Tech Blog

Using Delay Settings to Integrate your Audio System

Optimizing speaker and subwoofer performance with delay measurements

After using key measurements to verify all basic system functions, it's important to optimize your speaker and subwoofer performance using delay settings. Aligning the time of arrival of the audio signals from the full-range speakers and subwoofers improves system coherence.

In this tech blog, we will explore two methods for completing the time alignment process: Physical Delay using a four subwoofer home theater system, and Electronic Delay using a 2.2 stereo configuration. Both methods capitalize on the advanced technology of miniDSP products.

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1. Selecting a Method for Measuring and Applying Delays

There are two basic approaches for time alignment of all speakers and subwoofers within a group: Physical Delay Measurement and Electronic Delay Measurement.

The simplest method uses physical distance measurements. This requires that all the subwoofers be of the same design. In our example for this tech blog, we show a miniDSP 2x4 HD driving four subwoofers in a home theater system. Since everything is done with a tape measure and no electronic measurements, a full range timing reference speaker is not necessary.

The second approach uses Room EQ Wizard (REW) to calculate the delays electronically and is especially suitable for systems with various types of subwoofers and / or full range speakers. An advantage of using an acoustic timing reference signal to electronically measure delays is that it accounts for the effects of inline digital signal processing (DSP) and any wireless interfaces. In this example we measure a 2.2 stereo system that includes a miniDSP Flex, two full range speakers and two subwoofers, with one of the full range speakers used as the acoustic timing reference source.

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2. Physical Delay Measurement Method

Using physical measurements to determine the delay from the various subwoofers to the listening position assumes the subwoofers are the same design and have equivalent DSP latency.

Typical Measurement Layout

The diagram below depicts the physical layout and center position for making measurements. This example is for a home theater setup with four subwoofers, which will be delay corrected prior to being connected to the audio video receiver (AVR).

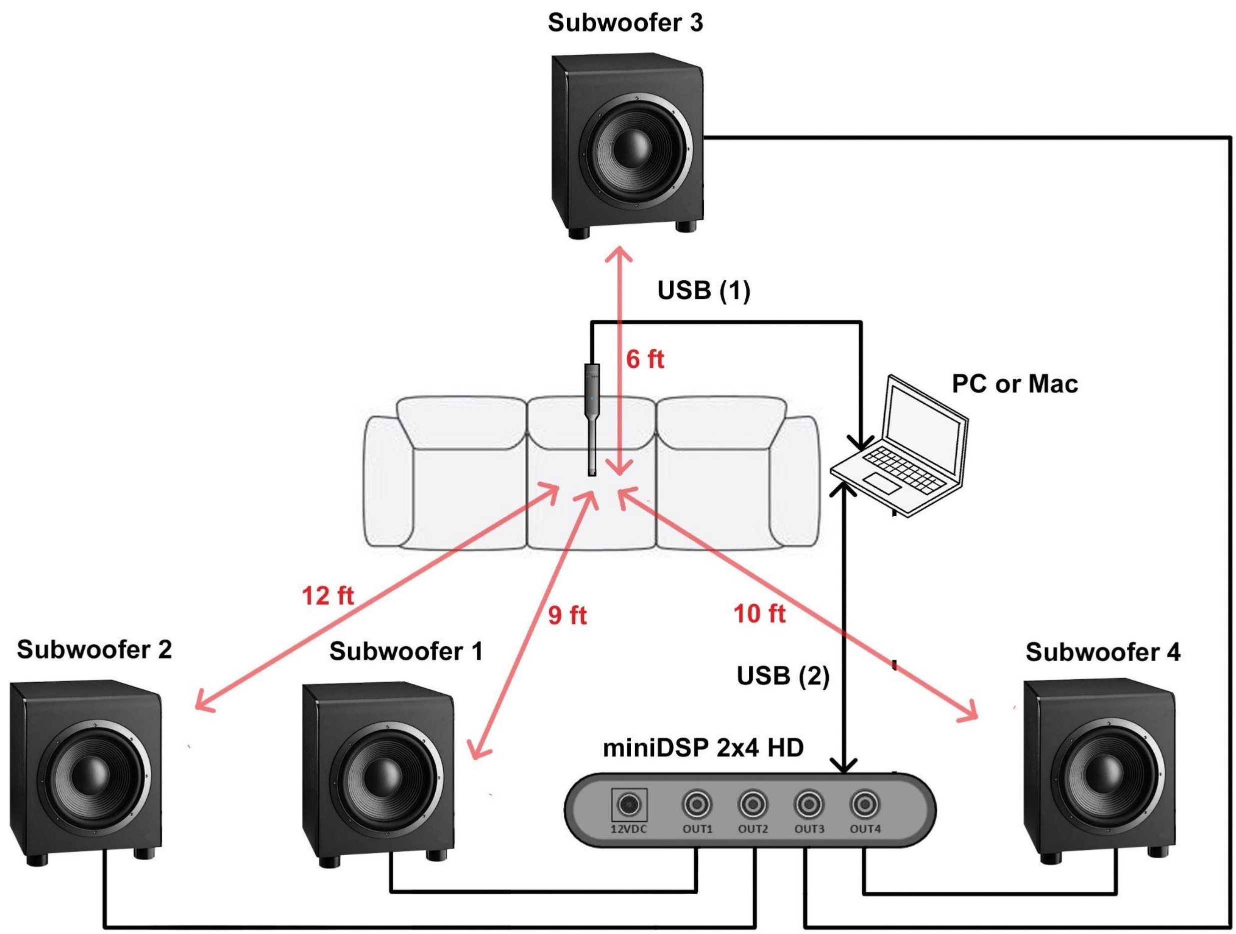

Diagram 1. Typical layout for measuring physical delay distances in a multi-subwoofer setup

Physical Delay Measurement Workflow

1. Measure the distance of the subwoofers from the central listening area
2. Calculate the difference in distance of each subwoofer from the farthest subwoofer in feet
3. Find the delay in milliseconds by dividing the distance in feet by 1.11 (sound travels at 1.11 feet per millisecond)
4. Complete the delay calculations for each subwoofer in your system (the spreadsheet below shows the delays calculated for our example)

Physical Delay Measurement	Sub 1	Sub 2	Sub 3	Sub 4	
Microphone in center of listening area. Measure distance to microphone.	9	12	6	10	ft
Subtract the farthest away subwoofer (Sub 2) distance to get the relative distance (-12 ft)	-3	0	-6	-2	ft
Delay to be added in Device Console (foot/1.11 sec) (see red box)	2.7	0	5.4	1.8	ms

Diagram 2. Physical delay measurement calculation spreadsheet

Inserting Delay Figures into Device Console

Once you have calculated the delays that need to be added to each of the subwoofers, you will insert the figures in the delay row of Device Console. Keep in mind that the closer the subwoofer, the more delay will be added. This ensures that all of the subwoofers are equal to the delay of the subwoofer that is farthest away.

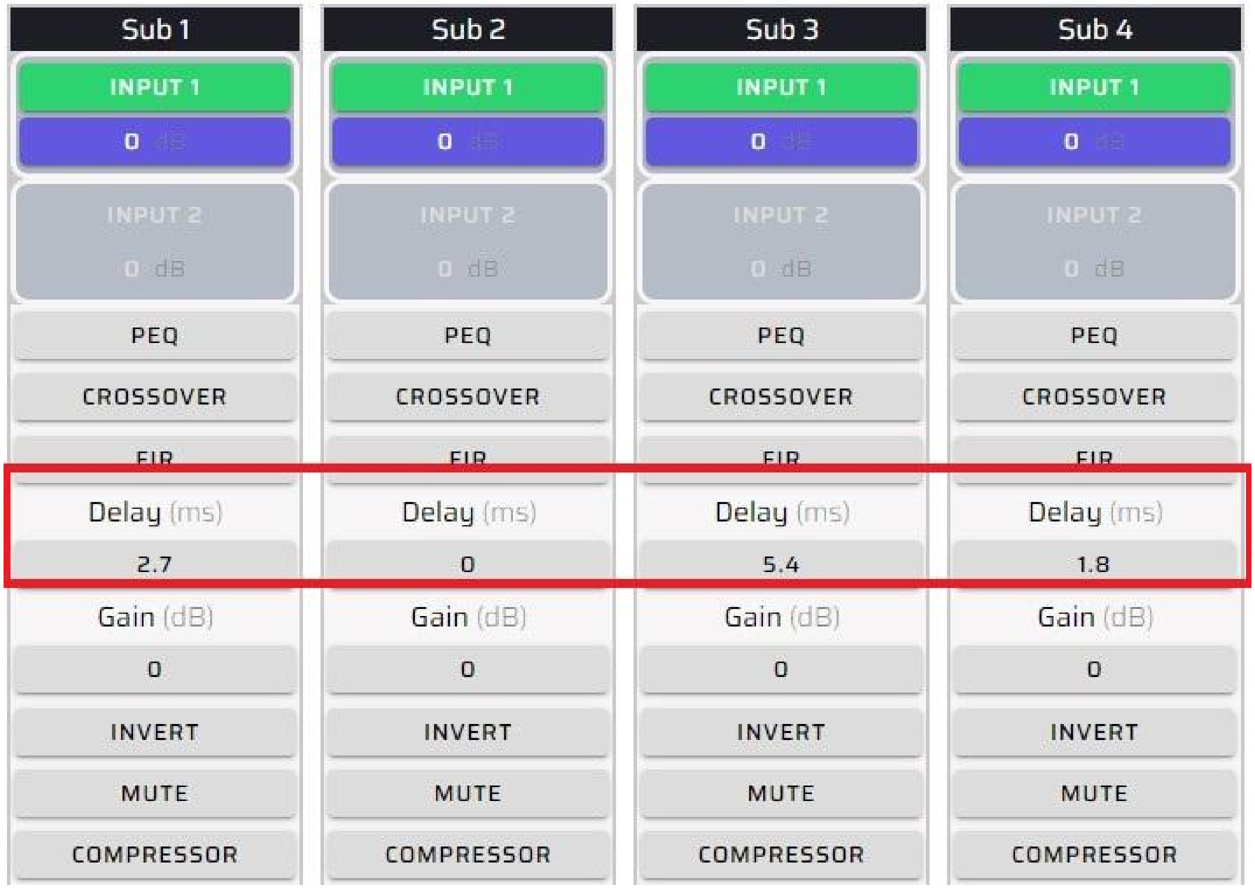

Diagram 3. Device Console with delay figures inserted

Next Steps

Now that you have inserted your delay measurements in Device Console, you will complete your crossover and relative level settings and then move on to either your REW or Dirac Live room correction project. With your subwoofer system now optimized, you can connect it to your AVR and calibrate the entire system using Audyssey, ARC, YPAO, Dirac, etc.

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3. Electronic Delay Measurement Method

Using REW to electronically calibrate delays is the most accurate method for ensuring the acoustic wavefronts of all speakers are coincident to the listening area. These delays should be calculated prior to running an REW or Dirac Live room correction project. Having delay settings in place will provide better results for your room correction project. As you proceed, be sure to check your work and verify it with physical measurements. Keep in mind that sound travels at 1.11 feet per millisecond.

Typical Measurement Layout

The diagram below depicts the physical layout and center listening position for making typical measurements. This example is for a 2.2 stereo system setup.

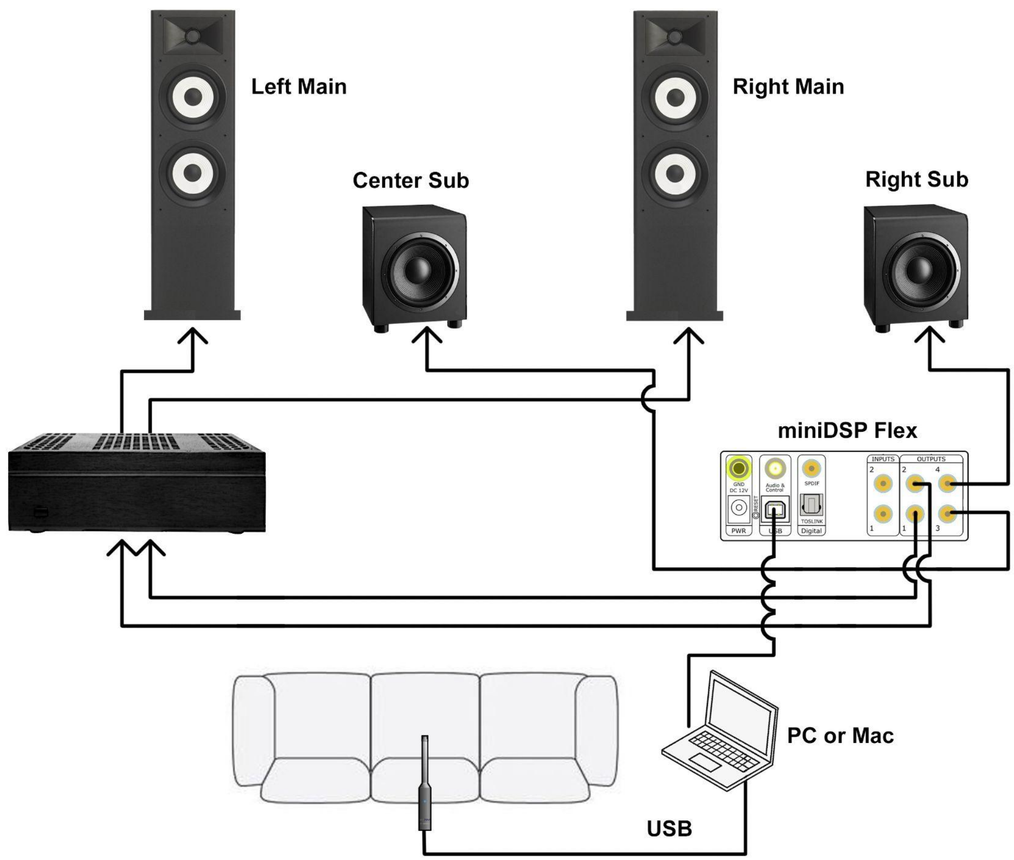

Diagram 4. Typical layout for electronically measuring delays in a 2.2 stereo system

Crossover and Equalizer Settings

Electronic delay measurements will be performed with all crossover and equalizer settings set to off or bypass. This ensures the most accurate delay measurements. Be sure to save your XML configuration files prior to bypassing and removing the crossover settings. Once you have completed all measurements and are satisfied with your delay settings, you can reinstall your basic Device Console XML configurations.

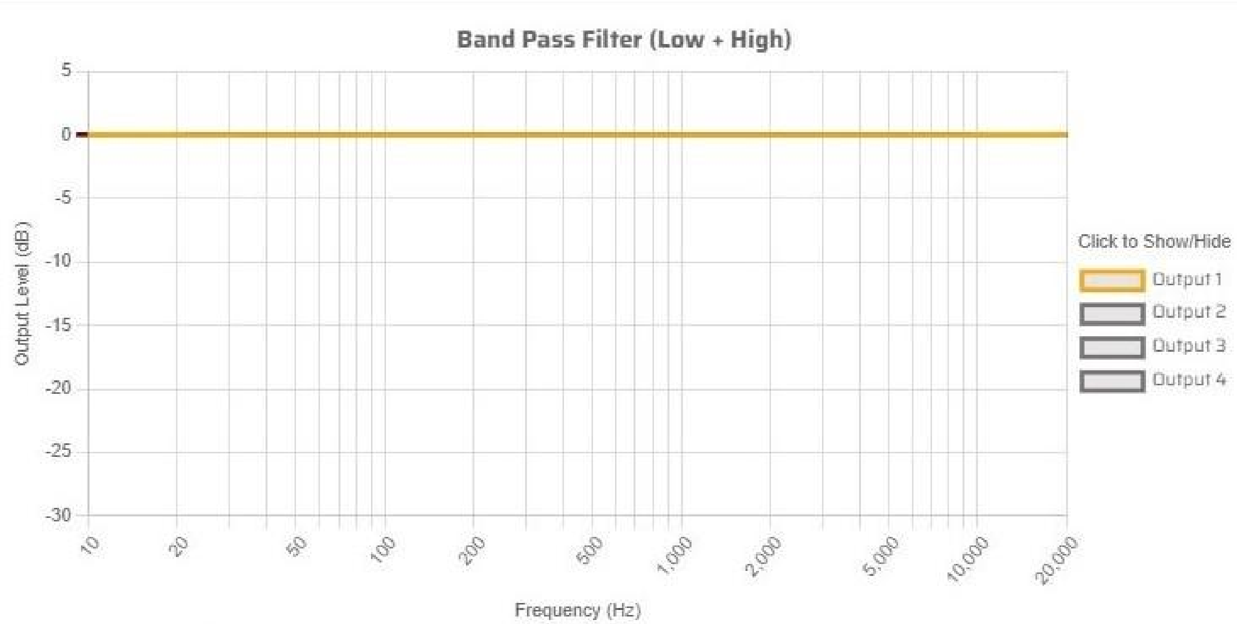

Diagram 5. All crossovers bypassed or turned off in Device Console

Acoustic Timing Reference Signal

An acoustic timing reference signal allows you to electronically measure the relative delays between the four speakers in a 2.2 system. The first step is to determine which of the speakers is closest to the listening area. Keep in mind that speakers with additional digital signal processing, such as subwoofers with DSP or wireless interfaces, can have significantly greater delay.

It's required that the test signals have sufficient bandwidth, preferably at least 250 Hz. In order to achieve this you need to turn off all crossovers or ensure they are set to their maximum frequency. The greater frequency range you can get out of the subwoofers, the more accurate the measurements.

Setting REW Preferences

On the REW preferences page, set the timing reference output to the left channel and set the speaker output (delay measurement signal) to the right channel. This corresponds to channels one (1) and two (2) on Device Console.

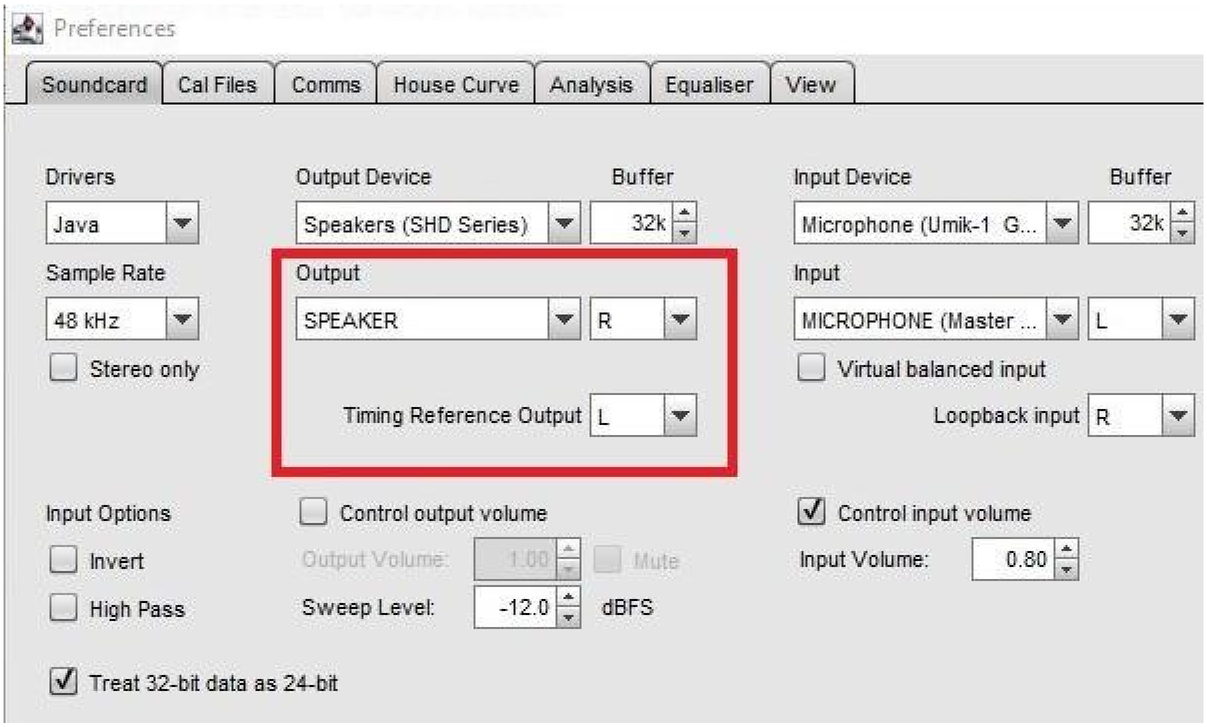

Diagram 6. The REW Preferences Soundcard tab showing timing reference signal on the left channel (1) and delay measurement signal on the right channel (2)

Measurement Reality Check

Before making actual delay measurements from the listening position, start out with the microphone near the acoustic timing reference output, in this case the left main speaker. Next, make measurements of all the other speakers and subwoofers in the system that are farther from this point. You should be able to confirm with a tape measure that your electronic measurements are true (sound travels at 1.11 feet per millisecond).

Electronic Delay Measurement Workflow

1. Verify the presence of the timing reference signal
2. Place the microphone in the center listening position
3. Measure each speaker / subwoofer delay relative to the timing reference source
4. Calculate the delay settings for Device Console
5. Enter the required additional delays into the Device Console delay row
6. Verify your delay corrections

Speaker Delay Measurement Selection

With the mute and routing matrix functions of Device Console, you can select which speaker / subwoofer is being measured for delay. In this first example, the leftmost main speaker (our acoustic timing reference) is generating both the timing reference signal on the left channel and the delay measurement signal on the right channel. The expectation is for this number to be close to zero, as the signals are coincident.

In the first measurement below, Device Console shows the timing reference signal and delay measurement signal coming from the left main speaker.

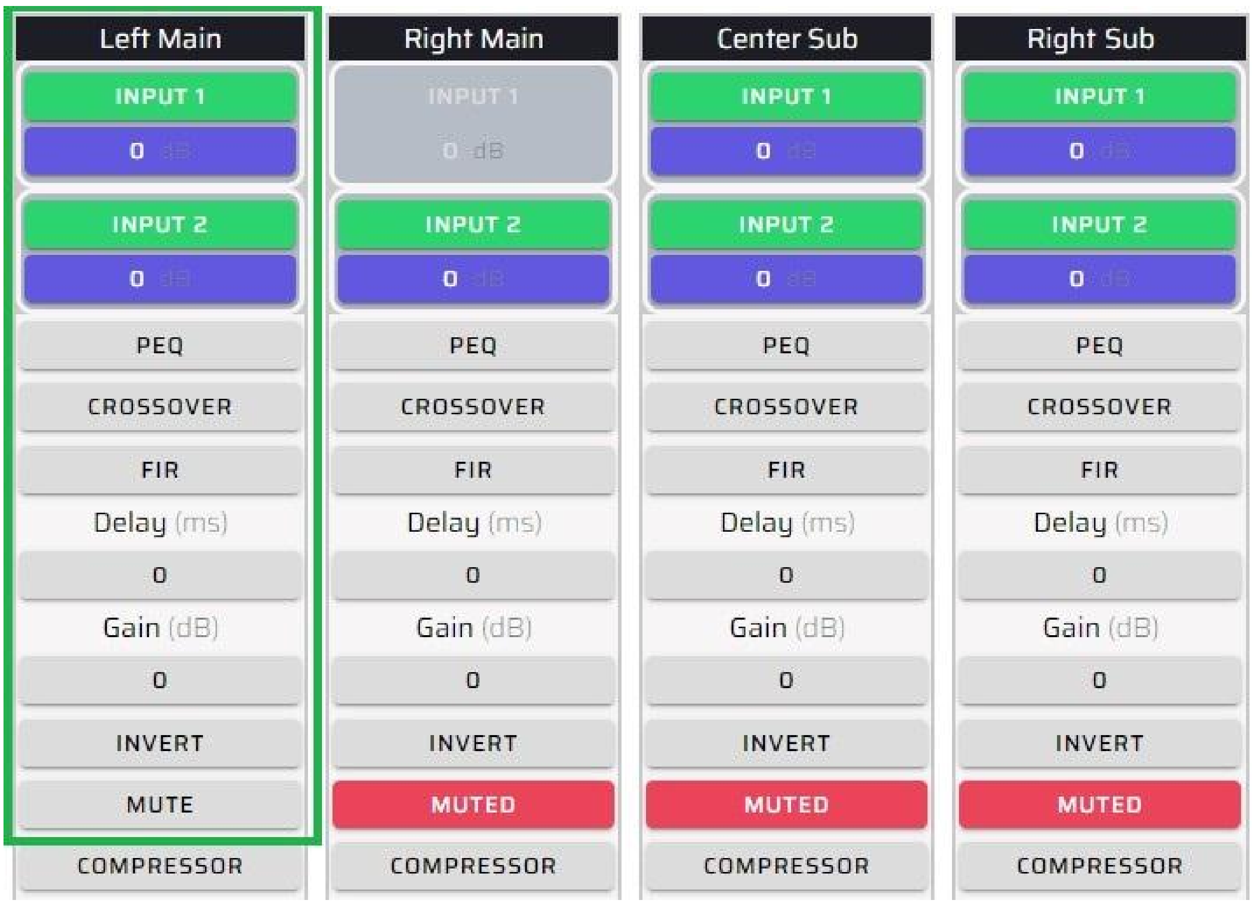

Diagram 7. Measuring delay on the same speaker that is generating the timing reference signal

In the second measurement below, Device Console shows the timing reference signal coming from the left main speaker and the delay measurement signal coming from the right main speaker.

Diagram 8. Measuring the delay of the right main speaker relative to the left main speaker (timing reference)

Once you have completed the delay measurements of the remaining speakers and subwoofers, the resulting REW display will have all of the delays listed on the left.

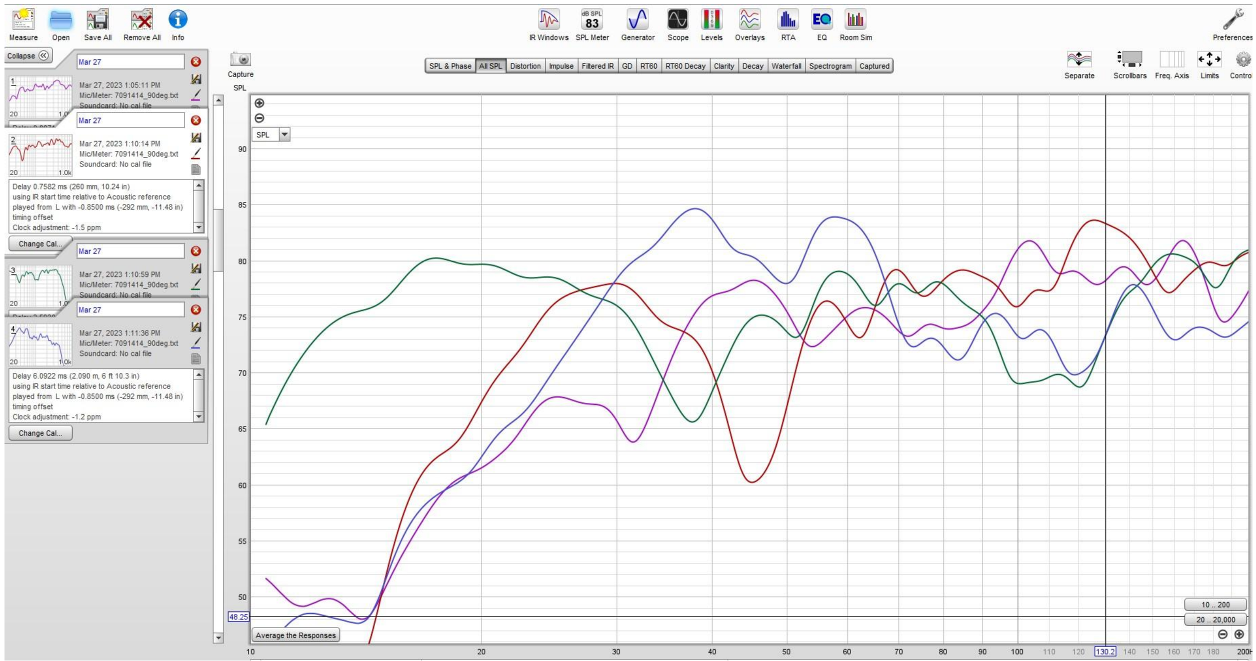

Diagram 9. Delay measurements of all speakers shown together, with the individual delay values on the left (see Diagram 10 for close up)

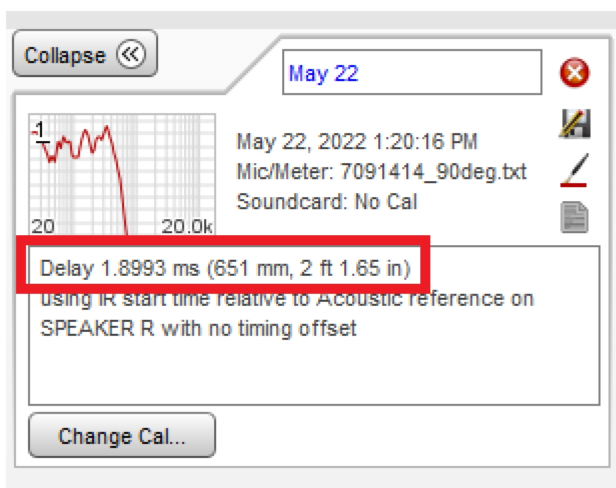

Diagram 10. Close up of REW delay readout

Calculating Delay Settings for Device Console

Once all your delay measurements are complete, transfer them from the REW page into a spreadsheet. You can then determine which speaker / subwoofer is the farthest away (physically and electronically) by identifying the largest delay value (right subwoofer in our example). In your spreadsheet subtract the largest delay value (6.1 ms) from all of the other delay measurements. See last row of spreadsheet below.

Electronic Delay Measurement	Left Main	Right Main	Center Sub	Right Sub	
Microphone in center of listening area. Left main normalized to 0 in delay offset (use timing reference offset).	0	3.6	.8	6.1	ms
Subtract the farthest away speaker distance to get the delay figure to be added in Device Console	6.1	6.1	6.1	6.1	ms
Delay to be added in Device Console (see red box)	6.1	2.5	5.3	0	ms

Diagram 11. Electronic delay measurement calculation spreadsheet

After completing your calculations, the resulting delay figures will be added as positive numbers in the Device Console delay settings row, highlighted in red below.

Diagram 12. Delay values are entered into Device Console

Verify your Delay Corrections

You should now have time aligned all of the speakers and subwoofers in your system to the center listening area. You can verify this by going through and repeating all of the delay measurements. You should expect to see variances of a few milliseconds or less.

Next Steps

Now that you have inserted your delay measurements in Device Console, you will complete or reinstall your crossover and relative level settings. It's now time to move on to either your REW or Dirac Live room correction project.

Deer Creek Audio Tech Series:
Key Concepts for Creating a High-Fidelity Audio System

We offer a series of Tech Blogs to guide you through the key concepts for the proper design, layout and execution of miniDSP-based audio systems. The guides can be read sequentially with each concept building on the previous one, or individually as in-depth discussions of specific topics.

Please watch for future Tech Blogs about:

- Initial System Verification
- Delay Settings
- Crossover Settings
- Relative Amplitude Settings
- Filters for Room Correction Using REW
- Frequency and Time Domain Room Correction Using Dirac Live
- Tuning to Taste

If you have questions or would like to discuss in more depth, feel free to give us a call or drop a line.