The Peersonic Ultrasonic recorder and monitor RPAx Rev 9.6
With update notes for RPA3-B at the end of file.

Primary design use – recording bat ultrasonic sound at full frequency up to 192kHz

Samples sound at 384,000Hz. Saves as wav files to SDHC FLASH memory.

A clock module can be added later, or taken pre-installed on the board at time of purchase.

Basic Enclosure	Battery Hatch Enclosure

Basic Features:
Displays fast recognition of peak energy frequency in real time.
Audio frequency down-shift for bat detecting, Heterodyne, Frequency Division, and Peak Detect.
Concurrent recording with all functions at 'full spectrum', to 4 Byte memory maximum.
Maximum number of individual files 3000. Maximum SDHC card tested 32GB.
Upload to PC or MAC via USB type B*.
Power saving sleep mode for long sessions.
Auto record or manual record.
USB upgradeable for hardware improvement or custom demands.
Files can be time stamped.

Introduction:
The Peersonic wide band recorder has been designed to provide low cost full spectrum equipment for wildlife applications. It is flexible as Peersonic can customise features in software for specific needs,

this is a feature that is often of interest to specialists, but yet the basic RPAx is designed to be appropriate for anyone from back garden wildlife enthusiasts to serious naturalists.

Whether you want to just listen to bats or concurrently record whilst checking the true ultrasonic frequency, or leave the RPAx out overnight to see what turns up, this is the perfect instrument.

It has been used to record all key species of UK bat as well as some tropical species in the Caribbean and Honduras rain forests, and a growing number of non UK European bats.

Out of the Box Start-up:
The Peersonic recorder will work straight out of the box, You will need batteries.

Insert three AA batteries. Any type can be used, but NiMH rechargeable are a good choice. Try to get them the right way round, but don't worry if you have them in reverse, nothing bad will happen. Reassemble and turn on using the slide switch on the right hand side.
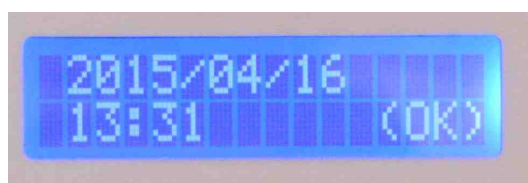

Time Set   **Battery Check**

Time Set:
The first display will be time, or if you have not purchased a clock module you will see ********** on the display briefly. To set the time turn the feature knob to chose year/month/day/hour/minute seconds. Chose by pressing the right button, accept by pressing the left button, move to ok and press the right button to accept, or, just wait a bit. Date and time are saved in the Last Modified part of the WAV file.

Battery Check:
The next display is battery voltage.
If the voltage is close to 3.4Volts things are getting a bit low. However a familiar battery level icon is not displayed as the RPAx is designed to operate with a variety of battery chemistries, and it is not feasible to predict the battery life without constraining the battery type used.
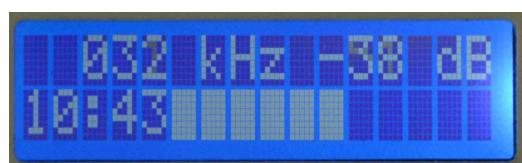
Normal user display in Numeric Screen mode.

Finally you will be in user display mode. The default conditions are.
Default audio monitor mode is Frequency Division, factory set to 18.
The display will show peak energy frequency detected, sounds above –40dB are likely to be of interest, however there is always some background sound due to the wide band microphone and radio noise. Usually this is below -60dB. Take care to note the minus sign -20dB is greater than –40dB.
Turning the control knob will change the division factor for Frequency Division audio monitoring. Since V9.6 the power bar (lower set of characters) is reduce to 11 blocks, the left hand five characters show the current time hh:mm, useful for taking notes.

Audio can be monitored using the earphone socket; a speaker is not included, as this will feed some of the converted audio back into the recording, which can make later analysis untidy.

The left button when pressed will immediately record to SD card as long as it is held.
The default minimum manual record length is 5 seconds, so if you press for 7 seconds you will get a 10 second recording as the timer will run on till the end of the next 5 second period.

Files can be uploaded to your PC or MAC via the microUSB-B socket on the upper right of the RPAx.

Control Interpretation:

The right side button is generally used to select menu features.
The left side button is used to step back down the menu, and when in signal display mode it is the record button.
The control knob is used in all cases to select menu items or chose menu levels depending upon the function required, e.g. input gain, volume control, heterodyne mix frequency and so on.
When the RPAx is in user mode (when you see the signal frequency and dB display) adjustment will always change the current audio parameters (e.g. mix frequency for Heterodyne).
The USB connector primarily uploads files for later analysis, but also is used for software upgrade and remote power supply for long sessions.

Menu and Features:

Pressing the right side button once selects the first level menu. The control knob scrolls the menu left or right for the main functions.
Pressing the right button takes the user deeper into the menu functions.
Pressing the left side button brings the user back up the menu hierarchy, eventually to the FFT display screen again. Take care not to accidentally record.

1. **Functions are as follows briefly explained:**
2. Brightness:
3. Record Menu:
    3.1. Input Gain (directly controls the analogue signal strength from the microphone)
    3.2. Auto Record (Sets auto record mode, the RPAx will trigger on a set threshold of sound from minus 100dB to 0dB)
    3.3. Manual record (Start-up default, the left button has to be used for recording), also allows setting of the minimum record time-out period.
4. Audio Menu:
    4.1. Frequency Division (sound is divided by a factor of 1 to 20, default is 18).
    4.2. Peak Detect (an experimental mode which will be enhanced see below).
    4.3. Heterodyne Mix (The signal is mixed with your choice of reference frequency)
    4.4. Volume setting (directly controls the earphone amplified volume, does not affect recorded sound level)
5. Memory Menu
    5.1. Delete Menu (Erases ALL recordings)
    5.2. Last Recording (See below for interpretation)
    5.3. File Letter, the first character of the file name can be set and saved for user identification.
    5.4. Save Settings (Saves any menu settings made which will then be restored on power up)
    5.5. Static setting (Restores to a default set for static recording when in use by a novice)
    5.6. Factory Settings (Restores default factory settings)
6. Sleep Mode
    6.1. Operation is suspended while the RPAx sleeps for a set time period. Battery life extended.

Detailed Menu Function descriptions:

Brightness: {Top menu}
LCD back light brightness control from dim to max.

The brightness can be taken down to darkness. Now you are in the dark! Marvellous!
However pressing the right button returns to the menu screen, and the display is always illuminated in that mode. If darkness has been chosen on pressing the left button again the display will be now in user mode and in the dark.
Pressing the right button at any time will bring back the menu screen, which will be illuminated, so adjustments can be made.

Turning down to dark can be useful if the RPAx is to be left out for a period of time, combined with 'save settings', everything can be set up as needed, then just turn on, put down, and retire.

Record Menu: {Top Menu}

Input Gain: {Record Menu – Input Gain}
The microphone module has its own amplifiers and bandwidth filters to boost the sound from the MEMS microphone chip. The microphones gain can be increased for weak signals, and reduced if too much clipping is encountered. So far an AGC (automatic gain control) has not been implemented as it might detract from the amplitude dynamics of the signal. However this can be done, and if popular could be a software upgrade

Manual record {Record Menu – Manual record}:
Start up mode, recording takes place while the left-hand button is depressed. Large files can be created, which are often more than needed, recording is 16 bits at 384kHz rate and all files are in non lossy .wav format (uncompressed PCM).
There is a minimum record period of 5 seconds as factory default, so a quick press will give a 5-second recording. This can be extended in 5-second chunks to 4 minutes. So a single press will give a discrete recording length. To do this press the right button when viewing Manual Record* on the display. Setting a lengthy record period creates a large file, but it can be useful for transect sessions.

Auto Record {Record Menu – Auto Record}:
A sound threshold can be set, when this level is exceeded recording will start, the recording will time out unless the sound level is sustained.
For example the default level is –20dB, any signal greater than that for example –18dB will trigger recording. Note the negative magnitude.
On pressing the left button there is a prompt for Maximum Length, this can be 5 seconds up to 4 minutes. The inverse of the manual record requirement it is intended to limit overly large files being created unnecessarily.
Field use has shown that normally, files of 4, 8, 16 and occasionally 32 Mbyte size are created. These are quite sufficient for analysis. Of course this depends upon bat activity.

Audio Menu {Top Menu}:

Frequency Division {Audio Menu – Frequency Division}:
Incoming signals are simply frequency divided down to an audible signal. The factor can be set as preferred. The start-up default is 18, so for example a 90kHz incoming signal is heard easily at 5kHz. When in the user display mode turning the control knob will adjust the division factor accordingly.

Heterodyne Mix {Audio Menu –Heterodyne Mix}:
The incoming signal is mixed with a reference signal, the difference frequency can be heard. The mix signal is not the bat signal; there can be confusion with other equipment. Here are some thoughts on the matter.

The simple maths is
Sound Heard = Bat audio – reference signal.

Nathusius Pipistrelle peak strength signal is 39kHz approximately. If the heterodyne mix frequency is set to 40kHz the peak sound heard will be 1kHz, as human hearing can nominally hear up to 12kHz (old folks) this is well in range. However Pipistrelles have some frequency modulated sweep in their calls so other sounds will be included. This is what makes up the familiar pattern of noise.
If the RPAx is set to say 96 kHz and a Greater Horseshoe passes by emitting 96kHz also then theoretically you will hear nothing as the two signals cancel out. However there is always enough modulation in tone to provide an audible sound.

Peak Detect {Audio Menu – Peak Detect}:
This does not help so much with species recognition, but does give a strong detect sound. The recorder is constantly running a Fourier analysis of incoming sound over the bat spectrum, the peak energy frequency is normally the most interesting, but there are other artefacts of interest. At this stage all

Peak Detect does is to take the peak signal and generate a sine wave tone related to that frequency but of course in the human audio range. Often users will pay more attention to the display, but this mode does help draw attention to an approaching bat.

As this is an experimental mode it is likely to be enhanced one day. Or it could be removed and replaced by another algorithm, using the program code space vacated thereby.

For the moment, it is a bit of fun.

Memory Menu {Top Menu – Memory Menu}:

Last Recording {Memory menu – Last Recording}
This shows the number of recordings made the duration in time of the last recording, the time remaining in minutes and seconds and percentage of free space.

There are some limits worth considering.

Depending a little on some artefacts associated with the SD card a 4GB memory will give 85 to 90 minutes of recording time total.

Maximum number of individual files is 3000 no matter how large the SD card; this is a limit of the file management system.

Files can be up to 4Gbyte in size, this is extremely large and unlikely to be very useful. Try to keep to shorter more relevant recordings or use auto record. 30 seconds is usually enough, most files of 10 seconds or so have more manageable data. However, the RPAx is quite useable for transect surveys of many 4 minute recordings. Try auto record, it will tend to focus on 4Mbyte - 8Mbyte files unless sound levels are sustained.

Delete Menu {Memory menu – Delete Menu} :
Press the right button to erase all files. You will be prompted and given a chance to reconsider this action.

Note that this is the ONLY way to erase files, it is not permitted to erase files from the PC or MAC via USB, this is partly a security against accidental data loss, but also an artefact of the storage system.

In order to be efficient with the limited code space on the processor used the file management system is not a common standard. It is not for example FAT16 or FAT32, so you cannot take the SD card out and plug it into your computer. We call the fat system BATFAT as we have a sense of humour. However this does not matter as files are uploaded via the USB cable.

It is probable that we will later create a small program that runs on a PC that will allow such direct transfer, but at this stage there is no work underway for that project.

File Letter {Memory menu – File letter}:
The user may enter up to three characters to personalise file names.

If only the first character is entered the file naming will contain the peak energy frequency detected in the first 5 seconds of recording. If three characters are used the frequency hint will be overwritten.

Eg -

Changing the letters to PWF will result in files named PWF__ABC

Changng the first character only would result in files P045_ABC thus providing a hint to the peak strength frequency contained in the recording.

Save Settings {Memory menu – Save settings}:
Settings are stored into battery backed memory on the clock module. When eventually the battery expires they will need to be re-entered.

The following settings are stored.

Brightness , all parameters in Record and Audio menus, sleep mode times, and the File letters from the memory menu.

When the RPAx is turned back on the saved settings will be applied.

Static settings {Memory menu – Static settings}:
Normally preferred settings are saved but the user, these are saved in battery backed memory in the RTC module. As a rule they will not be lost unless the CR1220 battery goes flat, or the RTC (time stamp module) is unplugged or interfered with.

It is often convenient to lend your RPAx to a novice for a few days, with your specific settings n place so they can leave out on a static survey.
In the case that they alter the settings, and then save those changes, you may want to restore to a known static mode, so that the data can continue to be collected without fuss.
In this case the restore Static settings feature is useful.
Defaults for this options are.
Brightness : 20
Auto record : -39dB and 10 seconds.
Sleep mode : sleep 5am wake 7pm.
Input gain -2dB.

Restore Factory settings {Memory menu – Factory settings}:
Restores to the following.
Brightness =30
Input gain =-2dB
Record mode is Manual record, minimum length 5 seconds
Audio mode is Frequency division factor 20
File first letter = F.

Sleep Mode {Sleep}:
Enter sleep start time and wake up time, normally day time. The RPAx will suspend operation on sleep , during this time power drawn will be approximately 5% of normal operating power.
On wake-up the RPAx will reset and **operate according to saved settings**.
Press RHB on Sleep Mode.
Enter "Sleep from" time – press LHB.
Enter "Sleep until" time – press LHB
In 15 minute chunks of time.

If the current time is within the set awake time the RPAx will remain ON as it should be active in this period. If the current time is inside the set sleep time there is a choice ...

"Go to sleep now? Yes?" - Press RHB for yes LHB for no.
If Yes the unit will immediately sleep and wake on the set time, after that it will be on during the set period only.
If not the unit will continue to operate, when the set period hits sleep time it will power down, after that will be active in the set period only.

Sleep mode will toggle between on and off, to cancel any settings of Sleep mode, just re-select, to bring settings back, or adjust, select again.

Sleep mode settings are now automatically stored.

USB Modes.

File transfer:
Press both left and right buttons and plug a micro USB cable into the socket at the top right of the RPAx. No need for the power to be switched on.
Files can now be copied over.
This is a read-only file system which can be safely unplugged from the computer without corrupting files. This means you cannot delete from the computer. Deletion is done from the recorders Memory Menu.
File naming includes much information. The first letter can be set so that up to 26 different RPAx recorders can be used and recordings are thereby not confused. The file name also contains the peak power frequency detected in the first 5 seconds. Sequential numbering is alpha based to allow 3000 files to be identified with three characters.
Plugging in the USB cable without pressing buttons allows for USB power from an external source, the recent change in mode is designed to make that a useable feature with sleep mode, on long term static deployments.

Eg.

P048_AAB
This file has the first letter 'P' to identify the user Peter.
The next three characters reveal a peak energy frequency detected, 48kHz.
AAB implies that this is the second file recorded in the session.

Sequential File Naming:
It can be useful to have files named sequentially, some analysis software has the option to page through files, providing they are numbered sequentially. By pressing both LHB and RHB while switching the file naming policy is changed.
File naming is now Alpha sequential.

Eg.
PAAA_027
Peter again for the first character.
AAA is the first file recorded.
027 suggests the strongest signal captured in the first 5 seconds was 27kHz.

Remote power Source:
Rather than use the batteries the recorder can be powered up by the USB cable. Press and hold the Left button whilst plugging the USB cable into a chosen source. The recorder will instruct you to release the left button when ready. The batteries are now switched out and power is taken from the remote source. If the USB supply voltage is between 3.3V and 4.2V the RPAx will power up without requiring the LHB to be pressed, however this needs special arrangement as all standard USB equipment delivers 5V.

Power Saving:
If no buttons are pressed for a period of 3 hours it is assumed that the RPAx is either not in use, or is left on auto record. The LCD backlight will dim to zero to save power and extend the overall backlight lifetime. Pressing either button will bring back illumination for another 3 hour period.

Software Upgrade:
Press the right hand button while plugging the USB cable into your computer. A file window will appear and the replacement software can be copied onto the bat recorder.
Software upgrades will be available in cases where
Minor improvements are made due to popular interest.
Major additional features are added, which may have a small purchase price.
Customer specified features are a possibility in a good business case.
If your version of Windows reports 'not enough space' or similar please review the document "Upgrading with Windows7 onwards".

Microphones and the RTC:

The microphone.
As standard the microphone supplied will capture signals up to about 180kHz. The tiny MEMS microphone chip is not flat over this spectrum but there are frequency linearising filters that adjust the overall response. There is also filtering to attenuate much of the unwanted sound below 10kHz, human speech, aircraft, wellington boots trudging trough mud etc. This is done deliberately as these sounds are generally unwanted, they also consume bandwidth that is better deployed 10kHz and above.
There is a coloured sticker on the mic board which corresponds to the colour of the control knob. This is useful if different microphones are to be used.
Custom tuned microphones can easily be made within certain limits. Other standard mic variants will be announced.

The Real Time Clock (RTC) or Time Stamp Module:

In order to keep cost down the clock function is available as a separate module, it is not expensive but would add to the overall entry level cost of the recorder. The intention is to make full spectrum recording affordable and available to all.

Of course time stamp is very useful when using auto record, but if the RPAx is being used in a familiar location at noted times it is still very useable even without time stamping.

The RTC also contains battery backed memory. This is used to provide save and recall for user settings. So your favourite settings can be quickly recalled as needed. Therefore save and Restore are only available on equipment with the RTC on board.

Batteries:
Any type of AA batteries can be used; the battery life depends upon the chemistry and rated power. The batteries shown normally give about 12+ hours of continual use. The manufacturers usually give an energy rating in mA/hours (milli Amp hours) , these shown here are 2000mA/H. Duracell make a 2400mAH cell which has given 16 hours continuous use in the field.
NiMH batteries perform best, Alkaline cells can be used as a reserve, but they have an unknown condition at purchase, also suffer from a gradual build up of internal resistance which can limit supply to the RPAx and sometimes cause unwanted noise.
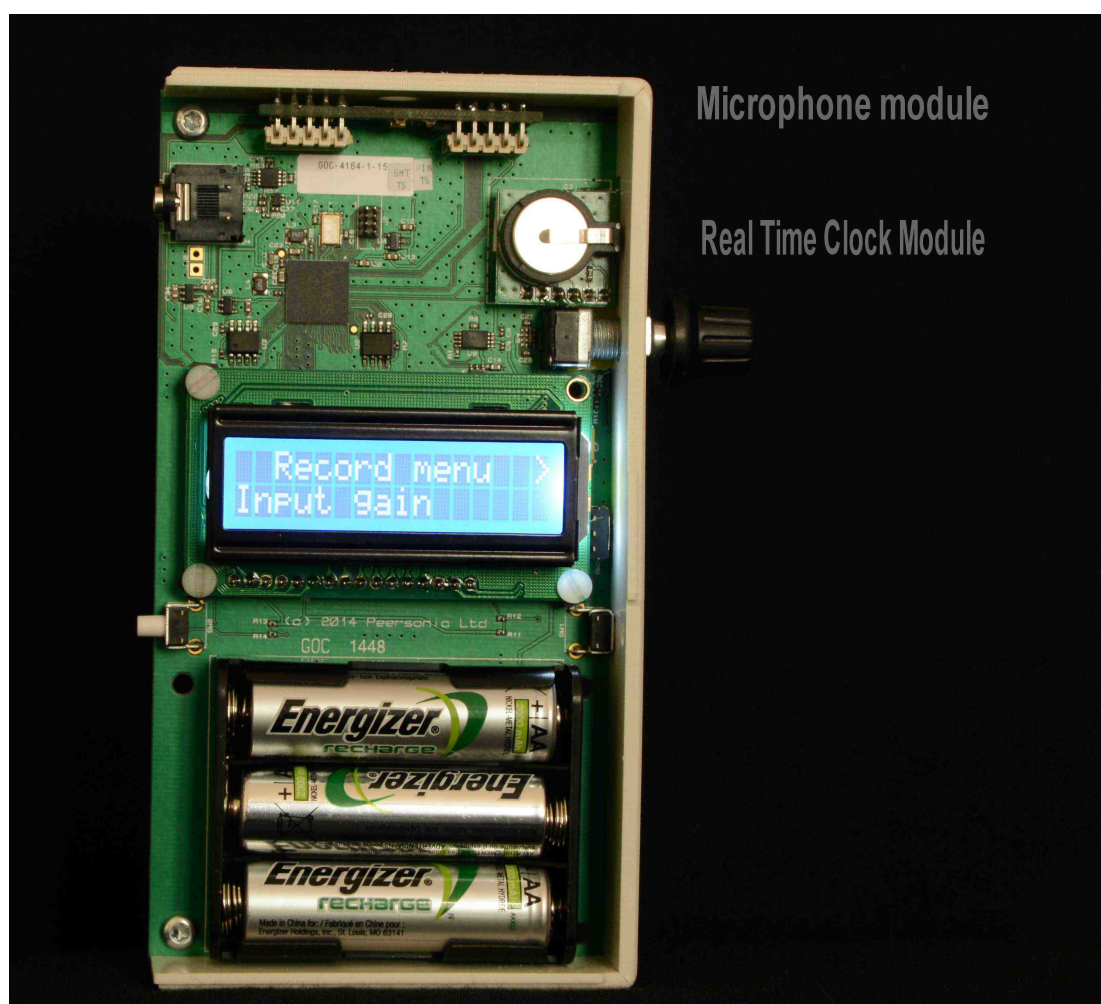
The RTC coin cell is of type CR1220.
Inside View:
The recorder is secured by two screws, this gives access to the battery compartment, real time clock module if needed for coin cell replacement and the microphone module.

Not shown, but the data is stored on SD card, which is inserted from the left under the display panel. When purchased, a tested card of appropriate size is included. Some variation in SD card manufactures operational parameters make it wise for us to test and supply. However generic cards can be tried, but not assured by Peersonic.

Analysis Software:

Peersonic do not produce Mac or PC based analysis software, there are many packages available from excellent free general purpose products to highly specific wildlife packages.

If purchasing one of these please ensure form the supplier that the product is capable of opening 16bit WAV files sampled a 384kHz.

A popular audio analyser that has been often used with the Peersonic Recorder is Audacity. As of this date it is free, and provides the key features needed for bat sound analysis.

A short user guide is available for using Audacity with Peersonic equipment separately.

Bat FAQS:
1. Although the USB connection can be used as an alternative power source, it does not charge the batteries.
2. If the RPAx is to be left for many hours it makes sense to dim the display backlight down to zero to save power, this also mitigates against gradual backlight degradation over time.
3. Various external power sources have been tried and proved over long periods
   3.1. PC or Mac USB port connection.
   3.2. Mains to USB mains chargers.
   3.3. USB hub extenders with 5 metre plus cable length.
   3.4. Smart-phone charger battery packs. Take care as these have many undocumented conditions of use. Power shut down is the main problem, as if the RPAx goes into sleep mode,there is a chance the USB power pack will turn off. This can sometimes be avoided with a pulsed load from Peersonic. Please enquire.
   3.5. A power bleed dongle is also available, this pulses the battery pack every 8 seonds so that it is fooled into staying on.
   3.6. An external power rev of the software V9.! Is also freely available, this subverts the USB detect on USB connect so the RPAx will take power on reset from the connection. File transfer is permitted by pressing the L&R buttons at USB connection.
4. When transferring files please only 'copy' files over. Cut and paste and delete will not work as the data is protected from accidental external deletion.
5. Please do not forget that these files are full spectrum recordings, if you want to listen to them they need slowing down (time expanding), neither you nor your computer are equipped to communicate at bat frequencies. Analysis software will do this for you.
6. The RPAxs supplied will come with an SD-HC card, which has been tested, if you wish to try cards of your own we cannot guarantee operation in all cases. SDHC type 4 have been tested to great length, 32GB maximum size, however due to the time taken to make exhaustive testing only 4GB and 8GB Type4 SDHC cards have been taken to near limits. Cards can vary from one manufacturer to another, Sandisk has proved to be consistent.
7. CLIPPING – If you get this message it means the bat sound is very loud and is saturating the microphone module. Decreasing Input Gain (See Record Menu) will resolve this.
8. Software upgrade issues with Windows7 onwards? Unfortunately Windows trys to save back to the read only RPAx before it allows a copy over of the new firmware.This is naughty. There is an easy solution to this which is documented in "Upgrading with difficult operating systems".
9. USB transfer, it is generally a good idea to use as short a cable as possible to ensure data timing integrity. USB extender cables can introduce data transfer issues. However should be ok for remote power supply.
10. *USB cable connector is micro USB type B, this has been in most common use since the evolution of the 'smart' phone. Beware the earlier micro USB type A . Image shows type A left type B right.

11. If you upgrade from RPA2 to RPA3 (eg V9.1 to V9.6 or further) do not worry! You just got a free upgrade, everything will work the same as before , but with additional features. The Old RPA2 does not have a side barrel connector, this is a hardware addition for longer term static survey use.

Additional Peersonic Documents:
Additional PDF documents are available to help both the novice and the professional to get the best out of a Peersonic bat recorder.
If not available on the web site please request via peter@peersonic.co.uk

Critcal FAQs : Short help on things that might need clarification, user issues and fixes.
Ten minute Guides:
1) **Identifying bats in Ten Minutes – for the absoloute novice on opening the box!**
2) **Using different detection modes – explains Heterodyne and Frequency Division.**
3) **Recording and analysing bats in a flash – first steps in recording.**
4) **Quick setup for static surveys – simplifies the user manual to one page on the subject.**
5) **Using Sleep mode – supplement to (4).**
6) **Getting the IP 66 weatheproof unit going – the IP66/67 has a separate manual also.**
7) **Getting the best out of batteries – this is worth taking note of, it saves money and time.**

Usig Audacity to Analyse bat recordings : Audacity is currently free , it makes a good bat analyser.
Using and Maintaing the remote microphone: A remote mic is used on the IP66/67 static Batman installation, it can also be used with the RPAx handheld enclosure.
Peersonic BatMan unit manual : "D" cell management unit in IP67 enclosure with RPAx.

Linux_Peersonic: A help guide on using Linux and Raspberry Pi as a host controller.

Bat Revision:

Here are some web sites, and books that will be helpful.

Web sites:

The Bat Conservation Trust:
Lots of info, conferences, training, the avenue to bat knowledge UK.
http://www.bats.org.uk/

Bristol University created site with a great identification and sound profile info for of each of our UK bats:
http://www.bio.bris.ac.uk/research/bats/britishbats/

Books:

British Bat Calls- A Guide to Species Identification, by Jon Russ
Invaluable handbook with ultrasound details for each UK bat and an excellent preamble on sound analysis techniques and details.
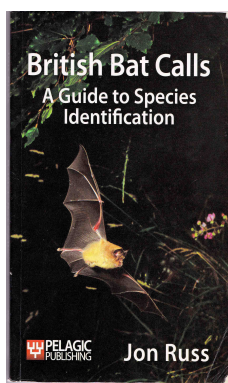
BATS Of Britain, Europe & Northwest Africa. –Dietz, Helversen & Nil.
Nice big book with excellent introduction to all aspects of bats, colour photographs, and descriptions of each individual species.

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Limits of use:

The enclosure is not waterproof.
Please observe WEEE directives for disposal of the electronics and any batteries used in operation.
All components are RoHS compliant.
This product passes CE certification directives.

29/6/2021 Update on hardware.

From 1/7/2021 All hardware will have the following upgrade, this does not affect any other function.
The RPA3 can be powered by a USB power bank. However, if put into sleep mode many of these non OEM mobile phone chargers will switch off. The reasoning is good, if you are charging a phone with LiIon cells, a slow overcharge can cause them to burst, or even explode. Therefore, the manufacturers of the units, have a device that turns the unit off if the demand current drops below a particular level.
Almost none of these companies specify that cut off point. But there are some who do, and they are gracious enough to provide a specification.
Therefore, I will put in a USB bleed device on all units after the date above.
This will ensure that for qualified power banks, the power will not be cut during sleep mode giving many many nights of use.

The specific designation will be on a gold sticker with RPA3-B as the latest revision.
This will be on the right hand side close to the USB socket as possible.

A separate advisory pdf is available with the approved power bank type.