Contents

Introduction / ReadMe

I started documenting information on Dirac Live® when I started using it in 2018 with a miniDSP 88A. I initially started out with AVS Forum member Markus767's Dirac documentation, and many of his valuable recommendations are interspersed throughout. However, this document has evolved over the years as I have collected information. Many may be familiar with my work, as I am the author of the original Audyssey Setup Guide from many years ago, and worked closely with Chris K. of Audyssey Labs during its development.

This guide is an overview of Dirac Live® which borrows from various sources, mostly from AVS Forum members, and credit is noted throughout the document. However, this is not simply a collection of posts, but rather an organized, methodical overview of the technology and calibration process.

I make many guides available to the community for free, but if you find the information in this guide useful, and wish to make a donation via PayPal Friends & Family, my username is: giomania@gmail.com

Thank you.

Dirac Live® Information

Dirac Live® Overview: https://live.dirac.com/overview/

Dirac Research White Paper - On Room Correction and Equalization of Sound Systems
http://diracdocs.com/on_room_correction.pdf

Dirac Live® Paid Upgrades and link to supported manufacturers:
https://live.dirac.com/home-audio/

This video featuring Jakob from DIRAC has some good information:
https://youtu.be/cFOjkU1EXRY

Dirac Live® History

https://mehlau.net/audio/dirac-live-2/

Dirac Live® 2

After a lengthy development process and missed launch in Q1 2018, Dirac Live® 2.1 has finally been released on 23.11.2018. It features a completely new user interface while no major new features – like simplified test signal/mic level setting, automated crossover selection or crossover splice optimization – have been added. Some major bugs from version 1 still exist in version 2, e.g. wrong speaker distance detection of upward firing Dolby enabled speakers. Some new bugs have been introduced.

Dirac Live® is first and foremost a tool for automated room correction, so user experience and user interface should be paramount. Unfortunately, Dirac Research chose to prioritize cross-platform support and looks over functionality. While beauty certainly lies in the eye of the beholder, a software user interface also has objective functional aspects ("Design is not just what it looks like and feels like. Design is how it works." – Steve Jobs). Here Dirac Live® 2 shows a strange tendency to favor decorative/less important elements while functional user interface elements are non-native, dimmed down, hidden, unreadable or even missing. As a result, some tasks are actually harder to accomplish than in version 1. Some features have even been crippled (e.g. test signal/mic gain adjustment) which makes Dirac Live® 2 less useful to the user.

Good news is that Dirac Live® 2 is available as a free upgrade to existing users.
See https://live.dirac.com/download/

Version 2.1.1 has been released on 10.12.2018 with usability improvements and bug fixes but generally all of the above still applies.

Version 2.1.2 has been released on 21.12.2018 with usability improvements and bug fixes but generally all of the above still applies.

Version 2.2.0 has been released on 26.02.2019 which finally provides a way of getting test signal and mic input level right.

Version 2.2.1 to 2.3 has been released during 2019 with usability improvements and bug fixes but some fundamental issues are still unresolved.

Version 2.4 has been released on 07.02.2020 with usability improvements and bug fixes but generally all of the above still applies.

Version 2.5.2 has been released on 08.04.2020 fixing a severe bug in the gain compensation algorithm. Earlier versions should not be used. This is the first version that can be considered ready for prime time since its first public release in 2018. It still can't handle upfiring Dolby Atmos enabled speakers though...

Dirac Live® 3

Version 3 has been released on 03.06.2020. The user interface is virtually the same as in version 2 but it comes with a new feature, "Bass Control" (although technically "Bass Control" was already available in 2.5.x). "Bass Control" encompasses a number of tools for optimizing the crossover region between sub(s)/sats and seat to seat differences when using multiple subwoofers.

"Bass Control" requires the AVR/P to run Dirac's own bass management DSP code. If the hardware supports it additional controls become available in the Dirac Live® app.

"Off": Regular single speaker optimization. Bass management has to be configured by the user in the the AVR/P.

"Upmix Only": Dirac bass management replaces the AVR/P's bass management. Visualize the crossover splice between sub(s)/sats.

"Full Bass Optimization": Same as "Upmix Only" but adds optimization of the crossover splice if a single sub is used (also applies to AVR/P's that split a single subwoofer signal to multiple outputs). If the AVR/P supports individually addressable subwoofer outputs "Bass Control" additionally reduces seat to seat differences besides optimizing the crossover splice.

Dirac Live® Frequency Resolution Implementation

Michael Boeker posted in a private Discord channel

Regarding Dirac Live® - What isn't disclosed by the various manufacturers is that they are limited to 1000 taps for the FIR filters and some use much less than that. StormAudio has much more processing power and can utilize 3000 taps. The number of taps and the sample rate determine the frequency resolution. Frequency resolution is both the minimum frequency that can be corrected and the spacing between the frequency domain data points. The actual correction is a little bit higher because it takes a few periods of the waveform to determine frequency. At 1000 taps, the frequency resolution is 47.6 Hz. At 3000 taps the frequency resolution is 16 Hz. Dirac Live® is mixed phase filtering (IIR & FIR). The frequency at which it transitions from FIR to IIR is determined by the number of taps. Fewer taps equate to a higher frequency. The higher the sampling rate, the wider the frequency resolution with a higher minimum frequency. For example, with 1000 taps, 192 kHz has a frequency resolution of 192.3 Hz. This is why Dirac Live® requires that manufacturers use 48 kHz so that FIR filters can be used to a much lower frequency.

At the StormAudio Dirac tech talk at MWAVE 2024, Matthew Trinklein mentioned the filter tap count on StormAudio allows finer filter resolution than competing products. The amount of filter taps on StormAudio is 3,076. The next product down in the count has 1,554, and most products have 1,100.

Dirac Live® Bass Control Information

Overview

Dirac Live® Bass Control (DLBC) is a bass management module feature available since software version 2.5x. It is supported in several manufacturer devices, sometimes at additional cost. It is displaying and correcting the interactions among the subwoofers and the main speakers. Due to phase differences between the subwoofers and satellite speakers, the crossover region isn't flat but shows (often severe) peaks and dips. Adding all-pass filters to the satellite speakers can reduce these phase differences, which smooths out the combined response within the crossover region. All-pass filters change the phase response without changing the magnitude response: https://en.wikipedia.org/wiki/All-pass_filter

In this post, AVS Forum member flax from DIRAC provided This short video of DLBC making the calculations on a project. It uses Artificial Intelligence (a genetic optimization algorithm) to perform a large number of calculations. There is a randomness factor, so two sessions with the same parameters can produce slightly different results... so export your best filters.

Theory

Audyssey published a series of papers years ago, and one addresses what DLBC is attempting to achieve. The paper, "Phase Equalization for Multi-channel Loudspeaker-Room Responses", Audio Engineering Society Convention Paper, 117th Convention, 2004; the abstract is below. DLBC is now making this accessible to a broader audience.

"ABSTRACT
Given a multi-channel loudspeaker system, in a typical single or multiple listener setup, the combined response of the loudspeakers will exhibit significant fluctuation around the crossover region due to non- coincident positions of any two loudspeakers. This fluctuation manifests as an undesired broad spectral notch or a peak around the crossover region. The spectral notch, for example, introduced around the crossover due to complex addition of the two loudspeaker responses, generally, cannot be compensated with only magnitude response equalization. In this paper, we present a recipe for compensating the spectral notch around the crossover region by designing a digital equalization filter using a stable all-pass network."

In this post, AVS Forum member flax from DIRAC explained the loss of bass when using DLBC: A common criticism of Bass Control with multiple subwoofers is the lack of bass after a calibration. Users find much more satisfying bass with standard Dirac Live® than when using Bass Control... why so? By using the same target for each sub their outputs will sum up in standard Dirac Live® as each sub is measured and corrected individually, while DLBC will take the summation into account and decrease their outputs accordingly.

Dirac Live® Bass Control Tiers

The Dirac Live® Bass Control Module is available in two tiers with distinct capabilities. In this post, AVS Forum member flax from DIRAC provided details on the different tiers available at the time. The tiers were simplified at some point later.

DLBC Multi Subwoofer

Technology Name in the Dirac Live® tool: Bass Control
Description: Allows equalization and time alignment of **multiple subwoofers** and each satellite speaker.
Calibration: Each subwoofer is analyzed, and the respective interactions are corrected to create a single-optimized subwoofer channel with the lowest variance within the listening area. Then the respective interactions between the subwoofers and all speakers at the crossover frequency are optimized with phase and magnitude.
Crossovers: The crossover selection process is automated by selecting the best crossover and some other parameters for an optimal final combined response. The user can still move the crossover to any point and see the predicted results in Dirac Live®.

DLBC Single Subwoofer

Technology Name in the Dirac Live® tool: Bass Management
Description: Allows equalization and time alignment of **a single subwoofer or a cluster of subwoofers** and each satellite speaker.
Calibration: The respective interactions between the **single subwoofer or a cluster of subwoofers** and all speakers are optimized with phase and magnitude.
Crossovers: The crossover selection process is automated by selecting the best crossover and some other parameters for an optimal final combined response. The user can still move the crossover to any point and see the predicted results in Dirac Live®.

For reference, the standard capability included with Dirac Live® is described below.
Description: Allows equalization and time alignment of **multiple subwoofers** and each satellite speaker.
Calibration: The subwoofers and all speakers are optimized with phase and magnitude.
Crossovers: The crossovers are manually selected and entered into the processor. The user can not see any predicted results from crossover selection in Dirac Live®.

Time-align and level match multiple subwoofers to the MLP prior to calibration?

If you care about the MLP over other seats, should you time-align and level-match multiple subwoofers prior to running room correction to multiple seats? In this video interview featuring Todd Welti, from 0:20:59 to 0:24:30, he said it couldn't hurt based on his experience using the REW room simulation model feature. See the video from. The caveat is that if using identical subwoofers, they should start with identical gain and delay settings.

Irregular Rooms

In this video interview featuring Todd Welti, from 0:45:38 – 0:48:40, he said for irregular rooms open to other areas, modes move down in frequency as the room gets larger, and therefore, the room mode issues are reduced. The interviewers noted the challenge of pressurizing larger rooms.

Square Rooms

In this video interview featuring Todd Welti, from 0:53:55 – 1:05:29, he said for square rooms, place 4 subwoofers mid-wall for the best response.

Caution when using a wide range of crossover frequencies

Later, in this post, Markus also advised: By the way, I strongly suggest to find a common crossover that works for all speakers. Adding multiple low passed signals in the redirected bass channel will lead to magnitude response issues (even when Linkwitz-Riley filters are used). The error will be small when the crossover frequency values are very close. But it can be massive if the crossover points are further apart – about 15dB interference dip with one crossover at 40Hz and another at 120Hz.

When asked to clarify this statement in this post, Markus said: If you're determined in buying speakers that can go down to 40Hz comfortably in their intended location then I'd recommend to set a 80Hz crossover for all speakers. If speakers can't go that low or if they can't go there without massive amounts of distortion, then setting appropriate and varying crossover points is the better tradeoff even if there's a certain amount of interference effects in the redirected subwoofer channel caused by non-matching phase responses of the bass management filters.

In my case, my L/R speakers can go down to 40hz easily but none of the others in my 7.1.4 setup can. My current settings are below. They are the Dirac recommended crossovers other than L/R. I assume the best compromise would be raising the L/R crossover point to 100hz and leaving everything else as is? I could create a separate Dirac filter with a 80Hz crossover point for 2 channel music only.

L/R - 80hz
C-100z
surrounds 100hz
rear - 110hz
4 tops 120hz

I'd leave it as it is. Just did a comparison of 120Hz plus 80Hz for my own setup. The error was just 1.5dB.

Reduced bass with DLBC

This issue was processor-dependent, and was fixed in a subsequent software release. It is retained for reference. AVS Forum member pink soda raised an issue with multichannel/up-mixed content and DLBC in this post. He found that DLBC can result in reduced bass at some frequencies when playing content from some pairs of speakers. He noted the most audible example is up-mixing stereo content with Auro 3D, which resulted in a loss of a considerable amount of bass in his system. While he believes he heard the same issue with movies, he felt it was not as severe, but he did not perform many listening comparisons with movies. Sdurani pointed out in this post that unlike the other two upmixers, Auro-Matic is copying entire channels of content (bass and all), since it doesn't use the matrix extraction + logic steering approach.

The issue is that while DLBC optimizes stereo pairs, it does not optimize any other combination of main speakers, such as L+C. As a result, DLBC can result in reduced bass at some frequencies when playing content from some pairs of speakers, and is dependent upon the all-pass filters Dirac Live® uses in the calibration.

To demonstrate this issue, he suggested performing the below test with Room EQ Wizard (REW). Note that he has a Monoprice HTP-1, so the setup items noted in bold below may not be possible on all processors:

Set the REW sweep to the L+R channels.
Turn off the amplifiers for the satellite channel speakers (only the subwoofers energized).
Set the processor to **all mono mode**.
In the processor, **disable all satellite channels except L+R**.
In the processor, do not change number of subwoofers used for the DLBC calibration.
In the end, this initial configuration will be a 2.x.0 speaker layout; x = the number of subwoofers.

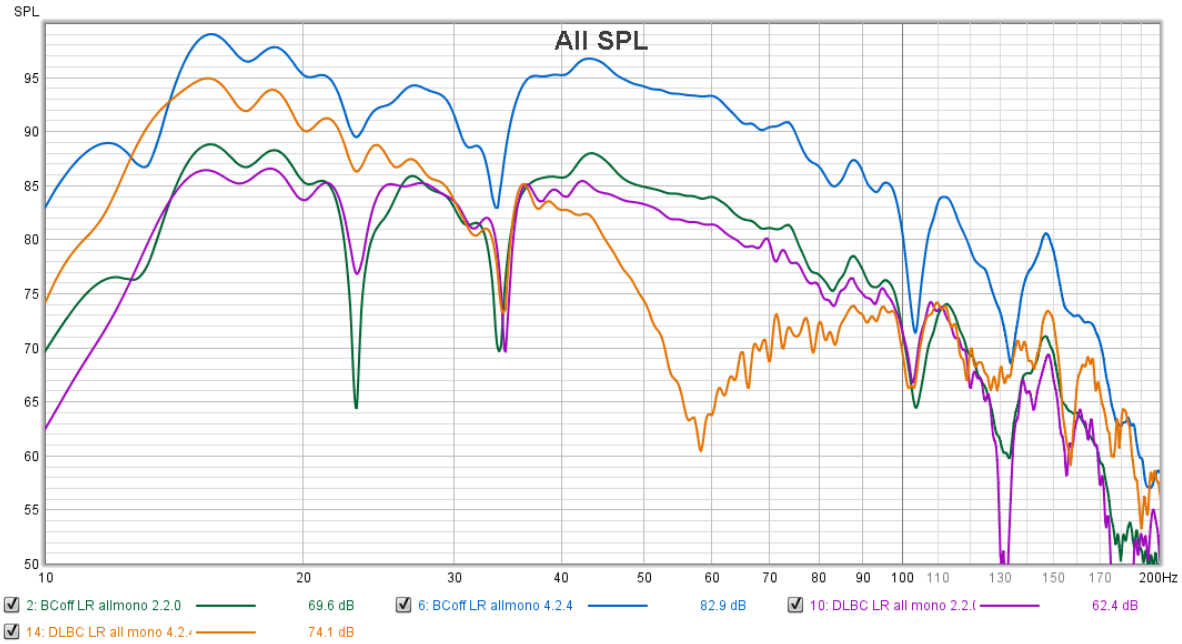
The above settings allow measurement of the bass-managed subwoofer response when the same signal is sent to all speakers simultaneously.

1. With 2.x.0 speaker layout, take one measurement with regular Dirac, and another with DLBC. These are the reference measurements.

2. Enable one other speaker or pair, and repeat measurements with regular Dirac and with DLBC. With regular Dirac, adding more speakers simply increases the SPL of the measurement across the whole frequency range, as expected. But with DLBC this was not always the case, depending on the particular speaker layout.

3. Take as many combinations of speaker layouts as needed until the issue is found.

In my case, enabling the center speaker resulted in less bass centered at around 60 Hz with DLBC. And the speaker layout that demonstrated the issue most clearly on my particular setup and calibration was 4.2.4, shown below. Comment: the center channel is not activated in 4.2.4.



In [this post], AVS Form member TimoJ confirmed he experiences this issue with his system when using a 4.2.4 configuration.

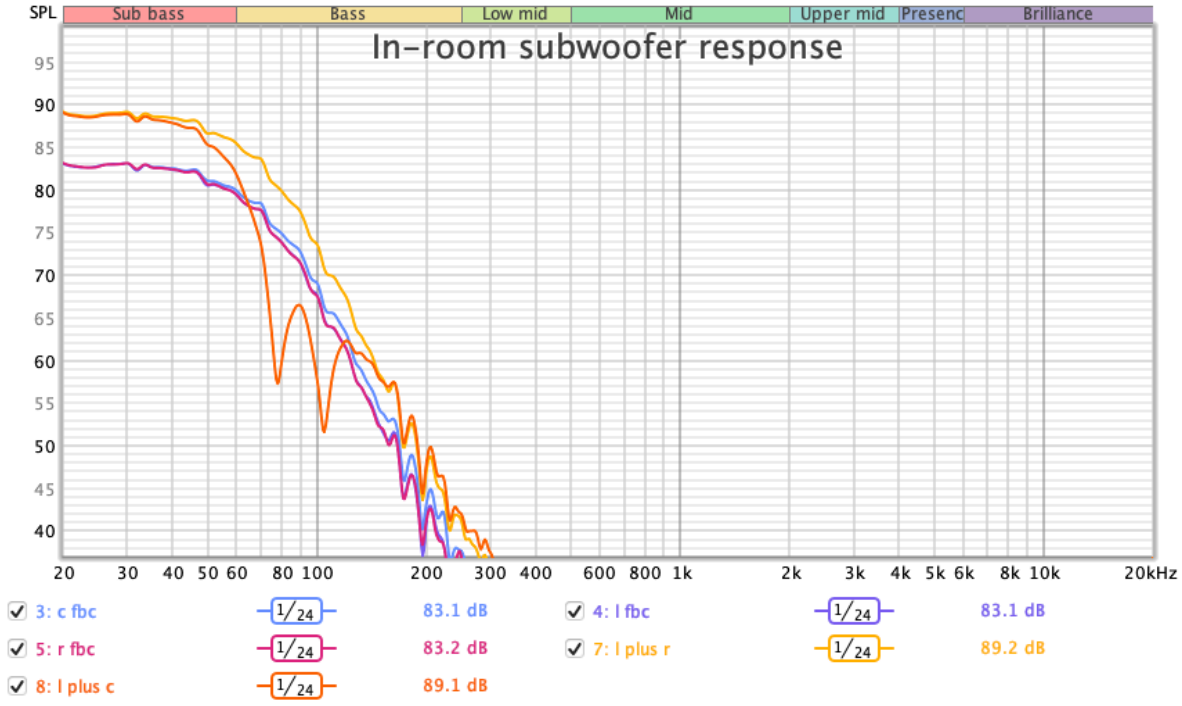
Then, in this post, AVS Forum member markus767 confirmed the issue, and provided measurements.

Looks like DLBC is applying individual all-pass filters to each redirected bass channel. This creates huge magnitude response distortions in the summed bass channel (orange trace below). Below some graphs for illustration.

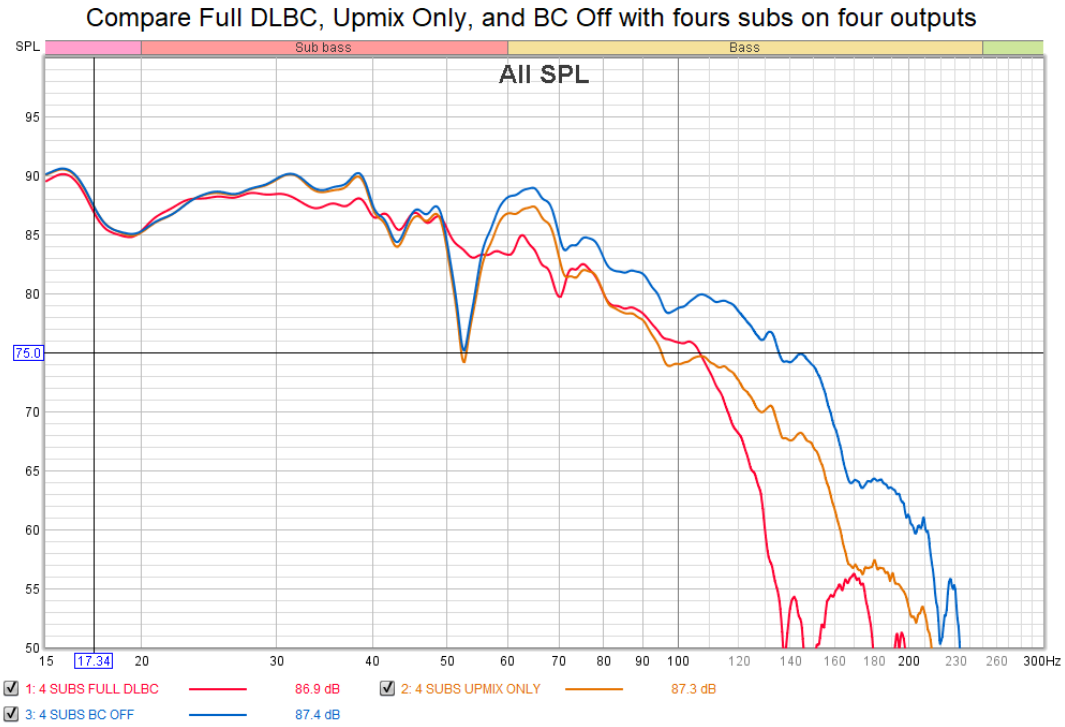
The solution to this issue is to remove the individual all-pass filters from each redirected bass channel and use (and optimize) just a single all-pass filter downstream of the bass management summing stage.

My recommendation for now is NOT to use Dirac Live® Bass Control and go back to "regular" DL or "upmix only".

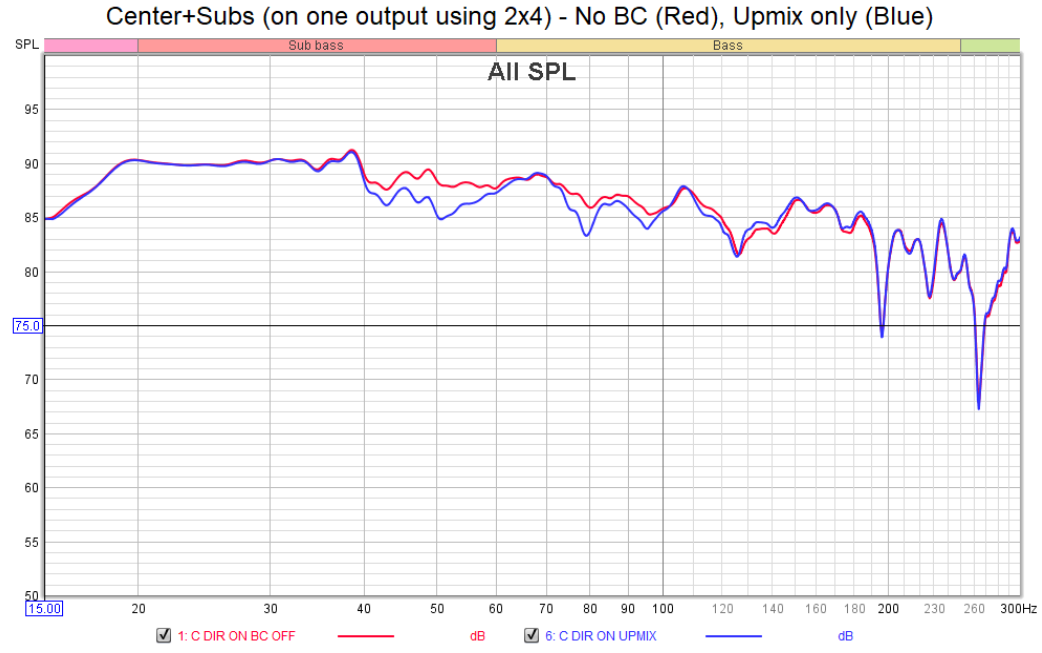
Note: Use "upmix only" when you have a single sub or single sub cluster (multiple subwoofers on a single subwoofer output) connected. Do NOT use DLBC off or "upmix only" with individual subwoofers on individual outputs as this will result in distortion similar to what is shown below.



AVS Forum member AustinJerry confirmed the issue in this post, and also posted a graph comparing confirming Markus' assertion that you should NOT use BC Off or Up-mix only when the subwoofers are connected to separate outputs:



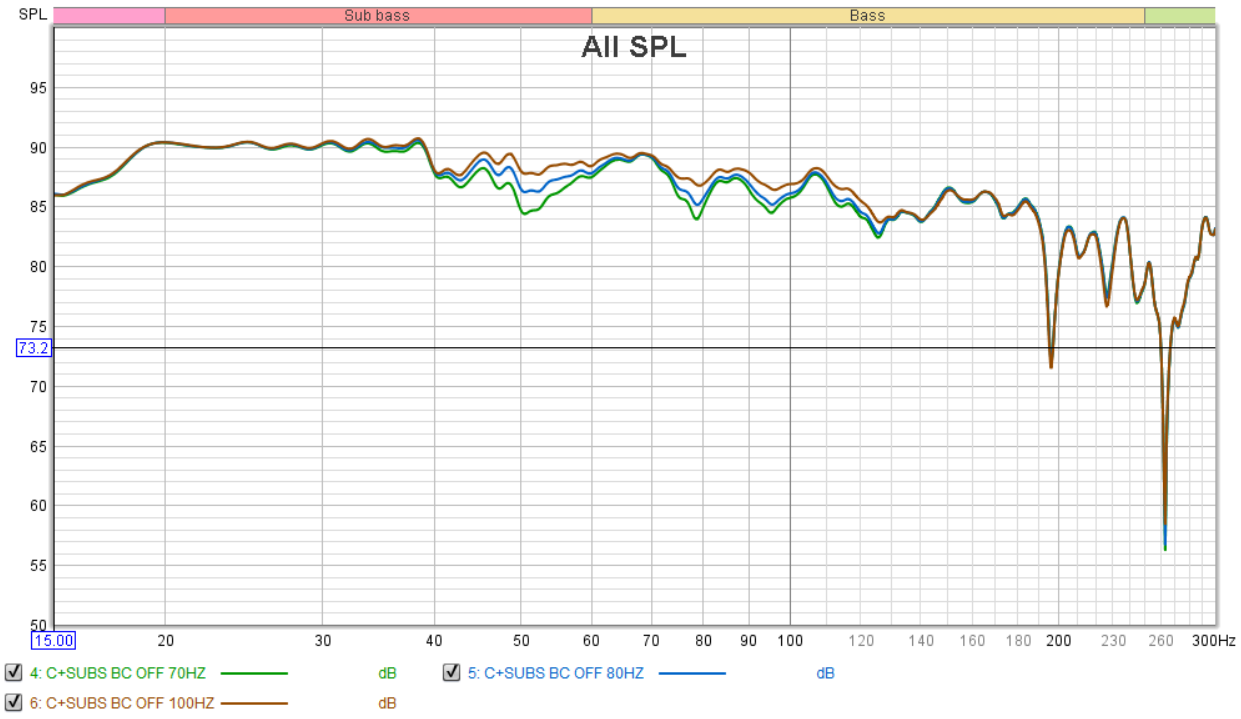
As you can see, the up-mix only and BC off options are considerably worse. Below is a measurement after removing DLBC and consolidating the subwoofers onto one output using the MiniDSP 2x4:



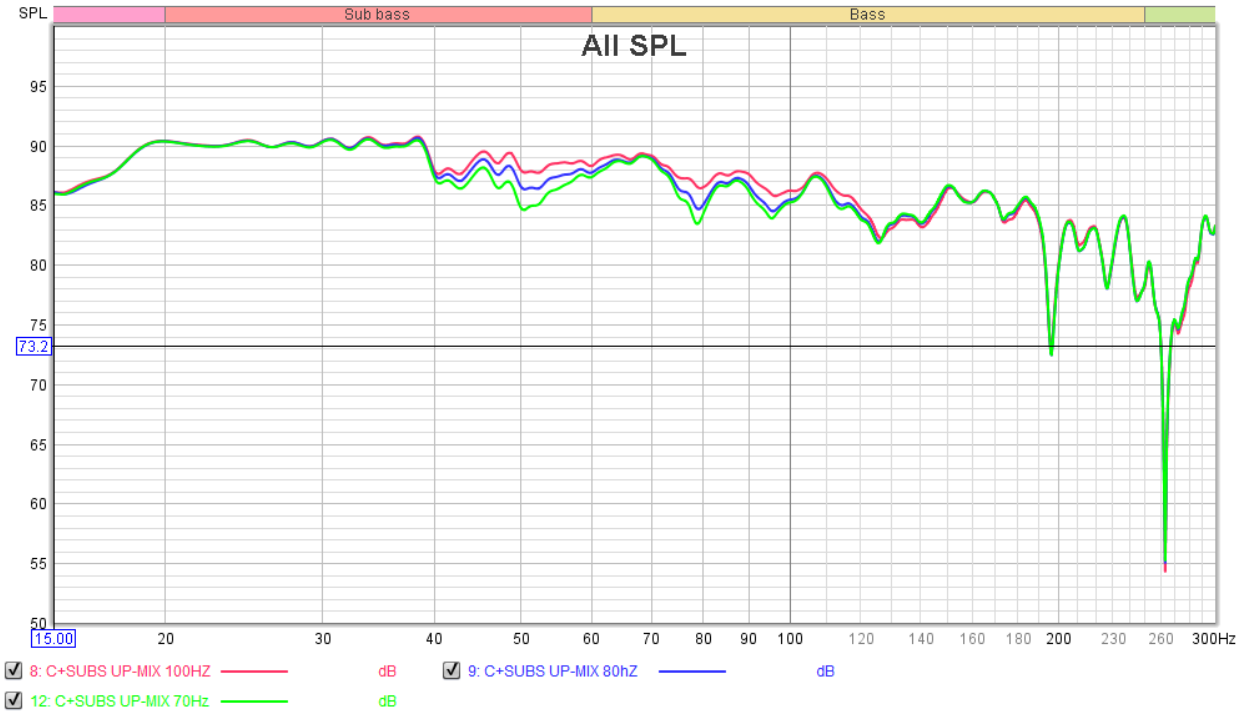
The measurement with BC Off and using the HTP-1 bass control looks to be somewhat better. Both are using a 100Hz crossover. So what would the advantage of using Upmix Only over BC Off be, if any?

The next day, Jerry performed some comparison measurements in [this post](). I wanted to run comparisons using 70Hz, 80Hz, and 100Hz crossover values for BC Off and Up-mix Only. I am **not** seeing the same differences that I reported yesterday. Perhaps I made a measurement mistake. You will see that BC Off and Up-mix Only are actually almost identical. The question remains--**is there an advantage to using Up-mix Only that is not revealed in frequency response measurements?**

Center+Subs with BC off - Crossovers @70Hz (Green), 80Hz (Blue) and 100Hz (Red).
100Hz appears to be best.



Center+Subs Up-mix Only - Crossovers @70Hz (Green), 80Hz (Blue) and 100Hz (Red). 100Hz appears to be best.



Center+Subs crossover @100Hz, BC Off (Red) and Up-mix Only (Blue). No clear favorite.

Dirac Live® Bass Control Single Sub + miniDSP

Dirac Live® Bass Control (DLBC) is correcting the interactions among single or multiple subwoofers and the main speakers. I submit that DLBC for a single sub is sufficient for a competent enthusiast with enough identical subwoofers, as long as they are properly configured. Multiple identical subwoofers can smooth out the response and eliminate the need for the DLBC Multi Sub option. This is especially important for systems that already have 15 channels, and only one subwoofer output available on a 16-channel processor, as the cost for a processor greater than 16 channels is significant.

A miniDSP 2x4 HD or DDRC-88A can be used for the multiple identical subwoofers, and those pre-optimized subwoofers can be presented to Dirac Live® as a single virtual subwoofer signal. Since there is only a single sub presented to Dirac Live®, the DLBC single sub version is sufficient to correct the phase differences between the combined subwoofer signal and the L/R speakers.

The benefit of DLBC is that it uses a combination of filters (IIR, FIR, all-pass IIR, and all-pass FIR) and delay to shift phase independently per frequency, when needed. Due to phase differences between the subwoofers and the L/R speakers, the crossover region may have peaks or nulls. Adding either IIR or FIR all-pass filters to the L/R speakers or subwoofer(s) can reduce these phase differences, which smooths out the combined response within the crossover region. All-pass filters change the phase response without changing the magnitude response: https://en.wikipedia.org/wiki/All-pass_filter.

If the goal is to EQ the sub response to be flatter, IIR filters are generally fine, as identical time-aligned subwoofers will have identical phase response for a given frequency. If you'd like to both flatten the response and flatten the phase using FIR, the maximum 4096 taps of the miniDSP 2x4 HD (@96 kHz) might not be quite enough, as noted in this thread, and this conclusion is supported by the Dirac Research White Paper – “On Room Correction and Equalization of Sound Systems” http://diracdocs.com/on_room_correction.pdf

Dirac Live® Active Room Treatment®

Introduction

The primary sources for the information in this section was from the documentation and videos that StormAudio published. The information presented here is organized into the various subject areas, and will be easier to follow versus reviewing all the source documentation and videos. Here is the source documentation.

Articles

Trinnov Reveals Details of WaveForming Redefines Low Frequency Reproduction - Audioholics

Documents

ART® Setup Guide
App. Note 1: Channel grouping and support settings
App. Note 2: Infra bass bypass
ART® – Advanced Guidelines & Tips
ART® Troubleshooting

Videos

AV Nirvana StormAudio Interview – CEDIA 2024 – 09/20/24

Trinnov Waveforming Technology Explained with Arnaud Laborie – 06/21/2023

Webinar with Dirac "The road to Active Room Treatment" – 04/11/2023

How-to make the best out of Dirac ART – 06/27/2023 Requires registration to view

How to perform a Dirac Live ART calibration – StormAudio

Dirac ART expert interview (part 1/3) – hollywoodzuhause

Dirac ART expert interview (part 2/3) – hollywoodzuhause

Dirac ART expert interview (part 3/3) – hollywoodzuhause

Dirac ART vs Trinnov Waveforming vs REW VBA – Obsessive Compulsive Audiophile

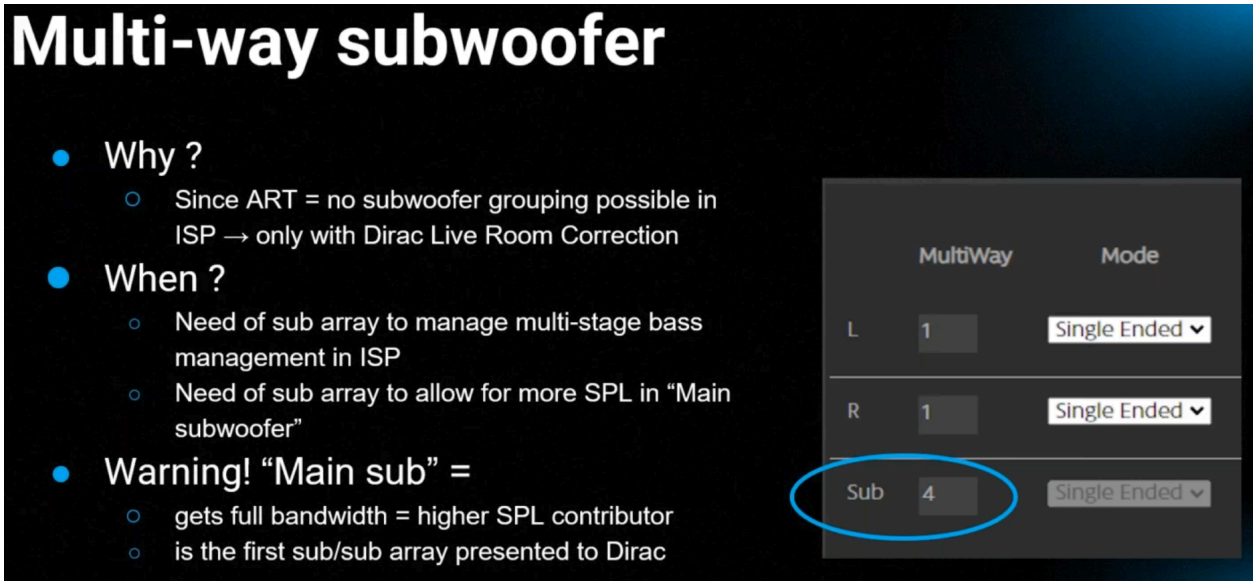
CEDIA 2023 Interview - Anthony Grimani – hollywoodzuhause, but the audio was processed by Clint Stuckey to improve audibility. The video starts at the point where the decay time is discussed, and specifically addresses the importance of the smoothness of the decay time.

Sunday Night AV Podcast (04/21/24) – Youthman interviews Mathias Johansson, Co-Founder of Dirac

Webinar How-to make the best out of Dirac ART – May 2024 Session

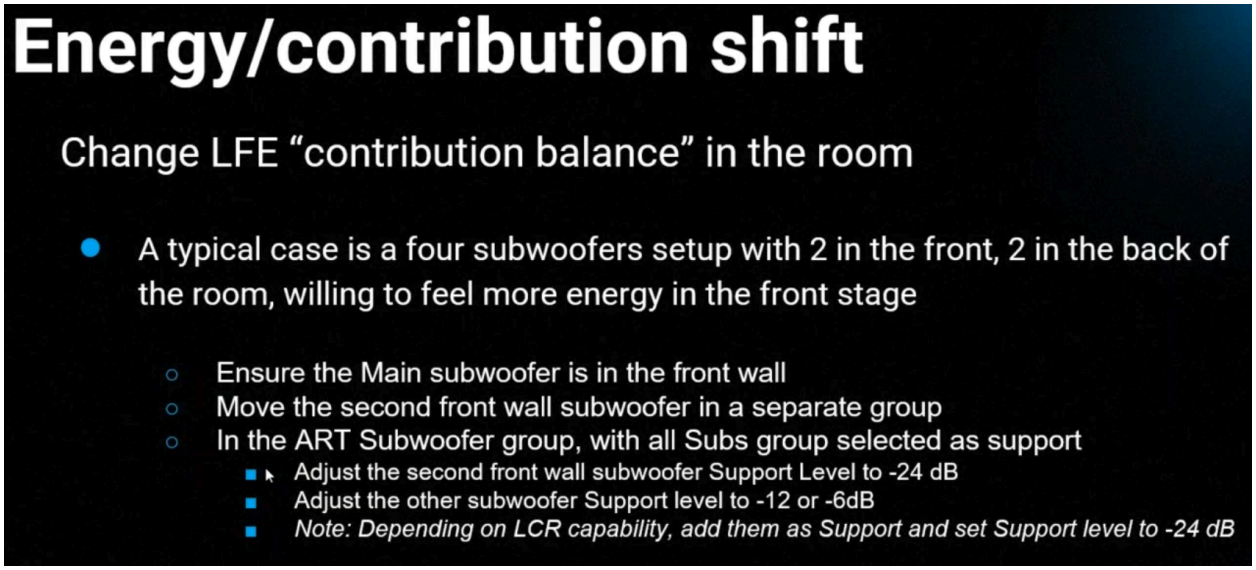
Some notes:

00:17:40 – 00:19:40 – Multi-way subwoofer is useful when subwoofers with different frequency range capabilities, or combining multiple similarly capable subwoofers for increased SPL support.

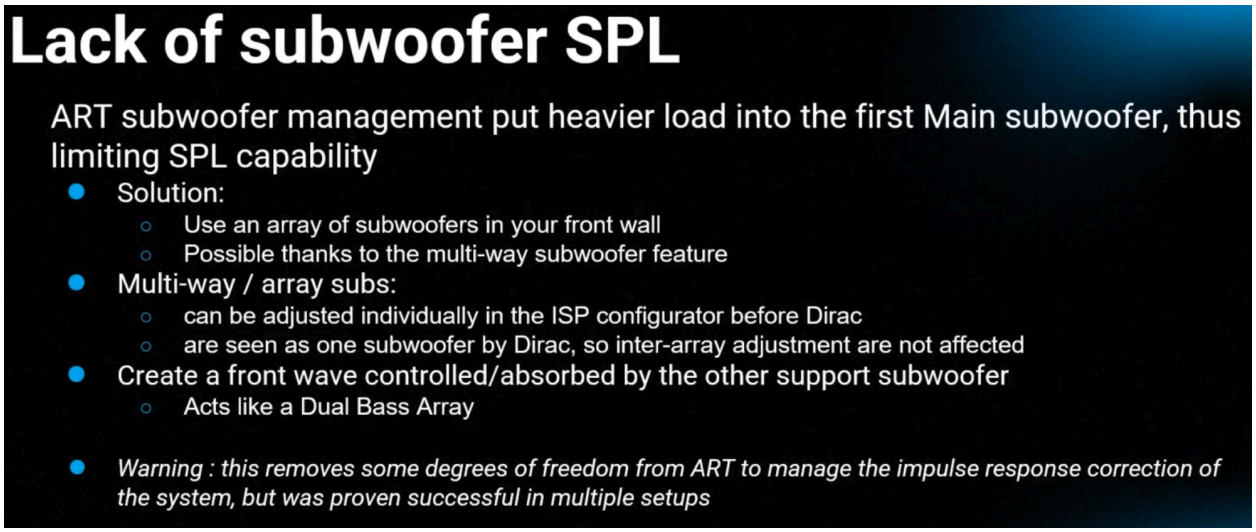


00:41:25 – 00:42:30 – Adjusting Support level to increase LFE contribution, but it also limits ARTs capability when you force it to adjust the compensation.

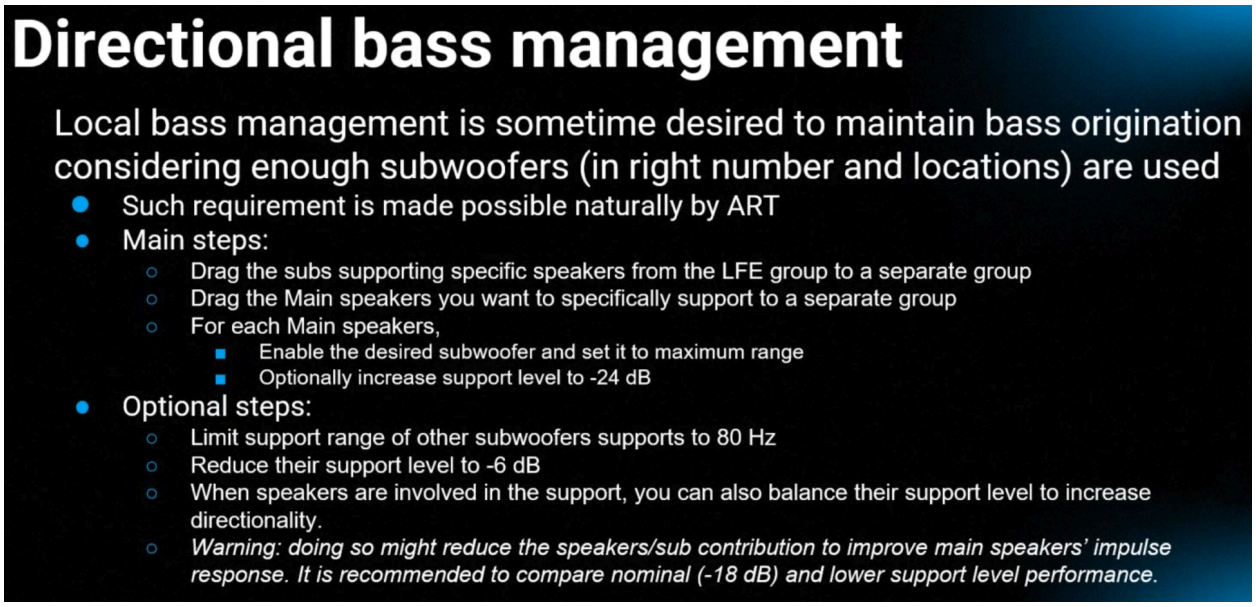
00:44:15 – 00:44:44 – Contribution Balance: Adding L/R speakers to LFE support for front wall bass wave.


Energy/contribution shift
Change LFE “contribution balance” in the room
A typical case is a four subwoofers setup with 2 in the front, 2 in the back of the room, willing to feel more energy in the front stage
Ensure the Main subwoofer is in the front wall
Move the second front wall subwoofer in a separate group
In the ART Subwoofer group, with all Subs group selected as support
Adjust the second front wall subwoofer Support Level to -24 dB
Adjust the other subwoofer Support level to -12 or -6dB
Note: Depending on LCR capability, add them as Support and set Support level to -24 dB

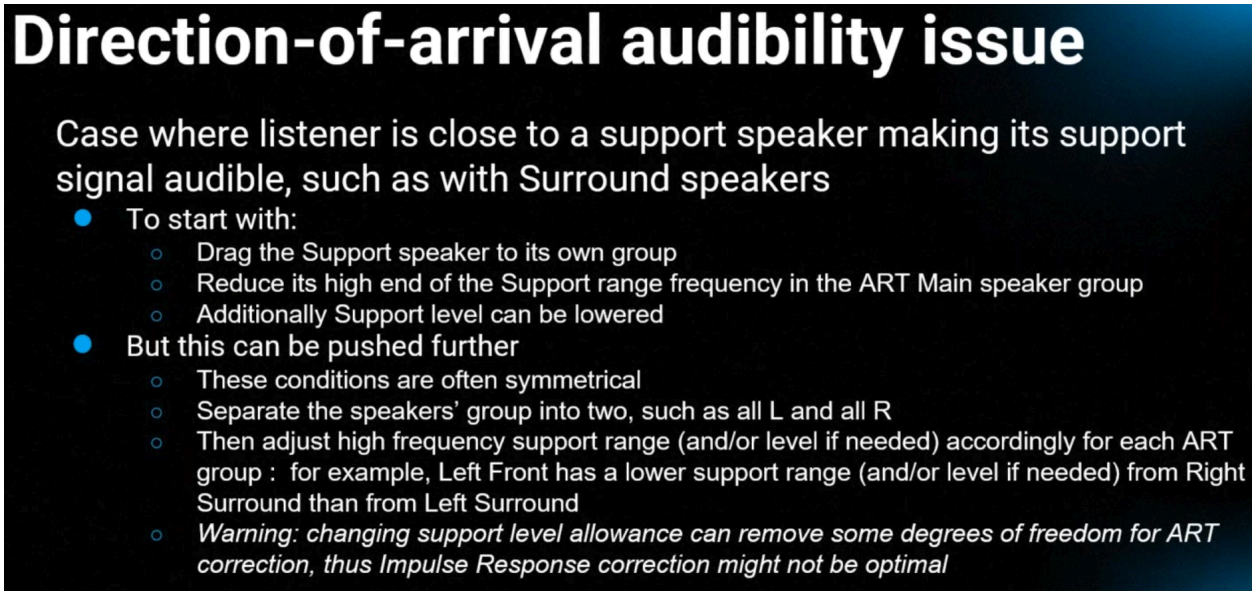
00:44:45 – 00:46:32 – Multiway subwoofers: Pre-align in ISP so they are aligned.



00:46:44 - 00:49:20 – Directional bass management: Compare nominal (-18 dB) and maximum 9-24 dB) support levels.



00:50:574 - 00:52:41 – Direction of arrival audibility:



01:09:45 – 01:12:20 – Q&A: Target curve vs speaker adjustment:

01:15:00

HCFR Podcast StormAudio Dirac ART – 05/22/24 Video is in French but you can set YouTube to translate and show the captions. Here are my notes that have been incorporated into this document where relevant.

At this time stamp, Sebastien from StormAudio is discussing why ART has not been released on other platforms; it was basically the measurement issues. He goes into detail on what they learned by working closely with Dirac. As I had opined previously, if this had been released with their shit-show software in the last year to D&M, it would have destroyed Dirac's reputation, and probably also the company financially.

At this time stamp, top speakers should only be supported by the base layer, as the difference in frequency between what the top speakers normally reproduce and the upper frequency of the subwoofers may be different. If the top speakers are capable of reproducing sound down to 80 Hz as measured at the listening position, then it may make sense to have the subwoofers support the top channels.

At this time stamp, it is recommended to do not allow the base layer speaker support the LFE group, unless the following applies:

- The LCR speakers have sufficient output capability down to 40 Hz so they can contribute significantly to pack a punch along with subwoofers on the front wall.

- If you have subwoofers on the side or rear walls, there may be a benefit in having the base layer speakers near the subwoofers support them, again, if the given speaker can contribute significantly to pack a punch along with subwoofers. The support provided to a given subwoofer should be to a nearby speaker, so that there is no localization.

At this time stamp, the balance is discussed, and the adjustment of F-Support Low, F-Support High, and Support Level. Support level equates to a lower negative number as greater support. F-Support Low is the cutoff frequency of the speaker. Separate the speaker groups in to matching model speakers.

At this time stamp, subwoofer capabilities are discussed. When using dissimilar subwoofers, and if the front subwoofers can sufficiently provide enough satisfactory SPL, then the other subwoofers should have their support reduced; for example, -6 support level. For subwoofers of the same capability, you can adjust support levels as desired.

At this time stamp, if adding the LCR to the front subwoofers, set them between -18 (default) to -24 (maximum) for a pressure wave from the front.

At this time stamp, if there are subwoofers all around the room, then you can create directional bass by separating all speakers into individual groups, vice the L/R pairs.

At this time stamp, if localization occurs due to speakers in close proximity to the listener, try lowering the frequency first, and then the support level, if necessary, to eliminate the effect.

At this time stamp, creating the individual speaker groups may limit ARTs ability to utilize the speakers in a uniform manner. Using different profiles with different calibrations may be desirable.

At this time stamp, the multi-way subwoofer option can create a bass array that has the front subwoofers acting together (verify with REW first), and the rear subwoofers cancelling.

At this time stamp, it is recommended to perform some pre-calibration work to know the native response of the LCR and LFE channels.

At this time stamp, it is cautioned that making post ART PEQ correction is not recommended due to the precise linear phase adjustment.

Unlocking the Secrets of Dirac ART's Future Potential – Poes Acoustics

What is ART®

Dirac Live® Active Room Treatment® (ART®) features industry-leading Multiple Input Multiple Output (MIMO) mixed-phase impulse response correction. Calibrate your speakers as a unified system, using the capabilities of each speaker to actively cancel out lingering bass and reduce room decay time. This leads to unmatched clarity and a larger, more uniform “sweet spot”, and reduces the need for in-room acoustical treatment.

Keep in mind that ART® processing is a mathematical concept. Just as with a mathematical equation, if the tool is given bad information, you will therefore experience a bad result. Reminder on what a Dirac Live® ART® calibration is made of:

1. Below 150Hz, Dirac-ART® aims to correct the direct path of speakers and some of the room reflections with the help of other supporting speakers.

2. Above 150Hz, a “classic” Dirac-Live correction is applied to speakers.

With traditional crossovers or bass management, the signal is simply cut in two parts and spread between a speaker and the subwoofers. ART® works differently, as the signal below 150 Hz is spread over the speakers and its supporting speakers to achieve a targeted direct path, phase, magnitude response, and room reflections removal.

Based on the defined target curve, this allows for additional degrees of liberty by creating:

- Filters for the speaker covering the full frequency range.
- Filters for the support speakers covering the ART® support frequency range.

At the StormAudio Dirac tech talk at MWAVE 2024, Matthew Trinklein mentioned the filter tap count on StormAudio allows finer filter resolution than competing products. The amount of filter taps on StormAudio is 3,076. The next product down in the count has 1,554, and most products have 1,100.

At CEDIA 2024, Gary Blouse from StormAudio discussed StormAudio’s implementation of Dirac Live, and the major differences between StormAudio and other products, during this video interview with AV Nirvana. Some notable information from the video is that:

The difference in StormAudio’s Dirac implementation is that they write their own code at this time stamp.

The application of separate ARM core processors for Dirac Live; there is one 1 processore on the base models, and 2 on the top models at this time stamp.

The specific application of the filter taps at this timestamp.

Trinnov® Waveforming®

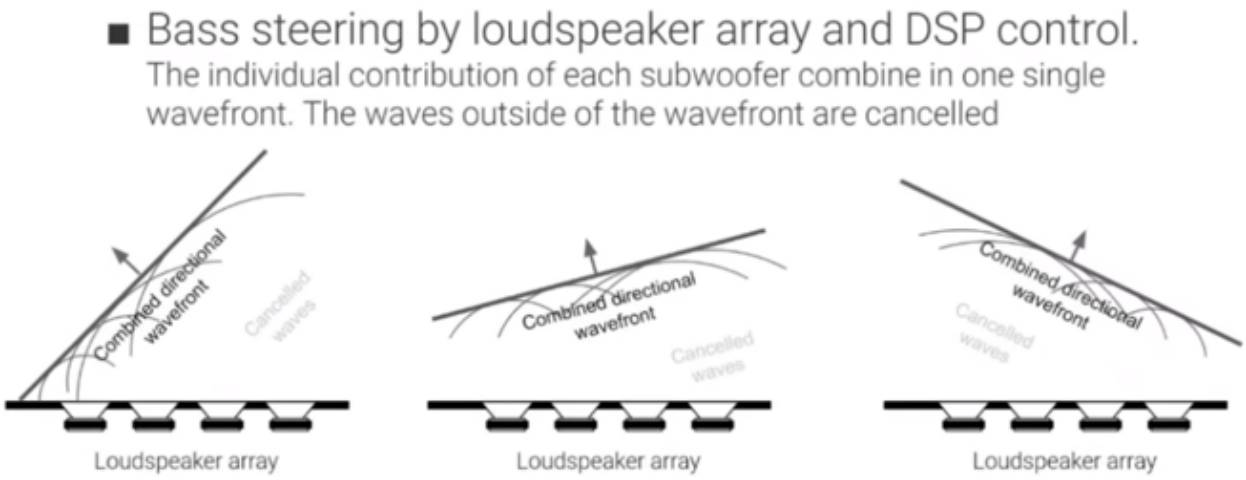
The Trinnov® Waveforming® technology uses Multiple Source Multiple Controller (MSMC), vice the MIMO mixed-phase impulse response correction in Dirac Live® ART ®. MSMC is a comprehensive approach that combines both preventative and curative methods of correction to achieve optimal performance. By leveraging the steering method and active cancellation, MSMC effectively addresses the most challenging acoustic issues while avoiding the creation of problematic conditions in the first place. This concept originated with the introduction of Double Bass Arrays (DBAs), which have long been recognized for their ability to produce superior bass in room environments.

Waveforming® and MSMC is more advanced due to a greater understanding of the 3D space. The Trinnov® 3D acoustics processing and allowance for a greater number of measurements in the room results in a greater understanding of the position of the listeners, loudspeakers, and subwoofers in the room.

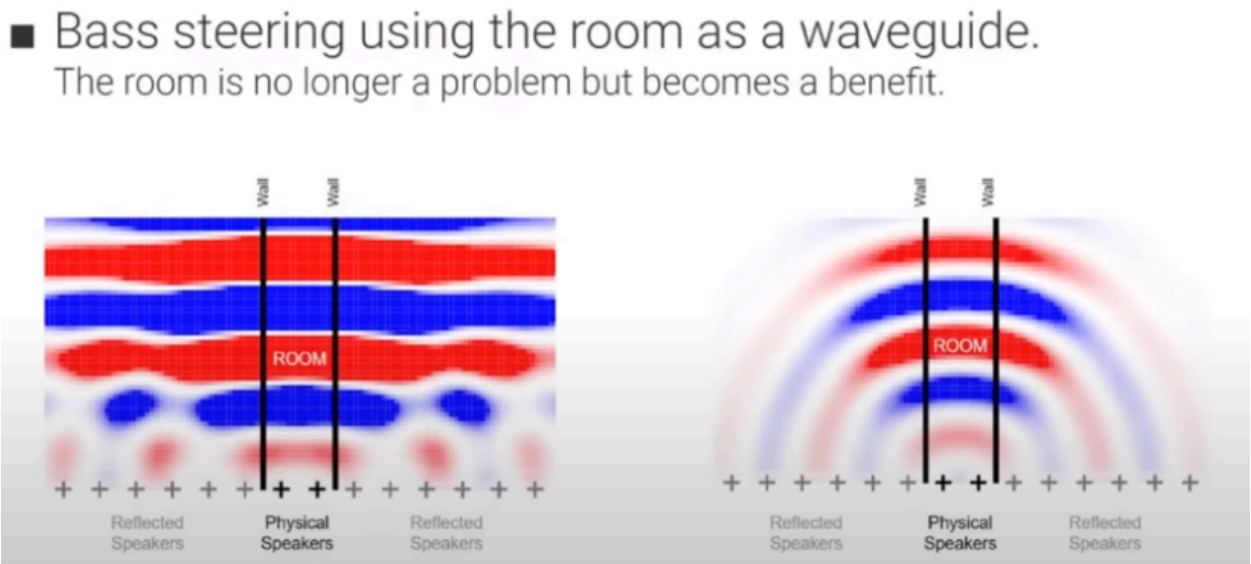
Despite the differences in the two solutions, both Dirac Live® ART and Trinnov® Waveforming® are using loudspeakers as active absorbers. Therefore, the reason for discussing Trinnov® Waveforming® is due to the information below that also helps understand Dirac Live® ART.

For a detailed explanation of the process used in the Trinnov® Waveforming® technology See Trinnov Waveforming Technology Explained with Arnaud Laborie video. Waveforming® uses Acoustic control by bass steering, using loudspeakers and subwoofers in arrays of at least two to control directivity, as detailed at this specific time stamp in the video.

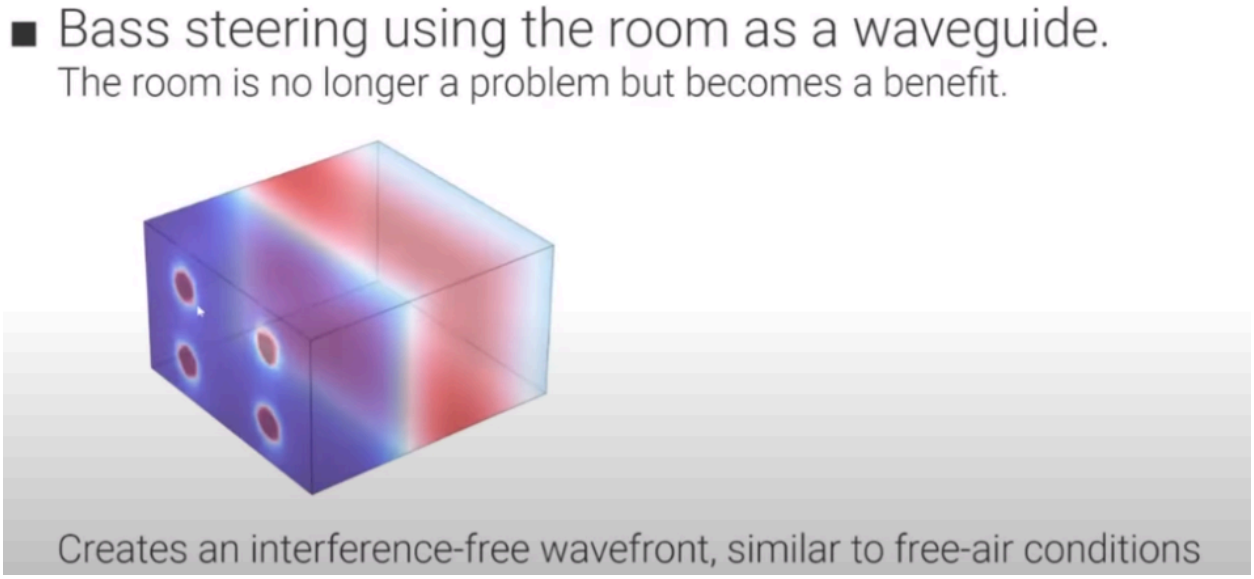
The below graphic is a representation of how the wavefront can be steered.



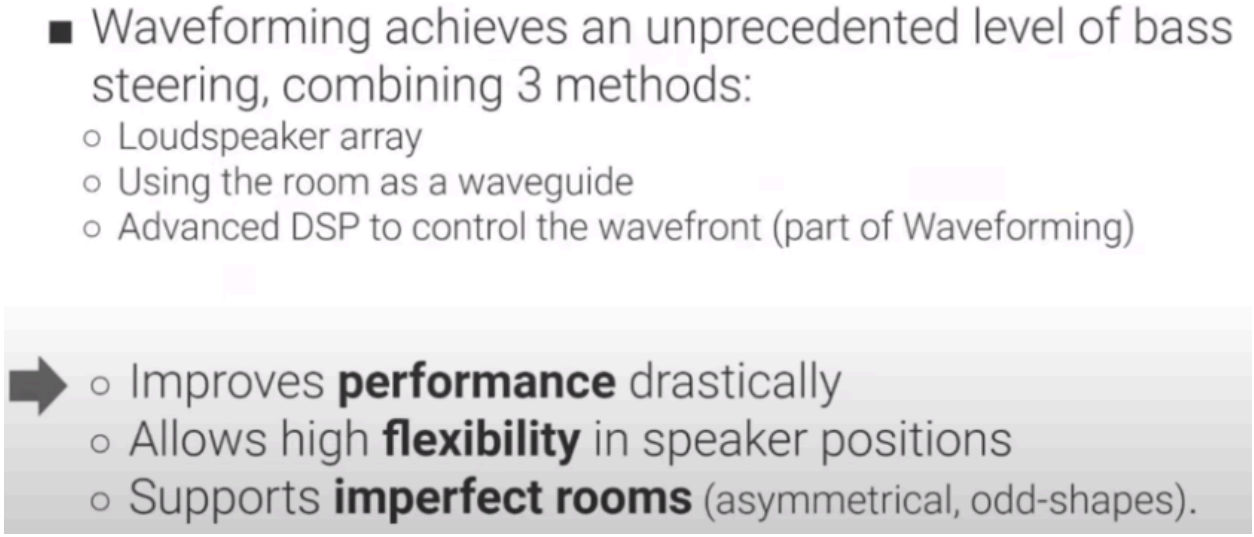
The below graphic is an example of using the room as a waveguide



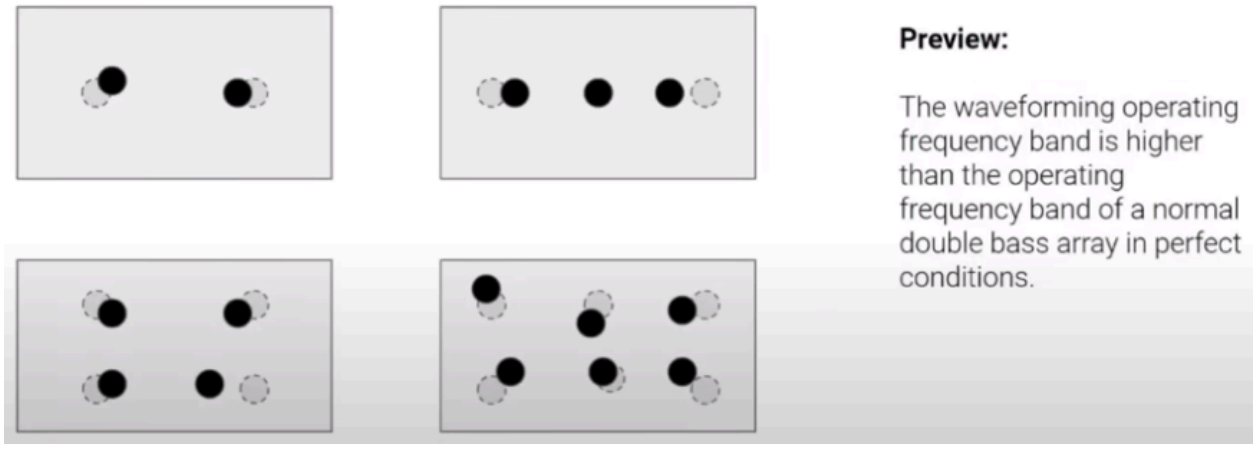
The below graphic uses one example with four subwoofers on the front wall to create a perfect wave front and uniform soundfield without any other interference is discussed at [this time stamp] in the video.



The below graphic highlights the overall benefits of Waveforming.

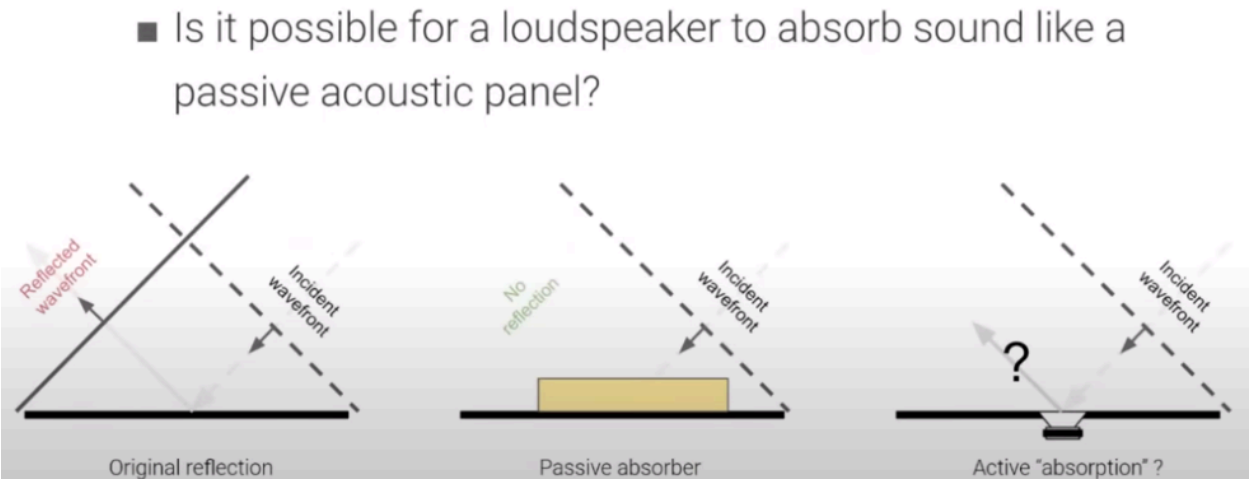


The below graphic illustrates differences between and higher performance of Waveforming versus a Double Bass Array, and discussed at this time stamp in the video.

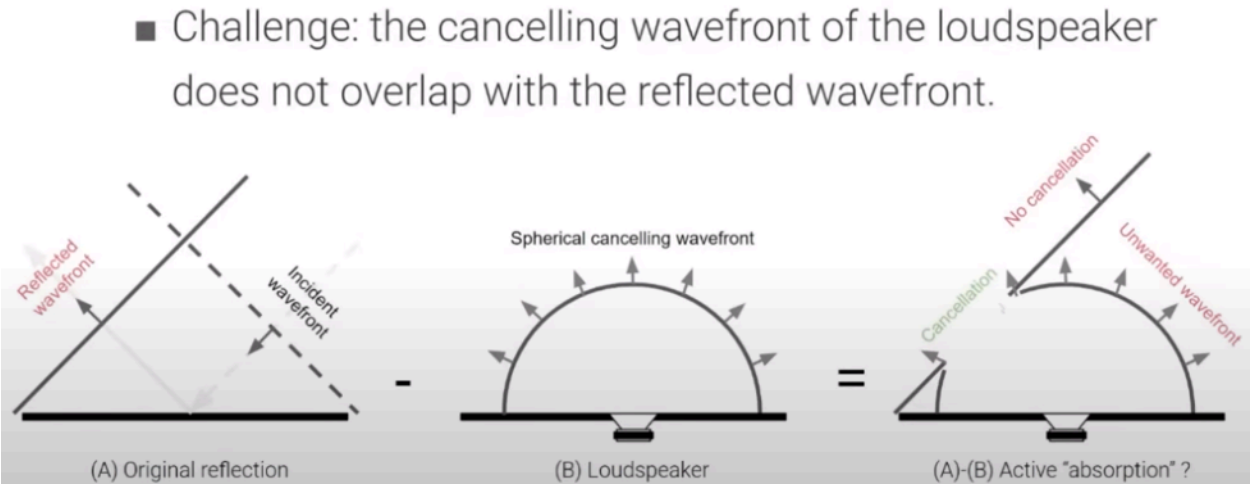


Both Dirac Live® ART and Trinnov® Waveforming® are using loudspeakers as active absorbers. The concept is discussed starting at this time stamp in the video.

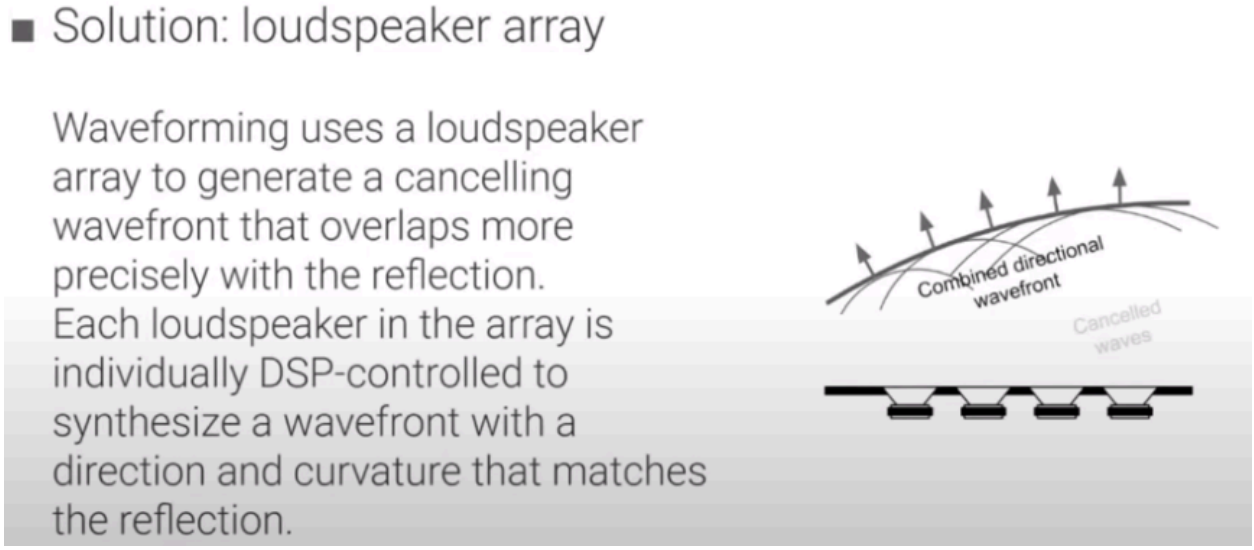
The below graphic illustrates the challenge of using loudspeakers as active absorbers, and is discussed at this time stamp in the video.



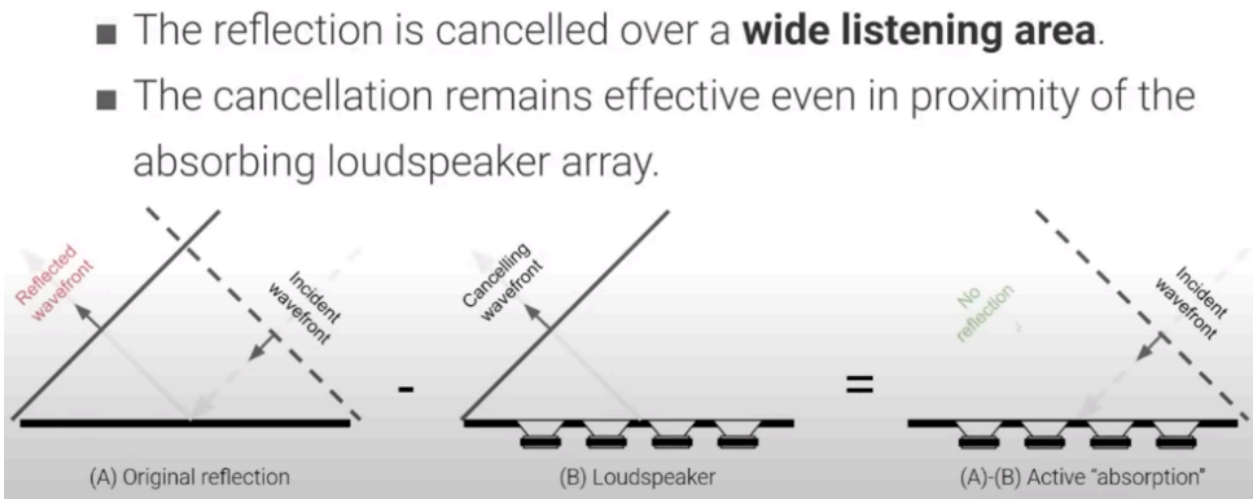
The below graphic illustrates the challenge of cancelling a planewave with a spherical wave using loudspeakers, and is discussed at this time stamp in the video.



The below graphic illustrates why an array (minimum of two loudspeakers), provides the control needed to invert and control the reflection using loudspeakers, and is discussed at this time stamp in the video.

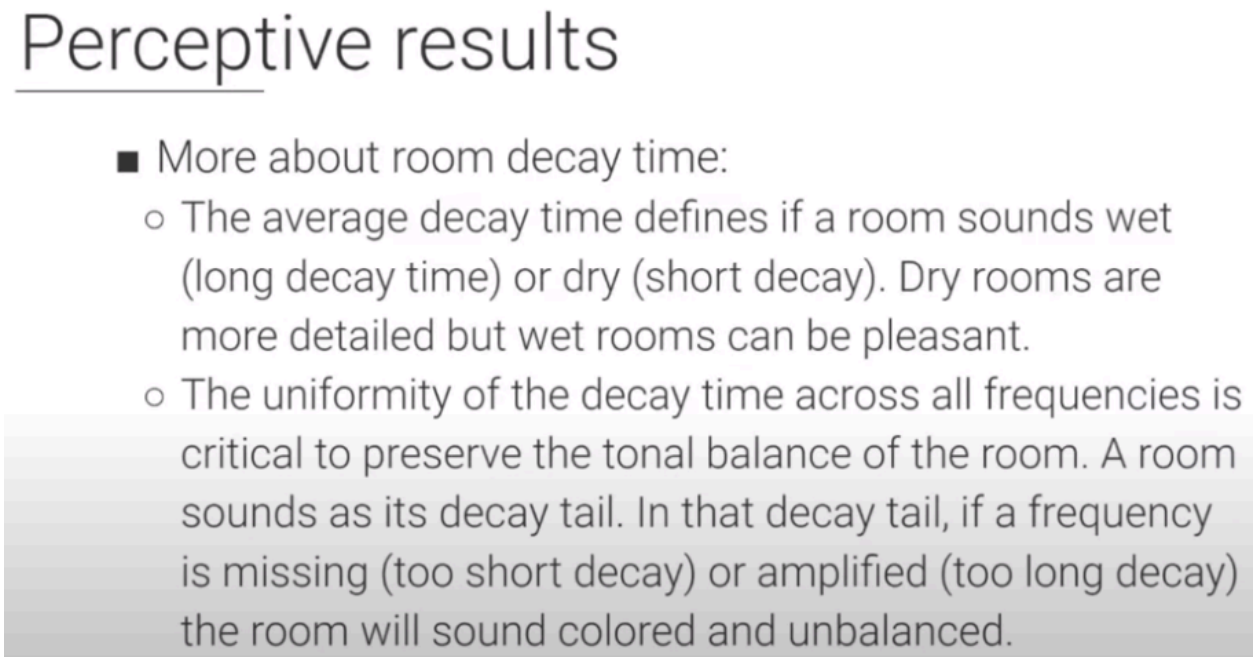


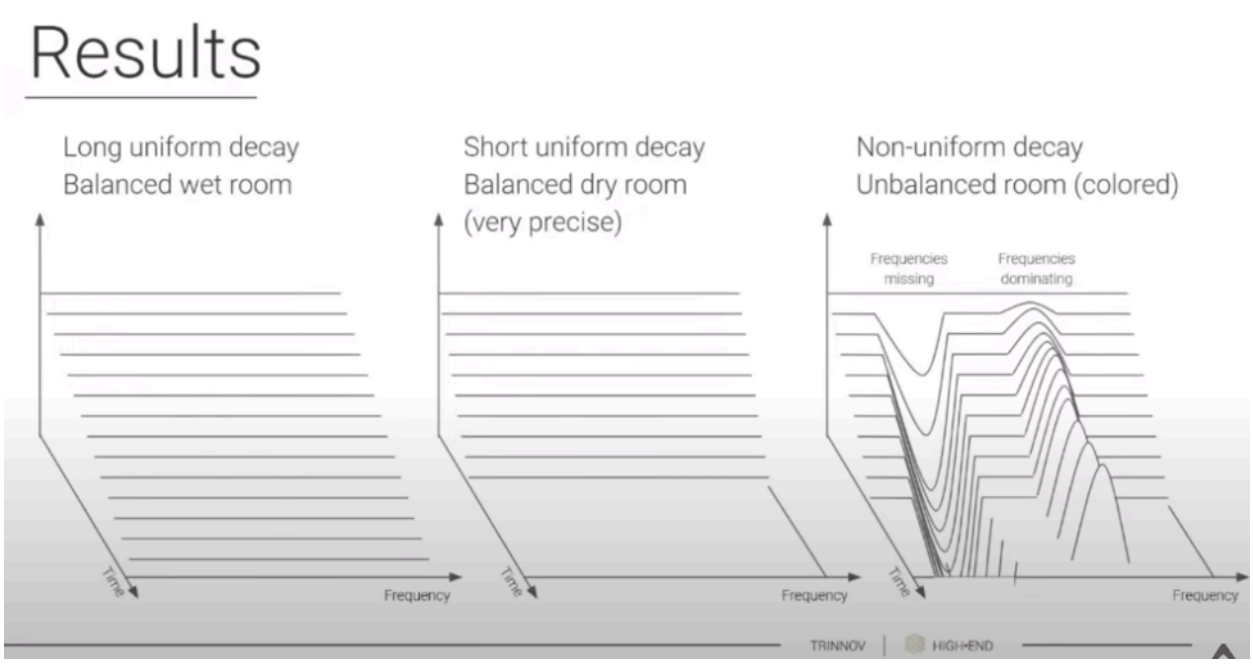
The below graphic illustrates the inversion and removal of the wavefront using loudspeakers, and is discussed at this time stamp in the video.



Reducing Decay Time

The below graphics illustrate the overall goal of both Dirac Live® ART® and Trinnov® Waveforming®, which is a uniform decay time, as discussed at this time stamp in the video.





Integration of Active and Passive Acoustics

As noted in this article by Matthew Poes, passive room treatments are still crucial, especially in the critical 100 – 150 Hz range. Active absorption methods are far superior in dealing with bass damping at lower frequencies. However, while active absorption can operate well above 80hz, each technology will have certain limitations. For Dirac Live® ART®, it will be limited by the number, position, and low-frequency capability of the speakers and subwoofers. For Trinnov® Waveforming®, it will be limited by the spacing of the woofers in the array and the crossover point.

Given the limitation of the active absorption methods, the goal should be to achieve a suitable overlap in active and passive absorption in the critical 100 – 150 Hz range. Using 4" passive absorbers, optimized for maximum efficiency within the 100 – 150 Hz range can provide significant benefits.

Compared to 4" passive absorbers, 2" passive absorbers are not particularly effective, exhibiting inefficiency at lower frequencies. For example, a 2" passive absorber will have effective absorption down to 300Hz, then start gradually diminishing. At 125Hz, the absorption coefficient of the 2" passive absorber is approximately 0.2, which is relatively low. However, with sufficient surface area, a 2" absorber can still contribute to overall absorption at 125 Hz. Therefore, 2" passive absorbers may require a greater area than mid and high frequency absorption.

Therefore, it is not sufficient to simply hang panels on the wall and consider the job done. Careful selection of absorbers is necessary, with a focus on critical concentration of absorption at the crossover region.

How ART® works

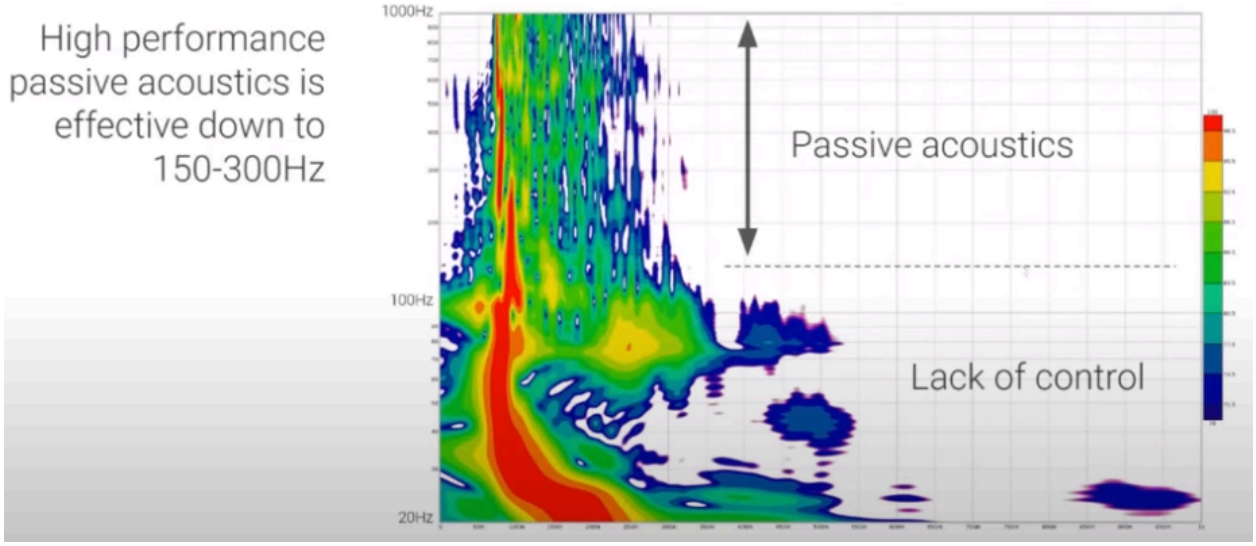
Since crossovers are no longer used with ART, every speaker is essentially "Large" and receives the full-range signal. How you configure it determines the lowest frequency it will receive.

When you support a given speaker group (however you determine to configure the group), you choose which other groups support the given speaker group, and set the FSL frequency, as the lowest point for support. If you happen to choose subwoofer(s) to support the given speaker group, then the measured low frequency of the subwoofer(s) will determine the lowest frequency it will receive.

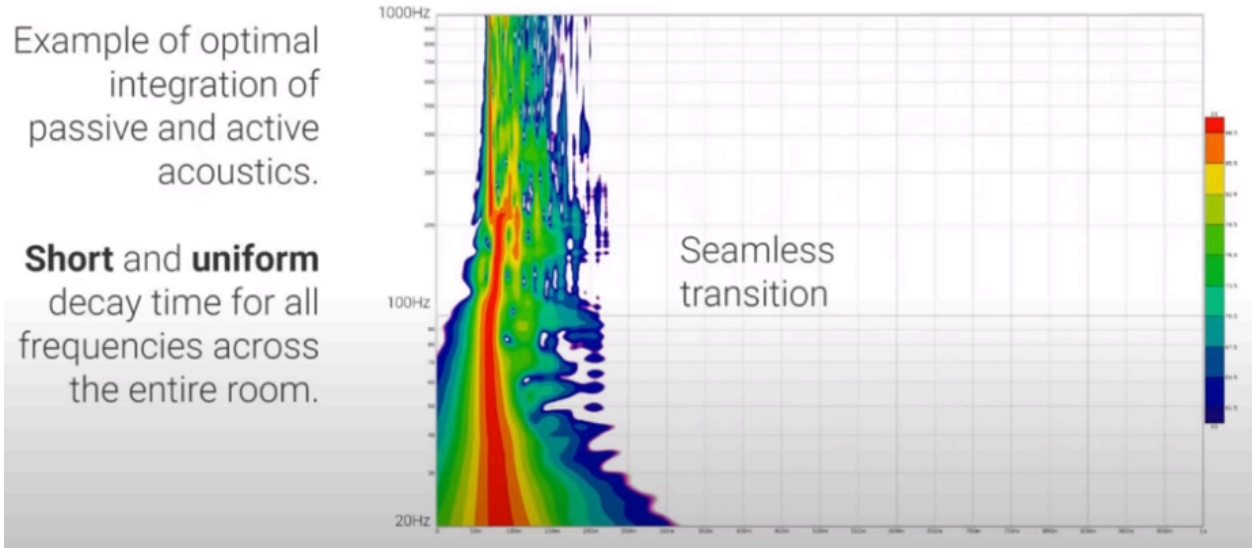
The discussion about the integration of active and passive acoustics in a room was discussed starting at this time stamp in the video

The below graphics illustrate the benefits of the integration of active and passive acoustics, as discussed at this time stamp in the video.

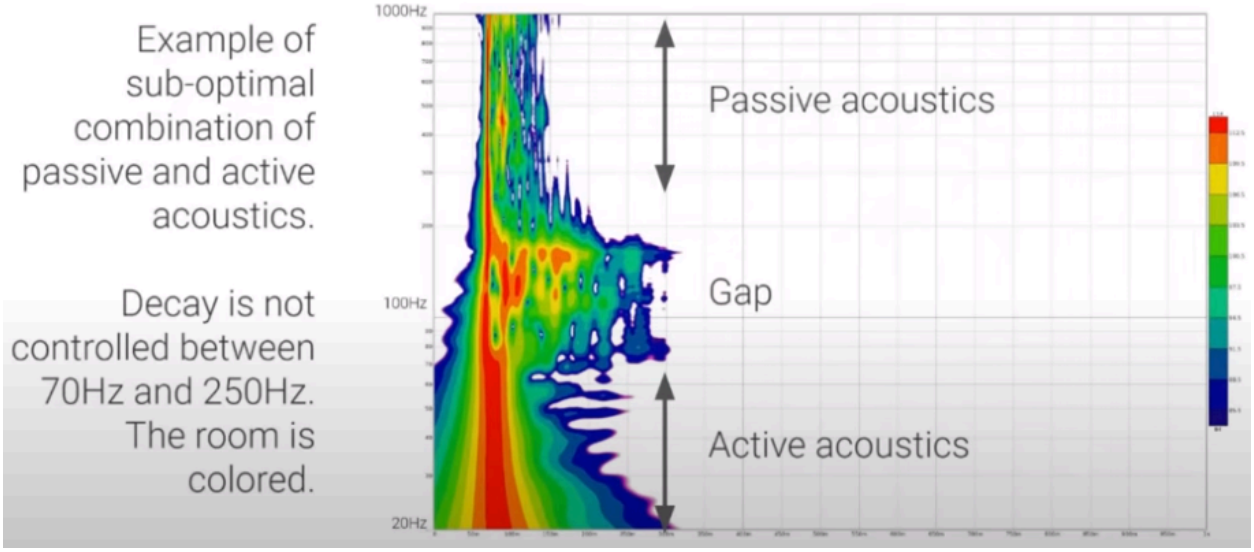
The below graphic illustrates the range of control (100 – 1,000 Hz) of typical passive acoustics.



The below graphic illustrates the result of using both active and passive acoustics.



The below graphic illustrates the result of using only passive acoustics, but sub-optimal in that they do not provide sufficient control down to 100 Hz.



Pre ART® Calibration

Introduction

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: It is recommended to perform some pre-calibration work to know what the response of the LCR and LFE channels.

It would also be beneficial to take near-field measurements of all base layer and top speakers in the room to inform the selection of the F-Support Low setting, rather than relying on the manufacturer specifications.

If concerned about damaging speakers, an HPF can be placed in the StormAudio EQ prior to running Dirac Live.

ART® Tips Overview

There is a lot of information below, and while key information is emphasized with highlighting, bold text, or red text, some of the most important information to consider during filter design is captured in this section for ease of reference.

Grouping Channels

Turns on or off the channels of the group supporting the input channels of the ART® group. i.e., the speakers in this group will act to support the speakers in this group. The use of this parameter depends on your specific speaker grouping. When adjusting this setting, it's important to consider the F-support High parameter in each group to achieve the desired effect.

While all speakers in a group share the settings, each speaker will be treated independently, and have their own filters for ART® support and Dirac Live® correction based on the measurements.

To customize the ART® settings to the specific capability of a speaker or subwoofer, separation into different groups is the first step. It is better to have an overlapping support frequency range between speakers instead of relying on a single group to manage a support frequency range.

Separating each speaker into its own group will utilize less filters and result in a more targeted approach by using only the speakers required to support a given group. For example, typically the base layer surround and back surround speakers are identical and would therefore be grouped together (4 speakers in one group). By splitting each of these speakers into their own group, it allows the end user to use the left surround to support the right surround, versus being forced to use all four surround speakers to support the right surround. While this approach is a lot of work, as the ART parameters now have to be adjusted in more groups, it might be worth the effort if you have the patience.

Using only the subwoofers – and if needed the front left and right speakers – to support the LFE Main channel usually results in focused LFE with adequate alignment. If the alignment is not satisfactory, consider changing the default support level settings. However, changing the support range should be carefully considered.

For example, if a 120 – 150 Hz support range was defined for L & R, the optimization would likely be poor for this limited support range, as ART® will add a Low-Pass filter at 120 Hz, and a High-Pass filter at 150 Hz for the support speaker signals. These filters would constrain the correction needed in the below 150 Hz. Provide ART® the most latitude to work properly, while staying within the frequency range capabilities of the speakers.

ART® Parameters

Fsiso

Fsiso (50-150 Hz) is the maximum frequency where speakers can support each other. Above this frequency a regular Dirac Live® correction will be applied. This critical parameter that acts like a crossover frequency in a bass-managed system. The goal is to find the highest Fsiso value for your system that still provides a great result. Lower Fsiso values are more robust but offer less benefit, while higher values provide more benefits but may reveal supporting speakers in the output. The Fsiso level must be ≤ the highest F-support High frequency of any support speaker.

Speaker Group Support

Turns on or off the channels of the group supporting the input channels of the ART® group. i.e., the speakers in this group will act to support the speakers in this group. The use of this parameter depends on your specific speaker grouping. When adjusting this setting, it's important to consider the F-support High parameter in each group to achieve the desired effect and to prevent revealing support speakers in the final result. If the LFE channel requires the support of speakers, it is recommended to reduce the F-support High frequency of the supporting speakers to match the F-support High frequency of the subwoofers.

There are a limited number of filters to apply to ART. As you select channels to support a channel group, the total filter count will change in the lower right corner of the Dirac Live® tool. The priority order below will maximize the ART® filter usage.

ART® Speaker Group Priorities

1st Priority - LFE Group

The goal is to provide focused LFE with a good feeling of alignment, and minimize the chance of localization above 80 Hz. Experimentation is encouraged with the default support range and support level settings. If there are subwoofers all around the room, then you can create directional bass by separating all speakers into individual groups, vice the L/R pairs.

In this specific time stamp, it is recommended to not allow the base layer speaker support the LFE group, unless the following applies:

- The LCR speakers have sufficient output capability down to 40 Hz so they can contribute significantly to pack a punch along with subwoofers on the front wall. Set the Support Level between -18 (minimum) to -24 (maximum) for a pressure wave from the front.

- If you have subwoofers on the side or rear walls, there may be a benefit in having the base layer speakers near the subwoofers support them, again, if the given speaker can contribute significantly to the subwoofers. The support provided to a given subwoofer should be to a nearby speaker, so that there is no localization.

- If the subwoofers do not have sufficient output between 120 - 150 Hz, and the base layer speakers have sufficient output to provide support. Again, localization is a key factor, so providing support from nearby speakers is recommended.

The StormAudio multi-way subwoofer option can create a bass array that has the front subwoofers (or any other optimized group of subwoofers) acting together and the rear subwoofers cancelling. The grouping requires verification with REW prior to implementation. When using dissimilar subwoofers, and if the front subwoofers can sufficiently provide enough satisfactory SPL, then the other subwoofers should have their support reduced; for example, -6 support level. For subwoofers of the same capability, you can adjust support levels as desired.

2nd Priority - Front L & R

All subwoofers should support the front L & R, followed by the other base layer speakers at ear level as needed. Base layer speakers are typically more capable than height or top speakers. However, adding more base layer speakers can have detrimental effects. See the post-Dirac analysis section for details.

3rd Priority - Center Speaker

Only the subwoofers and the front L & R as support for the center channel. Do not use Infra bass for the subwoofers supporting the center channel. Do not allow the center to support any other speakers.

4th Priority - Surround speakers

All subwoofers should support the surround speakers, followed by the other base layer speakers at ear level.

5th Priority - Height and Top Speakers

Height and Top speakers can use any of the available base layer speakers as support. However, it is recommended to exclude L, C, R as support. Using the subwoofers as support requires some further consideration, as the difference in frequency between what the top speakers normally reproduce and the upper frequency of the subwoofer range may be different.

If the Dirac Live tool measures the height / top layer speakers ≤ 80 Hz, then the subwoofers can provide support. If the Dirac Live tool measures the height / top layer speakers ≥ 80 Hz, then as long as the subwoofers can support up to this measured lower-level frequency, then the subwoofers can support them.

Support Level

Support level (-24 to -1) determines how heavily a speaker is used by the algorithm by controlling the amount of support the support speakers provide to the main speaker. -1 dB will contribute a minimal amount, -24 dB will contribute a maximal amount. Support level determines how heavily a speaker is used by the algorithm. To balance speaker usage and avoid distortion, change the support level values according to the position of speakers in the room. This helps in achieving the desired output without overloading specific speakers. I was in the JTR Speakers room at MWAVE 2024 when Matthew Trinklein from StormAudio was calibrating, and he recommended the following Support Levels:

Front L, C, R, and Wide speakers: -5 dB.
Base layer surround speakers: -9 dB.
Rear surround speakers: -12 dB.
Top layer speakers: ???
Main LFE subwoofers: -24 dB.
Support subwoofers: -19 to -24 dB. Do not use -18 dB, because it is too dry.

The Support Level is not a 1:1 operation, and may not always change the result of the calibration to the specified level, but set a maximum limit of use of a group. The default support level is -18 dB; the support level is adjusted as follows:

- Setting the support level higher from -18 dB to -6 dB will decrease support.
- Setting the support level lower from -18 dB to -24 dB will increase support.

Consider only changing these settings on one support group at a time before pressing the “Calculate” button, to see how the change impacts the overall speaker co-optimization.

Analysis: A support speaker that is far away from the main speaker being supported may be required to provide more support given the physical distance, whereas a support speaker closer to the main speaker may be able to provide less support. Theoretically, these could both have a similar effect on the corrected response. A goal would be to adjust the amount of the cancellation signal sent to a support speaker so that the combination of the program material + the cancellation signal does not overload (distort) the support speaker.

Support Frequency Range (F-support Low / High)

F-support Low (20 Hz – Fsiso) controls the lowest frequency of the support range. The support speakers for the selected group will contribute to the selected main speaker group down to this frequency. This parameter prevents small speakers from supporting frequencies below their rated specifications. Note: ART® may determine the speaker does not need to be used at this low frequency.

This is a crucial parameter to define for each speaker and subwoofer; do not set a lower frequency than the speaker is able to reproduce because this will lead to a poor optimization from ART®'s processing and eventually damage your speakers. By default, Dirac will not set a speaker supporting range below 50Hz, but this is low for some speakers and should be verified.

Do not trust the Dirac Live® tool measurement sweep to determine the frequency range, as room modes can affect the measurements. Ideally, take measurements **from near-field distance** to remove the room modes as a factor when checking the frequency range of a speaker. At a minimum, utilize the speaker data sheet, adding 10-15 Hz to the -3 dB low frequency (aka f3 point). If the speaker manufacturer specifications are known to be accurate, and can handle the published f3 frequency, set the F-support Low to that frequency.

F-support High (F-support Low – Fsiso) controls the highest frequency of the support range. The support speakers in this group will contribute to the selected main speaker group up to this frequency. For subwoofers, this value acts like a lowpass filter applied to the input signal. For full-range speakers, this parameter can be adjusted based on speaker position to prevent revealing support speakers in the final result. Overall, there is no reason not to let a capable support speaker act as support up to 150 Hz.

For subwoofers, the highest frequency it can reproduce is crucial if it is lower than the 150 Hz ART® limit. If a subwoofer does not have adequate frequency response up to 150 Hz, or if it is too close to the listener that it is audible, lower the F-support High frequency to match the upper range of the subwoofer. In such a scenario, you may want to allow speakers to support the subwoofer(s), as noted in this video, which starts at the relevant time stamp.
F-support Low (20 Hz – Fsiso) controls the lowest frequency of the support range. The support speakers for the selected group will contribute to the selected main speaker group down to this frequency. This parameter prevents small speakers from supporting frequencies below their rated specifications. Note: ART® may determine the speaker does not need to be used at this low frequency.

Support Settings Considerations

There are several factors to consider that may be influenced by changing ART® settings. These include: Coherence, direction of arrival, directivity, directional bass, distortion, load balancing, and SPL. The sections below provide more detail, here are some key elements:

Coherence

Since audio systems are usually symmetrical, you could separate all the speaker pairs into left and right groups, and configure each support group with respect to position.

Direction Of Arrival

There is consensus that the direction of arrival of sounds ≤ 80 Hz are not audible. The impulse response target of ART® support speakers align well with the main speaker, so this normally not a consideration when assigning support groups for the LFE channel. However, when the listening position is much closer to a support speaker than to the main speaker it is supporting, then this is a consideration when assigning support groups for the LFE channel.

Directivity

Directivity is the capacity to localize an audio source in space. ART® has two parameters available to mitigate directivity from support speakers located in close proximity to the listener

Directional Bass

Systems supporting directional bass management allow subwoofers positioned near a main speaker to receive bass content specifically for the associated channel. Dirac Live® ART® emulates directional bass management as a natural consequence of the concept of main and support speakers. This allows each main channel ideal properties, including extended bass capabilities without sacrificing imaging.

Distortion

It is important to ensure the ART® settings do not route too much low-frequency information to small speakers, as they may be forced into non-linear behavior that causes distortion, or destructive over-excursion that may eventually damage the speaker.

Infra bass bypass

Dirac Live® ART® enforces a steep high-pass filter at 20 Hz, preventing any content below 20 Hz present in a recording from being sent to any of the speakers, including capable subwoofers. Neither the Dirac Live® Room Correction or Bass Control technologies limit the amount bass; it is unique to ART®.

Dirac has implemented an optional “infra bass bypass” option. Enabling the option allows a low-passed version of the low frequency signals to pass through to each support channel group; this is typically only subwoofers. All speakers that have the infra bass bypass enabled will receive an equal share with equal gain of the infra bass bypassed content, such that they sum up to the target level set by the target curve.

Infra bass content is not phase corrected, therefore, there is a possibility the crossover band between the infra bass and the ART® region does not add up perfectly, and result in a small bump or dip around 20 Hz.

Infra bass can be enabled for the Left and Right speaker if they have the capability to play below 20 Hz. It should not be enabled for the Center speaker.

Grouping Channels

Introduction

The Dirac Live® tool allows the end user to adjust the groups of speakers. Active Room Treatment® groups should be arranged with speakers that have similar frequency response capabilities. However, splitting speakers into more groups also allows for more granularity in the number of filters used, while simultaneously increasing the time involved in the configuration. All speakers in a group share the following:

- A target curve.
- ART® defined supporting groups to help this group.
- ART® support settings to support other groups.

While all speakers in a group share the above settings, each speaker will be treated independently, and have their own filters for ART® support and Dirac Live® correction based on the measurements.

As an example, in a 2.2 system, you could use two or three groups:

- Two groups: Combine Left and Right speakers in one group, and Subwoofers in the second group if you want to use the subwoofers the same way.
- Three groups: Combine Left and Right speakers in one group, and place each subwoofer in separate groups if you want to control their interaction with front speakers independently.

For larger systems, the concept remains the same. Group speakers based on their usage and position, considering the speaker location impact on settings like Fsiso and F-support High. Choose groups that make the most sense for your system and listening position.

To customize the ART® settings to the specific capability of a speaker or subwoofer, separation into different groups is the first step. The second step would be to manually adjust the support range and support level that each channel group contributes to other channel groups.

The section below should provide clarifications on how to hand the following situations:

- Grouping subwoofers with dissimilar capabilities.
- Grouping identical subwoofers.
- LFE main channel effect on grouping.

Grouping Dissimilar Subwoofers

ART® has the flexibility to successfully incorporate subwoofers with dissimilar frequency response ranges. We recommend separating subwoofers with different capabilities into separate channel groups so they can be assigned separate support settings that optimize performance.

In the below example, the three subwoofers cannot reproduce frequencies above 120Hz. Note the overlapping frequency band coverage between L & R and the subwoofers. In this example, between 35 and 120, L & R and SUB 2 are acting together as supports. It is better to have an overlapping support frequency range between speakers instead of relying on a single group to manage a support frequency range.

Therefore, it is recommended to separate the subwoofers into individual groups to set their support range frequencies properly. Also, to provide ART® more liberty to correct the LFE signal, add the L & R speakers as support to each subwoofer channel.

SUB 1 supports	F-support Low frequency	F-support High frequency
L & R	35	150
SUB 1	13	80
SUB 2	25	120
SUB 3	20	90

Grouping Identical Subwoofers

If all the subwoofers are identical, we also recommend separating the subwoofers with less boundary gain from nearby walls into individual groups. When measuring a new project, the Dirac Live® tool will automatically adjust these settings based on the measurements.

If manual adjustment is required, the F-support Low and F-support High settings are used to adjust the subwoofer's rated bandwidth. Smaller subwoofers may have a bandwidth limitation in the low end, and require a frequency value higher than 20 Hz. Larger subwoofers designed for very low frequencies may have a bandwidth limitation in the high end, and require a frequency value lower than 150 Hz.

LFE main channel

The low-frequency effects (LFE) channel is a single discrete content channel in multichannel formats. It is usually defined to produce and deliver content below 120 Hz, and fits perfectly into the ART® support range below 150 Hz. Dirac Live® requires that a device configured with an LFE channel declares one of the speakers as the "LFE Main" channel; this is always the first subwoofer measured. The LFE Main channel serves as reference for the ART® impulse response correction at all the measured microphone positions.

The LFE signal is only sent to the LFE Main subwoofer, and support must be defined for this subwoofer. Due to the low frequencies present in the LFE channel, the other subwoofers are the most appropriate channels to support the LFE Main subwoofer, and this may be sufficient.

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: Use the StormAudio multi-way subwoofer option to create a bass array that has the front subwoofers acting together (verify with REW first), and the rear subwoofers cancelling.

However, in some difficult rooms, this may not be sufficient, so experimentation by adding other supporting speakers may be necessary. For example, if your subwoofers do not have sufficient response from 120 - 150 Hz, add the front left and right speakers as support for the LFE channel, if their frequency response is sufficient. If more support is needed to achieve satisfactory results from 120 - 150 Hz, first consider changing the default support level settings of the front left and right speakers. The next consideration for achieving a satisfactory response in difficult rooms is to add additional channels in support of the LFE channel.

Using only the subwoofers – and if needed the front left and right speakers – to support the LFE Main channel usually results in focused LFE with adequate alignment. If the alignment is not satisfactory, consider changing the default support level settings. However, changing the support range should be carefully considered.

For example, if a 120 – 150 Hz support range was defined for L & R, the optimization would likely be poor for this limited support range, as ART® will add a Low-Pass filter at 120 Hz, and a High-Pass filter at 150 Hz for the support speaker signals. These filters would constrain the correction needed in the below 150 Hz. Provide ART® the most latitude to work properly, while staying within the frequency range capabilities of the speakers.

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: If there are subwoofers all around the room, then you can create directional bass by separating all speakers into individual groups, vice the L/R pairs.

Application of Target Curves

Conceptually, in Dirac Live® ART®, target curves are assigned to main channels. When a subwoofer is separated into a different group than the main LFE channel, it will not have a dedicated target curve directly associated to it. It will instead contribute to attain the target of each main channel group it is set up to support.

ART® Parameters

If you are not satisfied with the sound performance with ART® using its default settings, in addition to applying customized target curves, there are several settings to explore, depending on the desired adjustments. These settings are:

- Group Support enable/disable
- Group Support Range
- Group Support Level (F-support Low / F-support High)

The information is intended to guide the user in the application of these settings, as well as provide information for some specific situations:

- Grouping subwoofers by taking their specific rated specifications into account.
- What is meant by an LFE main channel and how does that affect the grouping.
- Guidance on directional bass configurations.

Each ART® group has a set of sliders at the bottom of the Filter Design graph area. The sliders allow enabling or disabling the support speaker groups allowed to contribute to the selected ART® group. The sliders also allow easily setting the F-support Low and F-support High frequencies. The vertical dashed line can be moved to adjust the Fsiso frequency.

These ART® parameters, as well Support Level, are also accessed by clicking the triple-dot button in the top left corner of the channel group box which unfolds the parameter panel. This button is only available on ART® groups:

ART® Parameters Table

Parameter	Description	Comment	Default	Range
Fsiso	The maximum frequency where speakers can support each other. Above this frequency a regular Dirac Live® correction will be applied. The Fsiso level must be ≤ the highest F-support High frequency of any support speaker.	Fsiso is a critical parameter that acts like a crossover frequency in a bass-managed system. The goal is to find the highest Fsiso value for your system that still provides a great result. Lower Fsiso values are more robust but offer less benefit, while higher values provide more benefits but may reveal supporting speakers in the output.	150 Hz	50 to 150 Hz
Group *n* is supported by	Turns on or off the channels of the group supporting the input channels of the ART® group. i.e., the speakers in this group will act to support the speakers in this group.	The use of this parameter depends on your specific speaker grouping. When adjusting this setting, it's important to consider the F-support High parameter in each group to achieve the desired effect.	On	On or Off
Support level	Controls the amount of support the support speakers provide to the main speaker. -1 dB will contribute a minimal amount, -60 dB will contribute a maximal amount.	Support level determines how heavily a speaker is used by the algorithm. To balance speaker usage and avoid distortion, change the support level values according to the position of speakers in the room. This helps in achieving the desired output without overloading specific speakers.	-18 dB	-60 dB to -1 dB
F-support Low	Controls the lowest frequency of the support range. The support speakers for the selected group will contribute to the selected main speaker group down to this frequency. It has the same value as the low end of the corresponding support range slider.	F-support Low defines the lowest frequency at which a speaker can support another speaker. This parameter prevents small speakers from supporting frequencies below their rated specifications. Note: ART® may determine the speaker does not need to be used at this low frequency.	Detected range	20 Hz to Fsiso
F-support High	Controls the highest frequency of the support range. The support speakers in this group will contribute to the selected main speaker group up to this frequency. It has the same value as the high end of the corresponding support range slider.	F-support High defines the highest frequency at which a speaker can support another speaker. For subwoofers, this value acts like a lowpass filter applied to the input signal. For full-range speakers, this parameter can be adjusted based on speaker position to prevent revealing support speakers in the final result.	Detected range	F-support Low to F*siso*

Fsiso

Fsiso (50-150 Hz) is a critical parameter that acts like a crossover frequency in a bass-managed system. It is the maximum frequency where speakers can support each other. Above this frequency a regular Dirac Live® correction will be applied. This critical parameter that acts like a crossover frequency in a bass-managed system. The goal is to find the highest Fsiso value for your system that still provides a great result. Lower Fsiso values are more robust but offer less benefit, while higher values provide more benefits but may reveal supporting speakers in the output. The Fsiso level must be ≤ the highest F-support High frequency of any support speaker. Consider the speaker location impact on this setting to minimize localization.

Speaker Group Support

Turns on or off the channels of the group supporting the input channels of the ART® group. i.e., the speakers in this group will act to support the speakers in this group. The use of this parameter depends on your specific speaker grouping. When adjusting this setting, it's important to consider the F-support High parameter in each group to achieve the desired effect and to prevent revealing support speakers in the final result.

There are a limited number of filters to apply to ART. As you select channels to support a channel group, the total filter count will change in the lower right corner of the Dirac Live® tool. The priority order below will maximize the ART® filter usage.

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: Creating the individual speaker groups may limit ARTs freedom and ability to utilize the speakers in a uniform manner. Using different profiles with different calibrations may be desirable, if adverse affects are noticed in stereo music.

Group Support Priorities

1st Priority - LFE Group

The goal is to provide focused LFE with a good feeling of alignment, and minimize the chance of localization above 80 Hz. By default, ART® groups all subwoofers into a single group, but it is recommended to split them up into separate groups.

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: It is not recommended to have the base layer speaker support the LFE group, unless the following applies:

The LCR speakers have sufficient output capability down to 40 Hz so they can contribute significantly to "pack a punch" along with subwoofers on the front wall. At this specific time stamp, Sebastien noted that if adding the LCR to the front subwoofers, set them between -18 (default) to -24 (maximum) for a pressure wave from the front.

If you have subwoofers on the side or rear walls, there may be a benefit in having the base layer speakers near the subwoofers support them, so that there is no localization. However, the speaker should be able to contribute significantly to the adjacent subwoofer.

The LFE signal is then sent only to the first subwoofer in the list, and is referred to as the Main LFE subwoofer. Other subwoofers in the system would then be configured to support the Main LFE subwoofer. For subwoofers supporting the main subwoofer, set the support level to -24 dB, which provides for much better bass response. This change must be made in all speaker groups where the support subwoofers are used. Note: This may result in bass that is weighted towards the location of the Main LFE subwoofer.

Subwoofers that do not have sufficient output between 120 - 150 Hz may also require the support of other base layer speakers. First add the front left and right speakers, and if more support is needed to achieve the desired result, consider adding other base layer channels. Experimentation is encouraged with the default support range and support level settings. It is recommended to reduce the F-support High frequency of the supporting speakers to match the F-support High frequency of the subwoofers.

2nd Priority - Front L & R

These are the most important base layer speakers, and will benefit the most from being corrected with ART®. All subwoofers should support the front L & R, followed by the other base layer speakers at ear level as needed. Base layer speakers are typically more capable than height or top speakers. However, adding more base layer speakers can have detrimental effects. See the post-Dirac analysis section for details.

3rd Priority - Center Speaker

This speaker is critical for home cinema immersion, so the goal is to mitigate any potential overloading of the signal reproduced. Only the subwoofers and the front L & R as support for the center channel. Do not use Infra bass for the subwoofers supporting the center channel. Do not allow the center to support any other speakers.

4th Priority - Surround speakers

All subwoofers should support the surround speakers, followed by the other base layer speakers at ear level. Base layer speakers are typically more capable than height or top speakers.

5th Priority - Height and Top Speakers

If you have filters remaining, Height and Top speakers can use any of the available speakers as support. However, it is recommended to exclude L, C, R as support.

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: The top speakers should NOT be supported by the subwoofers, as the difference in frequency between what the top speakers normally reproduce and the upper frequency of the subwoofers may be different. If the top speakers are capable of reproducing sound down to 80 Hz as measured at the listening position, then it may make sense to have the subwoofers support the top channels.

Support Level

Support level (-24 to -1) determines how heavily a speaker is used by the algorithm by controlling the amount of support the support speakers provide to the main speaker. -1 dB will contribute a minimal amount, -60 dB will contribute a maximal amount. If you think of it like a punishment level, 0 dB is the least punishment, and -60 dB is maximum, and the higher you go the worse the result may be. So, for example, -5 dB is essentially like +5 dB of support.

Support level determines how heavily a speaker is used by the algorithm. To balance speaker usage and avoid distortion, change the support level values according to the position of speakers in the room. This helps in achieving the desired output without overloading specific speakers.

Matt recommended varying support levels to have less in front and more as you move towards the rear of the room. This reduces the possibility of noticing the correction

Support levels:

-5 dB on front L, C, R, and TF???
-9 dB on base layer surrounds and TM???
-12 dB on rear surrounds and TR???
-24 dB on main subs, and others vary don't use -18 because too dry.

The Support Level is not a 1:1 operation, and may not always change the result of the calibration to the specified level, but set a maximum limit of use of a group. The default support level is -18 dB; the support level is adjusted as follows:

- Setting the support level higher from -18 dB to -6 dB will decrease support.
- Setting the support level lower from -18 dB to -24 dB will increase support.

Consider only changing these settings on one support group at a time before pressing the "Calculate" button, to see how the change impacts the overall speaker co-optimization.

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: The balance is discussed, and the adjustment of F-Support Low, F-Support High, and Support Level. Support level equates to a lower negative number as greater support. F-Support Low is the cutoff frequency of the speaker. Separate the speaker groups in to matching model speakers.

At this specific time stamp, if all the subwoofers are of the same capability, then you can adjust as desired. However, if using dissimilar subwoofers, and if the front subwoofers can sufficiently provide enough SPL to satisfy the end user, then the other subwoofers should have their support reduced, so for example, they should be set to -6 support level.

At this specific time stamp, if localization occurs due to speakers in close proximity to the listener, try lowering the frequency first, and then the support level, if necessary, to eliminate the effect.

Support Frequency Range (F-support Low / High)

F-support Low (20 Hz – Fsiso) controls the lowest frequency of the support range. The support speakers for the selected group will contribute to the selected main speaker group down to this frequency. This parameter prevents small speakers from supporting frequencies below their rated specifications. Note: ART® may determine the speaker does not need to be used at this low frequency.

This is a crucial parameter to define for each speaker and subwoofer; do not set a lower frequency than the speaker is able to reproduce because this will lead to a poor optimization from ART®'s processing and eventually damage your speakers. By default, Dirac will not set a speaker supporting range below 50Hz, but this is low for some speakers and should be verified.

Do not trust the Dirac Live® tool measurement sweep to determine the frequency range, as room modes can affect the measurements. Ideally, take measurements **from near-field distance** to remove the room modes as a factor when checking the frequency range of a speaker. At a minimum, utilize the speaker data sheet, adding 10-15 Hz to the -3 dB low frequency.

F-support High (F-support Low – Fsiso) controls the highest frequency of the support range. The support speakers in this group will contribute to the selected main speaker group up to this frequency. For subwoofers, this value acts like a lowpass filter applied to the input signal. For full-range speakers, this parameter can be adjusted based on speaker position to prevent revealing support speakers in the final result. Overall, there is no reason not to let a capable support speaker act as support up to 150 Hz.

For subwoofers, the highest frequency it can reproduce is crucial if it is lower than the 150 Hz ART® limit. If a subwoofer does not have adequate frequency response up to 150 Hz, or if it is too close to the listener that it is audible, lower the F-support High frequency to match the upper range of the subwoofer. In such a scenario, you may want to allow speakers to support the subwoofer(s), as noted in this video, which starts at the relevant time stamp.

Support Settings Considerations

Introduction

There are several factors to consider that may be influenced by changing ART® settings. These include: Coherence, direction of arrival, directivity, directional bass, distortion, load balancing, and SPL. The sections below provide more detail, here are some key elements:

Coherence

Since audio systems are usually symmetrical, you could separate all the speaker pairs into left and right groups, and configure each support group with respect to position.

Direction Of Arrival

There is consensus that the direction of arrival of sounds ≤ 80 Hz are not audible. The impulse response target of ART® support speakers align well with the main speaker, so this normally not a consideration when assigning support groups for the LFE channel. However, when the listening position is much closer to a support speaker than to the main speaker it is supporting, then this is a consideration when assigning support groups for the LFE channel.

Directivity

Directivity is the capacity to localize an audio source in space. ART® has two parameters available to mitigate directivity from support speakers located in close proximity to the listener

Directional Bass

Systems supporting directional bass management allow subwoofers positioned near a main speaker to receive bass content specifically for the associated channel. Dirac Live® ART® emulates directional bass management as a natural consequence of the concept of main and support speakers. This allows each main channel ideal properties, including extended bass capabilities without sacrificing imaging.

Distortion

It is important to ensure the ART® settings do not route too much low-frequency information to small speakers, as they may be forced into non-linear behavior that causes distortion, or destructive over-excursion that may eventually damage the speaker.

Coherence

Since audio systems are usually symmetrical, you could separate all the speaker pairs into left and right groups, and configure each support group with respect to position. Speakers in close proximity to each other can provide support at a higher level with reduced risk of localization. This allows for defining left support with less constraint than the right support for a left speaker, etc. Mirror speaker pairs at opposite sides of the room are also in ideal positions to manage reflections and phase-correct each other.

Direction Of Arrival

There is consensus that the direction of arrival of sounds ≤ 80 Hz are not audible. The impulse response target of ART® support speakers align well with the main speaker, so this normally not a consideration when assigning support groups for the LFE channel. However, when the listening position is much closer to a support speaker than to the main speaker it is supporting, then this is a consideration when assigning support groups for the LFE channel. In this scenario, consider the following modifications to mitigate the direction of arrival:

- Place the close proximity support speaker in its own group and reduce the F-support High frequency level in the group it is supporting.

- If the system is symmetrical, separate the main speaker group into two and adjust the support level so that, for example, Left Front has a lower support range from Right Surround than from Left Surround. This will increase coherence and reduce localization.

Directivity

Directivity is the capacity to localize an audio source in space. For low frequencies, most people are not able to localize sound waves ≤ 80 Hz. This rule assumes that the listener is a sufficient distance from the speakers, and the room has some reverberation, absorption, and scattering of acoustical sounds. If you are positioned quite close to a speaker, you will be able to localize the acoustic signals, possibly even for low frequencies. For example, 80 Hz from a speaker located a few inches away can be localized. ART® has two parameters available to mitigate directivity from support speakers located in close proximity to the listener:

- Support Range
    - Reduce the F-support High frequency to reduce directivity.

- Support Level
    - Reduce the support level to reduce directivity by decreasing the energy in the support speaker. Increasing the negative value decreases support.

Directional bass

Systems supporting directional bass management allow subwoofers positioned near a main speaker to receive bass content specifically for the associated channel. Dirac Live® ART® emulates directional bass management as a natural consequence of the concept of main and support speakers. This allows each main channel ideal properties, including extended bass capabilities without sacrificing imaging. However, manual adjustments may possibly enhance this effect. Follow these steps to explore this option:

1. Separate the subwoofers designated to be assigned to support specific main channels into separate groups.

2. Separate the main speakers to be associated with specific subwoofers.

3. For each of the main channels moved into a separate group, re-load the preferred target curve.

4. For each of the main channels, enable the corresponding subwoofer and adjust the support ranges and support levels as to reach the desired effect. This is an iterative process of adjustments to increase or decrease ART® control:

    a. Ensure that each directional subwoofer is supporting its corresponding main channel maximally:

        i. Select the main channel to be configured.

        ii. Ensure the directional subwoofer is enabled and has the maximal range.

        iii. Increase the Support Level by decreasing the negative value to -24dB from the default of -18 dB.

5. Optional – Adjust the support settings other subwoofers to contribute less than the directional subwoofer.

    a. A potential consequence is limiting the maximum contribution of the subwoofer to optimize the impulse response of the main speaker. Therefore, comparison of the default settings to the following manual adjustments is recommended.

        i. Reduce the F-support High frequency to reduce contribution > 80Hz.

        ii. Reduce the Support Level by increasing the negative value to -6 dB from the default of -18 dB.

6. Optional – Adjust the support settings for other support speakers to increase or reduce their contribution to directivity of each main channel.
    a. A potential consequence is limiting the maximum contribution of the support speaker to optimize the impulse response of the main speaker. Therefore, comparison of the default settings to the following manual adjustments is recommended.

        i. Reduce the F-support High frequency of the mirror support speaker to mitigate contribution to directivity.

        ii. Increase the Support Level of the support speaker closest to the supported subwoofer by increasing the negative value to -24 dB from the default of -18 dB.

        iii. Reduce the Support Level of the mirror support speaker to mitigate contribution to directivity.

Distortion

It is important to ensure the ART® settings do not route too much low-frequency information to small speakers, as they may be forced into non-linear behavior that causes distortion, or destructive over-excursion that may eventually damage the speaker. If adding smaller speakers in support of the LFE channel is needed to achieve satisfactory results, follow these recommendations, and make the following adjustments in the Dirac Live® tool:

1. Review the speaker data sheet for the rated bandwidth and sensitivity.

2. Increase the F-support Low frequency of support speaker to 10-15 Hz above the -3 dB point on the speaker data sheet.

3. Reduce the Support Level of the smaller speakers to the LFE channel to -6 dB from the default of -18 dB.

4. If distortion remains unacceptable, then disable support from the smaller speakers.

LFE Load balancing

When using multiple subwoofers, the LFE load assigned to each of them with ART® may sometimes seem unbalanced. Please refer to sections on grouping both identical and dissimilar subwoofers, above, for further guidance.

SPL

ART® distributes the energy through the main speaker and its support speakers according to their measured magnitude and phase capabilities. Because the energy in the support frequency range is spread between multiple speakers, the overall SPL requirements are reduced. The energy can also be shifted between the support speakers by adjusting the Support Level and removing excess load from the speaker to be corrected; this is often critical for the LFE channel.

The reduction of SPL requirements is maximized when support speakers have identical frequency response in the support range, but most of the time that is not the case. Even when support speakers do not have identical frequency response in the support range, the overall load will be distributed between the support speakers with variations based on the measured capabilities. For example, if there was only one speaker in the room able to reproduce 53 Hz, then all the energy at this frequency will be distributed to that one speaker.

To ensure that SPL is split between your subwoofers, physically group some subwoofers to be considered as one speaker in the StormAudio ISP. The power needed by each subwoofer to achieve the same SPL will be divided by the number of subwoofers grouped. This will trade maximum SPL with reduced ability of ART® to manage the LFE channel.

Infra bass bypass

Introduction

Dirac Live® ART® enforces a steep high-pass filter at 20 Hz, preventing any content below 20 Hz present in a recording from being sent to any of the speakers, including capable subwoofers. Neither the Dirac Live® Room Correction or Bass Control technologies limit the amount bass; it is unique to ART®.

Dirac has implemented an optional “infra bass bypass” option. Enabling the option allows a low-passed version of the low frequency signals to pass through to each support channel group; this is typically only subwoofers. All speakers that have the infra bass bypass enabled will receive an equal share with equal gain of the infra bass bypassed content, such that they sum up to the target level set by the target curve.

Infra bass content is not phase corrected, therefore, there is a possibility the crossover band between the infra bass and the ART® region does not add up perfectly, and result in a small bump or dip around 20 Hz.

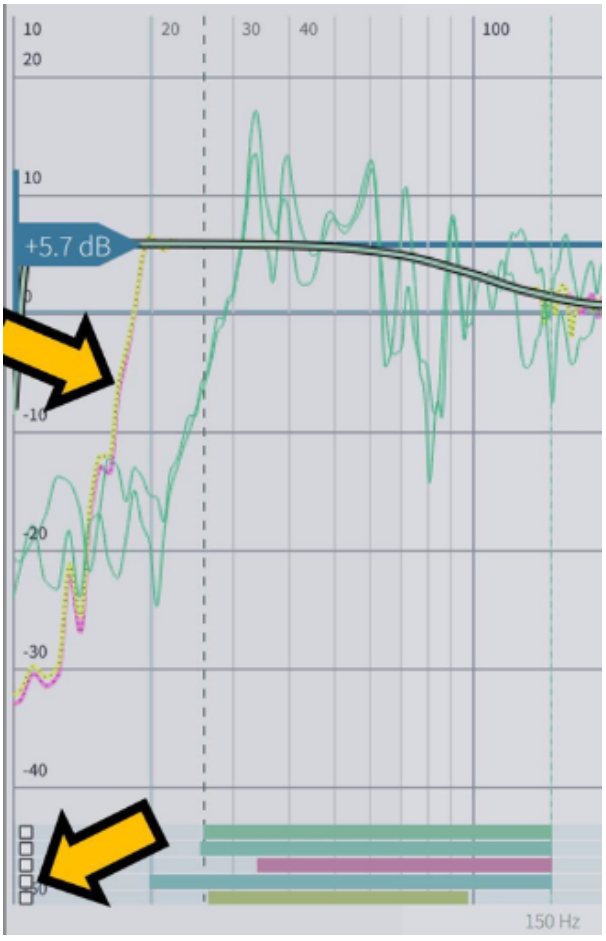
Infra bass can be enabled for the Left and Right speaker if they have the capability to play below 20 Hz. It should not be enabled for the Center speaker.

Enabling

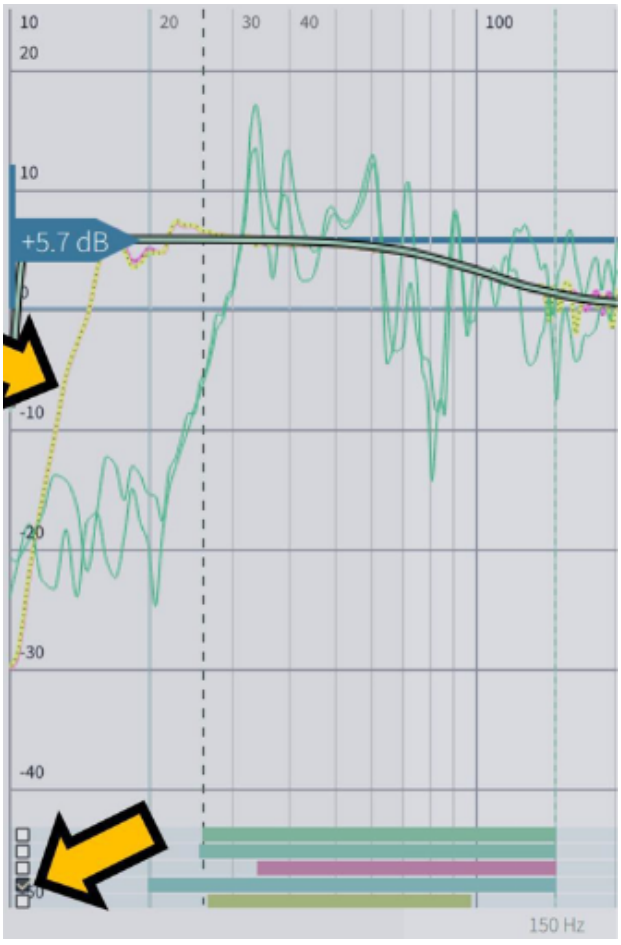
The infra bass bypass parameter is not accessible via the parameter panel that unfolds when clicking the triple-dot button in the top left corner of the channel group box. This parameter is only accessible in the graph area of the Dirac Live® tool via a checkbox. The checkbox will be visible for all speaker groups where the measured low frequency of a speaker group is ≤ 20.0 Hz. The checkbox can be made available for a particular loudspeaker group by dragging the support range for that group down to 20.0 Hz, but should only be done for speakers that have the capability to play below 20 Hz.

The images below show the infra bass checkbox and the effect on the predicted response in the example project. Note this represents an older Dirac Live tool version, because the infra bass boxes are shown for speaker groups that do not have frequency response down to 20.0 Hz.

Infra bass disabled



Infra bass enabled

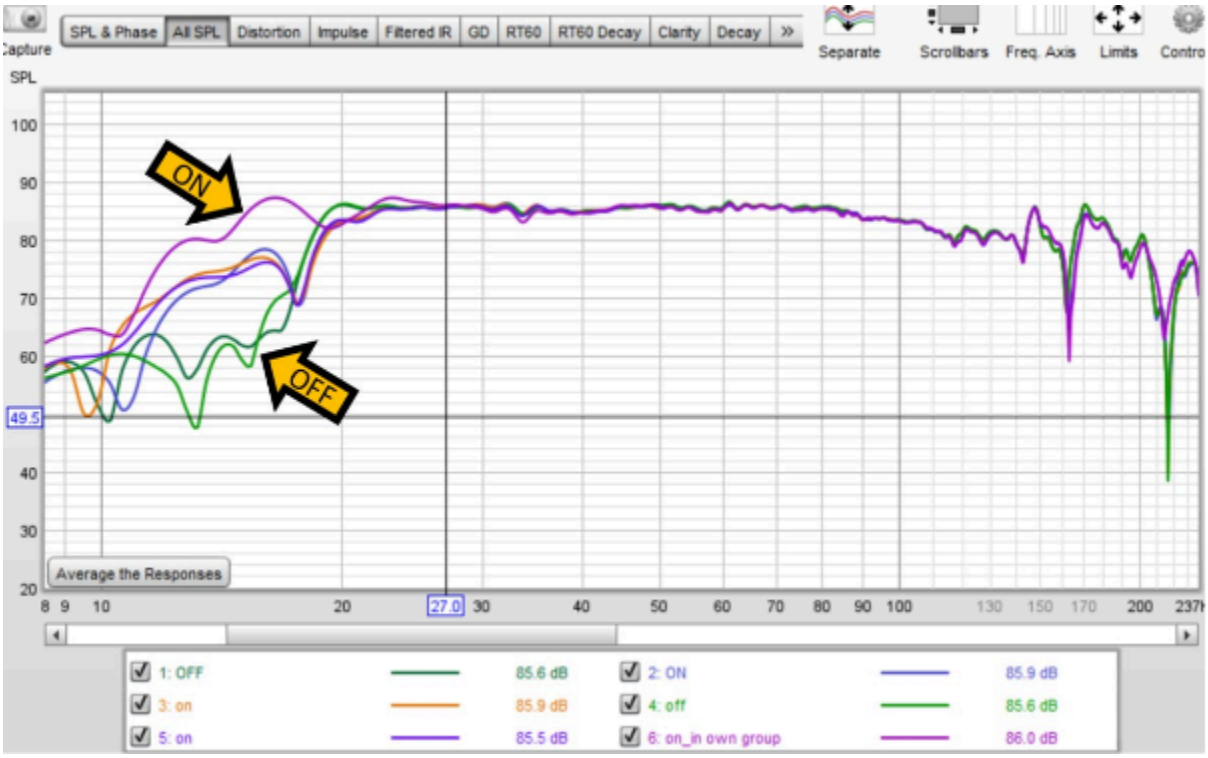


Recommended Use

The channel grouping made automatically by Dirac is based on meta data from the speaker configuration. Subwoofers will be automatically grouped together, even if they have very different specifications.

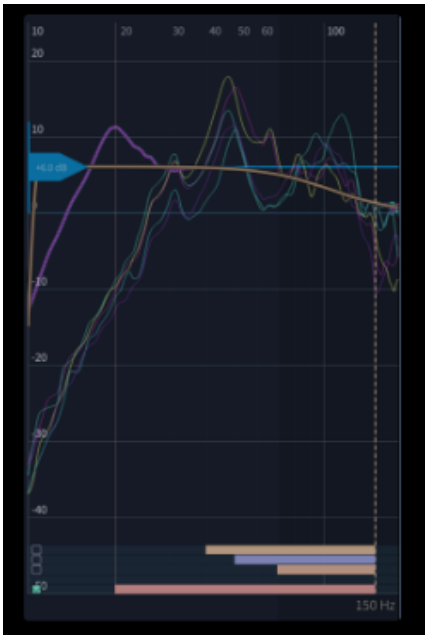
- If subwoofers have very different capabilities, it is recommended to separate them into two or more different channel groups. This will allow each group to maximize its performance without being limited by less capable speakers in the same group.

The REW measurement below shows the effect of the infra bass bypass ON and OFF. The best infra bass response is from grouping the most capable subwoofer(s) in a separate group. The orange/purple/blue contain different subwoofers in the same group.

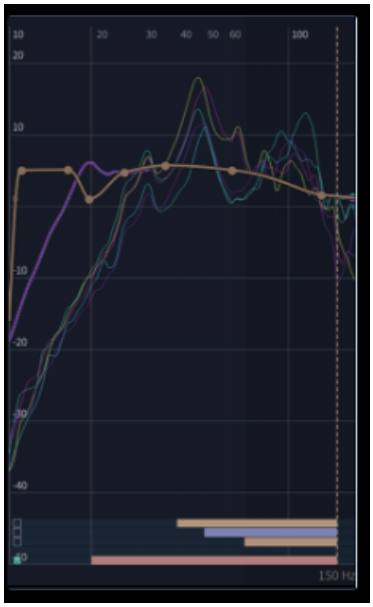


Limitations

Infra bass content is not phase corrected, therefore, there is a possibility the crossover band between the infra bass and the ART® region does not add up perfectly, and result in a small bump or dip around 20 Hz. However, this content is felt rather than heard, so it should not reasonably have any impact on the audible experience. The image below shows a ripple bump at 20 Hz due to enabled infra bass bypass option.



If the bump needs to be reduced or removed, add a corresponding notch in the target curve response, as shown below.



Target Curves for Dirac Live® 2/3

To add to the hair movement effect, add a slight boost at 35 Hz.
To add to the chest slam effect, add a slight boost at 63 Hz.

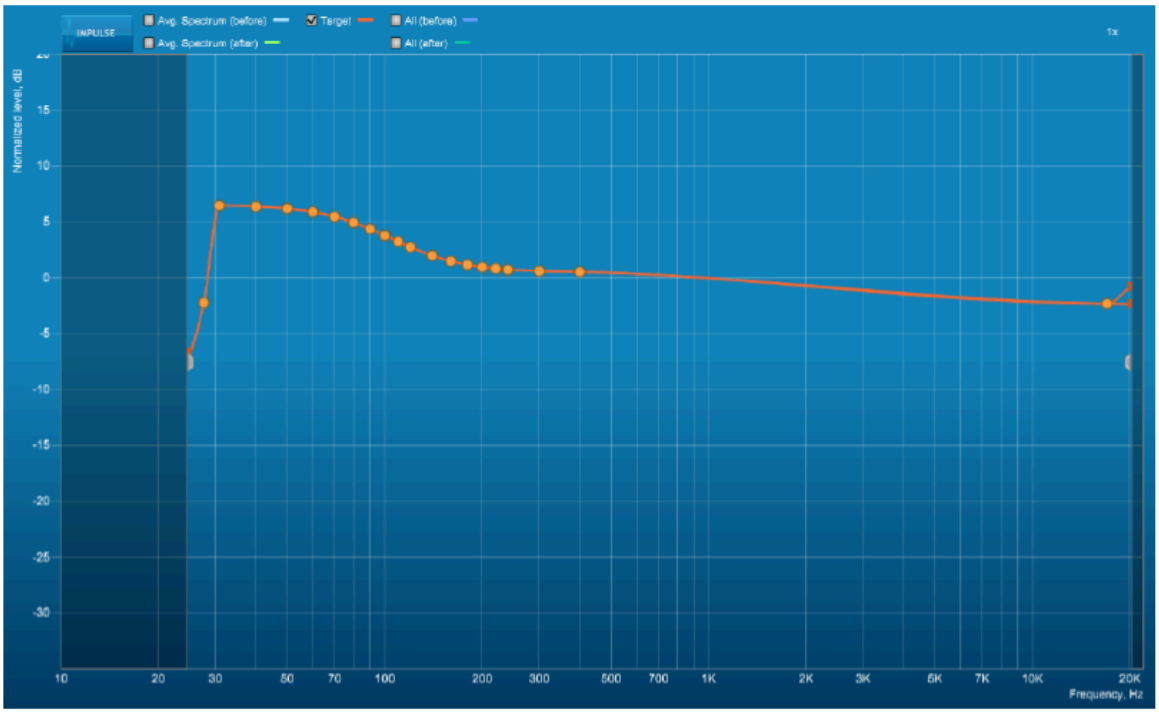
As noted in AVS Forum member Markus767's web site, Dirac Live®'s default target curve is known to sound bass-shy. Below are some additional target curves based on Harman research; they differ in the amount of bass boost. These target curves can be directly loaded from within Dirac Live® 2.5.2/3 and later.

- +4dB low frequency boost
- +6dB low frequency boost
- +8dB low frequency boost
- +10dB low frequency boost

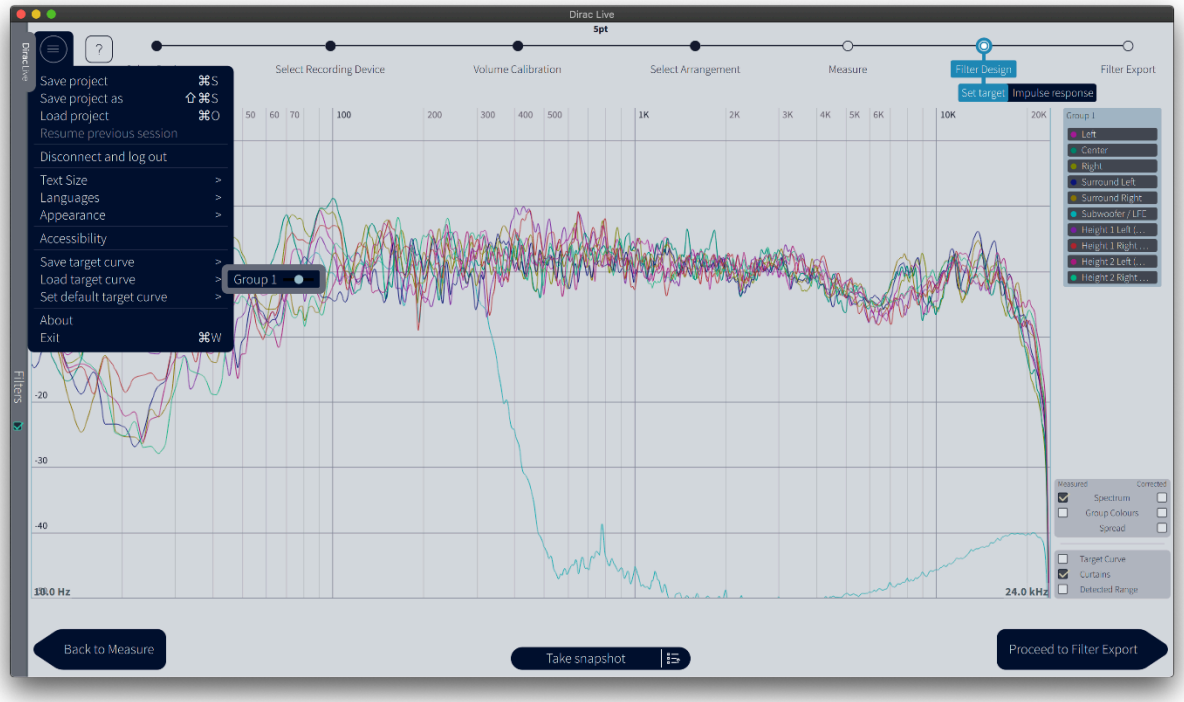
Note: The curves above and those in Dirac Live® 3.02 do not exactly follow the Harman curve recommendation, due to the elimination of the 2.4 dB treble cut above 2.5 kHz. The treble cut is in the standard Dirac target curve, which is a +2 low frequency boost. If the user wants to mimic the Harman curve, the curves would need to be modified.

As noted in AVS Forum member Austin Jerry's Custom Dirac Target Curves guide, the Harman target curve was based on the white paper authored by Sean Olive, Todd Welti, and Elisabeth McMullin titled "***Listener Preferences for In-Room Loudspeaker and Headphone Target Responses***", dated October 2013, available for download here.

According to the white paper, Section 6 "*The preferred in-room loudspeaker target response is not flat but has a bass boost of about 6.6 dB below 105 Hz and a treble cut of-2.4 dB above 2.5kHz*". A typical curve meeting these recommendations would look like this:



Note: Use the same target curve for all your speakers including the subwoofer. Do NOT use different target curves amongst speakers in the crossover region to the subwoofer(s) or you'll end up with a combined response that no longer follows the intended curve. Adjust high frequency fall-off according to your speaker's in-room response. The fastest way for applying a custom target curve is to first group all speakers and then load a target curve:



Bugs and quirks

https://mehlau.net/audio/dirac-live-2/

Post ART® Calibration

Introduction

In an HCFR podcast, Sebastien Gailleton from StormAudio stated the following at this timestamp: He cautioned that making post ART PEQ correction is not recommended due to the precise linear phase adjustment.

Dirac Live® Process Tips

Measuring the room

In the Dirac tech talk at MWAVE 2024, Matthew Trinklein from StormAudio stated do not leave the room during calibration, but rather stay in there and wear ear plugs.

Below are some excerpts from the tutorial written by AVS Forum member Markus767, located here., and modified in 2021 with information provided in the StormAudio Dirac Live® Basic Calibration video.

Position the microphone at the Main Listening Position

1. Connect the measurement microphone and place it at the main listening position.
    A. This is the most critical measurement, so take the time to get it right.
        i. Use a boom microphone stand.
        ii. Vertical placement: Measure from the ceiling to the center of your ear canal; with the top of the microphone at ear canal height.
        iii. Horizontal placement: Centered where your head would be positioned in the seat. For optimal imaging, use REW to measure the system delay of the left and right speakers to verify the microphone is acoustically centered.
        iv. During the Dirac tech talk at MWAVE 2024, Matthew Trinklein from StormAudio suggested that placing the microphone about 4” above ear height was favorable to 90% of customers. The issue is that due to the precedence effect, this will skew the sound field towards the base layer speakers. This may be preferable if the top layer speakers are not that capable nor ideally positioned.

Select Recording Device

1. Start Dirac Live®.
2. Select your AVR/AVP.
3. Load the calibration file for the microphone.
4. Make sure the correct microphone is selected.
    A. Note that the miniDSP UMIK-2 is capable of recording at 96 kHz for Dirac Live®. If you are using a Windows computer, ensure the Windows setting for microphone resolution is set to 96 kHz.
5. Proceed to the "Volume Calibration" tab.

Dirac Live® Volume Calibration

1. Move mic gain slider up to 100% as long as background noise level stays below -50dB.
   A. Make sure devices that are known to generate a lot of inaudible low frequency noise are switched off, e.g., HVAC, refrigerator, washer, dryer, etc. Such noise can invalidate measurements.
2. Note the Mic gain level; this is the noise floor of the room referenced below.
   A. When using a miniDSP UMIK-2, the noise floor will be lower than with the miniDSP UMIK-1.
3. Move the Master output level to a good starting level; -25 dB works in most cases.
4. Set all speaker channel levels to -10 dB to avoid potential damage.
5. Below is an example ready for individual speaker level calibration. Please note the speaker trim adjustment range lower level (-20 dB below) mimics the AVP / AVR adjustment range.

Speaker level calibration

1. Click "Play" button for the left speaker.
2. Increase individual channel level slider until the speaker plays the noise signal at ~30 dB above the room's noise floor, measured above.
3. Click "Play" button for each speaker successively. Omit subwoofer.
4. If you find that a speaker cannot be adjusted to the proper level in step 2, increase the "Master output" slider (unlock it if necessary) until that speaker plays the noise signal at ~30 dB above the room's noise floor, measured above.
5. If the "Master output" level is adjusted, go back and re-adjust the individual channel level sliders for the other speakers.

Subwoofer level calibration

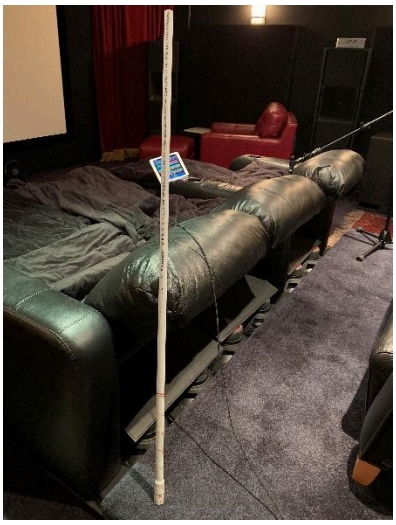
1. Click "Play" button for the subwoofer.
2. Set the individual channel level slider at 0 dB.
3. Adjust the level/gain control on the subwoofer until the noise signal 5-10 dB louder than the other speakers (~35-40 dB above the room's noise floor, measured above).
    A. The goal is to ensure Dirac Live® applies negative trim values to the subwoofers, but the necessity for this process is system dependent.

    B. Negative trim values in the AVP / AVR and higher gain at the subwoofer amplifier input allows for increased digital headroom, which is ideal for the LFE channel(s).

Select the arrangement

1. StormAudio recommends using the Tightly Focused arrangement with 9 measurement positions.
    A. In the Dirac tech talk at MWAVE 2024, Matthew Trinklein from StormAudio recommended using 6 measurement positions around the seating area.

Measurement Tools & Tips

This is a useful tool I made from a piece of 3/4" Grey PVC. I call it a Dirac measurement stick, and it allows for making fast and accurate microphone height adjustments while taking measurements at the various locations. You hold it up to the ceiling and place the top of the microphone at the desired pre-measured and marked distance from the ceiling.

When the tool above is used with this spreadsheet I made with the various measurement locations for both Dirac and StormAudio, it allows for fast and accurate microphone adjustments. For each worksheet, you can add your own data for the distances from the ceiling, relationship to the MLP measurement, etc. This allows for repeatable accuracy in your particular room when measuring.

Measurement Positions

Mathias Johansson, the Co-Founder of Dirac, in this video, at this specific time stamp, said 9 is a good rule of thumb, but you can get good results with more or less, and you should cover the area where people will be seated. He then stated that at the MLP you should take 3 measurements, and 2 measurements at the other seats.

Matt recommended 6 measurements around the seating area.

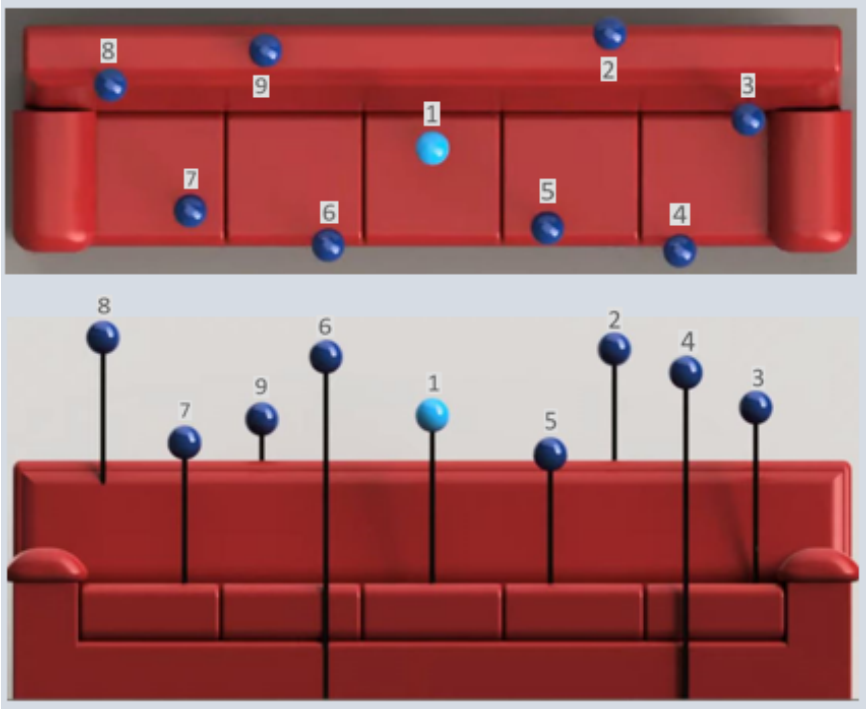
At the StormAudio Dirac tech talk at MWAVE 2024, Matthew Trinklein said the gains were set by weight: MLP primarily and then other measurements.

For seats with inclining head rests, take MLP measurement with it down, but alternate other measurements with it up 50% of the time.

Another measurement pattern recommendation is courtesy of the StormAudio Dirac Live® Basic Calibration video. In the video, these were the recommendations.

- Do Not measure points outside the listening area.
- No measurement position should be within 8-10" (20-25 cm) of another, or within 3 inches of an armrest or backrest.
- Avoid any of the measurement positions falling on the same x, y, or z axis; this will provide the software with a more comprehensive view of the listening area.

These are the recommended measurement positions for most calibrations. Rooms with complex acoustic interactions may require alternative measurements.



Imprecise Measurement Issues

In July and August, 2023, I experienced issues measuring with the Dirac Live tool version 3.6.6 or 3.6.7 and a UMIK-2. The problem started with an exclamation point after completing a sweep of one measurement position. StormAudio advised the exclamation point was an indicator the tool does not have sufficient phase information for that measurement. I reported the issues to Dirac and miniDSP, but there was no resolution at that time.

The basic issue causing this was that Dirac increased their sensitivity to the measurements to reveal and flag issues during the measurement sweeps. This change was necessitated by the introduction of Dirac ART on the StormAudio processor, and the coincident software update with version 3.6.6.

At the time, the Dirac Live tool provided no specific indication of what the issue was, so there are only two non-invasive solutions to try and get past the error: Repeat the measurement to see if it worked the second time, or move the microphone. Two additional invasive solutions that were suggested, but did not help consistently in my case, were adjusting the microphone gain in the Dirac Live tool to 104%, and using the miniDSP analog gain tool for the UMIK-2 to adjust the microphone gain. I was not happy with either of these solutions, but the only other option was to try using different hardware, but I had the same errors on two other computers. Dirac advised it would be awhile before they could attempt to fix this in the software.

StormAudio subsequently made this ART – Troubleshooting document available where they offered these tips:

1. Change USB port for your microphone (USB mics)
2. Increase master volume to improve signal to noise ratio
3. Change your MIC cable
4. Change computer
5. Change microphone

In November, 2023, Dirac made updates to their app, and the 3.8.x variants started including more information about the measurement errors. In December, 2023, Dirac Live employee and AVS Forum member flax posted about Dirac Live 3.9.1, in this post, which added a new feature to use the microphone in exclusive mode on Windows PCs for users experiencing recurring imprecise measurements.

Mathias Johansson, the Co-Founder of Dirac, in this video, at this specific time stamp, said the basic issue is that the timing of each measurement is critical with ART, and computers are not real-time operating systems. The data gathered is showing some trends, and these errors are more prevalent on Windows computers than on Mac's. Having other applications open or running in the background will impact the operation of the Dirac Live tool, and may exacerbate the problems.

To help mitigate this issue with Windows PCs, they added the exclusive mode. Newer Windows computers are less problematic. Some USB microphones may be more problematic than others, but this has not been confirmed yet. They have been working on the issue, and it is their top priority. They added the exclusive mode for Windows, and are developing other options.

Exclusive Mode

The updated tool Dirac Live 3.9.1 allows Windows PCs to opt-in for using the microphones in Exclusive Mode by adding a Windows Environment Variable: Exclusive Mode. This test feature is enabled via these instructions:

1. Right-click on This PC in Windows Explorer and select "Properties"
2. Click the "Advanced system settings" link
3. Open the "Advanced" tab
4. Click the "Environment Variables..." button
5. Click the "New..." button under "User variables for <username>"
6. Enter the following:
    a. Variable name: DAUDIO_WASAPI_NON_EXCLUSIVE
    b. Variable value: OFF
7. Click "OK"
8. Restart the Dirac Live application and calibrate.
9. Disable Exclusive Mode by either deleting the environment variable or by setting its value to "ON"

Measure the Main Listening Position (MLP) and verify the results

1. Measure all the speakers and subwoofers from the MLP position.
2. Click on "Proceed to Filter Design"; ignore the warning.
3. Uncheck the box to remove the target curve from the UI display.

4. Verify the frequency response for each speaker is correct according to their specifications.
5. If everything appears normal, click on “Back to Measure”.

Measure the remaining speakers and subwoofers

1. Use your preferred placement pattern to measure the remaining positions desired.
    A. The level of effort applied to this process varies on the individual.
    B. More information is provided below for those wishing to maximize performance.

When your measurements are complete, click "Proceed to Filter Design."

Dirac Live® Bass Control® Filter Process

If using Dirac Live® ART®, this section can be skipped.

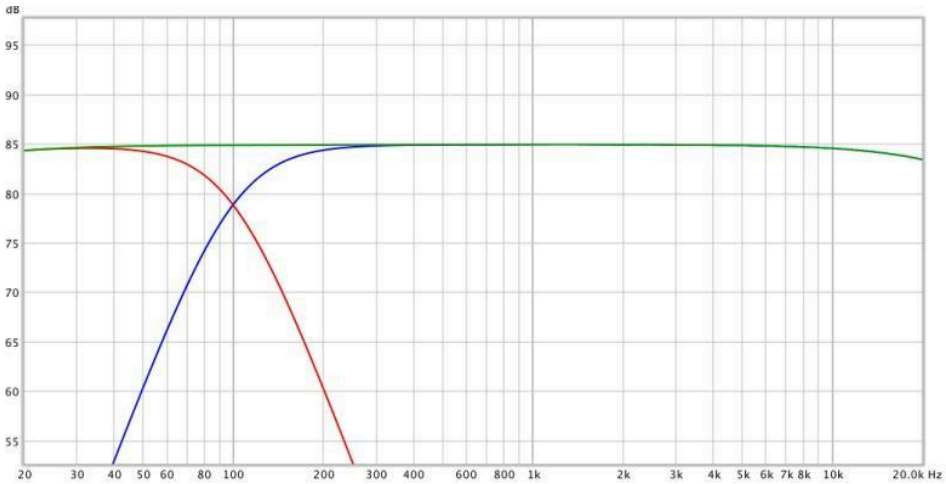
Dirac Live® Bass Control (DLBC) automatically groups speakers together and chooses the crossover point for each speaker group. The lowest crossover is 70Hz, even if the measured response allows a lower crossover. While the default crossover point usually provides excellent results, definitely experiment with alternative crossover frequencies, and DLBC will automatically recalculate. The goal is a smooth transition between the speakers and subwoofers, assuming you do not exceed the low and high frequency limits of your speakers and subwoofers. In this post, Flavio from Dirac Live® demonstrates improving the results by changing the default crossover.

This tutorial shows how to set crossover frequencies in an AVR/pre-processor for subwoofer and satellite speakers based on data captured by Dirac Live® room correction.

Basics

Bass management in AVRs provides crossovers that separate low and high frequencies. First the signal is split into two different channels. Then a high pass filter is applied to the channel that should carry only higher frequencies (signal going to a satellite speaker) and a low pass filter is applied to the channel that should carry only lower frequencies (signal going to the subwoofer). The crossover point is the frequency where the resulting two frequency response curves cross each other.

High and low pass filters aren't brick wall filters, i.e. both the subwoofer and the satellite speaker contribute to the response around the crossover frequency. The overlapping frequency region where there is significant interaction typically extends from about 1 octave below the crossover point (half the frequency) to about 1 octave above (double the frequency). Here's a graph showing how the low frequency portion (red) and the high frequency portion (blue) ideally combine (green). The crossover frequency in this example is 100Hz.

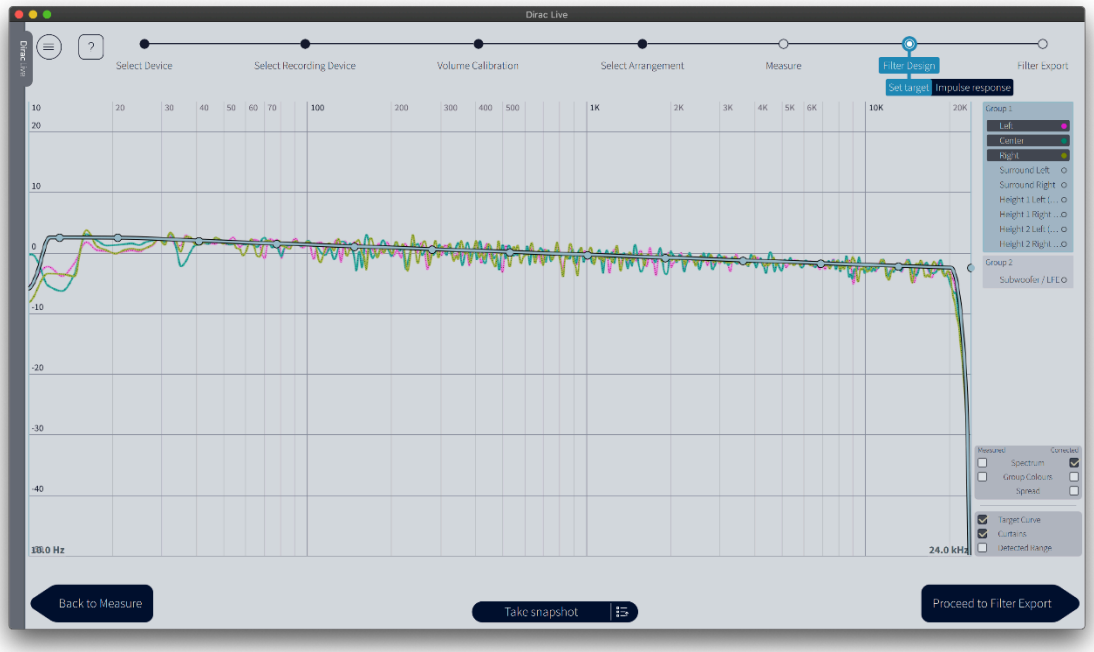


Determine potential crossover points

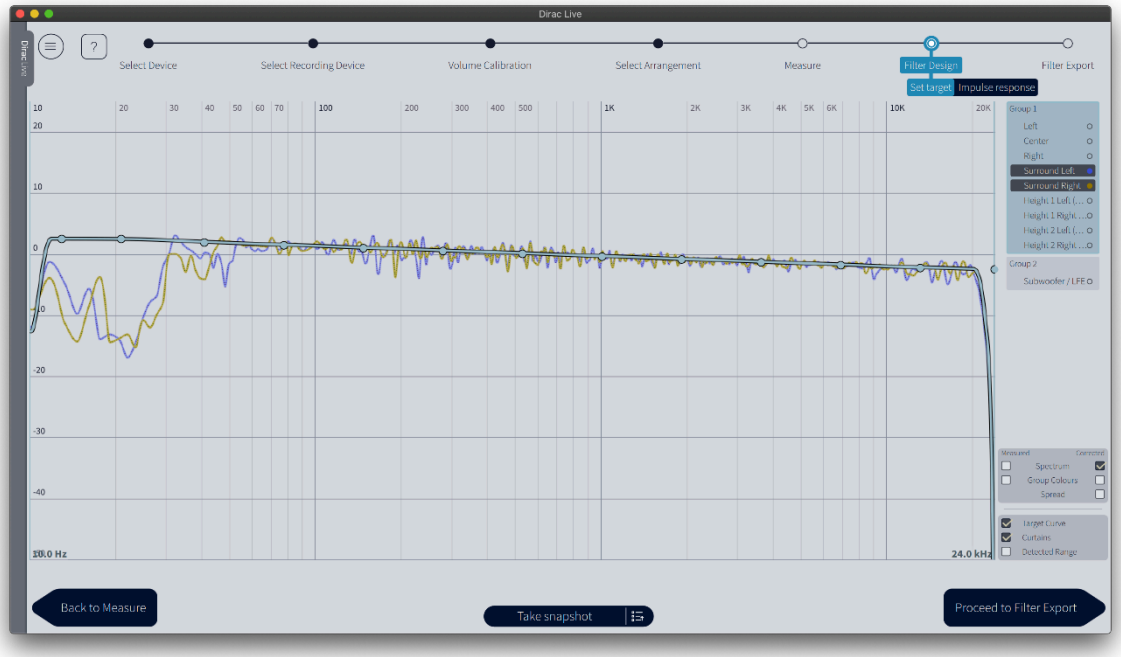
After measuring your speakers or opening a previously saved project go to "Filter Design". Examine the "Spectrum (Corrected)" curve for each satellite speaker (or group of satellites) and locate the frequency where the corrected response curve starts to fall off from the target curve at low frequencies. This is the low frequency cut-off point. The lowest usable crossover frequency is roughly 1 octave above. Then find the high frequency cut-off point for the sub. The highest usable crossover frequency is roughly 1 octave below.

At the StormAudio Dirac tech talk at MWAVE 2024, Matthew Trinklein recommended for LCR, adjust target curve so there is a max boost of 5 dB at a null. Not as critical for other channels. Matt stays within 4 dB for all channels because the customer is paying for the service.

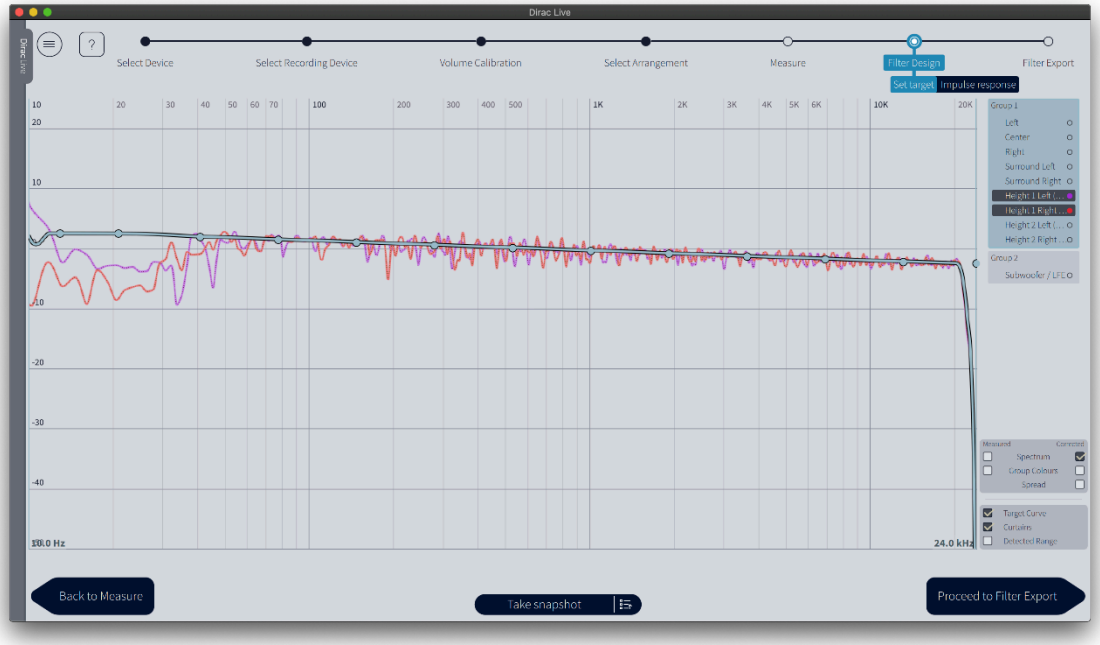
Here's some exemplary data:



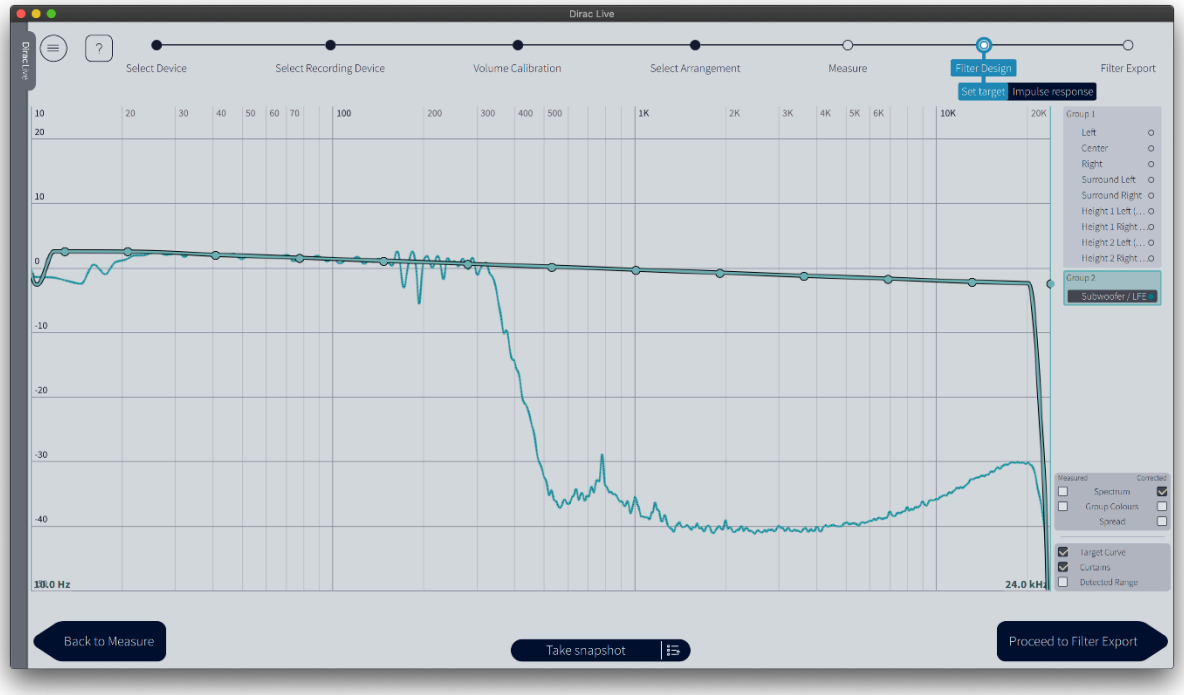
The lower cut-off points for the left, right and center speaker is at around 40Hz. This allows a crossover frequency of 80Hz (40Hz * 2 = 80Hz) or higher.



The lower cut-off point for the surround speakers is at around 53Hz. This allows a crossover frequency of 106Hz (53Hz * 2 = 106Hz) or higher.



The lower cut-off point for the top surrounds is at around 48Hz. This allows a crossover frequency of 96Hz (48Hz * 2 = 96Hz) or higher.



The upper cut-off point for the subwoofer extends beyond 300Hz. This allows a crossover frequency of 150Hz (300Hz / 2 = 150Hz) or lower.

Choosing appropriate crossover points

Generally speaking, the satellite/subwoofer crossover frequency should be as high as possible in order to benefit from spatially optimized, monophonic bass. On the other hand, the subwoofer(s) shouldn't become localizable which requires a crossover frequency of about 80Hz or lower. So ideally the target is a crossover point of 80Hz for all speakers.

Make sure you set the same crossover point for stereo pairs, i.e. left/right, left/right surrounds, etc. to avoid imaging issues; most AVR's don't allow differing frequencies for stereo pairs. It makes sense to use the same crossover point for all the front speakers (center, left and right).

If measurements show very high cut-off points for satellite speakers and therefore the crossover point would rise above 80Hz, you're risking your subwoofer(s) to become localizable. In such a case the first step is to change speaker and/or listening position. The early fall-off could be caused by room effects. Rerun Dirac Live® and check whether the response improved or not. If the speaker itself isn't capable of going deeper then it's time to get a better speaker. If any of this isn't possible then one needs to experiment with different crossover settings for that speaker. Often a hole in the frequency response caused by an inappropriately low crossover point is perceptually better than selecting a high crossover and the sub becoming localizable.

On the other hand, the speakers have to work harder which can push them over their electrical or mechanical limit.

Loudspeakers with a port

Special care has to be taken when bass reflex satellites or subwoofers are used. Below the tuning frequency of the port (this is the frequency where the woofer shows the least amount of excursion) the driver largely acts as if it is suspended in free air. Although it doesn't create much usable output it shows high excursion and is easily pushed beyond its mechanical limit. The voice coil can hit the pole plate resulting in physical damage. There's also a second effect called "dynamic compression". The voice coil heats up, the driver parameters change and the driver starts to compress (doesn't get any louder). Worst case the voice coil assembly gets too hot, burns out and the driver needs to be replaced.

Both conditions are easily met when room correction filters are applied. Dirac Live® can boost frequencies by as much as 10dB which is 10 times the power. The remedy for this is to know the speaker's port tuning frequency and apply a gentle fall-off via the target curve or use the left curtain to limit filter activity beyond the port tuning frequency (drag the left curtain to the right until the target curve "knee" roughly meets the "knee" of the corrected response fall-off). Tightly plugging the port will also make the speaker more robust at lower frequencies.

(Common) special cases

Unfortunately, AVR manufacturers haven't been very innovative when it comes to improving sound quality in areas where it would really matter, namely bass management. There is no automated solution for optimizing the crossover region between sub(s) and satellites (only exception is JBL Synthesis' ARCOS or Audyssey's now defunct installer kit). Some AVRs don't even have the ability to apply different crossover frequencies to different speakers. Don't waste your money on such inferior bass management implementations which prevent getting the best out of your amps, speakers and room.

A lot of AVRs come with bass management filters that don't sum to a flat response. For example, 24dB/octave Butterworth filters create a peak of 3dB around the crossover frequency. Some AVRs present a mixture of 6dB, 12dB or 24dB filters which can produce disastrous results. Bass management filters that work with Dirac Live® need to sum to a flat response, e.g. 24dB/octave Linkwitz-Riley filters (see example at the top).

Some (home theater) speakers are designed to fall off below about 80Hz. Such speakers won't work with Dirac Live® or any kind of room correction system because the usable speaker response needs to extend about 1 octave below the intended crossover frequency as explained above.

Some subwoofers have low pass filters that can't be switched off. Again, such a sub might not work with Dirac Live® because the usable frequency response needs to extend about 1 octave beyond the intended crossover frequency. If the sub's low pass filter is adjustable set it to the highest frequency available before running Dirac Live®.

Dirac Live® with Bass Control Crossover Challenges

Dirac Live® with Bass Control (DLBC) has added additional challenges due to the nature of how it works, and that no two calculation results may be exactly the same. In this post, AVS Forum member iStorm provided some guidance from his experience using DLBC: If there is a big dip at the crossover in any of the speaker sets, we re-calculate, and typically the dip will shift from the mains to the surrounds, for example. If this keeps occurring despite recalculating multiple times, then it typically means that Dirac might not have enough filters to make the crossover combination work.

I changed the crossovers on all of my surrounds to from 80 Hz to 90 Hz (with L, C, R still at 80 Hz) and there was no longer a big dip at the crossover point on any of the speaker groups. This is just an example and will depend on your room and speakers. In a perfect world I would like all of the speakers to be 80hz, but I am willing to compromise. I also like all of my speaker sets (L, C, R, and Surrounds, and Atmos) to have the same crossover.

Dirac Live® Active Room Treatment® Filter Process

If you prefer a video overview, StormAudio also made a video overview, located here. Alternatively, they also created the below step-by-step instructions.

1. If your device and license capabilities include ART®, then ART® will be selected by default in the correction technology section of the right-side sidebar of the Filter Design screen. If you have too few valid measurements, you will not be able to select this option.

2. ART® groups (also referred to as main groups) are speaker groups containing at least one input channel. They are shown on the right-side panel and can be managed just the same as in Dirac Live®, by dragging individual speaker channels in and out of each group.

    a. Active Room Treatment® groups are designed to simplify parameter settings for multiple speakers. Group speakers with similar parameters together for easier management. For example, in a 2.2 system, you could use two or three groups.

        1. Two groups: Combine Left and Right speakers in one group, and Subwoofers in the second group if you want to use the subwoofers the same way.
        2. Three groups: Combine Left and Right speakers in one group, and place each subwoofer in separate groups if you want to control their interaction with front speakers independently.

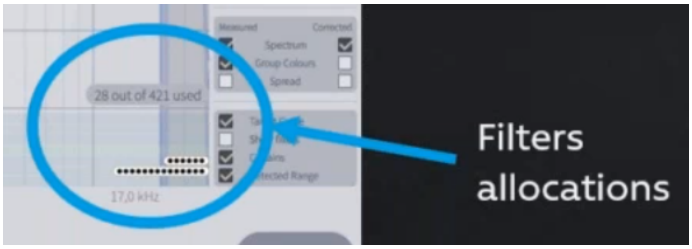
    b. For larger systems, the concept remains the same. Group speakers based on their usage and position, considering speaker location's impact on settings like Fsiso and F-support High. Choose groups that make the most sense for your system and listening position.

3. The main concept behind the powerful control of decay time in ART® is based on speakers being co-optimized to reach the desired impulse response and target curve by assigning speaker support groups to each ART® group. The frequency range at which a support group is allowed to contribute to an ART® group is called the Support Range. The Support Range is automatically detected from the measurements and set as default upon initializing the ART® filter design.

    a. Each ART® group has a set of sliders at the bottom of the Filter Design graph area. The sliders allow enabling or disabling the support speaker groups allowed to contribute to the selected ART® group. The sliders also allow easily setting the F-support Low and F-support High frequencies. The vertical dashed line can be moved to adjust the Fsiso frequency. The parameters panel is the only place where the Support Level can be adjusted. For descriptions of ART® parameters, see the sections above.

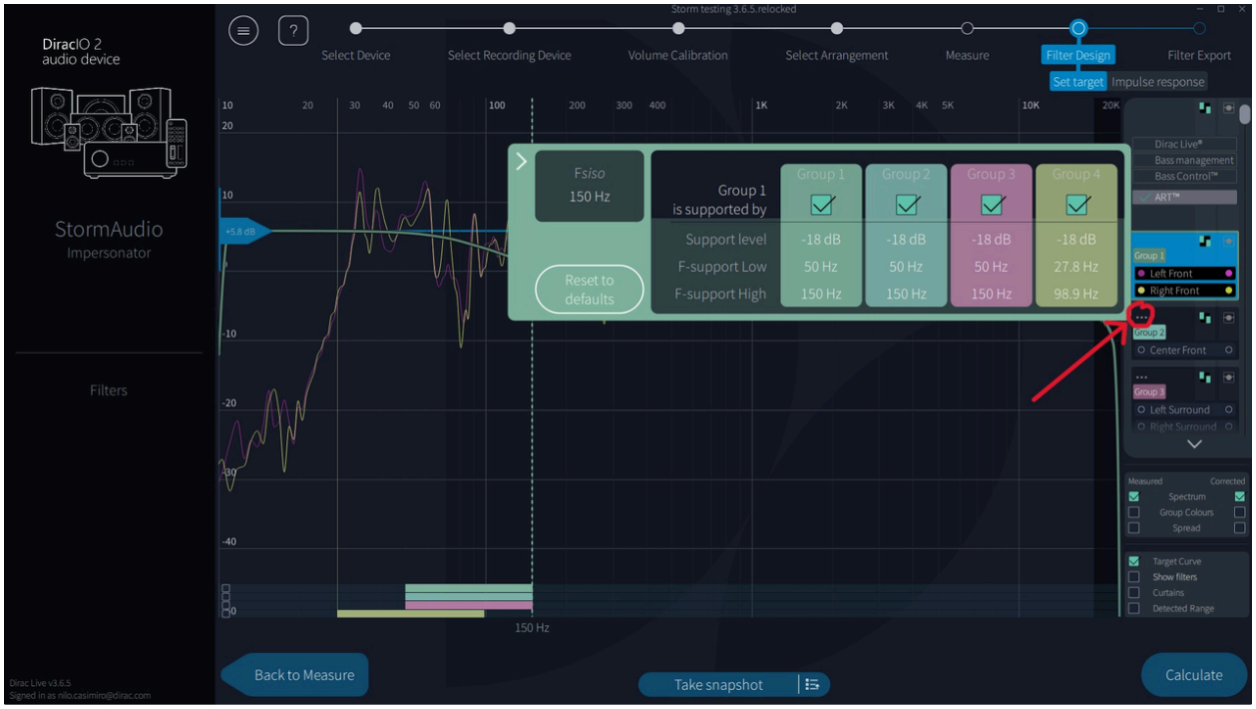
b. Each support group can be enabled or disabled from providing support to a particular ART® group by toggling a checkbox that appears when the mouse pointer hovers over its slider track.

4. ART® uses a lot of processing power. The number of available filters varies by manufacutrer. As you make changes to the groups, and add support speakers, the filter allocations will show in the lower right corner of the application.



5. The parameters for ART® are also accessed by clicking the triple-dot button in the top left corner of the channel group box which unfolds the parameter panel. This button is only available on ART® groups; for descriptions of ART® parameters, see the sections above. The parameters panel is the only place where the Support Level can be adjusted.

    a. Every ART® Group (main group) can be supported by every other channel group (support group). As a common setting, the upper limit to which the supporting groups are allowed to support the main group is specified in the Fsiso setting.



6. Edit the bass and treble target curve sliders in the Filter Design view (outside the parameters menu) to your liking. It is common to increase the bass slider on the left.

If you have several groups, these sliders can also be changed. It is common to change these to the same values as the first group.

7. After these edits, press "Calculate". It will take a little while to calculate the changes.

8. When your filter has been calculated, press "Proceed to Filter Export".

9. Export the filter to your device.

10. Your filter is now exported to your device. It is also shown on the left side of the Dirac Live® screen.

Post-Dirac Calibration Analysis

Speaker Levels

The first consideration before checking the speaker levels is to ensure the chairs are positioned as when they were measured, whether upright, or reclined. If speaker trim levels are checked post-Dirac, and measured from the MLP, there may be differences. Dirac sets the speaker levels based on all of the different microphone measurement positions in combination, not only from the first (MLP) measurement. The delays are set from the first (MLP) measurement.

The user may still prefer to adjust the levels based on external test tone generators measured from the MLP if watching is typically a solo experience. Two profiles could be used, depending upon the number of listeners in the theater.

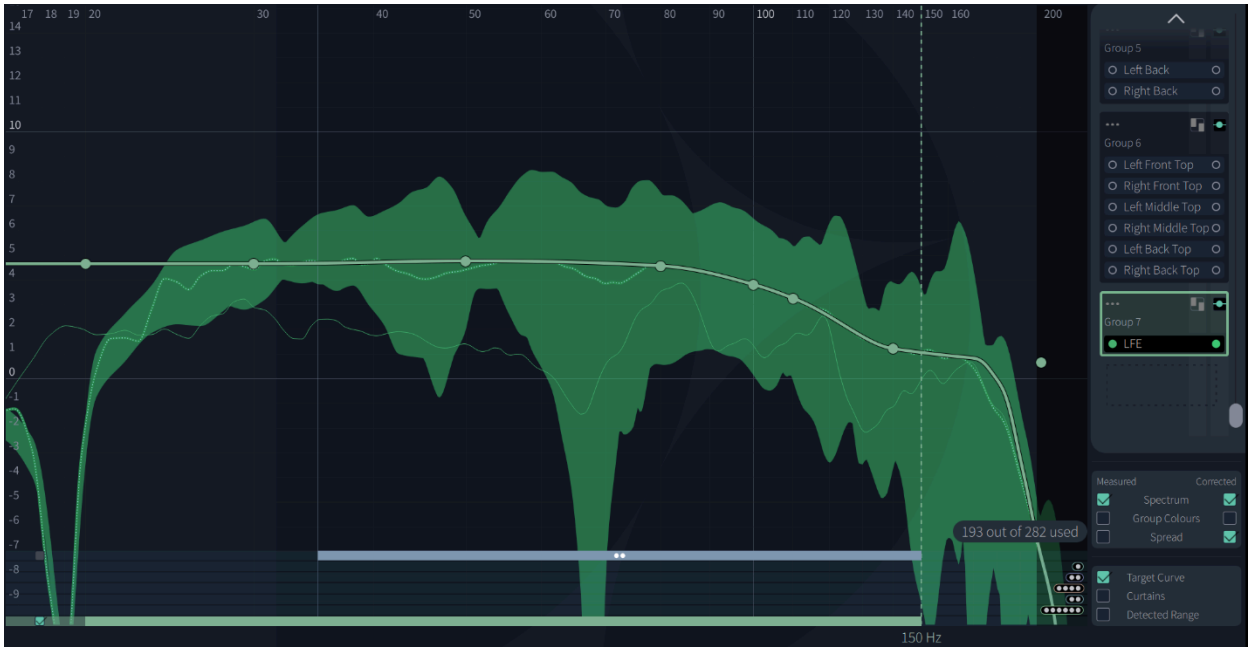
Post ART® Calibration Analysis

While the results calibrating with Dirac Live® ART® will vary based upon the subwoofers, speakers, and room, one observation by AVS Forum member Norixone in this post is that too much support for a given speaker group can make the bass sound dull; the effect is a little bit like reverb. If you add too much absorption into the room the resulting sound becomes unnatural. There is a similar effect with bass; if you go below a certain decay time, it feels like a lack of bass. Therefore, a minimalist approach to the number of speakers supporting a given speaker group may result in a more pleasing sound.

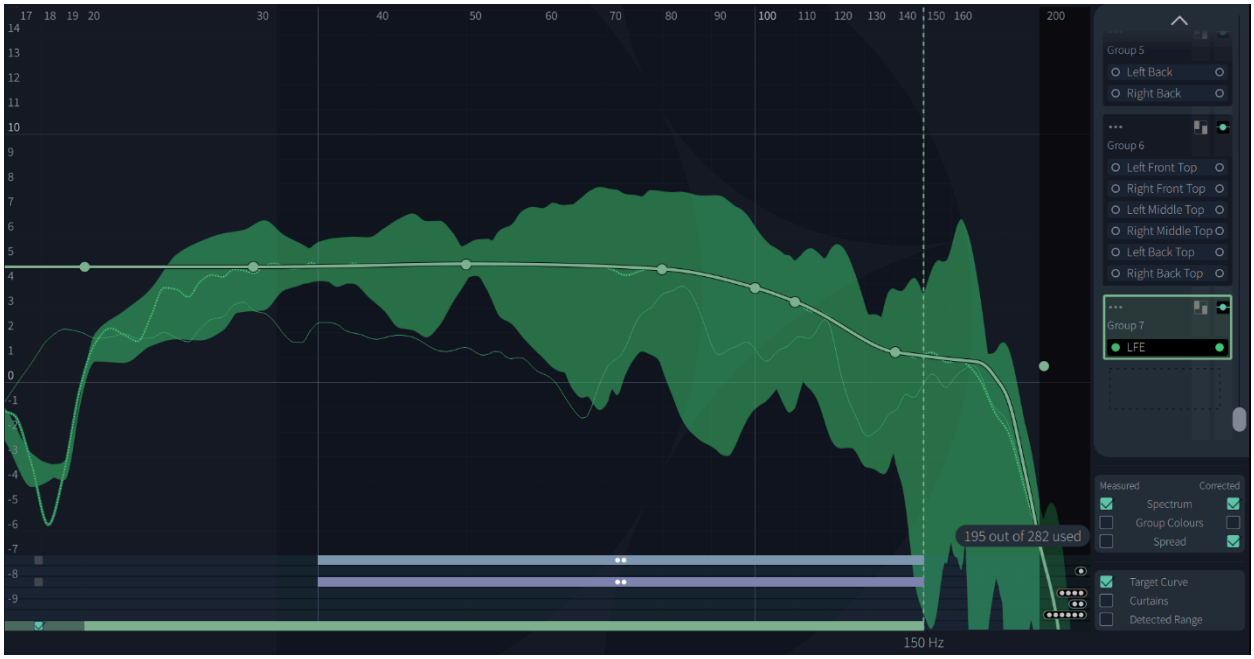
To mitigate this effect, utilize the spread graph in the Dirac Live® tool. The spread graph is a shaded area that represents the ± dB measured for the trace from all measurement positions; it can be selected for both the measured and corrected traces. In practice, there is a coherence between the spread graph and the phase graph. Compare the changes in the spread graphs as you make adjustments and calculate after each change. Utilizing saved screen shots will allow granular comparison as you switch rapidly between two images using ALT + Tab. The following adjustments made to a main speaker group will result in changes to the spread graph: Adding or removing speakers as support, Fsiso, Suport Level, F-support low, and F-support High.

The overall goal is to is to minimize the corrected spread. Below are two examples showing the change in spread when changing the amount of support speakers utilized.

Supporting speakers: FL, FR



Supporting speakers: FL, FR, LW, RW



The spread is minimized when more speaker support is added in the above examples. However, just because the predicted result is better, it may not always sound better. Listening tests are an important part of this process, and making adjustments to the project, exporting, and listening

again may be required. It is an iterative process that is very critical because of the complexity of ART® and the various parameter adjustments that are possible.

For listening testing, 2-channel music—ensure that no upmixer is enabled—will reveal if the surround support speakers can be localized or audible. Adjustment of the Support Level or the F-support High frequency level of the given surround speaker may be required.

Ensure the spread graph does not extend more towards the bottom for certain frequencies, as noted in the examples below, from this post. For example, while adding back speakers to support the L, C, R may provide a smoother calculated bass response, it may also degrade the signal above 150 Hz.

I have done a few tests comparing different ART setups. The most interesting thing I discovered, as others have observed, is how sound changes by changing the number of support channels or iterations of support channels. The most evident difference is with panning effects. In some configurations the sound was open, but with holes between areas. In other configurations, the sound closed-up around the listener, diminishing the panning effects.

The Dolby Atmos “Leaf” demonstration clip is useful to test the effect. If you add support speakers that result in a negative impact to the spread graph (i.e. the graph extending more towards the bottom for certain frequencies) whether above or below 150 Hz, the result is the sound closes-up around the listener, with diminished panning effects. However, the benefit may be speaker-to-speaker coherence during panning effects. Measuring with REW also reveals a phase change, which indicates a change in timing.

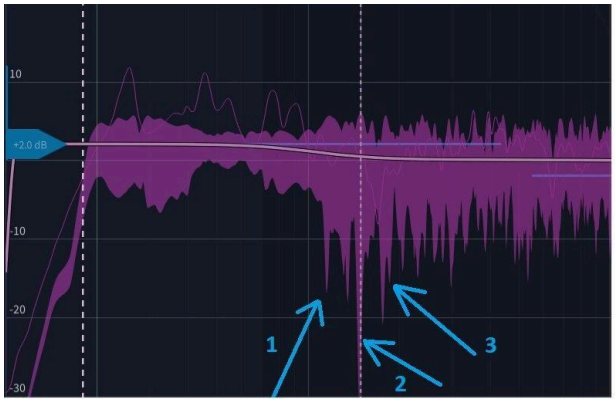
In the first picture below, you see my left channel supported by the right channel and subs. I have highlighted a spike with an arrow.

Adding the two surround left speakers as supporting channels changes the result:

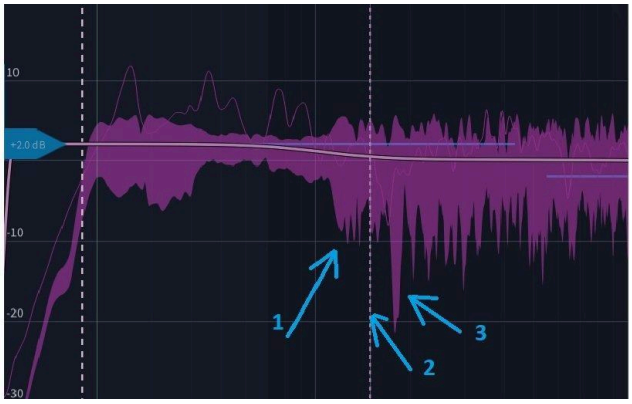

Select Device
Select Recording Device
Volume Calibration
Select Arrangement
Measure
Filter Design
Filter Export
Set target
Impulse response
Group 2
Center Front
Group 3
Right Front
Group 4
Left Surround
Left Surround 2
Group 5
Right Surround
Right Surround 2
Measured
Corrected
Spectrum
Group Colours
Spread
Target Curve
Show filters
Curtains
Detected Range
113 out of 126 used
150 Hz
18,2 kHz
Back to Measure
Take snapshot
Proceed to Filter Export

Now you would assume that this is a much better result and you should keep the two extra channels as support speakers, but when you look a little closer, there are some issues:

Group 1 – LF – Supported by RF



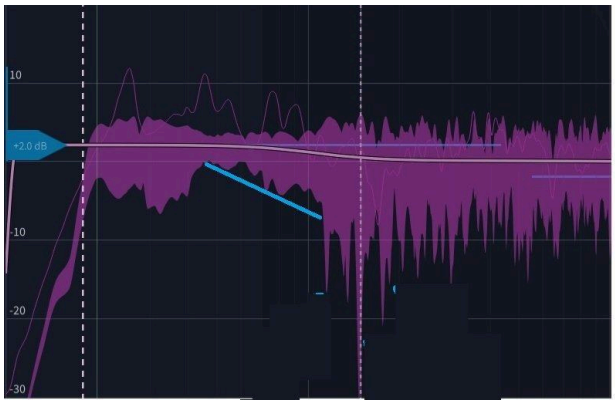
Group 1 – LF – Supported by RF, RS, BR



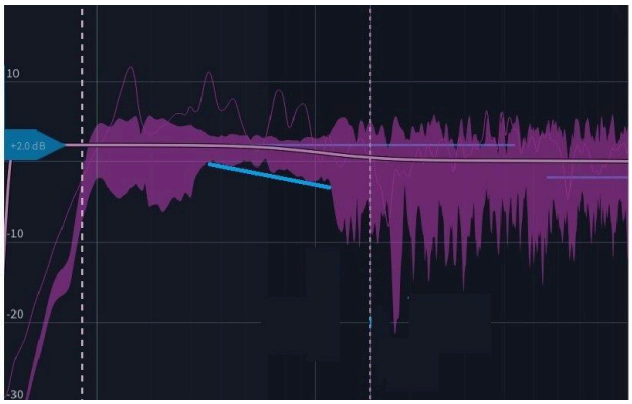
The spread graph near arrows 1 and 2 show improvement with the addition of the left surround supporting channels (graph on the right), but the area near arrow 3 is worse, and is beyond the 150 Hz high limit of the Fsiso (dotted line near arrow 2). The reason it became worse is because ART altered the phase response above the Fsiso 150 Hz limit.

Another effect of adding more support speakers is that bass can become more anemic, as seen with user complaints about bass being lacking with ART correction. This effect can also be seen it in the graph below, with a reduction in the overall spread between ~40-120 Hz:

Group 1 – LF – Supported by RF



Group 1 – LF – Supported by RF, RS, BR

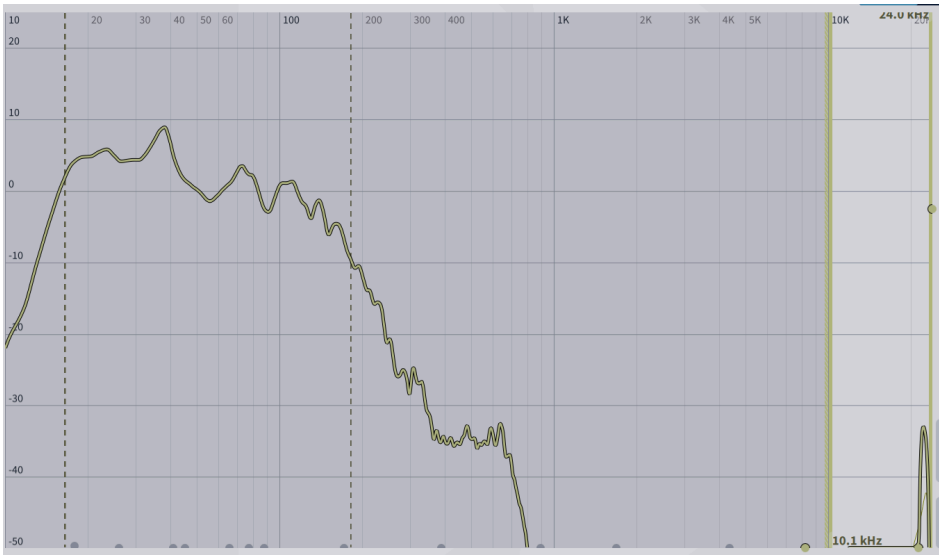


This spread graph analysis revealed detrimental effects by adding extra support speakers. The changes occurring above the Fsiso point also had an effect on the sound field, making it tighter in the graph on the right, rather than more spacious in the graph on the left. The goal was to examine the cause and effect, and the user can choose the preferred configuration.

LFE Channel Manual PEQ Correction with Dirac Timing & Mixed Phase Correction

This tip is courtesy of AVS Forum member SOWK. Some users may prefer to have manual PEQ correction on the LFE channel, but still have the benefit of Dirac Timing & Mixed Phase correction. This technique is also useful to mitigate the Dirac correction for tactile transducers. After setting up your manual PEQ on an external DSP device (miniDSP, etc.) and taking the Dirac measurements, perform the following:

1) During the Filter Design stage, lower the LFE channel target curve points to -50 dB.
2) Move the curtains to 10K-20K, so it won't correct the low frequencies.
3) Below is an example after having completed these steps.



Tactile Transducer Channel Setup

Introduction

Dirac is supposed to be working on a way to exclude tactile channels from the calibration. Mathias Johansson, the Co-Founder of Dirac, in this video, at this specific time stamp, said this feature will be coming in 2024. However, if you consider that most tactile devices operate below 20 Hz, and Dirac does not correct below 20 Hz, the argument can be made this is not much of an issue. The purist position is that the tactile channel should have no room correction at any frequency. Those are both sides of the spectrum, so the reader can decide.

This tip is courtesy of AVS Forum member SOWK. Currently, processors do not allow the addition of a non-corrected channel, which would be used for tactile transducers. To mitigate the Dirac correction for tactile transducers, move the curtains to 10K-20K, so it won't correct the low frequencies. Note: When using Dirac Live® Bass Control, all low-frequency channels are grouped together, so this technique is not possible.

Timing of tactile devices is another issue, since the delays set by Dirac Live are usually not able to be adjusted by the end user in order to properly perform this alignment.

The theory of Negative Delay

Tactile devices are always at closer physical distance to the listener than the far-field speakers and subwoofers. This would normally require the tactile device delay / distance to be greater than the far-field speakers and subwoofers to ensure the sound / feel both arrive at the same time. However, tactile devices always require their delay / distance to be less than the far-field speakers and subwoofers. This is frequently referred to as negative delay.

While this may seem contradictory, it is a due to a fundamental difference between a normal speaker or subwoofer driver with a small moving mass converting to sound waves moving through the air at the speed of sound versus a tactile device mechanically coupled to a large moving mass of the seating.

Since DSP devices do not allow negative delay / distance settings, the far-field speakers and subwoofers must have delay / distance settings greater than the tactile device to ensure the sound / feel both arrive at the same time. This additional delay is added to the AVP/AVR, and essentially creates negative delay for the tactile device.

There are several factors that require tactile devices have negative delay:

As noted above, the small moving mass of the subwoofer driver versus the large moving mass of the seating.
The additional A/D and D/A conversions caused by external DSP devices.
Group delay at low frequencies (tactile devices) versus higher frequencies (subwoofers).

Time Alignment Process

To perform the time alignment, adjust the delay of the far-field speakers and subwoofers until the sound you can hear (from the far-field subwoofers) and feel from the tactile device arrives at the same time. This can be challenging, but start by making large adjustments (+/- 40 ms) to feel the difference, and then start reducing the of adjustment amounts.

To ensure the time alignment is accurate, AVS Forum member aron7awol advised in this post, that very quick and powerful bursts are easier to expose time alignment errors versus slow bursts that will make it seem like the timing is accurate. There is a benefit to using music in that it has a rhythm that you can track, so then you are actually anticipating hearing & feeling the beat at a specific time, and when it doesn't happen perfectly it is more noticeable.

For setting timing with real content, in the film Bohemian Rhapsody, the second song (Radio Gaga) during the Live Aid concert has a very strong kick drum beat. Alternatively, there is a custom-made time alignment file made by AVS Forum member SOWK; download the file located here. This file contains a set of 20 impulses spaced 3 seconds apart. Each impulse has content from 1-80 Hz with a big peak at 30 Hz and full band content below 10 Hz with a peak at 6 Hz. The big peak at 30 Hz is intended to energize the subwoofer while the full band content below 10Hz energizes the tactile devices.

If you do not have a miniDSP, the initial recommendation is to start with the delay for LFE output for the tactile device set as the longest distance possible. Denon/Marantz AVRs only allow a 20 feet / 17.76 ms maximum difference between the shortest and longest speaker distance.

A miniDSP is a very valuable device because it has capabilities that far exceed many AVPs and AVRs. It offers several options for time-alignment of tactile devices. As noted in this post, AVS Forum member Nalleh performs pre-equalization of the subwoofers so the room correction does not add any room correction filters to the subwoofers, and therefore providing a linear LFE signal without room correction filters. Next, he adds a delay to the closest far-field subwoofers in the miniDSP output channels so that the room correction sees all subwoofers as the same distance / delay, and therefore will send a time-aligned signal to the TR devices.

The process of using a miniDSP and an Onkyo AVR with Dirac Live to time-align tactile transducers was detailed in this post by AVS Forum member Mikejl.

As noted in this post, AVS Forum member Nalleh also used Vibsensor to perform tactile time alignment with measurements, similar to how we use REW for speakers and subwoofers.

Note that the time alignment changes slightly with various PEQ filters, so once you settle on a combination of LPF filter (frequency and slope) and shelf filters, perform the time alignment again. This affect was measured by both AVS Forum members Nalleh and aron7awol. Nalleh tested using the far-field subwoofers and a microphone with an acoustic timing reference, as noted in this post. Aron7awol used a loopback timing reference from the miniDSP to measure the differences between an output without any filters to an output with filters, as noted in this post.