manual

SiltProfiler

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WL | delft hydraulics

SILTPROFILER

Contents

1 Introduction

This guideline document gives a concise description of the SiltProfiler and information required for operational use. The guidelines are primarily intended to support the user and operator of the SiltProfiler instrument. The intricate technical details of the design are not addressed.

The Chapter 2 Description introduces the main components of the system. The subsequent Chapter 3 Installation, elaborates on the installation of the user interface and the hardware. The functions of the user interface are addressed in Chapter 4 SiltProfiler User Interface. A brief description of the sensors is given in Chapter 5 Sensors.

Aspects about maintenance are covered under Chapter 6 Maintenance and last Chapter 7 Calibration describes a number of calibration methods.

2 Description

A description of the SiltProfiler in this Chapter is presented from the user's perspective. The main components, viz.
1. Profiler instrument,
2. Power supply and communication
3. User Interface

are addressed in this sequence.

2.1 Profiler Instrument

The SiltProfiler instrument is a frame with sensors that is dropped through the water column.

The instrument structure comprises a heavy steel bottom ring of hexagonal shape. This ring supports the instrument while on deck and acts as a protection to the sensors at impact on the bed. The hexagonal ring is also heavy to give the instrument sufficient weight and a low centre of gravity. Three flat steel bars are bolted to the upper structure, i.e. the stainless steel protection container cum instrument body.

Six holes in the bottom of the instrument body pass sensor cables to the inside. At the top end of the instrument body a removable hinge with a hoisting eye is attached. A plastic cylinder (the electronics container), partly protruding from the upper end of the instrument body, contains the electronics. Normally, when in operational use, the electronics container is kept in place by three ty-raps and also the hinge prevents the plastic cylinder to escape from the instrument body. At the lower end of the electronics container, that is inside the instrument body, the sensors are connected to water proof bulkhead connectors. The sensors proper are attached to a sensor support frame below the instrument body. The elevation of the sensor support frame can be adjusted vertically.

Five sensors are attached to the sensor support frame. Two light extinction sensors in a single housing are fixed by four Allen bolts inside a rectangular support bracket at the lowest end of the sensor support structure. The other sensors (temperature, conductivity and pressure) are attached to the sensor support structure by ty-raps. All sensors are pointing down.

The two light extinction sensors are fitted with flow guidance cylinders; the flow guidance should be below the sensor. One light extinction sensor has a light pass length of 5 mm (for high concentrations) and the other sensor has a light pass length of 30 mm to measure moderate concentrations.

The electronics cylinder contains interfacing electronics for the sensors and a data logger to control the power management, to acquire the sensor data and to communicate with the supervisor PC.

2.2 Power supply and communication

The instrument features a rechargeable battery for autonomous operation but can also be operated via an umbilical cable. The mode of operation (off, autonomous or umbilical) is determined by a waterproof power (cum communication) connector on top of the electronics container. Power supply is always via the power connector, even when the internal battery is used. The connector is identical to the one used on the RDI WorkHorse ADCPs.

The power modes are as follows.
off: a dummy connector is placed, hence, no connections are made. The dummy connector should be in place when the SiltProfiler is not in use to protect the contact pins of the top connector and to avoid short circuiting of the internal battery. Other wires are serve for ground and communication.
umbilical: two power wires are integrated in the umbilical, one wire is directly connected to the battery and can be used to charge the battery. A battery charger is connected to the umbilical connection box. The other power wire connects directly to the supply input of the SiltProfiler electronics. This wire can be used for external supply via a wall adapter or from another supply. The nominal supply voltage is 12 VDC, the absolute maximum supply voltage is 15 VDC; any higher voltage will result in damage to the electronics. Depending upon the load (operational mode of the SiltProfiler) and the supply voltage, the supply current can be as high as 500 mA.
autonomous: the SiltProfiler is brought in autonomous mode by connecting the internal battery to the supply input. For this a special 'power-on' connector is to be plugged on to the top connector. The power-on connector is actually a very short pigtail taking care of the required power connection; no other wires are connected though. Care should be taken not to loose the power-on connector.

The SiltProfiler monitors the power mode and sets the communication mode accordingly. In **autonomous** mode, communication is via a wireless connection. In that case no electrical cable is required, i.e. only a winch cable is needed for profiling and hoisting the SiltProfiler.

When in **umbilical** mode communication is via a wired serial line driver interface and power is derived from a wall adapter (mains) via the umbilical. At the operator's end the umbilical is connected to an interface box. The interface box on its turn connects to the serial interface of the operator's PC. Both the wireless and the serial line driver interfaces are enclosed by the interface box. A switch on top of the interface box selects between wireless and wired communication. It is the responsibility of the operator to put the switch in the proper position. The connection box also features an external battery charger and a connection cable for external power supply, e.g. via a wall adapter. The nominal supply voltage is 12 VDC.

The battery charger generates too high a voltage for safe operation of the SiltProfiler electronics, hence, it is not used for online power supply. However, the battery can be charged using the battery charger while the instrument is online and operating on the wall adapter / external supply (charger and wall adapter have to be engaged then).

The data logger communicates at a fixed baud rate (57600 baud) and applies 8 bits, no parity and 1 stop bit.

Datalogger software
To minimise the power consumption, the instrument supports active power management. Depending on the active state, certain features are switched on or off.

The data logger program operates in various states, viz.:
1. **at surface**
All features are switched off except the communication interface. When operating on the internal battery communication is via the wireless interface, when the umbilical cable is connected, the serial line driver interface is used. Via the user interface the operator may (de)activate one or more sensors, that is, he may switch sensor specific power on/off. Processing of user commands is supported while the instrument is 'at surface' state.

2. **armed (trigger)**
This state is entered when the operator sends the start pressure (depth) command. The SiltProfiler switches on the pressure sensor and monitors the actual pressure. As long as the measured actual pressure does not exceed the start pressure the SiltProfiler will stay in this mode. Processing of user commands is supported in 'armed' state. The supply for the extinction and conductivity electronics will be on to allow the electronics to settle.

3. **profiling**
As soon as the measured pressure exceeds the start threshold the SiltProfiler moves to the 'profiling' (dropping) state. All sensors will be in the power-on state but the wireless communication will be off to limit power consumption and to avoid possible interference with the measurements.

The 'profiling' state will terminate in one of several ways. Normally it ends when the pressure sensor measures decreasing pressure. To avoid unwanted early termination, e.g. due to waves, the termination threshold is set a 1 m (pressure decrease by about 10 kPa) above the maximum measured depth (in the pending profiling session).
The operator may also set a maximum depth threshold to terminate data collection.
Under exceptional conditions, e.g. in case the instrument is not recovered data collection will terminate after a time out.

When 'profiling' state is terminated all sensor supplies are switched off, except the pressure sensor.

4. **retrieval**
The 'retrieval' state is automatically reached when the 'profiling' state is terminated. The pressure sensor readings are monitored and upon reaching a pressure reading less than 300 the communication device (either wireless or serial line driver) will be switched on. Subsequently, the SiltProfiler starts transmitting 'READY' messages indicating that the data retrieval may be initiated.

Upon receiving the 'READY' message the user interface automatically executes the data retrieval / offload process. Obviously, the duration depends upon the amount of data that is to be transferred.

2.3 User interface

The operator controls the SiltProfiler via the user interface. Main steps in a measuring cycle are:
1. set-up of the instrument
2. initiation of a profiling session
3. retrieval of acquired profile data
4. inspection of collected profiles
5. conversion of binary data to ASCII / text

Note: when graphically inspecting collected files automatically a text file is generated.

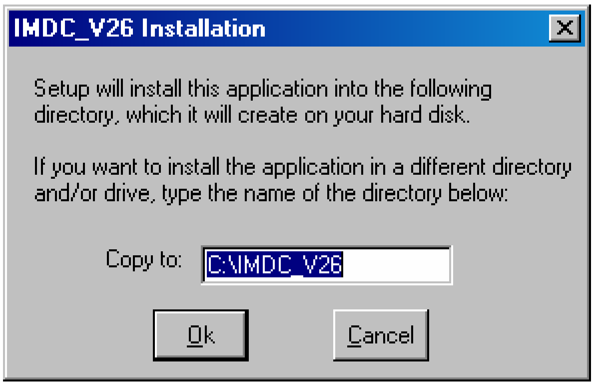
3 Installation

Before the SiltProfiler can be used the user interface software and the sensors and other hardware have to be installed. Next sub-chapters give brief instructions for software and hardware installation respectively.

3.1 Software

The user interface is based on the TestPoint environment. The installation is straight forward:

1. Execute Setup.exe from the directory with the installation files. A window similar to the following will popup. Accept the suggested directory path or type another path and press Ok. All required files will copied to the indicated directory.



2. After finishing the installation, a window showing an icon of the application. This icon may be dragged to the desktop for easy start-up.
3. The user interface is ready for use now.

- A file named 'imdc.ini' in the Windows directory contains application specific details. At first time start up it will be filled with default data. This file will become visible when the user interface is closed for the first time and changes were made.
- At installation and under use no changes are made to the windows registry.

3.2 Hardware

Installation of frame and sensors is fairly straight forward, special attention should be given to the cables, in particular inside the protection container.

assembling the frame

The stainless steel cylinder which contains the electronics module is mounted at the high end of the frame. The ss cylinder is supported by three heavy bars; the latter are firmly bolted to the flanges in the cylinder. The bars on their turn are bolted to the hexagonal bottom ring; while idle on deck, the instrument may rest on the ring. Take care to use self locking nuts to avoid unexpected loss of frame elements. All sensors are attached to a support structure in the open centre of the instrument (below the cylinder). The support structure can be adjusted in height by sliding it through two sets of clamps mounted on small flanges along the cylinder.

Normally the height of the extinction sensors is at about 15 cm above the bottom (while on deck).

The extinction sensors fit in the lower bracket of the sensor support. The rounded / streamlined edges of the extinction sensors should point down; this to allow the flow to pass smoothly through the sensors while the SiltProfiler is dropped to the bottom.

connecting the sensors

First the sensors are fixed on the sensor support frame. The extinction sensors are installed inside the rectangular bracket and fixed with small bolts. The streamlined edges on the sensor should face down. The other sensors may be ty-rapped to the two vertical support rods. Keep the sensors on the inside of the rods for best protection. The height of the sensor support frame may be adjusted as needed. If very close to the bottom the likelihood of damage due to stray stones or other bed material increases.

The connectors are only accessible when the plastic electronics container is lifted above the edge of the support frame. The hoisting bar has to be folded back then. Remove the top two bolts completely and just loosen the lower two bolts.

For each type of sensor a distinctive connecter is used, it is not possible to wrongly connect a sensor . However, the extinction sensors have identical connectors; hence, errors are possible but no damage will occur. The sensors are connected in the same sequence as they appear in the data message viz.:

1. temperature (2 electrical pins),
2. conductivity (5 pins),
3. long path extinction (6 pins),
4. short path extinction (6 pins) and
5. pressure (3 pins).

After connection (no connector should be left open) and carefully tightening of the locking sleeves, the electronics container may be put in place again. While doing so, gently pull the sensor cables through the holes at the lower end of the stainless steel body. When completely inserted three ty-raps may be used to secure the electronics container.

Gently push the excess length of the sensor cables back into cavity in the instrument body below the electronics container. The cables can be secured now with ty-raps.

power / communication connection

While handling the electronics container in the profiler body care should be applied to avoid damage of the sensor cables. In particular bending the cables close to the mouldings might result in broken wires. The power and communication connector bulkhead on top of the electronics container should always remain fitted with a mating connector to avoid short circuiting of the power / communication connector pins. Place the dummy connector when the instrument is not in use, place the power connector for autonomous mode or the umbilical connector for use on a cable.

NEVER lift the connector, **ALWAYS** push / pull in line with the contacts. If the connector is wrongly handled it may snap off. (See also RDI Workhorse manual)
A little silicone spray may be applied to reduce friction.

Several lengths of umbilical cable are included with the instrument. The longest section measures 50 m; it is an extension cable for connection to the instrument. however, it cannot be directly connected to the interface box. Since this cable may be submerged, both ends have water proof connectors, female on one end (for connection to the SiltProfiler) and male (inline version) for connection to another cable. There are two 'interface box' cables one of 25 m and one of 5 m length. The 'interface box' cables can be directly connected to the SiltProfiler or to the 50 m cable. In this way the following combinations can be made: 5m, 25m, 5+50m and 25+50m.

The 5m-version is primarily used for testing and charging of the battery package. The 25m-version can be used for profiling operation is not too deep water.

Both the 5m and the 20m-versions have a connector to connect to the interface box for power supply, charging and wired communication.

The SiltProfiler can be activated by either connecting an umbilical cable to the power – communication connector on top of the instrument or by placing the power connector. In the latter case the instrument is operated from the internal batteries and communicates by radio.

If an umbilical is connected the internal battery is not used and power supply has to come via the umbilical.

power / communication box
At the operator's end the serial port of the power / communication box is to be connected to the PC. Further the power supply has to be engaged. In case the umbilical is connected also the battery charger may be used (next to the power supply; the SiltProfiler does not operate from the battery charger but from the power supply only).

Also in case the communication is by radio the power supply is required. Obviously, the battery package cannot be charged then.

Put the communication switch on top of the power / communication box in the appropriate setting and the system is ready for use.

The operation of the SiltProfiler via the user interface is explained in next chapter.

4 SiltProfiler User Interface

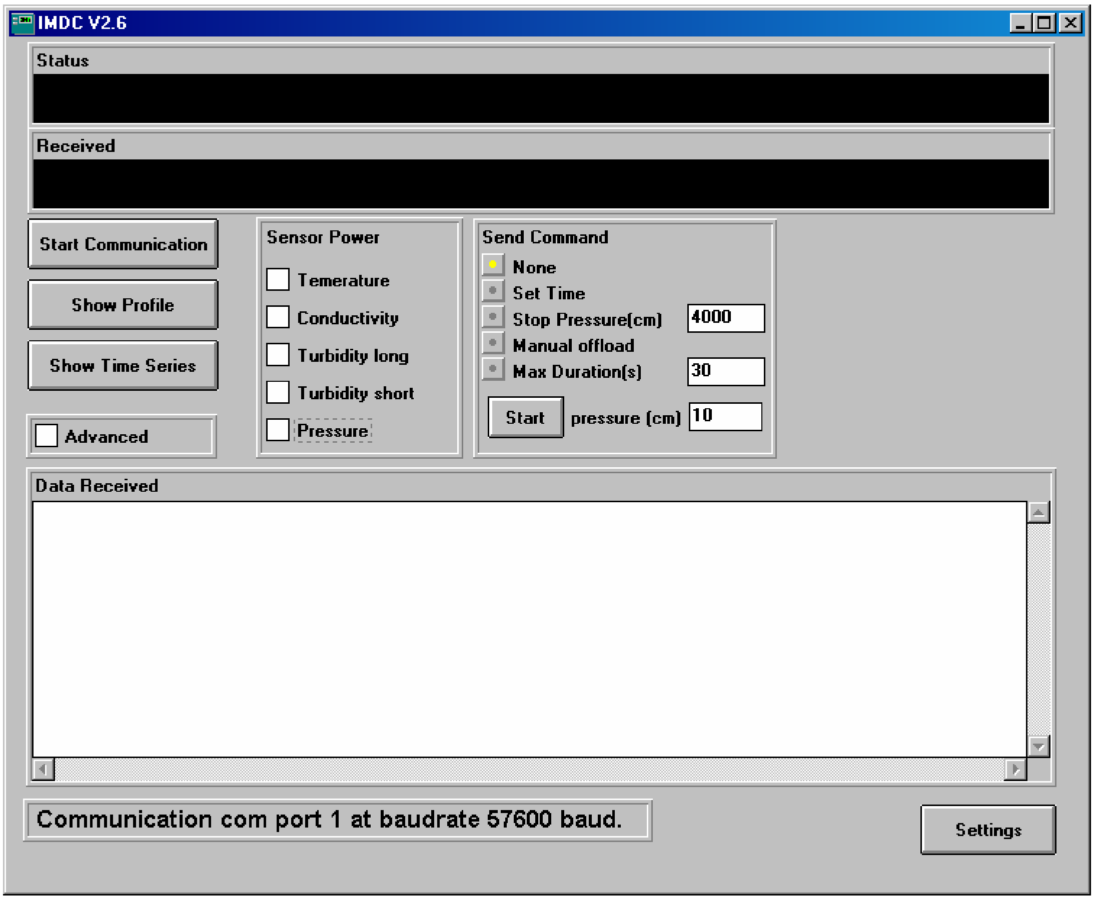
The SiltProfiler user interface is the main operating tool. It controls the communication between the operator's PC and the instrument.

The operator has access to several setting and control functions. Some are only available at a second level, e.g. the 'Settings' and the 'Advanced' features. There is a button to open the communication and another to start the measurements. Retrieved data can be visualized and converted from binary to ASCII by two 'Show' buttons. The progress of the communication is displayed in several windows.

Next chapters address the main functions and the their use.

4.1 Main window

At start-up of the user interface the main window as shown below is displayed.



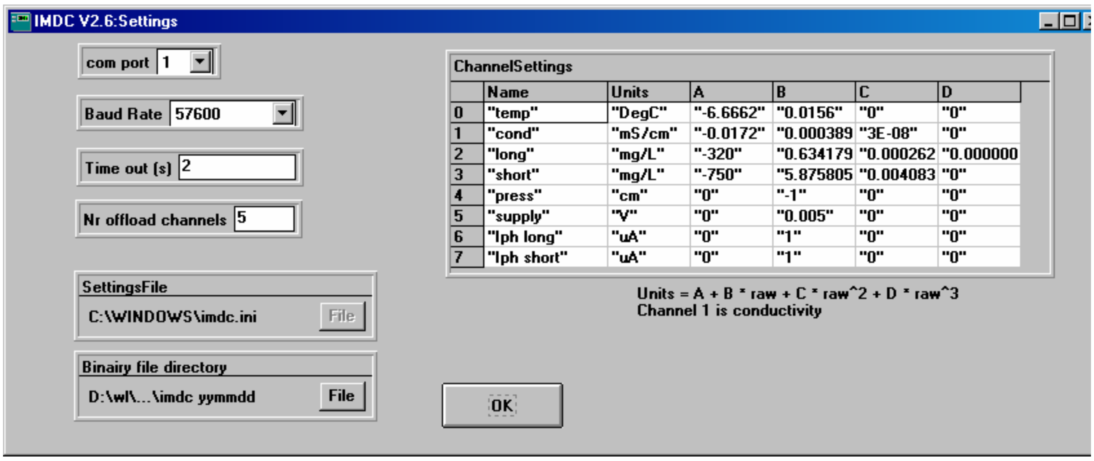
Next the various fields are explained briefly.

4.2 Settings

This button gives access to the settings window.

The parameters for the binary to ASCII conversion can be entered in this window. Also labels for parameter name and unit may be altered. Another section selects the communication port and the baud rate. It should be noted that the baud rate is of the SiltProfiler is fixed to 57600. The communication port and the baud rate are displayed on the main window.
The time out delay can be set, this affects the time before a software decides that communication fails.
The number of offloaded channels may be adjusted. In case 5 is selected only the sensor data is offload (if five sensors are connected), if 8 is selected all ADC channels will be offloaded, this takes more time. Two channels are test data and have no immediate use, the third channel is the supply voltage. Supply voltage is also collected via the ASCII data display.

The location of the setting file may be altered, default is c:\windows. The settings file contains the settings of the user interface, including the conversion coefficiens.



The binary file directory indicates where to find the binary data and is useful when converting the binary to ASCII.

4.3 Data windows

Five windows are associated with data communication. the following windows are permanently visible:

1. status
   This windows shows status messages like the 'Time out' messages.
2. received
   The last message received from the SiltProfiler is displayed in this window. While the SiltProfiler is in the 'at surface' mode sensor data are displayed this window. It should be noted though that only data obtained when sensor power is on is valid. The displayed values are in ADC units, i.e. the range is 0 to 4095. Each value is preceded by a label.
3. data received
   A brief history of all received data is displayed in this window. It is among others useful for monitoring the command exchange with the SiltProfiler.
4. engineering units
   The 'at surface' mode sensor data as mentioned under 2 (received) are converted to engineering units applying the conversion coefficients (entered under 'settings'). Special fields are 'time' and 'control'. The 'control' field displays the setting of the digital ports (power on/off, enable/disable) of the SiltProfiler.
5. raw
   In the 'raw' window the same parameters as in the 'engineering units' window are displayed, however, only as raw ADC values without conversion. This window is in

particular useful for calibration purposes. The 'raw' window is opened by selecting advanced.

4.4 Communication

The communication port and baud rate are selected under the 'Settings' button. Communication is opened by pressing the 'Open Communication' button. Subsequently, the button name changes to 'Close Communication' to indicate the new function of the button.

If 'Time out' messages are flashed in the status display the communication could not be established. To uncover the cause of failure the entire chain from PC to SiltProfiler may have to be accessed. Most import checks are listed below.

1. power supply to the communication / supply box
2. serial cable connected to PC
3. radio / cable selector switch on the communication / supply box in the right position

if communication via umbilical

4. umbilical cable connected to the communication / supply box
5. umbilical cable connected to the SiltProfiler (possibly via the an extension cable)

if communication via radio

4. power switch connector properly placed on the SiltProfiler. Occasionally, when the connector is inserted in a bouncing way the SiltProfiler may not start properly. If this occurs, remove the power switch connector, wait for say 15 seconds and insert is in one straight go.

4.5 Send Command

The operator may send commands to the SiltProfiler by selecting buttons in the 'Send Command' window. The commands are:

'Set Time'

The SiltProfiler has an internal clock, however, the clock has no back-up power and losses its settings when power is removed from the SiltProfiler. It is recommended to set time and date at startup. The time and date information is recorded in the header of the binary files.

'Stop Pressure'

When the pressure sensor detects a pressure that exceeds the 'stop pressure' data collection is ceased (provided that the instrument was in the profiling mode). Default value is 4000, i.e. the maximum value of the pressures sensor. The unit is cm. This is only a coarse setting because the measured pressure also depends upon barometric air pressure and the instrument zero offset.

'Manual Offload'

Should after profiling automatic data offload fail, manual offload may be activated by pressing the associated button. There is no distinction between automatically and manually offloaded files, except for the time of offload.

'Maximum duration'

The maximum duration of a profiling session may be limited by setting this value (in seconds). Data collection will cease after the set maximum duration. This setting is useful in case the instrument may be left at the bottom for some time. It should be noted that data collection will also stop in case the SiltProfiler is lifted by 100 cm above the deepest point / bottom.

'Start Pressure'

Because data collection starts as soon as the 'start pressure' is exceeded this button is the main activator of the SiltProfiler. The default value is 10 cm, to make to data collection start at greater depth a higher value is to be entered, taking the offset due to barometric pressure and instrument offset into account.

4.6 Sensor power

While in 'at surface' mode the SiltProfiler continuously transmit ADC data at a rate of a few times per second. The actual values have only meaning while the associated sensor receives power. Normally, at the surface' sensor power is switched of. By selecting the proper sensors in the 'sensor power' window any sensor may be activated (at the cost of increased power drain of the battery package).

4.7 Send Command Advanced

When 'Advanced' is selected, the operator may also set ports via the 'port on / off' buttons. Type the port numbers and toggle the required button to execute the port setting. Be aware that ports 5 and 6 should be low to enable the extinction sensors.

Also under 'Advanced' the sample time may be set. Sample time is expressed in ms. The minimum value is about 10 ms. The sample time may be tuned to the drop velocity (depending on the winch).

4.8 Show Profile

Collected binary profile data con be visualised in graphical form by this button. When selected the 'Profile Data' window emerges. The paths to the binary data directory and to the ASCII data directory can be chosen / altered by the operator.

When a file is selected (using the normal windows method) it is converted to ASCII and the results are recorded in a file with the same name but with extension. 'asc'. The data are also displayed in a profile graph.

Scaling can be automatic (auto scale selected) or manual. Scaling is in percent and may be adjusted by the operator by editing the X-scaling window (top right). Editing mode is activated by pressing the 'change scaling' button and changes are accepted by pressing the 'scaling ok' button. The table shows the values corresponding to 0% and 100%.

In 'auto scale' mode unexpected behaviour may occur. This caused by very high sensor readings when the SiltProfiler drops into mud.

Four traces can be (de)selected.

The displayed date and time are obtained from the file header (available from version V2.4 onwards).

4.9 Show Time Series

Sensor data can also be displayed in graphical time series format. File selection method is similar to 'Show Profile'. While converting a ASCII file is generated and saved in the directory as indicated under 'Show Profile'.

Only one trace can be shown at a time. Scaling is in engineering unit and automatic.

The Inspect button supports some zooming capabilities.

5 Sensors

In next paragraphs the implemented sensors are described.

5.1 temperature

Temperature is measured by a thermistor in a small stainless steel enclosure. The thermal properties of the sensor and its housing result in a fairly large response time (in the order of seconds) which prevents measurement of temperature microstructures.

The measuring range is -5 to +45ºC.

5.2 conductivity

Conductivity data are obtained using a four electrode type conductivity sensor. The electrodes are in direct contact with the water as opposed to inductive sensor type. Main reasons for using electrodes are the small measuring volume and fast response.

The measuring range of the sensor is 1 to 40 mS.

5.3 extinction (long and short)

The SiltProfiler supports two light extinction sensors; the sensors are combined in a single housing. Important features of the sensors are fast response and robustness. Profiling typically is a relative measurement, i.e. focus is on comparison of the readings taken in a profile and less on the absolute accuracy, therefore, the sensor design is optimised for speed and less for long term stability.

Basically, the sensor transmits infrared light through its measuring volume to an infrared photo detector at the opposing side of the measuring volume. The resulting light intensity over the measuring path is measured. The measured intensity as obtained from suspended sediment is compared with the intensity measured in clear sediment free water (reference measurement). The extinction is the decrease in measured intensity due to the suspended sediment. The natural logarithm of the light intensity ratio (sediment free / suspended sediment) is proportional to sediment concentration.

Both sensors have a similar measuring range when expressed in light intensity units. In the linear section of the measuring range the sensor reading is roughly equivalent to the number particles in the measuring volume. As a result, the measuring range increases with decreasing measuring volume, hence, the length of the light path. The sensor with the long light path (30 mm) has the small measuring and is intended for moderate concentrations. The sensor with the short light path (5 mm) can measure up to much higher concentrations at the cost of lower accuracy at low concentrations. The lower accuracy results in more zero drift and more noise when expressed in sediment concentration units, expressed in light intensity units both sensors feature similar stability and accuracy. The short path sensor has a measuring range exceeding 50 g/L and the long path sensor exceeding 8 g/L. It should be noted though that the actual measuring range strongly depends on the particle size distribution and the optical properties of the sediment. The sensitivity also depends upon the spatial distribution of the sediment particles, e.g. flocculation of the sediment will change the sensitivity.

It is essential that prior to starting measurements the reference (zero) reading of the sensor is established by taking a reading in clear water, preferable the same water as encountered at the measuring site after removal of the suspended sediment. The sediment can be removed by filtering or using decanted water after allowing the sediment to settle.

Both extinction sensors should be calibrated individually.

5.4 pressure

Pressure is measured with an absolute type pressure sensor with current loop interface. The absolute measuring range of the pressures sensor is 0 to 5 bar. The measuring range as a depth is reduced by about 10 m due the barometric pressure. To cater for the fluctuations of barometric pressure the operational measuring range starts at 900 hPa (displayed as 0 water depth) and ends at 4900 hPa (displayed as 4000 cm water depth).The effective measuring range is roughly equivalent to a water depth range of 0 to 4000 cm.

Keeping the sensor above the water surface and at a barometric pressure of 1000 hPa, the instrument will display 100 cm water depth. It is recommended to routinely check the above-water reading for correction of the recorded depth readings for barometric pressure.

5.5 optional sensors

Optionally, the SiltProfiler may be equipped with additional sensors. In the connector field below the Electronics Container, there is space for one more connector. All channels of the analogue-to-digital converter of the sensor controller are occupied; however, two channels are used for instrument development purposes only. One or both of these channels could be made available for additional sensors. To be thought off are a low concentration turbidity sensor, e.g. a backscatter type or a sensor for another profiling parameter.

6 Maintenance

The SiltProfiler is designed to be robust and tolerant to the operational conditions. However, some maintenance is required to maintain the required performance. In particular the electronics and sensors, batteries, connectors and cables, and metal parts need some care. Each of these categories is addressed below.

electronics and sensors
The electronics require no adjustment or other maintenance. The calibration of the instrument is fully covered by software.

The sensors are exposed to the environment and accumulate dirt which must be removed before it accretes in the sensors. While in operational use, first step in the cleansing process is to leave the sensors submerged, even during sailing from one profiling position to the other. However, care is to be taken to avoid collision with floating debris or worse.

Should mud stick to a sensor, it may be washed away by a moderate jet from a hose. In case the mud is persistent it may be carefully removed using a soft brush while spraying / jetting lots of water. Focus should be on avoiding scratching of optical windows of the extinction sensors; scratches will change calibration.

Mud between the (four) electrodes of the conductivity sensor may have a significant impact on sensor readings. NEVER use metal parts to remove mud or any other contamination. A tooth brush or similar may be used though. If needed the brush may be harder than the brush used for the extinction sensors.

The membrane of the pressure sensor is protected by a black plastic cone. A series of small holes around the cone allow the water pressure to enter. Holes may get chocked by mud. To remove the mud, the cone is to be unscrewed from the pressure sensor. The holes can be easily accessed then. In case mud enters the pressure sensor proper it should not be removed using any hard tool. Instead, the sensor may be carefully flushed with water. Persistent material may have to be kept wet for some time to soften it.

batteries
The battery package inside the electronics container should be switched off while not in use. The best way to do this is by placing the dummy connector on the bulkhead plug on top of the electronics container. To charge the battery the umbilical cable (preferably the 5 m one) is connected to the electronics container. The battery charger is activated by inserting it in a life power socket. The charging progress is indicated by a multicolour LED light. A small table on the charger body explains the meaning of the colours. The charging starts with a high current, after some time the current is decreased to avoid damage to the battery.

connectors and cables
Before connectors are removed or inserted, they should be clean. In particular when inserting a connector care should be taken to prevent dirt or water to enter. Some silicone spray may be used to reduce friction. Always push / pull straight in line with the bulkhead body. Avoid over bending / stressing of the cables, in particular the moulded sections (at the connectors and inline) should be handled with care.

Damage to cable jackets should be repaired before it is used again. If the damage occurs while submerged and water penetrates, the cable eventually may fail as a result of corrosion of electrical wires / contacts.

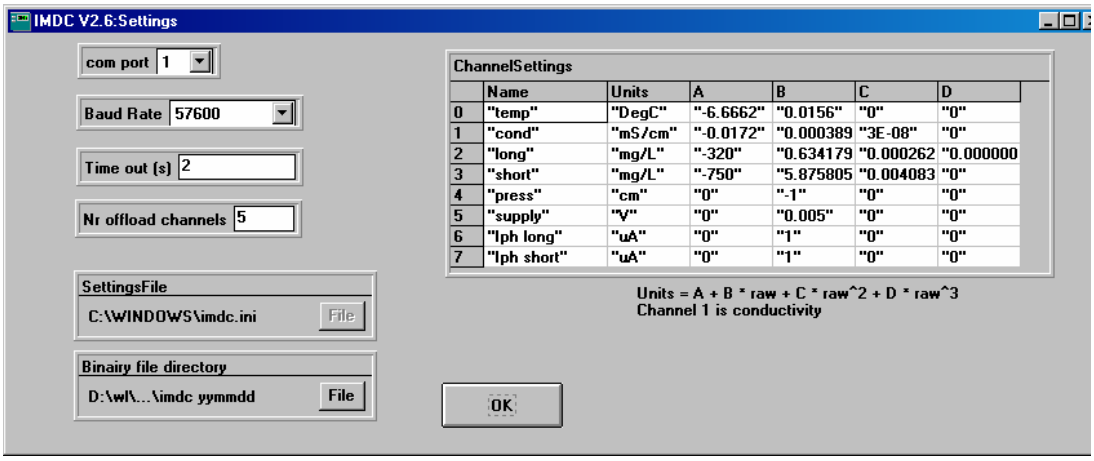
metal parts
Most metal parts are of stainless steel. Provided that instrument is only used for profiling and is not kept submerged permanently, no anodic protection is needed.

The hexagonal ring and the studs are of mild steel, occasionally they may need painting.

7 Calibration

For the conversion of sensor Analogue-to-Digital-Converter (ADC) samples to values expressed in SI units for each sensor conversion coefficients have to be established. Depending on the sensor type the conversion formula is of the first, second or third order. E.g. to convert ADC samples of the pressure sensor to actual pressure or depth values a linear (first order) formula suffices, for the extinction samples a third order formula may be needed.

In general, calibration is executed by subjecting the sensor to a series of parameter conditions, the equivalent values thereof are distributed over its measuring range. Simultaneously readings of the ADC are taken. For this the user interface has a special mode built in to support the calibration. To activate the calibration mode (also referred to as RAW mode) chose advanced in the main window. A 'column like' secondary window will appear. It displays sensor sample values in ADC units, i.e. ratio metric values ranging from 0 to 4095 (covering the 12 bit ADC range); the full input range of the ADC. At the bottom end of the RAW column the number of samples to average can be entered, the larger the number the better the signal to noise ratio but also the longer it takes to obtain a fully settled averaged value. The samples are collected at the update rate of the ASCII data in the 'Received' single line window pane, this allows assessment of the averaging time which is the product of the update rate and the 'Nr-averages'. The presented average is a moving average calculated of the last collected samples ('Nr-averages').



After calibration, the coefficients can be calculated using standard tools like Excel or similar. The obtained coefficients can be entered in user interface under the 'Settings' button. Enter A for the offset, that is the reading when the ADC sample is 0, B is the first order coefficient, C 2nd order and D 3rd order as shown in the example below. These coefficients are applied on the graphical output and the ASCII file. The coefficients are saved in the IMDC.ini file in the Windows directory.

7.1 temperature

Most conveniently, the temperature sensor is calibrated against a reference sensor. Both sensors have to be put in a well stirred calibration bin. Temperature may be adjusted step wise, e.g. around freezing point and heating the test bin at intervals. It is recommended to insulate the test bin to avoid rapid temperature change while collecting ADC samples.

7.2 conductivity

Like the temperature sensor, the conductivity sensor may be calibrated against a reference sensor. Adding plain salt (while reading the reference sensor and stirring) would be adequate to obtain various conductivity conditions.

7.3 extinction long

The extinction sensors can be calibrated in various ways. In the field calibration can be against readings of other instruments or by collecting (and analysing) water samples. In both cases the readings and samples have to be collected simultaneously with the SiltProfiler measurements.

For pre- or post deployment calibration in laboratory bottom sample material may be used. Special attention requires the separation between silt and typical bottom material like sand, shell and organic debris. It is assumed that the SiltProfiler while measuring on its way down to the bottom encounters silt but hardly sand.

1. One separation method is to wet filter the bottom sample, e.g. on 63 um filter and use the silt fraction for calibration. While filtering fresh water and a soft brush are applied to wash the silt through the sieve.
2. Dissolved salt is to be removed diluting and decanting. For this filtered silt material is caught in sizeable bin. Water is added to fill the bin completely and obtain maximum dilution. The material is well mixed and subsequently allowed to settle, e.g. overnight.
3. After adequate settling the top water is siphoned off as carefully as possible to avoid stirring up of the suspended silt. To assess salt contents the conductivity of the fluid may be measured. The dilution process is completed when the conductivity is just a bit higher than the conductivity of the used tap water (in the order of 0.5 mS/cm). The dilution process may be repeated a few times to obtain the required result. A last run could be made with demineralised water.
4. Subsequently all silt is collected and dried in a oven.
5. The dried material is crushed as fine as possible and subsequently grinded to silt flour. The same material needs to be grinded several times to reach the required fine material; eventually, the flour should have a smooth touch without hints of sand.
6. For calibration the extinction sensor is installed vertically and firmly in the calibration bin. This implies that the sensor is to be removed from its bracket. The suspension should easily flow through the measuring volumes of the sensors. Preferably, the calibration bin has spherical bottom to avoid corners where sediment could settle (or segregate). Two stirrers are needed, one egg shaped magnetic device and a mechanical (propeller) version. The calibration bin should be large enough to hold 4 to 5 L of sample. The amount of fluid in the calibration bin should be accurately known. Calibration can be executed using filtered (all sediment and other solid matter removed) water obtained at the survey site. Alternatively, demineralised water could be used. Flocculation may occur while the calibration is in progress.
7. The user interface is started and the calibration mode (Advanced) activated. A averaging duration of say 60 seconds would be adequate. This duration is selected by entering the nr-averages in the bottom filed of the RAW window.
8. Start with a zero reading before adding sediment to the calibration bin. Take care to avoid accumulation of bubbles on the sensor windows; it may be effective to allow the water to settle (several hours to a day) before it is used for calibration. Read and log the averaged values of both extinction sensors (long and short).
9. The calibration is executed by carefully weighing, adding and mixing the silt flour. A balance with a resolution of 0.1 mg would be needed. While weighing, the sample should be out of any AC induced draught. Best is using a special transparent box to encompass

the entire balance and sample. It is more important to know the precise weight of the added flour samples than to prepare samples of exactly the required weight. The latter is very time consuming and does not add to the accuracy. Care must be taken to ascertain that all sample is added to the calibration fluid; nothing should be left in the weighing container, on the water surface or the walls of the calibration bin.
This step is repeated as many times as needed. It is recommended to apply small increments at low concentrations and increase the increments at higher concentrations. The quality of the calibration can be monitored by entering the concentration values and readings in a spreadsheet and plot the results of each calibration step in a graph. At regular steps samples may be taken from the calibration bin for checking of the actual concentration.

7.4 extinction short

The 'short' extinction sensor has a much larger measuring range, hence, after finishing the calibration of the long sensor, calibration can focus on the short sensor only.

The higher the concentration of the suspension, the more difficult it becomes to keep it well mixed and completely in suspension. Also the noise of the readings will increase, among others due to turbulence and 'clouds' in the test bin. A side effect is that while the average ADC samples are still well below the maximum ADC value (4095), peak values may already exceed the maximum value. As a result the averaged value becomes biased (clipped) and appears to be lower than the actual value. Its occurrence is difficult to detect during calibration the calibration curve would show a tendency to bend away lower than expected values.

Due to its very measuring principle the zero readings of an extinction sensor require some special attention. The reason for this can be explained as follows. At fully transparent water (no sediment, colouring, etc.), hence at zero extinction, the maximum signal is obtained from the light receiver, i.e. the light transmission is at its maximum. A reading of zero is obtained by electronically subtracting a large and constant value (the 'clear water value') of the light receiver signal. This works fine when nothing changes in the sensor. In practice though, the electronic and in particular the optical properties of the sensor vary, e.g. due to aging, fouling, scratches on the sensor windows etc. Any change in / on the sensor would result in a changed reading (whereas the light transmission does not change). The built in 'clear water value' remains unaltered (it is not user accessible), hence, when the 'clear water value' is subtracted from the light receiver signal the result will not be zero anymore: the sensor offset has changed. E.g. a hair on the receiver window pane would result in a noticeable shift of the zero reading. This makes the extinction sensors sensitive to zero drift.

7.5 pressure

For calibration of the pressures sensor two methods could be chosen of. One by lowering the entire instrument to known depths while taking ADC samples. The actual suspension depth can be measured by attaching a (long) ruler tape to the SiltProfiler. The resulting conversion coefficient would also cater for the specific density of the water. A boat might be needed to reach sufficiently great depth. To cope with the rolling / pitching of the boat a large number of samples should be averaged to obtain stable values.

Alternatively, the pressure sensor may be calibrated against known pressures, e.g. generated by a pressure calibrator. To convert pressures in hPa to cm water column, the specific water density in the survey area has to be accounted for.

Under different tidal phases, the specific density of the water may vary, hence, the calibration coefficients may need adaptation to obtain accurate water depth readings. However, it is recommended not to alter the conversion coefficients but to correct the depth readings (if needed) during post processing.