Open Acoustic Devices

AudioMoth Operation Manual

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This operation manual is designed for both new and experienced AudioMoth users. It describes how to configure an AudioMoth device and how to change its on-board firmware. It also presents general tips for deployment, along with additional information, useful for maximising the utility of AudioMoth.

Contents

1 AudioMoth overview

AudioMoth is a low-cost, full-spectrum acoustic logger, based on the Gecko processor range from Silicon Labs. Just like its namesake the moth, AudioMoth can listen at audible frequencies, well into ultrasonic frequencies. It is capable of recording uncompressed audio to microSD card at rates from 8,000 to 384,000 samples per second.

Figure 1: *AudioMoth 1.1.0: A low-cost, low-power acoustic monitoring device developed for a wide variety of conservation projects.*

Released in 2017, AudioMoth has received constant support in the form of hardware, firmware and supporting software updates from the Open Acoustic Devices team.

The following manual was written to describe the operation of the following firmware and software:

- AudioMoth Firmware 1.8.0
- AudioMoth Configuration App 1.7.0
- AudioMoth Flash App 1.3.0
- AudioMoth Time App 1.1.0
- AudioMoth Filter Playground

1.1 Support

If you require assistance on any topics not covered by this operational manual, or wish to report a bug, contact the Open Acoustic Devices team and we will be happy to assist:

- Email us at: *theteam@openacousticdevices.info*
- Post on the support forum: *www.openacousticdevices.info/support*

1.2 Visual tour

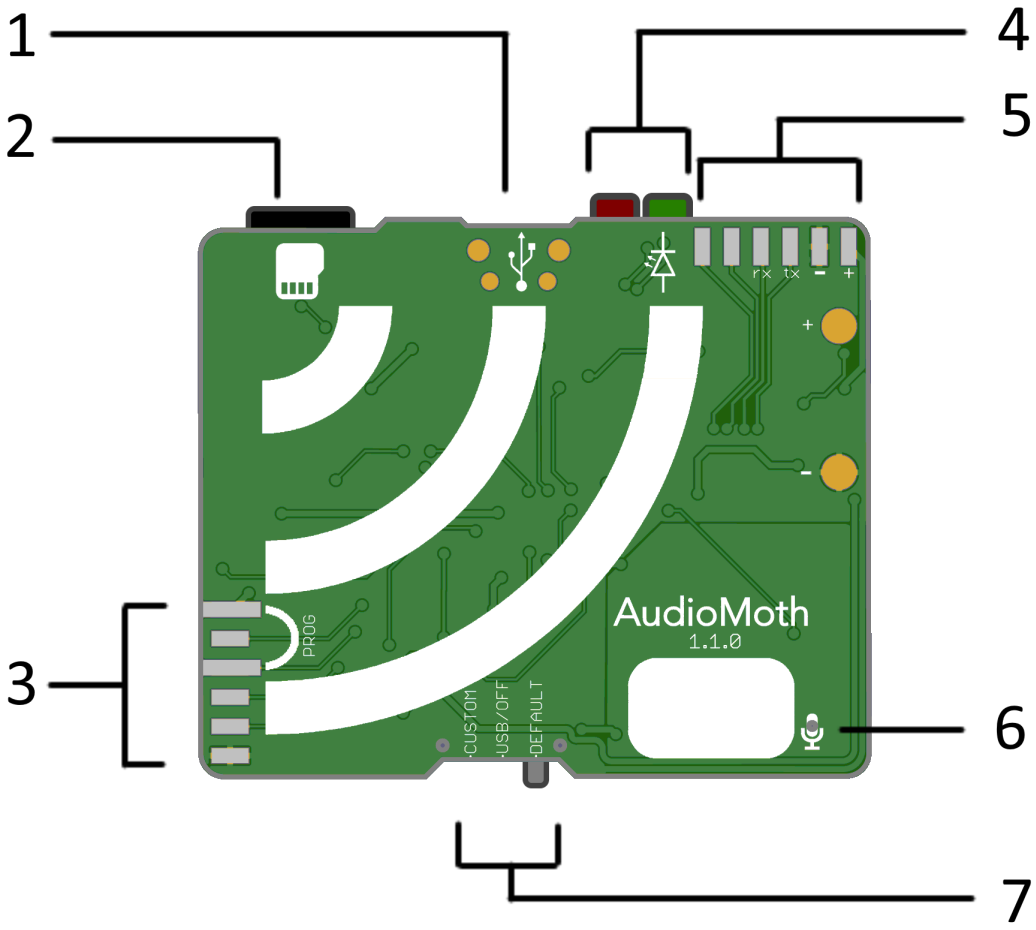


Figure 2: *Annotated diagram of an AudioMoth.*

1	**USB port:** Connect your AudioMoth to a computer using a standard microUSB cable.
2	**microSD slot:** Insert microSD card here to store recordings. For advice on purchasing the correct card, see Section 2.1.
3	**Programming header:** A series of pins which can be used to apply firmware to the AudioMoth.
4	**Status LEDs:** A green and a red LED used to communicate the status of the AudioMoth. See Section 3.2 for more information.
5	**Exposed GPIO pins:** A set of general purpose pins which can be used to communicate with and power external modules.
6	**Microphone:** An analogue MEMS microphone.
7	**Mode switch:** Change between three modes: CUSTOM, USB/OFF, and DEFAULT. See Section 3.1 for more information.

2 Preparation

2.1 Purchasing SD cards

AudioMoth supports microSD cards of any size, however performance may vary depending on the speed of the card.

We recommend using Sandisk Extreme UHS Speed Class 3 (U3) microSDHC and microSDXC cards due to its performance and wide availability. Other cards may also be used but be sure to test them first. Slower cards, such as Class 10 or UHS Speed Class 1 (U1) cards, may not work consistently at high sampling rates.

SD cards typically come formatted in one of two systems. Cards that are 32GB or less in size are normally supplied formatted using the MS-DOS (FAT32) system. Cards greater than 32GB are typically supplied formatted using the exFAT system. The process of calculating the storage requirements of a deployment is described in Section 4.8. Both FAT32 and exFAT file formats are fully supported by AudioMoth.

2.2 Purchasing batteries

On average, good quality alkaline AA batteries have a capacity of approximately 2600 mAh, whereas equivalent lithium batteries have approximately 3600 mAh. Due to the low power consumption of the AudioMoth in general, any AA battery is suitable for standard deployments. For more intensive deployments involving long recordings or high sample rates, we advise using lithium batteries to maximise lifetime. AudioMoth battery cells are arranged in series. The process of calculating the energy requirements of a deployment is described in Section 4.8.

3 Usage

3.1 Modes

The switch on the side of the AudioMoth controls the current mode of the device. AudioMoth has three modes of operation: USB/OFF, CUSTOM, and DEFAULT.

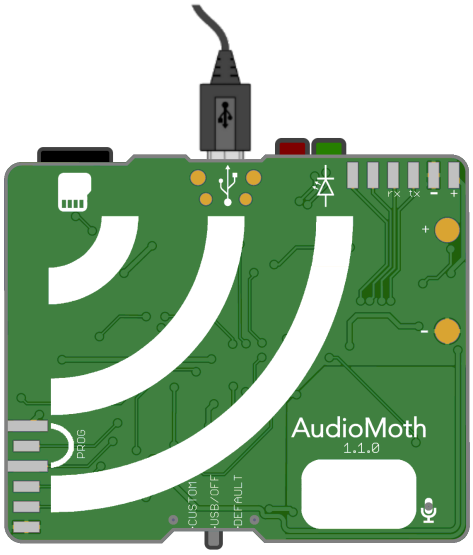


Figure 3: *An AudioMoth plugged in and ready for communication with one of the many supporting applications.*

3.1.1 USB/OFF

USB/OFF mode serves a dual purpose. When a USB cable is used to plug the device into a computer, this mode allows AudioMoth supporting software to communicate with the device and perform tasks such as configuring the recording schedule, setting the on-board clock, and applying new firmware. The steps required to performed each of these tasks are explained in Section 4 and 6 respectively. When not plugged in, an AudioMoth in USB/OFF mode is switched off, in a low power state, while still keeping track of the current time.

3.1.2 CUSTOM

If a recording schedule has been configured on a device, switching it to CUSTOM mode will start running the configuration. During periods defined by the recording schedule, the AudioMoth will alternate between recording and sleeping if cyclic recording is enabled or record constantly until the period ends if it is disabled.

If the clock has not been set, switching to CUSTOM mode will begin listening for an acoustic chime. This allows the time to be set prior to recording using the AudioMoth Chime smartphone app. As well as the time, some apps (such as the RFCx Companion app) include a deployment ID in the chime, which can be used to uniquely identify an instance of a device deployment.

An AudioMoth will not record in CUSTOM mode if the on-board clock has not been set. If the *"Always require acoustic chime on switching to CUSTOM"* option is enabled in the AudioMoth Configuration App, then the device will wait for a chime even if the clock has been set.

3.1.3 DEFAULT

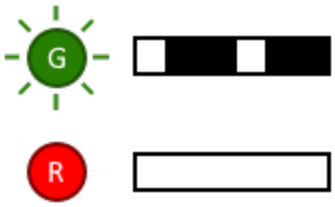
If you wish to start a recording outside an applied schedule, switch to DEFAULT mode and your AudioMoth will start recording continuously. This mode will use the sample rate and gain level of the current configuration. The clock does not need to be set to record in this mode.

3.2 What do the flashing LEDs mean?

AudioMoth has two colour LEDs, visible on the side of the device. Various combinations of these two LEDs flashing represent different modes of operation or tasks it is carrying out.

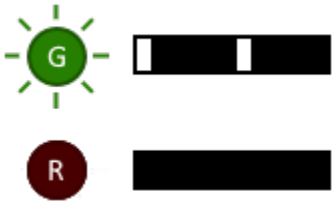
3.2.1 With switch set to CUSTOM

When a recording schedule has been set but the clock has not been set, or when the *"Always require acoustic chime on switching to CUSTOM"* is checked, the AudioMoth will listen for the acoustic chime from the AudioMoth Chime smartphone app. While doing this the red light will remain solid whilst the green flashes (100ms).

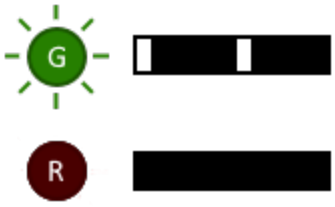


Once the chime has been played and accepted, the red LED will switch off and the green will be remain solid for a short period (2s), then the schedule will begin.

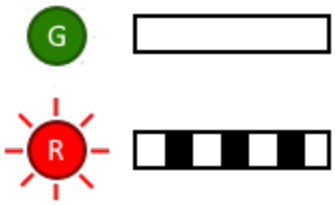
If *"Enable magnetic switch for delayed start"* is checked, the AudioMoth will flash (10ms) every 4 seconds until the magnetic switch has been triggered. Once that occurs, normal operation will begin.



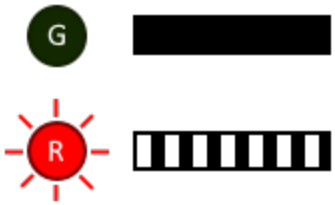
When sleeping between recordings a single green light will flash (10ms) while the red remains unlit.



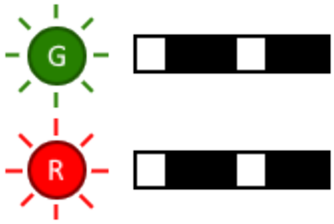
If *"Enable GPS for time setting"* is checked, five minutes before the start of each recording period, the AudioMoth will power up the GPS module and attempt to update the internal time setting. While doing this the green light will remain solid whilst the red flashes (100ms).



When making a recording a single red light will flash intermittently depending on the sample rate as the recording is written to the SD card.



On first switching to CUSTOM when no schedule has been set, both lights will flash (100ms).

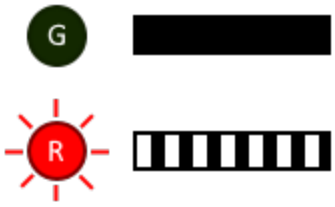


A long flash (500ms) of both LEDs occurs when there is a recording failure, due to an SD card write error or a low battery, that results in a recording being cut short.

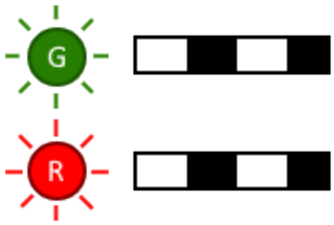
Short flashes (10ms) of both LEDs between recordings mean an earlier scheduled recording has been cut short due to a recording failure.

3.2.2 With switch set to DEFAULT

When making a recording a single red light will flash intermittently depending on the sample rate while writing to the SD card.



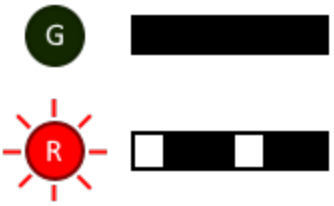
A long flash (500ms) of both LEDs occurs when there is a recording failure, due to an SD card write error or a low battery, that results in a recording being cut short. If this happens immediately on switching to DEFAULT check that the SD card is inserted correctly.



3.2.3 With switch set to USB/OFF

When connected to USB the green LED will remain solid while the red LED remains off.

When first switched to USB/OFF, the red LED will flash (100ms) a number of times corresponding to the current battery level of the device.



There are two battery level modes. The default one is intended for use with standard alkaline batteries (left), and a second more precise scale is available for use with NiMH and LiPo batteries (right). The second scale is selected using the *"Use NiMH/LiPo voltage range for battery level indication"* setting in the AudioMoth Configuration App (see Section 19).

Alkaline (V)	Flash Count
≥ 4.6	4
4.4 - 4.5	3
4.0 - 4.3	2
3.6 - 3.9	1
≤ 3.5	10 rapid

NiMH/LiPo (V)	Flash Count
≥ 4.3	1
4.2	2
4.1	3
4.0	4
3.9	5
3.8	6
3.7	7
3.6	8
≤ 3.5	10 rapid

3.3 Recordings

Every AudioMoth recording is timestamped to let you know the exact date and time it was created. This timestamp is included in the file name in the format "*YYYYMMDD_hhmmss.WAV*", as well as the metadata of each file.

Each recording's metadata includes information such as the recording date/time, the sample rate and gain level it was recorded at, the unique ID of the device which recorded it, and the battery level at the time of recording. Metadata editing software such as *exiftool* is required to view this information.

The AudioMoth timestamp and recording schedule is either set according to the local timezone of the user or UTC (Co-ordinated Universal Time). UTC is equivalent to GMT (Greenwich Mean Time) and does not change with daylight savings. Whether an AudioMoth uses local time or UTC time is a setting which is chosen when its configuration is applied (see Section 4.4).

3.4 Clock

In order to use the current time and date to name each recording, AudioMoth devices must keep track of the current time. When the batteries are removed and power to the device is lost, it is unable to keep track of the time and resets to 01/01/1970 at 00:00. For this reason, whenever the batteries are removed from your device, you must connect it to a computer and set the clock using either the AudioMoth Configuration App (usage described in Section 4), the AudioMoth Time App, or an acoustic chime (both described in Section 7).

4 Configuring a device

From AudioMoth firmware 1.5.0 onwards, a configuration applied to a device is kept even if power is lost. Only the current time is lost and must be reset before deploying in CUSTOM mode (see Section 25).

4.1 AudioMoth Configuration App

The AudioMoth Configuration App is one of several pieces of supporting software designed for use with your AudioMoth device. It allows you to alter the behaviour of an AudioMoth, create a recording schedule, save and load configurations, and expand recordings which have been compressed using amplitude threshold recording. For more information on amplitude threshold recording, see Section 4.6.1.

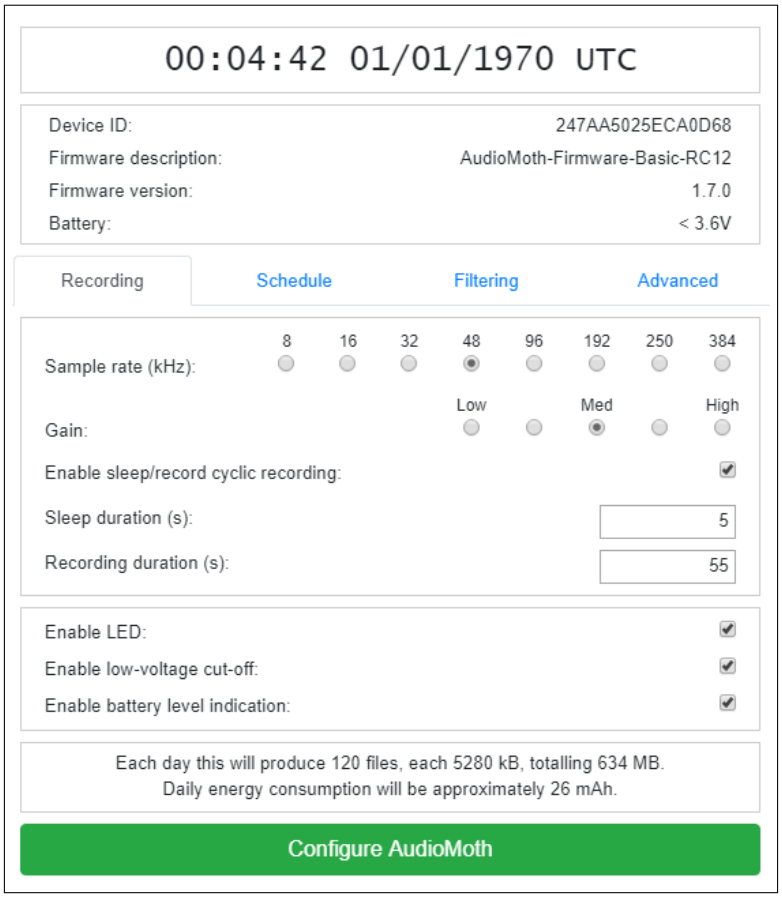


Figure 4: *The AudioMoth Configuration App, part of a family of software designed to support AudioMoth devices.*

The latest version of the AudioMoth Configuration App can be found at www.openacousticdevices.info/applications.

4.2 Choosing a sample rate

The first step to configuring an AudioMoth device is setting the sample rate. The sample rate is the number of audio samples captured per second. Higher sample rates result in recordings with a wider frequency bandwidth, but larger file sizes.

You should use a sample rate that is at least two times the highest frequency you wish to record. This is known as the *Nyquist rate* and is the minimum sample rate required to capture a particular frequency.

4.3 Choosing a gain level

The gain of a recording is the amount of amplification which is applied to audio as it is recorded. Assigning this value will require trial and error in your deployment conditions but can be left on medium for most locations without extreme background noise. If the gain is set too low, the target sound may not be audible in the recordings, if it is set too high, your recordings may clip and distort the original sound.

4.4 Creating a schedule

When configuring an AudioMoth for deployment you will likely wish to assign it a recording schedule. During the chosen recording periods an AudioMoth will either record constantly and produce files the length of the recording period or use the cyclic recording settings entered on the *Recording Settings* tab. If the *Enable sleep/record cyclic recording* is checked, your AudioMoth will alternate between recording and sleeping until the period ends.

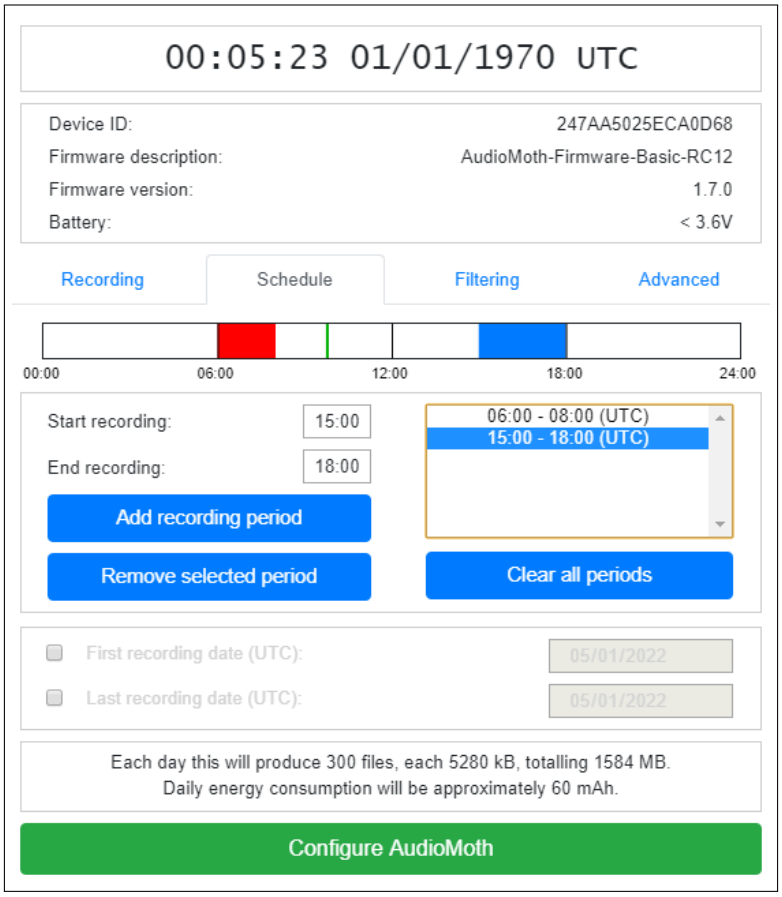


Figure 5: *An example recording schedule which will produce recordings in the morning and evening.*

You can create up to 4 recording periods of any length which will recur every 24 hours. Enter the start and end time of each desired period using the 24-hour format and press *Add recording period* to add each to the schedule. Recordings will always be split at midnight as a new day starts and the schedule restarts.

When you first open the AudioMoth Configuration App, it will use the Universal Co-ordinated Time (UTC) timezone. This is a timezone aligned to GMT which does not change with daylight savings time. If you wish to set a schedule using your local timezone instead, press ctrl + T (on Mac press cmd + T). This will switch the app and all assigned recording periods to use the timezone on the machine the app is running on.

When using a local timezone, the midnight split will still occur at the midnight in UTC. For example, if you use the app in GMT+2, this is offset from UTC by 2 hours and the split will occur at 02:00 (GMT+2).

On this tab you are also able to select a start and end date for the schedule. When a *First recording date* is enabled, the device will remain in sleep mode when set to CUSTOM. When the chosen date is reached the schedule will start.

4.5 Filtering

The AudioMoth Configuration App comes with three filters which can be used to limit the frequency components present in recordings produced by a configured AudioMoth. These filters are a low-pass filter, a high-pass filter, and a band-pass filter.

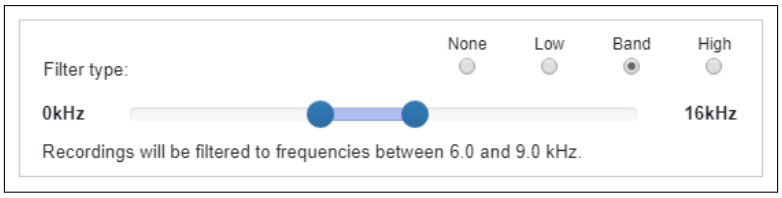


Figure 6: *Three optional filters which can be applied to recordings: low, high, and band-pass.*

The low-pass filter will reduce the amplitude of frequencies above the given frequency, the high-pass below the given frequency, and the band-pass outside a chosen band. The filters are first order Butterworth filters.

4.6 Triggered recording

Triggered recording is a recording mode where an AudioMoth will only collect samples when triggered by a specific event. Triggering can occur when the amplitude exceeds a given threshold, or when the response within a specific frequency band exceeds a given threshold. Triggered recordings result in a T.WAV file that represents a compressed version of the full-length recording with silent periods between these events removed. These files are valid WAV files and can be opened and played in any application. However, the silent periods can be restored later using additional tools within the AudioMoth Configuration App.

4.6.1 Amplitude threshold trigger

Recordings which use an amplitude threshold trigger result in trigger events when the amplitude exceeds the given threshold. By default, the amplitude range is displayed as between 0% and 100% of full-scale amplitude. However it can be changed to one of two alternate, equivalent representations (raw 16-bit amplitude or decibels) by selecting these scales from the File menu.

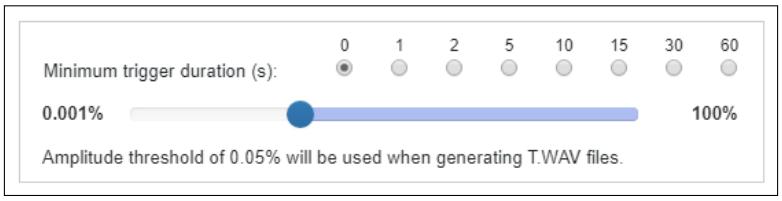


Figure 7: *Amplitude threshold trigger settings using a percentage scale.*

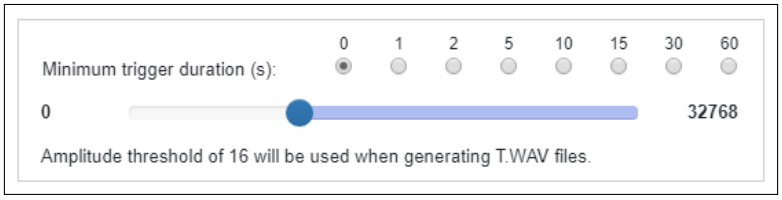


Figure 8: *Amplitude threshold trigger settings using a scale from 0 to 32768 (16-bit range).*

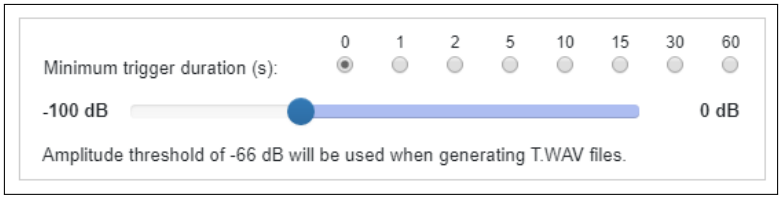


Figure 9: *Amplitude threshold trigger settings using a decibel scale.*

Amplitude threshold triggers can be useful in scenarios such as bat detection, where a high-pass filter can be used in conjunction to only record when loud, high frequency echolocation sounds are picked up. This means that devices can be deployed for much longer without having to replace the SD card as high sample rate recordings can quickly fill the storage.

4.6.2 Frequency trigger

Recordings which use an frequency trigger result in trigger events when the response within a particular frequency band exceeds the given threshold. As well as a threshold, the centre frequency and window length of the frequency band must be provided.

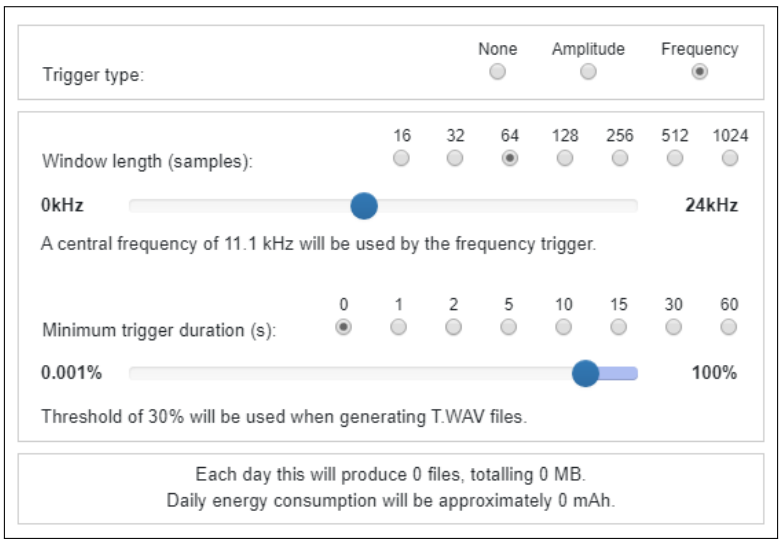


Figure 10: *Frequency trigger settings specifying a frequency band and a threshold.*

This triggering method uses a Goertzel filter to compute the frequency response. Determining the best settings centre frequency and window length for a particular application is best done using the using the AudioMoth Filter Playground (described in Section 8). This web-based application allows you to load existing AudioMoth recordings and experiment with amplitude threshold trigger and frequency trigger settings.

4.6.3 Minimum trigger duration

Selecting a *Minimum trigger duration* will that all triggered events written to the SD card are of at least this duration; continuing to collect samples even after a triggered event has ended. This is useful for situations such as detecting bat calls, where the initial impulse can trigger a recording and the quieter tail of the sound is also required.

4.6.4 Expanding triggered recordings

Triggered recordings only contain audio samples that were triggered by an event. However, they also contain encode the time between each event, and the original length recording, with silent periods inserted, can be restored using the “Expand AudioMoth T.WAV Recordings” tool, which is located within the AudioMoth Configuration App. The tool can be used by opening the expansion window through the *File* menu, or by pressing ctrl + E (on Mac press cmd + E). Expansion is done using one of two modes: “Duration-based” or “Event-based”.

Duration-based expansion takes an AudioMoth T.WAV file, expands all silent periods to their true length and, if a maximum file length is selected, divide this expanded recording into multiple files up to that length in size. As this division process may result in recordings containing only silence, the creation of such files can be disabled. As settings are changed, the information panel will explain the outcome of the expansion.

Expanded files will remove the *T* suffix and change the filename to the time at the start of the newly expanded recording. This will allow you to sort expanded recordings and easily navigate the dataset.

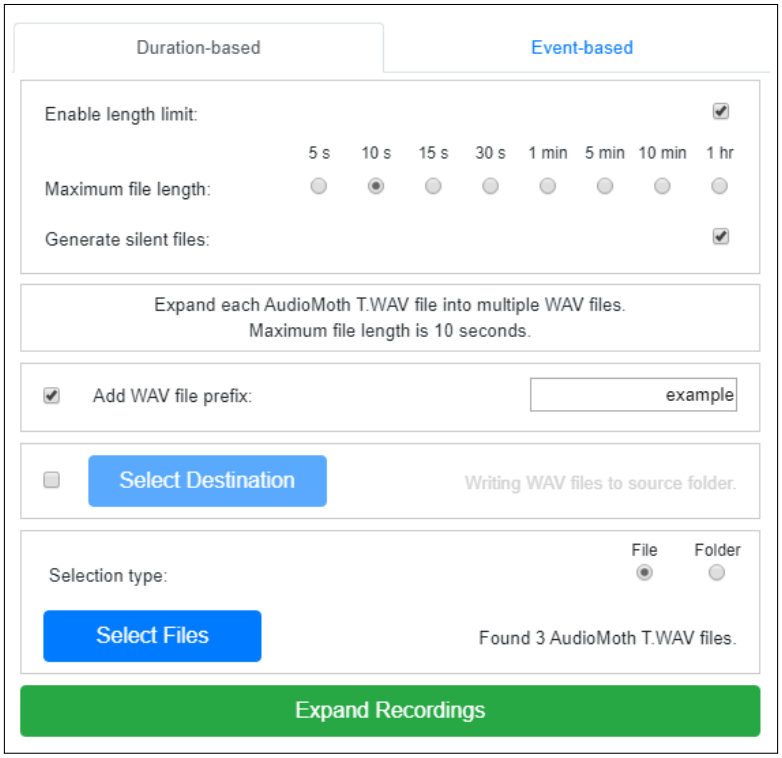


Figure 11: *Triggered recordings must be expanded to regain the spacing between acoustic events.*

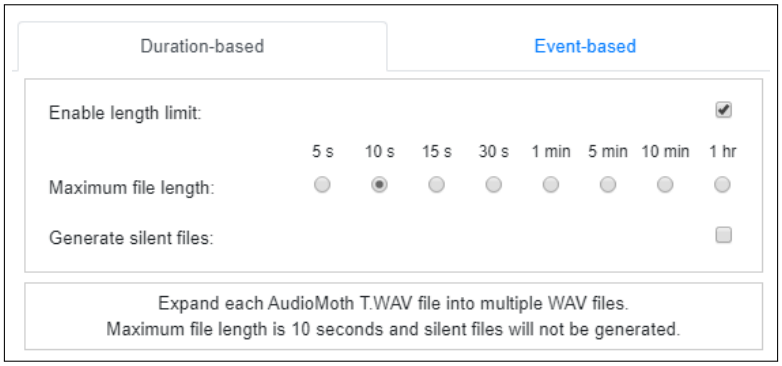


Figure 12: *Duration-based expansion settings which would expand an AudioMoth T.WAV file to create a set of recordings up to 10 seconds in length, skipping any files which would contain only silence.*

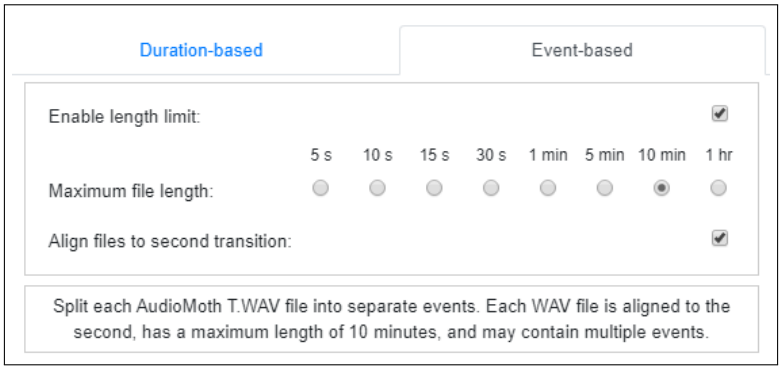


Figure 13: *Event-based expansion settings which would create a set of recordings up to 10 seconds in length. Each file represents a amplitude threshold event and will be padded with silence to align it to a second transition.*

Event-based expansion creates separate files for each triggered event. The filename of each separate file is changed to the time at the start of the newly expanded recording, with the milliseconds added if the files are not

second aligned. When the *Align to second transition* setting is enabled, files start on the closest second transition before the event. The file is then padded with up to 1 second of silence in order to align the start with that second transition.

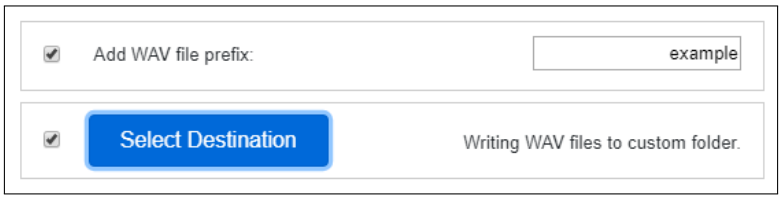


Figure 14: *Additional settings for the names and location of expanded files.*

The files you create can have a prefix added to their names using the *Add WAV file prefix* option. You can also select an output destination for expanded files. This is useful for expanding files on a full microSD card to a location on your machine for analysis.

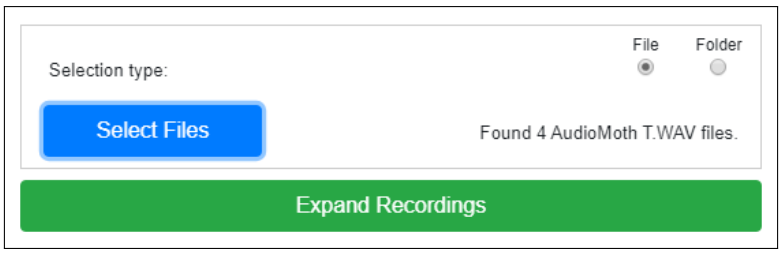


Figure 15: *File/folder selection for expansion targets.*

Finally, either one or more AudioMoth *T.WAV* files can be selected at once, or a directory containing multiple *T.WAV* files. When *Expand Recordings* is pressed the expansion process starts. Closing the progress bar window will cancel the operation.

4.6.5 Splitting recordings

The AudioMoth Configuration App also allows longer recordings to be split into smaller, more manageable files. This can be done using the split window, which can be opened through the *File* menu, or by pressing ctrl + P (on Mac press cmd + P).

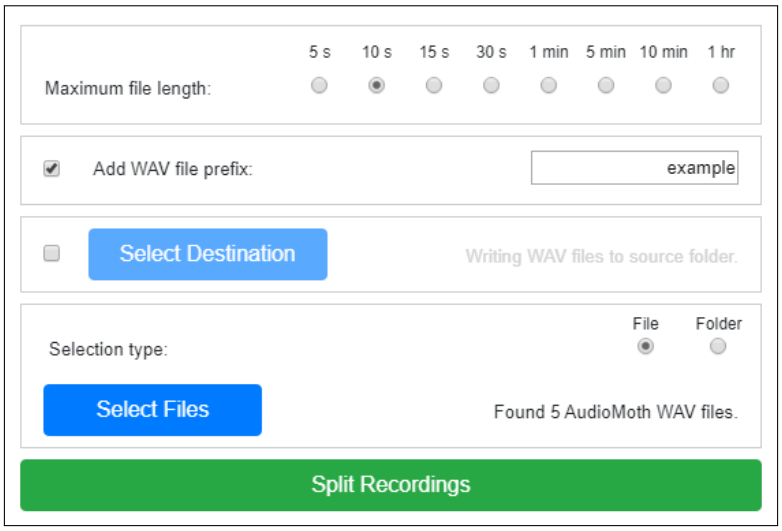


Figure 16: *Recordings produced by AudioMoth can be split into shorter, more manageable files using the inbuilt split utility.*

Select the max length each recording should be, then select a prefix to append to the resulting files and/or an alternate output destination (to prevent the original files from being overwritten). Finally, select either one or more *.WAV* files produced by an AudioMoth, or a directory containing multiple AudioMoth *.WAV* files and press *Split Recordings* to begin the process. Closing the progress bar window will cancel the operation.

4.7 Advanced settings

The final tab also includes the advanced settings. The first panel includes to control. *Always require acoustic chime on switching to CUSTOM* determines whether or not to require an acoustic chime before following the recording schedule in CUSTOM mode. If this is checked, then when switched to CUSTOM, even if the time has been set, the AudioMoth will wait for an acoustic chime before commencing the configured schedule. This chime could come from an AudioMoth mobile app, or any application implementing the acoustic chime generation (such as the RFCx Companion). *Use daily folder for generated WAV files* determines whether or not to store each dayś recordings in their own folder.

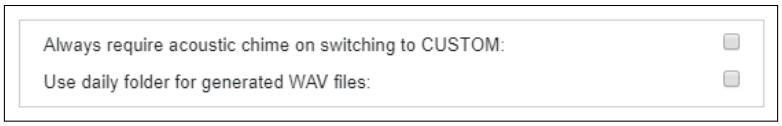


Figure 17: *The first set of additional advanced settings available on the final tab.*

The second panel contains four controls. *Use NiMH/LiPo voltage range for battery level indication*) determines whether or not to use the voltage range of NiMH/LiPo batteries in order to calculate the current battery level. Battery level is displayed when a device is switched to CUSTOM, before connection over USB has been established (see Section 3.2). Use this setting if your AudioMoth uses NiMH/LiPo batteries rather than standard alkaline batteries.

By default, a 48 Hz DC blocking filter is added to all recordings to clean up the audio slightly. To improve response to very low frequency sounds, such as infrasonic elephant calls, this filter can be disabled by checking *Disable 48 Hz DC blocking filter*.

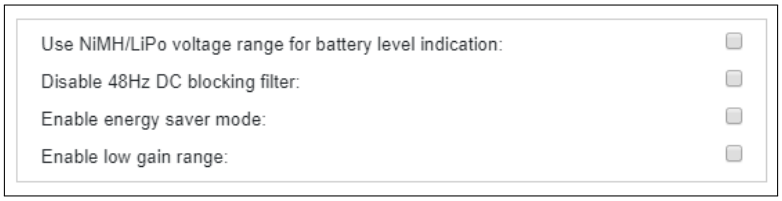


Figure 18: *The first set of additional advanced settings available on the final tab.*

For sample rates less than or equal to 48 kHz, checking *Enable energy saver mode* will reduce energy consumption at the expense of a slight reduction in recording quality. This is done by halving the internal oversampling rate which leads to a slight increase in the noise floor of the recordings. The energy reduction will be reflected in the lifespan estimation display.

Checking *Enable low gain range* will reduce the scale covered by the gain selection on the *Recording* tab, increasing your deviceś dynamic range and reducing the chance of clipping when recording in noisy environments.

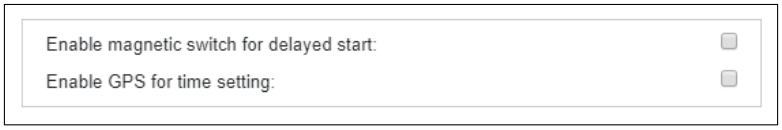


Figure 19: *The second set of advanced settings available on the final tab.*

The final panel includes two controls which require additional hardware on top of the AudioMoth device itself. The first is *Enable magnetic switch for delayed start*, which requires the AudioMoth GPS Board. When checked, your AudioMoth will remain in sleep mode and flash the green LED for 10 ms every 4 seconds when set to CUSTOM until the magnetic switch on the AudioMoth GPS Board has been switched. Once this has happened, normal operation will begin.

The second setting which requires the addition of the AudioMoth GPS Board is *Enable GPS for time setting*. Normally, clock drift on the AudioMoth results in the recording time drifting by up to 2 seconds a day. This can be avoided by using a GPS to set the clock at regular intervals. With this setting enabled and the GPS board attached, your device will update the on-board clock before each scheduled recording period. While attempting to get a GPS fix, the green LED will remain lit while the red LED will flash rapidly.

4.8 Estimating lifespan

The AudioMoth Configuration App uses the given recording settings and periods to calculate the approximate energy consumption of the device in mAh and storage consumption in bytes each day.

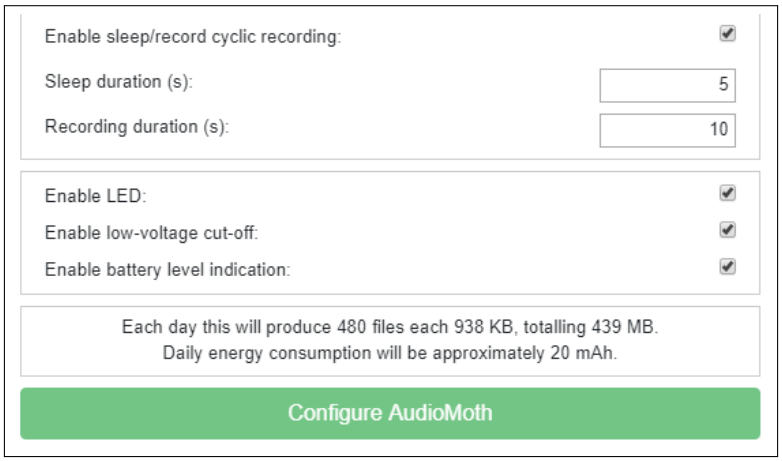


Figure 20: *Approximate energy and storage calculations produced by the AudioMoth Configuration App, given a recording schedule.*

Be sure to pick batteries and microSD cards with sufficient capacity for your deployment (see Sections 2.2 and 2.1). If amplitude thresholding is used then the approximation will be of the upper limit if the device was triggered at every possible opportunity.

4.9 Saving and loading configurations

The schedule and settings assigned in the AudioMoth Configuration App can be saved to an external file and loaded on another machine. With this you can produce a standard configuration and distribute it to anyone carrying out a deployment.

AudioMoth configuration files use the "*.config*" file extension and can be read with a standard text editor. To save your current configuration, click *Save Configuration* in the *File* menu or press ctrl + S (on Mac press cmd + S). Load a configuration by clicking *Load Configuration* or pressing ctrl + O (on Mac press cmd + O).

4.9.1 Example configurations

AudioMoth can be configured for a wide variety of applications. Here are a couple of example configurations which can be copied to a text document, saved with the *.config* extension, and loaded by the AudioMoth Configuration App to be applied to a device.

```
{
    "timePeriods": [{"startMins":1080,"endMins":1260}],
    "ledEnabled": false,
    "lowVoltageCutoffEnabled": true,
    "batteryLevelCheckEnabled": true,
    "sampleRate": 250000,
    "gain": 2,
    "recordDuration": 60,
    "sleepDuration": 60,
    "localTime": false,
    "dutyEnabled": true,
    "passFiltersEnabled": true,
    "filterType": "high",
    "lowerFilter": 60000,
    "higherFilter": 65535,
    "amplitudeThresholdingEnabled": true,
    "amplitudeThreshold": 448,
    "requireAcousticConfig": false,
    "displayVoltageRange": false
}
```

This configuration is designed to record bats using a 250 kHz sample rate, recording using both a high-pass filter set at 60 kHz and amplitude threshold recording between 18:00 and 21:00. The LED is also disabled to prevent the device from being spotted while deployed.

```
{
    "timePeriods": [{"startMins":240,"endMins":420}],
    "ledEnabled": true,
    "lowVoltageCutoffEnabled": true,
    "batteryLevelCheckEnabled": true,
    "sampleRate": 16000,
    "gain": 2,
    "recordDuration": 30,
    "sleepDuration": 300,
    "localTime": false,
    "firstRecordingDate": "2020-07-19",
    "lastRecordingDate": "2020-08-19",
    "dutyEnabled": true,
    "passFiltersEnabled": false,
    "filterType": "band",
    "lowerFilter": 6000,
    "higherFilter": 8000,
    "amplitudeThresholdingEnabled": false,
    "amplitudeThreshold": 0,
    "requireAcousticConfig": false,
    "displayVoltageRange": false
}
```

This configuration is designed to record a dawn chorus, recording at a much lower 16 kHz between 04:00 and 07:00. This configuration also only records between *19/07/2020* and *19/08/2020* (make sure you update these dates if you import this configuration).

4.9.2 Loading files created by AudioMoth Filter Playground

AudioMoth configuration files can also be generated by the AudioMoth Filter Playground, available at *playground.openacousticdevices.info*. Once a filter configuration has been set using the playground, pressing *Export* will save is as a *.config* file which can be opened in the AudioMoth Configuration App, loading the filter settings.

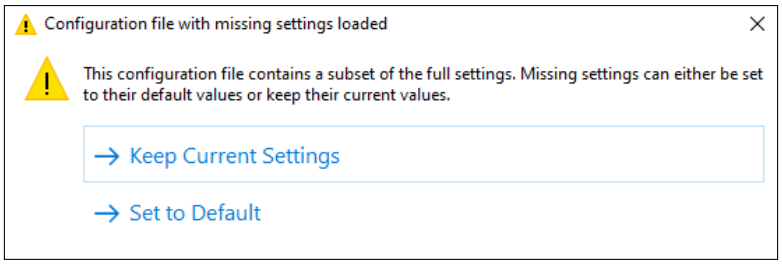


Figure 21: *The options given when configuration files are loaded from the AudioMoth Filter Playground.*

As the AudioMoth Filter Playground doesn't cover all available AudioMoth settings, such as the recording schedule, you'll be given a choice when loading a configuration file created by it. *Keep Current Settings* will overwrite the filter settings chosen in the AudioMoth Filter Playground but keep all other settings currently chosen. *Set to Default* will reset all settings not chosen in the AudioMoth Filter Playground to their default values they're set to when the AudioMoth Configuration App is first opened.

5 Cases and protection

AudioMoth requires protection when deployed in most environments. Rain, moisture in the air, and insects can all damage your device and render it unusable. Producing your own bespoke protective case is one option, however special care must be take to avoid limiting the acoustic sensitivity of the AudioMoth's microphone. It is for this reason that we recommend either deployment in grip-sealed plastic bags or an official AudioMoth IPX7 Waterproof Case, depending on the level of protection required.

5.1 AudioMoth IPX7 Waterproof Case

The AudioMoth IPX7 Waterproof Case is the official protective enclosure for AudioMoth 1.0.0, 1.1.0, and 1.2.0. The case is made from injection-moulded polycarbonate and comes with an adjustable velcro strap, which makes securing AudioMoth simple and easy. The case is compact and highly resilient and will house AudioMoth for extended periods of time in a wide variety of environments.

Figure 22: *The injection-moulded AudioMoth IPX7 Waterproof case.*

The case is sealed using a locking clasp and a compression o-ring which ensures water can't get in. The microphone port uses a Porelle acoustic vent to allow sound in while remaining waterproof. This way sound quality is maintained with the added protection.

6 Updating and applying new firmware

6.1 AudioMoth Flash App

AudioMoth is supported with regular firmware updates which fix bugs as they are discovered and add additional functionality to the device. In order to receive these updates you will need to use the AudioMoth Flash App to download and apply new firmware versions.

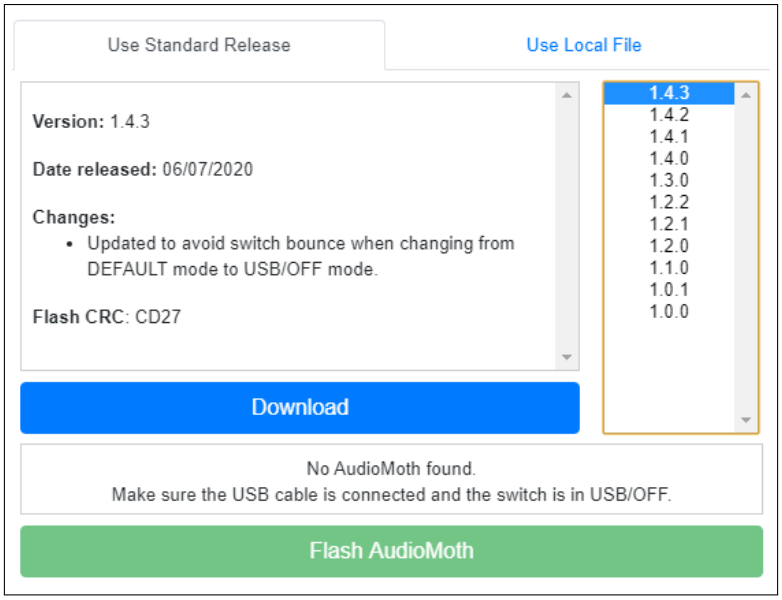


Figure 23: *The AudioMoth Flash App can be used to download and apply the latest AudioMoth firmware.*

The latest version of the AudioMoth Flash App can be found at www.openacousticdevices.info/applications.

6.2 Flashing with official firmware

When you first load the AudioMoth Flash App, ensure your machine has an internet connection so the app is able to pull information on all released firmware versions. Once the list has been loaded, click *Download* with the firmware version at the top of the list selected.

In order to apply firmware to your AudioMoth, it must be put into flash mode. From firmware version 1.3.0 onwards, AudioMoth devices can be automatically switched to flash mode using the AudioMoth Flash App. If you are updating from a newer version than 1.3.0, simply connect your AudioMoth using a USB cable and click *Flash AudioMoth*. The flash process can be performed with or without batteries fitted, but **be sure to fully cycle the power by removing and re-inserting batteries if they are fitted, prior to first using the updated AudioMoth.**

If your device currently has a firmware version older that 1.3.0, you will have to manually switch to flash mode. This can be done by using the instructions found by clicking *Show Manual Switch Instructions* in the *File* menu, or pressing ctrl + I (on Mac press cmd + I). This process requires a metal paperclip.

6.3 Flashing with custom firmware

AudioMoth firmware is open-source and extensive documentation is available online for adapting the code used to produce the standard firmware implementation. Once the custom firmware has been compiled for distribution, the resulting *.bin* can be applied to a device using the AudioMoth Flash App by clicking the *Use Local File* tab.

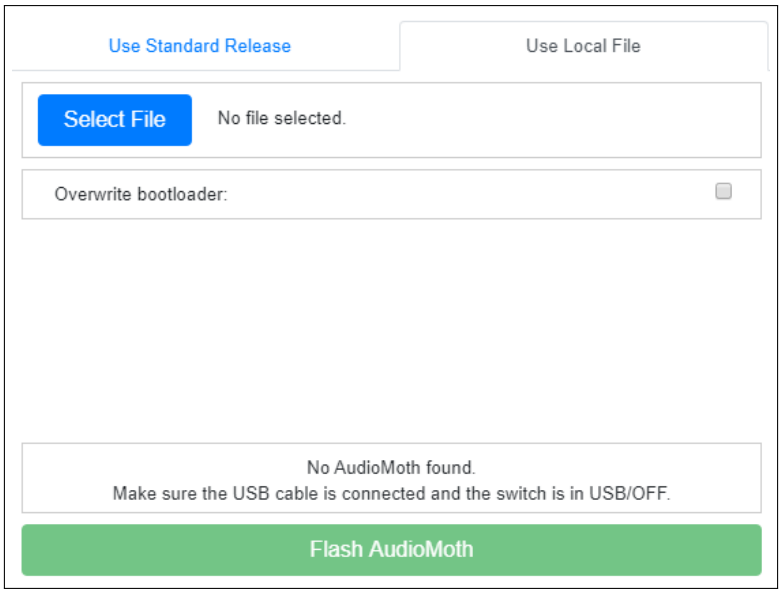


Figure 24: *The AudioMoth Flash App can apply custom firmware using binaries you have downloaded or compiled yourself.*

Once on the *Use Local File* tab, select the binary you wish to apply to your AudioMoth and click *Flash AudioMoth*. The flash process can be performed with or without batteries fitted, **be sure to fully cycle the power by removing and re-inserting batteries if they are fitted, prior to first using the updated AudioMoth.**

Certain firmware implementations will replace the bootloader of your AudioMoth and require the checkbox to be checked before flashing. **Use this setting with extreme caution as overwriting the bootloader can render your AudioMoth unusable.**

6.4 Automatic bootloader updates

Whenever firmware is applied to an AudioMoth, the Flash App checks the version of the device's bootloader. If an unsupported bootloader is found, this will be updated before the firmware flash occurs.

7 Setting the clock

For most users with the default AudioMoth firmware, setting the clock on an AudioMoth device is done using the AudioMoth Configuration App (described in Section 4). However, non-standard firmware is not required to support the Configuration App, meaning it may not be possible to set the clock this way.

7.1 AudioMoth Time App

The AudioMoth Time App allows users to both view information about a connected device (such as current firmware and battery level), as well as set the clock. Provided the variant firmware on your device uses the foundations laid out by the AudioMoth Project Github repository, the clock can always be set using the AudioMoth Time App.

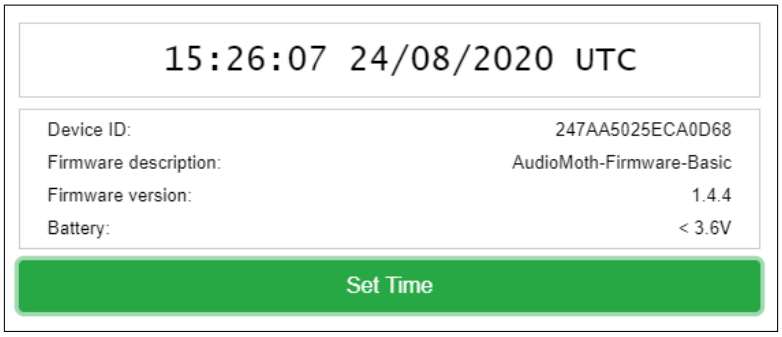


Figure 25: *The AudioMoth Time App, part of a family of software designed to support AudioMoth devices.*

The latest version of the AudioMoth Time App can be found at www.openacousticdevices.info/applications.

7.2 AudioMoth mobile app

The AudioMoth mobile app can be used to set the clock of a device using a short acoustic chime. This chime is encoded with the current time and can be used to set the clock without a USB cable or computer. Download the app from either the iOS or Google Play store, set an AudioMoth without a set clock to CUSTOM mode, and press *"Play Chime"*. If no chime is audible, ensure that the volume of your mobile device is set high enough and audio is not disabled on your mobile device.

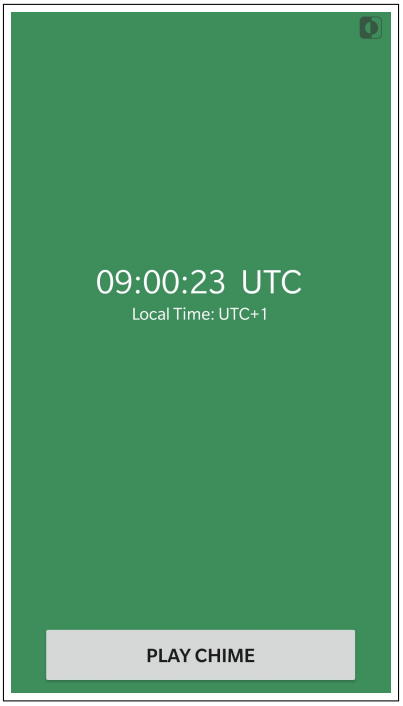


Figure 26: *The AudioMoth mobile app on iOS.*

If an AudioMoth is set to CUSTOM mode without the onboard clock being set (current time will be lost when device loses power), then it will begin waiting for an acoustic tone from the mobile app or any source which has implemented the tone (such as the RFCx Companion app).

By enabling the *"Always require acoustic chime on switching to CUSTOM"* setting (described in Section 4.7), a device will always return to this state and await a chime when switched to CUSTOM mode, even if the clock has been set.

The app is available on the following platforms:

- *iOS*
- *Android*

8 AudioMoth Filter Playground

The *AudioMoth Filter Playground* allows you to explore filter and amplitude threshold/frequency trigger settings on existing AudioMoth recordings before applying them on your AudioMoth in the field. In order to be certain that any filter and trigger settings directly correlate to how they'd function on your AudioMoth device, the app must use files recorded on an AudioMoth.

While all browsers are supported, Chrome allows you to load AudioMoth files directly from your computer. If you have not yet installed Chrome, you can still try out the AudioMoth Filter Playground by selecting one of the provided example files.

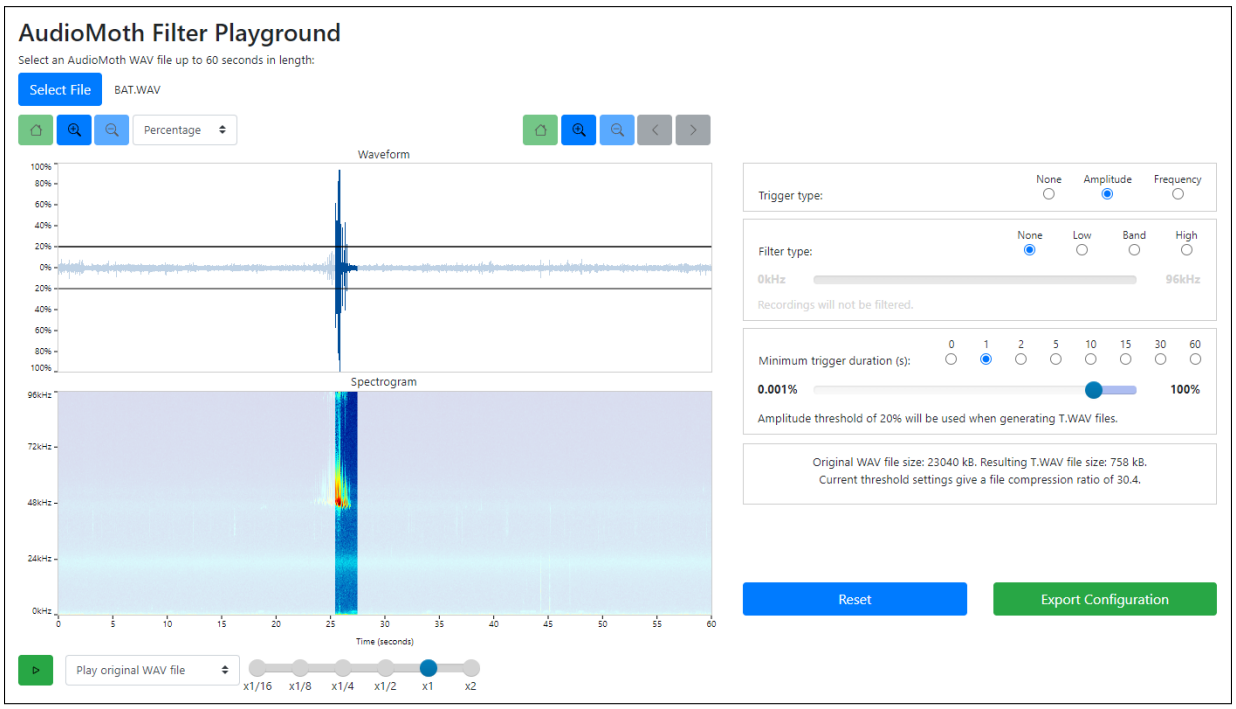


Figure 27: *AudioMoth Filter Playground displaying the effect of an amplitude threshold trigger on a recording.*

Once a file has been loaded, try out various configurations then view the resulting recording on the left. Areas of the spectrogram shaded white would not be recorded if an AudioMoth was deployed with the chosen configuration. When applying an amplitude threshold trigger, the black lines on the waveform plot represent the threshold value chosen. Samples which go above this line are recorded.

The plots will change when a frequency trigger is selected, showing the response of the currently selected frequency band and a spectrogram of the frequency information of the entire file. The black line on the frequency response plot is the threshold value, with samples above this line being recorded.

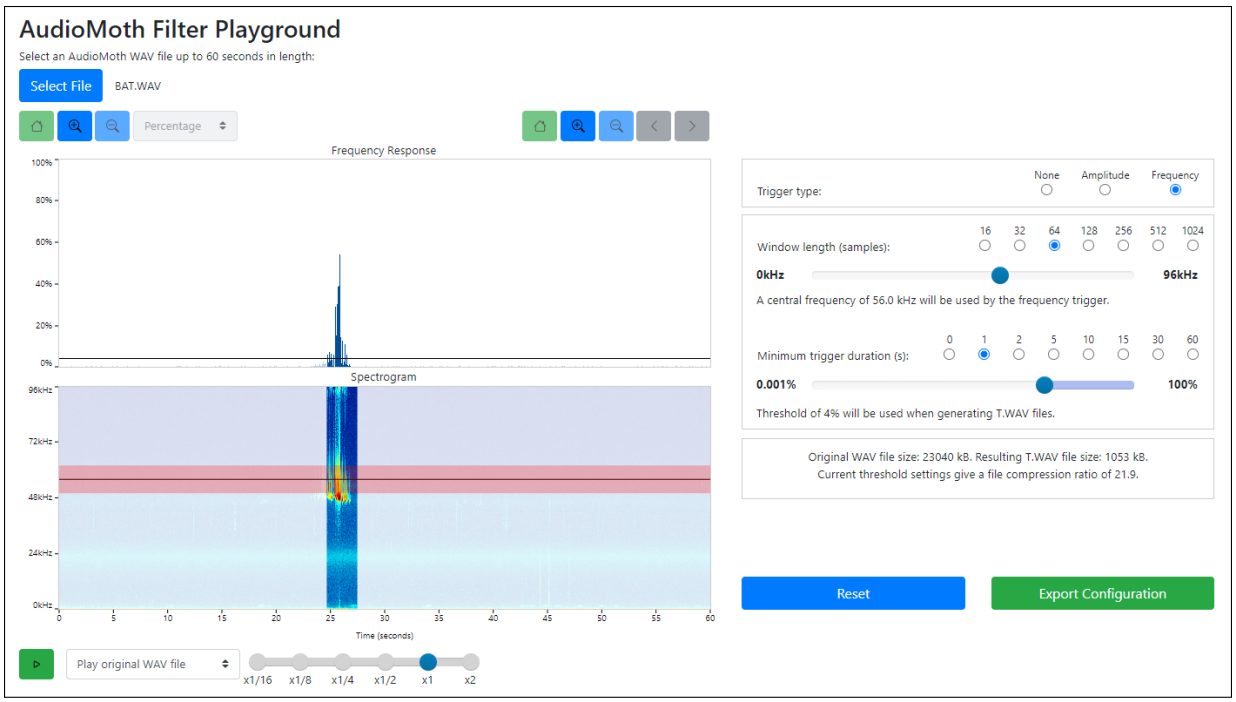


Figure 28: *AudioMoth Filter Playground displaying the effect of a frequency trigger on a recording.*

When applying a frequency trigger, AudioMoth uses a Goertzel filter. This Goertzel filter is displayed on the spectrogram plot as a red band. The response within this band is checked against the chosen threshold. As with the amplitude threshold trigger plots, areas shaded in white would not be recorded if an AudioMoth was deployed with the current configuration.

You can also play the resulting audio file using the controls in the bottom left. There are three playback modes which recreate three possible recording files this audio could produce. The first mode will simply play the audio normally. *Play resulting T.WAV file* will play the audio as if it was recorded using the current configuration, skipping over all periods below the threshold. *Play expanded T.WAV file* plays the audio as if it were recorded using the current settings then expanded using the process described in Section 16. Playback speed can also be altered using the adjacent slider.

Once you have a set of settings you're happy with, click *Export Configuration* to download a *.config* file which will allow you to load them into the AudioMoth Configuration App. The Playground does not contain a number of AudioMoth settings, including the recording schedule. When you load a *.config* file from the Playground a warning will appear and you will be given the choice to either keep currently entered values or set all settings not covered by the Playground to their default value.

9 Acknowledgements

This operational manual was produced by Open Acoustic Devices. Thanks to Tessa Rhinehart who produced an early AudioMoth guide which has helped the AudioMoth community greatly and informed which topics are useful for a new AudioMoth user to include in this guide.