

PART I - HARDWARE *(for the latest version go to BatAndCat.com)*

BatAndCat Box Controls and Connectors

1) Charging port:

Use only a USB C - USB A connector for charging (not a USB C to USB C). At least a 2A charger should be used. Connecting the charging cable does not turn on the device. However, disconnecting the charging cable turns the devices off. This is in order to make sure the user does not leave the device running after the charge. If you want the device to stay on, press and hold the white control button and then disconnect the cable.

(Note for legacy devices 98900001 through 9800024: Charges with maximum charging current of 1A can also be used, but the charging will be slower. These devices cannot be made to stay on while disconnecting the charging cable).

2) Charge Indicator LEDs: 4 LEDs in the top right hand corner; they light up progressively at 25% charge increments. During the discharge the indicators tend to show less available charge.

3) Power Button: It is located on the side of the box. It is used to turn the device off/on (more than 2 sec press) and checking the battery status (short press).

4) Power ON/OFF LED: This is the LED next to the Power Button. When the is on the system is powered on. When the LED is off, the system is powered off. Please note the battery indicator bar still operates when the module is off (short press).

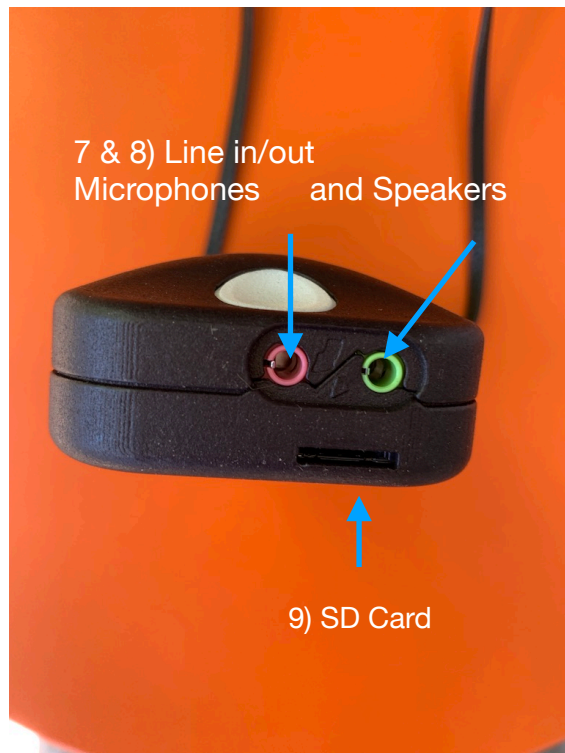
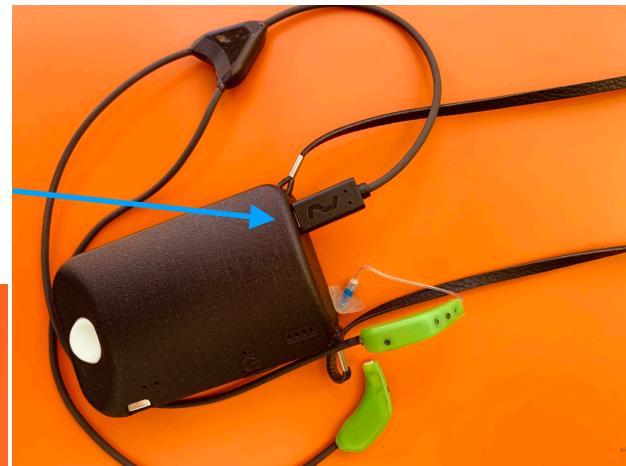
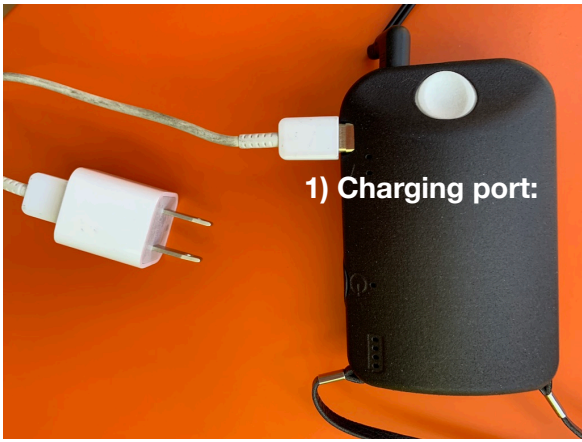
5) Programmable button: Located on the top cover of the box. It is factory programmed so that when pushed it lights up if the device is fully booted.

6) HDMI Headset Connector

7) Line In (Microphone) Connector

8) Line out (Speakers) Connector

9) SD card slot



10) microUSB B: When given to the user (subject) this port is closed using the supplied plug. The device is shipped with this plug in. Therefore only a USB C is supplied to the user and only a USB C port exists for them. This port can be used by the researchers to interact with the device instead of the WiFi. It does not charge the battery. It does power the device though and supplies energy for continuous operation. The device needs to be booted by plugging in the microUSB, and not by pressing on the Power Button. While running in the micro USB mode, the Power Button press should NEVER be used and the Power LED would thus not light up. Depending on the state of the device, a long press on the Power button may leave the device in different corrupt modes. Thus, after an accidental long press of the Power Button, it is advisable to reboot the device using the hardware reboot via plugging out and in the microUSB.

11) LED status lights above the micro USB B.

They indicate the booting state of the device. The device is fully booted when the leftmost LED stabilizes (uppermost LED in this picture)



Charging battery

Briefly push (short push) the Power button to check the charge. If all four LEDs (2) light up no charging is necessary. If one or none LEDs come up the charging is necessary. 2 or 3 LEDs would mean that you can work one hour or so without charge. The number of LEDs that is lit is not very accurate apart from the full charge (four LEDs). Particularly in the discharge cycle, the number of LEDs drops to one relatively fast while the charge is still very high. To charge the device use the supplied USB-C.

Extending battery life

To maximize battery life you should avoid keeping the battery charging after the full charge is reached. While you are working with the PHL in the lab charging the battery all the time will extend the battery life.

Starting the BatAndCat Box

1. Insert the SD card.
2. Briefly push the power button (3) and observe the number of LEDs lit (2). If you need to charge the system, you can charge it while working.
3. Start the system by pressing the Power Button (3) until the Power ON/OFF (4) light comes up. The device is now booting. The device is booted when the leftmost LED status light (11) has fully stabilized after a period of flickering. Also, the Programmable Button (5), lights up when pushed. If the button is programmed for some other use, this would no longer be the case.

Shutting down the BatAndCat Box

1. It is recommended to first shut down the MHA software system using an appropriate software command. This would safeguard the SD card software integrity. This command may vary depending on the application you are using. Wait about 5 seconds before proceeding with step 2. If you do not know the appropriate command you can go directly to step 2
2. Long push the Power button until the LED above (4) goes off. If the USB-C has been connected (1) pulling it out will also shutdown the system.

LOADING THE SYSTEM SOFTWARE MAHALIA

The system software for the MHA on this platform is referred to as Mahalia. It provides you a Linux operating system environment and supports the MHA software. This system can be loaded on a microSD card of 16 GB minimal capacity. 32 GB or more is however recommended to support future applications.

The newest version of the software can be loaded via a link in the Software Download tab on the BatAndCat web site.

You would need a microSD card burner and a software to download the file. If you do not have such software go to <https://www.balena.io/etcher/> and download the BallenaEtcher app. Run the app and burn the image on an SD card.

Put the card in the SD card slot (9) on the B&C Box before starting the box.

AN EXAMPLE OF USE

GUI: Demo, calibration, noise measurement etc.

This gui is located at <http://10.0.0.1:1880/ui>

This is a diagnostic gui; it provides for listening to individual microphones, playing different test signals, etc. It can be used for calibration of the system (your headsets are already calibrated).

It can be run on computers and smart phones.

Before you run the gui you need to connect to the WiFi "Mahalia...#" created by the B&C Box. Different numbers are associated with different boxes.

Follow these steps:

1. Power the B&C Box as detailed before.
2. Open the list of active WiFi's seen by your smart phone or computer
3. Select the Mahalia WiFi. If you are running multiple Boxes there would be multiple Mahalias. Also, with some systems (eg Safari on the Mac) the Mahalia WiFi shows in the list long after it is no longer present. Connecting to that WiFi will result in an error message. The error often occurs if the current Mahalia is not yet shown (system is still booting) and the previous one is still present giving an impression that this is the current one.
4. Go to the browser and type <http://10.0.0.1:1880/ui>
5. It may take some time (from a few seconds to a few minutes)
6. The system will be running when the gui becomes active. You can also STOP or RESET the system.
7. The most important screen of the app is the System control. There you can select which RIC you are using (S or M), can toggle between Front and Back (Rear) Microphones and adjust the level either by typing or tapping where the dot should be (dragging does not work). You can also connect a headset with or without a microphone. A good configuration for listening without feedback is to select both BTE and Line but connect only headset without the microphone. That way you direct the BTE microphones directly to the headset (no need to insert RICs). Notice that there is no feedback cancellation.
8. The system also contains the gentle software shutdown of the system. Wait 10 seconds or so after that before you push the power button to turn off the power.

9. The screen “Signal generator” is mainly used for testing output stages.
10. The screen “Compressor” is a demo of a hearing aid functionality.

TECHNICAL SPECIFICATIONS

A. The Bat&Cat Box

The system is equipped with three independent Analog Device ADAU1761BCPZ codecs

- o True 24-bit, 96 kHz stereo audio ADC and DAC codec
- o Better than 98 dB SNR

Each codec is independently addressed by the ARM CPU

The system has a total of six inputs and a total of six outputs

All inputs and outputs are capable of simultaneous sampling

This is providing six synchronized system capture streams and six synchronized system audio output channels

The system has Codec 3 exposed on one 3.5mm input jack and one 3.5mm output jack

Totally six inputs and six outputs from Codecs 1 to 3 are exposed on the micro-HDMI connector. Inputs are LINN and RINN, and outputs are LHP and RHP signals of the Codecs

Codec 3 signals on micro-HDMI are shared with 3.5mm jacks available on the BOX

Every input has a dedicated programmable gain amplifier, programmable between -12 dB to +55.25 dB gain

Each codec has a separate reference microphones ground exposed on the connector for the signal to noise improvement purpose

Every input has a 2K internal pull-up with 1 mA ultra-low-noise source power to drive condenser microphones if needed

The frequency response of the input pathways is flat across 20 Hz to 20 KHz

Added distortion to the input signals is near zero

Every input is equipped with RF filters to prevent interference from WiFi or Bluetooth activities

The system exposes a very low noise 3.1V, 250mA max, dedicated power for user applications. The power source has an independent ground pathway on the micro-HDMI connector

Codec outputs are single-ended with internal DC bypass and EMI filters, capable of driving loads down to 16 ohm

Built-in standard ARM system for easy programming
Sitara AM3358 ARM Cortex-A8 @ 1000MHz
512MB DDR3 RAM
NEON floating-point accelerator
4GB 8-bit eMMC onboard flash storage
External SD card

Wireless connectivity
Wi-Fi 802.11b/g/n
Bluetooth 4.1 plus BLE

System software compatibility
Debian with Cloud9 IDE on Node.js w/ BoneScript library
Third-party support for Android and Ubuntu

User-programmable button

User-programmable LED indicator

Built-in 2600 mAh lithium battery and charger for mobile operation of the device
Charging through a standard USB-C port
~ 3 hours charge time from an empty battery
No compromise on charge speed while operating
Hardware battery status and charge indicators

Based on the software load, up to 6 hours of continuous battery operation with full hearing-aid software suit running

B. The BTE extra low noise headset

The BTE headset is a binaural BTE system with two microphones on each side. It comes in two versions:

The subject version and

The researcher version

The researcher version has a longer cable and enables the researcher to keep the Bat&Cat Box on the table as well.

The system features Receiver In the Canal speakers (RICS). Two versions are available:

A. Speaker M: a higher power Sonion 113 dB peak RIC (E50D) and

B. Speaker S: a lower power Sonion 106 dB peak RIC (4400)

Each speaker is offered with a short, medium and long tube. Given the left and right versions, the total number of available speakers is thus 12.

The system arrives pre-calibrated for these speakers.

Four Sonion dome types are offered: Open 5 mm, Open 7 mm, Open 10 mm, and closed 12 mm.

These RICs are compatible with Widex and Phonak wax guards that we can also supply.

The equivalent input noise for speaker M is in the range 16 dB to 19 dB; and that of Speaker S is in the range 18 to 21 dB.



The ITE transparent headset “Hearpiece”

The device has been developed by Florian Denk and colleagues (University of Oldenburg) and InEar GmbH. It was adapted via an adapter (Bat&Cat Y adapter) to the Bat&Cat Box. Two models, with and without the vent exist. There are three microphones at the outer surface (two supported by the current Y adapter) and one in-ear microphone. In each earpiece, there are two balanced armature speakers with separate inputs. The one-size-fits-all acrylic shell fits in about 90% of all ears and has a fit comparable to an individual earmold. The earpiece is available both in a vented as well as an occluded configuration, as well as with and without microphone pre-amplifiers included in the ear. For more detail see <https://www.inear-monitoring.eu/en/hearpiece.htm>

Specifications	
Microphone sensitivity	-38 dB V/Pa
Supply voltage	3.0 - 3.6 V
Output sensitivity	100 - 110 dB SPL/V @1kHz depending on configuration
Max. output	110 dB
Cable length	1m



PART II - SYSTEM SOFTWARE

DEVELOPING NEW PROGRAMS AND SOME USEFUL LINKS

While it may be more convenient to use MHA and the computer input and output audio for developing new programs, the B&C system can be used directly.

In either case the basic MHA software should be loaded to the host computer first (see <http://www.openmha.org/download/>) as it contains various example programs, libraries etc. It does not need to be set to run.

Both the Computer and the B&C system can be programmed directly in the Linux environment or in Matlab.

The same <http://www.openmha.org/download/> page contains links to various manuals etc.

Here are a few other useful links:

Bugs in the software could be reported through Github's issue tracker:
<https://github.com/HoerTech-gGmbH/openMHA>

Users can ask questions in the user forum:
<https://forum.openmha.org/>

In general, request for individual user support and complete program development are offered by HoerTech: mha-support@hoertech.de

THE B&C BOX AS A REMOTE SERVER

The B&C is a remote server with respect to the user computer.

Two users are available; both with sudo privileges:

user: *mha* pass: *mahalia*

user: *root* pass: *toor*

The B&C Wireless IP address is 10.0.0.1

The B&C USB address is 192.168.2.2

Regarding USB networking: On the Mac, open System Preferences; then Networking. If USB is connected you will see a device called "RNDIS/Ethernet Gadget". Set IP Address to 192.168.2.1 and Subnet mask to: 255.255.255.0 (You may need to set first IPv4 configuration to 'manual').

USING THE B&C BOX

To operate in the Mahalia remote system from a terminal screed type:

```
$: ssh mha@10.0.0.1 (or for USB: 192.168.2.2)
password: mahalia
system response: mha@mahalia:~$
```

Note: In some circumstances (new card, switching card) the system will abort with "REMOTE HOST IDENTIFICATION HAS CHANGED". To proceed:

On WiFi:

```
ssh-keygen -R 10.0.0.1
```

On USB:

```
ssh-keygen -R 192.168.2.2
```

Sometimes, you would then fail again and be told: REMOTE HOST IDENTIFICATION HAS CHANGED

Delete line referencing the current IP above in the file /Users/caslavpavlovic/.ssh/known_hosts

E.G. If you are running USB delete line referencing 192.168.2.2

To **shutdown** the Box, position yourself in the host computer and press the PWR button.

Alternatively:

```
mha@mahalia:~$ sudo shutdown -h now (if a WiFi connection the system will hang at the end, but then exit with an error status - this is OK).
```

To **reboot/restart/stop/start**:

```
mha@mahalia:~$ sudo reboot now
mha@mahalia:~$ sudo systemctl reboot mahalia
mha@mahalia:~$ sudo systemctl restart mahalia
mha@mahalia:~$ sudo systemctl stop mahalia
mha@mahalia:~$ sudo systemctl start mahalia
```

To **see the recent log**:

```
mha@mahalia:~$ tail /tmp/openmha.log
```

Exit back to the host computer

```
mha@mahalia:~$ exit
```

WiFi

Once hearing aid is running and if WiFi interface is not used for user interface, you can shut down the WiFi:

```
mha@mahalia:~$ sudo systemctl stop hostapd
```

To check the status of WiFi:

```
sudo systemctl status hostapd
```

etc/mahalia

contains most of the critical files

etc/mahalia/config

This system configuration file is executed immediately on starting the system (nc, or ssh mahalia) and contains the basic MHA settings. These values (like the sampling reate) should agree with those in the configuration file for the specific program to be run. The latter could be located in this or other directories.

RUNNING MHA

If you are already in the terminal on the mahalia system you can either close the mahalia session, or if you want to continue working in the mahalia file system; stay there and open another terminal window.

To start MHA enter the MHA socket on 33337 using the TCP netcat utility:

```
$: nc 10.0.0.1 33337
```

New line appears and stays blank - you are in communication! to test press CR and you should get a comforting confirmation "success". You are now in the MHA socket and ready to invoke a particular MHA as discussed below.

This is not a Unix environment - do not expect Unix commands to work.

Also, there is no prompt in the command line.

Note that at this point a file called "config" (mandatory to be placed in / etc/mahalia), has been executed setting environmental variables via JACK

such as sampling rate etc. Subsequent changes to this file will NOT take effect unless you exit and re-enter again.

A particular mha is started using the read command:

?read:/ProgramAbsoluteFileName

e.g. if the program is mha-test.cfg located in /etc/mahalia:

?read:/etc/mahalia/mha-test.cfg

You should get a response: “success”

You are in the “unprepared state.”

The following is the sequence of commands:

cmd=prepare

cmd=start (to run MHA)

cmd=stop (to stop MHA)

cmd=release

cmd=quit

RESTARTING, STOPPING AND STARTING THE PROGRAM (I feel better about using restart only)

In some occasions, after exiting, the program can stubbornly stay in the memory and refuses to load a new program. in that case try:

```
mha@mahalia:~$ sudo systemctl restart mahalia
```

and perhaps:

```
mha@mahalia:~$ sudo systemctl stop mahalia
```

```
mha@mahalia:~$ sudo systemctl start mahalia
```

EDITING FILES

Any text editor (eg vi, nano). Nano is very intuitive and can be used immediately.

COPYING FILES FROM THE REMOTE SERVER TO THE HOST COMPUTER AND VICE VERSA

Open two windows, one in the host computer and the other on the remote system (Mahalia). **Do copying from the host computer terminal.**

For example to copy files from the host to the remote system:

```
€: scp MHA/bin/RegSet.sh root@192.168.2.2:/etc/mahalia/headsts/  
amplified/.
```

```
pass:toor
```

Or from the remote system to the host computer:

```
€: scp mha@10.0.0.1:/home/mha/scotsdale2019/* .
```

As another example, to copy all the files in the current directory and below to /home/mha/scotsdale2019 on the remote system:

```
€: scp -r . $HOME/Documents/Programs/headsets/ root@10.0.0.1:/  
etc/mahalia/headsets/
```

This one copies all files in node-red to /home/mha

```
€: scp -r root@10.0.0.1:/etc/mahalia/headsets/ $HOME/  
Documents/Programs/
```

Notice that you may need chmod 664 of the file to be overwritten. The recursive option -r copies all files recursively down the branches.

USB NETWORK - MAC setup

SETUP

Do not use the power cable.

Connect to the USB on the Mac.

Opened network settings

A new device pops up called "RNDIS/Ethernet Gadget".

Set (Advanced; TCP/IP) IPv4 configuration to 'manual', IP: 192.168.2.1,

Netmask: 255.255.255.0

Push "Apply"

You should be connected

USE: as WiFi, but the IP: 192.168.2.2

```
ssh mha@192.168.2.2
```

```
nc 192.168.2.2 33337
```

CALIBRATION AND REGISTER FILES

/etc/mahalia/headsets/amplified contains:

RegSet.sh : register setting file used by the programm to set registers. Change this file and execute it to experiment and return to original by copyng AmplifiedRegSet.sh.

calib_in.cfg : Input calibration values

calib_outM.cfg : output calibration values for M RIC at 2000 Hz

calib_outS.cfg : output calibration values for S RIC at 2000 Hz

speaker-m/calib.cfg : calibration frequency corrections at all frequencies

speaker-s/calib.cfg : calibration frequency corrections at all frequencies

/usr/local/bin

File: RegGet.sh

Can be executed to get the current register settings. Useful if you are experimenting with register settings. Also, gives the SystemCapture channels associated with each inout and output channel.

W