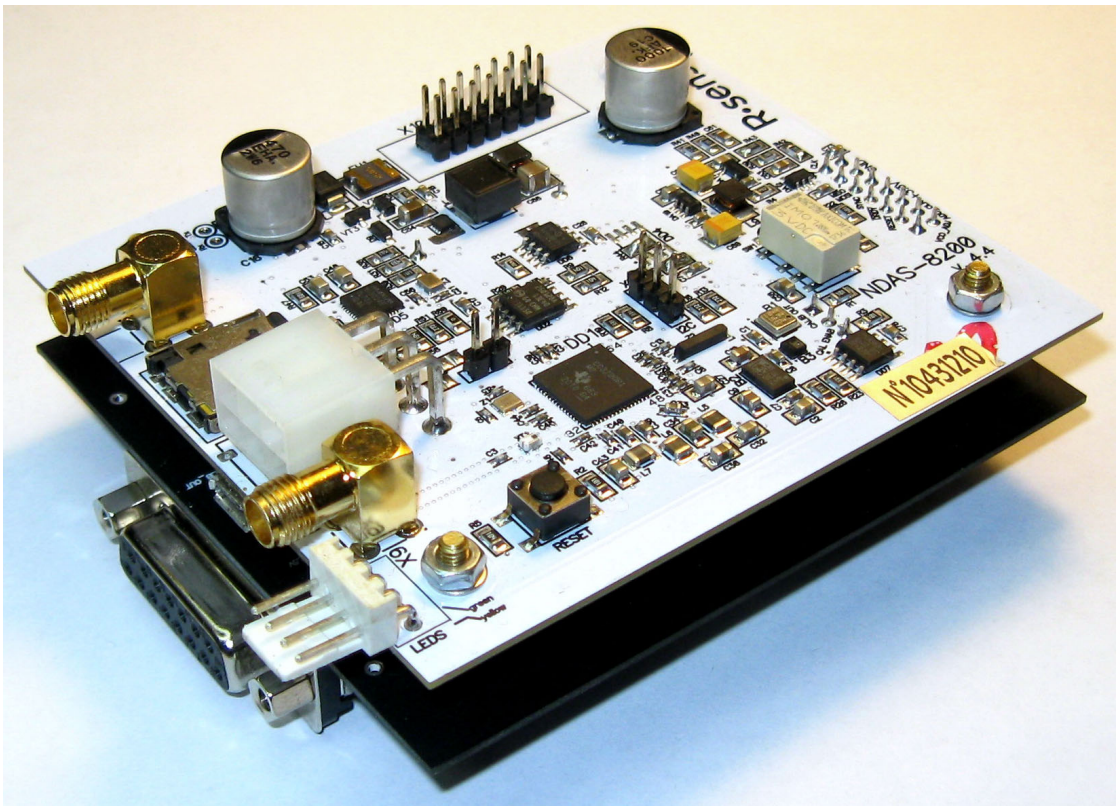
R·sensors

4-channel seismic signals recorder
NDAS-8224

OPERATION MANUAL



version 1.1

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The following notation is used in the document:

- Ordinary text in black.
- Important notices in orange.
- Critical information in red.

4-channel seismic signals recorder NDAS-8224 OPERATION MANUAL.

The information in this document has been carefully reviewed and is believed to be reliable for recorder NDAS-8224 firmware version 6.0.

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Additional documents to the Manual

(available at ftp://download.r-sensors.ru/NDAS/Manuals/)

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1. Introduction

NDAS-8226, a 4 channel 24-bit digital seismic recorder (hereinafter referred to as – 'recorder' or 'device') is designed for seismic and geophysical exploration. The built-in health and orientation sensors can help in further decoding of the obtained data.

The control of signal registration can be performed by operator in manual mode or according to a pre-programmed schedule. The built-in exact-time OCXO clock based on GPS or GLONASS system ensures the recorder's scheduled operation and precise time synchronisation.

Data is registered on the built-in non-volatile storage (SD-card). Along with the registration, the viewing of seismograms "on the fly" by means of a wired or wireless (if the recorder is not submerged under water) connection is possible. The stored data contains exact time and coordinates labels for further synchronization during processing and can be converted into several common formats by means of a supplied converter.

The following protocols are used to work with the recorder:

- USB type Full Speed connection for configuration and setup;
- USB type High speed connection for reading the stored data;
- IEEE 802.11 b/g/n Wi-Fi wireless connection for configuration and setup.

The recorder is not explosive, toxic or environmental pollutant.

DUE TO THE CONSTANT TECHNICAL IMPROVEMENT AND MODERNIZATION OF PRODUCTS, DESIGN AND SOFTWARE MAY BE SUBMITTED TO CHANGES NOT EXPRESSED IN THIS OPERATION MANUAL. PLEASE CONTACT THE MANUFACTURER FOR REFERENCES.

The recorder consists of the following parts (Fig. 1):

- White: processor board (1)
- Black: ADC board (2)

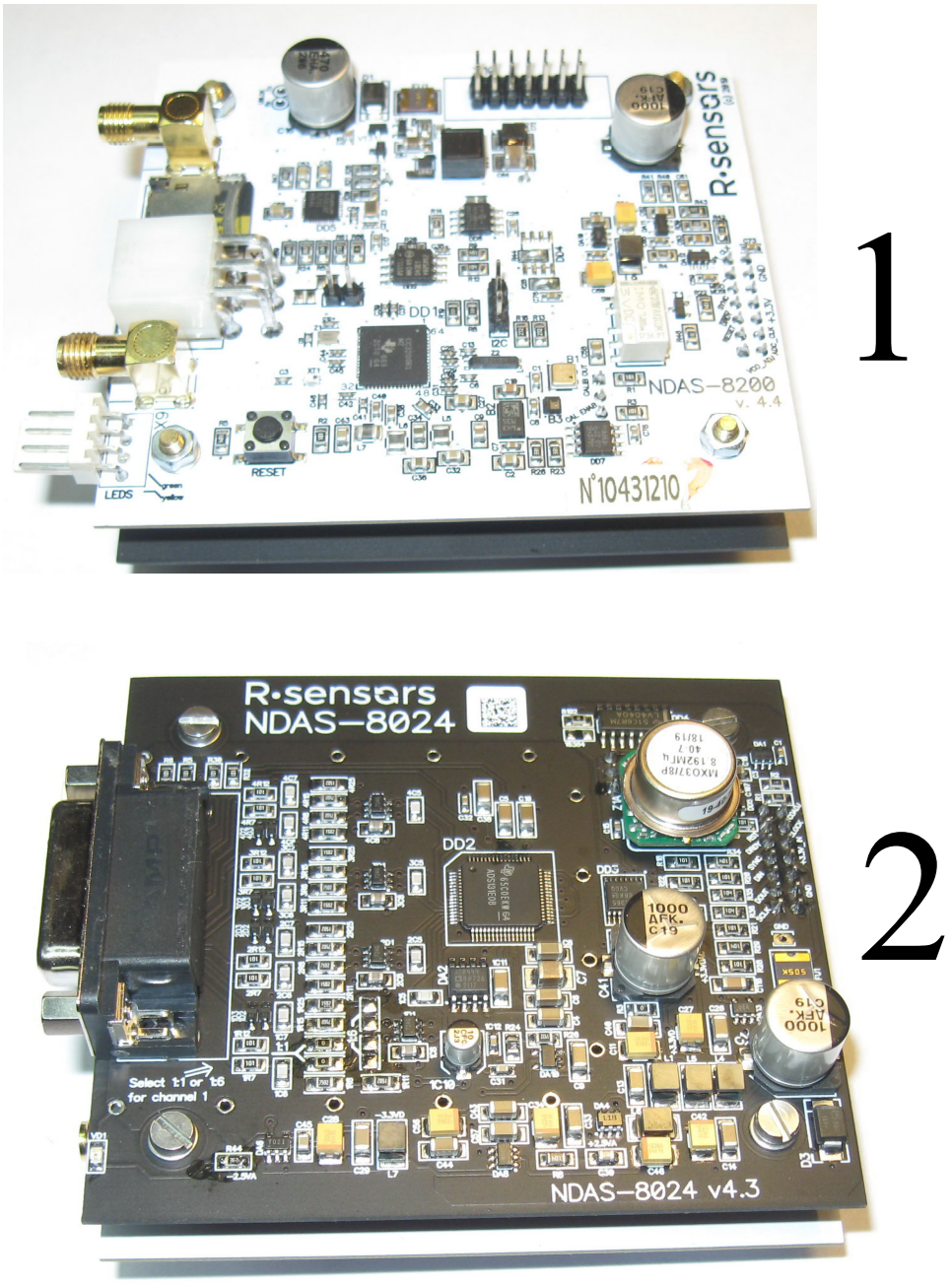


Fig. 1. The recorder's components

2. Delivery set and functions of connectors

The delivery set includes:

- Four channel 24-bit digital seismic recorder with two boards NDAS-8200 and NDAS-8024 connected in one module with a pre-installed 32 Gb SD card - 1 pc;
- MF-2x3F connector with 12 DS1073-02-FT cable contacts - 1 pc;
- USB-A/microUSB-B 0.3m cable - 1 pc;
- SMA-M – SMA-M 0.15m cable - 2 pcs;
- SMA-M / RP SMA-M adapter - 1 pc;
- SMA F/SMA F case connector - 2 pcs.;
- Wi-Fi antenna - 1 pc;
- GPS antenna with 5 meters cable - 1 pc;
- LED assembly - 1 pc;
- Operation Manual - 1 pc per batch;
- CD-ROM with latest software 1 pc per batch;
- Technical Passport - 1 pc.

The connectors' pinouts, pictures of cables and antennas are supplied in Appendix 2 to this Manual.

The following items are located on the module:

Processor (white) board:
- Power supply connector;
- SD card socket;
- LED connector;
- Wi-Fi SMA connector;
- GPS SMA connector;
- System connector;
- GPS clock battery.

ADC (black) board:
- ADC input DB-15 connector;
- Power presence LED;
- OCXO generator.

Location of the abovementioned items and a description of LED operation modes is supplied in Appendix 1 to this Guide.

3. Connection

A unipolar DC source with a nominal voltage of 12 V can be used to power the recorder. The acceptable supply voltage range is 3.8 – 17.0 V. For underwater operation a Li-Ion battery with 12.6 V nominal voltage is recommended. When the device is powered from a 12 V DC source, the average current consumed by the recorder is less than 50 mA.

A USB port connection can be used as an auxiliary power source. The load capacity of the USB port in this case must be at least 500 mA. The acceptable supply voltage range in the auxiliary channel is 4.5 .. 5.5 V.

For wireless operation, retrieving the precise coordinates and performing the exact time synchronization, Wi-Fi and GPS antennas respectively are used. The recorder displays the main status parameters through multifunctional connector by means of the LED indicator. The list of indicator operating modes is supplied in Appendix 1 to the Guide. The power supply presence is indicated by the LED installed on the ADC board.

4. Configuration and Operation

Turn on the power. After the boot, which takes several seconds, the recorder will try to synchronise the clock generator by means of GNSS receiver. The procedure requires a good view of the sky (ideally, an unobstructed view of the sky above 30° elevation angle) and takes from 30 minutes to 1 hour.

The current synchronisation status can be viewed either by LEDs if the led assembly is installed or over a wireless connection in NDAS program or the recorder's web-interface. After the synchronisation is achieved, the recorder is ready for operation.

The scheduled operations can be programmed via web interface (one event only) or the NDAS program (multiple events). Refer to the correspondent appendices to this Manual.

The recorder has health sensors, the readings of which are accessible via web-interface or NDAS program. The following parameter can be measured: main supply voltage, PCB temperature, humidity, tilt of the PCB, azimuth of the PCB. Location of the axes of sensitivity of magnetometer is supplied in Appendix 1 to this Guide.

4.1. Software installation and initial settings

To install NDAS software, a PC-compatible computer with the Windows operating system is required. The user manual for installing and using the program is supplied in Appendix No. 4 to this Guide.

The software for NDAS recorder and drivers are stored on the CD-ROM supplied with the device. To install NDAS software, unzip the program distribution package from the archive. Run the installation using the installer 'setup.exe'. Follow the instructions of the installer. Install and run NDAS program.

A user manual for using NDAS program is supplied in Appendix 4 to this Guide. The distributive of the latest version of NDAS program is available on the FTP server at: ftp://download.r-sensors.ru/NDAS/NDAS%20App/ .

To set the initial parameters, you need to connect the recorder via a low-speed USB channel. Use a USB A/microUSB B cable. Connect the recorder to the USB port of the computer. For the first time you turn it on, you may need to install the FTDI driver. The driver will be installed by the Windows OS in an automatic mode. In addition, the driver is included in the software package supplied with the recorder.

Pay attention to the compatibility of the downloaded software version and the firmware of the device. Compatible firmware versions are indicated in the "Release notes" document in the program distribution folder.

4.2. Initial settings of wireless connection

At the default settings, the recorder operates in the "station" mode and uses the following wireless network parameters for connection:

- SSID of 'NDAS';
- Password 'NDAS12345678';
- WPA2 security type
- IP address, network mask and Gateway are set by DHCP.

To change the initial wireless settings, you need to connect the recorder via a low-speed USB link. Use a USB A/microUSB B cable from the delivery set. Connect the recorder to the USB port of the computer. For the first time you turn it on, you may need to install the FTDI driver. The driver is installed by the Windows OS in an automatic mode. In addition, the driver is included in the software package supplied with the recorder. Run NDAS program with COM port connection selected.

Drivers are available for download from the FTP server at
ftp://download.r-sensors.ru/NDAS/Miscellaneous/NDAS%20One%20FTDI%20Drivers/
as well as from the manufacturer's website at
http://www.ftdichip.com/ Drivers / VCP.htm

If the required wireless network parameters do not match those indicated, you are required to connect the recorder via a low-speed USB link using a USB A/microUSB B cable and use the NDAS program to set the required wireless settings.

After the device is connected to a wireless network, the device can be configured and controlled both via a wireless (Wi-Fi) and a wired (USB-COM) connection. The type of connection is selected in the start window of the NDAS program.

4.3. Wireless connection modes

The recorder can be configured to operate in the following modes:

- **Station mode** - connection to the device via a Wi-Fi router;
- **Access Point** mode - connection to the device directly;

In the "access point" mode, the device creates its own Wi-Fi network, with a name consisting of the SSID of the network, the specified settings, and the serial number of the device. For example, if you specify "NDAS" in the SSID parameters, the devices will create networks with the names NDAS_RS003601, NDAS_RS003501, etc.

When operating in the "access point" mode, the network password must be at least 8 characters long.

In the "access point" mode, only one device is supported - a subscriber. Connecting the other device to the network disconnects the first one.

The static IP address settings are necessary for the device to operate in networks where there is no DHCP server. This option is available only in the "station" mode. In the "access point" mode, the device runs its own DHCP server which always assigns the IP address 192.168.37.1 to the device itself.

Do not use static IP settings in networks where a DHCP server is running as this will result in a conflict of IP addresses. If you want to assign the device a specified IP address, use the IP address reservation settings of DHCP server.

4.4. Operation in Main Mode

The recorder can operate in two modes:

- **Main mode**, including registration, schedule operation, changing and saving settings, and
- **Data Retrieving mode**, when high-speed data retrieving from a memory card is possible while signal recording is not possible.

Switch between the modes modes and configuring a recorder connected to a Wi-Fi network can be done by means of the NDAS software or the recorder's web interface.

To control and configure the recorder through a wired connection, you must use the NDAS program.

After the recorder is set to the Data retrieving mode, the low-speed **wired** connection will be lost. To restore the possibility to operate the recorder via the wired connection, you will need to reset the recorder by powering it off or switch the recorder to Main mode in wireless connection.

4.4.1. The NDAS Program

The following operations are possible in the NDAS program:

- View the current status of the recorder (power supply voltage, free space on the memory card, presence of a Wi-Fi and GPS signal, time synchronization status, other available parameters);
- Change of the SSID wireless network settings and the password, safe modes;
- Change of configuration parameters (sampling frequency, schedule recording setup, channel gain and range setting);
- Registration start and stop;
- Preview of retrieved data on the fly;

- Operations with the built-in SD card (deleting, recording switch on/off, switch to the data retrieving mode).

4.4.2. Web interface

The web interface is optimized for convenient configuring NDAS devices on smartphones and tablets. The web interface can be accessible through the browser of any device connected to the same network to which the device itself is connected. The device's web interface allows performing the same operations as the NDAS program, except for editing the recording schedule — only the first row of the table can be changed.

The settings web page can be accessible through entering the local domain name of the device titled as <serial number> .local (for example, *RS003601.local*) or directly by IP address.

A detailed user manual for working with the web interface is supplied in Appendix No. 5 to this Guide.

4.4.3. FTP server

An FTP server can be used to access files over the network on the device's memory card. To view contents of the file system and download necessary files, you can use any modern browser (Chrome, Firefox, IE, Safari), Windows Explorer as well as specialized programs such as Total Commander or FileZilla.

To access the FTP root directory, type the IP address of the device or the local domain name (if the system supports the Bonjour service) with the "FTP" prefix, for example, "ftp://192.168.0.100" or "ftp: // rs003601 .local ". The server accepts any username and password.

A detailed user manual for working with the FTP server is supplied in Appendix No. 6 to this Guide.

Since in the data retrieving mode the memory card is connected to the USB card reader IC directly, it becomes inaccessible for the processor. As a result, the FTP server does not operate when the device is this mode.

If the data is being recorded, the FTP server allows downloading all the files except for the files that are currently open for recording, namely the current SIVY file and the file of the current 1Hz recording.

4.4.4. Safe modes of FTP and Web servers

Safe modes have been introduced to eliminate the risk of accidental data corruption for cases in which access to the devices' interface and file system is open to a wide audience. In the safe mode of the web interface, an option to change instrument parameters and send start and stop commands is blocked. Only preview mode of settings and logged data is available. The FTP server's safe mode restricts access to the file system with the read-only mode. Safe mode settings can only be changed using the NDAS program.

4.4.5. Serial port and log output

All main events of the device firmware are accompanied by corresponding log messages that are transmitted to the serial port of the low-speed USB connection and can be displayed by terminal programs. In the Windows environment, such programs include “Tera term”, “DockLight”, “Terminal by Bray”, etc. When configuring the serial port parameters, the following values must be specified:

- Baud Rate - 115200;
- Data bits - 8;
- Stop bits - 1;
- Parity bits - 0;

For using the serial port, use a digital cable with a 10-pin female connector and a USB-A connector. The cable is connected to the multifunction connector.

When the wired connection is used, the NDAS program also exchanges data with the host device through the serial port, so in this case, you need to disable all terminal programs that can block access to the port. The reverse is also true - the NDAS program will block access to the serial port for other programs.

The NDAS program communicates with the device over the serial port using an internal data exchange protocol. Upon receipt of the first package having a header of the corresponding format, the device switches to the data exchange mode via the protocol. At the same time, all messages of the log file are also packed in the format of the NDAS package, but if necessary, the message body can still be read by any terminal program.

4.4.6. File system

The main directory of the recorder is a folder titled “RS_xxxxxxxx”, where “xxxxxxxx” is the serial number of the recorder. Inside of the main directory, the recorder creates subdirectories with recordings of signals called working directories as well as the LOGS directory, in which the operational logs are stored.

The system sets up the operational directory at the time the first record file is created. If at the time of creating the directory there is information about the current time, the name of the operational directory will be formed on the principle of "YYYY-MM-DD", that is year-month-day. If there is no time information, the name will contain “NO_TIME_xxx”, where “xxx” is the next number in order.

The operational directory remains unchanged as long as the device is operating, except for the following two cases:

- If the operational directory was created in the absence of time data, then after the synchronization procedure the operational directory will be changed, and all subsequent data will be recorded to the directory with the correct name.
- After switching the device from the data retrieving mode back to the main mode, the file system is initialized leading to the updating of the operational directory.

Inside the operational directory, the device creates recording files with a name in the form "YYYY-MM-DD HH-MM-SS", that is "year-month-day hour-minute-second", corresponding to the actual start time rounded to the second. Record files have the extension of * .siv.

When the option to record an additional one-Hz signal is turned on, a subdirectory with the name of "1Hz" is created in the operational directory, where additional files are recorded.

The LOGS folder contains text files of the system log with the format name LOG_xxx, where xxx is the file serial number. The content of the files duplicates the text messages displayed by the device on the serial port. The maximum size of the log file is limited to 1MB; if this size is exceeded, a new file is created with the following serial number. The data are recorded sequentially and the record continues to the latest file after reboot.

4.4.7. Time synchronization

This device automatically links the recorded data to the exact time obtained via the GPS/GLONASS receiver. The process of synchronizing the system clock with the exact time can take from 30 minutes to 1 hour, depending on the temperature conditions, the time passed from the last synchronization and the conditions for receiving the satellite signal at the installation site. The synchronization process goes through several stages:

- After connecting the GPS / GLONASS antenna, the receiver searches for satellite signals and, in the presence of a stable signal, performs a navigation task - that is determining the coordinates and time. At this moment, the "GPS" flag lights up in the NDAS program window, the "GPS" LED on the device's case begins to flash sparsely;
- The clock generator frequency is being tuned to set the clock of the system precisely;
- After the adjustment is completed, the system clock is corrected with an accuracy of better than 1 μs. At this moment, the SYNC flag is lit in the program window, and the SYNC LED on the device's case starts flashing regularly.
- After synchronization is complete, the GPS antenna can be installed that will not affect the regular operation of the device.
- However, if a GPS signal is present during recording, the device will continue to smoothly adjust the frequency of the clock generator as well as put time stamps every minute and measure the current drift of the clock. This will significantly increase the time accuracy of the recording and will improve the correlation of data taken from two independently operating devices.

Time synchronization is maintained until the device is rebooted. Changing of some parameters of the device may lead to its reboot resulting in the loss of synchronization.

For correct conversion of GPS time to UTC, the system maintains up-to-date information on the seconds of coordination, also called leap seconds. The update the number of seconds of coordination may occur once every six months, before the zero time of January 1st and July 1st. Changing the number of seconds of coordination may require updating the device firmware. Recalculation of seconds of coordination can take up to 15 minutes; the time synchronization in this case can be done only after the process is completed.

If the device is recording data at the zero time of January 1st or July 1st, even in case the number of seconds of coordination changes, the time will not be re-adjusted until the next recording stops in order to maintain the data integrity.

4.4.8. Modes of the registration

There are 4 possible modes of the registration:

- Manual mode – the registration is turned on and off manually using the NDAS program or via WEB interface;
- Immediate start - registration starts automatically whenever the device is turned on;
- Synchronous start - registration starts automatically after the time synchronization is completed;
- Schedule table - registration starts and ends automatically at the scheduled time.

When the device operates in the manual or immediate start mode, the presence of GPS synchronization is not necessary. If the signal recording began before synchronization occurs, the file header will not contain data on the exact time, and the files will be placed in a folder with the name of "NO_TIME_xxx", where "xxx" is the serial number of the folder.

If during the registration that was started before synchronization, the GPS signal appears, the device will begin the synchronization procedure without interrupting the recording. In this case, as soon as the procedure is completed, a new operational folder with the correct name will be created, and the next pile of data will be recorded to a new file with the correct time information.

When operating in the synchronous start mode, the device starts recording after the synchronization procedure is completed from the beginning of the next whole minute.

When operating in the table mode, the signal recording starts automatically at the preset time with the accuracy of one sample. Registration always starts after synchronization, but after the device is synchronized, the presence of a GPS signal is not necessary until the moment the power is turned off or the device is rebooted.

The device finds the nearest time line in the table and waits for the start time. If the current time is inside of one of the intervals specified by the table, the recording starts immediately from the next whole minute.

When reaching the end of the table, the device goes into the manual mode. If the option "shutdown after finish" is set, the device goes into the hibernation mode characterized by reduced power consumption. The device can be removed out of this mode by turning off the power.

In the event of a power failure at the moment of scheduled recording, the recording resumes only after restoring synchronization with the GPS signal. The presence of a GPS signal in this case is required for resuming scheduled recording.

4.4.9. Cyclic recording option

If the cyclic data recording option is enabled and there is no free space on the SD-card, the device starts deleting the oldest files to free up space. When using this option, attention must be paid to the following:

- Files are scanned only inside of the recorder's main directory — that is in a directory with the name of “RS_xxxxxxxx”, where “xxxxxxxx” is the serial number of the device. All other directories are ignored;
- Scanning is done only for files with the extension of ".siv". All other files are ignored;
- If after the cleaning procedure no files remain in the directory, the directory is also deleted;
- As an evaluation criterion, the file modification time attribute is used.

Carefully use the cycle recording option in the absence of synchronization. When the device is on, the clock starts from the same moment - January 1, 2017 – thus the files will be deleted in arbitrary order rather than in the order they were actually recorded.

Avoid configurations in which a large number of small files will be created on the device - this can slow down the file scanning function and potentially lead to data loss.

4.4.10. Option to record an additional 1 Hz frequency signal

When the option to record an additional signal is turned on, the device, in addition to the main data, starts recording files with a sampling frequency of 1 Hz. Files go to a subdirectory with the name of “1Hz”, and are named according to the same principle as the main files, with the addition of “1Hz”.

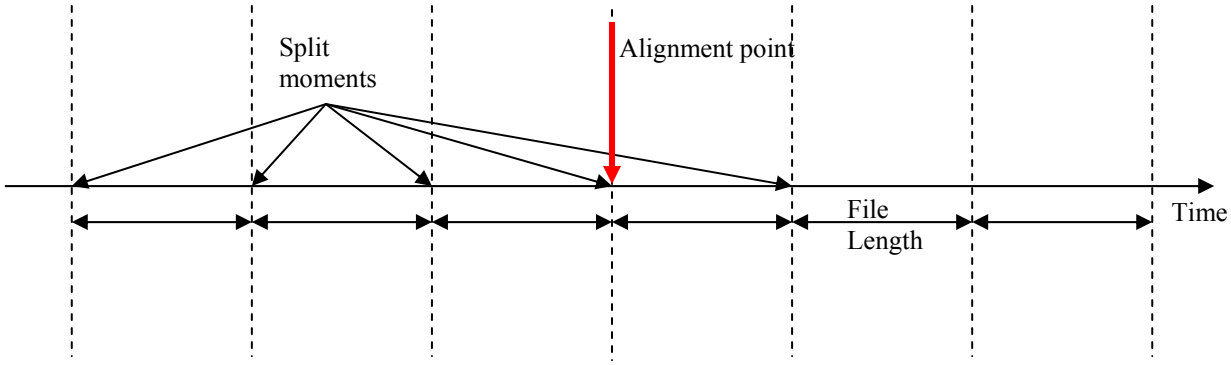
In most cases, the main and additional files are created synchronously (with an accuracy of 1 sample) and have the same name, however, some situations are possible in which the files will not be synchronized:

- If the SD card was removed during recording and then inserted back;
- If in the scheduled recording mode the memory card was inserted after synchronization was done and the start time was missed out;
- When the working directory has changed during the time synchronization process;

In all the above cases, the registration unit will create new files on the memory card, and the beginning of these files will correspond to the earliest data stored in the device buffers. Since the buffer size and the amount of data in the buffer for different signals and sampling rates are different, the time at which the files start will also differ.

4.4.11. Specified time file start aligning

The option to align the beginning of a file to a specific time affects the moment at which a split will be performed and a new file will be opened. This option is useful when it is necessary to acquire records of the same time intervals from several devices that are not started synchronously (not in the table mode). The moments of "splitting" are sample from the alignment time at intervals that are multiples of a given file length. The algorithm is illustrated in the figure below.



Example 1.
The file length is 3 hours, the alignment point is July 17, 2018, 16:00:00
Recording starts July 17 at 11:45.
A new file will be created at 13:00, then at 16:00, at 19:00 and then every 3 hours.

Example 2.
The file length is 1 hour, the alignment point is January 01, 2017, 00:30:00.
Recording begins on July 17, 2018, 12:43.
A new file will be created at 13:30, then at 14:30, and then in the middle of each new hour.

Example 3.
The file length is 24 hours, the alignment point is January 1, 2017, 18:00:00
Recording starts July 17, 2018 at 13:30.
A new file will be created at 18:00 and then every next day at the same time.

4.4.12. Data filtering

An analogue-to-digital (ADC) converter of the device generates a signal with a sampling frequency of 1000 Hz. Output signals with frequencies below 1000 Hz are formed by decimation, accompanied by anti-aliasing filtering of high frequencies.

Cascades of FIR filters with linear phase response are used as filters. For detailed information about the filtering algorithms used, contact the device manufacturer.

The general filter characteristics are presented in the table below:

Final sampling frequency, Hz	Delay *, ms	Edge of Passband, Hz	Edge of Stopband, Hz	Frequency response unevenness, mdB	Suppression coefficient, dB
500	63.5	200	250	0.7	-177
250	95.5	90	120	0.7	-175
125	349.5	50	62.5	1.4	-177
100	413	40	50	1.5	-177
50	573	18	24	1.5	-175
25	2483	10	12.5	2.2	-177
10	2960.5	3.6	4.8	2.3	-175

5	4679.5	1.625	2.425	2.6	-174
1	23779.5	0.325	0.485	3.4	-174

* The delay of the cascade of anti-aliasing filters is presented, without taking into account the signal delay in the ADC circuits which is 4.5 ms.

4.5. Operation in Data Retrieving Mode

The data retrieving mode is designed for a quick transfer of the recorded information from the device's SD card to a computer. To use the recorder in the data retrieving mode, connect it to a computer using a USB A/microUSB B cable.

Set the recorder into the data retrieving mode with the "Card reader" command in the NDAS program or the web interface. The recorder can be powered either via a USB port of a computer or via the main power supply.

To give a command to switch from the main to the data retrieving mode, the NDAS program must have either a wireless connection or a low-speed USB connection with the recorder.

In the data retrieving mode, the recorder's SD card is presented in the list as an external drive similar to a regular USB drive which allows reading/recording/formatting by means of the computer's operating system.

Note that in Data retrieving mode the low-speed connection is unavailable, so the backward switch command can be sent only over the wireless connection. The alternative way to exit the Data retrieving mode is reboot the recorder by pressing the reboot button or to switch off the recorder causing a reboot.

The device automatically exits the data retrieving mode when the USB-B cable has been disconnected or after a reboot has been done. In addition, this mode can be turned off through the NDAS program or the web interface.

The stored data can be retrieved over the network in the normal mode by means of the FTP server (see section 4.4.3). If the device is set to the data retrieving mode, the FTP server becomes unavailable.

4.6. Firmware Upgrade

The NDAS series devices manufactured since 2018 have a built-in bootloader which allows a safe upgrade of the firmware, the license file and the built-in web interface.

Each time the device is turned on or rebooted, the bootloader checks the root directory of the memory card for the following files and, if present, apply updates to:

- "ndas_firmware.bin" – a firmware file;
- "Ndas_bootloader.bin" – a bootloader file (unsafe, see note below):
- "ndas_license.dat" – a license file;
- "Ndas_webserver" - a folder with html-pages of the web interface;

To update, place the new file or folder in the root of the device's memory card in any possible way, making sure that the name is correct, then reboot the device and wait for the update process to complete. The process is accompanied by alternating frequent flashing of the LEDs, after the successful completion of which the LEDs go into the normal mode.

If necessary, during the update it is possible to observe messages displayed in the log file using one of the terminal programs (see section 4.2.5). All messages also go to the file BOOT_LOG.txt, which is created in the main directory on the memory card.

Make sure the firmware version of the device has been changed by means of NDAS program, the web interface or the log file content.

To download files as well as get up-to-date information about changes and compatibility, visit the FTP server at ftp://download.r-sensors.ru/NDAS/

If the firmware update is interrupted or failed, the device will boot in the safe mode using the default firmware. In this case, you can try to update again.
The mode at which the device has been booted can be found through the NDAS program, the web interface or the log file on the memory card.

The bootloader update procedure (file "ndas_bootloader.bin") is unsafe. In the event of an error or power failure during the update process, the device will become inoperative. To restore the operability of the device, it will be necessary to repair it at the manufacturer, therefore it is not recommended to update the bootloader unless absolutely necessary.

4.7. Compass and inclinometer operation

The recorder has an in-built inclinometer and a compass. The inclinometer determines the tilt angle with the vertical axis Z, which is perpendicular to the horizontal XY plane. The compass determines the angle between the magnetic direction to North and X axis. The sensors readings are being recorded during normal operation into the output .SIVY file and after a conversion are available in .CSV table. Prior to be used, the in-built compass needs a procedure of calibration.

To enter the calibration procedure, open the web page of the device. Choose 'Device info' button. In the bottom of the page click 'Compass calibration button' and enter the compass calibration menu (Figure 3).

The calibration requires each axis of sensitivity to be oriented up to store '+' value and down to store '-' data. The axis, which parameter is ready to be stored, i.e. oriented vertically, is highlighted with green. As soon as the green highlight appears, press the highlighted button 'store'. Make sure all six readings are stored at the same measurement. Do not change the place during taking the readings. The offset of each axis is calculated in the window to the right. After all offsets are determined, press 'Apply new offsets'. Now the azimuth is ready to be calculated with new offsets.

The output axis data can be change in order or direction if the device's axis of sensitivity do no match the recorder's. The following notion is used: the recorder magnetometer's axis are listed by numbers "1", "2", "3" while the axis of the device are listed by letters "X", "Y", "Z". Make sure the relations between the magnetic and velocity axes are correct.

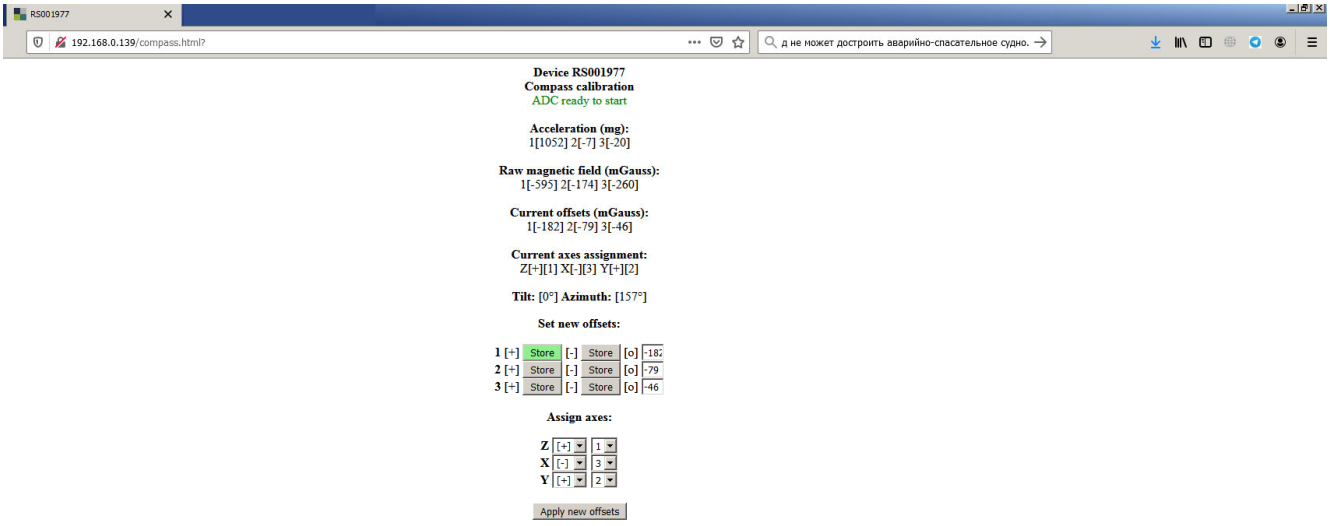


Fig. 3 Compass calibration window

The compass is susceptible to the environmental magnetic filed distractions. The correct operation requires the absence of ferroconcrete, iron or other sources of artificial magnetic field in the vicinity of the recorder. The precision of the azimuth calculations can be deteriorated if the recorder is not levelled in tilt angle.

4.8. GPS receiver battery

The GPS receiver of the recorder has a 3V CR2032 Lithium battery for keeping the real-time clock running during the off-state intervals. Make sure the battery voltage is sufficient (1.4V or more). If the battery's voltage is insufficient or no battery installed, the recorder starts the clock from the initial date and time of 1st January, 1970 every time the power is applied or after reboot. All recording made with initial time will be stored in 'No_time' folder, whereas the folder with the stored time will be crated if the RTC is running.

4.9. ADC hydrophone channel

The channel 1 of the recorder has 1:1 input divider and is optimized for a passive hydrophone; while the channels from 2 to 4 are equipped a 1:6 input divider and are optimized for active geophones MTSS-2003 or alike. The input divider 1:6 of the 1st channel can be activated by moving two zero-Ohm resistors as indicated in Appendix 1.

5. Carrying and storage

The recorder is strong enough and practically is not subject to damage during transportation. Use the packaging provided with it or any packaging materials to prevent damage to the connector on the housing cover and scratches on the housing. Storage temperature is from –25 to + 90°C.

6. Warranty and service

The warranty period of the product is 18 months. During this period, the replacement or repair of the defective product will be made at the expense of the manufacturer. After the warranty period, regular repair and maintenance charges will be applied.

7. Information about Manufacturer

Manufacturer:
R-sensors LLC; 141701, Russia, Moscow Region, Dolgoprudny, Zhukovskogo Street, 8A;
Tel.: +7 (498) 744-69-95, e-mail: r-sensors@mail.ru.

8. Technical specifications

ADC type	Sigma-delta
Number of channels	4
Input voltage range Hydrophone channel Seismic sensor channels	 ±4 V differential (±2 V single-ended) ±24 V differential (±12 V single-ended)
Input impedance	180 kOhm || 2700 pF
Dynamic range	132 dB
Gain coefficient (G)	1, 2, 4, 8, 12 Software selectable
ADC sampling rate	1, 5, 10, 50, 100, 125, 250, 500, 1000 sps (samples per second)
ADC resolution	24 bit
ADC noise performance	21.4 ENOB at Gain = 1 and 100 sps
Digital filter Cut-off frequencies	500 sps – 200 Hz 250 sps – 90 Hz 125 sps – 50 Hz 100 sps – 40 Hz 50 sps – 18 Hz 10 sps – 3.6 Hz 1 sps – 0.325 Hz
Calibration facility	Pulse or sine signal
GNSS receiver	Inbuilt GPS and GLONASS receiver
GNSS timing accuracy	< 1μS
Reference clock type	MXO37/8P – 8.192 MHz (OCXO)
Reference clock stability	5 ppb
Data recording mode	Continuous, by date
Data recording format	Internal with the possibility for conversion into binary (float), miniSeed, SEG-Y, ASCII, SAC

Technical specifications (continued)

Data storage	32 Gb flash storage
Data transfer	High-speed USB 2.0
Temperature range	-20°C .. +85°C (-4°F .. +185°F)
Supply voltage Standard Auxiliary	 3.8 – 17 V from power connector 4.5 – 5.5 V DC from miniUSB port
Max supply current	< 110 mA @ 5V DC from USB
Power consumption during stand-alone recording	< 400 mW
Battery control channels	1
Battery control input range	0..70V single-ended unipolar
Battery control input impedance	75 kOhm
Hydrophone power output	±2.5V, 1 mA max
Data transfer	Full-speed USB 1.1 (configuration) High-speed USB 2.0 (read data) Wi-Fi IEEE 802.11b / g / n
Inbuilt sensors for orientation determination	3-axis MEMS accelerometer 3-axis magnetic sensor
The output of orientation	Azimuth, Tilt
The orientation accuracy	+/- 3 deg
Inbuilt sensors for device health monitoring	Supply voltage sensor, Humidity sensor, Pressure sensor, Temperature sensor
Connector types	2xSMA-A for GPS/Wi-Fi antennas MF2x3 (DS1073-01-2x3-MR2T) – main power microUSB – data retrieving/device configuring DB15 – sensors input, hydrophone input & ±2.5V supply PBS-14 – system connector
Weight	0.095 kg(0.21 lb) – recorder, 0.155 kg (0.34 lb) - accessories
Dimensions	95 x 80 x 37 mm (3.74” x 3.15” x 1.46”)

APPENDIX 1. RECORDER OVERVIEW

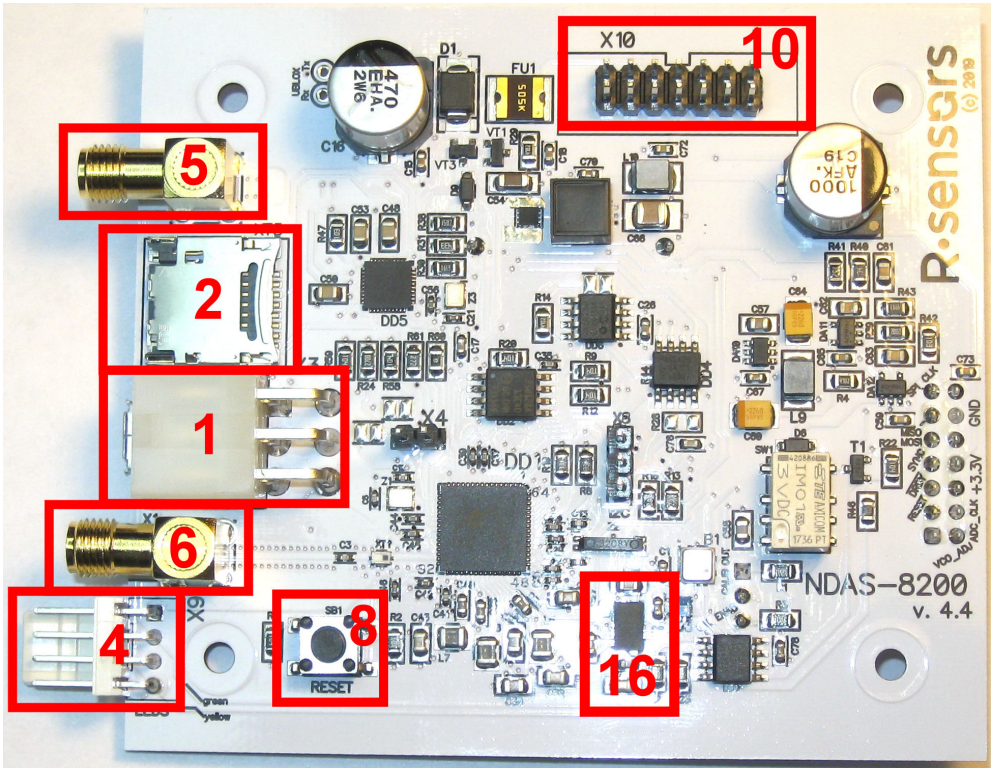


Fig. 1. The processor board. Top view

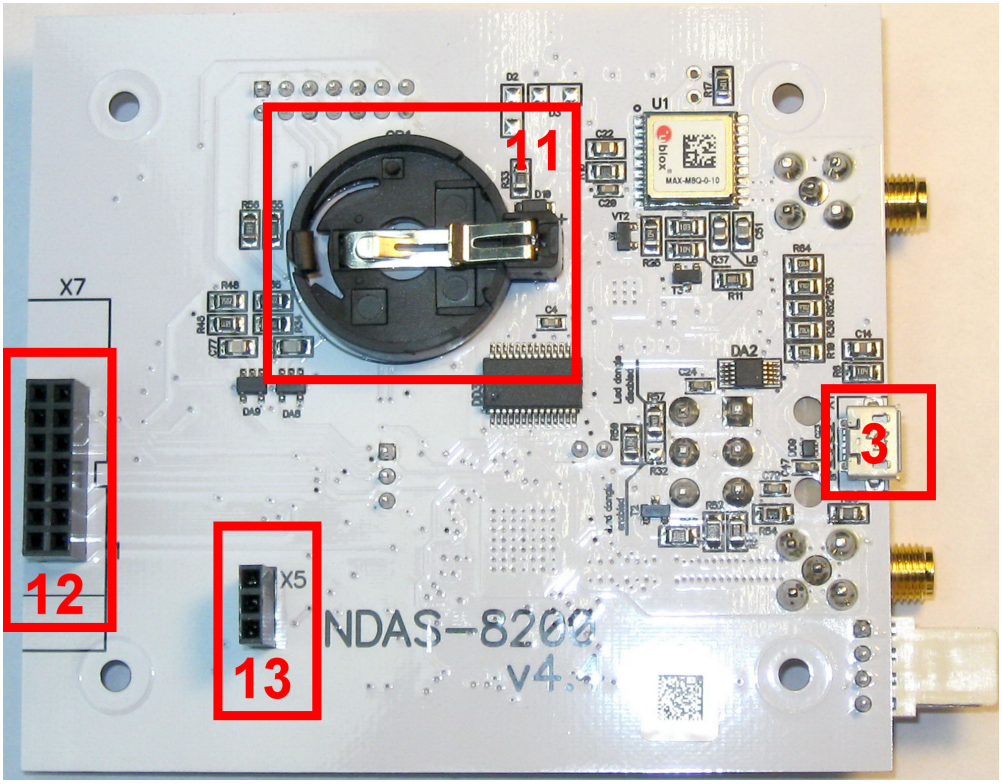


Fig. 2. The processor board. Bottom view

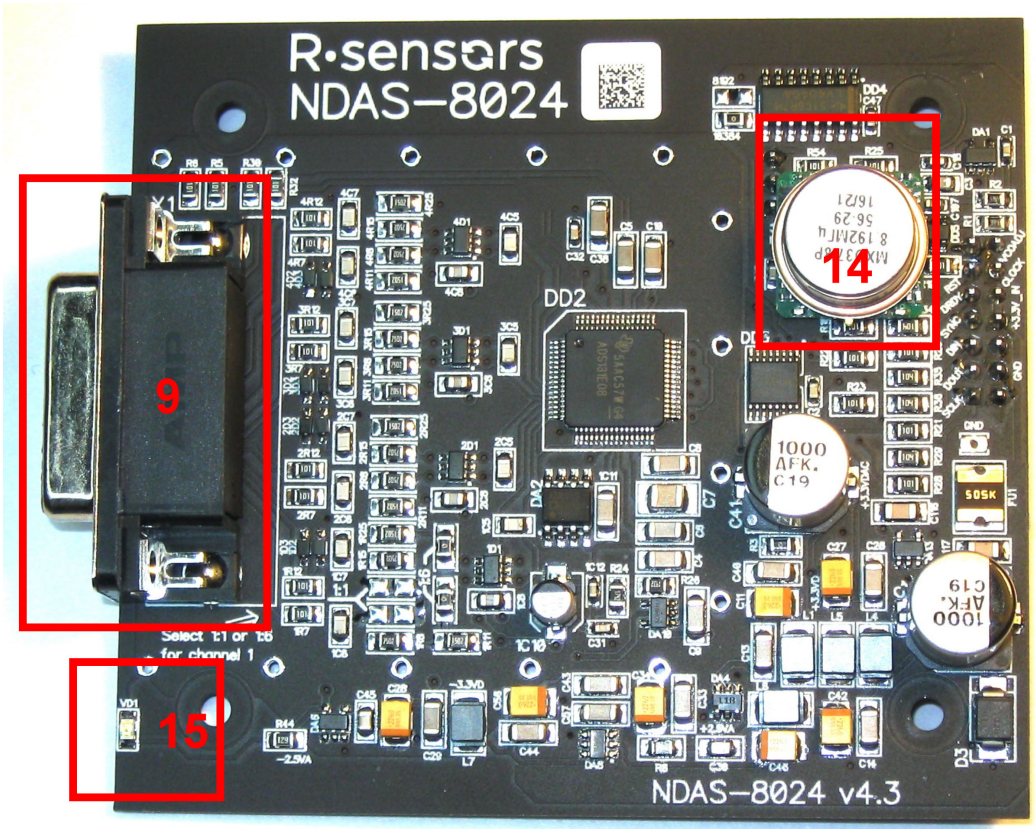


Fig. 3. The ADC board. Top view

Table 1. Marking in fig. 1 -3

No	Purpose
1.	Power connector
2.	SD card socket
3.	Micro USB connector
4.	LED indicators connector
5.	GPS antenna connector
6.	Wi-Fi antenna connector
7.	--
8.	Reset button
9.	ADC input connector
10.	System connector
11.	GPS receiver RTC battery
12.	Boards interconnector
13.	Boards interconnector
14.	OCXO generator
15.	Power LED
16.	Acceleration and magnetic sensor

Table 2. LED operation modes*

Color	Operating mode
Yellow – operating mode	100% off - no recording, schedule is not set 10% on / 90% off - waiting for a start on the schedule 50% on / 50% off - Signal recording in progress Blinking rapidly - incorrect parameters or error
Green - synchronization status	100% off - no satellite signal, no synchronization 10% on / 90% off - there is a satellite signal, no synchronization 90% on / 10% off - no satellite signal, there is a synchronization 50% on / 50% off - there is a satellite signal and synchronization

Magnetic and acceleration axes of sensitivity.

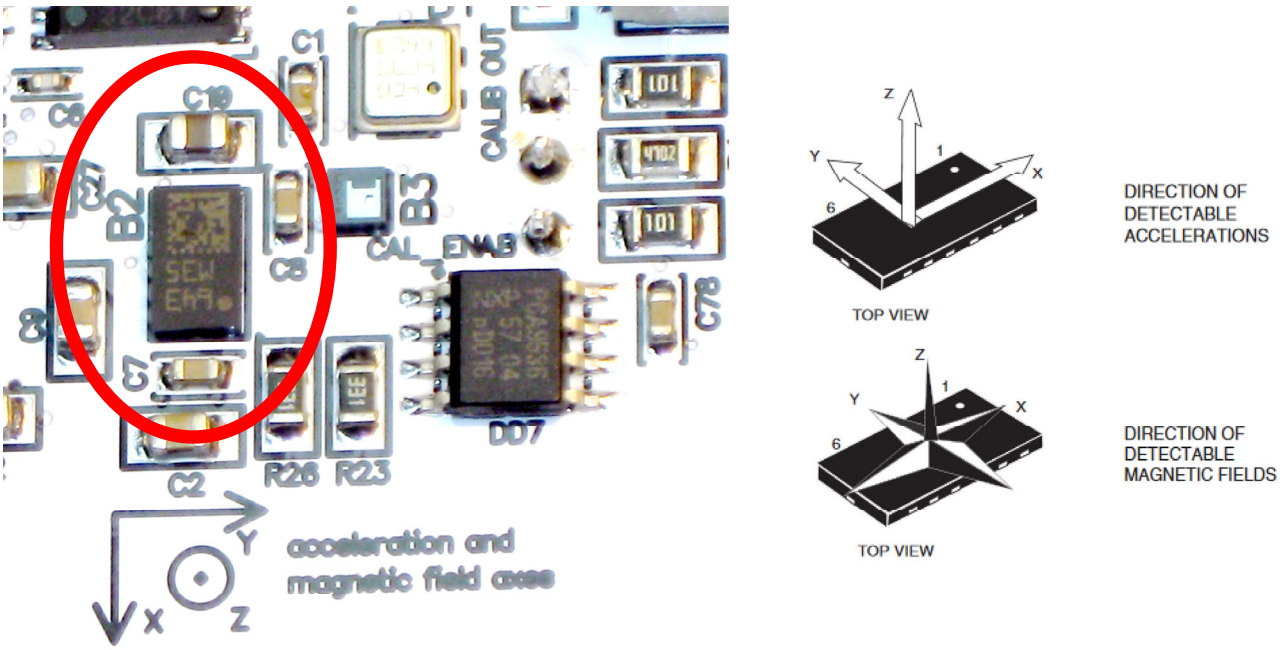


Fig. 4. Acceleration and magnetic sensor (denoted B2 in PCB) axes

* - When power is turned ON both LEDs light up for 1 second 3 times and then go out.

The axes of orientation of the acceleration and magnetic sensor are shown in figure 4. The correct readings of the azimuth require horizontal orientation of the board with tilt less than 5 degrees.

Setting the input divider for channel 1.

The first (hydrophone) channel has the input divider disabled by default. To enable the input divider move two zero-Ohm resistor from their current 1:1 positions (marked GREEN in Fig. 5) to 1:6 positions (marked YELLOW in Fig. 5). The parameters of the 1st channel with the input divider enabled match those of channels 2-4 (geophone channels).

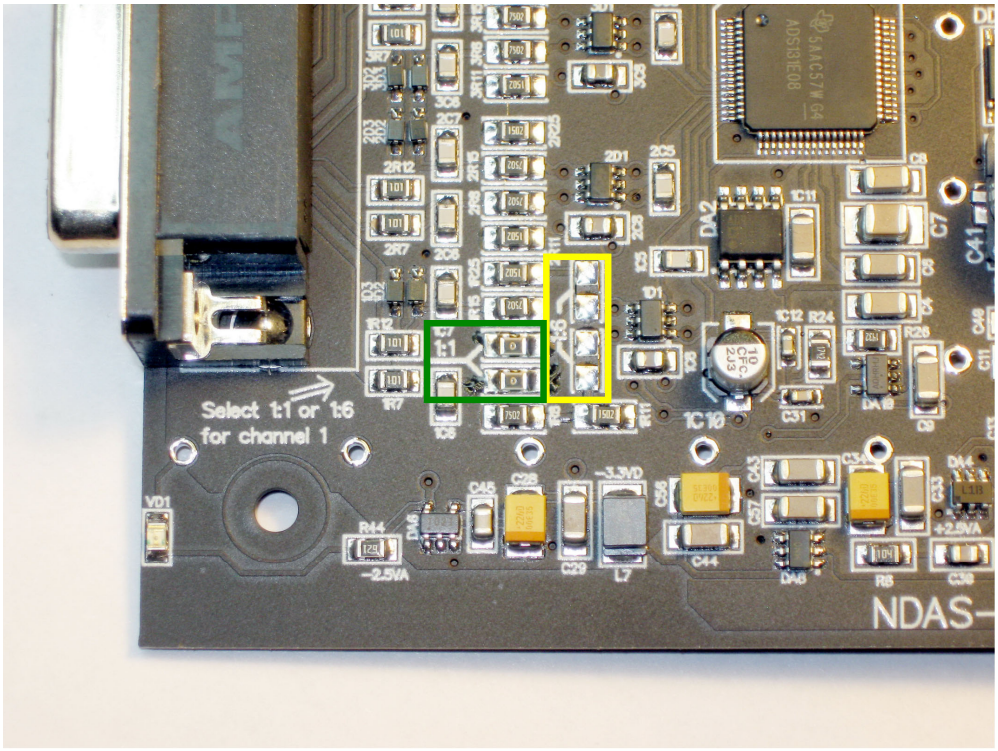


Fig. 5. Channel 1 input divider setting

APPENDIX 2. CONNECTORS AND CABLES

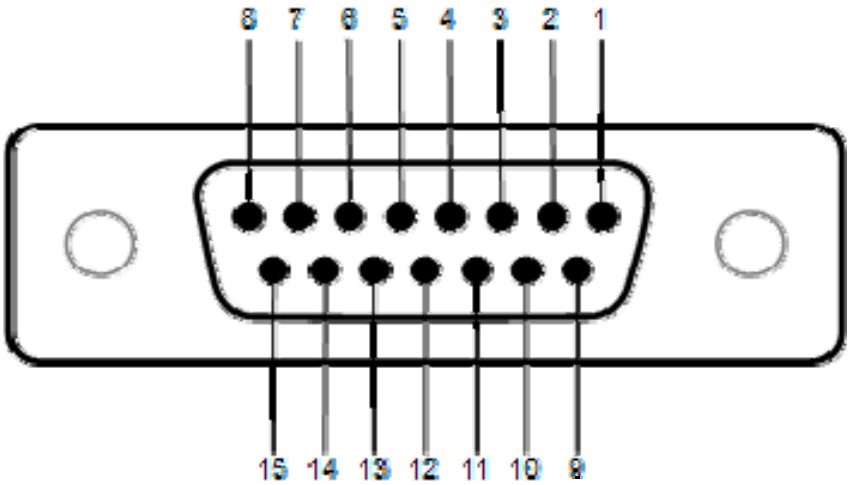


Fig. 1. ADC input connector pinout

Connector type: DB-15F	
Number	**Function**
1	**CALIB_EN**
2	**CH 1- (Hydrophone-)**
3	**CH 2- (Z-)**
4	**CH 3- (X-)**
5	**CH 4- (Y-)**
6	**No connect**
7	**-2.5 V**
8	**GND**
9	**CALIB_OUT**
10	**CH 1+ (Hydrophone+)**
11	**CH 2+ (Z+)**
12	**CH 3+ (X+)**
13	**CH 4+ (Y+)**
14	**No connect**
15	**+2.5 V**

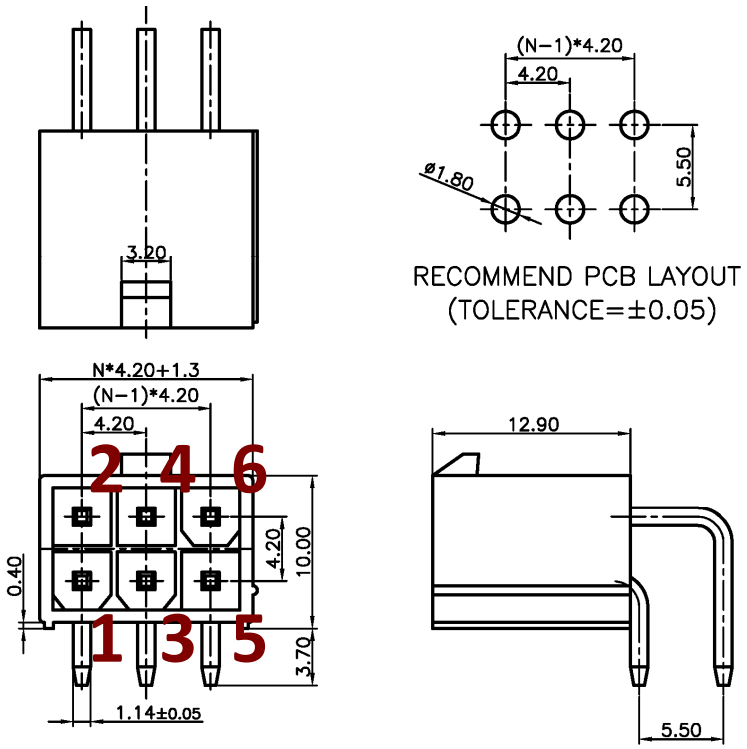


Fig. 2. Power connector pinout

Connector type: DS1073-01-2x3-MR2T6	
Number	**Function**
1	**Battery control (70 V max). Place 1.5kOhm.***
2	**Power "+" (3.7-17 V)**
3	**GND**
4	**Power "+" (3.7-17 V)**
5	**GND**
6	**No connect**

* For correct reading of the battery voltage, place a resistor 1.5 kOhm in series.

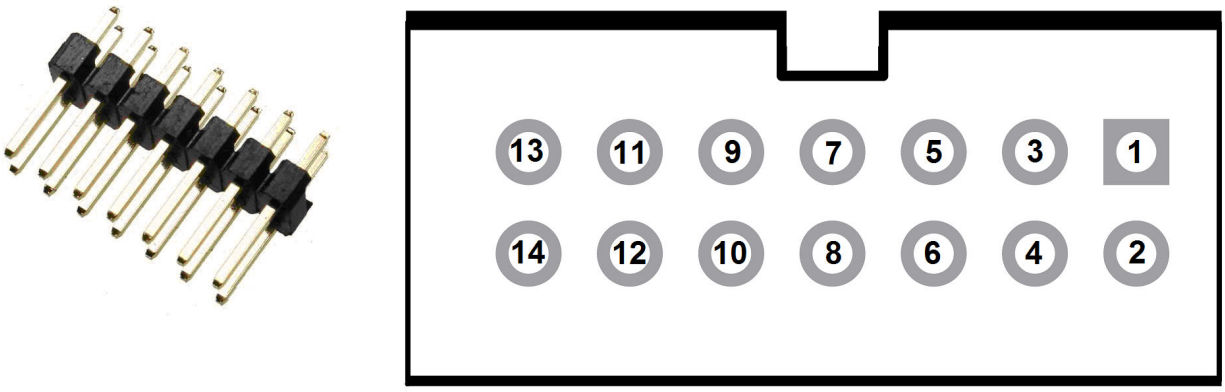


Fig. 3. System connector pinout, top view.

Connector type: DS1021-2*7SF11-B	
Number	**Function**
1	**UART2_RX (*reserved*)**
2	**UART2_TX (*reserved*)**
3	**I2C_SCL (*reserved*)**
4	**I2C_SDA (*reserved*)**
5	**GPIO 2 TimePulse in (*reserved*)**
6	**GPIO 1 Sensor Power (*reserved*)**
7	**ADC1_Input Input Power (*reserved*)**
8	**VCC 3.3V**
9	**Power "+" (3.7-17 V)**
10	**Power "+" (3.7-17 V)**
11	**GND**
12	**GND**
13	**ADC1_Input Input Voltage. Place 1.5kOhm.** [†]
14	**GPIO 3 Wi-Fi status (*reserved*)**

The system connector is mostly reserved for further development and for integration into NDAS-8224SBS underwater stations. However with the same signal present, this connector can be used instead of Power connector.

[†] For correct reading of the battery voltage, place a resistor 1.5 kOhm in series.

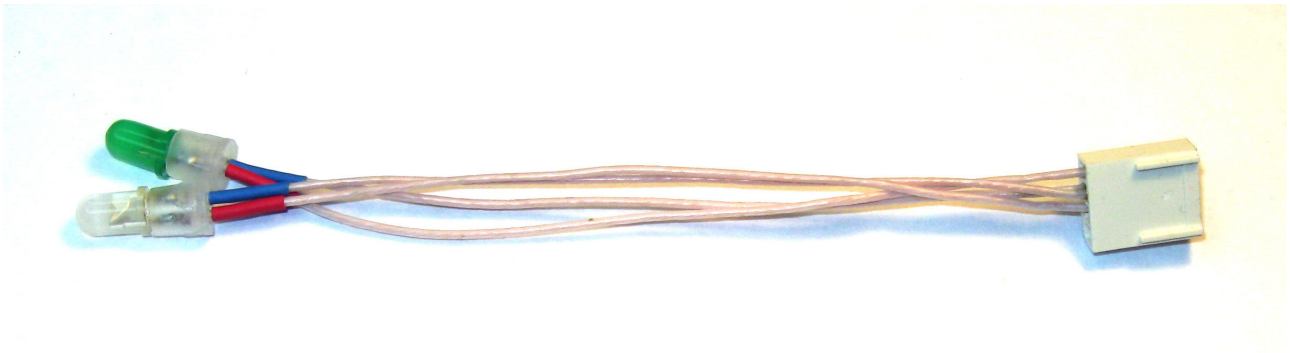


Fig. 4. LED assembly

Connector type: DS1070-4-F	
Number	**Function**
1	**No connect**
2	**Yellow led anode**
3	**GND**
4	**Green led anode**

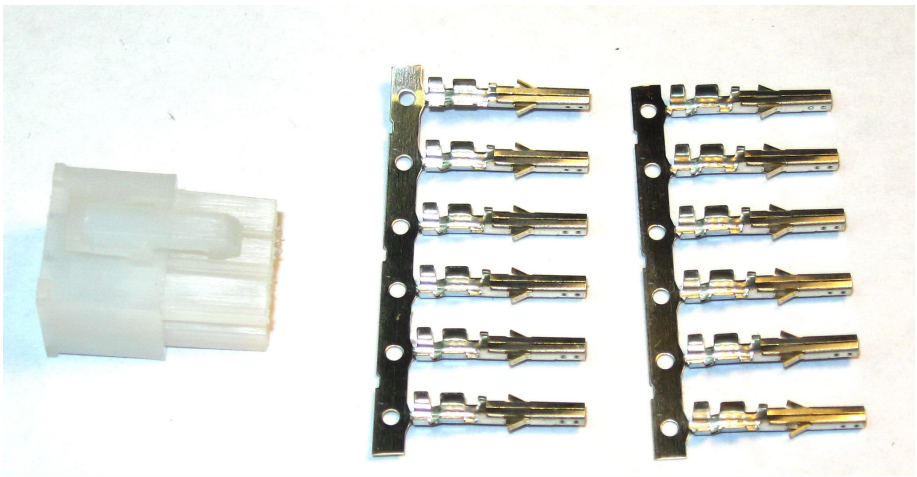


Fig. 5. MF-2x3F connector with 12 DS1073-02-FT cable contacts

Fig. 6. USB-A/microUSB-B 0.3m cable

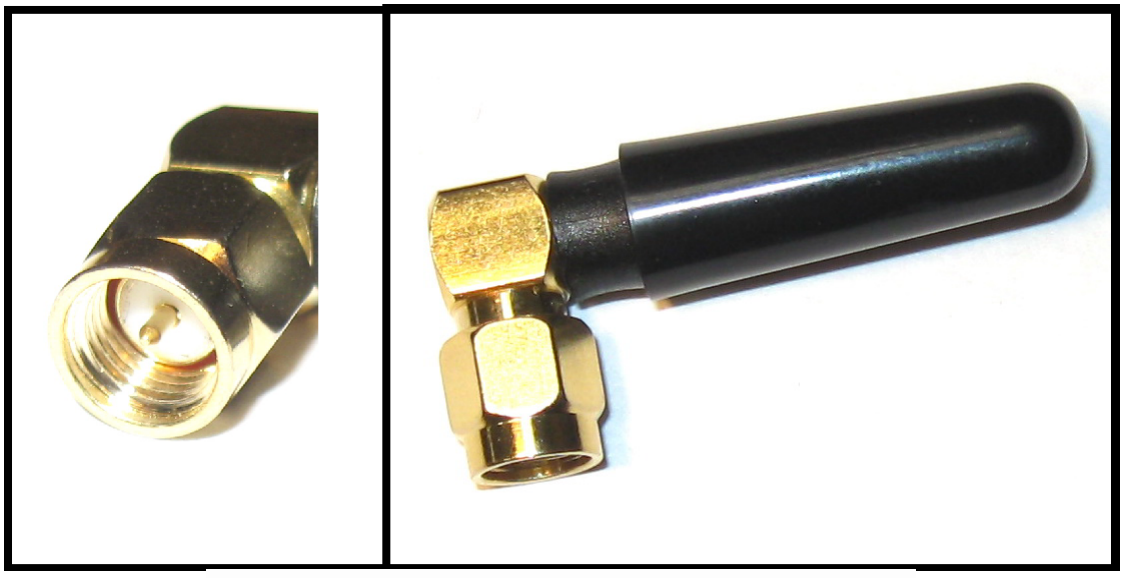


Fig. 7. WiFi antenna – connector, exterior view
(The exterior view of the antenna in the delivery set may vary)

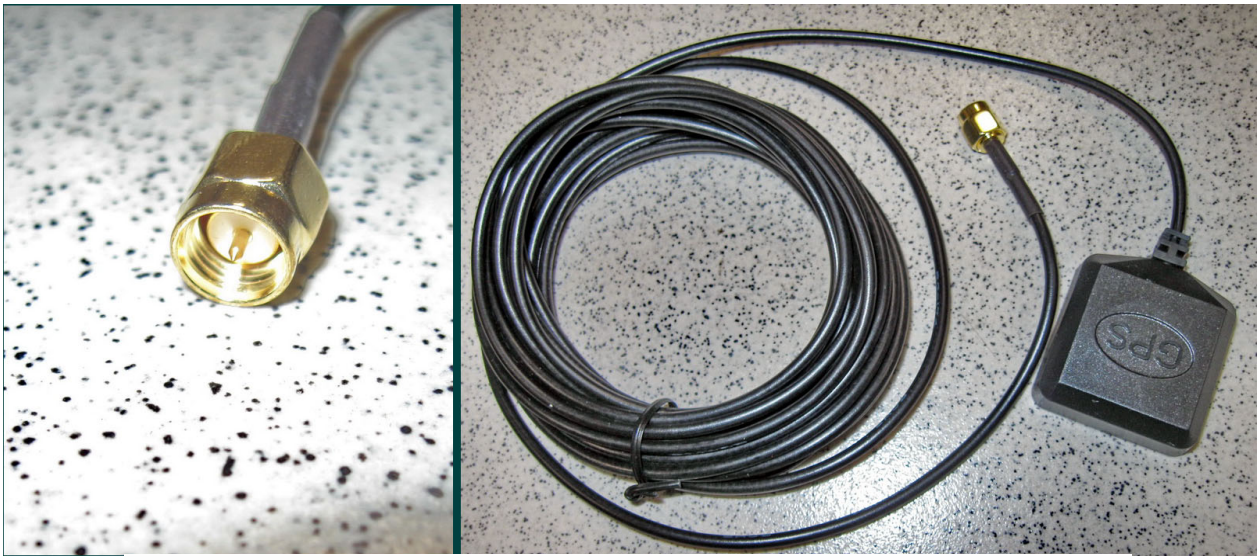


Fig. 8 GPS Antenna with 5 meters cable, connector and appearance

Fig. 9. *SMA-M / RP SMA-M adapter*

Fig. 10. SMA-F / SMA-F case connector

Fig. 11. SMA-M – SMA-M 0.15m cable

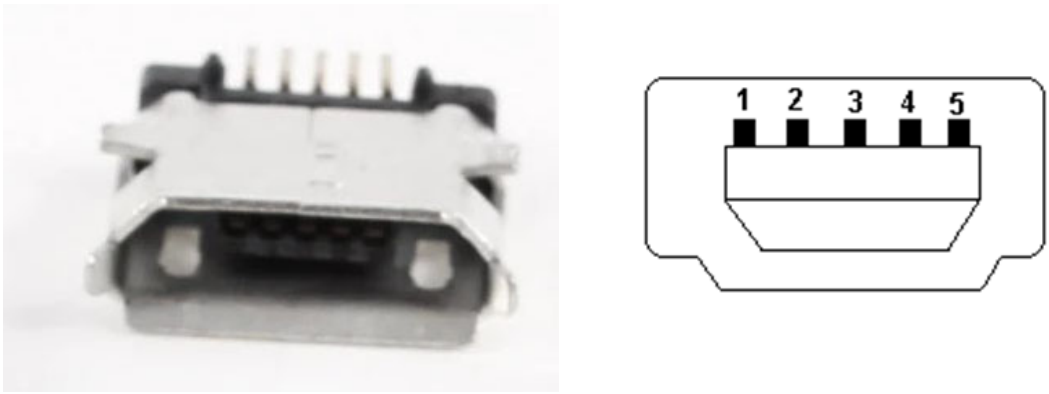


Fig. 12. Micro USB connector

MicroUSB connector pinout:

Connector type: microUSB	
Number	**Function**
1	**Power (5 V)**
2	**Data -**
3	**Data +**
4	**No connect**
5	**GND**