
Current consumption:	6mA · Ping rate (ping rate in pings per second)
Supply Voltage:	7-14VDC
Operating Temp.:	-10 to +50°C
Depth Capability:	300 meters

Electrical Connection:	18-pin Strain-proof Plug
Breaking Load:	1500kg
Material and Finish:	Durotong, Titanium, POM, Stainless Steal
Net. Weight:	1815 grams
Warranty:	Two years against faulty materials and workmanship. For subsurface cables: contact factory

*) The ± 0.08°C accuracy can be obtained for other ping rates provided the sensor is calibrated for this specific ping rate. Please contact factory if this is required.

Table A 2 Accessories for DCS 4100R

Setup software 4042 (included)
Maintenance Kit 3932
Up to 4 DCS can be used in a string interconnected by 3 ea Cables 3802/3808. Cable length must be specified
Cable 3803/3807 with one free end connects the upper DCS to the data reading device. Maximum length between the bottom DCS and the reading device is 15 meters
Cable 3904 with 9-pin D-SUB connector to PC
Power supply 3786, 12V/3A
Test Unit 3731

Appendix 2 Cables

Figure no.	Cable no.	Cable description
Figure A 1	3904	RS232 Test cable
Figure A 2	3803	Cable to Reading Unit for RS232 Communication system
Figure A 3	3807	Cable to Reading Unit for RS232 Communication system
Figure A 4	3802	Interconnecting cable for RS232 command system
Figure A 5	3808	Interconnecting cable for RS232 command system
Figure A 6	3810	Interconnecting cable for RS232 command system
Figure A 7	3863	Cable with 18PPT - 10 PPLS
Figure A 8	3809	Cable with 18PPT - 10 PPT
Figure A 9	3852	Cable with 18PP for DCS 4100R

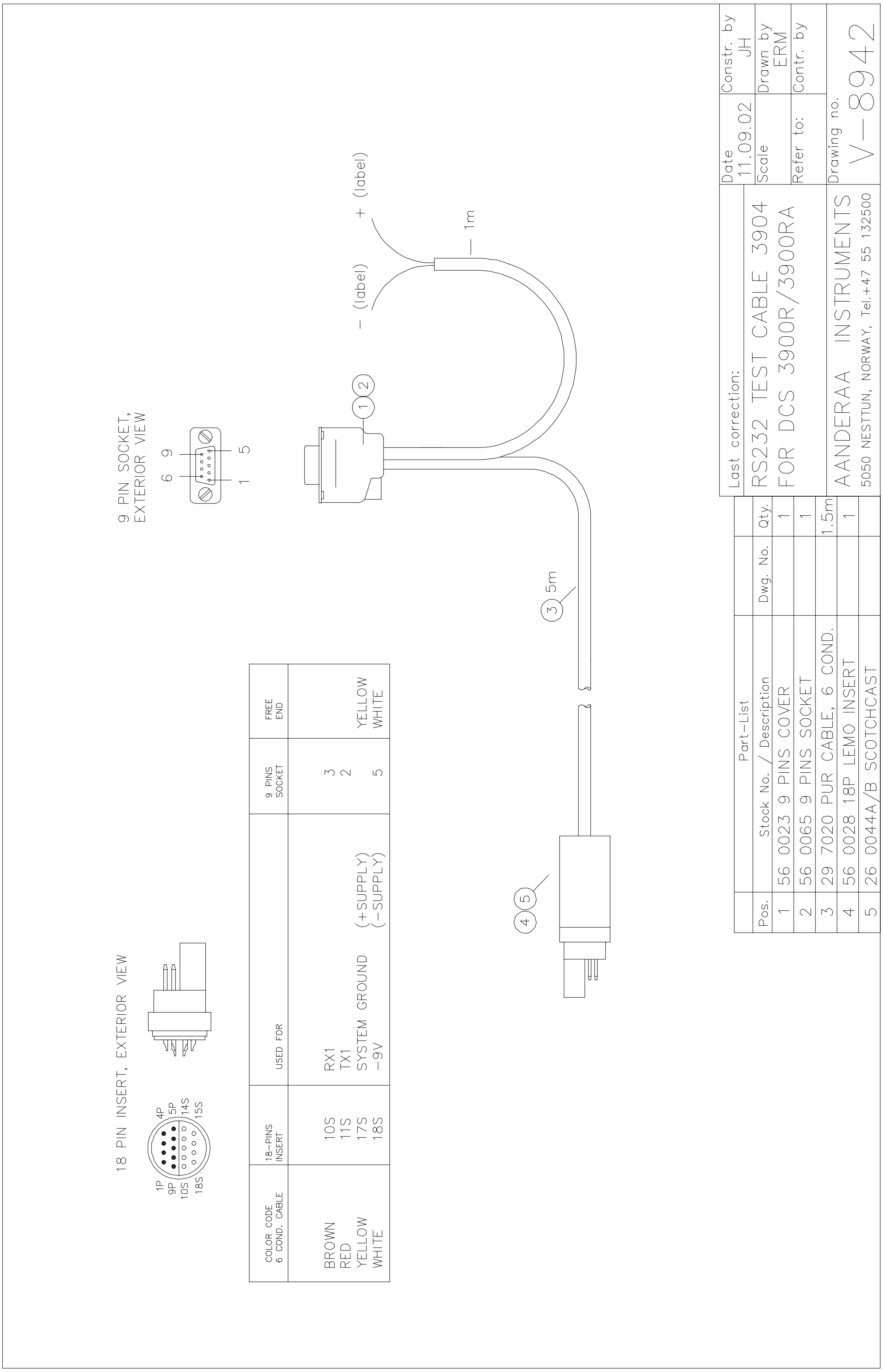
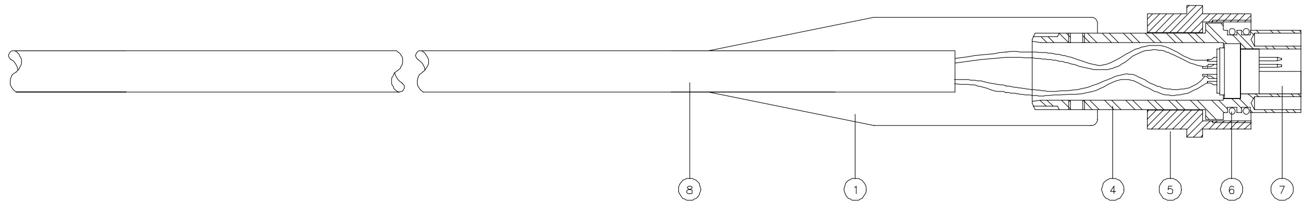
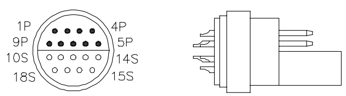


Figure A 1 Illustration of RS232 Test cable 3904

V–8531



18 PIN INSERT, EXTERIOR VIEW



Part–List			
Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2			
3			
4	96 5370 REAR PIECE	V–8465	1
5	96 4394 M32x1.5 NUT	V–8466	1
6	86 3014 O–RING 22x2		2
7	56 0028 LEMO INSERT 18P.		1
8	29 7015 PUR CABLE 18 COND.		–
9			

LEMO INSERT	19 CONDUCTORS PUR CABLE		
18 PIN	INNER LAYER	OUTER LAYER	FUNCTION
1P		ORANGE	FREE
2P		YELLOW	FREE
3P		GREEN	FREE
4P		RED BETW. BROWN AND ORANGE	RX4
5P		BLUE	TX4
6P	BLUE		RX3
7P	BROWN		TX3
8P	GREEN		RX2
9P		BROWN BETW. RED AND RED	TX2
10S		VIOLET	RX1
11S	ORANGE		TX1
12S	YELLOW		FREE
13S	RED		FREE
14S		GREY	FREE
15S		BLACK	CONTROL VOLTAGE
16S		WHITE	FREE
17S		RED BETW. BROWN AND BROWN	SYSTEM GROUND (+SUPPLY)
18S		BROWN BETW. BLACK AND RED	–9V (–SUPPLY)

Last correction: A 14.12.00 ERM	Date 28.09.00	Constr. by
CABLE 3803 WITH FREE END FOR DCS 3900R	Scale 1:2	Drawn by E.R–M
	Refer to:	Contr. by
AANDERAA INSTRUMENTS BERGEN, NORWAY, Tel. +47 55 132500	Drawing no. V–8531A	

Figure A 2 Cable 3803

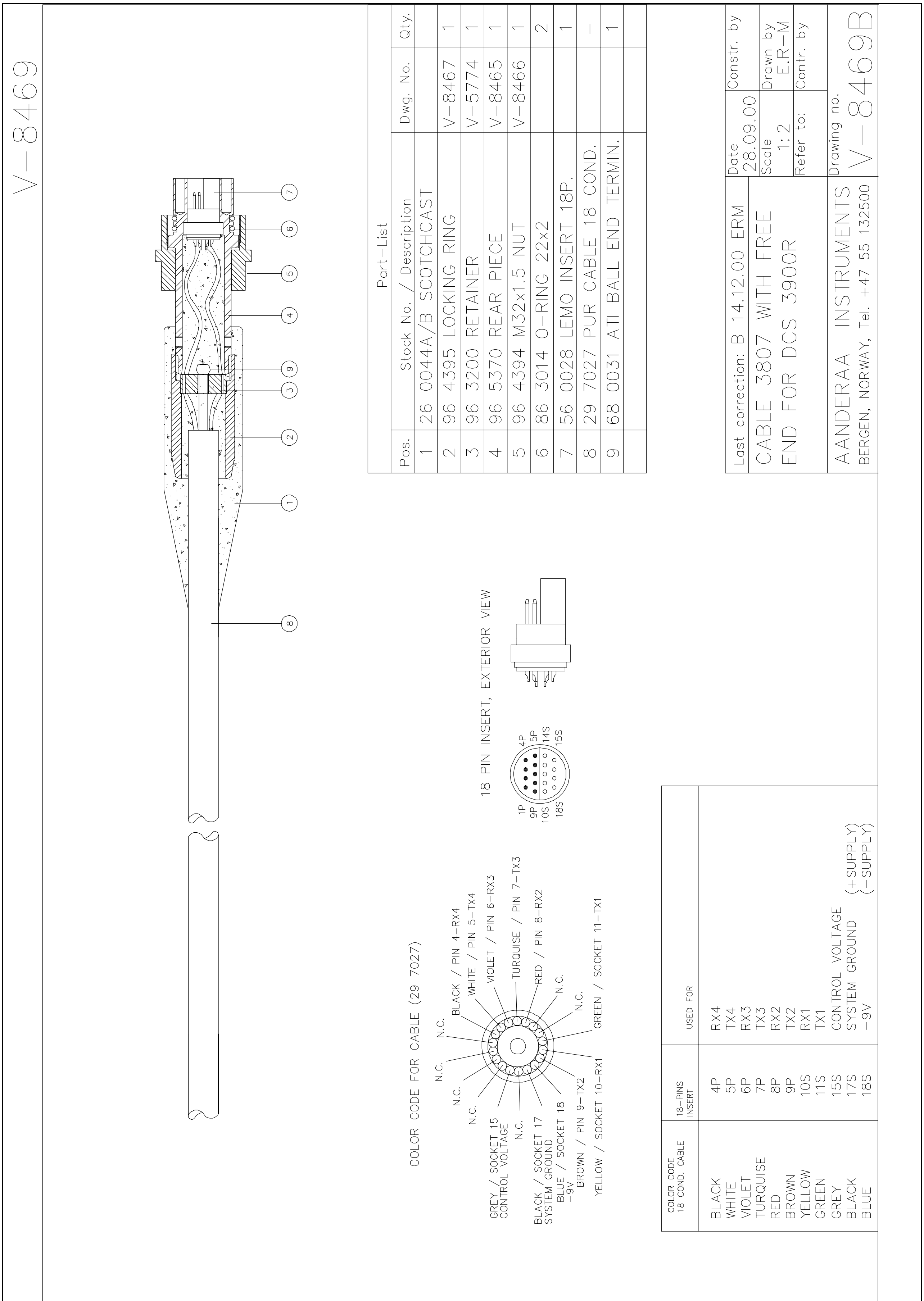
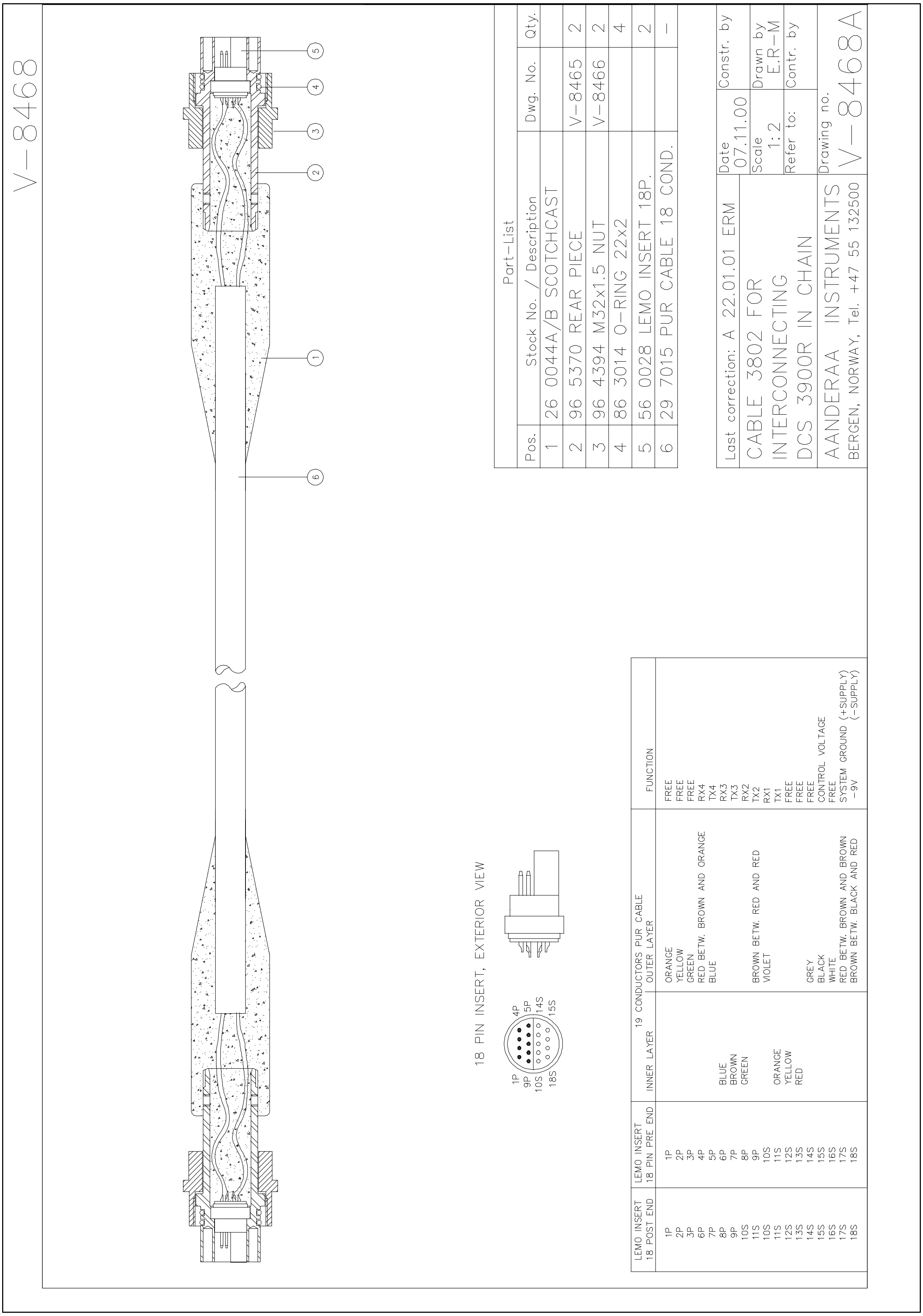


Figure A 3 cable 3807

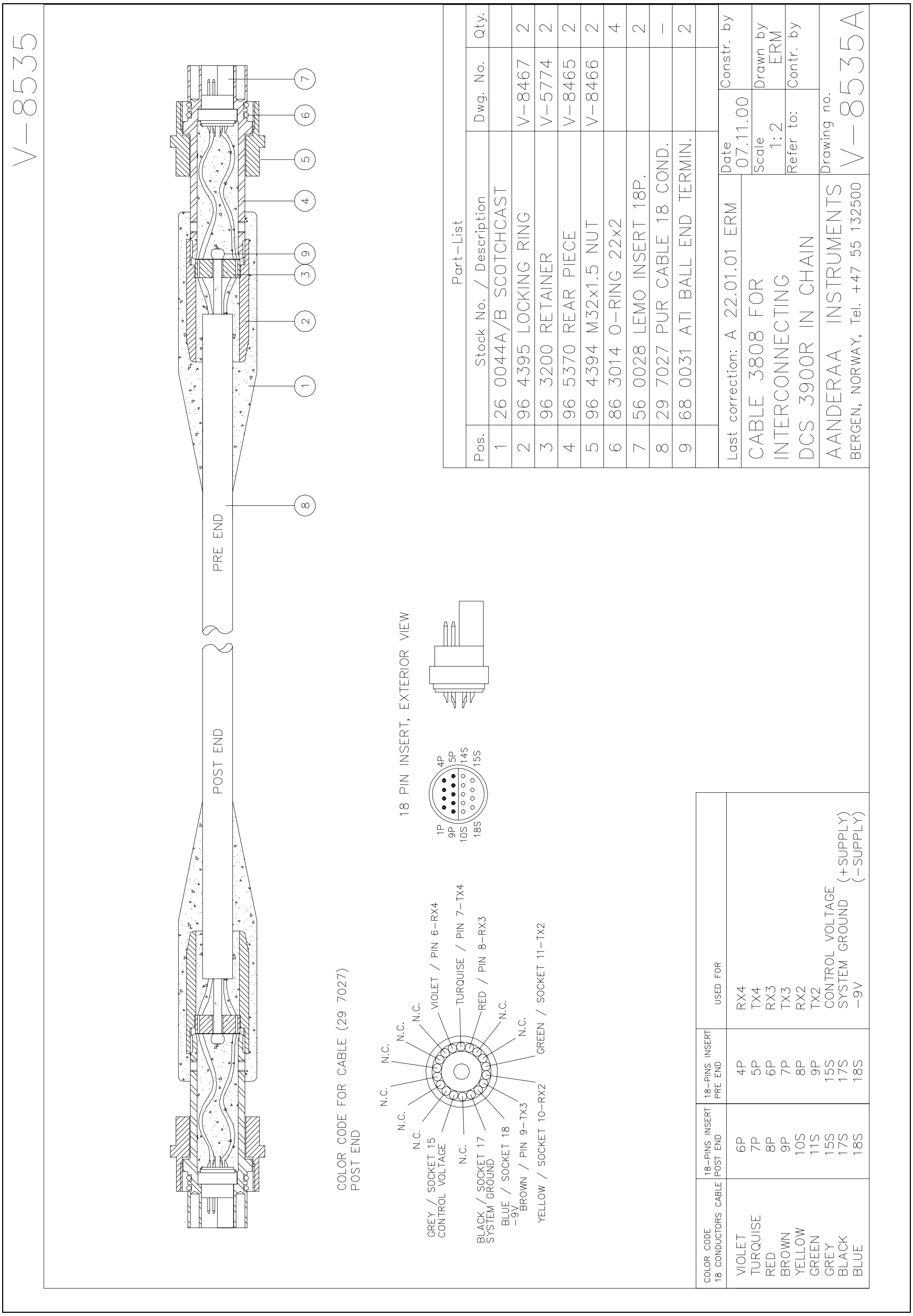


Part-List			
Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2	96 5370 REAR PIECE	V-8465	2
3	96 4394 M32x1.5 NUT	V-8466	2
4	86 3014 O-RING 22x2		4
5	56 0028 LEMO INSERT 18P.		2
6	29 7015 PUR CABLE 18 COND.		–

LEMO INSERT 18 POST END	LEMO INSERT 18 PIN PRE END	19 CONDUCTORS PUR CABLE INNER LAYER	OUTER LAYER	FUNCTION
1P	1P		ORANGE	FREE
2P	2P		YELLOW	FREE
3P	3P		GREEN	FREE
6P	4P		RED BETW. BROWN AND ORANGE	RX4
7P	5P		BLUE	TX4
8P	6P	BLUE		RX3
9P	7P	BROWN		TX3
10S	8P	GREEN		RX2
11S	9P		BROWN BETW. RED AND RED	TX2
10S	10S		VIOLET	RX1
11S	11S	ORANGE		TX1
12S	12S	YELLOW		FREE
13S	13S	RED		FREE
14S	14S		GREY	FREE
15S	15S		BLACK	CONTROL VOLTAGE
16S	16S		WHITE	FREE
17S	17S		RED BETW. BROWN AND BROWN	SYSTEM GROUND (+SUPPLY)
18S	18S		BROWN BETW. BLACK AND RED	-9V (-SUPPLY)

Last correction: A 22.01.01 ERM	Date 07.11.00	Constr. by
CABLE 3802 FOR INTERCONNECTING DCS 3900R IN CHAIN	Scale 1:2	Drawn by E.R-M
	Refer to:	Contr. by
AANDERAA INSTRUMENTS BERGEN, NORWAY, Tel. +47 55 132500	Drawing no. V-8468A	

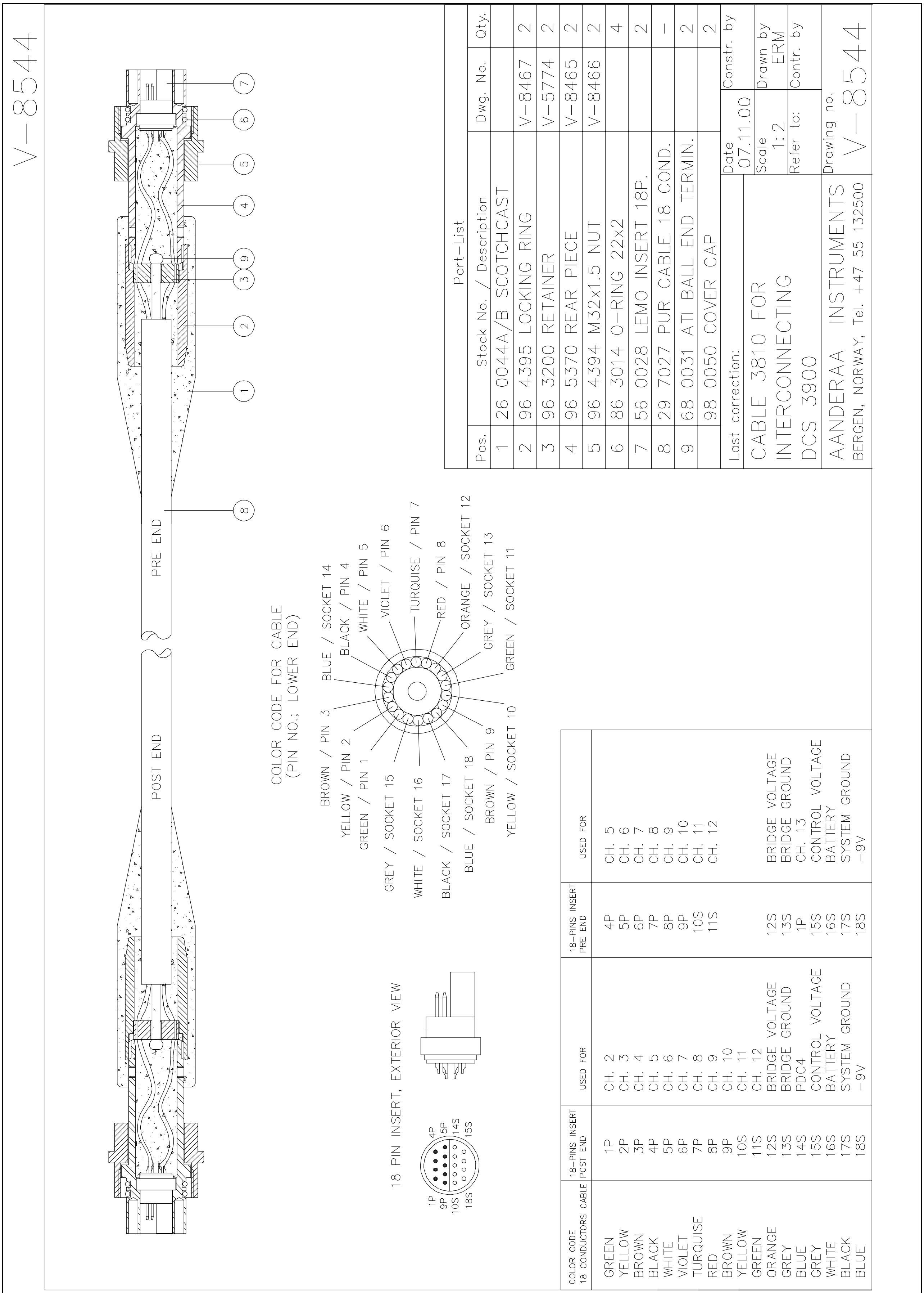
Figure A 4 cable 3802



Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2	96 4395 LOCKING RING	V-8467	2
3	96 3200 RETAINER	V-5774	2
4	96 5370 REAR PIECE	V-8465	2
5	96 4394 M32x1.5 NUT	V-8466	2
6	86 3014 O-RING 22x2		4
7	56 0028 LEMO INSERT 18P.		2
8	29 7027 PUR CABLE 18 COND.		–
9	68 0031 ATI BALL END TERMIN.		2

COLOR CODE 18 CONDUCTORS CABLE	18-PINS INSERT POST END	18-PINS INSERT PRE END	USED FOR
VIOLET	6P	4P	RX4
TURQUISE	7P	5P	TX4
RED	8P	6P	RX3
BROWN	9P	7P	TX3
YELLOW	10S	8P	RX2
GREEN	11S	9P	TX2
GREY	15S	15S	CONTROL VOLTAGE (+SUPPLY)
BLACK	17S	17S	SYSTEM GROUND (-SUPPLY)
BLUE	18S	18S	-9V

Figure A 5 Illustration of cable 3808



Part-List

Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2	96 4395 LOCKING RING	V-8467	2
3	96 3200 RETAINER	V-5774	2
4	96 5370 REAR PIECE	V-8465	2
5	96 4394 M32x1.5 NUT	V-8466	2
6	86 3014 O-RING 22x2		4
7	56 0028 LEMO INSERT 18P.		2
8	29 7027 PUR CABLE 18 COND.		-
9	68 0031 ATI BALL END TERMIN.		2
	98 0050 COVER CAP		2

Last correction:
Date 07.11.00 | Constr. by
Scale 1:2 | Drawn by ERM
Refer to: | Contr. by

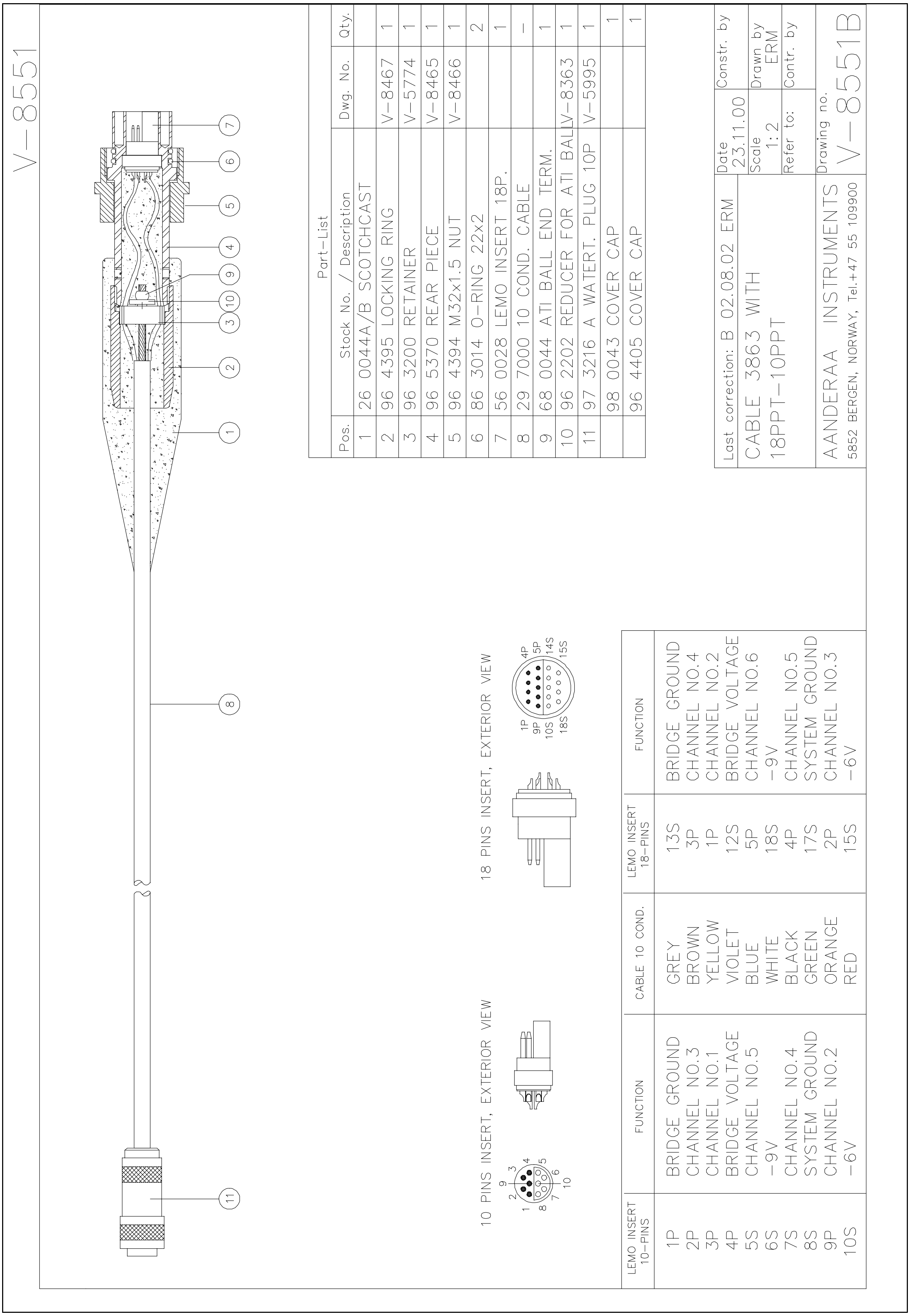
CABLE 3810 FOR INTERCONNECTING DCS 3900

AANDERAA INSTRUMENTS
BERGEN, NORWAY, Tel. +47 55 132500

Drawing no. V-8544

COLOR CODE 18 CONDUCTORS CABLE	18-PINS INSERT POST END	USED FOR	18-PINS INSERT PRE END	USED FOR
GREEN	1P	CH. 2	4P	CH. 5
YELLOW	2P	CH. 3	5P	CH. 6
BROWN	3P	CH. 4	6P	CH. 7
BLACK	4P	CH. 5	7P	CH. 8
WHITE	5P	CH. 6	8P	CH. 9
VIOLET	6P	CH. 7	9P	CH. 10
TURQUISE	7P	CH. 8	10S	CH. 11
RED	8P	CH. 9	11S	CH. 12
BROWN	9P	CH. 10		
YELLOW	10S	CH. 11		
GREEN	11S	CH. 12		
ORANGE	12S	BRIDGE VOLTAGE	12S	BRIDGE VOLTAGE
GREY	13S	BRIDGE GROUND	13S	BRIDGE GROUND
BLUE	14S	PDC4	1P	CH. 13
GREY	15S	CONTROL VOLTAGE	15S	CONTROL VOLTAGE
WHITE	16S	BATTERY	16S	BATTERY
BLACK	17S	SYSTEM GROUND	17S	SYSTEM GROUND
BLUE	18S	-9V	18S	-9V

Figure A 6 Illustration of cable 3810



Part-List

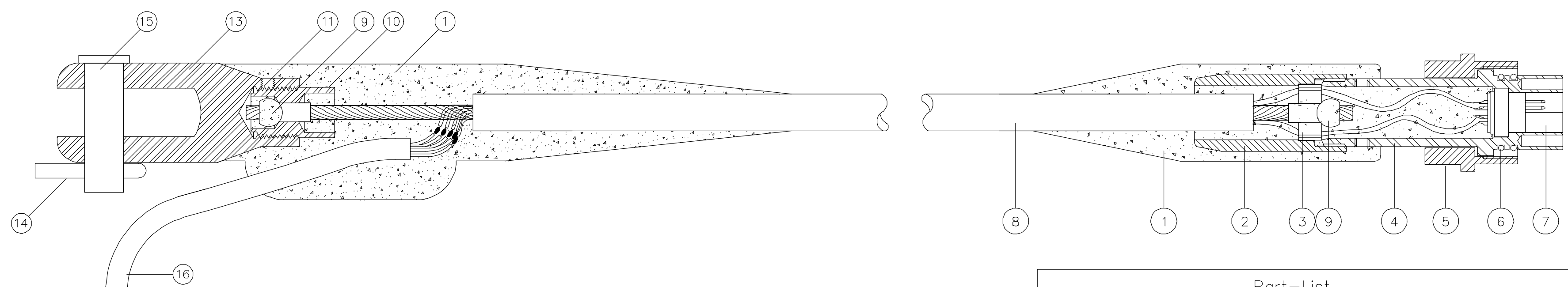
Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2	96 4395 LOCKING RING	V-8467	1
3	96 3200 RETAINER	V-5774	1
4	96 5370 REAR PIECE	V-8465	1
5	96 4394 M32x1.5 NUT	V-8466	1
6	86 3014 O-RING 22x2		2
7	56 0028 LEMO INSERT 18P.		1
8	29 7000 10 COND. CABLE		–
9	68 0044 ATI BALL END TERM.		1
10	96 2202 REDUCER FOR ATI BALL	V-8363	1
11	97 3216 A WATERT. PLUG 10P	V-5995	1
	98 0043 COVER CAP		1
	96 4405 COVER CAP		1

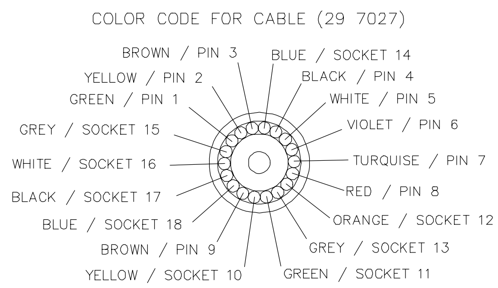
Last correction: B 02.08.02 ERM	Date 23.11.00	Constr. by	
CABLE 3863 WITH 18PPT-10PPT	Scale 1:2	Drawn by ERM	
	Refer to:	Contr. by	
AANDERAA INSTRUMENTS 5852 BERGEN, NORWAY, Tel.+47 55 109900	Drawing no. V-8551B		

LEMO INSERT 10-PINS	FUNCTION	CABLE 10 COND.	LEMO INSERT 18-PINS	FUNCTION
1P	BRIDGE GROUND	GREY	13S	BRIDGE GROUND
2P	CHANNEL NO.3	BROWN	3P	CHANNEL NO.4
3P	CHANNEL NO.1	YELLOW	1P	CHANNEL NO.2
4P	BRIDGE VOLTAGE	VIOLET	12S	BRIDGE VOLTAGE
5S	CHANNEL NO.5	BLUE	5P	CHANNEL NO.6
6S	-9V	WHITE	18S	-9V
7S	CHANNEL NO.4	BLACK	4P	CHANNEL NO.5
8S	SYSTEM GROUND	GREEN	17S	SYSTEM GROUND
9P	CHANNEL NO.2	ORANGE	2P	CHANNEL NO.3
10S	-6V	RED	15S	-6V

Figure A 7 cable 3863

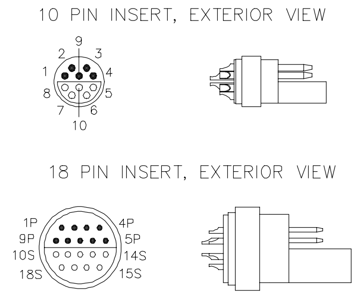
V−8552





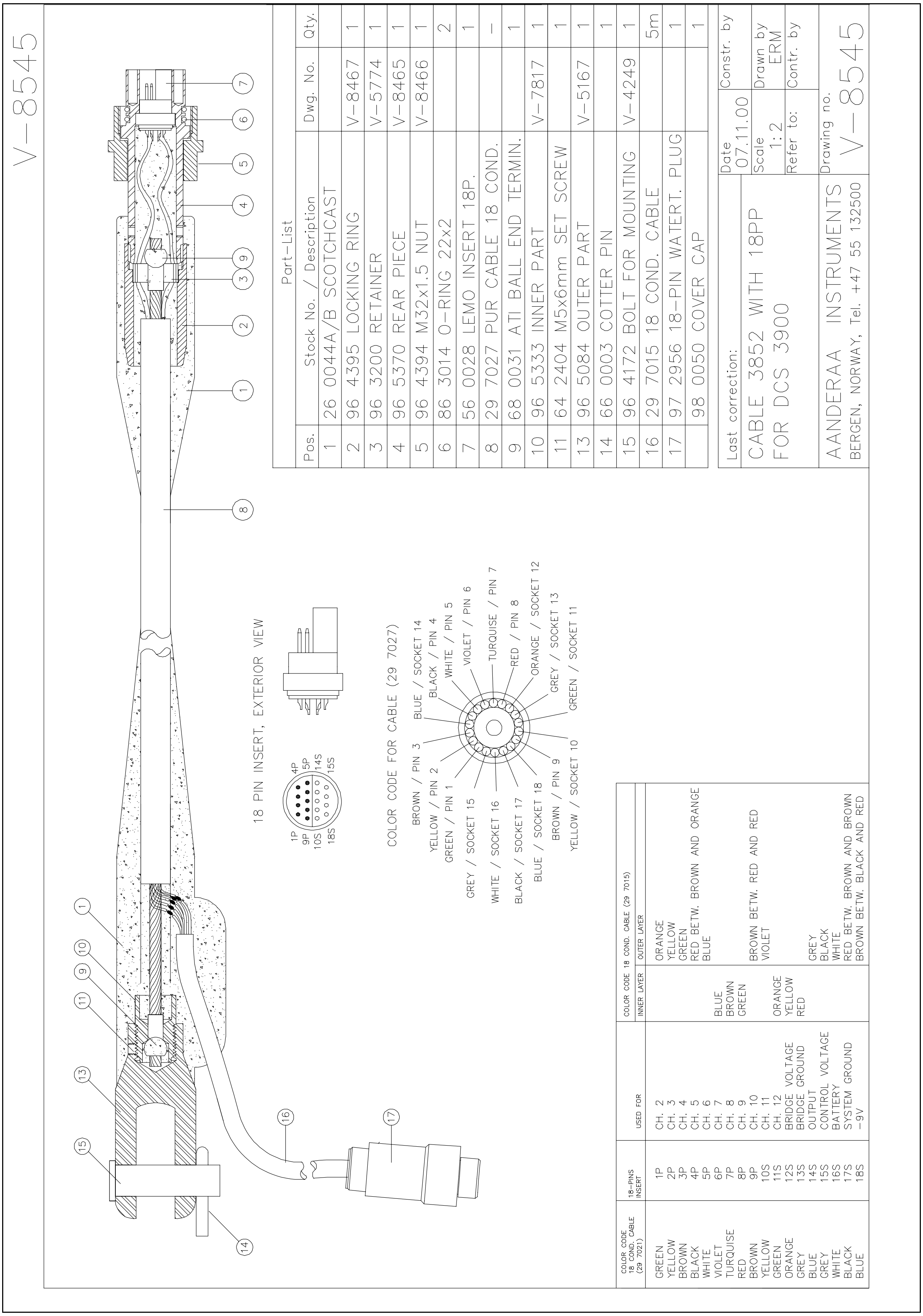
Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2	96 4395 LOCKING RING	V−8467	1
3	96 3200 RETAINER	V−5774	1
4	96 5370 REAR PIECE	V−8465	1
5	96 4394 M32x1.5 NUT	V−8466	1
6	86 3014 O−RING 22x2		2
7	56 0028 LEMO INSERT 18P.		1
8	29 7027 PUR CABLE 18 COND.		−
9	68 0031 ATI BALL END TERMIN.		1
10	96 5333 INNER PART	V−7817	1
11	64 2404 M5x6mm SET SCREW		1
13	96 5084 OUTER PART	V−5167	1
14	66 0003 COTTER PIN		1
15	96 4172 BOLT FOR MOUNTING	V−4249	1
16	29 7014 10 COND. CABLE		5m
17	97 3216A 10P WATERT. PLUG	V−5567	1
	98 0043 COVER CAP		1
	98 0050 COVER CAP		1

COLOR CODE 18 COND. CABLE	18−PINS INSERT	USED FOR	10−PINS INSERT	COLOR CODE 10 COND. CABLE
GREEN	1P	CH. 2	3P	YELLOW
YELLOW	2P	CH. 3	9P	ORANGE
BROWN	3P	CH. 4	2P	BROWN
BLACK	4P	CH. 5	7S	BLACK
WHITE	5P	CH. 6	5S	BLUE
VIOLET	6P	CH. 7		
TURQUISE	7P	CH. 8		
RED	8P	CH. 9		
BROWN	9P	CH. 10		
YELLOW	10S	CH. 11		
GREEN	11S	CH. 12		
ORANGE	12S	BRIDGE VOLTAGE	4P	VIOLET
GREY	13S	BRIDGE GROUND	1P	GREY
BLUE	14S	OUTPUT		
GREY	15S	CONTROL VOLTAGE	10S	RED
WHITE	16S	BATTERY		
BLACK	17S	SYSTEM GROUND	8S	GREEN
BLUE	18S	−9V	6S	WHITE



Last correction:		Date 23.11.00	Constr. by
CABLE 3809 WITH 18PPT−10PPT		Scale	Drawn by ERM
		Refer to:	Contr. by
AANDERAA INSTRUMENTS 5852 BERGEN, NORWAY, Tel.+47 55 109900		Drawing no. V−8552	

Figure A 8 cable 3809



Pos.	Stock No. / Description	Dwg. No.	Qty.
1	26 0044A/B SCOTCHCAST		
2	96 4395 LOCKING RING	V-8467	1
3	96 3200 RETAINER	V-5774	1
4	96 5370 REAR PIECE	V-8465	1
5	96 4394 M32x1.5 NUT	V-8466	1
6	86 3014 O-RING 22x2		2
7	56 0028 LEMO INSERT 18P.		1
8	29 7027 PUR CABLE 18 COND.		-
9	68 0031 ATI BALL END TERMIN.		1
10	96 5333 INNER PART	V-7817	1
11	64 2404 M5x6mm SET SCREW		1
13	96 5084 OUTER PART	V-5167	1
14	66 0003 COTTER PIN		1
15	96 4172 BOLT FOR MOUNTING	V-4249	1
16	29 7015 18 COND. CABLE		5m
17	97 2956 18-PIN WATERT. PLUG		1
	98 0050 COVER CAP		1

COLOR CODE 18 COND. CABLE (29 7021)	18-PINS INSERT	USED FOR	COLOR CODE 18 COND. CABLE (29 7015) INNER LAYER	OUTER LAYER
GREEN	1P	CH. 2		ORANGE
YELLOW	2P	CH. 3		YELLOW
BROWN	3P	CH. 4		GREEN
BLACK	4P	CH. 5		RED BETW. BROWN AND ORANGE
WHITE	5P	CH. 6		BLUE
VIOLET	6P	CH. 7	BLUE	
TURQUISE	7P	CH. 8	BROWN	
RED	8P	CH. 9	GREEN	
BROWN	9P	CH. 10		BROWN BETW. RED AND RED
YELLOW	10S	CH. 11		VIOLET
GREEN	11S	CH. 12	ORANGE	
ORANGE	12S	BRIDGE VOLTAGE	YELLOW	
GREY	13S	BRIDGE GROUND	RED	
BLUE	14S	OUTPUT		GREY
GREY	15S	CONTROL VOLTAGE		BLACK
WHITE	16S	BATTERY		WHITE
BLACK	17S	SYSTEM GROUND		RED BETW. BROWN AND BROWN
BLUE	18S	-9V		BROWN BETW. BLACK AND RED

Figure A 9 Illustration of cable 3852