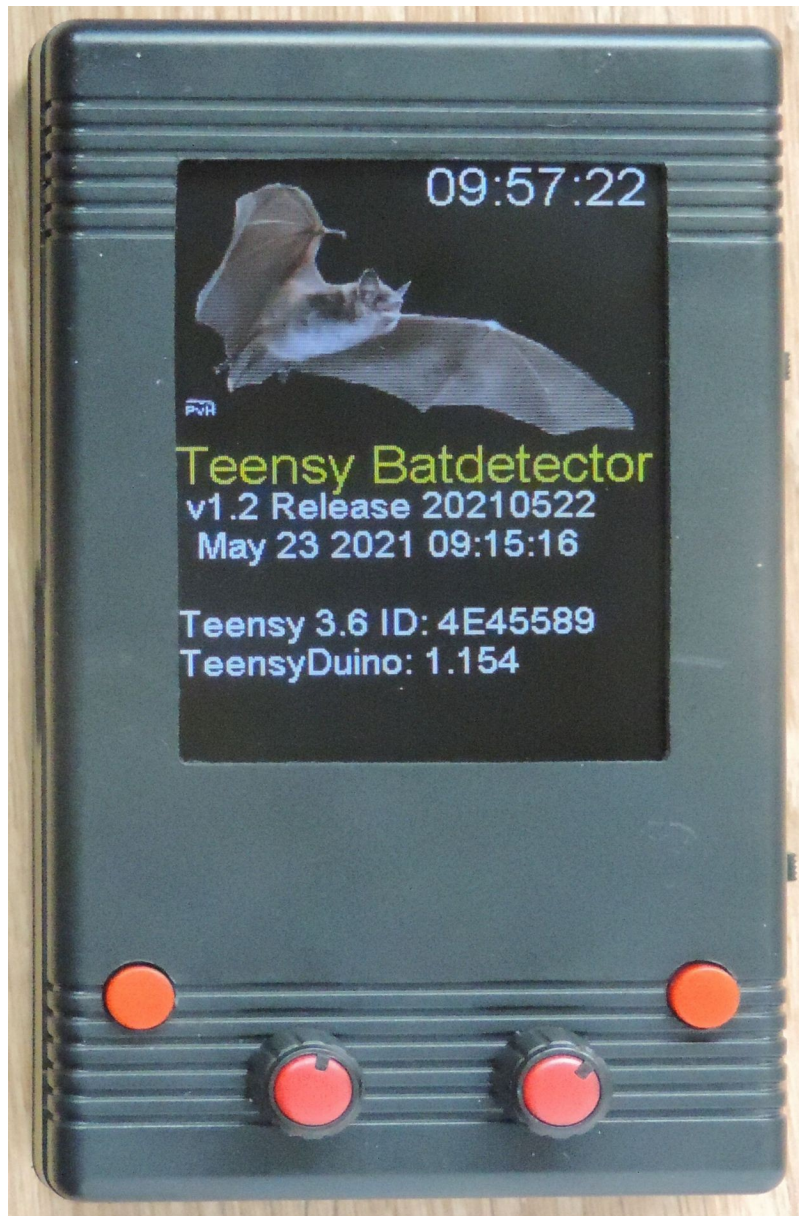# Teensy Batdector Manual

Software version 1.2

Picture in bootscreen by Paul van Hoof www.paulvanhoof.nl

The Teensy bat detector is a detector that you can build yourself. It uses a Teensy 3.6 "development board", Teensy Audioboard, 2.8" colour TFT display.

Small size, 116x68x36mm (4.7x2.7x1.5in)
Heterodyne, Auto Heterodyne, Frequency Division and Time Expansion detection modes
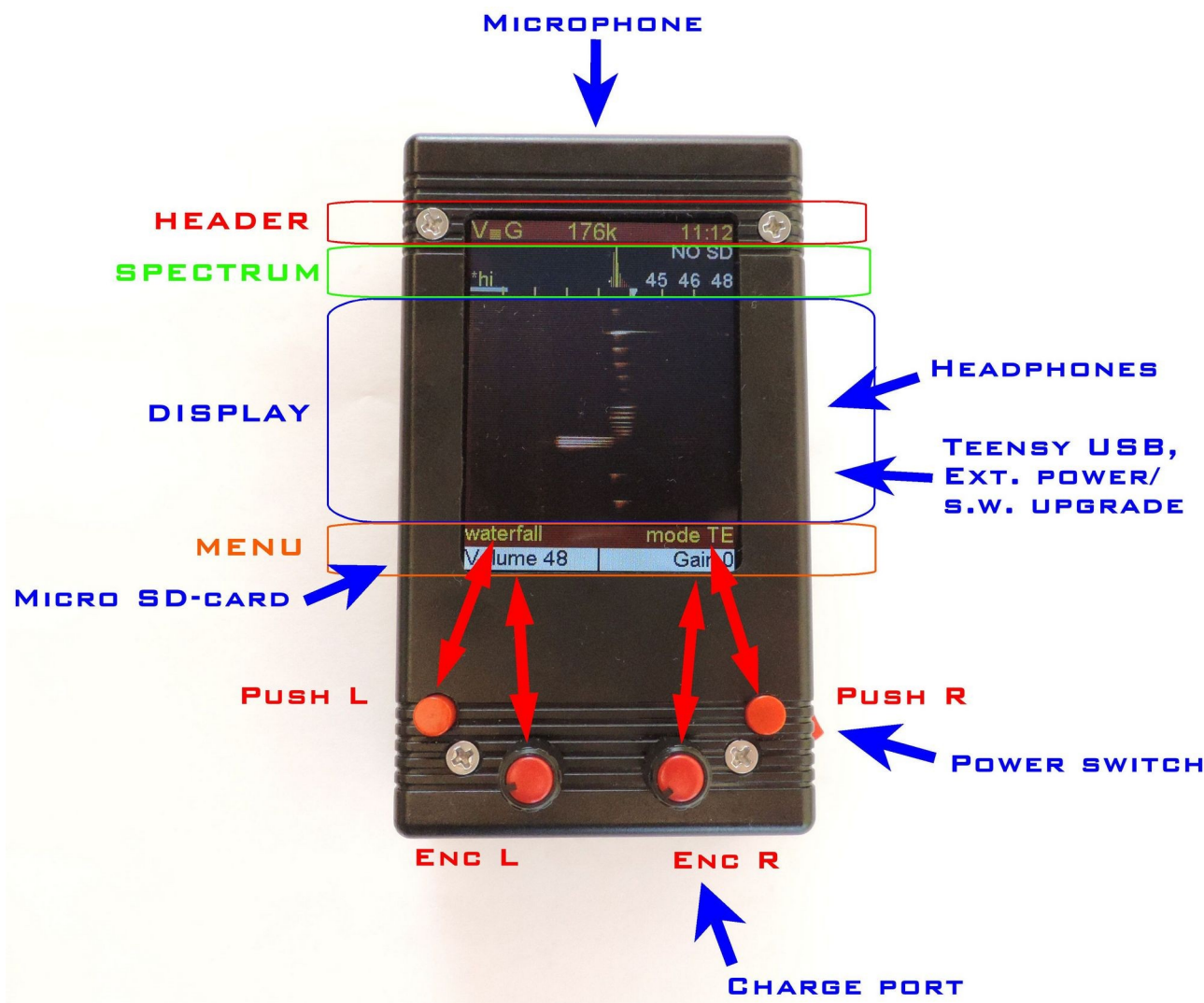High speed recording (up to 384kHz sample rate) on a CLASS 10 micro-CD card max. 32GB!
Automatic recording (start at ultrasound detection)
Two visualisation modes (Audio spectrum display or Waterfall display)
Display of received frequencies (Low/Hi/Peak)
Sensitive microphone that pics op sounds that are over 100khz
Can run over 20 hours on an internal battery, or be powered externally

MICROPHONE

HEADER

SPECTRUM

DISPLAY

MENU

MICRO SD-CARD

PUSH L

ENC L

HEADPHONES

TEENSY USB,
EXT. POWER/
S.W. UPGRADE

PUSH R

POWER SWITCH

ENC R

CHARGE PORT

V G   176k   11:12
                    NO SD
*hi   45 46 48

waterfall   mode TE
Volume 48   Gain 0

Hardware,
The microphone is mounted on the front, on the right side you will find a headphone jack and a micro USB for external power or upgrading software and a power switch.
On the back there is another micro USB jack for charging the power bank, and LEDs that will show the state of charge. On the left side there is a small slot to insert a Micro SD-Card.
Power switch, power bank and microphone positions are up to the builder, this (picture above) is how I like to build my detectors.

Controls
The bat detector has 4 controls, 2 push-buttons (PushL and PushR) and 2 encoders (EncL and EncR). The encoders also have a push-button function.

Pushbuttons (PushL PushR)
The push-buttons are used to switch between options based on the setting that is visible on the bottom line of the MENU section. In the image above the bottom line of the MENU states DISPLAY for PushL and DETECT for PushR. If the user presses PushL, recording will start, or the display-mode will change (when no SD card is present). If the user presses PushR the detector-mode will change. The push-buttons step through all possible options in a cyclic manner.

Rotary Encoders with push button (EncL EncR)
The encoders are used to step through the menu (see below) and allow selecting a specific menu-item and then changing the setting for that item.
To do this the user rotates the encoder until it shows the menu-item on screen (in yellow) that needs changing. Then the user presses the Encoder and the colour of the menu-item changes from yellow to white. The encoder can now be used to control the setting of this menu-item by rotating (up is clockwise) the encoder. After setting the menu-item the encoder needs to be pressed again to confirm the setting and the colour of the menu will change from white to yellow again.
The left-encoder has the full menu available but the right encoder only can be used to set a few (the most used) options.

Screensections
The screen is divided in 4 sections, a <u>header</u>, a small <u>power-spectrum</u> , a dynamic <u>display</u> and a <u>menu</u>.

The <u>header</u> shows for several parameters (gain(g), frequency(f), volume(v) and sample rate(s). Also temperature and GPS status is shown (optional) and time is on the far-right.

The <u>spectrum section</u> shows a compact spectrum of the latest processed sounds, every 10Khz of the spectrum is shown with a yellow divider on the bottom and the white marker shows the current frequency for heterodyne detecting,
On the top right 3 figures appear that will show the low-peak-high frequency (in Khz) of the latest ultrasound detection.

The <u>display section</u> is used to show the incoming signals, it can be set to 3 modes (waterfall (as shown above), spectrum or "no display"). The spectrum shows a live spectrum graph, the waterfall shows the spectrum over time and will scroll upwards every time a new signal is detected that has a peak above a set frequency (user set with menu "Signal peak above").

The 1st line of the menu shows the setting for a specific item that is controlled by the push-buttons. In the example above for instance pushing PushL will step the display through its modes and pushing PushR will change the detector-mode. When an SD card is placed PushL will be recoding start and stop.
The 2nd line of the <u>menu section</u> shows the menu items that can be changed by the encoders. The left encoder has access to all menu items but the right encoder is limited to a smaller set of the same menu.

The current options for the menu are :
- **Volume** (0..90)
  This set the volume of the headphones.
- **Gain** (0..63) This sets the amplification (gain) of the microphone signal
  (Try to keep this relatively low when recording, to keep harmonics out)
- **Frequency**
  Used in Heterodyne detection, is used to choose the mixing-frequency
  (when no heterodyne is selected "Freq.AUTO will be displayed)
- **Sample Rate** (8,11,16,22,32,44,48,88,96,176,192,234,281,352,384)
  The sample rate determines the maximum frequency that can be detected. Default this is set at 281k which translates to a maximum detection frequency of about 140khz.
- **Settings**
  Several settings pages for storing your personal sttings. (see below)

- **Waterfall disp/no graph disp/spectrum disp**
  Change the display mode, when no micro SD-card is placed, you can also use PushL for this function.
- **Play**
  Can be used to replay recordings.(See below)
- **Hipass**
  Can be used to set additional filtering to try and keep out crickets or other low frequency noise.

Push Button options
The right push-button (PushR) is used to set the detector mode or step through d/m/y and hh/mm in the settings menu. The detector can be set to the following modes :
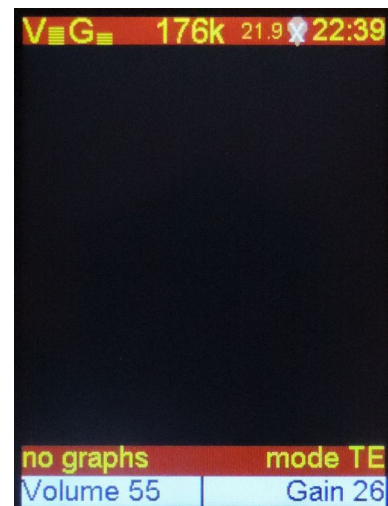
- **HT : manual heterodyne**.
  This sets the detector as a normal heterodyne. When selecting this the encoders will (by default) be change to allow control of the volume (left) and the frequency(right). The centre-frequency is set in Khz and the produced audio is based on the difference in frequencies between the incoming signal and the centre-frequency.
- **Auto HT : automatic heterodyne**
  This is the same as the HT mode but the centre-frequency is automatically controlled and will track the peak.
- **Auto_TE : automatic TimeExpansion**
  In this mode the detector will wait for an incoming ultrasound and then directly replay that signal but at a slowed down speed. During this time (currently) no new signals can be detected and therefore in this mode you can also miss clicks of bats but it sounds way much better than other detection modes.
- **FD : Frequency Divider**
  All incoming signals are divided by X to change them from ultrasonic to audible.
- **PASS**
  The detector does not process the signal and just allows you to listen to the audible part.

- **DISPLAY (**default function of PushL when no micro SD card is placed**)**
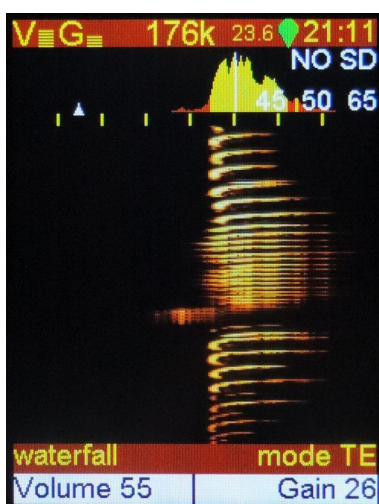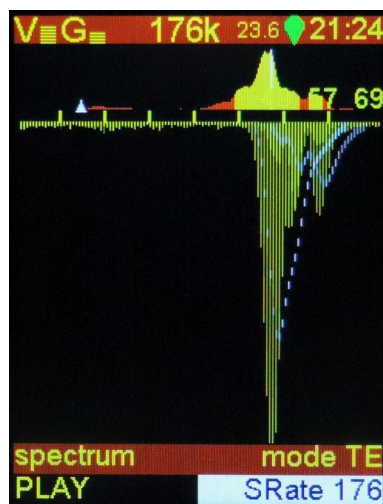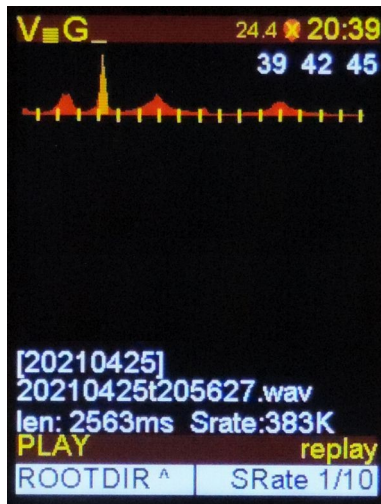

| Waterfall | Spectrum graph | No graph |

"No Graph" display setting was used to eliminate digital noises generated by the display, with the latest hardware there is hardly any unwanted noise.

- **PLAY**

By turning EncL, one can select Play, after pressing EncL, the following display appears.
PushL now gets the play function and rotating EncL will allow you to select the file. Pressing PushL will start the playback of the file.

The spectrum display on the top of the screens shows a power spectrum and min/peak/max frequency of the selected WAV file. This power spectrum is stored in the waf files recorded with a TeensyBat recorder.
Below we see the name of the folder we are in and the selected wav file. The duration of the file and the sample rate. (384 kHz is show as 383 as it is actually 383.9xx something)
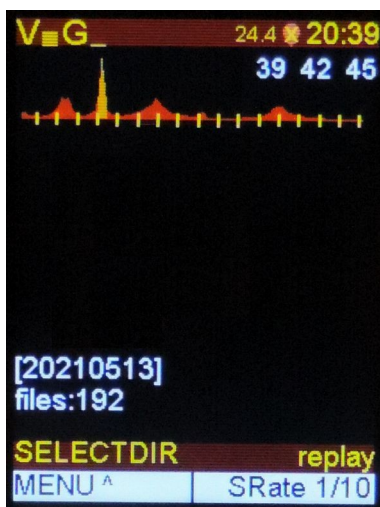
When you want to change to an other folder (date) press EncL. That will bring you to the root of the micro SD card.
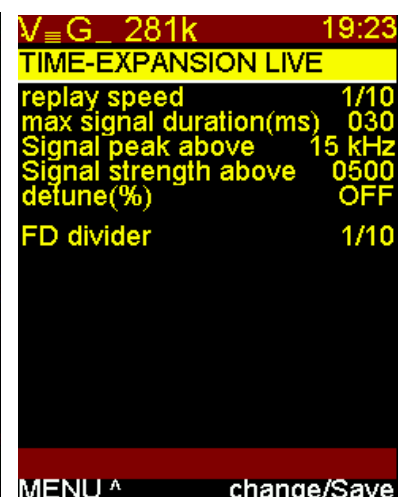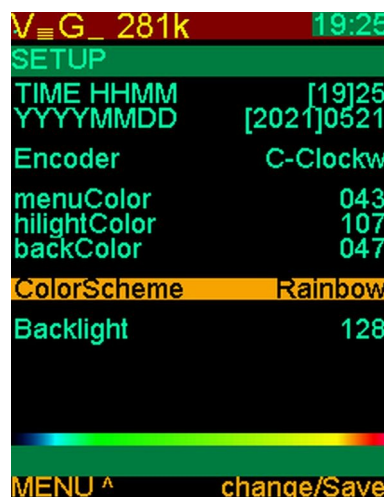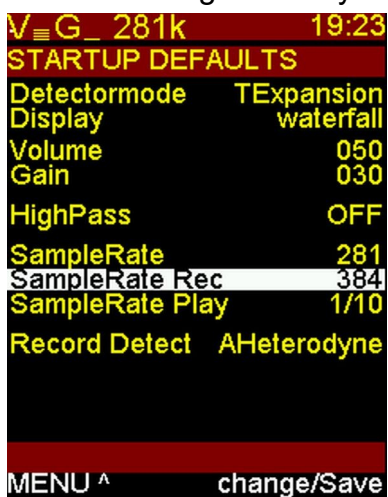
When you are in the root of the SD card you can turn EncL to select the folder (date) and press PushL to enter that folder. To exit playback press EncL again to return to the main functions (MENU).

EncR allows you to change the playback speed, standard 1/10 the of the original (1/5 to 1/20 possible) or select "Direct" for sample rates of 281kHz or lower to allow playback as if you are listening in live detection mode. (detection mode can be changed when in direct playback mode)

During playback you cal also use EncR to change the volume. Gain al also shown during playback, but has no effect.

Settings

We do have quite a big list of settings, you can change these to your wishes. The Save function saves all settings at once. If you do not press save but go back, the chosen settings will only work for that session.

V≡G_ 281k 19:23	V≡G≡ 281k 19:26	V≡G≡ 281k 21.6 ● 21:33
AUTORECORD	**SD-CARD**	**GPS DATA**
Recording SampleRate 384	Size 15481Mb	GPS LAT 53.212284
Signal Peak above 20 kHz	Used 7591Mb	GPS LON 5.907184
Signal Strength above 2000		GPS ALT 10000000.00
	PLAY folder [20210510]	GPS fixage 0.804
max Duration(s) of rec 010	Wav-files 34	GPS HDOP 42949672.00
max Silence(s) in rec 005		GPS SENTENCE 7
Pause(s) between rec 010		GPS FAILS 1
Display during rec ON		
MENU ^ change/Save	MENU ^ change/Save	MENU ^ change/Save

When EncL is not used yet and the menu name is yellow, EncR can select the different menu pages. Depending on GPS availability (and software) you can see several pages with settings.

Navigating the settings menu

Rotating EncL will move the active (white) line. (yelow on menu selection)
Rotating EncR will change the value for that line. (or change menu page)
Pressing EncL will exit the settings menu (altered values are chosen for this session only, so not stored)
Pressing EncR will store all the settings of all pages.

Startup defaults

Detector mode	T Expansion/Freq. Divider/Passive/Heterodyne/A-Heterodyne
Display	waterfall/spectrum/no graph/settings
Volume	Numeric value of the volume usually around 50
Gain	Numeric value for gain. normally around or lower.
HighPass	Off, 12-50Khz filters out (dampens) low frequencies
SampleRate	8-384 (sample rate used in "live listening/display" in kHz)
SampleRate rec	44-384 (sample rate used for recording in kHz)
SampleRate play	1/10 (1/5-1/20 or "Direct") "slow down replay factor"
Record Detect	A-Heterodyne/Heterodyne (live listening mode during recording)

Setup

Time	If you need to do any time correction…. Press PushR to switch between HH and MM (for file creation time)
YYYYMMDD	Year, month, day. Press PushR to switch between YY MM and DD (file creation date)
Encoder	Clockw/C-Clockwise (change the direction of your encoders)
Menu Color	000-127 change colours, just try an you will see.
HighlightColor	000-127
Back-Color	000-127
Color scheme	Changes the colour scheme used for the waterfall display, below you can see a preview of the colours.
Backlight	Backlight intensity setting, useful values are around 50-110

Time-expansion live

|	
Replay speed	10, 1/5-1/30 (This sets the time expansion rate, so it will change the pitch and duration of sounds heard in the headphones)
Max s. duration (ms)	This limits the time of an ultrasound signal for expansion 30, 15-200 (try lower values for calls with short sounds and pauses, higher values for longer sounds)
Sig. peak above	15, 15-35 This is used to set the lowest frequency on which time-expansion will be triggered.
Sig. strength above	500, 100-5000 sets signal strength threshold of TE trigger and waterfall updating. (low gain can use a lower setting, standard value is fine)
TE detune	This allows you to lower frequencies in time expansion. The speed will be the same, but you can lower the tones. It is a heterodyne mixer after time-expansion. (usually off but functional for higher frequencies if you don't want a large expansion factor)
FD divider	1/4 - 1/16 frequency division rate, changes pitch.

Autorecord

Recording Sample Rate	282 (176-384) this is the same value as in the defaults settings page
Signal peak above	15 (1-80) Frequency in Khz, only if a detected signal is above this setting and loud enough, recording will start)
Signal strength above	2000 (25-5000) This allows us to only start recording a strong enough ultrasound signal. Set to 500 it will still pickup weak signals, set to 5000 we need quite a strong signal to trigger auto record.
Max Duration(s) or rec	5-300 Sets the maximum file length (in seconds) during auto record.

Max Silence(s) in rec	1-30 If during autorecord no stong signals had been detected recording stops after x seconds.
Pause (s) between rec.	0-300 to set a minimum pause time between recordings.
Display during rec.	ON/OFF switches display during auto record

GPS DATA

These values are actually not setting but it displays the last GPS received data. The GPS receiver consumes a lot of battery power, switch it off when you don't need to have new GPS information.
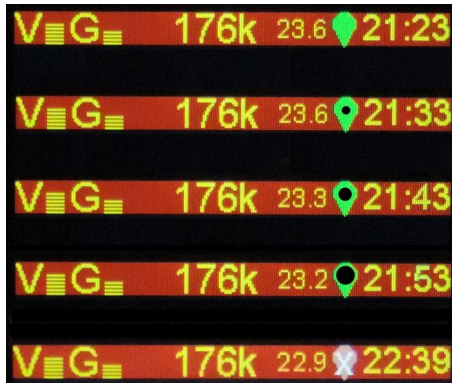
The GPS indicator droplet can tell you how old the last received data is. A dot will grow in the centre of the droplet, every 10 minutes GPS data was not updated the dot will grow a step bigger. Eventually the droplet will be red with a white X indicating the data is old.

If you had GPS reception before, the old data is stored in the metadata. If you only see the red droplet/X after powering up, no GPS data is stored. Lat/lon will be 0/0.

Auto record function.

To enter auto record, simply turn the left encoder until auto record is shown and press the encoder. This instantly activates the auto record mode.

Now the detector is waiting for an ultrasound signal if the parameters for frequency and volume are met (Low Frequency and Low signal strength) a recording session starts until x seconds after the sound is lost or the max duration timer is met.

A press on PushL will stop the auto record feature, you need to press EncL again to be able to change to back to the menu.

Be aware that the display can be set to off in the auto record settings menu, to save battery power. If you chose display off, a message will be shown for a few seconds that the display will be turned off. A press in PushL will activate the display again and stop the auto record session.
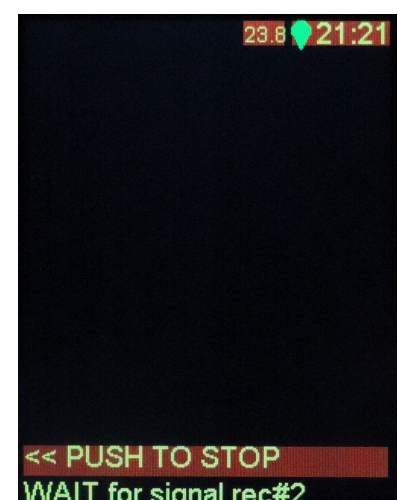(Display off needs a PWM display backlight modification)
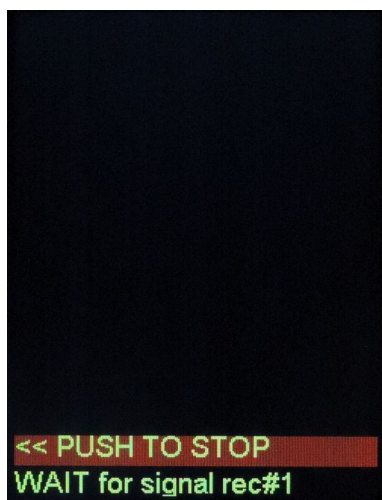
Autorecord is chosen	Autorecord is recording	Autorecord is waiting for the next event.

Trouble shooting :

"Factory reset"
If for any reason, the detector is not behaving properly due to a strange setting or something, you can reset to default values. Hold PushL and power on the TeensyBat and release PushL when "Resetting to defaults" is shown.

Encoders are working in reverse. After a reset or software update the encoder knobs can work in the opposite direction. You can change the direction of the encoders in the settings menu change C.Clockw / Clockw.

Live listening sound is softer or different during recording. During recording we can not simultaneously use live Time Expansion. The detector will switch back to (Auto)Heterodyne. In settings/defaults you can choose for heterodyne/auto heterodyne.

Play or Record not possible. If TeensyBat does not detect a micro-SD card this will show in the display as NO-SD. The menus with record and play functions will not appear. Use SDHC cards (NO SDXC) up to a maximum of 32GB. With a speed of class 10 or faster. I used genuine Kingston and Sandisk of 8 and 16GB. Cheap Chinese cards usually don't meet the speed markings. Be aware of counterfeit materials.

Battey does not charge. The USB connector next to the headphone jack can not be used to charge the battery. (depending of the way of construction) You can use this micro SD connector to power the detector using you smartphone charger, or power bank.
To charge the internal battery you need to use an other port, I usually build these on the short end that is facing toward you when handling the detector.

I hear no sound from the headphone jack. Use headphones or earphones (stereo/3 contacts jack-plug) and not a headset with four contacts.
Check the volume setting and detection mode ("Pass" will not produce bat sounds)

Display is scrolling but I hear no sound.
Keep in mind that if you are using TE, we need ten times the recording time to play the sounds we receive.
If you set gain very high, or TE low-peak on a low setting the waterfall can start scrolling.
This means sound is detected continuously and there is no time to play it properly.
Lower gain or raise the TE low-peak so TE is not activated all the time.

*As a bonus a small Easter egg was added. Hold down PushL for at least two seconds and see what you can find in the root of the SD ca*rd!

Edwin PE1PWF 25-05-2021