Teensy Bat Detector: interface based on version 1.3

Current sample rate.
Has to be more than twice the value of max target frequency.

Temperature sensor display (*optional*).

Current GPS status (*optional*).

	No position acquired
	Position acquired, shows number of satellites in view (+ if > 9)
	Position lost recently

Current volume and gain.
AGC will be displayed when **Automatic Gain Control** is active.

Current time based on internal clock. Can be modified in settings or auto-set if GPS present.

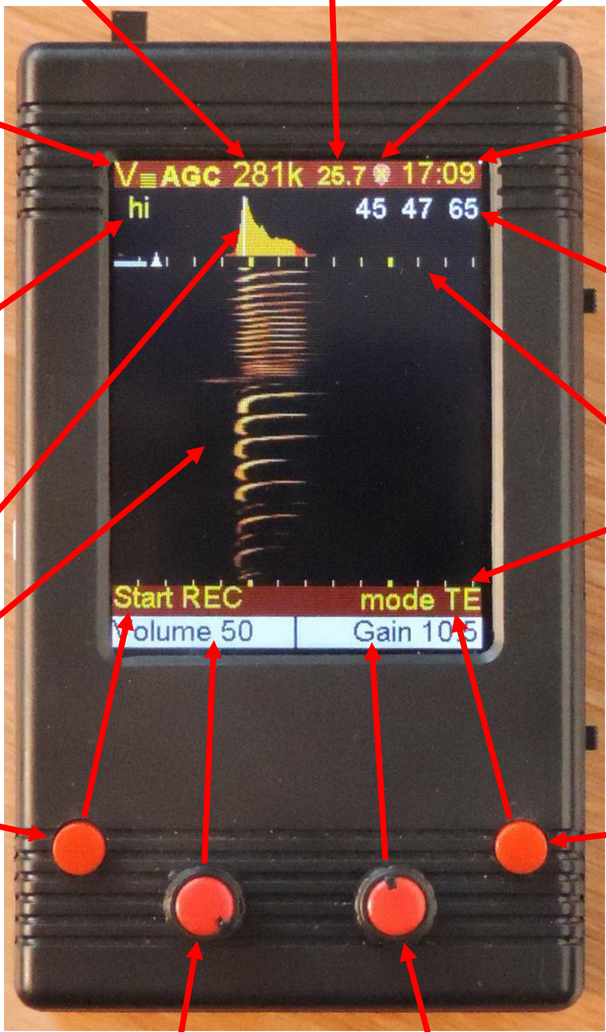
Software High-pass status.
hi = high-pass is active
White bar extent indicates frequency threshold (here set to 12 kHz)

Min, Peak, and Max frequency of recent signals.

Power spectrum of recent signals

Frequency scale (marks every 10kHz).
Auto-scales according to sample rate.
Repeats at the bottom of the display.

Spectrogram of recent signals



Left Button (**L-Button**).

Default function: start/end recording.
When this button is pressed during startup it will reset settings to factory defaults.

Right Button (**R-Button**).

Default function: cycle through listening modes.
When this button is pressed during startup the settings will be loaded from an SD card (if present).
Long press to write a screen capture to SD if card present.

Left encoder (**L-Enc**).
Default: Turn to change volume

Right encoder (**R-Enc**).
Default: Turn to change gain

The function of the encoders can be changed. To do this press the encoder to enter function change, then turn to select function and press the encoder again to activate function.

Teensy Bat Detector: Settings

Using the SETTINGS MENU

Press L-enc to set the L-Encoder to MENU_mode. Turn L-enc until it shows “SETTINGS” and press L_Enc again to select this option. The display will now show the **STARTUP DEFAULTS** settings page.

Once in the settings, rotate L-enc to highlight the option you want to change and then turn R-enc to change its value.

Accessing other pages:

Turn the L-enc until the page header (STARTUP DEFAULTS) is highlighted and then turn R-enc to cycle through other settings-pages.

Important note:

When finished changing settings, it is possible either:

- to simply exit the settings-menu (without saving) by pressing L-enc,
- or to save the changes by pressing the R-enc before exiting the settings-menu.

Exit without saving: changes are directly applied but will be kept only until the next power off.

When powering the device on again it will revert to the previous stored settings.

Save then exit: changes are applied and stored in EEPROM so they can stay in effect after powering off and on again.

If an SD card is present, settings will be written to a file on that SD card. You can keep a copy of that file (located in the root: TB_V13.cfg) on a computer for safekeeping. These configuration files can be shared between devices and with other users.

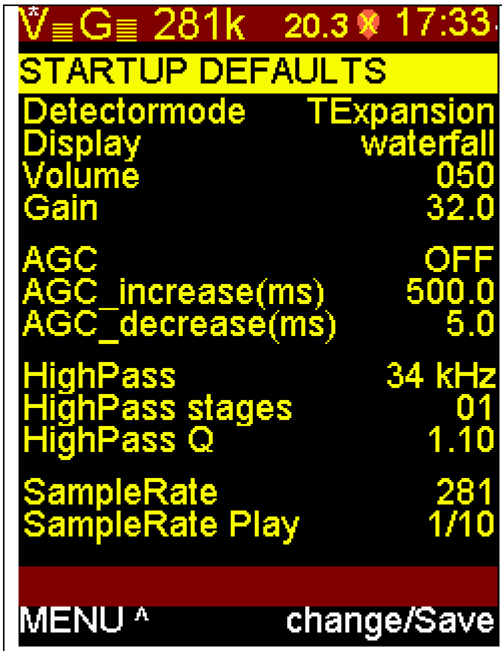
RESET settings:

At startup Settings can be restored to “factory” defaults and or to stored configuration files on an SD card.

To restore to “factory” defaults, keep the L-Button pressed when starting the Teensy Bat. The display will notify the reset to defaults.

To restore the settings to a previously saved configuration file (located in root: TB_V13.cfg) on an SD card press the R-Button during startup.

Teensy Bat Detector: Page 1 – STARTUP DEFAULTS



this shows the defaults

Note about the Q factor:

Q values below or above 1 can also affect frequencies **above** the chosen filter frequency.
For example, a setting of Q = 0.3, HighPass = 8kHz and stages = 3 attenuates frequencies up to 30kHz.
Read about filter Q on the internet and test setting before using in the field.

Detectormode:
Signal processing used at power-on.
Options are:

- Heterodyne = HT = heterodyne mode
- AHeterodyne = A-HT = auto heterodyne
- TExpansion = TE = Time Expansion (default)
- FreqDiv = F-D = frequency division
- Passive = Pass = no processing

Display: Type of graphical signal display.
Waterfall(default) / Horizontal Waterfall (T4.1 only) / Spectrum/ no Graphs.

Volume & **Gain:** Default sound volume and signal amplification used at startup.

AGC: Automatic gain control ON or OFF.
When on, the gain setting will be used as the maximum gain.
If incoming signal gets too strong, gain will be reduced to prevent saturation. When signal lowers again, gain will progressively increase back to the default value.

AGC_increase: Time in milliseconds before the gain increases while getting back to chosen gain. Default set to 500ms to allow slow recovery.

AGC_decrease: Time in milliseconds between reductions in gain in case of strong signal. Default set to 5 ms to allow a fast reaction to too strong incoming signals.

HighPass: All signals lower than the chosen frequency will be attenuated. The further below from this frequency a signal is, the stronger the attenuation will be. Depending on the Q setting of the HighPass this will also attenuate frequencies above the HighPass-filter.

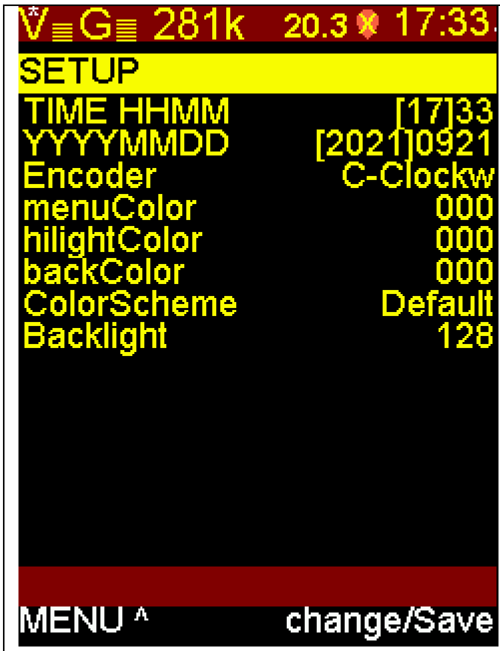
HighPass Stages (1 to 4) : Strength of the attenuation. One stage of HighPass will give a filter with 12dB attenuation per octave, each additional stage will add 12 dB. The filter therefore becomes steeper.

HighPass Q: The Q value sets the shape of the overall filter; a higher Q will make the filter steeper and a lower will attenuate more frequencies above the Filter-frequency.

SampleRate: Number of samples per second * 1000.
Should be set to at least twice the maximum frequency you want to record. For example, to record up to 140kHz, Sample rate should be <u>at least</u> 280 K.

SampleRate Play: Time Expansion slowdown factor used for playback of recordings.

Teensy Bat Detector: Page 2 – SETUP



this shows the defaults

Time / date: Can be used to manually set the current time and date.
These values are automatically set if the optional GPS module is installed and powered.
Setting the time/date is done using a combination of the R-Enc and R-Button. First select time or date.
The part of time/date between [] can be changed using the R-Enc, the position of the [] can be changed by pressing the R-Button.

Encoder: Sets the orientation of the two encoders' rotation (not all encoder models work in the same way). Set it and forget it … but don't forget to SAVE

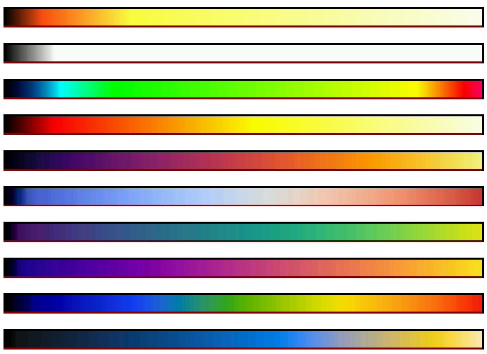
menuColor / highlightColor / backColor:
use this to change the colors used in the interface for text, selected text and backgrounds.

ColorScheme: Different color sets are available for the spectrogram display (see below). When selected the screen will show a preview of the ColorScheme on the bottom.

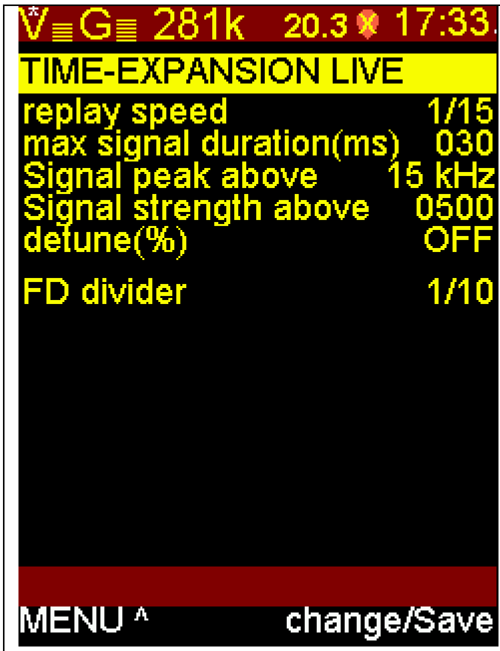
Backlight (OPTIONAL): Software controlled backlight intensity. This normally is set as low as possible to get a screen that is good readable in the dark and uses less energy. This feature is only present when PWM is enabled to control the brightness of the TFT.

Available color schemes:

Default
Grayscale
Rainbow
Fire
Inferno
Moreland
Viridis
Plasma
Rainbow1
ColorBlind



Teensy Bat Detector: Page 3 – TIME-EXPANSION LIVE



"TIME EXPANSION LIVE" is a mode that allows Time-Expansion to be used in real-time (sort of 😉).

The **replay speed** sets the slow-down of the replay, default this is 1/10 so a signal at 60Khz will be sent to the headphones at 6Khz.

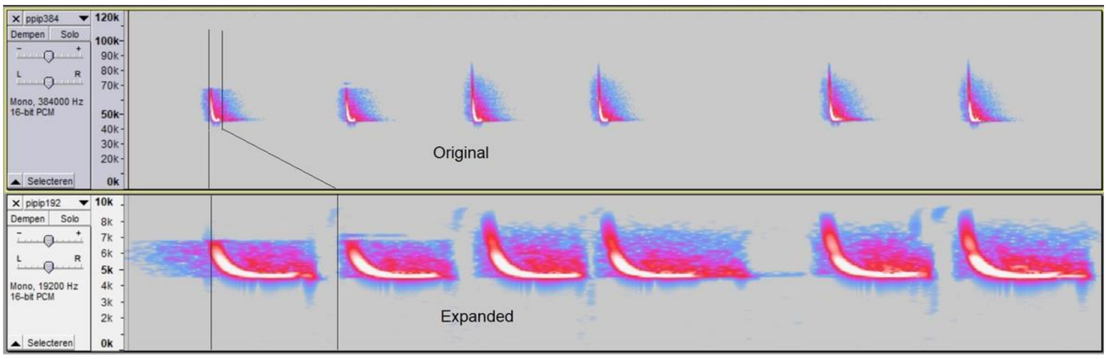
The device will wait for a signal that satisfies the values set in **Signal peak above** and **Signal strength above.** The moment such a signal appears the system will record the signal and replayed it slowed down to make the high frequencies audible. If the signal is longer than **max signal duration** replay will stop. After that, the device will wait for the next incoming "pulse" and start the cycle again. The concept behind TimeExpansion Live is that most calls from bats are very short (a few ms) and between calls there is a interval that is often far longer than the call itself (see graph below)

TimeExpansion therefore can make you listen to the bat calls at audible frequencies and still understand the "rhythm" of the calls.

Detune(%)-EXPERIMENTAL:
Using this option, the output at the headphones is restricted to a narrow sound band. If for instance you are listening with TimeExpansion Live (1/10 example) to pipistrelle bats with frequencies that peak around 40-50Khz you hear sounds of 4-5Khz. But if a horseshoe bat would pass you would probably not hear it as they produce sounds above 80Khz and translated to 8khz these are less audible. The detune function will lower sounds further so they become more audible.
If set to 80% this sets the heterodyne signal-generator to 80% of the peak-frequency of the incoming signal. So, a 80Khz signal will be downscaled to 8Khz by the TimeExpansion and the heterodyne will be set at 8Khz*0.8= 6.4Khz. The resulting sound at the headphones will be 2.6Khz.

FD divider
Sets the value used in the frequency division mode. Usually 1/10th.

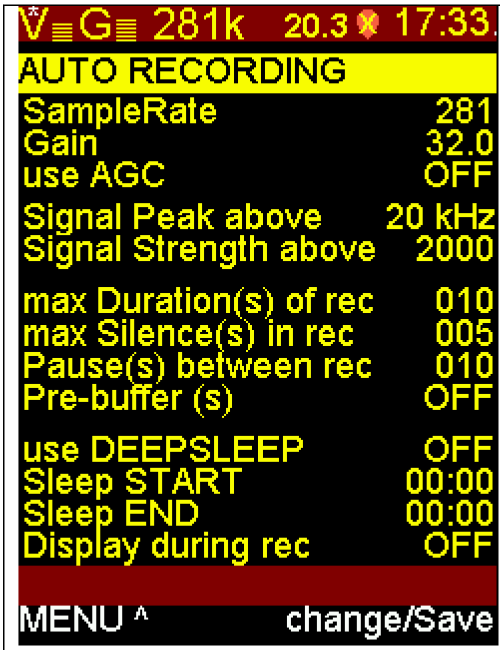
Time expansion live in image



The interval between calls is used to play back the slowed down call.

That way, as long as the call interval is a lot shorter than the slowed call duration, all calls will be heard.

Teensy Bat Detector: Page 4 – AUTO RECORDING



Auto recording mode is used for unattended monitoring.

SampleRate / Gain / Use AGC: These are recording parameters. Work in the same way as their manual recording counterparts.

Signal Peak above / Signal strength above: Threshold levels, recording will only start if both conditions are met.

Max duration(s) of rec: Recording will stop after n seconds, even if signal is still coming in.

Max silence(s) in rec: Recording will stop if there is no signal over threshold for more than n seconds.

Pause(s) between rec: Minimum waiting time before a new record can be started.

Pre-buffer(s) (OPTIONAL only T4.1):
Defines how many seconds of audio is stored prior to the actual triggered recording.

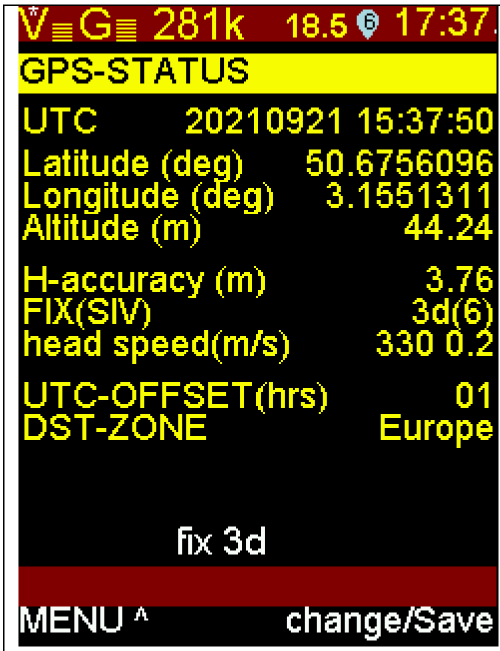
Using DEEPSLEEP: Set to ON to allow prolonged unattended auto recording without spending too much battery. The Teensy will be put to deep sleep mode (minimal energy use) and will wake up to start Auto Recording after the SLEEP END time.

Sleep START: Time at which the device will stop listening and enter deep sleep.

Sleep END: Time at which the device will wake up and start monitoring sounds.

Display during rec: Set to no to minimize energy use. Device will have to be switched off and back on again to power the display back on.
THIS IS OPTIONAL and only present if PWM is available to control the TFT.

Teensy Bat Detector: Page 5 – GPS STATUS



Only available if GPS module is present and powered on at startup.

This page has only two user-changeable parameters:
UTC-OFFSET: This allows the user to set the default difference between UTC and local-time.
DST-ZONE: This sets the daylight savings time setting corrections for Europe/N-America or None.

Activating this settings-page also forces the GPS to start updating continuously. This can be helpful if GPS-lock was lost.

IMPORTANT NOTE:
When the settings are displayed, sound processing is suspended to reduce the Teensy activity and thus reduces the quantity of RF noise generated by the processor/audioboard. RF from the processor does disturb the GPS.

If the number of satellites in view (SIV: 6) decreases significantly from the value displayed in the GPS-STATUS page when returning to listening mode (high processor activity), this means that the RF noise generated by the Teensy during sound processing (mainly from high speed I2S audio data) is negatively affecting the GPS reception. This is normal and as long as the SIV number is 3 or higher the position is probably reliable enough.

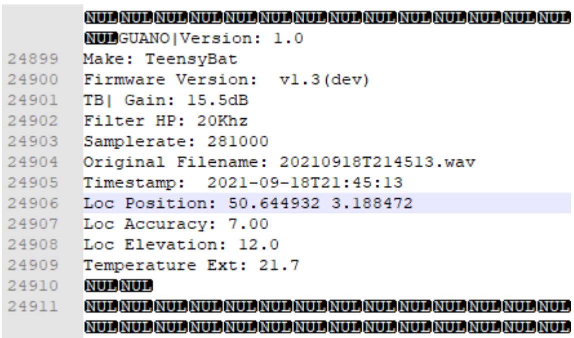
~~Putting some metal shielding and/or RF absorbing material around the Teensy board will strongly reduce that problem~~. THIS IS HARDWARE … needs to be in the hardware section of the manual.

The Beitian GPS should provide horizontal accuracy (H-accuracy) better than five meters when used in open sky conditions, but it probably still won't be as accurate as a dedicated GPS device.

GPS data, like temperature and other parameters, will be stored in the recorded wav files, according to the GUANO standard (see https://guano-md.org/)

You can see this data with a simple text editor, at the end of the wav file.

Please note that current wav editing software will lose the guano metadata when exporting/saving wave files.



Teensy Bat Detector: using the pre-buffer on for recording (Teensy 4.1 only)

The teensy board 4.1 can be upgraded during assembly with one or two PS ram chips, providing 8 or 16Mb of additional memory.

This memory can then be used by the code to continuously record incoming sounds into an endless ring buffer. Once the buffer is full the Teensy Bat will continue writing into the buffer from the starting position again, overwriting the oldest audio first.

If enabled (when compiling), this ring buffer is by default set to provide up to 4.5 seconds of pre-recording. This setting can be changed by the user. In theory a 16Mb PSRAM can be used to collect nearly 30 seconds of audio at 281K sampling. Currently the code is only using part of the available PSRAM for this purpose. The defaults are 10000 sample-blocks (each 128 samples) for the ring buffer and 2000 sample-blocks (of 128) for the buffer during recording.

When the recording is manually triggered (by pressing the L-Button), the past 4.5 seconds of sound, present in the ring buffer, are directly written to the SD card, but the recording starts also directly and will continue until the L-Button is pressed again.

Then the ring buffer starts to fill up again, and so on.

This enables the user to actively listen to incoming sounds, and decide to record them if they are interesting. When the recording starts, the recorded file will always contain the sound that triggered the user to press the recording button.

These 4.5 seconds are more than enough to compensate for human reaction time, have some time to decide whether to record or not, and in the end get a complete recording, including the sounds made by the animal as it was approaching, before it was even audible.

The ring buffer can also be used with auto recording, by default it will not add 4.5 seconds to each auto-recording but a user-set amount (see settings).

That way, there will be a better chance of getting sounds that were emitted by the approaching animal, but not yet strong enough to trigger the recording.