GRADE™

Genelec Room Acoustic Data Evaluation

GENELEC®

Contents

Chapter 1

Information

The following tables show information collected from Genelec GLM software and the AutoCal 2 room calibration algorithm.

GLM setup name	Stereo.sam
Group name	Stereo 2.1
Group description	RME Mac/PC
Room dimensions (LxWxH)(m/ft)	4.00 x 4.00 x 2.50 / 13.1 x 13.1 x 8.2
Room volume (m^3 / ft^3)	40 / 1400
Measurement date (local time)	2022-5-17 20:52:40
Report created	2022-05-17 21:53:37
GRADE version	2022-05-16
Microphone serial number	207614

Table 1.1: Measurement information.

Name	Serial number	UID	Firmware version	Calibration group ID
Left 8320A	8320APM1004984	1089992	1.8.1.4130	1
Right 8320A	8320APM1004985	1089996	1.8.1.4130	1
Sub 7350A	7350APM61001525	1064033	1.10.8.4406	0

Table 1.2: Monitor and subwoofer information.

1.1 Scope

This room acoustic report analyses the measurements taken by GLM's AutoCal calibration system. We hope this document can help you understand and improve your monitoring room acoustics and the placement of your monitors where necessary, for the purpose of professional monitoring. The metrics have been selected to present the most relevant information for loudspeaker systems that are used for high precision audio monitoring work: reliable frequency response, good imaging and accurate delivery of the envelopment within the recorded audio.

In professional monitoring, the aim is a neutral frequency response at the listening position. As variations in the listening level will affect the way we hear sounds, this level must be taken into account. Because exposure to high sound levels can affect your hearing, we recommend avoiding the regular use of sound levels that can harm the auditory system. This means keeping the daily and weekly sound exposure below 80 dB (LEX,8h) - see the EU Noise at Work Directive 2003/10/EC (http://data.europa.eu/eli/dir/2003/10) and EBU R128 (https://tech.ebu.ch/loudness).

While there may well be some simple improvements that you can make yourself, you should also find the depth of information in this report useful when discussing your room with acoustic treatment suppliers, acousticians and studio designers.

Chapter 2

Summary

Your monitoring system performance is summarised on this page. The table shows all the monitors and subwoofers in your system, along with an overall analysis of their characteristics.

The system performance is colour coded. The green colour indicates excellent performance. When the colour is yellow, your system performance is good, but you may want to consider improvements where possible. When the colour is red, your system may not have optimal performance and improvements may significantly enhance the quality of your monitoring system.

Monitor name	Operational room response (%)	Early reflection level (dB)	Early vs late sound ratio (dB)	T60 flatness, inside window (%)	Deepest notch below 300 Hz (dB)
Left 8320A	98	-17.1	5.8	100	-8.4
Right 8320A	93	-9.1	5.9	100	-11.1

Table 2.1: Summary of results, colour coded to indicate excellent/-good/problematic performance.

The Operational room response (%), Early vs late sound ratio (dB), T60 flatness, inside window (%) of your monitoring system and room are showing excellent performance. This provides good audibility of acoustic details.

The Early reflection level (dB), Deepest notch below 300 Hz (dB) of your monitoring system and room are showing good performance. However, there are certain areas where some improvements could increase the accuracy of your system even further. These are indicated in yellow.

Operational room response (%)	Early reflection level (dB)	Early vs late sound ratio (dB)	T60 flatness, inside window (%)	Deepest notch below 300 Hz (dB)
> 90	< -10	> 3	> 80	> -10
90 to 80	-10 to -3	3 to 0	80 to 50	-10 to -20
< 80	> -3	< 0	< 50	< -20

Table 2.2: Summary of the colour thresholds used in Table 2.1.

Chapter 3

Frequency domain analysis

The room compensations applied by GLM AutoCal reduce the sound colouration caused by the room, improve the similarity between the monitors in the room, and can increase the monitoring system's low frequency extension. If a subwoofer is used, GLM AutoCal sets the optimal crossover frequency in the room and aligns the subwoofer phase.

3.1 Frequency response

This section shows you the frequency responses with AccuSmooth smoothing applied. AccuSmoothing gives you good visibility of details at low frequencies so you can detect room resonance related effects, and also provides an accurate presentation of mid and high frequency response so you can understand how neutral or coloured the audio is in these frequencies. Each monitor is shown separately.

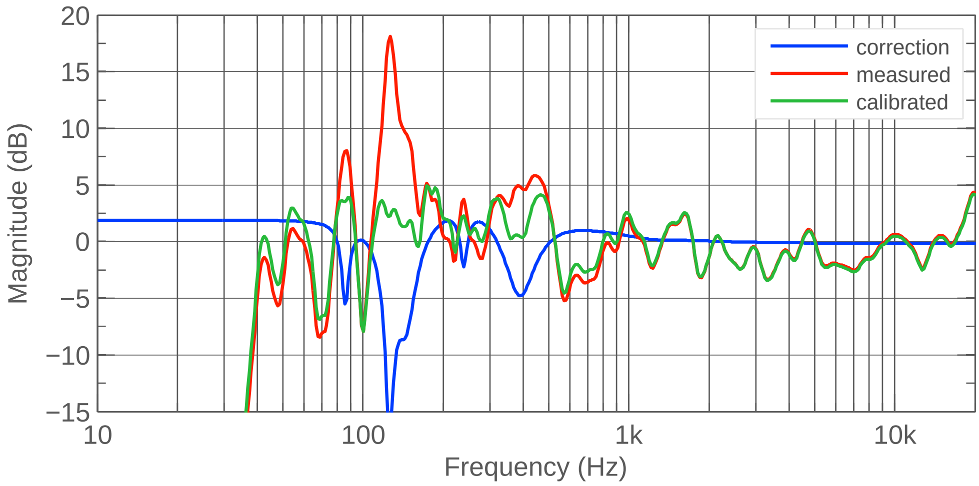

Figure 3.1: Left 8320A frequency response.

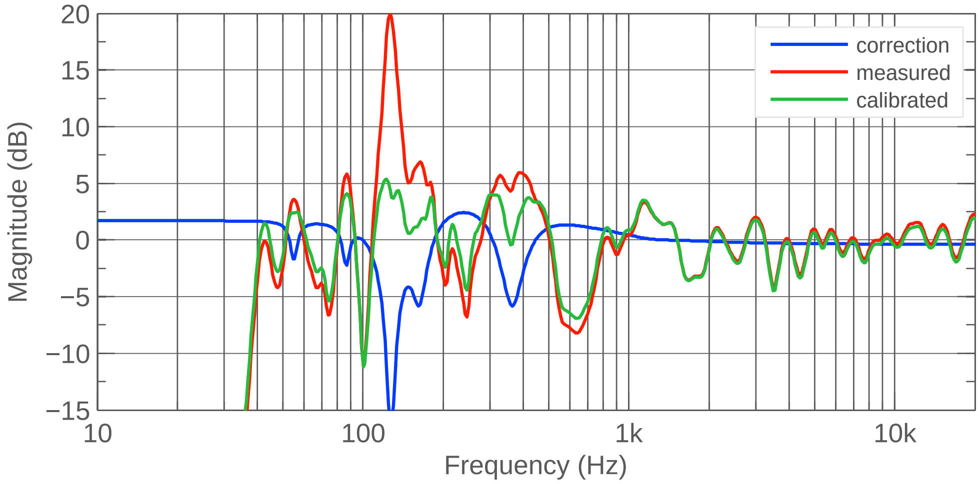

Figure 3.2: Right 8320A frequency response.

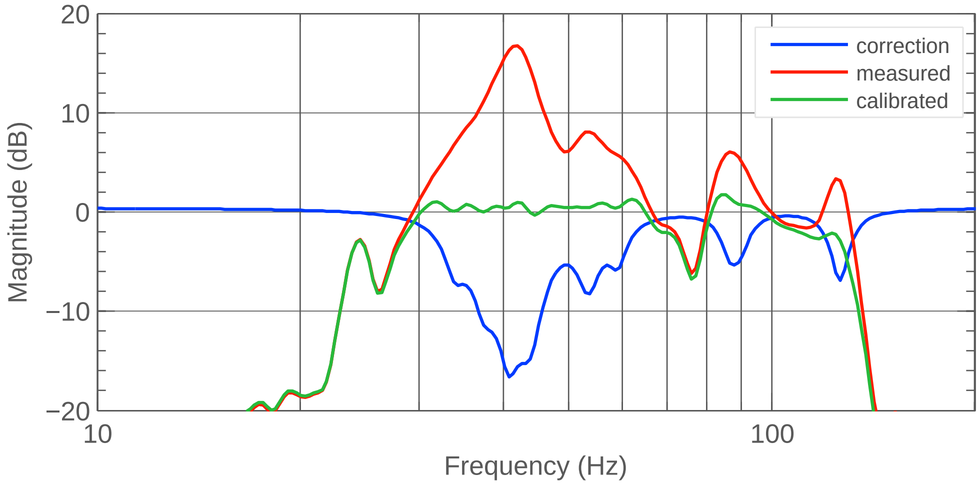

Figure 3.3: Sub 7350A frequency response.

In order to provide the maximum detail in the measurement data, the following AccuSmoothed comparison of all the monitors in your system shows the similarity between the monitors. When the curves overlap, the monitors in your system can deliver accurate imaging.

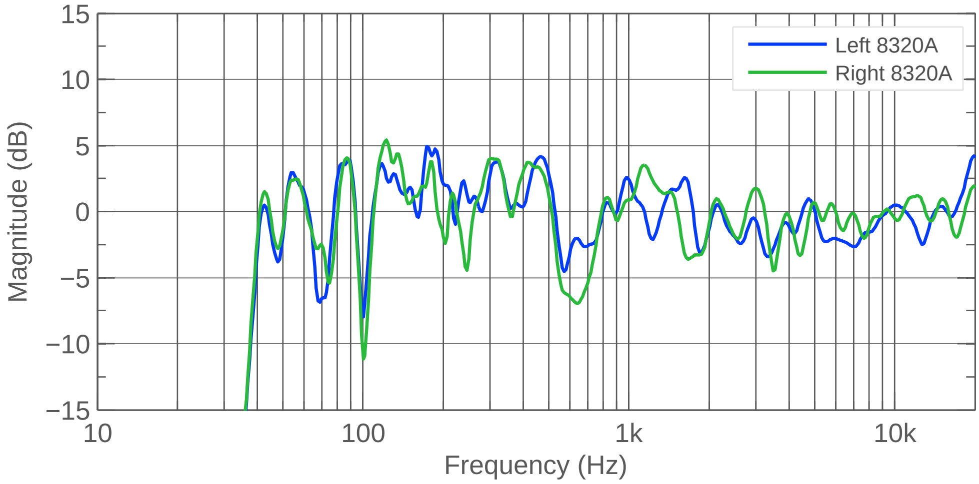

Figure 3.4: Frequency responses for monitors. AccuSmoothed.

One-octave smoothing of the frequency responses enables you to understand the general sound colour balance. When this curve is flat, the overall sound is balanced and does not tend to emphasise certain frequency areas over others. You can also see how similar the monitors are in terms of the general sound colour balance.

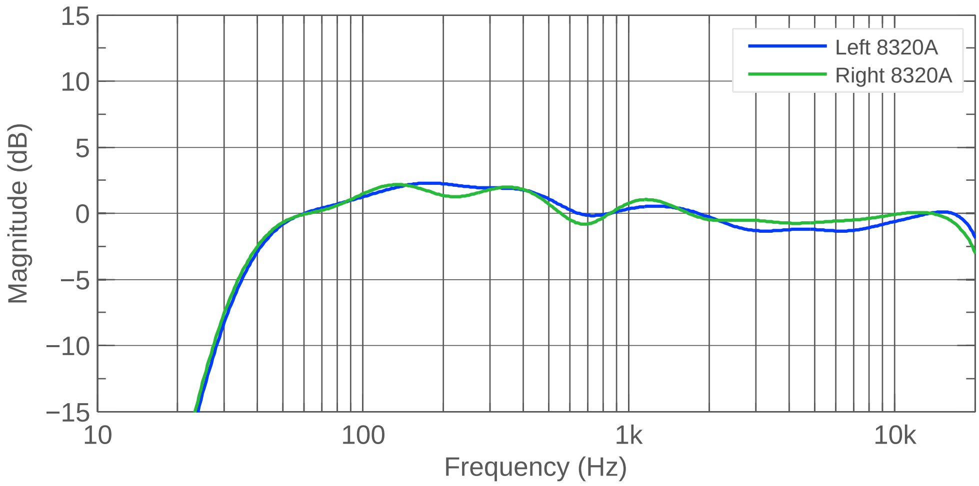

Figure 3.5: Frequency responses for monitors. One octave smoothing.

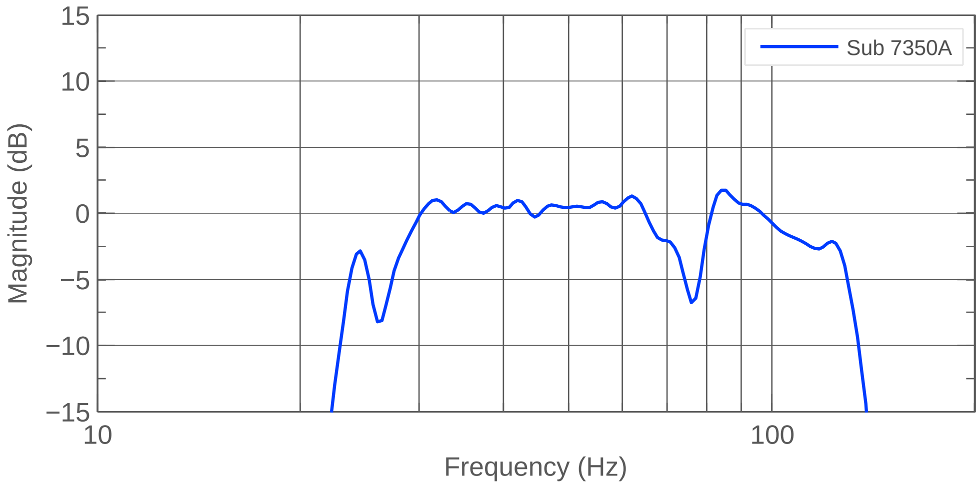

Figure 3.6: Filtered frequency responses for subwoofers. 1/12 octave smoothing.

3.2 Relative level compensation

The relative level compensation calculates the mean output level within the frequency range 0.5 - 3 kHz, and finds the compensations needed to set the same SPL for all monitors at the listening location. The subwoofer level is calculated in the frequency range 30 - 80 Hz, and is then set at the same level as the monitors. In this way, the level-related stereo imaging can work with the best accuracy.

Speaker name	Level compensation (dB)	Level offset after calibration (dB)
Left 8320A	0.0	0.0
Right 8320A	-0.4	0.0
Sub 7350A	-2.7	0.0

Table 3.1: Relative level compensation of speakers.

3.3 Low frequency extension

The -6 dB point at low frequency is related to the practical bass extension of your monitoring system and room, and how much the room acoustics either support or limit the bass output range.

At -6 dB the monitor outputs half of the average pressure in the mid-band frequencies. When the measured -6 dB point moves down in frequency compared to the anechoic measurement of your monitor, you gain in low frequency extension in your room. Monitor locations can have a significant effect here.

Speaker name	Model	Measured -6 dB point (Hz)	Anechoic -6 dB point (Hz)	Gain in low frequency extension (Hz)
Left 8320A	8320A	40.2	55.0	14.8
Right 8320A	8320A	39.6	55.0	15.4
Sub 7350A	7350A	23.5	22.0	-1.5

Table 3.2: Low cutoff -6 dB point.

Subwoofer name	Model	Measured -6 dB point (Hz)
Sub 7350A	7350A	133.9

Table 3.3: High cutoff -6 dB point for subwoofers.

3.4 Summing of symmetric monitors

Symmetric monitors are typically the left-right monitor pairs that are positioned in the room so that the room influences are similar on both monitors in the pair. This graph shows you how perfect the symmetry is at the listening position.

When the symmetry is good, the difference between the sum of complex pressure and sum of absolute pressure is close to zero level dB. The complex-valued sum is affected by any phase difference between the pair of monitors. A zero dB value indicates that the two monitors are perfectly in phase.

Phase mismatches are typically created by differences in acoustic reflections, caused by differences in monitor locations and room acoustics.

At high frequencies (above 2 kHz), reductions in the difference value is normal because the sound wavelength becomes small so that even insignificant differences are visible.

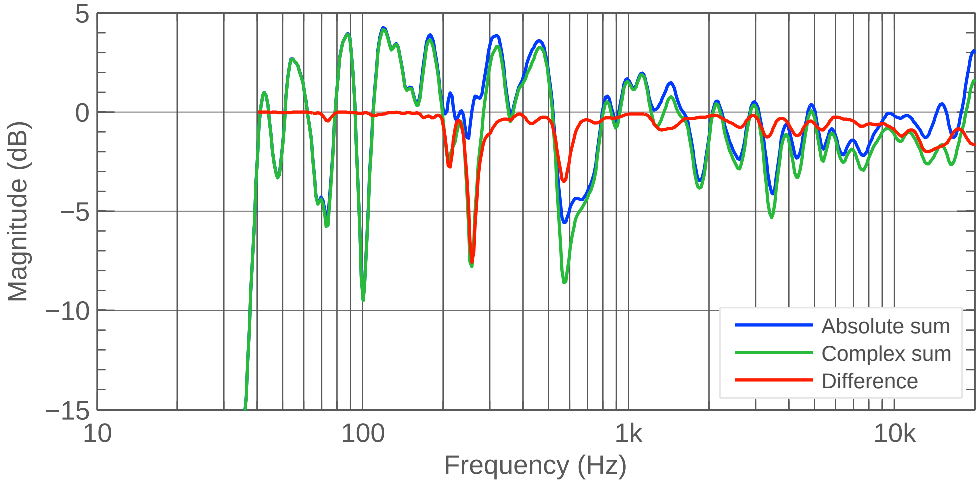

Figure 3.7: Difference between the sum of complex pressure and sum of absolute pressure. Calibration group ID 1.

Calibration group ID	Monitors in group	Difference, mean 100 Hz - 10 kHz (dB)
1	Left 8320A, Right 8320A	-0.9

Table 3.4: The mean difference between the sum of complex pressure and sum of absolute pressure.

3.5 Peaks and notches

This section shows you where you have the most influential narrow band colourations, before calibration. These are shown for each monitor separately.

Comments related to the following monitors: Right 8320A. We are observing a wide loss of sound level (also called a dip) below 200 Hz.

This typically causes the feeling that the system bass response is lacking or poor.

- A dip can be caused by an acoustic reflection from the nearest wall, typically behind a monitor. To remove this problem, try moving the monitor closer to the wall. Doing so will move cancellation frequencies up to a value where the monitor mainly radiates audio in the forward direction, so the effect of the back wall is minimised.
- Alternatively, move the monitors far away from the walls. This reduces the level of reflected audio, and makes the acoustic effect less detectable. For this approach, the monitors should be more than 1.1 metres (4 ft) from the nearest wall. Refer to Genelec Monitor Setup Guide for more details. https://www.genelec.com/monitor-placement
- You can also consider moving your listening position. This can help if the acoustic problem is only audible at a certain location in the room. When the dip is caused by audio reflecting off the side walls, you can reduce the level of reflection by adding absorption or diffusion materials on the reflecting surfaces. Note that recalibration of the monitors should be performed whenever the monitors or the listening position have been moved.
- A sufficiently thick absorbing layer is needed for lower frequencies, where the audio wavelength is long. When the dips are caused by reflections from the ceiling and floor, moving the monitor locations up or down may help.
- A very effective absorbing method for specific frequencies only is the Helmholtz resonator absorber. More information is available in the Genelec Monitor Setup guide: https://www.genelec.com/monitor-placement

Comments related to the following subwoofers: Sub 7350A. We are observing a wide loss of sound level (also called a dip) below 100 Hz.

This typically causes the feeling that the subwoofer output is lacking or poor.

- The nearest-wall reflections are a typical cause of such problems. Try moving the subwoofer closer to the nearest wall.
- Consider rotating the subwoofer so that the driver faces the wall, as this is even more effective in removing the effects of the nearest wall cancellation. Note that recalibration should be performed after moving subwoofers. When you do this, leave about 10 cm (4 in) of space between the subwoofer and the wall.
- The acoustic reflections from the side walls in the room can also cause this problem. To fix this, try moving the subwoofer closer to the side wall or towards a corner.

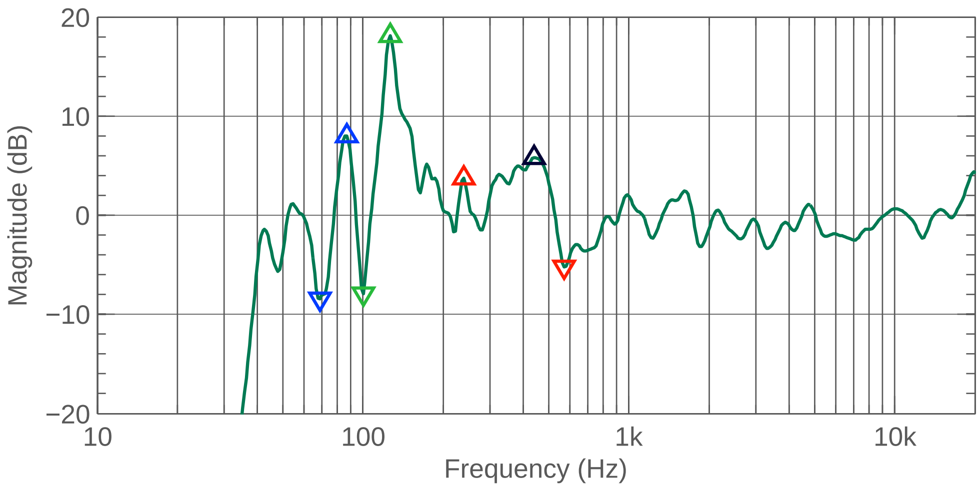

Figure 3.8: Left 8320A peaks and notches (before calibration).

Peak number	Centre frequency (Hz)	Gain (dB)	Quality factor
1	86.7	8.0	7.72
2	126.3	18.1	11.50
3	239.1	3.7	8.62
4	439.4	5.8	0.00
Dip number			
1	68.7	-8.4	6.8
2	100.2	-7.9	13.9
3	570.4	-5.2	2.4

Table 3.5: Left 8320A peaks and notches (before calibration).

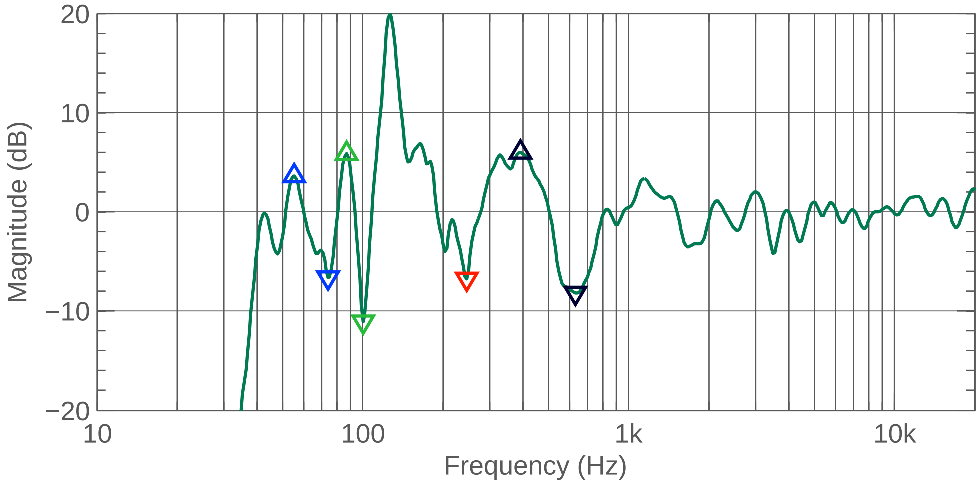

Figure 3.9: Right 8320A peaks and notches (before calibration).

Peak number	Centre frequency (Hz)	Gain (dB)	Quality factor
1	55.3	3.6	6.89
2	86.7	5.8	8.62
3	126.3	20.0	11.50
4	391.3	6.0	2.26
Dip number			
1	73.9	-6.6	5.5
2	100.2	-11.1	13.7
3	246.1	-6.8	8.7
4	631.3	-8.2	3.3

Table 3.6: Right 8320A peaks and notches (before calibration).

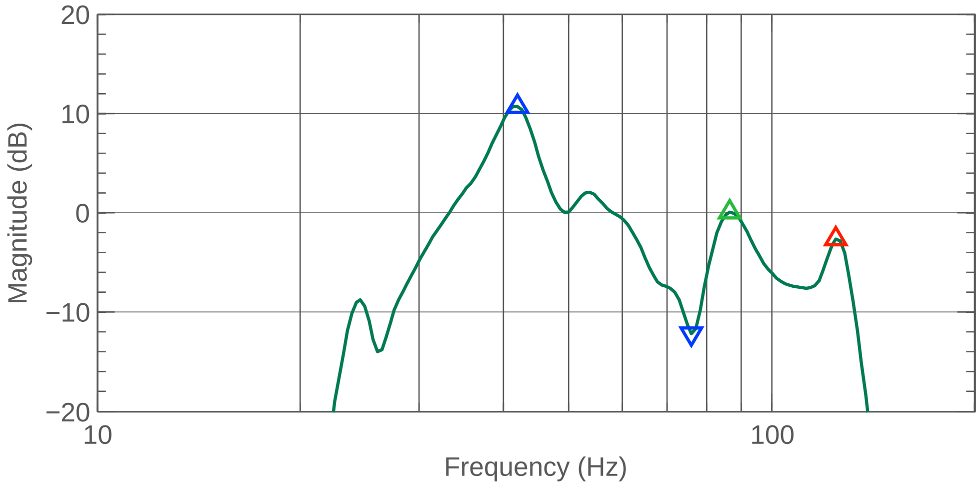

Figure 3.10: Sub 7350A peaks and notches (before calibration).

Peak number	Centre frequency (Hz)	Gain (dB)	Quality factor
1	42.0	10.7	6.99
2	86.7	0.1	6.79
3	124.5	-2.6	11.50
Dip number			
1	76.1	-12.2	11.5

Table 3.7: Sub 7350A peaks and notches (before calibration).

Chapter 4

Time domain analysis

4.1 Time of Flight

Differences in the times of flight (TOF) for audio between monitors indicate that they are at different distances from the listening location, or that the electronic delay alignment is not perfect.

About 1 ms of delay difference completely displaces the centre image in a stereo system to the nearest monitor.

Time alignments should show close to zero differences in order for all sound images to appear at the correct locations.

The time differences are also expressed as distances using the speed of sound in the air. This shows how much the monitor should move towards or away from the listener to remove the delay difference.

Time of flight is calculated using a filtered impulse response. The impulse response is bandpass filtered from 1 to 8 kHz.

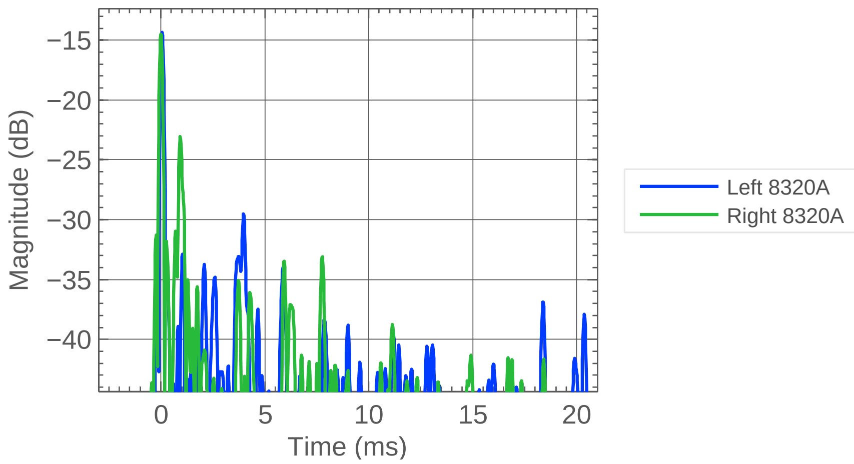

Figure 4.1: Bandpass filtered impulse responses of monitors, before time of flight compensation.

Monitor name	ToF compensation (ms)
Left 8320A	0.0
Right 8320A	0.1

Table 4.1: Time of Flight.

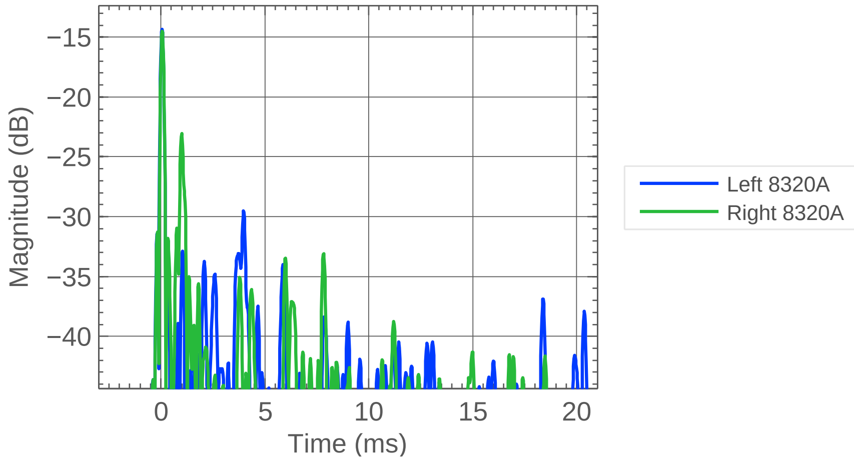

Figure 4.2: Bandpass filtered impulse responses of monitors, after time of flight compensation.

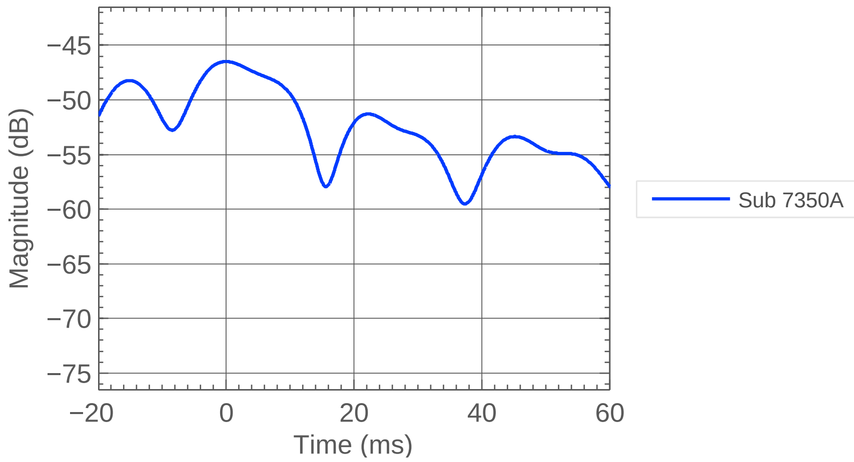

Figure 4.3: Lowpass-filtered impulse response envelopes of subwoofers.

4.2 All early reflections

Early reflections are the reflections of the sound arriving at your ears shortly (less than 15 ms) after the direct sound. Early reflections colour the audio and move the locations of sound images in your mix. For this reason, early reflections should be kept low. This section shows all significant room reflections in the acoustically sensitive midrange frequencies (1-8 kHz). Direct sound is scaled to 0 dB level. You can immediately see the level of reflections relative to the direct sound. Reflections higher than -15 dB are shown in the tables.

A -15 dB reflection causes a 1.4 dB ripple in the audio signal. The ripple is a frequency dependent variation in the sound level which colours the audio, causing sound colour inaccuracy.

The frequency response graph also indicates the lowest frequency of the acoustic cancellation that can result with each reflection. In reality the cancellations can also happen at higher frequencies, and can be more complicated since the reflections can interact with each other.

Comments related to the following monitors: Right 8320A. These monitors show high early reflection level. This can change the sound colour and alter imaging. The highest level of early reflection is less than 10 dB below the level of the direct sound.

Early reflections can affect monitoring performance by colouring the sound across a wide frequency range due to comb filtering, and can move and alter stereo imaging.

The time difference between the direct sound and the early reflections tells you the difference in acoustic path distance between the two. You can use this information to understand the probable location of the reflecting surface or object. To reduce the early reflection level, there are several options:

- Move the monitors further away from the reflecting surfaces.
- Move, turn, tilt or remove the reflecting surface to eliminate the early reflection.
- Add absorbance or diffusion materials to the reflecting surface, to reduce the level of the early reflection.

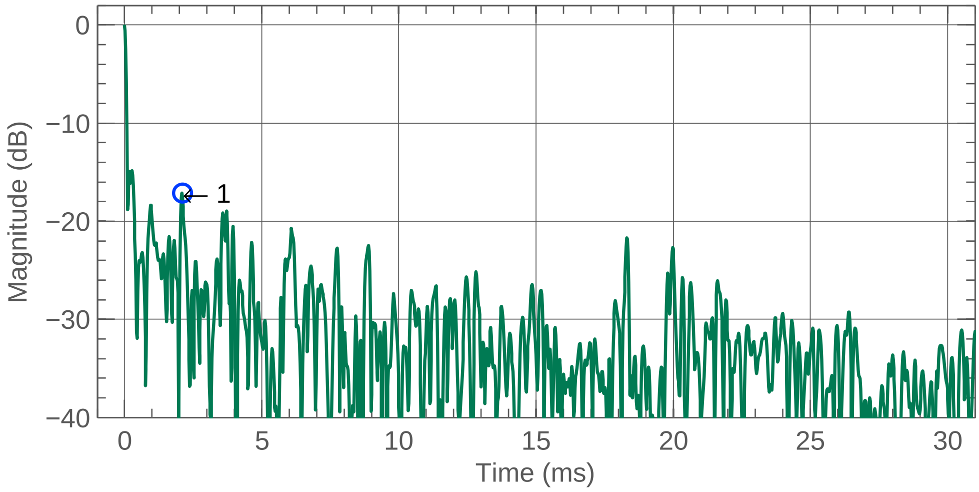

Figure 4.4: Left 8320A early reflections.

Reflection number	Gain (dBFS)	Time (ms)	Time in distance (cm / in)	Frequency of first dip (Hz)	Comb filtering ripple (dB)
1	-17.1	2.1	72 / 28.2	237.6	1.1

Table 4.2: Left 8320A. Peaks in impulse response.

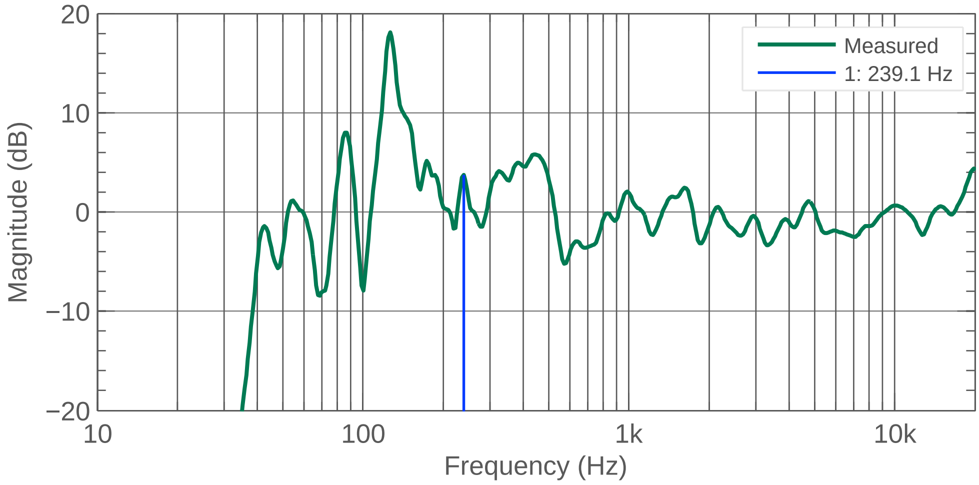

Figure 4.5: Left 8320A. Response and lowest cancellation frequency resulting from early reflection.

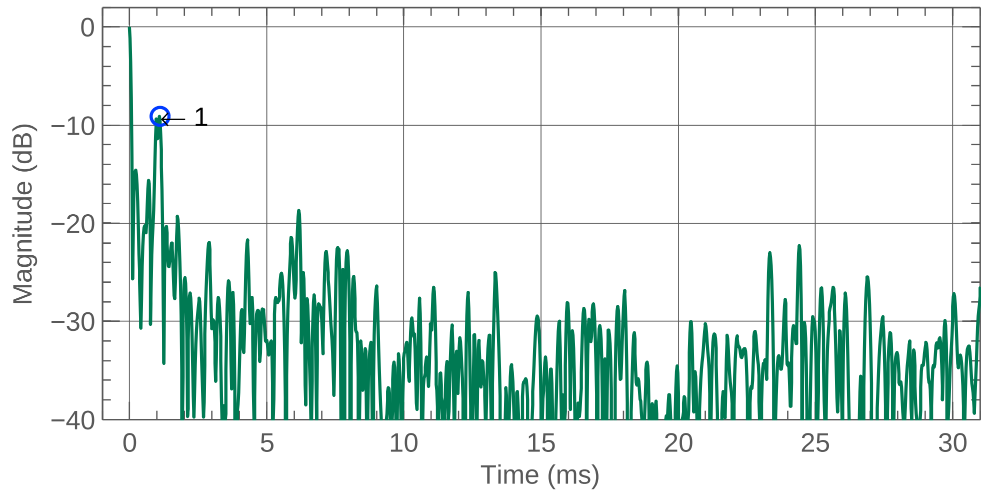

Figure 4.6: Right 8320A early reflections.

Reflection number	Gain (dBFS)	Time (ms)	Time in distance (cm / in)	Frequency of first dip (Hz)	Comb filtering ripple (dB)
1	-9.1	1.1	38 / 14.8	452.8	2.6

Table 4.3: Right 8320A. Peaks in impulse response.

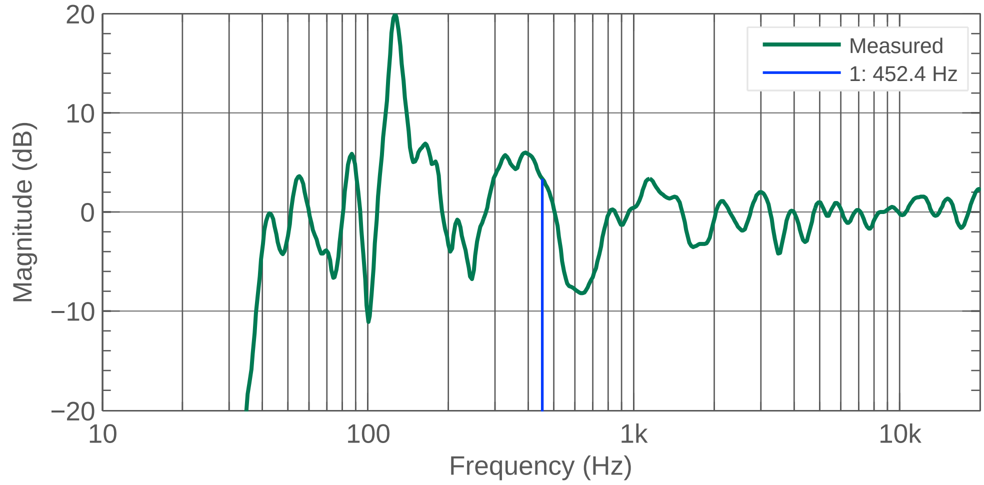

Figure 4.7: Right 8320A. Response and lowest cancellation frequency resulting from early reflection.

4.3 Early vs late sound

The Early vs. late sound plot shows the level of sound after the AutoCal optimisation. The 'Full' curve represents the sound level of the complete room response and contains the contributions of the 'Early' and 'Late' components. The 'Early' curve shows the sound level contributed by the sound in the room during the first 20 ms after the direct sound. During this time, sound travels a distance of 6.8 m (22 ft) in the room. The 'Late' curve shows the level contributed by the sound in the room after the initial 20 ms, until the reverberation has died out. 'Late' level describes the significance of the reverberation. All responses are 1/3rd octave smoothed.

The early vs. late sound shows the significance of the reverberation in determining the total sound colour. When the Late sound is low, more than 3 dB below the Full level, it is unlikely that the late energy will dominate your experience of sound colour. When the late energy level is high, close to the Full level, then the room reverberation dominates the sound colour you hear in the room. This is typical at low frequencies (below 500 Hz) where reverberation time is often significant, and sound takes longer to decay. At higher frequencies in a high quality listening room, the Early sound should remain higher than the Late sound.

For subwoofers, the early part is the level in the first 20 ms after the peak in the impulse response envelope, and the late part is the level after this point. The maximum impulse response is detected in the impulse response envelope after a 120 Hz lowpass filter. The delay of a subwoofer is usually much higher than that of a monitor since the subwoofer is reproducing a very narrow frequency band at a low frequency.

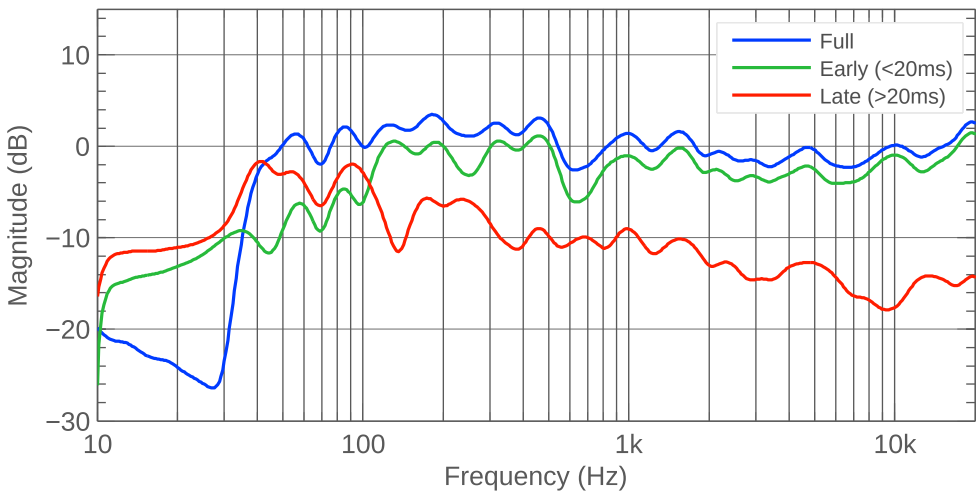

Figure 4.8: Left 8320A. Full, early and late frequency response.

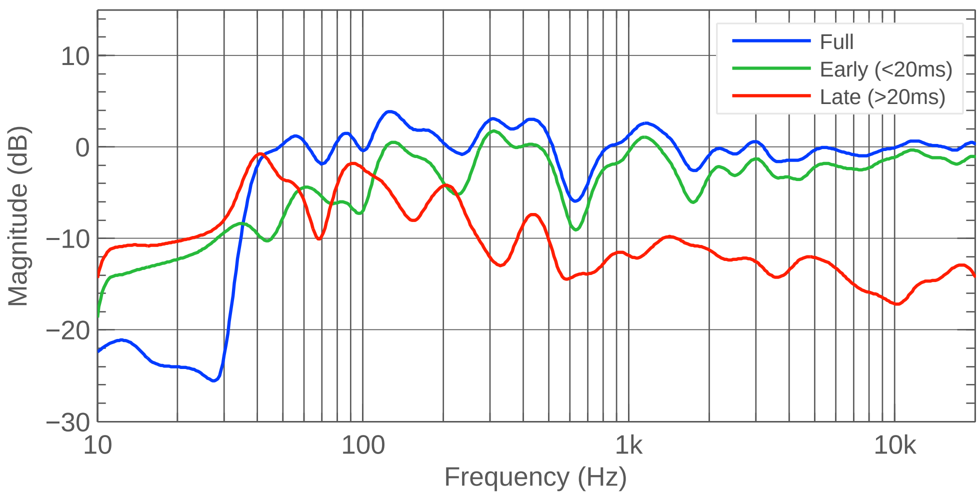

Figure 4.9: Right 8320A. Full, early and late frequency response.

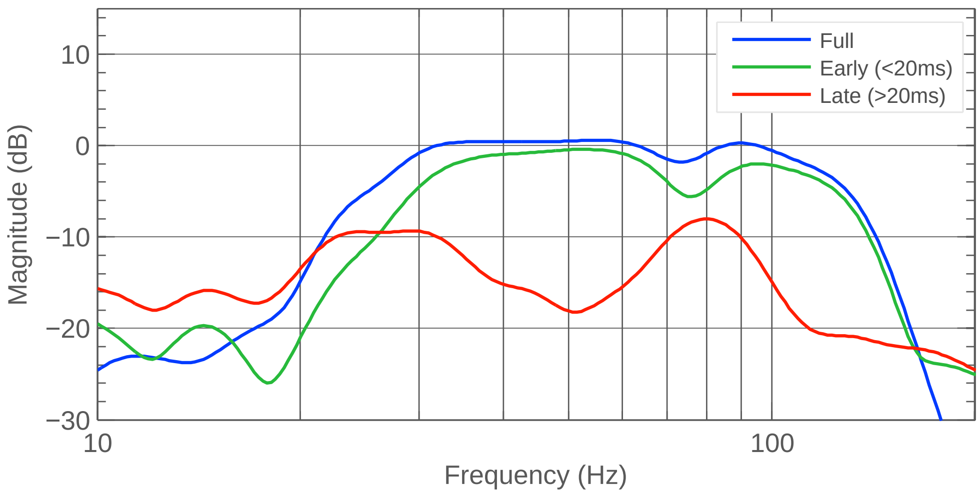

Figure 4.10: Sub 7350A. Full, early and late frequency response.

Monitor name	Early vs late sound ratio, 100 Hz - 10 kHz mean (dB)
Left 8320A	5.8
Right 8320A	5.9

Table 4.4: Early vs late sound ratio.

Chapter 5

Time-Frequency domain analysis

5.1 Reverberation time

Reverberation time (RT60) is analysed by looking at the decay time T60 of one-octave bandwidths. RT60 is the mean of the nine bands having centre frequencies from 63 Hz to 16 kHz. The T60 decay time in a listening room should be similar across all frequencies and be suitably low. Then, all details in the audio are audible in a balanced way. The most critical are the midrange of frequencies.

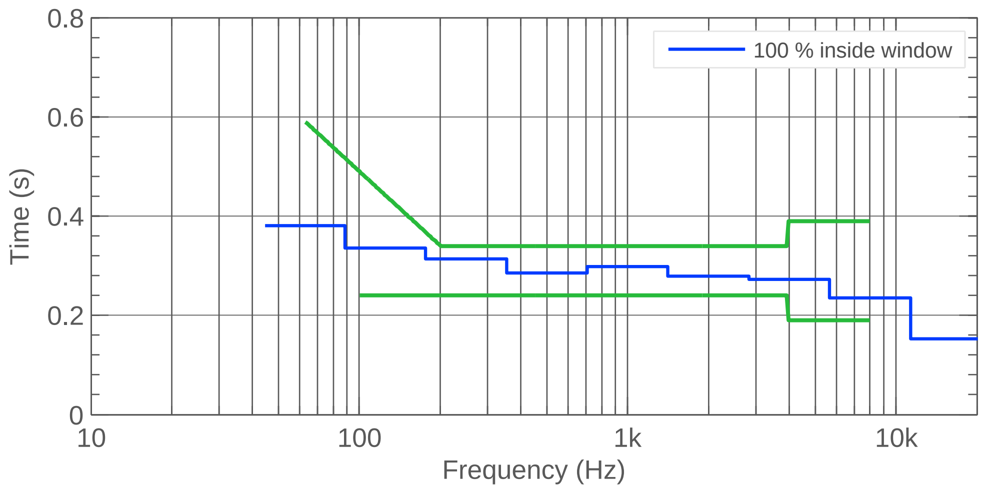

Figure 5.1: Mean decay time T60 of all monitors, after calibration. One-octave bandwidth.

Monitor name	RT60 (s)	T60 min (s)	T60 max (s)
Mean of all monitors	0.28	0.15	0.38
Left 8320A	0.28	0.14	0.37
Right 8320A	0.29	0.17	0.39

Table 5.1: Reverberation time RT60.

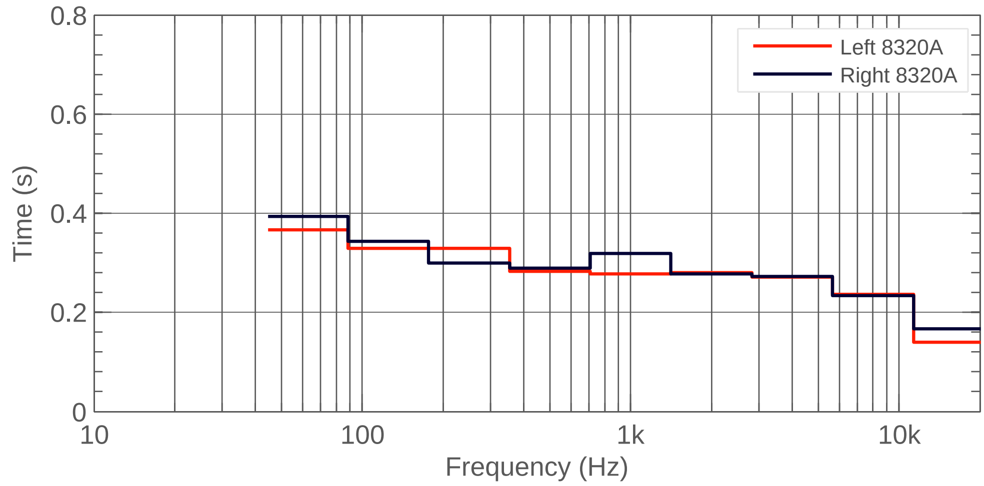

Figure 5.2: Decay time T60, after calibration.

5.2 Waterfall

Waterfall is good for spotting room resonances. Waterfall analysis shows you the decay time of audio at different frequencies.

The decay time shows how fast sound disappears after the loudspeaker has stopped playing.

Room resonances (room modes) can cause certain notes to 'ring' for a long time in a room. In a typical room, bass notes can resonate for up to half a second. At high frequencies you can experience 'flutter' echo between two parallel hard surfaces. This is the annoying 'ping' that you can hear after you clap your hands, for example.

Flutter echo and room mode resonances both lengthen the decay of sound in a room, and are visible in a waterfall plot. You can see the frequency of a resonance and how slow it decays relative to other frequencies.

Prominent room resonances are detected in the decay at 60 ms after the end of the audio signal. This method may not detect all the room resonances, but all the resonances are visible in the waterfall plot. The decay times of the prominent resonances are calculated. When the prominent resonance decay times are much longer than the typical decay time of other frequencies, the slowly decaying room resonances can mask other audio, and reduce the ability to hear details in the audio correctly.

The nearly horizontal sections at later time values in the detected resonance decay curves are not usually indications of acoustic delay, but indicate the noise level in the room.

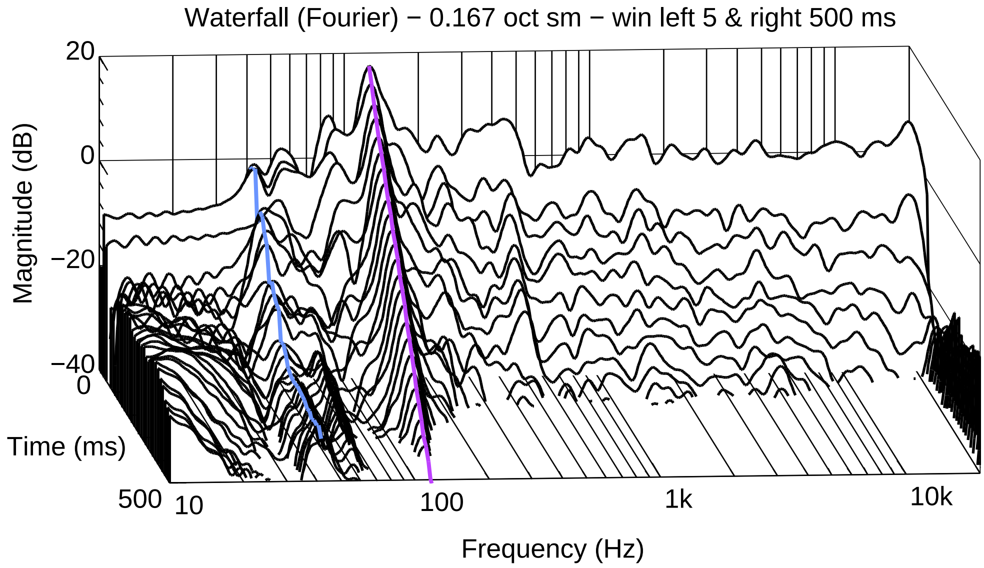

Figure 5.3: Left 8320A. Waterfall.

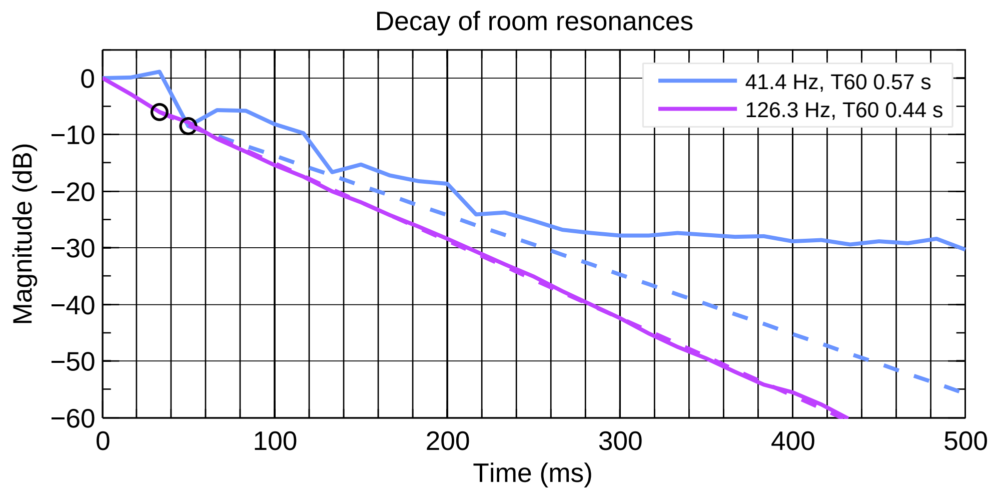

Figure 5.4: Left 8320A. Decay of detected resonances.

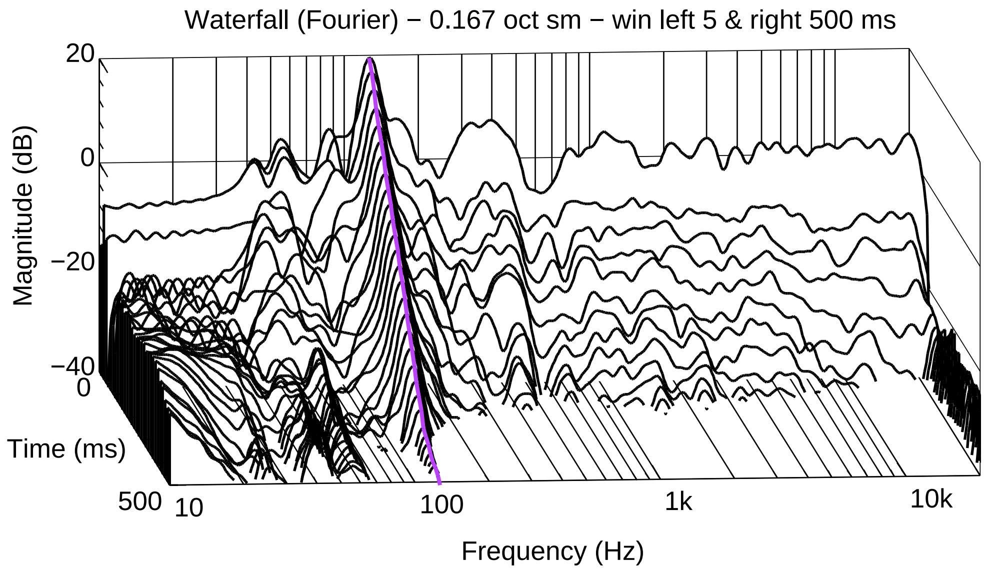

Figure 5.5: Right 8320A. Waterfall.

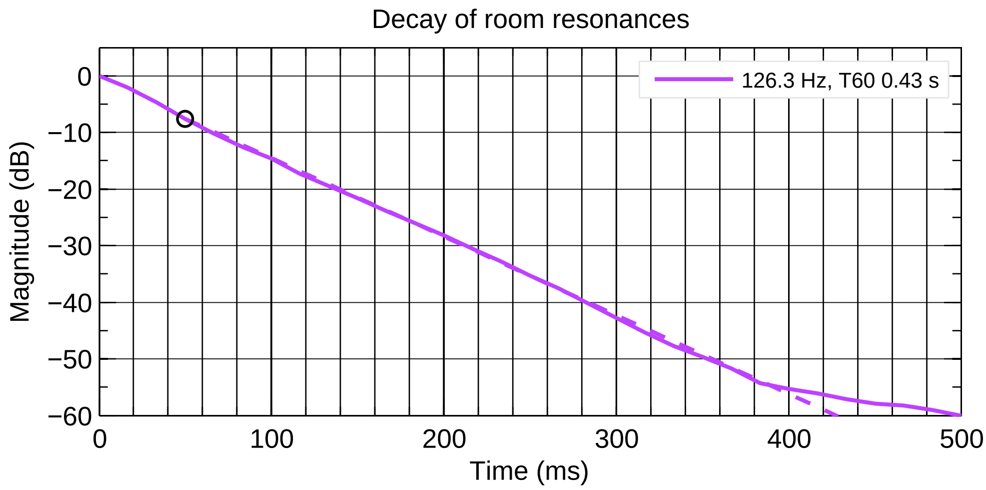

Figure 5.6: Right 8320A. Decay of detected resonances.

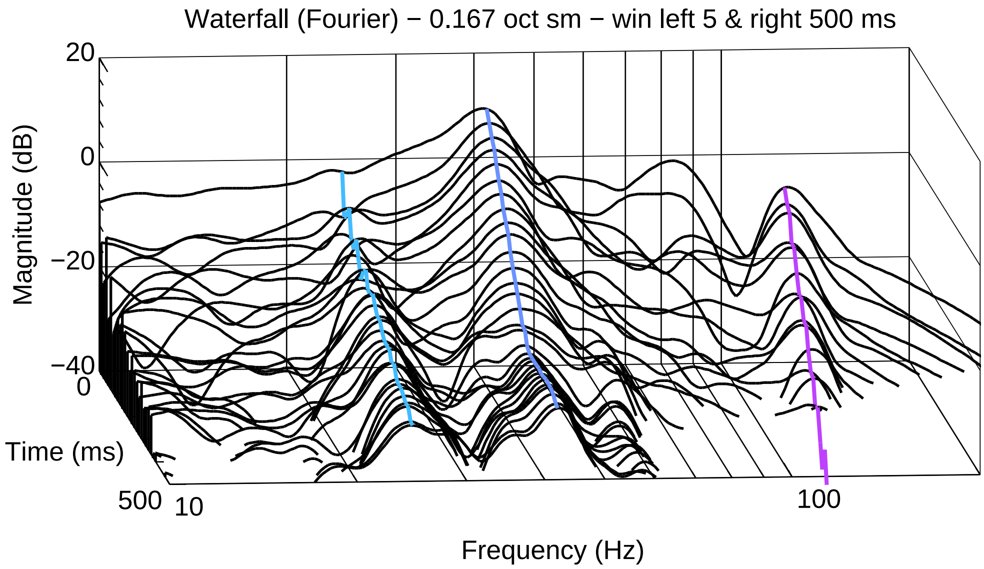

Figure 5.7: Sub 7350A. Waterfall.

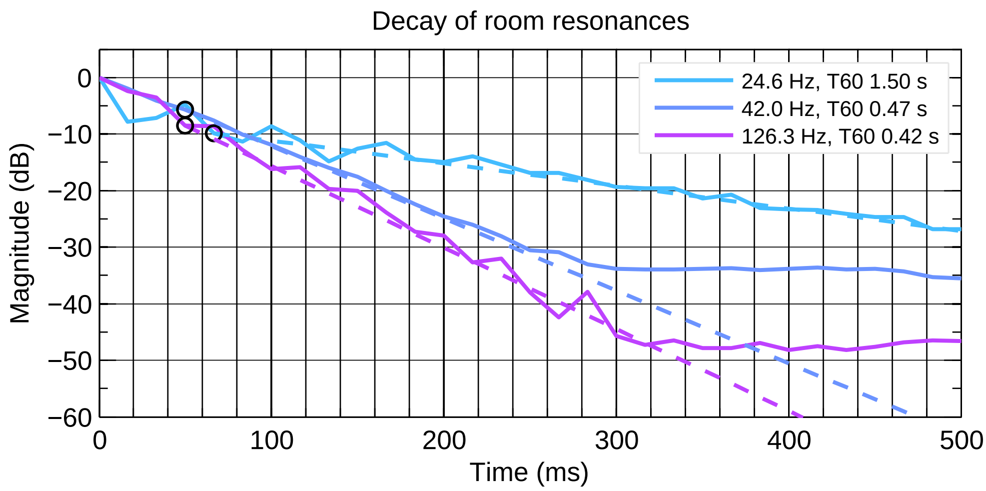

Figure 5.8: Sub 7350A. Decay of detected resonances.

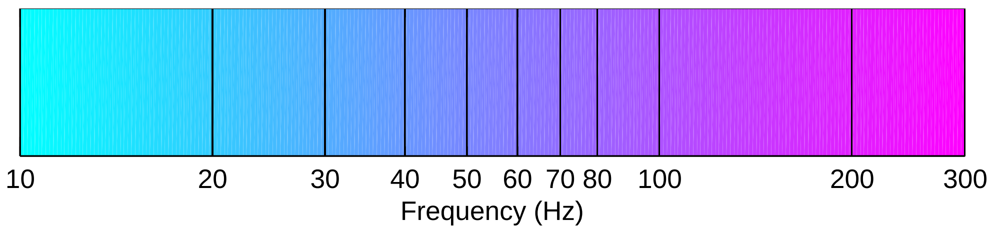

Figure 5.9: Colourmap for resonances.

Speaker name	Unit	Mode 1	Mode 2	Mode 3	Mode 4
Left 8320A	Freq (Hz) Gain (dB) Decay time T60 (s)	41.4 -7.3 0.57	126.3 6.7 0.44		
Right 8320A	Freq (Hz) Gain (dB) Decay time T60 (s)	126.3 9.3 0.43			
Sub 7350A	Freq (Hz) Gain (dB) Decay time T60 (s)	24.6 -12.3 1.50	42.0 1.7 0.47	126.3 -15.1 0.42	

Table 5.2: Room modes - all monitors and subwoofers.

5.3 Wavelet

Wavelet is good for spotting reflections. The wavelet analysis shows the decay of sound after the loudspeaker has stopped playing. This helps you understand how well the sound is controlled acoustically at different frequencies.

Early reflection problems can be seen using the wavelet analysis.

Compared to the waterfall plot, the wavelet plot has excellent time and frequency resolution. This means you can see when the sound level peaks, and at what frequency, after the loudspeaker has stopped playing audio in the room.

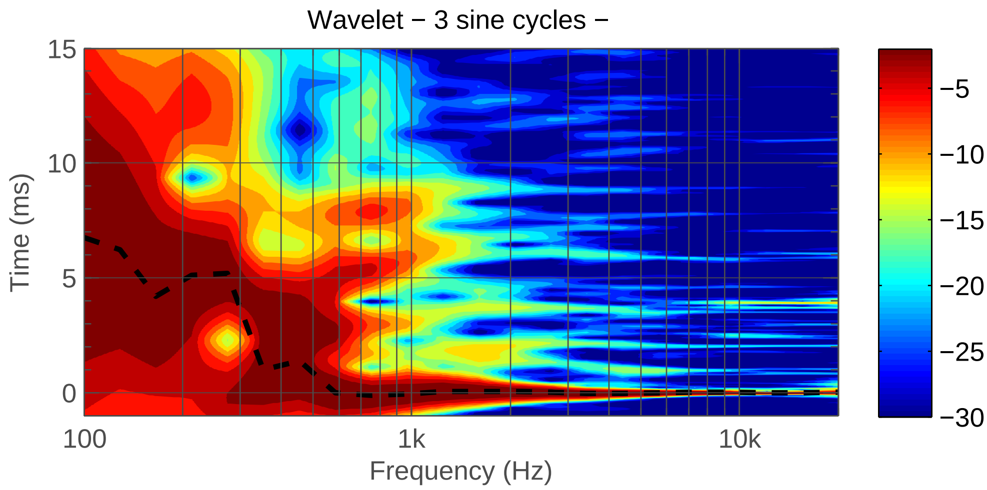

Figure 5.10: Left 8320A. Wavelet.

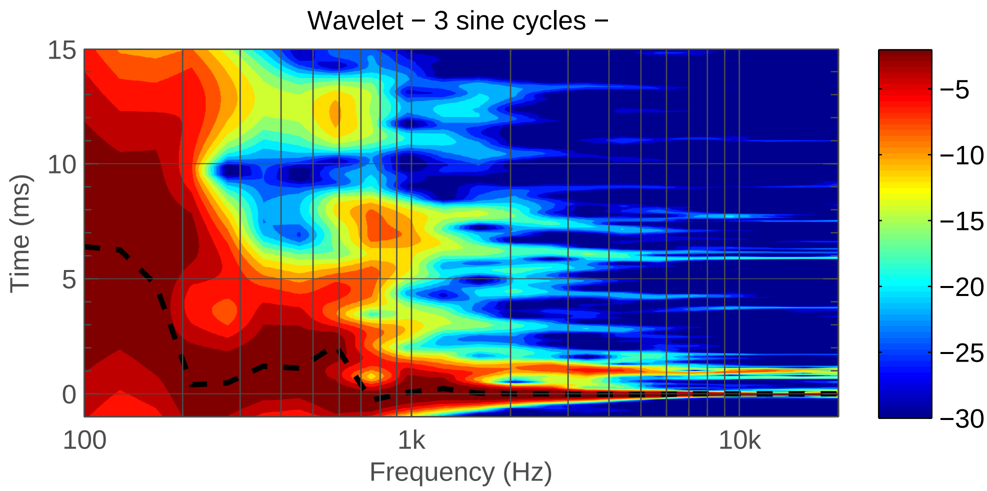

Figure 5.11: Right 8320A. Wavelet.

Chapter 6

ITU-R BS1116 compliance

ITU-R BS.1116 is a quality recommendation for broadcasting services describing high precision audio listening conditions, for monitoring applications such as recording studios, post-production and audio editing.

This section of the report compares your monitoring setup measurements and calibration results to the ITU-R BS.1116 recommendation. If your results are close to the recommendation, then your monitoring setup will have excellent precision for details in audio, enabling high quality audio engineering work.

You can freely download the full text of the ITU-R BS.1116 recommendation at https://www.itu.int/rec/R-REC-BS.1116/en

6.1 Operational room response curve

The frequency response at the listening location is called the Operational Room Response. To hear uncoloured audio, the Operational Room Response should show the same level across frequencies. The green limits indicate deviations that are usually safe and do not cause significant colourations.

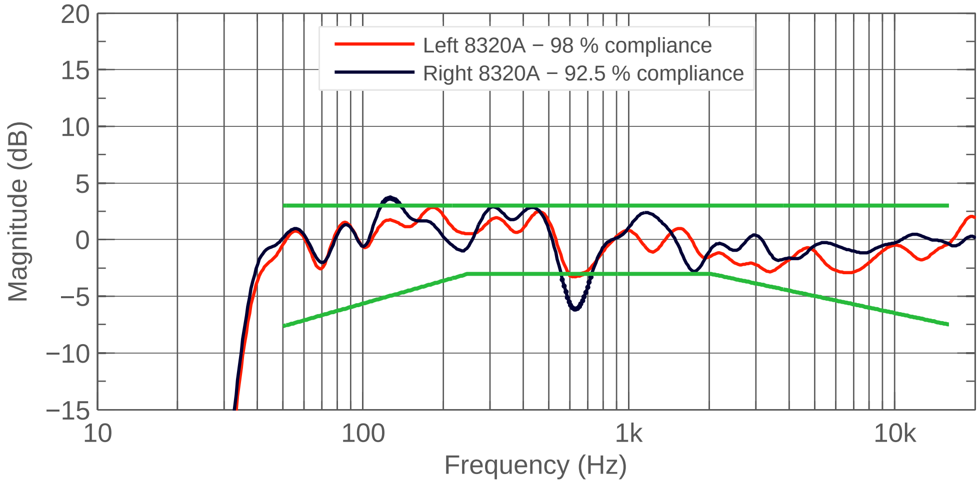

Figure 6.1: Operational room response curve.

6.2 Strongest early reflection

The ITU-R limit for early reflections is -10 dB relative to the direct sound level produced by the monitor. In theory, a -10 dB reflection causes a comb filtering effect that results in a 2.4 dB ripple (inaccuracy of sound colour) in the audio signal.

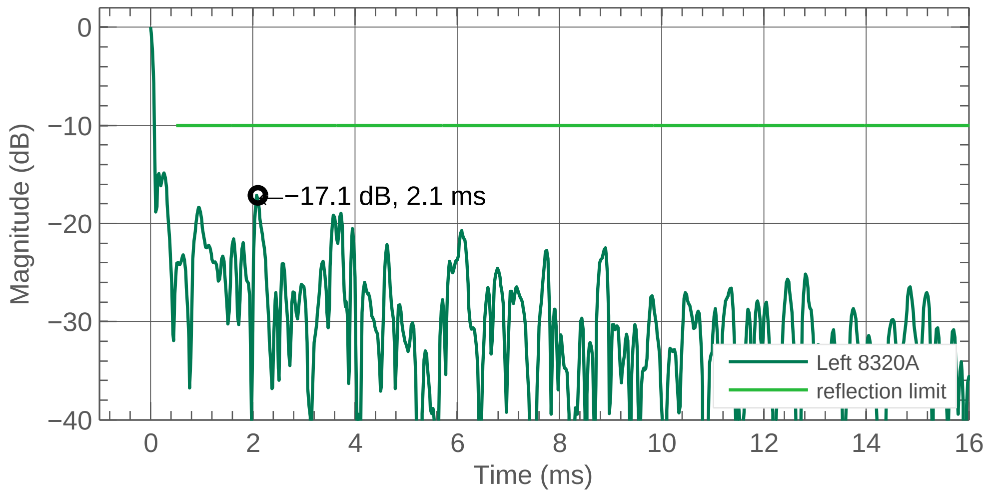

Figure 6.2: Early reflections. 1-8 kHz band. Level is relative to direct sound level.

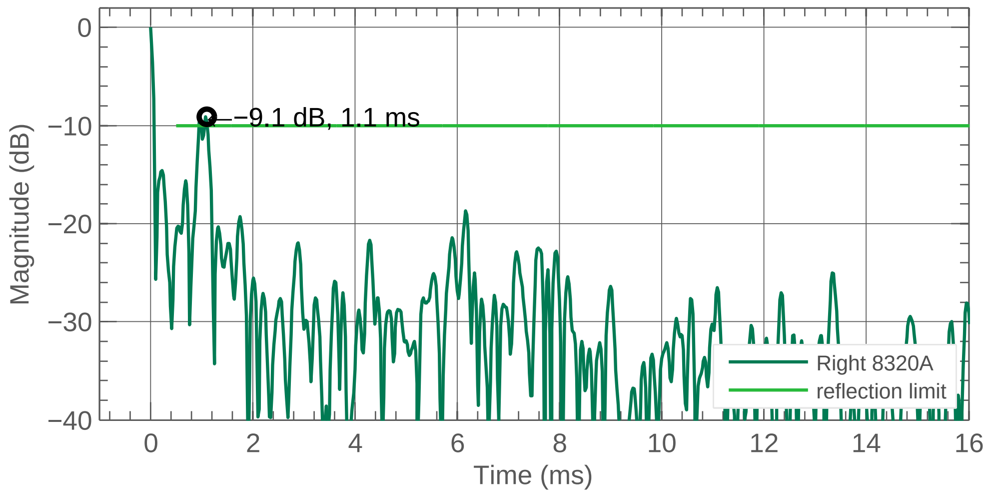

Figure 6.3: Early reflections. 1-8 kHz band. Level is relative to direct sound level.

6.3 Reverberation time

The recommended reverberation time depends on the volume of your room (Table 6.1). The room volume is calculated using the hard walls of your room. Please note that these walls may be hidden behind a layer of absorbent material, making the acoustic volume larger than the visible volume inside the room.

V (m^3)	30	60	100	300	600	1000
V (ft^3)	1100	2100	3500	10600	21200	35300
T60 (s)	0.17	0.21	0.25	0.36	0.45	0.54

Table 6.1: Room volume V and decay time T60.

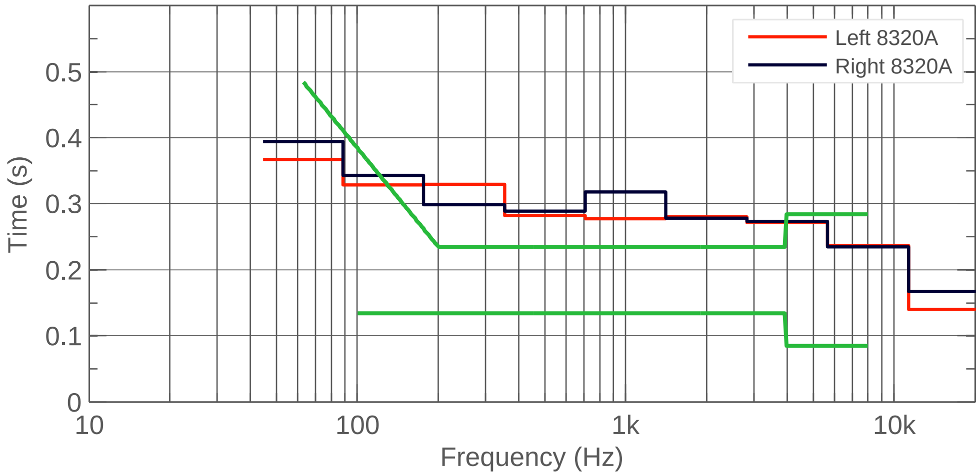

Figure 6.4: Decay time T60, after calibration. Target decay time Tm = 0.18 s (based on calculated room volume).

6.4 Summary of compliance

Monitor name	Model	Operational room response, inside limits (%)	Early reflections, number of problem peaks	Reverberation time RT60, inside limits (%)
Left 8320A	8320A	98	0	30
Right 8320A	8320A	93	1	28

Table 6.2: ITU-R BS1116 compliance summary.

Chapter 7

Glossary and Acronyms

Glossary

AccuSmooth AccuSmooth is a smoothing-in-frequency method applied by Genelec to provide maximum detail to acoustic measurements. This is a variable-width smoothing. The frequency range of the smoothing is 1/12th per octave below 250 Hz, and 1/6th per octave above 250 Hz. The AccuSmoothing applied to frequency response plots increases the visibility of the acoustically relevant details in the system frequency responses.

GLM Genelec Loudspeaker Manager (GLM) is a software app that runs on Windows or Mac computers. It issues management commands to all Genelec Smart Active Monitors for volume, mutes, solos, EQ, and offers automatic system calibration in a room. This includes individual monitor equalisation, and time and level alignment for more than 80 loudspeakers and subwoofers.

impulse response The impulse response of a system is the output of the system when presented with a short input signal called an impulse. The impulse response is the reaction of any system to a change, and it describes that reaction as a function of time. The impulse response of a room can be used to analyse early reflections of audio in the room. The impulse response can also be analysed further to understand how the room changes the level of audio, its timing and phase.

loudspeaker Can be a monitor or subwoofer. Commonly shortened to 'speaker'.

monitor A loudspeaker for audio monitoring purposes. Can produce full audible bandwidth from 20 Hz to 20 kHz. Usually there is some low frequency limitation.

one-octave smoothing One-octave smoothing applies a smoothing-in-frequency from half an octave below to half an octave above a given frequency, and assigns the mean of the pressure in this range to this frequency. This is useful for revealing wideband level variations. This can clearly display the general tonal balance of a monitoring system.

reflection Room walls and objects, such as furniture, reflect audio. Sound reflections can occur at any frequency and can colour the frequency response, making recording and mixing decisions difficult or inaccurate. The ratio of direct to reflective sound energy is important to know. The lower the reflection relative to direct sound, the smaller the influence the reflection has.

RT60 Reverberation time of a room. This is the time it takes for sound to decay by 60 dB.

subwoofer Loudspeaker which produces low frequencies only. Low frequency content can be 'bass managed' from monitors to subwoofers, reducing the LF workload of the monitors. This can increase maximum system SPL and reduce distortion in the monitors. Typical subwoofer bandwidth is 20 Hz to 120 Hz.

T60 Narrow-band decay time in a room. This is the time it takes for sound to decay by 60 dB within the given frequency range. In a room, T60 should be similar in low, mid, and high frequencies to prevent the room decay interfering with the sound colour balance.