NORTEK MANUALS

Nucleus Operations and Integration

Nucleus1000

Table of Contents

1 Introduction

The primary objective of this manual is to help users of the Nortek Nucleus to get familiar with the system. The manual includes chapters covering how to get the instrument up and running as quickly as possible, functional testing, basic software information, and tips for maintenance and troubleshooting. It also provides the information needed to control the Nucleus using commands, aimed at system integrators and engineers with interfacing experience.

Nortek online

At our website, www.nortekgroup.com, you will find technical support, user manuals, and the latest software and firmware. General information, technical notes, and user experience can also be found here.

Nortek FAQ

Our old forum where users from all over the world met to discuss and shared their experience with Nortek instruments has been converted to an FAQ section. If you have comments, questions, application tips, suggestions for improvements, or simply want to learn from others or share your own experience, we encourage you to comment on the relevant FAQ or start a topic in our new forum.

Your feedback is appreciated

If you find errors, omissions or sections poorly explained, please do not hesitate to contact us. We appreciate your comments and your fellow users will as well.

Contact Information

We recommend first contacting your local sales representative before the Nortek main office. If you need more information, support or other assistance, you are always welcome to contact us or any of our subsidiaries by email, phone or fax.

Email: inquiry@nortekgroup.com (general inquiries), support@nortekgroup.com (technical support)

Phone: +47 67 17 45 00

You can also write us at:

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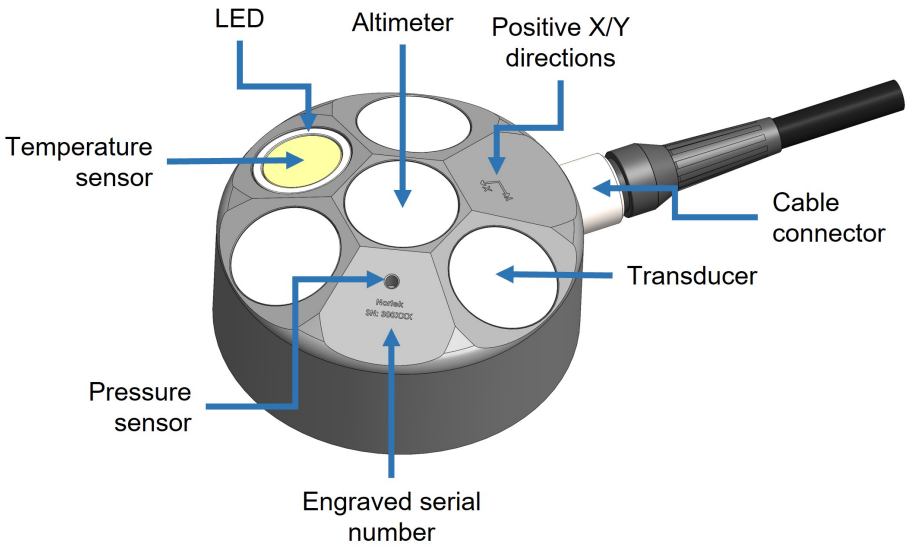
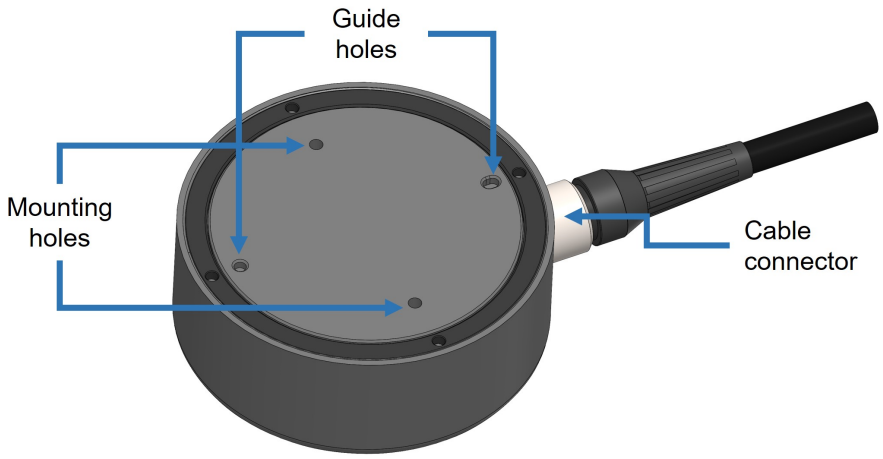
Version/revision	Date	Comments
2022.1	18.03.2022	Initial version

2 System Overview

The Nucleus1000 is an acoustic Doppler instrument which has the ability to estimate the velocity relative to the bottom (Earth being the frame of reference) or relative to the water.





The Nucleus has has three acoustic beams oriented in a diverging, convex configuration, plus a central altimeter transducer to measure the vertical distance to the seabed. It comes with a high precision pressure sensor for estimating depth, magnetometer for heading, IMU/AHRS for acceleration, and temperature sensor for calculating sound speed. It also has an LED ring around the temperature sensor to indicate the current mode; this will be a steady blue when the instrument is connected in command mode, and when in measurement mode it will blink every time the DVL or altimeter pings.

The system comes with either an open-ended penetrator cable or connector cable, which can be used for Serial or Ethernet communication. This must be terminated by the user. Refer to the Appendices for cable diagrams.

Specification	Nucleus1000
Frequency	1 MHz

Specification	Nucleus1000
Minimum altitude	0.05 m
Maximum altitude	50 m
Long-term accuracy	± 1.01 % ± 0.3 % (export controlled)
Ping rate	2 Hz
Maximum velocity	5 m/s
Velocity resolution	0.01 mm/s
Depth rating	300 m
Diameter	90 mm
Height	42 mm
Weight in air/water	535 g / 295 g

Nucleus1000 specifications.

3 Getting Started

This chapter is useful when connecting to the Nucleus for the first time, and deals with connecting the PC to the instrument and other information that is important for first time use.

3.1 Checking the Inventory

Check the content of the received package against the packing list included in the shipment. Do not hesitate to contact us if you find any part of the delivery missing.

Standard inventory

- Nucleus1000 instrument
- Open-ended cable
- Power/serial/ethernet interface unit
- USB drive with software

3.2 Communication

Communication to the Nortek Nucleus is through either a serial interface or a 100BASE-TX Ethernet interface. All commands and data formats are accessible on both physical interfaces. Communication with the Nucleus can be done through the Nortek Nucleus software, or any terminal window. The Nucleus will also appear on a PC network as "NortekNucleus-xxxx", where "xxxx" is the instrument serial number as engraved on the housing.

The Nucleus is provided with an open-ended comms/power cable for the user to attach their own connector. Please see the cable diagram in Appendices.

Ethernet communications

- IP address assigned when connected
- Raw TCP socket (Port 9000). If a TCP connection to the instrument is opened, it will become the main channel for all input and output, and serial interface will be disabled until the TCP connection is closed.

Serial communications (RS232 or RS422)

- Baud rate: 115200
- 1 start bit + 8 data bits + 1 stop bit
- No parity
- Least significant bit first

3.3 Power Supply

The Nucleus input voltage range is 10-32 VDC; we recommend 24 VDC. The switching frequency and harmonics of the power supply must be outside the Nucleus's acoustic bandwidth. Stay away from the frequency bands 1 MHz ±12.5% (875-1250 kHz).

Due to the peak current draw of the instrument there will be a voltage drop over the cable. Therefore a supplied voltage will have a maximum cable length associated with it. The table below details some common voltages and the maximum cable length that can be used.

V_{supply}	Maximum cable length
12 V	2 m

V_{supply}	Maximum cable length
15 V	5 m
18 V	10 m
24 V	30 m
28 V	50 m

Supplied voltages and associated maximum cable lengths.

4 Nucleus Operation

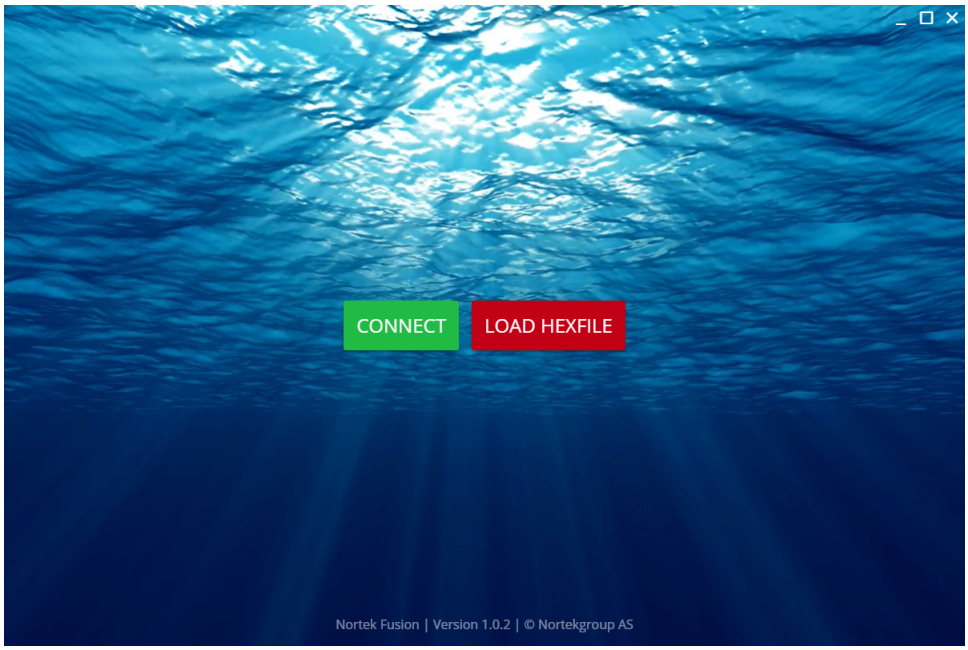
4.1 Nortek Nucleus Software

The Nortek Nucleus software is available on Microsoft Store, and is used to connect to, configure, and receive data from the Nucleus. Contact Nortek for a Linux version of the software.

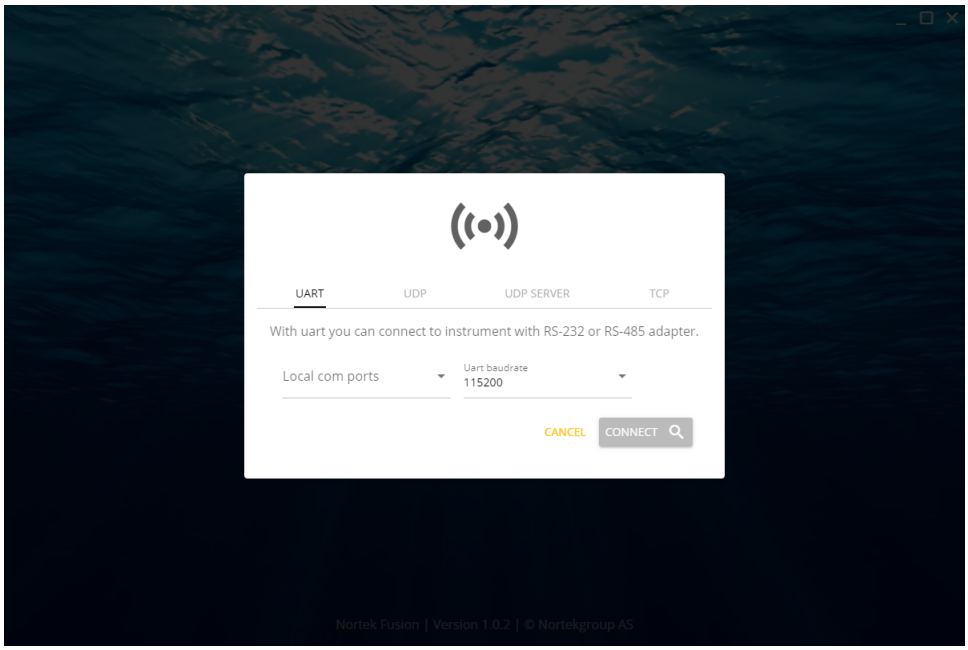
Nortek Nucleus software logo.

Connecting to a Nucleus

- Connect the Nucleus communications cable to the PC. Apply power through the power supply port.
- Open Nortek Nucleus. The start page will be shown as below. If you have previously connected an instrument, a quick Reconnect option will also be shown.



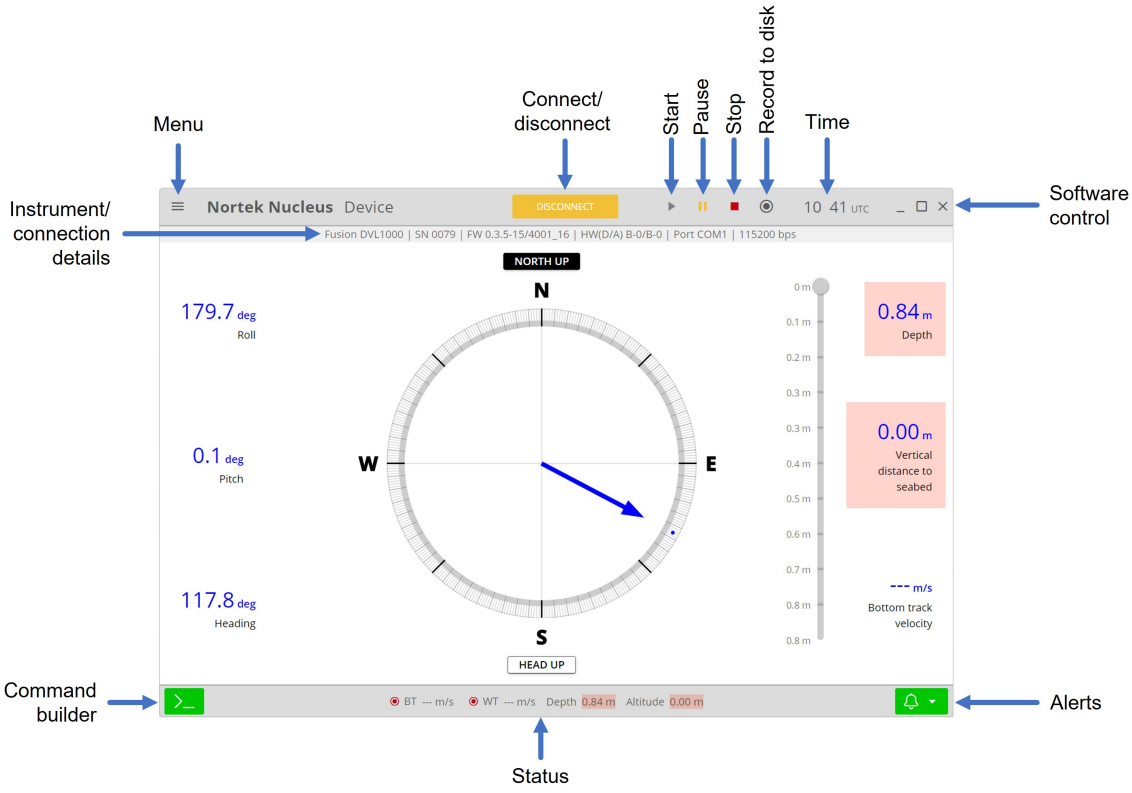
- Click Connect. This will open a connection window with two options:
  - UART: connect through a COM port with a specified baud rate
  - TCP: connect with an IP address, port number, and optional username and password



- Click Connect. This will initiate communication with the Nucleus.

Basic operation

When you connect to the Nucleus, you will see the Device page. See below for a list of functions available from most pages.



Loading a data file

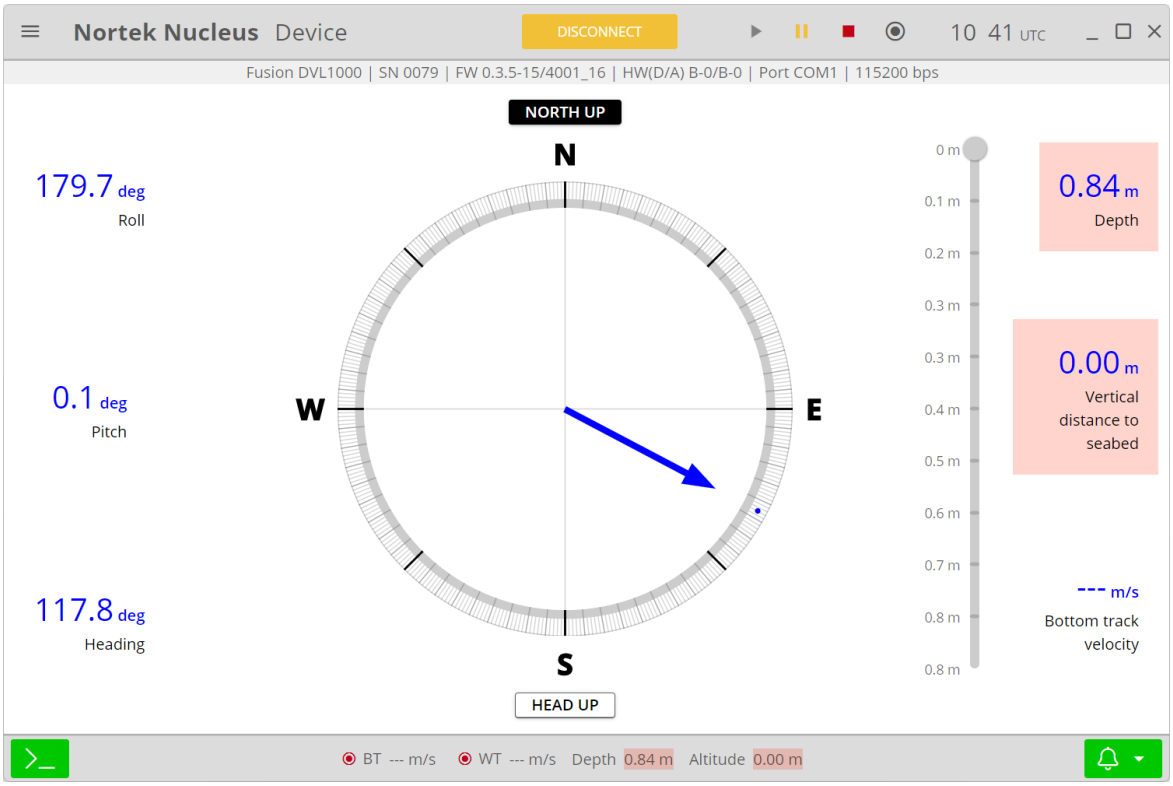
Without an instrument connected, you can load a saved file into the Nucleus software. On the start page, click Load Hexfile and choose the .hex file that you would like to play back. Use the start, pause and stop buttons to play the data.

4.1.1 Dashboards

Device

Here you will see a 3D representation of the tilt and heading of the Nucleus. You can choose between North Up and Head Up on the display.

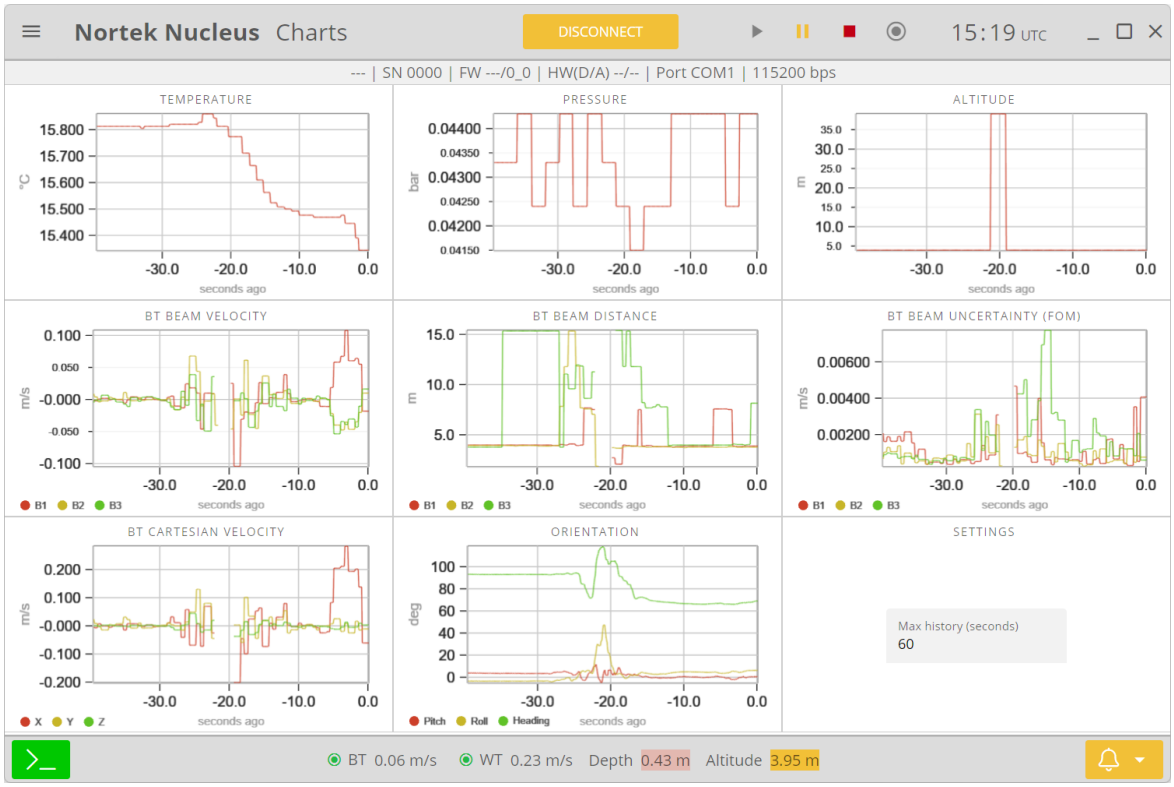
- Displayed parameters: pitch (°), roll (°), heading (°), depth (m), vertical distance to seabed (m), bottom track velocity (m/s)



Charts

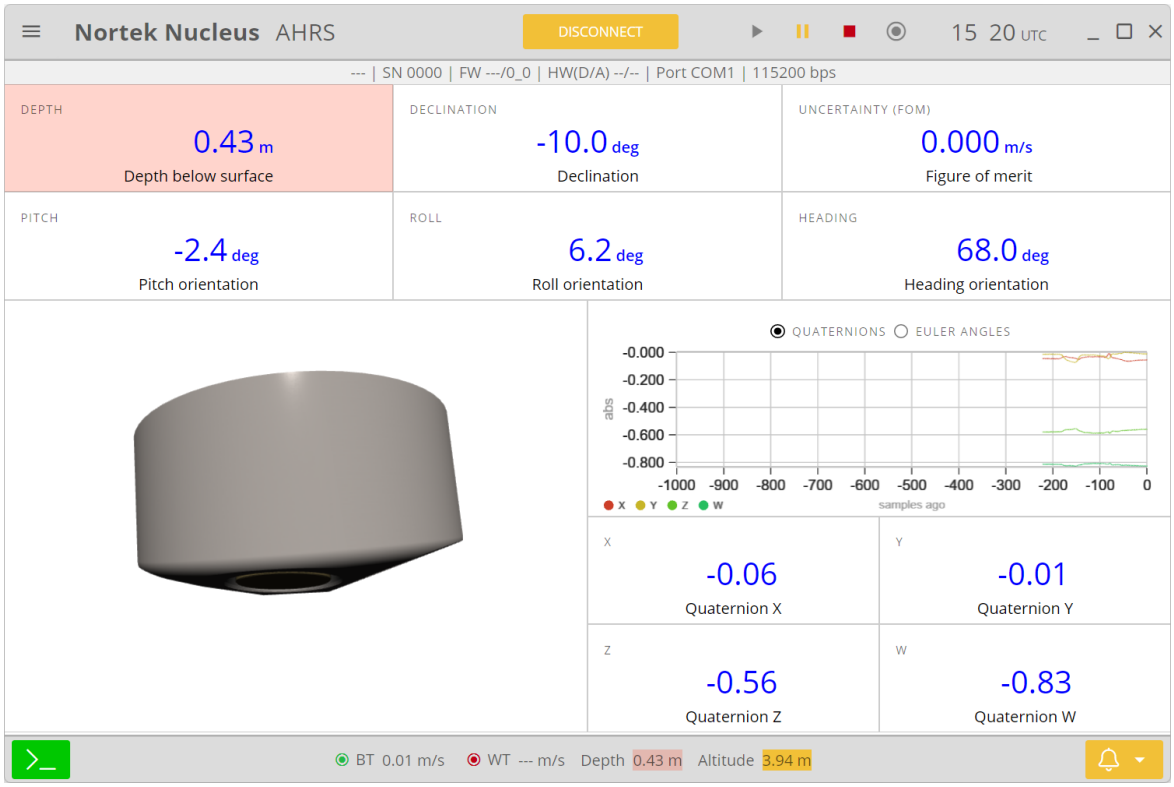
Here charts of sensor measurements over time are displayed. The amount of data displayed depend on the "max seconds history" option, where you can set the number of seconds into the past over which to display data.

- Displayed parameters: temperature (°C), pressure (bar), altitude (m), bottom track beam velocity (m/s), bottom track beam distance (m), bottom track beam uncertainty (FOM) (m/s), bottom track Cartesian velocity (m/s), orientation (°)



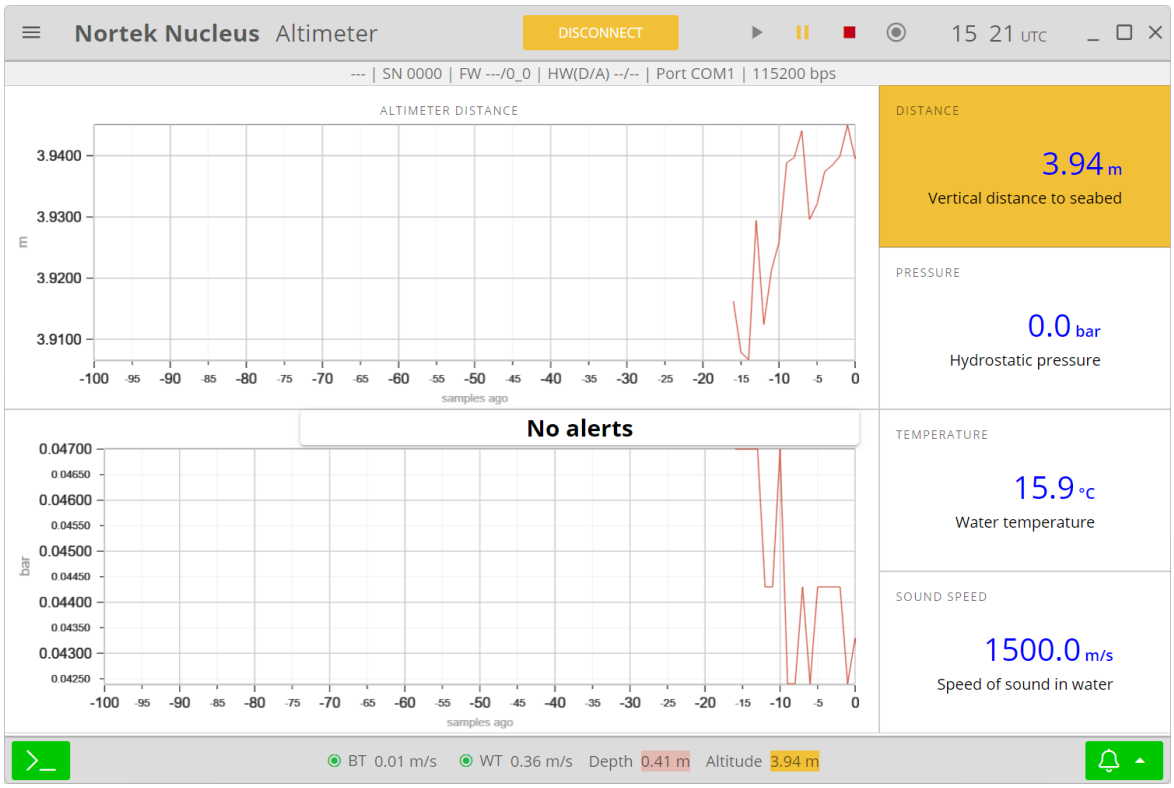
AHRS

- Displayed parameters: depth (m), declination (°), uncertainty (FOM) (m/s), pitch (°), roll (°), heading (°), quaternions/Euler angles X/Y/Z/W



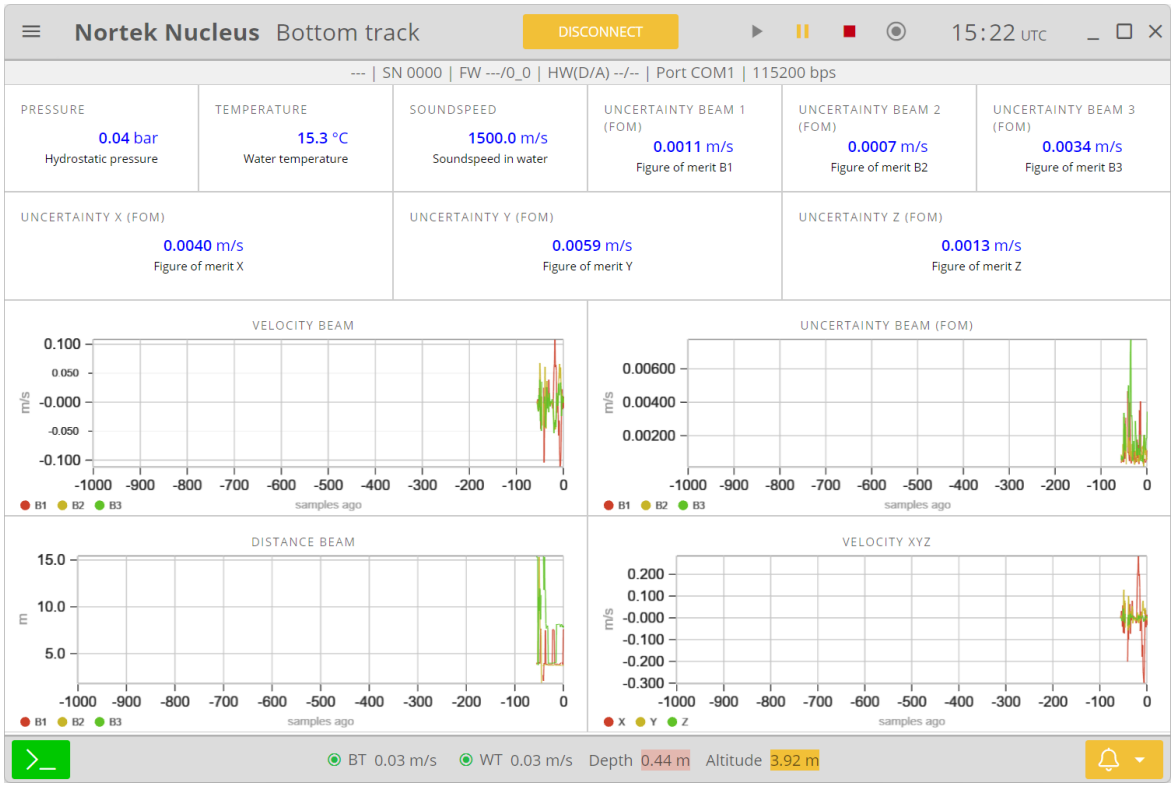
Altimeter

- Displayed parameters: distance (m), pressure (bar), temperature (°C), sound speed (m/s)



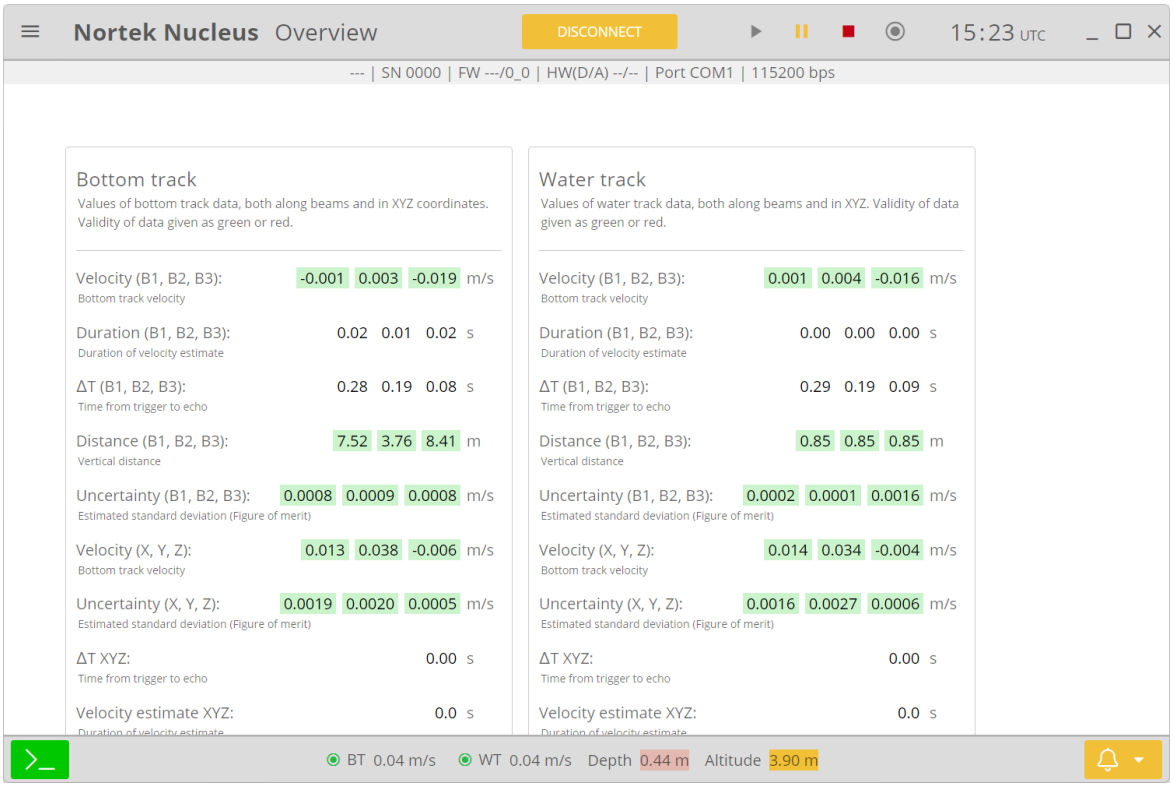
Bottom Track/Water Track

- Displayed parameters: pressure (bar), temperature (°C), sound speed (m/s), uncertainty (FOM) beam 1/2/3 (m/s), uncertainty (FOM) X/Y/Z (m/s)



Overview

Under this tab, every sensor parameter is displayed.

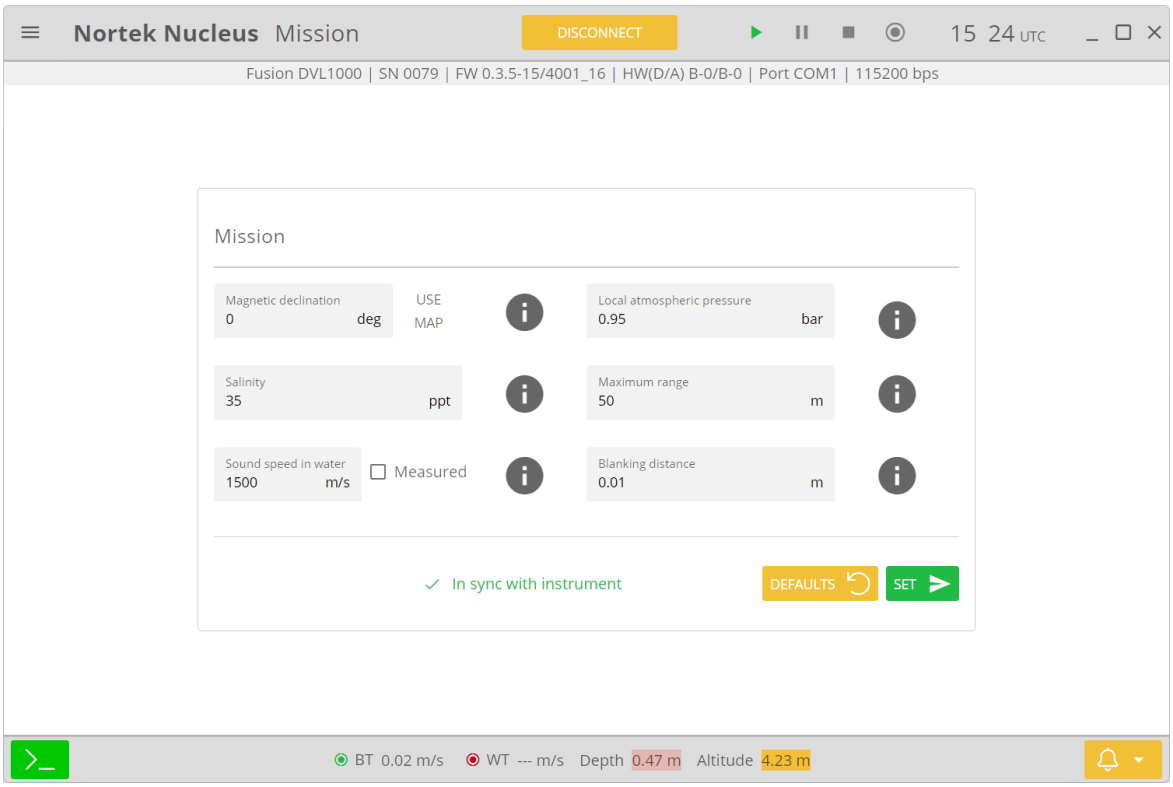


4.1.2 Instrument

Mission

Configuration of environmental offsets for the current mission. Use the info icons for more information about the parameter you are configuring.

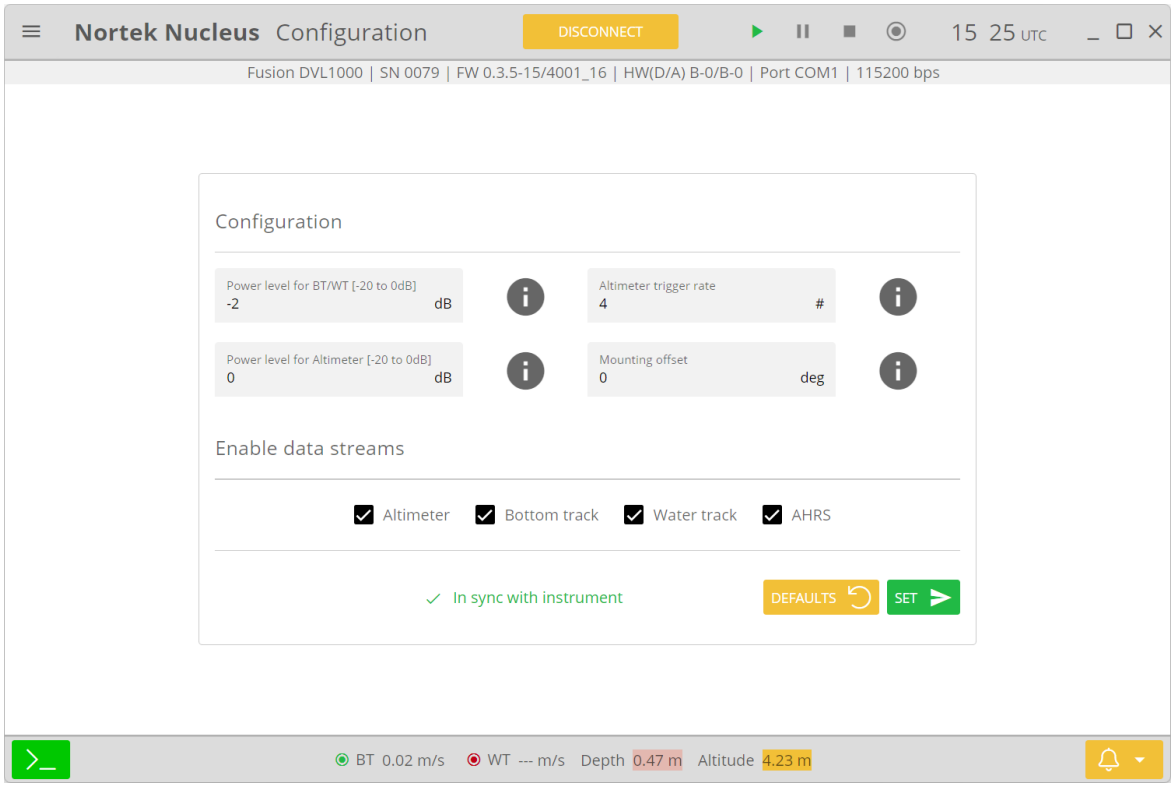
- Magnetic declination (°): offset between direction of magnetic North and true North in deployment area. You can use the map to select the deployment area.
- Salinity (ppt): salinity value in deployment area. This is important for accurate velocity estimates since salinity is used to estimate speed of sound.
- Sound speed (water, m/s): sound speed in deployment area. If you want the instrument to calculate the sound speed using the given salinity and temperature measurements, tick "Measured".
- Pressure sensor offset (bar): air pressure in deployment area
- Range for DVL & Altimeter (m): how far the DVL and altimeter will measure from the instrument
- Blanking DVL & Altimeter (m): blanking distance for the DVL and altimeter



Configuration

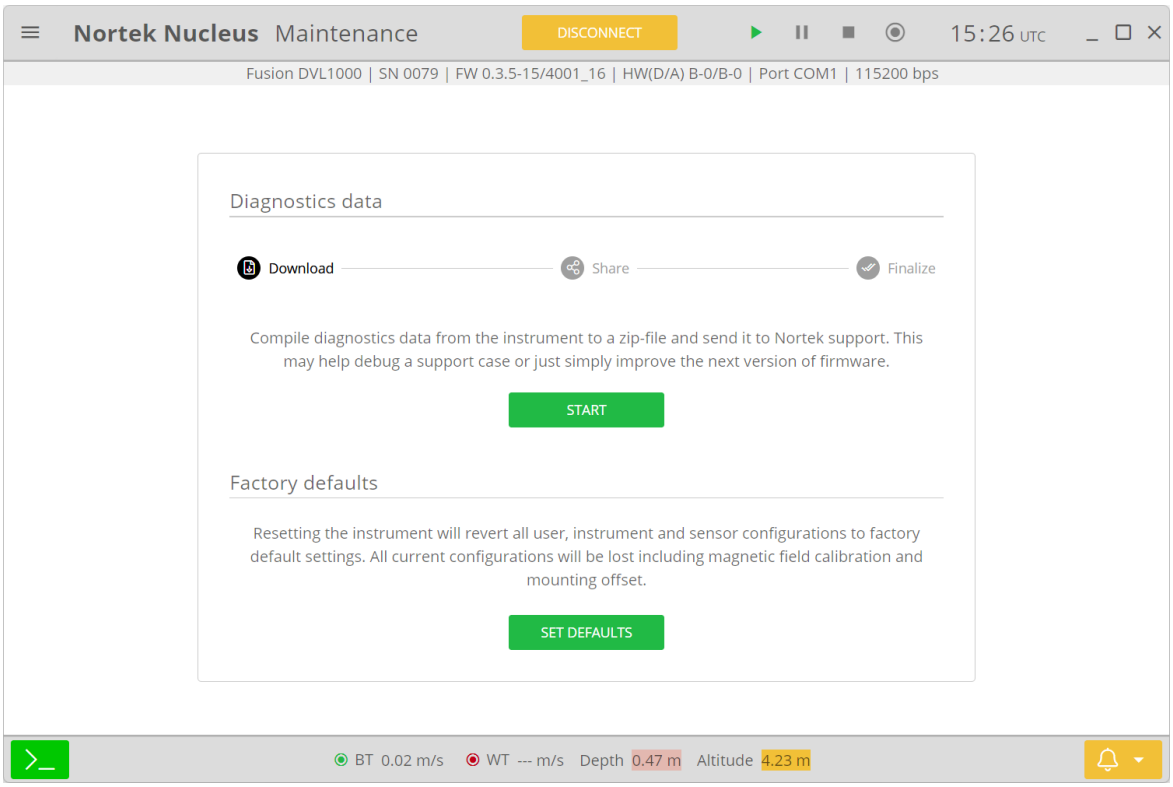
In this tab you can configure various settings for the instrument.

- Power level DVL/Altimeter (dB): the amount of power put into the water by the transducers. 0 dB is the maximum and -20 dB is the minimum.
- Altimeter trigger rate: the altimeter will be sampled every nth ping
- Mounting offset (°): the angle between the instrument's X-direction and the vessel's forward axis
- Tick boxes: you can include as many or as few of the available data streams as required. Note that for serial communication there is a throughput limitation. The maximum data throughput is determined by the baud rate. All data streams listed below are possible with 115 kbaud.



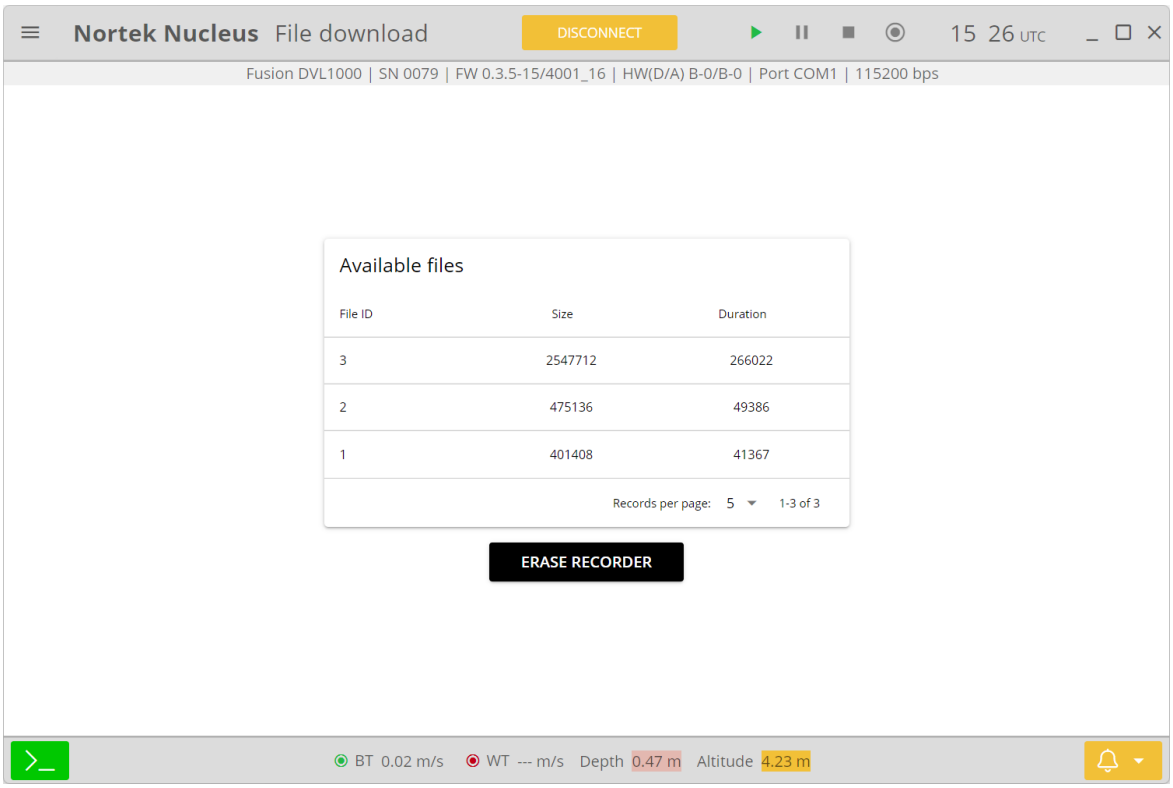
Maintenance

Download files that can be sent to Nortek Support if you have any issues with your instrument, or reset the instrument to factory defaults.



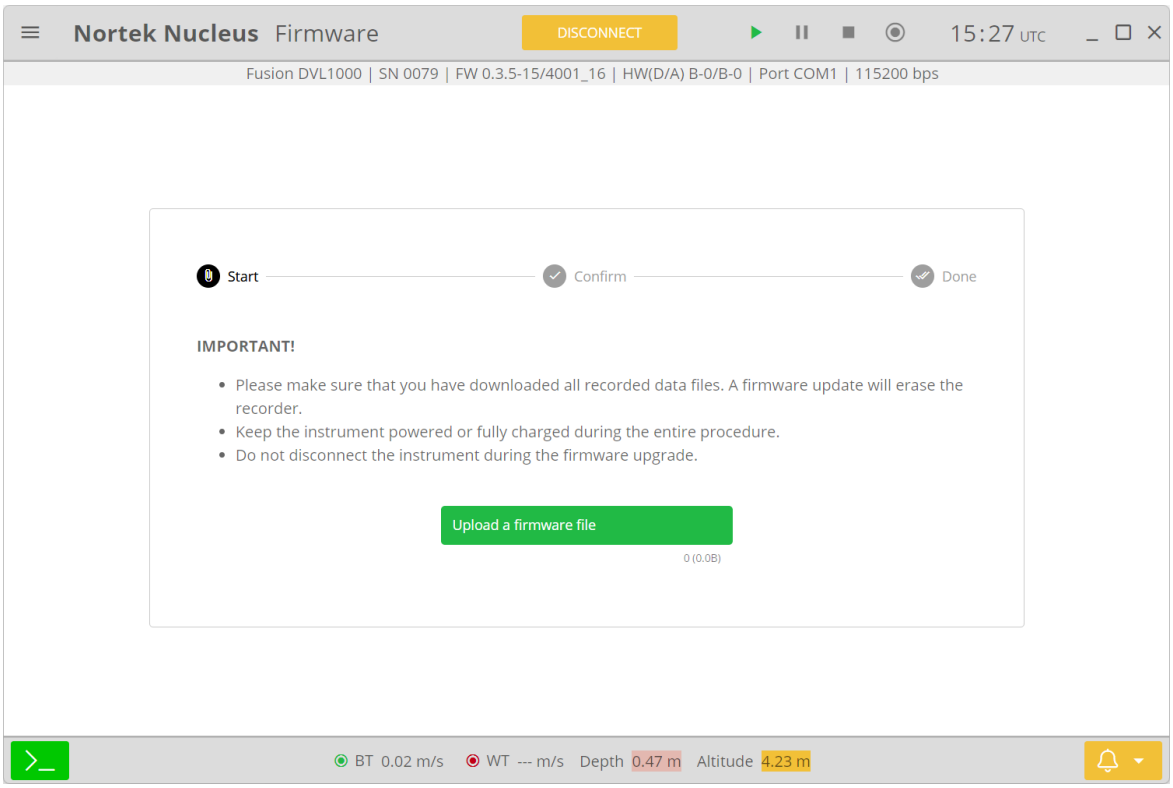
File download

Here you can see a list of files on the recorder. These will have the .hex extension, and can be played back in the software or converted to ASCII/MATLAB format. You can also format the recorder to clear it of files.



Firmware update

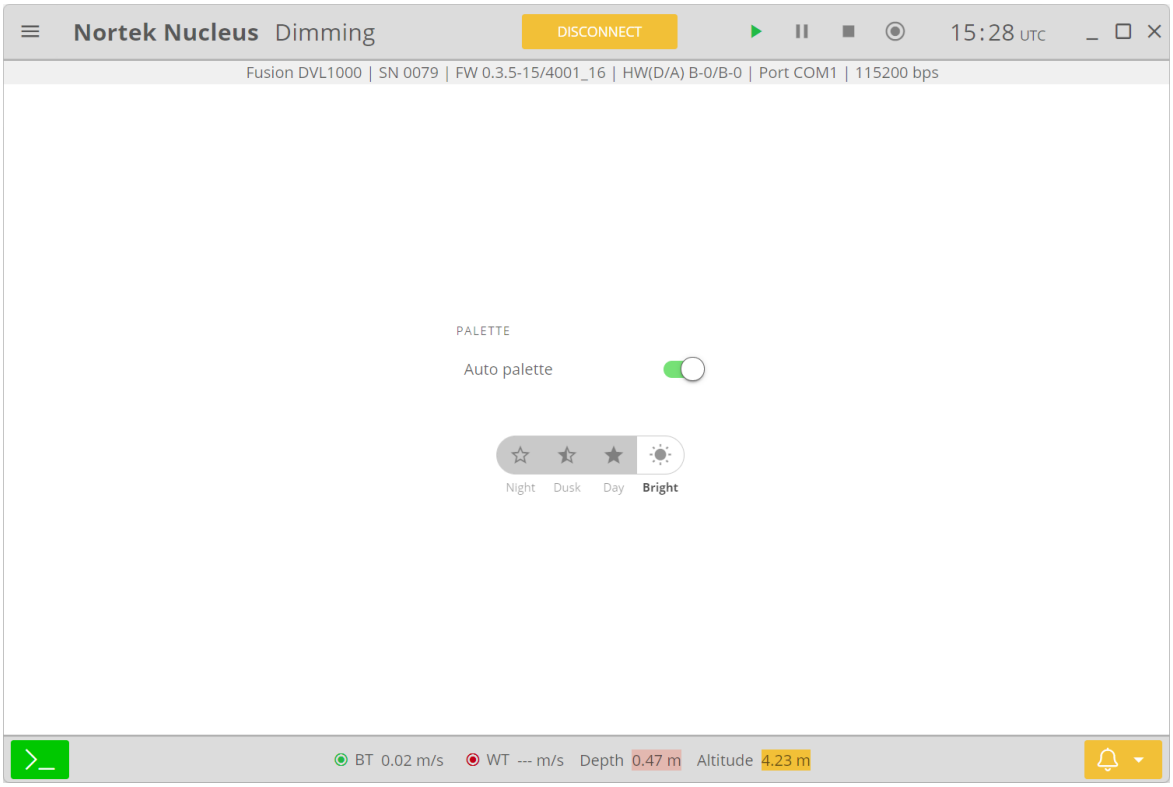
Keeping the firmware up-to-date is very important. Firmware updates will include improvements to measurements and bug fixes. Updating the firmware will format the recorder, so ensure that all data has been downloaded beforehand.



4.1.3 Software

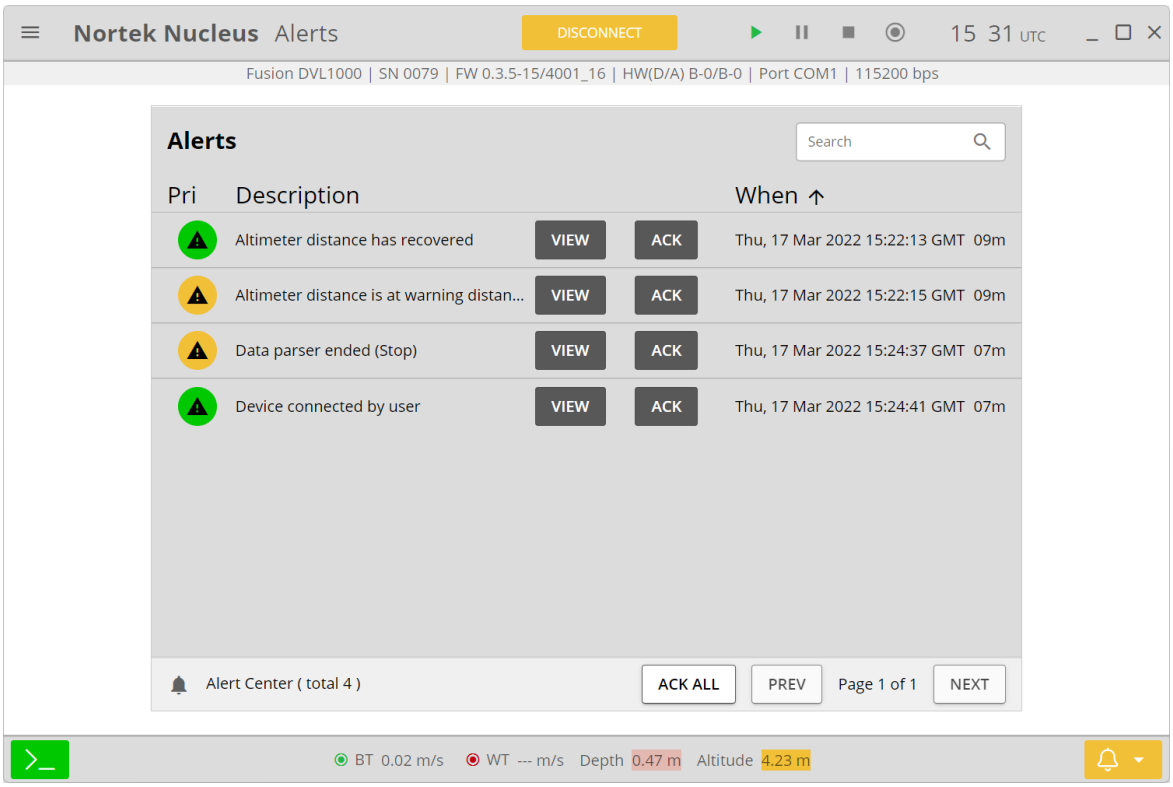
Dimming

The Nucleus software can be used in Night, Dark, Day, or Bright mode, which will change the brightness and palette of the GUI.



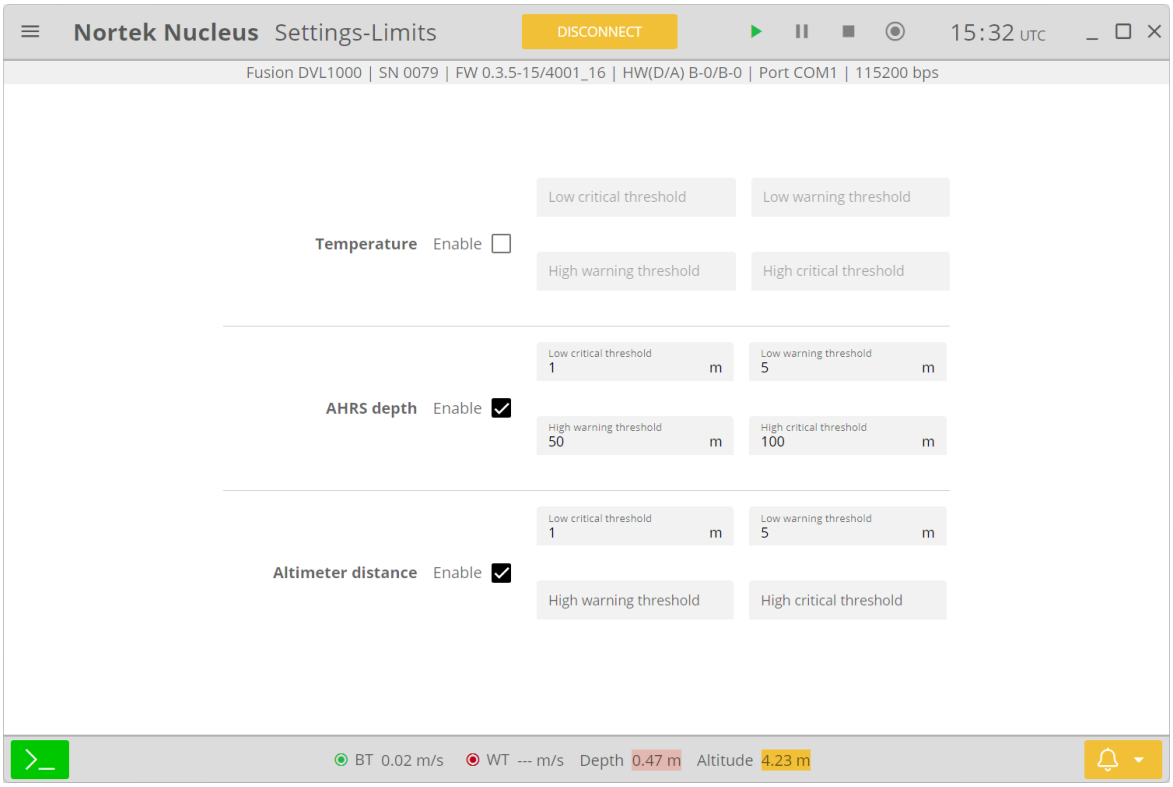
Alerts

Here you have a list of alerts that have been thrown during the mission. You can view or acknowledge them individually, or "ack all" to remove them all.



Alert limits

If required, the thresholds for alerts being thrown can be changed here.



Units

Here you can choose in what units the data will be displayed. **NOTE:** this will not change the units of the raw data in the .hex file or serial output, only the display units in the software.

Exit

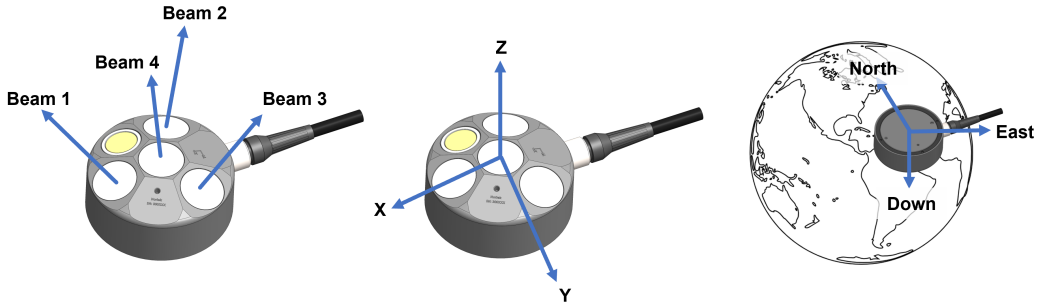
This will immediately exit the Nucleus software and disconnect from the instrument.

4.2 Start and Stop

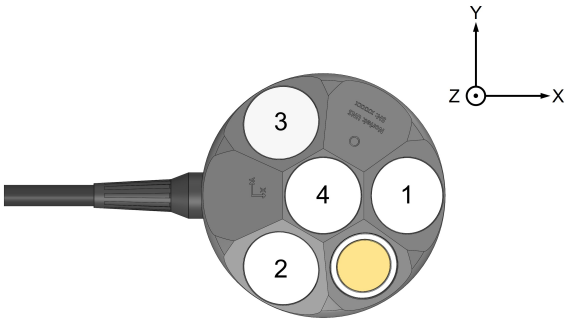
The Nucleus operates in two modes: measurement and command. The default state is command mode, i.e. if power is lost and reapplied, the instrument will revert to command mode.

4.3 Coordinate System

The Nucleus uses two Cartesian coordinate systems: XYZ or "instrument-referenced" coordinates, and North, East, Down (NED) or "Earth-referenced" coordinates. DVL velocities are reported in either XYZ or BEAM coordinates. In XYZ, a positive velocity in the X-direction goes in the direction of the positive X-axis. Use the right-hand-rule to remember the notation conventions for vectors. Use the first (index) finger to point in the direction of positive X-axis and the second (middle) finger to point in the direction of positive Y. The positive Z-axis will then be in the direction that the thumb points. In BEAM coordinates, a positive velocity goes in the direction that the beam points, and is considered the most "raw" form of the velocity.

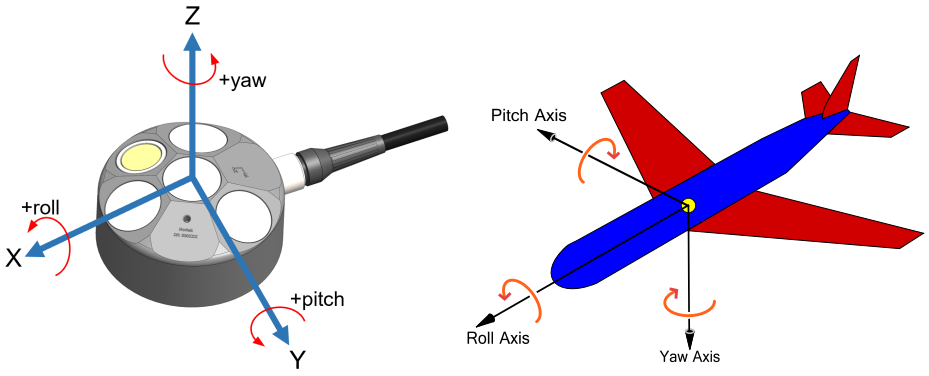


From left to right: BEAM, XYZ, and NED coordinate systems for the Nucleus, used for navigation and/or velocities.



Nucleus beam numbering and axes convention. Note that positive Z is pointing out of the page.

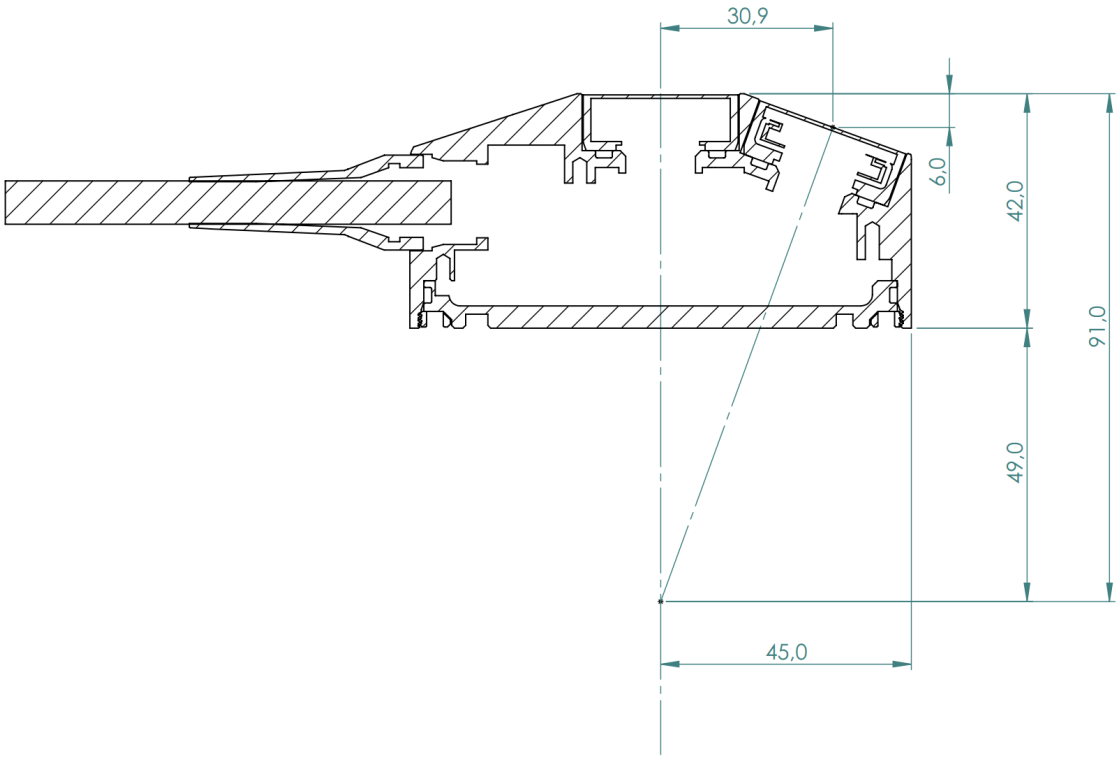
The Nucleus uses roll, pitch and yaw/heading to describe its orientation. When looking at the Nucleus down each axis, positive roll goes counter-clockwise around X, positive pitch goes counter-clockwise around Y, and positive yaw goes counter-clockwise around Z. Be aware that the Nucleus is designed to be mounted facing downward on a vehicle, so the definitions of pitch, roll and yaw will be relative to the vehicle.



Nucleus orientation on the instrument and when mounted downward-facing on a vehicle.

Nucleus origin

Those requiring a reference origin for the Nucleus may use the figure below. This information is typically used for the moment arm calculations with an INS. All measurements are in mm.



Origin for the Nucleus1000.

4.4 Installing Nucleus on Vehicle

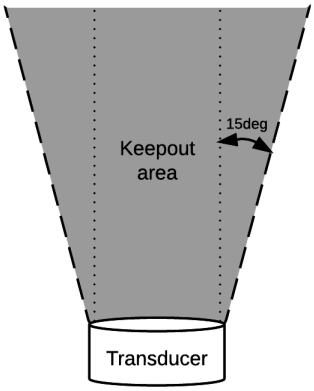
The Nucleus comes with two threaded mounting holes and two guide holes to facilitate installation on a vehicle.

Mechanical alignment

It is recommended but not required to install the Nucleus so that the X-axis points in the vehicles forward direction. This provides an intuitive representation of the data.

Beam clearance

Make sure to keep the area illuminated by the main beam, and a cone of 15 degrees around it, clear from any physical obstacles. These could interfere with the acoustics and bias the measurements.



Calibration
No calibration of the Nucleus is required before installation as it is provided pre-calibrated.

4.5 Functionality Test

Before operation, it is recommended that a functionality test is performed to ensure that the various components work as intended. Before continuing make sure that your instrument is properly connected to the Nucleus software.

Temperature
To test the temperature sensor simply read off the corresponding value under the Altimeter section and compare with the Nucleus's surrounding temperature.

Pressure
The pressure sensor outputs the absolute pressure value in units of dBar.

Recorder
The Nucleus's integrated recorder is designed to always record. The recorder is circular in design so that the oldest recordings are overwritten with the most current data. The size of the recorder is 16 GB. We recommend starting new missions with an empty recorder if you plan to store data internally. Before you erase the recorder, make sure that you have transferred all the data you want to retain.

- Click "Format Recorder" under Maintenance > List & download files.
- Use the FORMAT command.

4.6 Triggers

The trigger mode specifies what controls the acoustic pinging. This is either internal or external. Triggers are an advanced user feature and therefore it is currently not found in Nucleus software. Configuration of triggers is done via the command line as described in the Commands chapter. The default setting is internal with a sample rate of 2 Hz.

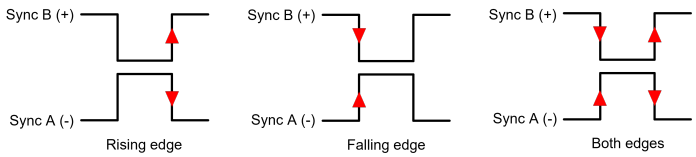
Internal
The internal sampling rate can be set at anything between 1 and 8 Hz. For long ranges the maximum sampling rate is reduced. When the Nucleus is configured for 50 meter range, the DVL

and altimeter's maximum permissible ping rate is 4 Hz. The maximum ping rate of 8 Hz may be achieved if the range is reduced to 25 meters.

External

The Nucleus can be triggered with either the "TRIG" command or RS485 control lines. It can trig on either Rising Edge, Falling Edge or Both Edges of an RS485 signal. When triggered the instrument will perform a complete ping (Tx and Rx) before it goes back to monitoring the trigger. Any triggers asserted during an ongoing ping will be ignored. The Nucleus uses a "Fast Trigger" functionality which means that it does not sleep between pings, remaining fully powered.

- For each trigger there are three transmit pulses from each of the DVL transducers and one transmit pulse from the altimeter. The maximum transmit pulse is 13.3 ms for the DVL and 200 μs for the altimeter.
- The latency (trigger to start of transmit pulse) is 100 μs.



5 Using the Command Interface

This section covers the commands that can be used to control a Nortek Nucleus. The instrument continuously listens to the physical interfaces for incoming commands. All commands and responses are ASCII strings and shall be terminated with newline character(s) <CR> and/or <LF>. Some pointers:

- All command parameters should be set explicitly, e.g.:
  ```
  SETTRIG,SRC="INTERNAL",FREQ=1,ALTI=4
  OK
  ```

- Sometimes you may get an ERROR response after tying to save the configuration or start/deploy the instrument. This doesn't necessarily mean that something is wrong with the instrument, but is most often a sign that the configuration is not permissible, is in conflict, or is a simple typographical error. Any ERROR response can be interrogated with **GETERROR**, e.g.:
  ```
  SETUSER,SA=90.0
  ERROR
  GETERROR
  64,"Invalid setting: Salinity","SETUSER,SA=([0.00;50.00])"
  OK
  ```
  Here, the instrument is reporting that we have set the salinity to be too high, and it provides the limits for the salinity that are allowed.

Command Limit Formats

The limits for the various arguments are returned as a list of valid values, and/or ranges, enclosed in parenthesis **()**. An empty list, **()**, is used for arguments that are unused/not yet implemented. Square brackets **[]** signify a range of valid values that includes the listed values. String arguments are encapsulated with **“”**, like for normal parameter handling. A semicolon, **;**, is used as separator between limits and values. The argument format can also be inferred from the limits, integer values are shown without a decimal point, floating point values are shown with a decimal point and strings are either shown with the string specifier, **“”**, or as a range of characters using **‘’** for specifying a character.

[1;128] – Integer value, valid from 1 to 128.
([1300.00;1700.00];0.0) – Floating point value, valid values are 0.0 and the range from 1300.00 to 1700.00.
(['0';'9'];['a';'z'];['A';'Z'];'.') – String argument with valid characters being . and the character ranges a-z, A-Z, 0-9.
("XYZ") – String argument with XYZ being the only valid string.
(0;1) – Integer value with two valid values, 0 and 1.

Regular interface example:

```
GETBTLIM
([1.00;50.00]),([5.00;5.00]),([0.01;5.00]),("OFF";"ON"),(-100;[-
20.00;0.00]),("MAX";"USER"),("OFF";"SERIAL"),(180),
("OFF";"SERIAL"),(180)
OK
```

NMEA interface example:

```
$PNOR,GETBTLIM*27
```

```
$PNOR,GETBTLIM,RANGE=([1.00;50.00]),VR=([5.00;5.00]),BD=([0.01;5.0
0]),WT=("OFF";"ON"),PL=(-100;[-
20.00;0.00]),PLMODE=("MAX";"USER"),CH1=("OFF";"SERIAL"),CH1_DF=(18
0),CH2=("OFF";"SERIAL"),CH2_DF=(180)*79
$PNOR,OK*2B
```

Command builder

The Nucleus Configurator software has a command builder that can be used to put together commands based on your requirements. In the example below, the command builder has been used to configure the altimeter settings; 50 m range, 0.5 m blanking distance, and 0 dB power level. Clicking "generate" will send the command string "SETALTI,RANGE=50,BD=0.5,PL=0" to the Nucleus.

6 Commands

This chapter contains an overview over all the commands, including a detailed description. Please refer to the previous chapter for examples, and how to use the commands.

6.1 List of Commands

Command	Description
START	Start measurement
STOP	Stop measurement.
TRIG	Trigger a DVL or altimeter measurement
FIELDCAL	Start field calibration procedure
SAVE	Save current settings
SETDEFAULT	Restore default settings
SETMISSION	Set mission settings
GETMISSION	Get mission settings
GETMISSIONLIM	Get limits for mission settings
SETINST	Set instrument settings
GETINST	Get instrument settings
GETINSTLIM	Get limits for instrument settings
SETAHRS	Set AHRS settings
GETAHRS	Get AHRS settings
GETAHRSLIM	Get limits for AHRS settings
SETBT	Set bottom track settings
GETBT	Get bottom track settings
GETBTLIM	Get limits for bottom track settings
SETALTI	Set altimeter settings
GETALTI	Get altimeter settings
GETALTILIM	Get limits for altimeter settings
SETTRIG	Set DVL and altimeter trigger settings
GETTRIG	Get DVL and altimeter trigger settings
GETTRIGLIM	Get limits for DVL and altimeter trigger settings
SETMAG	Set magnetometer settings
GETMAG	Get magnetometer settings
GETMAGLIM	Get limits for magnetometer settings
SETMAGCAL	Set magnetometer calibration values
GETMAGCAL	Get magnetometer calibration values
GETMAGCALLIM	Get limits for magnetometer calibration settings

GETERROR	Returns a full description of the last error condition to occur
ID	Get instrument Id
GETHW	Get board revisions
GETFW	Get firmware version
SETCLOCKSTR	Set instrument clock as string
GETCLOCKSTR	Get instrument clock as string
RESET	Reboot the instrument

6.2 Start

Command: START
Command type: ACTION
Start measurement.

Example:

```
START
OK
```

6.3 Stop

Command: STOP
Command type: ACTION
Stop measurement.

Example:

```
STOP
OK
```

6.4 Trigger measurement

Command: TRIG
Command type: ACTION
This command will trigger a DVL or altimeter measurement. Whether the command triggers a DVL or altimeter measurement is determined by the instrument, and is configurable through SETTRIG,ALTI.

Note! This command is only valid when trigger source is set to "COMMAND"; see SETTRIG,SRC. The command has no effect if measurements are not running.

Example:

```
TRIG
OK
```

6.5 Start field calibration

Command: FIELDCAL
Command type: ACTION
Start field calibration procedure. The field calibration will run until it is stopped by the STOP command or until it times out.

Example:

```
FIELDCAL
```

```
OK
```

6.6 Save settings

Command: SAVE
Command type: ACTION
Make current settings permanent.

Exactly one argument must be provided.

Argument	Description
CONFIG	Save all settings except MISSION and MAGCAL settings.
MISSION	Save MISSION settings. (see SETMISSION/GETMISSION)
MAGCAL	Save MAGCAL settings. (See SETMAGCAL/GETMAGCAL)

Note: When the START command is given, CONFIG and MISSION settings are saved automatically. MAGCAL settings are *not* saved; this means that if the instrument is rebooted (e.g. due to a power glitch) the measurements will continue with different magnetometer calibration values. Use SAVE,MAGCAL to make magnetometer calibration values permanent.

Example:

```
SAVE,CONFIG
OK
```

6.7 Restore default settings

Command: SETDEFAULT
Command type: ACTION
This command restores the given settings to their default values, i.e. the values they would have coming out of the factory. Notice that this command does not make the default values permanent; to do so you must issue the corresponding SAVE command after SETDEFAULT.

At least one argument must be provided.

Argument	Description
CONFIG	Restore all settings except MISSION and MAGCAL to default values.
MISSION	Restore MISSION settings to default values. (see SETMISSION/GETMISSION)
MAGCAL	Restore magnetometer calibration settings to default values. Default values are set individually for each instrument during factory calibration. (See SETMAGCAL/GETMAGCAL)

Note: SETDEFAULT restores to factory default values. If you instead want to restore to the previously saved values, use the RESET command or turn instrument power off, then on. This is particularly useful if you e.g. want to disregard the latest field calibration results.

Example:

```
SETDEFAULT,CONFIG
OK
```

6.8 Mission settings

Commands: SETMISSION, GETMISSION, GETMISSIONLIM
Command type: CONFIGURATION
Set and get mission specific settings.

Notice that these settings are not saved by SAVE,CONFIG; the SAVE,MISSION command must be sent to save changes in mission settings.

Argument	Description
POFF	Set the offset value of the pressure sensor. Unit: [dbar] | Valid Range: [0,11] | Default: 9.5
LONG	Initial position, Longitude. 9999 means unknown longitude. Unit: [deg] | Valid Range: [-180,180] | Default: 9999
LAT	Initial position, Latitude. 9999 means unknown latitude. Unit: [deg] | Valid Range: [-90,90] | Default: 9999
DECL	Declination of magnetic field Unit: [Deg] | Valid Range: [-90,90] | Default: 0
RANGE	DVL and altimeter range Unit: [m] | Valid Range: [1,50] | Default: 50
BD	DVL and altimeter blanking distance Unit: [m] | Valid Range: [0.01,5] | Default: 0.01
SV	Sound velocity. SV = 0 will set sensor to use measured sound velocity Unit: [m/s] | Valid Range: [0,1700] | Default: 1500
SA	Salinity Unit: [ppt] | Valid Range: [0,50] | Default: 35

Note: POFF: The pressure sensor measures the total pressure. POFF is defined as the difference between the hydrostatic and the measured pressure, enabling the system to calculate the hydrostatic pressure. Any error in POFF will directly propagate to error in hydrostatic pressure and thus also to depth estimation.

SETMISSION

Set mission settings

Example:
```
SETMISSION,POFF=9.50,LONG=9999.00,LAT=9999.00,SV=1500.00,SA=35.00
OK
```

GETMISSION

Get mission settings

Example:
```
GETMISSION,POFF,SV,SA
9.50,1500.00,35.00
OK
```

GETMISSIONLIM

Get limits for mission settings

Example:

```
GETMISSIONLIM,LONG,LAT
(9999;[-180.00;180.00]),(9999;[-90.00;90.00])
OK
```

6.9 Instrument settings

Commands: SETINST, GETINST, GETINSTLIM
Command type: CONFIGURATION
Instrument main configuration

Argument	Description
TYPE	System mode. SENSORS
ROTXY	Alignment offset Unit: [deg] | Valid Range: [-180,180]
ROTYZ	Alignment offset Unit: [deg] | Valid Range: [-180,180]
ROTXZ	Alignment offset Unit: [deg] | Valid Range: [-180,180]

Note: The Euler angles ROTYZ, ROTXZ, and ROTXY defines the rotation from VEHICLE to Nucleus. This is described by the principal rotations about the z, y and x axis in this specific order. In terms of the Euler angles ϕ, θ and ψ, this rotation is equivalent to

$Rbn = Rz,\psi Ry,\theta Rx,\phi$

The rotation Rnb from NED to body can be found by transposing the matrix

$Rnb = (Rbn)T$

SETINST

Set instrument settings

GETINST

Get instrument settings

GETINSTLIM

Get limits for instrument settings

6.10 AHRS settings

Commands: SETAHRS, GETAHRS, GETAHRSLIM
Command type: CONFIGURATION
Set and get AHRS settings.

Argument	Description
FREQ	Output frequency Unit: [Hz] | Valid Range: [1,100] | Default: 10
DS	Enable data stream for AHRS OFF, ON Default: ON
DF	Data format for AHRS data stream 210: Nortek binary AHRS format. Default: 210

Note: FREQ: This is how often AHRS data is output to the user. How often the AHRS is updated internally depends on the sampling frequency of the sensors.

SETAHRS

Set AHRS settings

Example:

```
SETAHRS,FREQ=5
OK
```

GETAHRS

Get AHRS settings

Example:

```
GETAHRS,FREQ
5
OK
```

GETAHRSLIM

Get limits for AHRS settings

6.11 Bottom track settings

Commands: SETBT, GETBT, GETBTLIM
Command type: CONFIGURATION

The BT command configures the Bottom Track and Water Track measurements.

Bottom Track and Water Track share the same data stream; this means that any changes to either DS or DF affects both.

Argument	Description
VR	Max velocity expected in the water column during deployment. Velocity range spans from -VR to +VR. Unit: [m/s] | Valid Range: [5,5] | Default: 5
WT	Measure Water Track velocity ON, OFF Default: ON
PL	Power level (range -20.0 dB to 0.0 dB, -100 dB to switch off transmit). Unit: [dB] | Valid Range: [-20,0] | Default: -2
PLMODE	Power Level Mode MAX, USER Default: MAX
DS	Enable data stream for Bottom Track and Water Track OFF, ON Default: ON
DF	Data format for Bottom track data stream 180: Nortek binary format. Bottom track will be output as data format 180, water track will be output as data format 190. Default: 180

Note: Lower power is sometimes desirable if there is an interest in reducing power consumption or if the DVL will only be operating close to the bottom. The maximum power level is range dependent, so the user may either let the firmware select the maximum (MAX) given the current configuration or choose a value (USER). If USER is selected, a power level of 0 dB represents maximum power output. Power is decreased by entering negative values.

SETBT

Set bottom track settings

GETBT

Get bottom track settings

GETBTLIM

Get limits for bottom track settings

6.12 Altimeter settings

Commands: SETALTI, GETALTI, GETALTILIM
Command type: CONFIGURATION
Set and get altimeter settings.

Argument	Description
PL	Power level (range -20.0 dB to 0.0 dB, -100 dB to switch off transmit). Unit: [dB] | Valid Range: [-20,0] | Default: 0

DS	Enable data stream for altimeter OFF, ON Default: ON
DF	Data format for altimeter data stream 170: Nortek binary altimeter format. Default: 170

Note: A power level of 0 dB represents maximum power output. Power is decreased by entering negative values.

SETALTI

Set altimeter settings

Example:

```
SETALTI,PL=-20"
OK
```

GETALTI

Get altimeter settings

Example:

```
GETALTI,PL
-20.00
OK
```

GETALTILIM

Get limits for altimeter settings

6.13 DVL and altimeter trigger settings

Commands: SETTRIG, GETTRIG, GETTRIGLIM
Command type: CONFIGURATION
These commands configure how the DVL and altimeter acoustics are triggered. By default the triggering is done internally, but if the instrument needs to coexist with other acoustic devices the user can choose to control the triggering through an external signal or through the TRIG command.

The DVL and altimeter use the same trigger and whether a trigger affects the DVL or the altimeter is configured through the ALTI parameter.

E.g. if ALTI=4 the first three triggers will trigger the DVL and the fourth trigger will trigger the altimeter and so on.

Argument	Description
SRC	Specifies trigger source for DVL and altimeter "INTERNAL": Internal triggering. The trigger frequency is specified by the FREQ parameter. "EXTRISE": Trigger on the rising edge of external trig signal

	"EXTFALL": Trigger on the falling edge of external trig signal "EXTEDGES": Trigger on both edges of external trig signal "COMMAND": Trigger by issuing a "TRIG" command
FREQ	Internal trigger frequency. For long ranges the maximum trigger frequency is reduced. This parameter is only effective when SRC=INTERNAL. Unit: [Hz] | Valid Range: [1,8]
ALTI	Altimeter trigger rate. Every Nth trigger, triggers an altimeter measurement. ALTI=0 disables the altimeter. 0, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 Default: 4

SETTRIG

Set DVL and altimeter trigger settings

Example:

```
SETTRIG,SRC="INTERNAL",ALTI=8
OK
GETTRIG
"INTERNAL",2.00,8
OK
```

GETTRIG

Get DVL and altimeter trigger settings

Example:

```
GETTRIG
"INTERNAL",2.00,4
OK
```

GETTRIGLIM

Get limits for DVL and altimeter trigger settings

6.14 Magnetometer settings

Commands: SETMAG, GETMAG, GETMAGLIM
Command type: CONFIGURATION
Set and get magnetometer settings.

Argument	Description
FREQ	Magnetometer data sample frequency Unit: [Hz] | Valid Range: [75,75] | Default: 75
CS	Output coordinate system UNS, MAG Default: UNS
METHOD	Method to estimate magnetic declination

	"AUTO": If initial position is set (SETMISSION,LONG,LAT), "WMM" is chosen, otherwise SETMISSION,DECL is used "OFF": Value from SETMISSION,DECL (declination) is used "WMM": World magnetic map is used. Requires initial position to be set (SETMISSION,LONG,LAT) Default: AUTO

SETMAG

Set magnetometer settings

Example:

```
SETMAG,FREQ=75,CS="UNS",METHOD="AUTO"
OK
```

GETMAG

Get magnetometer settings

Example:

```
GETMAG,FREQ,CS,METHOD
75,"UNS","AUTO"
OK
```

GETMAGLIM

Get limits for magnetometer settings

6.15 Magnetometer calibration settings

Commands: SETMAGCAL, GETMAGCAL, GETMAGCALLIM
Command type: CONFIGURATION
Set and get magnetometer calibration values.

The default values for these parameters are set individually for each instrument during factory calibration. Use SETDEFAULT,MAGCAL to restore factory calibrated values.

Users may set these parameters manually or they may be set through the field calibration procedure. Notice that these parameters will not be saved by SAVE,CONFIG nor the START command; use SAVE,MAGCAL to explicitly save the magnetometer calibration values.

Argument	Description
HX	Hard iron of magnetometer X Unit: [Gauss] | Valid Range: [-1,1]
HY	Hard iron of magnetometer Y Unit: [Gauss] | Valid Range: [-1,1]
HZ	Hard iron of magnetometer Z Unit: [Gauss] | Valid Range: [-1,1]
M11	Magnetometer compensation matrix element Valid Range [-2,2]

M12	Magnetometer compensation matrix element Valid Range [-2,2]
M13	Magnetometer compensation matrix element Valid Range [-2,2]
M21	Magnetometer compensation matrix element Valid Range [-2,2]
M22	Magnetometer compensation matrix element Valid Range [-2,2]
M23	Magnetometer compensation matrix element Valid Range [-2,2]
M31	Magnetometer compensation matrix element Valid Range [-2,2]
M32	Magnetometer compensation matrix element Valid Range [-2,2]
M33	Magnetometer compensation matrix element Valid Range [-2,2]

SETMAGCAL

Set magnetometer calibration values

Example:

```
SETMAG,HX=0,HY=0,HZ=0
OK
```

GETMAGCAL

Get magnetometer calibration values

Example:

```
GETMAG,HX,HY,HZ
0.0256,-0.0390,-0.0024
OK
```

GETMAGCALLIM

Get limits for magnetometer calibration settings

6.16 Get error

Command: GETERROR
Command type: INFO
GETERROR retrieves a full description of the last error condition to occur. The error number is returned first followed by a string with the text description of the last error condition. A second string is also returned which contains information on the valid range of the failing argument.

Argument	Description
NUM	Integer error value

STR	Text description

Example:

```
SETUSER, sa=90.0
ERROR
GETERROR
1,"Invalid setting: DVL Salinity","GETUSERLIM,SA=([0.0;50.0])"
GETERROR,NUM
1
GETERROR,STR
"Invalid setting: DVL Salinity","GETUSERLIM,SA=([0.0;50.0])"
```

6.17 Get instrument ID

Command: ID
Command type: INFO
Commands for accessing instrument name and serial number

Argument	Description
SN	Serial number Valid Range [0,2147483647]
STR	Instrument name

Example:

```
ID
"Nucleus1000",900002
ID,STR
"Nucleus1000"
```

6.18 Get hardware information

Command: GETHW
Command type: INFO
Get board revisions.

Argument	Description
DIGITAL	Board revision, digital board. Example: "B-1"
ANALOG	Board revision, analog board. Example: "B-1"

Example:

```
GETHW,DIGITAL
"B-1"
OK
```

6.19 Get firmware version

Command: GETFW
Command type: INFO
Get firmware version.

Argument	Description

STR	Nucleus version on format [Major].[Minor].[Patch] Example: "1.0.2"
MAJOR	Nucleus major version
MINOR	Nucleus minor version
PATCH	Nucleus patch version

Example:

```
GETFW,STR,MAJOR,MINOR,PATCH
"1.0.2",1,0,2
OK
```

6.20 Clock settings as strings

Commands: SETCLOCKSTR, GETCLOCKSTR
Command type: CONFIGURATION
Set or retrieve the Real Time Clock using a string. Must use the format as shown: yyyy-MM-dd HH:mm:ss

Argument	Description
TIME	Text string with this format yyyy-MM-dd HH:mm:ss (use UTC)

SETCLOCKSTR

Set instrument clock as string

Example:

```
SETCLOCKSTR,TIME="2020-11-12 14:27:42"
```

GETCLOCKSTR

Get instrument clock as string

Example:

```
GETCLOCKSTR
GETCLOCKSTR, TIME = "2014-11-12 14:27:42"
```

6.21 System reset

Command: RESET
Command type: ACTION
This command will do a system reboot. All settings will be re-loaded from their saved values.

Example:

```
RESET
OK
Nortek Fusion DVL1000
Version 1.0.0
OK
```

7 Data Formats

This chapter describes the Nortek Nucleus binary data formats for sensor output. Note that the binary data formats all use a common header that specifies how the rest of the data block should be interpreted. A data block is the data from and including one header to the next. Binary data are always sent as Little Endian.

About these chapters

Each sensor's data format is described in the following chapters. To avoid duplicating rows in the following tables, we have documented header and common data separately. This way, the chapter on one sensors data format will only contain the fields unique or this sensor. Take altimeter data as an example:

In short: The data format is the sum of header data, a common part and the part that is unique for altimeter. Se figure below.

A little longer: The header is the same for all data blocks. It is compact and quick to parse, and it contains information about the rest of the data (e.g. data type and size). This is documented separately as _HeaderData. We use the leading underscore to emphasize that this is a not a complete data format, but it is a part used by two or more data formats.

The same goes for other common data such as data format version number, offset to data and timestamp. This is documented separately in _CommonData.

Last, there are the unique fields such as pressure, distance and quality of altimeter data that is given in the table in AltimeterData.

The table below is an illustration on how common data fields (gray for header and blue for other common's) relate to the sensor specific data fields (green).

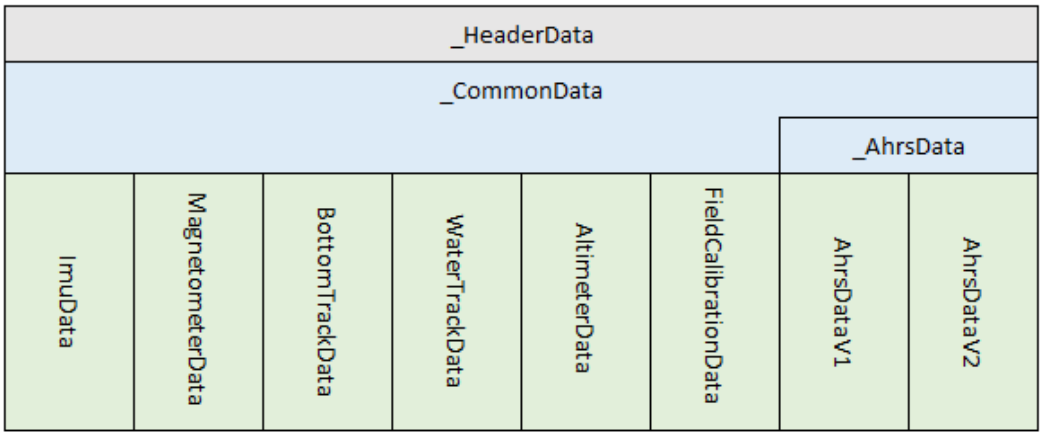


Figure: Showing how common data fields (gray for header and blue for other common's) the sensor data relate to the sensor specific data fields (green). Note that we use a leading underscore (_) to emphasize that this is not a sensor data format but is common and used by two or more data formats.

About the tables

Tables have the columns 'Field', 'Position/Size' and 'Description'. Position and size may need an explanation:

Position has the location of a field in the header or in the data that follows the header. E.g., the 'data series id' has position 2 (Note that we are counting from 0) in the header. Some positions are not fixed, but dependent on which fields are before it. In these cases, 'offset of data' (position 1 of the data - see _CommonData) can then be used to give the position of the following fields. In these cases, the position in the table will not be given as a number but as a variable name such as OFFSET. Variable descriptions are listed below the tables where they are used.

Size is the data type of field. In case of 'data series id' it is an unsigned integer of 8 bits (uint8). Note that not all fields have a specific data type but is an object using a required number of bits. E.g., the status bit masks often use 32 bits to provide 'ok'/'not ok' on several parts of the data. These object sizes and their descriptions are listed below the table where they are used.

7.1 _HeaderData

The header definition for binary data formats. Note that the header may be verified without reading the rest of the data block since it has its own checksum.

Field	Position Size	Description
Sync bit	0 uint8	Always 0xA5.
Header size	1 uint8	Number of bytes in the headers
Data series id	2 uint8	Defines the type of the following Data Record. NUCLEUS ids start at 0x80 0xA0 (160) - String data, eg. GPS NMEA data, comments,.. 0xAA (170) - Altimeter data 0xB4 (180) - Bottom track 0xBE (190) - Water track 0xD2 (210) - AHRS In most cases we have either 5 or 10 possible variants for each “sensor”. We have also left space for additional sensors.
Family id	3 uint8	Defines the Instrument Family. 0x20 is the NUCLEUS Family.
Data size	4 uint16	Number of bytes in the following Data Record.
Data checksum	6 uint16	Checksum of the following Data Record.
Header checksum	8 uint16	Checksum of all fields of the Header except the Header Checksum itself..

7.2 _CommonData

Used By: AhrsData, ImuData, MagnetometerData, BottomTrackData, WaterTrackData, AltimeterData, FieldCalibrationData

Common data definitions parsing nucleus data.

Field	Position Size	Description
Version	0 uint8	Data format version
Offset of data	1 uint8	Number of bytes from start of record to start of non-common data fields Unit: [bytes]
Time stamp	4 uint32	If the system time has been properly set, s represents POSIX time (number of seconds since January 1st 1970). s shall be interpreted as an unsigned integer to be Y2k38 safe. If system time is not set, s is the number of seconds elapsed since the START command. Unit: [s]
Micro seconds	8 uint32	Microseconds from last whole second Unit: [µs]

7.3 _AhrsData

Extends: CommonData
Used By: AhrsDataV1, AhrsDataV2
ID: 0xd2

Data definitions for parsing AHRS data.

Note the empty field of 3 bytes after the operationMode byte enabling dataset to begin on whole 32bit blocks

Field	Position Size	Description
Serial number	16 uint32	Instrument serial number from factory.
Operation mode	24 uint8	AHRS operation mode 0:Field calibration 1:Initializing 2:Regular AHRS mode
AHRS data.Roll	OFFSET float	Euler angles roll. Unit: [deg]
AHRS data.Pitch	OFFSET + 4 float	Euler angles pitch. Unit: [deg]
AHRS data.Heading	OFFSET + 8 float	Euler angles heading. Unit: [deg]

AHRS data.Quaternion W	OFFSET + 12 float	W quaternion
AHRS data.Quaternion X	OFFSET + 16 float	X quaternion
AHRS data.Quaternion Y	OFFSET + 20 float	Y quaternion
AHRS data.Quaternion Z	OFFSET + 24 float	Z quaternion
AHRS data.Rotation matrix	OFFSET + 28 float *3 *3	AHRS Rotation Matrix [3x3] The rotation matrix Rbn is defined as the rotation from body to NED. This can also be described by three principal rotations about the z, y and x axes in this specific order. In terms of the Euler angles ϕ, θ and ψ, this rotation is equivalent to Rbn = Rz,ψ Ry,θ Rx,ϕ The rotation Rnb from NED to body can be found by transposing the matrix Rnb = (Rbn)T
Declination	OFFSET + 64 float	Magnetic declination. Easterly positive. Unit: [deg]
Depth	OFFSET + 68 float	Depth below sea surface, estimated from pressure. Unit: [m]

Position and size variables:

Name	Description
OFFSET	Offset of data given at position 1 in this dataset. Number of bytes from start of record to start of data.

7.4 ImuData

Extends: CommonData
ID: 0x82

Data definitions for parsing NUCLEUS IMU binary data (DF130).

Field	Position Size	Description
IMU status	12 32 bits	IMU Status Bit description Object reference given in table below
Accelerometer.X	OFFSET float	X axis value Unit: [m/s2]
Accelerometer.Y	OFFSET + 4 float	Y axis value Unit: [m/s2]
Accelerometer.Z	OFFSET + 8 float	Z axis value Unit: [m/s2]
Gyro.X	OFFSET + 12 float	X axis value Unit: [rad/s]

Gyro.Y	OFFSET + 12 + 4 float	Y axis value Unit: [rad/s]
Gyro.Z	OFFSET + 12 + 8 float	Z axis value Unit: [rad/s]
Temperature	OFFSET + 24 float	Temperature in IMU Unit: [°C]

Position and size variables:

Name	Description
OFFSET	Offset of data given at position 1 in this dataset. Number of bytes from start of record to start of data.

Object reference: IMU status

IMU Status Bit description

Field	Position Size	Description
Has diagnostics data	0 bit	A 1 indicates Diagnostics data included (bit 1-10).
Has overrun data path	1 bit	Data path is overrun [DIAG_STAT 1]
Has flash update failure	2 bit	Flash memory update failure. A 1 indicates error [DIAG_STAT 2]
Has SPI communication error	3 bit	SPI communication error. A 1 indicates error [DIAG_STAT 3]
Has low voltage	4 bit	Standby mode. A 1 indicates insufficient voltage. The IMU will restart when when VDD>2.8V for 250ms. [DIAG_STAT 4]
Has sensor failure	5 bit	Sensor failure. A 1 indicates a failure in at least one sensor after self test. [DIAG_STAT 5]
Has memory failure	6 bit	Memory failure. A 1 indicates a failure in flash memory of IMU [DIAG_STAT 6]
Has gyro 1 failure	8 bit	Gyroscope 1 failure. A 1 indicates failure of gyroscope 1 after self test. [DIAG_STAT 8]
Has gyro 2 failure	9 bit	Gyroscope 2 failure. A 1 indicates failure of gyroscope 2 after self test. [DIAG_STAT 9]
Has accelerometer failure	10 bit	Accelerometer failure. A 1 indicates failure of accelerometer after self test. [DIAG_STAT 10]

7.5 MagnetometerData

Extends: CommonData
ID: 0x87

Data definitions for parsing nucleus Magnetometer data.

Field	Position Size	Description
Magnetometer status	12 32 bits	Magnetometer Status Bit description Object reference given in table below
Magnetometer.X	OFFSET float	X axis value Unit: [gauss]
Magnetometer.Y	OFFSET + 4 float	Y axis value Unit: [gauss]
Magnetometer.Z	OFFSET + 8 float	Z axis value Unit: [gauss]

Position and size variables:

Name	Description
OFFSET	Offset of data given at position 1 the dataset. Number of bytes from start of record to start of data.

Object reference: Magnetometer status

Magnetometer Status Bit description

Field	Position Size	Description
Is compensated for hard iron	0 bit	0 = Not compensated for hard iron, 1 = Compensated for hard iron

7.6 AhrsDataV2

Extends: AhrsData
ID: 0xd2
Version: 2

Data definitions for parsing AHRS data.

Field	Position Size	Description
Figure of merit	28 float	Quality measure of AHRS (0 when not running)
Fom. field calibration	32 float	Quality measure of Field calibration (hard iron)

7.7 BottomTrackData

Extends: CommonData
ID: 0xb4

The format is based on DF21 – DVL Bottom Track, but with slight modifications. Most significantly it supports only 3 beams.

Field	Position Size	Description
Status	12 32 bits	DVL status bit mask Object reference given in table below
Serial number	16 uint32	Instrument serial number from factory.
Sound speed	24 float	Sound speed Unit: [m/s]
Temperature	28 float	Temperature Unit: [°C]
Pressure	32 float	Pressure The hydrostatic pressure is here calculated as Measured Pressure – POFF. Unit: [Bar]
Velocity beam 1	36 float	Velocity beam 1 invalid estimates set to -32.768 Unit: [m/s]
Velocity beam 2	40 float	Velocity beam 2 invalid estimates set to -32.768 Unit: [m/s]
Velocity beam 3	44 float	Velocity beam 3 invalid estimates set to -32.768 Unit: [m/s]
Distance beam 1	48 float	Vertical distance along beam 1 invalid estimates set to 0.0 Unit: [m]
Distance beam 2	52 float	Vertical distance along beam 2 invalid estimates set to 0.0 Unit: [m]
Distance beam 3	56 float	Vertical distance along beam 3 invalid estimates set to 0.0 Unit: [m]
Uncertainty beam 1	60 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) for beam 1. invalid estimates set to 10.0 Unit: [m/s]
Uncertainty beam 2	64 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) for beam 2

		invalid estimates set to 10.0 Unit: [m/s]
Uncertainty beam 3	68 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) for beam 3 invalid estimates set to 10.0 Unit: [m/s]
ΔT beam 1	72 float	Time from the center of the bottom echo, which estimates the bottom track velocity, to the time indicated by timestamp Unit: [s]
ΔT beam 2	76 float	Time from the center of the bottom echo, which estimates the bottom track velocity, to the time indicated by timestamp Unit: [s]
ΔT beam 3	80 float	Time from the center of the bottom echo, which estimates the bottom track velocity, to the time indicated by timestamp Unit: [s]
Velocity estimate beam 1	84 float	Duration of velocity estimate (time velocity estimate) for beam 1. Unit: [s]
Velocity estimate beam 2	88 float	Duration of velocity estimate (time velocity estimate for beam 2. Unit: [s]
Velocity estimate beam 3	92 float	Duration of velocity estimate (time velocity estimate for beam 3. Unit: [s]
Velocity X	96 float	Velocity X Invalid estimates set to -32.768 Unit: [m/s]
Velocity Y	100 float	Velocity Y Invalid estimates set to -32.768 Unit: [m/s]
Velocity Z	104 float	Velocity Z Invalid estimates set to -32.768 Unit: [m/s]
Uncertainty X	108 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) in X dimension. Invalid estimates set to 10.0 Unit: [m/s]
Uncertainty Y	112 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) in Y dimension. Invalid estimates set to 10.0 Unit: [m/s]

Uncertainty Z	116 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) in Z dimension. Invalid estimates set to 10.0 Unit: [m/s]
ΔT XYZ	120 float	Time from trigger to echo of first beam used in the estimation of X, relative to timestamp Unit: [s]
Velocity estimate XYZ	124 float	Duration of velocity estimate for XYZ components Unit: [s]

Object reference: Status

DVL status bit mask

Field	Position Size	Description
Beam 1 velocity valid	0 bit	Beam 1 velocity valid
Beam 2 velocity valid	1 bit	Beam 2 velocity valid
Beam 3 velocity valid	2 bit	Beam 3 velocity valid
Beam 1 distance valid	3 bit	Beam 1 distance valid
Beam 2 distance valid	4 bit	Beam 2 distance valid
Beam 3 distance valid	5 bit	Beam 3 distance valid
Uncertainty beam 1 valid	6 bit	Beam 1 figure of merit (FOM) valid
Uncertainty beam 2 valid	7 bit	Beam 2 figure of merit (FOM) valid
Uncertainty beam 3 valid	8 bit	Beam 3 figure of merit (FOM) valid
Velocity X valid	9 bit	X velocity valid
Velocity Y valid	10 bit	Y velocity valid
Velocity Z valid	11 bit	Z velocity valid
Uncertainty X valid	12 bit	X figure of merit (FOM) valid
Uncertainty Y valid	13 bit	Y figure of merit (FOM) valid

Uncertainty Z valid	14 bit	Z figure of merit (FOM) valid

7.8 WaterTrackData

Extends: CommonData
ID: 0xbe

The format is based on DF22 – DVL Water Track, but with slight modifications. Most significantly it supports only 3 beams.

Water track data follows the same structure as Bottom track data, but when bottom track follows the most distant cell in the water column, water track will follow a cell where the water flow is assumed not impacted by the instrument.

Field	Position Size	Description
Status	12 32 bits	DVL status bit mask Object reference given in table below
Serial number	16 uint32	Instrument serial number from factory.
Sound speed	24 float	Sound speed Unit: [m/s]
Temperature	28 float	Temperature Unit: [°C]
Pressure	32 float	Pressure The hydrostatic pressure is here calculated as Measured Pressure – POFF. Unit: [Bar]
Velocity beam 1	36 float	Velocity beam 1 invalid estimates set to -32.768 Unit: [m/s]
Velocity beam 2	40 float	Velocity beam 2 invalid estimates set to -32.768 Unit: [m/s]
Velocity beam 3	44 float	Velocity beam 3 invalid estimates set to -32.768 Unit: [m/s]
Distance beam 1	48 float	Vertical distance along beam 1 invalid estimates set to 0.0 Unit: [m]
Distance beam 2	52 float	Vertical distance along beam 2 invalid estimates set to 0.0 Unit: [m]
Distance beam 3	56 float	Vertical distance along beam 3 invalid estimates set to 0.0 Unit: [m]

Uncertainty beam 1	60 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) for beam 1. invalid estimates set to 10.0 Unit: [m/s]
Uncertainty beam 2	64 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) for beam 2 invalid estimates set to 10.0 Unit: [m/s]
Uncertainty beam 3	68 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) for beam 3 invalid estimates set to 10.0 Unit: [m/s]
ΔT beam 1	72 float	Time from the center of the echo of the cell, which estimates the water track velocity, to the time indicated by timestamp Unit: [s]
ΔT beam 2	76 float	Time from the center of the echo of the cell, which estimates the water track velocity, to the time indicated by timestamp Unit: [s]
ΔT beam 3	80 float	Time from the center of the echo of the cell, which estimates the water track velocity, to the time indicated by timestamp Unit: [s]
Velocity estimate beam 1	84 float	Duration of velocity estimate (time velocity estimate) for beam 1. Unit: [s]
Velocity estimate beam 2	88 float	Duration of velocity estimate (time velocity estimate for beam 2. Unit: [s]
Velocity estimate beam 3	92 float	Duration of velocity estimate (time velocity estimate for beam 3. Unit: [s]
Velocity X	96 float	Velocity X Invalid estimates set to -32.768 Unit: [m/s]
Velocity Y	100 float	Velocity Y Invalid estimates set to -32.768 Unit: [m/s]
Velocity Z	104 float	Velocity Z Invalid estimates set to -32.768 Unit: [m/s]
Uncertainty X	108 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) in X

		dimension. Invalid estimates set to 10.0 Unit: [m/s]
Uncertainty Y	112 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) in Y dimension. Invalid estimates set to 10.0 Unit: [m/s]
Uncertainty Z	116 float	Estimated velocity uncertainty reported as one standard deviation (Figure of merit - FOM) in Z dimension. Invalid estimates set to 10.0 Unit: [m/s]
ΔT XYZ	120 float	Time from trigger to echo of first beam used in the estimation of X, relative to timestamp Unit: [s]
Velocity estimate XYZ	124 float	Duration of velocity estimate for XYZ components Unit: [s]

Object reference: Status

DVL status bit mask

Field	Position Size	Description
Beam 1 velocity valid	0 bit	Beam 1 velocity valid
Beam 2 velocity valid	1 bit	Beam 2 velocity valid
Beam 3 velocity valid	2 bit	Beam 3 velocity valid
Beam 1 distance valid	3 bit	Beam 1 distance valid
Beam 2 distance valid	4 bit	Beam 2 distance valid
Beam 3 distance valid	5 bit	Beam 3 distance valid
Uncertainty beam 1 valid	6 bit	Beam 1 figure of merit (FOM) valid
Uncertainty beam 2 valid	7 bit	Beam 2 figure of merit (FOM) valid
Uncertainty beam 3 valid	8 bit	Beam 3 figure of merit (FOM) valid
Velocity X valid	9 bit	X velocity valid
Velocity Y valid	10	Y velocity valid

	bit	
Velocity Z valid	11 bit	Z velocity valid
Uncertainty X valid	12 bit	X figure of merit (FOM) valid
Uncertainty Y valid	13 bit	Y figure of merit (FOM) valid
Uncertainty Z valid	14 bit	Z figure of merit (FOM) valid

7.9 AltimeterData

Extends: CommonData
ID: 0xaa

Suggestion based on Data format DF30 Altimeter measurements.

Field	Position Size	Description
Status	12 32 bits	Altimeter status bit mask Object reference given in table below
Serial number	16 uint32	Instrument serial number from factory.
Sound speed	24 float	Sound speed Unit: [m/s]
Temperature	28 float	Temperature Unit: [°C]
Pressure	32 float	Pressure The hydrostatic pressure is here calculated as Measured Pressure – POFF. Unit: [Bar]
Distance	36 float	Altimeter distance from seabed. Unit: [m]
Quality	40 uint16	Altimeter quality. Figure of merit (FOM)

Object reference: Status

Altimeter status bit mask

Field	Position Size	Description
Altimeter distance valid	0 bit	Altimeter distance valid
Altimeter quality valid	1 bit	Altimeter quality valid
Pressure valid	16	Pressure valid

	bit	
Temperature valid	17 bit	Temperature valid

7.10 FieldCalibrationData

Extends: CommonData
ID: 0x8b

This data format is streamed when FIELDCAL command is run.

Field	Position Size	Description
Field calibration status	12 32 bits	Field calibration status bit description Object reference given in table below
Hard iron.X	OFFSET float	X axis value Unit: [gauss]
Hard iron.Y	OFFSET + 4 float	Y axis value Unit: [gauss]
Hard iron.Z	OFFSET + 8 float	Z axis value Unit: [gauss]
Soft iron matrix	OFFSET + 12 float *3 *3	A 3x3 soft iron matrix (s_axis) in row-major order.
New point.X	OFFSET + 48 float	X value
New point.Y	OFFSET + 48 + 4 float	Y value
New point.Z	OFFSET + 48 + 8 float	Z value
Figure of merit	OFFSET + 60 float	Figure of merit.
Coverage	OFFSET + 64 float	Percent of sphere covered. Unit: [%]

Position and size variables:

Name	Description
OFFSET	Offset of data given at position 1 the dataset. Number of bytes from start of record to start of data.

Object reference: Field calibration status

Field calibration status bit description

Field	Position Size	Description

Point used in estimation	0 bit	0 = not used, 1 = used First bit in status describes if the point is stored to be used in the batch estimation. Not all points are used due to limited storage/ processing time.

8 Maintenance

We recommend a regularly scheduled procedure which will act as a preventative measure to ensure your instrument continues functioning as intended. The following sections can be used as a maintenance guideline for the components that may be exposed to wear and tear. The Nucleus housing should not be opened unless instructed by Nortek; any unauthorised access will void the warranty.

8.1 Instrument Care

All Nortek instruments are intended for use in water. Other fluids may have an adverse effect on the materials used. If the instrument has been subjected to environmental conditions outside the specified design limits (refer to the Technical Specification for your instrument for the limits), mechanical tolerances of non-metal components may be affected.

- Rinse the instrument with fresh water after every deployment.
- When cleaning the external surfaces use a mild detergent and pay special attention to the transducers. Regular cleaning is the best way to avoid problems related to biofouling.
- Conduct a Functionality Test after the maintenance procedure has been finished, to ensure that the instrument is working as expected.
- The screws used to secure the instrument using the threaded M4 holes must be **titanium** to avoid galvanic corrosion.

8.2 Connector Care

It is extremely important to keep connectors clean. Follow the procedures below to extend the life of your connectors and reduce the risk of corrosion or water ingress.

Before mission:

- Demate the connector set.
- Flush the connector set with compressed air and remove dirt. Remember to also check the female connector.
- Check that both connectors are dry. If not, let them air-dry.
- Inspect connector for damage, corrosion and cuts.
- Inspect connector O-rings and replace if necessary.
- Apply a thin film of 3M Silicone Spray or equivalent to the connector. Use silicone lubricant grease (Molykote 111 or equivalent) on the O-rings.
- Mate the connector halves and check if they are properly mated.

After mission and before storage:

- Flush the connector set with compressed air and remove dirt.
- Check that both connectors are dry. If not, let them air-dry.
- Inspect connector for damage, corrosion and cuts.
- Inspect connector O-rings and replace if necessary.
- Mate with dummy plug if available.

8.3 Cable Care

- Do not pull on the cable to disconnect connectors.
- Avoid sharp bends at cable entry to connector.
- Ensure that the cable is fixed to the mounting fixture to avoid mechanical stress to the connection.
- Elastomers can be seriously degraded if exposed to direct sunlight or high ozone levels for extended periods.

9 Appendices

9.1 Glossary

Term	Definition
Accuracy	A value giving the degree of closeness of a velocity measurement to the actual velocity
Altimeter	A vertically-orientated beam used to measure the distance from the instrument to the seabed
Baud rate	The speed at which data is transferred over a communications cable
Beam coordinates	Along-beam velocities. The reported velocities are positive when the motion is towards the transducer.
Blanking distance	The period/distance immediately after a pulse is transmitted during which the instrument does not listen for returned pulses - this is to give the transducers time to settle before the echo returns.
Bottom track	A method which measures the velocity of the seabed as the platform moves above it.
Break	A break command is used to change between the various operational modes of the instrument and to interrupt the instrument regardless of which mode it is in. When break is received in command mode, you can see that the LED is switched off for a short time.
DVL	Doppler Velocity Log; an acoustic instrument that measures the speed and direction of a platform relative to the seabed or other reference level.
ENU coordinates	East, North, Up; Earth-referenced coordinates that take into account the tilt and heading of the instrument. N is magnetic North, and is reported as 0°. E is reported as 90°. Often used for upward-facing instruments.
Euler angle	Three angles used to describe the orientation of a rigid body with respect to a fixed coordinate system.
Firmware	Internal software of the instrument, as opposed to the instrument software running on a PC. Availability of new firmware versions is shown on the instrument web interface.
Heading	The direction in which the instrument is pointing relative to Magnetic North.
Keepout area	The area to either side of a beam where obstructions might interfere with the data; generally 15°.
LED	Light Emitting Diode.
Magnetic declination	The difference in degrees between True North and Magnetic North at a given location
NED coordinates	North, East, Down; Earth-referenced coordinates that take into account the tilt and heading of the instrument. N is magnetic North, and is reported as 0°. E is reported as 90°. Often used for downward-facing instruments.

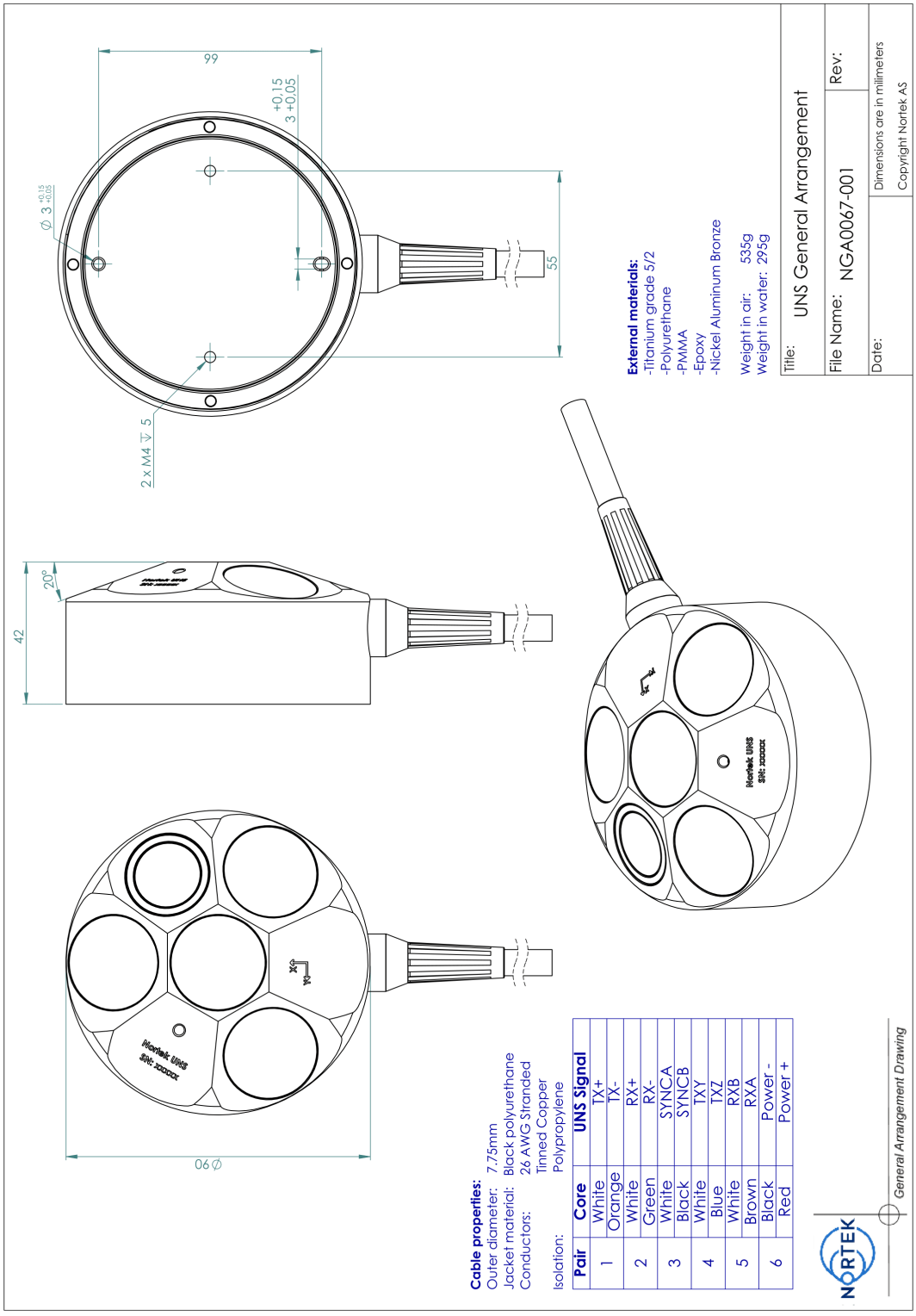
Term	Definition
Noise floor	The amplitude of the internal noise of the instrument. This will limit the minimum detectable signal that can be received.
Pitch	Rotation/tilt around the Y axis.
Pressure	The pressure exerted on the instrument by the weight of water above it; often used as a proxy for depth below the sea surface.
Pressure offset	Due to atmospheric pressure variations, the sensor signal may have an offset. Note that the sensor does not output negative values. Set the offset before deployment.
Quaternion	Mathematical notations representing spatial orientations and rotations of elements in three dimensional space.
Roll	Rotation/tilt around the X axis.
Salinity	The amount of salt dissolved in sea water; required for speed of sound calculations.
Sidelobe	The acoustic beams focus most of the energy in the center of the beams, but a small amount leaks out in other directions. Transducer sidelobes are rays of acoustic energy that go in directions other than the main lobe. Because sound reflects stronger from the water surface than it does from the water, the small signals that travel straight to the surface can produce sufficient echo to contaminate the signal from the water.
Sound speed	The speed at which sound travels through seawater; affected by temperature, salinity, and pressure.
Trigger	A signal to the instrument to wake up. This can be internal or external.
Uncertainty /FOM	The Figure of Merit (FOM) is a measure of measurement uncertainty of the reported velocity value, and is reported as an expected standard deviation.
Water track	A method which assumes a 0 m/s velocity for a plane of water below the platform, and then measures the velocity of the platform relative to this; used when the seabed is not in range.
XYZ coordinates	Cartesian coordinate system. A positive velocity in the X-direction goes in the direction of the X-axis arrow. Use the right-hand-rule to remember the notation conventions for vectors. Use the first (index) finger to point in the direction of positive X-axis and the second (middle) finger to point in the direction of positive Y. The positive Z-axis will then be in the direction that the thumb points.
Yaw	Rotation/tilt around the Z axis.

9.2 Cable Diagrams

Pair	Core		Signal	Pin
1	White		TX +	1
	Orange		TX -	2
2	White		RX +	3
	Green		RX -	4
3	White		SYNCA	5
	Black		SYNCB	6
4	White		TX + (Y)	7
	Blue		TX - (Z)	8
5	White		RX + (B)	9
	Brown		RX - (A)	10
6	Black		PWR -	11
	Red		PWR +	12

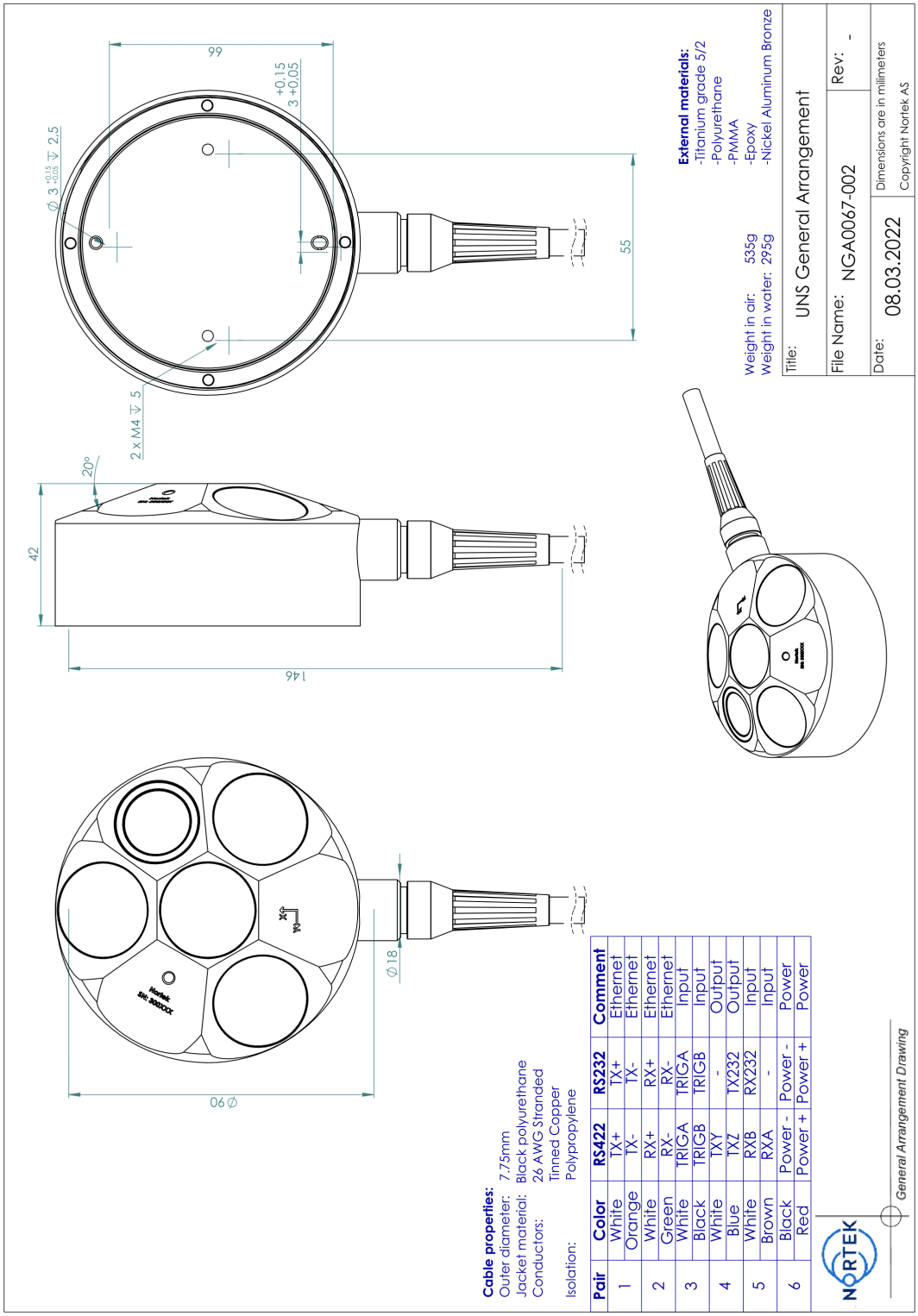
9.3 Mechanical Drawings

Nucleus with penetrator cable



Pair	Core	UNS Signal
1	White	TX+
	Orange	TX-
2	White	RX+
	Green	RX-
3	White	SYNCA
	Black	SYNCB
4	White	TXY
	Blue	TXZ
5	White	RXB
	Brown	RXA
6	Black	Power -
	Red	Power +

Nucleus with connector cable



Pair	Color	RS422	RS232	Comment
1	White	TX+	TX+	Ethernet
	Orange	TX-	TX-	Ethernet
2	White	RX+	RX+	Ethernet
	Green	RX-	RX-	Ethernet
3	White	TRIGA	TRIGA	Input
	Black	TRIGB	TRIGB	Input
4	White	TXY	-	Output
	Blue	TXZ	TX232	Output
5	White	RXB	RX232	Input
	Brown	RXA	-	Input
6	Black	Power -	Power -	Power
	Red	Power +	Power +	Power

9.4 Proforma Invoice

NOT A SALE

Temporary export to Norway for repair

Sender (Exporter)	Receiver
Name:	Name: Nortek AS
Address:	Address: Vangkroken 2
City:	City: N-1351 Rud
Country:	Country: Norway
Tel:	Tel: +47 67 17 45 00
E-mail:	E-mail: support@nortekgroup.com
Ref:	Customs Account No.: 322 68 794
	VAT/Company No.: 996 707 415 MVA

About the goods	
Date:	Description of Goods:
Delivery Terms:	**No. of Units:**
Delivery method:	**Weight:**
Tracking no:	**Origin: NO**
Reason for Export:	**Total Value:**
Return for repair	**Nortek RMA No.:**
Temporary	

Place:
Date:
Exporter's Name: