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, FAQs, and the latest software and firmware. General information, technical notes, and user experience can also be found here.

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 or phone

Email: inquiry@nortekgroup.com (general inquiries), support@nortekgroup.com (technical support)
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Version/revision	Date	Comments
2022.1	06.04.2022	Initial version
2022.2	27.04.2022	Appendix and data format edits
2022.3	25.05.2022	Communication protocol edits
2022.4	23.06.2022	Detail on firmware processes and field calibration
2022.5	13.07.2022	Minor edits
2022.6	27.09.2022	Commands and data format updates, communication edits
2022.7	17.10.2022	Minor edits
2022.8	19.12.2022	Minor edits
2023.1	27.03.2023	Minor edits & Removed DeltaT XYZ
2023.2	02.05.2023	Updated images and dataformats
2023.3	14.06.23	Changed wording from "Station keeping" to "crawler mode".

		Included sampling rate chapter

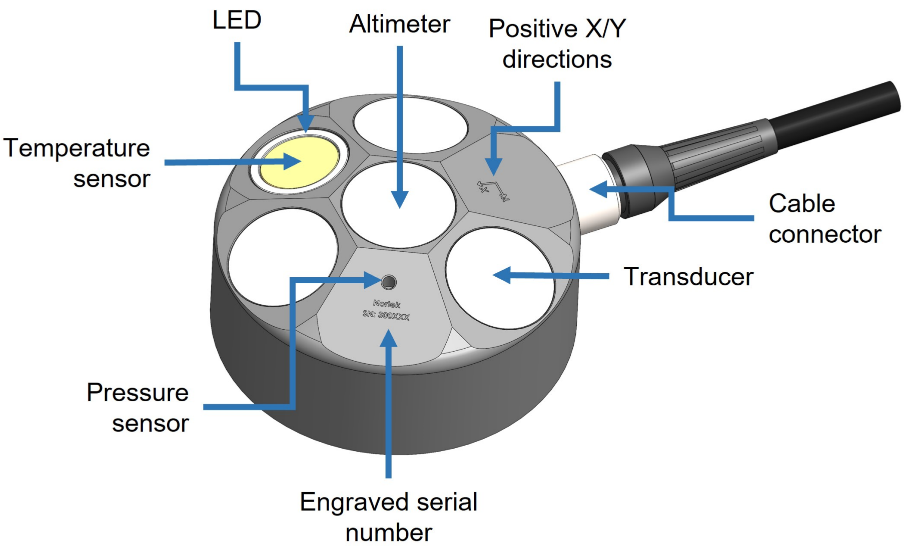
2 System Overview

The Nucleus1000 is an instrument designed to facilitate navigation in GPS-denied areas. It contains acoustic Doppler functionality alongside sensors that enable AHRS functionality.

The acoustic Doppler function, referred to as DVL (Doppler Velocity Log), enables the Nucleus to estimate the velocity relative to the bottom (Earth being the frame of reference) or relative to the water. These two operations are known as "bottom track" and "water track". To perform the DVL function, the Nucleus has three acoustic beams oriented in a diverging, convex configuration, plus a central altimeter transducer to measure the vertical distance to the seabed. These diverging beams can also be used to collect current profiles to measure the velocity of the water (licensed feature).

The Nucleus is also equipped with a magnetometer and an IMU (Inertial Measurement Unit) for angular rate and acceleration. Together these sensors perform the function of an AHRS (Attitude and Heading Reference System), estimating pitch, roll and heading.

It also contains a high precision pressure sensor for estimating depth and a temperature sensor for calculating sound speed. It has an LED ring around the temperature sensor to indicate the current mode; this will be a steady blue when the instrument is in command mode, and when in measurement mode it will blink every time the DVL or altimeter pings. The titanium housing reduces both noise and the risk of mechanical damage.



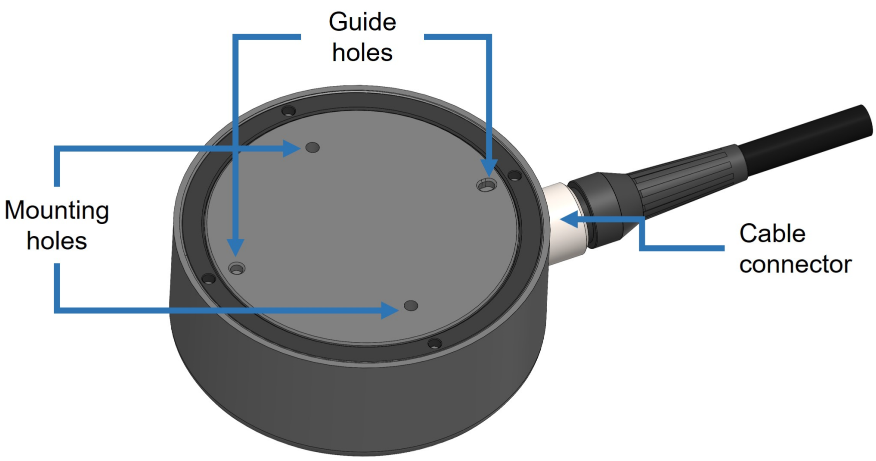


Figure 1: Nucleus overview

The system comes with an open-ended 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
Minimum altitude	0.1 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

Table 1: 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 with wet-end connector
- 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 ether physical interface. Communication with the Nucleus can be done through the Nortek Nucleus software, or any terminal window supporting serial and/or TCP.

The Nucleus is provided with an open-ended communications/power cable for the user to attach their own connector. When ordering there is a choice of cables supporting either RS232 or RS422. Ethernet is supported on both cables. Please see the cable diagram in Appendices.

Serial communications (RS232 or RS422)

Serial communication is immediately available when the instrument is powered on, and will output:

```
Nortek Nucleus1000
Version 2.0.2
OK
```

The electrical interface used for serial communications can be either RS232 or RS422 depending on the cable selection.

Serial configuration:

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

The serial interface is disabled when a TCP connection is established, and enabled again when the TCP connection is closed.

Ethernet communications

By default the instrument is configured to use DHCP, so in a typical network environment it should automatically be assigned an IP address on the local network. If no IP address has been assigned after 30s, the instrument will assign itself the link-local address 169.254.15.123. This address can e.g. be used when connecting the instrument directly to a laptop. Optionally, the instrument can instead be configured to use a static IP address. Use the SETETH command to configure the static IP, the subnet mask and the default gateway.

Regardless of the method used for assigning the IP address, the instrument should be available on the local network through the host name "NORTEK-xxxxxx.local", where "xxxxxx" is the instrument serial number as engraved on the housing.

Communication is done using a raw TCP socket at port 9000. When connecting you will be prompted for a password. The default password is "nortek". When a TCP connection is established it will become the main channel for all input and output, and the serial interface will be disabled until the TCP connection is closed.

Note that when the instrument is powered on it will take some time before it responds to its host name and IP address. How long it takes depends on the method used for IP address assignment and the networking environment.

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
15 V	5 m
18 V	10 m
24 V	30 m
28 V	50 m

Table 2: Supplied voltages and associated maximum cable lengths

4 Nucleus Operation

4.1 Data Collection

Instrument modes

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. This can be thought of as an "idle" mode, where the Nucleus is waiting to receive commands.

Default, Saved and Active settings

The Nucleus contains two sets of stored settings, Default settings and Saved settings. Default settings are set in the factory and can be copied to the Active settings using the SETDEFAULT command. Saved settings are set by the user and can be saved from the Active settings with the SAVE command. Saved settings can be copied to the Active settings with the RESTORE command. At power on, the instrument will automatically load the Saved settings.

The Active settings define how the instrument behaves during the current mission and can be changed by the user, typically with a command beginning with "SET". Examples are SETAHRS and SETBT. When the desired settings are applied, a SAVE command can be issued to update the Saved settings. SAVE must be used with an additional argument (e.g. SAVE,MAGCAL).

When the user is ready to start measurements, this can be done through the commands START or FIELDCAL. Both START and FIELDCAL will store the MISSION and CONFIG Active settings to Saved settings before the measurements start. The START command is meant for general use, whilst FIELDCAL is specifically meant for calibrating the magnetic system, i.e. finding magnetic calibration values (hard and soft iron parameters). Please see the Field Calibration chapter for details. Neither SAVE nor FIELDCAL will store the MAGCAL Active settings.

Measurements are stopped by the STOP command. After a STOP command is issued, the instrument will automatically update the MAGCAL values in the Active settings with the values that have been calculated during the measurements. These values will be used if a new START or FIELDCAL is issued (either as static values or as initial values). If the MAGCAL values are required after power-down, they must be saved to Saved settings (use SAVE,MAGCAL).

If you have changed the settings unintentionally, you can replace them with Saved settings or Default settings using either RESTORE or SETDEFAULT. You can either restore all settings or just a subset using the RESTORE and SETDEFAULT additional arguments.

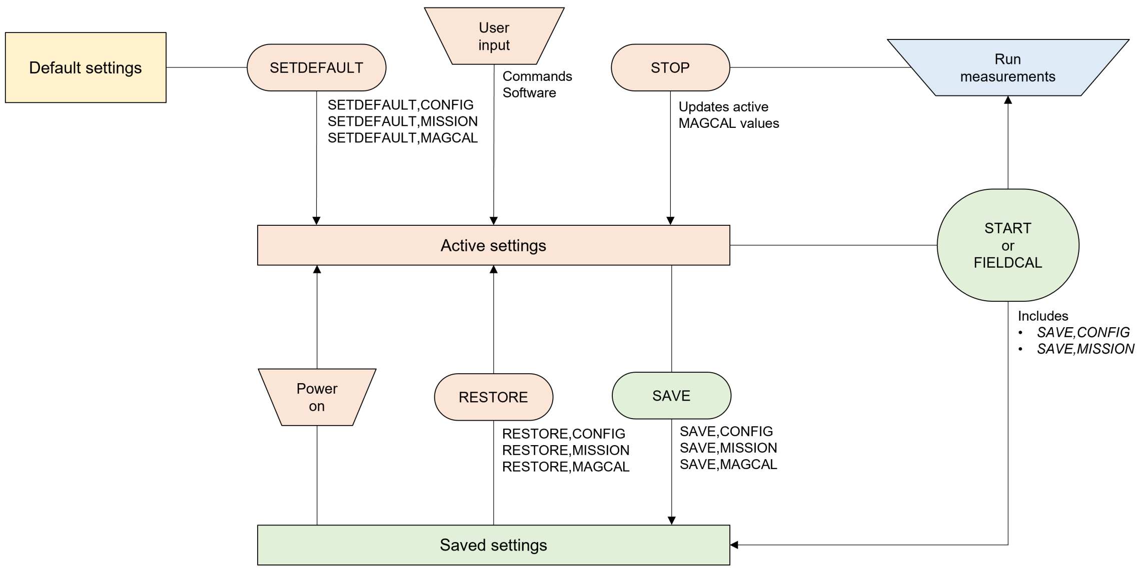


Figure 2: Process flow of applying and saving settings

4.2 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.

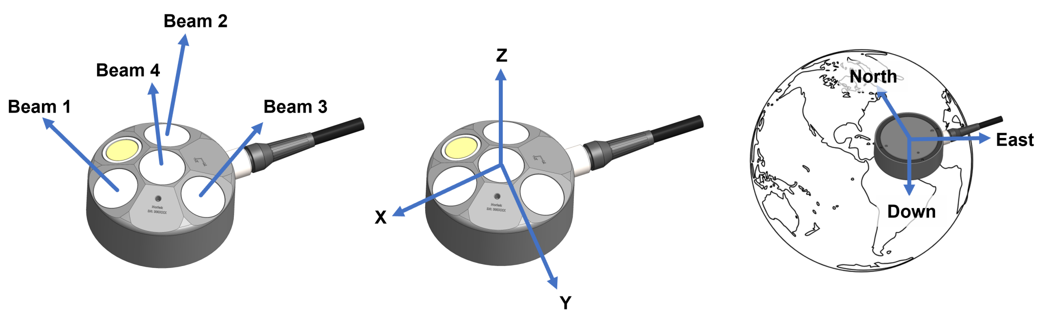


Figure 3: From left to right: BEAM, XYZ, and NED coordinate systems for the Nucleus, used for navigation and/or velocities.

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.

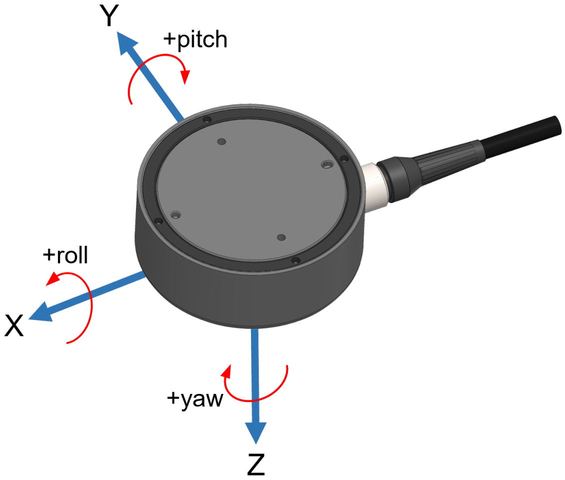


Figure 4: Nucleus orientation on the instrument when mounted downward-facing on a vehicle

Magnetic compass

While an AHRS can use a magnetic compass to determine heading, it is important to note that the system doesn't solely rely on the compass for accurate readings. The presence of magnetic disturbances, such as from nearby electronics or nearby steel-structures can affect the compass's accuracy. Therefore, the system takes the compass reading as a reference point and uses other sensor data to make a best guess of the actual heading. This approach ensures that the system provides reliable heading information even when magnetic interference is present. The goal is not to find magnetic north, which is not a dependable source due to its vulnerability to nearby magnetic fields, the goal is to display an accurate heading.

4.3 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.

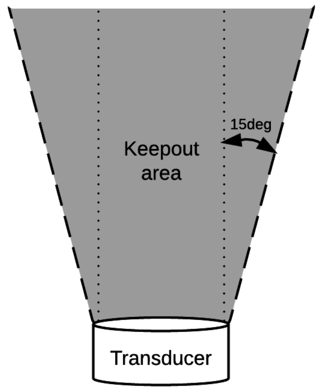


Figure 5: Transducer keepout area

Calibration

Traditionally there is a calibration step that is necessary to estimate and remove any misalignments between AHRS (heading) and the bottom tracking DVL. The Nucleus arrives pre-calibrated and thus removes the misalignment between these two sensors. Options to address static disturbances of the magnetic field (Hard and Soft Iron distortions) are found in the Field/Magnetic calibration tool.

Non-stationary field distortions such as those created by thrusters cannot be easily compensated.

4.4 Field/Magnetic Calibration

The heading estimate from the Nucleus is derived from the magnetometer sensors, and therefore one must be aware that this sensor may be biased by the environment or vehicle itself. The way the Nucleus handles magnetic disturbances are twofold, depending on static or varying fields. This can be done by changing the AHRS mode; please see SETAHRS for further details.

Static magnetic disturbances

Static field disturbances may be calibrated and removed by conducting a field calibration. This may be done for each vehicle deployment or one time and stored for future use. This should be repeated before every mission if any of the equipment is moved relative to the instrument.

After performing a successful field calibration, the user should store the MAGCAL parameters with SAVE,MAGCAL. If the parameters are not satisfactory, they can be restored to the factory values with SETDEFAULT,MAGCAL, or to the saved settings with RESTORE,MAGCAL or a power cycle. When the magnetometer is properly calibrated, the system is ready to start measuring.

Varying magnetic disturbances

If the magnetic environment around the instrument is expected to vary during the mission, it is possible to continuously estimate the MAGCAL values in normal operation. If measurements are run with estimated MAGCAL values, these values can be stored in the saved settings for later use, or they can be restored to default or previously saved values. If no action is taken, the instrument will continue with the estimated MAGCAL values until power is lost or new values are estimated or set by the user.

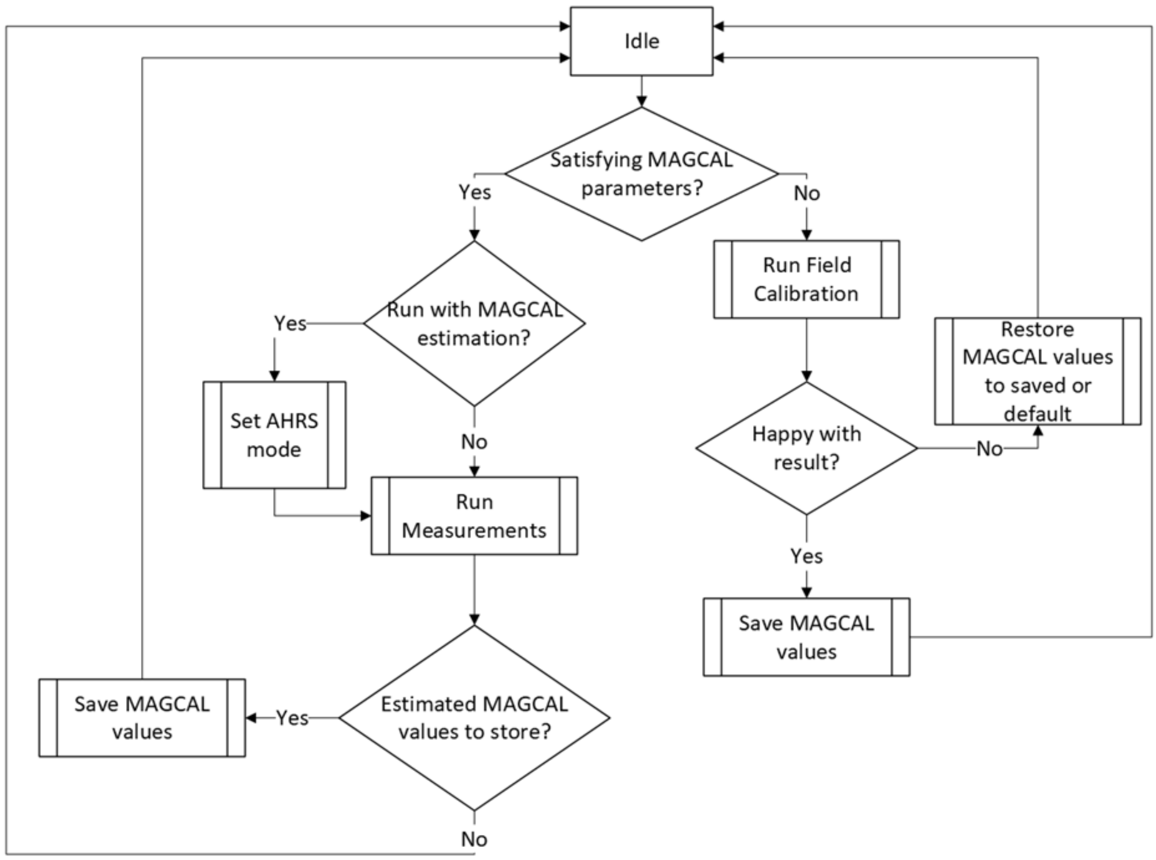


Figure 6: Field calibration decision chart

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.

DVL/Altimeter

The DVL and altimeter are more complex to check for functionality but this may be done in a large water tank where the Nucleus's beams are unobstructed and directed to the tank bottom. This is ideally 50 cm from the bottom. Closer is possible but for small tanks one must be aware that the acoustic conditions are often less than favorable.

AHRS

The tilt and heading may be confirmed by rotating the Nucleus about its three primary axes. The dashboard provides a view for the AHRS.

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. Note that 1 dBar is approximately equivalent to 1 meter submerged depth seawater. The functionality may be confirmed by submerging the Nucleus in water. An alternative and simplified test is to blow air into the sensor hole.

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 7 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 and Acoustic Sampling

The trigger mode specifies what controls the acoustic pinging. This is either internal or external. Internal triggers are essentially the configured sampling rate, and the triggering is managed internally. External triggers may be used when the end users wants to explicitly control when the DVL and altimeter ping. This is often of interest when trying to de-conflict various acoustic instruments onboard the vehicle.

Triggers are an advanced user feature and therefore are currently not found in the 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 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 is a transmit pulse from each of the DVL transducers. The maximum transmit pulse is 13.3 ms for the DVL.
- Each SETTRIG,ALTI ping will trigger one transmit pulse from the altimeter. The maximum transmit pulse is 200 μs for the altimeter.
- The latency (trigger to start of transmit pulse) is 100 μs.

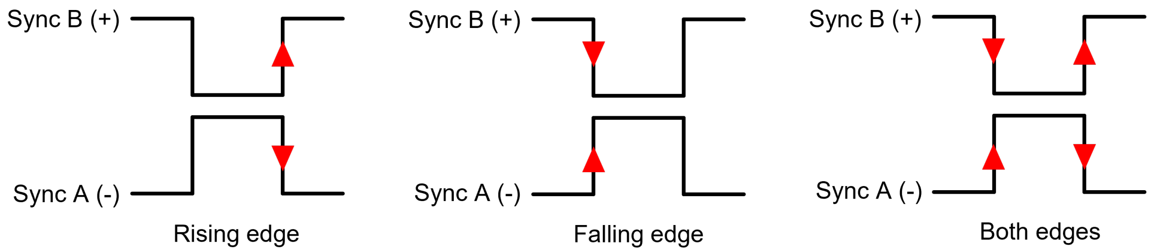


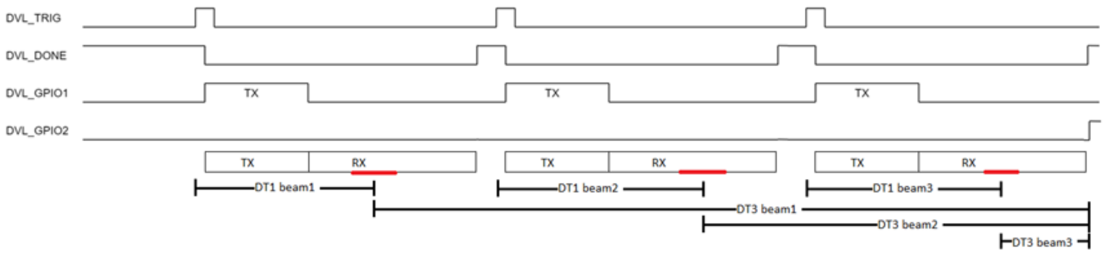
Figure 7: Nucleus trigger operation

Timing

ΔT as described in the Bottom Track and Water Track data formats is described as:

- ∆T beam 1/2/3: Time from the center of the echo of the cell, which estimates the water track velocity, to the time indicated by timestamp.

This can be used to get the exact timing of the bottom echoes. The diagram below describes how the timing of the trigger affects the interleaved pings of the DVL.



Nucelus Trigger Timing

4.7 Maximum sampling rate

The maximum sampling rate for current profiling (ADCP) or bottom tacking (BT) depends on a variety of factors, including the configured BT range and the use of an altimeter(ALT).

If you are operating the instrument at a depth of 50m, the maximum sampling rate achievable is 4Hz. This ensures that the BT pings separates each ALT and ADCP ping, as illustrated below:

Spec	4Hz	ADCP=1	ALT=1					
Type	BT	ALT	ADCP	BT	ALT	ADCP	BT	ALT
Counter	1	2	3	4	1	2	3	4
Time	1				2			

Answer: at max range, 1.3Hz

If the instrument is operated within a limited range of 25m, a higher sampling rate of up to 8Hz can be achieved.

Spec	8Hz	ADCP=1	ALT=1													
Type	BT	ALT	ADCP	BT	ALT	ADCP	BT	ALT	ADCP	BT	ALT	ADCP	BT	ALT	ADCP	BT
Counter	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Time	1								2							

Answer: 2.6Hz

Sequence

If the instrument is still operated at 8Hz, but you change the ALT sampling rate to 2, the sequence would change to:

Spec	8Hz	ADCP=1	ALT=2													
Type	BT	ADCP	BT	ADCP	ALT	BT	ADCP	BT	ADCP	ALT	BT	ADCP	BT	ADCP	ALT	BT
Counter	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Time	1								2							

The reason for this is that the unit doesn't define specific "seconds" but operates continuously, resulting in an irregular sample rate.

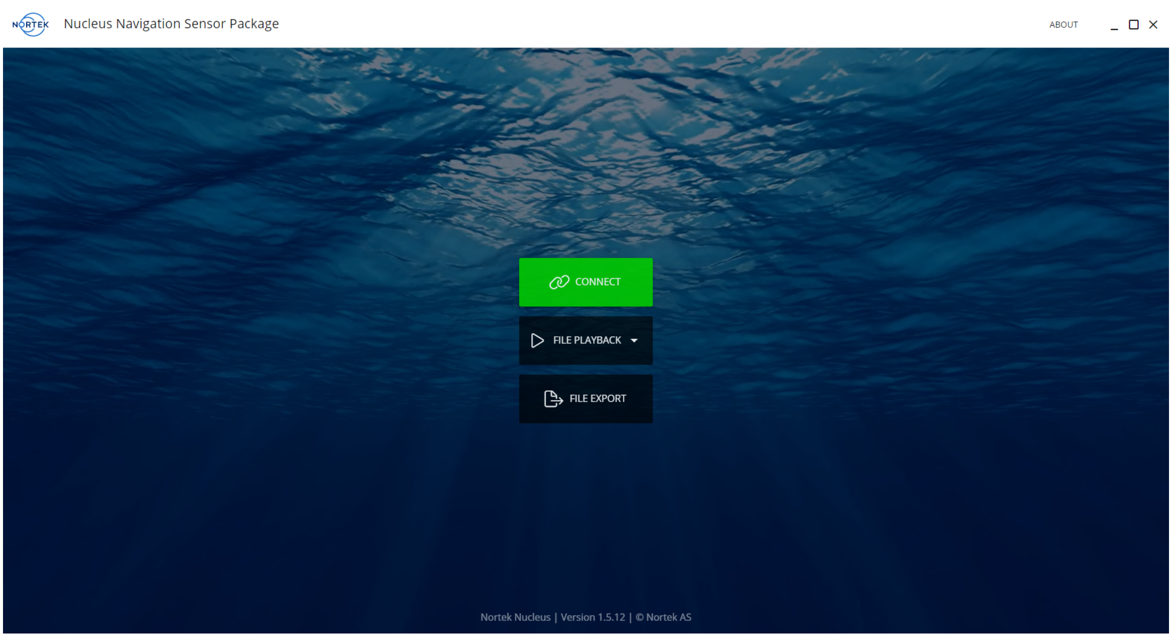
5 Nortek Nucleus Software

The Nortek Nucleus software is available on Microsoft Store, and is used to connect to, configure, and receive data from the Nucleus.

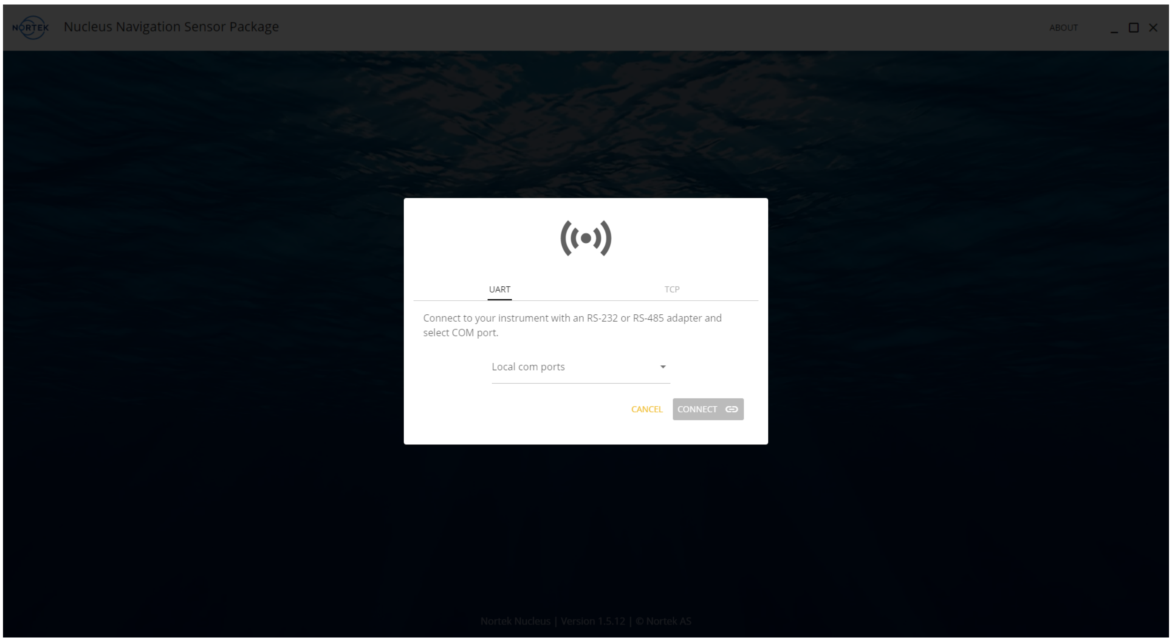
Figure 8: Nortek Nucleus software logo

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.



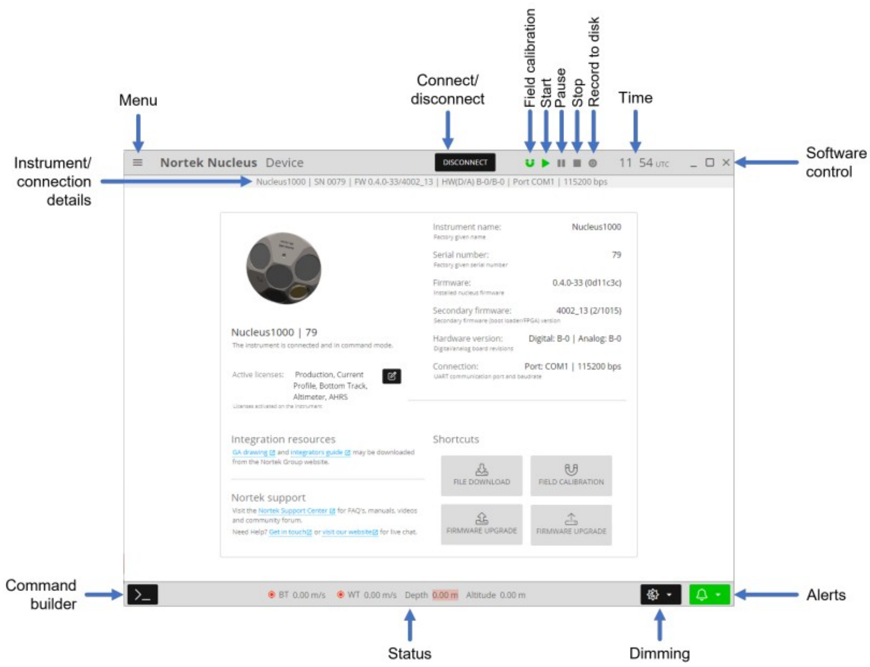
- Click Connect. This will open a connection window with two options:
  - UART: connect through a COM port with a specified baud rate
  - TCP: connect with an IP address, port number, and password. The Nucleus has a fixed IP address of 169.254.15.123. See Communication section for more information



- 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

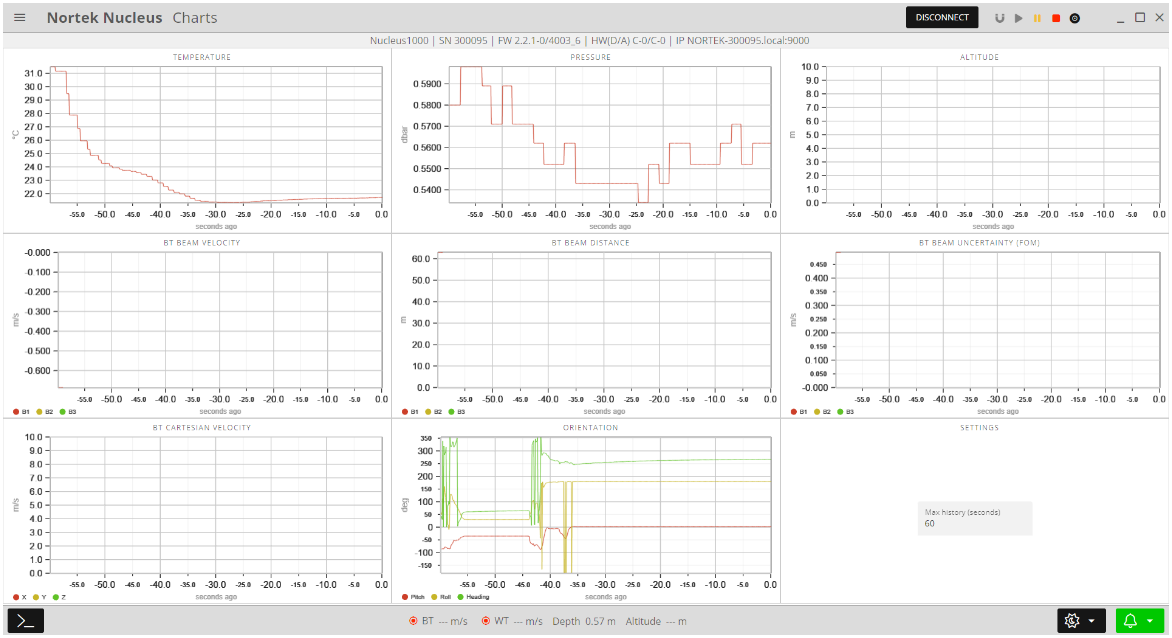
Without an instrument connected, you can load a saved file into the Nucleus software. On the start page, click File Playback and choose the .nucleus file that you would like to play back. Use the start, pause and stop buttons to play the data. The File Playback menu also has the option of playing the inbuilt default data file so you can view example data.

5.1 Dashboards

Charts

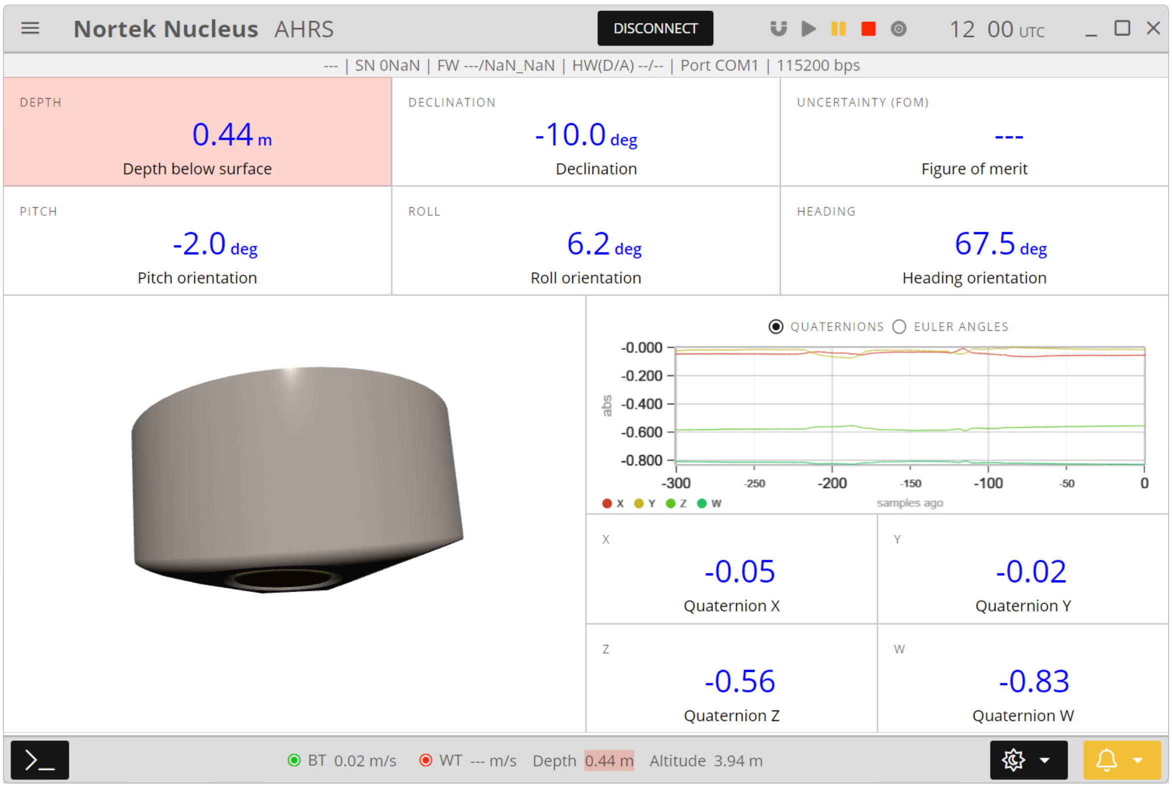
Here charts of sensor measurements over time are displayed. The amount of data displayed depend on the "max seconds history" option, where you can set the number of seconds into the past over which to display data.

- 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

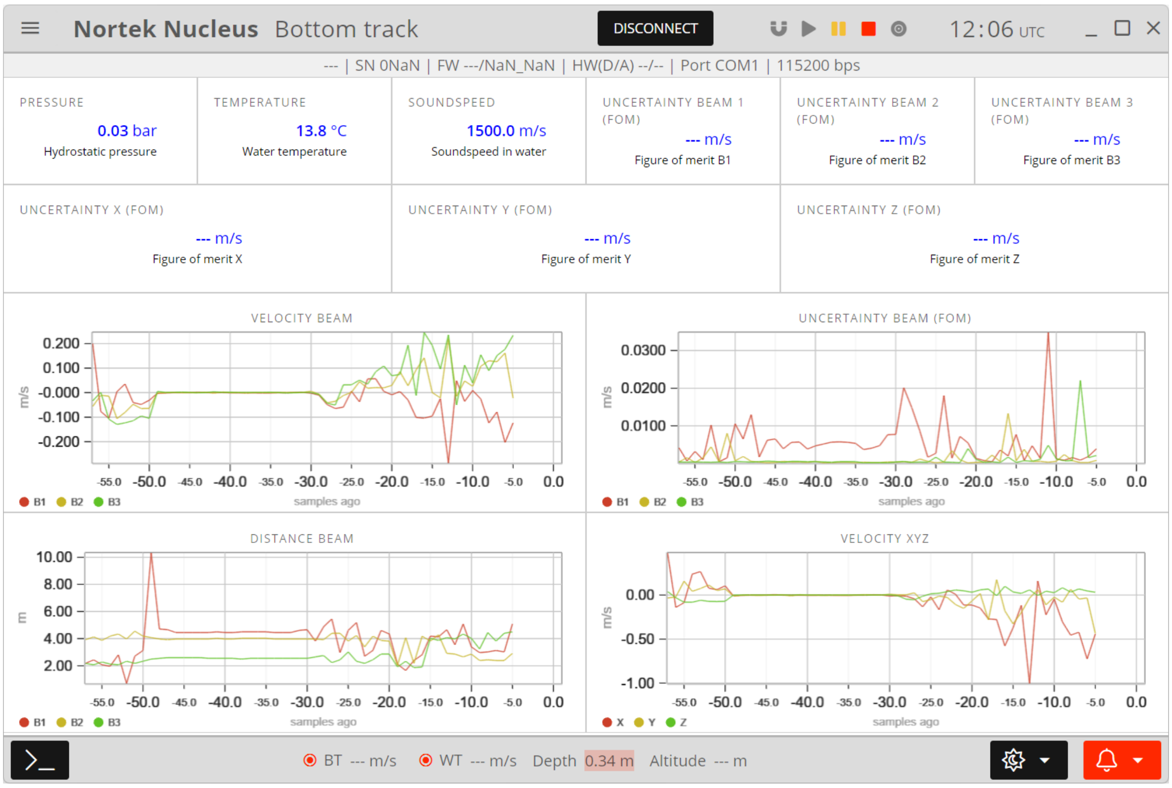


Altimeter

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

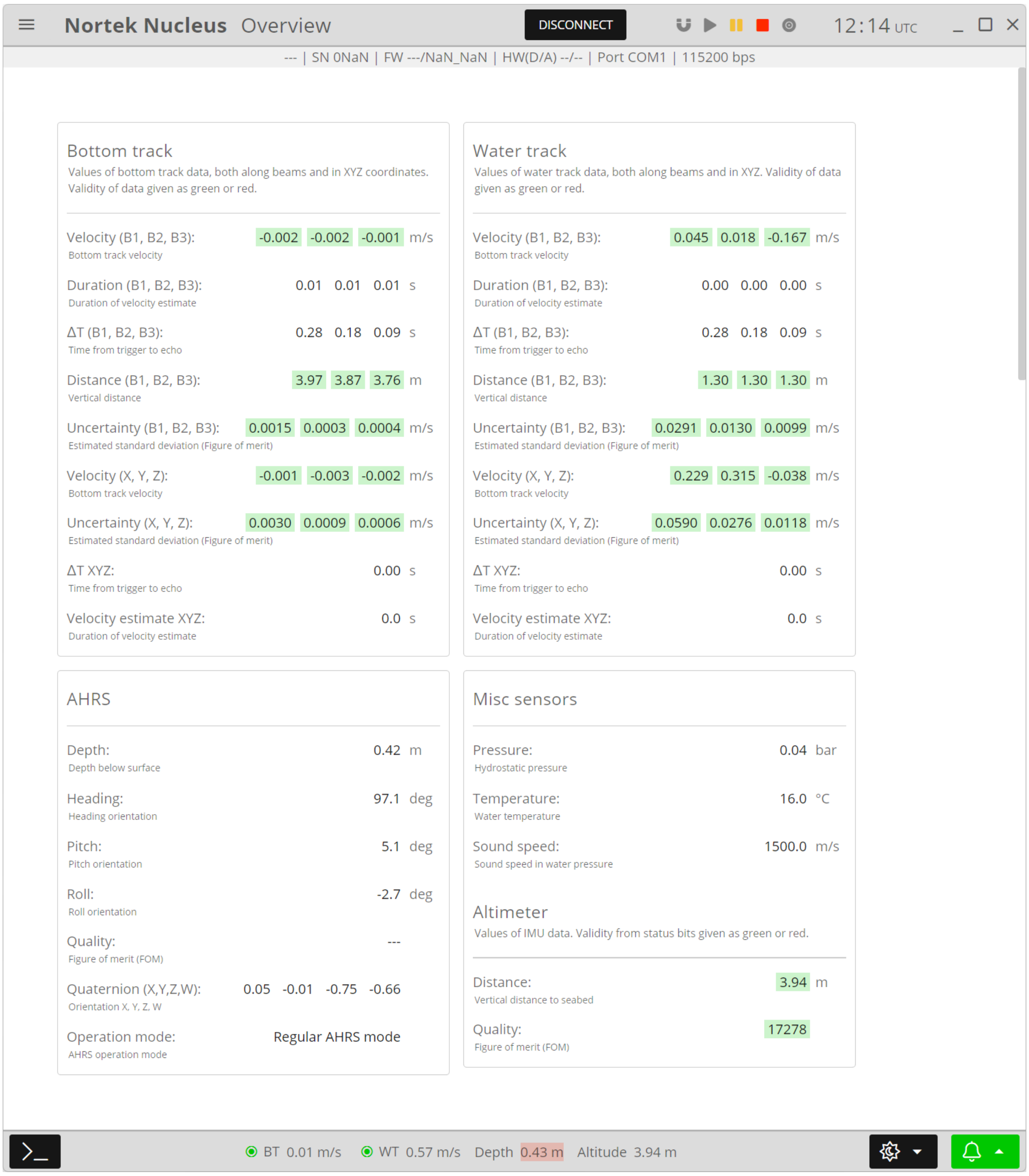
Bottom Track/Water Track

- 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.



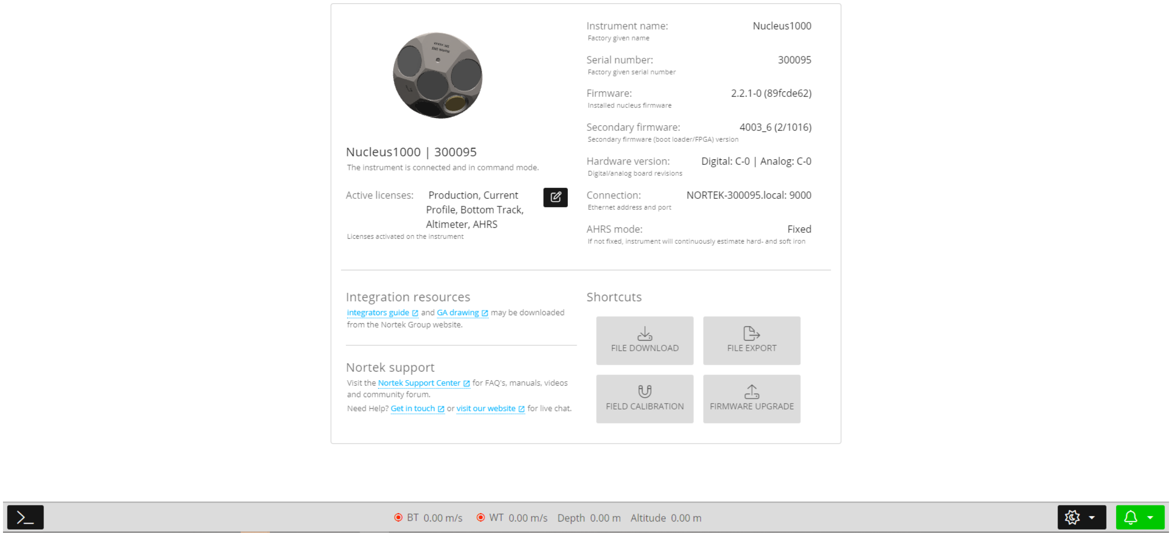
5.2 Instrument

Device

The Device tab will change depending on the current mode. In Command mode, here you can find information about the instrument, including instrument name, serial number, current firmware and hardware versions, and connection information. From this page you can also access file download, field calibration and firmware upgrade utilities, and find links to support information such as GA drawings, manuals, and the Nortek support site.

In Measurement mode, the page will be replaced by a 3D representation of the tilt and heading of the Nucleus. You can choose between North Up and Head Up on the display.

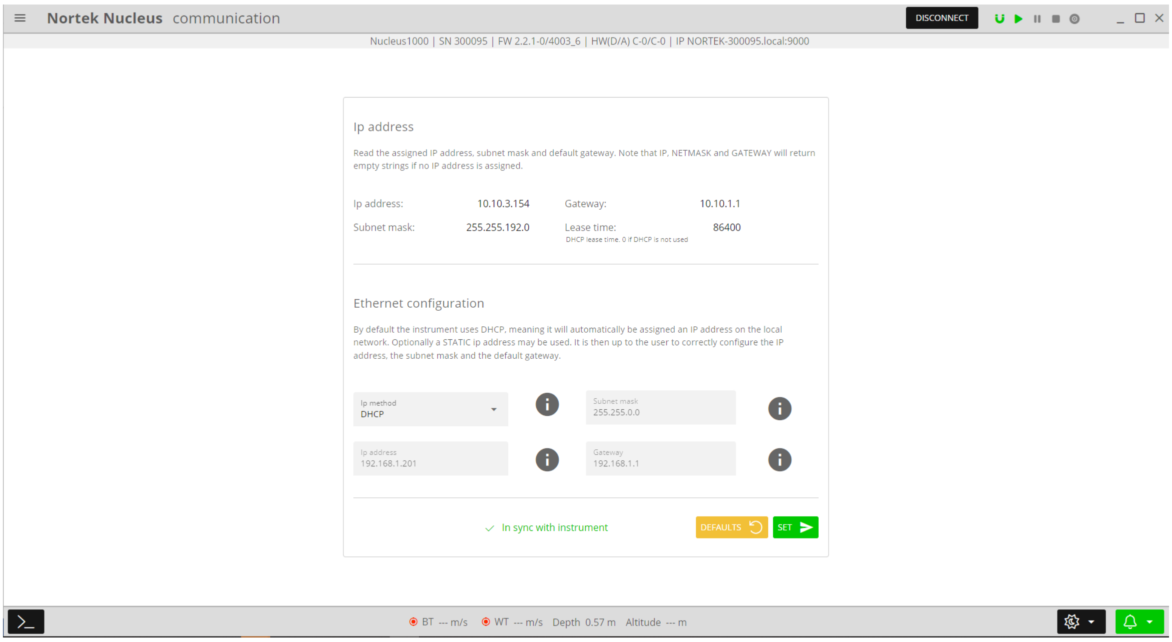
- Displayed parameters: pitch (°), roll (°), heading (°), depth (m), vertical distance to seabed (m), bottom track velocity (m/s)



Device tab in command mode.

Communication

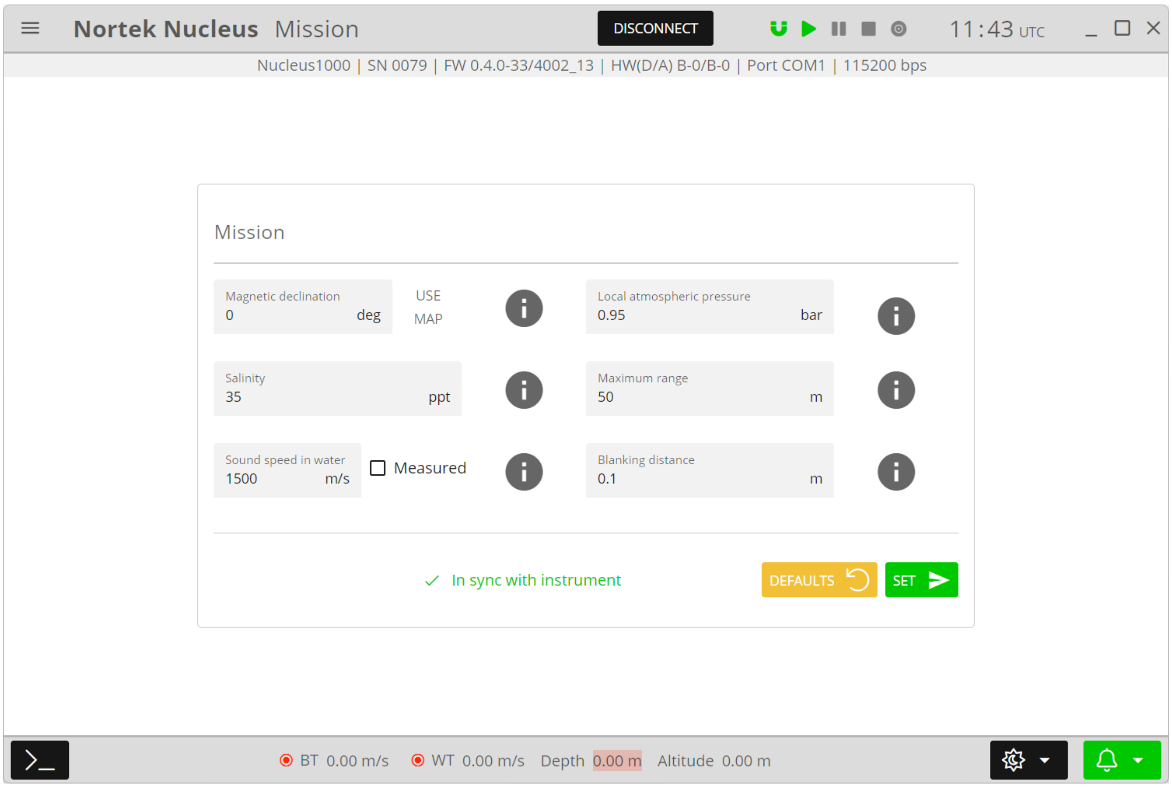
Configure the communication protocols to the Nucleus



Mission

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

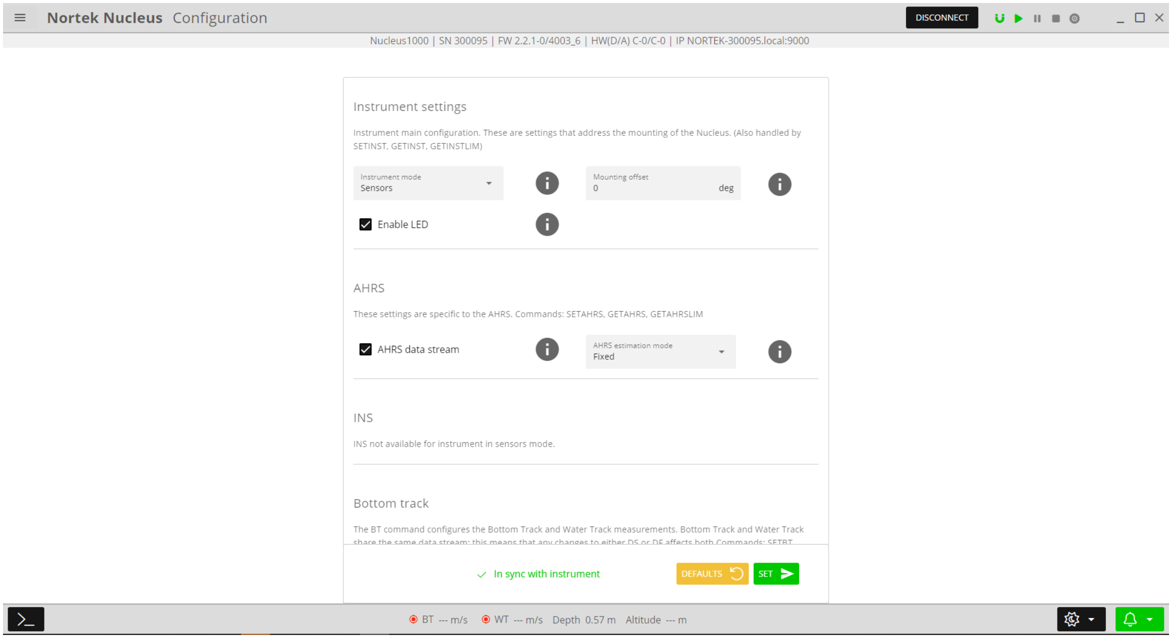
- Magnetic declination (°): offset between direction of magnetic North and true North in deployment area. You can use the map to select the deployment area.
- Salinity (ppt): salinity value in deployment area. This is important for accurate velocity estimates since salinity is used to estimate speed 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

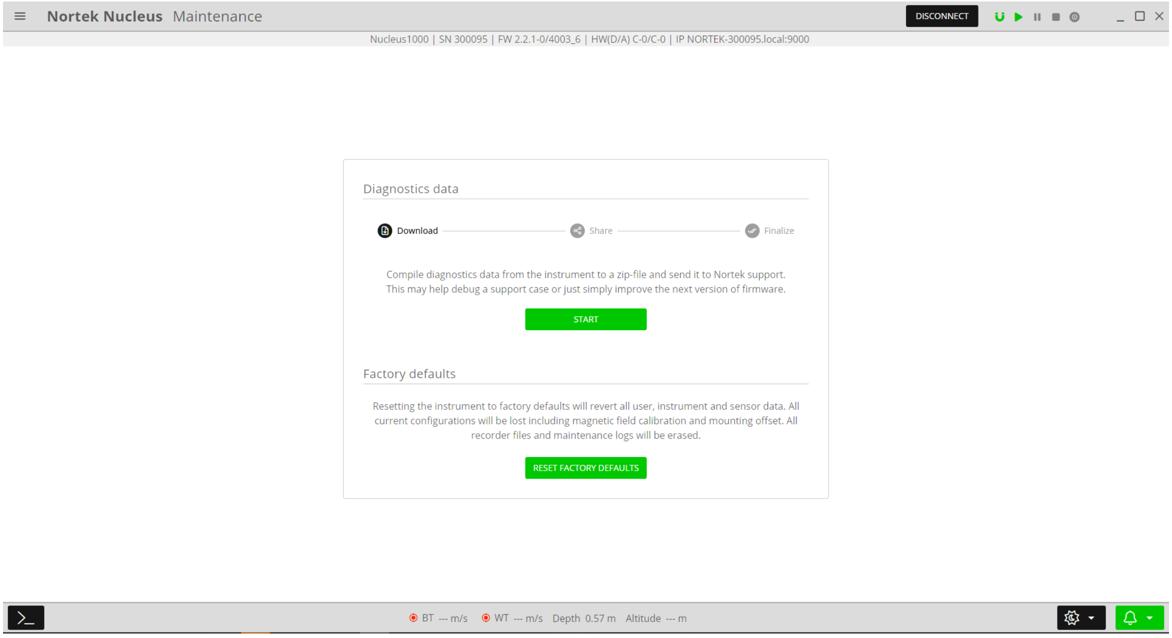
In this tab you can configure various settings for the instrument.

- 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

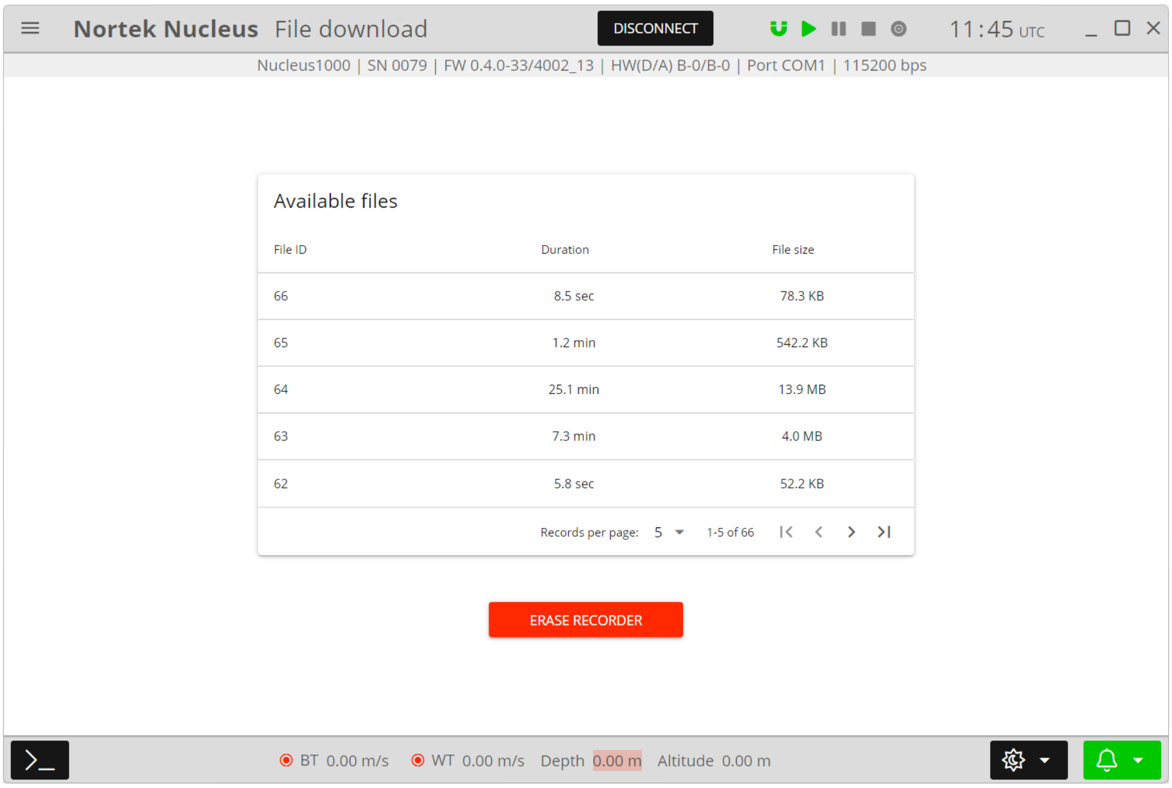
Download files that can be sent to Nortek Support if you have any issues with your instrument, or reset the instrument to factory defaults.



File download

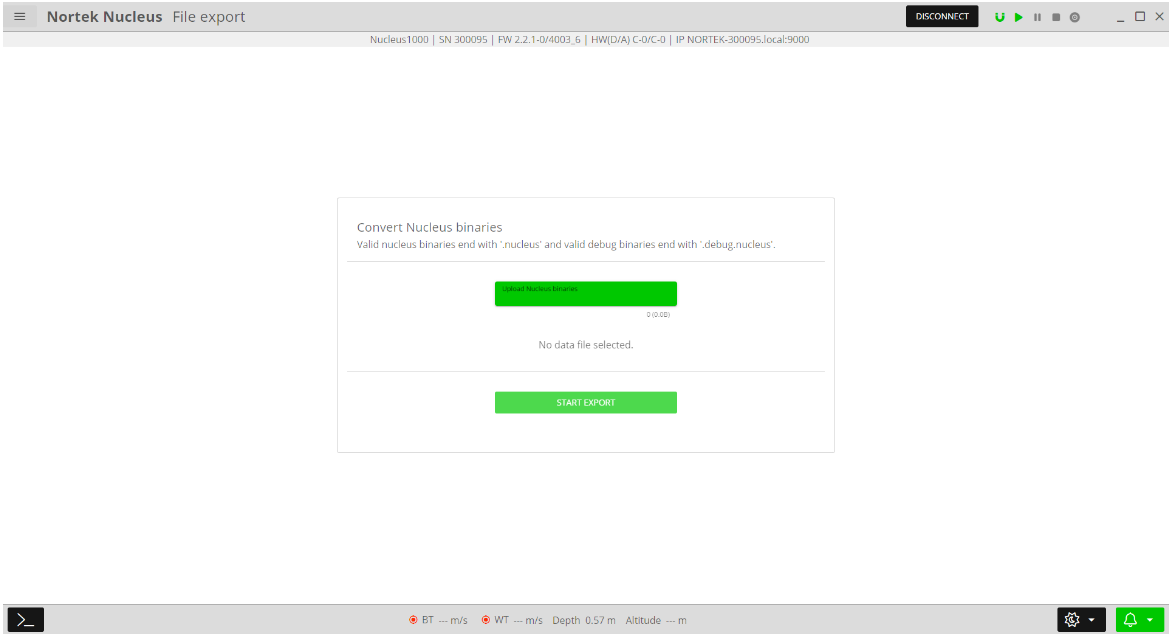
Here you can see a list of files on the recorder. These will have the .nucleus extension, and can be played back in the software or converted to ASCII/MATLAB format. You can also format the recorder to clear it of files. Please refer to the Data Formats chapter for more information.

For each "start" and "stop", the Nucleus will create a new file on the recorder. To download the recorder data, press the file you wish to download, before pressing "Download recorder", and "Download Debug" if needed.



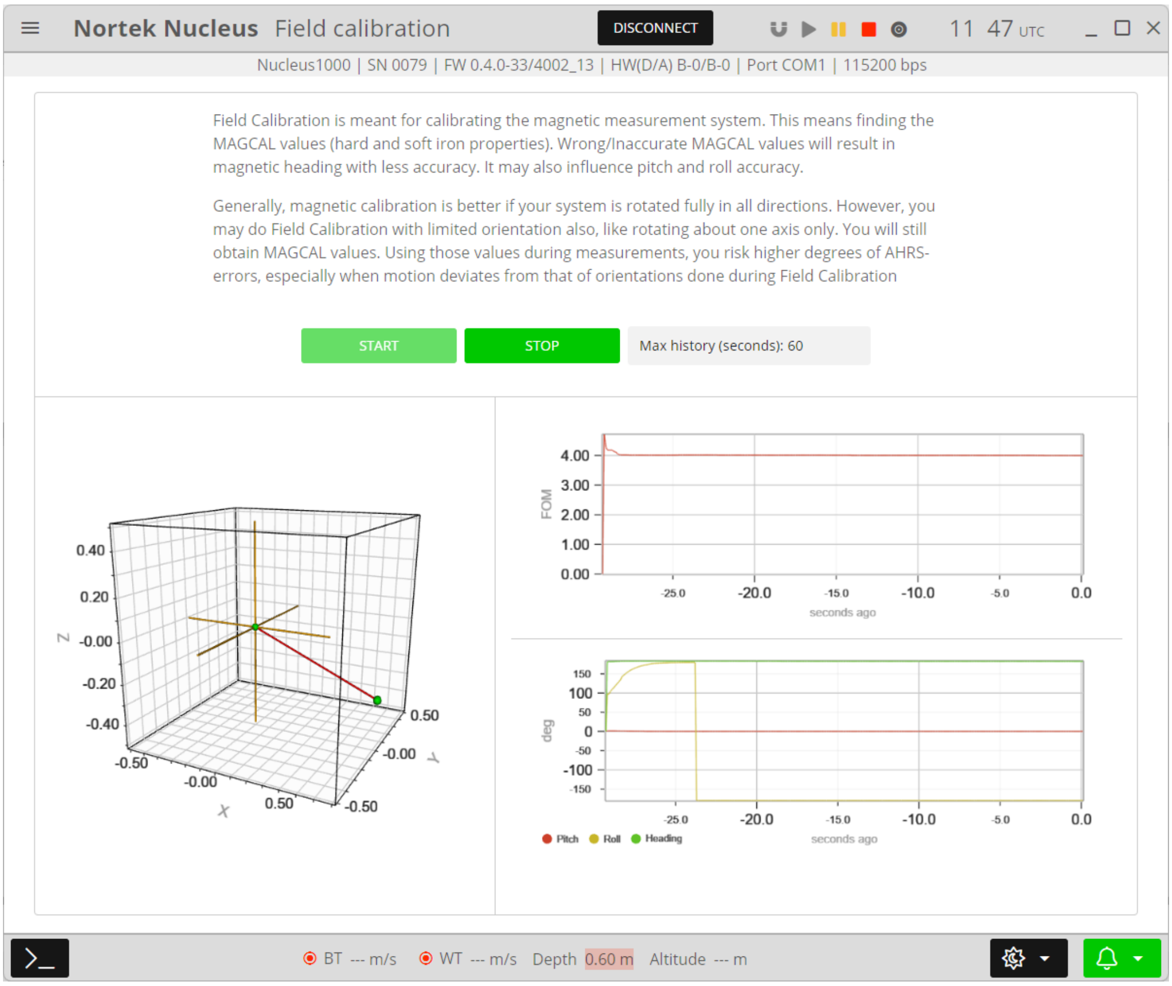
File Export

Here you can convert valid '.nucleus' files to CSV



Field calibration

Here you can perform a field calibration. Please see the information in the software and the Field Calibration chapter for more information.

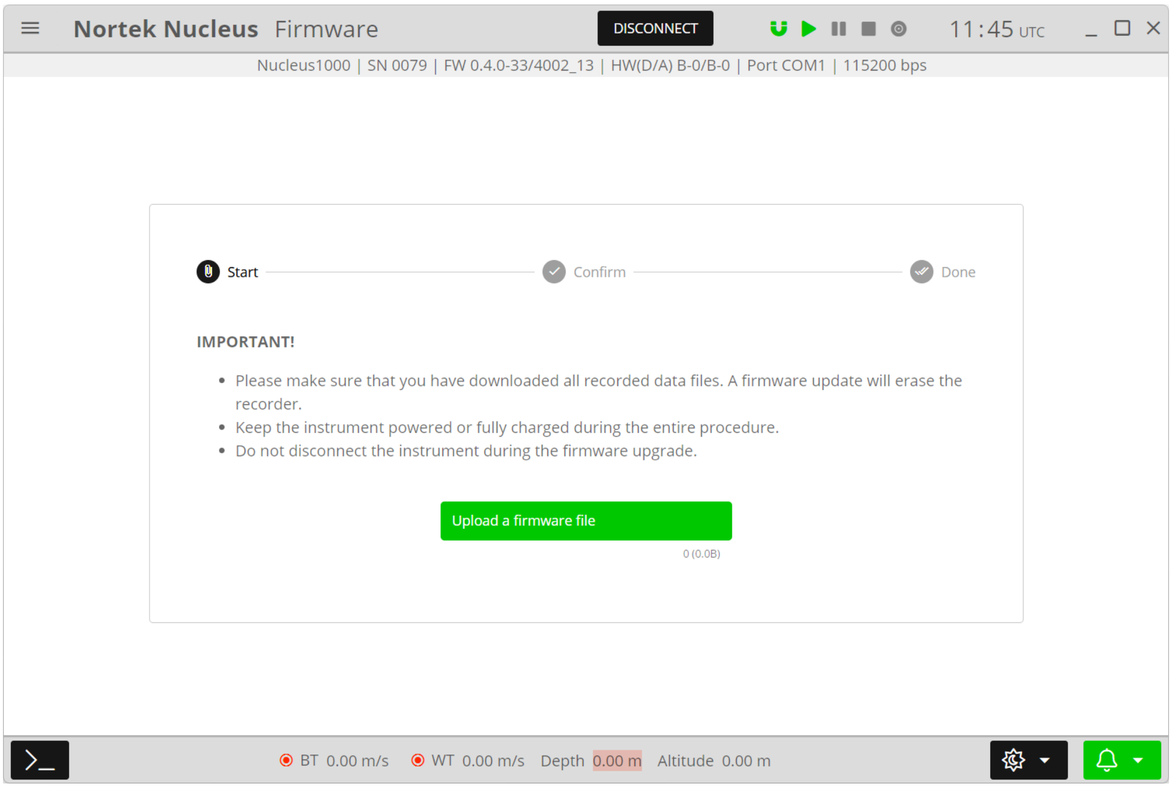


Spectrum viewer

Spectrum viewer can be used to detect unwanted noise.

Firmware update

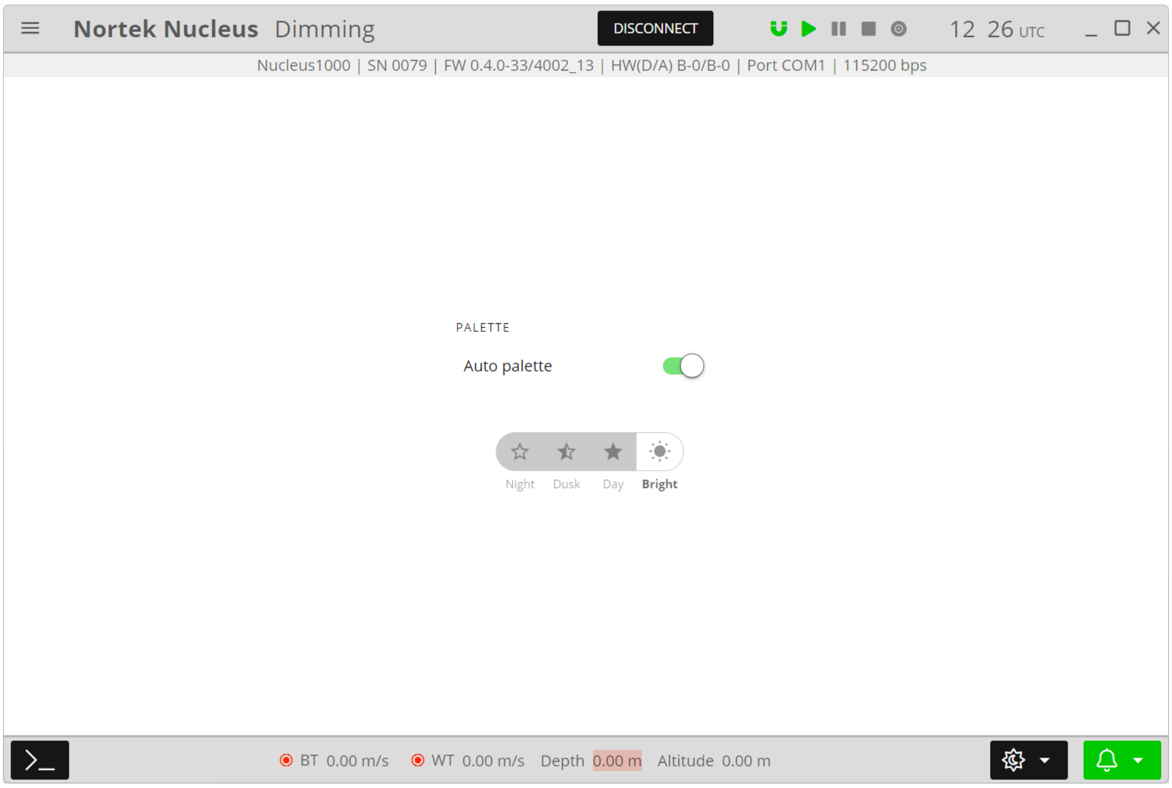
Keeping the firmware up-to-date is very important. Firmware updates will include improvements to measurements and bug fixes. Updating the firmware will format the recorder, so ensure that all data has been downloaded beforehand.



5.3 Software

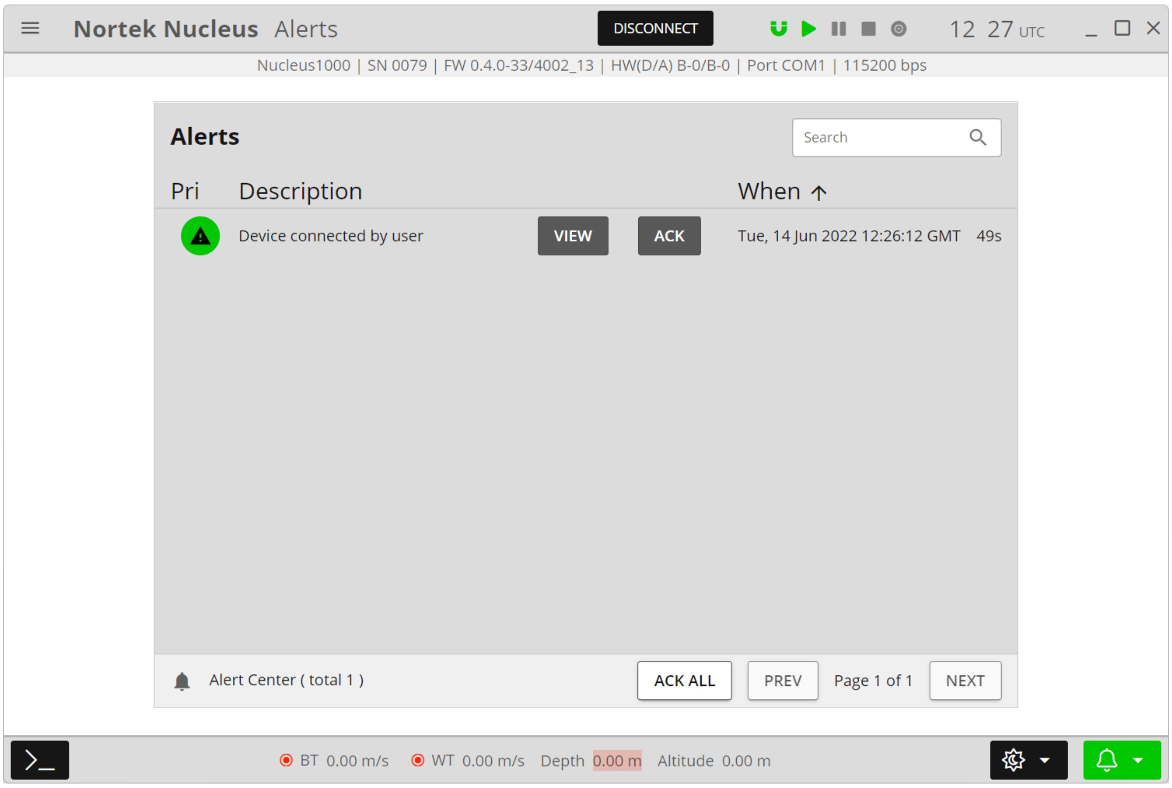
Dimming

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



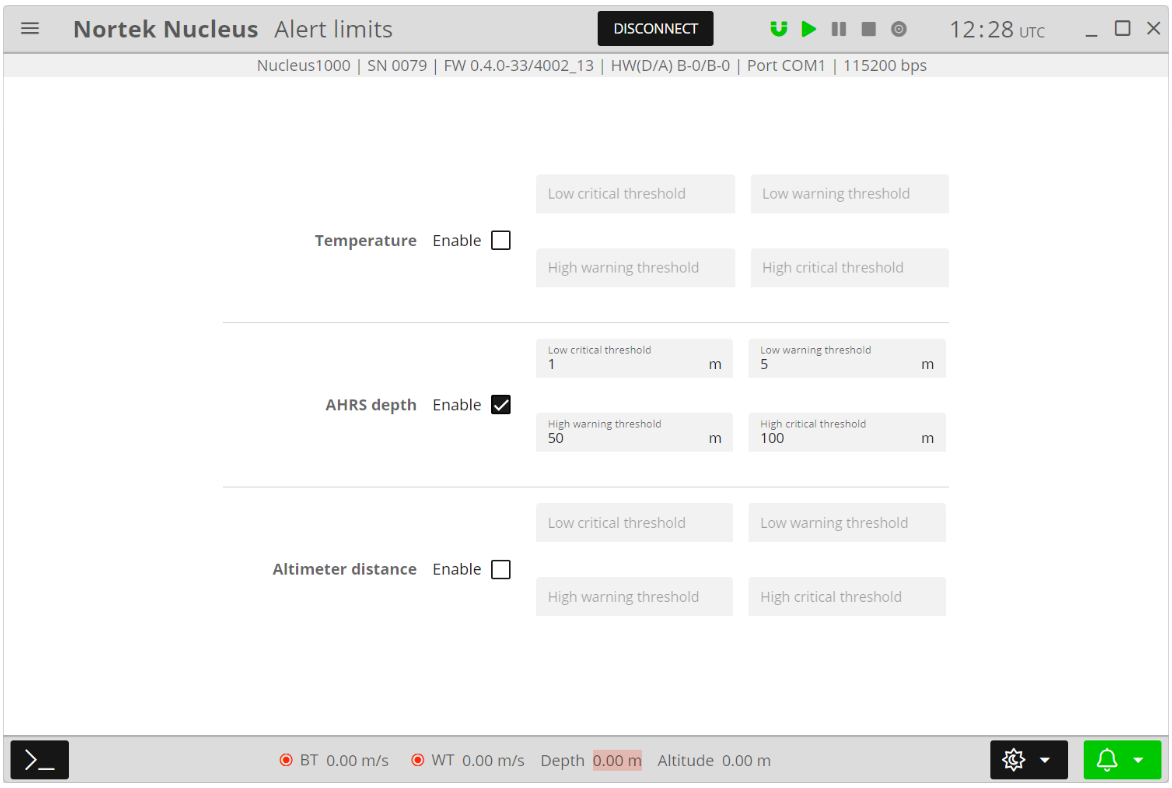
Alerts

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.



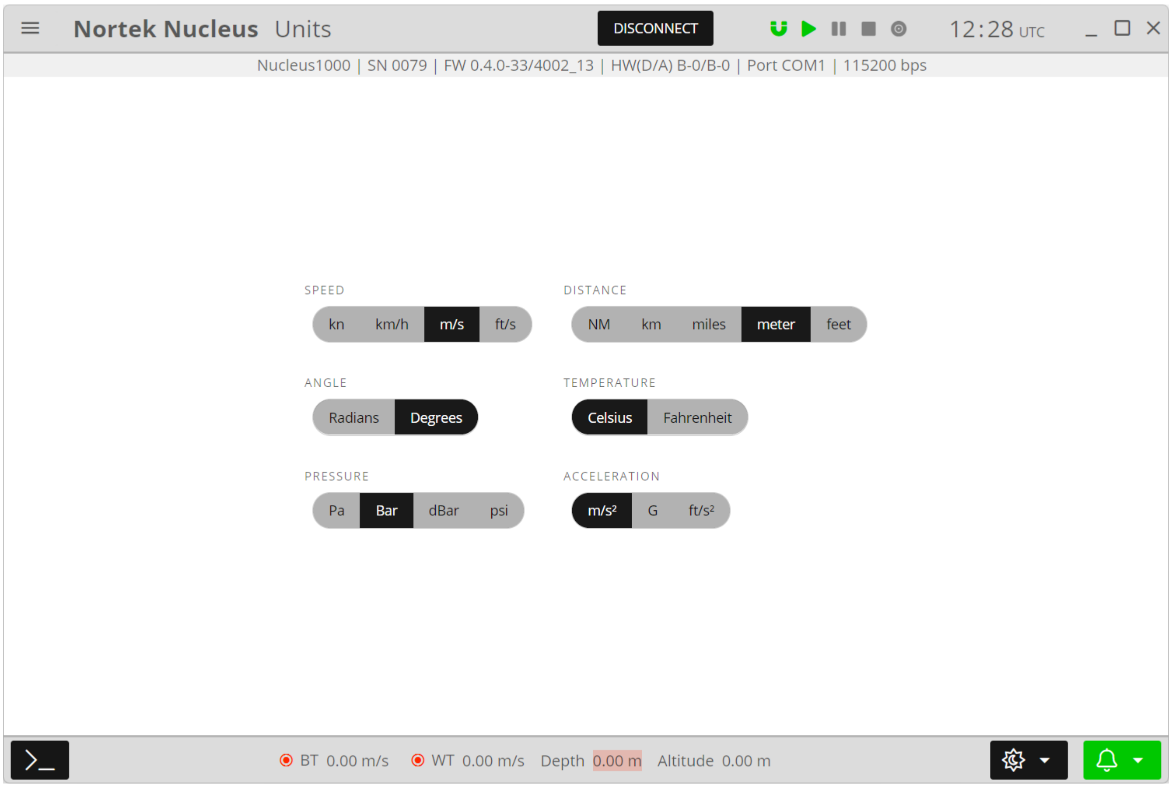
Alert limits

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



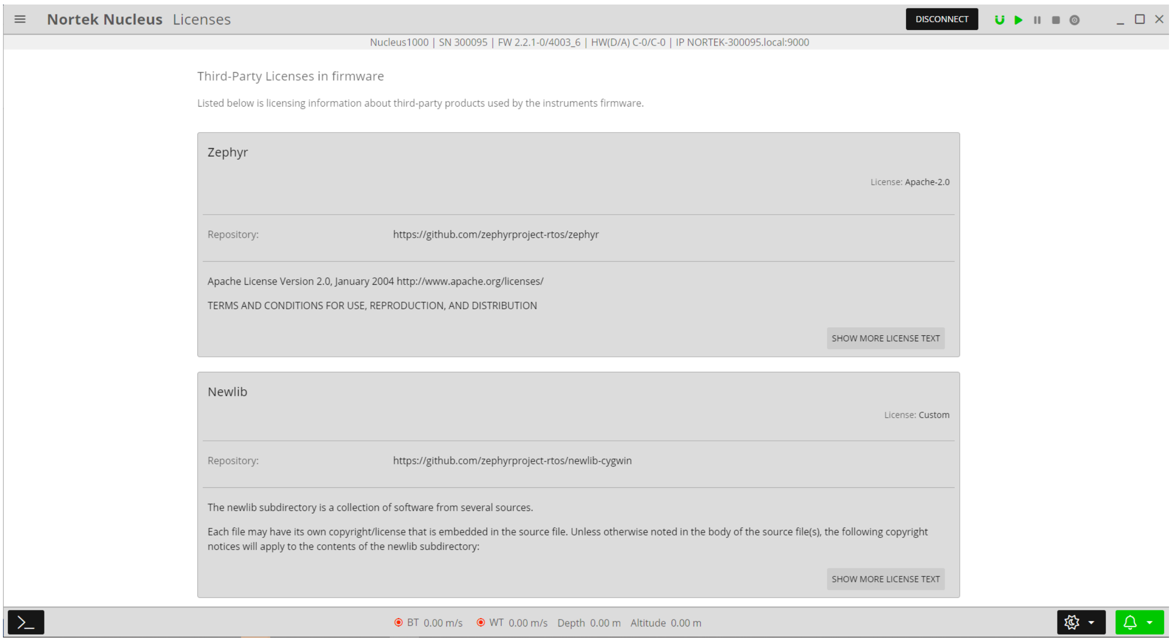
Units

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.



Licences

List of all third-party licenses in the Firmw are



Exit

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

6 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
  ```

- Commands may contain a single argument, without the need to enter all arguments associated with the command.
  ```
  SETTRIG,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.:
  ```
  SETMISSION,SA=90.0
  ERROR
  GETERROR
  64,"Invalid setting: Salinity","SETMISSION,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
("NORMAL";"AUTO"),([5.00;5.00]),("OFF";"ON"),(-100;[-
20.00;0.00]),("MAX";"USER"),("OFF";"ON"),(180)
```

```
OK
```

NMEA interface example:

```
$PNOR,GETBTLIM*27
$PNOR,GETBTLIM,MODE=("NORMAL";"AUTO"),VR=([5.00;5.00]),WT=("OFF"
;"ON"),PL=(-100;[-
20.00;0.00]),PLMODE=("MAX";"USER"),DS=("OFF";"ON"),DF=(180)*7D
$PNOR,OK*2B
```

7 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.

7.1 List of Commands

Below is a list of all available commands with a short description and information about which mode they can be used in. For more information about each command see the following chapters. The arguments that can be used with each command are described in the respective chapter. Note that some of the commands requires at least one argument to be used.

Command	Description	Mode
START	Start measurement	COMMAND
STOP	Stop measurement.	MEASUREMENT
TRIG	Trigger an acoustic measurement	MEASUREMENT
FIELDCAL	Start field calibration procedure	COMMAND
SAVE	Save active settings	COMMAND
SETDEFAULT	Revert to default settings	COMMAND
RESTORE	Restore settings from saved values	COMMAND
SETMISSION	Set mission settings	COMMAND
GETMISSION	Get mission settings	COMMAND
GETMISSIONLIM	Get limits for mission settings	COMMAND
SETINST	Set instrument settings	COMMAND
GETINST	Get instrument settings	COMMAND
GETINSTLIM	Get limits for instrument settings	COMMAND
SETAHRS	Set AHRS settings	COMMAND
GETAHRS	Get AHRS settings	COMMAND
GETAHRSLIM	Get limits for AHRS settings	COMMAND
SETFIELDCAL	Set field calibration settings	COMMAND
GETFIELDCAL	Get field calibration settings	COMMAND
GETFIELDCALLIM	Get limits for field calibration settings	COMMAND
SETBT	Set bottom track settings	COMMAND
GETBT	Get bottom track settings	COMMAND
GETBTLIM	Get limits for bottom track settings	COMMAND
SETALTI	Set altimeter settings	COMMAND
GETALTI	Get altimeter settings	COMMAND
GETALTILIM	Get limits for altimeter settings	COMMAND
SETCURPROF	Set current profile settings	COMMAND
GETCURPROF	Get current profile settings	COMMAND

GETCURPROFLIM	Get limits for current profile settings	COMMAND
SETTRIG	Set trigger settings	COMMAND
GETTRIG	Get trigger settings	COMMAND
GETTRIGLIM	Get limits for trigger settings	COMMAND
SETIMU	Set IMU settings	COMMAND
GETIMU	Get IMU settings	COMMAND
GETIMULIM	Get limits for IMU settings	COMMAND
SETMAG	Set magnetometer settings	COMMAND
GETMAG	Get magnetometer settings	COMMAND
GETMAGLIM	Get limits for magnetometer settings	COMMAND
SETMAGCAL	Set magnetometer calibration values	COMMAND
GETMAGCAL	Get magnetometer calibration values	COMMAND
GETMAGCALLIM	Get limits for magnetometer calibration settings	COMMAND
SETETH	Set Ethernet settings	COMMAND
GETETH	Get Ethernet settings	COMMAND
GETETHLIM	Get limits for Ethernet settings	COMMAND
READIP	Read IP address	COMMAND
GETERROR	Returns a full description of the last error condition to occur	COMMAND
ID	Get instrument Id	COMMAND
GETHW	Get board revisions	COMMAND
GETFW	Get firmware version	COMMAND
SETCLOCKSTR	Set instrument clock as string	COMMAND
GETCLOCKSTR	Get instrument clock as string	COMMAND
GETALL	Retrieves all relevant configuration information for the instrument	COMMAND
REBOOT	Reboot the instrument	COMMAND
LISTLICENSE	List all license keys in the instrument	COMMAND
ADDLICENSE	Add license key	COMMAND
DELETELICENSE	Delete license key	COMMAND

7.2 Start

Command: START
Command type: ACTION
Mode: COMMAND

This command will start measurement, data output, and data recording.

Measurements will continue until a STOP is issued or power is removed. The Nucleus remains in an idle state and does not start measurements until a START is issued.

Example:
```
start()
```

7.3 Stop

Command: STOP
Command type: ACTION
Mode: MEASUREMENT

This commands stops measurement. See section 4.2 on Data Collection for more details.

Example:
```
stop()
```

7.4 Trigger measurement

Command: TRIG
Command type: ACTION
Mode: MEASUREMENT

This command will trigger an acoustic measurement. The measurement will either be Bottom Track, Altimeter or Current Profile; these measurements are interleaved and are configured through SETTRIG.

Note: This command is only valid when the trigger source is set to "COMMAND"; see SETTRIG,SRC.

This command has no effect if measurements have not been started by START or FIELDCAL.

Example:
```
trigger()
```

7.5 Start field calibration

Command: FIELDCAL
Command type: ACTION
Mode: COMMAND

Start field calibration procedure. The field calibration will run until it is stopped by the STOP command or until it times out.

Example:
```
fieldcal()
```

7.6 Save settings

Command: SAVE
Command type: ACTION
Mode: COMMAND

This command makes the current settings permanent or new default following a power cycle.

At least one argument must be provided.

Argument	Description
ALL	Save all settings.
CONFIG	Save all settings except COMM, MISSION and MAGCAL.
COMM	Save communication settings. (Ref SETETH/GETETH)
MISSION	Save MISSION settings. (Ref SETMISSION/GETMISSION)
MAGCAL	Save MAGCAL settings. (Ref SETMAGCAL/GETMAGCAL)

Note: When the START command is given, CONFIG, COMM 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 next time the START command is given the magnetometer calibration values may be different. Use SAVE,MAGCAL or SAVE,ALL to make magnetometer calibration values permanent.

Example:
```
saveSettings({config: true})
```

7.7 Revert to default settings

Command: SETDEFAULT
Command type: ACTION
Mode: COMMAND

This command reverts 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
ALL	Revert all settings to default values.
CONFIG	Revert all settings except COMM, MISSION and MAGCAL to default values.
COMM	Revert communication settings to default values. (Ref SETETH/GETETH)
MISSION	Revert MISSION settings to default values. (Ref SETMISSION/GETMISSION)

MAGCAL	Revert magnetometer calibration settings to default values. Default values are set individually for each instrument during factory calibration. (Ref SETMAGCAL/GETMAGCAL)

Note: SETDEFAULT reverts to factory default values. If you instead want to revert to the previously saved values, use the RESTORE command. This is particularly useful if you e.g. want to discard the latest field calibration.

Example:

```
setDefault({config: true})
```

7.8 Restore saved settings

Command: RESTORE
Command type: ACTION
Mode: COMMAND

This command restores the saved settings into active settings. This can be useful if you have unintentionally changed settings, or if you want to discard the magnetometer calibration after doing a field calibration.

At least one argument must be provided.

Argument	Description
ALL	Restore all settings.
CONFIG	Restore all settings except COMM, MISSION and MAGCAL.
COMM	Restore communication settings. (Ref SETETH/GETETH)
MISSION	Restore MISSION settings. (Ref SETMISSION/GETMISSION)
MAGCAL	Restore MAGCAL settings. (Ref SETMAGCAL/GETMAGCAL)

Example:

```
restoreSettings({config: true})
```

7.9 Mission settings

Commands: SETMISSION, GETMISSION, GETMISSIONLIM,
Command type: CONFIGURATION
Mode: COMMAND

Set and get mission specific settings. These settings are unique to the location, environment, or application.

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] | Values: [0; 11] | Default: 9.5
LONG	Initial position, Longitude. 9999 means unknown longitude. Unit: [deg] | Values: [-180; 180]; 9999 | Default: 9999
LAT	Initial position, Latitude. 9999 means unknown latitude. Unit: [deg] | Values: [-90; 90]; 9999 | Default: 9999
DECL	Declination of magnetic field Unit: [Deg] | Values: [-90; 90] | Default: 0
RANGE	DVL and altimeter range Unit: [m] | Values: [2; 50] | Default: 50
BD	DVL and altimeter blanking distance Unit: [m] | Values: [0.1; 5] | Default: 0.1
SV	Sound velocity. SV = 0 will set sensor to use measured sound velocity Unit: [m/s] | Values: [0; 1700] | Default: 1500
SA	Salinity Unit: [ppt] | Values: [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.

RANGE,BD: In CRAWLER mode, the limits for the RANGE and BD arguments differ from those specified above. Use GETMISSIONLIM,RANGE,BD to see the valid values (after SETBT,MODE="CRAWLER"). Also note that enabling CRAWLER mode will update the values of RANGE and BD.

SETMISSION

Set mission settings

GETMISSION

Get mission settings

GETMISSIONLIM

Get limits for mission settings

7.10 Instrument settings

Commands: SETINST, GETINST, GETINSTLIM,
Command type: CONFIGURATION
Mode: COMMAND

Instrument configuration.

Argument	Description
TYPE	System mode. SENSORS, NAV
ROTXY	Alignment offset Unit: [deg] | Values: [-180; 180]
ROTYZ	Alignment offset Unit: [deg] | Values: [-180; 180]
ROTXZ	Alignment offset Unit: [deg] | Values: [-180; 180]
LED	Enable or disable the LED ON, OFF Default: ON

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,ψRy,θRx,ϕ

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

Rnb = (Rbn)T

SETINST

Set instrument settings

Example:
```
setInstrument(mode: "SENSORS", alignmentOffsetXY: 4.3)
```

GETINST

Get instrument settings

GETINSTLIM

Get limits for instrument settings

7.11 AHRS settings

Commands: SETAHRS, GETAHRS, GETAHRSLIM,
Command type: CONFIGURATION
Mode: COMMAND

These settings are specific to the AHRS. The data output is configured here as well as the Mode. The mode specifies indicates how the magnetometer integrated into the AHRS algorithms. A fixed correction will use existing calibration, while an estimation is an updated correction during the course of the mission.

Argument	Description
FREQ	Output frequency Unit: [Hz] | Values: [1; 100] | Default: 10
MODE	AHRS mode 0: Fixed hard iron / soft iron 1: Hard iron estimation 2: Hard and soft iron estimation Default: 0
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({outputFrequency: 5})
```

GETAHRS

Get AHRS settings

GETAHRSLIM

Get limits for AHRS settings

7.12 Field calibration settings

Commands: SETFIELDCAL, GETFIELDCAL, GETFIELDCALLIM,
Command type: CONFIGURATION
Mode: COMMAND

These settings specify how the Field Calibration is performed when using the STARTFIELDCAL command. These settings take effect when starting the instrument with the FIELDCAL command.

Argument	Description
MODE	Field calibration mode 1: Hard iron estimation 2: Hard and soft iron estimation Default: 2

SETFIELDCAL

Set field calibration settings

Example:
```
setFieldCal({mode: 1})
```

GETFIELDCAL

Get field calibration settings

GETFIELDCALLIM

Get limits for field calibration settings

7.13 Bottom track settings

Commands: SETBT, GETBT, GETBTLIM,
Command type: CONFIGURATION
Mode: COMMAND

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 affect both Bottom Track and Water Track.

CRAWLER mode uses a different acoustic measurement method which is more accurate and higher precision. The method, however, is limited to low altitudes and low speeds. In AUTO mode, the transition between CRAWLER and FAST_ACQ modes occur at 7.5 meters altitude or along beam velocities of 15 cm/s (43 cm/s in the horizontal).

Argument	Description
MODE	Bottom Track operating mode Note! Changing operating mode will cause some other argument values to change, see notes below. "FAST_ACQ": Bottom Track operating in fast acquisition mode "CRAWLER": Bottom Track operating in CRAWLER mode. "AUTO": Bottom Track will automatically switch between FAST_ACQ and CRAWLER modes depending on velocity and distance. Default: FAST_ACQ
VR	Velocity range along beam (spans from -VR to +VR).

	Default value and limits shown below apply to Bottom Track in FAST_ACQ mode. For CRAWLER mode, VR must be in the range [0.05,0.40]. Unit: [m/s] | Values: [5; 5] | Default: 5
WT	Measure Water Track velocity Water Track is not available in CRAWLER mode. ON, OFF Default: ON
PL	Power level (range -20.0 dB to 0.0 dB, -100 dB to switch off transmit). Unit: [dB] | Values: [-20; 0]; -100 | Default: -2
PLMODE	When set to Max the power level is always maximum. The User setting will use the value set with PL. 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. If USER is selected, a power level of 0 dB represents maximum power output. Power is decreased by entering negative values.

When changing MODE, some arguments will switch to their mode-specific default value. This is true for arguments SETBT,VR,WT and SETMISSION,RANGE,BD. Argument limits are also affected when changing MODE; use GETBTLIM,VR,WT and GETMISSIONLIM,RANGE,BD after mode change to see the limits.

SETBT

Set bottom track settings

GETBT

Get bottom track settings

GETBTLIM

Get limits for bottom track settings

7.14 Altimeter settings

Commands: SETALTI, GETALTI, GETALTILIM,
Command type: CONFIGURATION
Mode: COMMAND **License:** Altimeter

Configure Altimeter measurements.

When enabled, Altimeter measurements are interleaved with Bottom Track measurements. Use SETTRIG,ALTI to enable the Altimeter and configure the interleave ratio.

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

DS determines whether Altimeter data will be output on the active communication interface, but it is SETTRIG,ALTI that determines whether or not the Altimeter is enabled. If the Altimeter is enabled but DS="OFF" the Altimeter data will only be written to the recorder.

SETALTI

Set altimeter settings

GETALTI

Get altimeter settings

GETALTILIM

Get limits for altimeter settings

7.15 Current profile settings

Commands: SETCURPROF, GETCURPROF, GETCURPROFLIM,
Command type: CONFIGURATION
Mode: COMMAND **License:** CurrentProfile

Configure Current Profile measurements.

The instrument can be configured to collect Current Profile data. When enabled, Current Profile measurements are interleaved with Bottom Track and Altimeter measurements. Use SETTRIG,CP to enable Current Profile and configure the interleave ratio.

Current Profile configuration involves setting a RANGE, a blanking distance (BD) and a cell size (CS). The measurement profile will extend from BD to RANGE, and the number of bins in the profile is given by (RANGE-BD)/CS.

Argument	Description
RANGE	Current Profile range Unit: [m] | Values: [1; 30] | Default: 30
CS	Cell size Unit: [m] | Values: [0.2; 2] | Default: 0.5
BD	Blanking distance Unit: [m] | Values: [0.1; 10] | Default: 0.5
DS	Enable data stream for Current Profile OFF, ON Default: ON
DF	Data format for Current Profile data stream 192: Nortek binary Current Profile format Default: 192

Note: DS determines whether Current Profile data will be output on the active communication interface, but it is SETTRIG,CP that determines whether or not Current Profile is enabled. If Current Profile is enabled but DS="OFF" the Current Profile data will only be written to the recorder.

SETCURPROF

Set current profile settings

GETCURPROF

Get current profile settings

GETCURPROFLIM

Get limits for current profile settings

7.16 Trigger settings

Commands: SETTRIG, GETTRIG, GETTRIGLIM,
Command type: CONFIGURATION
Mode: COMMAND

Configure trigger settings for Bottom Track, Altimeter and Current Profile.

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 SRC and FREQ arguments determine how and how often acoustic measurements are triggered. The ALTI and CP arguments determine how often those triggers will start altimeter and current profile measurements, respectively. All triggers that are not altimeter or current profile triggers will start Bottom Track measurements. So for a given trigger frequency, increasing ALTI or CP will decrease the number of Bottom Track measurements.

Example: If ALTI=4 and CP=6, then there will be three Bottom Track samples between each altimeter sample and five Bottom Track samples between each Current Profile sample. If the trigger frequency is 2Hz the average sample rates will be 0.43Hz for the altimeter, 0.26Hz for Current Profile and 1.3Hz for Bottom Track (and Water Track)

Argument	Description
SRC	Specifies trigger source "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. This parameter is only effective when SRC=INTERNAL. Note! Max trigger frequency depends on the acoustic range. For high values of SETMISSION,RANGE the maximum trigger frequency will be less than the maximum value stated here. If the trigger frequency is too high for the selected range, and error will be reported by SAVE, START or FIELDCAL. Unit: [Hz] | Values: [1; 8]
ALTI	Altimeter interleave ratio. The ratio, N, specifies that every Nth Bottom Track measurement will be replaced by 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
CP	Current Profile interleave ratio. The ratio, N, specifies that every Nth Bottom Track measurement will be replaced by a Current Profile measurement. CP=0 disables current profiling. 0, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 Default: 0

SETTRIG

Set trigger settings

GETTRIG

Get trigger settings

GETTRIGLIM

Get limits for trigger settings

7.17 IMU settings

Commands: SETIMU, GETIMU, GETIMULIM,
Command type: CONFIGURATION
Mode: COMMAND

The IMU command configures the output from the Inertial Measurement Unit (IMU).

Argument	Description
FREQ	IMU output frequency Unit: [Hz] | Values: [100; 100] | Default: 100
DS	Enable data stream for IMU OFF, ON Default: OFF
DF	Data format for IMU data stream 130: Nortek binary IMU format. Default: 130

SETIMU

Set IMU settings

Example:
```
setImu({dataStream: "ON"})
```

GETIMU

Get IMU settings

GETIMULIM

Get limits for IMU settings

7.18 Magnetometer settings

Commands: SETMAG, GETMAG, GETMAGLIM,
Command type: CONFIGURATION
Mode: COMMAND

Configure how the magnetometer is used.

Argument	Description
FREQ	Magnetometer sample frequency Unit: [Hz] | Values: [75; 75] | Default: 75
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
DS	Enable data stream for magnetometer OFF, ON Default: OFF
DF	Data format for magnetometer data stream 135: Nortek binary magnetometer format. Default: 135

Note: The FREQ argument specifies the *sampling* frequency of the magnetometer. Output samples are fewer, and may come at irregular intervals. This is because the magnetometer output is filtered, preventing noisy samples to be published.

SETMAG

Set magnetometer settings

Example:
```
setMagnetometer({sampleFrequency: 75, method: "AUTO", dataStream: "ON", dataFormat: 135})
```

GETMAG

Get magnetometer settings

GETMAGLIM

Get limits for magnetometer settings

7.19 Magnetometer calibration settings

Commands: SETMAGCAL, GETMAGCAL, GETMAGCALLIM,
Command type: CONFIGURATION
Mode: COMMAND

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 neither 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] | Values: [-1; 1]
HY	Hard iron of magnetometer Y Unit: [Gauss] | Values: [-1; 1]
HZ	Hard iron of magnetometer Z Unit: [Gauss] | Values: [-1; 1]
M11	Magnetometer compensation matrix element Values: [-2; 2]
M12	Magnetometer compensation matrix element Values: [-2; 2]
M13	Magnetometer compensation matrix element Values: [-2; 2]
M21	Magnetometer compensation matrix element Values: [-2; 2]
M22	Magnetometer compensation matrix element Values: [-2; 2]
M23	Magnetometer compensation matrix element Values: [-2; 2]
M31	Magnetometer compensation matrix element Values: [-2; 2]
M32	Magnetometer compensation matrix element Values: [-2; 2]
M33	Magnetometer compensation matrix element Values: [-2; 2]

SETMAGCAL

Set magnetometer calibration values

GETMAGCAL

Get magnetometer calibration values

GETMAGCALLIM

Get limits for magnetometer calibration settings

7.20 Ethernet settings

Commands: SETETH, GETETH, GETETHLIM,
Command type: CONFIGURATION
Mode: COMMAND

These commands are used for configuring Ethernet settings.

By default the instrument is configured to use DHCP, meaning it will automatically be assigned an IP address on the local network.

If a DHCP server is not available on the local network the instrument can instead be configured to use a static IP address. It is then up to the user to correctly configure the IP address, the subnet mask and the default gateway.

Regardless of the method used for assigning the IP address, the instrument should be available on the local subnet through hostname "NORTEK-xxxxxx.local", where xxxxxx is the instrument serial number as engraved on the housing.

When the SETETH command is provided over a serial connection the Ethernet settings take effect immediately. If SETETH is provided over a TCP connection the active device configuration will be updated immediately (and can be saved with the SAVE command), but changes to the actual Ethernet interface will only take effect when the active TCP session is closed. So if you are connected through TCP and then change the static IP address, the instrument will not respond to the new address until you disconnect. The instrument will never be assigned more than one IP address. Notice that this behavior also applies for SETDEFAULT,COMM, which implicitly calls SETETH with default settings.

Argument	Description
IPMETHOD	Method used for obtaining an IP address. "DHCP": Automatic assignment using DHCP. "STATIC": Static assignment using the arguments below. Default: DHCP
IP	Static IP address. Only effective when IPMETHOD="STATIC". Default: "192.168.1.201"
NETMASK	Subnet mask. Only effective when IPMETHOD="STATIC". Default: "255.255.255.0"
GATEWAY	Default gateway. Only effective when IPMETHOD="STATIC". Default: "192.168.1.1"
PASSWORD	The password required on TCP connect. An empty string (SETETH,PASSWORD="") will disable the password prompt entirely. Max length is 20 characters. Note! GETETH will not return this parameter. Default: "nortek"

Note: The actual IP address can be queried by the READIP command. If you are not able to connect to the instrument because you don't know its IP address, you can connect through the serial port and then do READIP.

If the instrument is configured for DHCP but no IP address is provided within 30s, the instrument will assign itself the IP address 169.254.15.123. This IP address can be used when connecting the instrument directly to a laptop.

SETETH

Set Ethernet settings

GETETH

Get Ethernet settings

GETETHLIM

Get limits for Ethernet settings

7.21 Read IP address

Command: READIP
Command type: INFO
Mode: COMMAND

Read the assigned IP address, subnet mask and default gateway.

Argument	Description
IP	Assigned IP address.
NETMASK	Subnet mask.
GATEWAY	Default gateway.
LEASETIME	DHCP lease time. (0 if DHCP is not used) Unit: [s]

Note: IP, NETMASK and GATEWAY will return empty strings if no IP address is assigned.

7.22 Get error

Command: GETERROR
Command type: INFO
Mode: COMMAND

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])"
```

7.23 Get instrument ID

Command: ID
Command type: INFO
Mode: COMMAND

Commands for accessing instrument name and serial number

Argument	Description
SN	Serial number Values: [0; 2147483647]
STR	Instrument name

Example:
```
getId({serialNumber: true, instrumentName:"true"})
```

7.24 Get hardware information

Command: GETHW
Command type: INFO
Mode: COMMAND

Get board revisions.

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

Example:

```
getHardware({boardDigitalRevision: true})
```

7.25 Get firmware version

Command: GETFW
Command type: INFO
Mode: COMMAND

Get firmware version.

Argument	Description
STR	Nucleus version on format MAJOR.MINOR.PATCH[-EXTRA] Example: "1.0.2"
MAJOR	Nucleus major version
MINOR	Nucleus minor version
PATCH	Nucleus patch version
EXTRA	Nucleus version extra information string. Usually empty (""). Max 10 chars.

Example:
```
getFirmware({fwMajorVersion: true, fwMinorVersion: true})
```

7.26 Clock settings as strings

Commands: SETCLOCKSTR, GETCLOCKSTR,
Command type: CONFIGURATION
Mode: COMMAND

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:
```
setClock("2020-11-12 14:27:42")
```

GETCLOCKSTR

Get instrument clock as string

7.27 Get all

Command: GETALL
Command type: INFO
Mode: COMMAND

GETALL retrieves all relevant configuration information for the instrument.

Example:
```
getAll()
```

7.28 Reboot the instrument

Command: REBOOT
Command type: ACTION
Mode: COMMAND

This command will do a system reboot. All active settings will be re-loaded from their saved values.

Example:
```
reboot()
```

7.29 List license keys

Command: LISTLICENSE
Command type: INFO
Access: User
Mode: COMMAND

List all license keys stored in the instrument.

Example:
```
listLicenseKeys()
```

7.30 Add license key

Command: ADDLICENSE
Command type: PRODUCTION
Mode: COMMAND

Add a license key to the instrument. Adding additional license keys will unlock new features.

Argument	Description
KEY	The license key to add

Note: License keys are unique for each instrument. Trying to add a license key for another instrument (like the one in the example) will fail.

Example:

```
addLicense("9H3F5PE47HUUB")
```

7.31 Delete license key

Command: DELETELICENSE
Command type: PRODUCTION
Mode: COMMAND

Delete a license key from the instrument.

Argument	Description
KEY	The license key to delete

Example:

```
deleteLicense("9H3F5PE47HUUB")
```

8 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.

In short: The data format is the sum of header data, a common part and the part that is unique for the given sensor data. 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 for the sensor data. E.g. for Altimeter data we have pressure, distance and quality of altimeter data. These are given in the table 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).

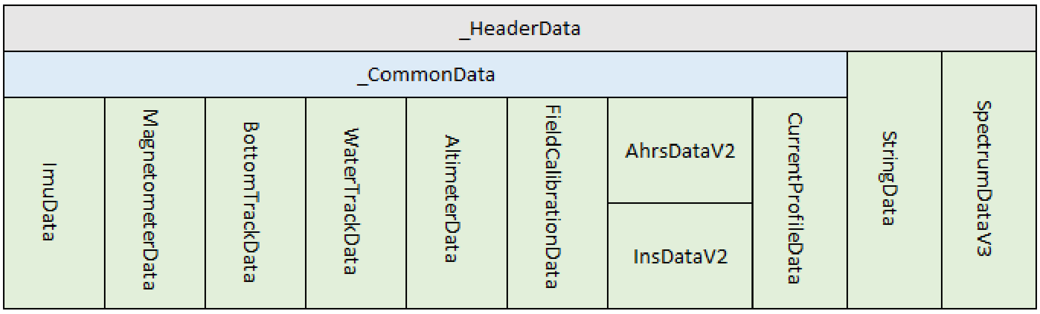


Figure: Showing how common data fields (gray for header and blue for other common's) the sensor data relate to the sensor specific data fields (green). Note that we use a leading underscore (_) to emphasize that this is not a sensor data format but is common and used by two or more data formats.

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.

8.1 _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 0x82 (130) - IMU data 0x87 (135) - Magnetometer data 0x8B (139) - Field calibration data

		0xA0 (160) - String data, eg. GPS NMEA data, comments,.. 0xAA (170) - Altimeter data 0xB4 (180) - Bottom track data 0xBE (190) - Water track data 0xD2 (210) - AHRS data 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..

8.2 _CommonData

Used By: AhrsDataV1, AhrsDataV2, ImuData, MagnetometerData, AltimeterData, FieldCalibrationData, BottomTrackData, WaterTrackData, CurrentProfileData

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]
Flags	2 8 bits	Common flags Object reference given in table below
Timestamp	4 uint32	If the "POSIX time" flag is set, Timestamp represents POSIX time, i.e. the number of seconds since January 1st, 1970. If the "POSIX time" flag is not set, Timestamp is the number of seconds elapsed since the START commmand. See documentation for SETCLOCKSTR for more information. Unit: [s]
Micro seconds	8 uint32	Micro seconds elapsed since Timestamp Unit: [µs]

Object reference: Flags

Common flags

Field	Position Size	Description
POSIX time	0 bit	Set if timestamp is based on instrument system time.

8.3 AhrsDataV2

Extends: _CommonData
ID: 0xd2
Version: 2

Data definitions for parsing AHRS data.

Field	Position Size	Description
Serial number	16 uint32	Instrument serial number from factory.
Operation mode	24 uint8	AHRS operation mode 0:Field calibration 2:Regular AHRS mode
Spare	25 3 bytes	Empty field of 1 byte enabling the following data to begin on whole 32bit blocks
Figure of merit	28 float	Quality measure of AHRS (0 when not running)
Fom. field calibration	32 float	Quality measure of Field calibration. (outputs 0 if hard iron is not estimated).
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.

8.4 InsDataV2

Extends: _AhrsDataV2
ID: 0xdc
Version: 2

Data definitions for parsing INS data. Note that both SETINST,TYPE="NAV" is required in addition to the SETNAV parameters.

Field	Position Size	Description
Figure of merit INS	OFFSET + 72 float	Quality measure of INS (0 when not running)
INS status	OFFSET + 76 32 bits	INS status bit description. Object reference given in table below
Course over ground	OFFSET + 80 float	Course over ground Unit: [deg]
Temperature	OFFSET + 84 float	Unit: [°C]
Pressure	OFFSET + 88 float	Hydrostatic pressure. Unit: [Bar]
Altitude	OFFSET + 92 float	Height above sea floor as measured by the altimeter. Unit: [m]
Latitude	OFFSET + 96 double	Unit: [°]
Longitude	OFFSET + 104 double	Unit: [°]

Reserved	OFFSET + 112 double	
Position NED.x	OFFSET + 120 float	X position in NED. Unit: [m]
Position NED.y	OFFSET + 120 + 4 float	Y position in NED. Unit: [m]
Position NED.z	OFFSET + 120 + 8 float	Z position in NED. Unit: [m]
Velocity NED.x	OFFSET + 132 float	Vx. Velocity in NED. Unit: [m/s]
Velocity NED.y	OFFSET + 132 + 4 float	Vy. Velocity in NED. Unit: [m/s]
Velocity NED.z	OFFSET + 132 + 8 float	Vz. Velocity in NED. Unit: [m/s]
Velocity vehicle.x	OFFSET + 144 float	Vx. Velocity in vehicle. Unit: [m/s]
Velocity vehicle.y	OFFSET + 144 + 4 float	Vy. Velocity in vehicle. Unit: [m/s]
Velocity vehicle.z	OFFSET + 144 + 8 float	Vz. Velocity in vehicle. Unit: [m/s]
Speed over ground	OFFSET + 156 float	Speed over ground Unit: [m/s]
Turn rate.x	OFFSET + 160 float	Turning rate in vehicle X. Unit: [deg/s]
Turn rate.y	OFFSET + 160 + 4 float	Turning rate in vehicle Y. Unit: [deg/s]
Turn rate.z	OFFSET + 160 + 8 float	Turning rate in vehicle Z. Unit: [deg/s]

Object reference: INS status

INS status bit description.

Field	Position Size	Description
Lat/Lon is valid	0 bit	True if output of LatLon is valid data

8.5 ImuData

Extends: _CommonData
ID: 0x82

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

Field	Position	Description

	Size	
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
IMU data valid	0 bit	Indicates if IMU data is valid or not.

8.6 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

8.7 AltimeterData

Extends: _CommonData
ID: 0xaa

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 velocity	24 float	Configured or measured sound velocity. See SETMISSION,SV. Unit: [m/s]
Temperature	28 float	Temperature in water Unit: [°C]
Pressure	32 float	Hydrostatic pressure. Calculated as measured pressure minus the configured offset. See SETMISSION,POFF. Unit: [Bar]
Distance	36 float	Altimeter distance from seabed. Unit: [m]

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 bit	Pressure valid
Temperature valid	17 bit	Temperature valid

8.8 FieldCalibrationData

Extends: _CommonData
ID: 0x8b

This data format is streamed when FIELDCAL command is run.

Field	Position Size	Description
Reserved.	0 bit	
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.
Reserved.	OFFSET + 48 float	
Reserved.	OFFSET + 48 + 4 float	
Reserved.	OFFSET + 48 + 8 float	
Figure of merit	OFFSET + 60 float	Figure of merit.
Reserved.	OFFSET + 64 float	

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.

8.9 BottomTrackData

Extends: _CommonData
ID: 0xb4

Data format for DVL Bottom Track.

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 velocity	24 float	Configured or measured sound velocity. See SETMISSION,SV. Unit: [m/s]
Temperature	28 float	Temperature in water Unit: [°C]
Pressure	32 float	Hydrostatic pressure. Calculated as measured pressure minus the configured offset. See SETMISSION,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 to cell along beam 1 invalid estimates set to 0.0 Unit: [m]
Distance beam 2	52 float	Vertical distance to cell along beam 2 invalid estimates set to 0.0 Unit: [m]
Distance beam 3	56 float	Vertical distance to cell 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]
deltaT 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]
deltaT 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]
deltaT 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]
Time velocity estimate beam 1	84 float	Processed pulse length for velocity estimate for beam 1. Unit: [s]
Time velocity estimate beam 2	88 float	Processed pulse length for velocity estimate for beam 2. Unit: [s]
Time velocity estimate beam 3	92 float	Processed pulse length for 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]
deltaT XYZ	120 float	Time from trigger to echo of first beam used in the estimation of XYZ-velocities. Unit: [s]
Unused	124 4 bytes	4 unused bytes

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	Z velocity valid

	bit	
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

8.10 WaterTrackData

Extends: _CommonData
ID: 0xbe

Data format for DVL Water track.

Water track data follows the same structure as Bottom track data, but where bottom track follows the most distant cell in the water column, water track will follow a cell where the water flow is assumed to not be 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 velocity	24 float	Configured or measured sound velocity. See SETMISSION,SV. Unit: [m/s]
Temperature	28 float	Temperature in water Unit: [°C]
Pressure	32 float	Hydrostatic pressure. Calculated as measured pressure minus the configured offset. See SETMISSION,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 to cell along beam 1 invalid estimates set to 0.0 Unit: [m]
Distance beam 2	52	Vertical distance to cell along beam 2

	float	invalid estimates set to 0.0 Unit: [m]
Distance beam 3	56 float	Vertical distance to cell 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]
deltaT 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]
deltaT 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]
deltaT 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]
Time velocity estimate beam 1	84 float	Processed pulse length for velocity estimate for beam 1. Unit: [s]
Time velocity estimate beam 2	88 float	Processed pulse length for velocity estimate for beam 2. Unit: [s]
Time velocity estimate beam 3	92 float	Processed pulse length for 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]
deltaT XYZ	120 float	Time from trigger to echo of first beam used in the estimation of XYZ-velocities. Unit: [s]
Unused	124 4 bytes	4 unused bytes

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

8.11 CurrentProfileData

Extends: _CommonData
ID: 0xc0

Data format for Current Profile. Notice that the number of cells, and thus the length of the packet, will depend on Current Profile configuration.

Field	Position Size	Description
Serial number	16 uint32	Instrument serial number from factory.
Sound velocity	24 float	Configured or measured sound velocity. See SETMISSION,SV. Unit: [m/s]
Temperature	28 float	Temperature in water Unit: [°C]
Pressure	32 float	Hydrostatic pressure. Calculated as measured pressure minus the configured offset. See SETMISSION,POFF. Unit: [Bar]
Cell size	36 float	Cell size as configured through SETCURPROF,CS. Unit: [m]
Blanking	40 float	Blanking distance as configured through SETCURPROF,BD Unit: [m]
Number of cells	44 uint16	Number of cells in current profile data. This value determines the dimensions of the velocity, amplitude and correlation data described below.

		See the documentation for SETCURPROF for an explanation on how this parameter relates to the current profile configuration.
Ambiguity velocity	46 int16	Ambiguity velocity, corrected for sound velocity Unit: [m]
Velocity data	OFFSET int16 *NC * 3	Array of int16_t. Three elements, X, Y, and Z, per cell. All X-values first, followed by all Y-values, and lastly all Z-values. NC = Number of cells. Unit: [mm/s]
Amplitude data	OFFSET + 6 * NC uint8 *NC * 3	Array of uint8_t. One element per cell per beam. NC = Number of cells. Unit: [0.5 db/count]
Correlation data	OFFSET + 9 * NC uint8 *NC * 3	Array of uint8_t. One element per cell per beam. NC = Number of cells. Unit: [%]

8.12 SpectrumDataV3

ID: 0x20

Data definitions for parsing amplitude spectrum data.

Field	Position Size	Description
Version	0 uint8	Version number of the Data Record Definition. Should be 3
Offset of data	1 uint8	Number of bytes from start of the record to start of the actual data. Unit: [# bytes]
Configuration	2 16 bits	Record configuration bit mask Object reference given in table below
Serial number	4 uint32	Instrument serial number from factory.
Date and time	8 uint8 *8	The date and time of the data record. Year: Is given as years from 1900. Month: January is 0. Milli seconds: Are given by the hundreds. That is as desi seconds.
Micro seconds	12 uint16	Remaining micro seconds (Date object has milliseconds resolution)
Speed of sound	16 uint16	Speed of sound used by the instrument. Raw data given as 0.1 m/s Unit: [m/s]
Temperature	18 int16	Reading from the temperature sensor. Raw data given as 0.01 °C Unit: [°C]

Pressure	20 uint32	Raw data given as 0.001 dBar Unit: [dBar]
Beams and bins.Number of beams	30 uint16	Bit 15–13 (3 bits) represent number of beams (NB) 1110 0000 0000 0000 Active beams represented as string of 1s and 0s.
Beams and bins.Number of bins	30 uint16	Bit 0-12 (13 bits) represents number of bins (NB) 0001 1111 1111 1111
Blanking	34 uint16	Distance from instrument to first data point on the beam. Raw data given as cm or mm depending on status.blankingDistanceScalingInCm Unit: [m]
Temperature PressureSensor	37 uint8	Temperature of pressure sensor: T=(Val/5)-4.0 Raw value given as 0.2 °C Unit: [°C]
Data set description	54 uint16	Data set description. 0-3 Physical beam used for 1st data set. 4-7 Physical beam used for 2nd data set. 8-11 Physical beam used for 3th data set. 12-16 Physical beam used for 4th data set.
Power level	59 int8	Configured power level Unit: [dB]
Real time clock temperature	62 int16	Real Time Clock temperature reading Unit: [°C]
Error status	64 16 bits	Error bit mask Object reference given in table below
Extended status	66 16 bits	Extended status bit mask Object reference given in table below
Status	68 32 bits	Status bit mask. Note that bits 0, 2, 3, 4 are unused. Object reference given in table below
Ensemble counter	72 uint32	Counts the number of ensembles in both averaged and burst data
Spectrum data.Start frequency	OFFSET float	Start frequency value Unit: [Hz]
Spectrum data.Step frequency	OFFSET + 4 float	Step frequency value Unit: [Hz]
Spectrum data.Frequency data	OFFSET + 64 int16 *BEAMS *BINS	Frequency spectrum amplitude data. There is room for 16 floating points for a spectrum header before the frequency data. Unit: [dB]

Position and size variables:

Name	Description
BEAMS	Matrix first dimension is number of beams. Eg: [[f_start, .., f_{start+step*(bins-1)}]_{beam1} [f_start, .., f_{start+step*(bins-1)}]_{beam2} .. [f_start, .., f_{start+step*(bins-1)}]_{beams}]
BINS	Per beam, frequencies are given as an array of length as number of bins. First element is the start frequency and frequencies increment by step frequency per element of the array. Eg: [[f_start, f_{start+step}, f_{start+step*2}, .., f_{start+step*(bins-1)}] _{beam1}, .., ..]
16+BEAMSxBINSx2	If configuration.hasSpectrumData is false, spectrum data is length 0. RAW: !this.configuration.hasSpectrumData ? 0 : this.beamsAndBins.numberOfBeams*this.beamsAndBins.numberOfBins *2 + 16*4
OFFSET	Number of bytes from start of record to start of data.

Object reference: Configuration

Record configuration bit mask

Field	Position Size	Description
Has pressure sensor	0 bit	Pressure sensor value valid
Has temperature sensor	1 bit	Temperature sensor value valid
Has spectrum data	15 bit	Amplitude spectrum data included.

Object reference: Error status

Error bit mask

Field	Position Size	Description
Data retrieval FIFO error	0 bit	Data retrieval FIFO error
Data retrieval overflow	1 bit	Data retrieval overflow
Data retrieval underrun	2 bit	Data retrieval Underrun
Data retrieval samples missing	3 bit	Data retrieval samples missing

Measurement not finished	4 bit	The Measurement and data storage/transmit didn't finish before next measurement started.
Sensor read failure	5 bit	Sensor read failure
Tag error beam 1 (In-phase)	8 bit	Tag error beam 1 (In-phase)
Tag error beam 1 (Quadrature-phase)	9 bit	Tag error beam 1 (Quadrature-phase)
Tag error beam 2 (In-phase)	10 bit	Tag error beam 2 (In-phase)
Tag error beam 2 (Quadrature-phase)	11 bit	Tag error beam 2 (Quadrature-phase)
Tag error beam 3 (In-phase)	12 bit	Tag error beam 3 (In-phase)
Tag error beam 3 (Quadrature-phase)	13 bit	Tag error beam 3 (Quadrature-phase)

Object reference: Extended status

Extended status bit mask

Field	Position Size	Description
Processor idles < 3%	0 bit	Indicates that the processor Idles less than 3 percent
Processor idles < 6%	1 bit	Indicates that the processor idles less than 6 percent
Processor idles < 12%	1 bit	Indicates that the processor idles less than 12 percent
Extended status should be interpreted	15 bit	If this bit is set the rest of the word/ extended status should be interpreted

Object reference: Status

Status bit mask. Note that bits 0, 2, 3, 4 are unused.

Field	Position Size	Description
Blanking distance scaling in cm	1 bit	Bit 1: Scaling of blanking distance 0: mm scaling 1: given in cm

8.13 StringData

ID: 0xa0

String Data Record, eg. GPS NMEA data, comment from the FWRITE command.

Field	Position Size	Description
String	0 Size of record	String data record.

9 Maintenance

Preventive maintenance is your primary tool to keep your instrument in shape and ready for action and deployment. 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 unauthorized access will void the warranty. Please contact Nortek for further assistance if in any doubt.

9.1 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.

9.2 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.

9.3 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.

10 Appendices

10.1 Glossary

Term	Definition
Accuracy	A value giving the degree of closeness of a velocity measurement to the actual velocity.
AHRS	Attitude and Heading Reference System; provides attitude and heading measurements to aid inertial navigation.
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.
IMU	Inertial Measurement Unit; provides angular rate and acceleration for inertial navigation.
Keepout area	The area to either side of a beam where obstructions might interfere with the data; generally 15°.
LED	Light Emitting Diode. A light on the instrument that indicates the current mode.
Magnetic declination	The difference in degrees between True North and Magnetic North at a given location

Term	Definition
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.
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.

10.2 Parsing Nucleus Data

This section will cover the correct approach to parse the data from a Nucleus packet.

Take the following data from the Nucleus:

```
00 00 00 00 A5 0A D2 20 6C 00
8A E5 F9 C6 02 24 00 00 02 00
00 00 00 35 0C 00 00 00 00 00
04 00 00 00 00 00 00 00 02 00
00 00 CB 82 77 3E 00 00 A0 40
AC A0 25 BF BC 74 4A BF 6B B6
8D 43 63 EC 48 BF 11 AA 0E 3C
4E 7C FB 3A F1 9E 1E 3F 6D B9
6D 3E 7A FF 78 3F 7D E5 FE 3B
19 FB 78 BF 9A 93 6D 3E F5 72
83 3C 69 23 62 3C 7C FC 38 BC
94 F5 7F 3F 00 00 00 00 FF FE
2D 3F A5 0A D2 20 6C 00 6E 4B
DD 2C 02 24 00 00 02 00 00 00
```

In order to parse this data we will first refer to the _HeaderData table to figure out what we are working with and how to proceed with the parsing.

10.2.1 Locate header data

In the _HeaderData table, as with ALL other tables, the **Position Size** column provides information about the byte locations for every data field that is to be extracted from the data, as well as the size of the field, which refers to how many bytes the specific field consists of.

Also from the first entry in _HeaderData we know that the sync byte should always be 0xA5, and that the "sync bit" field only has a size of one byte (uint8). Looking at the retrieved data from the Nucleus we see that the first occurrence of a byte value of 0xA5 is 5 bytes into the stream. We therefore assume that the 4 first bytes belong to a previous package and start the parsing at the byte with a value of 0xA5.

From _HeaderData we see that the "Header Size" field follows the "sync bit" field at position 1 and also only consist of 1 byte (uint8). The value of this byte is 0x0A which converts into the decimal value 10 which tells us that the header consist of 10 bytes. With this information we can illustrate how to extract the header data with the following table:

Bytes	A5	0A	D2	20	6C	00	8A	E5	F9	C6
Position	0	1	2	3	4	5	6	7	8	9
Field	sync bit	header size								

Looking at the _HeaderData table we can now identify which data fields consist of which bytes by referring to the **Position Size** column and assigning the fields to the corresponding byte position. Assigning the data fields gives the following table:

Bytes	A5	0A	D2	20	6C	00	8A	E5	F9	C6
Position	0	1	2	3	4	5	6	7	8	9
Field	sync bit	header size	data series id	family id	data size		data checksum		header checksum	
Table	_HeaderData									

Note that each field has a defined start position and size given by the **Position Size** column. I.e. in the case of the "Data size" field this position is 4 and the size is uint16 (2 bytes), therefore this field starts at position 4 in the data and also includes the byte at position 5. The same logic follows for "Data checksum" and "Header checksum".

10.2.2 Extract header information

With the fields properly allocated, necessary information can be extracted from the header to further parse the data.

- The "Data series id" is 0xD2 which tells us that this package contains AHRS data.
- The "Family id" is 0x20 which tells us that data belongs to the Nucleus family. This will always be the case with packages from a Nucleus device, but in the case of another Nortek product, this value would be different.
- The "Data size" consist of two bytes. Since these bytes are little endian the value of data size becomes 0x006C which equals 108, meaning that the data packet consists of 108 bytes.
- The "Data checksum" also consists of two bytes and its value is 0xE58A. This will be used to calculate whether the data in the package is valid.
- The "Header checksum" then becomes 0xC6F9 and is used to check if the header data is valid.

With all the data extracted the next step is to calculate the header checksum to verify that the extracted data is valid. The calculation should be performed on all the bytes in the header excluding the header checksum itself, that is bytes 0-7. The calculation can be performed using the following python code:

```
def checksum(packet):
	checksum = 0xb58c
	for u, v in zip_longest(packet[::2], packet[1::2], fillvalue=None):
		if v is not None:
			checksum += u | v << 8
		else:
			checksum += u << 8 | 0x00
		checksum &= 0xffff
	return checksum
```

In this case the calculated checksum matches the checksum from the "header checksum" field and the header data is therefore valid.

Now that all the data in the header is valid it is necessary to check if the sensor data is valid. The value of "Data size" is 108, this means that the 108 bytes that follows the header is the bytes in data. The checksum of the sensor data will be calculated based on these bytes using the previous checksum code and the result should match the value of "Data checksum" field from the header. In this case the values match, which means that the sensor data is valid.

With all the data extracted from the header and with its validity confirmed we are ready to parse the sensor data

10.2.3 Extract data

10.2.3.1 Extract common data

The header has provided necessary information to start extracting the sensor data. The first byte of the sensor data is the byte that follows immediately after the header. "Data size" from the header data tells us that the sensor data consists of 108 bytes. These bytes and their position are listed in the table below. The remaining bytes from the Nucleus data coming after these bytes are therefore not a part of this package and will not be a part of the parsing.

Bytes	02	24	00	00	02	00	00	00	00	35	0C	00	00	00	00	00	04	00	00	00	00	00	00	00	02	00	00	00	CB	82	77	3E	00	00	A0	40
Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Bytes	AC	A0	25	BF	BC	74	4A	BF	6B	B6	8D	43	63	EC	48	BF	11	AA	0E	3C	4E	7C	FB	3A	F1	9E	1E	3F	6D	B9	6D	3E	7A	FF	78	3F
Position	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Bytes	7D	E5	FE	3B	19	FB	78	BF	9A	93	6D	3E	F5	72	83	3C	69	23	62	3C	7C	FC	38	BC	94	F5	7F	3F	00	00	00	00	FF	FE	2D	3F
Position	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107

To parse the sensor data we will first need to refer to the _CommonData table, since the common data will be a first part of this data regardless of which sensor data is in the package. By referring to the Position Size column in the _CommonData table we are able to locate which fields consists of which bytes in the data. The table below illustrates which bytes that belongs to the different fields in the common data.

Bytes	02	24	00	00	02	00	00	00	00	35	0C	00	00	00	00	00	04	00	00	00	00	00	00	00	02	00	00	00	CB	82	77	3E	00	00	A0	40
Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Field	Version	Offset of data			Time stamp				Micro seconds																											
Table	_CommonData																																			
Bytes	AC	A0	25	BF	BC	74	4A	BF	6B	B6	8D	43	63	EC	48	BF	11	AA	0E	3C	4E	7C	FB	3A	F1	9E	1E	3F	6D	B9	6D	3E	7A	FF	78	3F
Position	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Bytes	7D	E5	FE	3B	19	FB	78	BF	9A	93	6D	3E	F5	72	83	3C	69	23	62	3C	7C	FC	38	BC	94	F5	7F	3F	00	00	00	00	FF	FE	2D	3F
Position	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107

Note! Bytes 2 and 3 do not belong to any particular field. These bytes are not in use but may be used in a future version of the Nucleus. This is why it is **crucial** to refer to the **Position Size** column in these data tables to locate the correct position of the different data fields and NOT assume that all the data fields follow one another byte for byte.

With the _CommonData fields mapped out to their corresponding bytes we get more necessary information for the parsing.

- The "Version" field value is 0x02, which converts to 2. Meaning that the version of this data output is 2, which is necessary information in order to select the correct tables for parsing the data.
- The "Offset of data" value is 0x24, which converts to 36. This value is crucial for further parsing of the data.
- "Time stamp" and "Microseconds" both consists of 4 bytes and are little endian, so their values becomes 0x0000002 and 0x000C3500 respectively.

10.2.3.2 Extract AHRS data

From the header we know that the data in this package is AHRS data. From the common data we extracted 2 pieces of information that are necessary to further extract the AHRS data. These are "Version" and "Offset of data".

Firstly, since it is AHRS data we will need to refer to the _AhrsData table to find the correct fields for this data. Secondly, since it is version 2, we also need to refer to the _AhrsDataV2 table to supplement the _AhrsData table with more fields for this data. Lastly, when referring to the **Position Size** column in the _AhrsData table we see that several field positions are given by "OFFSET" + a value. The value of "OFFSET" is given by "Offset of data" value obtained from the Common data.

Using the _AhrsData table we find that "Serial number" and "Operation mode" both have a specified value for **Position Size** at 16 and 24 respectively, and can easily be located in the Nucleus data. The next field is "AHRS data.Roll" which is given by the "OFFSET" value of 36, meaning that this field is located at byte position 36. Likewise the field "AHRS data.Pitch" is given by "OFFSET + 4" which means that this field is located at position 40.

The remaining fields in this table can be located using the same logic.

Since the version number is 2 we also need to refer to the _AhrsDataV2 table to completely extract all the fields from this sensor data. In this table we have the fields "Figure of merit" and "Fom. field calibration" which are located in position 28 and 32 respectively. Adding these fields gives us the final mapping of fields to bytes which can be seen in the following table.

Bytes	02	24	00	00	02	00	00	00	00	35	0C	00
Position	0	1	2	3	4	5	6	7	8	9	10	11
Field	Version	Offset of data			Time stamp				Micro seconds			
Table	_CommonData											

Bytes	00	00	00	00	04	00	00	00	00	00	00	00
Position	12	13	14	15	16	17	18	19	20	21	22	23
Field					Serial number							
Table					_AhrsData							

Bytes	02	00	00	00	CB	82	77	3E	00	00	A0	40
Position	24	25	26	27	28	29	30	31	32	33	34	35
Field	Offset of data				Figure of merit				Fom. Field calibration			
Table	_AhrsData				AhrsDataV2							

Bytes	AC	A0	25	BF	BC	74	4A	BF	6B	B6	8D	43
Position	36	37	38	39	40	41	42	43	44	45	46	47
Field	AHRS data.Roll				AHRS data.Pitch				AHRS data.Heading			
Table	_AhrsData											

Bytes	63	EC	48	BF	11	AA	0E	3C	4E	7C	FB	3A
Position	48	49	50	51	52	53	54	55	56	57	58	59
Field	AHRS data.Quaternion W				AHRS data.Quaternion X				AHRS data.Quaternion Y			
Table	_AhrsData											

Bytes	F1	9E	1E	3F	6D	B9	6D	3E	7A	FF	78	3F
Position	60	61	62	63	64	65	66	67	68	69	70	71
Field	AHRS data.Quaternion Z				Ahrs data.Rotation matrix							
Table	_AhrsData											

Bytes	7D	E5	FE	3B	19	FB	78	BF	9A	93	6D	3E
Position	72	73	74	75	76	77	78	79	80	81	82	83
Field	Ahrs data.Rotation matrix											
Table	_AhrsData											

Bytes	F5	72	83	3C	69	23	62	3C	7C	FC	38	BC
Position	84	85	86	87	88	89	90	91	92	93	94	95
Field												
Table	_AhrsData											

Bytes	94	F5	7F	3F	00	00	00	00	FF	FE	2D	3F
Position	96	97	98	99	100	101	102	103	104	105	106	107
Field					Declination				Depth			
Table	_AhrsData											

Note! As with the common data, several bytes are not mapped to a specific field. Also, the fields from the _AhrsDataV2 table are located in-between the fields of the _AhrsData table. This further proves the necessity of referring to the **Position Size** column when assigning the different fields to their bytes

10.3 Cable Diagrams

N2650-001/002 Nucleus Pigtail Cable for RS422/232 and Ethernet Communication

Pair	Core		RS422	RS232	Comment	Pin
1	White		TX+	TX+	Ethernet	1
	Orange		TX-	TX-	Ethernet	2
2	White		RX+	RX+	Ethernet	3
	Green		RX-	RX-	Ethernet	4
3	White		TRIGA	TRIGA	Input	5
	Black		TRIGB	TRIGB	Input	6
4	White		TXZ	-	Output	7
	Blue		TXY	TX232	Output	8
5	White		RXB	RX232	Input	9
	Brown		RXA	-	Input	10
6	Black		PWR -	PWR -	Power	11
	Red		PWR +	PWR +	Power	12

10.4 Adapter Interface Board

The Nucleus comes with an unterminated cable as standard. An adapter interface board can be ordered for bench testing.

- 12 pin connector for the unterminated Nucleus cable; the wire colors are indicated in writing on the board.
- Standard power jack for power input.
- USB connector/Ethernet RJ45 for communications to the PC.
- RS232EN jumper which must be mounted if using RS232. Leave it unmounted for RS422.
- TRIG_IN pins for a TTL signal external trigger.

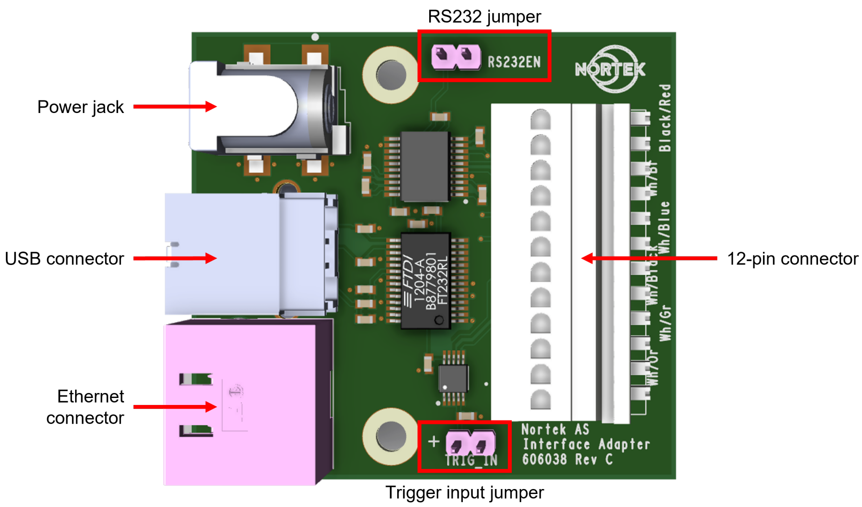
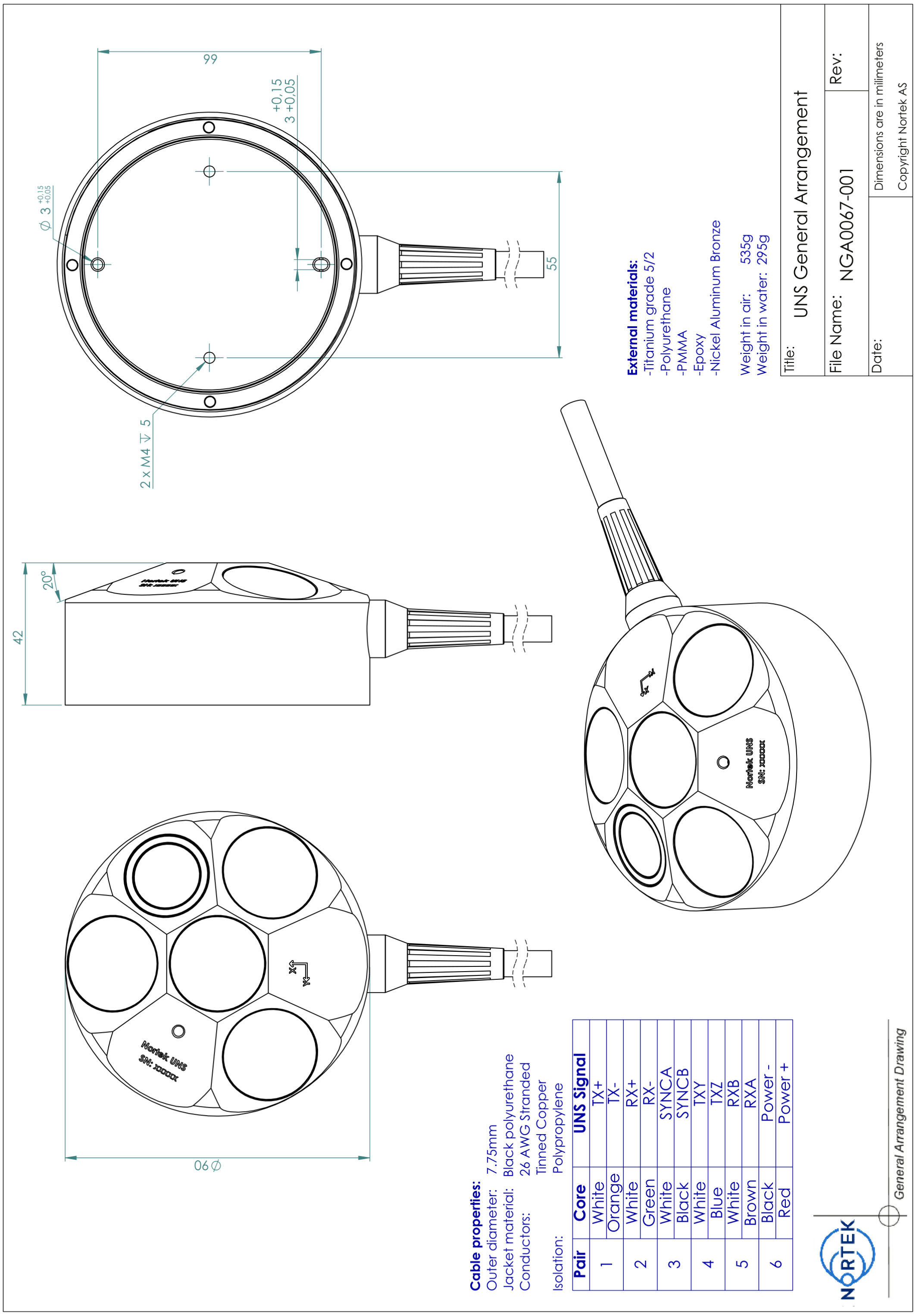


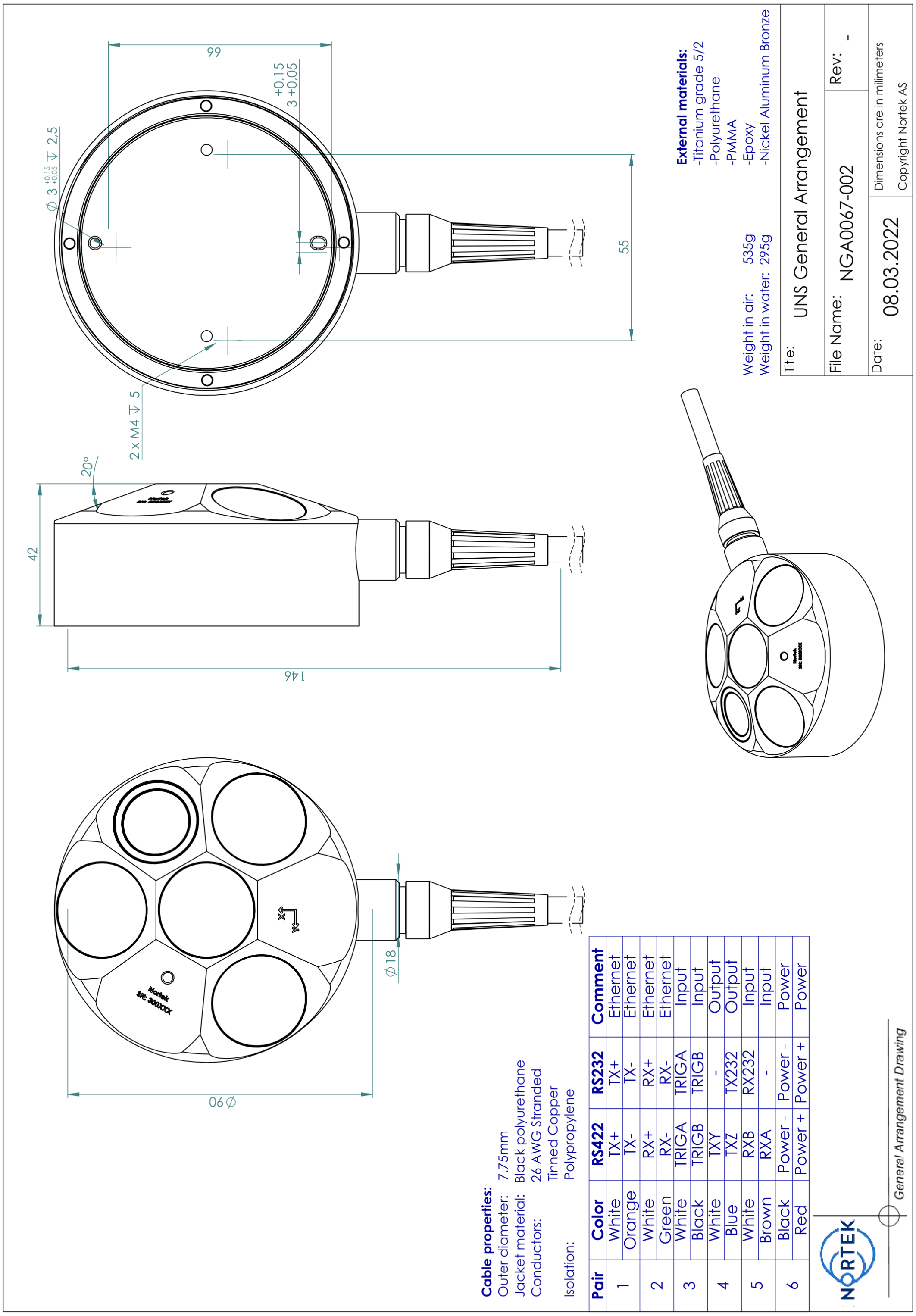
Figure 9: Nucleus adapter interface board components

10.5 Mechanical Drawings

Nucleus with penetrator cable



Nucleus with connector cable



Nucleus Origin

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.

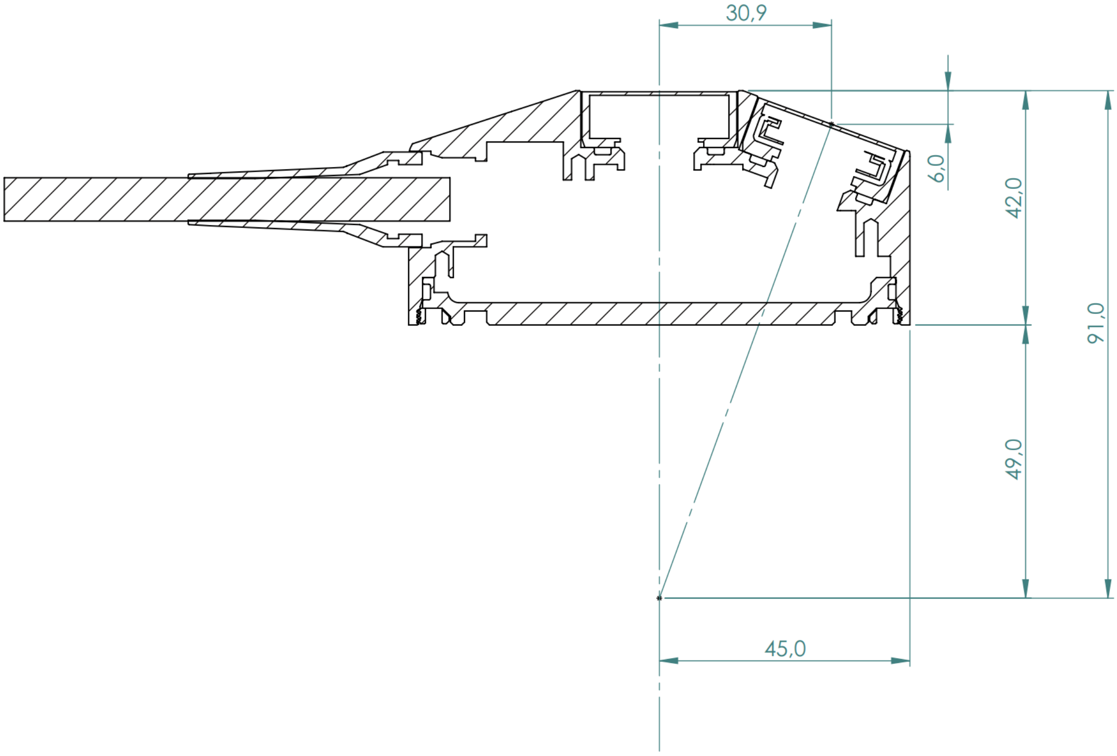


Figure 10: Origin for the Nucleus

10.6 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: