PC3.5 Review

Secrets of Home Theater and High Fidelity

Written By: Dr. David A. Rich

Phase Technology Premier Collection Bookshelf Speakers

Written by Dr. David A. Rich
Secrets of Home Theater and High Fidelity

Phase Tech Bookshelf Speaker Introduction and Driver Technology

This Phase Technology Premier Collection Bookshelf Speaker is a rather unique speaker. Most bookshelf speakers are two-way designs with a single small woofer. The advantages of a three-way design are well known as illustrated in my measured results to follow. A few bookshelves are three-way with a single small woofer. This speaker has two 6.5" woofers. Its low end can match a floor-standing with similar-sized woofers. Usually this driver deployment is found in speakers designed for in-wall applications where the vertical center channel is behind the screen.

PHASE TECHNOLOGY PREMIER COLLECTION PC-3.5 LCR BOOKSHELF SPEAKER

- Tweeter: 1" soft dome
- Midrange: 1.5" soft dome
- Woofer: 2 x 6.5" flat-piston drivers with butyl rubber surround
- Frequency Response: 36 Hz - 22 kHz
- Sensitivity: 91 dB
- Impedance: 4 Ohms
- Finish: Black gloss, natural cherry
- Dimensions: 7.9" W x 22" H x 12.3" D
- Ship Weight: 32 lbs.
- Price $1000 each
- Phase Technology
- Secrets Tags: Speakers,Two Channel,Bookshelf Speakers

The speaker's footprint is not much larger than a typical two-way bookshelf. The height is not much larger, so it works in any application where a floor-standing speaker is not viable. The weight is higher with the extra drivers in the box. The speaker has curved side panels, which enhance its appearance. The sides curve inwards slightly at the speaker front. The modest 7" width of the front baffle reduces diffraction effects. Phase Tech also claims the curves reduce cabinet resonance.

The Phase Tech Premier Collection line comes in two finishes: cherry and high gloss black. Phase Tech reports the cherry has a natural finish and then they are coated with a satin extremely durable polyurethane coating. The high gloss black has 8 layers of hand sanded and polished clear polyurethane coating on top of black polyurethane. The high quality finish extends to the front panel, allowing the speaker to be displayed without the grille in a typical home environment. The grille is held on by magnets making it easy to remove before a listening session.

The midrange and tweeter assembly rotates for vertical or horizontal (center channel) placement. I tested the assembly in its vertical deployment for both two- and three-channel deployments. You can go to the Phase Technology web site to see the assembly rotated to the center channel position. I am not showing it here to prevent confusion with regards to what deployment of the PC-3.5 was used for this review.

The history of Phase Technology has been discussed in prior Secrets reviews and is available at http://www.phasetech.com/history2.html

Phase Technology is best known for its soft-dome driver, which is the star attraction in the PC-3.5. In 1959, Avery Fisher contracted with the founder Bill Hecht to produce speakers for Fisher. As Ken Hecht, Bill's son, tells the story, the Fisher speakers with conventional hard domes were constantly being damaged at HiFi shows as people poked at them. Avery Fisher wanted a mock up of the tweeter with a soft dome that would not be damaged at the shows. The mock-up, to Bill's surprise, actually produced sound. In 1964, the large Fisher XP-10 floor-standing speaker with a soft dome tweeter was introduced to critical acclaim. Numerous variants followed, but Fisher became more intent on putting lots of drivers in low-cost boxes limiting what Bill Hecht could produce. Hecht, not wanting to be tied to the fortunes of one company, began operating under the United Speaker Systems brand and sold OEM drivers to many companies. With the soft dome under patent protection (3,328,537), the business grew rapidly.

United Speaker Systems sells complete designs to the public under the Phase Technology brand, including the state-of-the-art active speakers called dARTS. The DSP code and the hardware are custom designed by Phase Technology, putting the company in a league with larger manufacturers of professional audio monitors. The speaker, under review here, is one step down from the dARTS system and is passive. An explanation of the name Phase Technology will become evident in the measurement section.

Figure 1   Midrange - Tweeter Module

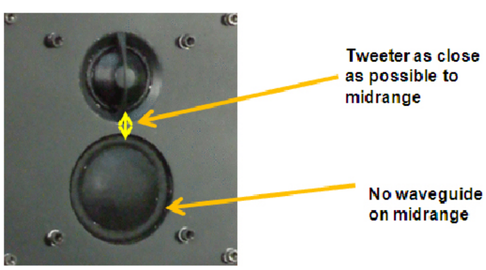


Figure 1 shows the midrange - tweeter module of the PC-3.5. You are looking at soft dome drivers with 48 years internal development. Placing the drivers close together reduces interference effects associated with non-coincident drivers are minimized. In turn, the speaker has good vertical radiation patterns even with the crossover between the midrange and tweeter at a high 4.5kHz. The small distance between the midrange and tweeter is possible as a result of the novel aspects of the Phase Tech driver design. There is no waveguide on the midrange (figure 1). Dome midranges normally have a waveguide to improve efficiency at the cost of wide dispersion.

Note the domes have no protection over them. To prevent damage I recommend the grille be put in place whenever the speaker is not in use.
The woofers are also of proprietary construction. The flat-piston is evident in the accompanying photos of the complete speaker at the top of the review. Figure 2 shows a side view of the solid flat piston driver. The back of the cone is a conventional cone shape, which

Figure 2   Side View of Solid Flat Piston Cone

terminates to a spider and voice coil. The cone is a solid molded material Phase Tech calls Rigid Polymer Foam (RPF). The cone is coated with glass fiber in the front and Kevlar in the conical back. Phase Technology patent (4,566,178) for the RPF driver addresses the unique assembly requirements of the Solid Piston. Most woofers are assembled by centering the voice coil from the front of the speaker before the dust cap (the dome shaped piece in the center of the cone) is glued on. Solid Piston RPF drivers do not have a dust cap or a means of getting to the voice coil from the front so Phase Technology invented a "reverse assembly process" that uses computer aided manufacturing to assemble the woofer from the rear.

Phase Tech says the complete cone is about half the weight of a conventional polypropylene cone. The alignment of the flat front positions the wave launch to start at the front baffle, which is important in the crossover to the midrange as we will see in the measurement section.

The design issue is that the three-3 dimensional structure is more complex to model than a simple cone. Reducing resonance in the cone is thus more difficult. The measurement section below appears to show the resonance of the woofer is comparable with that of a standard driver for a speaker in this price range. For additional details, a YouTube video of Ken Hecht demonstrates the driver's construction. The woofers have butyl rubber surrounds and a cast aluminum alloy baskets.

Speaker systems with high performance to price ratios are often equipped with custom house drivers. Surprisingly, one value-oriented company, well known for driver innovations, introduced a new set of speakers at CES with drivers from an external source. This is clearly not the direction in which Phase Tech will to go.

Phase Technology Bookshelf Speakers In Use

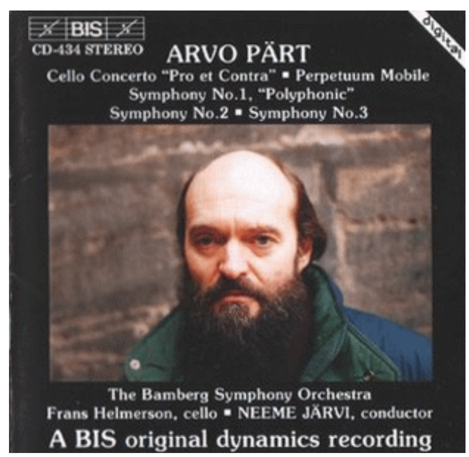
I do not judge a speaker on a few CDs. Instead, I use at least 15 cuts ranging from string quartets to Mahler-sized orchestras. With the cuts on one CD-R, I can complete the initial evaluation in ten minutes. Marketing manager Tony Weber (a classically trained composer who studied under some of the most important American composers of the last century), formerly at Phase Tech, and now at Cary Audio pushes the limit farther with nine reference CD-Rs of eight different cuts each. This approaches what I call the random pull test: go to your collection and pull something out at random. I find 30% of classical CDs are well recorded so you have a 30% chance that your random selection will sound good on a well-designed speaker without intentional voicing. If it's cooked to sound good on specially selected discs chosen by the manufacturer (this is the standard CES trick for the $200,000 class) then the speaker will fail the random pull test.

The first reaction to the speaker is its wave launch. Unlike a three-way floor-standing speaker, all instruments emerge from a single point at the center of the speaker. In a floor stander with the woofer – midrange crossed over at 500Hz – 1kHz, the image shifts with the range of each instrument. Low brass and bass violin emerge from the bottom, oboes and clarinets in the middle, and the upper octaves of the violin or flute near the top. This is unnatural compared to the concert hall experience. Some floor standing speakers have a crossover below the frequency that the room dominates (250Hz and below). Floor standing speaker with a crossover that low will not exhibit the shift in vertical image.

The apparent size of lower-pitched instruments increases in the vertical direction as the PC-3.5s woofers become active, emulating the sonic characteristics of instruments that dwell in the music's bass line -- think of the size of a double bass or the bell of a trombone. The wave launch of the PC-3.5 increases the depth of the image, with the large brass sounding as if they are at the rear of the stage behind the strings.

On the Vladimir Ashkenazy recording of the Rachmaninov Etudes Tableaux Op 39 (reissue with other works Decca 455234), the hallmark clarity of Ashkenazy's finger work is apparent as is the pianist's joy in playing works of his countryman. The sound of the hammers striking the strings is well conveyed in this perhaps a little too close recording.

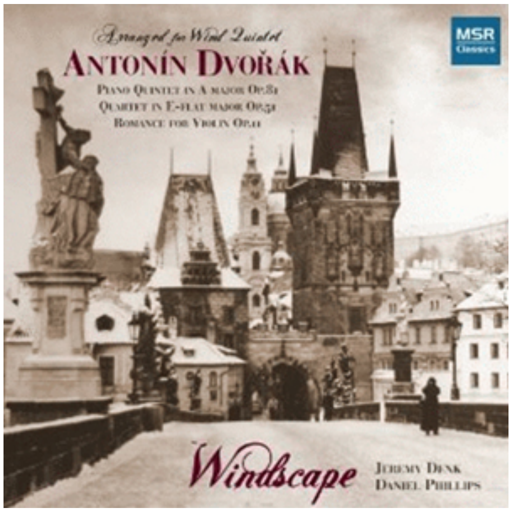
Despite its small form factor, the PC-3.5 provides full-range bass response without the port tuning that creates an artificial bump in the 100Hz range. Britten's Young Person's Guide to the Orchestra, which sequentially highlights each orchestra section, well illustrates the speaker's performance at the bottom end. I used the Pavo Jarvi performance with the Cincinnati Symphony (Telarc SACD 60660). The tympani solo has a strong initial whack, but also a clear tonal center thereafter. Differently pitched tympani match in tonality. One clearly hears the mallets striking the heads as the player moves among the drums. In the double bass section, the bowed strings are distant. If you want even more impressive low-end smoothness, add a good room EQ. This speaker loves being EQed at the bottom. Unlike most ported speakers, it is not significantly affected if the room EQ tries to extend the low end with a 6dB boost at 40Hz.



The unique style of Arvo Pärt's 3rd symphony is transitional, sandwiched between his twelve-tone serialism and his minimalist stage. The work ranges from chamber-like intimacy to the full breadth of the orchestra. On Neeme Järvi's first recording (BIS CD434) of the work, the PC-3.5 showed no signs of non-linearity at least to levels that I was willing to tolerate. The fortissimo trumpet solo near the end was clear without any signs of taxing the speaker's limits.

Bernard Herrmann's score for On Dangerous Ground requires a huge orchestra. Charles Gerhardt conducts the RCA Classic Film Score series recording of the work which was reissued last year on the 100th anniversary of the composers birth (RCA Red Seal 88697 81264). Engineer Kenneth Wilkinson preserves the orchestra's great sound and allows Herrmann's music to stand on its own merits without reference to pictures. The large horn and brass sections challenge the speaker to not only avoid compressing the dynamics, but also avoid obliterating the counterpoint of the string passages. The Phase Tech PC-3.5 handles the task nicely, with the strings remaining smooth and distinct. I listened to the CD on several two-way mini-monitor designs; the strings are either lost or turn strident because the woofer has too much to do.

I compared the Phase Technology speakers with a similarly priced Infinity C336 (now discontinued) speaker that also generates close to benchmark-like measurements (I reviewed it for AudioXpress) but uses a aluminum/ceramic driver material, a cone midrange, and a waveguide on the tweeter.



The Infinity speaker sounded dry, yet with a slight edgy coloration. The flute on the Windscape recording of Dvorak Arranged for Winds (MSR 1175) sounds more brittle, while the PC-3.5 floats the flute in space with more harmonic richness.

Without the waveguide, there is a less localization of the cabinet. A good illustration of this is Vaughan Williams Five Variants on Dives and Lazarus (Chandos 8502). The string sound is richer and the ensemble spreads across the stage. The narrow baffle may also help the speaker to achieve this.

There are similar differences with the Jerusalem Quartet's recording of Haydn's Lark quartet (Harmonia Mundi 2962030). As the first violin ascends the E string, the Phase Technology offers a more airy sound.

Without tweaking its placement, the Infinity C336 shines with the smooth octave to octave balance at and above the midrange. This can be attributed to the differences in the radiation patterns. The Infinity C336 off-axis energy is reduced in comparison to the PC-3.5. A 75 degree offset in the horizontal direction the Infinity C336 is down 7dB at 4 kHz in comparison to 3dB down for the PC-3.5. At 10kHz, the difference in respective output levels between the two speakers grows to 6dB. The result is less energy from wall reflections, making these speakers more room tolerant, but at a cost. The C336 tweeter had a resonance at 15kHz peak with an amplitude increase of 3dB from the 10kHz baseline. The audibility of this artifact is debatable.

PC-3.5 requires more attention to toe-in angles and its distance from the rear and side walls. Too much toe-in results in a sound that is too forward in the upper midrange. The distance between the PC-3.5s and the listener is more forgiving since the smaller length of the combined driver set allows the sound field to converge at a closer distance. Both speakers are friendly with respect to seating height.

The Phase Tech is perfect as a matched center. A floor stander in the center of the room looks a little strange. A typical center channel will sound out of kilter.

The typical placement of a center channel in a home theater will significantly degrade the sound of multichannel audio. A detailed discussion on center channel placement is found at the link below. In this Technical Article, We Don't Need No Stinking TV's, the Phase Technology PC 3.5 was often used for subjective evaluations of a system with optimally placed speakers

RCA and Mercury released numerous SACDs from master in the 1950s recorded in three-channel sound. One example is the famous Reiner Chicago Symphony Orchestra recording of Rimsky-Korsakov Scheherazade (RCA SACD 66377) under which the speakers virtually disappear. The sound of the woodwinds from a real center speaker emulates the concert hall effect. Unlike stereo, the mind need not create a virtual center.

The CSO brass require a speaker than can work well at high SPLs when the score requires it, but the sound never turns course in this three-channel recording played on the PC-3.5s. At the same time, the solo violin passages are smooth and well articulated. With the sound directed between the left and center speakers, the violin's wave launch is well portrayed.

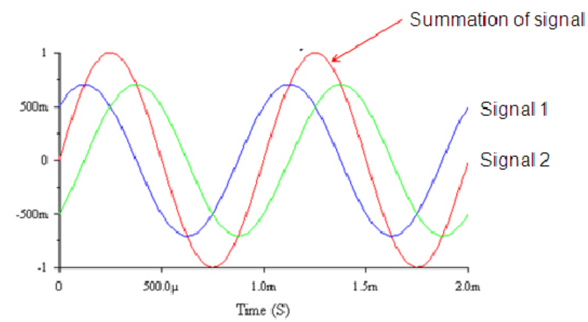
It would have been interesting to run five Phase Tech PC-3.5s in multichannel, but it is rare to invest that much money in the rear channels. Phase Tech supplied the PC-1.5 matching two-way mini monitor for the rear installation of a five channel setup. This is more typical of how the PC series can be deployed. The combo of three PC-3.5s and two PC-1.5s in the rear produce truly exceptional multichannel sound on well-recorded SACDs using the Sherwood R-972 AVR with Trinnov EQ on. Unfortunately, most current multichannel classical discs have only ambience in the center channel since the recording engineers anticipate consumers will deploy a thin, on wall, center channel below the flat screen TV. The 1950s recordings, with a true center channel, are much closer to the real thing than these new SACDs, which are, in effect, stereo recordings with ambience from the rear speakers.

Phase Technology PC-3.5 Speakers on the Bench

I identified crossover frequencies at 950Hz between the woofer and midrange, and 4,500Hz between the midrange and tweeter. The crossover occurs when the acoustic output declines to 0.5 (-6dB). After the transition band, the slopes are approximately 24dB/octave. These measurements imply a fourth-order filter response (electrical plus acoustical). In a properly designed system with even-order slopes, the drives are in-phase at the crossover. Since both drivers are in-phase, the total response is the summation of the magnitude responses. Each driver supplies half the total acoustic output (0.5 + 0.5 = 1.0). The proprietary solid piston flat woofer cones enhance the in-phase property at the crossover to the midrange. Now you can appreciate why the company took the name "Phase Technology."

In-phase drivers at the crossover are critical. Figure 3 shows odd order crossovers are not in phase. Typically these would be first- and third-order Butterworth filters. The drivers are separated by 90 degrees at the crossover. The total response is not only the summation of the magnitude response; the phase difference must also be considered. The summation of the response is, in fact, 45 degrees out of phase with each driver.

Figure 3 Odd Order Crossover



Composite output signal is not in-phase with the driver signals

Note the 0.7 amplitude of each signal from the drivers in figure 3, not one-half as with the even-order network. We need the extra amplitude, given the drivers' phase offset, to approach unity gain with both drivers active.

For most speakers, as with this one, the drivers are not coincident in the vertical plane. The amplitude response changes in the vertical direction as the arrival time of the wave fronts of the two drivers change and a phase offset emerges. With an even-order network, the result can only be a reduction in amplitude since each driver is producing half the acoustic output on axis to the drivers. With an odd-order network, it is possible to have an increased amplitude response with a change in the vertical offset (0.7 + 0.7 = 1.4). An advantage of the odd-order networks is they produce flat power response which is generally considered less important for speakers designed for home use.

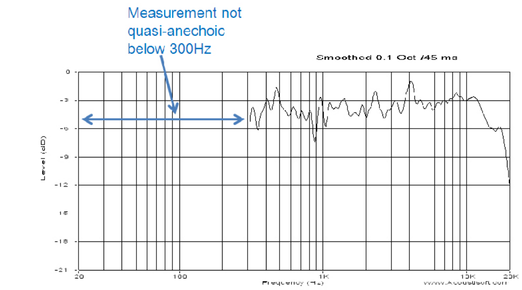
The combination of the fast acoustic rolloff (24db/octave) of the crossover, which minimizes interaction of the drivers outside the crossover region, and the in-phase response at the crossover yields minimal changes in the vertical radiation pattern as the offset angle is increased. More details on how the crossover design affects the vertical radiation patterns can be found in an article I wrote for Sensible Sound (pages 12 – 19 of the Dec 2005 issue). The text is online in The Free Library (www.thefreelibrary.com) but the figures are only in the physical magazine.

Note that the speaker PC-3.5 is not linear phase. For high-order crossover networks, the phase of the far-field response varies with frequency. This effect is rarely audible in double-blind tests reported in AES conference papers above 200Hz. A speaker with poor radiation patterns, however, can be easily discerned by the ear. I was able to bring the speaker into linear phase using the Trinnov room EQ, which does phase and amplitude correction. I heard no audible difference with the PC-3.5s, which yield a near-perfect impulse response with phase equalization enabled (not shown).

Cascading a digital correction filter in front of a passive network is not the optimal way to use DSP. An active speaker with a DSP crossover provides much more flexibility in the optimization of the speakers performance in the time and frequency domain. This is why the next line up in the Phase Tech lineup is an active DSP based system.

Quasi-Anechoic Measurements

Figure 4 NRC Listening Window



Microphone 1 meter back
Summation of on axis response +/- 15 degrees vertical and +/-15 degrees horizontal
Smoothing 0.1 octave
Total span of graph in Y axis is 21dB
45msec gate time to remove first refection in this room

Figure 4 shows the NRC (National Research Center of Canada) listening window (direct summed with +/- 15 degrees of the tweeter axis vertical and horizontal). My measurements with the Acoustisoft R plus D software are at 1 meter. Moving farther than 1 meter raises the frequency to which these quasi-anechoic measurements are accurate since room reflection corrupts the measurements in my test room. At 1 meter, the measurements are good to 300Hz, which approximates when the room characteristics start to dominate over the speaker characteristics at the listener's seat (Toole Sound Reproduction: The Acoustics and Psychoacoustics of Loudspeakers and Rooms, Focal Press 2008).

A discussion of the pioneering work of Dr. Floyd Toole at the NRC (long before his association at Harman) would be appropriate here, but the space is too limited, and it is best to read his book or for the deep dive, the original AES papers. The Cliff Note version: the NRC team developed a method to statistically quantify the sound of a speaker using a trained listening team and double-blind testing procedures. The measured response characteristics of the speakers used in the listening tests were next examined with the goal of identifying design criteria to yield superior sound quality in the controlled listening tests. Upon achieving the goal, the design criteria were published.

The sequence of events is not arbitrary. Intentionally, the NRC knew the proper order was to first have listeners qualify the attributes of a good sounding speaker, and then attempt to characterize why they sounded good. The date of appearance of the classic AES papers makes this clear:

Toole, F. E. "Subjective Measurement of Loudspeaker Sound Quality and Listener Preference" Journal of the AES Vol. 33, Feb 1985

Toole F. E. "Loudspeaker Measurements and Their Relationship to Listener Preference" Journal of the AES Vol. 34, Part 1, April 1986 April and Part 2, May 1986

Looking at the PC-3.5 it is unclear if Phase Technology engineers have been influenced by the NRC papers in their development work, or established their guidelines for quality-sounding speakers independently. A Phase Technology 3 way floor standing speaker introduced back in 1989 answers the question. The design and independent measurements from Stereo Review show a fully realized modern speaker. 1989 is too early for a production product to have been designed from the NRC AES papers.

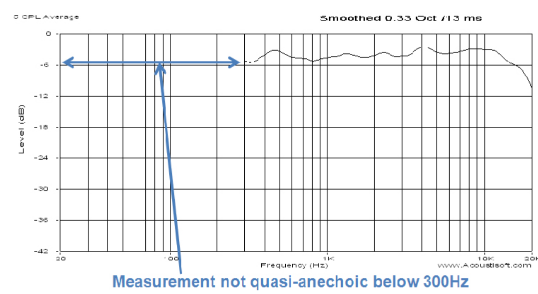
Ken Hecht writes: "This was done on our own. We were using FFT analysis back then to analyze diffractive effects and radiation patterns".

I perform many of the tests advocated by NRC as important in identifying a good sounding speaker within a controlled environment. One significant omission from my test set is power response. I cannot measure a speaker's power response, which is also used to calculate directivity indexes with frequency.

Since I am limited to 300Hz, I set the gate time to 45msec for figure 4. The curve is high resolution at 0.1 octave smoothing to highlight significant (and audible) high Q resonances. (See Dr. Toole's text as a reference for this statement). Unfortunately, since this is my first speaker review for Secrets, I have no comparable to present on this website; nonetheless, this result is excellent as the total span of the curve covers no more than 21dB in the Y axis. The response aberrations at 900Hz are associated with the crossover and not a resonance. The midrange also is admirable, with only a small peak at 2.5kHz and perhaps something around 4kHz, although this deviation is close to the crossover and its exact origin is hard to pinpoint. Above 5kHz, in the range of tweeter the curve is as smooth as glass. These results are not magic, but the result of nearly 50 years of soft dome development at Phase Technology.

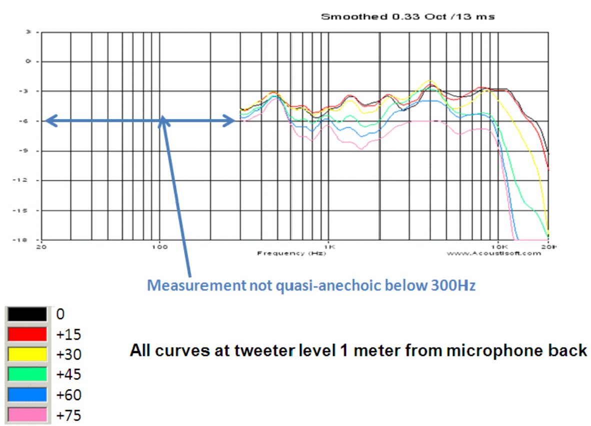
Figure 5 shows the NRC listening window as typically presented in some magazines and manufacturer literature One-third octave smoothing does not show the resonances clearly. This curve also has a span in the Y axis of 42dB, which is more typical of the range in which these curves are presented in some magazines and manufacturer literature. You can see with the loss of information content as smoothing and Y axis span are altered.

Figure 5 NRC Listening Window as Typically Presented



Smoothing 0.33 octave
Total span of graph in Y axis is 42dB

Figure 6 Horizontal Radiation Pattern



All curves at tweeter level 1 meter from microphone back

Figure 6 shows the horizontal radiation pattern. This is again a 1 meter near field measurement. Each curve represents a step of 15 degrees from the center of the speaker. These are at one-third octave smoothing to make the overlaid curve easier to read. I did look at these curves at higher resolution smoothing, but found nothing additional to report on driver performance. The curve shows measurements to a very wide 75 degrees. Examining wide angles is critical to account for early wall reflections in the room. Work at the NRC informs us a good sounding speaker (trained listeners in a double-blind test) needs to have monotonic off-axis response with an increasing downward slope as the angle increases. In practice, some non-monotonic behavior occurs around the crossovers as one moves from a narrowing dispersion pattern of the larger driver to the wider dispersion pattern of the smaller driver.

We can see only a small non-monotonic trajectory at 800Hz-1000Hz and a slightly more significant deviation at 1.7kHz– 3kHz at the widest angles (green, blue and pink curves). Again, since this is my first speaker review at Secrets, there are no comparable curves on this website; but this is a truly excellent result.

The NRC research tells us reflections from the ceiling and floor also contribute to the sound at the listening seat. These reflections are dominated by the vertical radiation patterns that can look worse than the horizontals. The crossover dominates and this dynamic exemplifies the company's name. All the drivers are in-phase at the crossover. Repeating from above, the response deviation around the crossover will be minimized and any response deviation should be negative.

Figure 7 shows the vertical radiation pattern. Each curve steps from -10 degrees below the tweeter at 1 meter to 15 degrees above the speaker. Moving back to 9 feet, the listener would be 2.5 feet above the tweeter axis to be the equivalent of 15 degrees above the tweeter at 1 meter. That is an average person standing with the speaker on a 24 inch stand (tweeter at 36 inches). -10 degrees is 1.5 feet down or 1.5 feet above the floor. That is the on-axis response of a child sitting on the floor, but floor bounce is the primary concern at this angle.

Figure 7 Vertical Radiation Pattern

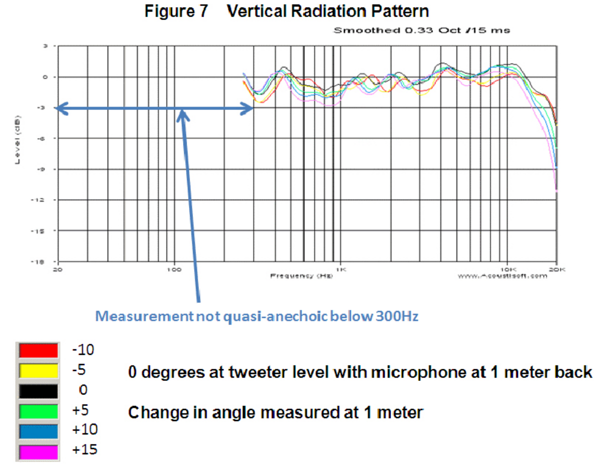


Figure 7 shows us virtually nothing at these angles. At negative angles the sight reduction in amplitude in the curves below 500Hz is a measurement artifact. For negative angles the measurement microphone moves closer to the floor and picks up a floor reflection. Ideally the speaker should be rotated instead of moving the microphone but this is not workable for me.

Dual 6.5 inch woofers are equivalent to 13 inches in the vertical direction, so they are somewhat directional above 500Hz and the curve returns to baseline as the 1.5 inch midrange takes over. The crossover leaves few visible artifacts in the curve. No peaking is seen in the curves as expected from the in-phase crossover. The same story holds at 4.5kHz. Extraordinary!

In-Room Measurements

I have had many bad experiences with defective speakers or poorly designed speakers that caused me to waste time listening before identifying the defects in the measurements. The key measurement for finding a speaker's weakness is the in-room response. Measuring this first also permits one to identify the optimal placement in the room and, in the case of a bookshelf, the optimal stand height. I make no apologies now for measuring first since many PC-based room EQs enable the listener to make measurements to improve speaker placement.

Figure 8 Averaged Measurement of In Room Response

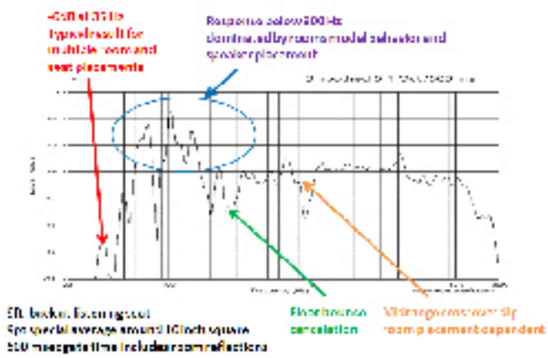
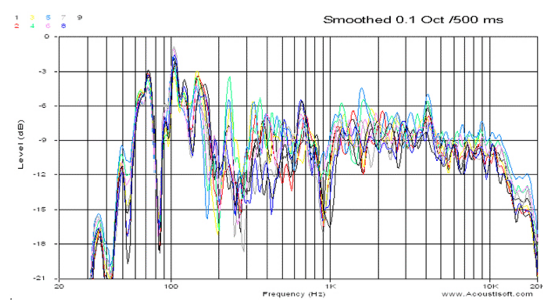


Figure 8 shows an averaged measurement at 9ft back at the listening seat. This is a full range curve with a 500msec gate time. The measurement incorporates all the early reflections in the room. The span of the Y axis is again 21dB. This is a spatial average of nine points around 1.5 foot square. Again, it is a 0.1 octave smoothed curve.

Figure 9 Nine Single Shoot Curves Used to Produce the Averaged Curve



Individual response curves averaged in figure 8

9 points are around 10 inch square and center

Figure 9 shows the nine single shoot curves used to produce figure 8 One sees the single-shot curves are too corrupted by local effects to be usable at 0.1 or finer resolution.

Note how close the in-room curve (figure 8) is to the 1 meter listening window (figure 4). The most prominent deviation is the notch at the 950Hz crossover point. It is not clear why it is more prominent in this curve than the listening window (figure 4). I studied the audibility of this type of notch and found it relatively inaudible, in double blind tests, if the width is narrow.

Cochenour B., and Rich, D. A., "A Virtual Loudspeaker Model to Enable Real-Time Listening Tests to Examine the Audibility of High-Order Crossover Networks" AES 115th Convention, Oct 2003, Preprint 5908

Compared to the listening window (figure 4) the 2kHz peak is not apparent in figure 8, although the 4kHz is retained. Other than this effect, the figure depicts a resonance free result for both the midrange and tweeter. Please note this speaker is not voiced. The response is absolutely flat: the high-end roll off matches the near field, an immediate consequence of the wide dispersion of the drivers' range. The bump in the bottom end in figure 3 is the room gain, not a bump in the speaker's anechoic response. Different rooms, speaker placements, and seat placements will produce different response below 300Hz. The objective is a speaker with a flat anechoic low-end response so speaker placement can achieve a good low-end in-room response. Unfortunately, speakers with an intentional mid-base bumps move more quickly off the showroom floor.

Without the typical dip in the 1kHz – 3kHz range and a more extended top end roll off, the speaker sounds differently than a speaker with intentional voicing. The difference between the best possible passive cone-based speakers selling for under $10,000 and a speaker in six figures is skillful intentional voicing that fools people into thinking the speaker is worth the price of the average house. It appears the higher the price, the more complex the voicing with more peaks and dips intentionally introduced. When compared with the PC-3.5 at matched levels, the voicing is obvious.

Some room EQs allow the listener to put these voicings back in the speaker when desired. It does not work the other way. If the speaker's in-room response has been manipulated, it cannot be brought back to flat because a properly functioning EQ system measures only the in-room response (figure 8). If the direct anechoic response (figure 4) does not match the in-room response, the anechoic response gets messed up as the EQ adjusts the in room response. A room EQ also has no knowledge of the quality of the radiation patterns (figures 6 and 7) and can do nothing to correct sub-optimal ones.

Those who make $200,000 speakers might suggest otherwise, but a speaker's sound is the result of listening window response, radiation patterns, directivity indices, driver resonance, distortion, and in room response. I do not have the equipment to measure distortion to which others have access. A common source of distortion around the tweeter crossover arises as a result of the tweeter getting too much energy below the crossover. First-order crossovers are bad news here.

The speaker does have a low end limitation. After all, it is two 6.5 inch woofers in a bookshelf enclosure. I measured the speaker in a number of locations to examine the low frequency limit. It looks to be -6dB down at 35Hz in-room consistent with the near-field response of the woofer and port (not shown). Floor standing three-way speakers in this price range (not to be confused and, in my opinion, never to be purchased 2.5 way systems) will go slightly lower and produce less distortion in the bass at higher SPLs. This is the advantage of more cone and box area. Higher SPLs can be achieved with the PC-3.5 by adding a subwoofer. The ideal crossover is about 70Hz. Forget subwoofers if a good room EQ is not present in the chain (at this point that is the Anthem ARC outside of 5 figures); otherwise, there sound quality between 50Hz and 90Hz will be compromised.

Phase Technology Bookshelf Speaker Conclusion

The PC-3.5 is designed well, so it sounds great. The key attraction is the speaker's size. It can be placed anywhere a mini monitor can. It goes much lower in the bottom end and has better radiation patterns than is achievable with a 6.5 inch woofer and 1 inch tweeter with the addition of the midrange. Also, a key advantage of the midrange is that resonance effects at the woofer's top end are reduced with the lower 950Hz crossover. Distortion at the tweeter's bottom end is also reduced with the higher 4.5kHz crossover.

Some audiophiles believe a two-way mini-monitor enables a more converged sound space owing to the small baffle. At 7 inches, most mini monitors are actually wider than the PC-3.5. The speaker is only 7 – 10 inches taller than the typical mini monitor.

The PC-3.5 costs more than a typical mini monitor. So if your cash is limited, what to do? Use well-designed high-value equipment from major manufacturers. An Onkyo C7030 CD player (I used a Sony, which is less well crafted, but is what I had access to) sitting on the Yamaha R-S700 receiver (I tested the speaker with an older Yamaha unit that had the equivalent power amp) will work just fine. I heard no degradation in sound quality from the electronics. Total price of the electronics is $750. The $2750 total system cost with the Phase Technology 3.5s is the equivalent of what most audiophiles spend picking a mini monitor and more expensive electronics.

Even with more space for a larger speaker and the cash for more expensive electronics, I would recommend putting this speaker on your list. It is competitive to floor-standing speakers at twice the price for the SPL levels at which I tested; indeed, it may be preferable to some floor standers. Retention of the stable vertical image over frequency and the wide horizontal dispersion of the PC-3.5 with deeper bass and lower bass distortion at high SPLs normally require a four-way system. In the $4500 price range, two PC-3.5s, two well placed mono subwoofers, and a good digital room equalizer/bass management system form a 4 way system which would be competitive with some speaker systems costing over $10,000.