EC1500

ELECTRICAL CONDUCTIVITY SENSOR

1500 4-20mA output | **1500S** SDI-12 interface | **1500S4** combined 4-20mA & SDI-12

environmental systems & services

PRODUCT USER MANUAL

es&s

www.esands.com

8 River Street Richmond VIC 3121 Australia | T + 61 3 8420 8999 | F + 61 3 8420 8900 | environmental@esands.com

ES&S Quality Assurance Statement

ISO9001 accreditation

ES&S is currently an AS/NZS ISO9001:2008 certified organisation.

This certification is evidence that sound practices are used to get high quality instrumentation to your organization within a reasonable time interval. Standard practices are used for all areas of manufacture, beginning with the efficient procurement of incoming orders, right through to shipment.

Stringent quality assurance procedures are applied to all aspects of manufacturing, including the calibration of scientific instruments against NATA traceable references. Every sensor is accompanied by a test and calibration certificate that can be used as reference information as well as evidence of sensor accuracy.

Terms of Warranty

The warranty covers part or complete replacement, repair or substitution of new instrumentation that has failed in part or completely within the warranty period. While every effort has been made to supply robust and user friendly instrumentation, the warranty does not cover instruments incorrectly installed, misused or operated in conditions outside those specified. The warranty does not cover shipment costs for instrumentation, installation or removal and, under no circumstances whatsoever, indirect or consequential losses caused by the failed instrumentation.

ES&S believes the warranty conditions to be fair and just and in accordance with standard business practices worldwide. ES&S reserves the right to arbitrate any warranty issues and will ensure that warranty issues are treated with the highest standards of professional conduct.

At ES&S we believe your investment in our products and services is a good decision and we will therefore ensure all your requirements are met at all times, both now and in the future.

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What is electrical conductivity?

Electrical conductivity is a measure of how easily an electrical current can flow through a substance. It is easily measured by low cost meters and is the inverse of resistance. Conductivity plays a major role in water quality measurement as it is a direct indicator of dissolved impurities. Pure water has extremely low conductivity (resistance of greater than 10 megaohms) meaning it allows very little electrical current to flow. As soon as impurities, in the form of dissolved salts, enter the water, resistance decreases, flow of electricity increases and therefore conductivity increases. By measuring the conductivity, the amount of dissolved solids can be easily determined. While an EC sensor cannot determine the type of dissolved salts, it can provide a good indicator of how suitable the water is for a large number of uses. For example, and EC sensor installed in a river downstream of a farming area can provide valuable information about how much the water is being contaminated by fertilizer runoff during rain events. It the same water is being used for viticultural irrigation, salt content must be low to ensure plantations are not endangered by water that is too salty.

How is conductivity measured?

Measuring conductivity is very straight forward. Simply place two electrical probes 1m apart into the water sample. Apply a known voltage to the probes and measure the current flowing through the probes. Using the formula V=IR, the resistance of the water sample can be determined. To convert to conductivity, take the inverse of resistance. Ie:

R = V/I then Conductivity = 1/R (in Siemens or 1/ohms)

For example, apply 1V to the probes (1m apart) and current flow is 0.001A, resistance is 1,000 ohms. Conductivity is 1 milliSiemens or 1,000 microSiemens

For practical applications it is not desirable to use two probes 1m apart. Instead, a probe can be manufactured into a compact probe containing both electrodes. The measuring principle remains the same.

How does the 1500 conductivity sensor work?

The 1500 EC sensor employs a unique measuring technique. Instead of electrical contact probes, it uses an inductive (or magnetic) method to determine conductivity. Two coils are placed a known distance apart. One coil has an oscillating current applied that forms a magnetic field inside the coil centre. The other coil receives the magnetic flux produced inside the transmit coil. However, because of the coil arrangement the receiving coil will only receive signal if a conductor is placed in the middle of the coils. If water is allowed to flow through the coil centre, impurities in the form of dissolved salts will once again provide the necessary magnetic coupling.

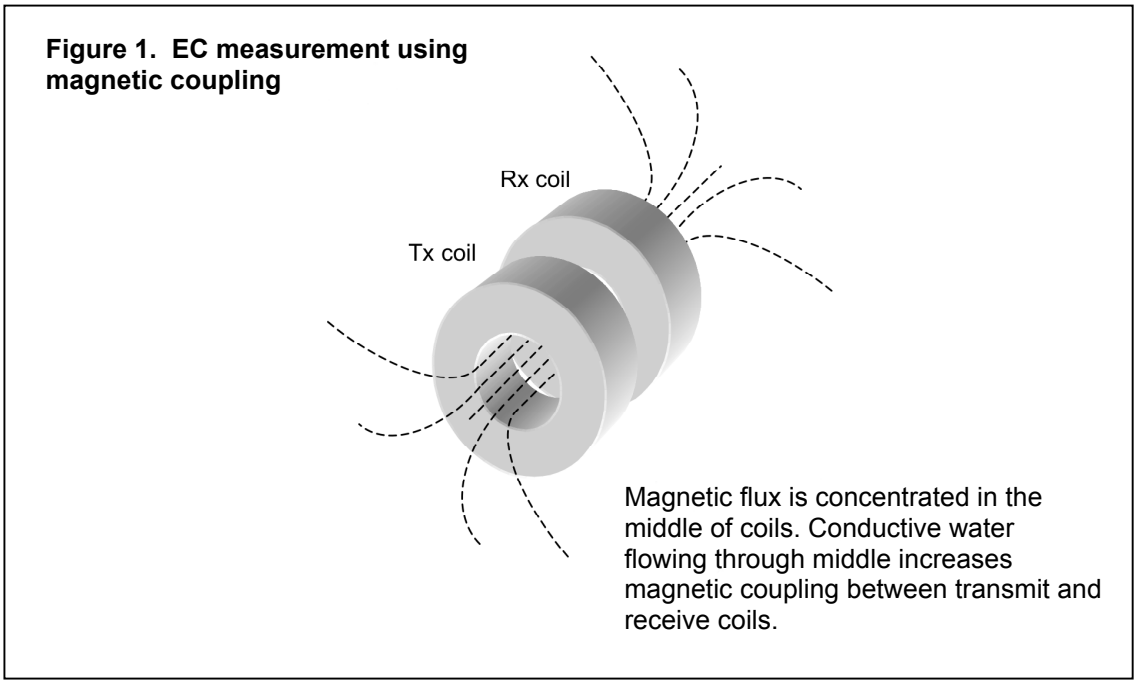


Figure 1. 1500 Sensor measurement principle

The above diagram shows how the sensor works. Transmit (Tx) coil forms a magnetic flux inside the coil pair. Conductive water increases the magnetic coupling which is seen as a transfer of oscillating current in receiver (Rx) coil. The degree of transfer is an indication of water conductivity.

What is temperature compensation?

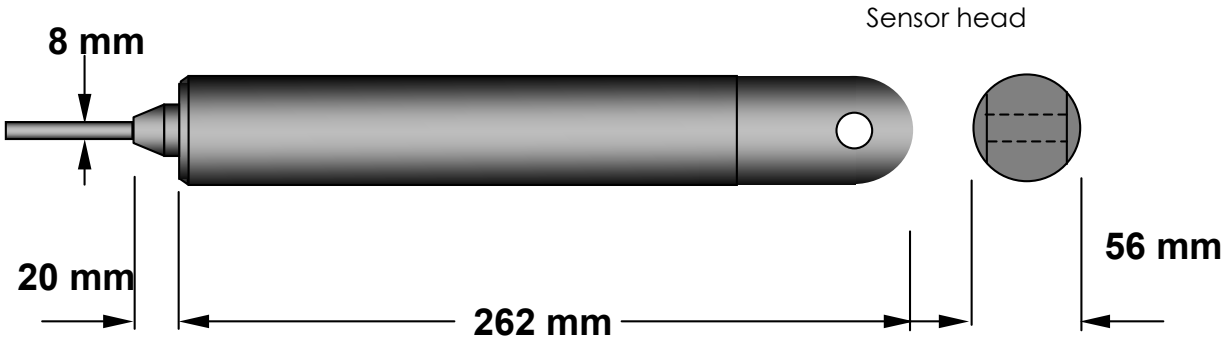
Like resistance, conductivity changes with temperature. The lower the temperature, the less the conductivity and this is because electrons find it harder to flow through dissociated salt molecules at lower temperature. This makes measurement confusing when actually trying to determine the water conductivity over a temperature range. To overcome this effect, conductivity measurements at any temperature are output as if the temperature is 25°C and is called *temperature compensated output.*

The relationship between compensated and non compensated (raw) output is linear and simply put, a percentage is added or subtracted from the raw measurement to determine compensated output. For the 1500 EC sensor, the compensation is set at approximately 2% per °C. For temperatures below 25 °C the proportion is subtracted and is added for temperatures above 25°C. Of course the temperature needs to be measured for compensation and therefore the 1500 EC sensor has an internal temperature sensor. As an additional feature, the 1500 EC sensor also has a separate temperature output available to loggers and controllers as a 4-20mA signal. Temperature compensation operates between 0 and 50°C, the typical expected water temperature for most environmental conditions.

$$\text{Corrected EC @ 25ºC in uS/cm} = \frac{\text{Raw E.C. Reading in uS/cm}}{1 + 0.02\ (\text{Sample Temperature} - 25ºC)}$$

Sensor description

Figure 2. Sensor dimensions



The 1500 sensor is a fully submersible device used for measuring water conductivity. It is constructed from durable machined plastic components and epoxy resins. For reliability, there are no wetted metal components to corrode making this sensor suitable for high conductivity (high dissolved solids) application and even for water with high acidity. The 1500 EC sensor is designed for very long term deployment at unattended monitoring stations.

The sensor head is fully epoxy encapsulated and has a hole through the middle to allow the flow of water through it. It is here that the water provides magnetic coupling for the measurement to take place.

An 8mm diameter submersible rated cable is hardwired to the back of the sensor (length specified during ordering). Although care must be taken to secure the sensor at all times, the sensor may be suspended from the cable for short periods such as during installation.

Once installed and powered, the sensor will measure conductivity from zero to full scale, as indicated on the sensor body in microSiemens.

The "dry" end of the cable has four wires for supply, ground and current output signals. Connectors can be fitted for direct connection to ES&S equipment (such as the 3500 logger) or custom connectors can be fitted upon request.

There are no moving parts on the 1500 EC sensor, and no serviceable components. This sensor is a dual output 3 wire current loop device as detailed in the *Installation* section.

Installation

Site Selection

Before installing a 1500 EC sensor it is recommended a suitable site be selected first. The installation and maintenance complexity as well as the reliability of the instrument in critical applications depends on the site chosen and the length of cable required can then be determined.

Well chosen sites:
- slow flowing water (no stratification)
- minimal or no accumulation of debris around sensor
- easy and safe access, away from waterway traffic
- sensor head is always submerged in at least 200mm of water
- sensor head is at least 100mm from bottom and at least 50mm from any metal
- sensor cannot be dislodged during high flows

Avoid sites with:
- very low or stagnant water flows
- where debris can accumulate inside sensor head
- excessive air bubbles in water
- difficult or unsafe access
- high siltation rates
- where sensor will be exposed in air during low flows

The following is also recommended for EC sensor installation

- Install the sensor out of direct sunlight, especially when in shallow water. Sunlight will heat the sensor head to produce a false temperature and compensated EC reading.
- Algae will tend to grow within the sensor hole. This can be minimized by covering the sensor with a shield to make the head as dark as possible. No sunlight means no algae
- Silt can accumulate in the sensor hole. Install the sensor so water can flow through the hole.

Typically, most sites that are already equipped with hydrographic instrumentation can be used for installation of the 1500 EC sensor.

EC1500 Model Types

There are three EC1500 models:
- **EC1500** - 4-20mA output Only
- **EC1500S** - SDI-12 output Only
- **EC1500S4** - SDI-12 & 4-20mA output

Installation Orientation

For correct installation the following installation restrictions apply

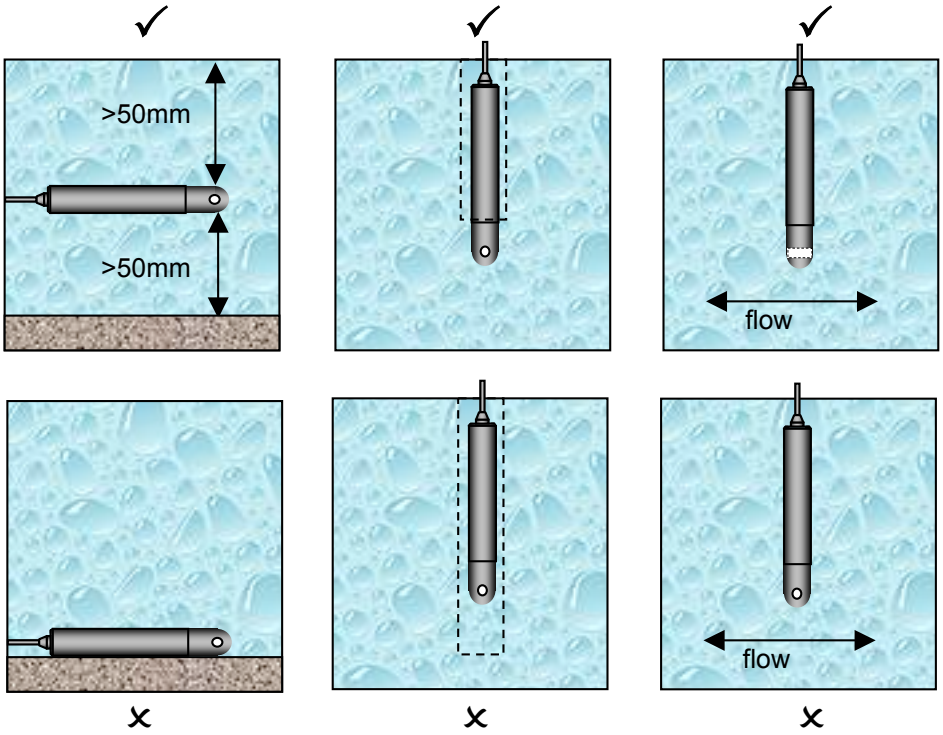


Figure 3. Sensor orientation

With the exception of the head (with hole trough it), the rest of the sensor can be completely covered. If 50mm ID poly tube is used for installation, a suitable compression gland is available from irrigation hardware suppliers. The sensor outside diameter is smaller than the compression gland internal diameter and can be clamped easily and securely using this method. When this system is used, the sensor head must protrude from the gland by as least 60mm.

Sensor Clearance

Correct orientation of the sensor will help to reduce the build up of silt and debris within the hole in the center of the EC head. Where algal blooms are likely it is recommended the sensor is covered with a sun shield, keeping the sensor in the shade, thereby reducing algae buildup. When installing a shield, ensure the shield clears the sensor head by at least 50mm. The shield should ideally be installed 100mm from the sensor, and cover the sensor sufficiently from direct sunlight. A shield will also prevent excessive temperature variations.

Site preparation

Before the sensor can be installed, the site must be prepared to ensure the sensor will be secured, protected and serviceable.

The following recommendation is based on typical installation methods practiced by today's hydrographers. Several variations of this method are used to suit particular applications.

Please study the diagram below. Site preparation involves the installation of a larger plastic tube along the waterway bank as shown. The tube should ideally be continuous but may also be made from sections. One end of the tube must be installed into the water ensuring the sensor optical path will not be obstructed according to the previous section *Sensor Clearance*. The other end can be terminated in a junction pit that is large enough so that the sensor can be inserted from the pit. Typically, an underground electrical pit is used as this also allows a sensor carrier assembly to be inserted easily. The pit must be installed on a stable part of the bank that cannot erode.

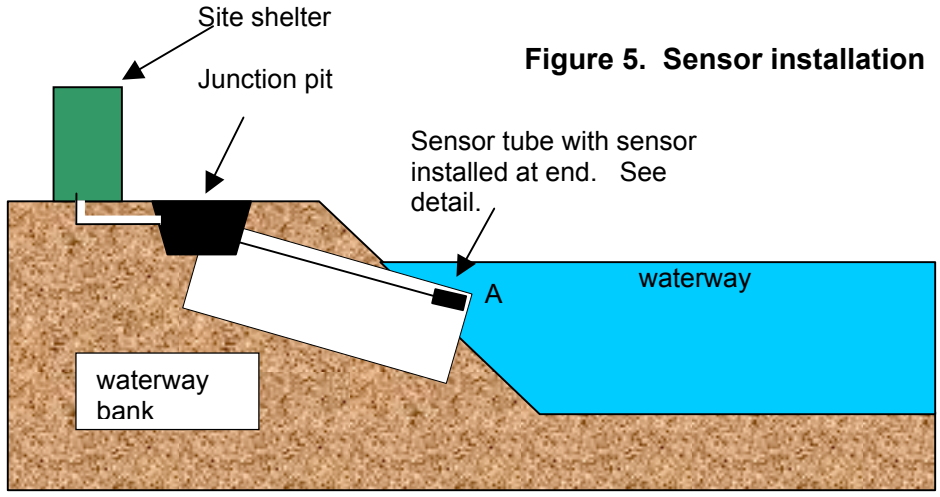


Figure 5. Sensor installation

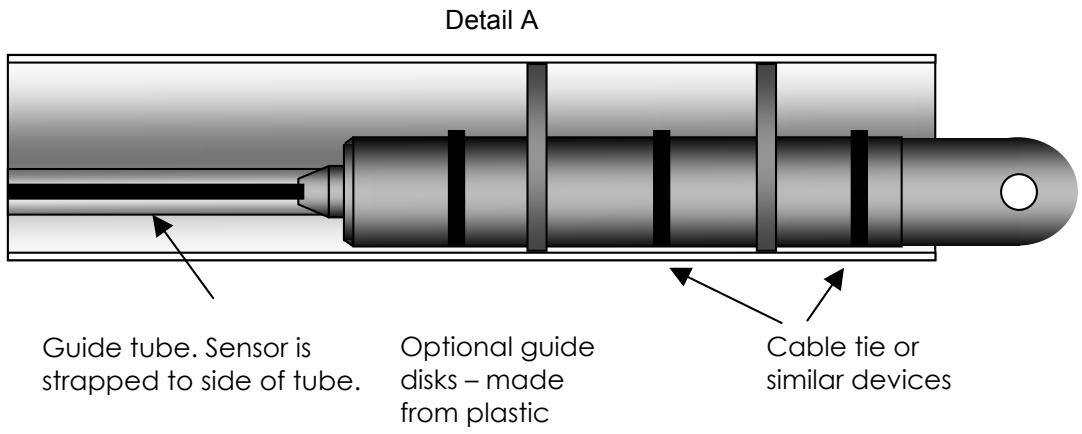


Figure 6. Sensor installation

EC1500 Model Types

EC1500 4-20mA

The diagram below shows the electrical circuit equivalent of a 4-20mA output 1500 EC sensor.

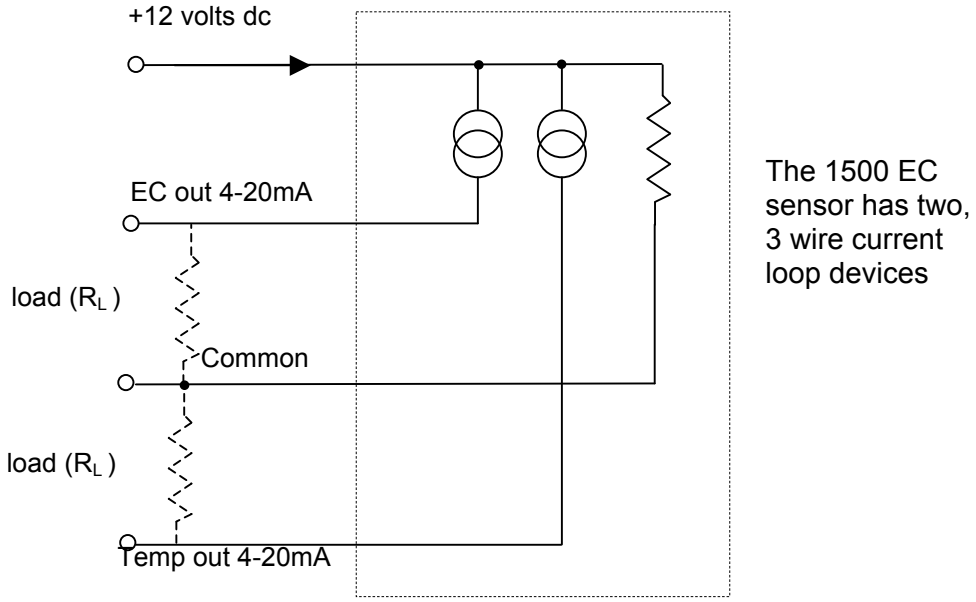


Figure 7. EC1500 4-20mA electrical equivalent circuit

A single cable is hardwired to the 1500 sensor. The diagram below shows the configuration and typical connection of the sensor to power and controlling equipment.

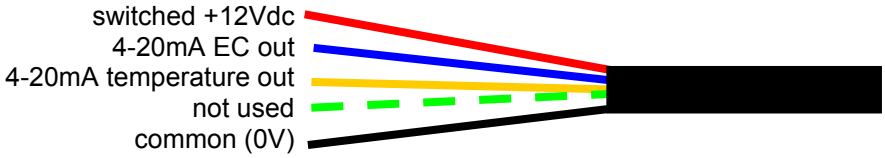
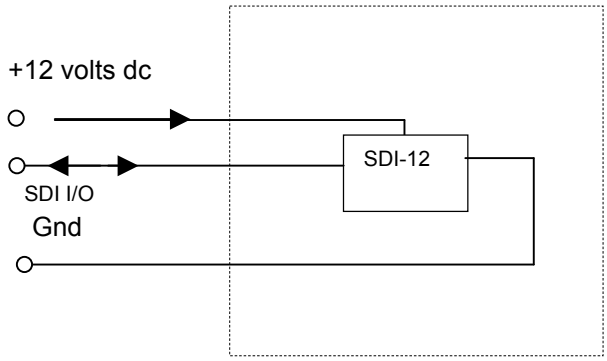


Figure 8. EC1500 4-20mA conductor designation

The EC1500 Sensor is used in 4-20 mA mode only, the Green wire is not required & the Blue and Yellow wires are EC and Temperature 4-20 mA outputs. The red wire is 12V power and the black wire is Gnd.

Conductor Colour	Conductor Designation	Requirement	ES&S 3-pin	ES&S 5-pin
red	switched +12vdc input	80 mA	A	A
blue	4-20mA output, EC	Source current	B	B
black	common	0V	C	C
yellow	4-20mA output, Temp	Source current	B (plug 2)	D
green	Not used			E

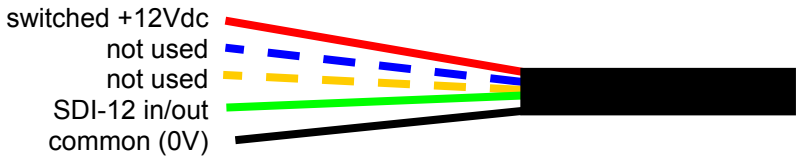
EC1500S SDI-12



The EC1500S sensor is an SDI-12 sensor

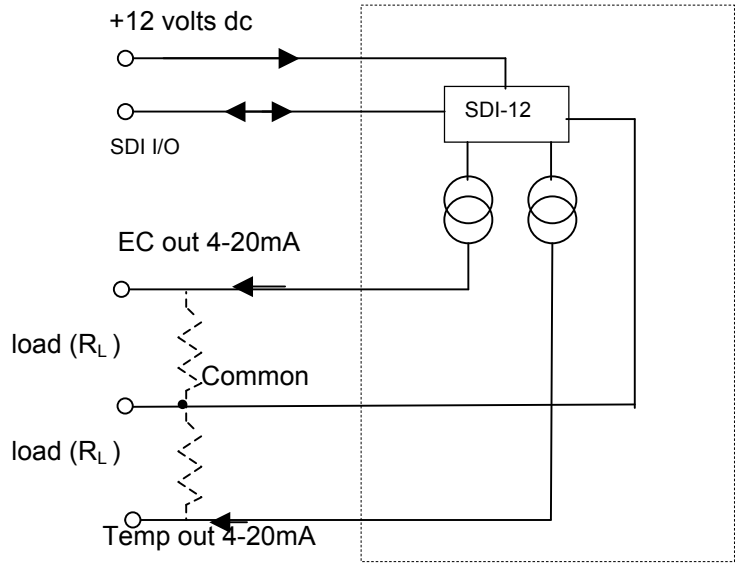
Figure 9. EC1500S electrical equivalent circuit

A single cable is hardwired to the 1500 sensor. The diagram below shows the configuration and typical connection of the sensor to power and controlling equipment.



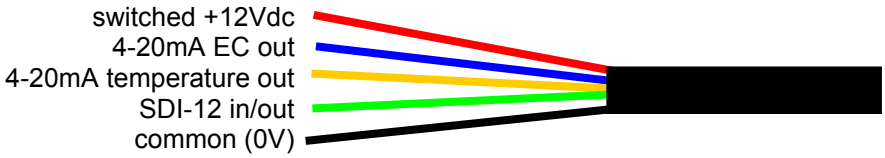
Conductor Colour	Conductor Designation	Requirement	ES&S 3-pin	ES&S 5-pin
Red	switched +12vdc input	80 mA typ	A	A
Blue	Not used		B	B
Black	common	0V	C	C
Yellow	Not used		B (plug 2)	D
Green	SDI-12 in/out	SDI data		E

EC1500S4 Combined SDI-12 and 4-20mA sensor electrical connection



The EC1500S4 is an SDI-12 sensor plus two 3 wire current loop devices

Figure 11. EC1500S4 electrical equivalent circuit



Conductor Colour	Conductor Designation	Requirement	ES&S 3-pin	ES&S 5-pin
red	switched +12vdc input	80mA min	A	A
blue	4-20mA output, EC	Source, max 120Ω load Note: 1	B	B
black	Common	0V dc	C	C
yellow	4-20mA output, Temp	Source, max 120Ω load Note: 1	B (plug 2)	D
green	SDI-12 in/out			E

Note: 1 The 4-20mA output of the EC1500S4 MUST have a load resistor of 0 – 120R. If the 4-20mA output is not used, connect the blue and yellow wires to common.

1500 4-20mA Interface

EC1500 and EC1500S4

To obtain a measurement from the 1500 sensor:

- Install the sensor according to recommendations in Section *Installation*.
- Apply power to the sensor
- 1500: 2 x 4-20mA current output will be produced at the respective outputs.
- 1500S: Conductivity data is available on the SDI-12 bus

A current output signal will be available for measurement after 1 second. For power conserving applications, the sensor can be switched off immediately after the reading is attained. The sensor can also be left on continuously if required.

The 4-20mA current output will be available for reading 1 second after switched power is applied.

With proper care and routine maintenance, the sensor can be left operating unattended for several months. Of course, as each application will be different, it is recommended that the total time between services is determined experimentally.

1500S SDI-12 Interface

EC1500S and EC1500S4

The SDI-12 interface of the EC1500S and EC1500S4 handles all of the communication and power down features of the SDI-12 protocol.

All standard SDI-12 commands are supported. In addition, extended commands can be used to calibrate sensor outputs. Each of the measurements can be scaled and offset with user supplied calibration coefficients. The factory sets these parameters so the output is in µS/cm.

Any changes to these parameters should take into account their factory calibration values as these have been established by measurement for each sensor. The SDI-12 Interface also has an on board temperature sensor.

The interface has been fully tested with the NR Systems SDI-12 Verifier.

Note that the EC1500S1and EC1500 S4 are 11 cm longer than the 4-20mA EC1500.

Note that some of the earlier EC1500S had an SDI-12 interface with the output data scaled 4-20.

SDI-12 Commands

The commands assume that the sensor address is 0, but any address could be substituted into the commands below. "\r\n" is carriage return and line feed characters.

Calibration coefficients are modified by extended "X" commands, and are indexed by a 2 dimensional array, where the first zero based index is the measurement index, and the second is the parameter.

Measurement	Index
Sensor 1	0
Sensor 2	1
Sensor 3	2
Temperature	3

Each measurement has 3 parameters:

Parameter	Index	Default Value
Offset	0	0.0
scalar	1	1.0
resistor gain	2	(Rs+Rp)/Rp

Example:

To calibrate the output of the second sensor such that it's voltage is multiplied by 2 and an offset of 3 is added to the result using the following transfer function:
out= 2*x+3,
the following two extended commands would be used:
0XSET VAR[1,0]=3!
0XSET VAR[1,1]=2!

SDI-12 Command Table

Command	Description	Typical Response
?!	Returns address of a single sensor on the SDI-12 bus	"0\r\n"
0!	Ping, returns same address	"0\r\n"
0V!	Verify command. Subsequent 0D0! command will return the version of the Interface	"00001\r\n"
0M!	Begin a measurement. Subsequent 0D0! command will return the 3 measurements and the temperature.	"00034\r\n"
0MC!	Begin a measurement and respond with CRC on subsequent 0D0! command.	"00034\r\n"
0C!	Begin a concurrent measurement. (Same as 0M! command but no service request is issued.)	"00034\r\n"
0CC!	Begin a concurrent measurement and respond with CRC on subsequent 0D0! command.	"00034\r\n"
0D0!	Get data is called after a 0M!, 0MC!, 0C!, 0CC!, and 0V! commands. If called after the 0V command then the single result is the version number, otherwise it returns 4 results, namely the 3 sensor voltages, and the internal temperature of the interface.	Response to 0V! "0+2.0\r\n" , Otherwise: "0+1.1+2.2+3.3+25.0\r\n"
0XSET VAR[m,p]=VAL!	Set and store one of the calibration coefficients indexed by m,p, where m is the measurement, and n is the parameter	"0XACK\r\n"
0XLOAD VAR[M,N]!	Retrieve and store the calibration coefficients indexed by m,p, where m is the measurement, and n is the parameter, to a string buffer ready to be retrieved by the 0XGET command.	"0XACK\r\n"
0XGET!	Retrieve the string buffer that was filled from the previous 0XLOAD command	"0X +1.1\r\n"
0XER!	Retrieve a string for the last error generated by the use of an X command.	If no error: "0XOK\r\n" Possible errors: "0XER BAD COMMAND\r\n" "0XER BAD MEASUREMENT INDEX\r\n" "0XER BAD COEF INDEX\r\n"

Internal Temperature Sensor

Models EC155S and EC1500S4 have an internal temperature sensor, however for higher accuracy it must be calibrated by the end user

Example program to read SDI-12

The following program can be used with the Campbell Scientific CR1000 logger.

Program name: CR1000 sample display reading.CR1

```
'Date written: 3/06/2009 using the CRBasic programming tool from
' Campbell Scientific LoggerNet 3.4.1

'This program is used to test the SDI-12 Interface using a
'Campbells CR1000 logger.
'
'Sensor powered from 12V terminal and a G terminal, and with SDI-12 'on C1
terminal.
' Logger   C1----green-------Sensor SDI-12
'          12V --red--------Sensor Power +ve
'          G ----black------Sensor Ground

'The program below will collect data each second from the four SDI-12
'Interface channels.

'Use one of the Data Displays from the loggerNet Connect Screen.
'Set the table cells to sdidata(1) to sdidata(4).
'The information from each of the four channels of the SDI-12 Sensor
'Engine will be displayed and updated every second.


Public sdidata(4)  'sdidata(1) conductivity
                   'sdidata(2) temperature
                   'sdidata(3) not used
                   'sdidata(4) temperature of SDI IF uprocessor


BeginProg
  Scan(1,Sec, 3, 0)
    SDI12Recorder(sdidata, 1, "0", "M!", 1.000, 0)
  NextScan
EndProg
```

Maintenance

The 1500 sensor will require little periodic maintenance to ensure that measurements remain accurate. While all wetted components are no metallic and cannot corrode in high salt or acidity liquids. Debris, silt and algae lodged in the hole can cause inaccurate readings. It is recommended the sensor is checked during every visit, or at least every 3-6 months. You may find the sensor will not require any maintenance for even longer periods however, warmer climates or high silt laded rivers and streams can accelerate these effects..

General

- Ensure the sensor is not affected by debris, silt or algae (or marine growth). The sensor should be removed from its installed location for a thorough inspection. Using the recommended installation method outlined in the section Installation, removal should be easy and maintenance staff do not need to enter the waterway
- Ensure the installation is sound and the sensor is still secure from moving and there are no obvious signs of erosion or damage.

Calibration check

The sensor output can be checked against a reference instrument if it is available. Ideally, the measurement should be taken in the same solution as the sensor while the sensor is installed. If there is a large difference, an installation problem may be highlighted. All sensor measurements should be within the specified accuracy.

- compare the sensor measurement to that of the reference instrument.
- ensure the reference instrument calibration error is also known.

Specifications

Range_____Standard ranges of 500, 1000, 2000, 5000, 10000, 20000, 50000, 60000 uS/cm. Other ranges available on request.

Accuracy_____EC: Linearity < 3% of full scale
Temperature < 0.2%/ °C of FS over the range 0 to 30 °C.

Temperature range -10 to 60 °C storage, operating: 0 to 50 °C

Zero & Full Scale Setting_____+/- 0.1% of full scale setting

Response Time____2 seconds to full accuracy

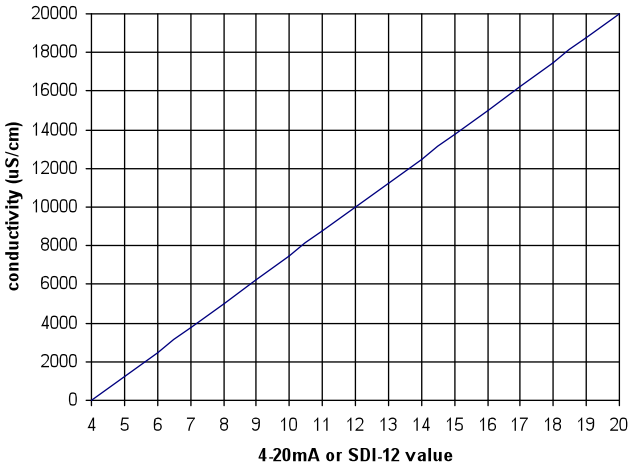
Type_____Magnetic inductive coupling

SDI-12 Output_____EC in uS/cm (standard)
The SDI-12 output of the EC1500S and EC1500S4 can also be scaled at the factory to read 4-20. Check with factory.

4-20mA Output___Scaled to maximum range.

1500 Analogue	4-20mA current
1500S/S4 Scaled SDI-12	4-20

Example for 20000uS/cm probe:



In general, the transfer function is:

Conductivity = $\frac{Cm}{16}$(R-4) uS/cm, where Cm = Max range, R=reading

So, for Cm=20000uS/cm: Conductivity = 1250(R-4) uS/cm

Power Supply_____10-15 V unregulated, current capability >500mA
0.3mAh per reading on average (typical)

Surge _____Secondary surge protection, Can absorb 0.6J of energy

Dimensions_____1500: 262 long,56 dia (mm)
1500S/S4: 240 long,46 dia + 106 long, 56 dia (mm)

Ordering information

Item description	code
Electrical conductivity sensor	1500
Cable, hardwired to sensor, 10 meters std (other cable length available on request)	1510
Connector, 2 x 3 pin male plugs fitted to 1510 cable with "V" splice to sensor cable	1520
Connector, 5 pin male plug fitted to 1510 cable	1530
Extension cable with 5 pin male plug and 5 pin female jack, meters	1540

Note: For EC with SDI-12 output, add "S" to the above ordering codes.
Example: SDI-12 Electrical conductivity sensor: 1500S

Contact Details

Environmental Systems & Services Pty. Ltd.

Address: 8 River Street
Richmond, Victoria, 3121
Australia

PO Box 939
Hawthorn, Victoria, 3122

Phone: 03 8420 8999
Fax: 03 8420 8900

Int'l phone: +61 3 8420 8999
Int'l fax: +61 3 8420 8900

email: environmental@esands.com
web: www.esands.com

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PumpPro 6150

The PumpPro 6150 combines an integrated air compressor module and levelpro 6100 advanced liquid level sensor to form a fully self contained hydrostatic pressure sensor designed to measure water and liquid levels reliably and accurately.

Dipmeter

The Water Level Indicators Dipmeters are typically used to measure the depth of water levels in boreholes, standpipes or observation wells.

environmental systems & services | 8 River Street Richmond Victoria 3121 AUSTRALIA
T +61 3 8420 8999 | **F** +61 3 8420 8900 | environmental@esands.com | **www.esands.com**