Manual

Four Electrode Conductivity Instrument

Model 6536

Revision History

File name / Revision	Date	Authors
Previous version BX	2004	RS/ JH
Unidata Manual - 6536 Four Electrode Conductivity Issue 2.0	2007	AB/CB/JH/MS/KC
Unidata Manual cover only- 6536 Four Electrode Conductivity Issue 2.1.doc	2008	DM
Unidata Manual - 6536 Four Electrode Conductivity Issue 3.0.docx - Reformat	17/09/2013	MP

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1.0 INTRODUCTION

The Model 6536B Four Electrode Conductivity Instrument is a complete data logging system for monitoring the specific conductance of solutions. It is designed for permanent field installation and can monitor the natural environment or industrial processes. The instrument consists of a small sensing probe that is connected by cable to a battery powered measurement and recording instrument.

Three in-built ranges allow the single instrument to cover a wide range of conductivities. The instrument utterings meaning it will work at its optimum resolution throughout the entire operating range. This enables monitoring of saline conditions while still accurately measuring flushes of fresh water.

Graphite electrodes, combined with a zero potential measurement technique, maximise stability and reduce the affects of algae growth and deposition of sediment or water pollutants.

The probe requires very little maintenance and the instrument's ultra-low power consumption makes it ideal for remote, unattended operation. It will operate for many months from a single 12 volt battery.

Temperature is measured within the probe and may be logged and used to provide precision compensation of the measured conductivity. Both measured and temperature-compensated conductivity can be recorded.

The instrument includes an integrated Starlog-compatible MicroLogger, providing all the standard features found in Starlog such as SDI-12 communications, intelligent battery supervision, a modem interface, and all the programmability found in Starlog Data Loggers.

The 6536B instrument can be linked to other Unidata Starlogger, MicroLogger or Starflow instruments that are monitoring flow or water quality. The sensor can be mounted with a Model 6526B Starflow water flow measurement system to provide a complete salt load recording package.

2.0 MEASURING ELECTRICAL CONDUCTIVITY OF NATURAL WATERS

The specific conductance or electrical conductivity (EC) of water is a physical measurement widely used as a basic indication of water quality. It measures the total of all ions in the solution. Since these ions result from salts in solution they reflect the effects of natural and human processes on water quality.

There are approximate relationships between temperature compensated EC and the total dissolved solids in ppm (parts per million) or mg/l (milligrams/litre) in the solution. Depending on the chemistry of the sample, other relationships can be developed between EC and hardness of water, and EC and salinity.

2.1 Electrical Conductivity Measurement

Electrical conductivity is defined as the ability of a solution to conduct an electric current. It is measured as the electrical conductance of a one centimetre cube of the solution at a known temperature. The units used are siemens per centimetre (S/cm). Derived units frequently used are:

To convert S/cm to		Multiply by ...
milliSiemens / centimetre	mS/cm	1000
microSiemens / centimetre	us/cm	1,000,000
Siemens / metre	S/m	100
milliSiemens / metre	mS/m	100,000

The Model 6536B Four Electrode Conductivity Instrument measures the electrical conductivity in units of micro Siemens per centimetre (us/cm). This can be recalked to any desired units by editing Transducer 1 within the scheme and entering a suitable scaling factor. For details, see the Section 6.0 Using Starlog Software on page 12.

2.2 Electrical Conductivity Of Solutions

The electrical conductivity (EC) of a solution is related to the concentration and composition of the dissolved salts. In natural waters this is a complex mix and varies over a wide range, from low concentrations in rainwater and snow to very high concentrations in salt lakes. Some examples of the EC of water are:

Distilled water	0.5uS/cm
Domestic water	500 to 800uS/cm
Sea water	56,000uS/cm
Salt lakes	180,000uS/cm

The Model 6536B Four Electrode Conductivity Instrument measures from 0 to 200,000uS/cm and can monitor the full range of electrical conductivity found in the natural environment and most industrial processes.

2.3 Effect Of Temperature On Solution Conductivity

The electrical conductivity of all electrolytes vary with temperature. The variation is almost always positive and of a magnitude from 0.5%–3% per degree C, depending on the nature and concentration of the conducting ions in the solution. For example, the temperature coefficient for a sodium chloride (NaCl) solution is approximately 1.65%/°C at 25°C. This means that the electrical conductivity of a solution of sodium chloride changes by 1.65% of its value at 25°C for each degree temperature change of the solution.

Although the temperature coefficient is known for a great number of "pure" electrolytes, it is not well known for many natural waters as these may be a complex mix of various electrolytes. A default value of 2.0%/°C is frequently used however the correct value may vary depending on the geology of the region and the source of the water.

2.4 Adjusting For Temperature Effects

Since the electrical conductivity varies with temperature, it is a common practice to compensate the measured value by adjusting it to a standard temperature (normally 20°C or 25°C), provided the water temperature and the temperature coefficient of the solution is known.

This process may introduce significant errors because of uncertainties about the coefficient. Temperature compensation, where applied over a wide temperature range, can be the most significant factor in determining the overall accuracy of a conductivity measurement. The advantage of automatic temperature compensation is the removal of temperature effects from the data. The disadvantage is that the errors introduced when the factor is unsuitable may be unacceptable for some projects.

The temperature compensated conductivity is computed as:

$$C_{rt} = \frac{C_t}{1 + (\frac{\alpha}{100} \times t - rt)}$$

Where:

C = Compensated conductivity (us/cm) at reference temperature.

Ct = Measured conductivity at sample temperature t. (us/cm).

α = Temperature coefficient at reference temperature (%/°C).

t = Measured water temperature (°C).

rt = Reference temperature (e.g. 25°C).

The temperature compensation factor for a solution can be determined by temperature testing a sample from your site. Warm and cool the sample through the expected temperature range, then record a range of uncompensated conductivity and temperature readings, including your reference temperature. Calculate the electrical conductivity variation per degree Celsius, as a percentage of the electrical conductivity at the reference temperature. Repeat this with other samples taken under different flow conditions, as the water quality may change. This data will indicate the factor to use and the variation. With the correct factor in use, the conductivity should not change when the temperature of the solution changes.

The temperature compensated data you log will display small steps as the temperature changes. This is caused by the resolution of the temperature data which moves in steps of 0.0612°C, introducing equivalent steps into the computed data.

For research projects it is more accurate to log the uncompensated conductivity and temperature. A temperature effect will be apparent in the data. In post processing, an analysis of this effect can sometimes be used to indicate the temperature factor to be used for temperature compensation.

3.0 EQUIPMENT INSTALLATION

3.1 Selecting A Site

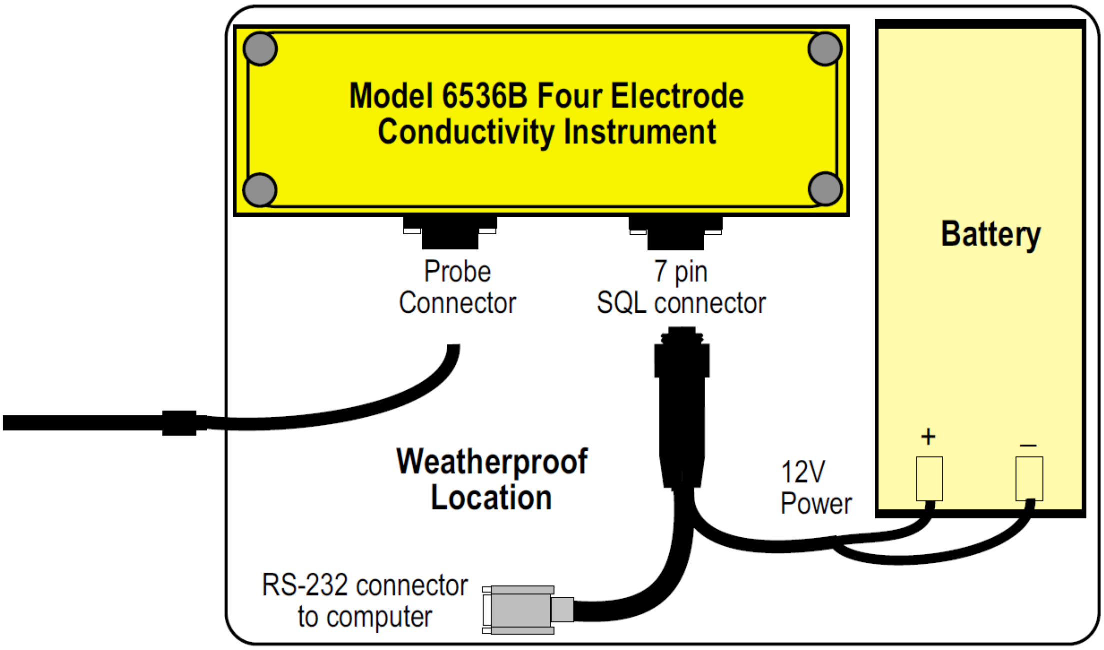
In large natural streams thermal and density stratification can result in considerable differences in water quality in different locations in the channel cross-section. When selecting a site, avoid stagnant locations near the banks or bed, deep pools, and behind weirs. If in doubt, test the actual variation of electrical conductivity in the section or profile, using a hand held instrument. The location selected for the probe should expose it to a free flow of water that is well mixed and representative of natural flow, particularly when flows are small. At sites with persistent variations, more than one instrument may be required to accurately monitor the water quality.

At some sites sampling will be at a specific location, such as the intake for a pump and the probe should be installed at the location of interest.

3.2 Instrument Installation

The instrument electronics are enclosed in a housing which offers a socket for the probe cable. A second plug is used for the special cable with a 9-pin computer connector and a 12V battery lead.

The Model 6536B Four Electrode Conductivity Instrument and battery should be housed in a weatherproof location, protected from accidental damage and interference. The probe and cable are designed for permanent submersion. A typical instrument installation is shown below:



3.3 Probe Location And Housing

The probe installation should allow it to be removed for maintenance and returned to the same location. A PVC duct can be used with the probe inserted and pushed to the end using the cable. This duct should protect the cable from damage. The end, which can be fitted with an open grille or drilled like a sieve, should be fixed at the desired sampling location, protected from damage.

3.4 Power Requirements

The instrument is powered by an external battery. There is no internal battery. The instrument can be disconnected for up to fifteen minutes to exchange batteries, without memory loss. A rechargeable sealed lead acid 12 Volt battery with a capacity of 12Ah is recommended. The power consumption is approximately 0.1Ah/day at one minute log intervals, and 0.02Ah/day at five minute intervals.

The battery should be located in a dry, clean and safe location.

3.5 Instrument Installation Procedure

To install, please do the following:

1. Insert the probe into its duct and housing. Connect the probe cable into the Input Signals plug.
2. Plug in the battery/communication cable and connect the battery.
3. Connect your PC and start the Starlog Software. Select the scheme prepared for the instrument.
4. Load the Scheme and review the Scheme Test Mode.
5. If you have good quality test instruments, check the temperature and electrical conductivity readings of the solution adjacent to the probe and compare them to the logged values.
6. Document the details of the site, installation and water quality for future reference.

3.6 Connecting To Other Unidata Instruments

This instrument can be connected to any other Unidata Starlog data logger capable of using the SDI-12 option. To configure the instrument to be a Sensor, use the CDT Editor in Starlog Software. See the Section 6.5 Using The CDT Editor on page 15.

The «SQL» Connector socket details are as follows:

7 Pin Communications Plug			Computer Socket		Modem Plug
SQL Pin#	**Wire Colour**	**Signal Description**	**D25**	**D9**	**D25**
1	red & orange	+12V - Battery +ve	-	-	9 +12V
2	yellow	RxD (OUT) - RS232 serial data from Conductivity Instrument	3	2	2 TXD(IN)
3	black	TxD (IN) - RS232 serial data to Conductivity Instrument	2	3	3 RXD(OUT)
4	white	RTS(IN) - Request to Send	4	7	8 CD(OUT)
5	purple	SDI-12 Data In/Out - HSIO Clock & Counter 0	-	-	22 RING(OUT)
6	blue	OUT - Pump sampler - CMOS control HSIO data	-	-	20 DTR(IN)*
7 centre	green & brown	GND - Battery -ve / Signal ground	7	5	7 GND

To connect the instrument to the termination strip of a Starflow or Starlogger use the Model 6603/LE «SQL» cable. This cable has a plug to connect to the Conductivity Instrument «SQL» socket at one end and wires for the terminals of termination strip at the other.

To connect to a Starflow instrument, use the Model 6013K Starflow Termination strip and connect the conductivity instrument as though it were a second Starflow. See the appendices in the Starflow Users Manual for connection information, and SDI-12 operation.

To connect to a Starlogger, see the appendices of the Starlogger Hardware Manual 6244 for SDI-12 instructions.

4.0 USE AND MAINTENANCE OF THE PROBE

For best results, use of the Model 6536P probe with the Model 6536B.

4.1 Probe Connections

The following connections are used with the Model 6536B Probe socket.

Plug Terminal	Cable Colour	Function
1	Red	Thermistor
2	Yellow	Voltage – (inner electrode)
3	Black	Current + (outer electrode)
4	White	Current – (outer electrode)
5	Green	Voltage + (inner electrode)
6	Blue	Thermistor
7	Shield	Shielding

4.2 Probe Maintenance

Fundamentally, the conductivity measuring cell does not age. It is unaffected by natural waters. In industrial processes the cell's life can be shortened or the cell can even be damaged by excessive temperatures or corrosive measuring solutions such as strong acid and lye solutions, or organic solvents.

Contamination	Cleaning Solution	Reaction time at room temp.
Water-soluble substances	De-ionized water	any
Grease and oil	Warm water and household cleaning solution	any
at heavy contamination	Spirit	max. 5 minutes
Lime and hydroxide coatings	Acetic acid (10%)	any

A thorough cleaning is recommended for measurements of low conductivities.

5.0 SPECIFICATIONS

5.1 Instrument Specifications

EC Operating Range:	0 to 200,000uS/cm in three auto-ranged stages.
EC Accuracy:	±0.5% of reading between 1–100,000uS/cm.
EC Resolution:	0.01uS/cm.
Temperature Range:	-20 to 60°C.
Temperature Accuracy:	±0.1°C.
Temperature Resolution:	0.0612°C.
EC Temperature Compensation range:	0 – 60°C.
Channels:	Conductivity 0 – 200,000 (uncompensated). Conductivity 0 – 200,000 (temperature compensated). Conductivity 0 – 65,535 (uncompensated). Conductivity 0 – 65,535 (temperature compensated). Water Temperature. Battery Voltage.
Scan Rate:	5 seconds to 5 minutes (programmable).
Log Interval:	5 seconds to 1 week (programmable).
Memory:	120K CMOS.
Instrument Cable:	«SQL» cable with computer and battery connections.
Power Source:	Supplied by external battery 12V DC. Small solar panel ensures continuous operation. Instrument is reverse polarity protected.
Power Consumption:	55mA operating, 50uA standby Consumption: 0.1Ah per day (at 1 minute scan rate).
Housing Material:	ABS.

5.2 Probe Specifications

Sensor Type:	Four (4) Electrode, cocentric graphite.
Immersion Depth:	36mm minimum to total length (<80ºC) maximum maximum 120mm (<100ºC).
Pressure Resistance:	2 bar.
Cell Constant:	0.475cm-1 ±1.5%.
Connections:	Cable: 7-pin SQL» plug - IP67 Measuring Cell - IP68
Thermistor Type:	Integrated NTC (30k/25ºC)
Material:	Epoxy, black
Dimensions:	15.3mm diameter x 120mm long shaft 21.7mm diameter connection head. 162.5mm total length
Sensor Cable:	6 metres standard. Other available lengths are 1.5m, 3m, 10m, 15m and 20m.

6.0 USING STARLOG SOFTWARE

6.1 Installation

The Model 6536B Four Electrode Conductivity Instrument is fully programmable using Starlog Software.

6.2 Hi-Resolution And Low-Resolution Options

In the Model 6536B Four Electrode Conductivity Instrument there are two data logging options to suit different applications. The Hi-Resolution Instrument (4 byte) is the default when you create a scheme. If you prefer to configure the instrument for low-resolution recording, then you can add the Model 6536B/LR Instrument to the Scheme (and in that case, you will probably want to delete the Model 6536B from the Instrument List for that Scheme).

Model 6536B-Four Electrode Conductivity Instrument (Hi-Res)

To achieve the large range (0 - 200,000 us/cm) and high resolution of the instrument, conductivity is logged as a four byte value, displayed as EC (Electrical Conductivity) or EC.TC (Electrical Conductivity Temperature Compensated). You will need to ensure your data processing system can use four byte values.

Model 6536B/LR - Four Electrode Conductivity Instrument (Low-Res)

An alternative transducer can be selected with a reduced range, 0 - 65,535uS/cm, which is adequate for the range from fresh to sea water, logged as a two byte value displayed as ec and ec.tc. This instrument must be selected as the SDI-12 Sensor, if this is required.

The instrument always measures and displays the uncompensated electrical conductivity and temperature. A temperature compensated electrical conductivity is then computed and displayed. Default values of 2% per °C and 25°C are used to compute the Temperature Compensated Electrical Conductivity (EC.TC or ec.tc) shown on the screen. You can adjust these default values using the CDT Editor of Starlog Software.

Each Conductivity Instrument offers you the option to log any or all of the following:

- Uncompensated Electrical Conductivity.
- Compensated Electrical Conductivity.
- Water temperature (Temp).
- Battery Voltage (Battery).

Channel Definition

Address	Name	Units	Description
200	ec	1uS/cm	16 Bit
202	ec.tc	1uS/cm	16 Bit
212	Temp	0.0625ºC	Water Temperature
214	Batt	0.01V	Battery Voltage
216	EC	0.01uS/cm	32 Bit
220	EC.TC	0.01uS/cm	32 Bit

6.3 Scheme Definition

To use the Model 6536B Four Electrode Conductivity Instrument you first create a Scheme using Starlog Software.

The steps are:

1. Use the CDT Editor to set the reference temperature and compensation factor. For details, see Section 6.5 Using The CDT Editor on page 15.
2. Use the Scheme Editor to create a Scheme. From the list of Hardware options, select the Model 6536B - Four Electrode Conductivity Instrument and add it to the scheme.
3. If you want to use the low-resolution option, from the Instrument list, select the Model 6536B/OR.
4. Program the Four Electrode Conductivity Instrument with this scheme.

6.4 Transducer Details

The features of the Instrument, including its transducers, scaling details and so on, are shown in the following windows.

The Model 6536B Four Electrode Conductivity Instrument (Hi-Res) has the following transducers:

- Electrical Conductivity 4 Byte, (EC).
- Electrical Conductivity (compensated), 4 Byte, (EC.TC).
- Temperature.
- Battery.

Transducer details are shown below.

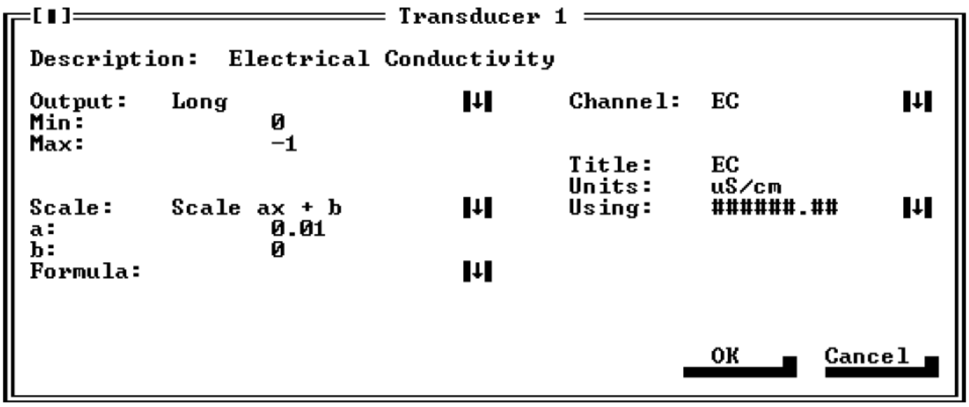
The Model 6536B/OR Four Electrode Conductivity Instrument (Low-Res) has the following transducers:

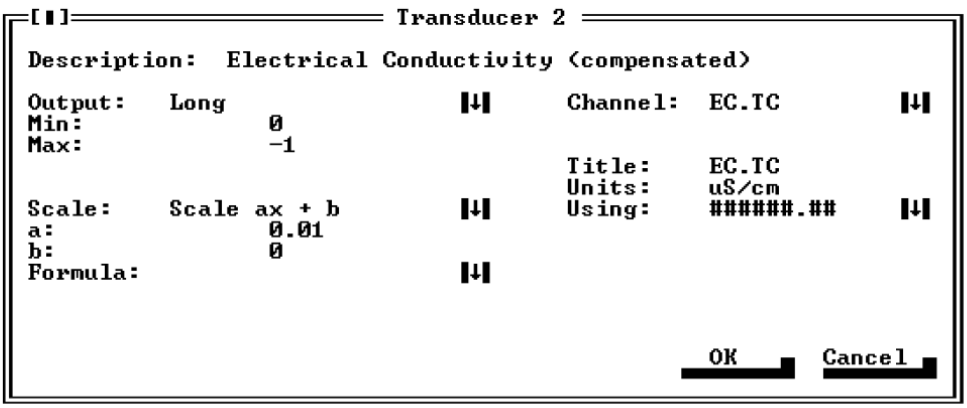
- Electrical Conductivity 2 Byte, (ec).
- Electrical Conductivity (compensated), 2 Byte, (ec.tc).
- Temperature.
- Battery.

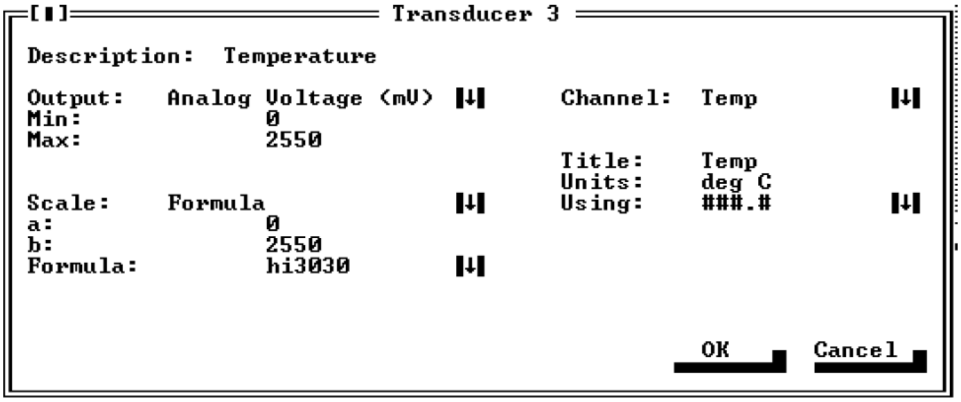
Transducer details are the same except Channel and Title are lowercase and Output is Word not Long for ec and ec.tc.

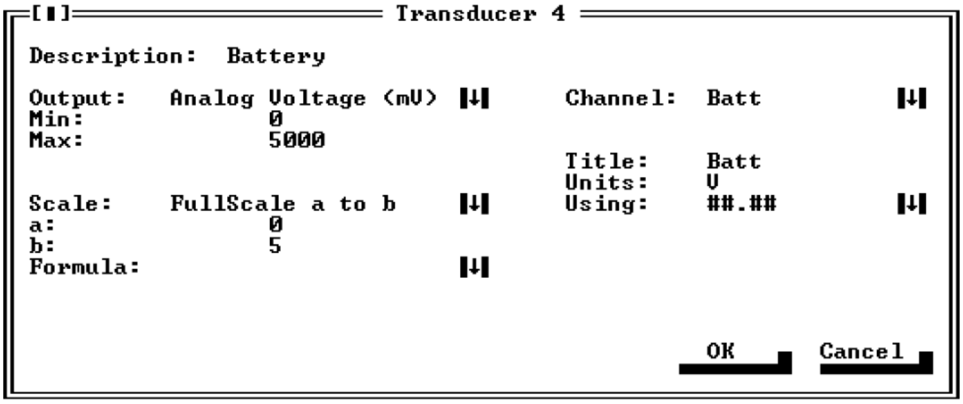
To convert to different units of electrical conductivity, the following may be entered in the transducer details next to the b of the scaling equation(ax + b), Units: and Using:

Units	Using	Scale b:
mS/cm	###.#####	0.00001
mS/m	#####.###	0.001
S/m	##.######	0.000001







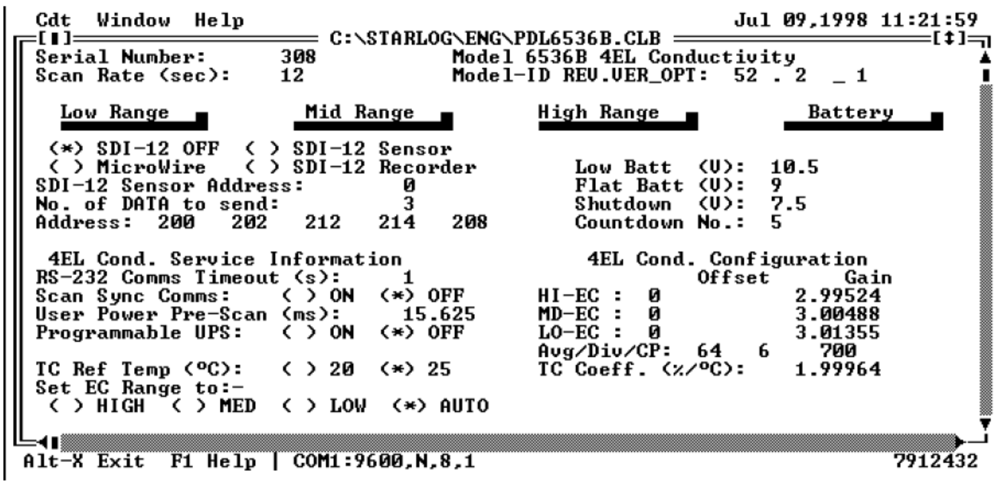


6.5 Using The CDT Editor

You need to use the CDT Editor in the Starlog Software Package to configure the Model 6536B Four Electrode Conductivity Instrument for conditions at your measuring site.

Do the following:

1. Select CDT Editor from the System Menu.
2. Then Upload the instrument configuration using Alt-U.



3. Choose the Temperature Reference used in your country; 20 or 25.

   Enter the Coefficient recommended for the solution you are monitoring. This is determined by laboratory testing of the solution.

4. These are the only factors you should need to set using the CDT Editor.

5. Download the new CDT to the Instrument.

6.5.1 Configure As An SDI-12 Sensor

To configure the instrument to be a Sensor, use the CDT Editor in Starlog Software.

Do the following:

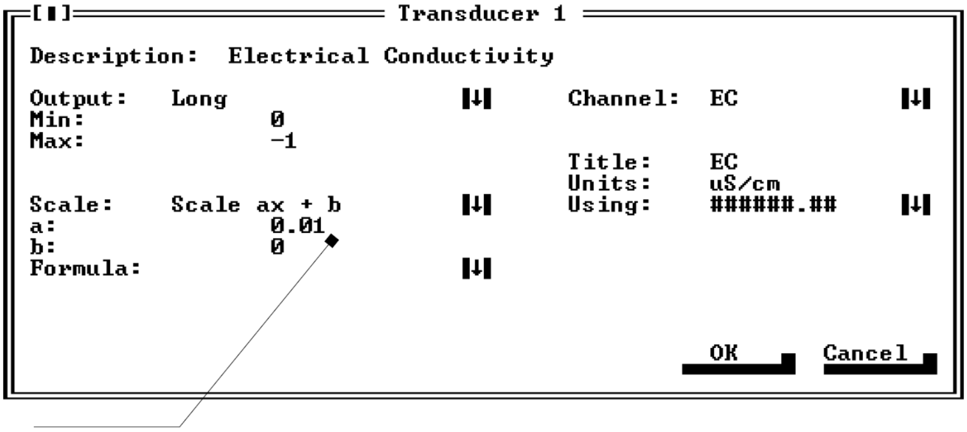
1. Select the SDI-12 Sensor option.
2. Enter the number of data to send.
3. Then check that the addresses listed are appropriate (see the Channel Definition table on page 13).

7.0 CALIBRATION

When it is manufactured the instrument is electronically calibrated in all ranges to an accuracy of 0.5% of reading through the range of 1-100,000uS/cm. This should be stable for the life of the instrument. It can be checked and adjusted by Unidata.

The probe is manufactured to have a cell constant of 0.475/cm +/- 1.5%. This can be checked by the use of known solutions, provided they are sufficiently accurate.

An incorrect cell constant will affect all readings by the same percentage error. If the EC or ec display in Scheme Test differs from your check solutions, adjust the transducer scaling. Remember this will alter the displayed and unloaded data from this site.



For example:
If calibration checks consistently show the logged conductivity is 1% high, adjust this factor to 0.0099 for each EC transducer.

For example: If calibration checks consistently show the logged conductivity is 1% high, adjust this factor to 0.0099 for each EC transducer.

8.0 APPENDIX A -TETRACON 325 PROBE

It is also possible to use the TetraCon® 325 Probe (manufactured by WTW) with the Model 6536B.

8.1 A - 1 Probe Connections

The manufacturer's plug has been exchanged to suit the Model 6536B Probe socket. The following connections are used -

New Plug Terminal	WTW Cable Colour	Function
1	Brown	Thermistor
2	Black/Blue (Blue)	Voltage – (inner electrode)
3	Grey	Current + (outer electrode)
4	White	Current – (outer electrode)
5	Black/Black (Pink)	Voltage + (inner electrode)
6	Yellow	Thermistor
7	Screen	Analogue Ground
	Green	Unused