

## Introduction to the Soundskrit Mantis Headset Kit

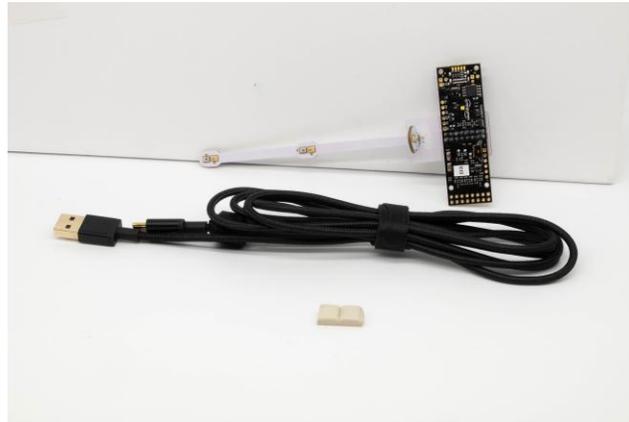


Figure 1: Soundskrit Mantis Kit

The Soundskrit Mantis kit is designed to evaluate the performance of Soundskrit microphones and software in a headset scenario. Our most powerful headset configuration is to combine an omnidirectional and dipole microphone to enable several software features. There are three positions on the Mantis board with an omnidirectional microphone and an SKR0410 dipole microphone. One near the mouth as in a boom headset, one further back for a reduced boom length, and one near the ear as found in boomless, wireless headphones.

There are two software algorithms running on the Arm Cortex M7 processor for each microphone pair. The first is our high directivity beamformer which maximizes SNR and reduces background noise without distortion. This algorithm is compatible with existing machine learning based noise reduction algorithms and will enhance their performance. The second is our nonlinear DSP beamformer. Our nonlinear beamformer mutes the microphone unless speech is coming from  $\pm 60^\circ$  and further reduces non-speech noise when the microphone is unmuted. This is a very lightweight and low latency algorithm based on traditional DSP methods.

The processing all runs embedded and does not require any programs on your PC.

What's In the Box	
Mantis Board	The Mantis development board with 3 dipole microphones and 3 omnidirectional microphones.
USB A to USB C Cable	A cable to connect the board to your PC.
Mounting Putty	Putty to mount the board to an existing headset for evaluation.
Cable ties	Two Velcro cable ties to securely route the USB cable along the headset are included on the USB cable.

## Contents

Introduction to the Soundskrit Mantis Headset Kit .....	1
Mantis Board Overview .....	3
Included Beamforming .....	4
How to Use the Mantis Board .....	7
Recording Audio with the Mantis Board .....	8
Recommended Demos .....	10
Use with Video Conferencing.....	11
Additional Support.....	15
Revision History .....	15

## Mantis Board Overview

The Mantis board has a USB-C connector and 6 MEMS microphones. The “front” of the board is the bare side of the PCB. When using the board, face the bare side of the PCB toward the mouth. Each algorithm uses one omnidirectional microphone and one dipole microphone. This fundamental pair is located in three different positions so that you can compare the performance difference between a headset with a full-length boom, a shorter boom, and one without a boom. These fundamental pairs will be referred to as the boom pair, middle pair, and earcup pair respectively. Generally, the performance on the boom pair and middle pair is very similar and these have the best vocal quality and the highest noise rejection. The earcup pair trades of performance to embed the microphones in the earcup rather than using a boom.

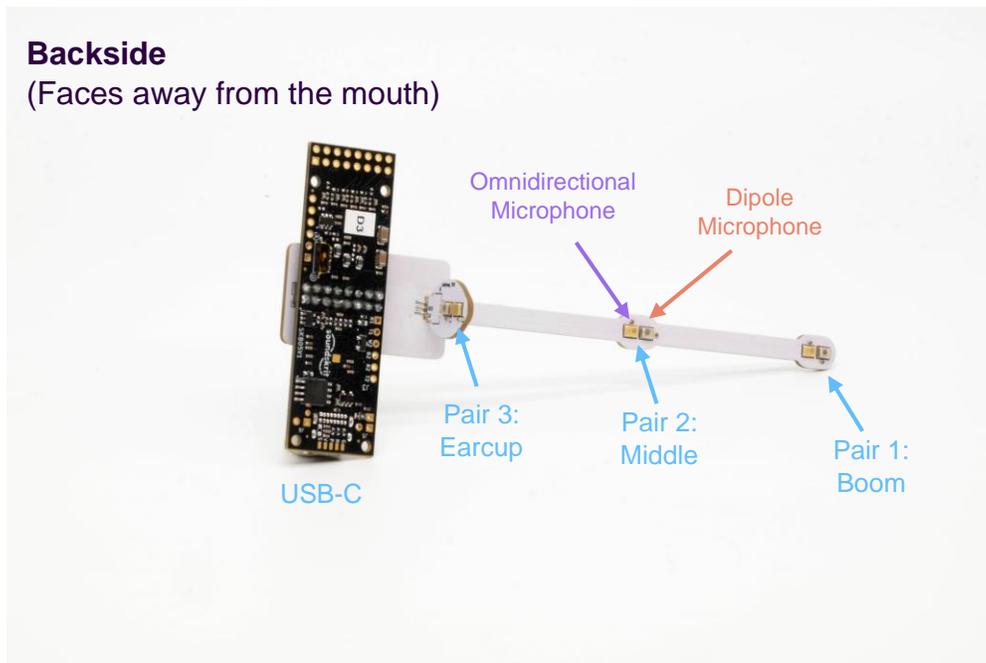


Figure 2: Mantis board microphone pairs

For this demo kit, the earcup microphone pair protrudes from the board. In a final product, the microphones can be integrated inside the headset and do not need to stick out as on this board. In a production product, like a pair of headphones, a gasket would be used to mount the microphones inside the headphones with the port holes on the same surface. For more information on integrating the microphones such that the ports are on the same surface, see our application note: [AN-300 Integration Guide for Directional MEMS Microphones](#)



Figure 3: Example of microphones inside of a headset earcup

## Included Beamforming

Once the Mantis board is connected, you can take a recording. The USB output will have six channels. Channels 1 and 2 are for the microphone pair at the end of the boom near the mouth, channels 3 and 4 are for the middle pair, channels 5 and 6 are for the pair that sits at the earcup. The first of each of these pairs is the high-directivity beamformer and the second of each is the nonlinear beamformer. These algorithms are tuned for headset distances and will not perform well if used at a distance greater than 5-10 cm.

To learn more about combining an omnidirectional and dipole microphone to create adjustable polar patterns, check out our article: [Combining Microphone Polar Patterns](#).

All channels implement a high pass filter set to 80 Hz.

USB Output Channels		
Boom pair	Ch1	High-directivity beamformer
	Ch2	Nonlinear beamformer
Middle pair	Ch3	High-directivity beamformer
	Ch4	Nonlinear beamformer
Earcup pair	Ch5	High-directivity beamformer
	Ch6	Nonlinear beamformer

### Channels 1, 3, 5: SimplyDSP high directivity beamformer

A beamformer which creates a polar pattern which maximizes directivity and SNR. This lies between a hypercardioid and a supercardioid. This polar pattern maximizes the acoustic noise rejection and improves the SNR over other polar patterns. Below is the polar pattern of the beamformer at each position.

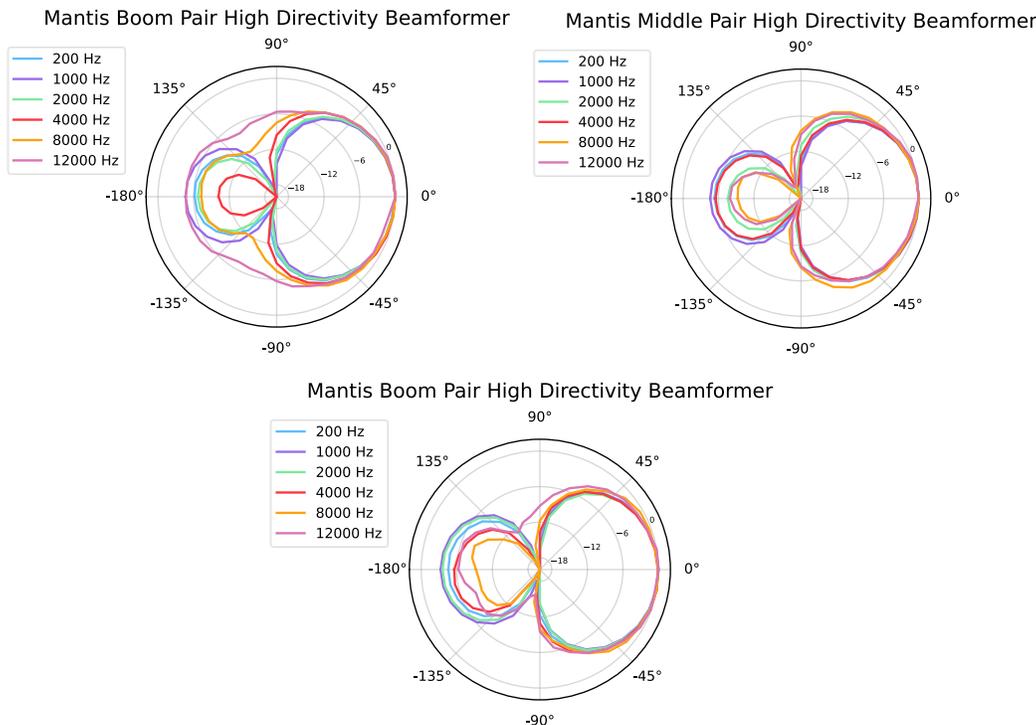


Figure 4: High directivity beamformer polar patterns at each position

### Channel 2, 4, 6: SimplyDSP nonlinear beamformer

Our nonlinear beamformer uses phase information provided by the omnidirectional-dipole pair to mute the microphone unless speech is coming from  $\pm 60^\circ$ . This “activation zone” is pictured below. When the microphone is unmuted, the cardioid beamformer is used and this phase information is used to further reduce non-speech noise.

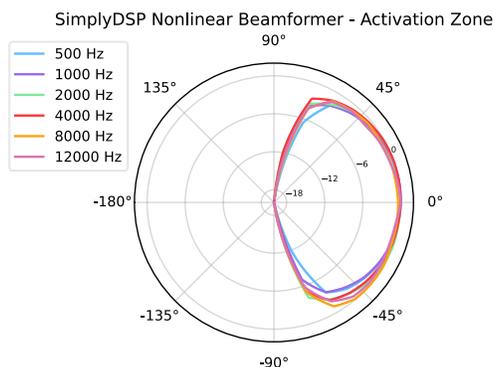


Figure 5: Nonlinear beamformer activation zone

All polar patterns above are measured from 50 cm to the microphone, since the microphone should be directional in the far field to reject ambient noise. Measurements from very close distances would look different.

## How to Use the Mantis Board

There are two methods to mount the Mantis board to a headset and take recordings. First, for quick demos you can use the included putty to mount the board to the right side of your headset with the cable hanging down. Place the putty on the space of the board where there are no solder joints. Adding putty toward the end with the solder joints will help with stability but will be more difficult to remove. Adjust the boom to be positioned near the corner of your mouth.



Figure 6: Putty on the Mantis board



Figure 7: Mantis board with the cable facing down

Second, to improve stability for longer term use, mount the board to the left side of your headset with the USB connector facing up. Route the cable over the top of the headset and secure it to the headband with the attached Velcro cable tie.



Figure 8: Mantis board with cable routed over the headband

The frequency response of the Mantis is tuned for positions as shown in the two photos above. Mounting the board differently, e.g. above the ear or much lower, might lead to a sub-optimal sound.

## Recording Audio with the Mantis Board

To record audio with the Mantis board, we recommend installing [Audacity](#). Audacity is a trusted, free to use, multiplatform suite of tools for recording and working with audio files.

Once you have installed Audacity, we need to configure the software for use with the Soundskrit SPIDAR board. Configure the settings as listed below:

Audio Host	Windows WASAPI
Input <sup>1</sup>	<i>Digital Audio Interface (Soundskrit 6Ch 24bit)</i> – Ensure the non-loopback version of the driver is selected
Output	Your listening device
Channels	6 Recording Channels

<sup>1</sup>WASAPI has two versions of each input option, the regular and the loopback, to record from all six channels the non-loopback mode must be selected. If this is configured correctly, there will be six recording channels listed, while the loopback will only allow two. Non-loopback is typically the second of the two versions.



Figure 9: Audacity host selection

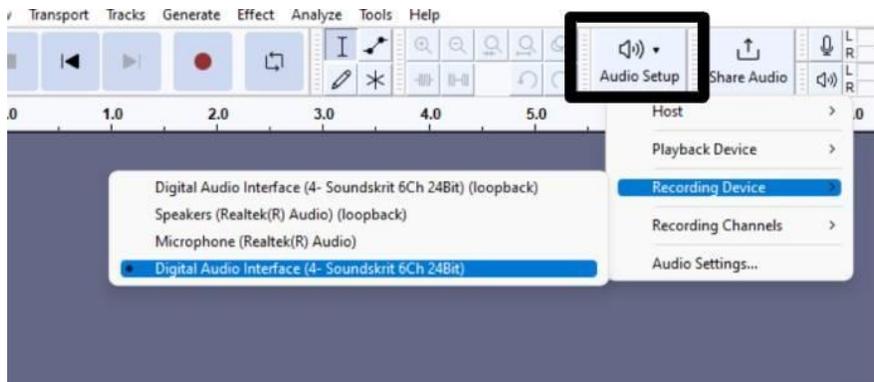


Figure 10: Audacity device selection



Figure 11: Audacity channel count selection

When you take a recording, all 6 channels will be recorded whether there is a microphone connected or not.

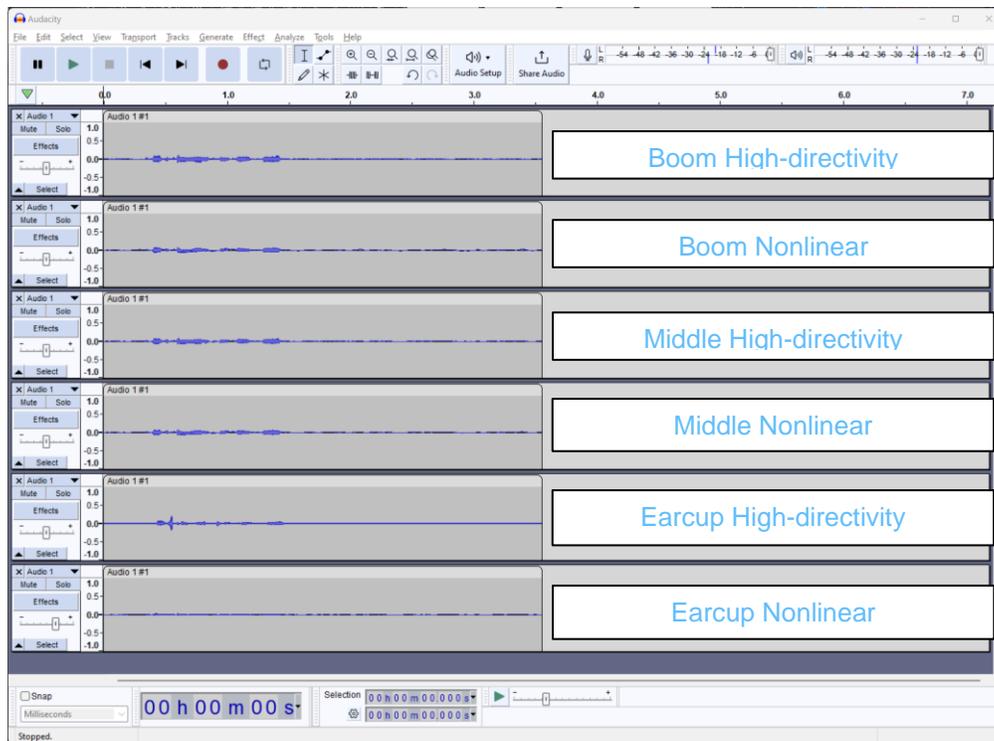


Figure 12: Output channels

## Recommended Demos

Below are instructions on how to demonstrate each of the processing features available in this kit.

First, play ambient noise from a speaker a couple meters away from the Mantis board. The speaker should be enough distance away to simulate diffuse noise such as from a crowd or general background noise. Try talking into the board.



*Figure 13: Mantis board positioned near the corner of the mouth*

Both algorithms will reduce the noise, the high directivity beamformer is a pure beamformer so this will have the highest voice quality and evenly hush the background noise. The nonlinear beam will have stronger noise reduction and completely mute when the user is not talking, but there will be some distortion in the voice.

Next, to test the nonlinear beamformer, have the Mantis board facing your mouth. Talk into the microphone. The voice should come through full and clear. Have a colleague speak into the other side of the board, their voice will be completely muted. Then, have them speak at the same time as you near the board. Despite someone speaking, your voice will still come through clearly and the microphones will be completely muted when you are not speaking.

## Use with Video Conferencing

To test out the Mantis with video conferencing, the output must be configured such that there is only an output on channel 1 and all other channels are muted. To configure the firmware, you will need to install an SSH terminal emulator such as [Tera Term](#). First, install Tera Term and in the new connection menu, connect to the Mantis board. The Mantis board will be listed as a serial device named COMX: USB Serial Device (COMX)

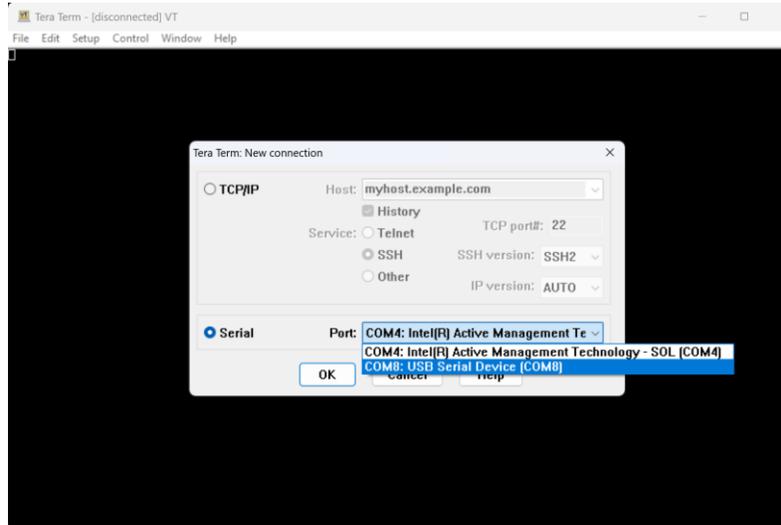


Figure 14: Tera Term new connection

Once connected, go to Setup → Terminal, and configure the new-line settings as LF for both receive and transmit and enable local echo.

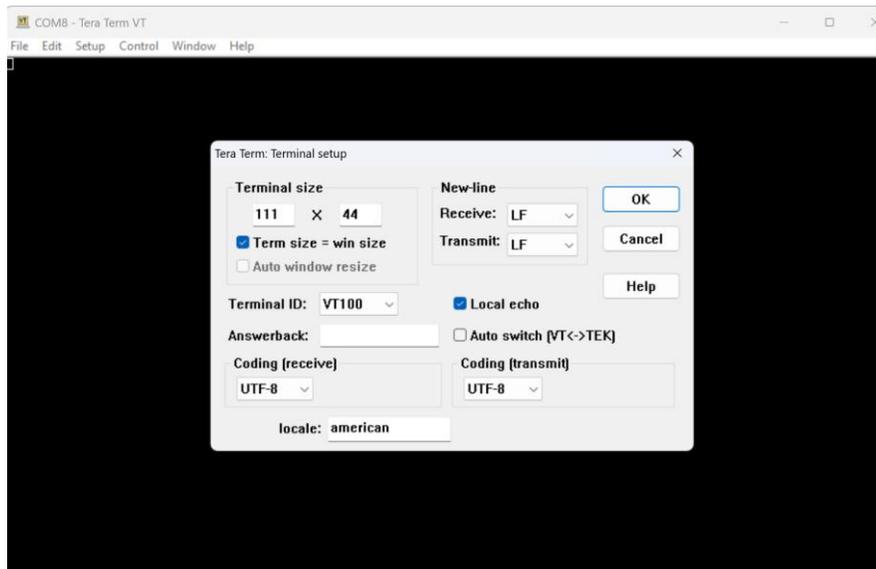


Figure 15: Tera Term terminal setup

Now you can interface with the Mantis board firmware. To begin, reset the audio configuration using the command **reset**. This will display the default configuration. To view the current audio configuration at any point, send the command: **get audio**.

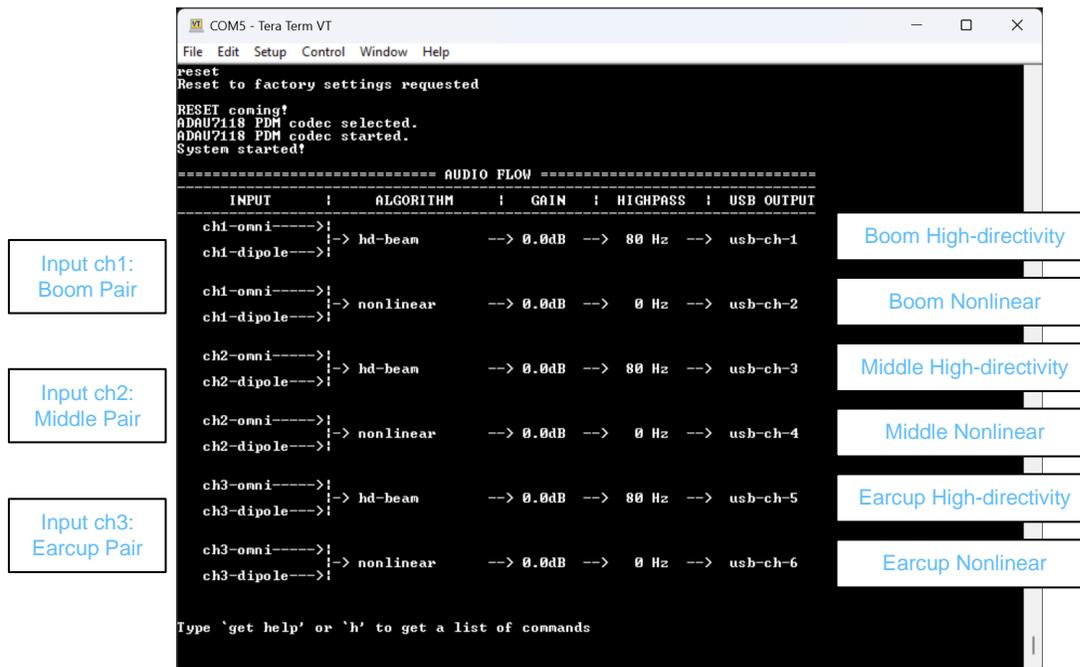


Figure 16: Current audio configuration

Here you can see the current configuration of the audio and how they are connected to the USB output channels. For example, USB output channel 1 uses the microphones on the boom pair, input ch1, applies the high directivity beamformer, labeled as “hd-beam”, and applies the highpass filter at 80 Hz.

For the nonlinear beamformers, the highpass filter is integrated into the processing algorithm so the highpass should not be set.

Next mute all output channels using the command: **mute a**

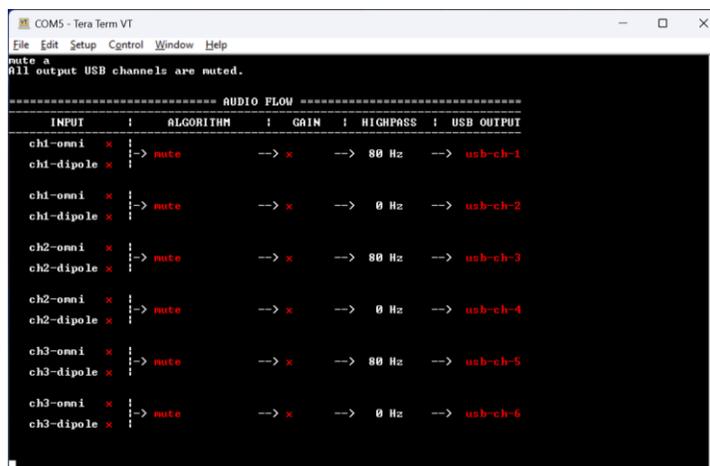


Figure 17: Muting the output channels

Next, we will set usb-ch-1 to be the output configuration you want to use over video conferencing. Then we will need to disable or enable the high-pass filter as needed.

The command for to set the USB output is: **link <in pair> <algorithm type> <out usb>**

```

COMS - Tera Term VT
File Edit Setup Control Window Help
link 1 nonlinear 1
===== AUDIO FLOW =====
INPUT | ALGORITHM | GAIN | HIGHPASS | USB OUTPUT
-----|-----|-----|-----|-----
ch1-omni----> |> nonlinear  --> 0.0dB --> 80 Hz --> usb-ch-1
ch1-dipole----> |
-----|-----|-----|-----|-----
ch1-omni x |> mute      --> x    --> 0 Hz  --> usb-ch-2
ch1-dipole x |>
-----|-----|-----|-----|-----
ch2-omni x |> mute      --> x    --> 80 Hz --> usb-ch-3
ch2-dipole x |>
-----|-----|-----|-----|-----
ch2-omni x |> mute      --> x    --> 0 Hz  --> usb-ch-4
ch2-dipole x |>
-----|-----|-----|-----|-----
ch3-omni x |> mute      --> x    --> 80 Hz --> usb-ch-5
ch3-dipole x |>
-----|-----|-----|-----|-----
ch3-omni x |> mute      --> x    --> 0 Hz  --> usb-ch-6
ch3-dipole x |>

```

Figure 18: Setting the nonlinear algorithm on channel 1

To set the high pass filter, use the command: **set highpass <out usb> <on/off>**

```

COMS - Tera Term VT
File Edit Setup Control Window Help
set highpass 1 off
The highpass filter on output channel 1 is disabled.
get audio
===== AUDIO FLOW =====
INPUT | ALGORITHM | GAIN | HIGHPASS | USB OUTPUT
-----|-----|-----|-----|-----
ch1-omni----> |> nonlinear  --> 0.0dB --> 0 Hz  --> usb-ch-1
ch1-dipole----> |
-----|-----|-----|-----|-----
ch1-omni x |> mute      --> x    --> 0 Hz  --> usb-ch-2
ch1-dipole x |>
-----|-----|-----|-----|-----
ch2-omni x |> mute      --> x    --> 80 Hz --> usb-ch-3
ch2-dipole x |>
-----|-----|-----|-----|-----
ch2-omni x |> mute      --> x    --> 0 Hz  --> usb-ch-4
ch2-dipole x |>
-----|-----|-----|-----|-----
ch3-omni x |> mute      --> x    --> 80 Hz --> usb-ch-5
ch3-dipole x |>
-----|-----|-----|-----|-----
ch3-omni x |> mute      --> x    --> 0 Hz  --> usb-ch-6
ch3-dipole x |>

```

Figure 19: Setting the highpass filter off on channel 1

Below is a table with all the configurations available for the Mantis board.

Setting the output configuration				
<in pair>		<algorithm type>		Highpass on/off
1	Boom pair	<i>hd-beam</i>	High directivity	On
2	Middle pair	<i>nonlinear</i>	Nonlinear beamformer	Off
3	Earcup pair	<i>omni-eq</i>	Omnidirectional microphone equalized to match with the dipole	On
		<i>dipole-eq</i>	Dipole microphone equalized to match with the omni.	On

With these commands, we can set the output channel to be either of the beamforming algorithms or as the equalized single omnidirectional or dipole microphones. For comparative purposes, we always recommend the equalized microphones for the most direct comparison.

For example, to use the earcup high directivity beamformer on channel one for video conferencing, use the below commands:

```

reset
mute a
link 3 hd-beam 1
set highpass 1 on
get audio
    
```

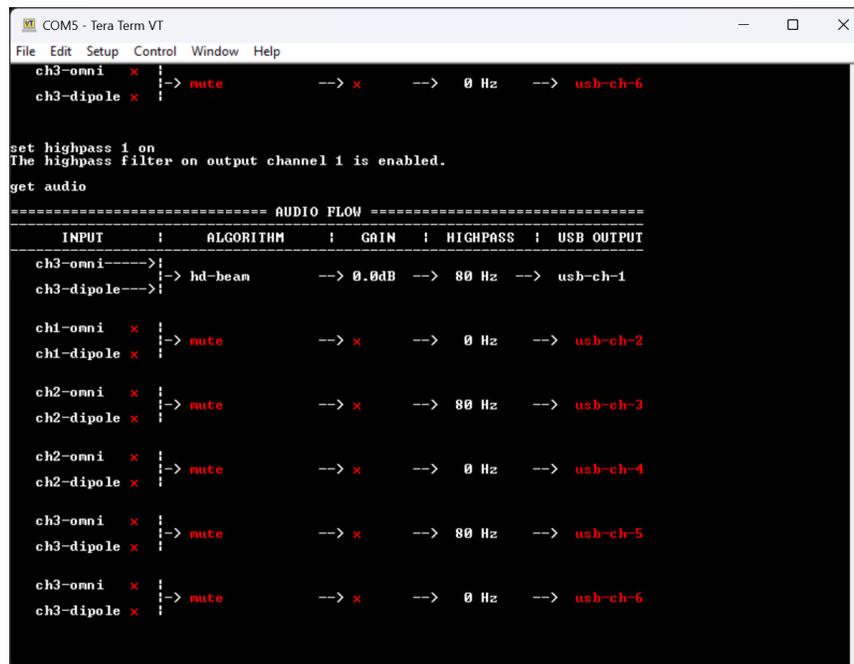


Figure 20: Results of example commands

## Additional Support

For further information on Soundskrit's products, visit our website at <http://www.soundskrit.ca> where you can find more application notes, datasheets, and purchasing information. If you have any questions or need technical support, please reach out to [applications@soundskrit.ca](mailto:applications@soundskrit.ca).

## Revision History

Revision Label	Revision Date	Sections Revised
-	March 2024	Initial release



Soundskrit developed the first high-performance directional MEMS microphone on the market, leveraging years of research in bio-inspired MEMS based on how spiders and other insects in nature hear. In combination with Soundskrit's in-house audio processing algorithms, directional microphones can be used to capture and isolate any sound in an environment with a fraction of the size, power, and computation of traditional omnidirectional-based microphone arrays.

Soundskrit was founded in 2019 and is headquartered in Montreal, Quebec with an R&D facility in Ann Arbor, Michigan.

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