6D6

Seismic Datalogger

Manual V1.4

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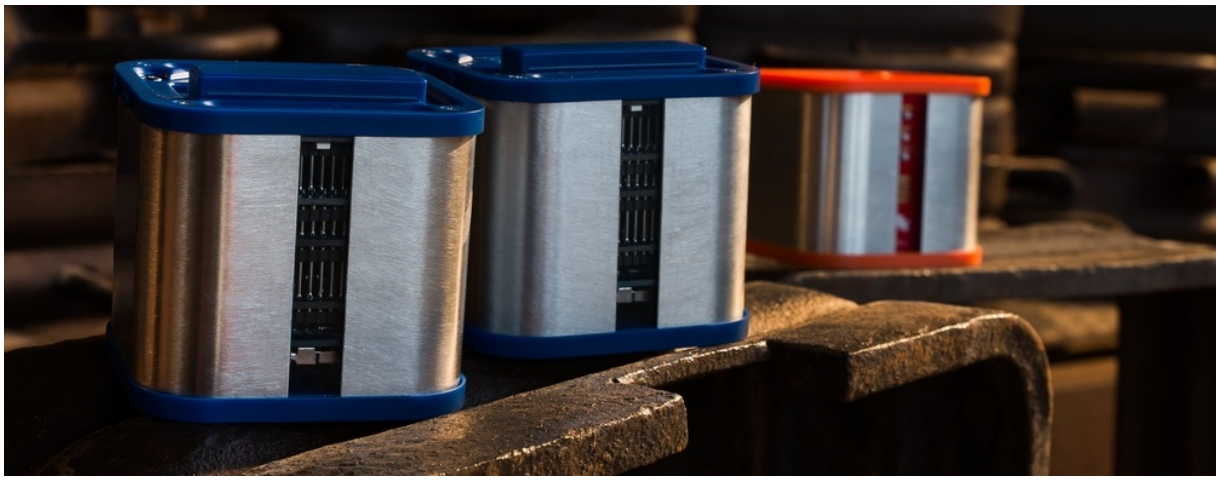
Contents

1 Overview Seismic Datalogger “6D6”



Modular Basic Datalogger, Power consumption 125mW, 9 - 24 Volt[1]

A/D Converter Module:

- four synchronous channels, Signal-Noise-Ratio better 142dB, 32 bit
- modular system, change of modules possible
- FIR-filter, filter-delay already corrected in raw data

Timing and Oscillator Module:

- RTC 0.02 ppm buffered with incorporated battery, keeps clock synchronized permanently
- CSAC Atomic Clock as an alternative (but **doubles** the power consumption)

Data Storage Module:

- Data are stored on external StiK^{TM} or SDXC-Flash card
- StiK^{TM} can be changed without opening the pressure vessel

Processor Module:

- Ultra-Low-Power, AIS positioning after pop-up as an option

[1]See page 48 for further details.

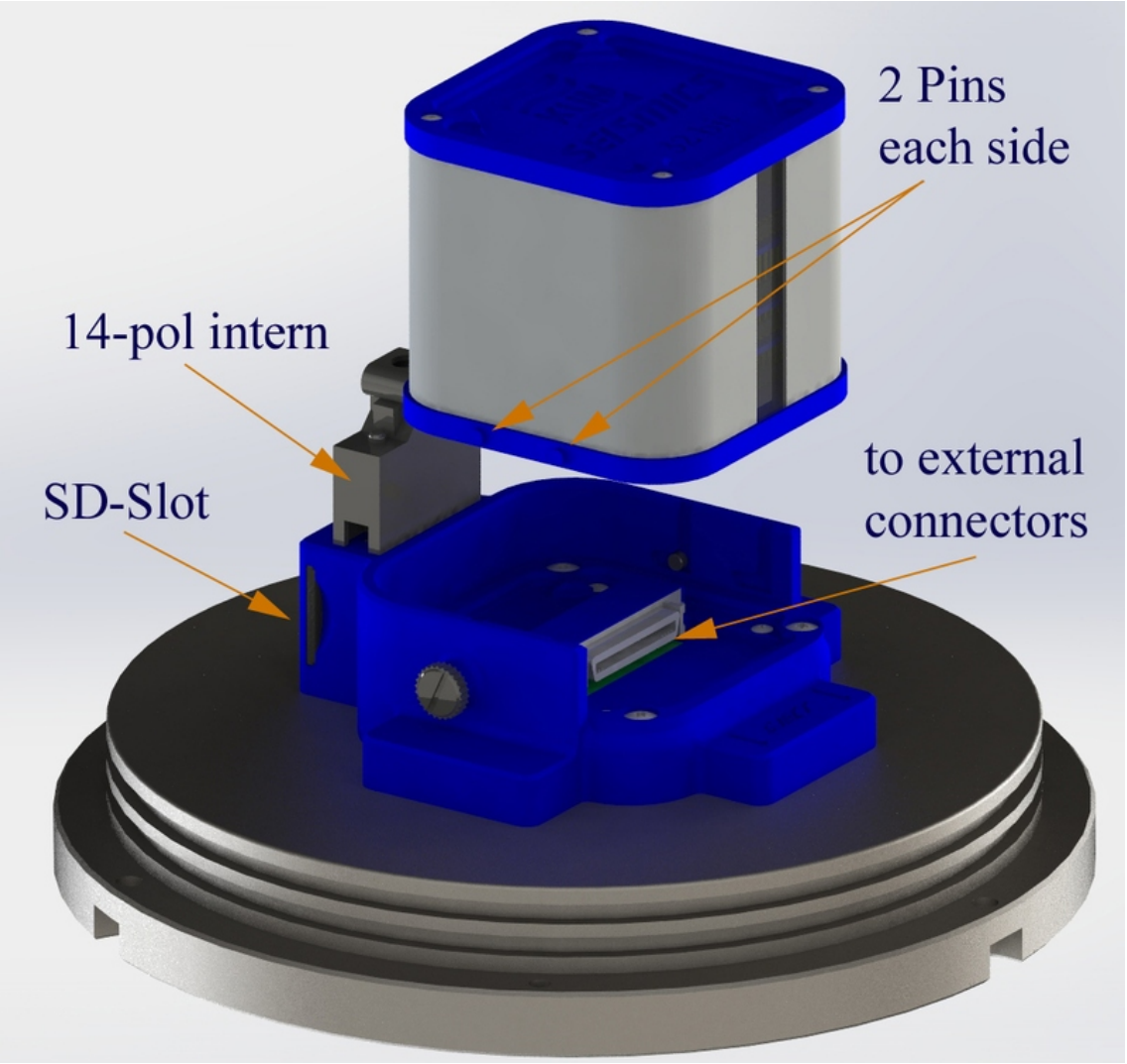
Command & Control-Module:

- 700MHz ARM Cortex CPU, integrated webserver
- programming of the datalogger using any standard web browser
- online data when connected
- update of the firmware using the browser

2 Connection and Use of the Datalogger

2.1 Connection

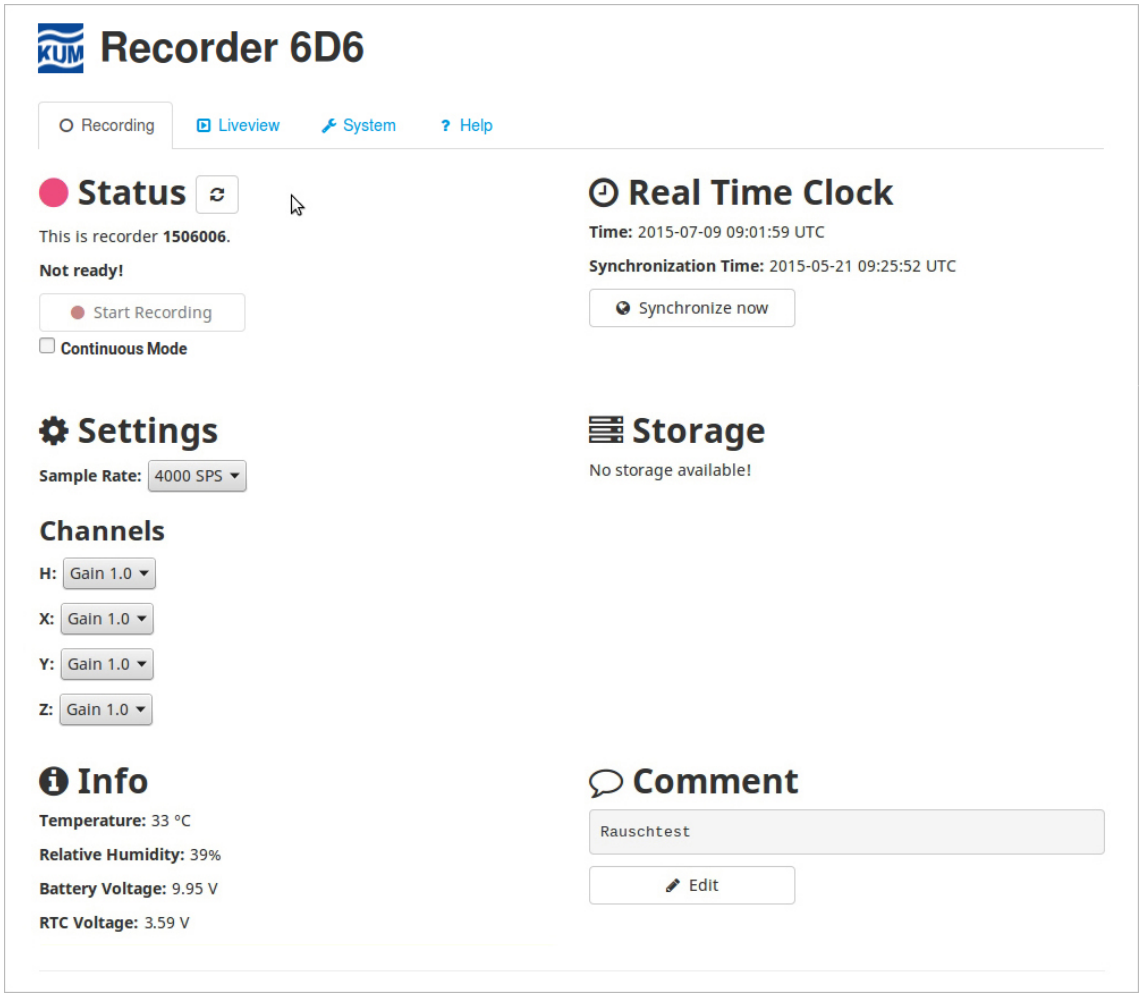
The power for the datalogger comes from inside the pressure tube normally. There exist four little pins top on both sides of the recorder that fit into a bayonet nut to guide the connector. After placing the datalogger fix it by carefully tightening the knurled screws. The recorder is ready for use now.



Recorder and Mount

2.2 Web Interface

The basic configuration of the datalogger "6D6" has a web-server integrated, added by an Access-Point inside "DIRC in the box". If connected to DIRC in the box a WiFi is established and you can use any web browser for communication. It takes about 30 seconds for the datalogger to boot, as soon as the LED lights permanently the WiFi is ready for use. The SSID of the net always starts with "6D6" followed by the serial number of the datalogger. You will find the complete SSID on a sticker placed on the logger. The default password is "seismics". Connect your device (laptop, tablet or smartphone) to the WiFi and type the IP-address (it is *always* "10.0.0.1") into the address field of your web browser. The following website will appear:



Homepage of the "6D6" datalogger

2.2.1 Status

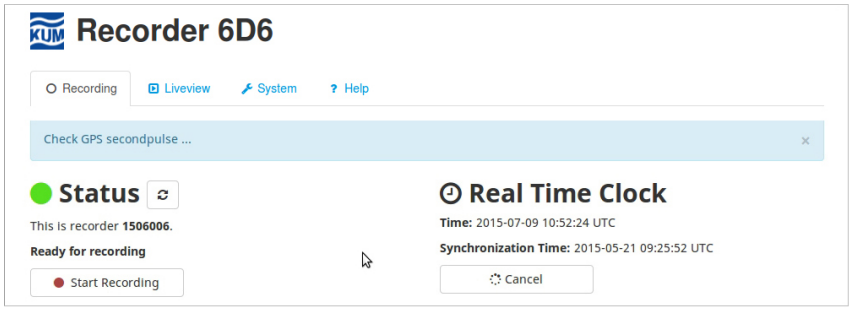
You can not start a recording in the example above because there is no storage available – this is indicated by both the magenta colored LED of the datalogger and the magenta colored dot on the web site.

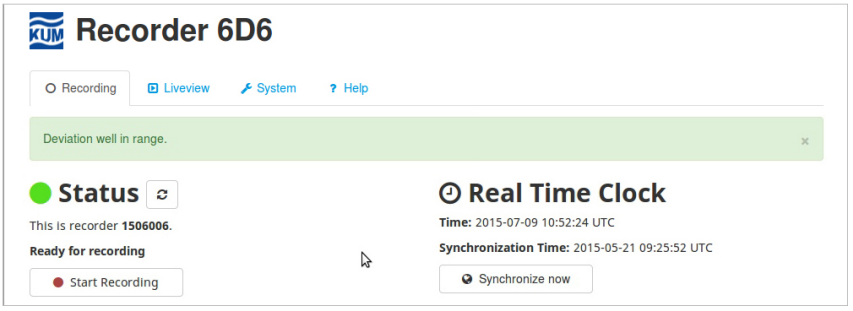
2.2.2 Real Time Clock

It is shown in the area "Real Time Clock" that the clock is synchronized. If an external GPS called "UHURA" is attached, you may synchronize it again (but you do not need to).

Important: In contrast to other dataloggers the "6D6" has its own clock battery incorporated. Therefore it is not mandatory to synchronize the clock *directly before* use or *directly after* end of recording – you might do both synchronizations in the lab at home, even months before or after operation.

To synchronize the GPS-system "UHURA" is used (see page 30). Click "Syncronize now" to synchronize the datalogger with a valid GPS-pulse. The datalogger will comment the process inside colored bars.





Remark: if there is no GPS connected, synchronization naturally fails. In that case, the past synchronization is still valid!

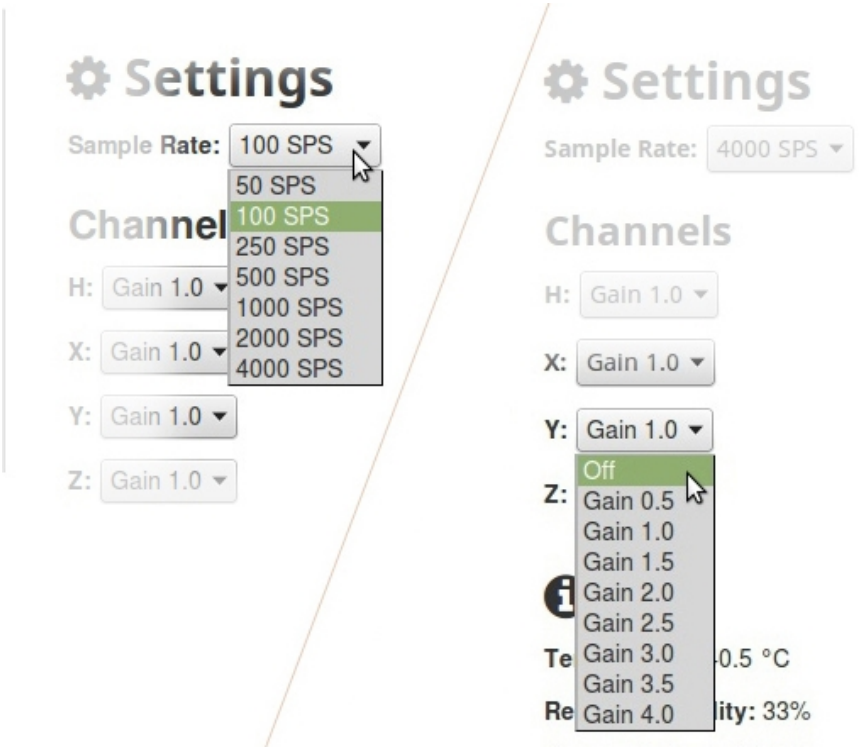
2.2.3 Comment

You can use the button “Edit” to add some comments to your experiment:

You only can edit the comment if no recording is running.

2.2.4 Settings

To change number and gain of the channels and the samplerate use the buttons in the area "Settings".



2.2.5 Memory Requirements

The required memory is depending on both samplerate and recording time. The system records with 32 bit (= 4 byte), so the required memory is: $M = 4 \cdot 60 \cdot 60 \cdot 60 \cdot 24 \cdot 30 = 10,5$ MB per channel per month per sps.

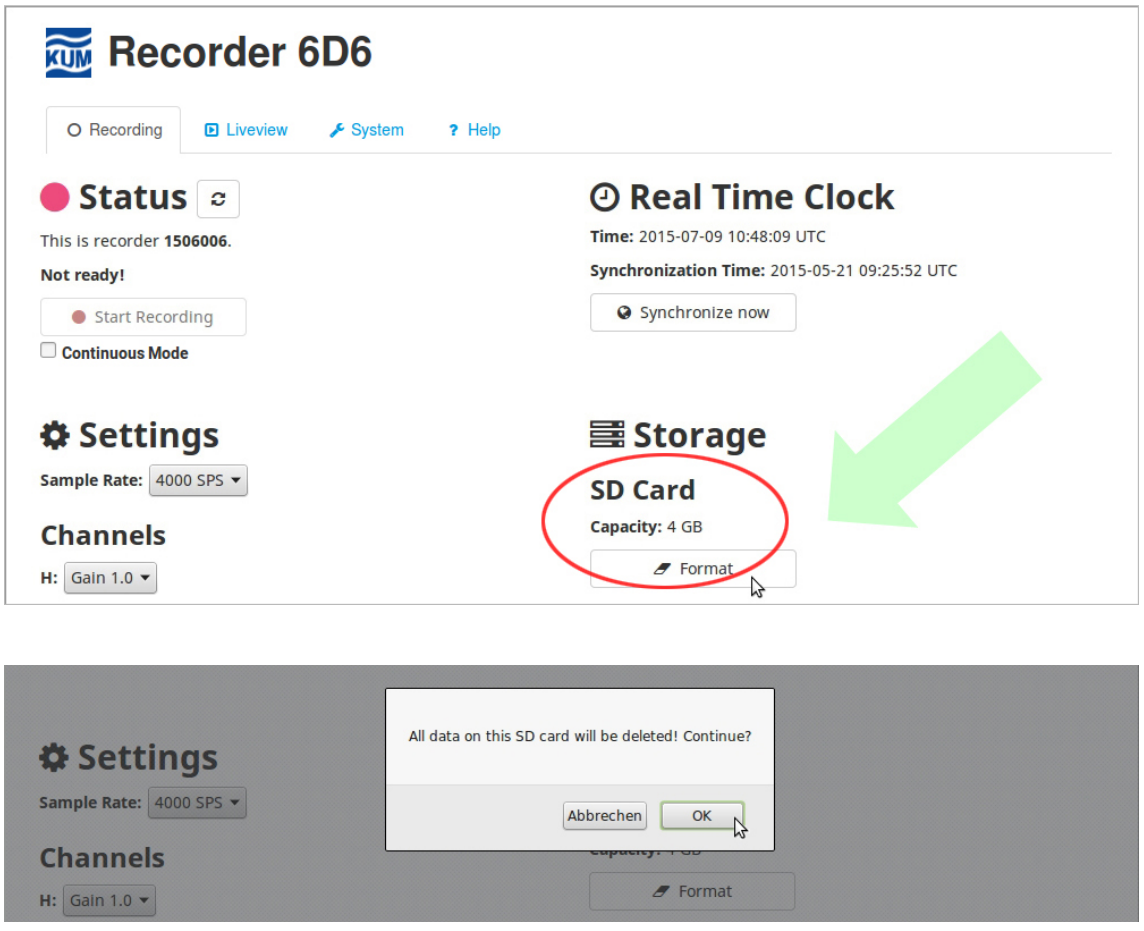
Example: At four channels and a samplerate of 250 sps you will need a monthly memory of: $4 \cdot 250 \cdot 10,5$ MB$= 10,5$ GB.

2.2.6 Storage

If you connect a new storage module, it must be formatted according to the SD card standard (4 GB in this example). Storage that has been used with a datalogger before will be erased before use. A common warning here: Please verify that you have backed up the existing data.

Two different storage modules are available: An SD card that is placed inside the mount of the datalogger, and the storage module "StiK^{TM}" that is placed on a connector outside of the endcap of the pressure vessel.

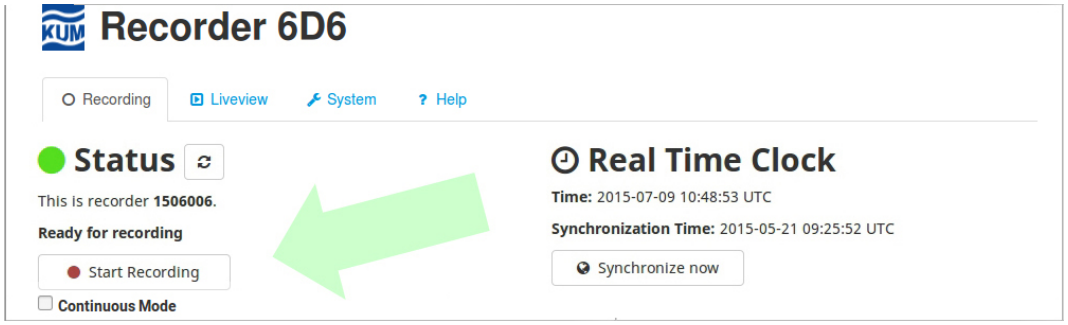
A SD card will be shown with the title "SD card" while the pressure-resistant external storage is called "StiK^{TM}" on the web page. If both the storage modules are connected to the datalogger, generally StiK^{TM} is priorized.



Formatting a SD card

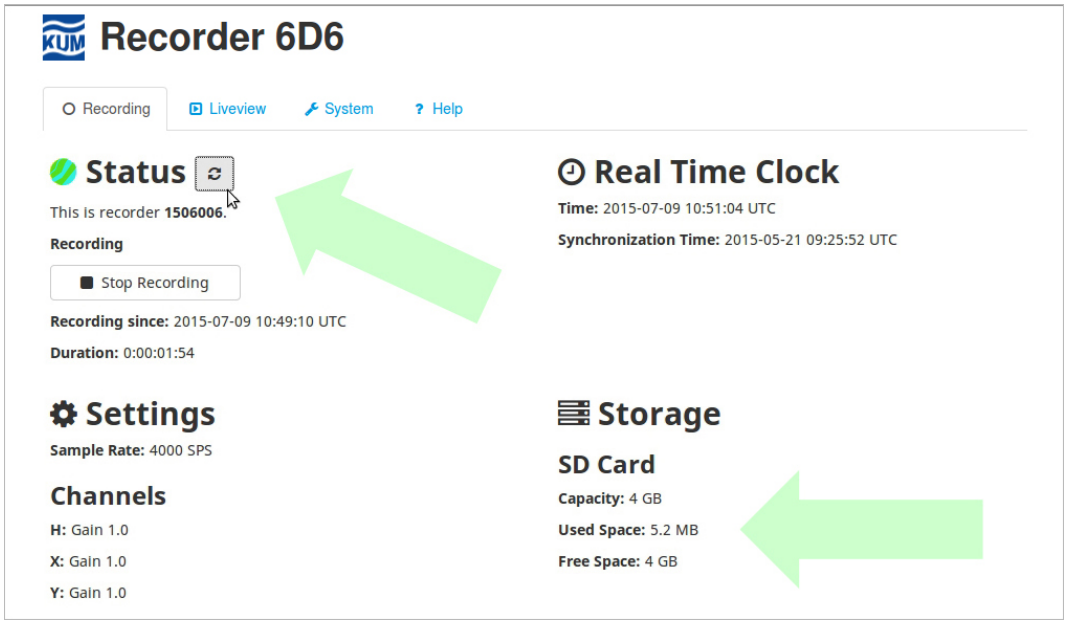
2.2.7 Recording

After formatting the storage the datalogger indicates “ready for recording” using a green dot at the web page (and a green LED at the datalogger itself).



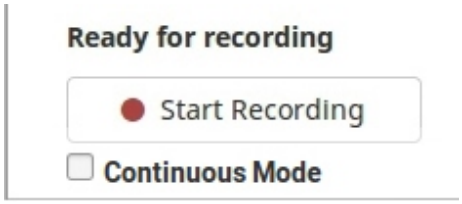
Click “Start recording” to start a new recording. In case there is still any data on the SD card it will be erased after user verification. During recording, the green light of the datalogger will flash for a while and stop flashing after a couple of minutes to preserve battery power.

You can use the refresh-button to check the rising amount of stored data.



2.2.8 Continuous Recording

Another unique feature of the recorder is the so-called "continuous recording".



Selecting the Checkbox will enable continuous recording. A warning appears that *any* storage will be formatted 30 seconds after attaching. After clicking on the "Start Recording"-Button either of two possibilities happen:

- In case a storage medium is attached: the seismometer will be switched on and a recording will start. As soon as you remove the storage medium after recovery, the seismometer will be switched off and the recorder switches to idle.
- In case *no* storage medium is attached: the seismometer will *not* be switched on and the recorder switches to idle. As soon as you attach a storage medium, the recorder wakes up, the seismometer will be switched on and a recording is started. *Remark: the levelling-countdown of the seismometer is restarted.*

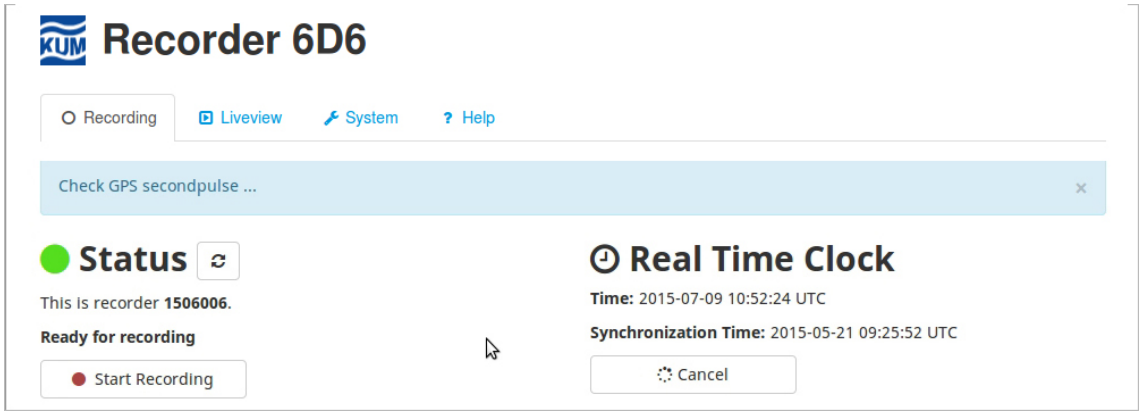
You can switch between sleep-mode and recording mode as often as neccessary without restarting a recording via web-interface. Timestamps are regularly multiplexed into the data-stream, this enables very fast turn-around times: recover the instrument, remove the StiK^{TM} , attach a new StiK^{TM} and anchor, deploy the instrument - that's it. *Remark: It is possible to determine the skew afterwards when you have finished all recordings.*

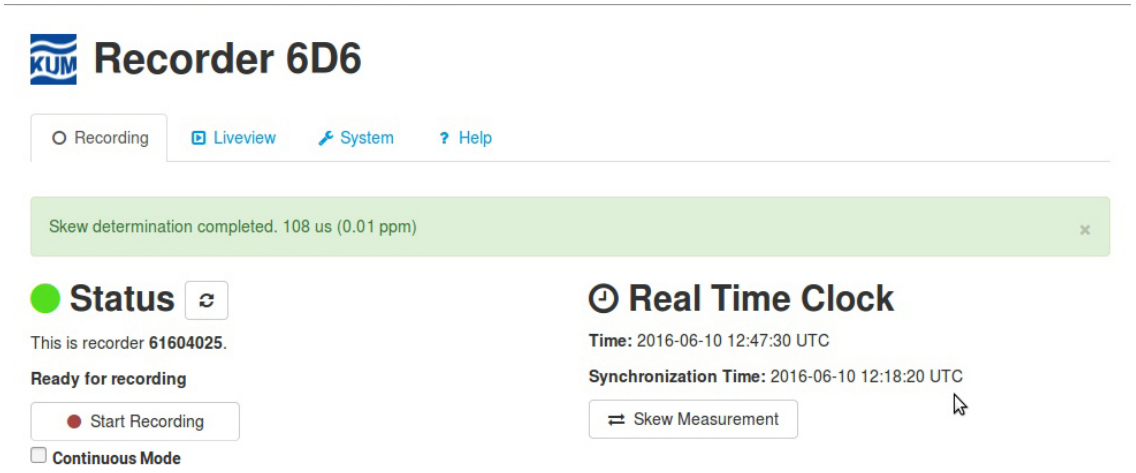
The recorder 6D6 is robust against short voltage drops. In case a *short* voltage drop happens accidently during a recording the recorder will analyze the data on the storage medium and will – in case the recording has been interupted – continue recording. There will be a small gap in the data, but the recording continues.

If in continuos mode the recording continues as well after a short voltage drop. The storage medium will *not* be formatted. Only in case there is no storage medium attached, the recorder will go to sleep and format any storage medium that will be newly attached.

2.2.9 Skew

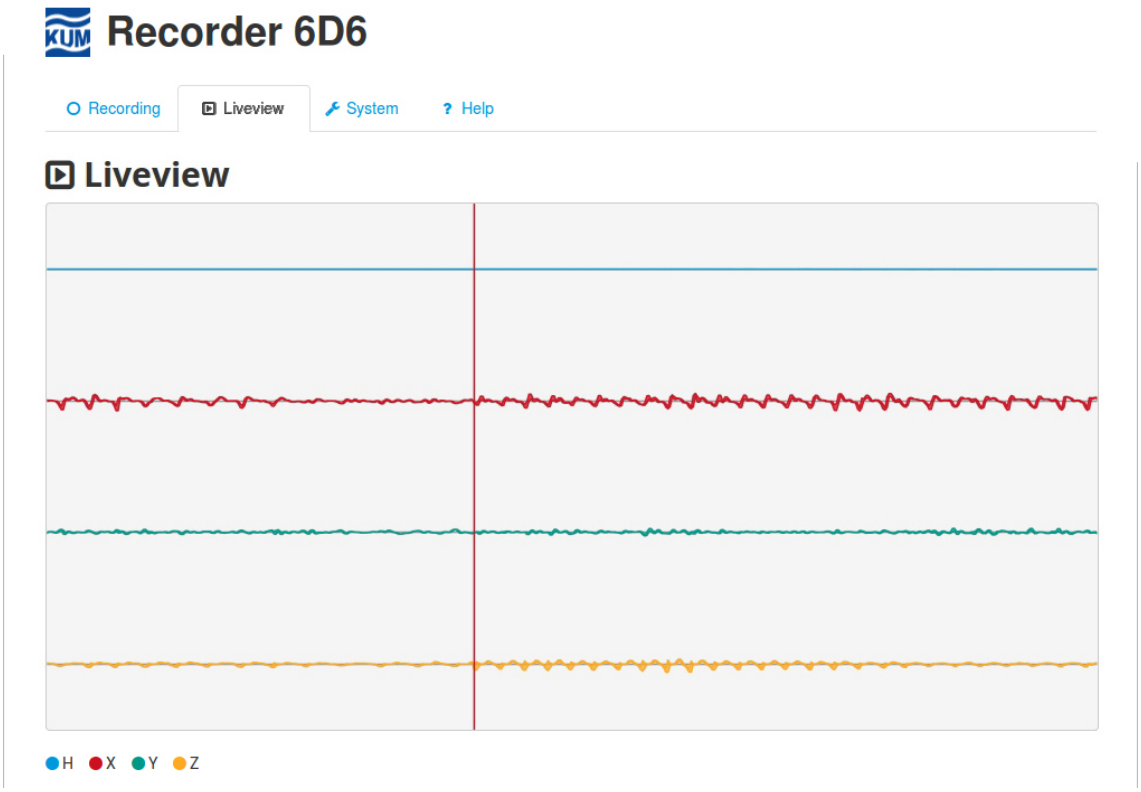
After recording you can make a second GPS fix to determine any clock drift. A colored bar will show the progress – in this example a deviation of 108 μs.





2.2.10 Liveview

Click on “Liveview” in the task menu to switch to a display of online data from all the channels in use:

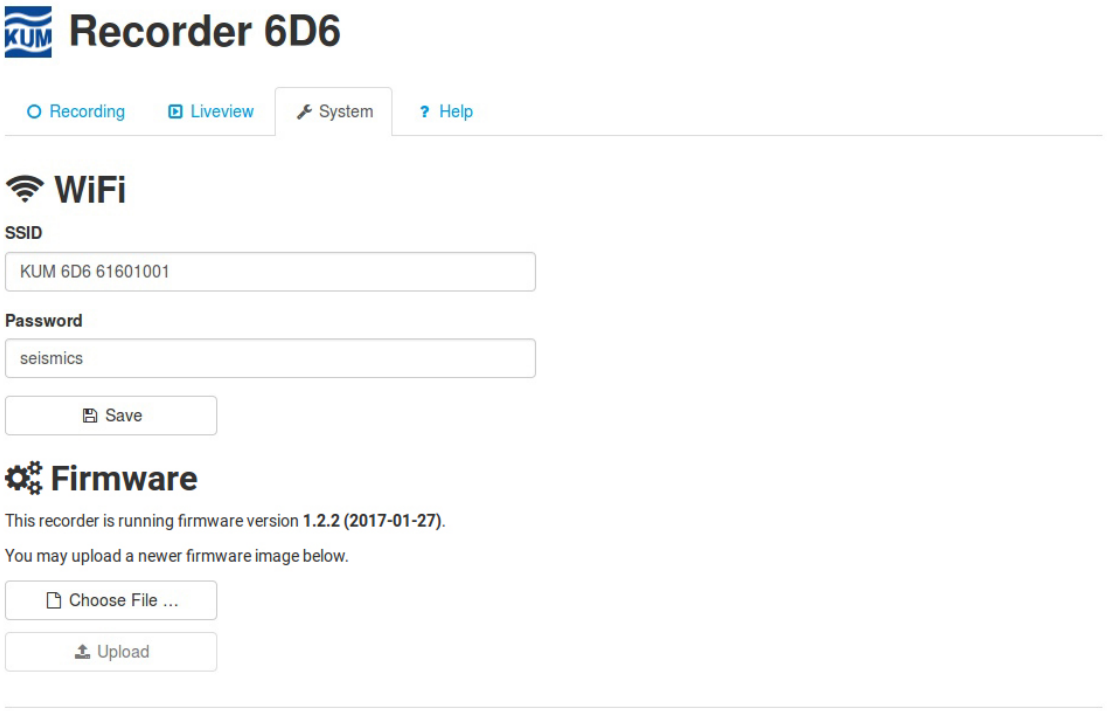


Please note that the signals shown are just a coarse representation of the data recorded – even on a 4k screen it is not possible to show four channels of 32 bit data...

2.2.11 System

Use the item “System” in the task menu to change to the system’s options. You may change SSID and password for this datalogger, however, we recommand to do so with good reasons only[2]

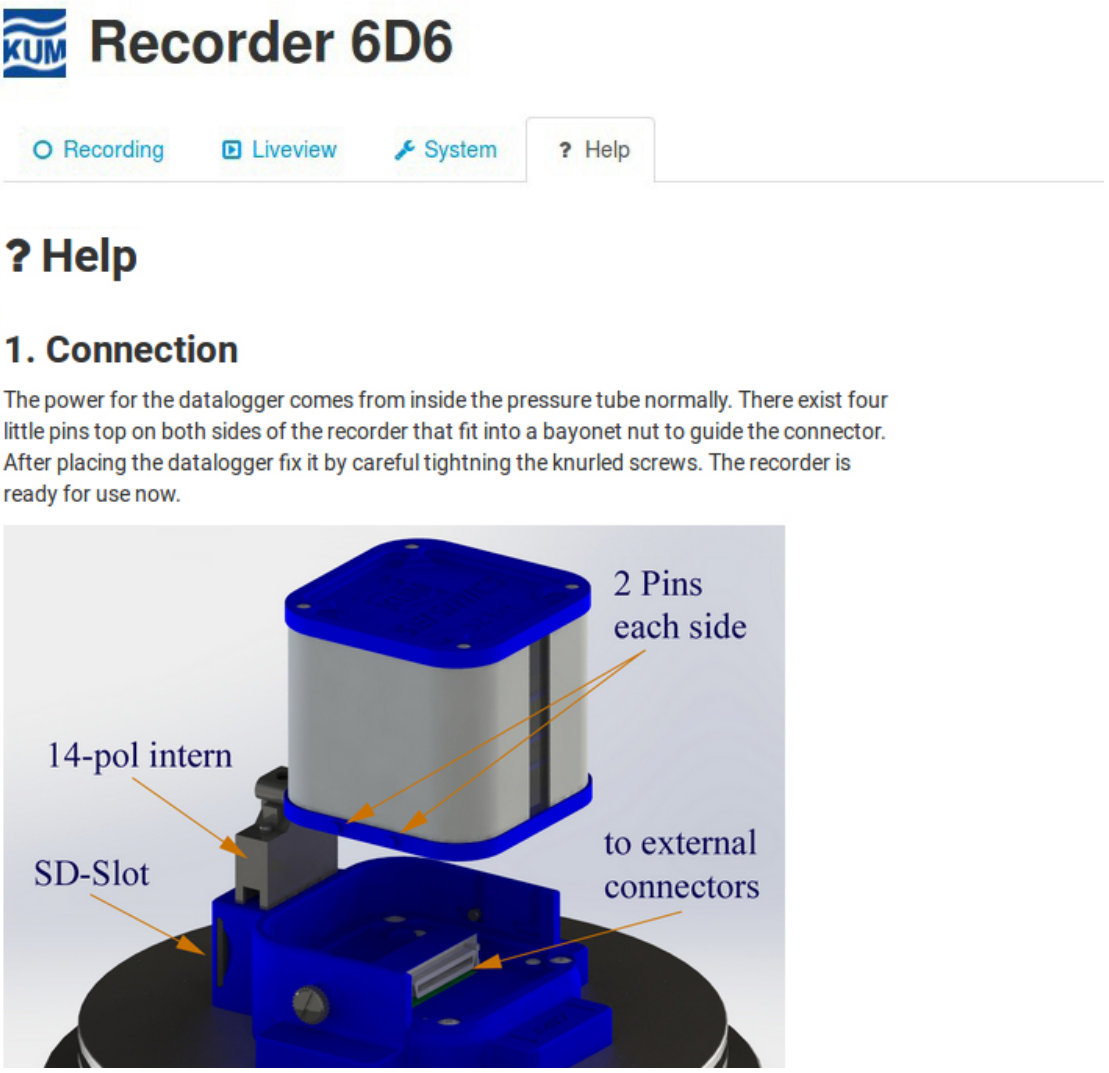
You can also upload a new firmware image to the datalogger, if necessary.



[2]In case you have lost your new password you can connect the “6D6” to a PC directly, using the builtin ethernet of “DIRC in the Box”. Navigate to this web-page to see both SSID and password in plain text.

2.2.12 Help

At this tab you will find a html-version of this chapter.



3 Downloading the Data and Conversion

3.1 Installing the Software

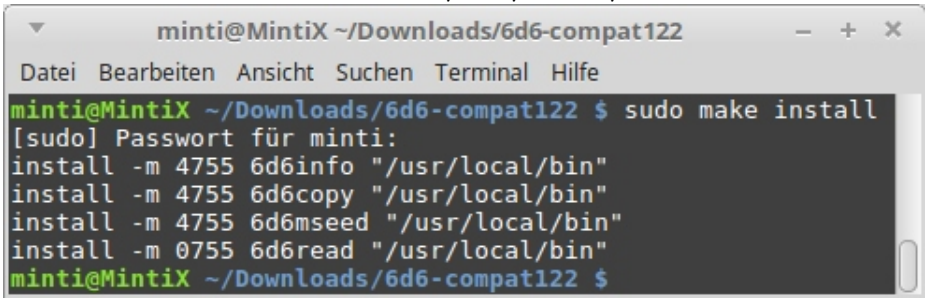
To download and convert the data the software "6d6-compat" is mandatory. It runs on any standard Linux operating system. "6d6-compat" is open source software, we strongly encourage you to join in working on it. You can download it here:
`https://github.com/kum-kiel/6d6-compat/releases`.
Please note: for programming the datalogger any laptop or tablet with a web browser can be used[3], no matter if Linux, Windows or OS X is running. *For downloading and converting the data a Linux-computer is mandatory.*

You will get just the binaries here:
`https://github.com/KUM-Kiel/6d6-compat/releases/download/vX.X.X/`
`6d6-compat-yyyy-mm-dd-X.X.X-linux-i386.tar.gz`.

Installing the Binaries

The file you need to download is named
`6d6-compat-yyyy-mm-dd-X.X.X-linux-i386.tar.gz`

To install, open a terminal, move to the download directory and type "`sudo make install`"
Now the software is installed at `/usr/local/bin`:



[3]Tested with Firefox, Chrome, Safari, Opera and Internet Explorer 11

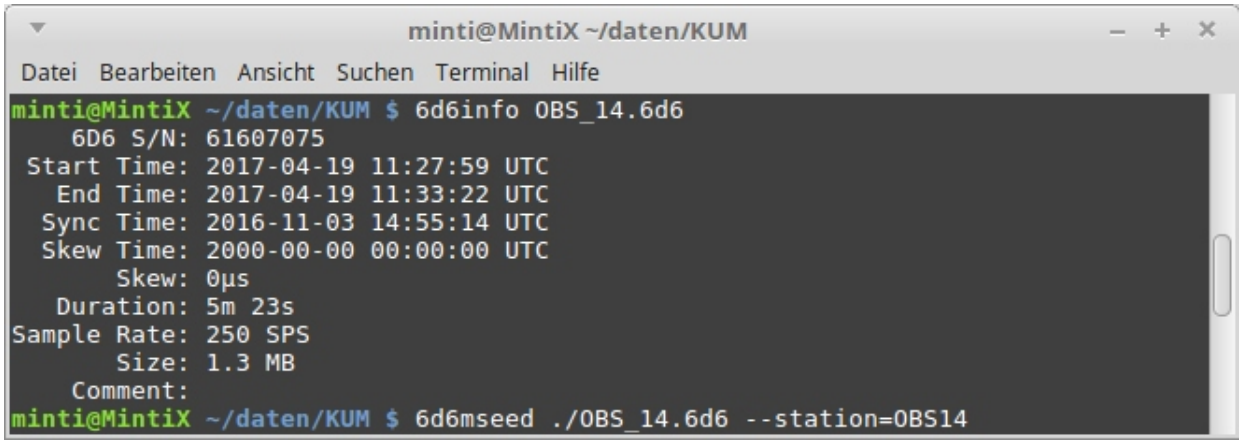
6d6compat: Commands

After re-opening the terminal you can use commands as follows:

6d6info This will show some basic information like the start time, the duration or the serial number of the datalogger.

Use it as follows: `6d6info /dev/sdX1`

This will show some basic information like the start time, the duration or the serial number of the datalogger:



6d6copy Copy a SD card to tho file system.

Use it as follows: `6d6copy /dev/sdX1 file.6d6`

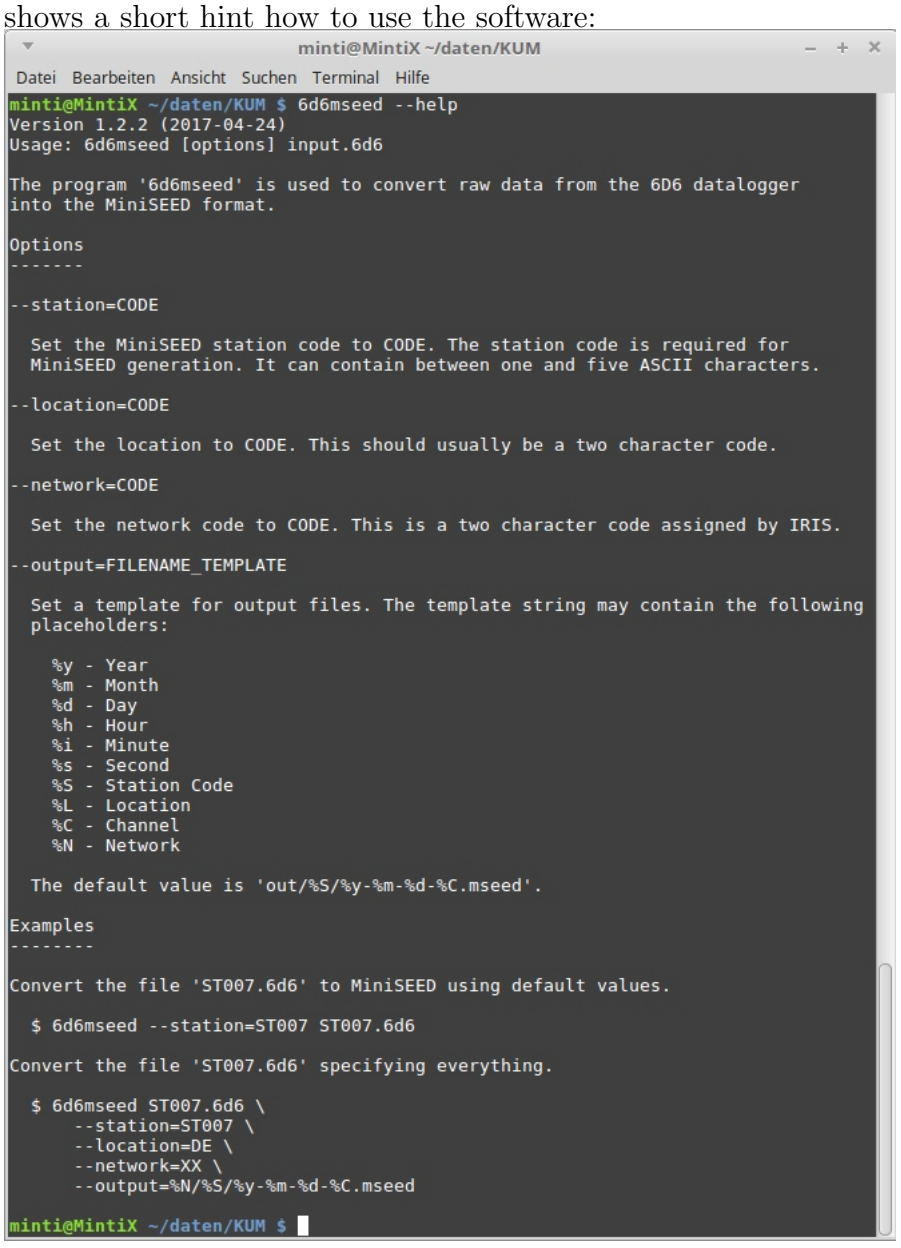
This will copy the contents of `/dev/sdX1` to `file.6d6`. Replace `sdX1` with the proper drive letter. On some systems this could also be `/dev/mmcblk0p1` or similar. Information about how the SD-card is named is logged in the file "`syslog`". You will have permanent access to the file using "`sudo tail -f /var/log/syslog`" .

6d6mseed Converts a .6d6-Datei to MiniSEED.

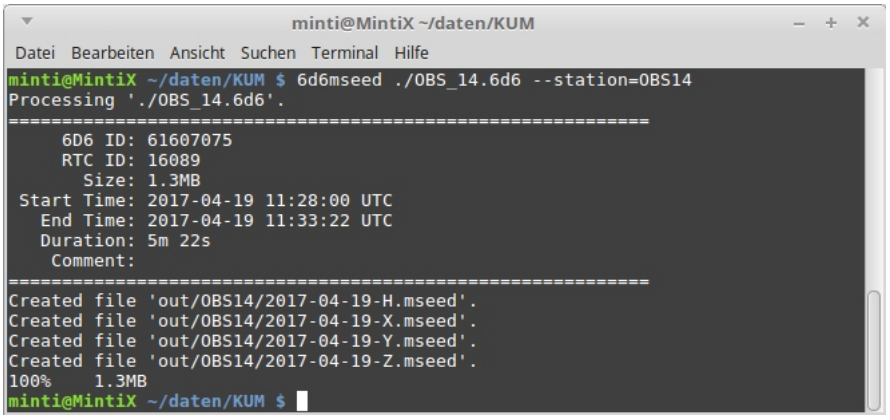
Use it as follows: `6d6mseed --station=CODE file.6d6`. This way day-files will be created that – beside the first and the last day –last from Midnight to Midnight. Using the option `--cut=3600` will create fiules of 3600 seconds length – and other fiole length simular.

This will create a folder with the MiniSEED files. The program `6d6mseed` produces SEED from the recorded data as well as a logfile `events.txt` and a file `engineering.csv` with battery voltage, temperature and some more engineering data. Using the suffix `--help`

shows a short hint how to use the software:



During the conversion the progress is shown continuously:



When data conversion is completed you can continue evaluating the data (for example with PQL II, see next chapter).

6d6read Converts a .6d6 file to a .s2x file.

Use it as follows: `6d6read < in.6d6 > out.s2x`

Note the angle brackets! They are important! This converts the input .6d6 file to .s2x. With the s2x-format you can use Send2X-tools. Attention: with this format you have to correct the skew manually with the Send2X tools!

Update

If neccessary, you can download the most recent version of `6d6compat` and replace the old one by simply typing `sudo make install` .

3.2 PQL II

The software `PQL II` is provided free of charge from the **IRIS PASSCAL Instrument Center** for different operating systems.

You can download it here `www.passcal.nmt.edu/ftp/software/pql/`. Only `rpm` packages exist for linux users, if your linux is based on ubuntu you can use `alien` to install `PQL`.

3.3 PQLX

The software `PQLX` is also provided from the **IRIS PASSCAL Instrument Center**. `PQLX` supports a database and fascinating new tools like checking the sensors performance over a

large number of instruments and deployments. For installation and more information, please refer to the documentation `IRIS` supplies.

4 Details of the datalogger 6D6

The datalogger "6D6" is a complete new development. More than 20 years experience in manufacturing seismic dataloggers helped us to design this unit, however, the hardware is all-out new and free of legacy. Our main focus was highest signal fidelity at lowest power consumption, closely followed by the intention to build a straightforward unit save to use both in the lab and on board.

The external storage "StiK^{TM}", the battery-buffered clock and using a web browser for communication are just a few features that reflect this point of view.

4.1 Clock

- 0,02 ppm / 0,65 sec per year / 1,7 ms per day
- 5 years backup battery
- -10 to +80 linear
- CSAC possible (but **doubles** the power consumption)

4.2 Pre-amplifier

The pre-amplifier boards are designed modular, they are quick and easy to change. This way, you can use the channels for different purposes. You can even tell us your own ideas what amplifier you need and we will design and incorporate it into the 6D6.

Currently three pre-amplifiers are available from stock:

4.2.1 Pre-amplifier: Hydrophone (passive) with active pre-amplifier

The hydrophone pre-amplifier ist equipped with a hardware high-pass for frequencies down to 10 mHz (100 s). Hardware-default for amplification is a gain of four.

- Input range: 1250 mV_{pp} / $\pm$ 625 mV
- Sensitivity: 3436 counts per nanoVolt (0,291 nanoVolt per count)
- Signal-Noise-Ratio: better 120 dB

4.2.2 Pre-amplifier: Geophone (passive) with active pre-amplifier

There is no high- or low-pass integrated into the geophone-board. Default for the gain is four as well as for the hydrophone.

- Input range: 1250 mV_{pp} / ± 625 mV
- Sensitivity: 3436 counts per nanoVolt (0,291 nanoVolt per count)
- Signal-Noise-Ratio: better 120 dB

4.2.3 Attenuator: Seismometer (active) with passive attenuator

The seismometer pre-amplifier can be adjusted for any active seismometer. Currently, attenuators are available for the Trillium Compact 120 from Nanometrics and for the older CMG-40T from Guralp.

Pre-amplifier Trillium Compact:

- Input range: 40V_{pp} / ± 20V
- Sensitivity: 107,37 counts per μVolt (9,313 nanoVolt per count)
- Signal-Noise-Ratio: better 142 dB

Pre-amplifier CMG-40T:

- Input range: 20V_{pp} / ± 10V
- Sensitivity: 214,75 counts per μVolt (4,657 nanoVolt per count)
- Signal-Noise-Ratio: better 142 dB

4.3 Main Compute Module

The main processor is placed on the Processing and Interfacing Terminal Module. Its purpose is as follows::

- Management of the AD-converter
  - Configuration
  - Synchronisation

  - Request and storage of the data

- Synchronization and configuration of the clock
- Request and storage of the engineering data
  - Temperature
  - Humidity
  - Battery voltage
  - Clock buffer battery voltage
- Initialising and management of the SD-card or StiK^{TM}
- Communication with User Interface (Command and Control Module)

4.4 Storage

You can attach two different kinds of storage to the datalogger: your choice should be the K.U.M. StiK^{TM}. It is pressure resistant down to 12000 m waterdepth and available in various capacities up to currently (2016) 200 GB. StiK^{TM} is attached from outside of the pressure vessel, there is no need to open the pressure vessel when using it.

As an alternative, you can use internal SD cards which are available up to 512 GB today (2016). Cards up to 2 TB are supported.

We strongly insist that you use SD-cards provided from K.U.M. only - you can not rely on power calculations if you use alternative cards. Intense tests have shown a range of five times the power consumption of different cards available on the market. Also, K.U.M. cards are guaranteed to be formatted according to the SD card standard.

You might attach both storage types at the same time to the datalogger, there exists a strict control hierarchy :

1. If in recording mode, any additional card will be ignored.
2. StiK^{TM} is preferred. In case StiK^{TM} is attached, the SD-card will be ignored.
   a) In case a SD-card is attached, and you then attach StiK^{TM}, the datalogger will switch to StiK^{TM}.
   b) If you remove StiK^{TM}, the datalogger will switch back to the SD-card.

5 Optional Upgrades

Due to its completely modular design you can add channels or change their characteristics. You can also increase the sample rate to 8000 Hz or higher. Currently, upgrades exist as described in the next chapters – please talk to us if you have more ideas how our datalogger can be upgraded.

5.1 Additional channels

The basis datalogger incorporates a module with four channels with sampling rates up to 4000 Hz at 32 bit. Simply by adding a second module you can enhance the datalogger to a seven channel instrument.

5.2 Electromagnetics – Magnetotellurics

Marine Electromagnetics/Magnetotellurics are of increasing importance in the field of geophysics. The datalogger 6D6 therefor is already prepared to support such technics. You just need to swap the pre-amplifier boards to get an EM-instrument – or you add a second AD-module to get a combined seismic-EM datalogger.

5.3 Internal GPS and AIS

Despite the high reliability and low spatial drift of our OBS-systems, the recovery of the instrument has been a time consuming job so far. To highly decrease recovery times the datalogger can be equipped with a combined GPS/AIS system: directly after ascending to the sea surface it looks for satellites. As soon as a GPS-fix is established both the clock drift is determined and the precise position is sent to the ships bridge using AIS. The OBS appears on the digital sea map and can be picked up much faster. As the data are already time corrected when the system gets on board, one can immediately remove the external StiK and download the data.

6 Accessories

6.1 SD-cards

During the development of our datalogger we made exhaustive tests with cards of various manufacturers. We realized that even at same specs the power consumption of cards can vary by a factor of five! We strongly recommend to only use SD-cards that have been tested by K.U.M. as we can not guarantee the power consumption of the complete system with alternative cards. Also, K.U.M. cards are guaranteed to be formatted according to the SD card standard. **Do not – never ever – format SD cards with your OS' format function!**

6.2 Storage StiK™

StiK™ is a thumb-sized external storage medium in its own pressure casing that is available with up to 200GB capacity. Operation and recovery of the instrument has never been so easy: after recovery rinse the pressure vessel with sweet water, remove the StiK™and get it to the lab to download the data - thats it. There is no need to open the pressure tube nor to fiddle about with a laptop or cable on deck.

When performing subsequent deployments the improvement is even more considerable: if you run the datalogger in "`continuous mode`" it immediately starts a recording when you attach a storage medium and falls asleep when you remove it. After recovery you remove the storage, attach a new one and you can re-deploy the instrument immediately.

StiK™is designed to withstand 12000 m water depth.

6.3 GPS UHURA

Our GPS receiver “UHURA” can be manufactured with 20m, 50m or 100m cable. The water-tight housing has brackets to mount it on the railing for free sky sight.

In addition to GPS-data “UHURA” is able to receive data from GLONASS and will receive data from GALILEO and BEIDOU as soon as available.

You should run “UHURA” at least 15 minutes before connecting it to a datalogger: it is just every 15 minutes that the number of leap-seconds is transferred from the GPS-satellites. GPS-time runs continuously while UTC takes into account leap-seconds – there are 17 up to now (June 2016). In case the number of leap seconds is not yet transferred, the UTC time can be inaccurate by some complete seconds.

UHURA provides NMEA-data with both 4800 and 9600 baud and a second pulse with integrated DCF77-encoding.

6.4 Junction Box DIRC

How it works

To communicate with the datalogger you will need “DIRC in the box”. If connected to “DIRC”, the webserver inside “6D6” boots and provides its webpages. You can communicate with the datalogger as described in chapter 2.2.

The USB-interface of a PC provides enough power to supply both the communication with the datalogger, the GPS-system “UHURA” (see page 30) and the interfaces for data download. However, if you want to supply an external harddisk or charge the internal battery, you should use the power supply that comes with “DIRC”. The battery lasts for 8 hours, we recommend to use the power supply whenever possible. The LED “Battery” lights red when the battery is in use and green when not in use.

An ethernet-interface is incorporated inside “DIRC”. A Linux-PC has drivers already installed, for Windows you will have to install the driver manually:
`http://www.microchip.com/SWLibraryWeb/producttc.aspx?product=OBJ-LAN95xx-WINDOWS`

In addition, “DIRC” spans an access-point. This way, you do not need a PC for communication with the datalogger, a tablet or smartphone will do as well.

For data download, however a Linux-PC is mandatory. Attach StiK^{TM} or SD-card to the slot and use the free software 6d6compat to download the data using USB. Also use 6d6compat to convert the data into your preferred format.

Attention: As already mentioned, if you use a laptop or a very long USB-cable, the USB-power might be too weak to supply both UHURA and charge the internal battery. The LED will indicate weak power by flashing. In this case use a shorter cable, a USB-3 connection or the external power supply.

Data and Connectors

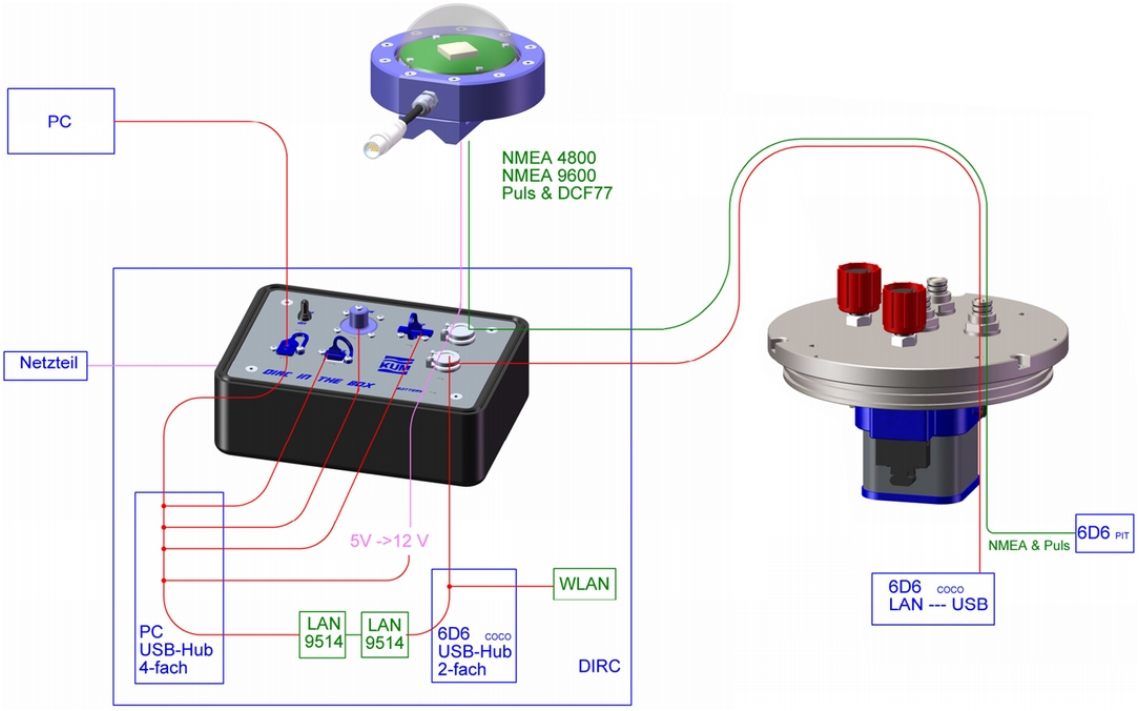


Chart of DIRC

DIRC is equipped with 6 connectors and a switch:

- the switch enables battery charge and WiFi
- USB to be connected to a PC. The PC supplies power for both battery charge and internal USB-hub including ethernet for datalogger communication (on a pc other than Linux, you will need to install a driver for the ethernet adapter).
- a socket for StiK to download the data
- a socket for USB-flash to store the data
- a socket for the GPS UHURA. Data will be transmitted with RS485 at both 4800 and 9600 baud, added by the second pulse. In addition the second pulse is DCF77-encoded

- a socket for datalogger communication

6.5 Junction Box KIT

DIRC's kid brother is called – KIT. Its just an USB-SD-card adapter and it is only used to download data.

6.6 Cases

We supply robust outdoor cases for “6D6” and all accessories individually. If you need a case for four 6D6, two DIRC and 16 StiK^{TM}– just ask.

7 Appendix

7.1 Pinout

14-pin connector of the Datalogger socket

Pin	Purpose	Description
1	X+	Pos. Trillium output
2	Y+	Pos. Trillium output
3	Z+	Pos. Trillium output
4	AGD	Trillium analogue GND
5	GND Trillium	Power GND Trillium
6	VCC Trillium	Power Trillium
7	V+	VDD Battery
8	X-	Neg. Trillium output
9	Y-	Neg. Trillium output
10	Z-	Neg. Trillium output
11	TX	TX Trillium [4]
12	RX	RX Trillium
13	nb	unused
14	V-	VSS Battery

Attention: As soon as a seismometer is connected to a power source it starts to consume energy. The power consumption is much higher if the seismometer is not levelled or if levelling is not possible as on board of a vessel. We recommend to avoid – at a running 6D6 – long delays before deployment. If a recording in "continuous mode " is running please attach the storage shortly before deployment only or, with external seismometer, wait until deployment before attaching the seismometer cable.

Remark: The sensor Trillium is switched on by the datalogger 6D6. If 6D6 is removed or switched off Trillium is switched off automatically. In addition, the sensor Trillium switches off when the voltages drops 9 Volts.

[4]Trillium needs a separate RS232 for defining the levelling schedule.

50-pin connector

Pin	Function	Notes	Used in base system
1	VBAT +	battery pack plus	yes
2	GND -	battery pack minus	yes
3	NC01	nc	no
4	H+	hydrophone +	yes
5	H-	hydrophone -	yes
6	X+	geophone/seismometer X+	yes
7	X-	geophone/seismometer X-	yes
8	Y+	geophone/seismometer Y+	yes
9	Y-	geophone/seismometer Y-	yes
10	Z+	geophone/seismometer Z+	yes
11	Z-	geophone/seismometer Z-	yes
12	NC02	nc	no
13	1PPS	second pulse from external GPS, CMOS level	yes
14	NMEA	NMEA messages from ext. GPS, CMOS level	yes
15	NC03	nc	no
16	TX	transmit data serial RS232, regular level +/-10V	yes
17	RX	receive data serial RS232, regular level +/- 10V	yes
18	LEVEL	Trillium: Power supply on (FET)	yes
19	NC04	nc	no
20	Z1-	optional second 3 channel sensor	no
21	Z1+	optional second 3 channel sensor	no
22	Y1-	optional second 3 channel sensor	no
23	Y1+	optional second 3 channel sensor	no
24	X1-	optional second 3 channel sensor	no
25	X1+	optional second 3 channel sensor	no
26	SCLK-2	SPI clock signal for external SD card	yes
27	MISO-2	SPI receive data from ext. SD card	yes
28	MOSI-2	SPI transmit data to ext. SD card	yes
29	TX1	trillium RS232 transmit	yes
30	RX1	trillium RS232 receive	yes

Pin	Function	Notes	Used in base system
31	NC05	nc	no
32	RREQ	Request Releaser Status	no
33	RSTAT1	Releaser Status 1	no
34	RSTAT2	Releaser Status 2	no
35	AIS	turn AIS/GPS/IMU on (on release?)	no
36	RELEASE	I/O signal, request release from releaser	no
37	VUSB+	USB Power +	yes
38	DN	USB Data -	yes
39	DP	USB Data +	yes
40	VUSB-	USB Power -	yes
41	VCNC	Power for CNC board, externally switched	yes
42	NC11	nc	no
43	NC12	nc	no
44	DET1	SD card detect 1	yes
45	VCC3.3	VCC for SD card	yes
46	CSSD1	CS for SD card 1	yes
47	DET2	SD card detect 2	yes
48	CSSD2	CS for SD card 2	yes
49	AIN3	optional analog input	no
50	NC14	nc	no

7.2 Coefficients of the FIR-Filter

FIR-filter coefficients are the same for any 6D6 datalogger. The FIR-filter steps 1 to 4 are used for all samplerates, step 5 is added for samplerates 50 and 100 only.

Coefficient	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**
Faktor	1/512	1/8388608	1/134217728	1/134217728	1/65536
Dezimierung	2	2	4	2	5
h_0	3	-10944	0	-132	4
h_1	0	0	0	-432	-14
h_2	-25	103807	-73	-75	-46
h_3	0	0	-874	2481	-85
h_4	150	-507903	-4648	6692	-119
h_5	256	0	-16147	7419	-127
h_6	150	2512192	-41280	-266	-91
h_7	0	4194304	-80934	-10663	0
h_8	-25	2512192	-120064	-8280	141
h_9	0	0	-118690	10620	308
h_{10}	3	-507903	-18203	22008	455
h_{11}		0	224751	348	527
h_{12}		103807	580196	-34123	468
h_{13}		0	893263	-25549	243
h_{14}		-10944	891396	33460	-145
h_{15}			293598	61387	-644
h_{16}			-987253	-7546	-1150
h_{17}			-2635779	-94192	-1521
h_{18}			-3860322	-50629	-1601
h_{19}			-3572512	101135	-1255
h_{20}			-822573	134826	-400
h_{21}			4669054	-56626	961
h_{22}			12153698	-220104	2731
h_{23}			19911100	-56082	4722
h_{24}			25779390	263758	6681
h_{25}			27966862	231231	8335
h_{26}			25779390	-215231	9442
h_{27}			19911100	-430178	9830

Coeffinient	Step 1	Step 2	Step 3	Step 4	Step 5
h_{28}			12153698	34715	9442
h_{29}			4669054	580424	8335
h_{30}			-822573	283878	6681
h_{31}			-3572512	-588382	4722
h_{32}			-3860322	-693209	2731
h_{33}			-2635779	366118	961
h_{34}			-987253	1084786	-400
h_{35}			293598	132893	-1255
h_{36}			891396	-1300087	-1601
h_{37}			893263	-878642	-1521
h_{38}			580196	1162189	-1150
h_{39}			224751	1741565	-644
h_{40}			-18203	-522533	-145
h_{41}			-118690	-2490395	243
h_{42}			-120064	-688945	468
h_{43}			-80934	2811738	527
h_{44}			-41280	2425494	455
h_{45}			-16147	-2338095	308
h_{46}			-4648	-4511116	141
h_{47}			-874	641555	0
h_{48}			-73	6661730	-91
h_{49}			0	2950811	-127
h_{50}			0	-8538057	-119
h_{51}			0	-10537298	-85
h_{52}				9818477	-46
h_{53}				41426374	-14
h_{54}				56835776	4
h_{55}				41426374	
h_{56}				9818477	
h_{57}				-10537298	
h_{58}				-8538057	
h_{59}				2950811	
h_{60}				6661730	
h_{61}				641555	

Coeffinient	Step 1	Step 2	Step 3	Step 4	Step 5
h_{62}				-4511116	
h_{63}				-2338095	
h_{64}				2425494	
h_{65}				2811738	
h_{66}				-688945	
h_{67}				-2490395	
h_{68}				-522533	
h_{69}				1741565	
h_{70}				1162189	
h_{71}				-878642	
h_{72}				-1300087	
h_{73}				132893	
h_{74}				1084786	
h_{75}				366118	
h_{76}				-693209	
h_{77}				-588382	
h_{78}				283878	
h_{79}				580424	
h_{80}				34715	
h_{81}				-430178	
h_{82}				-215231	
h_{83}				231231	
h_{84}				263758	
h_{85}				-56082	
h_{86}				-220104	
h_{87}				-56626	
h_{88}				134826	
h_{89}				101135	
h_{90}				-50629	
h_{91}				-94192	
h_{92}				-7546	
h_{93}				61387	
h_{94}				33460	
h_{95}				-25549	

Coeffinient	Step 1	Step 2	Step 3	Step 4	Step 5
h_{96}				-34123	
h_{97}				348	
h_{98}				22008	
h_{99}				10620	
h_{100}				-8280	
h_{101}				-10663	
h_{102}				-266	
h_{103}				7419	
h_{104}				6692	
h_{105}				2481	
h_{106}				-75	
h_{107}				-432	
h_{108}				-132	
h_{109}				0	

7.2.1 Impulse-Response and Step-Response

The (Linear Phase filtered) Impulse-Response for higher samplerates is displayed below, followed by the graphics for samplerates 50 and 100:

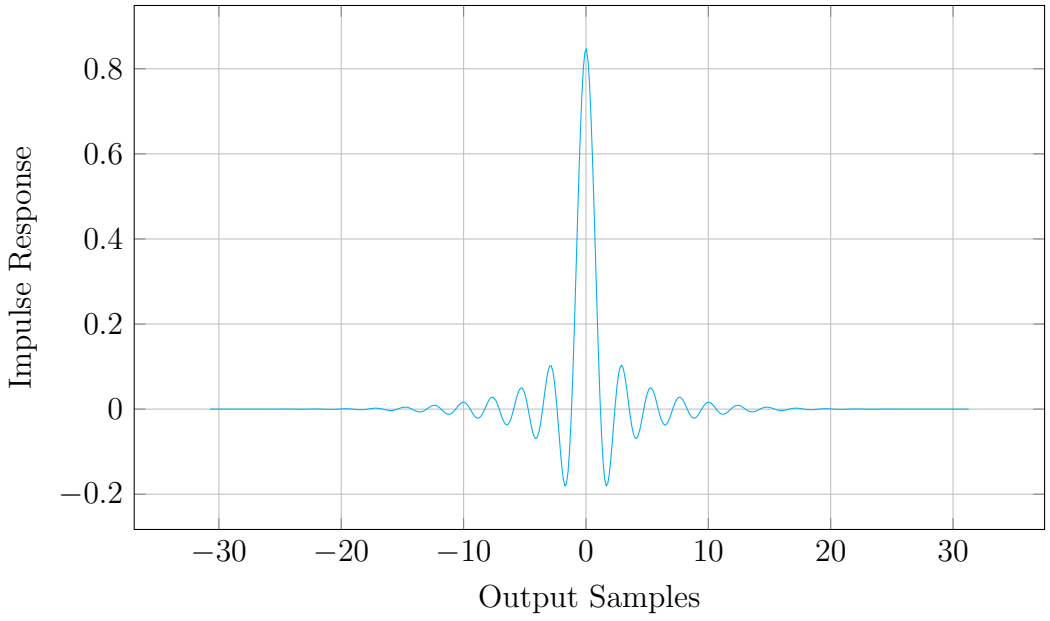


Figure 1: Impulse Response for samplerates $\geq 250\,\mathrm{SPS}$

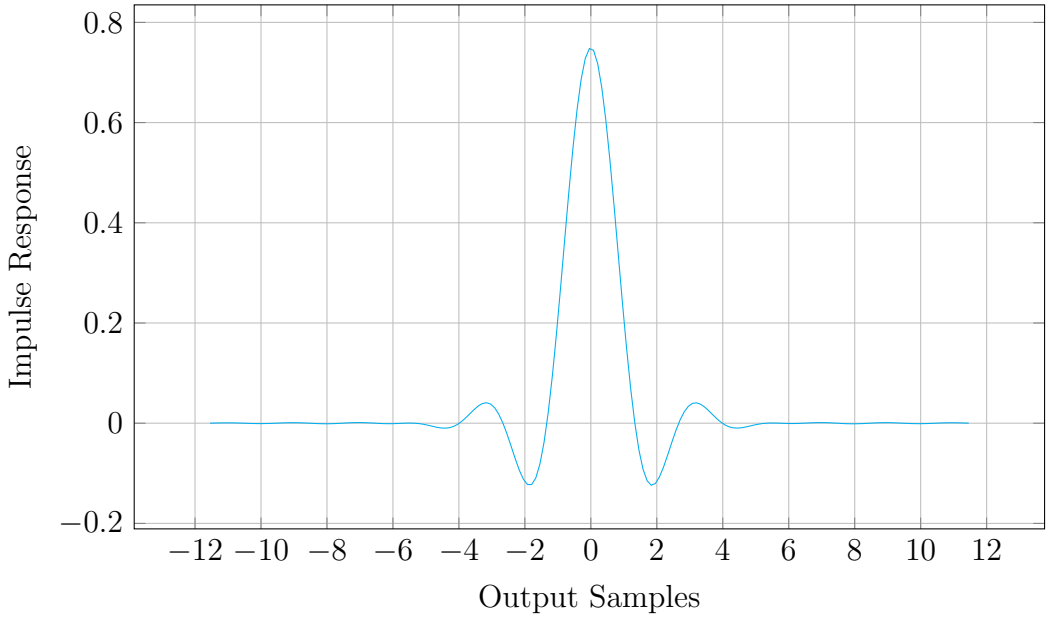


Figure 2: Impulse Response at samplerates $< 250\,\mathrm{SPS}$

7.2.2 Convolution of two filter

Below you can see the Impulse-Response of the Linear Phase Filter (blue) and the Minimum Phase Filter (green). The datalogger "6D6" *always* uses the Linear Phase Filter.

In case you prefer a Minimum Phase Filter you can apply it to the data afterwards by convolution of both filter (grey in the picture). The result is not exactly the same but very close to the pure Minimum Phase filtered response.

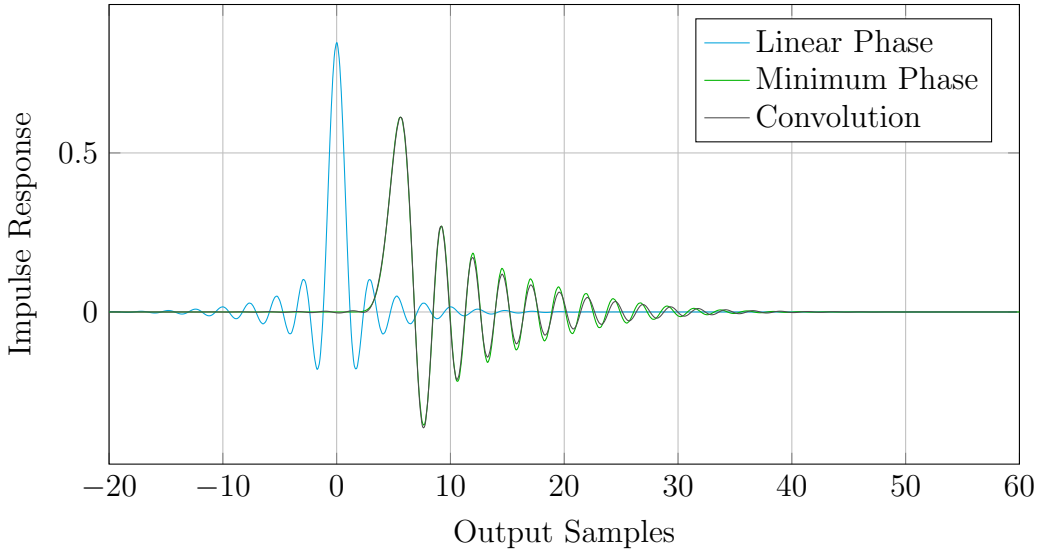


Figure 3: Convolution Impulse Response Linear and Minimum Phase

Here the Step Response of the Linear Phase (blue) and Minimum Phase Filter (green) as well as the Convolution (grey) is shown. Again, there is very good coincidence between the convolution and the original Minimum Phase filter.

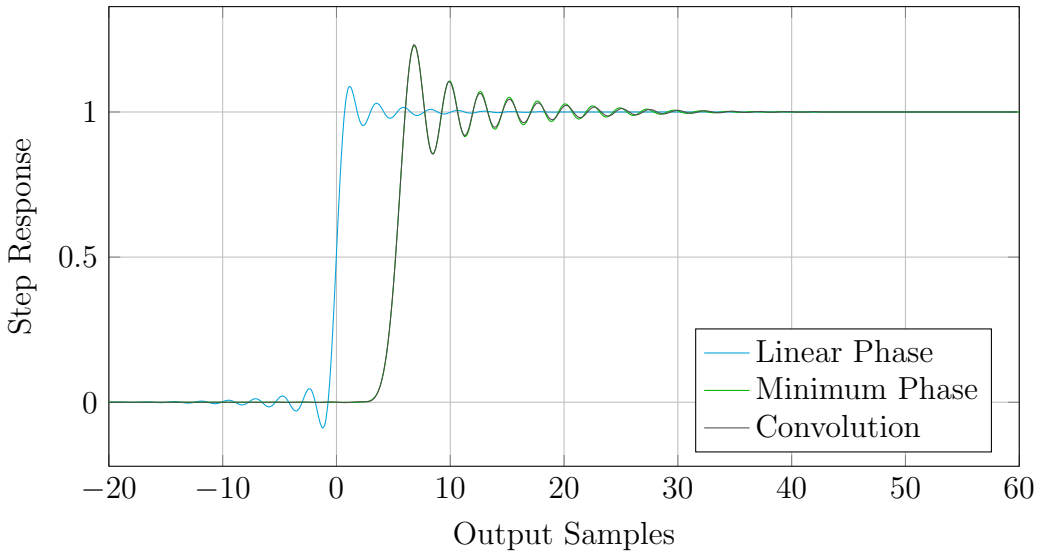


Figure 4: Convolution Step Response Linear and Minimum Phase

7.3 Frequently Asked Questions

What kind of software do I need? `6d6compat` is mandatory. You can download this package for free, please refer to page 19. It is used to download the data and covert it to your requested data format.

What data formats are supported? Currently (April 16, 2018) mSEED and Send2X are supported, SEED, SEG-Y and further formats are in preparation. In case you need a special format please talk to us – we want to emphasize that any help for the open source software "seisconvert2" is welcome. Your help might speed up the implementation of your format...

There is a flashing plug in the bottom right corner – what does it mean? The flashing plug indicates a static web site due to a lost connection. Please check your WiFi (or Ethernet) connection in that case.

My batteries have been empty at recovery. Are my data down the drain? Fortunately not. The clock of 6D6 is buffered for several years and the data are time-stamped permanently. You can attach new batteries to the 6D6, attach the SD-card and GPS and make your skew measurements.

I formatted my SD-card accidently. Are my data down the drain? Yup.

May I connect a geophone to a seismometer channel and vice versa? Definitely No! The output voltage of a seismometer is much higher than the range of a geophone input. On the contrary if you connect a geophone to the seismometer input you will get poor signals barely existing.

I would like to record ?Marine Mammals?Icebergs?Aliens? – does it work? We don't know. But we can develop pre-amplifier modules in accordance to your needs.

My sensor supplies data using ?RS232?SPI?Ethernet? – does it work? We will manage it.

I would prefer a atomic clock / CSAC – does it work? Yes, the datalogger is that modular that even a CSAC is supported. Please keep in mind that the CSAC alone consumes 125mW – the power consumption of the datalogger will double in that case.

7.4 Meaning of LED-colors

Green Ready for recording.

Green flashing Running in "continuous mode" and waiting for storage media.

Blue flashing Communication running.

Green-magenta flashing A recording is running. LED shuts off after 5 minutes.

Magenta Not ready for recording (Synchronised? Storage media? Battery voltage?).

Red flashing Should not happen – an error occurred. Check all connections, in case of need remove battery for 5 minutes and restart.

DATASHEET 6D6

POWER

Power system	Protected electronic re-settable fuse design with low voltage disconnect and restart, reverse battery and short circuit protection, 9 to 24 Volt
Ultra-low power	125mW @ 4-channel continuous recording @ 1000sps
Communications	2.5W typical; 4-channel continuous recording @1000sps real-time Ethernet with data graphical displayed

SENSOR INPUTS

Channels	4, simultaneous sampling
Input Range	hydrophone/geophone: 1,25 Volt peak to peak seismometer: 40 V peak to peak
Sensitivity	107,35 counts per μV (2^{32} bit per 40 Volt)
Input Impedance	hydrophone: 50 MΩ geophone: 100 kΩ seismometer: 114,3 kΩ

TIMING

Timing system	Internal MCXO clock
Timing accuracy	0.02 ppm

DIGITIZER PERFORMANCE

Type	Proprietary sigma-delta
Filter type	Linear phase, shifted to Zero-Phase
FIR Filter delay	corrected in raw data
Dynamic Range	>142dB @ 100sps
Shorted input noise	140 nanoVolts RMS typical at 100sps
Sample rates	50, 100, 200, 250, 500, 1000, 2000, 4000 sps
Software gain	selectable 0.5 / 1 / 1.5 2 / 2.5 / 3 / 3.5 / 4
High Pass Filter	hydrophone only: 0.01Hz

INTERNAL DATA STORAGE

Standard	SDXC-Flash-card slot
External	StiK, pressure resistant to 12.000 m waterdepth

STORAGE CAPACITY

SD-card	up to 512GB (available in 2016, specified to 2TB)
StiK	up to 200GB (available in 2016, specified to 2TB)
Recording modes	start-stop or continuously triggered by storage hot-plugging
File system	proprietary

DATA RETRIEVAL

Data Download	media exchange
Media exchange	hot-plugging

CONFIGURATION

Communication	remotely using any web browser over WiFi or Ethernet

REAL-TIME DATA

Interfaces	Ethernet or WiFi
Data type	graphically displayed in web-browser

INTEGRATED USER INTERFACE

LED indicators	System status multi-colour LED

CONNECTORS

Internal connector	14-pin for power and seismometer
External connector	50-pin for power, any type of sensors and communication

SENSOR SUPPORT

Sensor types	Broadband active and short period passive
Sensor power	Sensor power 9-25 V, switched on/off as required from recorder
Serial interface	Supports Nanometrics “Trillium compact”

ADDITIONAL LOGGING

Logged data	Power supply voltage Temperature GPS timing and channel parameters 16 housekeeping voltage inputs (10-bit) Configuration External Events

SOFTWARE

Operating system	Linux
Applications software	6d6-compat, open-source

ENVIRONMENTAL

Operating temp.	-10°C to +80°C
Storage temp.	-10°C to +80°C
Length	82 mm
Width	82 mm
Depth	80 mm
Weight	240 g

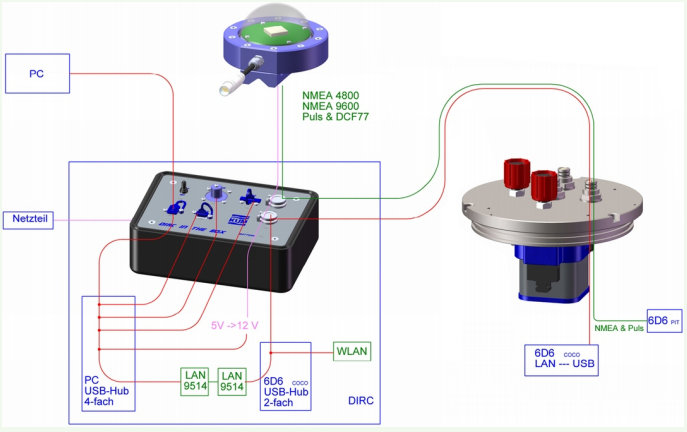
OPTIONS

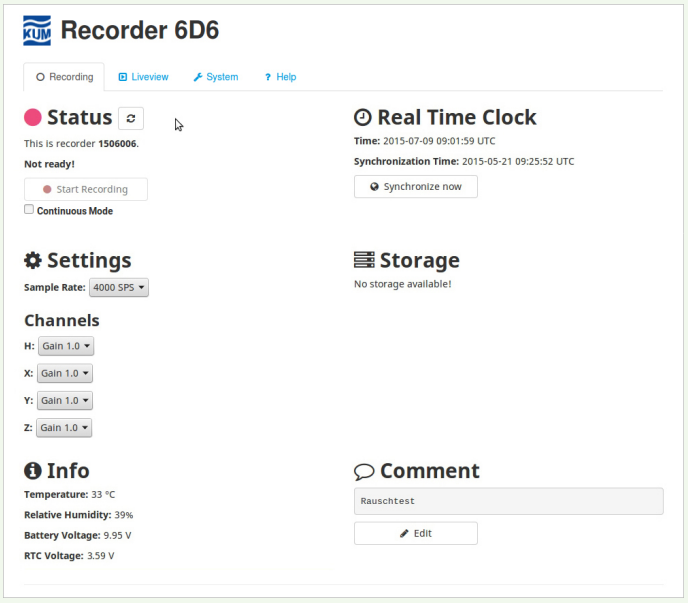
channels upgradeable to multiples of 4
CSAC clock (but doubles power consumption)

Before Deployment

Quick Reference Guide

Please note: in case the system does not react as described here, please read the more detailed manual.



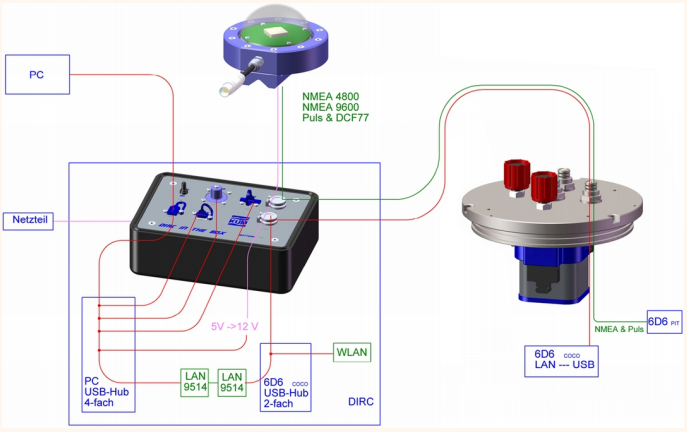


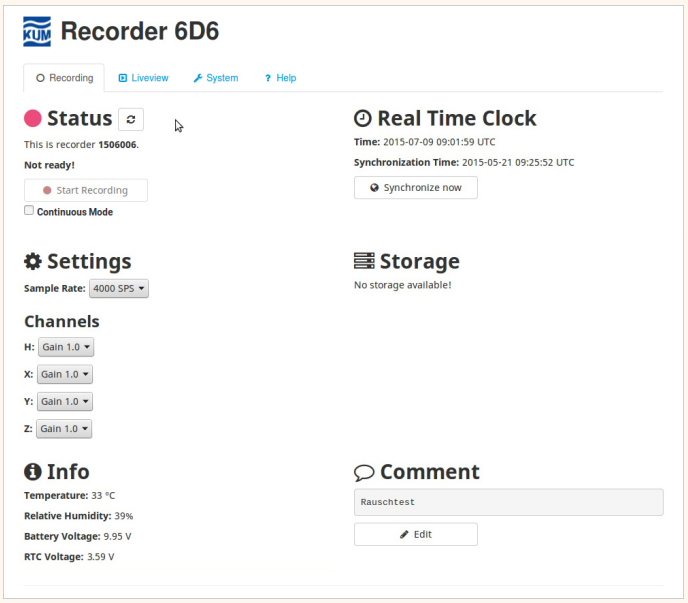
1. Connect UHURA with DIRC.
2. Connect your Linux-pc to DIRC using the USB-B cable and switch on DIRC. The external power supply is not mandatory.
3. Connect the datalogger into the bayonet joint of the end cap's socket and lock it.
4. Connect the 14-pin internal battery connector and lock it. This also connects the internal seismometer.
5. Connect the end cap of the pressure tube with DIRC using the socket "COM".
6. After 30 seconds the datalogger flashes blue for a second: the web server has been started and DIRC is connected to the web server with the internal USB-ethernet adapter.
7. Your pc will connect automatically with the web server using the USB-ethernet adapter.
8. Start a web browser and enter the IP-adress "10.0.0.1" at the adress field. You are now connected to the datalogger.
9. Connect a StiK^{TM} or a SD-card to the datalogger. Both capacity and used data – if existing – is shown in the area "Storage".
10. Where applicable erase the memory. Adjust channels, gain and sample rate in the areas "Setting".
11. Synchronize the datalogger – make sure UHURA has been running for at least 15 minutes.
12. "Status" button is colored green by now. In case it is not, stop here and carefully read the manual.
13. You can start a recording now.
14. Check if all sensors (hydrophone and seismometer) are connected and working .

After Recovery

Quick Reference Guide

Please note: in case the system does not react as described here, please read the more detailed manual.





1. Connect UHURA with DIRC.
2. Connect your linux-pc to DIRC using the USB-B cable and switch DIRC on. The external power supply is not mandatory.
3. Connect the end cap of the pressure tube with DIRC using the socket “COM”.
4. After 30 seconds a the datalogger flashes blue for a second: the web server has been started and DIRC is connected to the web server with the internal USB-ethernet adapter.
5. Your pc will connect automatically with the web server using the USB-ethernet adapter.
6. Start a web browser and enter the IP-adress “10.0.0.1” at the adress field. You are now connected to the datalogger.
7. Both capacity and used memory is shown in area “Storage” and the “Status” button is flashing.
8. Stop the recording.
9. Synchronize the datalogger – make sure UHURA has been running for at least 15 minutes.
10. Remove the storage medium. You now can disconnect the datalogger from DIRC.
11. Connect the storage medium to DIRC.
12. Start a terminal and the software “`6d6info`” and “`6d6copy`” to download the data.

8 WARNING – READ THIS FIRST!

All personnel involved with the installation, operation, or maintenance of the equipment described in this manual should read and understand the warnings and recommendations provided below.

WARNING

This manual is a reference book only. It does not claim completeness and refers to other literature in certain chapters. This manual cannot and shall not substitute an instrument introduction through an expert. Programming and deployment of an autonomous deep-sea instrument is an utmost complex affair and require the detailed know-how of all components and their composition in order to guarantee successful operation. Thats why we expressly recommend that solely trained personnel shall operate and maintain the instruments.

Static Sensitive Devices

This equipment contains devices that are extremely sensitive to static electrical charges. Therefore extreme care should be taken when handling them, as static electricity may be present on the body and clothing. Normal handling precautions involve the use of anti-static protection materials and grounding straps for personnel.

High Voltages

High Voltage may be present in all parts of the Datalogger 6D6 . Use caution when the electronics are removed from their containers for servicing.

Improper Line Voltage

Operation with improper line voltage may cause serious damage to the equipment. Always ensure that the proper line voltage is used.

Hardware Variations and Compability

The Datalogger 6D6 contains both standard and proprietary hardware. At times K.U.M. may change the standard components due to their availability or performance improvements. Although the component manufacturers, along with their models and styles may change from unit to unit, replacement components will generally be interchangeable. K.U.M. will make every effort to see that replacement components are interchangeable. K.U.M. may also change certain hardware per customer requirements. Therefore, portions of this manual, such as parts lists and test features, are subject to change.

These sections should be used for reference only. When changes are made that affect Datalogger 6D6 operation, they will be explicitly noted.

Purpose of this Manual

The purpose of this manual is to provide the user with information on the setup, operation, care, and features of the Datalogger 6D6 . Although this manual encompasses the latest operational features of the Datalogger 6D6 , some features of the Datalogger 6D6 may be periodically upgraded. Therefore the information in this manual is subject to change and should be used for reference only.

Warnings, Cautions, and Notes

Where applicable, warnings, cautions, and notes are provided in this manual as follows:

WARNING!

Identifies a potential hazard that could cause personal injury or death to yourself or to others.

CAUTION!

Identifies a potential hazard that could be damaging to equipment or could result in the loss of data.

NOTE:

Recommendations or general information that is particular to the material being presented. It may also refer to another part of this manual or to another manual.

Liability

K.U.M. has made every effort to document the Datalogger 6D6 in this manual accurately and completely. However, K.U.M. assumes no liability for errors or for any damages that result from the use of this manual or the equipment it documents. K.U.M. reserves the right to upgrade features of this software and to make changes to this manual without notice at any time.

Warranty statement

All equipment manufactured by K.U.M. is warranted against defective components and workmanship for a period of one year after shipment. Warranty repair will be done by K.U.M. free of charge. Shipping costs are to be borne by the customer. Malfunction due to improper use is not covered in the warranty, and K.U.M. disclaims any liability for consequential damage resulting from defects in the performance of the equipment. No product is warranted as being fit for a particular purpose, and there is no warranty of merchantability. This warranty applies only if:

- The items are used solely under the operating conditions and in the manner recommended in Seller's instruction manual, specifications, or other literature.

- The items have not been misused or abused in any manner, nor have repairs been attempted thereon without the approval of K.U.M. Customer Service.
- Written notice of the failure within the warranty period is forwarded to Seller and the directions received for properly identifying items returned under warranty are followed.
- The return notice authorizes Seller to examine and disassemble returned products to the extent Seller deems necessary to ascertain the cause for failure.

The warranties expressed herein are exclusive. There are no other warranties, either expressed or implied, beyond those set forth herein, and Seller does not assume any other obligation or liability in connection with the sale or use of said products. Any product or service repaired under this warranty shall be warranted for the remaining portion of the original warranty period only.

Equipment not manufactured by K.U.M. is supported only to the extent of the original manufacturer's warranties.

Returned Material Authorization

Prior to returning any equipment to K.U.M., a Returned Material Authorization (RMA) number must be obtained. The RMA will help us identify your equipment when it arrives at our receiving dock and track the equipment while it is at our facility. The material should be shipped to the address provided in the K.U.M. Customer Service section. Please refer to the RMA number on all documents and correspondences as well. All returned material must be shipped prepaid. Freight collect shipments will not be accepted.

CAUTION! Never attempt to ship portable topside units in their storm case alone. Although rugged, these cases are not intended to be used as shipping containers, and the delicate internal components could be damaged if used in this manner.

All shipments must be accompanied by a copy of your proforma invoice, showing the value of the material and the reason for its return. When shippend from outside the European Union: If the reason is for repair, it must be clearly stated in order to move through customs quickly and without duties being charged. Whenever possible, please send copies of original export shipping documents with the consignment.

Final Disposal

The Datalogger 6D6 contains materials (especially batteries) that need proper disposal. Please contact customer service if your local disposal contractor is in doubt.

Customer Service

Customer service personnel at K.U.M. are always eager to hear from users of our products. Your feedback is welcome, and is a valuable source of information which we use to continually improve these products. Therefore we encourage you to contact K.U.M. Customer Service to offer any suggestions or to request technical support:

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