ANIMAL SOUND LABS
SYSTEMS FOR NON-INVASIVE
WILDLIFE MONITORING

MOBILE ULTRASOUND RECORDING DETECTOR

LUNABAT DFR-1 PRO

User Manual

NOTE! The manufacturer reserves the right to change the parameters and method of service without prior notice. Due to the continuous process of introducing improvements, some of the functions listed in this manual may vary depending on the firmware version being downloaded.

The manual edition (version 1.3) applies to the firmware version no 7.35

CONTENT

1. Preparation for work

1.1. Power supply

Open the battery compartment, arrange the ribbon to facilitate removal of the battery at the bottom of the battery compartment, and insert two AA / R-6 rechargeable batteries (or primary batteries) in the correct polarity as described on the bottom of the battery compartment and close the cover. Inserting the cells is easiest to start by inserting the positive poles first. And removing is easier when removed negative poles first. You can help yourself by holding the positive pole with your finger and pulling the ribbon moved towards the negative pole.
The detector has built-in protection against reverse polarity of the battery and accidental reverse insertion will only cause a lack of power and the ability to turn on the device.
The PRO version of the detector has also the possibility to power it from external 5V voltage source via microUSB socket [12], eg. power bank. Connecting external voltage to micro-USB socket disables the internal AA cells. Disconnecting external voltage (or the USB plug) causes short break of supply power because of internal power switching to internal source (AA cells) so it's best to turn off the recording when you remove the USB cable.

ATTENTION: In the case of battery replacement - if the detector has been switched off correctly by pressing ⏻ button or automatically closed after the power supply has dropped, then after removing the batteries from the battery compartment, the internal clock and real time clock as well as the setting of the listening volume potentiometer will be sustained from the internal supercapacitor. So it's time from about 1 minute to a maximum of a few minutes to exchange cells for new / charged ones. After switching off the power supply (even after the automatic shutdown due to the low voltage level), the internal clock operates and consumes a very small current - about 250uA, which allows it to work for at least several dozen hours without too deep discharge of the batteries. In the case of power from alkaline batteries - the clock will be even a dozen or so - several dozen days until the voltage drops to approx. 0.84V /cell but the Ni-MH batteries can be permanently damaged if not charged as soon as possible.

1.2. Memory card

The memory card (SDHC or SDXC type) formatted in the FAT32 file system, with 32 or 64kB clusters should be inserted into the slot [7] located on the bottom / side wall of the device (press card until you hear a clear click / catch from the card slot).
The SD card should be inserted with contacts facing down (subtitles on the top side).
The first use of the memory card immediately after formatting is associated with a slightly longer than usual time of access to the card due to the search and the possible lack of configuration file (CONFIG.LUN), which will be created with default configuration settings: 256kHz sampling, 60min files, FS HPF = OFF, FD HPF = LOW, GPS = ON, REC LEVEL = 063, TRIGGER LEVEL = 063

Note: in case of recording problems you can format the card in the device from the user's MENU or on the computer using SD Formatter software (to download from https://www.animalsoundlabs.pl from the "Download" tab on the subpage of the detector or from the address: https://www.sdcard.org/downloads/formatter/

1.3. GNSS module and / or i2c sensors.

Connect the GPS / GNSS receiver plug or module with other sensors to the expansion socket [10], paying attention to the "key" located both in the plug and in the socket. The key in the socket should be on the upper side of the device. Tighten the fixing nut on the plug clockwise.

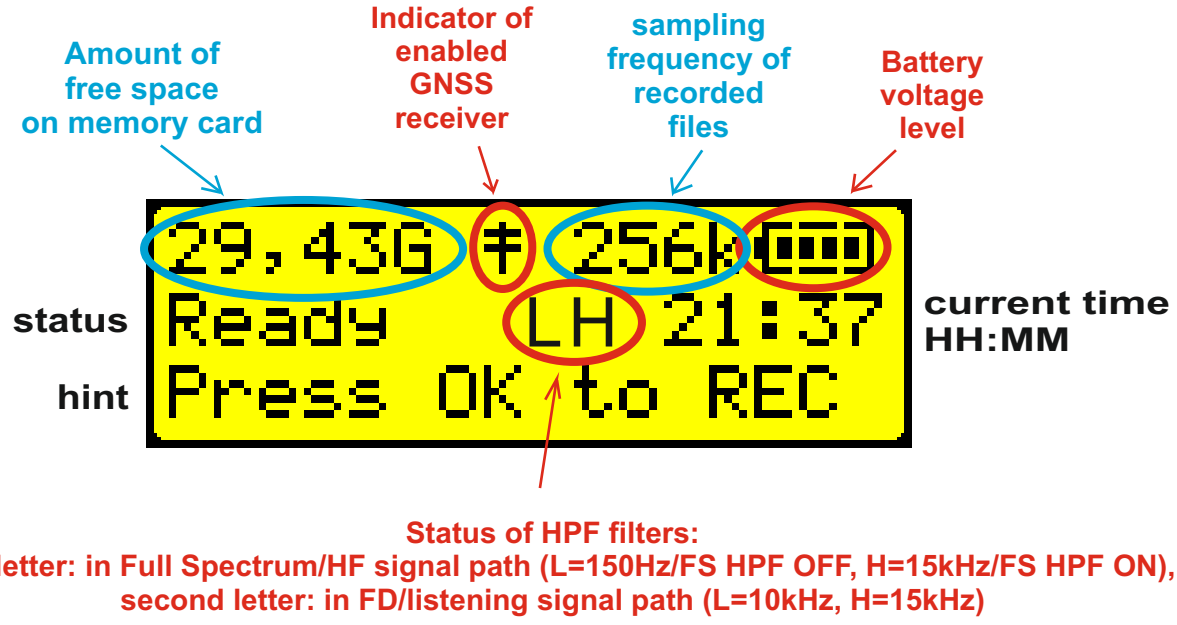
1.4. Microphone

As in the case of the GPS / GNSS receiver plug, insert the microphone or microphone extension cable plug into the microphone jack [1] maintaining the polarity (the "key" in the plug is facing upwards) and tighten the nut fixing the plug to the socket.

NOTE: The PRO version of the detector has a built-in high voltage generator (200V) to polarize the membrane of future electrostatic microphones (eg MC-1, MC-2) and this generator is activated automatically when such a microphone is detected in the mic socket.

1.5. Switching on the detector

Briefly press the power switch marked with ⏻. After displaying the device name and the firmware version and after trying to detect the GNSS receiver and reading the amount of free space on the memory card and trying to find a configuration file on it, the detector is ready for operation. If there is no configuration file (CONFIG.LUN) in the main directory on the memory card - the default settings will be applied and cause the detector to be ready for operation in manual mode (FD listening and waiting for the manual start of recording). The following information will be displayed on the LCD:



2. Working with the detector

2.1. Listening and setting up the listening volume

In standby mode (descriptions as in the picture above) the detector, while waiting for the recording to start, has already started the FD (Frequency Division) detection path enabling the audition of ultrasounds transformed into human sounds 10 times lower than the original ultrasonic signal. Listening may be on the built-in loudspeaker [4] or on headphones connected to the headphone jack [13]. Connecting a headphone or 3-pin minijack (stereo, 3.5mm) to the headphone jack disconnects the built-in loudspeaker.
In the PRO version of the detector it is possible to prevent the deactivation of the built-in loudspeaker when a 4-pin minijack plug is connected, in which an additional ring (4th pin) is not connected to the ground or to an external microphone (special optional accessory cables to the detector) and you can not use for example headphones from cell phones.

The volume control switches [9] are used to set the listening volume. They are connected to 32-point digital potentiometer. By default, when the detector is started for the first time (or after a long absence of batteries / accumulators in the battery compartment), the digital potentiometer is set to the "middle" position and the listening volume can be reduced completely (lower **VOL** button) or doubled by pressing 16 times or longer holding down the upper **VOL** button.

The volume setting is remembered after the power is turned off and restored when the detector is turned on. It is also remembered when replacing the batteries, provided, however, that the exchange itself takes place within a maximum of 45-60 seconds after removing the previously used batteries / accumulators. It should also be noticed that the battery replacement itself takes place after the detector is turned off. The power supply of the digital volume potentiometer is sustained from the built-in supercapacitor only after switching off the power supply with the ⏻ switch [17] or after automatic shutdown due to low battery.

NOTE: If the batteries are removed from the detector while the detector is switched on in the standby mode, then the memory setting of the listening volume potentiometer will be reset to the default value (mid position = approx. 6dB lower and 16clicks lower than the maximum possible volume setting).

2.2. Recording with listening

In the standby mode, press **OK** button on the keyboard (the right button is highlighted in blue or its description is highlighted in white). Broadband recording will start with the Sampling Frequency set in the menu (or the default). The default sampling frequency (256 kHz) allows recording of signals with frequencies up to approx. 125 kHz (more information - Table 1 on the end of the instruction).

If you want to record the signal processed by the parallel FD detection path (which is used for listening), select the sampling frequency 24 or 48 kHz - switching the signal source from the HF path to the FD path will be done automatically.
After connecting the headphones to the headphone jack [13], the built-in loudspeaker will be disconnected, if the connected headphone plug is the classical 3-pin stereo connector.

ATTENTION: remember that the LunaBat DFR-1 PRO detector is actually two devices in a common housing and the paths of both devices (HF/FS and FD) work in parallel. Although they have a common supply and you can switch the recording from the FD path as a signal source, the FD path sensitivity will always be worse than the HF path sensitivity, due to the principle of operation (FD detection threshold and permanently enabled separate high pass filter with lower limit frequency of 10 or 15 kHz), so the listening or recording from the FD signal path will not always be consistent with the HF path record. From the HF path more information can be saved than from the FD detection path, and therefore not always a lack of sounds from the listening loudspeaker (which is permanently connected to FD signal path) means that echolocation or social voices in the HF path will not be recorded. The recording level indicator, however, shows the actual level of the recorded signal.

2.3. Recording without listening

Because the broadband recorder covers a very wide bandwidth from ca. 150 Hz to almost half of the sampling frequency (so-called "Nyquist frequency"), so it will also record the sounds coming from the listening loudspeaker.
In order to obtain the best possible quality and resolution of recordings (especially intended for later automatic or semiautomatic processing), it is recommended to isolate the unwanted ambient sounds (including the sounds of the listening loudspeaker) by:

- listening with a moderate volume on the headphones, or
- reducing or completely silencing the listening volume level - by using listening volume control buttons [9]
- enabling the **FS High Pass Filter** in the menu.

The recording is finished after pressing the **BACK / BK** button (the left button is highlighted in blue or description is highlighted in white).

3. Detector settings (SETTINGS)

In the standby mode, right after the detector is switched on and the information is displayed on the display as in Fig.1 on page 5, the main settings menu can be accessed - press the **MENU / DOWN** button.
The main menu of the detector (for firmware v7.35) has the following items:

> PRESET
> SET REC LENGTH
> SET SAMPLE RATE
> SET REC LEVEL
> SET TIME & DATE
> DISPLAY T & RH
> GPS ON/OFF
> GPS FIX CONFIG
> GPS FIX STATUS
> SAVE KML
> FD HPF Low/High
> FS HPF ON/OFF
> FORMAT SD CARD

The selection of the current function is made by scrolling the available in the loop options with the **UP** or **DOWN** buttons and entering the option with the **OK** button. Going back to the previous level - **BACK** button.

3.1. Selecting the recording mode (PRESET)

As the first option available in the main menu you will see:

To enter the settings of this function, press **OK**. You can choose between two modes of operation:
- continuous recording started manually - **CONTINUOUS** mode, and
- automatic recording triggered by the signal level - **TRIGGER AUTO** mode *(this function was introduced experimentally)*.

3.1.1. Continuous recording, manually activated (CONTINUOUS)

After confirming with the **OK** button of the **CONTINUOUS** mode, the detector will switch to the manual recording mode (activated manually with the **OK** button and stopped with the **BACK** button) which is also the default mode. After confirming this mode, the previously used menu item (main menu) will be displayed on the LCD. The files with the maximum length set in another item of the main menu will be recorded (look at section 3.2) one after another until the pressing of **BACK** button .

3.1.2. Automatic recording triggered by the signal level (TRIGGER AUTO) - *an experimentally introduced function*

After confirming **TRIGGER AUTO** mode, set the sensitivity (the operating threshold) of the system that automatically starts the recording. Then you will see on LCD:

Use the **UP** or **DOWN** buttons to set the value between 0 and 127 and confirm with the **OK.** button. The lower values correspond to the highest sensitivity (even a very low sound will trigger the recording), while the larger values correspond to the lowest sensitivity (only a very loud sound will trigger the recording).
Every time, when the intensity of ultrasound exceeds a certain level corresponding to the sensitivity set here, the WAV file of the length set in another item of the main menu (look at section 3.2) will be started (after arming).
In the detector the 00063 value is set by default to half of the scale of the digital potentiometer that sets the sensitivity. If the 00063 value is changed and confirmed with the **OK** button in the menu - it will be saved in the config.lun file so that there is no need to set this value the next time the detector is started.

ATTENTION: Automatic recording has been introduced experimentally and for now is being tested and will be modified, therefore at the current stage (firmware v.7.35) it is recommended to create rather continuous recordings and manual or automatic selection of fragments of recordings should be done on PC.

*ATTENTION: With automatic recording, to minimize the number of unnecessary write operations and the number of "empty" recordings, it is recommended to put the detector still (eg on a tripod) and, if possible, to eliminate potential interference, also by: lowering the listening volume or listening on headphones, using the **MF-1** windshield microphone, or for switching on the **FS HPF FILTER = ON** (in another main menu item), if only ultrasounds and sounds above approx. 15 kHz are to be recorded.*

3.2. Selecting the length of recordings (REC LENGTH)

In order to facilitate later work with recordings on continuous (and automatically triggered recordings), WAV files are created. Those WAV files have the length corresponding to the maximum time of a single recording (defined in menu). In manual recording mode, if the recording is not stopped before the defined maximal recording time (of single file) has elapsed - after this length has been reached, the next WAV file will be automatically recorded. The active record can be interrupted at any time by pressing **BACK** button and then restarted at any time by pressing **OK** button.
In auto-triggered recording mode, no files will be created unless the signal level (after the end of creation of the heading of the WAV file) still exceeds the threshold set in **SET THRESHOLD** menu item. If in this case the next recording will be initiated - subsequent files with the length defined in **REC LENGTH** item will be created until the signal decreases and will be lower than defined threshold level.
In current firmware version (v7.35) the maximum length of subsequently recorded files can be set from 3 seconds to 60 minutes.
The default value is set to 60 minutes.
This setting is saved in the **CONFIG.LUN** configuration file on memory card.

ATTENTION: Due to the fact that with a large number of files the relative length of gaps (in relation to the length of the recordings itself) starts to increase, depending on the number of recorded files -so with the current firmware it is not recommended to use many short files, but rather smaller number of longer recordings, eg. a few minutes to several tens of minutes.

3.3. Sampling rate selection (SET SAMPLE RATE)

The current firmware has 5 sampling frequency values: 24, 48, 192, 256 and 384 kHz, while 24 and 48 kHz are always recorded with an audio signal from a parallel FD detector, and for 192, 256 and 384 kHz - a fullband (full-spectrum) signal is recorded without any detection - ultrasounds are recorded directly from the HF signal path.
In regions where there is no ultrasounds above ~ 95kHz, eg echolocation of the lesser horseshoe (*rhinolophus hipposideros*), sampling frequency 24kHz or 192kHz can be used to reduce the size of WAV files saved (for 192kHz - about 30% smaller files than 256kHz and 2x smaller files than at 384kHz, for 24kHz over 10x smaller files than 256kHz sampling and 16x smaller files than 384kHz sampling).

3.4. Setting the time and date (SET TIME & DATE)

The detector has a built-in real-time clock. The current hour and minute are displayed on LCD in standby mode and during recording. On the basis of the current time and date, the names of WAV files and TXT logs are also created with an accuracy of 1 second. In addition, files created on the memory card will also have an assigned date and exact time of creation in the so-called file attributes (to be read in any file explorer on the computer).
To set the current date and time, in the standby mode press the **DOWN / MENU** button and use the **UP or DOWN** buttons to scroll through the selection options from the main menu to the **SET TIME & DATE** position and enter the submenu by pressing **OK**.
The detector clock can be set in two ways - manually or automatically (using the optional GPS / GNSS receiver and after obtaining a 2D or 3D fix).

3.4.1. Manual setting the time and date (MANUALLY)

In the MANUALLY submenu, set the day, month and year in sequence, followed by the hour and minute. The currently changed value is marked with the cursor (character **„>**").
Changes to the selected values are made by pressing the **UP / DOWN** buttons, confirm and go to the next position with the **OK** button.
After setting and confirming the hour and minute, you should exit the menu to the ready state by pressing **BACK**.
In the current version of the firmware (v.7.35) the current time is displayed on the LCD during the recording and in the standby mode in 24-hour format as **HH: MM** (**HH**-hour, **MM**-minute).

3.4.2. Automatic setting the time and date (SYNC WITH GPS)

By connecting an optional GPS / GNSS receiver, you can automatically synchronize the clock and date in the detector with a very accurate GPS system clock signal sent along with the data used to obtain the fix.
To do this:
- connect the GPS / GNSS receiver to the expansion socket [10] and **THEN** enable the detector,
- enable the receiver in the settings of the **GPS ON / OFF** submenu (by default the receiver is turned on automatically when the detector is started, unless it was previously disabled in the CONFIG.LUN configuration file, for more details see Chapter 3.6),
- set up with the detector / receiver in a place with good visibility of the sky and wait for the bearing (2D Fix or 3D Fix).

After obtaining a 2D or 3D fix in the main menu, select the **SET TIME & DATE** item and then, using the **UP / DOWN** buttons, scroll to the **SYNC WITH GPS** position and select it with **OK** button. The following message will be displayed: **CHECKING** - detector checks the fix / bearing status. If there is no fix at this time a message:

FIX NEEDED! will be displayed. In this case, you must wait or change the signal reception location until a 2D or 3D fix is obtained and restart the synchronization. If during the check (**CHECKING** message) there is a 2D or 3D fix, the received time in the format **HH:MM+TZ** will be displayed:

(**HH**- hour in 24-hour format, **MM**: minute, **TZ** - time shift). Press **UP / DOWN** buttons to enter the appropriate offset value for the local time zone, eg for the area of Poland, set **TZ** to +02. When you change the time zone, the time displayed will also change:

Finally, confirm the change by pressing **OK** and leave the menu by pressing **BACK**.

NOTE: Obtaining a fix (bearing) is preceded by receiving usable data from at least three (2D Fix) or four (3D Fix) satellites, the first sign of receiving the correct and appropriately strong satellite signal is synchronization of the GPS / GNSS receiver's clock with the GPS system clock signal, and it is signaled by flashing of the blue LED [6] over the LCD. Usually immediately a 2D or 3D fix is obtained. Obtaining the correct 2D / 3D coordinates follows after a minimum of time 30 sec from starting the receiver in good weather conditions and good visibility of the sky. If the visibility of the sky is worse, the first fix can be obtained after a few minutes. After obtaining the fix (and to be exact: when correct data from satellites are received and classified as „usable data") then the required strength of signals from the satellites is already lower than during obtaining the first fix (and usable data from subsequent next satellites, so it is a good idea to stay a little longer in the place with good sky visibility to „catch" more satellites and then you can go to the places with smaller sky visibility). The very moment when the detector correctly interprets the incoming data and obtains the fix with a sufficiently high accuracy can be determined by observing the coordinates in status view in the position of the GPS FIX STATUS menu (after activatiion SHOW> function by pressing OK button). When the coordinates stabilize to the 3 decimal places (3 digits after dot) then it can be concluded that sufficient accuracy of the bearing (below 2.5 m.) was obtained and it is the maximal accuracy that can be obtained from consumer free-available signals from GNSS systems.

3.5. Viewing temperature and relative humidity (DISPLAY T & RH)

After selecting this function, you can view the current temperature and relative humidity readings from the built-in sensor in degrees (°C) and in percent R.H. It should be remembered that the built-in sensor is placed inside the detector housing (just behind the opening on the front panel, behind the waterproof membrane) and therefore has some (quite large) thermal inertia, so for example a detector started outside after removing it from the warmer room or after prolonged storage in other conditions than during work (also by holding it in warm hands, or putting still warm batteries just removed from the charger) - the detector has a slightly different temperature than the environment, which affects the reading of both temperature and relative humidity from the built-in sensor. Therefore, correct indications will be displayed after the temperature stabilizes near the sensor, which may take from several dozen seconds to several minutes, depending on the temperature difference of the detector housing and the surrounding environment, and air circulation near the sensor.

NOTE: Due to the relatively high sensitivity of the temperature and humidity sensor and the fact of placing it in a common housing together with other components of the detector, it is permissible and normal to increase the external temperature reading by up to 2-3°C as the work progresses and depending on the mentioned air circulation near the sensor, this should be taken into account. The sensor can be used to approximate ambient temperature and relative humidity, eg. over 45°C or below 0°C and at R.H. above 85%, the detector should be turned off and protected against condensation, eg by placing it in a dry and ventilated place, or in a closed container with humidity absorbers. To ensure more accurate outdoor temperature and humidity measurements, optional external sensors connected to the expansion slot will be available soon.

3.6. Activating the GPS / GNSS receiver (GPS ON / OFF)

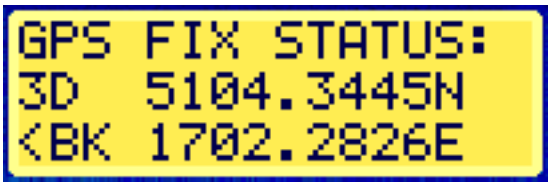
By default, it is on, but if it is off (receiver not connected to the [10] socket) or saved state in the detector configuration on the memory card is: **GPS = OFF** - the receiver is turned off and disconnected from the power supply.
In the current firmware (v.7.35) after disabling it (**GPS = OFF**) - the receiver does not store received ephemerides, which means that after re-enabling the detector, the so-called ***Cold Start*** will happen and there will be the relatively longest reacquisition time (TTFF - Time To First Fix) which can take at least 30 seconds in good sky visibility and good weather conditions.
Currently, the GNSS module is switched on in *Full mode* (maximum current consumption, constantly updated bearing, one stage of the LNA amplifier permanently enabled). In subsequent versions of the firmware it is planned to add the functions of energy-saving in GNSS receivers).

In receivers with a built-in *Locus* logger (GP-1 through GP-4) and firmware version >6.15, support for this logger was introduced and the route could be logged regardless of saved .txt files in the receiver's internal flash memory.
With each recording (for firmware > v.6.15b) along with .wav files, the data from T & RH sensors and bearing data in NMEA0183 format are also saved in text files (extension .txt), which can be used in current firmware versions (starting from v.7.1) to create a **Google KML** file in a separate main menu item (**SAVE KML**). The *Locus* logging was replaced with this function in current versions of firmware.
Activation of the GPS / GNSS receiver is performed by pressing the **UP / DOWN** buttons and setting the **ON** option from the **GPS ON / OFF** position of the main menu.

*NOTE: when enabled in the menu (or by default after inserting a blank memory card without the **config.lun** configuration file) then the GNSS receiver, if it is not detected in the expansion slot [10] or it will have a malfunction - then it will be automatically turned off also in the menu.*

3.7. GPS receiver status monitoring (GPS FIX STATUS)

In the main menu, select **GPS FIX STATUS**. If the GPS / GNSS receiver has been connected and activated, but there is no bearing - the following message is displayed: *** Working**. If 2D or 3D fix is obtained - *** 2D FIX** or *** 3D FIX** information is displayed, while the bottom right of the display shows the **SHOW>** option. By pressing **OK** we can get a preview of the received coordinates in the *NMEA0183* format, eg:



wait for stabilization of those decimal digits

3.8. Save the KML file (SAVE KML)

After selecting this item in the main menu, the **dump.kml** file is generated based on information stored in the **.txt** logs along with the recordings. If you want to select only certain logs associated with the recordings - you must delete the remaining logs (.txt files) from the memory card (or move them to another directory if you want to keep them). After the correct creation of the **dump.kml** file containing the coordinates of the places where the recordings were created, and after opening this file in **Google Earth** or **Google Maps** (or other compatible software) - in the waypoint comments, apart from the txt / wav file names (containing the date and time of creation), there will be also temperature and relative humidity readings.

3.9. High pass filters (FS HPF and FD HPF)

The LunaBat DFR-1 PRO detector has two independently adjustable high-pass filters:

- filter in the recording path (**FS HPF**), which can be turned on or off (by default it is off),
- filter in the tapping line (**FD HPF**), whose lower frequency can be set to 10kHz (**Low**) or 15kHz (**High**).

When the FS HPF filter is turned on, almost no audible sounds will be recorded (frequencies below 15kHz like: conversations, steps in grass and other undesirable disturbances). It is recommended to activate the filter during automatic or manual recording in strong wind, loud audible noises, or when walking in dry grass / on dry leaves, etc. After disabling the FS HPF filter, the lower limit frequency of recorded signals is approx. 150 Hz, which enables recording of the audible part of the band, eg verbal comments, social voices and other sounds audible by human.

When recording from the FD path (for 24 or 48 kHz sampling frequency) and during listening, the **FD HPF** filter is always on, so that the listening from built-in loudspeaker does not respond to audible interference noises. However, you can change the lower bandpass frequency of this filter, for example, not to suppress social voices or echolocation at low frequencies from exotic species of bats (eg some *tadarida* species, which have echolocations lower than 15kHz).

During Full Spectrum recording with FS HPF filter enabled or FD recording you can temporarily disable HPF filter and switch to FS/HF signal path for making verbal comment by pressing and holding **COM** switch [19].

The listening path (FD) allows to record and / or listen the signals with frequencies from ~15kHz (**FD HPF=High / 15kHz**), or from ~10kHz (**FD HPF= Low / 10kHz**), which after processing by frequency-division detection circuits corresponds to audible sounds, respectively, from ~1.5kHz or from ~1kHz.

During the recording and in the standby mode in the middle text row on LCD (to the left from the current hour), the status of both filters is displayed in the form of two letters:

- the first letter for the **FS HPF** filter: the letter **H** if the filter is on (lower limit frequency / Fd = 15kHz), or the letter **L** if the **FS HPF** filter is off (Fd=150Hz, which is the limit of the rest of the FS signal path in the detector);
- the second letter for the **FD HPF** filter: the letter **H** if the lower limit frequency is set to 15kHz, or the letter **L** if the lower limit frequency is set to 10kHz.

NOTE: In the event of insufficient suppression of strong wind gusts, you can further suppress them by placing the MF-1 windshield on the microphone, available as an accessory for the ME-series microphones. It also protects to a certain degree before the microphone gets wet by raindrops, however, the fast soaking of the foam ceases to be effective after some time and the wet foam also begins to absorb more and more ultrasounds until they will be completely suppressed.

3.10. Formatting the memory card (FORMAT SD CARD)

In a computer running Linux, OS or Windows (using additional software), as well as in a detector, you can format the SDHC / SDXC memory card in the FAT32 file system using 32 or 64 kB clusters.
These are recommended values, at which the detector most effectively records the wav files, especially at higher sampling frequencies.
After selecting the **SD CARD FORMAT** option in the main menu, select the cluster size (**SET CLUSTER SIZE**) - usually **64K** clusters are recommended for writing large files, for saving more files to save space on the card or for other reasons (better continuity of recording on a given card at high speeds) - you can use formatting with **32K** clusters. It's best to determine it experimentally with the memory card.

NOTE: Formatting the memory card deletes ALL of the data stored on it! It is also necessary to ensure an appropriate level of battery voltage when formatting the card, due to the possibility of logical errors on the card in the event of voltage decay during the formatting.

3.11. Changing the recording level (SET REC LEVEL)

From the 7.20b firmware version, the possibility of changing the gain of input circuits from the menu level has been activated. The gain level control range is adjusted in 128 steps from the value of 000 (corresponding to the lowest trigger sensitivity) to the value 127 (corresponding to the highest trigger sensitivity).
The default value is 063 (half of the range of digital potentiometer). It is set at the start of the detector without a memory card inserted in the SD slot, or in the case when there is no **config.lun** configuration file on the memory card (eg immediately after formatting the card and before the detector is first switched off). This setting is saved in the **config.lun** file on SD card, so that after restarting the detector (with inserted memory card containing this file) you do not need to readjust the setting.

NOTE: After uploading a new firmware to the detector, it is recommended to remove the old **config.lun** *configuration file from the memory card (it is in an older format that may not include storing the state of microphone sensitivity level). After deleting this file and reusing the detector, a new configuration file with default values will be created on the card. REC LEVEL will be set to the default value of 063, which corresponds to a sensitivity of about 2x smaller (-6dB) from the maximum possible to achieve.*

4. Updating the detector firmware (Firmware Update)

4.1. Before you upgrade the firmware, please obtain:
- a computer with a Windows operating system with Administrator rights (or another system with a properly configured Windows emulator),
- USB-microUSB cable (like for a mobile phone, also available as an accessory for the detector),
- freshly charged AA / R6 accumulators or new good quality alkaline batteries,
- thin oblong object (needle, unbent office clip, safety pin, etc.)

4.2 Download from the *www.animalsoundlabs.pl* website from the **Download** tab (on the subpage of the LunaBat DFR-1 PRO detector) the latest firmware for the detector in the form of a file with the extension **.zip** and then unpack it on the computer's hard drive (file with the extension **.hex**) In the package will also be a program for updating the detector: ***LunaBat Updater v1.3.exe.***

4.3. Insert charged batteries or new, good quality alkaline batteries in the battery compartment.

4.4. Connect the detector to the computer with a *USB-microUSB* cable, the microUSB plug should be inserted into the [12] socket with the wider side of the plug facing the front/top of the device, and the narrower side of the plug should be facing down towards the microphone socket [1].

4.5. Turn on the detector with the ⏻ button and check the voltage on the indicator in the upper right corner of the LCD display (at least 3 dashes should be visible).

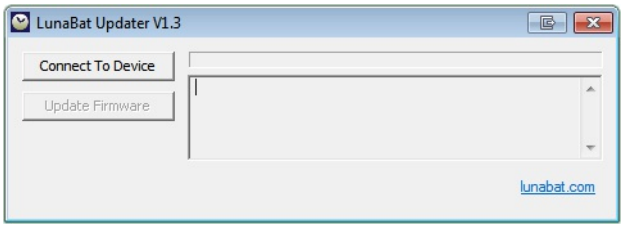
4.6. Press and hold **DOWN / MENU** button pressed and with a thin, round object press the **RESET** button located behind the small hole [14] located on the connector panel. The detector should switch to the firmware update mode and display the following message on the display:

Firmware Update Mode

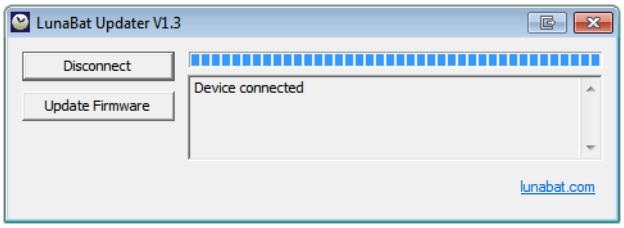
v.1.3

4.7. Wait until the *HID / USB device driver* is installed, if the detection of new hardware starts and after the correct installation of the driver in the system, run **LunaBat Updater v1.3.exe**.

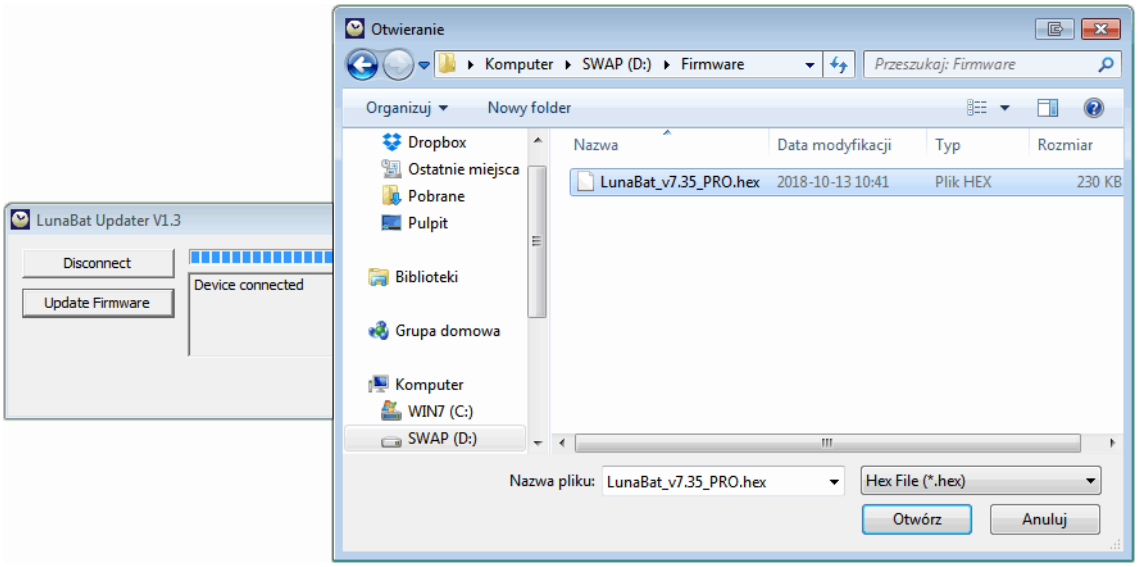
4.8. In the LunaBat Updater window, click the **Connect To Device** button:



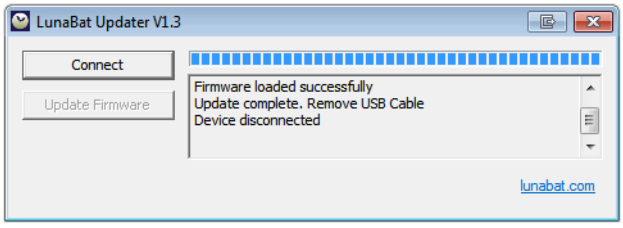
4.9. After the program detects the detector successfully, the program window will display the following message:



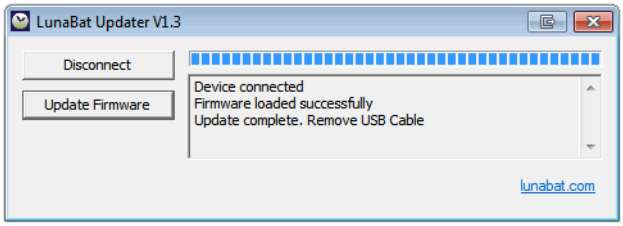
4.10. Click the **Update Firmware** button and point to the .hex file with the latest firmware (from the location where the file was previously unpacked):



4.11. Check and confirm (click the **Open** button) and wait for the update, which should take up to several or dozen seconds. After the update is completed, the program will display the following message:



4.12. Close the connection between the program and the detector by clicking the **Disconnect** button:



Then disconnect the USB cable from the detector, which should restart at this time and the actual firmware version number should be displayed during startup.

4.13. Close the program and disconnect the USB cable from the computer.

*NOTE 1: After uploading a new firmware, the old **config.lun** configuration file must be removed from the memory card, otherwise the default values of **REC LEVEL** and **TRIGGER LEVEL** will not be set correctly so that it may, for example, lead to complete silencing of the recording path, which will make it impossible to record any signals!*

NOTE 2: Power failure during upgrade can damage the detector! So take care of a good source of power!

5. Useful tips

During the detector's operation, the battery voltage is measured every 60 secs and the status of the voltage level indicator on the display is updated. If the voltage drops to approx. 2.0V (1V / cell) - the recording will be stopped and the detector will be automatically turned off for safety so as not to discharge the batteries excessively. After switching off the device or even before the automatic shutdown, replace the batteries / batteries with new / charged
important. Because at the voltage of about 2.0V, both batteries and Ni-MH batteries have little remaining charge, and their internal resistance increases strongly - such cells can temporarily "regain" part of the voltage after switching on again, but again discharged very quickly to level 2.0 V and there is then an increased risk of being able to discharge faster than the low voltage detection system can react and the recording started may not be completed properly. You can then recover them on your computer using data recovery software or using, for example, the *Scandisk* program (or *chkdsk* command), but only if there is no more recording on the card because the unfinished recording will be overwritten with a new data.
After turning off the power supply due to the low voltage level, it is always best to immediately replace the batteries with the new / charged ones.

In the PRO version, the detector has independent additional protection against excessive discharging of the batteries, which prevent the detector from being turned on at a voltage lower than approx. 2.1V and also by hardware - if the supply voltage is lower than approx. 1.85V.
The built-in broadband recorder is one of the most energy-efficient broadband recorders on the market, but the working time depends on the total power consumption of the whole device. The consumption itself is affected by:
- backlight on (about 4% of the entire device);
- operating mode (switching on the recording increases the consumption by approx. 50%);
- sampling frequency (higher frequency = higher power consumption);
- connected sensors, eg GPS / GNSS receiver models: GP-1, GP-2 or GP-3, the lowest power consumption has GP-3;
- selected mode of GPS / GNSS receiver power supply (currently only Full Power mode is available) + approx. 5-10%;
- selected set / system of received satellites oras bearing status - the lowest current consumption of the receiver is for a single GPS system and established 3D tributary, the highest intake - with GPS + Glonass + Galileo on and off or loss of signal from at least 3 satellites;
- the volume of tapping sounds (from a few to a dozen or so% depending on the average volume of sounds from the loudspeaker, the headphones consume less energy);
- battery / battery voltage - the lower the voltage - the greater the power consumption and the faster the voltage drop, that is why used batteries with lower voltage than new ones (despite relatively similar capacity) cause significantly shorter operation time to switch off, despite the large amount of charge remaining still in such batteries.

6. Approximate working times in different conditions. LSD Ni-MH batteries:
a) Sanyo / Panasonic Eneloop or Fujitsu White / Fujitsu Blue (min.1900mAh), listening or occasional sounds coming from the loudspeaker:
- without backlight, without GNSS or GNSS switched off - to ~6h30m,
- recording with backlight, without GNSS or GNSS switched off - up to ~6h20m
- backlight, GNSS enabled - up to ~5h30
- without recording, only eavesdropping, no backlight, no GNSS or GNSS receiver switched off - up to ~8-9h

b) Sanyo / Panasonic Eneloop Pro or Fujitsu Black min.2450mAh, conditions of the day:
- recording without backlight, without GNSS or GNSS switched off - up to ~7h50m,
- recording with backlight, without GNSS or GNSS switched off - up to ~7h35m
- recording with backlight, GNSS enabled - up to ~7h15m
- without recording, only listening, without GNSS /switched off - to ~11-14h

At temperatures lower than ca. 8°C or higher than ca. 35°C, the operating time may be shortened due to the fact that the batteries are subject to temperature changes.

7. Maximum total length of the recording on memory cards:

SAMPLING FREQUENCY	MAX. RECORDED FREQUENCY	60min FILE SIZE	MAX. REC. TIME ON 16GB CARD	MAX. REC. TIME ON 32GB CARD
384 kHz	to ~190 kHz	2 764 800 044 B	5h 47m	11h 34m
256 kHz	to ~125 kHz	1 843 200 044 B	8h 40m	17h 21m
192 kHz	to ~95 kHz	1 382 400 044 B	11h 34m	23h 8m
48 kHz	to ~23 kHz	345 600 044 B	1d 22h 18m (46h 18m)	3d 20h 35m (92h 36m)
24 kHz	to ~11,7 kHz	172 800 044 B	3d 20h 35m (92h 36m)	7d 17h (185h)

By using higher capacity memory cards, recording times increase in proportion to the capacity increase

8. Other comments

The memory card is best inserted and removed when the device is turned off, inserting it after starting will not cause damage and often the normal recording will be possible, however, it may happen when the card is removed several times while the detector was on (in standby mode) and / or some changes will be made on it, eg after inserting into a computer reader - then a logical error may occur (Error No. 6). It is enough to turn the detector off and on again.
If for some reason the detector showed an error and / or could not be switched off - it can be reset using a thin object eg wire, paperclip, needle - press the RESET microswitch located under the hole [14] on the connector panel above the headphone socket.
It may also help to remove the batteries from the socket and wait a few minutes before restarting. After switching on the detector (and if the GPS / GNSS receiver was previously disconnected or turned off in the menu and it was activated in the menu again), wait a few dozen seconds to several minutes before the GPS / GNSS receiver will synchronize its internal clock with the GPS system clock. After first fix on the given position is achieved it is recommended to wait some few moments in the same place because during the subsequent readings the bearing will be more and more accurate. In hard terrain and/or weak weather conditions, or weak sky visibility a few minutes delay with the start of recording is also recommended. Also for setting the reading from humidity and temperature sensors (about 1-2 minutes for the temperature sensor and approx. 2-3 minutes for the humidity sensor, due to the presence of a waterproof membrane protecting the sensor itself). In extreme cases, the detector may heat up or cool even longer.

And although the record itself can be started immediately, it is necessary to take into account possible errors in the temperature and humidity readings. If the GNSS receiver is not turned off in the menu and will not be physically disconnected from the detector - after switching off the detector (⏻ switch) it will be kept in standby mode (very low power consumption by the receiver - approx. 7 uA) and will store the previously acquired bearing in the internal memory and received *ephemeris*, so that when the power is turned back on the bearing (fix) will happen very quickly depending on the time that has passed since the last bearing and detector being in the off state, so:
- if the break lasts up to several dozen minutes (max. 4 hours), after the detector is turned on the GPS / GNSS receiver will start in **Hot Start** mode and fix will be available very quickly, practically immediately after the detector is switched on (within 1-2 seconds after enabling the detector),
- if the break lasts longer than several dozen minutes (over 4 hours) - after enabling the detector, the so-called **Warm Start** will happen and depending on the model of your GPS / GNSS receiver, a fix will be obtained in about 5-15 seconds after switching on the detector.

NOTE: A few-dozen seconds from the moment the GNSS indicator [6] comes on, you can start the record, the bearing will be set, but the temperature and humidity readings will be stabilized after about 2-3 minutes from the detector activation (if it has just been removed from the packaging) or taken out of the room or car, inside which there was a different temperature and / or humidity.

In order to obtain the fastest possible bearing, the detector or the receiver itself (connected to the detector by extension cable) should be placed in the place where the sky's visibility is as high as possible, and it can also be over a large metal surface, eg the roof of the car.
After obtaining the bearing, the maximum signal strength is no longer needed and you can go with the receiver to places with less signal strength or sky visibility.

ATTENTION! Do not remove the memory card or GPS / GNSS receiver from the socket while recording. This may result in the recording not being completed and the logical damage to the files on the card may occur, so it may be necessary to recover the recorded file from the memory card by using recovery software.

If the listening function of the built-in loudspeaker is switched on during recording, it can be significantly silenced during loud sounds and loud listening (for a cleaner broadband recording) by temporarily covering the built-in loudspeaker openings with, for example, the thumb.

In firmware v7.35 coordinate writing to .txt logs takes place at the end of writing each WAV file, so you can break the recording by pressing **BACK** button to mark the place and begin the new recording by pressing **OK** button.

Technical specification:

Powering ..... 2 cells AA / R6 (1,2-1,5V)
or via micro USB connector (~3,5V...5,5Vmax)
Average power consumption *(recording @256kHz, no GNSS)* .....~700mW
Current consumption in SLEEP mode *(with SD card removed)* ..... < 250uA
Current consumption in SLEEP mode *(with SD card installed)* ..... < 650uA

Working time (for cells Fujitsu Black min. 2450mAh) :
- listening without recording, backlight on, no GNSS ..... up to 11-12h
- listening with recording, backlight on, no GNSS ..... up to 7,5-8h
- listening with recording, backlight on, GNSS on ..... up to 7-7,5h

Detection types used:
- for listening ..... *Frequency Division* type (with amplitude retention)
- for recording ..... *Full Spectrum* (High Frequency Direct Recording) or *Frequency Division* type (from listening signal path @ 24 or 48kHz)

Division ratio of the built-in FD detector 1:10

Recording frequency band (-3dB) :
- FS HPF off, HF recording (Fs=192-384kHz) ..... 0.15 kHz - 0,49 Fs
- FS HPF on, HF recording (Fs=192-384kHz) ..... 15 kHz - 0,49 Fs
- FD HPF=High, FD recording (Fs=24-48kHz) ..... 1.5 kHz - 0,49 Fs
- FD HPF=Low, FD recording (Fs=24-48kHz) ..... 1.0 kHz - 0,49 Fs

(for more informations look at Chapter 7 on page 21)

Averaged noise level relative to the full level (0dB=F.S.)
HF (High Frequency / Full Spectrum recording):
- with ME-4 mic, FS HPF off ..... -56 dB
- with ME-4 mic, FS HPF on ..... -58 dB
- with ME-5 mic, FS HPF off ..... -58 dB
- with ME-5 mic, FS HPF on ..... -60 dB

FD recording :
- with ME-4 mic, FD HPF High ..... -59 dB
- with ME-5 mic, FD HPF High ..... -62 dB

Harmonic and intermodulation distortions ..... <0.15%

Relative sensitivity threshold for 30kHz *(ME-4 mic)* ..... 34dB SPL

Accuracy of the built-in clock *(without manual or GPS updates)* ..... up to 60sec/month

External dimensions *(without microphone & wrist strap)* 79x117x33mm

Weight *(with ME-series mic, without batteries)* 240g

Front panel and connector panel

1. Removable microphone
2. Rubberized edges
3. Keyboard buttons
4. Loudspeaker
5. LCD display
6. GNSS fix indicator
7. Memory card
8. Wrist strap
9. Listening volume controls
10. Expansion connector
11. Built-in temperature and humidity sensor
12. Micro-USB socket
13. Headphone socket
14. Reset button
15. Tripod socket
16. Signal level indicator
17. Power switch
18. Highlight switch
19. Verbal comment switch