Sunset Lounge – Case Study

2026 CEDIA Best Home Cinema


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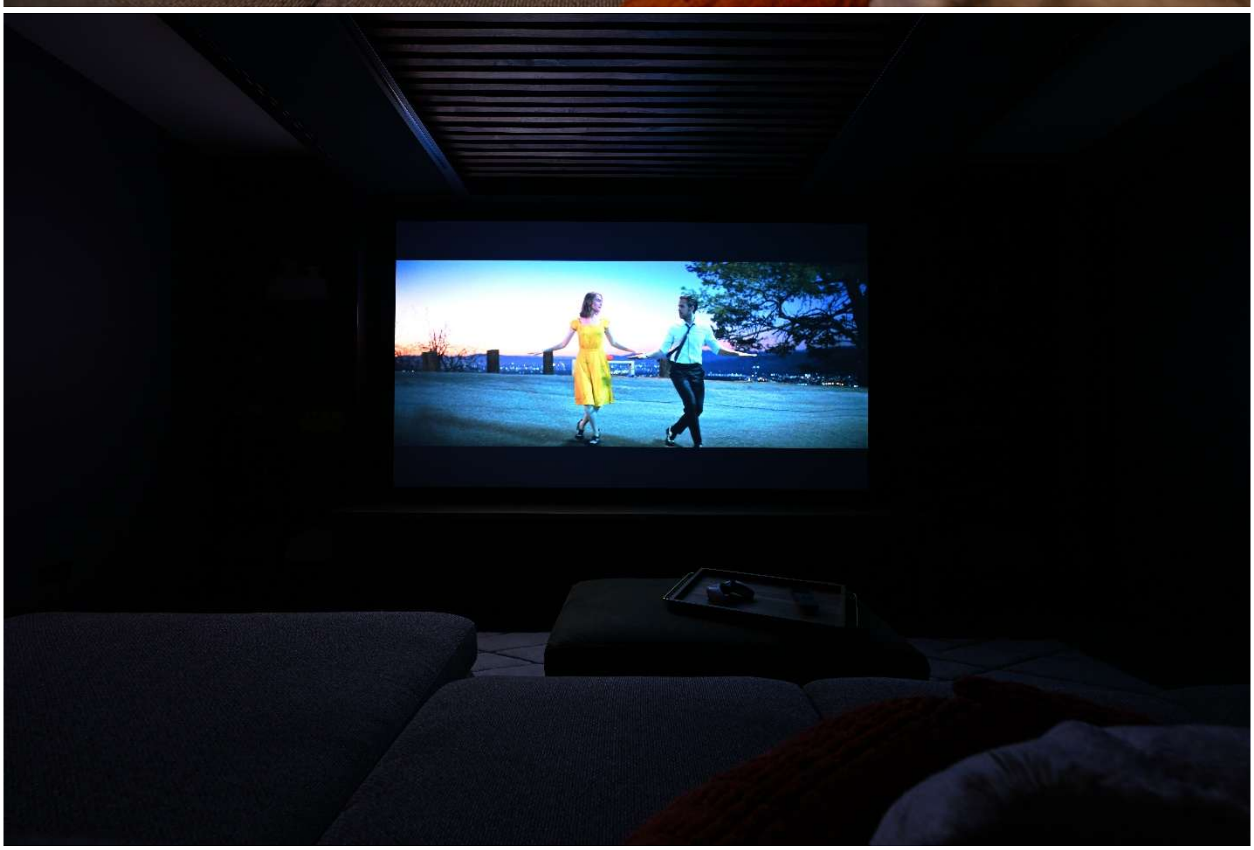

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Discovery

In a theater project we strive to combine the multiple room uses, an objective performance target, the desired aesthetic, and an understanding of the budgetary constraints to define the user experience. We then design and engineer a system that balances the inevitable compromises to exceed the client's expectations.

Humans relax when we are comfortable and undistracted. Only then can we have an incredible immersive experience - technology should disappear completely leaving only the art of cinematic content. This project gave us the chance to test that principle in a family basement room on a constrained budget, for a couple with two teenage kids and a single audiophile in the household.

The primary client is an AV/IT professional with personal connections to AV manufacturers throughout his career. At the beginning of his journey, he visited Sonance's demo facility. Early in his process he decided upon the room speaker configuration as 7.1.4 with 4 subs. Sonance advised on the speaker models without knowing the final room layout and gave him industry accommodation pricing for the complete set, which were purchased prior to meeting us.

We met with the client and his wife to discuss a theater design contract that would allow us to spend appropriate discovery time, get to know each other, and to define the desired experiential outcome for the entire family. Our discussions of RP22 and our standards-based approach to theater design resonated with them. We created architectural renders and budget estimates in this initial phase to ensure we were on target with their goals.

It is helpful to take a step back from what the client initially asks for and talk with them about their family life and how they see themselves using the room. The room needed to be a center of family life, not a single purpose space with little versatility. The multiple functions of the room can dictate the seating and room layout, which was the case here. They have 2 kids, one in college, and family that frequently visits. Most of the time the audience would include just 1-2 people, but as many as 5 are possible. The room needed to be an enticing place to encourage the teenage kids to join their parents for family time - so a sectional with a massive chaise and ottoman was optimal for their family snuggling to watch *Stranger Things* - theater seats with cupholders need not apply. The client's wife said that she wouldn't likely use the room often - as she doesn't watch much TV. She *was* excited when told that it would be the quietest room to read a book in their open-plan modern house that lacks acoustic separation.

A demo in our RP22 Level 2 room solidified the Level 2 audio target with a matched-performance projection system. It also yielded notes on what the clients responded to most, which shaped the project goals.

The balance of compromises is engineered into the design. We included the client in the important compromise discussions, allowing them to be informed as to the tradeoffs selected throughout the project process.

They wanted a “wow” moment when entering the room for both family enjoyment and resale value. The interior design needed to stand out among the typical basement theaters of the area. The clients shared vision boards with clean modern designs, natural wood, built-in bookcases, and lots of visual interest. Equipment in the front of the room, other than the projection screen, should be hidden. They did not like the look of traditional fabric covered walls and wanted the room to look more like a snug, cozy family room.

Equipment upgrades are easy; room infrastructure changes are not. The room infrastructure is designed with acoustic considerations that would reveal subtle sonic differences between ordinary and high-end equipment. An upgrade path is not only possible but would yield excellent results.

The gear selected needs to be high-value, with pre-planned high-performance options if the client gets the upgrade bug.

The family was given detailed instructions and a homework assignment; a list of different audio/video qualities based on the RP22 performance-balancing “wheel” with additional video objectives to consider. This allowed them to prioritize and articulate their preferences to us so we could understand where best to make use of a constrained budget.

For audio, they identified that dialog clarity, immersion, envelopment, bass impact, and tonal balance (in that order) for a single listener are the most important. The room interior acoustic design would be critical to achieve these goals. Dynamic range and sound isolation were also considered important, but they acknowledged that budgetary constraints would limit what could be delivered.

Audio is the part of a movie that emotionally moves many of us, including our client. Ensuring balanced performance across all 21 RP22 parameters stacks up to a predictable immersive audio experience. The client prioritized audio as the most important aspect of the system.

Consistent timbre, phase uniformity across all speakers, level-matched channels, and speaker-to-speaker delay timing are critical to creating a 3D acoustic bubble. Using speakers with similar sonic characteristics and well-sorted room acoustics like in this project - together with proper calibration are the keys to achieving this.

Ultimate video fidelity wasn't going to fit the initial budget. Compromises for video were acceptable to the client for better audio. For video, a large, bright image is the most critical for them to feel immersed in the experience. The theater demo with varied material allowed them to zero in on a horizontal field of view preference of around 55 degrees. They also shared their viewing habits as being everything from Formula 1 Racing to Netflix to movies. The client agreed with our assessment that a 1.78:1 aspect ratio screen was the right choice for their viewing habits and room.

The room was an unfinished section of the basement with bare-stud load-bearing walls dictating the dimensions. Room layout was carefully considered. The client was open to our suggestion for the best screen and seating locations. During discovery, we determined the furniture needed to accommodate up to 5 family members on a deep, slouchy sectional with only 1 picky audiophile. A traditional deeper-than-wide theater with 2 rows of seats could have been a reasonable option for a different family. The wider-than-deep layout chosen allows a single-row massive sectional, a vestibule for noise isolation, and a remote projector location in the adjacent storage room.

When we visited to take photos of the finished room, the clients told us how much the room has changed their family life. The husband said, "The girls have me watching musicals I wouldn't normally care about… Greatest Showman and Wicked, for example. Or the list of Disney movies they realized I haven't watched." Their younger daughter told us she regularly listens to music and is often kicked out by her dad so he can watch something. The wife excitedly told us that she has had movie nights with her friends. She filled the drawers in the vestibule with movie theater snacks in perfect rows (we didn't have the heart to take one out of its place when she offered.)

Lighting Design

We wanted both direct lighting for reading/cleanup and low-level indirect lighting for casual TV watching. The lighting would be off to maximize contrast for serious content. The client also wanted decorative wall sconces in the rear of the room. A floor lamp provides accent lighting for the reading nook on the chaise. We selected LED strip downlights integrated into the ceiling beams. These lights have black lenses that make them nearly invisible when off - although being shiny, they do reflect some of the projected image light. We added up-lights in two groups to the beams. These light the walnut slat accents in the ceiling as well as the light grey ceiling area to the sides. The lighting reflecting off the outer ceiling areas provides diffuse general room lighting. We added vertical LED strip lights to the bookshelves to highlight the client's collections, blocking the light at each shelf intersection. All LED lights use 0-10V dimmers for smooth dimming control from the Crestron system.

The clients wanted the fixed screen to look unique and purposeful, so we added color-changing DMX-controlled LED lights to the floating screen surround, facing out to reflect off the millwork.

The four lighting presets were initially set up by our team but can be changed by the client within Crestron HomeOS when the mood strikes him. The presets are common between the Crestron remote, iPhone App, and the entry dimmer switch - which is also the 120V dimmer for the wall sconces.

HVAC Considerations

Major HVAC system modifications with a new zone or dampers with a dedicated thermostat were out of scope for this project. We did, however, make suggestions as to the routing of the supply and return ducts to minimize noise transmission and limit the HVAC noise inside the room. Ceiling ducts for the floor above needed to stay and were covered with sound deadening to provide some isolation and prevent rattles. The spaces between the joists and studs were filled with fiberglass insulation. The supply vent duct is directed into an acoustic plenum box above the screen and exits into the room through a long linear vent to reduce air velocity. The return vent is in the rear corner of the room, converting an existing wall void into an acoustic plenum box to allow for acoustic isolation from the mechanical room.

Audio Design

Speaker selection is ideally done towards the end of the process, once the necessary performance parameters are determined during discovery, design, and engineering. The client was open to the idea of changing speakers if it could be shown that they weren't the right choice for the design goals of the room.

The client provided speakers are of excellent quality, but some weren't the right product selection for the room. Sonance's team suggested their "surround" models for the side, rear, and overhead surrounds. These speakers have "splayed" dual full-range concentric drivers, designed to create a diffuse surround experience. This feature would be detrimental in our design, as 7 identical listener-level speakers would be best in a system with appropriate listener-level speaker locations. Any additional dispersion from the dual drivers would put extra energy into the room in areas that would not benefit the listeners. The simpler design would provide more controlled dispersion (and likely smoother frequency & phase response) for more precise, immersive imaging.

The in-ceiling speakers initially purchased were also designed to create a diffuse surround experience and were similarly not well suited to a design with 4 overhead speakers in appropriate locations.

With our encouragement, the client sent a request to Sonance to exchange the listener-level surround speakers for the same model as the LCR and to exchange the in-ceiling speakers for the single concentric driver version, more closely matching the directivity of the LCR. Sonance understood our design goals and were happy to swap the surround speakers out for the right product.

The in-ceiling speakers are large, square boxes designed to fit between joists and couldn't be angled due to joist spacing. In order to maximize consistency across the entire listening area, we wanted to point the speakers directly at the RSP. The solution was to install the speakers below the ceiling and hide them inside architectural beams running from the front to the back of the room. This provided aesthetic interest to the ceiling and allowed the area between and inside the beams to be used for acoustic treatment, hidden behind black fabric and walnut slats that were inspired by the client's vision board.

REW room simulation was used in the design stage to predict and avoid problematic subwoofer modal location issues across the listening area. As there is a single seating row, 2 subs along the front wall at the ¼ and ¾ points and 2 subs along the rear wall at the ¼ and ¾ points provided the most even frequency response and seat-to-seat consistency for all seating positions in the REW simulation.

They didn’t want to see piano black subwoofers when watching a movie. One of their vision board photos had a waterfall credenza countertop below a flatscreen. We used this concept to create a hidden subwoofer area with a walnut top and sides, concealing the subs while keeping them in the right locations. The void space was filled with acoustic insulation to reduce the resonances created by the semi-enclosed space and act as a small bass trap for the room. The rear subs would be out of view and were simply placed on the floor.

The front millwork that conceals the front subs was sized to accommodate high-output, larger 15” sealed subs should the client want to replace the smaller Sonance subs. The area has custom removeable panels in matching black fabric for future service and upgradeability. The in-room measured results with the Sonance subs showed -3dB extension to approximately 27Hz and the client has decided to keep them for now.

A single row, wider-than-deep room layout makes it tricky to balance the compromises. Listener locations simultaneously need to be away from the back wall, avoid room modal problem areas, allow correct zonal locations for multiple listeners, and minimize the angles between the surrounds for the critical RSP and adjacent seats.

The RP22 “adjacent seat” is directly beside the RSP on the chaise, at a 29” distance from the centerline RSP – easily within their spousal cuddling seating habits. Speaker locations are optimized for the RSP first, while allowing the adjacent seat to meet Level 2. The other seats are for kids and grandparents and were not heavily factored into the RP22 compromises.

The rear wall is close (1.34m) to the listening seats due to the room orientation. The angle between the rear surrounds is a balancing act; too wide and they don’t meet RP22 Level 2, but moving them in narrows the optimal listening area based on zonal location recommendations. The rear surround angle chosen was to ensure that 3 people can be within the listening area defined by the zonal location recommendations while the two end seats on the sectional are outside the zonal recommendation. This is just one example of how simultaneously calculating all location-based RP22 parameters for all seats was used to optimize the speaker placement.

Several of the existing studs in the room were not in the right locations for the surround speakers. These were relocated to allow for the as-built speaker locations to be precisely where the RP22 optimized design required. The speaker installation rings were screwed to the furring strips holding the acoustically isolated drywall, not touching the studs.

The noise isolating entry door had a very tight position tolerance in the design and could only go in one place. The bookshelves in the front needed to be 12” deep for the books. The spacing of the entry light switch was placed as tight to the millwork as possible, with the door frame placed tight to that backbox. This was to allow for the proper acoustic panel spacing and side surround speaker locations to work with our targeted RP22 angles.

Video Design

Based on client discovery, the image needs to be immersive in size and bright enough for HDR. Brightness calculations and budget considerations led to product selection of a brighter Epson projector with an e-shift 4K imager rather than a dimmer native 4K projector from Sony or JVC at similar cost. The horizontal field of view at the RSP was optimized to 55.5 degrees on a 120" wide, 1.78:1 aspect, acoustically translucent woven screen. The screen is fairly low gain (approximately 0.8), as a compromise to have the least effect on the sound. This demanded a bright projector to meet the client's video brief.

Our brightness calculation with the 3300 lumen projector gave us 127 nits. This will provide reasonable brightness for HDR, which should be at least 108 nits based on Dolby Cinema commercial exhibition cinema standards.

The chosen projector could benefit from a video processor for HDR processing, which could be added later. A future upgrade to a more expensive, native 4K projector is possible without any room modifications.

The room orientation was partially chosen to accommodate the projector and equipment rack in the adjacent mechanical/storage room. This allows the distracting noise of the projector to be removed from the room. The projector port was selected for its optical and acoustic isolation properties (40+ STC) with dual glass elements of different thicknesses. The equipment rack location was selected to be directly below the projector shelf to allow the use of short passive HDMI cables without extenders or active electronics. Servicing the HDMI pathway in this system will be simple and there is no need for compression or conversion.

A floating screen concept was utilized with a gallery-wrap screen surface with the matched set of LCR speakers behind. This provided a unique look in the recessed area created by the shelving. The wall area behind the screen was able to be used for acoustic absorption. The edges around the screen were covered with black fabric that would absorb any light overflow around the image. This black area functions to enhance perceptual contrast just like a wide velvet surround of a typical fixed screen. The screen surface was pulled out 6.5 inches from the speaker baffles to reduce audible effects from the proximity of the screen surface. The recessed image and dark paint colors chosen for the room prevent the screen's light from illuminating objects on the shelves.

The unique screen placement with color-changing LED glow sets the room apart from the crowd. The overall visual effect is of an image that floats free of the dark void surface behind it, limiting visual distraction. Of course, the lights surrounding the screen are off during serious viewing.

The concealed subwoofer location below the screen limited the lower edge of the image, resulting in a head-tilt of 12.2 degrees to the center. This is within the ergonomic rule of thumb of 15 degrees for optimum viewing comfort.

Acoustic Design

The acoustic design started with the room infrastructure. We wanted to build a room that was quiet by design within a limited budget. The room layout (and an existing load bearing wall) allowed space for an entry vestibule. Closing both the vestibule outer double-doors and the inner engineered sound isolation door makes for a quiet space.

HushFrame isolation blocks were installed with wood furring strips for the ceiling, side walls, and rear wall. The electrical outlets and speaker frames for the room are isolated from the studs, screwed to the furring strips.

One of the noise isolation goals for the ceiling was to keep drywall penetrations to a minimum to reduce sound transmission to the open living space above. The lighting is integrated into the beams, and the low voltage wiring is fed directly to the mechanical room. Tighter spacing of the isolation blocks in the ceiling accommodated the weight of the ceiling beams, ceiling speakers, and acoustic treatments.

The room interior acoustic design has as much influence on sound quality as the speakers and equipment. We installed the acoustic absorption behind the fabric and the projection screen first. The surface-mounted acoustic panels were added close to the project completion when we demonstrated the flutter echo and "zingy-ness" without the panels to the client.

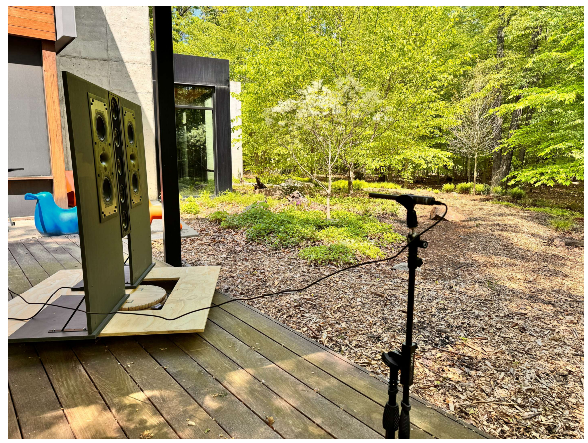
On calibration day, there were leaf blowers just outside. The isolation solution was proven successful as they were not audible from inside the room.

RP22 Design Process & SPL Calculations

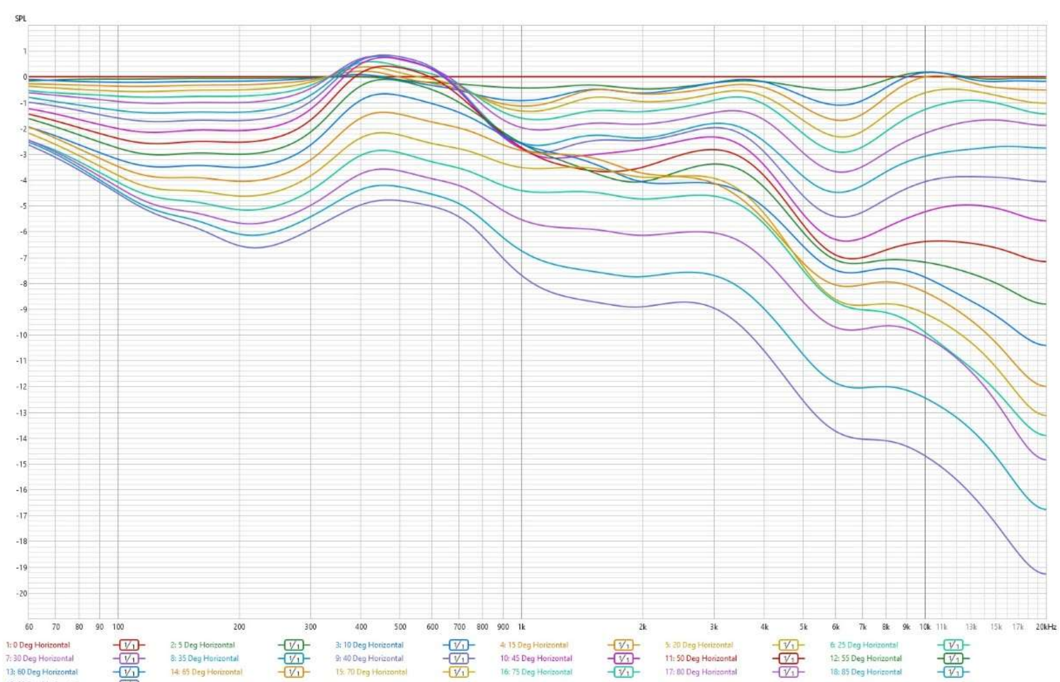
Sonance provides limited engineering data for their speakers, so we measured the horizontal dispersion ourselves to verify suitability for purpose and to determine the best way to integrate them into the overall design. We temporarily mounted the R2 between our demo Perlisten speakers mounted in small "baffles" and placed everything on a turntable. We were primarily looking at horizontal dispersion referenced to on-axis with 1-octave smoothing per RP22, so boundary gain and the floor bounce weren't a particular concern.

Sonance R2 Speaker Measurements (UMIK-1 @2m)

Sonance R2 Horizontal Response Testing



Sonance R2 LCR Speaker Horizontal Dispersion (1 Octave Smoothed, Normalized to 0 Degrees On-Axis)



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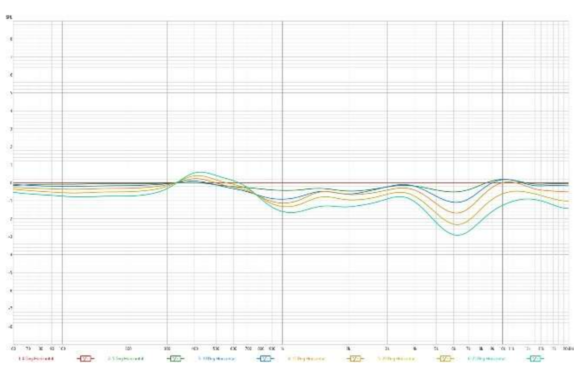
The similarities of the curves above and the generally wide-dispersion characteristic (-6dB down at 45˚ off-axis) of the speaker gave us confidence that it would work well in our design. The speaker also had a reasonably smooth overall frequency response (not shown). The Left/Right speakers mounted flush in the walls would have a similarly-shaped first reflection response as the direct response, allowing that reflection to remain untreated and be beneficial to the soundstage without changing the timbre.

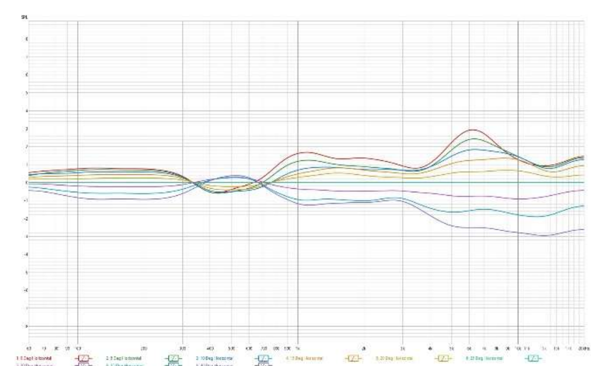
We used our REW measurements to plot 1-octave smoothed response predictions for the listening area for flush mounted R2 speakers – shown below normalized at 0 degrees for the center speaker (+0.5dB, - 3dB across all listener angles), 25 degrees for the left/right (+- 3dB across all listener angles), 5 degrees for the side surrounds (+- 0.5dB across all listener angles), and 40 degrees for the rear surrounds (+5.5dB, - 7dB across all listener angles). The rear surrounds are much less ideal across the listening area, but the client was involved in the discussion about the aesthetic vs the performance tradeoffs. This prediction showed the R2 would be suitable in a RP22 Level 2 room with the speakers installed flush in the walls, as per the aesthetic preference of the clients.

Predicted Response Variance across Seating Area

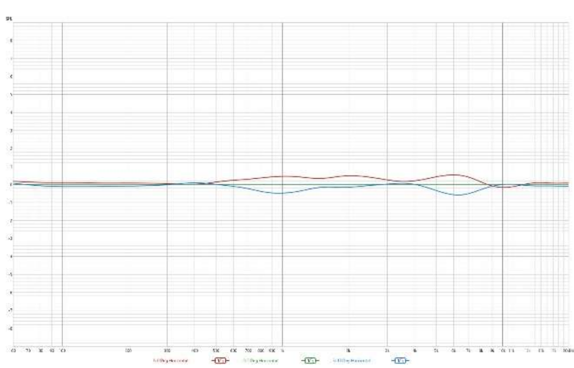
Front Center Channel



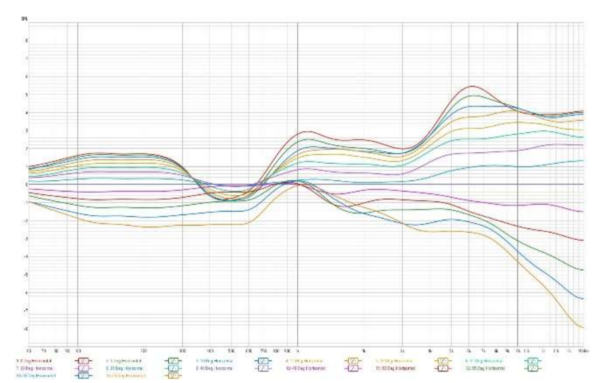
Front Left/Right Channels



Surround Left/Right Channel



Surround Back Left/Right Channels



With an amplifier driving the speaker to its max power handling, accounting for distance to RSP and 1.5dB for screen fabric losses, their anechoic max SPL levels would ***nearly*** meet RP22 Level 2 minimums as LCR speakers (0.3dB short for the FL/FR, 0.5dB headroom for FC).

The max SPL calculations for the other speaker locations met RP22 Level 2 minimums with appropriate amplification. The client was informed that the FL and FR speakers can't be shown to fully produce RP22 Level 2 SPL levels in the design stage, and they were OK with the small variance from the room target.

The selection of AV processor and amplifier was an effort of balancing compromises. The client wanted excellent performance, but the budget constraint demanded a good-enough solution with expansion opportunities. An Anthem AV receiver was chosen, knowing it has limitations to reaching RP22 level 2 max SPL with the internal amplifiers (short by 1.0dB for the FL/FR, 0.3dB for the FC, and 0.6dB for the TFL/TFR speakers).

Adding external amp channels using the AVR's preamp outputs could satisfy RP22 level 2 when the client decides to upgrade, assuming the speakers can take the modest additional power (0.3dB above their power handling rating). External amplification would provide headroom for short peaks beyond the RMS power handling capabilities of the speakers and better power supplies to ensure sufficient power to drive multiple channels simultaneously.

The client's end-game choice of processer and amplification is the Trinnov Altitude CI and Amplitude 16. They would greatly increase calibration and processing flexibility. The noise floor would also be reduced from the combined speakers at the RSP by an estimated 8.2dB SPL over the Anthem receiver (generally below the level of audibility at the RSP, however). This planned upgrade could be easily integrated to improve overall sound quality.

RP22 Calculation Spreadsheet

We use engineering data to make predictions before the room is built. Once the room is under construction, changes are either expensive or impossible.

We created our RP22 spreadsheet tool to be able to simultaneously calculate multiple RP22 parameters for all seats. This allows us to modify speaker locations, for example, to balance the tradeoffs that are inevitable between competing RP22 parameters - optimizing the design with the specific project goals in mind. Frequently, enhancing one aspect of design is to the detriment of something else. It is more important to consider all the RP22 parameters in balance and how they interact with each other than to hyper-focus on any one attribute.

Partial Detail of our RP22 Spreadsheet

Sunset Lounge, RP22 Calculations - As-Built, Integrated Amplifier	**Level**	**Data/Min/Max**	**FL**	**FC**	**FR**	**SL**
Preamp/DAC			None	None	None	None
Amp			Anthem MRX (Main)	Anthem MRX (Main)	Anthem MRX (Main)	Anthem MRX (Main)
Speaker			Sonance R2	Sonance R2	Sonance R2	Sonance R2
RP22 Target (Level)	2					
X Location, R/L (Delta RSP, m)			-1.359	0.002	1.360	-2.632
Y Location, F/R (Delta RSP, m)			3.083	3.083	3.083	0.156
Z Location, Up/Dn (Delta RSP, m)			0.291	0.291	0.291	0.291
Screen/Fabic/Other Losses (dB)			1.5	1.5	1.5	0
DSP EQ Headroom (dB)			3	3	3	3
Anticipated Room Gain (dB)			3	3	3	3
Front Wall Distance (Delta RSP, m)		3.083				
Left Wall Distance (Delta RSP, m)		2.632				
Right Wall Distance (Delta RSP, m)		2.632				
Rear Wall Distance (Delta RSP, m)		1.343				
Total Room HVAC and Non-Speaker Noise @RSP (NCB, Design Estimate)		24				
Estimated Room HVAC Noise (dB SPL @8kHz)		16				
Calculated Total Speaker Noise Floor @Listening Position (dB SPL)		6.3				
Combined Total Noise Floor with HVAC (dB SPL, Estimated)		16.4				
Combined Total Noise Floor with HVAC (NCB, RP22 Paramter 15)	2	24.4				
Screen Wall Speakers Outside Zonal Locations (RP22 Paramter 3)	4	0				
Upfiring Speakers Used (RP22 Paramter 8)	4	No				

The process starts with speaker locations (in x,y,z coordinates) referenced to the RSP. We extract these from our 3D CAD model and convert them to metric units. For anechoic SPL calculations, it uses these coordinates to calculate the straight-line distances between the speakers and multiple listening positions. The spreadsheet also calculates all angles from all seats to all speakers and many other factors related to RP22. It is an iterative process for each project to get the speakers in the right locations to maximize the size of the listening area.

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First Reflection Points Calculation

We calculate first reflection points for the RSP so we can make informed decisions on whether to do nothing, absorb, or diffuse them for the RSP. The reflection's delay relative to the direct sound, the corresponding anechoic propagation loss, and their location inform our decisions.

Sunset Lounge First Reflection Points for RSP from LCR Speakers (Imperial Units Used to Coordinate with 3D CAD Model)

Measurements (Enter Distances in Green Cells)	Total (Inches)	Feet	Inches
Room Width	207.3	17	3.3
Room Depth	174.3	14	6.3
Distance from L Speaker to Left Wall (X1)	52.6	4	4.6
Distance from C Speaker to Left Wall (X1)	103.6	8	7.6
Distance from R Speaker to Left Wall (X1)	154.7		
Distance from L Speaker to Right Wall (X1)	154.7		
Distance from C Speaker to Right Wall (X1)	103.6		
Distance from R Speaker to Right Wall (X1)	52.6		
Distance from L/R Speakers to Front Wall (X1)	0.0	0	0.0
Distance from L/R Speakers to Rear Wall (X1)	174.3		
Distance from C Speaker to Front Wall (X1)	0.0	0	0.0
Distance from C Speaker to Rear Wall (X1)	174.3		
Distance from Listener to Left Wall (X2)	103.6		
Distance from Listener to Right Wall (X2)	103.6		
Distance from Listener to Front Wall (X2)	114.7	9	6.7
Distance from Listener to Rear Wall (X2)	59.6		
Distance along Front/Rear Wall, L/R Speaker to Listener (Y)	51.1		
Distance along Side Wall, L/R Speaker to Listener (Y)	114.7		
Distance along Side Wall, C Speaker to Listener (Y)	114.7		
Ceiling Height	109.5	9	1.5
Listening Height	36.0	3	0.0
Speaker (Tweeter) Height	47.5	3	11.5
Distance from Listener to L/R Speaker	125.5	10	5.5
Distance from Listener to C Speaker	114.7	9	6.7
Delay from L/R Direct Sound to LP (ms)	9.3		
Delay from C Direct Sound to LP (ms)	8.5		
L/R Speaker Angle (Radians)	0.4		
L/R Speaker Angle (Degrees)	24.0		
Speed of Sound (inch/s)	13500		

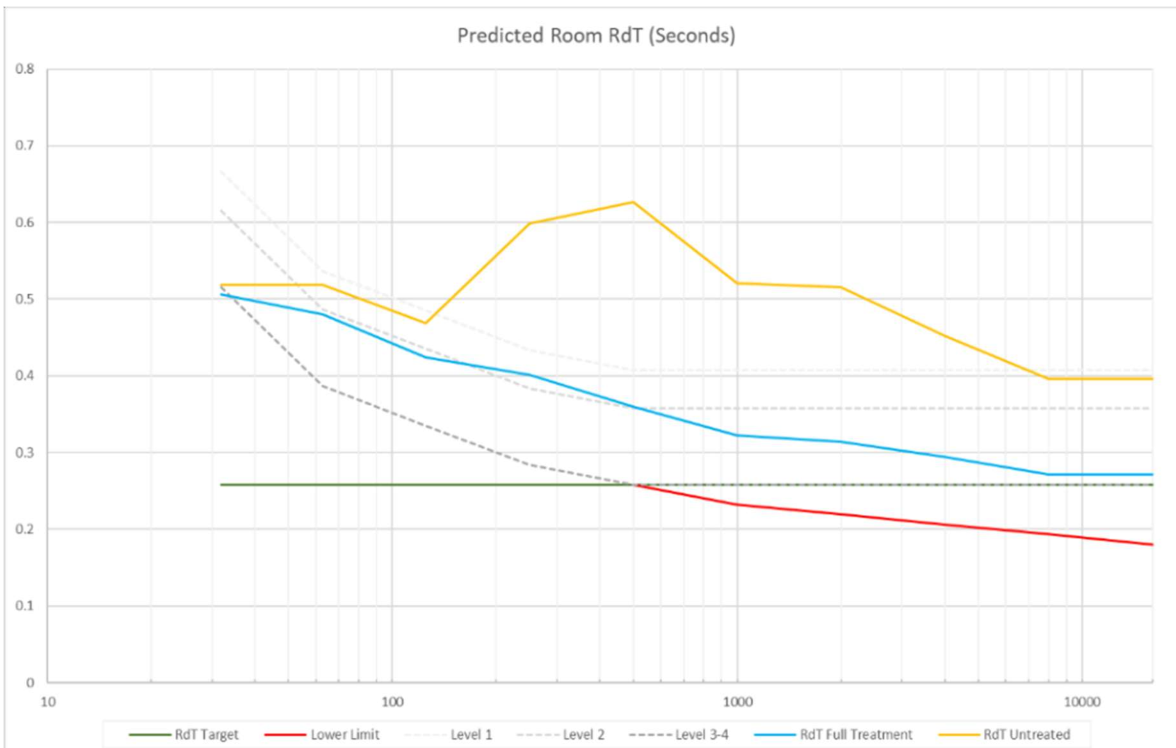
First Reflection Points (For Sunset Lounge - Absorb Green, Diffuse Yellow)	Distance (in)	Distance (ft)	Delay Relative to Direct (ms)	Propagation Loss for Reflection (dB)
Left Speaker Wall Reflection Points				
Distance along Left Side Wall from LP to L FRP (LW-L)	76.1	6' - 4.1"	5.1	-3.8
Distance along Right Side Wall from LP to L FRP (RW-L)	46.0	3' - 10"	11.6	-7.0
Distance along Front Wall from LP to L/R FRP (FW-L)	51.1	4' - 3.1"	0.0	0.0
Distance along Rear Wall from LP to L/R FRP (RR-L)	13.0	1' - 1"	8.4	-5.6
Right Speaker Wall Reflection Points				
Distance along Left Side Wall from LP to R FRP (LW-R)	46.0	3' - 10"	11.6	-7.0
Distance along Right Side Wall from LP to R FRP (RW-R)	76.1	6' - 4.1"	5.1	-3.8
Distance along Front Wall from LP to L/R FRP (FW-R)	51.1	4' - 3.1"	0.0	0.0
Distance along Rear Wall from LP to L/R FRP (RR-R)	13.0	1' - 1"	8.4	-5.6
Center Speaker Wall Reflection Points				
Distance along Left Side Wall from LP to C FRP (LW-C)	57.3	4' - 9.3"	9.1	-6.3
Distance along Right Side Wall from LP to C FRP (RW-C)	57.3	4' - 9.3"	9.1	-6.3
Distance along Front Wall from LP to C FRP	0.0	0' - 0"	0.0	0.0
Distance along Rear Wall from LP to C FRP	0.0	0' - 0"	8.8	-6.2
Floor Reflection Points				
Distance from LP to Floor FRP from C Speaker, along C Axis (F-C)	49.4	4' - 1.4"	1.6	-1.5
Distance from LP to Floor FRP from L/R Speaker, along Sound Path (F-L/R)	54.1	4' - 6.1"	1.4	-1.3
Distance along Side Wall from LP to Floor FRP from L/R Speaker	22.0	1' - 10"		
Distance along Front Wall from LP to Floor FRP from L/R Speaker	49.4	4' - 1.4"		
Ceiling Reflection Points				
Distance from LP to Ceiling FRP from C Speaker, along C Axis (C-C)	62.2	5' - 2.2"	4.0	-3.4
Distance from LP to Ceiling FRP from L/R Speaker, along Sound Path (C-LR)	68.1	5' - 8.1"	4.4	-3.4
Distance along Front Wall from LP to Ceiling FRP from L/R Speaker	27.7	2' - 3.7"		
Distance along Side Wall from LP to Ceiling FRP from L/R Speaker	62.2	5' - 2.2"		

The ceiling acoustical absorption is specifically placed at the first reflection points of the LCR speakers to minimize reflections for the RSP to enhance dialog intelligibility and prevent vertical image spread. The side wall absorbers were placed to absorb the contralateral reflections, but not the ipsilateral reflections (for example, at the left speaker to the right wall first reflection point, leaving the left speaker to the left wall first reflection point untreated.) This resulted in the center channel's first reflections to the side walls not being treated. The LCR speakers' first reflections on the rear wall were all diffused.

We feel this acoustic treatment approach was warranted for a room that was also designed for 2-channel music listening in addition to surround sources. The stereo imaging result is well balanced in the room with a precise sound stage and good envelopment.

Reflection Decay Time (RdT) Calculation

The overall RdT prediction was challenging - as the massive, upholstered sectional would be a large portion of the total room absorption - but was an unknown. We chose acoustic panels to ensure the RdT predictions were smooth across the full frequency spectrum, with a slight downward tilt. We purposefully treated the room to a higher predicted RdT than our desired target. Knowing that the sectional's absorption was an unknown, we would prefer to err on the side of a livelier room. We didn't want to over-treat the room and could add more absorption to the walls later if needed.

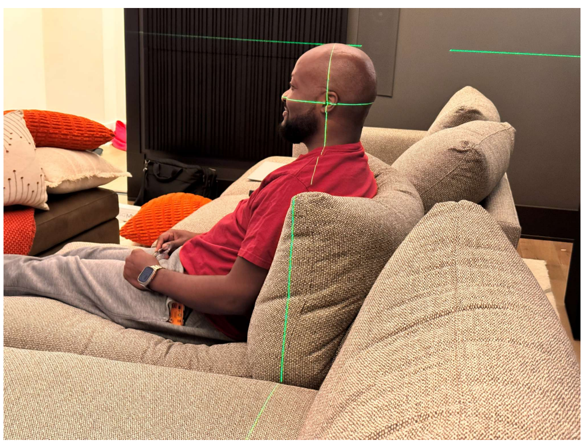


Audio Calibration and Verification

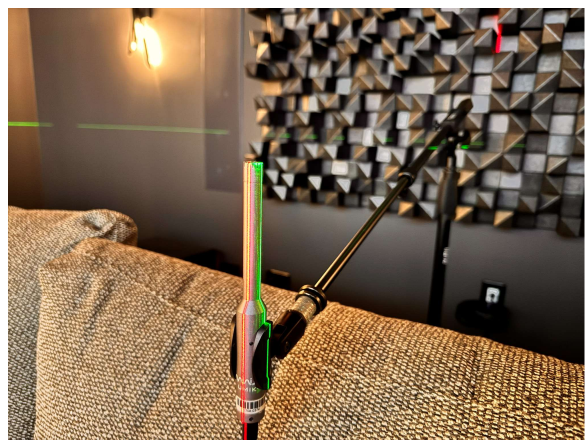
The initial audio room equalization was done using Anthem ARC Genesis with an Anthem calibration microphone connected to a laptop. ARC settings for the bass management crossovers were determined by analyzing the individual frequency responses of the LCR/surrounds/uppers and subs. The ARC target curve was adjusted by ear incorporating client feedback.

Further adjustments to the delay and levels of the speakers and subs were made after ARC setup, but prior to the RP22 verification measurements. The automatic calibration resulted in 3dB less bass in our independent measurements than shown in its graphs. Listening to the tonal balance in the room validated that adding 3dB to each of the subwoofer's levels was the right subjective bass amount for our ears and the client's. The verification measurements taken several months after the initial calibration show the final result.

Client Seated to Determine Calibration & Couch Location



Anthem ARC Calibration Mic Position

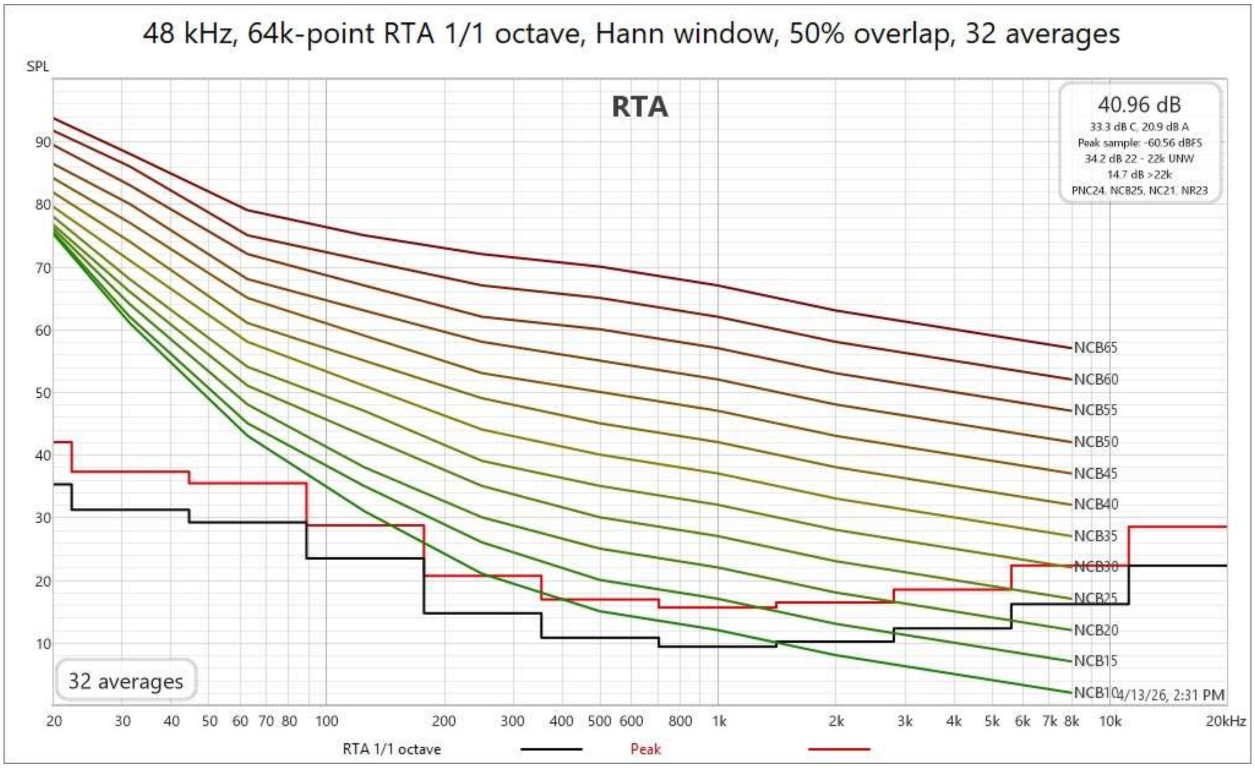


With this project, we wanted to demonstrate that a Level 2 room could be verified in a single day using simple, inexpensive tools, with analysis and documentation completed in an additional day. We used a MiniDSP UMIK-1 for most measurements, with a MiniDSP UMIK-2 for the noise floor measurement. We used REW and a NVidia Shield loaded with discrete 7.1.4 channel sweeps from 20Hz-20kHz. For speaker level setting, the Anthem's internal pink noise generator was used.

We narrowly missed our Level 2 target for max SPL, which relied on predictions, not measured in room. We also found some early reflections that were likely from the projection screen structure or millwork. Since these are below 1ms behind the initial impulse they are not likely to be directly audible but could be noticed as a coloration or timbre change.

RP22 Parameter 15 – Background Noise Floor

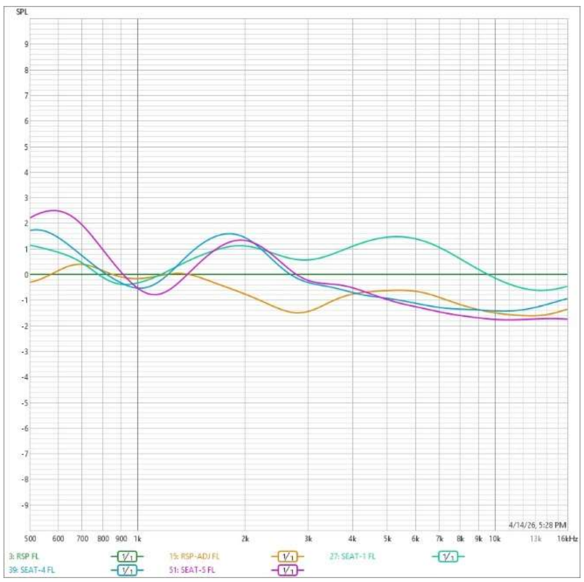
The noise floor measurement below was limited by the MiniDSP UMIK-2 microphone. NCB25 is the lowest number we have seen using this mic. The room noise measured identically with the isolation door open or closed, but the background noise level in the room was dramatically different - demonstrating that the microphone was the limiting factor.



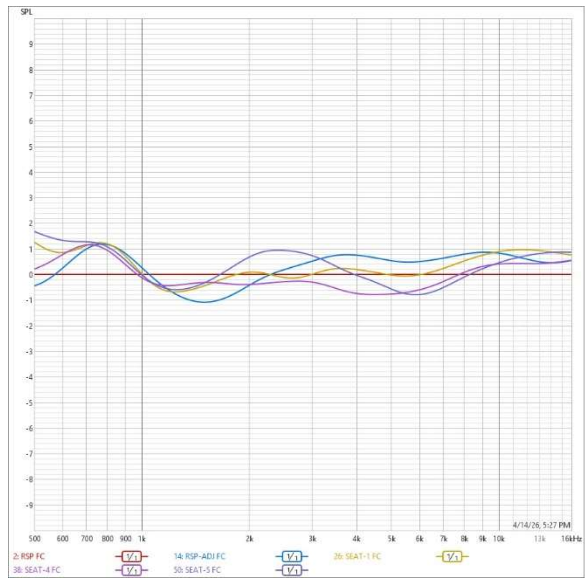
Parameter 16 - Seat-to-Seat Frequency Response Variance Across all Screen Wall Speakers (Plots Normalized to RSP):

These plots show the frequency response consistency across the listening area, with the RSP normalized and shown as a straight line. The RSP adjacent seat shows variation within RP22 Level 2 tolerances, as predicted.

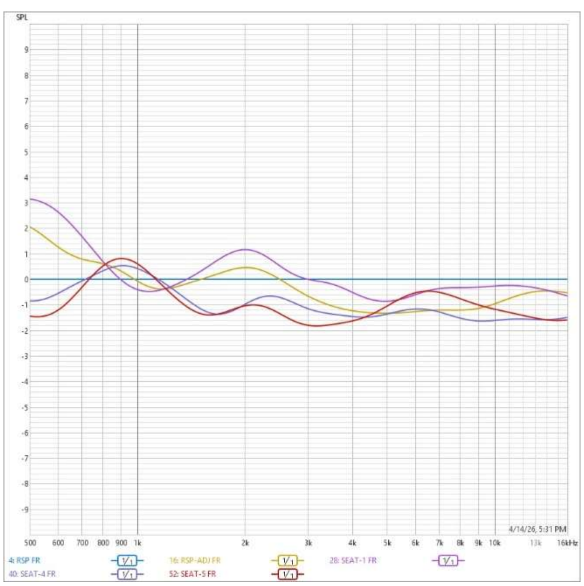
Front Left Channel



Front Center Channel

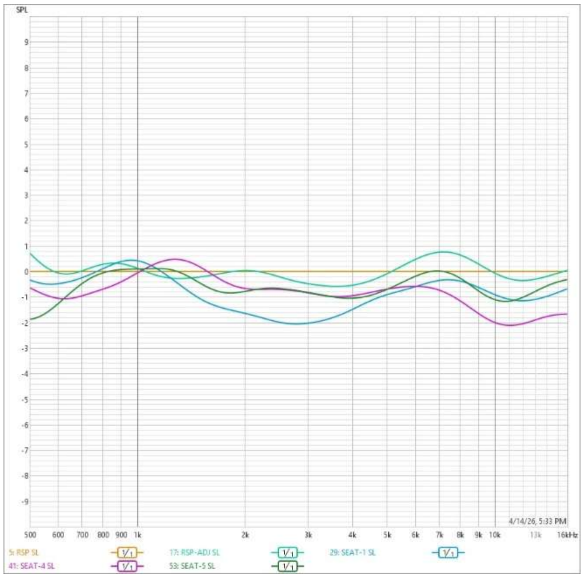


Front Right Channel

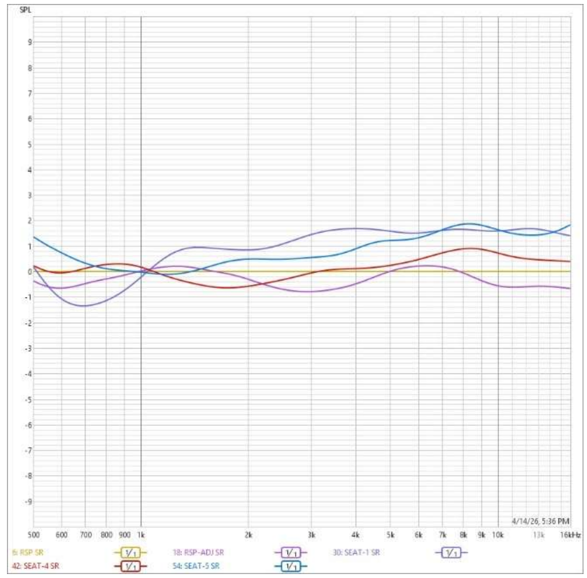


Parameter 17 - Seat-to-Seat Frequency Response Variance Across all Wide/Surround/Upper Speakers (Plots Normalized to RSP):

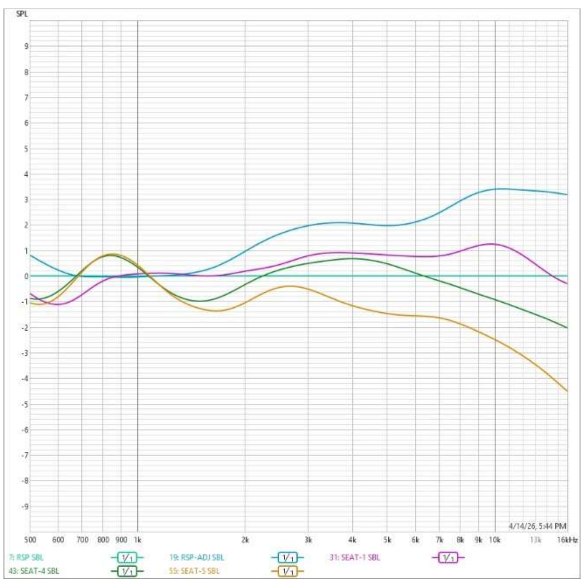
Surround Left Channel



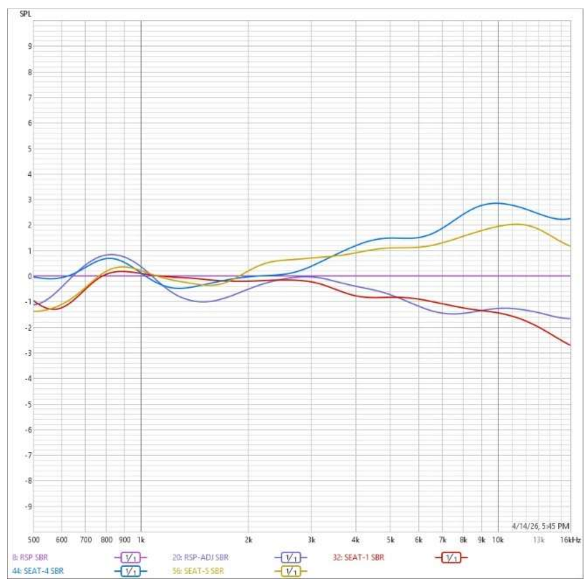
Surround Right Channel



Surround Back Left Channel

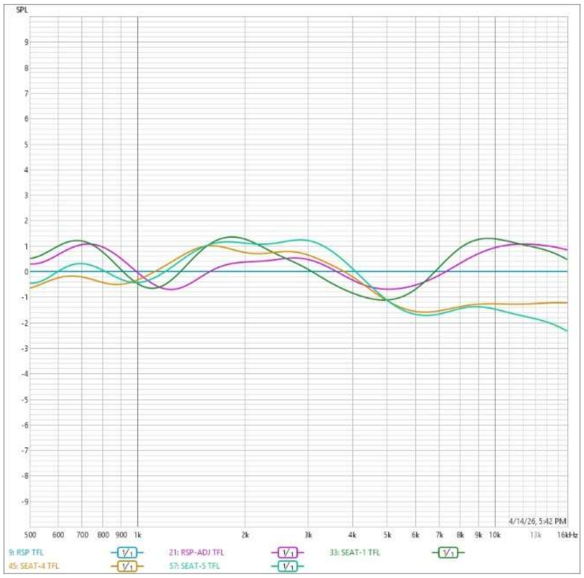


Surround Back Right Channel

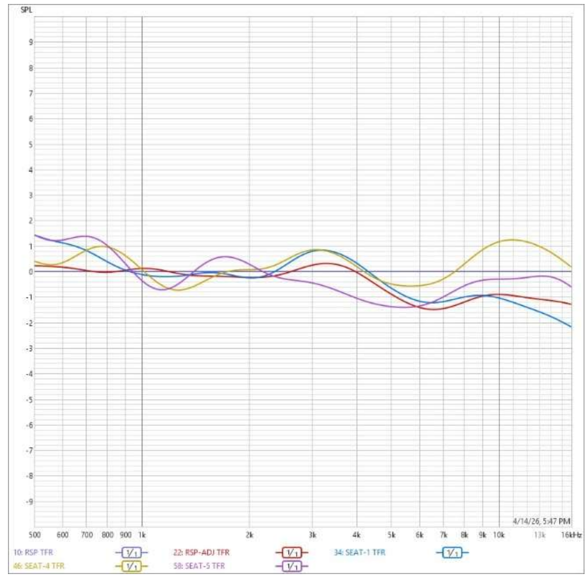


Parameter 17 (Continued):

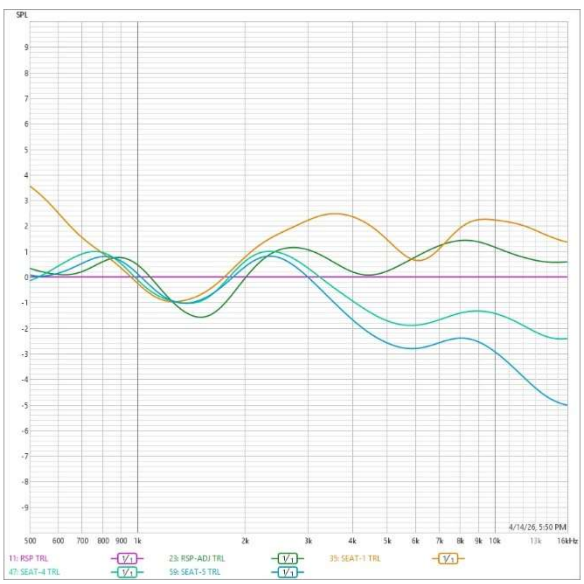
Top Front Left Channel



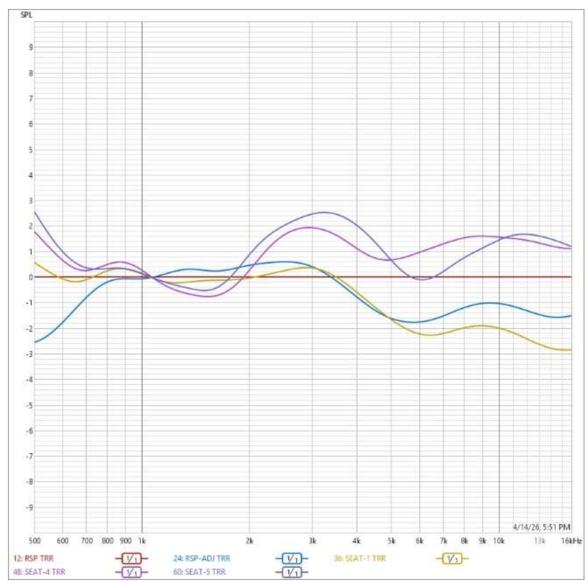
Top Front Right Channel



Top Back Left Channel



Top Back Right Channel



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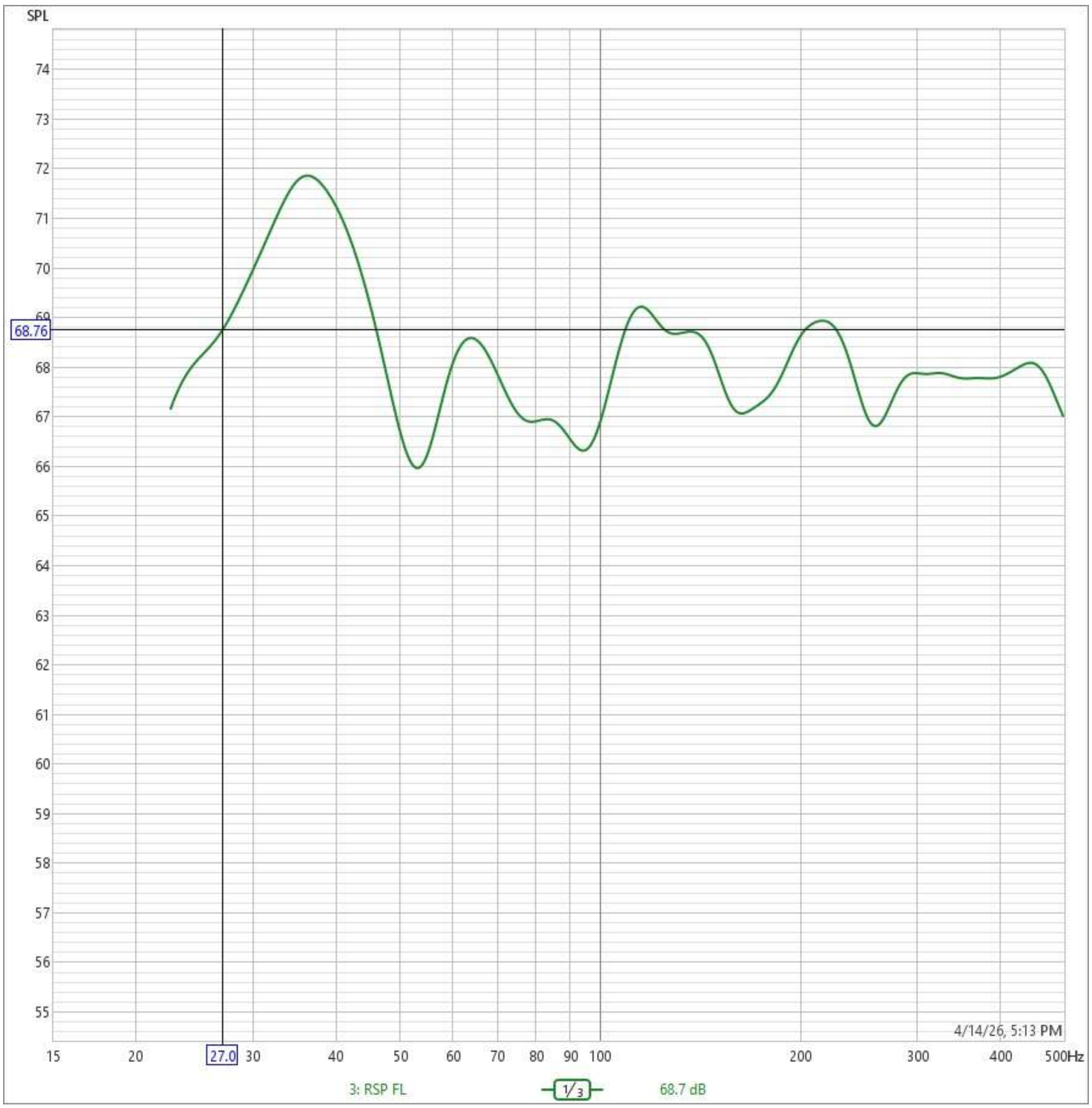
Parameter 18 - In-Room Bass Extension -3dB Cut Off Frequency Point:

The bass extension for the room is shown below with the -3dB down point at around 27Hz. The response shown is from a 20Hz-20kHz sweep of the bass-managed left channel with a single microphone position (no spatial averaging). The results were similar for the center and right channels.

Bass Response (not Spatially Averaged), Front Left Channel



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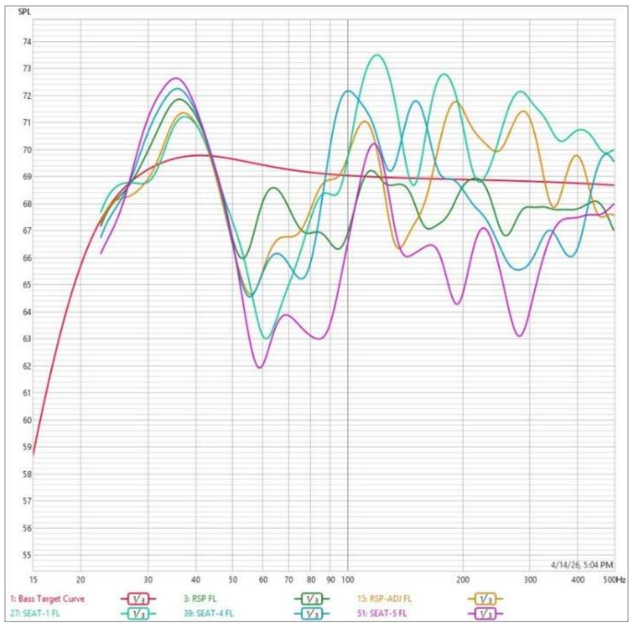
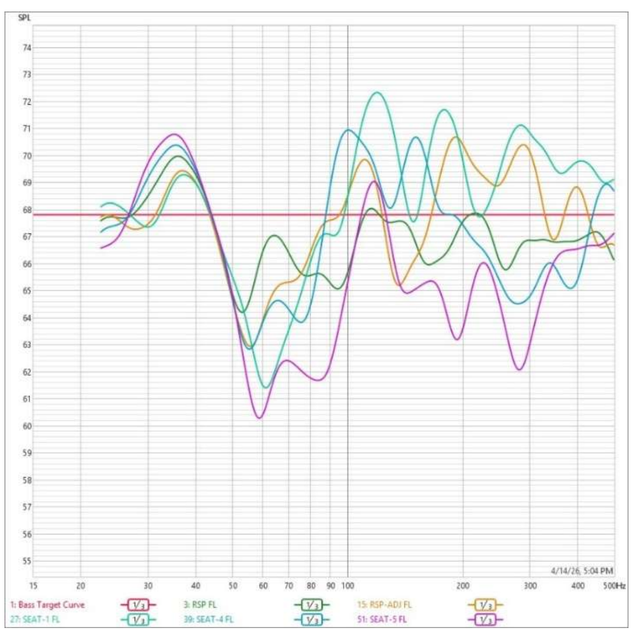
Parameter 19 - Frequency Response below the Room's Transition Frequency at the RSP Relative to Target Curve:

Anthem doesn’t have an easy method to export the target curve, so an approximate target curve was created in REW. The lower plot is normalized to the target curve for analysis.

Frequency Response w/ Target Curve (not Spatially Averaged)



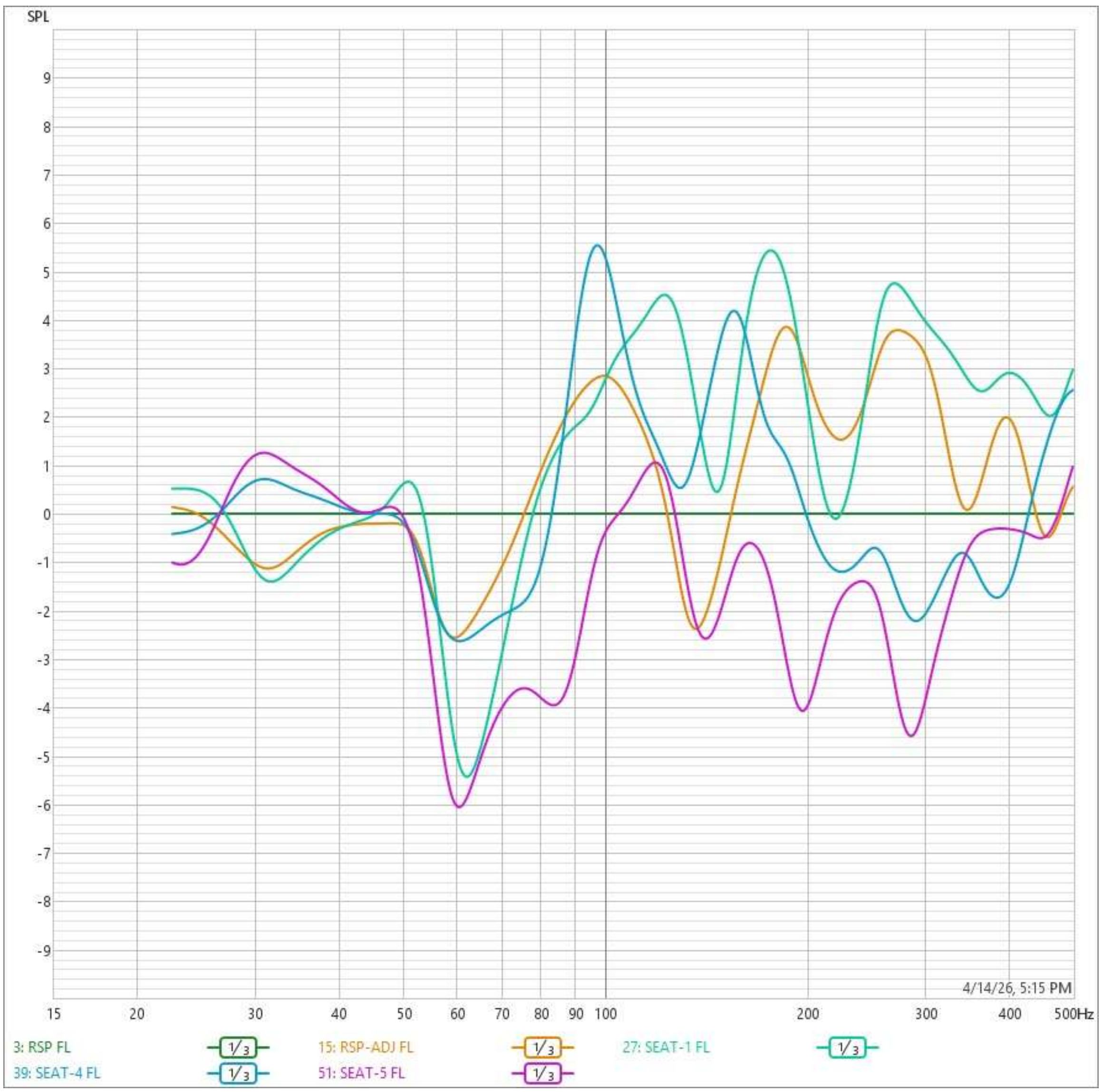
Frequency Response Normalized to Target Curve (not Spatially Averaged)



Parameter 20 - Seat-to-Seat Frequency Response Relative to Measured RSP Response below the Room's Transition Frequency:

The low frequency consistency between listening positions is shown below, normalized to the RSP. The response shown is from a 20Hz-20kHz sweep of the bass-managed left channel with a single microphone position (no spatial averaging). The results were similar for the center and right channels.

Frequency Repose Normalized to RSP Response (not Spatially Averaged)



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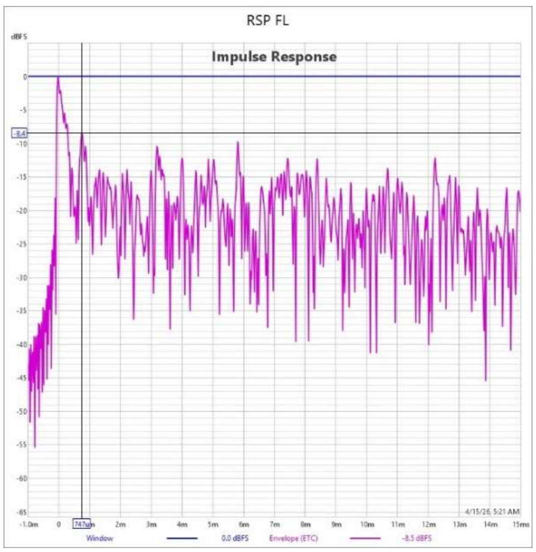
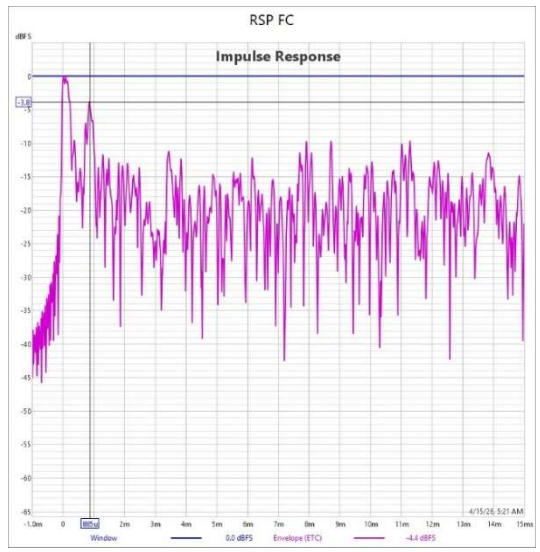
Parameter 21 – Level of Early Reflections Relative to Direct Sound (0-15ms, 1-8kHz):

These impulse response measurements show early reflections for the LCR, likely from the walnut cabinetry. While they do show significant reflections, these primarily occur at less than 1ms, which should be integrated with the direct sound by our brains. The remainder of the early reflections were within level 2 targets.

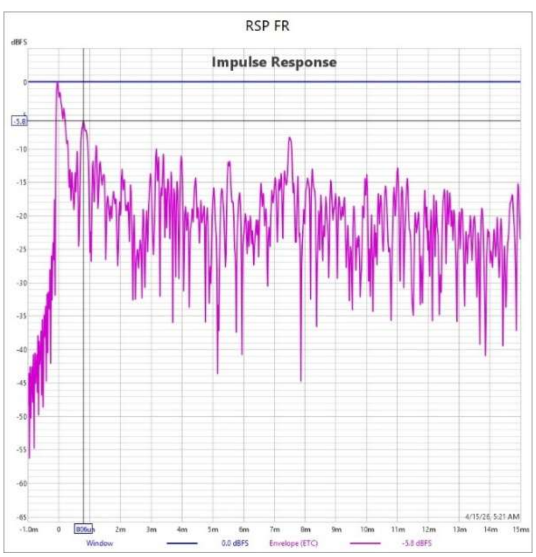
Front Left Channel Impulse Response (Unfiltered)



Front Center Channel Impulse Response (Unfiltered)



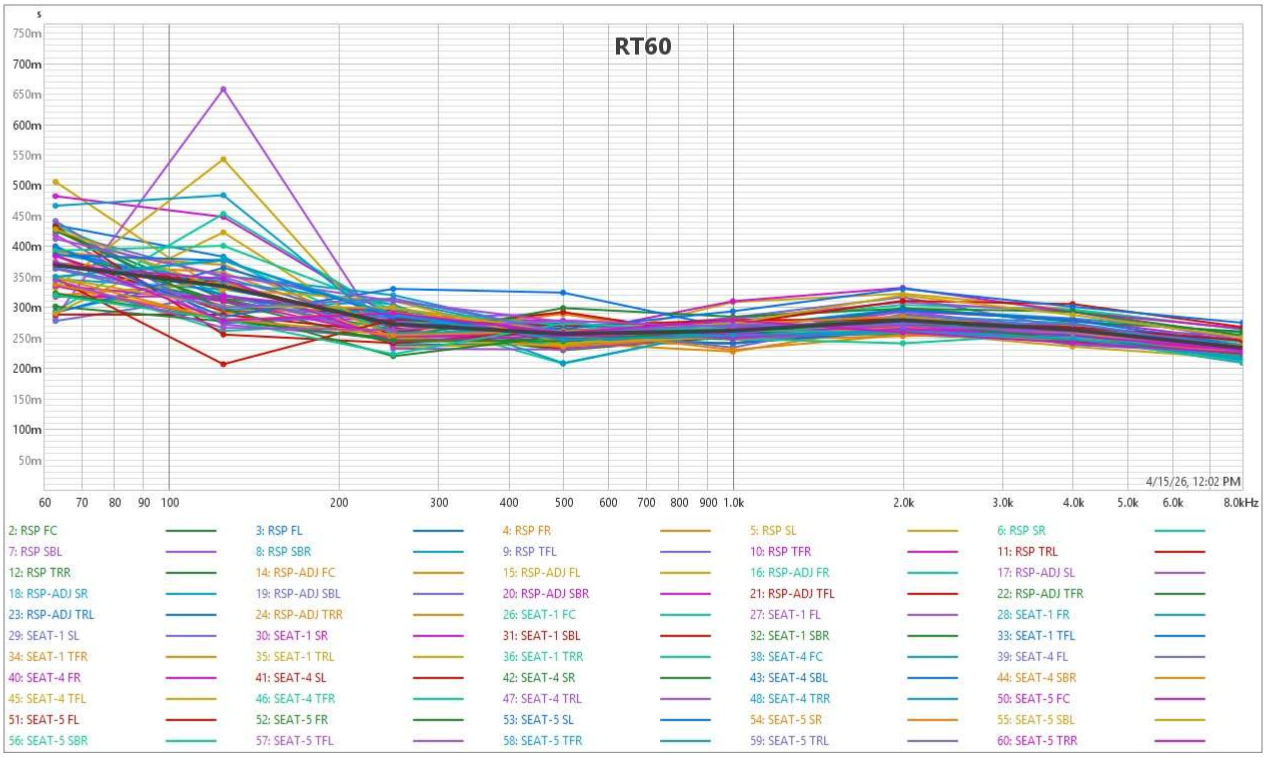
Front Right Channel Impulse Response (Unfiltered)



Additional Measurement - Reflection Decay Time (RdT):

The RdT (T30) result was on target for the room size, which was calculated to be 0.258 seconds for this room. The plot below is from individual measurements from all seats with all channels used as the stimulus. The resulting average (in black) shows smooth response across the full frequency spectrum. There is consistent response for all seats in the stochastic region, above the room's transition frequency. The variation in the plots at 125Hz is due to the modal behavior of the room.

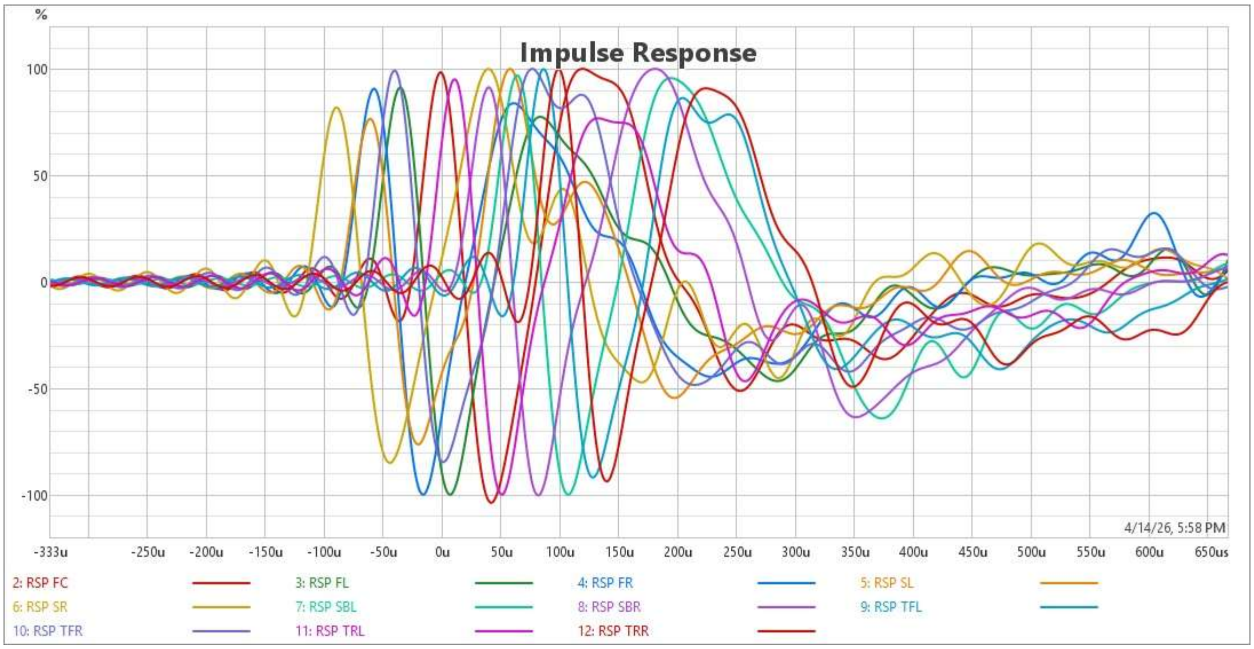
RdT (T30) – All Speakers as Stimulus (Swept Sine), All Listening Seats as Measurement Points



Additional Measurement - Speaker-to-Speaker Delay Time at RSP:

The speaker to speaker delay times between channels were aligned to within the tolerance of the Anthem AVR’s capabilities (2 inches, or 0.15ms) for all channels at the RSP.

Impulse Response at RSP, All Speaker Channels



Viewing Geometry & Brightness

During discovery, a 55˚ horizontal field of view with a 1.78:1 aspect ratio was determined to be the right target for the client with the content they typically watch. A screen surface of 120” x 67.5” at the 114” viewing distance gave us a 55.5˚ horizontal field of view with a 12.2˚ head tilt angle. This provides a comfortable, immersive video experience.

Screen Size and Geometry Calculations

Image Width (Inches)	**120**
Image Height (1.78:1, Inches)	**67.5**
Image Height (2.4:1, Inches)	**50.0**
Viewing Distance to Image (Inches)	**114**
Viewing Height Offset to Center of Image (Inches)	**-24.75**
Multiple of Image Height (2.4:1)	2.3
Calculated Vertical Field of View (1.78:1, @0° Head Tilt)	33.0
Calculated Vertical Field of View (2.4:1, @0° Head Tilt)	24.7
Calculated Horizontal Field of View (On-Axis)	55.5
Calculated Head Tilt - Eye to Image Center Angle (On-Axis)	12.2

We anticipated 80% of the projector manufacturer’s claimed brightness after calibration. The projection screen is specified to have a 0.8 gain and the projector port is specified with a 99% transparency, which results in a 0.79 gain for the brightness calculation. Our brightness prediction for the display system was 127 nits, which works well for both SDR and HDR content. The projector’s laser power setting can be reduced if desired for SDR content.

Brightness Calculations

Projector Brightness (Lumens, Manufacturer Rating)	**3300**
Projector Brightness (Estimated Lumens, Calibrated)	**2640**
Screen Gain (Include Port Glass and Anamophic Lens Loss)	**0.79**
Screen Dimensional Units	**Inches**
Image Area (sq m)	**5.23**
Image Luminance (Nits)	127.4

Using our X-Rite Display 3 Pro II colorimeter, we measured a calibrated 123 nits (36.1 footlamberts) at the center of the image, which is very close to our prediction.

Construction Details

The client didn't have a general contractor for the construction, so we made an introduction to a local builder that we had worked with successfully on past projects. We knew the general contractor (GC) would be able to handle the unusual acoustic isolation and millwork details necessary for the project. At the conclusion of the design phase, we provided the GC with sketches and renders of the room concept. The client contracted directly with the GC for the construction.

Renders from our 3D Room Model Provided to GC for Pricing and Coordination

HushFrame with a single layer of 5/8" drywall was selected as a good balance between costs and isolation performance for the ceiling, back, and side walls. As the front projection wall was an exterior poured-concrete wall with millwork, we decided that it could be more simply constructed without the HushFrame construction. The existing and new ceiling air ducts were treated with sound deadening in an effort to reduce sound transmission and possible rattling.

HushFrame Block Detail with Furring Strips

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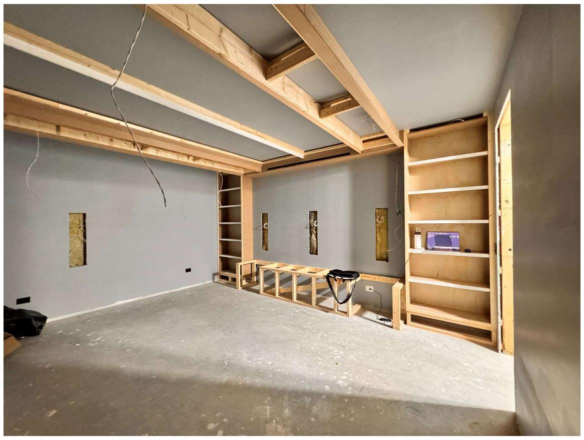
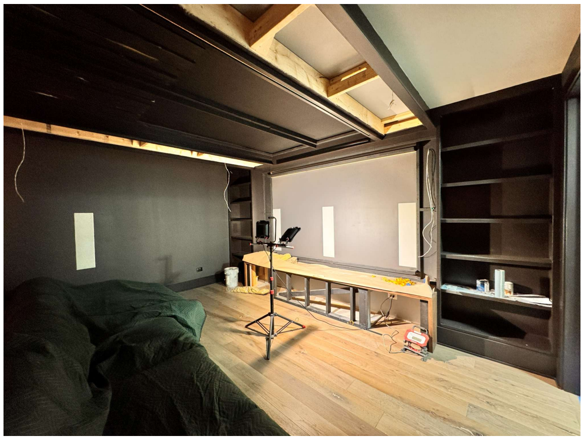
These photos show the construction of the millwork and the start of the built-in acoustic treatment. The bottom photos show the improvised 2D diffusor that we asked the GC to build using scrap pieces of lumber. This area is directly over the RSP and would limit hard reflections in that location. The areas between and inside the beams were painted black as the acoustical fabric that was to cover it has some visual translucency, and we didn't want any of the acoustical details to be visible.





The ceiling detail was designed to specifically accommodate the ceiling speakers and the ceiling's acoustical needs. This had multiple benefits. The speakers didn't need to penetrate the HushFrame isolated ceiling, the speakers could be aimed directly at the RSP using a laser line, and it provided an area of acoustic absorption behind the walnut slats and black fabric. It also gave visual interest to the room design.

For the wall behind the projection screen, we wanted to have absorption behind the screen and between the speakers. This absorption was intentionally dark grey as it is left exposed behind the screen. The black fabric being installed in this photo was only needed around the perimeter. Our 3D model was helpful to ensure the grey insulation area was going to be hidden from all visible angles. The projection screen floats in space and rests against the wood blocking that can be seen along the top and bottom of the acoustic absorption panels.

This photo shows half of the ceiling with black fabric and half uncovered. Once the fabric between the beams was installed, the GC came back to add the walnut slats. These slats added visual appeal and provided some acoustic diffusion.

Equipment Rack Location Showing the Projector Shelf and On-Wall LED Lighting Drivers

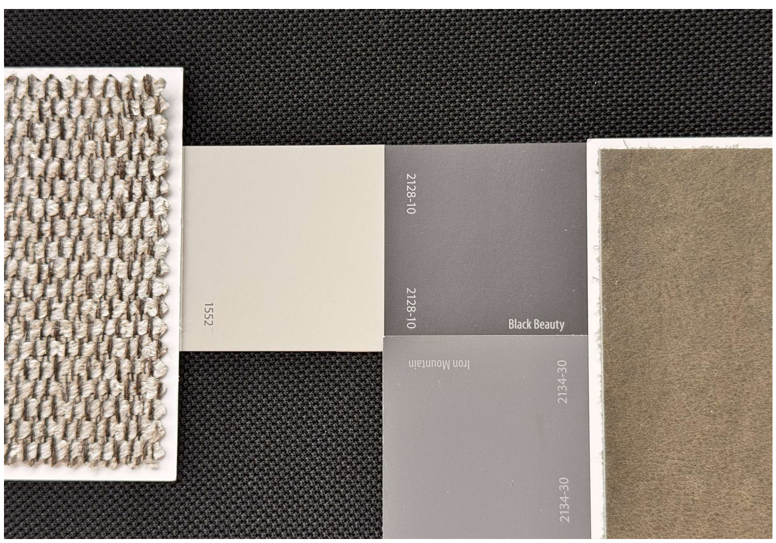
Interior Design Process

The clients had many family room visual examples on their vision board. They were mostly clean-lined modern spaces with wood and light-colored paint. Our team collaborated on the interior design directly with the clients. The goal was to remove visual distractions with the lights off, while keeping the room aesthetically interesting.

They wanted bookcases on the sides of the screen to provide visual interest with the lights on. They were delighted when we told them a hardwood floor with an area rug wouldn't be an acoustics problem if taken into consideration in the overall acoustic design. When shown on-wall panel acoustic options of from Artnovion, they preferred that look to fabric walls. They also wanted wood slats to be part of the design language. We encouraged the wood finish to be matte, and not shiny.

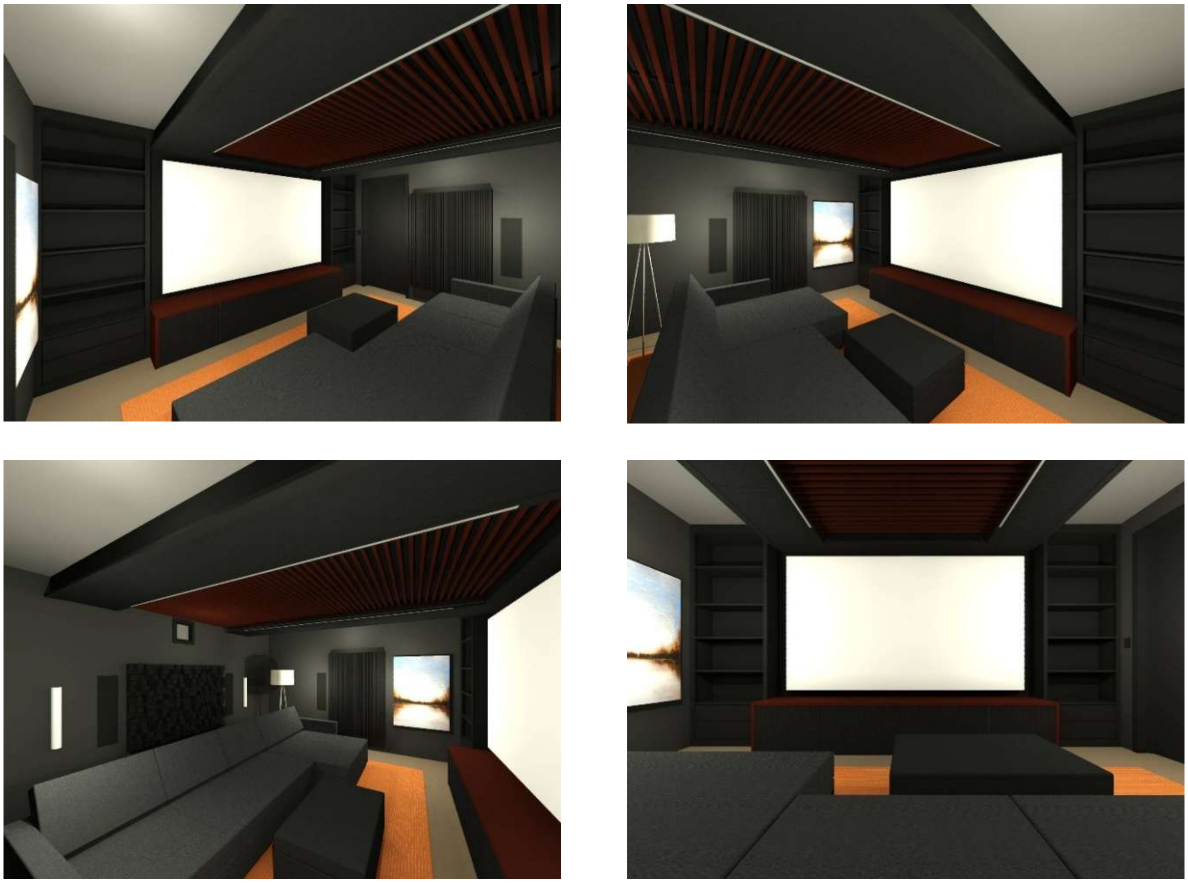
The sectional seat backs are low, based on our input to allow for an unobstructed pathway between their ears and the rear speakers.

Finishes Palette: Upholstery Fabric, Black Acoustic Fabric, Paint Samples, Leather



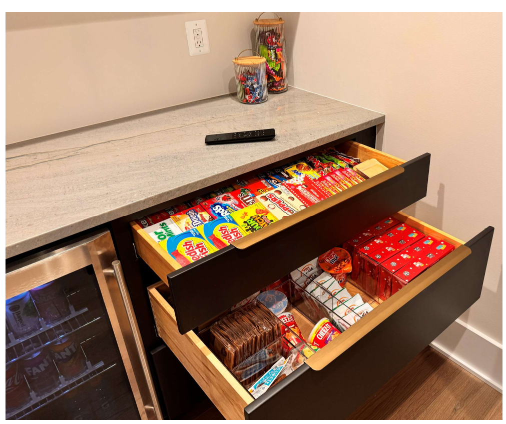
The black void aesthetic wasn't an option for this project, but the light colors from their vision board were not going to work, either. Some compromises to the video and audio performance were made, balancing performance and the desired feel of the room. The mostly dark colors of the room were carefully chosen to enhance the intra-frame (checkerboard) contrast ratio. The exact shades of the walls, ceiling, millwork, woodwork, furniture, and carpet were selected together to provide a warm and inviting space for the family. The light-color carpet and outer ceiling area are mostly out of view from the seating positions and are not substantially lit by the screen.

Room Renders Created to Show Design Intent



We couldn't convince them on a bright orange carpet, and they are still looking for an art canvas for the side wall – but the renders we created were essential in communicating our design ideas and getting the green-light for the project.

In the End, Comfort and Snacks Matter to the User Experience



The room looks and functions like a lounge but was built like a cinema.

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