

Seismic recorder

Baykal-8

Technical description



Introduction

This document contains a description of the seismic signals recorder "Baykal-8", its technical characteristics, as well as the product and software instructions.

Technical data

Characteristic	Unit	Value
Number of channels	pcs.	6
Data width	bit	24
Input type		Differential
Input impedance		40kOhm, 4700pF in parallel
Sampling frequency FD	sps	100, 125, 200, 250, 400, 500, 800,1000, 2000, 4000
Bandwidth (-3dB)	Hz	0 - 1680
Hardware gain G		1, 2, 4, 8, 16, 32, 64
Maximum input voltage (differential) at G=1	Volts	± 2.5 (± 12.5 with hardware divider)
Conversion coefficient At G=1 At G=16	nV/count	$303.7 \pm 0.4\%$ $19.05 \pm 1\%$
Input noise at: G=1; FD=100 G=1; FD=1000 G=16; FD=100	uV	< 1.0 < 1.2 < 0.2
Effective resolution at G=1; FD = 100 G=1; FD=1000 G=16; FD=100	bit	>21.5 >21.0 >21.0
Non-volatile memory type		MicroSD
Non-volatile memory capacity	Gb	8
Internal oscillator frequency stability of (-20 - +60 °C)		$\pm 3 * 10^{-7}$
Timing accuracy External GPS Internal GPS	usec	± 2 ± 1
Power supply	V	10 – 28 ^{*1)} DC
Power consumption ^{*2,} Standby mode Recording mode	W	< 1.0 < 2.0
External active sensors power capacity		+5V (100 mA) -5V (100 mA)
Data recording format		Miniseed
PC interface for configuration and data capture		USB 2.0 HS, Ethernet 10/100

Maximum recording stream speed to memory card: FD=100 FD=1000	Kbyte/sec	2,86 28,6
Minimum recording stream speed to memory card: FD=100 FD=1000	Kbyte/sec	0,51 5,1
Ethernet protocols		FTP, Seedlink, Telnet
Operation temperature range.	°C	-30 ÷ +60
Case dimensions	mm	170x80x180
Recorder weight	kg	2,2

*1) Power supply circuit includes 1A fuse.

*2) Measured with Ethernet module offline. Activation of Ethernet connection increases power consumption per 200 mW.

Device package delivery

- Seismic signals recorder "Baykal-8"— 1pcs
- FQ14-7Z connector for Supply cable/GPS – 1 pcs
- MicroSD-memory card 8 Gb (supplied pre-installed in the recorder).
- GPS antenna – 1 pcs
- FQ24-10Z connector for sensors – 2 pcs

Supplier:

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Recorder layout and functions

The description of the recorder front panel

The front panel of the recorder has the following:

- "PW" socket for the recorder power supply. The same socket is used for external GPS module connection.
- Sensors '1' and '2' connectors.
- "ANT" socket for GPS-antenna for internal GPS module.
- Ethernet-socket
- USB-socket
- LEDs "TIME" and "MODE" to indicate the device status.
- Buttons "A" and "B"



Figure 1: The recorder front panel

Signal attenuation by means of hardware divider

The amplitude of the signal applied to the analog inputs must not exceed +/- 2.5 V (differential). If the connected sensor shows output values outside that range, the input signal can be reduced by switching the ADC input to the divider. To do this, remove the device from the case and switch inputs to the appropriate connectors on the ADC board. Each channel has two inputs, the first one letting pass the signal unchanged, while the second divides the signal by 1.02: 5.04 ratio. In the

figure 1, the red colour denotes connectors without the divider, while the blue colour denotes connectors with the divider.

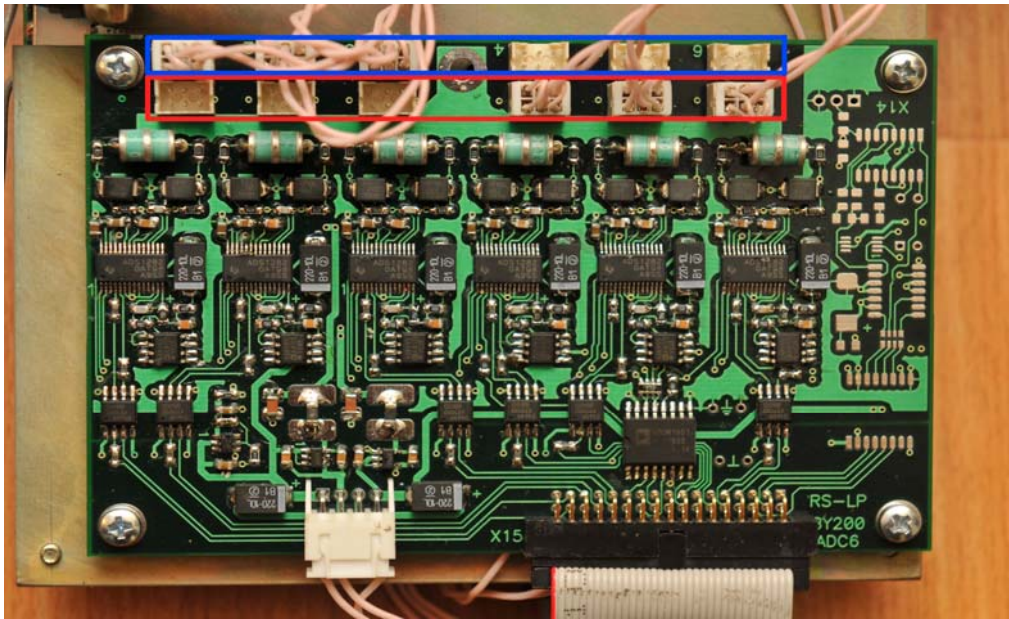


Figure 2: ADC board. The red colour denotes connectors without divider, the blue colour denotes connectors with a division by 1.02 : 5.04

Replacing the SD-card

The device records data onto the internal MicroSD memory card. To replace the card, take the device out of the case, open the card socket (red square in Figure 3), replace the card and close the socket.

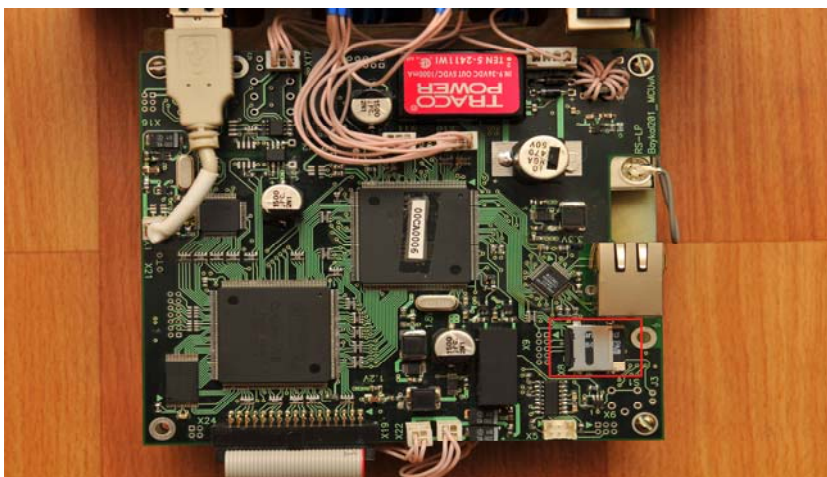


Figure 3: Recorder processor board. The red square denotes SD-card socket.

Recorder registration mode

When switching to the registration mode, the ADC board is powered on and ADC is initialized in accordance with the settings (sample rate, channel gains). Then the digitized stream is processed - if necessary: it is filtered and decimated, as well as analyzed for the content of events by STA / LTA criteria. Next, the data is packaged into MiniSEED format and the received miniseed-blocks are saved onto the microSD-card. The block size is 512 bytes. The data is first saved in a circular buffer and upon reaching the end of the card recording begins again, overwriting the old data.

Recorder manual control

The recorder manual control is performed from its front panel. TIME and MODE LEDs show the current device state:

TIME:

- Red — GPS-antenna is not connected
- Yellow — GPS- antenna is connected, but not yet synchronized.
- Green — GPS-synchronization has been performed.

MODE:

- Yellow — the device is in the standby mode
- Green — the device is in the registration mode.

Switching between the modes is performed by pressing “A” button. ***The device should be powered by the PW connector to register data. If the device is powered only by the USB connector, the data can not be registered.***

“B” button is reserved for further use.

Telnet server

Telnet server is used for remote configuration and management of the device status. This server uses port 23 for incoming connections. Upon connection, the server displays the recorder software version and its unique ID number, as well as requires a username and password. If the wrong data is entered or if incorrect values are entered, the server terminates the connection.

After a successful authentication the server displays the prompt ">" and switches to the standby mode. After each command the server either displays "Ok", which means the command has been successfully completed, or an error message. In both cases, the server displays a new prompt and waits for the next command. If there is no any activity within 30 seconds, the server automatically terminates the connection.

Here is the list of the supported commands:

- *help* - displays a brief overview of the available commands
- *state* – displays a brief information about the station state
- *set* <parameter_name> <value> - set the parameter value to the required one. The value Is

entered 'as is', that is, without any spacers or commas.

- *show* < parameter_name > - displays the value of the requested parameter
- *show_all* – displays the names of all parameters with their types and values
- *save_setup* – saves the pre-set values
- *start_reg* – switches the device into the registration mode
- *stop_reg* – stops the registration
- *reboot* – reboots the recorder
- *quit* – terminates the connection

Parameters chart

The following chart shows all available parameters which can be set or requested with the commands *set* and *show*, respectively.

Parameter	Type	Description	Correct value range
filelength	Int	Length of the recorded file in seconds	5-86400
eth_ip	IP	IP-station address	
eth_gateway	IP	IP-gateway address	
eth_netmask	IP	Subnet mask	
eth_mac	Byte[6]	MAC-station address	
ftp_login	Char[16]	ftp server login	
ftp_password	Char[16]	ftp server password	
station_name	Char[16]	Station name	
location_name	Char[16]	Default sensor type	
frequency	Int	Sampling frequency	10, 50, 100, 125, 200, 250, 400, 500, 800, 1000, 2000, 4000
extend_band	Bool	Use a filter with a cutoff frequency 0,47 from the sampling frequency (the default cutoff frequency is 0, 42). Not available for 4000 Hz frequency.	0,1
start_on_power	Bool	Switch to registration mode upon turn-on.	0,1
low_pw_check	Bool	Stop registration if the power is critically low.	0,1

write_meta	Bool	Write metadata of baykal format. It is necessary for correct reading in XX format.	0,1
write_logs	Bool	Write logs into the general data flow. If this option is active, log file will be dubbed in the data flow as miniseed-blocks with the ASCII coding type.	0,1
ext_gps_on	Bool	Get time from the external GPS module.	0,1
gps_pwsave	Bool	Turn off internal GPS module between the sync acts.	0,1
gps_period	Bool	Time between the sync acts.	0,1
gps_method	Int	Time adjustment method: method 0 provides more accurate adjustment, but may work unstable in the conditions of poor reception of GPS signals, method 1 provides less precise, but more stable adjustment in the conditions of poor reception of GPS-signals.	0,1
channel[n]/disabled	Flag	A flag indicating whether the channel is active. The unused channels data is not recorded on the internal data storage device and are not streamed.	true, false
channel[n]/name	String[16]	Channel name	
channel[n]/gain	Int	Gain index in the according chart (below)	0-6
channel[n]/offset	Int	Channel offset. This value is subtracted from each digitized value for this channel.	
channel[n]/type	String[16]	Sensor type (location code).	
channel[n]/invert	Flag	The channel inversion around zero	true, false

Here is the chart of the channel gains:

Index	Gain
0	1
1	2
2	4
3	8
4	16
5	32
6	64

Seedlink server

Seedlink server is designed for data download in MiniSEED format. You can find detailed information about Seedlink protocol on IRIS website (<http://www.iris.edu/data/dmc-seedlink.htm>) and in description of SeisCompP packet (<http://www.seiscomp3.org/>). You can find detailed information about MiniSEED format in Manuals section on IRIS website (<http://www.iris.washington.edu/manuals/>).

Seedlink server listens to incoming connections on port 18000.

Supported commands:

- *HELLO*
- *BYE*
- *STATION*
- *SELECT*
- *DATA*
- *END*
- *INFO* (partially)

The initialization order of Seedlink connection

A typical sequence of initializing the connection is given below:

- The client establishes the connection.
- The client sends STATION command.
- If the requested station name does not match the set, the server breaks the connection
- The client sends SELECT command.
- The client sends DATA command with optional argument of Blocket number. Regardless of the existence of a given Blocket, the command succeeds (The server responds with 'OK').
- The client sends END command.
- The server begins data transmission.

FTP server

FTP-server is intended for remote viewing and downloading files recorded by the file recorder. This server uses port 21 for incoming connections and a range of ports from 4096 on 5128 for data passing. It supports passive mode only.

Supported commands:

- *PWD*
- *PASV*
- *LIST*
- *QUIT*
- *CD*
- *SIZE*
- *RETR*
- *REST*
- *CWD*
- *ABOR*

Working with baykal-control programme

Baykal-control programme is designed for recorder configuration, as well as its status control and data reading.

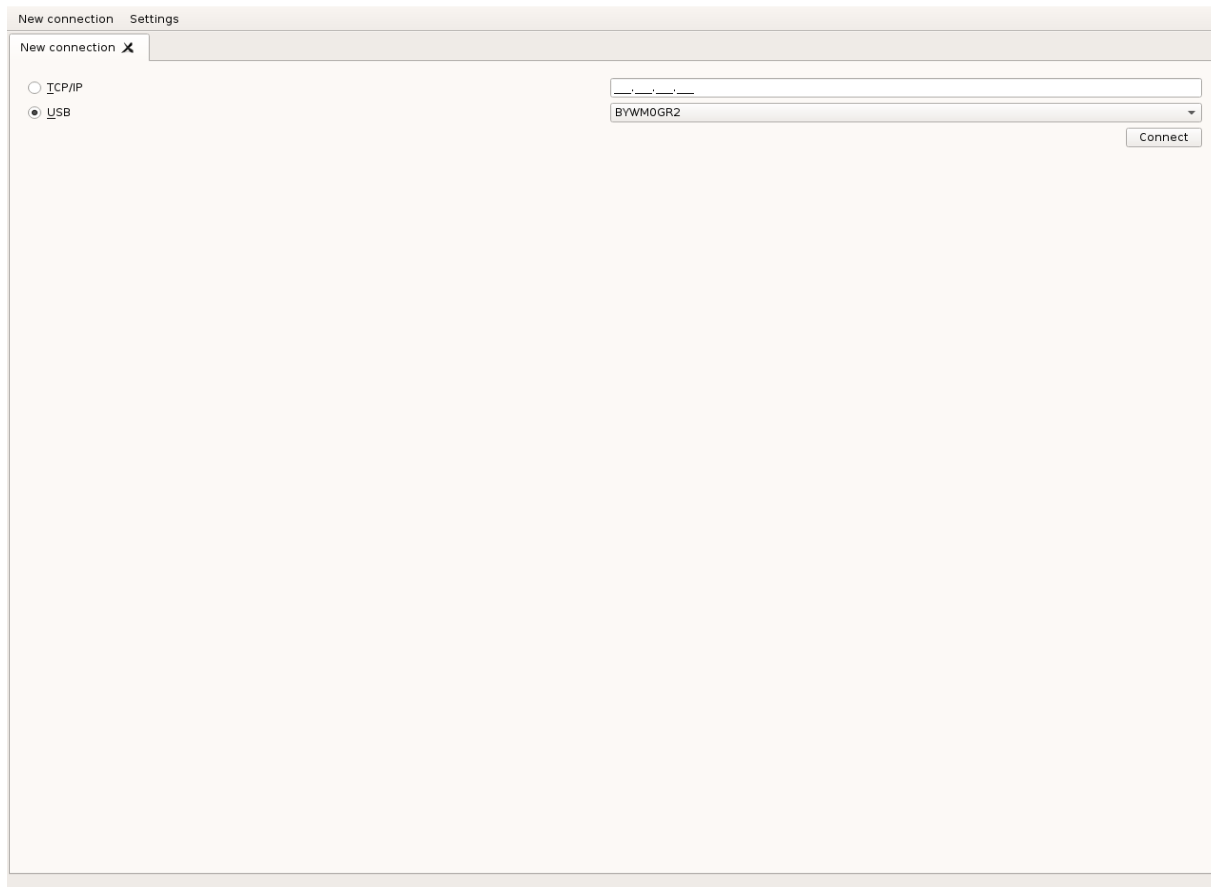


Figure 4: Connection to the recorder dialogue

Connection to the recorder

To connect to the recorder, select "New connection" in the main menu of the programme. A dialog box appears, as shown in the figure below. Select the connection settings in this box. To connect via TCP / IP, select the appropriate option and enter the desired IP-address. For USB connection, select "USB" and select the device serial number in drop-down menu (if you are currently connected to only one device, this menu will have only one option). **To connect via USB, USB driver installation is required (supplied with the recorder software).**

The recorder state control

Upon connection, the main window opens a new tab for this device.

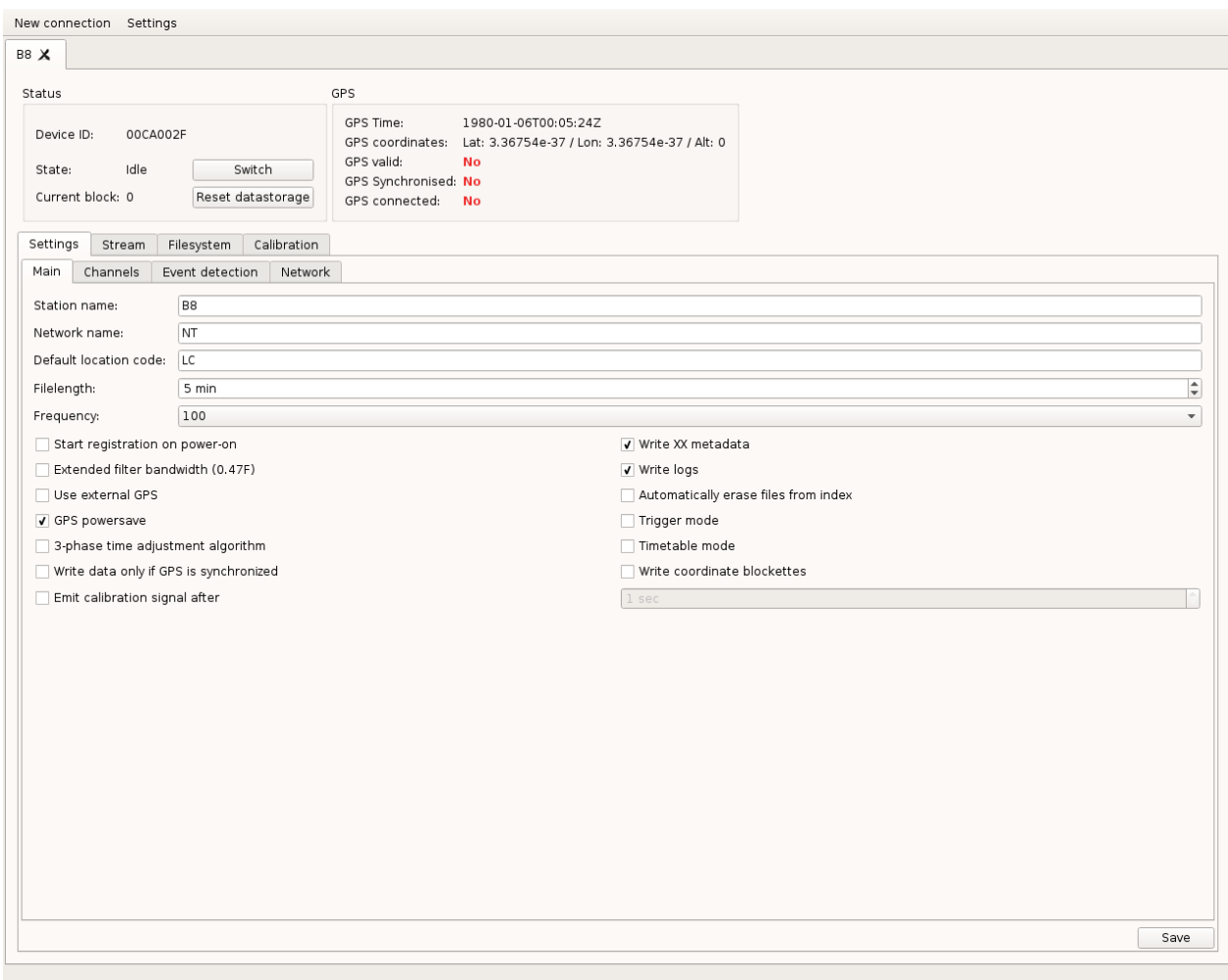


Figure 5: Settings/Main tab

In the upper part shows the device current status, as well as GPS-time, coordinates, and the current record pointer (see Streaming below). The button "Switch" switches the device to registration mode, and the tab "Settings" will be blocked and will remain blocked until the termination of the registration mode.

The recorder configuration management

The device configuration controls are located in the tab "Settings" and are divided into 4 groups - "Main", "Channels", "Event detection" and "Network". After changing the settings, click "Save" button in the lower right corner to record the changed values. The "Main" group has the following settings (top to bottom):

- Station name. According to MiniSEED standard, the length of this field cannot exceed 5.
- Network name. This value is recorded into all MiniSEED Blocket recorded by this device. According to MiniSEED standard, the length of this field cannot exceed 2.
- Default location code — default location code, pre-set into MiniSEED Blocket, if it is not stated for the channel
- Filelength – length of the recorded files in the recorder.
- Frequency – recording sample rate.
- Start registration on power-on – if this option is active, the device automatically switches to registration mode on power-on.
- Extended filter bandwidth – this option selects a set of filter coefficients with a cutoff frequency of 0.47 from sampling frequency (default filter with has a cutoff frequency of 0.42 from sampling frequency).
- Use external GPS – this option makes the recorder use external GPS module instead of the internal one.
- GPS powersave — this option allows the recorder to switch off GPS when it is not needed to lower power consumption.
- 3-phase time adjustment algorithm — turns on three-phase algorithm of time adjustment, which has better performance in poor reception of GPS signals.
- Write XX metadata — write extra information about gains and coordinates, which will be used in reading XX format files.
- Write logs — write logs in miniseed Blocket files.
- Automatically erase files from index — erase files from the file system when the appropriate place in the ring buffer is overwritten by a new file.
- Trigger mode — turns on trigger mode. The device will track STA/LTA readings and on criterion response will write a specific period of history, the event and pre-set time-lapse after the event.
- Timetable mode — timetable mode switch on.
- Write data only if GPS synchronized — the recorder will write data only if the time is synchronized .
- Emit calibration signal after — if this setting is active, the device will make a 1-second length calibration signal after a pre-set number of seconds after the start of the recording.

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New connection
Settings

Status

Device ID: 00CA002F

State: Idle Switch

Current block: 0 Reset datastorage

GPS

GPS Time: 1980-01-06T00:06:20Z

GPS coordinates: Lat: 3.36754e-37 / Lon: 3.36754e-37 / Alt: 0

GPS valid: **No**

GPS Synchronised: **No**

GPS connected: **No**

Settings
Stream
Filesystem
Calibration

Main
Channels
Event detection
Network

Number	Name	K	Gain	Type	Offset	STA/LTA	Invert sign
<input checked="" type="checkbox"/> 1	CH0	1	16		0	<input type="checkbox"/> 2	<input type="checkbox"/>
<input checked="" type="checkbox"/> 2	CH1	1	16		0	<input type="checkbox"/> 2	<input type="checkbox"/>
<input checked="" type="checkbox"/> 3	CH2	1	16		0	<input type="checkbox"/> 1	<input type="checkbox"/>
<input checked="" type="checkbox"/> 4	CH3	1	1		0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input checked="" type="checkbox"/> 5	CH4	1	1		0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input checked="" type="checkbox"/> 6	CH5	1	1		0	<input type="checkbox"/> 0	<input type="checkbox"/>

Virtual channels:

Number	Name	Type	Base channel	Frequency	Offset	STA/LTA	Invert sign
<input type="checkbox"/> 7			1	/0	0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input type="checkbox"/> 8			1	/0	0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input type="checkbox"/> 9			1	/0	0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input type="checkbox"/> 10			1	/0	0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input type="checkbox"/> 11			1	/0	0	<input type="checkbox"/> 0	<input type="checkbox"/>
<input type="checkbox"/> 12			1	/0	0	<input type="checkbox"/> 0	<input type="checkbox"/>

Save

Figure 6: Settings/Channels tab

"Channels" tab contains two lists of channels - a list of physical channels, where the physical channels parameters of the device are displayed, and a list of virtual channels that are created by dividing the frequency of one of the physical channels.

There are following settings for the physical channels:

- Checkbox next to the channel number denotes if this channel will be written or not.
- Name – contains channel name. According to MiniSEED standard, the length of this field cannot exceed 3. Standard channels name coding is given in SEED Reference Manual, Appendix A.
- K – conversion coefficient for this channel. This parameter makes sense only in reading data in XX format.
- Gain – gain for this channel.
- Type – location code value for this channel. According to MiniSEED standard, the length of this field cannot exceed 2. It can be empty.
- Offset – permanent offset value for this channel. The stated offset is calculated from each point of this channel.
- STA/LTA – value for events detection.
- Invert sign – this option includes signal inversion relative to zero.

There are following settings for the virtual channels:

- Number — channel number. Checkbox next to the channel number denotes if this channel will be written or not.
- Name – contains channel name. According to MiniSEED standard, the length of this field cannot exceed 3. Standard channels name coding is given in SEED Reference Manual, Appendix A.
- Type – location code value for this channel. According to MiniSEED standard, the length of this field cannot exceed 2. It can be empty.
- Base channel — base channel number.
- Frequency — frequency divider for this channel.
- Offset – permanent offset value for this channel. The stated offset is calculated from each point of this channel.
- STA/LTA – value for events detection.
- Invert sign – this option includes signal inversion relative to zero.

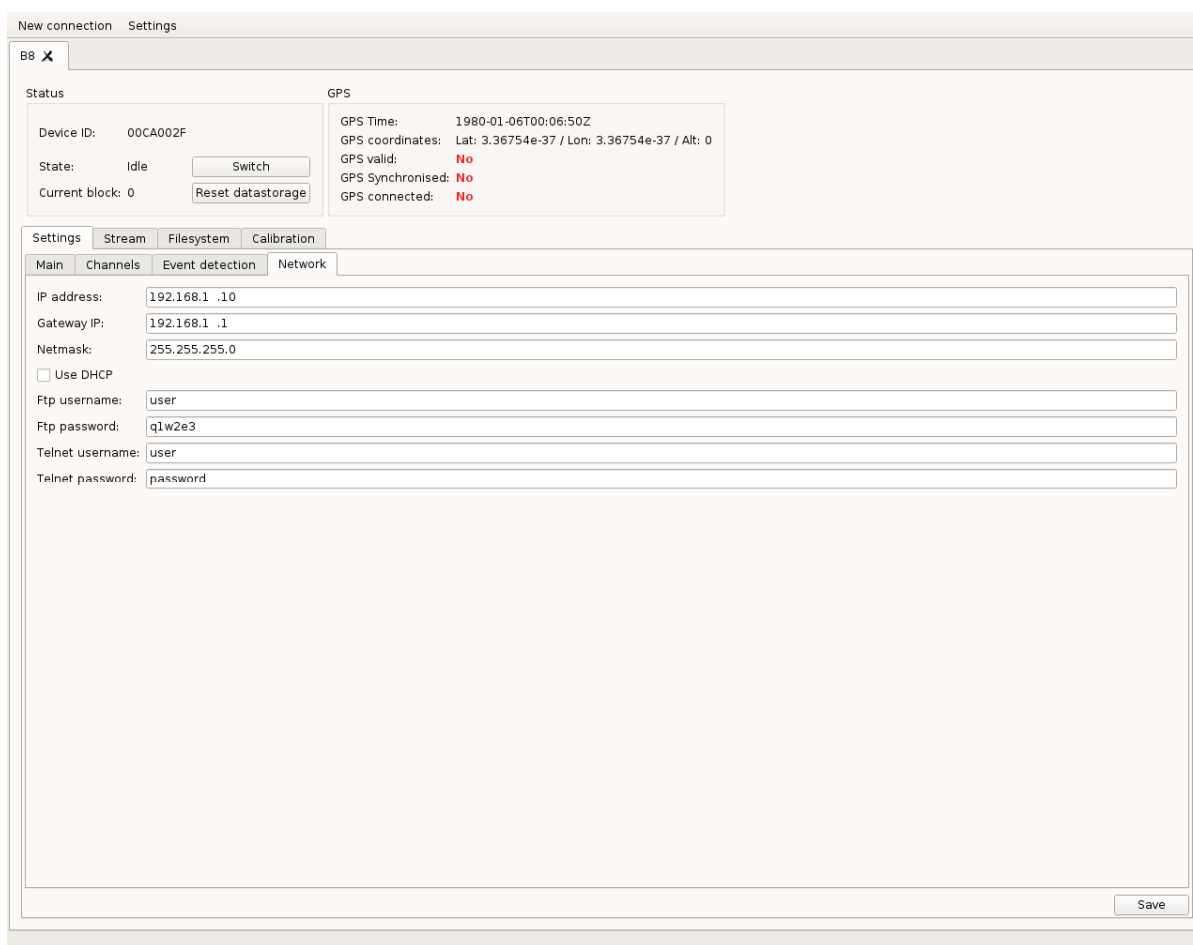


Figure 7: Settings/Network tab

Network tab includes the following options:

- IP address, Gateway IP, Netmask — TCP/IP-device settings. These parameters must be set upon connection via USB. New values of these parameters take effect after restarting the recorder.
- Ftp username/password – authentication options for FTP server.
- Telnet username/password – authentication options for Telnet server.

Event detection tab includes the following options:

- STA window length, LTA window length — window lengths where STA and LTA are calculated, respectively.
- Pre-event time — time length that will be recorded on criterion triggering in trigger mode
- Post-event time — time length that will be recorded after the criterion triggering in trigger mode.
- Minimum event time — minimum file length in trigger mode.

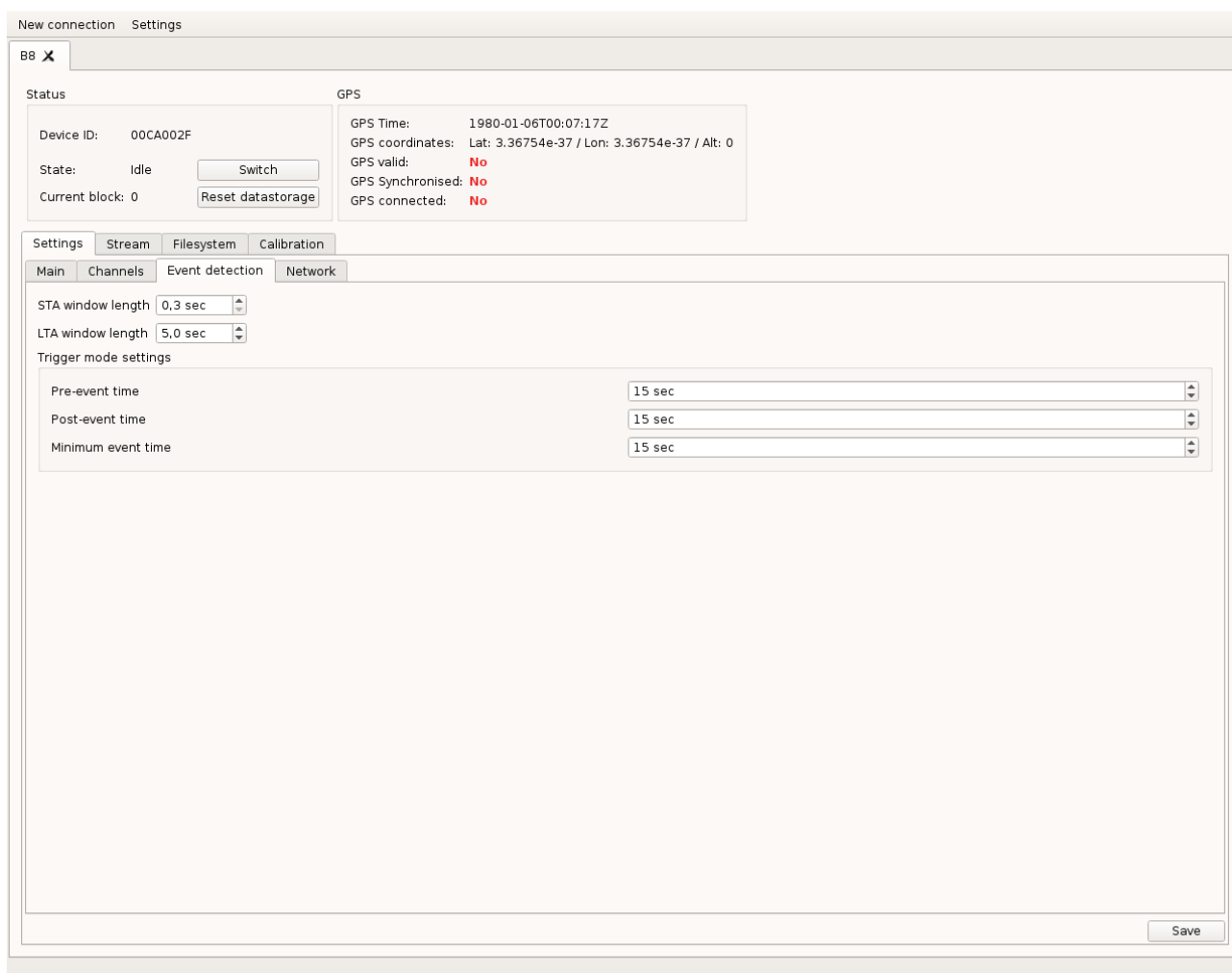


Figure 8: Settings/Event detection tab

Streaming

Note: streaming may be performed without baykal-control programme, upon Seedlink protocol by means of SeisComP and similar software package. The description of SeisComP configuration is beyond the scope of this document.

For streaming and data visualization use the tab "Stream".

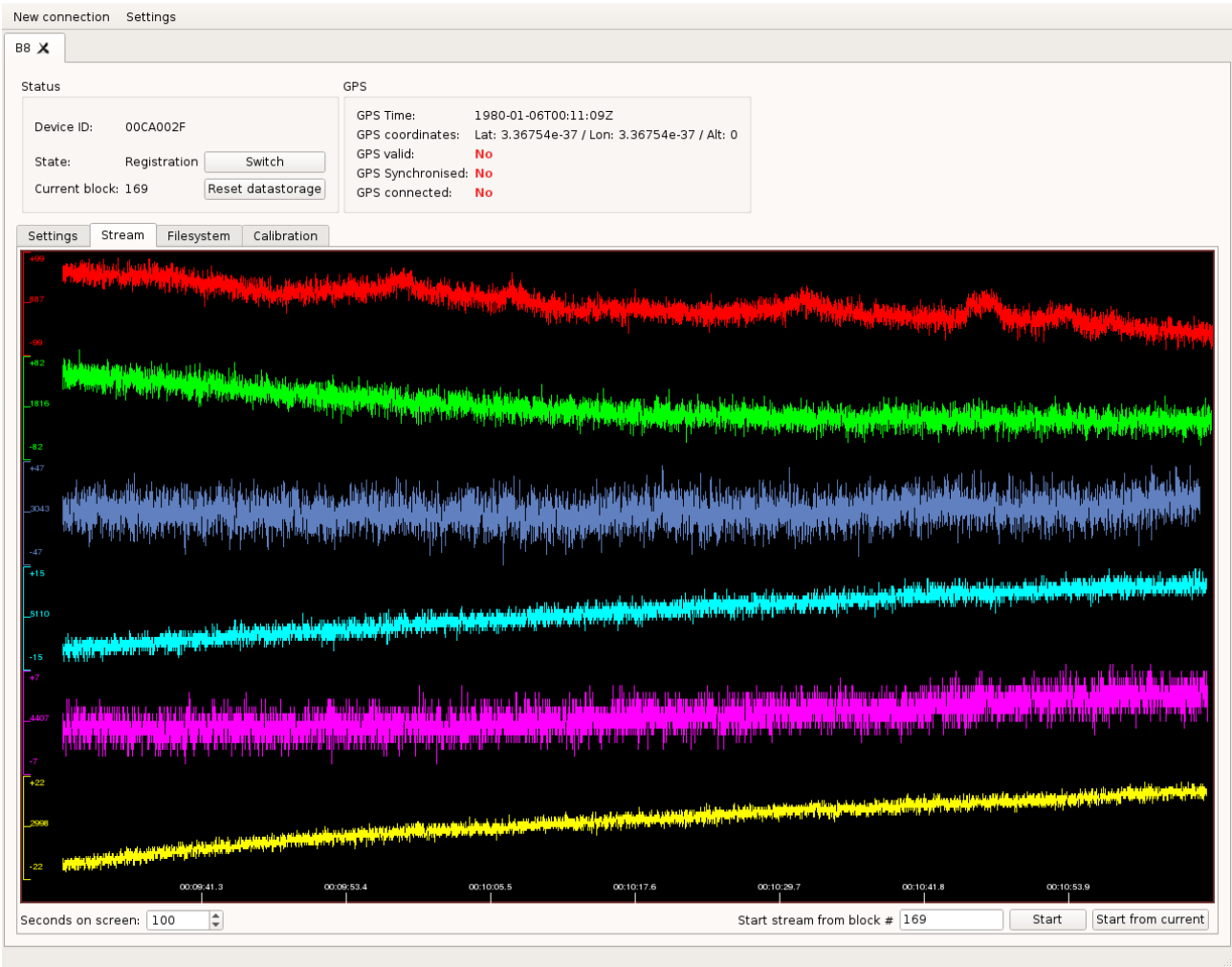


Figure 9: Stream tab

The data obtained in this mode can be written either in XX format or in MiniSEED format. To display the streaming mode settings dialogue, press the Settings button on the top panel of the programme. This dialog offers the following options:

- Stream format – file record format
- Stream root directory – root directory for stream files writing.
- Stream filename scheme – file name scheme when writing in XX format.
- Stream file length: length of files into which the stream will be divided.

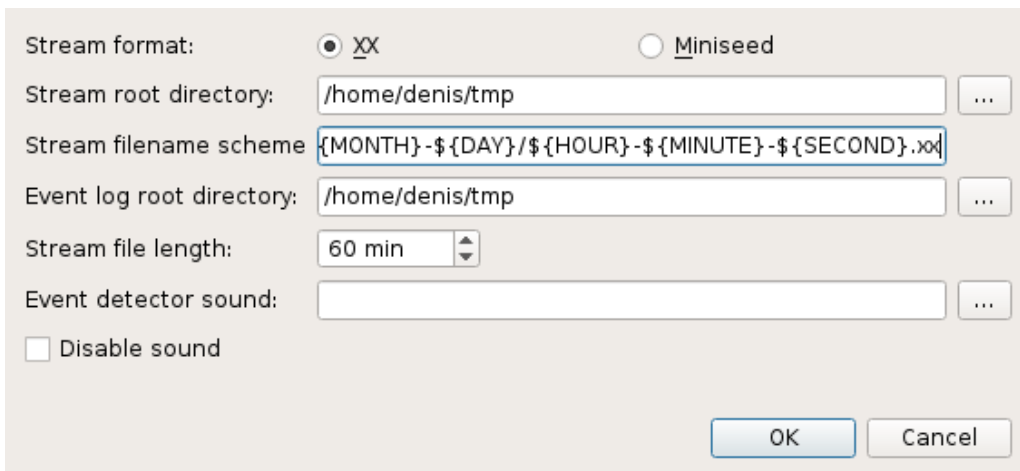


Figure 10: Stream parameters setting tab

You can start stream transmission with the button "Start stream". You can also set the starting block number. Pressing «Start from current» starts transmission from the current recording block..

Browsing and reading files from the recorder

Filesystem tab has a window of the recorder file system view. The recorded files can be downloaded to the specified directory in XX or MiniSEED format.

The file system has two levels - the root has directories with the files. Each directory can be accessed in two ways - by its number or by the name with the date of the first file.

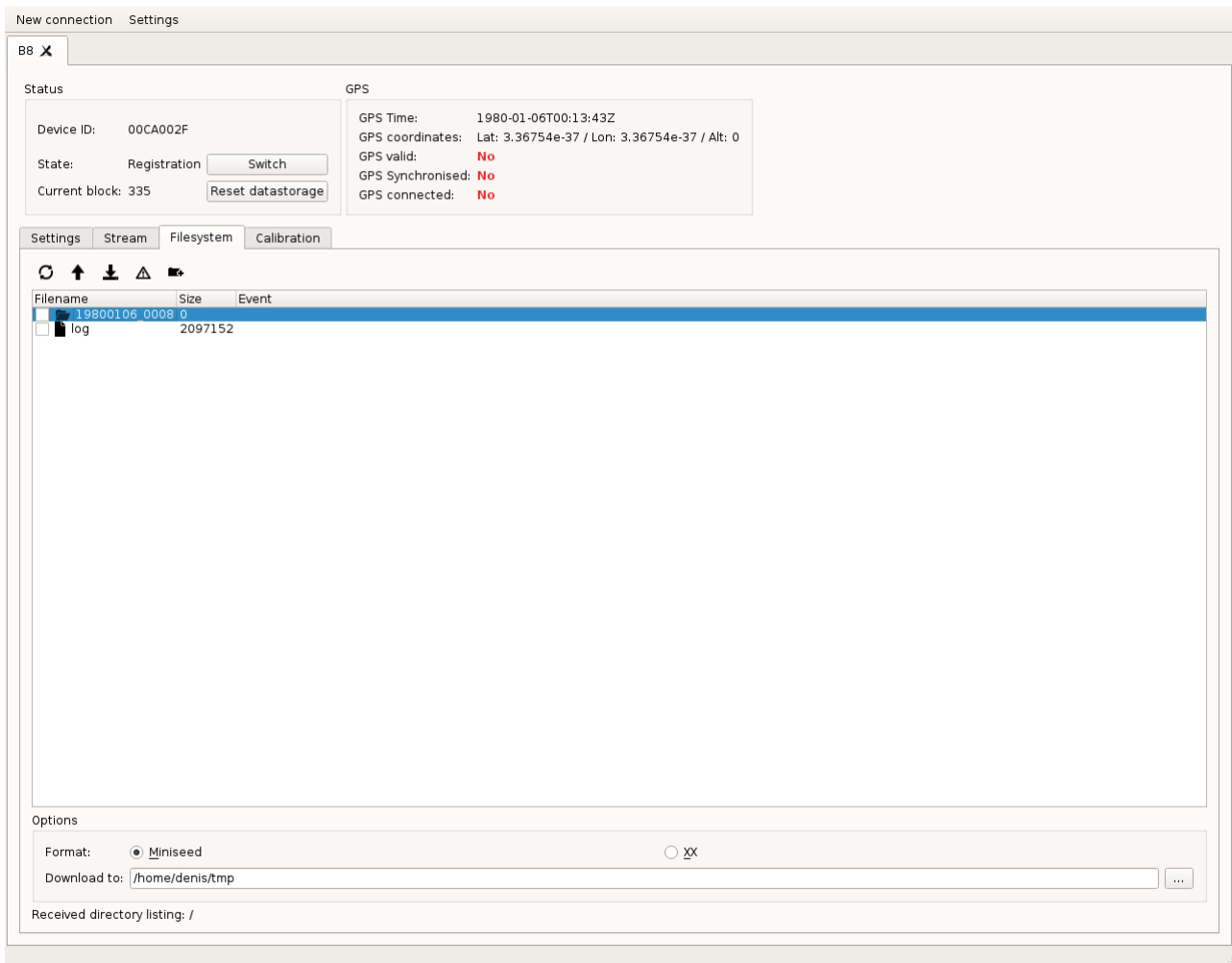


Figure 11: Filesystem tab

Using an external GPS module

If the GPS signal cannot be received in the recorder location, the device synchronization and time set can be performed with the help of external GPS module which is connected to the recorder by a twisted-pair wire up to 500 m long with wave impedance of 14-160 Ohm (for example, CAT8). The connections pinout is described in "Recorder connectors pinout" part. You can switch the device to the use of external GPS in baykal-control programme (see "recorder configuration" part) or with telnet server ("ext_gps_on" parameter).

Software upgrade procedure

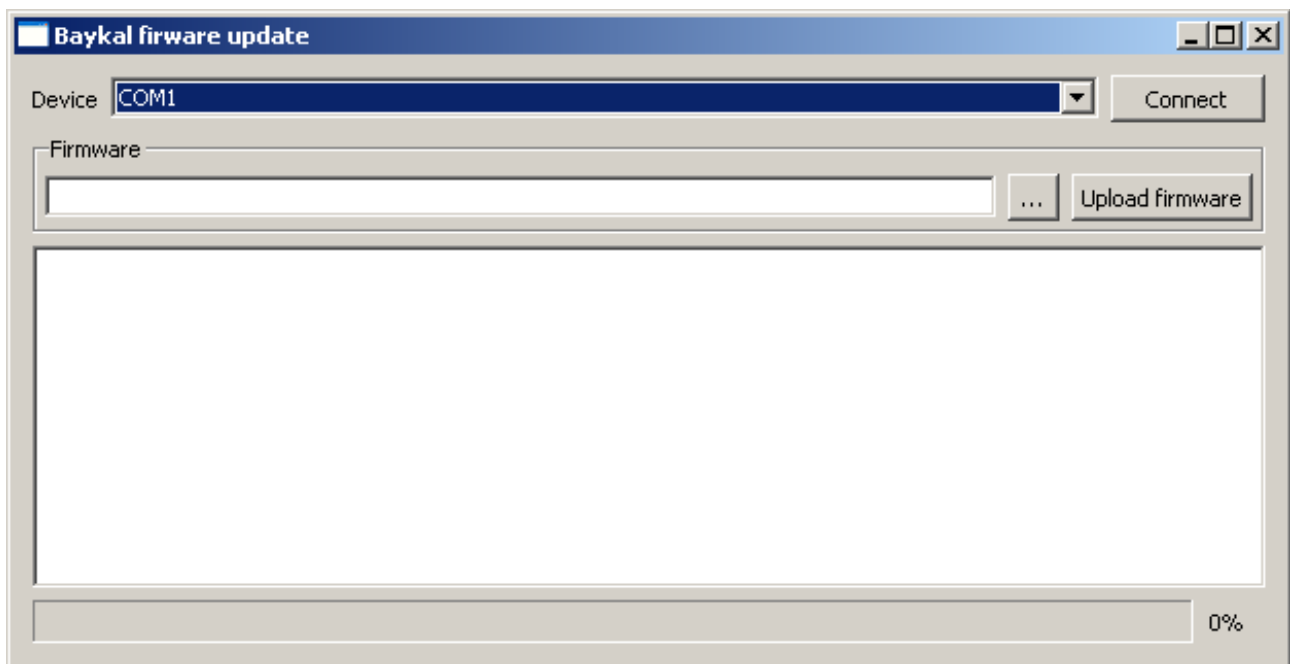


Figure 12: A window of baykal-upgrade programme

The recorder software upgrade is performed with the programme baykal-upgrade. The programme layout is shown in Figure 12.

To perform firmware, the following steps are required:

1. Disconnect the device from power.
2. Press "A" button and connect the device to the computer via USB.
3. Wait until "MODE" LED turns red.
4. Run baykal-upgrade programme.
5. Choose COM port according to the device in the "Device" drop-down menu (the port number depends on the system configuration).
6. Press Connect.
7. Press "..." button and choose firmware file (supplied by the device manufacturer).
8. Press Upload firmware button.

9. Wait until the end of the flashing process.
10. Close the programme.
11. Disconnect USB cable.

Recorder connectors pinout

PW connector pinout:

Connector type: FQ14-7ZJ	
PIN	Function
1	+GPS_RX
2	-GPS_RX
3	+GPS_TX
4	-GPS_TX
5	N/C
6	+POWER_IN/+GPS_POWER
7	-POWER_IN/-GPS_POWER

Sensors connectors pinout:

Connector type: FQ24-10Z	
PIN	Function
1	+ADC1
2	-ADC1
3	+ADC2
4	-ADC2
5	+ADC3
6	-ADC3
7	N/C
8	GND
9	+5V
10	-5V

External GPS connector pinout (connector type: C091 31W008 100 2):

Connector type: C091 31W008 100 2	
PIN	Function
1	+GPS_TX
2	N/A
3	+GPS_RX
4	-GPS_TX
5	-GPS_RX
6	+GPS_POWER
7	-GPS_POWER
8	N/A

External GPS connector pinout (connector type: FQ14-7ZJ):

Connector type: FQ14-7ZJ	
PIN	Function
1	+GPS_TX
2	-GPS_TX
3	+GPS_RX
4	-GPS_RX
5	N/C
6	+POWER_IN/+GPS_POWER
7	-POWER_IN/-GPS_POWER

Connection to the recorder via Ethernet

This chapter describes how to connect the recorder to a PC via Ethernet interface directly.

For direct connection (without routers), configure the IP-address of the computer network card. In Windows XP, go to Control Panel> Network Connections, select the network adapter, right-click on it, choose "Properties" from the drop-down menu, select "Internet Protocol" in the dialog that appears and click "Properties". In the new window, select "Use the following IP-address" and in the fields for the IP-address, subnet mask and gateway to enter the required settings. The default settings for the recorder are as follows:

- IP-address: 192.168.1.2
- Subnet mask: 255.255.255.0
- Main gate: 192.168.1.1

The default recorder IP is 192.168.1.10. This can be changed by baykal-control programme. Changing the recorder IP-address should be performed upon connection via USB and after changes restart the recorder.

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