NORTEK MANUALS

Nucleus Operations and Integration

Nucleus1000

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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

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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
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2023.1	27.03.2023	Minor edits & Removed DeltaT XYZ
2023.2	02.05.2023	Updated images and dataformats
2023.3	14.06.2023	Changed wording from "Station keeping" to "crawler mode". Included sampling rate chapter

Version/revision	Date	Comments
2023.4	02.08.2023	Restructured first half of the manual. Removed chapter 6. Updated "Commands" chapter examples.
2023.5	10.11.2023	New command APPLYTAG, communication edits and parsing comments
2024.1	19.01.2024	Update Nortek Nucleus Software related content
2024.2	20.08.2024	New Firmware 4.0.1 with new, non-backwards compatible changes, update the Nucleus software aswell. Configurable coordinate system for current profile. Updated RevA and RevB cable pinout
2024.3	03.12.2024	Update manual with system overview for Nucleus1000 (300m) and Nucleus1000 1000m

Table 1: Document history

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.

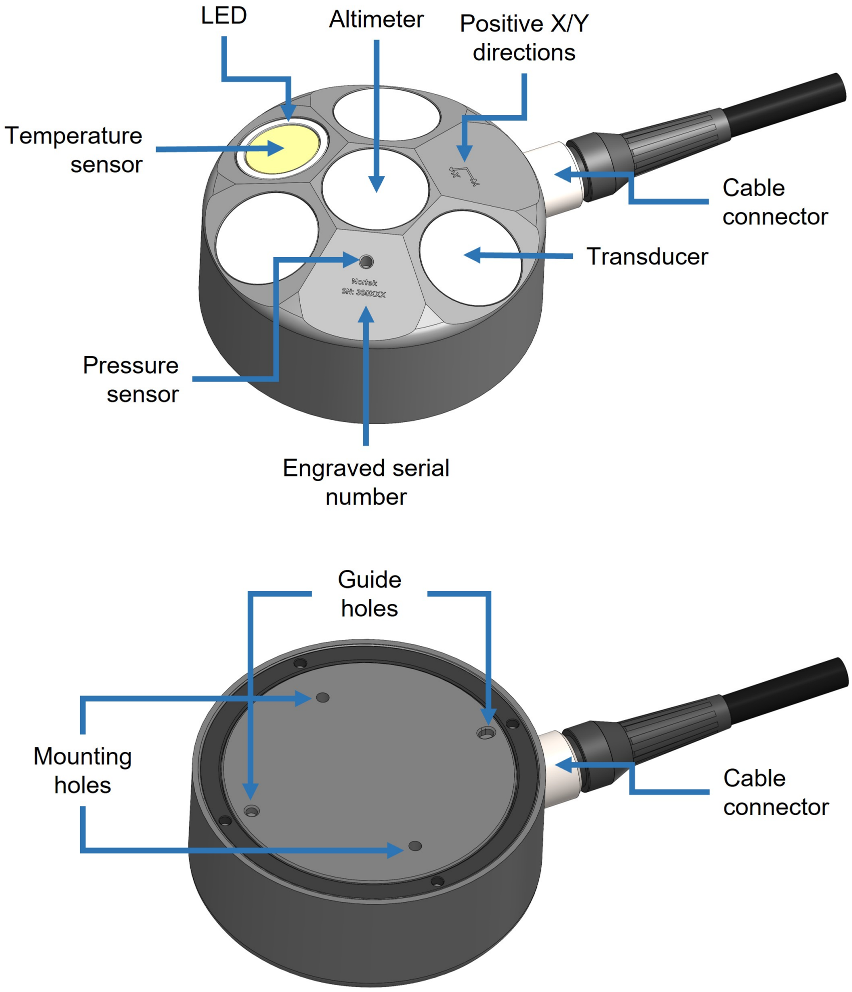


Figure 1: Nucleus overview

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 (300m)**	**Nucleus1000 1000m**
Frequency	1 MHz	1 MHz
Minimum altitude	0.1 m	0.1 m
Maximum altitude	50 m	50 m
Long-term accuracy	± 1.01 % ± 0.3 % (export controlled)	± 1.01 % ± 0.3 % (export controlled)
Ping rate	2 Hz	2 Hz
Maximum velocity	5 m/s	5 m/s
Velocity resolution	0.01 mm/s	0.01 mm/s
Depth rating	300 m	1000 m
Diameter	90 mm	90 mm
Height	42 mm	47 mm
Weight in air/water	535 g / 295 g	690 g / 415g

Table 2: 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.

The Nucleus connector cable type is either RS422 or RS232, based on what you ordered. Both cable types support Ethernet communication.

Standard inventory

- Nucleus1000 instrument
- Nucleus wet-end connector with specified end
- Power/serial/Ethernet interface unit
- USB drive with software

3.2 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 3: Supplied voltages and associated maximum cable lengths

3.3 Connecting to the Instrument to PC

Communication to the Nucleus1000 is through either a serial interface or a 100BASE-TX Ethernet interface. All commands and data formats are accessible on either physical interface. The serial interface is disabled when a TCP connection is established, and enabled again when the TCP connection is closed.

Connecting to the instrument can be done with:

- The Nortek Nucleus software (Used in Connecting With the GUI)
- The terminal based, python Nucleus driver (https://github.com/NortekSupport/nucleus_driver)
  - And in addition contains a ROS2 driver and a blueOS extension
- Any terminal window supporting serial and/or Telnet (e.g. PuTTY)

For additional information on connecting to your instrument, refer to the sections on Communication and Ethernet. Connectivity troubleshooting steps can be found under Troubleshooting

Serial communications (RS232 or RS422)
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 Diagrams to determine how to wire your device.

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

```
Nortek Nucleus1000
Version 4.0.1
OK
```

Ethernet communications
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. The different IP address assignment modes are:

1. DHCP: A DHCP server (e.g. a router) in the network is used to assign an IP address.
2. AutoIP: Link-local address assignment
3. Static IP: Manually assign/set IP address (by the user)

Ethernet communications DHCP - Default configuration
A Dynamic Host Configuration Protocol (DHCP) server handles IP address assignment and the instrument can be connected to using:
- The hostname "NORTEK-xxxxxx.local", where "xxxxxx" is the instrument serial number as engraved on the housing
- Assigned IP by the DHCP server

Ethernet communication AutoIP/Link-local address (directly to your PC)
If the instrument is in DHCP configuration and no IP address has been assigned after 30s, the instrument will assign itself the link-local address. This address can be used when connecting the instrument directly to a laptop

Nucleus Link-local address: 169.254.15.123
Nucleus Link-local subnet mask: 255.255.0.0

Ethernet communication static IP (directly to your PC)
Static IP address can be set with SETETH. or under the communications settings in the The Nortek Nucleus software. Use the AutoIP address if the instrument is set to DHCP mode and you are connected directly to your pc.

This allows you to control what IP address the instrument will be available on. This is recommended for networks without a DHCP server or network environments where you are familiar with how its defined.

Ethernet communications (Raw TCP)
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.

3.3.1 Connecting With the GUI

The Nortek Nucleus software is available in the Microsoft Store and as a web app (web app only allows serial connection), and is used to connect to, configure, and receive data from the Nucleus.

Figure 2: Nortek Nucleus software logo

Connecting to a Nucleus

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

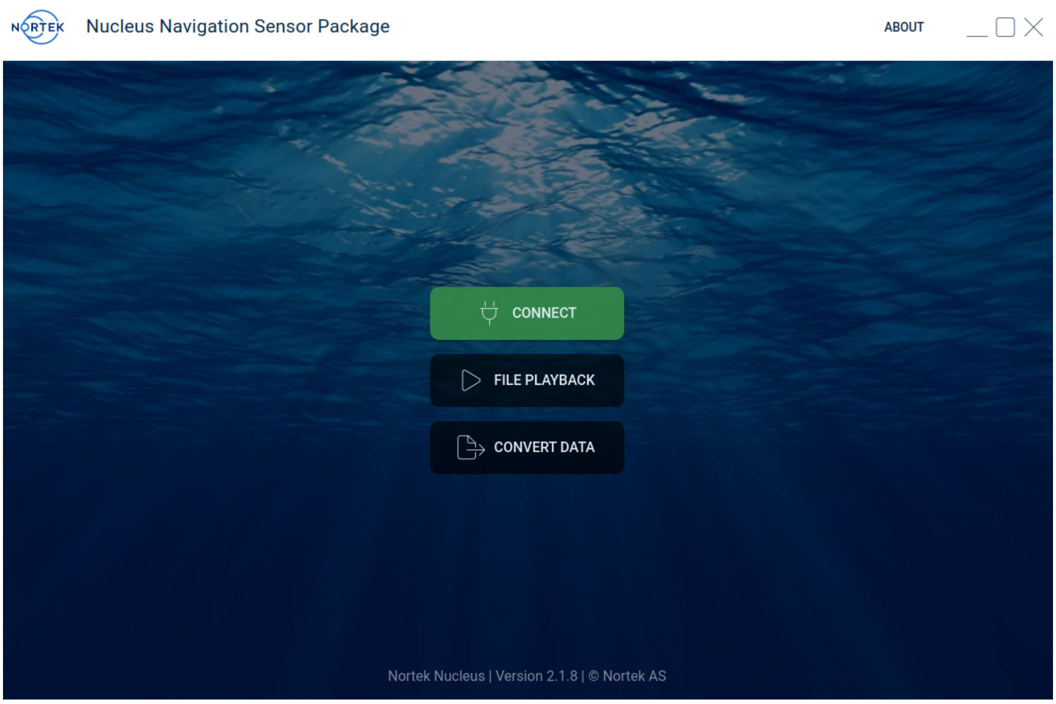


Figure 3: Nortek Nucleus Software start page

- Click Connect. This will open a connection window with two options:
- UART/Serial: Connect through a COM or TTY port with a specified baud rate
  - Windows typically lists "COMx" ports, while linux will list "ttyUSBx" ports
- TCP has three options:
  - Connect using the serial number engraved on the Nucleus.
  - Connect using hostname "NORTEK-xxxxxx.local", where "xxxxxx" is the serial number.
  - Connect with an IP address.

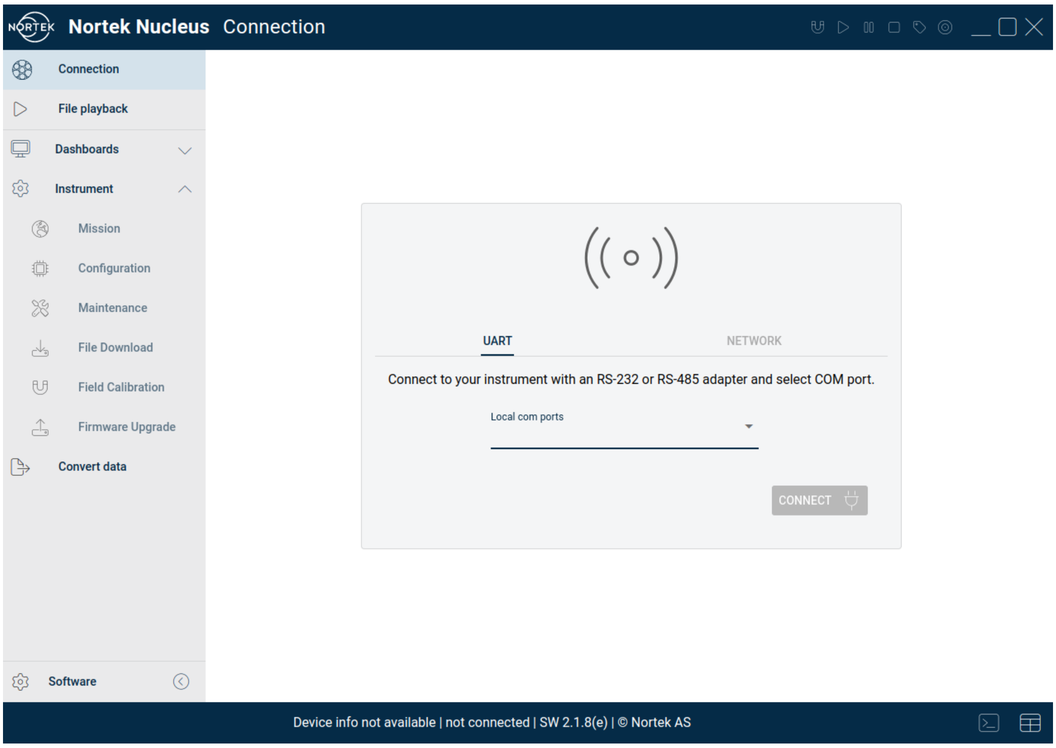


Figure 4: Connection page

- Click Connect. This will initiate communication with the Nucleus and display the Connection page when connected successfully.

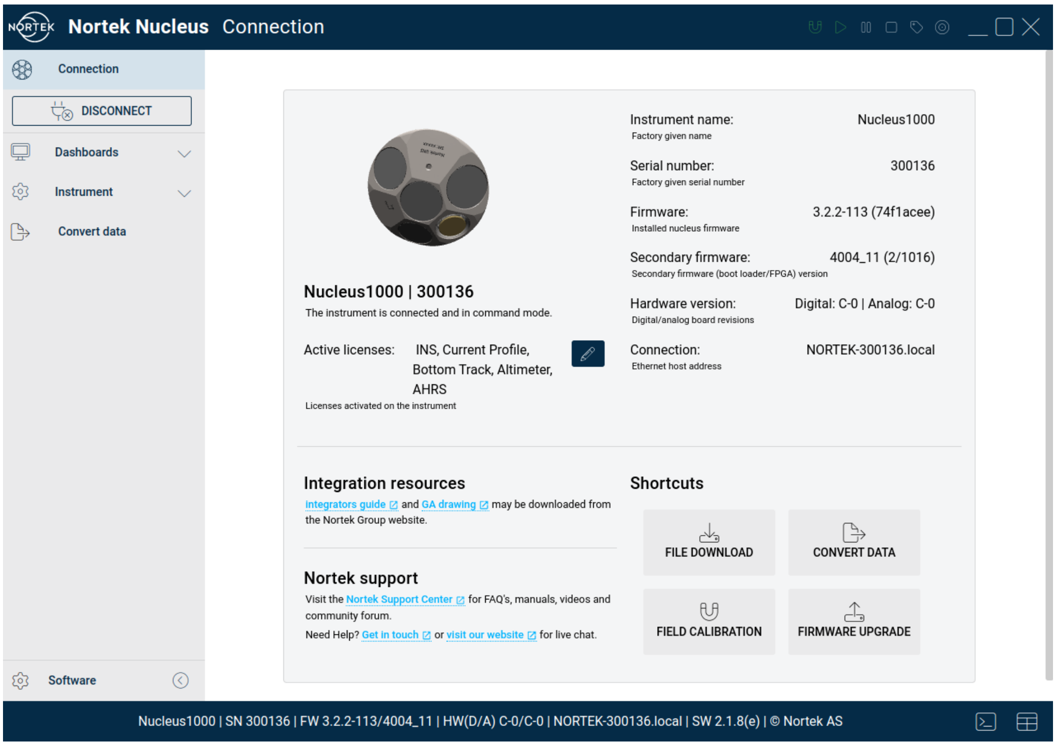


Figure 5: Nucleus1000 connection page

3.4 Updating Firmware

Keeping the firmware up-to-date is very important, since the 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. To get the newest firmware navigate to the Nortek Software page, find Nucleus Firmware, then press download to request the firmware.

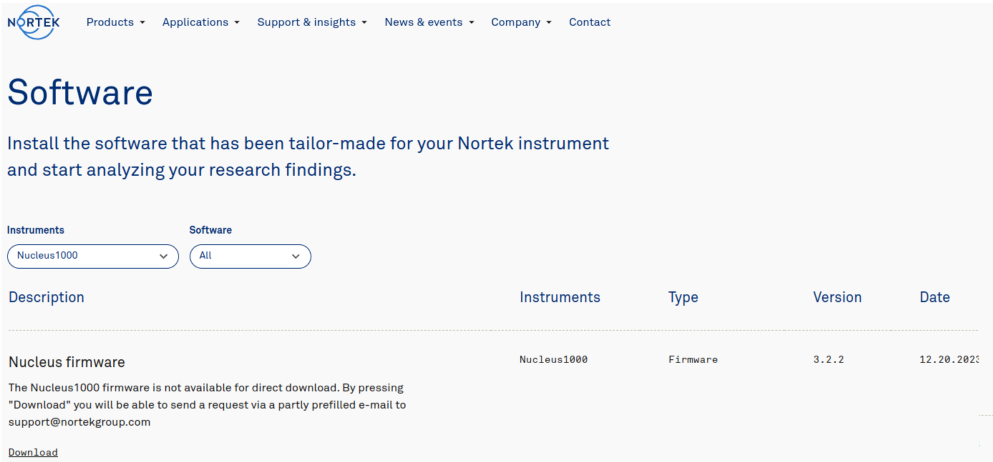


Figure 6: Nortekgroup software download page

In the Nortek Nucleus Software, navigate to "Instrument > Firmware update". Press "Upload a firmware file", select the file you downloaded in the earlier step and follow the steps in the GUI.

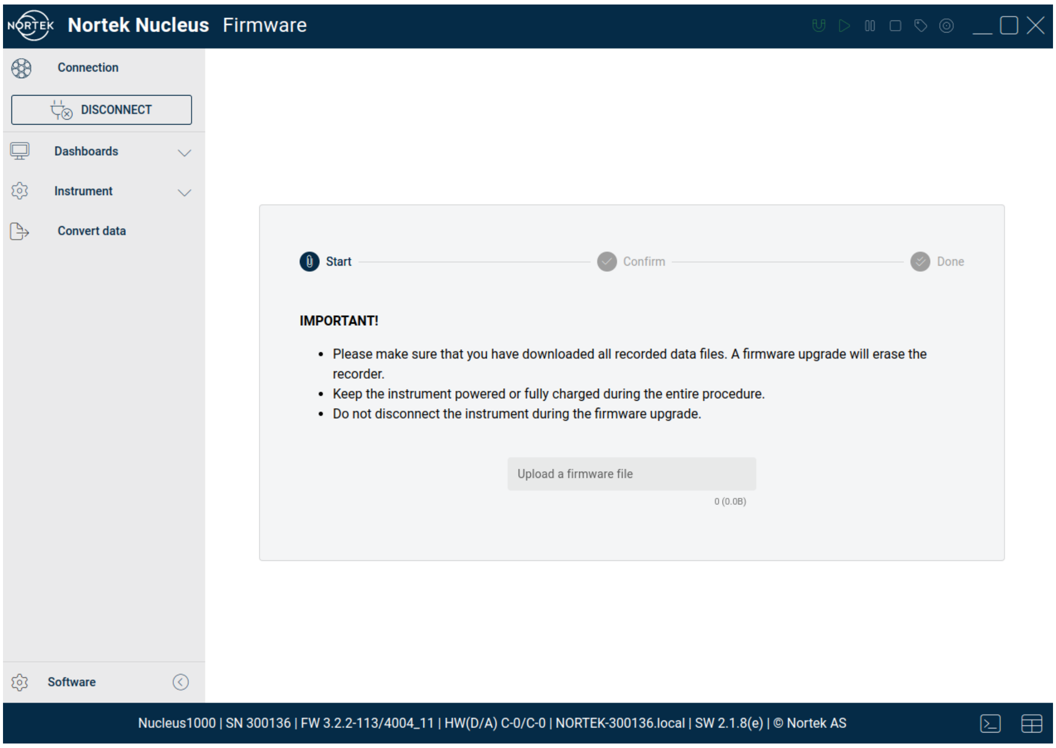


Figure 7: Nortek Nucleus Software, firmware update page

3.5 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. Double check that the data stream (DS) is turned on for the specific components that you want to view/access.

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 in the GUI 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.

3.6 Installing Nucleus on Vehicle

When installing the Nucleus on a vehicle, it's essential to reduce potential interference from noisy sources. Sources that might affect the performance can be:

- Power-cables/lines
- Battery (presence and discharge)
- Motors
- Transformers
- Thrusters

Since the Nucleus may be exposed to non-stationary field distortions (created by e.g. thrusters), some of the noise that occurs can be dampened by gyro stabilization and an adaptive mode. To learn more about what kinds of noise can impact the Nucleus and how the instrument deals with them, please read the sections Heading - How it Works and What it is and Sources of Error.

Mounting

The Nucleus comes with two threaded mounting holes and two guide holes to facilitate installation on a vehicle. See Mechanical Drawings for physical specifications.

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, see Coordinate System for more details.

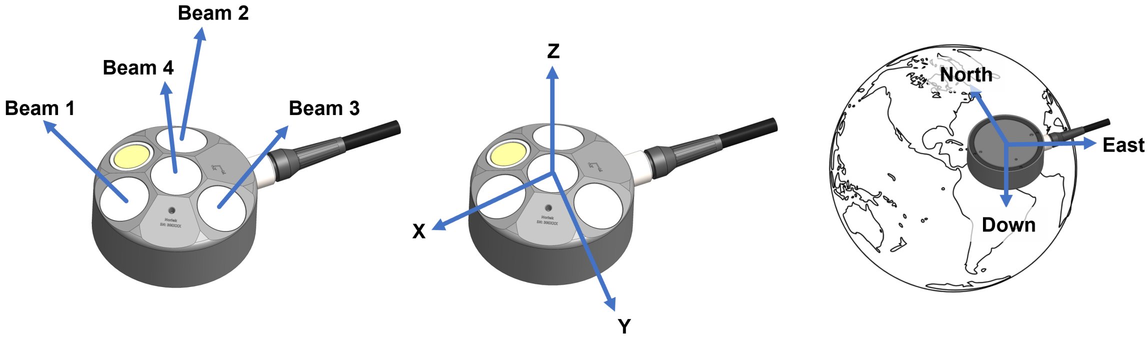


Figure 8: From left to right: BEAM, XYZ, and NED coordinate systems for the Nucleus, used for navigation and/or velocities

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.

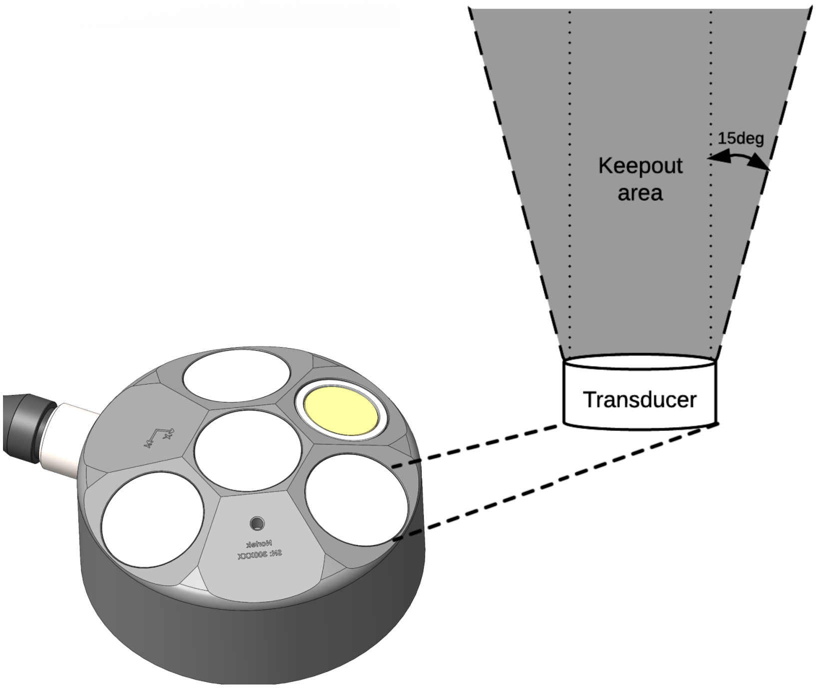


Figure 9: Transducer keepout area

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.

4 Basic Operation

This section explains how to get started with some of the core functions of the Nucleus. Some functions might not be available since they require an additional license to be used. Licenses can be changed from the Licenses tab under "Instrument > Maintenance > Licenses".

4.1 Measuring Velocity - DVL

One of the fundamental features of the Nucleus is its ability to measure velocity. The instrument can determine its own velocity in relation to the seabed/bottom, which is referred to as Bottom Track (BT) velocity. Additionally, it is capable of measuring its velocity relative to the water, known as Water Track (WT). This operates by pinging off the particles in the water and the measurement volume is typically a few meters from the Nucleus. Water track is less accurate than bottom track, but useful when the bottom is out of range.

All velocity measurements are obtained by emitting an acoustic pulse from the slanted transducers and estimating the Doppler shift in the return pulse. The instrument provides velocity outputs along the beam axes, known as beam velocities, as well as in an XYZ coordinate system fixed within the instrument.

Quick set-up:

Step	Command	Software	Comment
1	SETBT, MODE = “FAST_ACQ” / “AUTO” / “CRAWLER”	-	See information about Tracking Mode below
2	SETBT,DS=”ON”	Go to Instrument/Configuration Check Bottom Track data stream	Ensure BT data is transmitted
3	SETBT,WT=”ON”	Go to Instrument/Configuration Check Water Track data stream	Set this if WT data is wanted
4	START	Press Play button	Start measurement
5	STOP	Press Stop button	Stops measurement

Table 4: Bottom and Water track setup via command line

Several additional arguments can also be set, to adjust the behavior of the instrument.

Tracking mode

The bottom detection mode allows for three different options for detecting the bottom. The modes are as follows:

Fast_Acq mode

This mode is intended for general Nucleus use and is used for the Nucleus’ full range of distances from the bottom as well as the full range of velocities. It is the bottom track legacy mode of the Nortek Nucleus.

Crawler mode
The crawler mode is for aiding vehicles that intend to operate in station keeping mode or move very slowly. The advantage of the Crawler mode is that it has lower uncertainty in the velocity estimates, but is limited in range and beam velocity. The minimum detectable distance is 0.1 m and the maximum is 10 m. The default beam velocity limit is 0.15 m/s, which defines the velocity range (VR). The velocity range spans from -VR to +VR. The beam velocity limit ranges from [0.05, 0.4] m/s. Bottom track estimates exceeding the beam velocity limit gets ignored. The horizontal velocity range is approximately 2.9 times greater than the beam velocity range which translates to a maximum velocity of 0.44 m/s for the default beam velocity.

Auto mode
Auto mode is a hybrid mode that consists of Fast_Acq and Crawler.. As the name suggests, the Nucleus will automatically change between Fast_Acq and Crawler based on distance to the bottom and the measured velocity. In Auto mode, the Nucleus will switch to Crawler mode after a consistent detection of 10 consecutive pings with an along-beam velocity of 0.1 m/s and a bottom distance below 7.5 meters. To handle accelerations, the Nucleus will switch back to Fast_Acq mode on the first detection of an along-beam velocity above the 0.1 m/s threshold. It will also switch back to Fast_Acq mode after 4 consecutive missed detections or 4 detections above the before mentioned range limit.

4.1.1 Water track

NB! Enabling/disabling the water track measurement completely is done with SETBT,WT. Choosing how and whether the measurements get used for INS estimates are done with SETWT and SETNAV.

Velocity estimates from Water Track (WT) are only available when the vertical range beneath the Nucleus is at least 2 meters. As the vertical range increases, the WT cell gets larger.

In the figure below, the top sub figure describes where the water cell starts and stops, based on the vertical range beneath the Nucleus. There is no measurements if the vertical range is less than 2 meters. As the vertical range increases the WT cell starts further way from Nucleus, until it flattens out, same goes for where it stops.

The bottom sub figure shows the delta between WT start and stop as the vertical range increases.

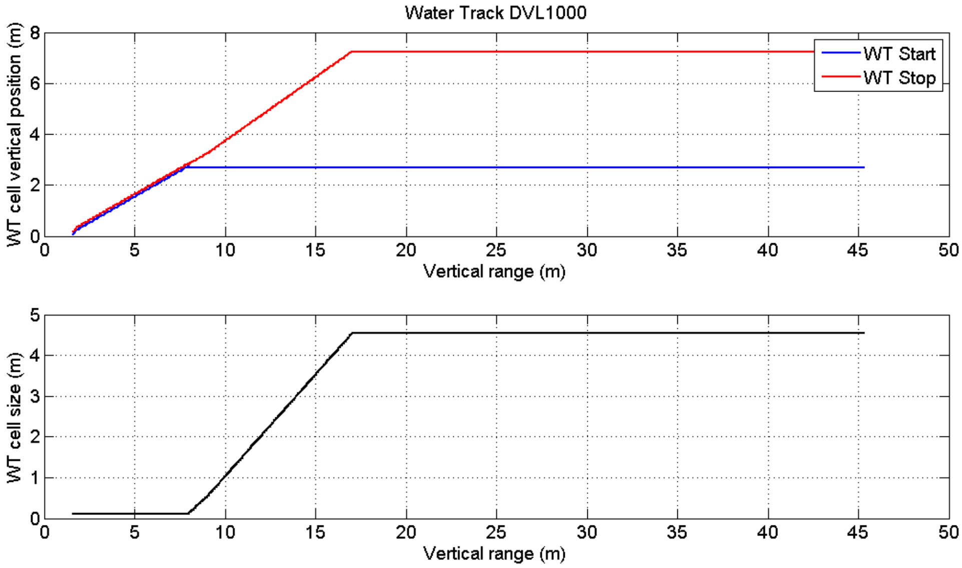


Figure 10: Top subfigure: Illustrates where the WT cell starts and stops. Bottom subfigure: Shows how the WT cell increases in size.

Water track mode - FIXED

For areas with predictable current patterns and/or access to external measurements, it will be beneficial to use set the mode to FIXED. This will assume that the velocity and direction of the current is fixed, then provide a velocity estimate for the Nucleus based on water track measurements. The velocity estimate will be used to estimate the INS data. See UPDATECUR for how to update current velocity and direction during runtime,

Water track mode - ESTCUR

For areas with unpredictable current patterns and/or the lack of external current measurements, you can use ESTCUR. This will estimate the direction and velocity of the current, then provide a velocity estimate for the Nucleus based on watertrack measurements. The velocity estimate will be used to esitmate INS data.

4.2 Orientation Estimates - AHRS

The AHRS (Attitude and Heading Reference System) is a vital component of the Nucleus instrument, providing accurate measurements of orientation. It combines accelerometers, gyroscopes and magnetometers to determine the instrument's orientation in three-dimensional space. The AHRS calculates pitch, roll and heading angles, enabling precise navigation, motion tracking, and stabilization. Orientation is given in pitch, roll, and heading, as DCM (Direction Cosine Matrix), and as quaternion. The heading is based on magnetic measurements and aided by gyroscopes.

Quick set-up

Unless you are aware that you have significant disturbances in your magnetic measurements, we advise to first try setting up the measurement as if it has low levels of disturbances:

Quick set-up (low noise)

Calibrate your magnetic compass, if you haven't done so already. Make sure it is mounted on the vehicle as it will be used.

Step	Command	Software	Comment
1	SETFIELDCAL, MODE = 1	Go to the compass calibration page and select hard iron	Set up calibration with hard iron only
2	FIELDCAL	Press the start button	Starts the calibration
3			Rotate your instrument
4	STOP	Press Stop	Stops the calibration and measurement
5	GETMAGCAL		Returns calibrated hard iron parameters
6	SAVE,MAGCAL	Press Save Calibration	Saves hard iron parameters and reset soft iron

Table 5: Low noise compass calibration

Perform a regular measurement to check if your system performs acceptable:

Step	Command	Software	Comment
1	SETAHRS,MODE=0	Go To Instrument/Configuration Set AHRS estimation mode = Fixed	Use fixed hard and soft iron values
2	START	Press Play button	Start measurement
3			Perform motion
4	STOP	Press Stop button	Stop Measurements
5			Review performance

Table 6: Check calibration performance steps

If performance is acceptable, the MAGCAL values are already saved and will be used next time instrument is powered on. The instrument can be used as in the regular measurement explained above. If performance is not within expectations, this may be due to:

a) Poor calibration. Re-do the calibration, and make sure your motion is smooth and covers all/many orientations
b) System requires compensation of soft iron also. Re-do calibration, but use SETFIELD,MODE = 2 (selects hard and soft iron calibration).
c) There is too much noise. The assumption that hard and soft iron can be compensated with static values fails. Try setting up the system as in the “high noise” case described below.

Quick set-up (high noise)

Make sure the instrument is mounted on the vehicle it should be used. Perform a regular measurement to check if your system performs acceptable:

Step	Command	Software	Comment
1	SETAHRS,MODE = 1	Go To Instrument/Configuration Set AHRS estimation mode = Hard iron	Continuous estimation of hard iron
2	START	Press Play button	Start measurement
3			Make sure to rotate the instrument a few rounds in all possible directions to allow good initialization
4			Perform operation
5	STOP	Press Stop button	Stop measurements
6			Review performance

Table 7: Steps for continuous hard iron parameter estimation during operation

If performance is acceptable, it is encouraged to save the last estimates of hard and soft iron (SAVE,MAGCAL). This can assist with shorter start-up time next time. The instrument can be used as in the regular measurement explained above. If performance is not within expectations, this may be due to:

a) Poor estimation. Make sure instrument motion is sufficient to observe the compensation parameters (hard and soft iron). This is especially true in the start-up phase.
b) System requires compensation of soft iron also. Re-run measurement and check performance, but use SETAHRS, MODE = 2 (continuous estimation of hard and soft iron), or if you use the Software: Go to Instrument/Configuration, and set AHRS estimation mode = Hard and soft iron.
c) The amount of magnetic disturbance is too high. Review design of vehicle and placement of instrument, focusing on reducing magnetic disturbance.

Magnetic declination
Setting magnetic declination is recommended to ensure that output heading is better aligned to true north. If heading should be aligned to magnetic north, magnetic declination should be set to zero.

- Setting declination to a fixed value:
  1. SETMISSION, DECL = xx (sets declination angle)
  2. SETMAG,METHOD = “OFF” (ensures that the instruments selects the SETMISSION,DECL angle)
- Setting declination based on the World Magnetic Map (WMM):
  1. SETMAG, METHOD = “AUTO” (alternatively METHOD = “WMM”)
  2. SETMISSION, LAT = yy, LONG = zz (WMM requires knowledge of position)
  3. SETCLOCKSTR, TIME = “yyyy-mm-dd hh:mm:ss” (Not required, but knowledge of time improves accuracy of WMM)

Calibration modes
AHRS settings in the Commands chapter outlines the three different modes (0, 1 or 2) for utilizing the AHRS, based on the desired calibration against different types of iron (Hard/Soft) and their fixed or variable values. It is important to note than when operating in the fixed hard/soft iron mode (MODE=0), a field calibration should be performed before deployment. In cases where iron levels are expected to vary (MODE=1 or 2), the calibration becomes adaptive. In this scenario, it is necessary

to drive the Nucleus in a few circles before operation, allowing the instrument to automatically calibrate itself. Engaging in any driving activity prior to this calibration may result in offsets and unreliable data.

4.3 Position Estimates - Navigation

The Nucleus incorporates various sensors that work in conjunction to offer precise estimations of the instrument's movements underwater. By understanding and implementing the correct operational procedures and ensuring the appropriate license is installed, you can rely on the Nucleus to provide real-time positional estimates.

Position

The Nucleus can provide position estimates using two coordinate systems: Latitude/Longitude, which specifies the location on the Earth's surface, and a local NED coordinate system, which denotes North, East, and Down directions. This local coordinate system provides a relative position from a known start position.

Quick set-up

The instrument will always estimate the local NED position. It will assume it starts at X= 0, Y = 0. However, to estimate the Latitude/Longitudinal position, the instrument must be provided with a starting point:

Step	Command	Software	Comment
1	SETINST,TYPE="NAV"	Go to Instrument/Configuration Set Instrument mode = "Navigation"	Enables position estimates Requires INS-license
2	SETMISSION,LONG=xx,LAT=yy (SETMISSION,DECL=zz)	Select advanced mode (ctrl+alt+n) Go to Instrument/Mission Set Longitude, Latitude, or use map (Set Magnetic declination, or use map)	Setting longitude and latitude is required to have valid Long-Lat output. This also makes it possible to estimate magnetic declination based on World Magnetic Mag (see SETMAG)
3	SETAHRS,MODE={0,1,2}	Go to Instrument/Configuration Set AHRS estimation mode.	Depends on use, and properties of the vehicle, see "Orientation Estimates - AHRS"
4	SETNAV,DS="ON"	Go to Instrument/Configuration Check AHRS data stream	Ensures INS data is transmitted
5	START	Press the Play button	Start your measurements. The filter requires some time to settle, and during which the position estimates may drift

Step	Command	Software	Comment
6	UPDATEPOS,*argument=*	Go to Dashboard/INS Select new position in map, and hit “update vehicle position”	If needed, this will update, or move, the current position. Updating X,Y will not update LongLat, and vice versa. They all have to be updated explicitly. This can be applied any time during measurement.
7	STOP	Press Stop button	Stops measurement

Table 8: Navigation mode setup for Nucleus1000

Several additional arguments can also be set to adjust the behavior of the instrument. See Commands for more information.

Assumptions and sources of error

It is well-known that relying solely on inertial sensors to estimate velocity leads to a growing error in velocity estimate. In turn, this leads to an even faster-growing error in position estimate. Therefore, the DVL velocity measurements are crucial to improve velocity estimate, and also the position estimate. However, there may be situations, such as when distance to the seabed is too large, or when velocity measurements will be lost over a period of time. In such cases, the instrument will in the very short term rely on the inertial measurements, but quite fast, it will switch mode, and start to enforce a decaying velocity. Lacking knowledge of true velocity, this imposed decaying velocity, may be quite wrong, and can become a significant source of error in the position estimate.

In addition to erroneous or inaccurate velocity measurements, there are other significant sources to the positional error to consider. One major contributor is heading. Any error in the heading measurements will propagate and result in positional inaccuracies. Heading errors can arise from various sources, please see “Orientation Estimates - AHRS” for more information on this.

Magnetic declination is set at the START of each measurement. Using UPDATEPOS to adjust LatLong coordinates while in measurement mode, does not update magnetic declination (even if WMM is used to find declination). Neither is the magnetic declination updated when moving over shorter or longer distances. The magnetic declination is assumed fixed throughout a measurement.

4.4 Doing Multiple Acoustic Measurements - DVL/Altimeter/Current Profile

Multiple acoustic measurements can be conducted simultaneously, utilizing the Nucleus’s DVL, Altimeter, and Current Profiling functions. These measurements provide valuable data on velocity, depth, and water currents; this enables a comprehensive understanding of the vehicle’s relation to the underwater environment.

Step	Command	Comment
1	SETBT,MODE="FAST_ACQ"/"AUTO"/"CRAWLER"	Set up the Bottom Track
2	SETALTI,DS="ON"	Enable data stream of Altimeter
3	SETCURPROF,DS="ON"	Enable data stream of Current Profile

Step	Command	Comment
4	SETBT,WT="ON"	Enable Water Track, if wanted Note that no water track is performed while in "CRAWLER" mode
5	SETBT,DS="ON"	Ensure data is streamed
6	SETTRIG,SRC="INTERNAL",FREQ=2,ALTI=xx,CP=yy	Schedule the BT/Altimeter/Current profile pings Here xx and yy is the interleave ratio of pings relative to the baseline ping which is the Bottom Track
7	START	Start your measurements and estimations

Table 9: Multiple acoustic measurements setup

Several additional arguments can also be set to adjust the behavior of the instrument. See Commands for more information.

Additional considerations for current profiles

When using the current profile option, one will see that the current profile is composed of a series of range bins with an independent estimate of current at each range. The extent of the profile is determined by the start (Blanking distance), spatial resolution (Cell size), and end of the profile (Range).

The estimates from the current profile are based on single pings and are provided in the coordinate system of the Nucleus, which is X, Y, Z. The current profiles are in the instruments frame of reference, so any velocity of the vehicle will be included in the estimate. If an Earth frame of reference is desired, then the vehicles velocity as well as attitude need to be accounted for.

Current profile estimates also include measures of amplitude and correlation. These may be used to quality control the estimates. Estimates that have either low amplitude (typically 26 dB for noise free environments) or Correlation below 50% should be discarded.

4.5 Downloading Data Files

Downloading captured data files from the Nucleus can be done using the Nortek Nucleus Software. The downloaded file will be in the format of a .nucleus file and how to convert it to a readable format is done is shown in Converting data files.

First connect to the instrument, then navigate to Instrument > File download. Select the desired recording and then press the button "SAVE RECORDER DATA". Select where to save the .nucleus file and hit save.

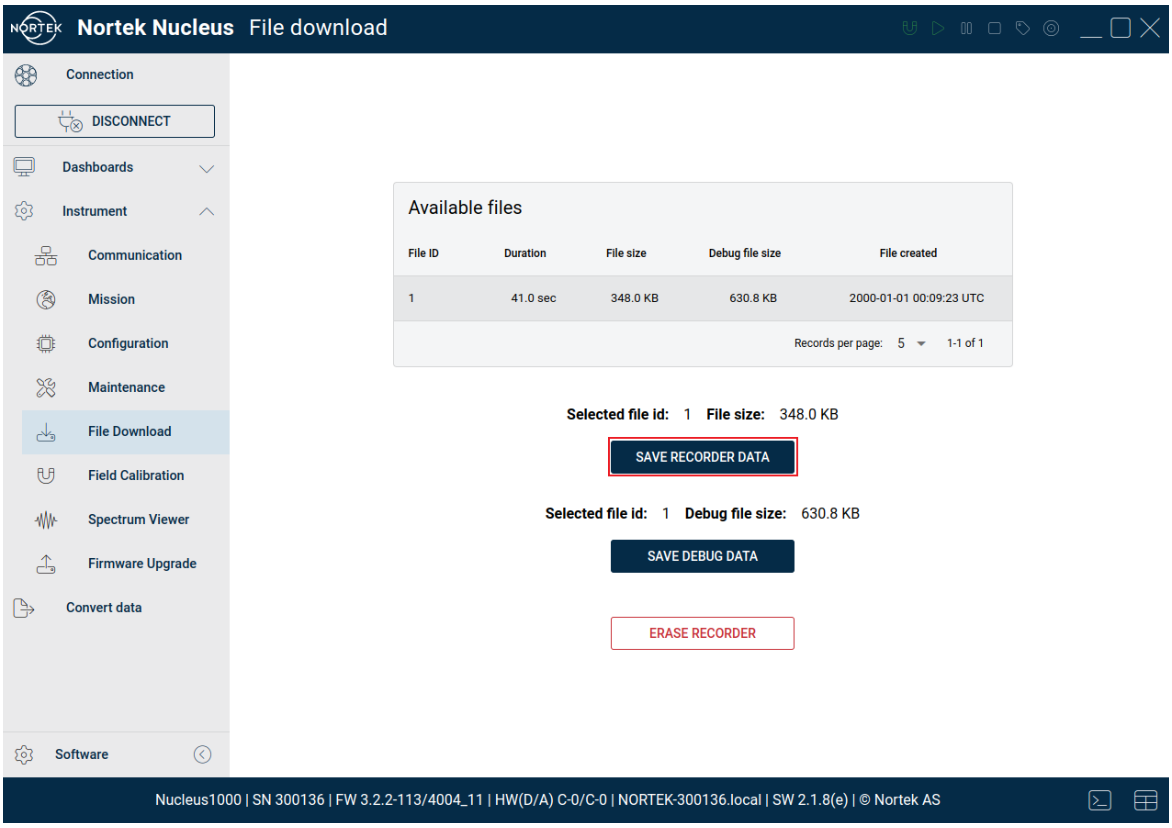


Figure 11: Nortek Nucleus Software, downloading data from the instrument

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.

4.6 Converting Data Files

The Nortek Nucleus Software has a built converter, that converts the downloaded data from the Nucleus into a readable file type (It is also possible to convert the data with the nucleus_driver).

The conversion/export page can be found under the "Convert Data" page.

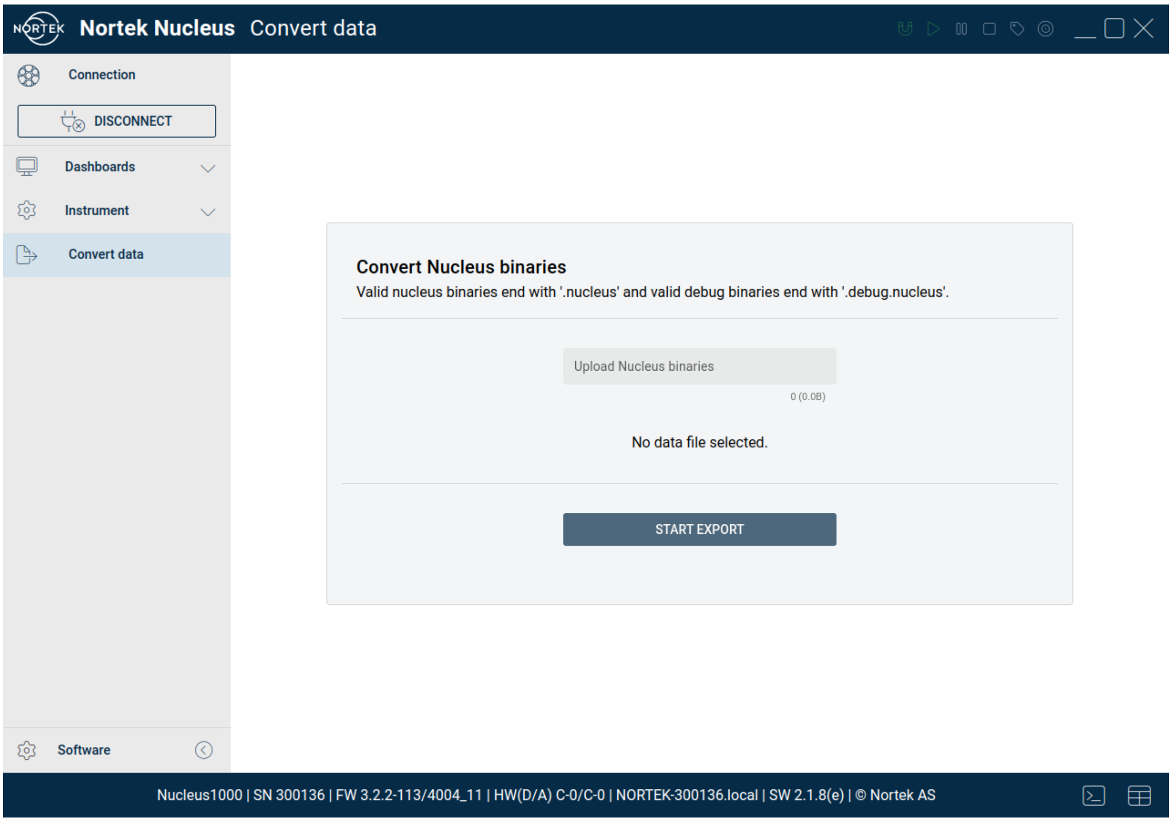


Figure 12: Nucleus file convertion page

Press "Upload Nucleus binaries" and select the .nucleus file that was saved during the step Downloading data files. Then select the desired output format, press "START EXPORT" and select where to save the file.

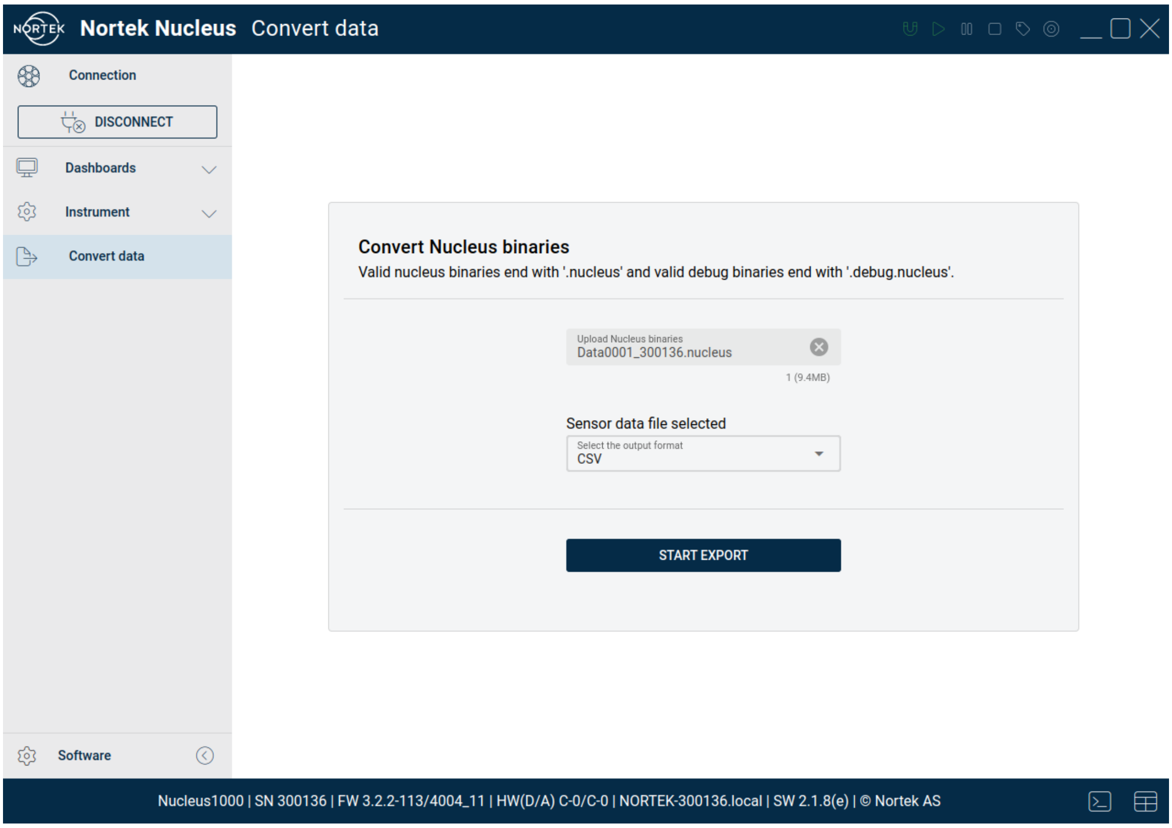


Figure 13: Exporting binary file to csv

4.6.1 Converted Data File

The converted .csv file has one data entry for each row and the type of data is specified by id and className. StringData (id 160) is by default included early and only once in the file, and contains the configuration and system settings. The remaining rows will contain sampled instrument data. The different ids and classNames are described in Data Formats.

Example of how the exported file might look like (The file generated by the Nucleus Software is semicolon separated):

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	id	className	family	isValid	size	sizeData	sizeHeader	headerCheckSum	dataCheckSum	string	version	timeStamp	microSeconds	status.altimeterDistanceValid	accelerometer.x
2	160	StringData	32	true	1233	1223	10	57698	64458	ID	STR="Nucleus1000"	SN=300046 GETHW	DIGITAL="C-0"	ANALOG="C-0" GETFW	STR="3.1.2"
3	130	ImuData	32	true	54	44	10	4582	12551		1	1696487346	992340		0.912697970867157
4	180	BottomTrackData	32	true	138	128	10	33507	41342		1	1696487346	882689		
5	190	WaterTrackData	32	true	138	128	10	44084	51909		1	1696487346	882689		
6	130	ImuData	32	true	54	44	10	61146	3579		1	1696487347	2348		0.723442018032074
7	130	ImuData	32	true	54	44	10	58834	1267		1	1696487347	12358		0.841387987136841
8	135	MagnetometerData	32	true	38	28	10	63495	5939		1	1696487347	14678		
9	130	ImuData	32	true	54	44	10	8085	16054		1	1696487347	22368		0.915748000144959
10	135	MagnetometerData	32	true	38	28	10	16088	24068		1	1696487347	28929		
11	210	AhrsDataV2	32	true	118	108	10	17570	25395		2	1696487347	28929		
12	220	InsDataV2	32	true	218	208	10	59725	1904		2	1696487347	28929		
13	130	ImuData	32	true	54	44	10	19249	27218		1	1696487347	32378		0.436942994594574
14	130	ImuData	32	true	54	44	10	26073	34042		1	1696487347	42357		1.10546004772186

Figure 14: Example view of file exported to csv

4.7 Contacting support - Debug and Diagnostics Files

When experiencing problems and requiring assistance from support, it is important to provide the following items in the request:

- Nucleus data file
- Debug file
- Support file

To download the support file, connect to the instrument, go to "Support" and get the file.

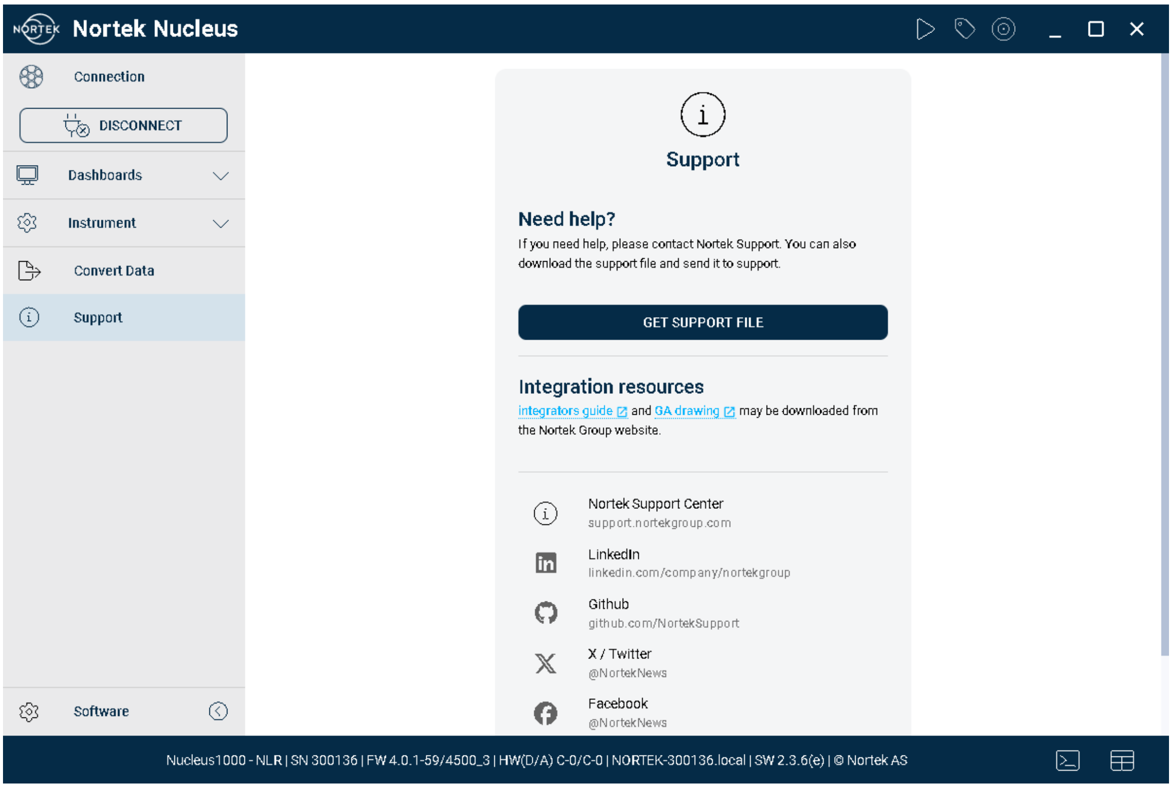


Figure 15: Support file download page

For the debug files, navigate to "Instrument > File download". Select the desired recording where the error occurred and then press the button "SAVE DEBUG DATA". Select where to save the file and hit save.

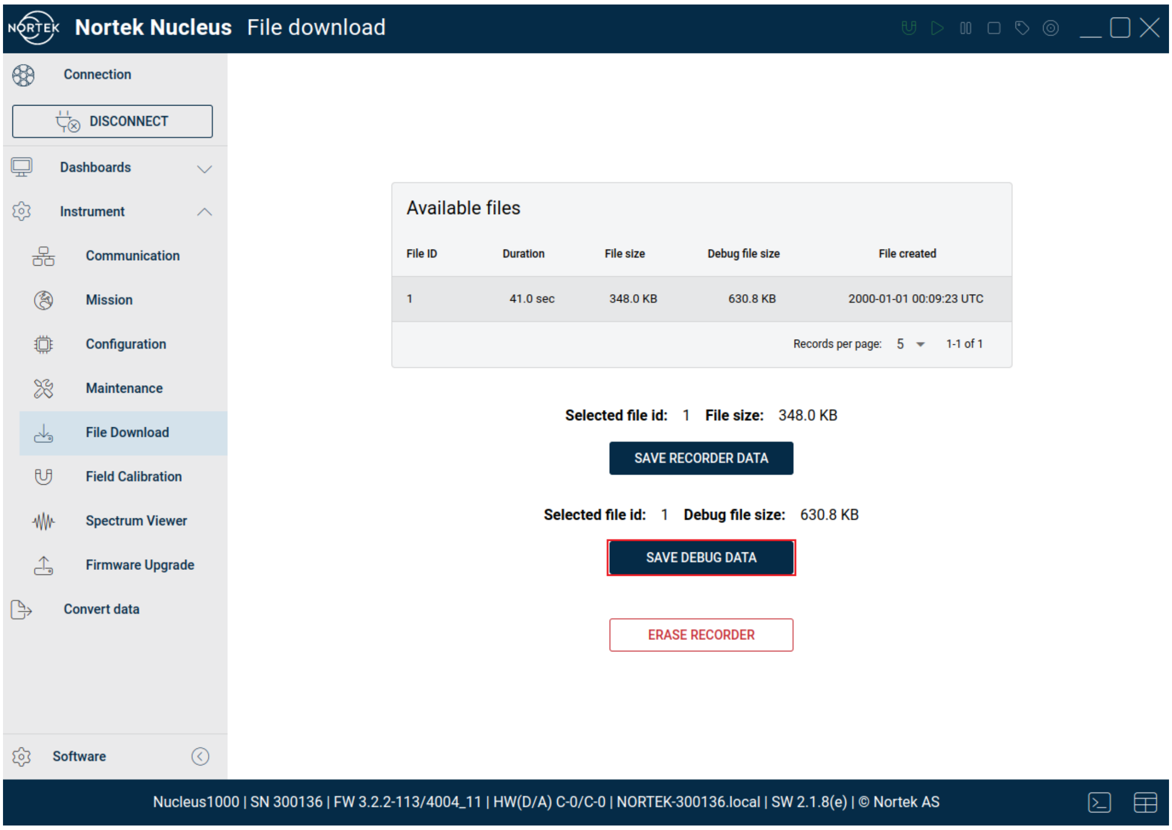


Figure 16: Download page for getting debug data for a single recording

5 Nucleus Operation

The Nucleus operates in two states: measurement and command. The default state is command, i.e. if power is lost and reapplied, the instrument will revert to command state. This can be thought of as an "idle" state, where the Nucleus is waiting to receive commands.

5.1 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.

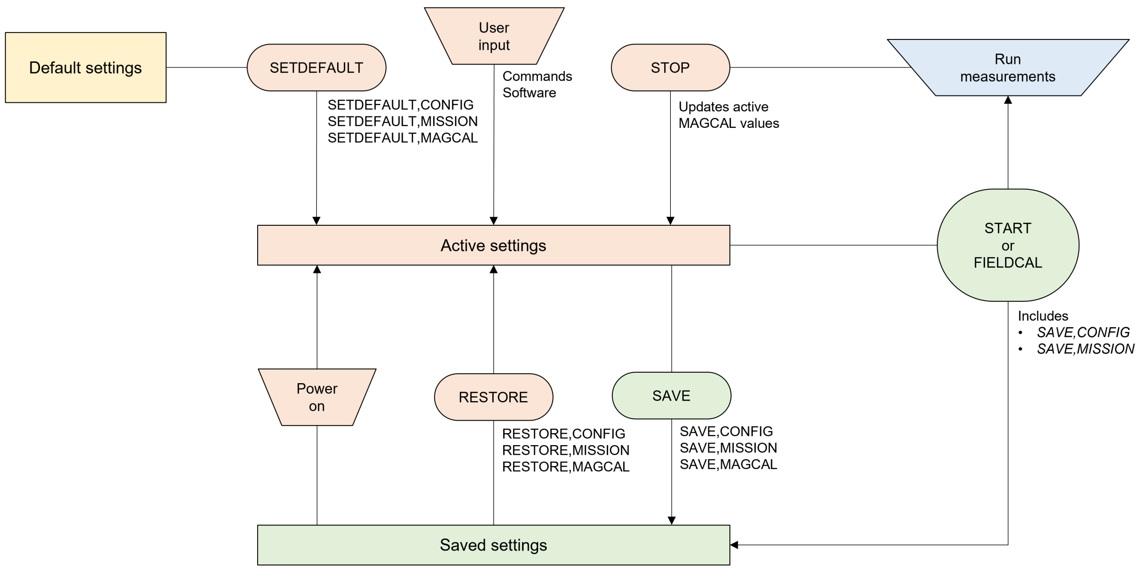


Figure 17: Process flow of applying and saving settings

5.2 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.

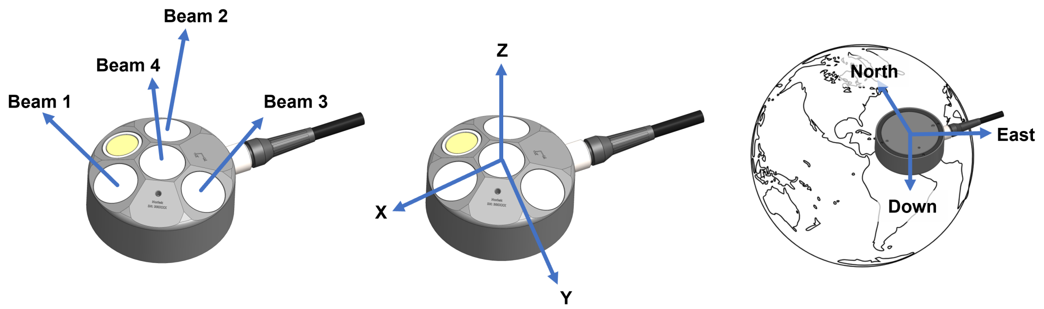


Figure 18: From left to right: BEAM, XYZ, and NED coordinate systems for the Nucleus, used for navigation and/or velocities.

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.

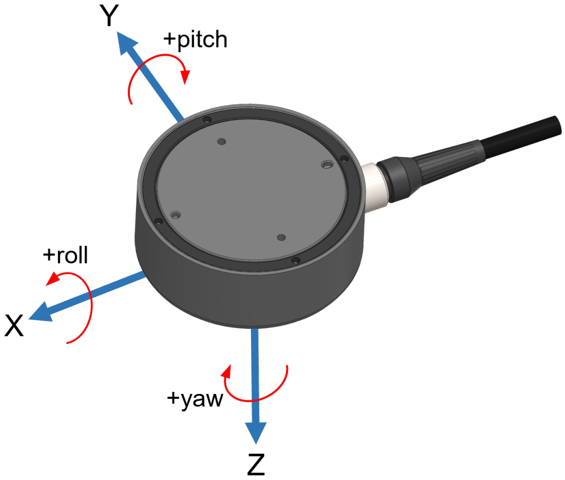


Figure 19: Nucleus orientation on the instrument when mounted downward-facing on a vehicle

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.

5.3 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.

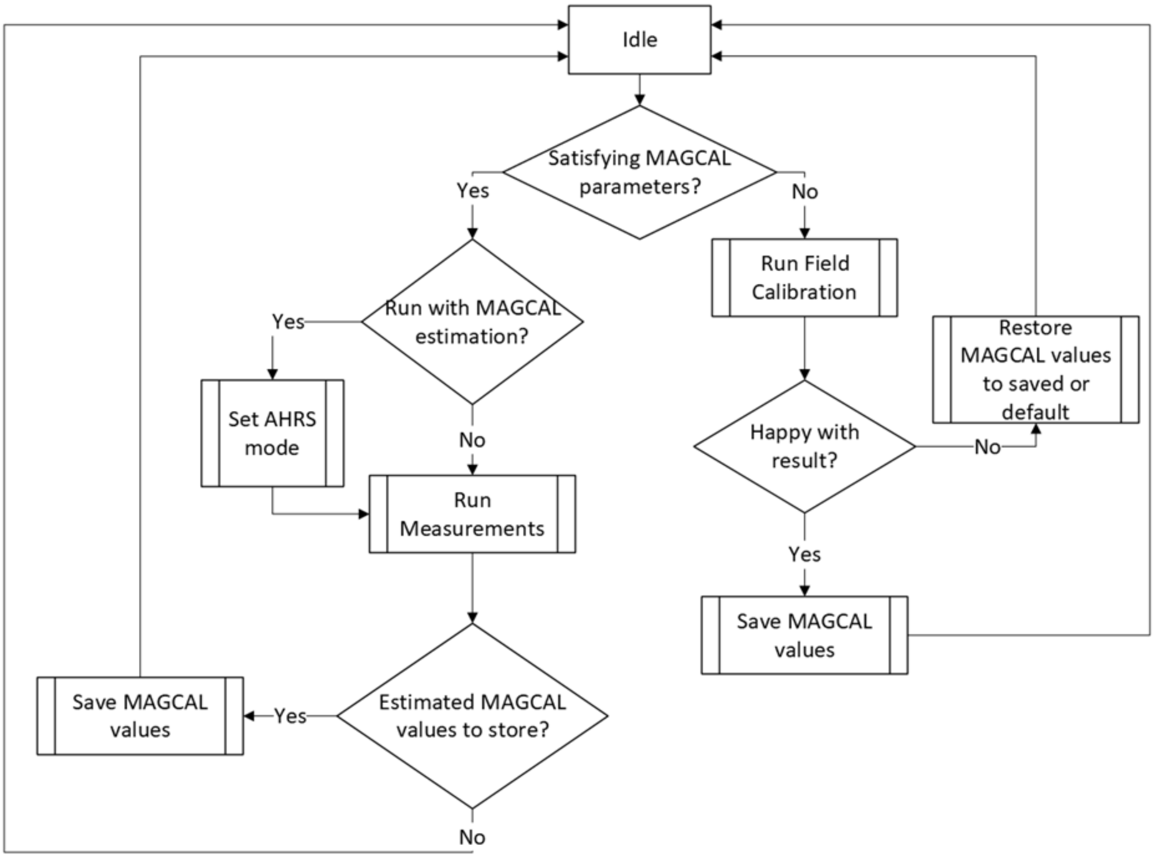


Figure 20: Field calibration decision chart

5.4 Heading - How it Works and What it is

The Nucleus contains magnetometers. From these measurements, we can find magnetic North. In addition, the Nucleus also includes a MEMS IMU.The IMU contains 3 accelerometers and 3 gyroscopes. The gyroscopes measure angular rate.

In the Nucleus, both magnetometers and gyroscopes are actively used to find the Heading. A somewhat simplified view on it, is that:

- The magnetic heading originating from the magnetometer measurements is assumed to be correct in the long run.
- On shorter timescales, the Nucleus relies on filtered gyroscope readings to update heading.
- This is what we call “Gyrostabilized Heading”, and this is the Heading output of the Nucleus.
- The "Gyrostabilized Heading” is also compensated for magnetic declination.

The quality of the gyroscopes is crucial for the effectiveness of the gyrostabilized heading system. These gyroscopes serve as a short-term reference for the heading, helping to differentiate the actual heading from disturbances in the measured magnetic heading. The performance of the gyrostabilized heading system in maintaining a stable heading and suppressing disturbances depends on the quality of the gyroscopes.

For instance, let's consider a stationary instrument. If the compass experiences a sudden and significant shift in heading due to an external factor (a disturbance), but quickly returns to its original value, the gyroscopes can be trusted to provide a stable heading during that brief period. As a result, the gyrostabilized heading system effectively mitigates the heading shift caused by the disturbance.

If the heading shift persists for an extended period, the reliability of the gyroscope diminishes, and more weight is placed on the magnetic heading when calculating the gyrostabilized heading.

In summary, the gyrostabilized heading system depends on the gyroscopes' quality to accurately maintain stable heading and filter out disturbances. Higher-quality gyroscopes enable longer and more reliable stabilization, while prolonged disturbances reduce the trustworthiness of the gyroscopes, necessitating a greater reliance on the magnetic heading for calculating the gyrostabilized heading.

True North, Magnetic North, and Declination

True North refers to the geographic North Pole, which is the northernmost point on the Earth’s axis of rotation. Magnetic north, on the other hand, refers to the direction indicated by a magnetic compass needle. This is equal to the direction of the Earth’s magnetic field projected onto the Earth's surface. The difference between true north and magnetic north is known as magnetic declination. Magnetic declination varies depending on the location on the Earth’s surface. In some areas, the magnetic north and true north align closely, resulting in minimal or zero declination. However, in many locations, there is a significant difference between true north and magnetic north.

The declination varies spatially, and also over time. Maps and mathematical models for declination exist; the model used by the Nucleus the World Magnetic Map. By setting position (Longitude, Latitude, and preferably also time) in the instrument, the Nucleus can calculate the declination at the given location.

The heading output is always compensated for the declination, but it is up to the user to either set the declination to zero or any other value, or configure the instrument to calculate declination based on World Magnetic Map.

5.4.1 Sources of Error

The performance of the heading estimate of the Nucleus can be degraded by different factors. Below are some of the most frequently encountered.

Compass calibration

The presence of ferromagnetic materials (steel, magnets, etc) or magnetic fields induced by nearby objects can cause magnetic interference. This leads to errors in the compass readings. Similarly, bias offsets in the magnetometers will cause errors in compass readings.

These errors may originate from the sensors themselves, the instrument, or other nearby sources. The instrument must therefore be evaluated while mounted on the vehicle.

Often, these effects are classified into hard iron and soft iron. Hard iron refers to the presence of permanent magnetization in an object. A practical example is a permanent magnet placed on the same vehicle as a magnetometer. The magnetometer measurement will have a constant bias, due to the magnet, regardless of the vehicle's orientation. This bias is often referred to as hard iron. If the bias is found, the measurement can be compensated to eliminate the offset. . Soft iron refers to a (material) effect that distorts the magnetic field. Unlike hard iron, soft iron is orientation dependent. If values are found, the readings can be compensated to restore the magnetic field.

If these effects are static, as they most often are (i.e. they do not change with time), then they can be identified and compensation can be done using fixed values. Also, the cause of the effects has little importance in this context, the important thing is whether it can be compensated using a hard iron and/or soft iron model.

The process of identifying them is what we call Field Calibration. A successful Field Calibration involves rotating the instrument in a number of different orientations. After the Field Calibration, the calibration result must be confirmed, and the compensation parameters stored for future use.

Vehicle noise
Some errors will vary with time. An example is power cable with varying current. That will induce electromagnetic interference that also varies with time. This will in turn create a time-variable source of error in the magnetic heading. Some additional sources of noise in magnetometer measurements are:

- Power-cables/lines
- Battery (presence and discharge)
- Motors
- Transformers
- Thrusters

Since the Nucleus utilizes a gyrostabilized heading, parts of this noise will be mitigated by the gyro stabilization scheme. In addition, the Nucleus also includes a method that continuously estimates the hard iron (and possibly also soft iron) effect.

Environment
The environment the instrument operates in, may also give rise to error in heading. An example is a ship hull, where the steel will influence the magnetic field in its proximity. A local, spatially varying distortion of the magnetic north can be seen. And if the ship is moving, it will also be varying with time. Typical examples resulting in such anomalies are man-made structures, and environments that include man-made structure, like:

- Ships
- Docks and piers
- Offshore structures
- Pipelines

Once again, the Nucleus utilizes gyrostabilized heading, to supress the anomalies. In principle, this is done in the same manner as with suppressing noise from the power cables. There is, though, a significant difference. The time-scale they operate on can be quite different. The distortion of the magnetic north, from the above-listed environments, is often seen as a slowly varying effect. As explained in the first part of “Heading – How it works and what it is”, the efficiency of mitigating slowly varying effects is generally lower than fast varying effects.

Note also, if one operates locally in an environment with a fixed, distorted magnetic field, this will be directly reflected as a heading offset. It can be adjusted by setting the magnetic declination to the local value.

Declination/World Magnetic Map
The output heading is always compensated for by the known magnetic declination; whether this is from the World Magnetic Map or applied by the user. If the declination is set incorrectly, heading will be given with a corresponding error relative to the true north.

If the declination is obtained from the World Magnetic Map, it should be noted that there are inaccuracies in the model. In rare cases they can exceed 10 degrees. Anomalies on the order of 3-4 degrees are not uncommon. It is also worth noting that the declination at a given location may fluctuate over time.

5.5 Other Sources of Error

For navigation which is based on the dead reckoning – heading and velocity, there are sources of error that can include, but are not limited to the following:

1. Misalignment between the heading sensor and the velocity (DVL) sensor. This is factory calibrated. This is not zero and will lead to position errors for one way distance traveled. Interestingly, any error (cross-track) accumulated during one way travel will be cancelled out if the direction changes 180 degrees and the heading biased is unchanged – effectively a reverse accumulation.

2. Velocity estimates based on the Doppler measurements require that the speed of sound of the fluid is known. The fluid here is most commonly sea water, which has a speed of sound based on pressure, salinity, and temperature. Pressure needs to be significant before it modulates the speed of sound. Salinity and temperature have a much more significant impact on the speed of sound. The Nucleus has a temperature sensor that has sufficiently good accuracy and response time to contribute to the estimation of speed of sound. The challenge comes from the salinity, which is not measured but must be specified at configuration time by the end user. This is default 35 ppt, which is typical of sea water. Given that the end user estimates the salinity within 2 ppt, then the calculated estimate of speed of sound, based on pressure and temperature measurements and a fixed salinity, the position errors is approximately 0.2% of distance traveled.

   Temperature tends to be the dominant source of variation in speed of sound. Salinity tends to be more stable except for coastal waters where freshwater runoff can be significant and there is no good communication with the open ocean.

3. Velocity estimates are based on the DVL's Doppler measurements. These acoustic transmissions reflect off a boundary and are received by the same transducer. The receptions are typically weak and require good sensitivity of the DVL. If noise is present, then detection and received signal content can be compromised. Noise adversely affects the performance of the DVL in two manners. The first is that the maximum distance for bottom detection is reduced, the second is that the velocity estimates may be biased.

   Understanding whether this is a potential problem requires using the built in spectrum analyzer. This tool is accessible from the Nucleus App and helps identify if there is noise in the DVL's operating band. If noise is discovered, then a process of searching for the source and removing is the next course of action. Contact Nortek for further guidance on noise mitigation.

5.6 Losing Bottom Track

Bottom track is central in both vehicle control and navigation. When bottom is not detected, it may be caused by noise, bottom is out of range, or acoustics are complicated by the environment - enclosed spaces with challenging, acoustic multi-path.

Tanks and other enclosed spaces can be challenging because the environment may lead to acoustic multi-paths or multiple reflections that can compete with the primary echo. This is particularly problematic for enclosed spaces that are constructed of metal; these materials can be excited by the acoustics and retransmit the acoustic energy in unpredictable manners – this is effectively "ringing" of the enclosed space. The challenge can be reduced by increasing the Nucleus distance from the bottom so the maximum permissible range for the installation or operation is used. In some cases, it may be interesting to reduce the power level by increments of 3 dB and explore if this helps.

It is important to note that poor performance in a laboratory test tank is not indicative of performance in standard marine environments. Understandably, a laboratory tank is a natural place to begin system integration and test, but it is not suitable for qualifying or verifying performance for a vehicle intended to operate elsewhere.

5.7 Acoustic Triggers and 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 to anything between 1 and 8 Hz, but can be limited by the operating range set with SETMISSION,RANGE. See Maximum Sampling Rate for trigger-range relation.

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.

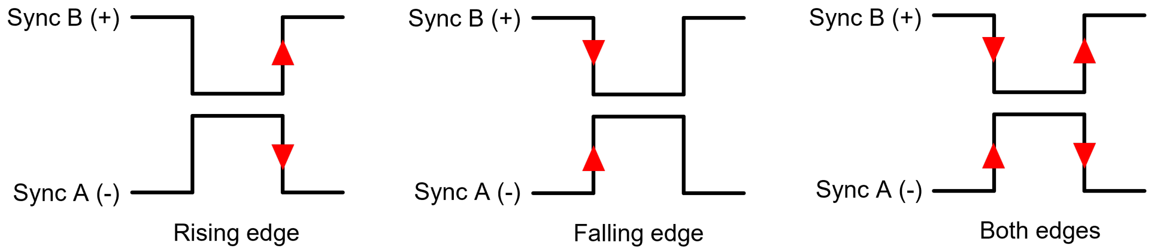


Figure 21: Nucleus trigger operation

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

- ΔT 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.

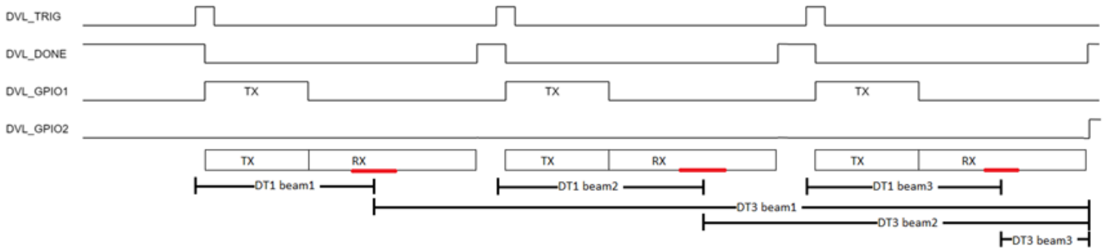


Figure 22: Nucelus Trigger Timing

5.8 Maximum Sampling Rate

The acoustic sampling rate of the instrument is limited by its trigger frequency. Specifically, the maximum acoustic sampling rate is constrained by the distance set with the command SETMISSION,RANGE. This setting directly affects the instrument's trigger frequency. The range limits are tied to the instrument's capabilities and the speed of sound in water. Below is a table listing various potential ranges and their corresponding achievable trigger frequencies.

Range	Maximum trigger frequency
50m	2Hz
49m	3Hz
44m	3.5Hz
36m	4Hz
30m	4.5Hz
25m	5Hz
21m	5.5Hz
18m	6Hz
15m	6.5Hz
13m	7
11m	7.5Hz
<=9m	8Hz

Table 10: Acoustic trigger frequencies limited by range

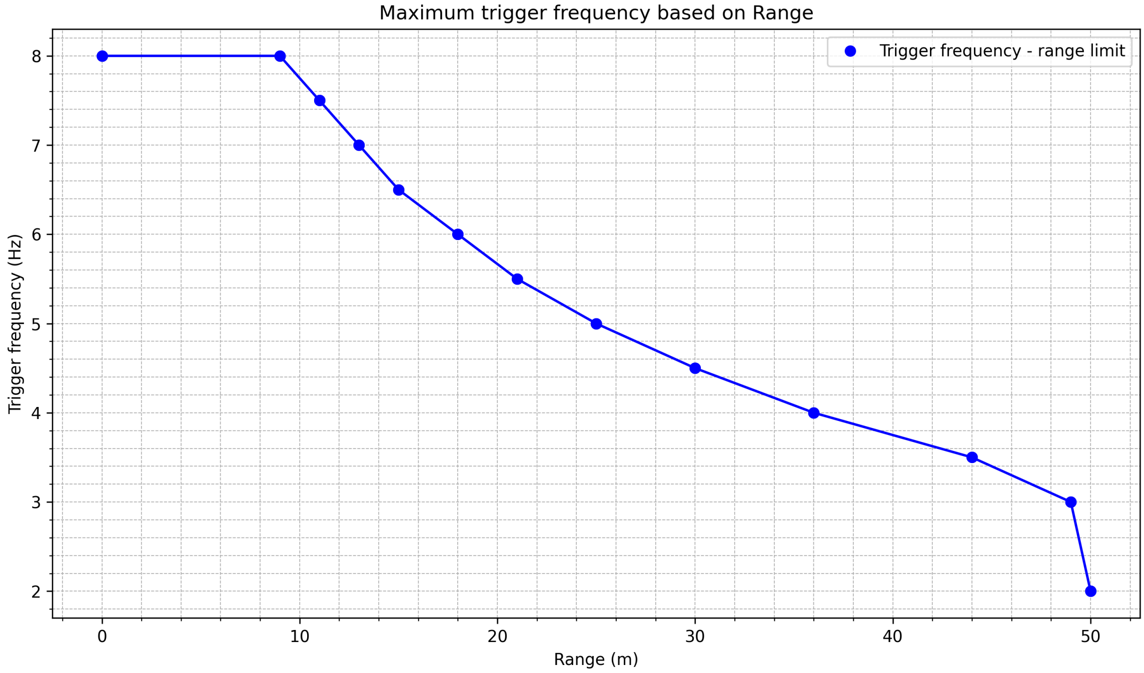


Figure 23: Trigger frequency limits by range, for acoustic measurements

The maximum sampling rate for the individual acoustic measurements are limited by the trigger frequency and the interleave ratio for the specific measurement type. Bottom track (BT), current profile (ADCP) and the use altimeter(ALTI). See check the SETTRIG command for more information.

Example 1:
If you are operating the instrument at a depth of 50m, the maximum sampling rate achievable is 2Hz. With an interleave ratio at 2 for both the ALTI and ADCP measurements, the BT pings separates each ALTI and ADCP ping.

Command	Comment
SETMISSION,RANGE=50	Sets the mission range to 50 meter
SETTRIG,SRC,"INTERNAL"FREQ=2,CP=2,ALTI =2	Sets the trigger to internal at 2Hz, and the interleave ratio at 2 for CP and ALTI

Table 11: Command line settings for measurement

	Trigger order							
Type	BT	ALTI	CP	BT	ALTI	CP	BT	ALT
Counter	1	2	3	4	5	6	7	8

Table 12: Trigger order

Measurement type	Sampling frequency
BT	0.67Hz
CP	0.67Hz
ALTI	0.67Hz

Table 13: Approximate sampling frequencies for the acoustic measurements

Example 2:
If you are operating the instrument at a depth of 50m, the maximum sampling rate achievable is 2Hz. With and interleave ratio at 6 for ADCP and 4 for ALTI measurements, the sampling frequency and trigger order will be change from the example above.

Command	Comment
SETMISSION,RANGE=50	Sets the mission range to 50 meter
SETTRIG,SRC="INTERNAL"FREQ=2,CP=6,ALTI=4	Sets the trigger to interal at 2Hz, and the interleave ratio at 6 for CP and 4 for ALTI

Table 14: Command line settings for measurement

	Trigger order																	
Type	BT	BT	BT	ALTI	BT	BT	CP	BT	ALTI	BT	BT	BT	ALTI	BT	CP	BT	BT	ALTI
Counter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Table 15: Trigger order

Measurement type	Sampling frequency
BT	1.3Hz
CP	0.26Hz
ALTI	0.43Hz

Table 16: Approximate sampling frequencies for the acoustic measurements

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>, the terminal is not case sensitive. 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 enabled interface example:

```
GETBTLIM
$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
SETNAV	Set navigation settings	COMMAND
GETNAV	Get navigation settings	COMMAND
GETNAVLIM	Get limits for navigation settings	COMMAND
SETFIELDCAL	Set field calibration settings	COMMAND
GETFIELDCAL	Get field calibration settings	COMMAND
GETFIELDCALLIM	Get limits for field calibration settings	COMMAND
APPLYNAV	Apply NAV settings during mission. This command is only valid after START command.	MEASUREMENT
APPLYNAVLIM	Get limits for APPLYNAV.	COMMAND
SETBT	Set bottom track settings	COMMAND
GETBT	Get bottom track settings	COMMAND

GETBTLIM	Get limits for bottom track settings	COMMAND
APPLYTAG	Apply a tag to the dataset during mission. This command is only valid after START command.	MEASUREMENT
SETWT	Set water track settings	COMMAND
GETWT	Get water track settings	COMMAND
GETWTLIM	Get water track setting limits	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
UPDATEPOS	Update local position during mission. This command is only valid after START command.	MEASUREMENT
UPDATEWT	Update how Water Track measurements are included in NAV estimation and current velocity during mission. This command is only valid after START command.	MEASUREMENT
UPDATEWTLIM	Get limits for UPDATEWT.	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
OK
```

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
OK
```

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:
```
TRIG
OK
```

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.

Example:
```
FIELDCAL
OK
```

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:
```
SAVE,CONFIG
```

```
OK
```

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
OK
SAVE,CONFIG
OK
```

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:

```
RESTORE,CONFIG
OK
```

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

Example:

```
SETMISSION,POFF=9.50,LONG=9999.00,LAT=9999.00,SV=1500.00,SA=35.0
0
OK
```

GETMISSION

Get mission settings

Example:

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

GETMISSIONLIM

Get limits for mission settings

Example:

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

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:
```
SETINST,ROTXY=4.3,LED="OFF"
OK
```

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,FREQ=5,MODE=2
OK
```

GETAHRS

Get AHRS settings

Example:

```
GETAHRS,FREQ
5
OK
```

GETAHRSLIM

Get limits for AHRS settings

7.12 Navigation settings

Commands: SETNAV, GETNAV, GETNAVLIM,
Command type: CONFIGURATION
Mode: COMMAND **License:** INS

Configure navigation data output.

Argument	Description

FREQ	Output frequency Unit: [Hz] | Values: [1; 100] | Default: 10
DS	Enable data stream for navigation OFF, ON Default: ON
DF	Data format for navigation data stream 220: Nortek binary navigation format. Default: 220
USEWT	Use Water Track in navigation estimation. See SETWT for configuring Water Track settings OFF, ON Default: OFF

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

SETNAV

Set navigation settings

Example:
```
SETNAV,FREQ=25
OK
```

GETNAV

Get navigation settings

Example:
```
GETNAV,FREQ
25
OK
```

GETNAVLIM

Get limits for navigation settings

7.13 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
OK
```

GETFIELDCAL

Get field calibration settings

Example:
```
GETFIELDCAL,MODE
1
OK
```

GETFIELDCALLIM

Get limits for field calibration settings

7.14 Apply NAV settings during mission

Command: APPLYNAV
Command type: CONFIGURATION
Mode: MEASUREMENT

This command can be used to change certain NAV settings during a mission. The arguments here are a subset of the arguments for the SETNAV command. When the START command is given, the active settings for SETNAV is always used. APPLYNAV only works after the START command, and the applied values are only valid until the STOP command.

Argument	Description
USEWT	Use Water Track in navigation estimation. See SETWT for configuring Water Track settings OFF, ON Default: OFF

Example:
```
APPLYNAV,USEWT="ON"
```

OK

7.15 Get limits for APPLYNAV

Command: APPLYNAVLIM
Command type: CONFIGURATION
Mode: COMMAND

This command is only valid in command mode (i.e. not between START and STOP commands).

Argument	Description
USEWT	Include Water track in navigation estimation OFF, ON Default: OFF

7.16 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

7.17 Apply tag to the dataset

Command: APPLYTAG
Command type: CONFIGURATION
Mode: MEASUREMENT

Use this command to tag, or mark, your measurement data. A typical use is that an interesting observation is made, and a tag is consequently applied. The tag will be seen in both the datalog, and the output data stream. This makes it easier to identify the time of the observation, when looking at the dataset afterwards.

Argument	Description
NAME	Name of the tag to be added to data logs.

	Max length is 50 characters. Only ASCII characters are allowed.

Example:
```
APPLYTAG,NAME="tag1"
OK
```

7.18 Water track settings

Commands: SETWT, GETWT, GETWTLIM,
Command type: CONFIGURATION
Mode: COMMAND

The SETWT command configures how Water Track measurements are used in navigation estimation and sets the initial current velocities. Current velocities should be provided in the NED frame.

Argument	Description
MODE	Change how Water Track measurements are included in NAV estimation. "FIXED": Assumes that current direction is fixed in NED and uses it for NAV estimation "ESTCUR": Estimates current direction in NED from WT measurements and uses it for NAV estimation Default: FIXED
CURX	Set the initial current velocity in x direction to value. Unit: [m/s] | Values: [-10; 10] | Default: 0
CURY	Set the initial current velocity in y direction to value. Unit: [m/s] | Values: [-10; 10] | Default: 0
CURZ	Set the initial current velocity in z direction to value. Unit: [m/s] | Values: [-10; 10] | Default: 0

Note: Be sure to read the section about Water Track in the manual to understand how the different modes work.

SETWT

Set water track settings

Example:
```
SETWT,MODE="FIXED",CURX=3.3
OK
```

GETWT

Get water track settings

Example:
```
GETWT,MODE
```

```
FIXED
OK
```

GETWTLIM

Get water track setting limits

7.19 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

Example:

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

GETALTI

Get altimeter settings

Example:

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

GETALTILIM

Get limits for altimeter settings

7.20 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), cell size (CS), and coordinate system (COORD). The measurement profile will extend from BD to RANGE, and the number of cells in the profile is given by (RANGE-BD)/CS.

The coordinate system can be set to either BEAM or VEHICLE. In BEAM mode, the Current Profile cells are returned in the instrument beam coordinate system. In VEHICLE mode, the cells are returned in the vehicle coordinate system.

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
COORD	Change the coordinate system in which the Current Profile cells are returned BEAM, VEHICLE Default: BEAM
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

7.21 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

Example:

```
SETTRIG,SRC="INTERNAL",ALTI=8,CP=16
OK
```

GETTRIG

Get trigger settings

Example:

```
GETTRIG
"INTERNAL",2.00,4,0
OK
```

GETTRIGLIM

Get limits for trigger settings

7.22 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,DS="ON"
OK
```

GETIMU

Get IMU settings

Example:
```
GETIMU
100,"OFF",130
```

GETIMULIM

Get limits for IMU settings

Example:
```
GETIMULIM
([100;100]),("OFF";"ON"),(130)
OK
```

7.23 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:
```
SETMAG,METHOD="WMM"
OK
```

GETMAG

Get magnetometer settings

Example:
```
GETMAG,FREQ,METHOD
75,"AUTO"
OK
```

GETMAGLIM

Get limits for magnetometer settings

7.24 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

Example:

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

GETMAGCAL

Get magnetometer calibration values

Example:

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

GETMAGCALLIM

Get limits for magnetometer calibration settings

7.25 Update position during mission

Command: UPDATEPOS
Command type: CONFIGURATION
Mode: MEASUREMENT **License:** INS

Use this command to update the position of the Nucleus during mission.

Argument	Description
X	Set local position of Nucleus to value. Unit: [m] | Values: [-99999; 99999]
Y	Set local position of Nucleus to value. Unit: [m] | Values: [-99999; 99999]
DX	Move local position of Nucleus by value. Unit: [m] | Values: [-99999; 99999]
DY	Move local position of Nucleus by value. Unit: [m] | Values: [-99999; 99999]
LONG	Set longitudinal position. Unit: [deg] | Values: [-180; 180]
LAT	Set latitudinal position. Unit: [deg] | Values: [-90; 90]

Note: Local position cannot be simultaneously set and moved. Setting local position for one axis and moving local position for another axis is not allowed(X and DY for example)

Update of local position does not influence longitudinal and latitudinal position. Similarly, update of longitude and latitude does not change local position. Update of longitude and latitude does not update magnetic declination.

Example:

```
UPDATEPOS,X=33.20,Y=15.00
OK
```

7.26 Update water track during mission

Command: UPDATEWT
Command type: CONFIGURATION
Mode: MEASUREMENT **License:** INS

Use this command to update the current velocity during mission. Current velocities should be provided in the NED frame

Argument	Description
MODE	Change how Water Track measurements are included in NAV estimation. "FIXED": Assumes that current direction in NED is fixed and uses it for NAV estimation "ESTCUR": Estimates current direction in NED from WT measurements and uses it for NAV estimation
CURX	Update current velocity in x direction to value. Unit: [m/s] | Values: [-10; 10]
CURY	Update current velocity in y direction to value. Unit: [m/s] | Values: [-10; 10]
CURZ	Update current velocity in z direction to value. Unit: [m/s] | Values: [-10; 10]

Example:

```
UPDATEWT,MODE="FIXED",CURX=1.10,CURY=0.50,CURZ=0.20
OK
```

7.27 Get limits for UPDATEWT.

Command: UPDATEWTLIM
Command type: CONFIGURATION
Mode: COMMAND **License:** INS

This command is only valid in command mode (i.e. not between START and STOP commands).

Argument	Description
MODE	Available values for updating how water track measurements are included in NAV estimation and current velocity during mission. "FIXED": Assumes that the current direction is fixed in NED and uses it for NAV estimation "ESTCUR": Estimates current direction in NED from water track measurements and uses it for NAV estimation
CURX	Limits on setting current velocity in x direction. Unit: [m/s] | Values: [-10; 10]
CURY	Limits on setting current velocity in y direction. Unit: [m/s] | Values: [-10; 10]
CURZ	Limits on setting current velocity in z direction. Unit: [m/s] | Values: [-10; 10]

7.28 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

Example:
```
SETETH,IPMETHOD="STATIC",IP="10.42.1.160",NETMASK="255.255.0.0",
GATEWAY="10.42.1.1"
OK
```

GETETH

Get Ethernet settings

GETETHLIM

Get limits for Ethernet settings

7.29 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.

Example:
```
READIP
"10.42.68.132","255.255.255.0","10.42.68.1",3600
```

```
OK
```

7.30 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
LIM	Valid limits as text

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])"
```

7.31 Get instrument ID

Command: ID
Command type: INFO
Mode: COMMAND

Commands for accessing instrument name and serial number

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

Example:

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

7.32 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:
```
GETHW,DIGITAL
"B-1"
OK
```

7.33 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:
```
GETFW,STR,MAJOR,MINOR,PATCH
"1.0.2",1,0,2
OK
```

7.34 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:
```
SETCLOCKSTR,TIME="2020-11-12 14:27:42"
```

GETCLOCKSTR

Get instrument clock as string

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

7.35 Get all

Command: GETALL
Command type: INFO
Mode: COMMAND

GETALL retrieves all relevant configuration information for the instrument.

Example:
```
$PNOR,GETALL*38
$PNOR,ID,STR="Nucleus1000",SN=58*31
$PNOR,GETHW,DIGITAL="B-1",ANALOG="B-0"*37
$PNOR,GETFW,STR="1.0.0",MAJOR=1,MINOR=0,PATCH=0,BUILD=0,HASH="71
d3ad7",DVLFW=4002,DVLMINOR=10,DVLBOOT=2,DVLFPGA=1014*19
$PNOR,GETCLOCKSTR,TIME="2022-05-04 13:24:08"*4F
$PNOR,GETINST,TYPE="SENSORS",ROTXY=0.00,ROTYZ=0.00,ROTXZ=0.00*73
$PNOR,GETMISSION,POFF=9.50,LONG=9999.00,LAT=9999.00,DECL=0.00,RA
NGE=50.00,BD=0.10,SV=1500.00,SA=35.00*03
$PNOR,GETAHRS,FREQ=10,DS="ON",DF=210*46
$PNOR,GETBT,MODE="NORMAL",VR=5.00,WT="ON",PL=-
2.00,PLMODE="MAX",DS="ON",DF=180*38
$PNOR,GETALTI,PL=0.00,DS="ON",DF=170*58
$PNOR,GETTRIG,SRC="INTERNAL",FREQ=2.00,ALTI=2*1B
$PNOR,GETIMU,FREQ=100,DS="OFF",DF=130*60
$PNOR,GETMAG,FREQ=75,CS="MAG",METHOD="AUTO",DS="OFF",DF=135*07
$PNOR,GETMAGCAL,HX=0.0000,HY=0.0000,HZ=0.0000,M11=1.0000,M12=0.0
000,M13=0.0000,M21=0.0000,M22=1.0000,M23=0.0000,M31=0.0000,M32=0
.0000,M33=1.0000*23
$PNOR,OK*2B
```

7.36 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
OK
Nortek Nucleus1000
Version 1.0.0
OK
```

7.37 List license keys

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

List all license keys stored in the instrument.

Example:

```
LISTLICENSE
LISTLICENSE,"GTJX5ZM1XLB","Bottom Track",1
LISTLICENSE,"7X21EB5MXLB","Altimeter",2
LISTLICENSE,"AJH6N26UXLB","Current Profile",3
LISTLICENSE,"1CGYMA13XLB","AHRS",4
OK
```

7.38 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,KEY="9H3F5PE47HUUB"
OK
```

7.39 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,KEY="9H3F5PE47HUUB"
OK
```

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 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 data format will only contain the fields unique for this data format.

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).

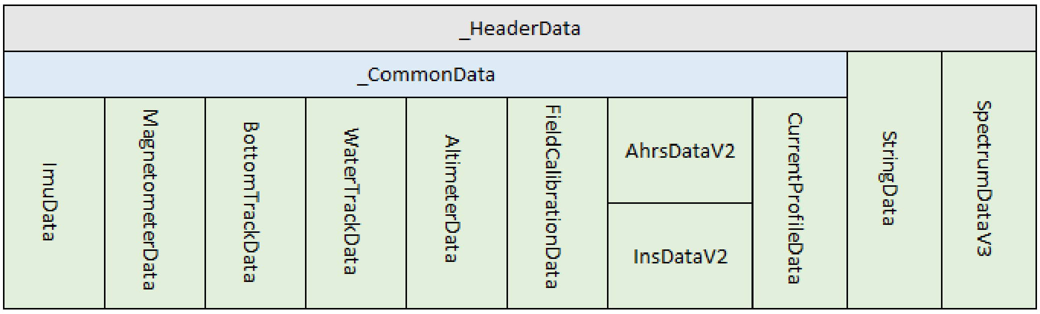


Figure: Showing how common data fields (gray for header and blue for other common's) relate to the sensor specific data fields (green). Note that we use a leading underscore (_) to emphasize that this is not a sensor data format but is common and used by two or more data formats.

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 byte	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 0xC0 (192) - Current profile data 0xD2 (210) - AHRS data 0xDC (220) - INS 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	AHRS operation mode

	uint8	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 Size	Description
IMU status	12 32 bits	IMU Status Bit description Object reference given in table below
Accelerometer.X	OFFSET float	X axis value Unit: [m/s2]
Accelerometer.Y	OFFSET + 4 float	Y axis value Unit: [m/s2]
Accelerometer.Z	OFFSET + 8 float	Z axis value Unit: [m/s2]
Gyro.X	OFFSET + 12 float	X axis value Unit: [rad/s]
Gyro.Y	OFFSET + 12 + 4 float	Y axis value Unit: [rad/s]
Gyro.Z	OFFSET + 12 + 8 float	Z axis value Unit: [rad/s]
Temperature	OFFSET + 24 float	Temperature in IMU Unit: [°C]

Position and size variables:

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

Object reference: IMU status

IMU Status Bit description

Field	Position Size	Description
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 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

8.10 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 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 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.
Current Profile Configuration	20 8 bits	Current profile configuration bit mask. Object reference given in table below
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/s]
Velocity data	OFFSET int16 *3 *VEL_NC	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. Coordinate system for the cells is set with SETCURPROF,COORD. NC = Number of cells. Unit: [mm/s]
Amplitude data	OFFSET + 6 * NC uint8 *3 *AMP_NC	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 *3 *CORR_NC	Array of uint8_t. One element per cell per beam. NC = Number of cells.

		Unit: [%]

Position and size variables:

Name	Description
VEL_NC	Second dimension of velocity data is number of cells pr beam.
AMP_NC	Second dimension of amplitude data is number of cells pr beam.
CORR_NC	Second dimension of correlation data is number of cells pr beam.

Object reference: Current Profile Configuration

Current profile configuration bit mask.

Field	Position Size	Description
Coordinate system	1-0 2 bits	Bit 1-0 (2bits): Coordinate system b00: VEHICLE b01: BEAM

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. 3 - DF3 20 - DF20
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.
Year	8 uint8	Number of years since 1900.
Month	9 uint8	Month number counting from 0 which is January.
Day	10 uint8	Day of the month
Hour	11 uint8	24 hour of the day
Minutes	12	Minutes.

	uint8	
Seconds	13 uint8	Seconds.
Hundred micro seconds	14 uint16	Hundred micro seconds from last whole second. Unit: [100 µs]
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	30 16 bits	Number of bins in the frequency spectrum. Object reference given in table below
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: Beams and bins

Number of bins in the frequency spectrum.

Field	Position Size	Description
Number of beams	15-13	Number of active beams.

	3 bits	
Number of bins	12-0 13 bits	Number of bins.

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 Troubleshooting

10.1 Communication

The easily forgettable troubleshooting steps

- Check cables - Power cables, Ethernet, UART, Jumper pin on the Adapter Interface Board
- Is the Nucleus is in DHCP or Static IP configuration?
- Close and reopen Software or scripts
  - Some programs might still run in the background even after closing them. This means that they still might occupy the serial or network port you want to use. Use task manager to close them or simply reboot your PC.
- Power cycle - Instrument, Computer, Switch, Router, etc... as needed

Instrument connected through Ethernet cable

- Is the device in DHCP or Static network mode?
  - You might need to change the network settings for your computer to the same subnet as your Nucleus.
- Check network cabling connection: If your computer has light emitting diodes (LEDs) next to the connection where the Ethernet cable plugs into the computer, check if the LEDs are lit to indicate the current status of the network device. If the LEDs are not glowing/blinking, check that the connector is ok and try to re-plug. Refer to your computer's manual for information about the Ethernet port LED.
- Check the LED on the switch or router. The LEDs should be lit when there is a connection between the computer, the network router or switch and the instrument. If not, try switching it on and off to reset the switch/router.
- If an Ethernet switch is used, its Ethernet port should also show an active Ethernet link. Try connecting with a different cable. If not, there is a problem with the computer connection.
- If you have a button for turning on/off the wireless network antenna on your computer, turn this off.
- Connect the cable directly from the computer to the instrument to bypass all of the network wiring and router. Is the PC showing that the link is active? Wait a minute or two and check again.
- If the connection was lost all of a sudden; run a test and analysis function in Windows (see step-by-step description below)

Figure 24: Ethernet LEDs blinking

Test and Analysis function in Windows:

1. Click "Start"
2. Click "Control Panel"
3. Click "Network and Sharing Center"
4. Click "Change Adapter Settings"

5. Right-click “Ethernet Instance". The icon that represents your Ethernet connection
6. Click "Diagnose." The analysis function in Windows will examine the failed connection and show an explanation of the problem and some advices to fix the problem

Checking ethernet connectivity through terminal (Windows)

1. Click "Start" and search for "Command Prompt"
2. Open Command Prompt
3. To check the IP-address of you PC, write "ipconfig" and hit enter. You should see a IPv4 Address.
    a. If this is empty you should check your network connection and check out Changing Ethernet settings Windows 10/11 system settings
4. Check if you can reach your instrument by pinging, write "ping NORTEK-xxxxxx.local" and hit enter
    a. See if you can reach the device by hostname (replace xxxxxx with the serial number on your device): "ping NORTEK-xxxxxx.local" and hit enter
    b. If you know the IP address of your instrument, replace the hostname with the address. E.g.: "ping 10.0.0.200" and hit enter
5. Did you get a response?
    a. Yes! Then try to connect to the address
    b. No. Checkout the troubleshooting steps for ethernet or try to connect over UART

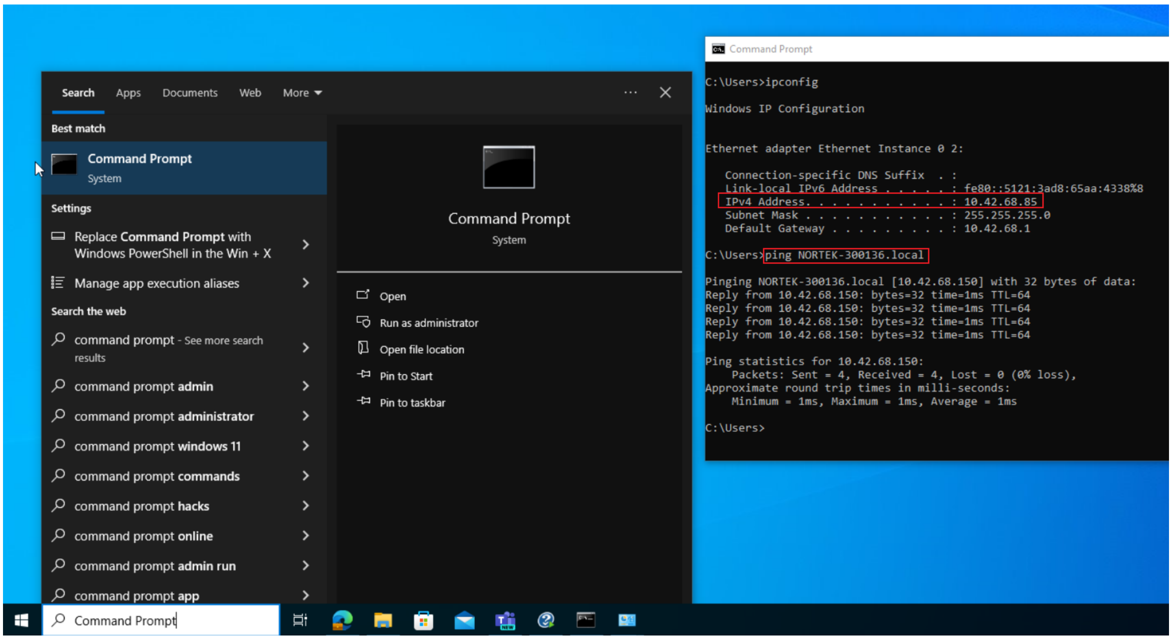


Figure 25: Pinging the instrument with Command Promt

Checking Ethernet connectivity through terminal (Linux)

Follow the same steps as in "Checking Ethernet connectivity through terminal (Windows)". Open a terminal, but instead of checking your ip-address with "ipconfig" you should use "ip a" to check the ip address for your PC. Checkout Changing Ethernet settings (Ubuntu) if you need a static address on your computer.

Instrument is connected through serial communication cable

- Does the instrument have a source of power?
- Wrong serial port. Check that the correct serial port is selected.
    - Windows: Go to Start - Control Panel - Systems - Hardware - Device Manager - Ports (look for USB Serial Port, and see if the device disapears if you disconnect the USB cable)

  - Linux: Open a terminal - Write "ls /dev/tty*" - Look for devices like /dev/ttyUSBX or /dev/ttyACM0
- Wrong baud rate. Open a terminal emulator (e.g. PuTTY) and try to cycle the power on the serial connection. If gibberish/nonsense or nothing, check the baud rate settings
- There is a problem with the Adapter Interface Board. Refer to Adapter Interface Board

The blue LED indicator light on the instrument is not lit or solid
- Is the instrument powered?
- Is the instrument measuring (the led is blinking)? Disconnect and reconnect the power cable.

Cable
Cables are often exposed to heavy use and the connector might loosen or break. Using a multimeter to test pin to pin through the cable may reveal any bad connection or breakage.

11 Appendices

11.1 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.

Table 17: Glossary Table

11.2 Parsing Nucleus Data

This section will cover the correct approach to parse the data from a Nucleus packet (ROS 2 example and data parse example can be found on [https://github.com/nortekgroup/nucleus_driver.git)](https://github.com/nortekgroup/nucleus_driver.git).

NB! Some byte positions are empty/reserved for future use! Be sure to match "Field" with "Position" and "Size".

NB2! The Data series id tells you the format of the data that comes after _HeaderData. When you're parsing the following Data Format, make sure to account for the size of _HeaderData in your indexing so the positions specified makes sense.

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.

11.2.1 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 byte" 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 byte" 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 byte	header size								

Figure 26: _HeaderData example bytes

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 byte	header size	data series id	family id	data size		data checksum		header checksum	
Table	_HeaderData									

Figure 27: _HeaderData byte position description

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".

11.2.2 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 instrument, 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

11.2.3 Extract data

11.2.3.1 Extract Dommon 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

Figure 28: Example bytes after _HeaderData

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

Figure 29: Examlpe bytes with _CommonData byte description

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.

11.2.3.2 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	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								Serial number								Offset of data				Figure of merit				Fom. Field calibration			
Table	_CommonData																_AhrsData												AhrsDataV2							

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
Field	AHRS data.Roll				AHRS data.Pitch				AHRS data.Heading				AHRS data.Quaternion W				AHRS data.Quaternion X				AHRS data.Quaternion Y				AHRS data.Quaternion Z				Ahrs data.Rotation matrix							
Table	_AhrsData																																			

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
Field	Ahrs data.Rotation matrix																												Declination				Depth			
Table	_AhrsData																																			

Figure 30: _CommonData, _Ahrs_Data and AhrsDataV2 byte position example

---

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

---

11.3 Communication and Ethernet

Connections between the instrument and computer can be made in one of two ways.

- Ethernet (via direct connection or router/switch)
- RS232/RS422 through the serial port. Serial communication baud rate: 115200
  - Check which protocol your cable uses and set the jumper pin accordingly on the Adapter Interface Board

How to connect directly to Nucleus1000

1. Connect to Nucleus either trough UART (serial) or by Ethernet.
2. Configure Nucleus to use a static IP :
   a. With the Nucleus Software, go to Setup>Communication and select IP method "Static":

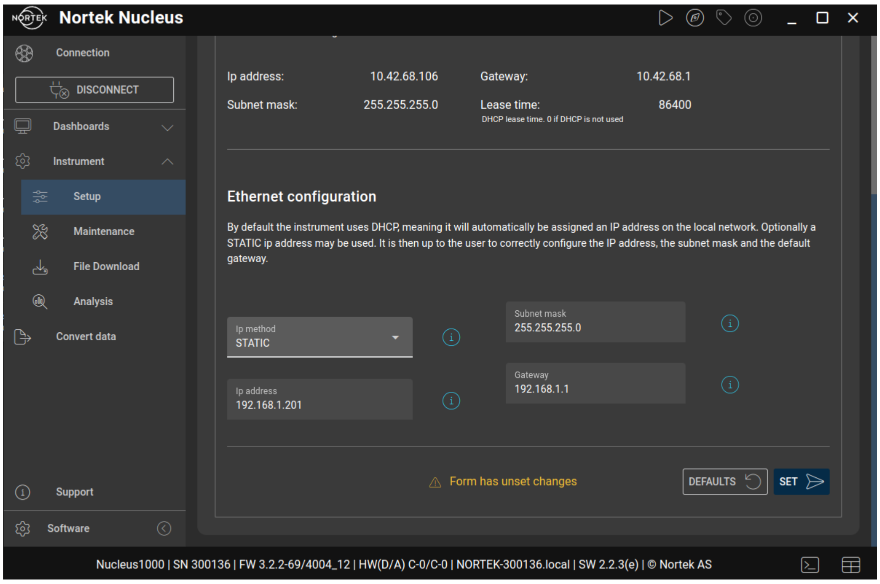


Figure 31: Setting static IP address with the Nortek Nucleus Sotware

   b. Using command line/connection with putty:
      i. SETETH,IPMETHOD="STATIC",IP="192.168.1.201
      ii. SAVE,COMM
   c. If connected through Ethernet, disconnect and re-connect to make the new IP address effective
3. Verify that the new IP address is effective by typing READIP into the command line:
   a.

```
$PNOR,READIP*24
$PNOR,READIP,IP="192.168.1.201",NETMASK="255.255.255.0",GATEWAY="192.168.1.1",LEASETIME=0*7B
$PNOR,OK*2B
```

4. Power cycle the Nucleus and connect an Ethernet cable directly from your PC to the Nucleus (not through a router or switch).
5. Configure your PC to use static IP in the same range as the Nucleus. Follow the relevant Ethernet settings guide for your computers operating system:
   a. Steps for Windows 10/11 using system settings
   b. Steps for Windows using control panel
   c. Steps for Ubuntu using network GUI
6. You should now be able to connect to the Nucleus from the PC directly using "192.168.1.201" as IP address. If not, refer to the Troubleshooting section.

NOTE! To revert the settings you made on your PC Ethernet adapter, select "Automatic (DHCP)" where you selected "Manual."

Serial communications (RS232 or RS422)
NB! The cable that came with the instrument is either RS232 or RS422.

The Adapter Interface Board handles either RS232 or RS422 if the jumper pin is placed correct.Without the adapter interface board, checkout Cable Diagrams for wiring.

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

Details about the Ethernet connection
100BASE-TX Ethernet interface
The first time using the instrument, the network address needs to be properly configured for the network. The IP address can be assigned in one of the three ways:

1. DHCP: A DHCP server (e.g. a router) in the network is used to assign an IP address.
2. AutoIP: Link-local address assignment
3. Static IP: Manually assign/set IP address (by the user)

As shipped, the instrument uses options 1 and 2. This means that it will try to automatically configure the IP address for the network that the instrument is plugged into.

If a DHCP server is detected it takes approximately 30 seconds to negotiate for and assign an IP address to the Ethernet interface. If you are using a broadband router, it is likely you are using a DHCP Server to assign IP Addresses. Common private network address schemes include 192.168.x.x and 10.0.x.x subnets, with the Subnet mask of 255.255.255.0 or 255.255.0.0

If a DHCP server is not detected (usually because of being directly connected to a computer) and the request for an IP Address is not fulfilled, the instrument will automatically assign itself IP addresses using the AutoIP protocol. DHCP must first time out before the AutoIP protocol starts, so this will result in a delay of approximately 30 seconds before an IP address is finally assigned. A standard AutoIP address sits in the 169.254.x.x range, with the subnet mask being 255.255.0.0.

When using automatic IP address assignment, there is generally no way of knowing which address was assigned to the instrument. To determine the assigned IP address, you can
- Connect using the hostname "NORTEK-xxxxxx.local" and use the GUI or "READIP" command to get the the IP address
- Connect to the device through serial while a Ethernet cable is connected to the instrument and your PC/router. Use the GUI or "READIP" command to get the the IP address.

For more details about the DHCP or AutoIP there are many articles available in the public domain. These are standard protocols used by most Internet based equipment.

Ethernet communication with network switch
If you want to use a network switch for your setup, you need to check the manual for your specific switch and its limitations.

11.3.1 Changing Ethernet settings Windows 10/11 system settings

1. Open the windows menu, search for "Ethernet Settings" and open the settings menu.

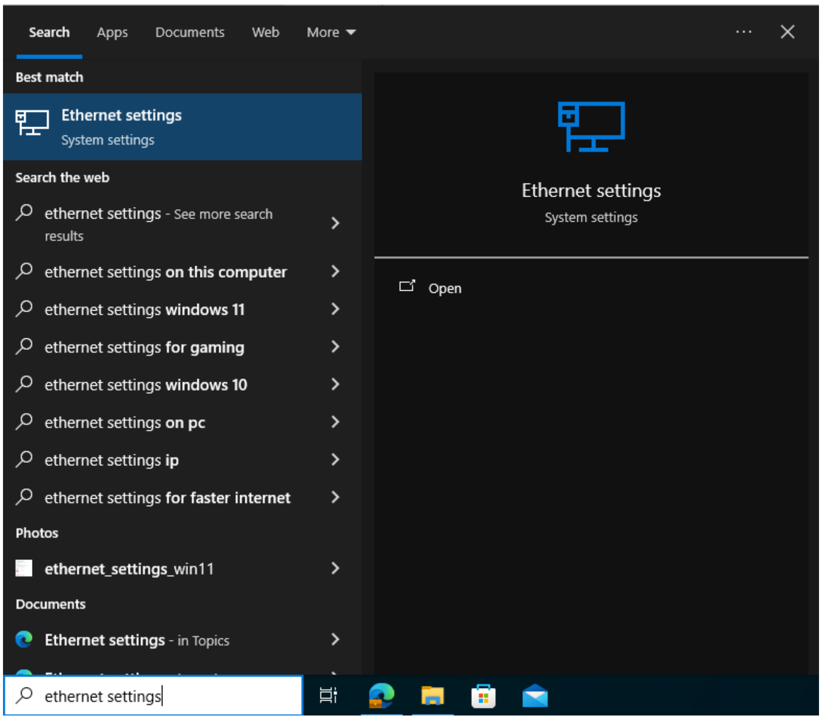


Figure 32: Accessing Ethernet Settings in Windows 10/11

2. Select the Network you will be using.

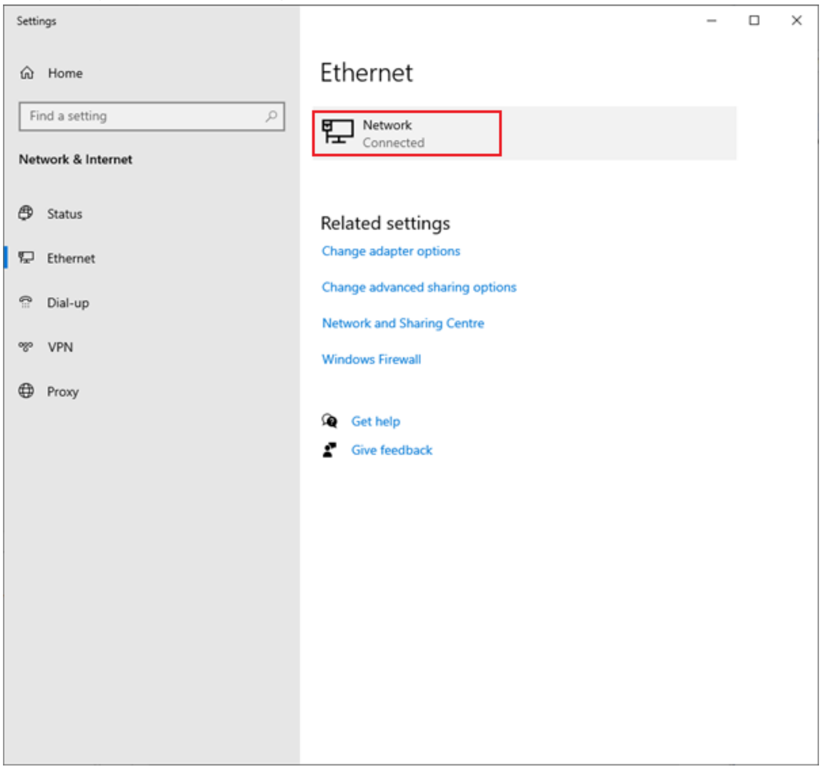


Figure 33: Selecting network adapter connected to the instrument

3. Click "Edit" to change the network settings for the adapter you selected.

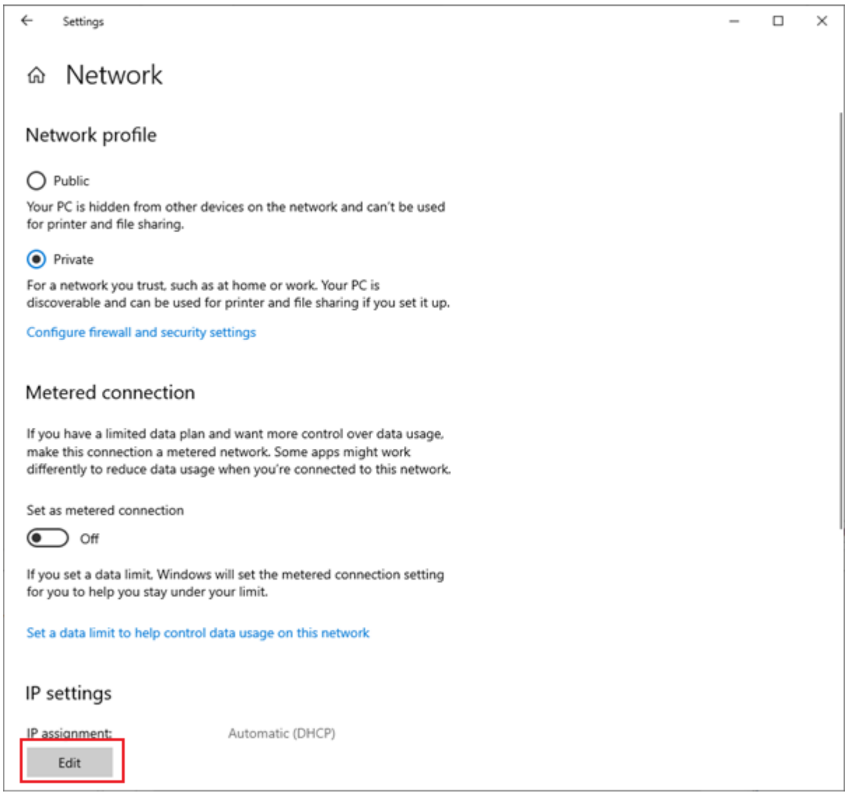


Figure 34: Edit the network adapter

4. Select "Manual" and save.

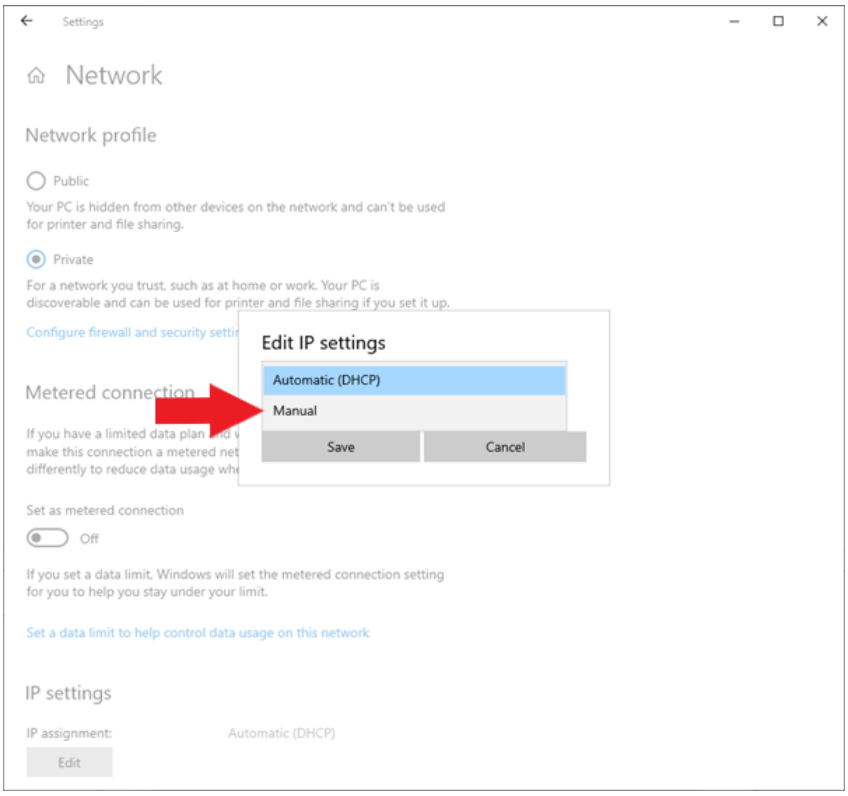


Figure 35: Select manual mode

5. Turn on IPv4.

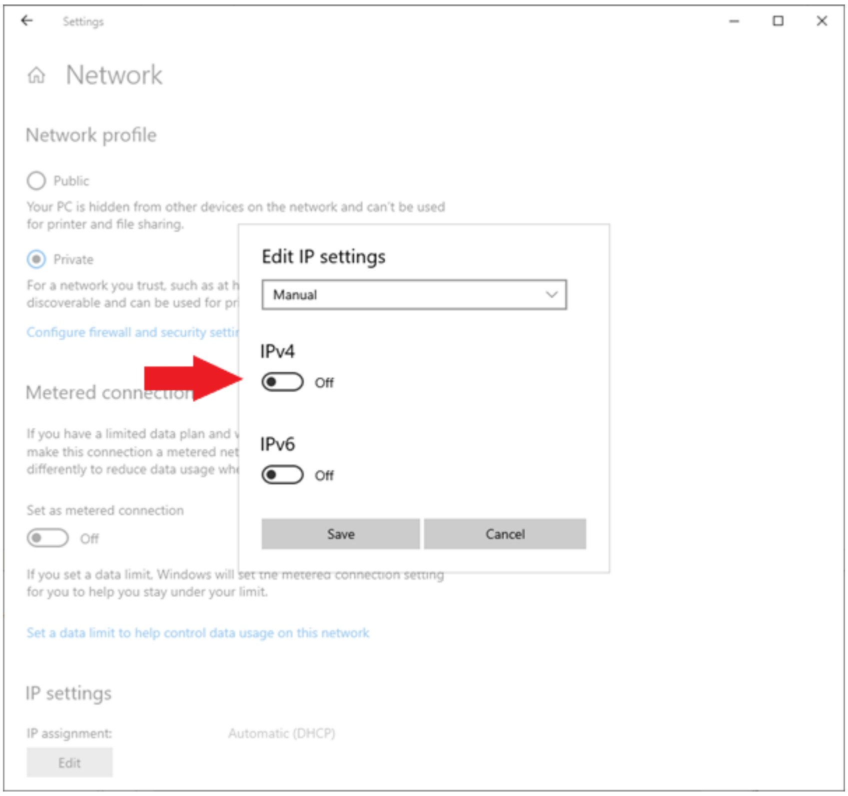


Figure 36: Turn IPv4 on

6. Enter the desired values in 1, 2, and 3, then press "Save." The example in the image should work if you followed "**How to connect directly to Nucleus1000**".

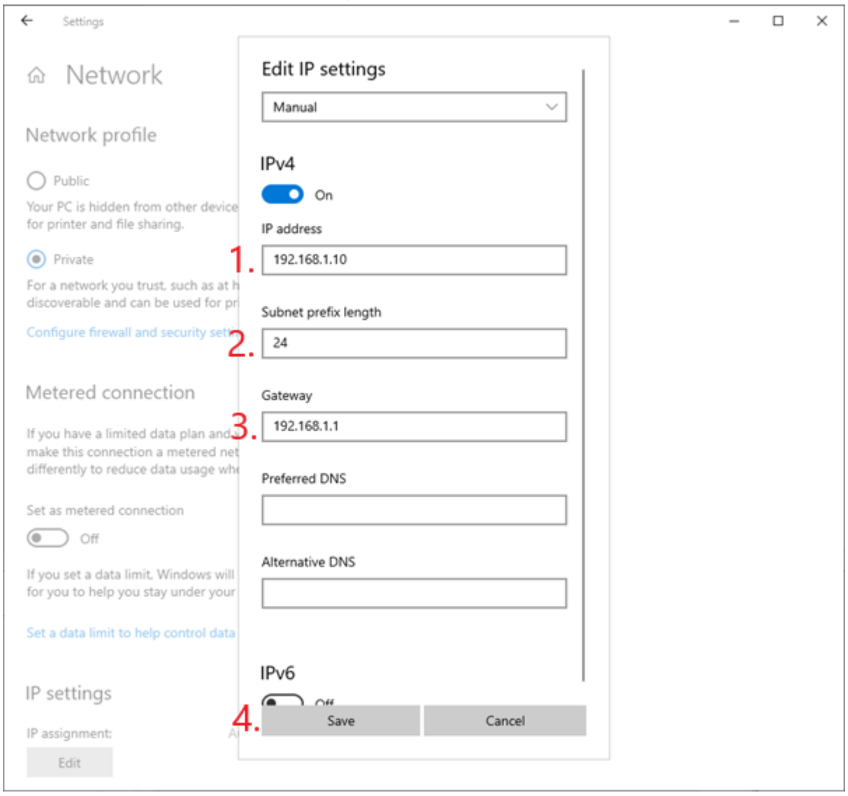


Figure 37: Set network adapter values and save

11.3.2 Changing Ethernet Settings Windows Control Panel

1. Open the windows menu, search for "Control Panel" and open the menu.

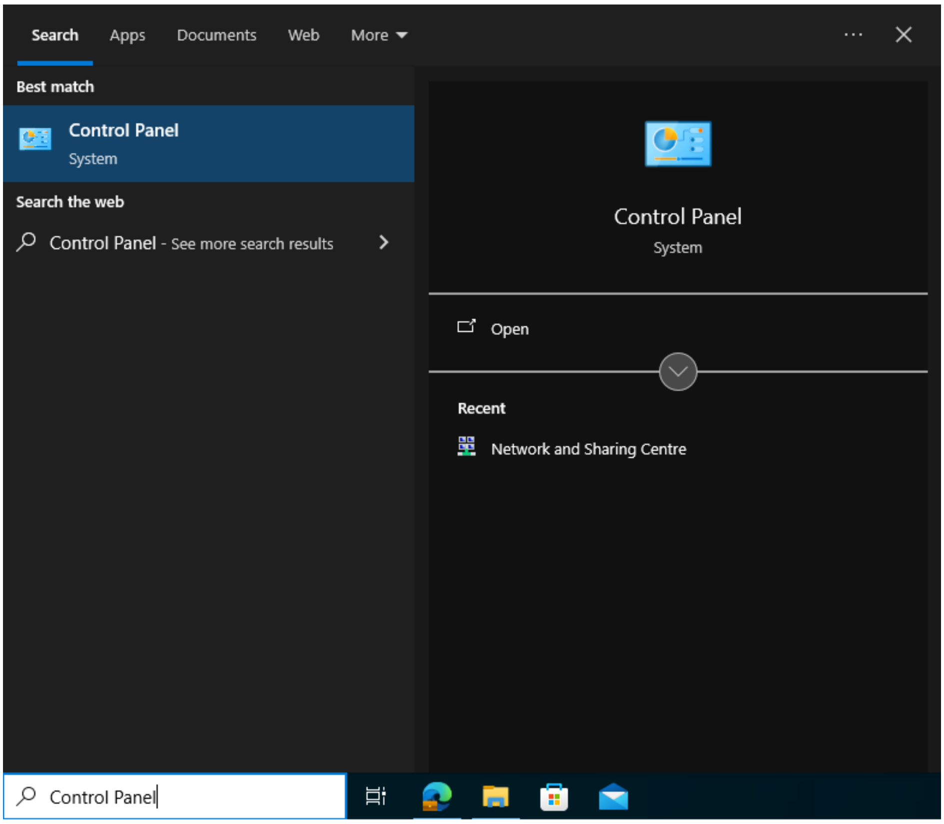


Figure 38: Opening Windows Control Panel

2. Press "Network and Internet."

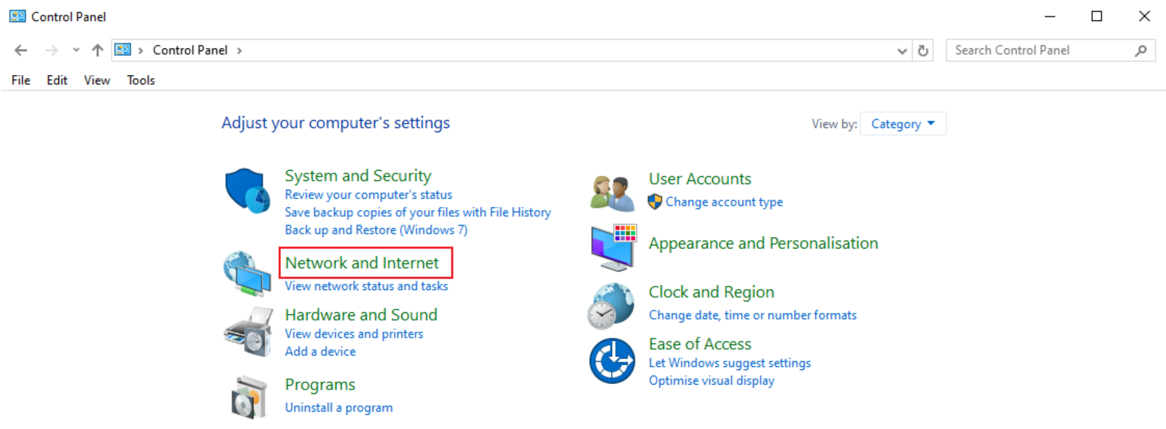


Figure 39: Select Network and Internet settings

3. Press "Network and Sharing Centre."

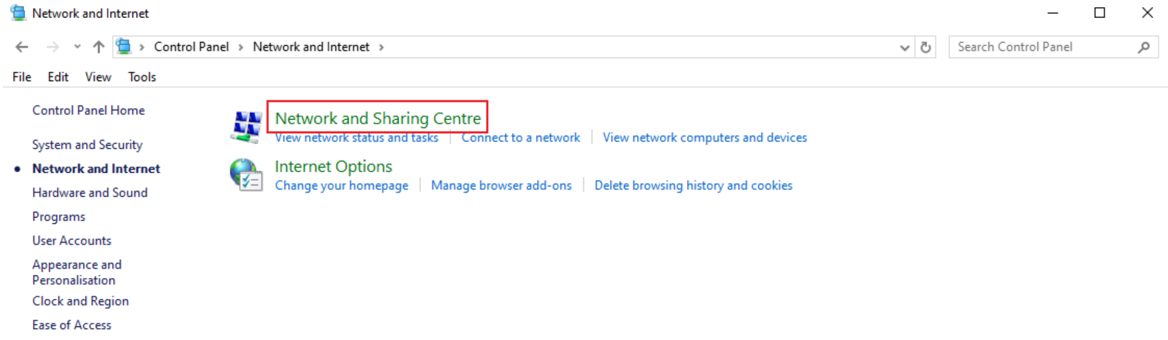


Figure 40: Select Network and Sharing Centre

4. Press "Change adapter settings."

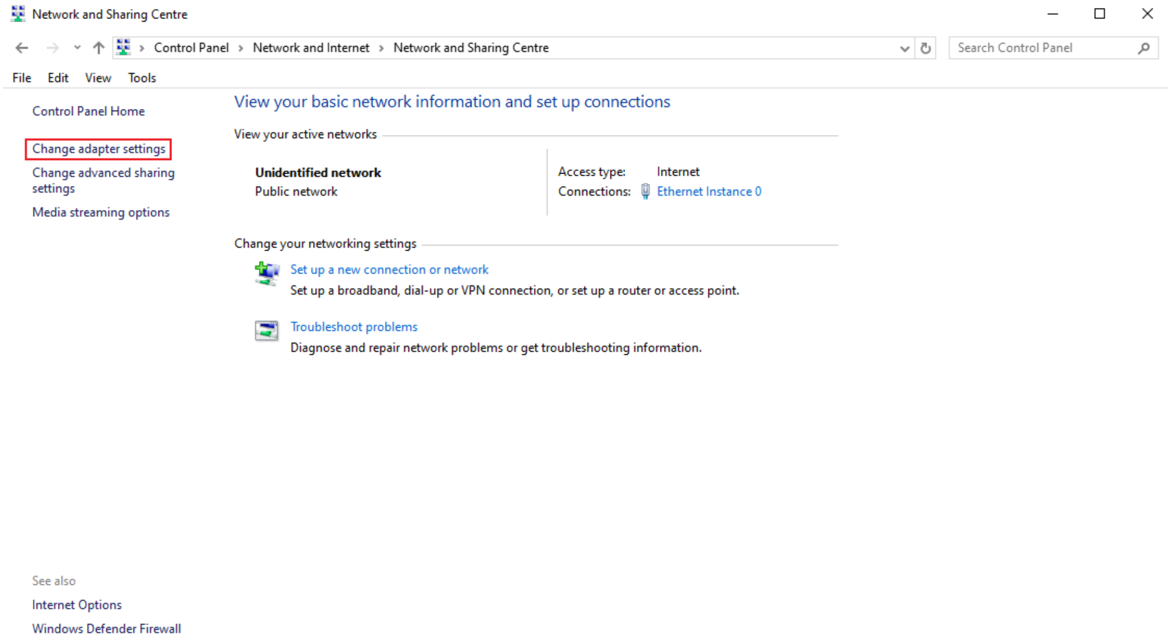


Figure 41: Select Change adapter settings

5. Select the network adapter you will be using. Right click on it and select "Properties."

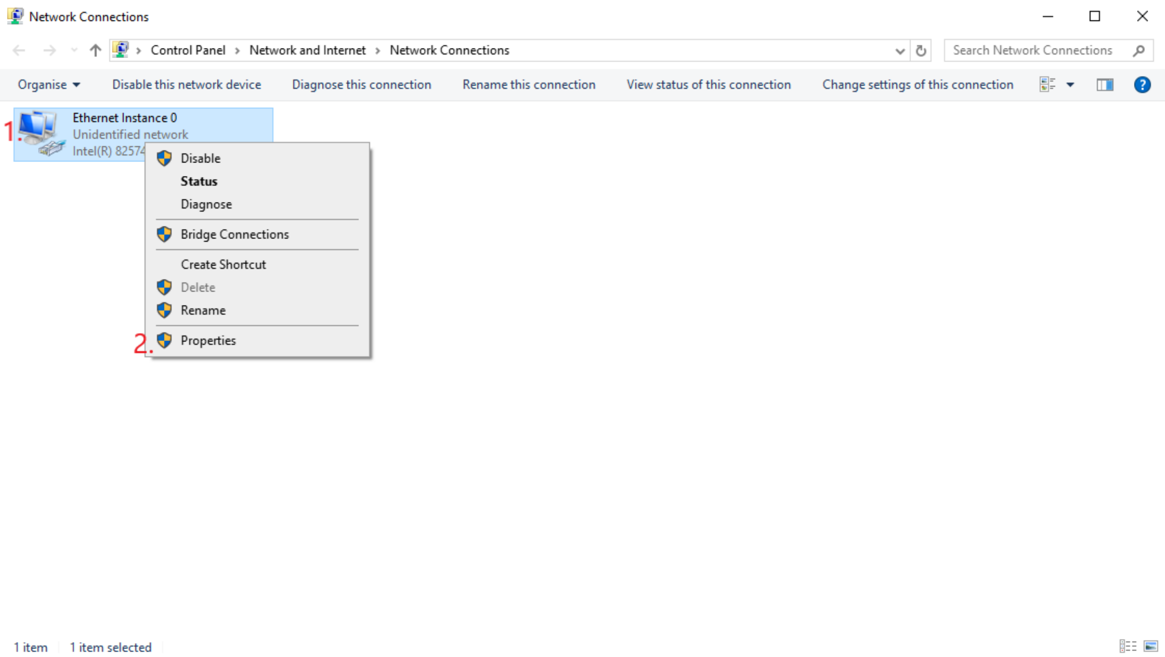


Figure 42: Select ethernet adapter connected to instrument and change the properties

6. Select "Internet Protocol Version 4 (TCP/IPv4)," press "Properties," Select "Use the following IP address:" and enter the desired values. Then hit "OK." The example in the image should work if you followed ["How to connect directly to Nucleus1000"](#).

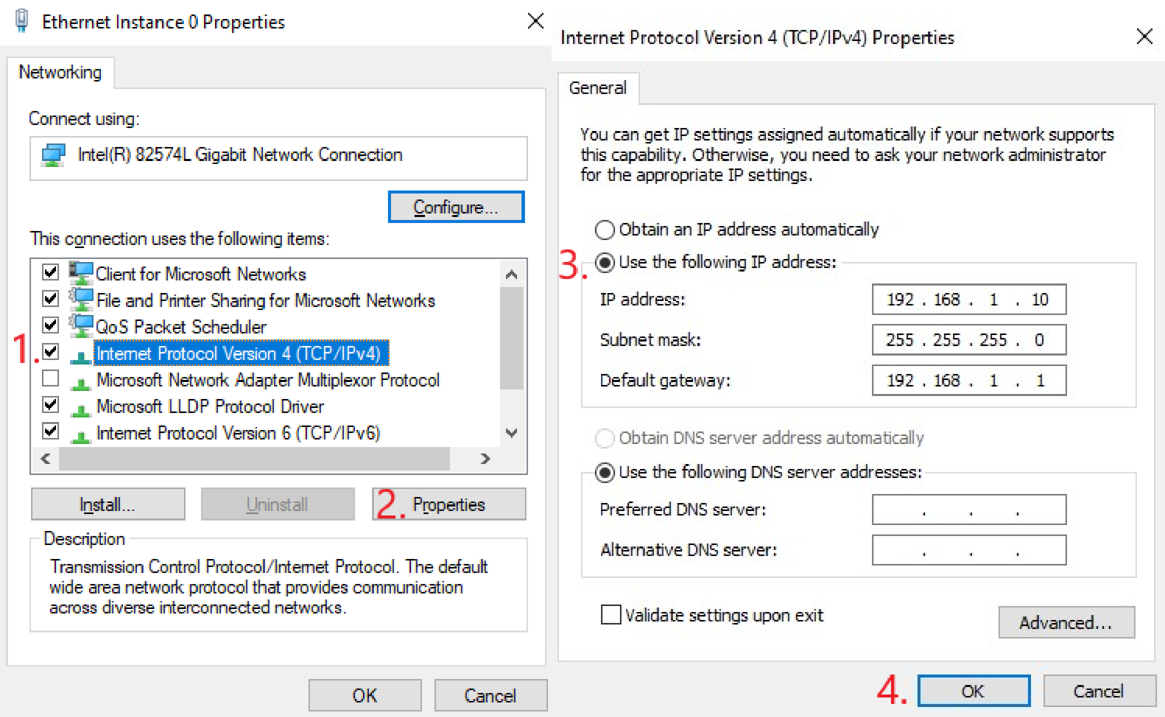


Figure 43: Select Ipv4 properties and add the desired values

11.3.3 Changing Ethernet settings (Ubuntu)

For Linux server based systems look up the documentation for e.g. "networkd", "netplan" or similar.

1. Press the super key (e.g. windows key), search for "Network" and open the menu

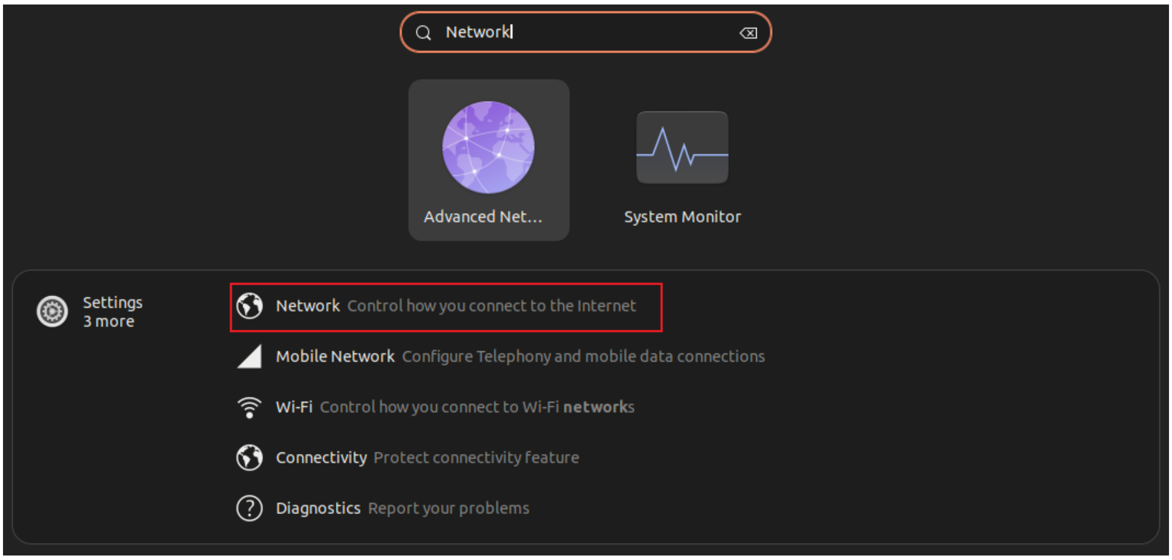


Figure 44: Access GUI Network settings in Ubuntu

1.1. Alternatively you can access the network menu from the upper right corner.

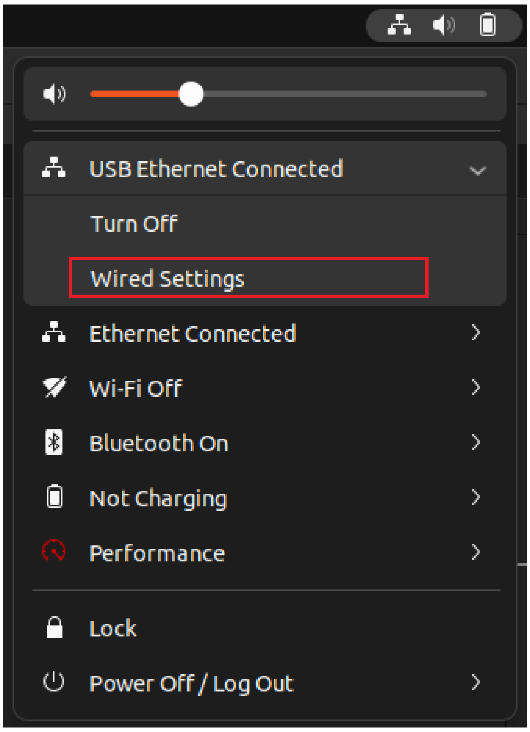


Figure 45: Access GUI Network settings in Ubuntu

2. Press the settings wheel on the network adapter you will be using.

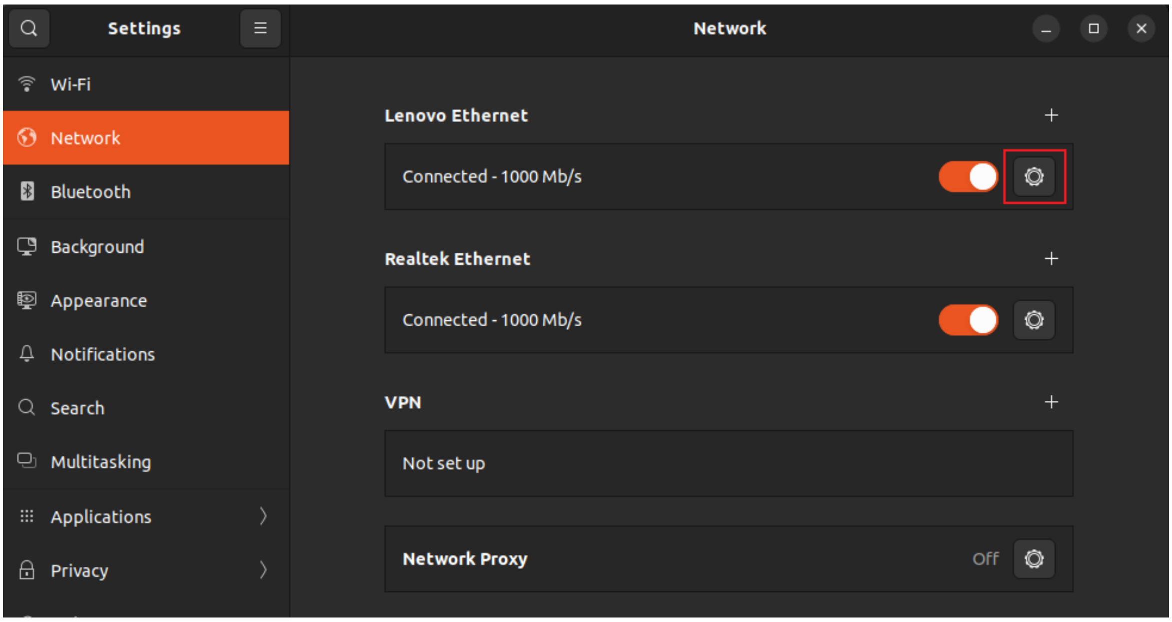


Figure 46: Press the settings wheel for the network adapter conencted to the instrument

3. Select "Manual", enter the desired values and hit "Apply." **NOTE!** After hitting "Apply," you might need to disable/enable the network adapter for settings to take effect.

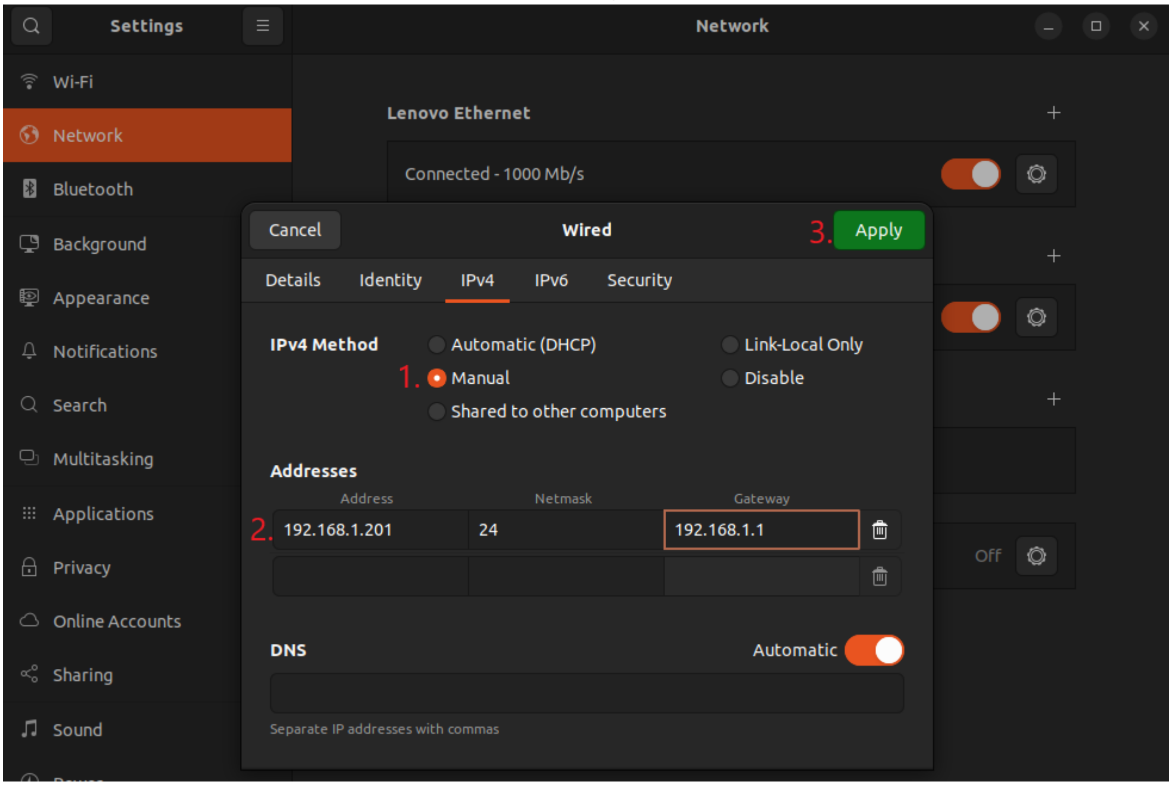


Figure 47: Select manual and enter the desired values, then hit apply

11.4 Cable Diagrams and Pinout

NOTE! When checking the pins/wires with a multimeter, some will not "short." This behavior is due to the electronics within the cable. Be sure to follow the correct revision for your cable.

11.4.1 Nucleus connector to open ended cable

The Nucleus connector pins changes based on the serial communication type.

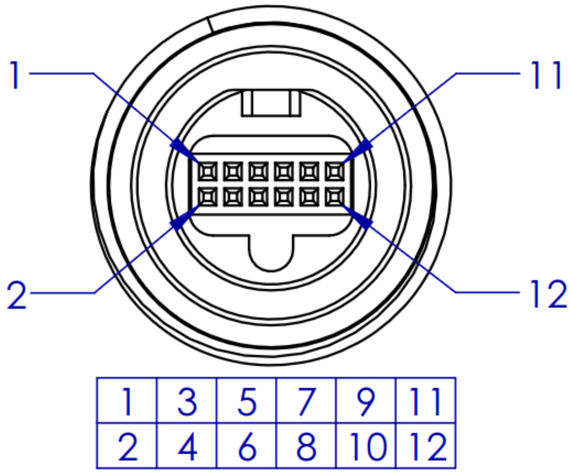


Figure 48: Nucleus Connector pin numbering

Pair	Color RevA	Color RevB	Nucleus Connector	RS232	RS422	Comment
1	White	Red	4	TX+	TX+	Ethernet
	Orange	Orange	2	TX-	TX-	Ethernet
2	White	Yellow	1	RX+	RX+	Ethernet
	Green	Green	3	RX-	RX-	Ethernet
3	White	Tan	12	TRIGA	TRIGA	Input
	Black	Pink	10	TRIGB	TRIGB	Input
4	White	Violet	5	-	TXY	Output
	Blue	Blue	7	TX232	TXZ	Output
5	White	White	8	RX232	RXB	Input
	Brown	Brown	6	-	RXA	Input
6	Black	Black	11	PWR -	PWR -	Power
	Red	Grey	9	PWR +	PWR +	Power

Table 18: Nucleus Connector to open ended cable based on comms type

11.4.2 Nucleus connector to Adapter Interface Board

To wire the Nucleus Connector cable to the Adapter Interface Board, match the color and wire pair to the corresponding pins on the Adapter Interface Board. Older Adapter Interface Boards have color codes labeled on the PCB. However, the provided image indicating the positions of input wire 1 and input wire 12 is applicable to all Adapter Interface Boards.

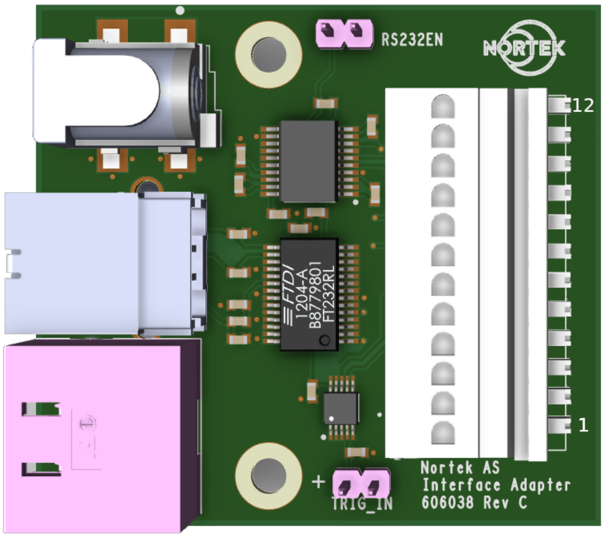


Figure 49: Nucleus Adapter Interface Board S

Pair	Color RevA	Color RevB	Adapter Interface Board input	Nucleus Connector pin	Comment
1	White	Red	1	4	Ethernet
	Orange	Orange	2	2	Ethernet
2	White	Yellow	3	1	Ethernet
	Green	Green	4	3	Ethernet
3	White	Tan	5	12	Input
	Black	Pink	6	10	Input
4	White	Violet	7	5	Output
	Blue	Blue	8	7	Output
5	White	White	9	8	Input
	Brown	Brown	10	6	Input
6	Black	Black	11	11	Power
	Red	Grey	12	9	Power

Table 19: Nucleus Connector to Adapter Interface Board wiring

11.4.3 Nucleus connector to Subconn

The pinout for the Subconn connector changes based on what kind of communication that is selected.

Figure 50: Subconn MCIL8F pin numbering

Subconn pin	Ethernet+trigger	Ethernet+RS232	RS422+trigger	RS232+trigger
1	PWR -	PWR -	PWR -	PWR -
2	PWR +	PWR +	PWR +	PWR +
3	Ethernet RX-	Ethernet RX-	TXZ	TX232
4	Ethernet RX+	Ethernet RX+	TXY	-
5	Ethernet TX-	Ethernet TX-	RXA	RX232
6	Ethernet TX+	Ethernet TX+	RXB	-
7	TRIGA	TX232	TRIGA	TRIGA
8	TRIGB	RX232	TRIGB	TRIGB

Table 20: Subconn pinout based on comms type

11.5 Adapter Interface Board

The Nucleus comes with an unterminated cable as standard, this cable supports either RS422 or RS232, based on what you ordered. Both cable types supports Ethernet. An adapter interface board can be ordered for bench testing.

NB! Remember to mount the RS232EN jumper if you have a RS232 cable. Leave it unmounted for a RS422 cable.

Adapter board:

- 12 pin connector for the unterminated Nucleus cable
- Standard power jack for power input (Power Supply).
- USB connector/Ethernet RJ45 for communications to the PC.
- RS232EN jumper.
- TRIG_IN pins for a TTL signal external trigger.

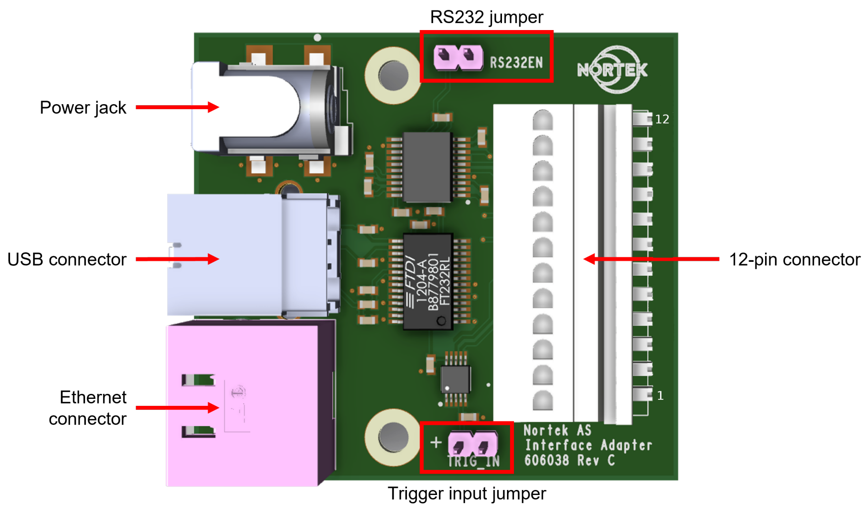


Figure 51: Nucleus Adapter Interface Board components

11.6 Mechanical Drawings

The physical size of the Nucleus1000 (300m) and the Nucleus1000 1000m differs slightly, so select the specific drawings for your instrument type.

- Mechanical Drawings Nucleus1000 (300m)
- Mechanical Drawings Nucleus1000 1000m

11.6.1 Mechanical Drawings Nucleus1000 (300m)

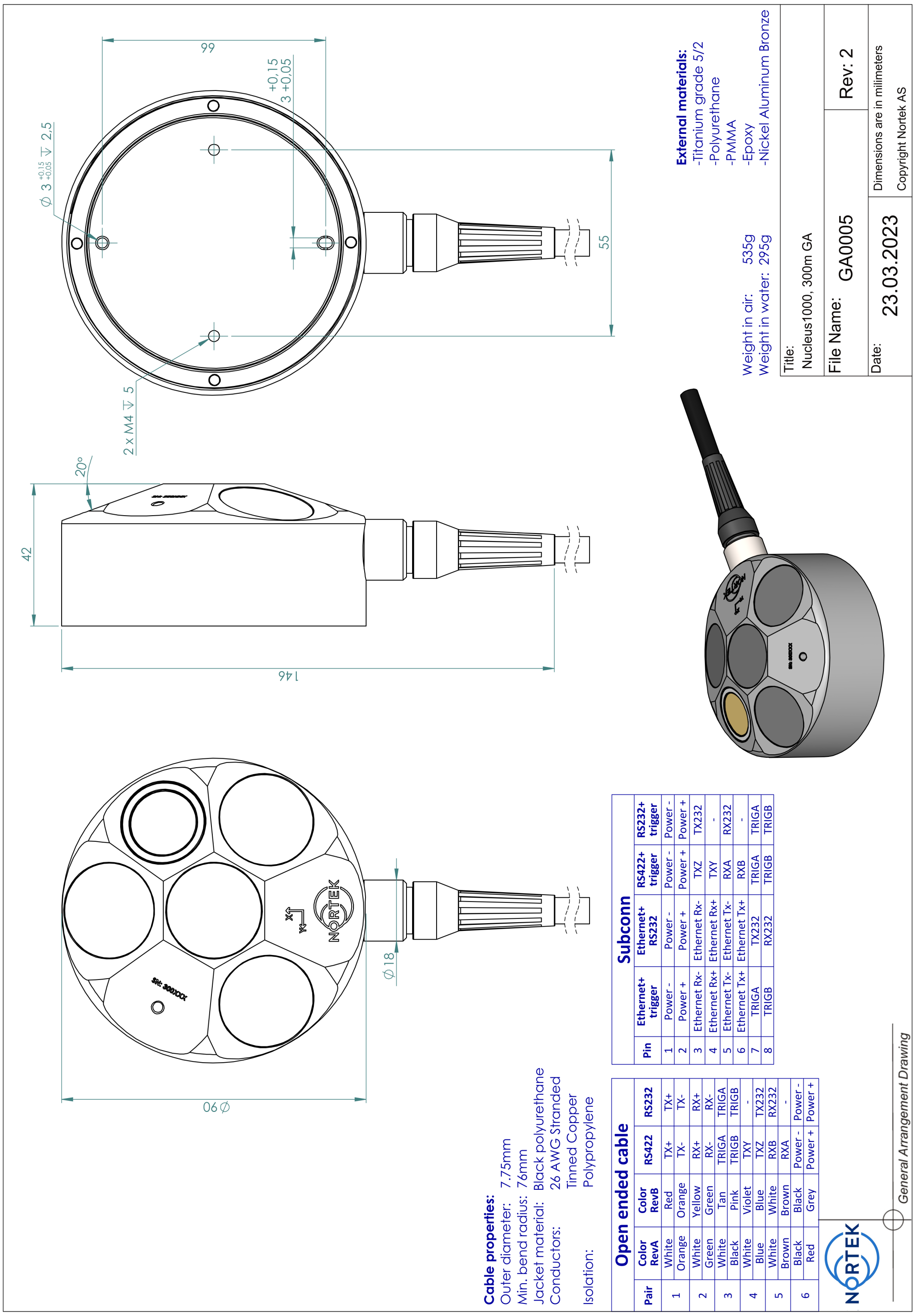
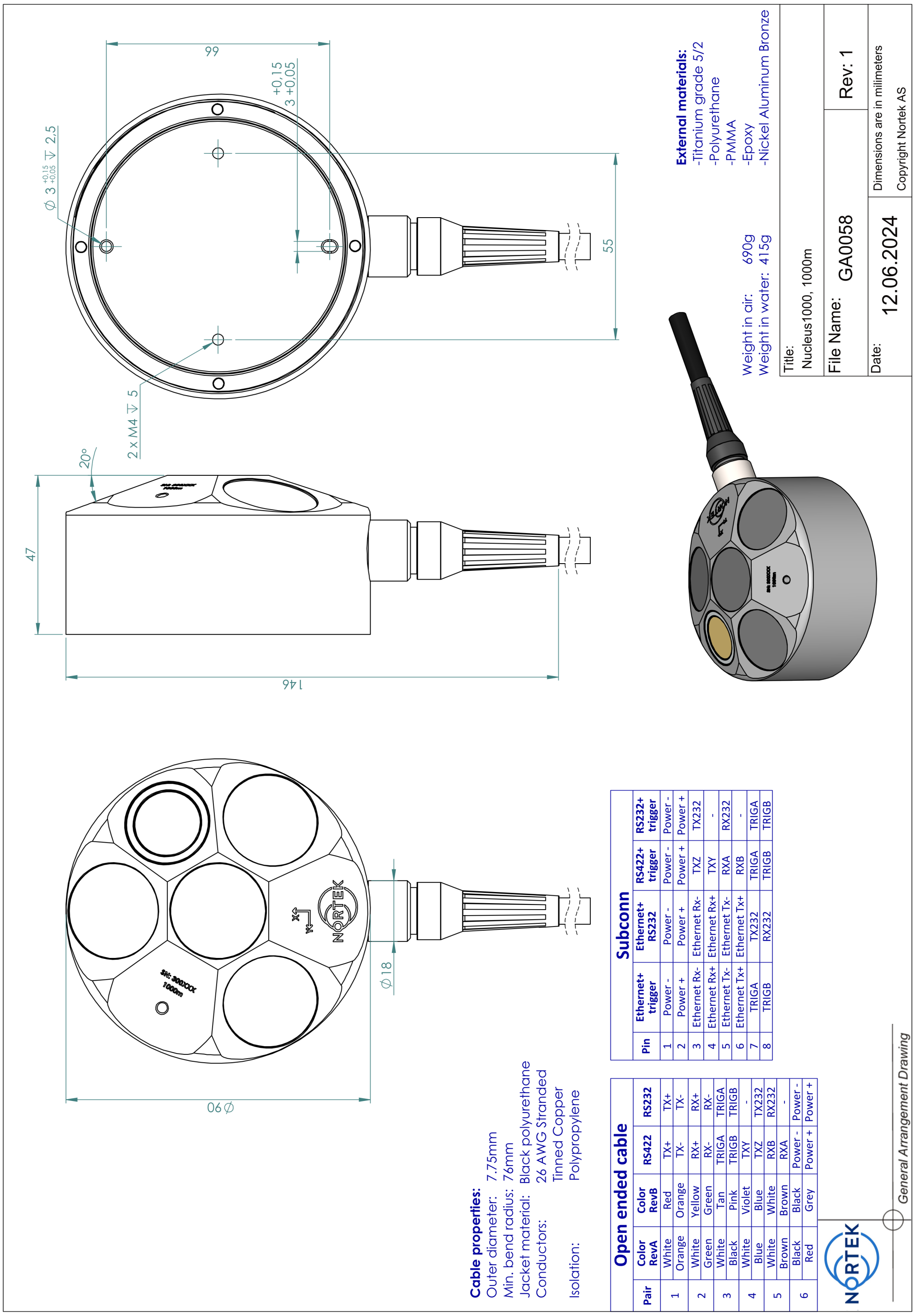


Figure 52: Mechanical Drawing of Nucleus1000 (300m)

11.6.2 Mechanical Drawings Nucleus1000 1000m



Open ended cable

Pair	Color RevA	Color RevB	RS422	RS232
1	White	Red	TX+	TX+
	Orange	Orange	TX-	TX-
2	White	Yellow	RX+	RX+
	Green	Green	RX-	RX-
3	White	Tan	TRIGA	TRIGA
	Black	Pink	TRIGB	TRIGB
4	White	Violet	TXY	-
	Blue	Blue	TXZ	TX232
5	White	White	RXB	RX232
	Brown	Brown	RXA	-
6	Black	Black	Power -	Power -
	Red	Grey	Power +	Power +

Subconn

Pin	Ethernet+ trigger	Ethernet+ RS232	RS422+ trigger	RS232+ trigger
1	Power -	Power -	Power -	Power -
2	Power +	Power +	Power +	Power +
3	Ethernet Rx-	Ethernet Rx-	TXZ	TX232
4	Ethernet Rx+	Ethernet Rx+	TXY	-
5	Ethernet Tx-	Ethernet Tx-	RXA	RX232
6	Ethernet Tx+	Ethernet Tx+	RXB	-
7	TRIGA	TX232	TRIGA	TRIGA
8	TRIGB	RX232	TRIGB	TRIGB

Figure 53: Mechanical Drawing of Nucleus1000 1000m

11.6.3 Mechanical Drawing Nucleus origin

Nucleus origin

Those requiring a reference origin for the Nucleus1000 may use the figure below. This information is typically used for the moment arm calculations with an INS. All measurements are in mm.
For the Nucleus1000 1000m, the moment arm will be the same.

Nucleus1000 1000m height + distance to origin beneath nucleus = moment arm:

	Nucleus1000 (300m) moment arm	Nucleus1000 1000m moment arm
Nucleus1000 height	42mm	47mm
Distance beneath Nucleus to origin	49mm	44mm
Moment arm length	91mm	91mm

Table 21: Moment arm for Nucleus1000

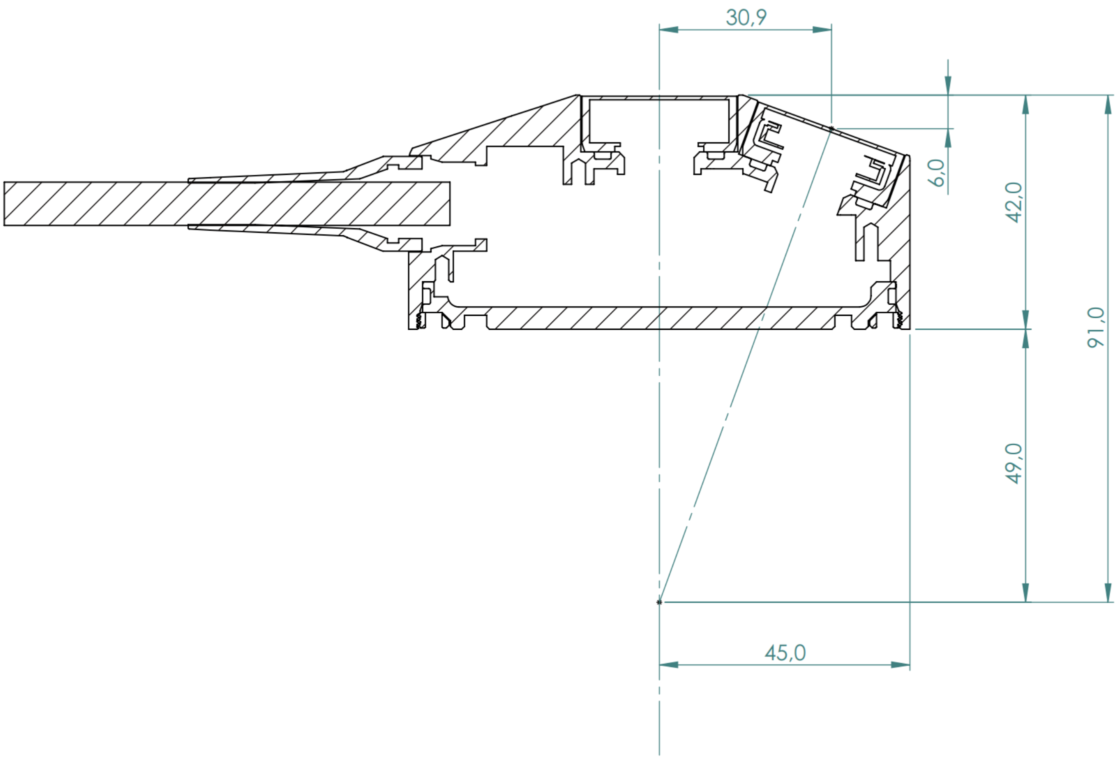


Figure 54: Origin for the Nucleus1000 (300m)

11.7 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: