



3-COMPONENT BROADBAND
MOLECULAR-ELECTRONIC DIGITAL
FORCE BALANCED SEISMOMETER CME-6011ND

USER MANUAL



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version 03

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This manual uses the following notations:



- important notice (in orange)



- critical notice (in red)



DUE TO A PERMANENT TECHNICAL IMPROVEMENT AND MODERNIZATION OF THE PRODUCTS, CHANGES WHICH ARE NOT DESCRIBED IN THIS USER MANUAL AND WHICH DO NOT AFFECT THE CONDITIONS OF INSTALLATION, OPERATION AND TECHNICAL CHARACTERISTICS CAN BE INTRODUCED IN THE DESIGN.

1. Overview

The CME-6011ND, a digital 3-component broadband molecular-electronic force balanced seismometer (hereinafter referred to as 'seismometer' or 'instrument') is designed for recording the Earth's surface vibrations in 3 orthogonal directions. The instrument can be used both for permanent seismic stations and for portable field installations.

This seismometer contains 3 identical high-sensitive molecular-electronic sensors – transducers arranged along the three orthogonal axes denoted in picture 1 as Z, N and E and equipped with force feedback, an amplifier's electronic board (later referred to as "analog subsystem") and an autonomous wireless data logger's board (later referred to as "digital subsystem"). All parts are fixed on a single base and placed into a protecting external case. The feedback coil of each transducer may act as a calibration coil and let form and control the standard sensor's responses.

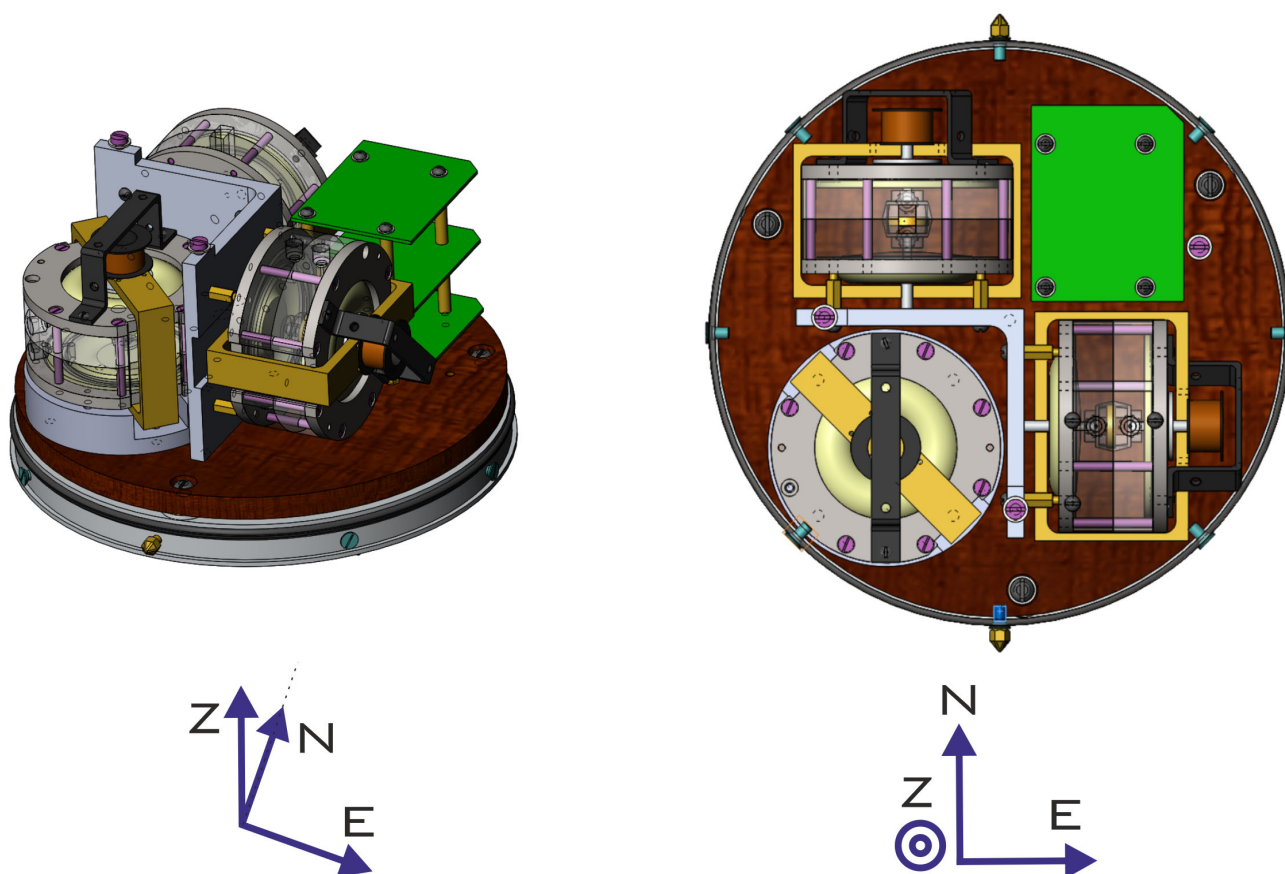


Fig.1 The transducers' geometrical configuration of CME-6011ND.

Each transducer has 2 pairs of mesh electrodes (see picture 2) which are placed into potassium-iodine or lithium-iodine electrolyte. Whenever a voltage is applied symmetrically to both pair of the electrodes, there settles a steady gradient of concentration of ions between the electrodes. As a result, two identical currents start flowing between the both pair of the electrodes.

Being exposed to an external mechanical force due to the seismic motion of the ground, the working fluid inside the transducers is moved between the electrodes of the sensing cells, bringing to or drawing away from them more ions of the dissolved substance. The convective flow of charged ions causes an electrical response at the electrodes, which results in a current difference between the two pairs of electrodes. This electrical response is being amplified and converted into an electrical signal (voltage) by the amplifier board with the amplitude proportional to the velocity of an external action (vibrations of the ground surface). The voltage generated this way is converted into a stream of 32-bit samples, which afterwards are stored on the instrument's memory card or transmitted further via communication channels.

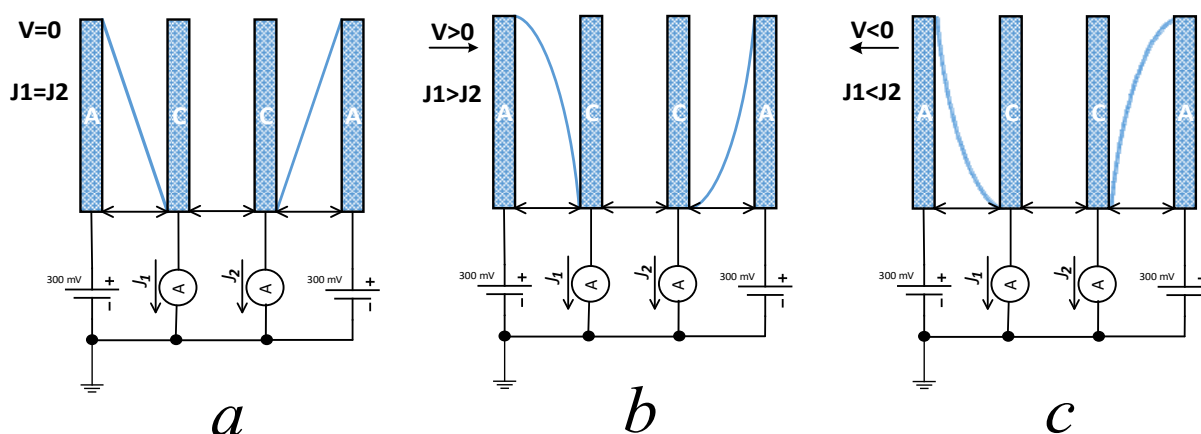


Figure 2. The distribution of active component concentration in electrolyte.
(a – steady state, b and c moving to the right and left respectively).

The following hardware interfaces are used to operate the seismometer:

- A wired connection - USB High Speed (v.2.0) for configuring, control and reading of the acquired data;
- A wireless connection - Wi-Fi IEEE 802.11b/g/n type for configuring, control and reading of the acquired data.

The seismometer is not explosive or toxic and does not cause any pollution to the environment.

2. Delivery set and connectors function

The delivery set includes:

- The CME-6011ND seismometer in a package;
- A 1.5 meter 9-pin connector power cable with pigtails;
- A Standard digital USB A/B cable;
- A Leveling feet set (3 pcs.);
- A Technical passport.

The following items can be additionally supplied:

- A User Manual with appendices – 1 copy per batch;
- A Software CD - 1 copy per batch;
- A DH-20-J09PE-03-001 female connector.

The assignment of the cable wires and connector pinouts as well as the pictures of are supplied in Appendix 2 to this Manual.

The following connectors and indicators are located on the top cover of the instrument:

- A CNLINKO DH-20-C07SX-03-401 multifunctional connector;
- A standard USB-B connector;
- A Green LED for time synchronization status;
- A Yellow LED for operating mode status;
- A Blue LED for Wi-Fi connection strength status.

Location of the connectors, description of the operating modes and location of the indicators are given in Appendix 1 to this Manual.

3. Connection

A unipolar DC power supply with a nominal voltage of 12 or 24 volts should be used to power the seismometer (hereinafter – main supply). The permissible voltage range for the main power supply is 9...36 V. When powered from a 12V supply, the average current consumed by the seismometer is about 100 mA and depends on the input action intensity. At the moment of turning on or whenever a strong input signal is applied, the current can increase up to 270 mA for the duration span of the strong action and for several minutes after the strong signal ceased. It is desirable to use a linear voltage regulated power supply or an accumulator unit.

The power pins for the main supply are located on the multifunctional connector.

In case of configuring, setup or reading of the acquired data the digital subsystem can be connected to a USB port alone. The powering from the main power supply in this case is not necessary. The load capacity of the USB port must be at least 500 mA, which is a standard value. The permissible voltage range for the backup channel is 4.5...5.5 V.



The analog subsystem is functional only when the device is powered from the main supply source. When the device is power from USB solely, the analog subsystem is powered off and not functional, while the digital subsystem is completely operational.



Be careful when applying power to the multifunctional connector! Applying a voltage over 5.5 volts to the USB power pins will damage the instrument.

Different configurations of power supply are given in Appendix 3 to this manual.

For operation using external coordinates and synchronization by the GPS system, a built-in GPS/GLONASS antenna is used, which is located under the radio-transparent cover. No additional equipment is required for the seismometer to operate.

For wireless operation via Wi-Fi connection, a built-in antenna located under the radio-transparent cover is used. No additional equipment is required for the seismometer to operate.

4. Installation and Operation

Unlike traditional broadband electromechanical instruments, molecular-electronic seismometers are extremely durable and therefore not equipped with locks and other special devices for carrying, packaging, unpacking and transportation. The seismometer does not need a mass centering and hence does not have the output of the mass position sensor and the input signal for mass centering. The seismometer does not require a precise level adjustment and operates correctly at installation tilts up to 15°. However, an error in orientation in horizontal plane results in a corresponding error in orientation of axis of sensitivity.

The adjusting feet with two locknuts are screwed into the corresponding holes on the bottom of the seismometer case before using the seismometer.

Place the seismometer on a firm horizontal surface so that the arrow "↑" on the upper plane of the case is oriented to North. Then the pointers in the lower part of the case will be directed along the axis from North to South. Use the pointers to set the azimuth of the instrument precisely. Using the level located on the top cover of the instrument case, adjust the height of the legs to ensure that the seismometer is placed horizontally. Screw the feet into the bottom as deep as possible to minimize the distance between the ground and the sensor. To inspect the tilt angle, use the bubble level on the top cover of the sensor (see fig. 3).

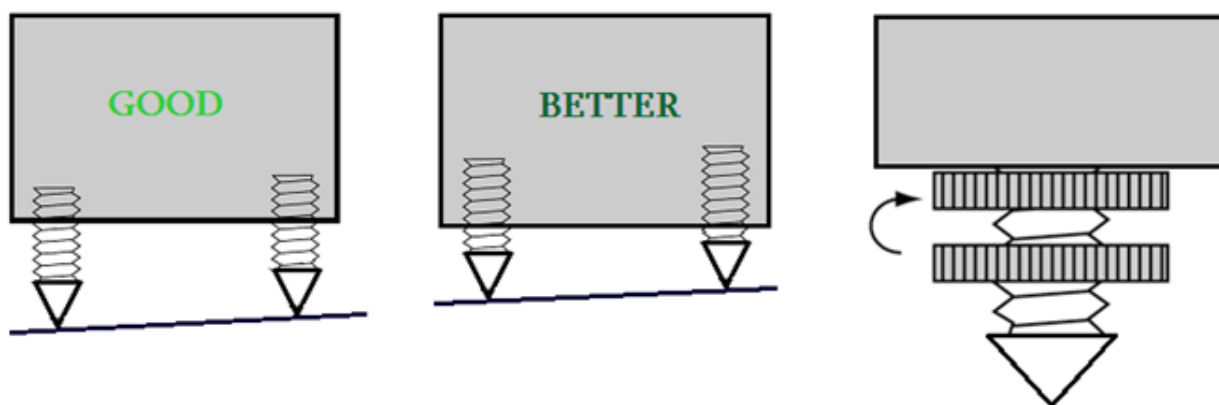


Figure 3. The tips for the sensor's leveling.

After the device is horizontally aligned, secure the legs with the locknuts against the bottom of the seismometer case. Use the pointers on the bottom of the case to accurately align the azimuth of the instrument.

Apply power from the multifunctional connector or from the USB connector.

Operating modes of the digital subsystem of the seismometer:

- Main mode – the instrument is in the standby mode or the data is being logged;
- Card reader mode – the SD card of the seismometer becomes accessible to external devices, data logging is impossible.

4.1. Software installation and Initial settings

4.1.1. Software installation

The NDAS and drivers software are stored on the CD if it is supplied with the instrument. In addition, the distributive of the latest version of the software is available on the FTP server at <ftp://download.r-sensors.ru/NDAS/>

Installation of the NDAS software requires a computer running under Windows OS. Before installing a new version of the software, it is recommended to close and uninstall the old one, then restart the computer if needed. A user guide for installing and operating the software is given in Appendix 4 to this Manual.



Pay attention to the compatibility of the downloaded software version and the firmware of the instrument. Compatible versions of the firmware are specified in the 'Release notes' document in the software distributive folder.

To change the initial wireless connection parameters, you may need to connect the device via USB and use the NDAS program in USB/COM mode to set the required parameters. Use the supplied USB A/B digital cable to connect. Connect the device to the computer's USB port. When you turn it on for the first time, you may need to install the FTDI driver. In most cases the driver is installed automatically by Windows. In addition, the driver is included in the software supplied with the device. Run the NDAS program by selecting the COM port connection.

The drivers are available to download from the FTP server at <ftp://download.r-sensors.ru/NDAS/Miscellaneous/NDAS%20One%20FTDI%20Drivers/> or from the manufacturer's website at <http://www.ftdichip.com/Drivers/VCP.htm>

4.1.2. Initial wireless settings

By default settings, the seismometer operates in the 'station' mode and uses the following wireless network parameters for connection:

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

If your network parameters differ from the specified, you will need to connect the seismometer via USB connection and use the NDAS software to set the required wireless connection parameters.

4.1.3. Wireless connection modes

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

- ‘Station’ mode – connection to network via a Wi-Fi router;
- ‘Access point’ mode – connection directly to the instrument.

In the ‘access point’ mode, the instrument creates its own Wi-Fi network, with the name consisting of the specified SSID of the network defined from the settings, and the serial number. For example, if you specify ‘NDAS’ in the SSID parameters, the seismometers will create a networks with the names of NDAS_RS003601 and so on.



In the ‘access point’ mode, the network password must have at least 8 and no more than 20 characters length.

Static IP settings are required to operate in networks without a DHCP server. This option is only available in the ‘station’ mode. In the ‘access point’ mode, the instrument has its own running DHCP server, which always assigns the IP address 192.168.37.1 to the seismometer.



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

4.2. Operation in the Main Mode

The NDAS software is needed to manage and configure the instrument via USB connection.

The control and configuration of the seismometer connected to a Wi-Fi network can be carried out by means of both the NDAS software and the instrument’s web interface.

4.2.1. NDAS software

The NDAS software can provide the following:

- View the current status of the seismometer (voltage, free space on the memory card, presence of Wi-Fi and GPS signals, time synchronization status, other available parameters);
- Setting the parameters of SSID wireless network, password, safety modes;
- Changing of configuration parameters (sampling rate, setting the scheduled records, setting the input gain of the channels);
- Manual start and stop of registration;
- Preview of the received data on the fly;
- Operations with the built-in SD card (clear, start registration, switch to the data reading mode);
- Emitting of testing signals.

4.2.2. Web Interface

The web interface is optimized for easy configuration of NDAS devices on smartphones and tablets. The web interface can be accessed via a browser on any device connected to the same network as the seismometer itself. The web interface allows you to perform the same operations as the NDAS software, but for editing the schedule recording table as only the first row of the table will be available for editing.

To access the device by IP address, type `http://xxx.xxx.xxx.xxx` in the address bar, where xxx.xxx.xxx.xxx is the device's IP address (for example, 192.168.0.192).

The access to the web page with the settings can be performed by entering the local domain name of the instrument represented as `<serial>.local` (for example, *RS003601.local*) or directly via the instrument's IP address.

A detailed user guide for the web interface is provided in Appendix 5 to this Manual.

4.2.3. FTP server

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

To access the FTP root directory, type with the prefix "FTP" the IP address of the instrument e.g. <ftp://192.168.0.100> or in case the Bonjour service is available, the local domain name e.g. "ftp: //rs003601.local". The server accepts any username and password.

A detailed user guide for handling the FTP server is provided in Appendix 6 to this Manual.



The FTP server is unavailable whenever the instrument is set in card reader mode.



If the data is being registered, the FTP server allows you to download all files except for the files that are currently open for writing – the current SIVY file as well as the current 1-Hz record file.

4.2.4. Safe modes of FTP and Web-servers

Safe modes are designed to prevent data loss for the cases in which access to the interface and file system is open to a wide range of users. In the safe mode of the web interface, the instrument parameters can't be changed and start and stop commands are blocked. Only reading of the instrument's parameters and preview of the acquired data are available. The safe mode of the FTP server restricts access to the file system with the 'read only' mode. The safe mode settings can only be changed through the NDAS software only.

4.2.5. Serial port and Log display

All major events of the instrument firmware come along with corresponding log messages which are translated to the serial port of USB connection and can be displayed by programs for operating with the terminal. In the Windows environment, such programs include 'Tera term', 'DockLight', 'Terminal by Bray' and so on. Specify the following values to configure the serial port:

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



When using a wired connection, the NDAS software also communicates with the instrument through the serial port so in this case you should disconnect all terminal programs which can block access to the port. And vice versa: the NDAS software will block access to the serial port for other programs.

The NDAS software communicates with the instrument through the serial port by means of an internal communication protocol. Upon the receipt of the first package which has a corresponding format header, the instrument switches to the protocol communication mode. In this case, all messages of the log file are also packed into the NDAS package format but, if necessary, the message body can still be read by any terminal program.

4.2.6. File System

The main directory of the instrument is a folder named 'RS_XXXXXXX' where 'XXXXXXX' is a serial number of the seismometer. Inside the main directory the instrument creates subdirectories, which are called 'working directories' with signal records as well as the 'LOGS' directory in which working logs are being stored.

The system sets up a working directory at the time of creation of the first record file. If there are valid data on the current time at the time of creation of the directory, the name of the working directory will be formed according to the principle of 'YYYY-MM-DD' that is year-month-day. If there is no time information, then the name will include 'NO_TIME_XXX' where 'XXX' is the next number in the order.

The working directory remains unchanged during the time of the instrument's continuous operation except for the following two cases:

- If the working directory was created in the absence of time data, then after the synchronization procedure is completed, the working directory will be changed and all subsequent data will be written to the directory with the correct name.

- After switching the instrument from the card reader mode back to the main mode, the file system is initialized that results in updating the working directory.

Inside of the working directory, the instrument creates recording files with a name of 'YYYY-MM-DD HH-MM-SS' that is 'year-month-hour hour-minute-second' corresponding to the actual start time rounded off to a second. Recording files have an extension of '* .siv'.

When you turn on an option of registering an additional 1-Hz signal in the working directory, a subdirectory with a name of '1Hz' is being created which holds additional files being recorded.

The 'LOGS' folder contains text files of the system log with a format name of 'LOG_xxx' where 'xxx' is a file sequential number. The contents of files duplicate text messages which are transmitted to the serial port by the instrument. The maximum size of a log file is limited to 1 Mb, as soon as the size is exceeded, a new file with the next sequence number is created. The data are written consecutively and in case of a reset, the recording continues to the latest file.

4.2.7. Time Synchronization

This instrument automatically associates the recorded data with the exact time received by the GPS/GLONASS receiver. The process of synchronizing the system clock with the exact time can take from a few seconds up to 30 minutes – it depends on temperature conditions, the time which has passed from of the latest synchronization and conditions for receiving the satellite signal at the installation place. The synchronization process goes through several stages:

- After connecting the GPS/GLONASS antenna, the receiver searches for satellite signals and, in case of a steady signal, provides a solution to a navigation task – it determines coordinates and time. At this point, the 'GPS' flag lights up in the NDAS software window and the 'GPS' LED on the case starts blinking slowly;
- The clock generator is being adjusted - till a fine-tune to the clock;
- After the adjustment is completed, the system clock is corrected with an accuracy better than 1μs. At this point, the 'SYNC' flag lights up in the software window and the 'SYNC' LED on the case starts blinking regularly.
- After the synchronization is completed, you can turn off the GPS antenna – this will not affect the instrument's normal operation.
- However, if a GPS signal is present during the recording, the instrument will continue to adjust smoothly a frequency of the clock as well as to put time stamps each minute and measure the current drift of the clock. This will significantly improve a time accuracy of recording and will improve the correlation of recording of two devices operating independently.



The time synchronization is retained until the instrument is being reset. In most cases changing of parameters of the instrument results in its reset and loss of synchronization as a result.

To convert the GPS time into UTC correctly, the system maintains up-to-date information on coordination seconds, also known as leap seconds. Updating the number of seconds of coordination may occur once in six months just before January 1 and July 1. Changing the number of seconds of coordination may require updating the instrument's firmware. Recalculating the seconds of coordination may take up to 15 minutes and the time synchronization can be performed only after the process of recalculation is over.



In order maintain the integrity of the record whenever at the zero time of January 1 or July 1 the data logging is running, the time will not be corrected even in case the amount of leap seconds were changed until the next stop of the recording.

4.2.8. Registration Modes

There are 4 modes of the registration:

- Manual mode – registration is started and stopped manually through the NDAS software or WEB-interface;
- Immediate start – registration starts automatically when the instrument is turned on;
- Synchronous start – registration starts automatically after the synchronization is done;
- Operation by the schedule – registration starts and stops automatically at a set time.

The GPS synchronization is not necessary in the manual and immediate start modes. In case the signal recording started before synchronization, the files header will miss data of the exact time and the files will be placed in a folder of 'NO_TIME_XXX' where 'XXX' is a sequence number.

If during the registration that was started before the synchronization, a GPS signal will appear – the instrument will start a synchronization procedure without interrupting the recording. In this case, once the procedure is completed, a new working folder with a correct name will be created and the next data block will be written to a new file that has the correct timing data.

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

While in operation by the schedule, the signal recording starts automatically at a set time with an accuracy of up to one count. Registration in this mode always starts after synchronization being done, but after the instrument is synchronized, the presence of a GPS signal is not necessary until the moment the power is turned off or the instrument is reset.

The instrument finds the time-nearest row in the table and waits for the start time. If the acquired current time is within one of the intervals set up by the table, the recording starts immediately from the next whole minute. In any case the registration will stop at the end of the current table interval. Then the instrument proceeds to the next row of the table.

When the end of the table is reached, the instrument switches to the manual mode. If the 'shutdown after finish' option is set – the instrument goes into a hibernation mode which results in a reduced power consumption. The return from the hibernation mode can be done via switching the power supply.

In case of a power failure while the scheduled recording is being performed, it will resume only after the synchronization with a GPS signal is restored. The presence of a GPS signal in this case is necessary to resume a schedule recording.

4.2.9. Cyclic Recording Option

If the option of a cyclic data recording is enabled and there is not enough space on the SD card, the software starts deleting the oldest files to free more space. While using this option, you have to pay attention to the following:

- Scanning of files occurs only inside of the logger's main directory – meaning the directory named 'RS_xxxxxxx' where 'xxxxxxx' is the serial number of the seismometer. All other directories are ignored;
- Scanning occurs only among files with the extension of '.siv'. All other files are ignored;
- If after the cleaning procedure no files remain in the directory, then such a directory is also deleted;
- A time attribute of the file modification is used as an evaluation criterion.



Be careful when using the cyclic recording option if there is no time synchronization. When you turn on the instrument, the clock starts from the same moment – on January 1, 2017, so the files will be deleted in the sequence which differs from the one the files were actually written.



Avoid configurations in which a large number of small files will be created on the instrument – this can lead to a slower operation of the file scanning function and also may lead to a data loss.

4.2.10. Option to record an additional signal of a 1-Hz frequency

When you turn on the option of recording an additional signal, in addition to the main data the instrument starts recording additional files with a 1-Hz sample rate. The files get into a subdirectory called '1Hz' and are named by the same principle as the main files except for the '1Hz' suffix.

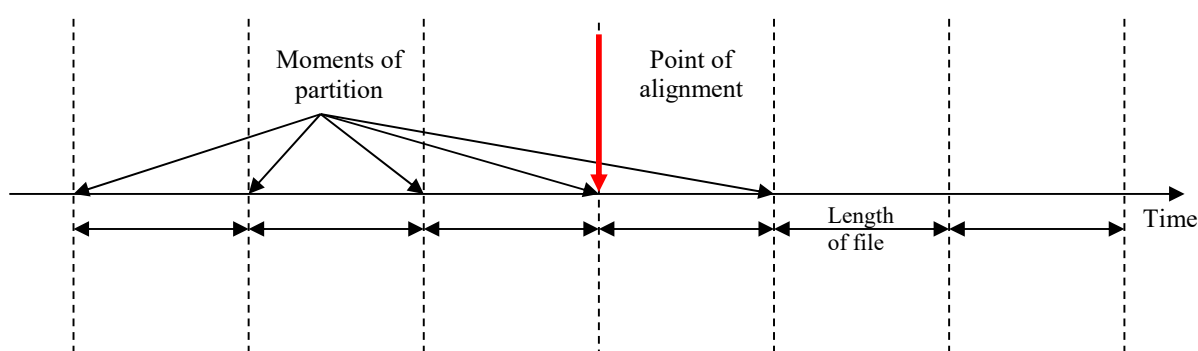
In general, main and additional files are created synchronously (at an accuracy of 1 count) and have the same name but there are possible situations in which they will be desynchronized:

- If the SD card was removed during recording and then inserted back;
- If, in the schedule recording mode, the memory card was installed after the synchronization had been performed and the start time had been skipped;
- If the working directory of the software has been changed during a time synchronization process.

In all the above-mentioned cases, the registration module firmware will create new files on the memory card with the earliest data stored in the buffer being the beginning of these files. Since the buffer size and the amount of data in the buffer for different signals and at different times are different, the start time of the files will also differ.

4.2.11. Option to align the beginning of files to a certain time

An option to align the beginning of files to a certain time affects the moment at which the partition is made and a new file is opened. This option is useful in a case when it is necessary to get records of the same time intervals from several instruments that are not started synchronously (not in the table mode). The moments of 'partition' are counted from the alignment time through intervals that are multiples of the specified length of the files. The algorithm is shown in the figure below.



Example 1.

A length of a file is 3 hours, a point of alignment is 17 July 2018, 16:00:00.

The record starts on 17 July 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.

A length of a file is 1 hour, a point of alignment is 01 January 2017, 00:30:00.

The record starts on 17 July 2018 at 12:43.

A new file will be created at 13:30, then at 14:30 and then in the middle of each next hour.

Example 3.

A length of a file is 24 hours, a point of alignment is 01 January 2017, 18:00:00.

The record starts on 17 July 2018 at 13:30.

A new file will be created at 18:00 and will continue to be created every day at the same time.

4.2.12. Data Filtering

The instrument's analog-to-digital converter generates a signal with a sampling rate of 1000 Hz. Output signals with frequencies below 1000 Hz are generated by a decimation going along with an anti-alias filtering of high frequencies.

FIR (finite impulse response) filter cascades with a linear phase response are used as filters. Contact the manufacturer to learn more about the filtering algorithms.

General characteristics of the filters are presented in the table below:

Finite impulse response, Hz	Delay*, msec	Edge of passband, Hz	Edge of stopband, Hz	Unevenness of frequency response, mdB	Coefficient of suppression, 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

* - Delay of a cascade of anti-aliasing filters presented without consideration of an additional signal delay caused by the ADC inner circuits which is 4.5 msec.

4.3. Operation in the Card Reader Mode

The Card Reader mode is used to transfer quickly the recorded information from the SD-card of a seismometer to a PC for further processing. To use the seismometer in the card reader mode, connect it to a PC using a USB A/B standard digital cable.

Switch the seismometer to the card reader mode using the 'card reader' command of the NDAS software or the web interface. The seismometer in this mode can be powered via either of USB ports or via the main power channel.



To give the command to switch to the data reading mode, the NDAS software must have either a wireless or USB connection with a seismometer.

In the card reader mode, the seismometer's SD-card looks like an ordinary external flash drive with all operations – read / write / format - which are similar to a standard USB drive under a PC operating system.

The instrument automatically escapes of the data reading mode when the USB-B cable for files transfer is disconnected as well as after a reset. In addition, the mode can be switched off by means of the NDAS software or the web interface.



The FTP server can be used to read data over the network (see section 4.2.3).
If the instrument is in the card reader mode, the FTP server becomes unavailable.

4.4. Firmware Upgrade

NDAS series instruments manufactured after 2018 have a built-in bootloader which allows to perform a secure update of the firmware, the license file and the web interface pages.

Each time the instrument is powered on or reboots, the loader checks the root directory of the memory card for the presence of the following files, and, if any, updates them:

- ndas_firmware.bin – a firmware file;
- ndas_bootloader.bin – a bootloader file (**unsafe – see the note below**);
- ndas_license.dat – a license file;
- ndas_webserver – a folder containing html-pages of the web interface.

To update, place the file or folder into the root of the instrument's memory card in any available way, you have to be sure that the name is correct, reset the instrument and wait until the update process is completed. The process goes along with alternating frequent flashing of the LEDs, after this process is successfully completed, the LEDs go into a normal mode.

If necessary, during the time of updating you can watch the messages display in the log file by means of one of the terminal programs (see section 4.2.5). All messages also get into BOOT_LOG.txt which is created in the main directory of the memory card.

Make sure the firmware version has been changed through the NDAS software, the web interface or the contents of the log file.

The files for download and the latest information about the changes and compatibility are available on the FTP server at <ftp://download.r-sensors.ru/NDAS/>



If the firmware update is interrupted or failed, the instrument will boot in a safe mode using the default firmware. In this case you need to retry the update.
The version of the latest boot can be checked through the NDAS software, the web interface or through the log file on the memory card.



The bootloader updating procedure ('ndas_bootloader.bin') is unsafe. In case of an error or a power failure, the instrument will stop operating during the update process. To restore the functionality, it will be necessary to repair it at the manufacturer's facility, therefore it is not recommended that you update the loader without a strong necessity.

5. Conditions of operation

The seismometer is protected from fluctuations of temperature and atmospheric pressure, however, to reduce a level of undesirable effects caused by temperature changes and air convection, it is recommended covering it with a casing of porous heat-insulating material (foam, polyurethane foam and the like).

After unpacking, installing and connecting, the instrument will be operational within 10-15 min. Within first 24-72 hours, depending on the ambient conditions, the noise level will be little higher and sparse spikes may occur in the output signal. This is normal for settling.

In accordance with the international standard of a dust and water protection, the seismometer's degree of protection is IP 67 that is no ingress of dust (dust-tight) and allowable immersion, up to 1 meter (3 ft 3 in) depth for 30 minutes (water does not penetrate in the amount which can interfere with the operation).



The instrument must not be immersed in water for long periods of time or be installed in water-flooded areas without an additional protection!

6. Calibration

Analog circuits of the seismometer have a flat-speed response in the entire bandwidth with a -3 dB slope at the edges of passband. The analog circuits are calibrated and adjusted with a ± 1 dB precision.

The seismometer is capable to self-test for a vertical channel by giving reference signals of a sinusoidal and rectangular shape. Horizontal channels do not have a capability to self-test due to absence of feedback circuits.

7. Carrying and Storage

The seismometer is quite strong and practically is not subject to damage during transportation. Use packages provided with the seismometer or any packaging materials to prevent damage to the connectors and scratches on the case. A temperature range for storage is from -15 to +70°C (low temperature version -40...+70°C).



It is not recommended to turn the device upside down or keep it in lateral position during transportation. The transportation in these positions will result in longer settling period with higher noise level.

8. Warranty and Service

The warranty period of the product is 18 months. Within this period the instrument which proves defective should be returned to the manufacturer for free repair or replacement.

This warranty shall remain valid provided there are no signs of opening and/or external damage to the housing resulting from abnormal use of the device.

After this period the regular repairing charges will apply.

9. Manufacturer Information

Manufacturer:

R-sensors LLC

Likhachevsky lane 4, Bldg 1, Office 101, Dolgoprudny, Moscow region, 141701, Russia

Tel.: +7 (498) 744-69-95

E-mail: r-sensors@mail.ru, web site: <http://r-sensors.ru/>

10. Specifications

10.1 Electrical Specifications

Supply voltage, main source	12/24 V DC nominal (9 – 36 V permissible range)
Supply voltage, auxiliary source (USB)	5 V DC nominal (4.5 – 5.5 V permissible range)
Power consumption* from the main source during stand-alone recording nominal / peak	1200 mW / 3250 mW
Power (Current) consumption** from the auxiliary source nominal / peak	650 mW (130 mA) / 900 mW (180 mA)

10.2 Mechanical Specifications

Connector types	DH-20-C09SX-03-401 9-pin multipurpose male connector USB-B – a high-speed USB port
Weight	8.0 kg
Dimensions	Diameter: 204 mm Height (handle excluded): 208 mm Height (handle included): 250 mm
Case material	Body - stainless steel Upper cover - caprolone

* - depends on the input action intensity and operation mode

** - see notes on page 7

10.3 Analog subsystem

Sensor type	Molecular-electronic seismic velocimeter
Axes (sensors)	3 Cartesian axes – Up (Z), North (N), East (E)
Axes (output axes)	3 Cartesian axes – Up (Z), North (N), East (E)
Conversion coefficient	2000 V/(m/sec)
Output signal type	analog, differential
Clip level	± 20 V (or ± 10 mm/sec)
Bandwidth (options)	30 sec (0.033 Hz) – 50 Hz (default) 30 sec (0.033 Hz) – 100 Hz (optional) 60 sec (0.0167 Hz) – 50 Hz (optional) 60 sec (0.0167 Hz) – 100 Hz (optional) 20 sec (0.05 Hz) – 50 Hz (optional)
Maximum installation tilt	$\pm 15^\circ$
Temperature range (options)	- 12..+55°C - 40..+55°C (low temperature)
Output impedance	1000 Ohm
Self noise at 1 Hz	2.5 nm/sec (5.0 μ V)
Dynamic range at 1 Hz	132 dB
Integral noise in the band 0.0167 (60 sec) – 50 Hz 0.1 (10 sec) – 20 Hz	36.6 nm/sec (71.2 μ V) 9.0 nm/sec (18 μ V)
Cross-axis coupling	-60 dB

10.4 Digital subsystem

ADC type	Sigma-delta
Number of channels	3
ADC sampling rate	1, 5, 10, 25, 50, 100, 125, 250, 500, 1000 Hz
ADC resolution	24 bit
ADC effective number of bits	21.6 bits at 100 sps
ADC signal to noise ratio	131.8 dB
Data recording format	Internal, converter to binary (float), miniSeed, SEG-Y, ASCII, SAC
GNSS receiver	GPS / GLONASS
GNSS timing accuracy	< 1μS
Reference clock stability	±0.5 ppm
Data recording mode	Manual, schedule, autorun on power-up, autorun on GPS synchronization
Data storage	32 Gb micro SD flash storage (class 10)
Data transfer protocols	Full-speed USB 1.1 (configuration) High-speed USB 2.0 (data reading) Wi-Fi IEEE 802.11b/g/n (wireless)
Temperature range	-25...+85°C – Extended Temperature microSD -45...+85°C - Industrial Temperature microSD
Inbuilt sensors for instrument's health monitoring	Voltage supply, temperature sensor, compass, tilt.
Sensors calibration	Pulse, sinus

APPENDIX 1. LOCATION OF CONNECTORS AND MODES OF INDICATION

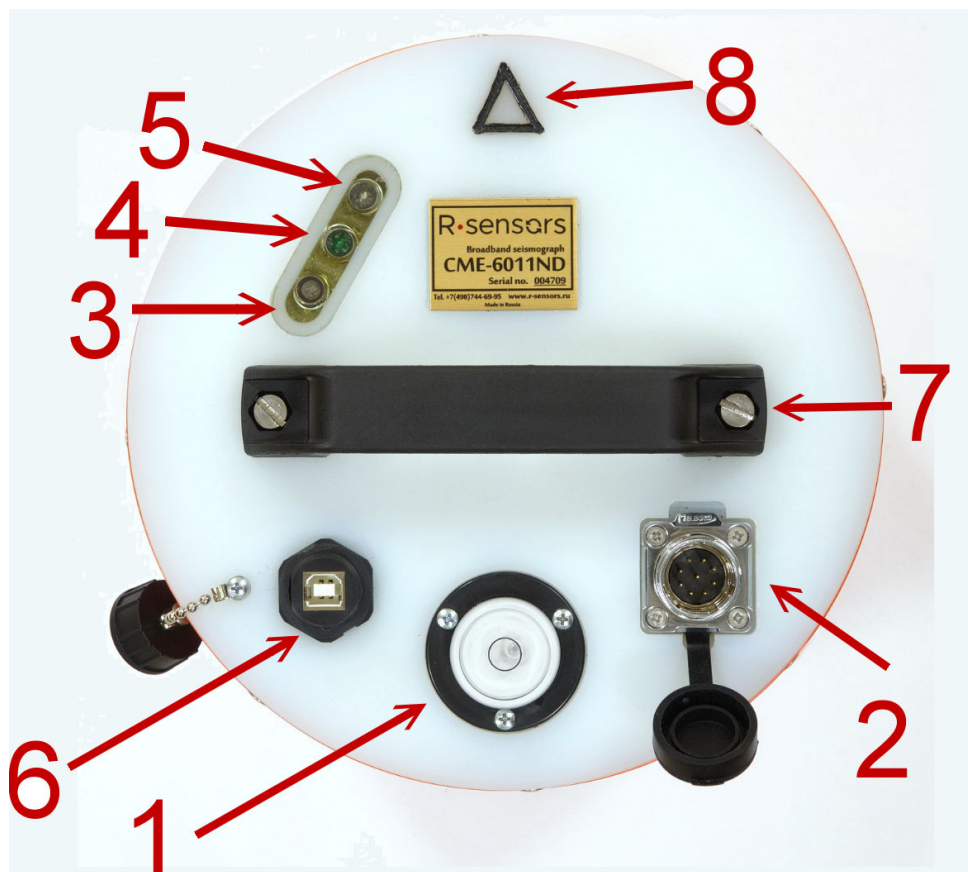


Fig. 1. Connectors and Indicators

Table 1. Denoted in the figure 1.

№	Purpose
1	Bubble level
2	Multifunctional connector
3	Yellow LED 'REG' (mode of operation)
4	Green LED 'GPS' (synchronization status)
5	Blue LED 'WiFi' (wireless connection status)
6	USB-B connector
7	Handle
8	North (N axis) direction arrow

Table 2. Modes of LED Operation*

*After powering or reboot while the firmware is being loaded, the LEDs flash ‘frequently’ for 4-8 seconds, then go out.

Color	Mode of Operation
Yellow – mode of operation	<p>2% on / 98% off – no recording, no schedule set up</p> <p>10% on / 90% off – waiting to start on the schedule</p> <p>50% on / 50% off – signal recording</p> <p>Frequent flashing - incorrect parameters or error</p>
Green – synchronization status	<p>100% off – no satellite signal, no synchronization</p> <p>10% on / 90% off – there is a satellite signal, no synchronization</p> <p>90% on / 10% off – no satellite signal but there is synchronization</p> <p>50% on / 50% off – there is a satellite signal and synchronization</p>
Blue – Wi-Fi connection strength	<p>No blink – no connection</p> <p>Single blink synchronous with yellow – weak connection (lower than -60 dB)</p> <p>Double blink synchronous with yellow – moderate connection (from -60 dB to -50 dB)</p> <p>Triple blink synchronous with yellow – strong connection (better than -50 dB)</p>



Fig. 2. N axis (Noth-South) pointer

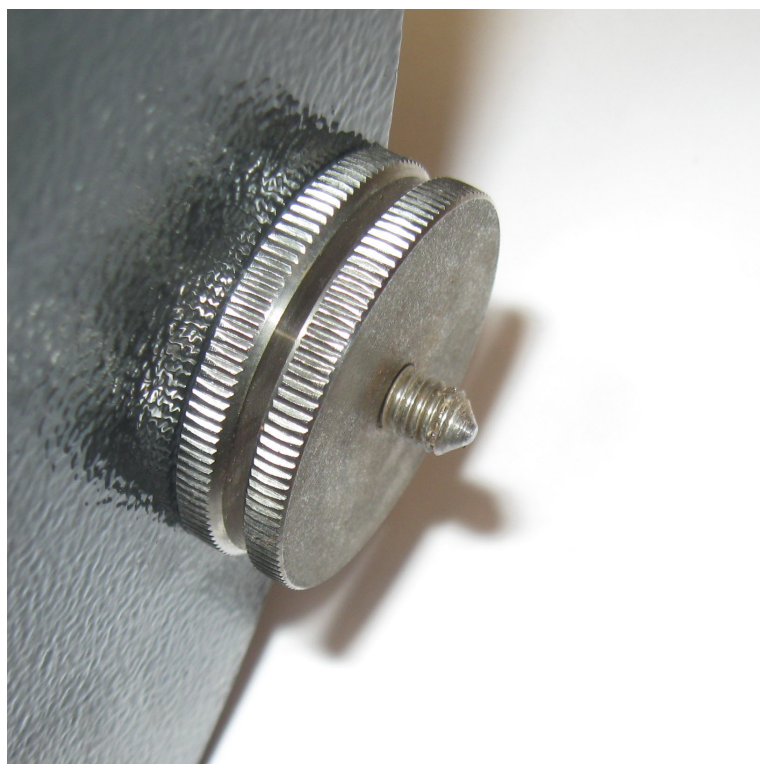


Fig. 3. The leg's installation on the case

APPENDIX 2. CONNECTORS, CABLES, ANTENNAS

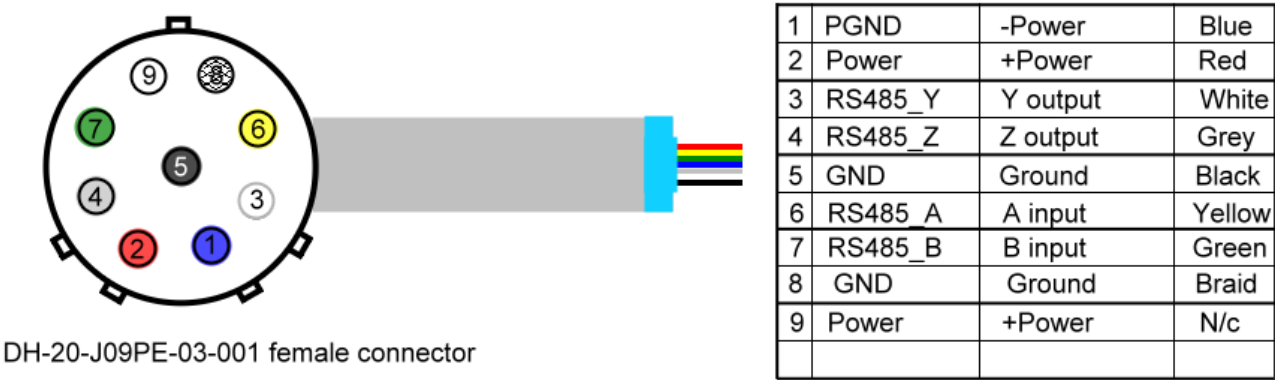


Fig. 1. Multifunctional connector, combined cable



Fig. 2. Multifunctional connector, power cable



Fig. 3. Standard USB A/B cable

APPENDIX 3. CONNECTION METHODS IN DIFFERENT MODES

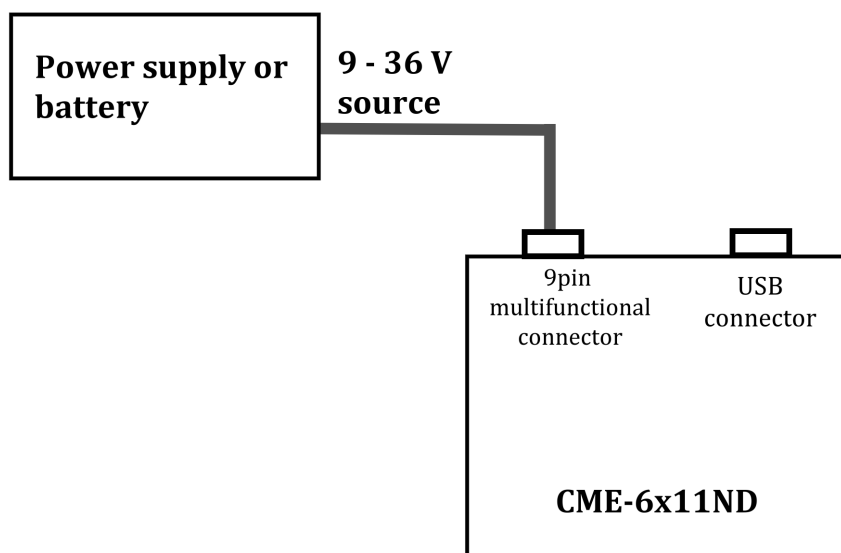


Fig. 1. Power supply from the power supply (main operating mode)

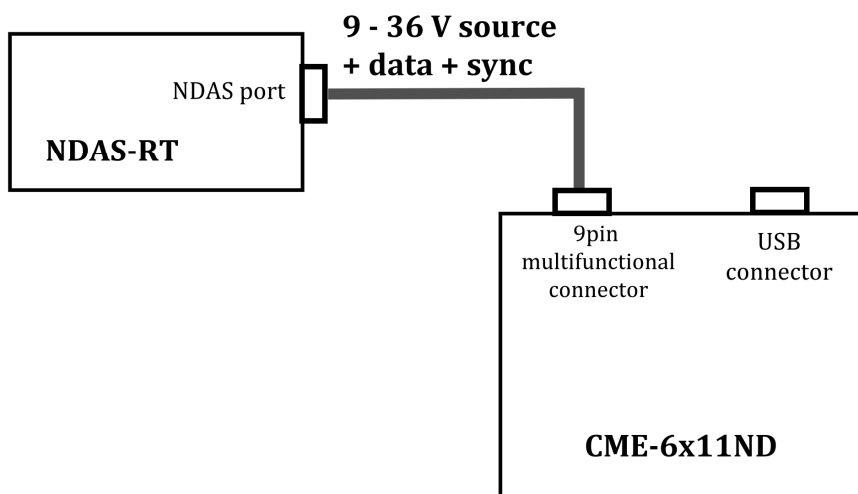


Fig. 2. Working with NDAS-RT. Power supply, data transfer and synchronization via cable through NDAS-port (main operating mode)

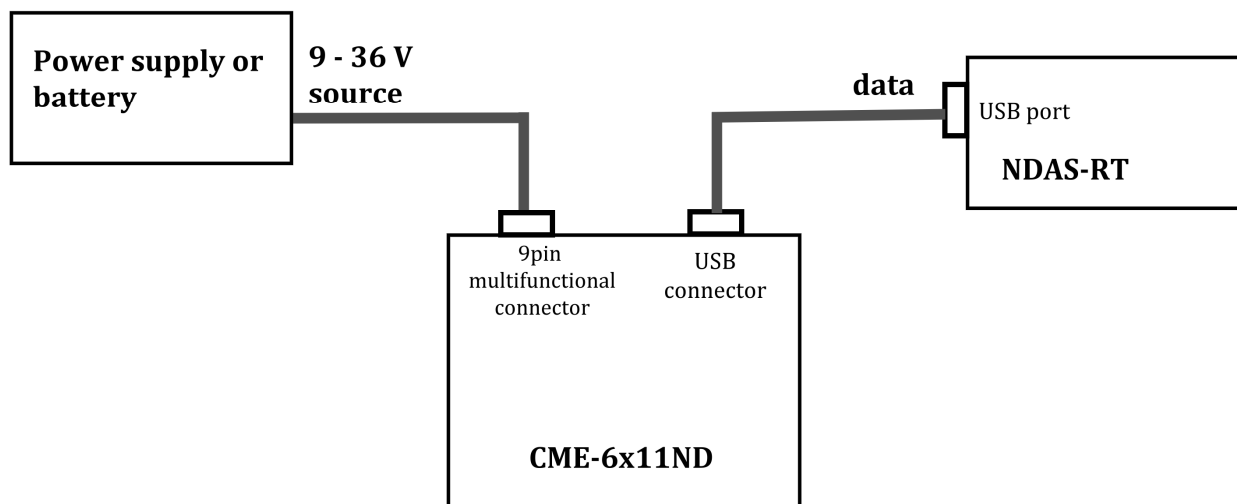


Fig. 3. Power supply from the power supply, data transfer to NDAS-RT via the USB port. (main operating mode, SD card reading mode)

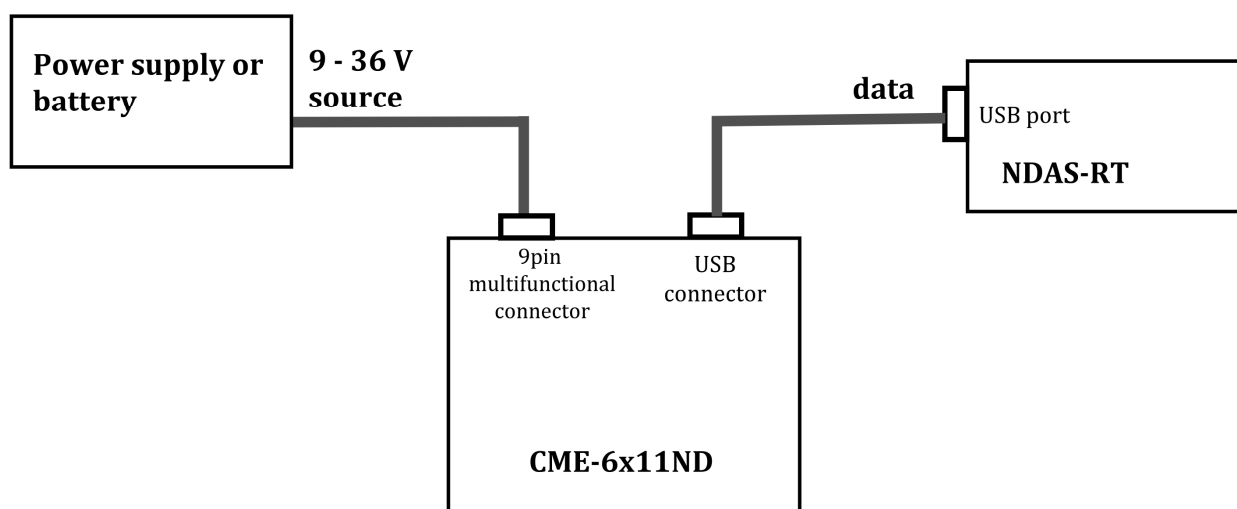


Fig. 4. Power supply from the power supply, data transfer to the computer. (main operating mode, SD card reading mode). When connected only via USB (without a power supply), only setup and reading of saved data is possible.

