Users Manual

Integrated Wave Sensor
and
Data Acquisition Unit

Version 3

Fugro OCEANOR AS
Pir-Senteret, N-7462 Trondheim, Norway
Tel: + 47 7354 5200, Fax: + 47 7354 5201, e-mail: oceanor@oceanor.com

OCEANOR Wavesense Users Manual				
Rev	**Date**	**Originator**	**Checked & Approved**	**Issue Purpose**
1	24 Sep 2008	SEAa	PS	Initial release, using Geni 3 Users Manual as start
2	26 Jan 2009	TS		Added option for storing raw data from wavesense

TABLE OF CONTENTS

1. Introduction

The Wavesense is a robust integrated wave sensor and data-logger designed for operation in remote locations, intended for use with battery and solar panel power. It features a high-end 32-bit processor and large internal storage capacity. Extreme mechanical robustness is achieved by use of robust aluminium housing, high quality connectors, components with extended temperature range and no moving parts. Proven Linux operating system and modular C++ application software take care of software reliability. Expandability is ensured by use of the PC/104 industry standard internal bus.

Wavesense is closely related to the Oceanor Geni datalogger. In fact it shares most parts, but it is equipped with an additional wave sensor board. It is mechanically different due to the mounting requirements of the wave sensor board.

Various versions of the Wavesense exists, depending on the requirements of the application. The main hardware differences between the versions are the number of external sensors that may be interfaced. Also the actual software will depend on the application. Both software and hardware may be updated to support new sensors and communication options. This manual describes all versions, but your version may not support everything described in this manual. Hardware versions currently available are:

- Wavesense – *fp6* Datalogger with internal wave sensor and
- Wavesense – *fp10* Datalogger with internal wave sensor and
- Wavesense – *fp11* Datalogger with internal wave sensor and interface as full version of Geni

2. Mounting

The sensor is labelled with the sensor axis definitions on the housing. These define the sensor oriented co-ordinate system, X, Y and Z, as well as how the sensor should be mounted in terms of North, East and Down. The software in the sensor assumes that the X-axis of the sensor is pointed towards what is defined as the North direction of the buoy, the Z-axis directly down and the Y-axis will then point in the East direction of the buoy. It is important that these directions are followed.

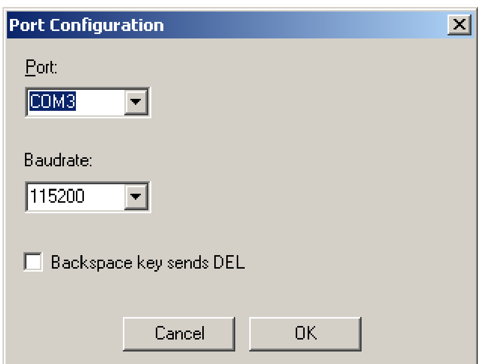
Care should be taken to mount the sensor in a mechanical stable way, vibrations must be avoided and the sensors Z-axis should point exactly vertically when the buoy is floating on the (still) water.

3. Connecting to the Geni

3.1 Alternative 1: Serial Line

The program for communicating with the Wavesense from a PC, via a serial line is called **gLink**. Normally the format of the serial line is RS-232, but in some cases the line from Wavesense may also be RS-422 making a 422-232 adapter necessary. The default serial port used by gLink is COM1, but this may be changed using the File -> Setup menu or by selecting the icon 

This brings up the dialog:



The correct baudrate is 115200 and the Backspace key sends DEL should be unchecked. (The Wavesense 2000 uses 19200 baud and Backspace key sends DEL checked)

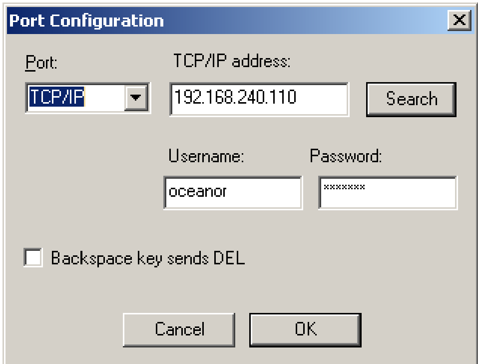
In fact when data transfer is not needed, any terminal program may be used. gLink is only needed for file up/down load. The default settings for the serial port are:

- 115200 baud
- no parity
- 8 databits
- 1 stopbit.

When the PC is connected, the user is required to log into the Wavesense. The user is prompted by the string ‘login’ from the Wavesense. Enter ‘oceanor<CR> and enter ‘oceanor’ as password. Once logged in the user may look at the latest measurements, run diagnostic programs or transfer data.

3.2 Alternative 2: Network connection

The Wavesense may also be connected to a 10/100base-TX Ethernet. Also in this case **gLink** may be used to connect to the Wavesense from a PC. Select TCP/IP in the setup dialog:

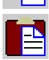


First time the Wavesense is connected the TCP/IP network address is not known. The Wavesense obtains its network address using DHCP. The DHCP server may be the standard network server when both the Wavesense and the PC is connected to a larger network, or in case the only equipment is the PC and the Wavesense, a network switch having DHCP server capabilities. To find the network address, press the Search button. This will populate a list of all Wavesense's in the network. The process takes some time, be patient! Finally enter 'oceanor' as both Username and Password.

3.3 gLink Terminal Mode settings

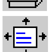
The gLink terminal window is shown in the Figure below. The buttons on the main toolbar perform the tasks (from left to right):

Copy selected text to clipboard. Menu: "Edit" "Copy". Keyboard: <Alt >e -> c .

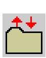


Paste selected text from clipboard. Menu: "Edit" "Paste". Keyboard: <Alt >e -> p.

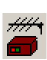
Print text in terminal window to default printer. Menu: "File" "Print. Keyboard: <Alt >f -> p.



Set terminal size variables in Linux terminal driver to actual size of gLink window. It is required to be on the command line of the Wavesense to do this, on the 'oceanor@geni… prompt. The window size of the terminal window may be varied freely. **Very important feature!** Menu: "Edit" "Size". Keyboard: <Alt>e ->s.

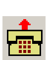


Change to file transfer mode (more about this in the next section). Menu: "Mode" "File Transfer". Keyboard: <Alt>m ->f. Requires connection to a serial port or network address.



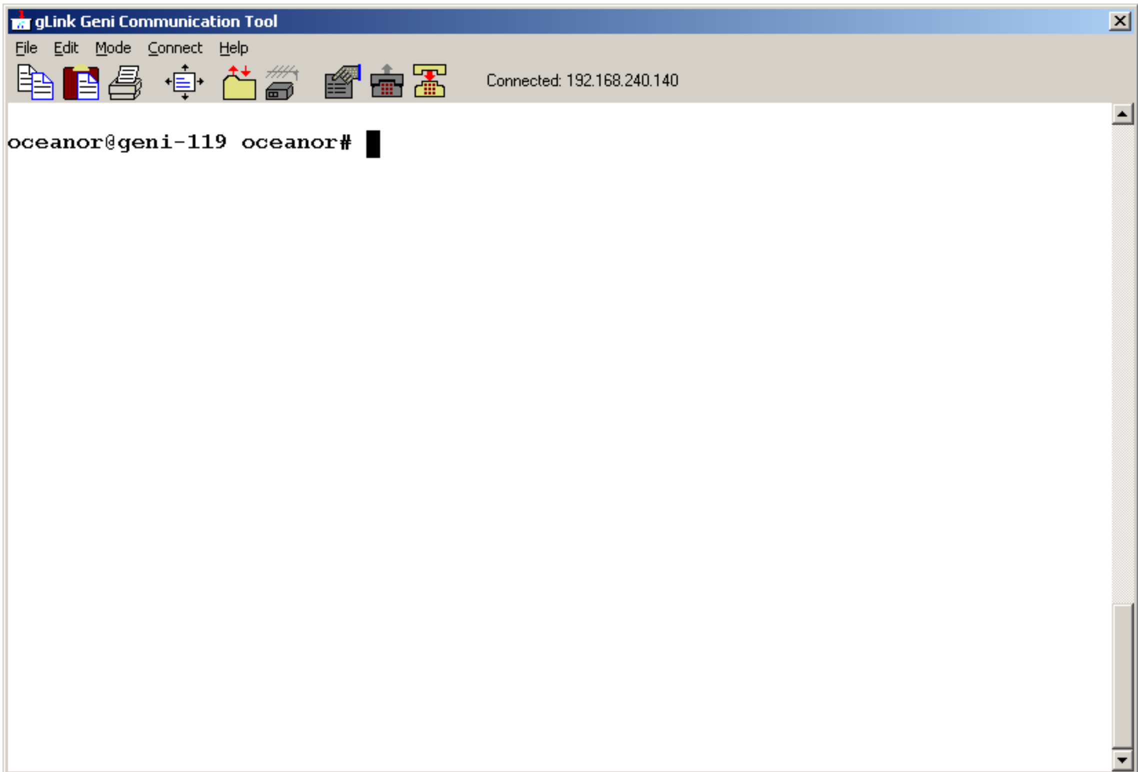
Change to data reception mode. This mode is detailed in section **Error! Reference source not found.**. Menu: "Mode" "Data Reception". Keyboard: <Alt>m ->d. Requires connection to a serial port.

Setup port configuration options. Used to select serial port or network address as discussed above. Menu: "File" "Setup". Keyboard: <Alt>f -> s. **Requires no connection** to a serial port or network address (use the disconnect button).



Connect to a serial port or network address. Automatically performed on startup and after setup port configuration. Menu: "Connect" "Connect". Keyboard: <Alt>c -> c. Requires no connection to a serial port or network address.

Disconnect from the current connection. Menu: “Connect” “Disconnect”. Keyboard: <Alt>c -> d. Requires connection to a serial port or network address.



4. Frequent tasks

4.1 Viewing system status in real time

To view the collected data in real time, connect a PC (or terminal) to the WAVESENSE via a serial port or via a network connection. From the command line prompt (oceanor@geni…) enter:

menu<cr>

this starts the menu program which at any time show the last measurement for all parameters in the database, various system messages and a list of processes running on the system. There are a number of options in the program which can be used by pressing keys:

TAB	Change to next window
+	Expand current window
-	Shrink current window
DOWN	Move cursor to the next line

UP Move cursor to the previous line
c Chat with serial sensor
a Monitor analog sensor
x Start/stop data acquisition

Commands in the process window
s Start data acquisition for the current process
i Stop data acquisition for the current process
r Restart the current process
t Terminate the current process
1 Enable more output for the current process
0 Disable more output for the current process
f Toggle filter to show only messages for current process

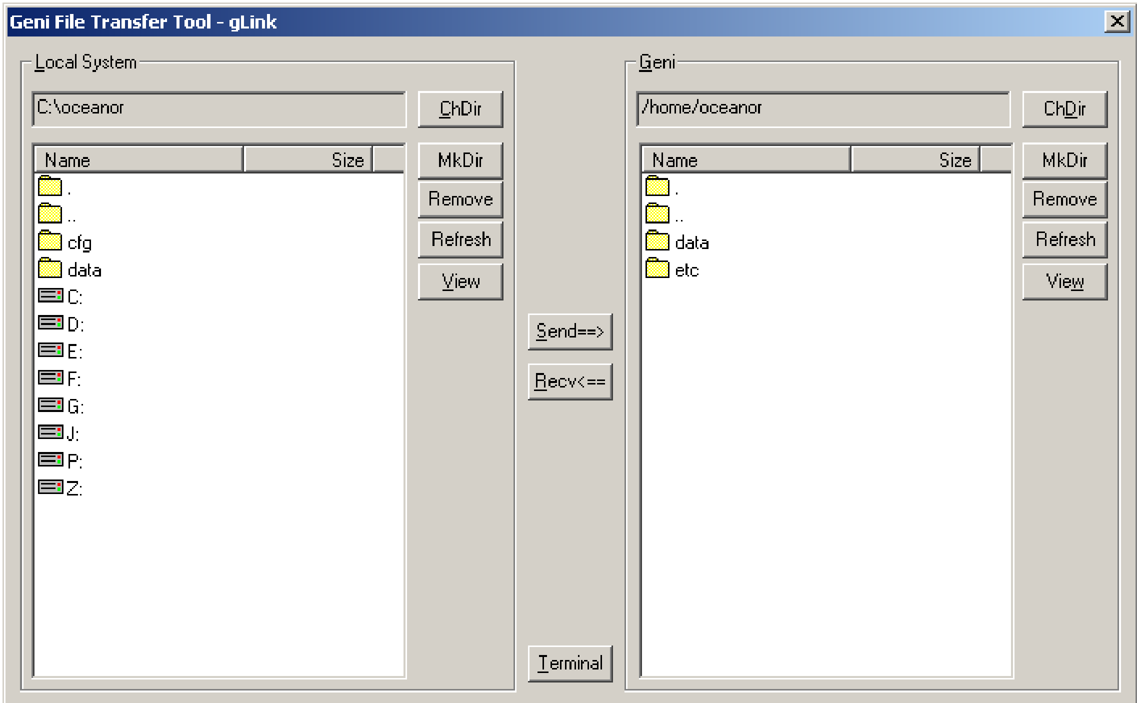
Commands in the log window
e Empty all log files
f Toggle filter. If filter is enabled only the messages from the current process is shown

Commands in the parameter window
s Start data acquisition for the process sampling the current parameter
1 Enable more output for the process sampling the current parameter
0 Disable more output for the process sampling the current parameter

4.2 Data and configuration up/down load

The gLink program has three modes, terminal mode, file transfer mode and data reception mode. In the terminal mode it acts as a standard terminal emulator, enabling the user to log in to the Wavesense. In file transfer mode it acts as a file transfer utility, enabling up/down load of data, program and configuration files. Data reception mode is used when gLink is running on a PC connected to a GSM or UHF modem in the data reception. To switch to file transfer mode, select 'Mode' and then 'File Transfer' in the gLink menu. Note that you have to be on the command line of the Wavesense to do this, that is on the 'oceanor@geni…' prompt.

The file transfer dialog is intuitive and presents a tree view of both the PC and Wavesense file systems, see the figure below.



Note that you may move in the directory trees by double clicking on the directory names, to move upward in the tree, double clicking on the '..' directory. To go back to terminal mode again, press the 'Terminal' button.

Logging in as oceanor means that your initial directory is /home/oceanor. There are a large number of other directories on the Wavesense. These all belong to the system and should not be changed. (the oceanor user have no permission anyway). Also they are located on a different storage medium and take up no space which could be used for data.

4.3 Load a new configuration

The system has a set of configuration files. These files completely describe how the system should operate. The software is in principle identical in all Wavesense systems. The set of configuration files are generated using the GeniCfg tool, described in section **Error! Reference source not found.**. When configuration files have been changed, they should be uploaded to the Wavesense using the file transfer dialog as described above. The configuration files must be located in:
/home/oceanor/etc

All configuration files are located in this directory. When new files have been generated (using GeniCfg) they should be copied to this directory (remember to backup the old ones!) To use the new configuration files it is required to stop and start the data acquisition to load the new configuration. This is done by pressing <x> in menu (answer yes), waiting a few seconds and pressing <x> once more.

4.4 Download data files

All data files generated are located in:
/home/oceanor/data

The files are typically named NNN.pff, where NNN is a number. The actual number on the files will vary from system to system and is further described in section **Error! Reference source not found.**. During service, the files should be copied to a PC using the file transfer dialog and the files deleted.

4.5 Correct the system date and time

Stop the data acquisition by pressing <x> in the menu program. On the command line enter:

date 123123592008.00

where the format for the date command is:
[MMDDhhmm[[CC]YY][.SS]]
CC
Century (e.g. 19 if the year is 1997)
YY
Year modulo 100 (e.g. 97 if the year is 1997)
MM
Numerical month of the year (01 for January, 02 for February, etc.)
DD
Day of the month
hh
Hour of the day
mm
Minute of the hour
SS
Seconds of the minute

Restart the system by entering on the command line:

shutdown –r now

5. Diagnosing the system in case of problems

The most important tool in diagnosing problems is the system message log file, **/var/log/messages**. If you contact Fugro OCEANOR technical support regarding problems, it is likely they will ask for this file. The directory /var/log also contains backups of older versions of this file, as well as other log files. During service, the files should be copied to a PC. The files should not be deleted but emptied using the menu program.

5.1 Show informational messages from one or more programs

In the process list window in menu, with the cursor on the program in question, press the <1> key. This will cause the program to show more information about its execution, not only the error messages in the message window. You may also press <f> to filter out messages from other programs in the log window.

5.2 Start a program outside of the normal execution cycle

In the process list window in menu, with the cursor on the program in question, press the <s> key. This will cause the program to start data acquisition immediately, not wait for the normal time of execution.

5.3 Serial sensor test and debugging

Press <c> in menu to communicate directly with a serial sensor. You will be prompted for power line that controls power to the sensor (if any), serial port, serial port setting and if you want to stop data acquisition. The safe option is to always stop data acquisition. However, if you know that the data acquisition from this sensor is not ongoing or going to start in the near future, you may choose not to stop data acquisition.

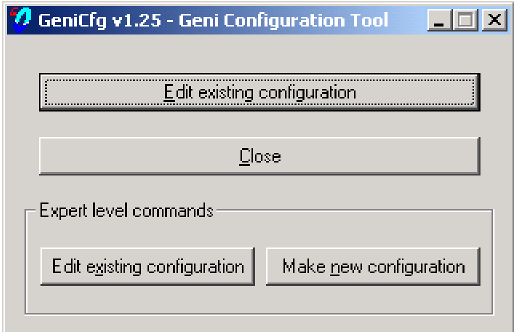
When all parameters above have been given, the sensor is connected to your PC. Commands may be entered to the sensor and the output will show on the screen. Enter <CTRL> B to exit sensor communication.

5.4 Analog sensor test and debugging

Monitor the voltage values output from an analog sensor by pressing <a> in menu. You will be prompted for power line that controls power to the sensor (if any).

6. Changing system configuration

The program for system configuration is called GeniCfg. Since the system software is built up in a modular and extremely flexible way, this means the user has to carefully configure everything by using the many dialogs of GeniCfg. To reduce the complexity, the program is organised as a wizard, leading the user through a number of steps. The program has two modes, User and Expert Mode, see the Figure below. The Expert mode is for making new configurations when the buoy is in the factory and for making radical changes to the configuration which normally involves hardware changes, adding new sensors etc. The User mode is for normal configuration of a system, changing location, name of parameters, resolution etc. **Do not use the program in expert mode only because you consider yourself an expert**.



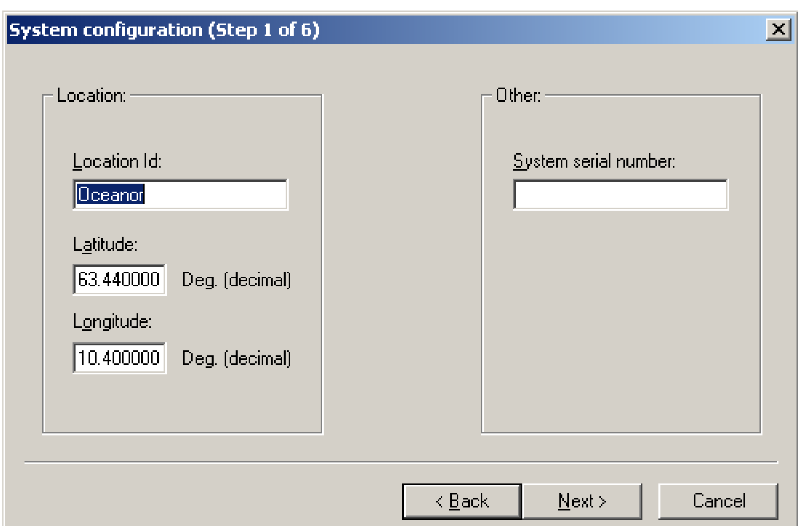
When the user selects to edit an existing configuration, a directory with xml files must be specified. For a new configuration the configuration will be empty, nothing measured, nothing calculated, nothing stored and nothing transmitted.

The wizard consists of a total of 6 steps.

1. System configuration
2. Data acquisition programs configuration
3. Data analysis programs configuration
4. Data transmission programs configuration
5. Data storage programs configuration
6. Finalising the configuration and writing new configuration files to a specified directory

6.1 System configuration

This step in the wizard is used to identify the system.



Location Id: Name of the location where the system is located. This is later used to identify the data.

Latitude and Longitude: Location in decimal degrees. This is later used to identify the data.

System serial number: Serial number string, used for book-keeping.

6.2 Common settings

Before going on to the next steps in the wizard, we will go through the settings which are common in many of the following dialogs.

6.2.1 Scheduling

The scheduling settings include:

- Acq. Int.. Time interval in seconds between each activation of the program. Synchronised so that the program will be run at all times during the day where the number of seconds since midnight is dividable by the acquisition interval. Actually the system counts time as seconds since 1/1 1970 so it is run at any time where seconds since 1970 is dividable by the acquisition interval.
- Start Time. Time interval in seconds which works as an offset to the acquisition interval. If for instance acquisition interval is set to 3600 and start time set to 3540, this will cause the program to start working at 60 seconds before every hour.
- #Samples. Number of measurements in one measurement cycle.
- Sample int. Time interval in ms between each measurement.
- Duration. Time interval in seconds specifies the maximum time the program has to do the job. If a program is not finished within this limit, it is stopped.

Example: Acq. Int is 3600 seconds, #Samples is 600, Start Time is 3000 and Sample Int. is 1000 ms means that the measurements will start at 10 minutes to the hour and last for 10 minutes, each measurement separated in time by 1 second (1000 ms).

6.2.2 Power management

Most of the data acquisition and data transmission programs contain a section for power management. If the option is checked, the power line, which the equipment is connected to, must be specified. Also a time interval in ms must be specified. This is the delay after the unit is switched on till the program starts to operate it.

6.2.3 Database channels

The data acquisition and analysis programs generate data that is stored in a memory location, the channel in the database. The name of this channel may be chosen freely. This channel will occur in the data storage programs where number of bits, lower and upper limit etc. will be specified. It is important to choose the name carefully and be consequent as this name will also appear in the presentation software when the data is to be presented to the user.

The channel configuration also frequently contains the following settings:

- Unit. Measurement unit, used in the presentation part of the system
- Type. Parameter type, used in the presentation part of the system
- Height.
- Scaling function
- Scaling constants C0, C1, C2, C3 and C4.

The possible choices for the 'Scaling' 'Function' along with the formulaes used are:

Polynom, X is output from sensor, Y is output (in any unit):

$$Y = C0 + C1X + C2X^2 + C3X^3 + C4X^4$$

Thermistor, X is output from sensor, Y is output (in deg. C):

$$Y = \frac{1}{C2 + C3\ln(C0 + C1X) + C4(\ln(C0 + C1X))^2} - 273.15$$

10Power, X is output from sensor, Y is output (in any unit):

$$Y = C0 \cdot 10^X + C1$$

Compass_sin and Compass_cos, X_s is sine output from sensor, X_c is cosine output from sensor, Y is output (in degrees):

$$Y = \operatorname{atan} 2\left(C0_s + C1_s * X_s, C0_c + C1_c * X_c\right)$$

Vector_Speed, X_n is north component of wind/currrent speed output from sensor, X_e is east component of wind/currrent speed from sensor, Y is output (in same units as from the sensor):

$$Y = \sqrt{X_n \cdot X_n + X_e \cdot X_e}$$

Vector_Direction, X_n is north component of wind/currrent speed output from sensor, X_e is east component of wind/currrent speed from sensor, Y is output (in degrees):

$$Y = \operatorname{atan} 2\left(X_e, X_n\right)$$

Vector_Direction, X_n is north component of wind/currrent speed output from sensor, X_e is east component of wind/currrent speed from sensor, Y is output (in degrees):

$$Y = \operatorname{atan} 2\left(X_e, X_n\right)$$

For Vector_Speed and Vector_Direction it is a relation between the order of the output parameters and the parameters from the sensor.

1) If the Vector_Speed parameter is the first, the order of the parameters from the sensor is north, east.
2) If the Vector_Direction parameter is the first, the order of the parameters from the sensor is east, north,.

Wind Direction, this function is used for the wind direction parameter when an Aanderaa SSU board is connected. The compass must be on the next channel in the SSU board.

Salinity, X_t is temperature in degrees Celsius and X_c is conductivity in mmho. It is important that the that the order of the parameters from the sensor is conductivity , temperature. The formula is as defined in the practical salinity scale 1978: e.l. Lewis, IEEE ocean eng. Jan 1978. Output from the formula is salinity in ppt.

Salinity_TC, same as Salinity except that the order of the parameters from the sensor is temperature, conductivity.

Royce_Temp. This formula is hardcoded in the software and no scaling constants are used. The formula is intended used with the Royce oxygen sensor. The output from the sensor is converted into deg. C.

Royce_O2. The formula is intended used with the Royce oxygen sensor. The output from the sensor is converted into mg/L of dissolved oxygen. The scaling constants are used for:

*C*0: nominal salinity in ‰. This is used to compensate the salinity values

*C*1: gain factor of signal amplifier (if present). Due to the low output signal of the Royce oxygen sensor, particulary when a thick membrane is used, a signal amplifier may be present.

*C*2: Scaling constant of the sensor. This parameter is automatically adjusted during oxygen sensor autocalibration

Conductivity. This formula is similar to the Polynom formula except that the output variable is temperature compensated. The temperature compensation is 2 percent decrease per degree celcius using 20 degrees celcius as zero point. The Royce_Temp parameter is used for temperature.

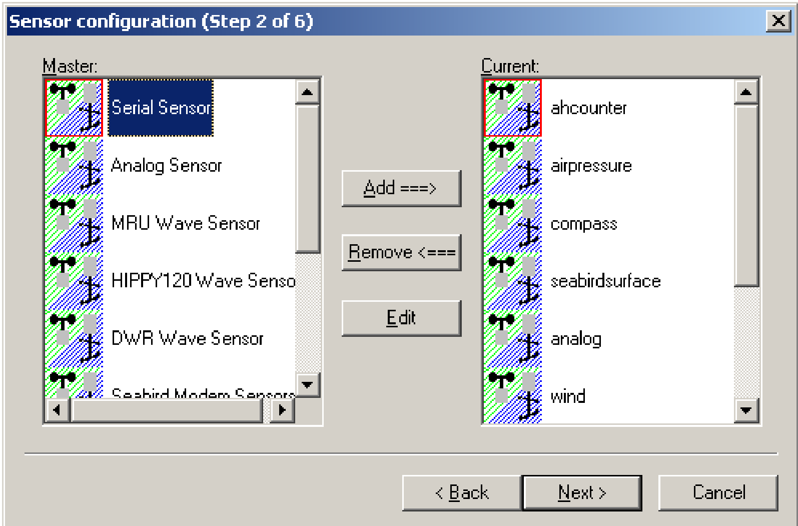
Ionic_Concentration. This formula is used for calculation of Nitrate concentration in water.

6.2.4 Serial numbers

Most programs have a serial number entry in the dialog box. This entry is not vital for the operation of the system, but is intended as a reference so that it is possible at a later stage to go back and find out exactly which sensor/equipment was in use at that time. This means it is a good idea to enter the correct serial number for all devices.

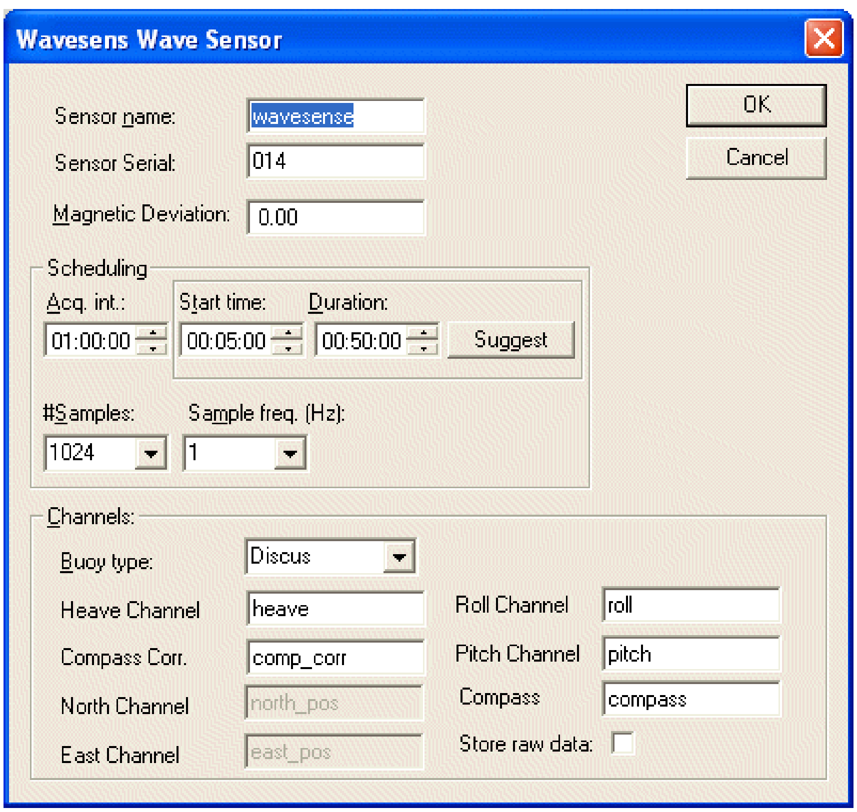
6.3 Sensor configuration

The sensor configuration dialog shows the possible sensors on the left and the selected sensors on the right. Sensor processes may be added, deleted or edited.



6.3.1 Wavesense Wave Sensor

Editing or adding a Wavesense sensor within geniCfg gives the dialog:



‘Magnetic Deviation’ is used to correct for compass deviation at a given location.

The scheduling settings include:

'Acq. Int.'. Time interval between each activation of the program. Synchronised so that the program will be run at all times during the day where the number of seconds since midnight is dividable by the acquisition interval. Actually the system counts time as seconds since 1/1 1970 so it is run at any time where seconds since 1970 is dividable by the acquisition interval.

'Start Time' Time interval which works as an offset to the acquisition interval. If for instance acquisition interval is set to 01:00:00 and start time set to 00:05:00, this will cause the program to start working at 5 minutes past every hour. Due to the sensor warm-up and filter algorithms the actual measurements will start 1 minute and 25 seconds later that 'Start Time'

'#Samples'Number of measurements in one measurement cycle.

'Sample freq' Sample frequency in Hz for the wave timeseries.

'Duration Time' interval in seconds specifies the maximum time the program has to do the job. If a program is not finished within this limit, it is stopped. This parameter is not user settable. The data acquisition always lasts for:

- 45 minutes and 31 seconds in case of '#Samples'=2048 and 'Sample freq.'=2 Hz.
- 22 minutes and 46 seconds in all other combinations of '#Samples' and 'Sample freq.'

When the acquisition is complete, the analysis phase starts and due to the complex algorithms, approx. 25 minutes is needed for calculations. The internal measurement frequency is always 6 Hz and the data is re-sampled at 1 or 2 Hz as the last operation in the analysis. Redundant measurements are purged from both ends of the time series so that number of measurements out is always 1024 or 2048.

Example: Acq. Int is 01:00:00, #Samples is 1024, Start Time is 00:05:00 and Sample freq. is 1 Hz means that actual measurements used for the analysis will start at 11 minutes 26 seconds past the hour and the output data is available approx. 53 minutes past the hour.

'Buoy Type' Select spar for Seawatch and Seawatch mini, and discus for Wavescan. Spar type gives the output data heave and relative position east and north. Discus type gives heave, roll, pitch, compass.

'Heave Channel' is the parameter name for the heave time series (unit meters).

'Compass Channel' is the parameter name for the compass time series (unit degrees).

'Compass Corr. Channel' is the parameter name for the compass data used in the wind direction and the current direction calculations in other processes (unit degrees).

'East Channel' is the parameter name for the relative east position time series (unit meters).

'North Channel' is the parameter name for the heave time series (unit meters).

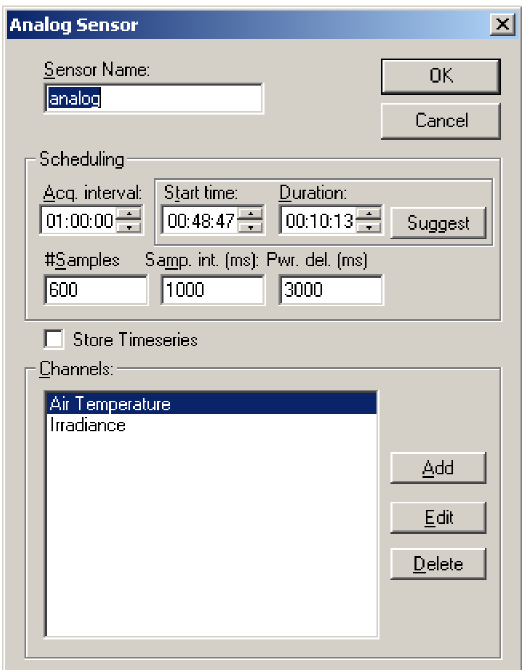
'Roll Channel' is the parameter name for the sine of the roll angle with respect to the horizontal plane time series (unit none, range [-1 1]).

'Pitch Channel' is the parameter name for the sine of the pitch angle with respect to the horizontal plane time series (unit none, range [-1 1]).

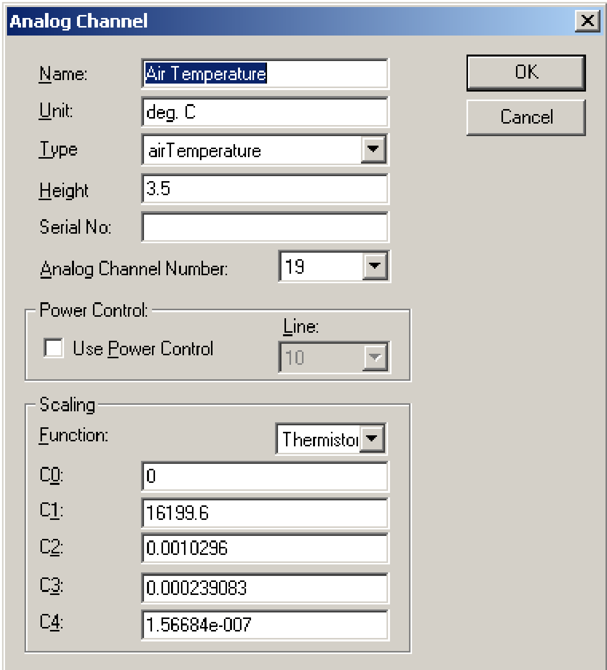
'Store raw data' Check this field to make the raw sensor data available. The following parameters will be available: acceleration-x, acceleration-y, acceleration-z, magfield-x, magfield-y, magfield-z, rate-x, rate-y, rate-z, temp-wavesense.

6.3.2 Generic analog sensors

Editing or adding an analog sensor gives the dialog:



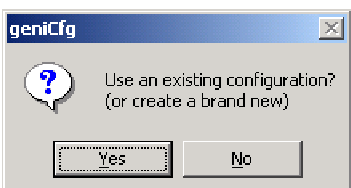
In this dialog the 'Store timeseries' setting determines if the process should store all '#Samples' data or just the average value. To add more sensors measured by this process, press the 'Add' button and the following dialog appears:



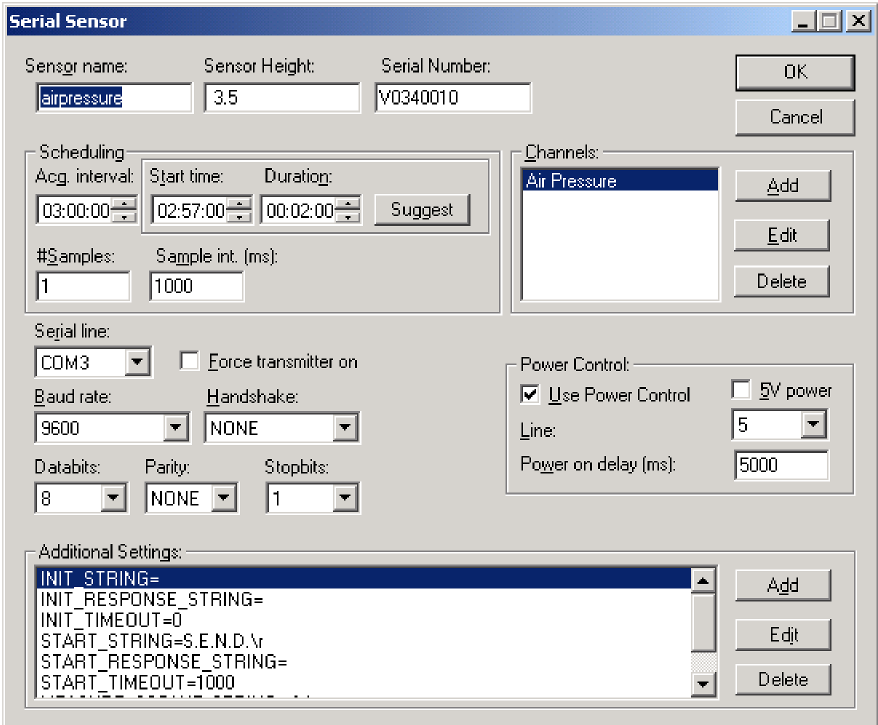
Important settings here is the 'Analog Channel Number' which is determined by the input the sensor is connected. The other parameters have been discussed previously.

6.3.3 Generic serial sensors

Adding a serial sensor gives the dialog:



Answering *No* in this dialog means creating a new sensor configuration. Answering *Yes* allows for import of an already existing sensor configuration from a different set of configuration files. A basic set of configuration files is included with the installation of GeniCfg. When the filename is selected, or by answering *No* in the dialog, or by editing a sensor the following dialog appears:



This process is made to fit most standard serial sensors on the market. It has most of the features listed under the analog sensor section, and in addition it has settings for the serial line and configurable commands used to communicate with the sensor.

Of the standard serial port configurations it is worth mentioning the ‘Force transmitter on’ setting which overrides the standard feature on the Wavesense serial ports, that after a certain period of inactivity on the port, the transmitter is turned off. Normally this setting can remain unchecked.

The ‘Addition settings’ section contains sensor specific commands:

- INIT_STRING: Command to initialise the sensor after power on
- INIT_RESPONSE_STRING: Answer from the sensor on the INIT_STRING
- INIT_TIMEOUT: Period in ms to wait for the INIT_RESPONSE_STRING
- START_STRING: Command to make the sensor start measurements
- START_RESPONSE_STRING: Answer from the sensor on the START_STRING
- START_TIMEOUT: Period in ms to wait for the START_RESPONSE_STRING
- MEASURE_SSCANF_STRING: This is a string describing the format of the data sent from the sensor. It is used as an argument to the sscanf function call in “C” and for a reference on the format use look in a “C” programming book.
- MEASURE_TIMEOUT: Period in ms to wait for the measurements.

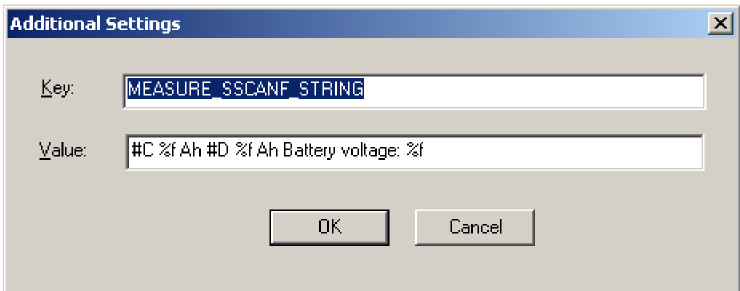
One important difference between the INIT... and START... commands is that the INIT... is given only once during a measurement cycle, whilst the START... is given before each sample. Both the INIT... and START... commands may contain ‘.’ letters which has the special meaning that it causes a 10 ms pause for each '.'. This is important to use for many sensors as they often contain micro controllers, which are not able to read the high data rate Wavesense uses.

Example of MEASURE_SSCANF_STRING:

The sensor sends out data on the following form:

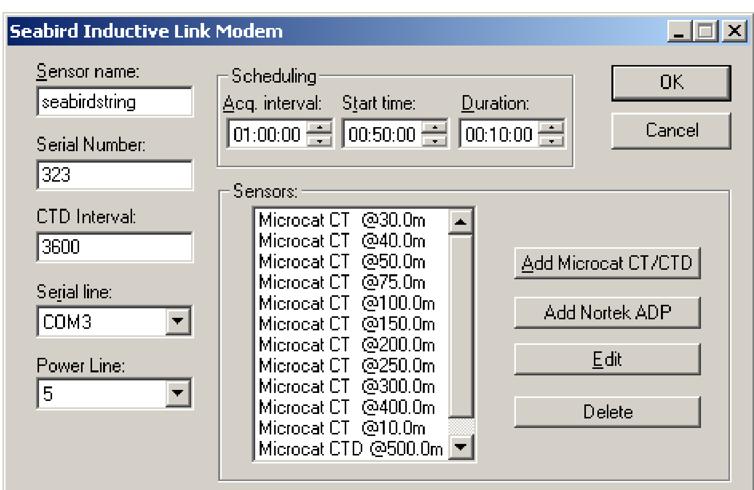
#C 1.05 Ah #D 2.10 Ah Battery voltage: 10.9

which means that the dialog must be filled in like:

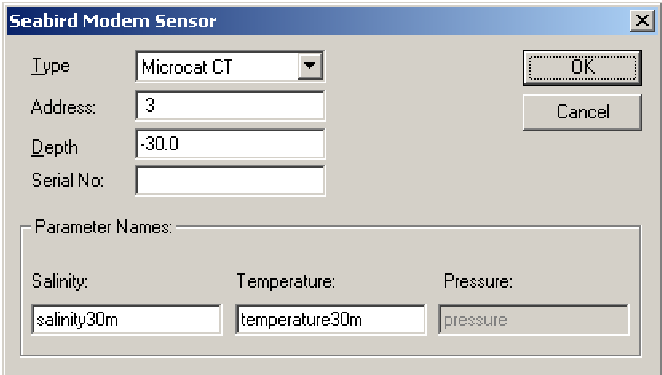


6.3.4 Seabird Inductive Modem

The underwater sensors connected to the Wavesense via the Seabird Inductive Modem is configured in the following dialog box. The Microcat CTD sensors and the Nortek ADP sensor are fully controlled by the Wavesense and setup by the Wavesense SW. The ADP and CTD sensors are run in a combined mode, both storing data internally and sending data to the Wavesense. The *CTD Interval* parameter specifies the internal logging interval of the CTD sensors. The data recorded/sent in the Wavesense is only at *Acq. Interval* time intervals.

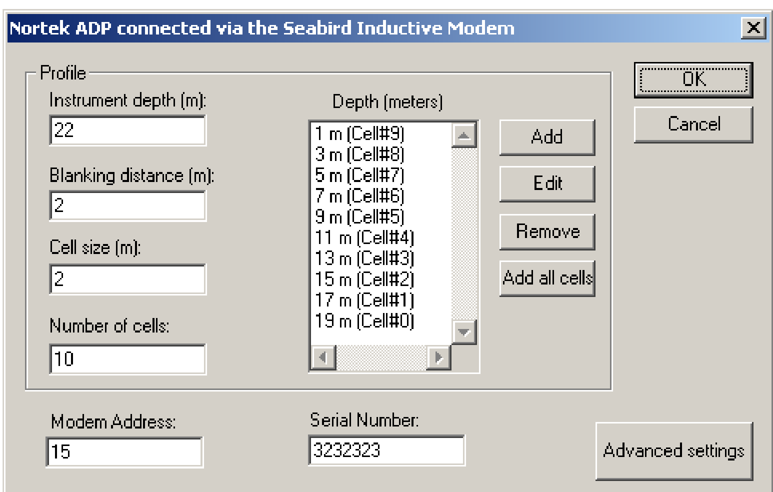


Sensors may be added, deleted and edited by the 'Add Microcat CT/CTD', 'Add Nortek ADP', 'Delete' and 'Edit' button. 'Add Microcat CT/CTD' and 'Edit' on a CTD sensor brings up the dialog:



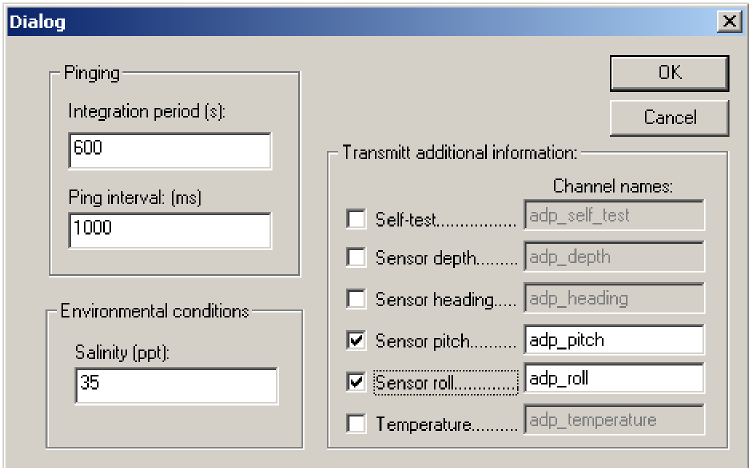
Where the sensor address (please refer to the Microcat manual for information how to configure the address), height (=-30 m for 30m depth), sensor type (CT or CTD) and database channels are configured. Please notice that the Wavesense SW calculates and stores salinity instead of conductivity.

'Add Nortek ADP' and 'Edit' on an ADP sensor brings up the dialog:



The ADP sensor is assumed connected via a Seabird Inductive Modem. The address of the modem on the inductive cable is configured in the *Modem Address* field. The profile measured by the ADP is set by the *Blanking distance*, *Cell size* and *Number of cells* fields. These should be set according to the actual location and within the limitations given in the ADP Users Manual. Please refer to the Nortek ADP documentation. The actual depths where the current speed and direction is registered in the Wavesense is determined in the *Depth* list box. Please note that these can be (and in most cases will be) a subset of all measured depths of the current profile.

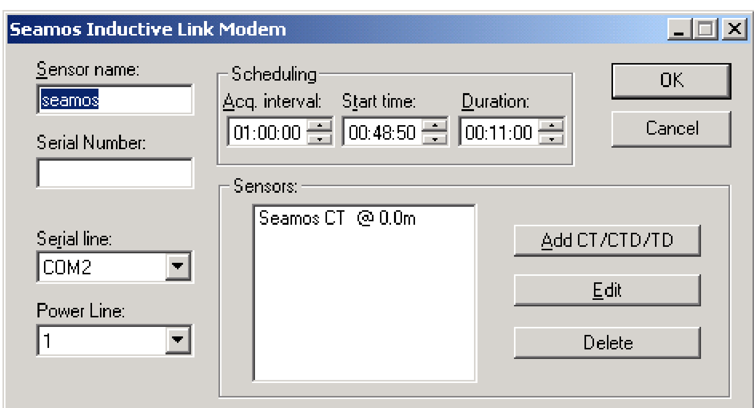
Pressing the 'Advanced settings' button brings up the dialog:



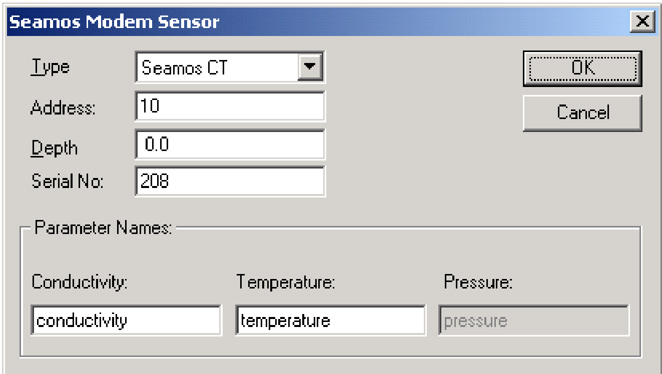
Here, the nominal *Salinity* of the deployment site, the *Integration period* and the *Ping interval* must be entered. If the sensor is setup to integrate over 600 s and the *Ping interval* is 1000 ms, this means that the data will averaged over 600 pings. Storage/transmission of some of the other parameters measured in the sensor may also be selected in this dialog.

6.3.5 Seamos Inductive Modem

The underwater sensors connected to the Wavesense via the Seamos Inductive Modem is configured in the following dialog box. The Seamos CTD sensors are fully controlled by the Wavesense and setup by the Wavesense SW.



Sensors may be added, deleted and edited by the ‘Add CT/CTD/TD’, ‘Delete’ and ‘Edit’ button. ‘Add CT/CTD/TD’ and ‘Edit’ on a CTD sensor brings up the dialog:



Where the sensor address (please refer to the Seamos SeaProfiler USER GUIDE for information how to configure the address), height (=-30 m for 30m depth), sensor type (CT, PT or CTD) and database channels are configured. Please notice that the Wavesense SW calculates and stores conductivity and not salinity.

6.3.6 Wind sensor

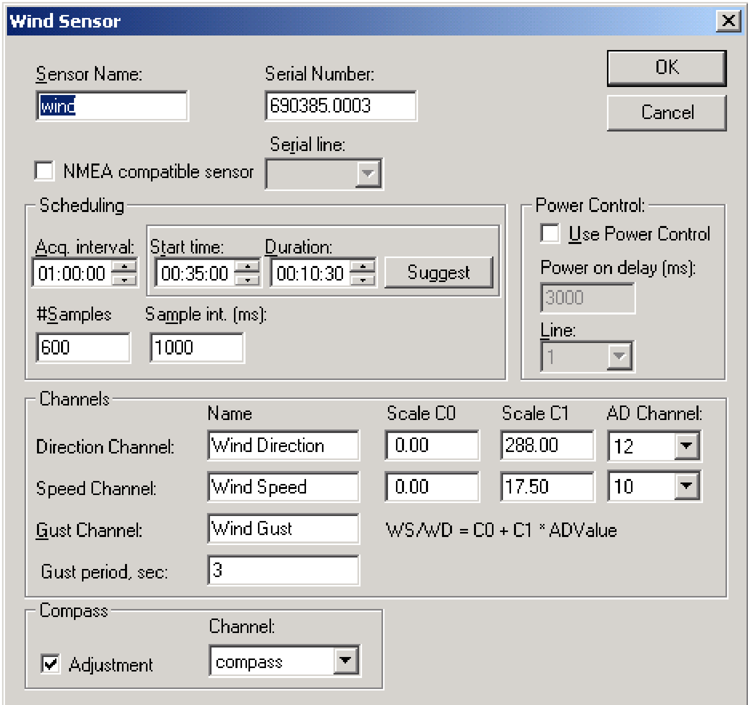
The wind sensor process is used to interface to wind sensors having analog or frequency outputs and sensors having serial output. The process uses a WMO compliant analysis method, giving out average wind speed in the interval, vector average wind direction and a configurable period of the calculation of wind gust (Default 3 sec). There is also an option for compass adjustment of the wind direction.

To select a serial output sensor, check *NMEA compatible sensor*, else a analog or frequency sensor is assumed. Serial sensors are assumed to output NMEA 0183 compatible measurement strings. Examples are:

$WIMWV,120,R,002.10,M,A*4F<cr><lf> (Vaisala WS425)

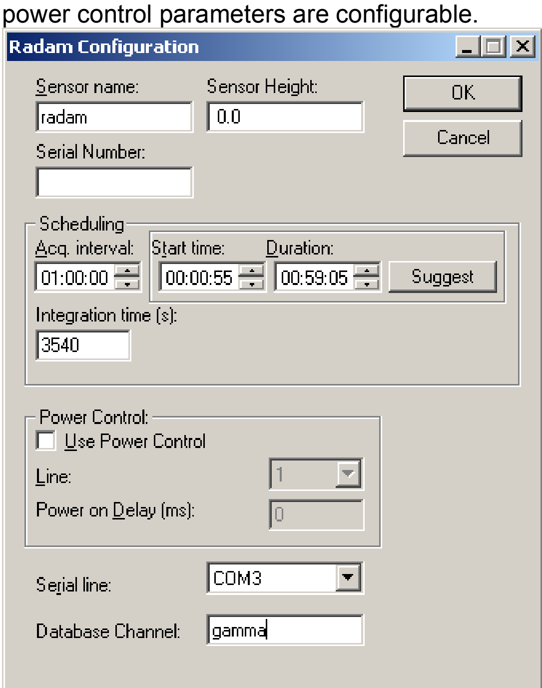
$ IIMWV,120,R,002.10, M, A,*5D<cr><lf> (Gill Windsonic)

It is also assumed that the the sensor is set up to use 4800 baud, no parity, 8 data bits, 1 stop bit. The data strings should be sent from the sensor automatically every *Sample int.* ms. The data should be averaged over *Sample int.* ms internally in the sensor (i.e. no additional averaging, the software will calculate gust values).



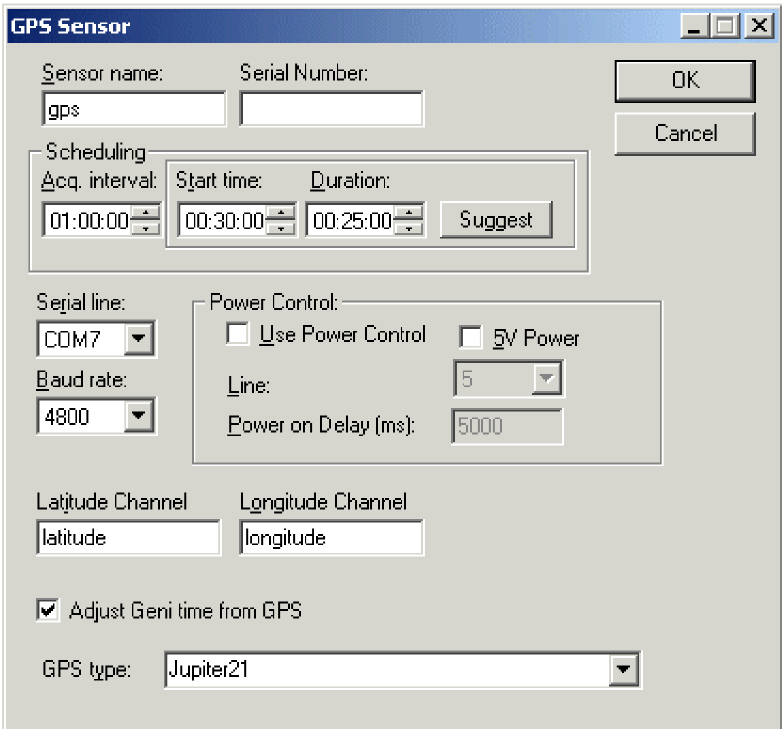
6.3.7 Radam Gamma radiation sensor

The radam gammma radiation sensor process requires few settings, only scheduling, serial line and power control parameters are configurable.



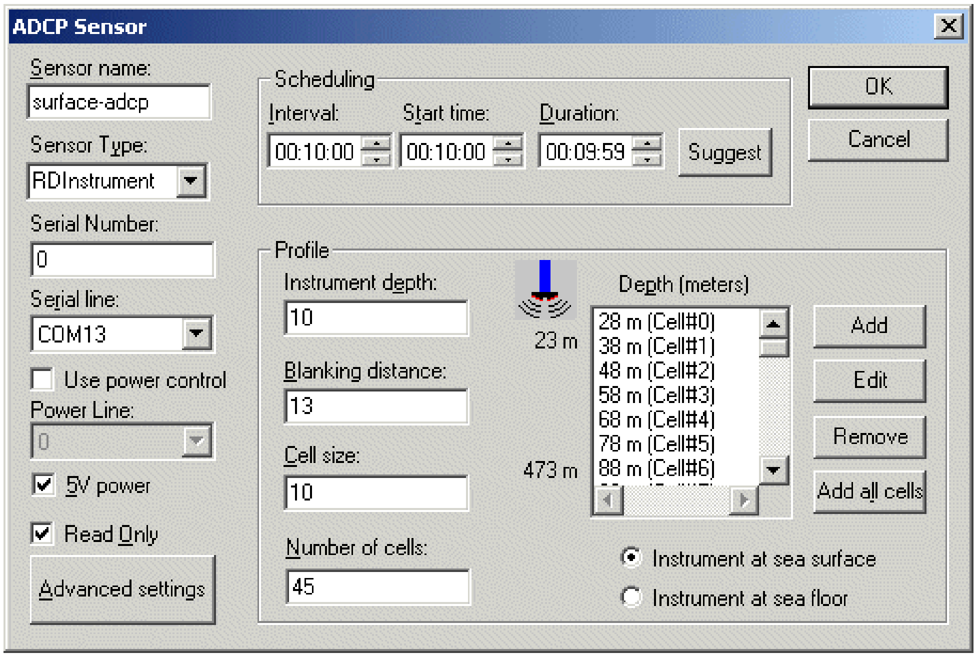
6.3.8 GPS sensor

The GPS sensor process requires setting of scheduling, serial line, power control parameters and database channels for longitude and latitude. The GPS type may be selected on a drop down list and currently Connextant Jupiter 11, Jupiter 21 and Garmin is supported. Other GPS units that supports NMEA should be possible to use. There is an option to adjust the Geni time from the GPS.



6.3.9 ADCP sensor

Currently supported ADCP sensors are RD Instrument's Workhorse ADCP and Nortek Continental. The sensor type is selelected in a drop-down list. Every field must be filled out in order for proper operation. It is strongly recommended reading the ADCP manuals prior to changing any settings in these property boxes.



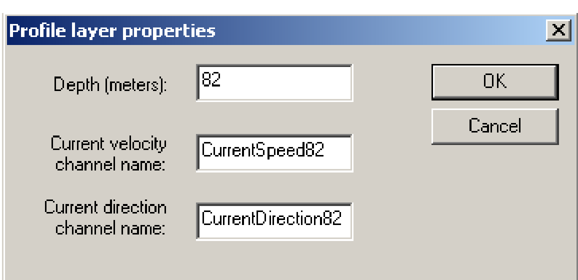
Serial line, P*ower control*, *Scheduling* and *Serial number* are common settings. See 6.2 for instructions.)

Set *read only* if you have configured the ADCP in advance and do not want the Geni to change anything. With this option enabled the Geni will not send any command to the ADCP, it will only listen for data coming from it.

Instrument depth is the depth of the sensor itself. When mounted on the Wavescan buoy it will be about 2 meters.

Blanking distance, please see the ADCP manuals for proper setting this parameter.

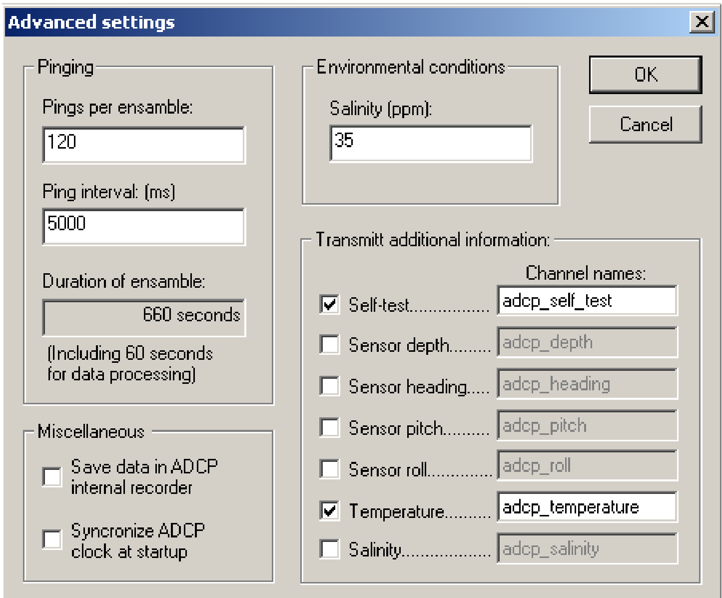
Cell size and *number of cells* organize the profile. Pressing the *Add* button to enable data acquisition of the individual cells. The dialog box below appears:



Enter the desired depth for the measurement. The program will automatically suggest channel names. Press OK when done.

To add all possible cells in a profile, press the *Add all cells* button.

Pressing the *Advanced settings* button brings creates the dialog box below.



<u>Pinging:</u>

The *Advanced settings* dialog box offers ability for setting number of pings and interval per pings. The program itself calculates the total ping time required and adds 60 seconds extra for data transfer to Geni2000 and processing time.

Note! **When setting new ping interval period, make sure that the interval period is not shorter than the actual time the ADCP use per pings.** If that happen the total ensemble will take more time then the program estimates and the Wavesense will not be able to load data from the ADCP. The ping duration depends of the speed of sound in water and the depth where the current is to be measured. Use the program BBSS (on the tool-CD enclosed to the sensor) to calculate the speed of sound. The ADCP sensor manuals give detailed information. However, the default ping interval of 5000 ms should be enough for any depth this sensor is designed for.

When the pinging settings are changed, click the *Suggest* button in the main dialog box. This will adjust the scheduling so it fits the new pinging.

<u>Environmental conditions:</u>

The S*alinity* is the ocean salinity at the location where the buoy shall operate. It is used for speed of sound calculation.

<u>Transmit additional information:</u>

Additional to the current data, the ADCP sensor returns status information about environment and sensor alignment. Some of this information is available and could be enabled by checking the option box for it. (The *Salinity* sensor is not implemented yet and should not be checked.)

<u>Miscellaneous:</u>
The ADCP sensor has its own intern recorder (A PCMCIA card). Checking this options will enable it. Note! If this recorder is not enabled, any information on it will automatically be deleted at buoy start-up.

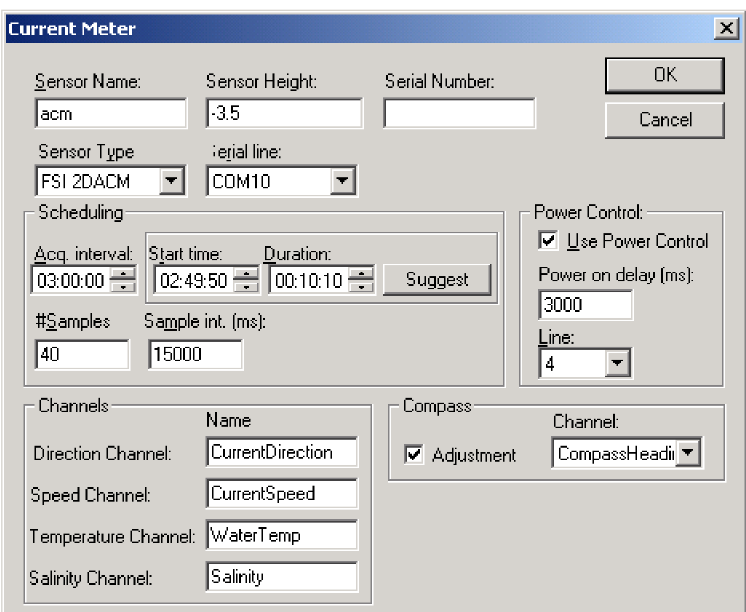
The ADCP sensor has its own built-in clock. When using the internal recorder, it is recommended synchronizing this clock to the Wavesense clock.

6.3.10 River sensor

The River sensor is the system needed to configure the sensors, pumps and valves in a Riverwatch system. The documentation is contained in a separate document, the Riverwatch Configuration and Testing Users Guide.

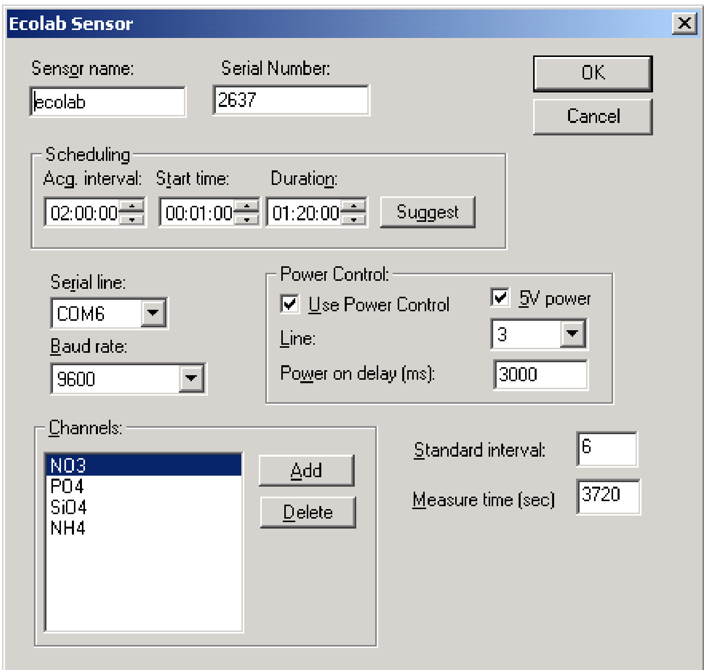
6.3.11 Current Meter

The current meter process is used to interface current meters having serial output when an external compass is needed. If the internal compass in the current meter is used, the Generic Serial Sensor process is normally used. It is only when the internal compass is too much disturbed by the surrounding magnetic field that an external compass is needed and hence the Current Meter process. The process uses vector averaging and compensates for compass readings to obtain average current speed and direction over the selected period. The type of current meter is specified in the *Sensor Type* and only these sensors are currently supported.



6.3.12 EcoLAB

The EcoLAB Advanced Multi-Chemistry Analyzer from EnviroTech LLC is configured in the dialog box below.

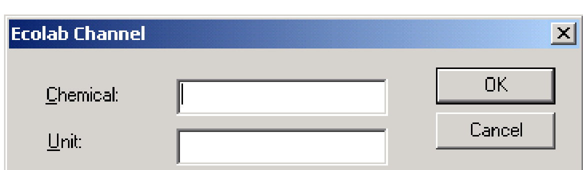


Special settings for this sensor are:

'Standard interval' Perform a calibration of the sensor using the onboard standards every 'Standard interval' cycle.

'Measure time' Maximum time in seconds to wait for the measurements to complete.

'Channels' All parameters output from the sensor should be specified in this list. The name must be identical to the actual parameter name in the EcoLAB scripts. Pressing the 'Add' button gives the dialog:

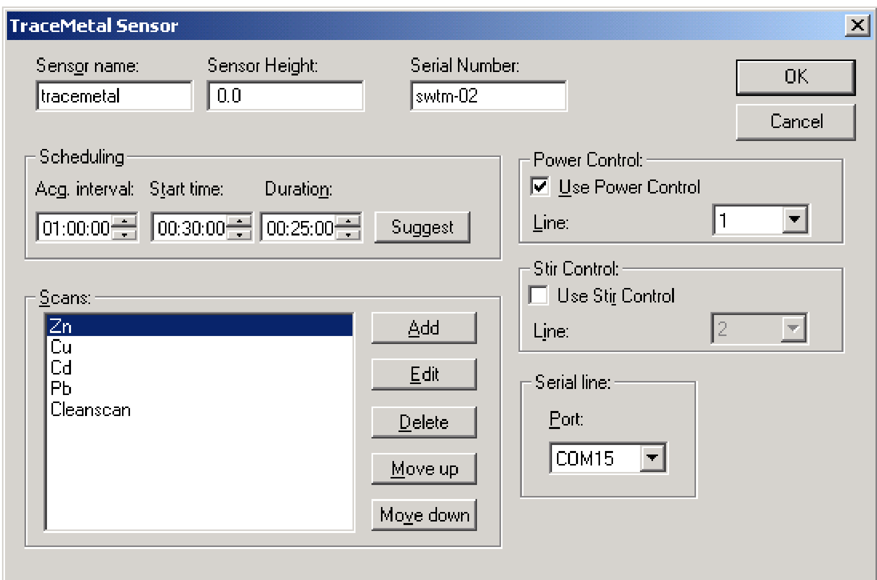


where the name of the chemical (parameter) and the unit must be filled in.

Before connecting this sensor to the system read the Operating Manual from Envirotech, connect the sensor to a PC and verify its operation by running the scripts *sample* and *standard*. The sensor comes from the factory with serial port settings: 19200,N,8,1, change this to 9600,N,8,1 by editing the file /cfg/main.cfg on the sensor (detailed procedure in the sensor manual). If there are errors during operation, some of the scripts may need to be changed, please refer to the sensor manual for the procedure. When the sensor operates as wanted, change the setting ESCAPECHARS to DISABLED in /cfg/main.cfg on the sensor before connecting it to the system.

6.3.13 OCEANOR Trace Metal Sensor

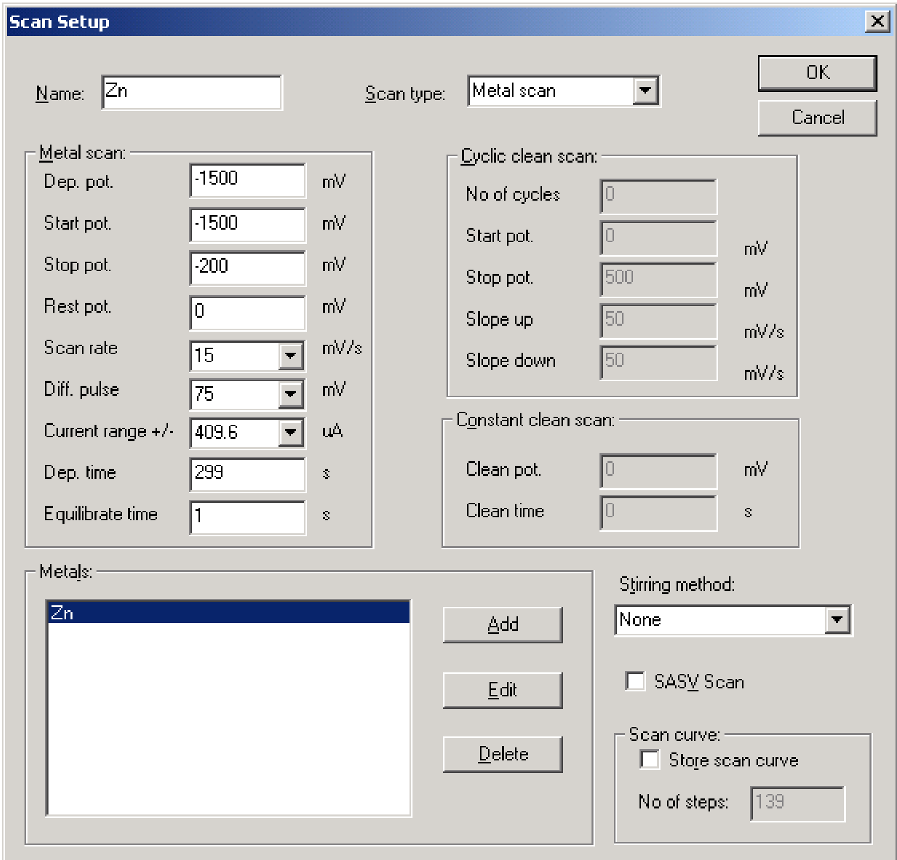
The OCEANOR Trace Metal Sensor, made by Fugro OCEANOR, is a sensor designed for measuring heavy metals in a marine environment. Detailed documentation may be found in the instruments Users Manual. Adding a new sensor or editing an existing brings up the dialog below:



The tracemetal process will perform a set of scans during each measurement cycle. The order of the scans will be as shown in the dialog box. The scan type may be a metal scan or a clean scan. A metal scan will usually try to detect one or more metals. Usually a clean scan is done before a metal scan.

The sensor may be equipped with a stirring mechanism; in this case **'Use Stir Control'** should be checked.

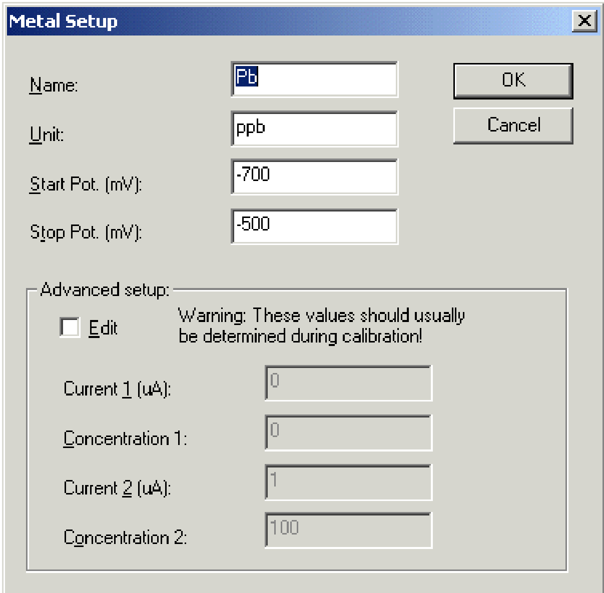
To add new scans use the '**Add'** button. To view or edit an existing scan select it from the list and click on the '**Edit'** button. Both actions give you the '**Scan Setup'** dialog:



The scan type may be a '**Metal scan'**, '**Cyclic clean scan'** or '**Constant clean scan'**. Depending on the scan type some of the fields in the dialogue will be inactive. For a metal scan you can specify one or more metals as shown in the dialog box above. Please refer to the instrument Users Manual for details about each setting in the dialog box above.

Check '**Store scan curve'** if you want to store the raw scan curve. Metals are detected by finding peaks on this curve. During testing it may be useful to see this curve. The number of steps (points) on this curve is calculated based on the start and the stop potential and the scan rate.

New metals are added by pressing '**Add'**. Press '**Edit'** to view the currently selected metal. This will bring up the dialog box below:



For each metal specify the unit and the start and stop potential where the metal peak will be detected within.

The calibration values (Current1, Current2, Calibration1, Calibration2) may be changed if you click on the '**Edit'** check box. But usually the calibration values are determined later with the '**tdebug'** program (see the instrument Users Manual).

6.3.14 SeaWatch Deep Sea Module

The SeaWatch Deep Sea Module (**sdsm**) is a very accurate water pressure sensor used for tsunami warning systems. The sensor process requires setting of scheduling, serial line, baud rate and parameter names for water depth, water temperature, battery voltage and sdsm mode.

Sdsm mode is one of the following: **normal**, **continuous**, **test** or **deployment**.

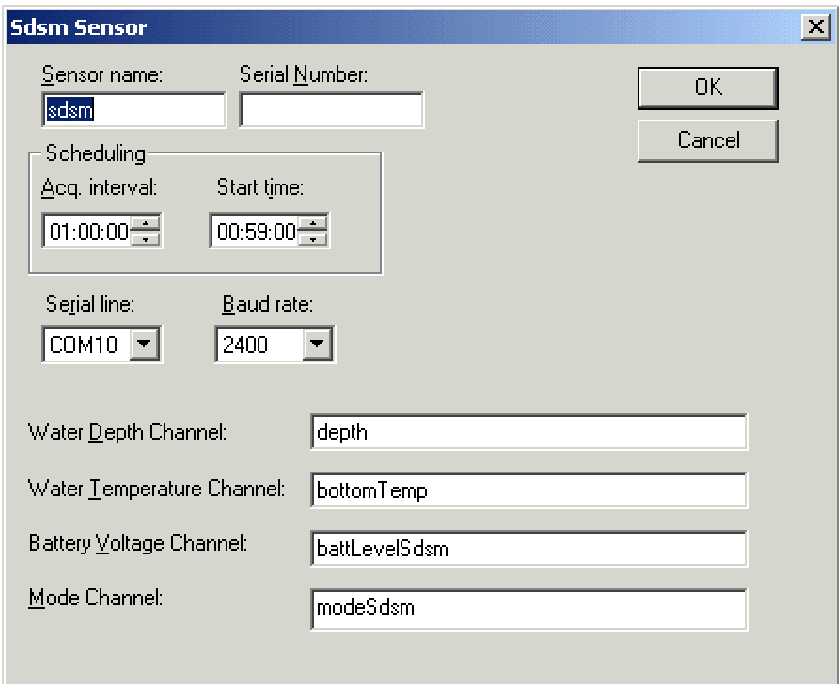
Normal mode is the regular mode when everything is normal and no sudden pressure changes has been detected. In this mode the Geni reads the parameters from the sdsm only according to the scheduled interval.

Continuous mode is entered when the sdsm detects a sudden pressure change, which could be a possible tsunami. In continuous mode the sdsm will generate data every 15 seconds. The sensor will stay in this mode for 4 hours and then return to normal mode.

Test mode can be entered by a command from the land station. The sdsm will then enter a simulated tsunami state. This is made for testing purposes.

Deployment mode: After power on of the sdsm sensor, it will stay in deployment mode for 2 hours. This will prevent the sensor to enter continuous mode caused by pressure changes during deployment.

It is possible to command the sdsm to enter any mode from the land station.



6.3.15 Tide Gauge

The Tide Gauge is used in tsunami warning systems for measuring the tidal water level. It will trigger a tsunami warning if the water level drops below or rises above a specified alarm level for more than the specified alarm period.

The configuration requires setting of scheduling, serial line and baud rate. In addition it has the following special settings:

Sensor Level: The vertical distance from the transducer to your local zero level (Usually mean sea level)

Lower Alarm Level: The lower level that will trigger a tsunami alarm if measured continuously for more than the Alarm Period.

Upper Alarm Level: The upper level that will trigger a tsunami alarm if measured continuously for more than the Alarm Period.

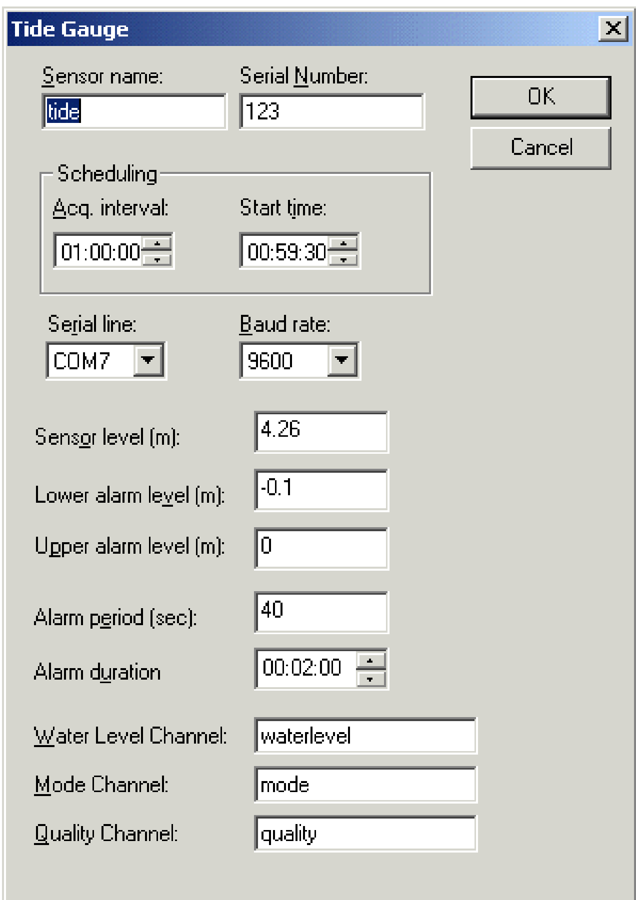
Alarm period: How long the water level should be below or above the alarm level before a tsunami alarm should be triggered.

Alarm duration: How long to stay in continuous mode after a tsunami detection before returning to normal mode.

Water Level channel: Parameter name of water level.

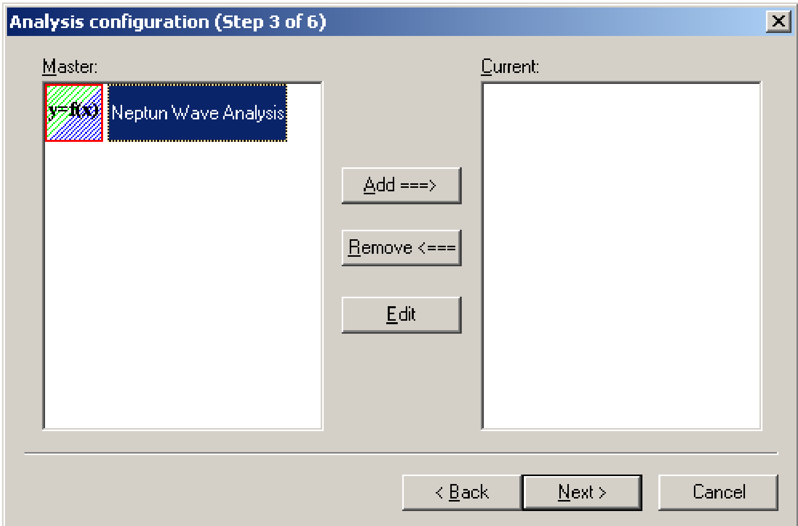
Mode channel: Parameter name of tide mode. Tide mode can be normal or continuous.

Quality channel: Parameter name of the quality number. The quality number is used for verification of the measurement accuracy.



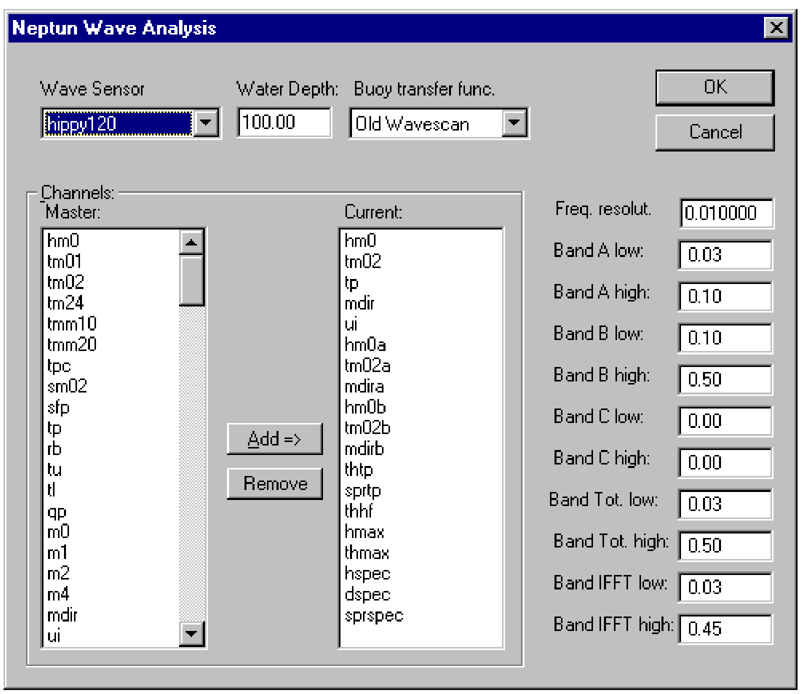
6.4 Data analysis configuration

The data analysis step is used to specify which analysis processes to run when the data acquisition is complete. A data analysis process takes the data from the database, processes and puts new data to the database. Currently, only ‘Neptun Wave Analysis’ is available.



6.4.1 Neptun wave analysis

Editing or adding a Neptun wave analysis process gives the dialog:



The wave analysis software main objective is to take input time series of wave motion and calculate significant wave height, various wave periods, wave directions and a number of other wave parameters.

The ‘Wave Sensor’ is used to define the process that produces the input heave/surge/sway or heave/roll/pitch/compass time series.

‘Water Depth’ is used in the so-called dispersion relation and must be set to the locations water depth.

‘Buoy transfer func.’ sets the transfer function used during compensation of the acquired spectra for the wave to buoy motion transfer. Possible values are: Seawatch, Wavescan, Old Wavescan. Only the Old Wavescan does any actual compensation, the others give a unity transfer function. Old Wavescan in this context refers to buoys sold by Seatex having a so-called long under-structure.

‘Freq. resolut.’ is the frequency resolution of the internally calculated spectra. These spectra is used as a basis for the calculations of most spectral parameters.

The frequency limits on the right-hand side in the dialog box above is used to define limits for the various frequency bands. Some parameters are calculated only for the ‘Tot. band’, whilst others are calculated for up to four bands, ‘Tot.’, ‘A’, ‘B’ and ‘C’.

A zero upcross analysis is run on the time series resulting from a FFT and an IFFT using the frequency limits for the ‘IFFT band’.

All parameters calculated is shown in the ‘Master’ section on the left hand side of the dialog. Any of these parameters may be selected by using the ‘Add’ button and deselected by the ‘Remove’ button. Note that these list boxes supports selection by <CTRL><Left mouse button> and <SHIFT><Left mouse button>

6.4.1.1 Non-directional Analysis

Wave elevation data from all buoys, independent of whether they are directional buoys, such as the Wavescan, or non-directional such as the Waverider are subjected to a heave wave analysis. There are two main analyses, spectral and zero-crossing analyses.

A Fast Fourier Transform is first applied to the wave elevation time series. The raw periodogram is corrected for the wave sensor heave transfer function. After correction, an inverse transform is applied to generate corrected time series on which the zero-crossing analysis is applied (see next section).

The heave wave spectrum is computed by applying a moving average to the raw spectrum over 8 adjacent frequencies giving spectral estimates with 16 degrees of freedom and a moving average smoothed periodogram is used to determine the peak in the heave spectrum. Note that the peak period, Tp, is actually 1/fp where fp is the frequency for which S(f) attains its maximum. The spectral moments from which various wave parameters, such as the significant wave height, are calculated are computed from the raw unsmoothed spectrum.

The zero upcrossing analysis is next performed and is fully described in Torsethaugen and Krogstad (1979). It basically identifies each individual wave in the time series from adjacent upcrossings of the wave elevation through the still surface. This routine contains a “small wave discrimination” criterion, which eliminates small insignificant waves due to ripples in the record. Apart from the height and period, other parameters such as the steepness is calculated and stored for each identified wave. For each record various parameters such as the mean wave height, the significant wave height, maximum wave height etc. are calculated from the array of individual wave characteristics.

The calculated wave parameters are given in Table 1 and Table 2.

Table 1. Heave parameter definitions from zero-upcrossing analysis

TIME DOMAIN	
Nz	Number of single waves
Hs	Average of the third highest waves
Hmax	Height of highest wave
Hmean	Average height of individual waves
hs1max	Height of steepest wave
Ts	Average period of the one third highest waves
Tz	Average period of individual waves
Thmax	Period of the highest wave
S1mean	Average wave steepness
S1max	Steepness of steepest wave
sigs1	Standard deviation of individual steepness
S1hmax	Steepness of highest wave
S2	Steepness based on Hs and Tz: S2 = Hs/(1.56Tz2)
S3	Steepness based on hs and ts: s3 = hs/(1.56ts^2)

Table 2. Heave parameters computed from spectral analysis. The parameters can be found for 4 frequency bands **'Tot.', 'A', 'B' and 'C'**

FREQUENCY DOMAIN	
m0, m1, m2 and m4	Moments of the spectrum about the origin: $\int f^k S(f)df$, where *S(f)* is the spectral density and the wave frequency, *f,* is in the range <Band xx low> – <Band xx high> Hz
hm0	Estimate of Hs, *Hm0* = $4\sqrt{m0}$
tm01	Estimate of Tz (mean wave period), *tm01 = m0/m1*
tm02	Estimate of Tz, *Tm02* = $\sqrt{\frac{m_0}{m_2}}$
tm24	Estimate of Tc (the duration of recorded time series divided by number of crests): *tm24* = $\sqrt{\frac{m_2}{m_4}}$

Tmm10	Estimate of Ts (average period of 1/3 highest waves), $tmm10 = m\text{-}1/m0$
Tmm20	Estimate of Ts, $Tm_{-20} = \sqrt{\frac{m_{-2}}{m_0}}$
Tpc	Estimate of Tp, $Tpc = m\text{-}2\ m1/m0^2$
sm02	Estimate of wave steepness, $Sm02 = Hm0/(1.56Tm02^2)$
Sfp	Maximum spectral density
Tp	Period of spectral peak
Rb	Width of spectrum peak, $Rb = f1 - f2,\ S(f1) = S(f2) = 0.10\ S(1/Tp)$
Tu	Upper wave period of significance; 5% of the energy has higher periods
Tl	Lower wave period of significance; 5% of the energy has lower periods
Qp	Spectrum width parameter $Qp = \frac{2}{m0^2} \int_{0.04Hz}^{0.5Hz} S(f\ )^2\, df$

Table 3. Heave parameters computed from the spectral analysis

Hm0lf	Low frequency significant wave height: $Hm0Lf = 4\sqrt{\int_{0.07Hz}^{0.05Hz} S(f)df}$

6.4.1.2 Directional Wave Analysis

For Wavescan, the directional analysis works on the three calibrated time series after the pitch/roll series have been rotated into the north-east reference system using the wave compass series (account is taken of the deviation between magnetic and true north):

i) Heave series (denoted H)
ii) Slope in the East direction (denoted E)
iii) Slope in the North direction (denoted N)

In the case of a displacement buoy (heave and relative position in east and north is measured), (Seawatch, Seawatch Mini), the following parameters are input to the directional wave analysis:

i) Heave series (denoted H)
ii) Relative positon East (denoted E)
iii) Relative position North (denoted N)

For heave, the analysis is as described in the previous section.

The discrete Fourier Transforms of the series are corrected for the buoy's hydro-mechanical behaviour and the wave sensor transfer function.

Each of the nine possible auto- and cross-spectra are computed and smoothed using a moving average of 16 adjacent frequencies giving spectral estimates with 32 degrees of freedom.

The directional wave spectrum may be expressed as

$$E(f,\theta) = S(f)D(f,\theta)$$

where

$$\int_0^{2\pi} D(f,\theta)d\theta = 1$$

and *S* is the one dimensional frequency spectrum and *D* is the directional distribution

$$D(f,\theta) = \frac{1}{2\pi} + \frac{1}{\pi}\int_{n=1}^{\infty}(a_n(\omega)\cos n\theta + b_n(\omega)\sin n\theta$$

The Fourier coefficient a1, b1, a2 and b2 are related to the auto- and cross-spectra of the time series (e.g. Longuet-Higgins et al, 1963). The program works with the scaled coefficients (Long, 1980).

$a_1 = Q_{HE}/(C_{HH}(C_{EE} + C_{NN}))^{1/2}$

$b_1 = Q_{HN}/(C_{HH}(C_{EE} + C_{NN}))^{1/2}$

$a_2 = (C_{EE} – C_{NN})/(C_{EE} + C_{NN})$

$b_2 = 2C_{EN} /(C_{EE} + C_{NN})$

In these relations C denotes the co-spectrum and Q the quad-spectrum and the indices H, E and N are defined as previously.

A variety of directional wave parameters may defined from the Fourier coefficients. The following are calculated from the Fourier coefficients:

i) Mean Wave Direction, $\theta_0(f) = \arctan(b_1 / a_1)$

ii) Circular Standard Deviation or spreading,

$$\sigma_0(f) = \left\{2(1-(a_1^2+b_1^2))^2\right\}^{1/2}$$

iii) Mean Spectral Wave Direction, MDIR = arctan (b/a) where

$$a = \int_{flow}^{fhigh} S(f)\cos(\theta_0(f))df \Big/ \int_{flow}^{fhigh} S(f)df$$

(this is effectively a weighted wave direction for the entire wave spectrum)

iv) Unidirectivity Index, UI = $(a^2 + b^2)^{1/2}$, is an indicator for the unidirectionality of the spectral wave components. If all the mean wave direction components are propagating in the same direction, UI = 1, and for two wave fields which are equal and opposite with respect to direction, UI = 0.

The calculated wave directional parameters are given in Table 4 and 5.

Table 4. Directional wave parameters computed from spectral analysis. The parameters can be found for 4 frequency bands **'Tot.', 'A', 'B' and 'C'**

FREQUENCY DOMAIN	
Mdir	Mean spectral wave direction
Ui	Unidirectivity index

Table 5. Directional wave parameters

FREQUENCY DOMAIN	
thtp	Mean wave direction at the spectral peak period
thhf	High frequency mean wave direction. Frequency band between 0.8·*fs/*2 and 0.9·*fs/*2 Hz where *fs* is the sampling frequency.
thlf	Low frequency mean wave direction. Frequency band between 0.05 and 0.07 Hz
sprtp	Wave spreading at spectral peak period
stokes_drift	Current speed calculated from the heave wave spectrum in cm/s. The formula used is: $Stokes\_drift = 100\left(1 - 2 \cdot SprTp^2\right)\left(2\int \frac{(2\Pi f)^3}{g} S(f)df\right)$ The frequency *f*, is in the range <*Band Tot. low*> – <*Band Tot. high*> Hz

6.4.1.3 Output of wave spectra

In addition to storage of all parameters listed in Tables 1 to 5 and storage of the measured time series from the wave sensor, it is also possible to store the calculated directional wave spectra, as the one dimensional spectrum, together with mean direction and spread.

Table 6. Wave spectrum parameters

hspec	Heave spectrum $S(f)$ averaged in frequency according to the 'Freq. resolut.' Setting in the bneptun dialog box. The size of the spectrum is $0.5 \cdot f / freq.resolut.$, where *f* is the sampling frequency of the wave sensor
dspec	The mean direction $\theta_0(f) = \arctan(b_1 / a_1)$ averaged in the same way as the heave spectrum
sprspec	The directional spread $\sigma_0(f) = \left\{2(1-(a_1^2 + b_1^2))^2\right\}^{1/2}$ averaged in the same way as the heave spectrum

To facilitate transmission of wave spectra over satellite link with limited bandwidth and Datawell Directional Waverider compability, it is also possible to store/transmit wave spectra in this compact format (one spectrum requires only approx. 31 bytes)

Table 7. Datawell Waverider compatible wave spectrum parameters

dwr_df	DF
dwr_f0	F0
dwr_mdir1	Direction
dwr_s0	S0
dwr_mdirrest	Direction of the remaining frequency range
dwr_sqrtm0	$\sqrt{m_0}$

6.4.2 References

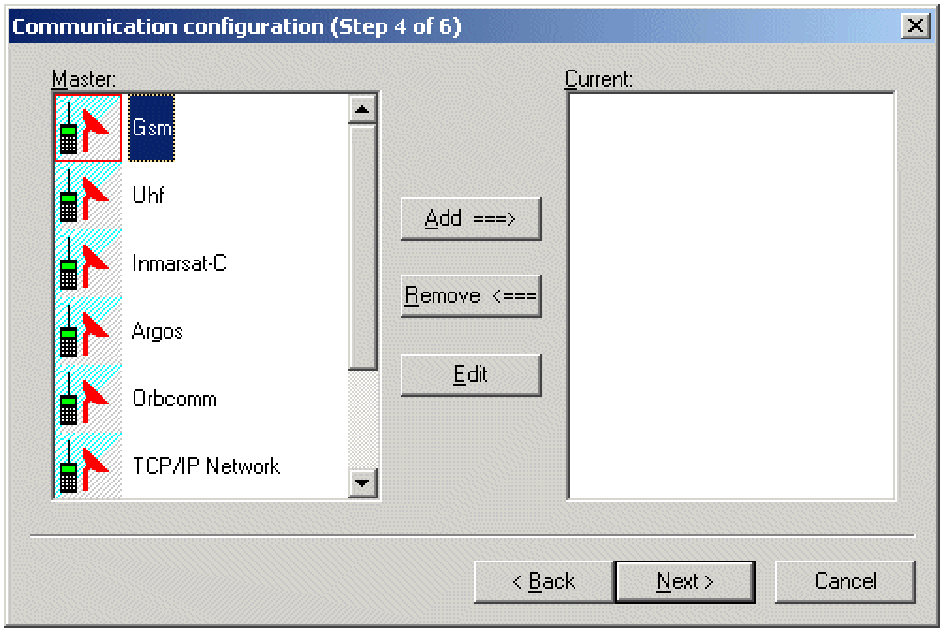
Long, R.B.: The statistical evaluation of directional estimates derived from pitch/roll buoy data, J. Phys. Ocean., Vol. 9(1980) pp. 373-381.

Longuet-Higgins, M.S. , D.E. Cartwright and N.D. Smith: Observations of the directional spectrum of sea waves using the motion of a floating buoy, in Ocean Wave spectra, Prentice-Hall, pp. 111-136 (1963).

TORSETHAUGEN, K and KROGSTAD, H.E., 1979: NEPTUN – A computer Program for the analysis of Ocean Wave Records. IKU report no. P-218/1/79.

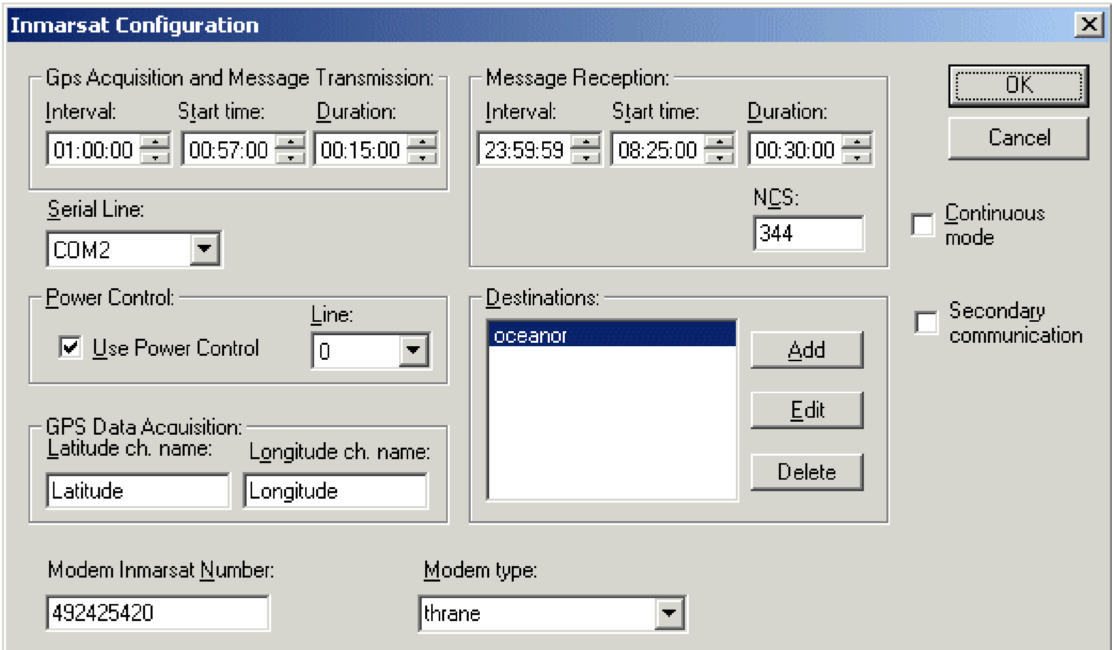
6.5 Data transmission configuration

The data transmission step is for defining which communication device to use for data transmission. Several devices may be used simultaneously. Currently the choices are Panasonic Orbcomm modem, Trimble Inmarsat-C modem, Hayes compatible telephone or GSM modem, UHF radio modem, Argos PTT, TCP/IP Network or Iridium modem.



6.5.1 Inmarsat

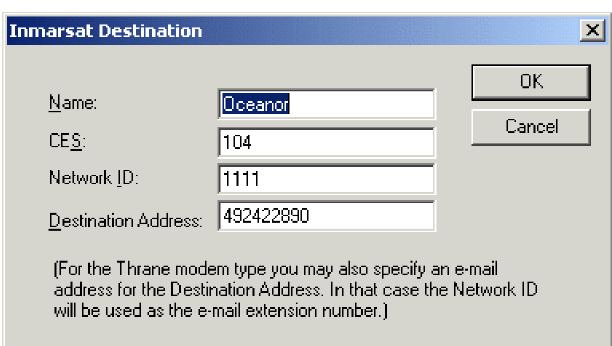
For Inmarsat communication you may choose between a Trimble Galaxy and a Thrane&Thrane modem. Both modems contains a GPS receiver. This means that three functions must be covered in the configuration of the interface process, message transmission, message reception and GPS data collection.



Select continuous mode if you want the process to be active all the time. This option must be enabled if you have configured a SeaWatch Deep Sea Module or a Tide Gauge. Normally this option is disabled and the modem is powered off after every transmission to save battery power.

Select secondary communication if you want to use Inmarsat only as a backup transmission medium. This requieres that you also have another communication prosess configured at the same time, for instance UHF. Then Inmarsat will only be used if the UHF transmission fails.

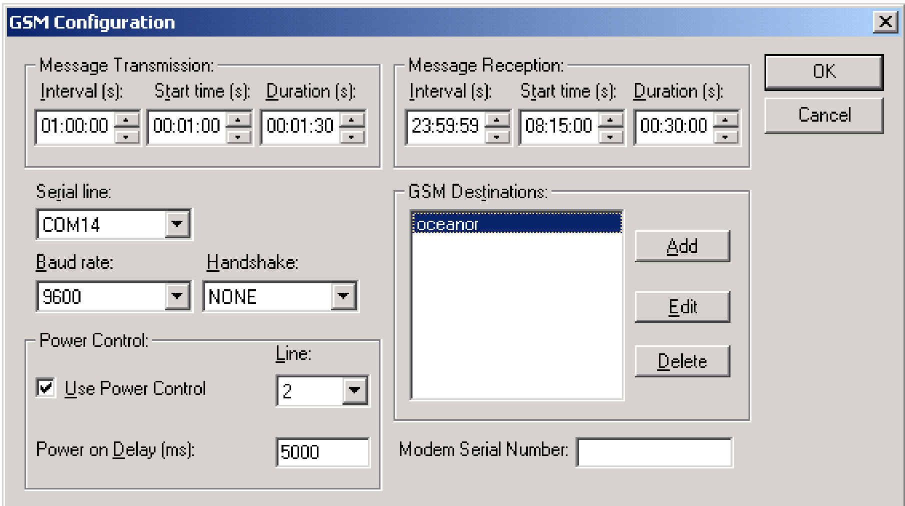
It is possible to set-up one or more destinations. By pressing the ‘Add’ button, the following dialog appears:



Name is a descriptive name, NCS (Network Control Station) is found in the Trimble documentation and varies according to your location and Inmarsat provider. The same with CES (Controlling Earth Station) and Network ID. Destionation address is the address of your receiving Inmarsat modem.

6.5.2 GSM

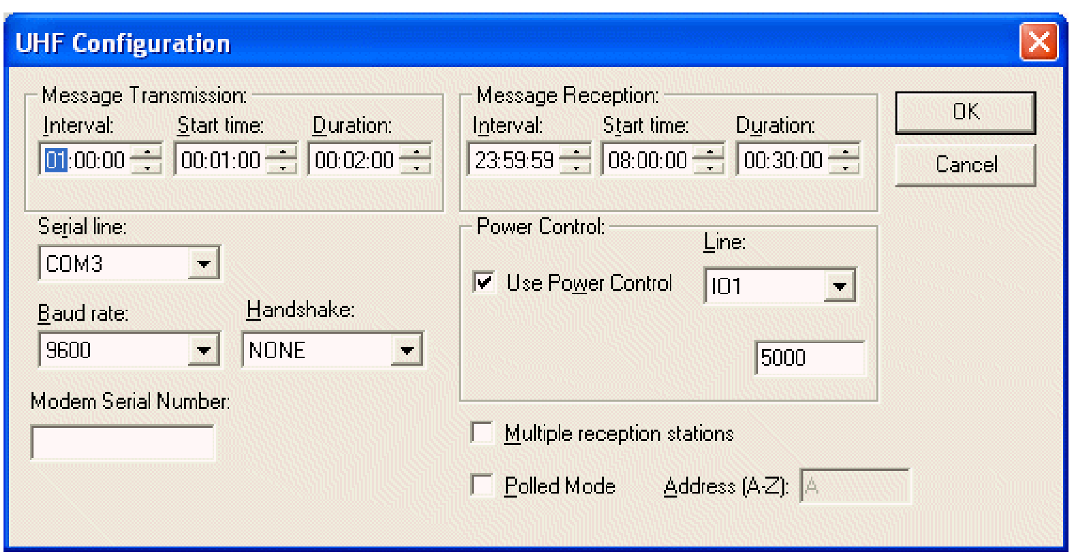
The GSM process configuration covers a wide range of communication devices. All Hayes compatible modems, including GSM modems are supported.



The Message Reception time configures when the system may be dialled up. After a dial up connection is established, the system may be controlled completely through gLink as described elsewhere in this manual and files may be transferred in both directions. In additon, the system will keep the connection for 30 seconds after every data transmission and may then be controlled in the same way.

6.5.3 UHF

The UHF process configuration covers all UHF radios having a direct pass-through operation mode are supported. This will in fact also work for a direct cable connection.

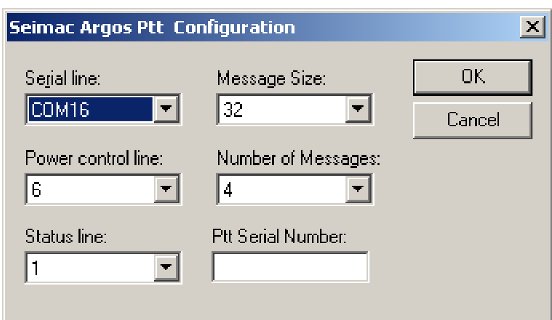


Select ‘multiple reception stations’ if you have more than one receiver. In this case the buoy will not wait for acknowledge.

Enable ‘Polled mode’ and select an address in the range A to Z if the buoy are to be in polled mode. In polled mode the buoy will not send any data before it is queried from the land station. If this option is disabled the buoy will send data according to the time scheduling without waiting for a query from the land station.

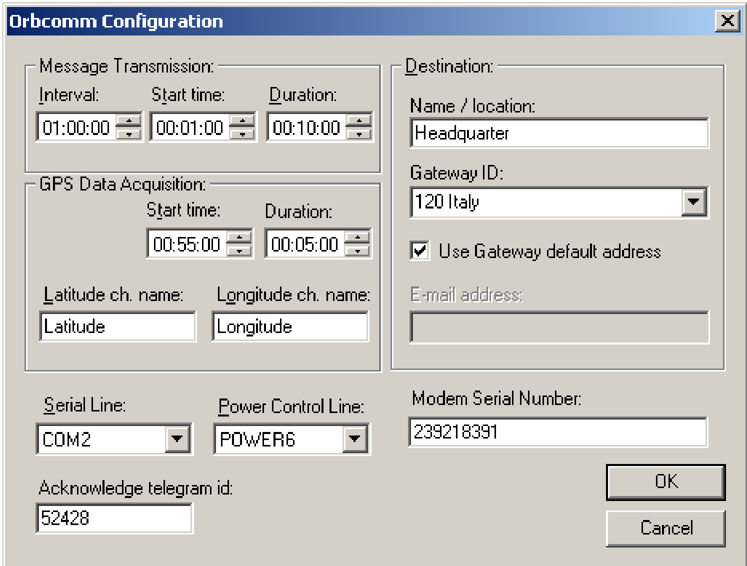
6.5.4 Argos

The Argos process configuration covers setup of the Seimac Wildcat Argos PTT interface process. Serial line, Power control line and the input Status line is configurable. Also the number of messages enabled in the PTT must be set. The message size is 32 or 31 byte, depending on the size of the Argos Id as given by the Service Argos.



6.5.5 Orbcomm

The Panasonic KX-G7101 Satellite Communicator (SC) also contains a GPS receiver. This means that setup of both message transmission and GPS data collection are covered in the dialog. Message reception is implicitly covered as the Orbcomm process always asks the system for incoming messages after every transmission.



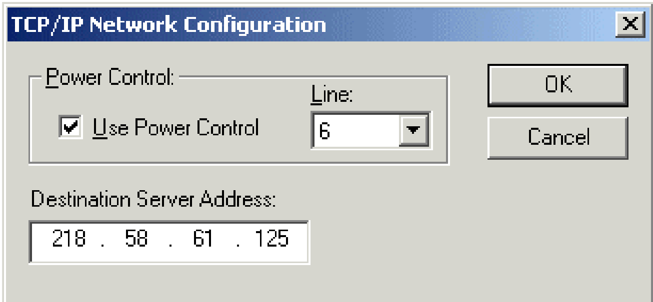
The SC is powered on at the *GPS Start time* and GPS data is collected first, then any messages are sent and the Gateway is inquired to find out if there are any incoming messages. If so, the incoming messages are dowloaded to the system. Finally, if there are no more actions the SC is powered off. At the latest this happens when the time *Message Transmission Duration* has passed after *Message Transmission Start time*.

The *Acknowledge telegram id* identifies the acknowledge telegrams sent from the system to the receiver. If for instance a user sends a reboot command to the system, an acknowledge message will be sent back, having *Acknowledge telegram id* as Message Id.

Destination of the outgoing data messages are setup using the *Gateway ID* and the *E-mail address* fields. The *Gateway ID* must match the Orbcomm system Gateway where the modem is registered. When registering the SC, a default e-mail address must also be provided. If the telegrams are to be sent to this address, simply check the *Use Gateway default address*, if not, uncheck the *Use Gateway default address* and fill in the *E-mail address* field.

6.5.6 TCP/IP Network

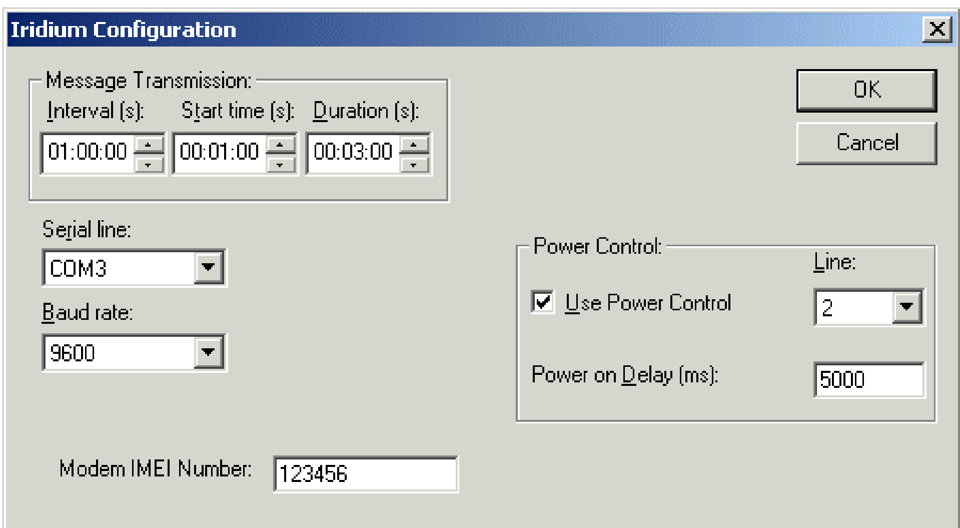
The TCP/IP process covers communication devices capable of sending data by TCP/IP on the Internet. The destination server address is the IP address of the receiving station.



6.5.7 Iridium

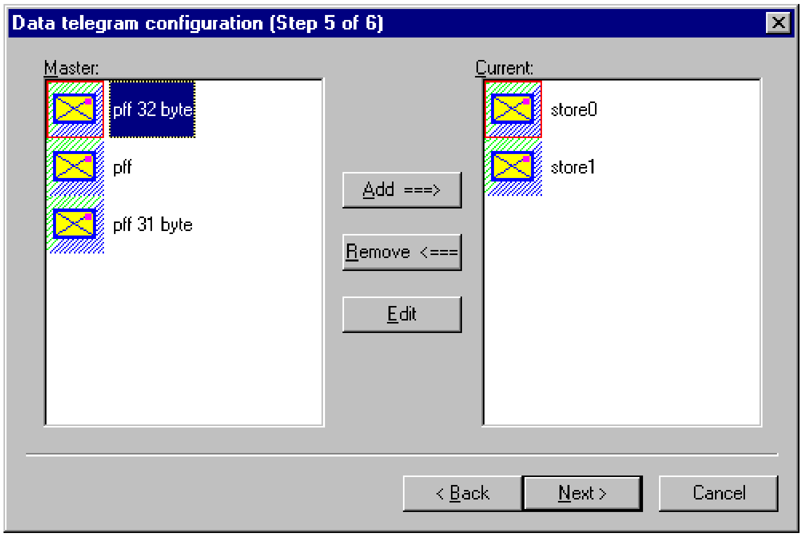
The Iridium modem sends data as mail to one or more e-mail addresses. The list of e-mail addresses is configured when you order the SIM card which is required to use the Iridium system.

The IMEI (International Mobile Equipment Identity) number is the serial number of the modem.



6.6 Data storage configuration

Configuring the data storage means adding one or more telegrams, see the figure below.



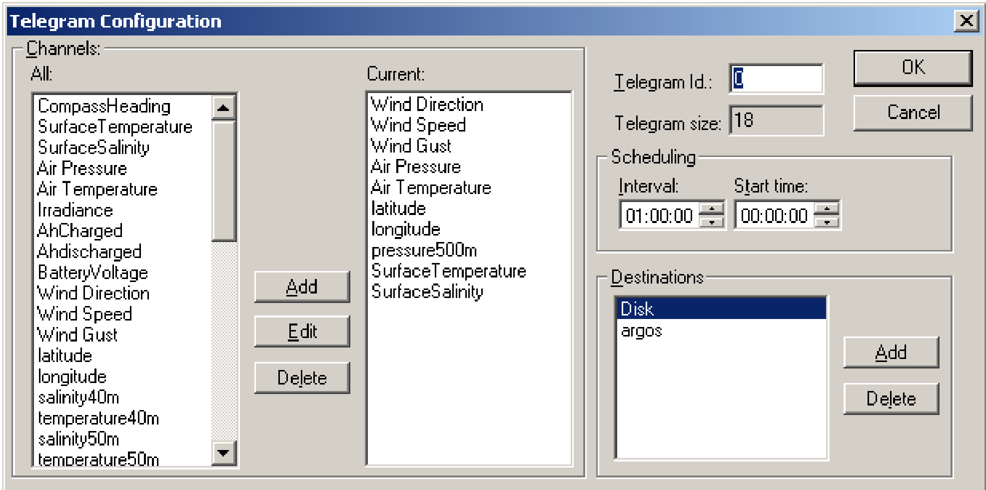
The supported telegram types are:

- Pff 32 byte – Packed File Format, fixed length of 32 byte
- Pff – Packed File Format variable length (version 2)
- Pff 31 byte – Packed File Format, fixed length of 31 byte

One telegram may be sent to one or more locations, all locations defined in the data transmission section and to the internal Flash disk. Typically, the calculated parameters are sent via a satellite link and stored to the Flash disk, whilst the more voluminous raw data is stored only on disk. The difference between Pff and Pff 32/31 byte is the message format. Pff has 10 bytes overhead, a variable size up to 8196 byte and a time resolution of 1 second. Pff 32/31 byte has a fixed size of 32/31 byte, 5 bytes overhead and a time resolution of 10 minutes. Normally it is Pff that is used and 32/31 byte is only used in systems where data is to be sent via Argos.

6.6.1 Pff telegram configuration

Adding or editing a telegram gives the dialog:



The 'Telegram Id' is an important number which must be chosen with care. The function of this number is to act as a key when the data is to be read. This number must be unique in your whole system and changed whenever any changes have been made to the systems configuration which affects the format of the data stored. 'Telegram Id' may be a number between 0 and 65535 for pff v2 and 0 to 255 for pff v1.

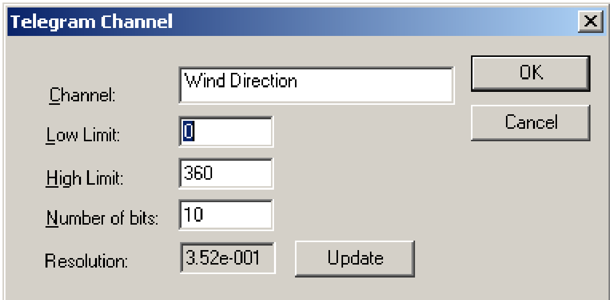
Telegram size is a read only parameter that shows the size of the selected telegram in bytes.

In the figure above, the telegram is saved to disk and sent to the 'argos' location every 3600 seconds, at 0 seconds past the 3600, i.e. exactly at every hour. The 'argos' location was defined during the add Argos transmission dialog, and the number and name of locations will change according to how the transmission part of the system is set up.

It is also possible to add a COM port to the Destinations list. This is used for instance when you have two Genies/Wavesenses in one buoy and want to exchange data between them. A serial cable is then used between the units. The values for the parameters selected will then be sent out on the COM port according to the telegram schedule interval. The format is space separated ASCII float values. On the receiving end you should configure a standard serial sensor process to decode the data.

The parameters defined in the sensors and analysis steps of the configuration appears in the 'All' list. The 'Current' list shows the parameters included in this telegram.

Pressing the 'Add' button in the 'Channels' section adds a parameter to the telegram. A parameter may be included in several telegrams. The dialog appearing is:



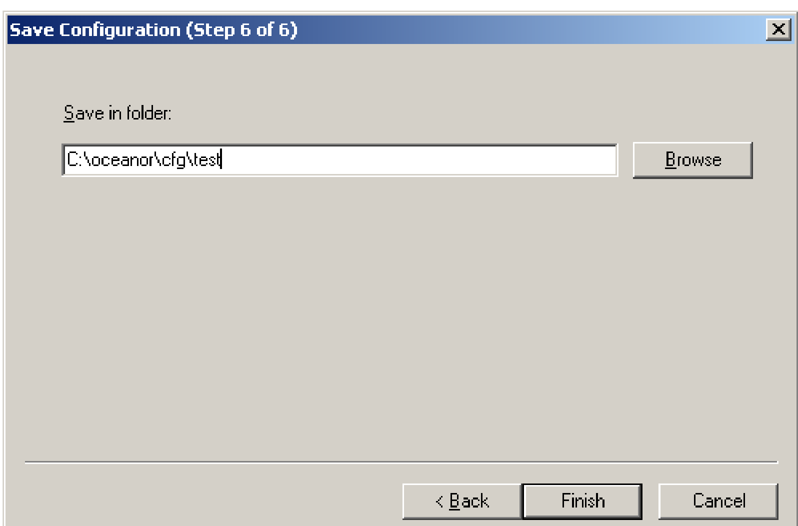
When the data is inserted into the telegram, they are converted to integer numbers. ‘Low Limit’ is the lowest number possible to transfer for this parameter in the telegram, and ‘High Limit’ is the highest number. It is extremely important to configure these numbers according to the location of the system.

‘Number of bits’ gives the resolution of the parameter transferred in the telegram.

The ‘All’ and ‘Current’ lists supports selection by <CTRL><Left mouse button> and <SHIFT><Left mouse button>. When multiple parameters are selected, they are all given the same ‘Low Limit’, ‘High Limit’ and ‘Number of bits’.

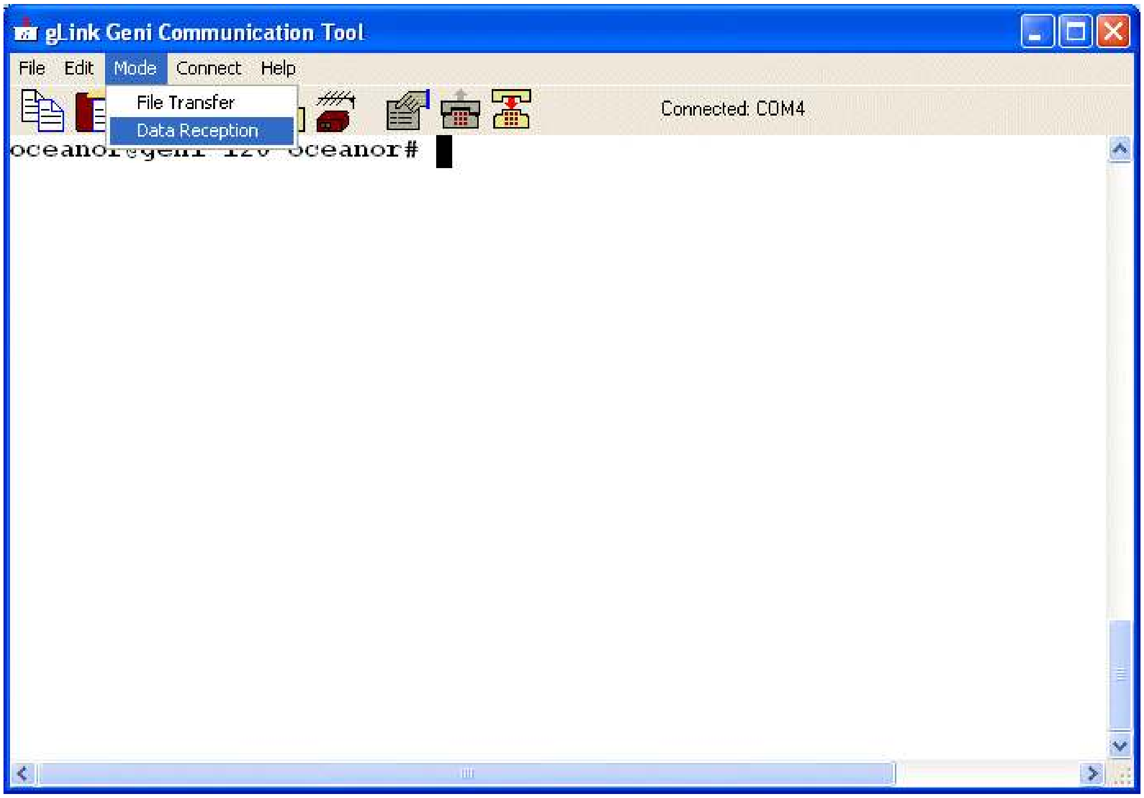
6.7 Saving the configuration

This is the last dialog box in the wizard. As seen on the figure below, it contains a path to the directory where the new xml files will be saved. If the directory does not exist, it is created. If it contains any xml files, the user is prompted the old files should be overwritten

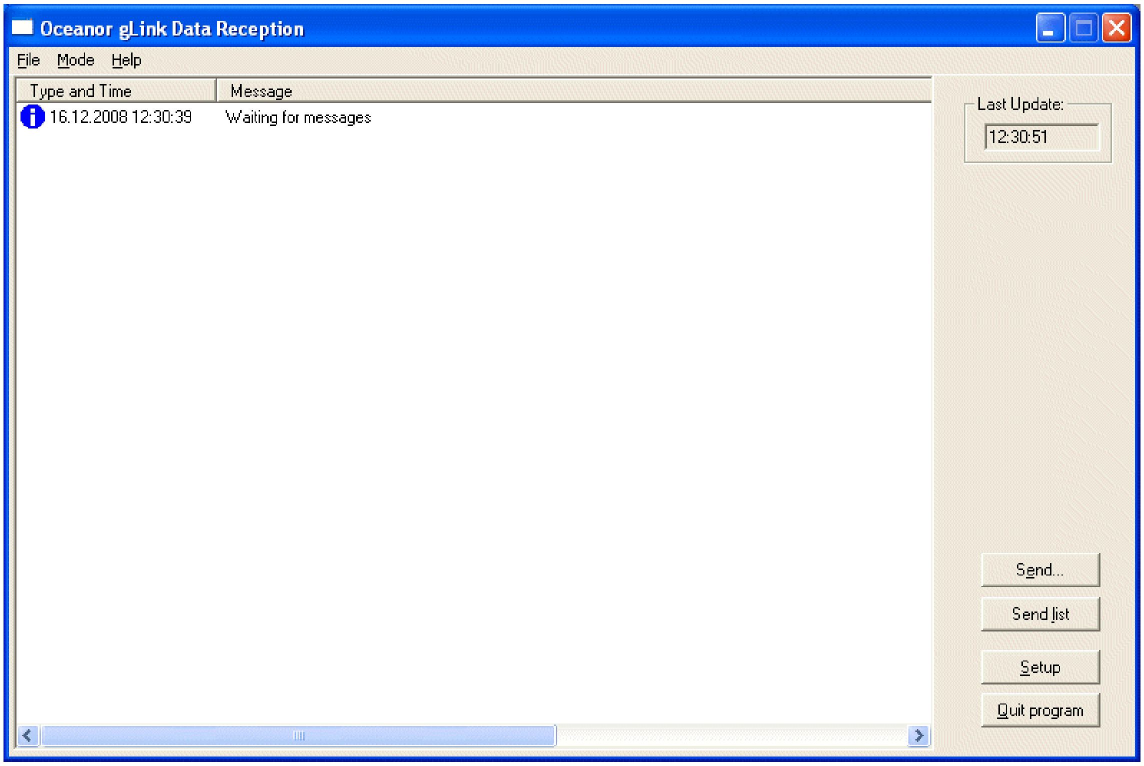


7. Data reception and remote control via radio or telephone modem

gLink version 2.0 and later may be used as data reception and remote control software when the system communicates via radio or telephone modem. Selecting the ‘Data Reception’ in the ‘Mode’ menu as shown below starts data reception mode.

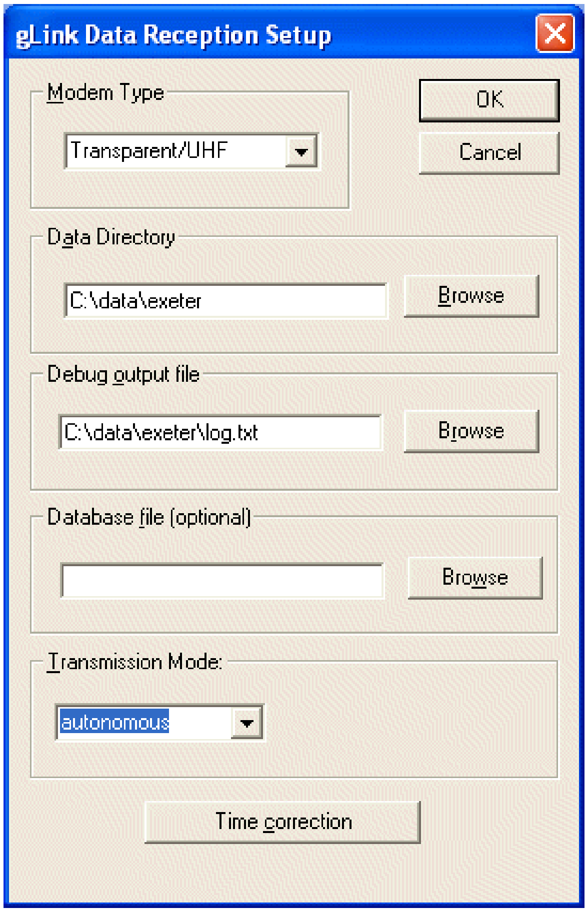


This closes the terminal window and opens the Data Reception dialog box as shown below. Please note that serial port and baud rate should be set in Terminal mode before entering Data Reception mode. The baud rate should be set equal to the baud rate between the Wavesense and the modem in the remote end.



As data is received, information about this is shown in the above dialog box.

It is possible to configure in which directory the data is saved by selecting 'Setup' in the 'File' menu. The modem type and filename where the messages shown in the dialog are optionally saved, are also possible to enter here.



7.1 Remote control

Via the telephone or radio modem connections, the remote system may be controlled in much the same way as connected via a direct serial line. The only differences are that a lower baud rate is usually used and that the remote system only has the modem powered on at certain times, due to power preservation. Contact to the remote system may be established in two ways:

1. Wait for an incoming data connection and wait until the data is received, switch immediately into Terminal mode and press <Enter>. Log into the system as normal and operate the remote system as connected directly to it.
2. Wait for the Message Reception time (specified in geniCfg during configuration) and if a telephone modem is used, dial up the remote system entering the following command in Terminal mode:
   ATDNNNNNNN<Enter>
   where NNNNNN is the telephone number of the remote system. Wait for a CONNECTED message from the modem, press <Enter> and log into the system as normal. If a radio modem is used, a dial up command is not necessary, simply press <Enter> and log into the remote system.

When remote control is finished, enter ‘exit’ on the Wavesense command line and the connection will be closed. The Duration setting in the Message Reception (specified in geniCfg during configuration) limits the time the system may be under remote control. When this time has elapsed, the user is disconnected and the remote modem powered off.

7.2 Telephone modem setup

Telephone modem in this context means both GSM and fixed line modems, the only limitation is that the modem must use the Hayes command set. The following settings must be given (the commands shown within the paranthesis are the actual commands and must be checked with the modem documentation as they may vary from modem to modem):

Local modem:

Auto answer on (**ATS0=1**)
Ignore DTR (**AT&D0**)
Hardware handshake on (**AT&H1**)
Carrier detect signal follows line state (**AT&C1**)

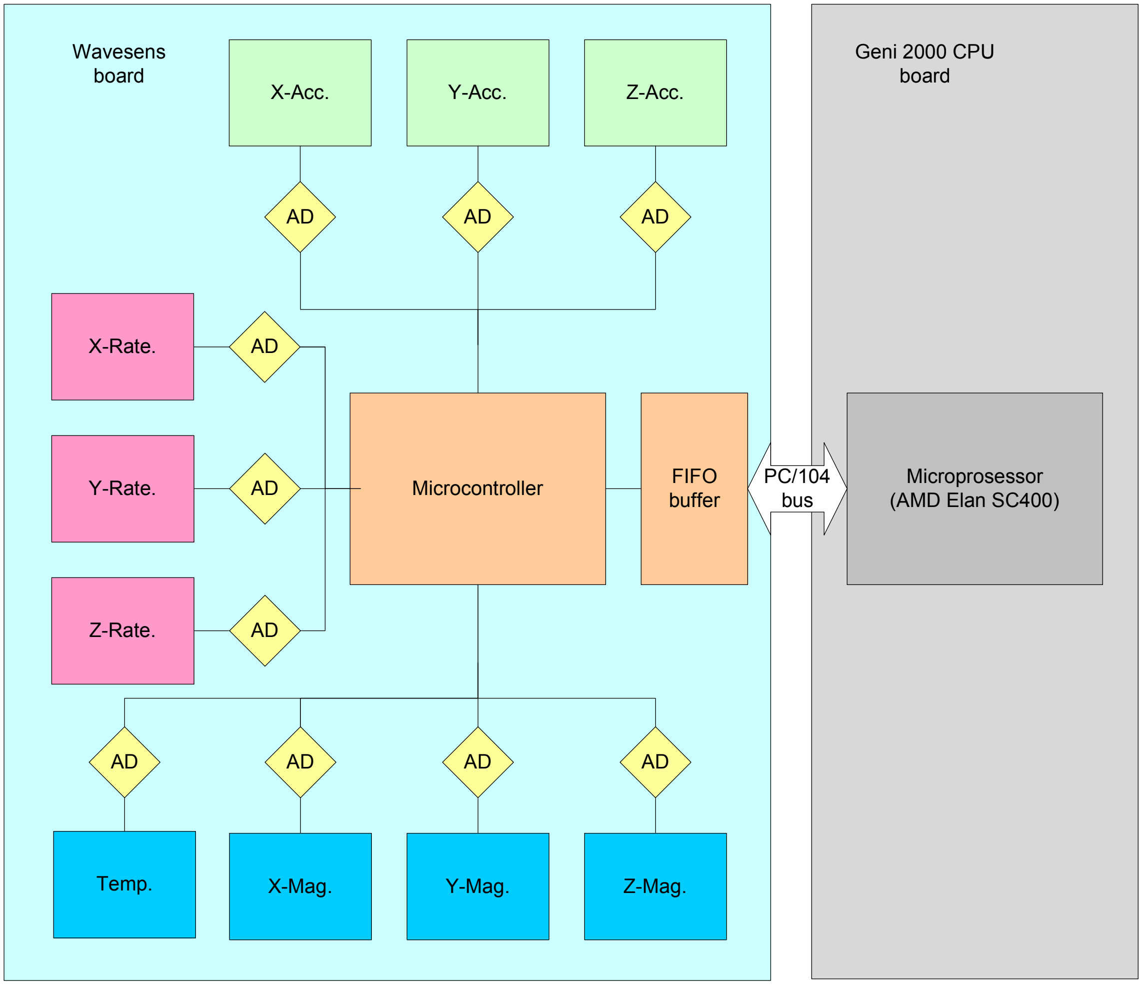
Remote modem:

Auto answer on (**ATS0=1**)
Ignore DTR (**AT&D0**)
Hardware handshake off (**AT&H0**)

The settings are saved in the modem by entering **AT&W**. Please note that in some cases, it may be compability problems between modems of different make. The modems must be tried together and dial up from an analog modem to a digital GSM modem may for instance not be possible. Also, data correction protocols should always be used.

8. Wave measurements principle of operation

The wave measurements working principle is the same as for most inertial sensors. Accelerometers, angular rate sensors and magnetic field sensors mounted in all three axis directions makes up the basic sensing elements. Each of these 9 sensors are interfaced to it own precision 24 bit Delta-Sigma AD-converter. This enables simultaneous sampling of the acceleration vector, the magnetic vector and the rotation around the sensors axis. A microcontroller controls the AD-conversions and delivers the measurements to the main CPU via a FIFO buffer. See the figure below for a schematic view of the different parts of the Wavesense.



9. Calibration

9.1 Static performance

The accelerometers, angular rate sensors and the magnetic field sensors are calibrated in the laboratory as the last part of the manufacturing process. Each basic sensors offset, gain, nonlinearity, cross-coupling and temperature dependence is determined in the process. A total of 216 parameters for all sensors are determined in the calibration process. The calibration takes place in a specially designed calibration facility. The accelerometers are calibrated using the local gravity vector, the angular rate sensors by rotating the sensor at a constant speed and the magnetic field sensors by using a previously determined uniform magnetic field.

9.2 Dynamic performance

All basic sensors used (accelerometers, angular rate sensors and magnetic field sensors) have dynamic ranges that go far beyond the necessary range for wave measurements, i.e. periods of 1 second to 30 seconds. The filtering and integration algorithms do not introduce any damping or phase shift on the signals either, meaning that the sensor has an ideal transfer function and correction of the measurements is not necessary.

Appendix A. Specifications

General Specifications

Input Voltage:	9- 15 V
Supply Current:	270 mA (active, wave data acq. inc. network) 160 mA (active, inc. network), 110 mA (active, no network), 75 mA (idle)
Dimensions (wlh):	266x208x163 mm
Temperature range:	÷5 - 70 °C
Shock resistance:	1000 m/s^2
Weight:	4.25 kg

Wave Sensor Specifications

Range:

Period 1 – 30 seconds

Heave Not limited

Relative position east and north Not limited

Heading 0 – 360 deg.

Roll 0 – 90 deg.

Pitch 0 – 90 deg.

Static accuracy (rms):

Acceleration 0.02 m/s^2

Angular rate 0.03 deg./s

Heading 0.5 deg.

Roll 0.1 deg.

Pitch 0.1 deg.

Dynamic accuracy (rms):

Heading 0.5 deg.

Roll 0.2 deg.

Pitch 0.2 deg.

Heave 0.1 m

Relative position east and north 0.1 m

Sensor Inputs

- 16 Differential analog inputs. 16 bit resolution, +/÷5V range. Optional inputs are 0-20 mA, PT 100 and other resistance based sensors are also supported
- 18 RS-232, 1 RS-485 and 2 RS-422
- 1 Frequency in
- 26 digital in/out (TTL level)

- 11 lines for sensor power supply.

All ports are ESD protected and the serial ports are capable of up to 250 kbit/s transfer rates.

Storage Capacity

CPU Board:

- 512 Mb Flash memory (CompactFlash) for data storage (can be extended on request)
- 32 Mb of Flash memory for program storage
- 64 Mb of SDRAM for system software

Miscellaneous

Battery backed Real Time Clock. Initial accuracy 1 min./month. Automatic correction when GPS is available

Processor

PXA255 XScale RISC processor running at 400 MHz.

Software

- Linux 2.6 operating system
- Fugro Oceanor modular software for data acquisition, data analysis, data storage and transmission.

Appendix B. Software architecture

The software is built on loosely interconnected modules running under Linux. The modules are multi-threaded processes running in separate address spaces using hardware memory management. Inter-process communication is achieved through shared memory and named pipes.

The GNU tool chain is used for software development. This ensures openness and reliability; the GNU tool chain being one of the most thoroughly tested and widely used compiler suites in the industry.

A software watchdog monitors the correct operation of each module. Modules not functioning correctly will be removed from the process queue. If a single module fails because of hardware problems or similar, this will not affect other modules. Care has been taken to eliminate possible deadlocks or infinite loops in worst case scenarios, both within modules and in the high-level interaction between modules.

The modular design of the WAVESENSE software makes upgrading and adding new modules easy. Adding a new module does not affect existing sensor modules in any way. In addition to generic analog and serial sensor interface processes, more special modules for other sensors exist and may be adapted. The generic modules may be adapted to a wide range of sensors without any additional programming being necessary. Figure 1 shows some of the modules in the system.

The WAVESENSE may be reconfigured both on-site and remotely through any of the available communication options. The different modules read their configuration from XML files generated by a user friendly configuration tool for Microsoft Windows.

The software is fitted to both low and high bandwidth scenarios. The WAVESENSE may be connected directly to a conventional LAN or WAN with TCP/IP or only send and receive minimal datagrams by satellite. Bandwidth and memory is conserved through the use of a compact data storage scheme.

The WAVESENSE 3 software has been designed and implemented with the experiences from the earlier WAVESENSE systems in mind. The code base from earlier WAVESENSE systems has been used as a reference to avoid typical problems with new software systems.

Figure 1 shows the different programs/modules in the system. Please note that the Figure may not be complete and show all modules that exists for every system. The main purpose is to show the system architecture. The following subsections give a brief description of the different modules.

Figure 1. Block diagram showing some of the modules in the Wavesense software

9.3 Process manager: pman

The pman program is the manager of all other programs and has a number of important tasks:

- Creation of all shared data modules
- Start-up of all data acquisition, communication and calculation programs
- Monitoring of all programs and restart of a program stopping due to failure
- Message distribution between all programs, if a message is sent from a process it is received by pman and distributed to all other programs
- Toggling the hardware watchdog circuits input so that it doesn't restart the system
- Setting up operating system alarms for starting and stopping the different activities in the system. This includes measurement start-up, measurement stop, send data start, receive data start, send and receive stop. The alarms are distributed as messages to each relevant process.
- Put the processor in sleep mode whenever the system is idle and no users are connected

pman is configured from a xml configuration file and must be started with the name of this configuration file as argument. Example for normal operation:

pman

Additional command line arguments are:

- -v Be verbose and make all other programs to be verbose
- -p Disable the power saving mode and make the system stay on the whole time
- -d Debug mode, functions as normal except that no other program is started. This is useful when a program needs debugging and the operator wants no interaction from other programs
- -i Force pman to operate in the foreground, not change into daemon mode.

9.4 System start-up

As the last part of the Linux startup procedure, it starts the cron daemon. The cron configuration file has an entry making pman run at startup.

9.5 Wavesense data acquisition

This software is responsible for fetching the acceleration, angular rate, magnetic field strength and temperature data from the microcontroller located on the Wavesense board, scaling, filtering, conversion from sensor XYZ co-ordinate system to inertial NED co-ordinate system and integration of accelerations into position data. The output parameters from this module are time series of relative positions in North, East, Down and Compass. Optionally, Roll and Pitch angles may be output instead of relative positions in North and East.

9.6 Data acquisition programs in general

All data acquisition programs have two processes (threads). The message router thread that reads and responds to any message sent from pman. This thread runs continuously. The worker thread is started when a start message is received from pman. This thread does the actual reading of the data from the sensor, either via the A/D interface or via a serial line. Often it also switches sensor power to save energy when the sensor is not in use. The data acquired is stored in the database module (libdb). After acquisition is completed, a complete message is sent to pman.

The programs are configured from a xml configuration file and must be started with the name of this configuration file as argument. The start is normally performed by pman, but in some situations it may be useful to run only some of the programs. An example for normal operation:

analog /home/oceanor/etc/analog.xml &

Example for verbose operation:

analog /home/oceanor/etc/analog.xml –v &

9.7 Data calculation programs in general

Calculation programs perform some kind of analysis on the data measured by the data acquisition programs. This analysis is usually rather complex, so it is worthwhile to have a separate program. One example is Bneptun, the wave parameter calculation program. The calculation program usually receives a dedicated message from the process preparing the input data when the input data is ready in the database. The program then starts its worker thread, performs the calculations and put the results back to the database. Upon completion the worker thread sends the process complete message. The programs are started the same way as the data acquisition programs and are configured in the same way from xml files.

9.8 Data communication programs in general

The communication programs also behave in much the same way as the calculation and acquisition programs. The main difference is that the communication programs usually have 2 or 3 worker threads, one for transmission, one for reception and one for gps data collection (if this is built into the data transmission hardware). Only one of these threads is active at the time. The messages to transmit are read from the memory pools (a pool is a special memory location in the database), which are filled by the data storing program(s). Messages arriving when either of the working threads are active, is checked for correct format and put into a separate pool in the database. A message is sent to the message handling program, transfer, to make it process the message.

9.9 Data storing program, store

The data storing program reads data from the database channels, formats messages according to the pff dataformat and loads the messages into one of the pools in the database. If enabled, the message is also stored in the /home/oceanor/data directory.

Appendix C. System software update

It is possible to update the software. All Fugro OCEANOR software resides in the directories located under /usr/local. Please contact Fugro OCEANOR technical support if you need software updates. Some of the updates require you to log in as root. The root password is ‘geni’.

Appendix D. Calibration Certificate