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Fachmagazin für Veranstaltungstechnik

Article
from issue 12/2015

Linear 5 LTS A and Sub 4000 A

HK Audio's Long-Throw Compact PA

This fully active PA system with a horn-loaded top unit and band-pass subwoofer is said to perform as powerfully as a point source, yet be scalable. Put to test, the top unit and subwoofer demonstrated their capacity for powerful performance.

Text and measurements: Anselm Goertz | Photos: Anselm Goertz, HK Audio

» ... It can be confirmed without hesitation that HK Audio has landed a big hit with the Linear Series LTS A and Linear SUB 4000 A ...«

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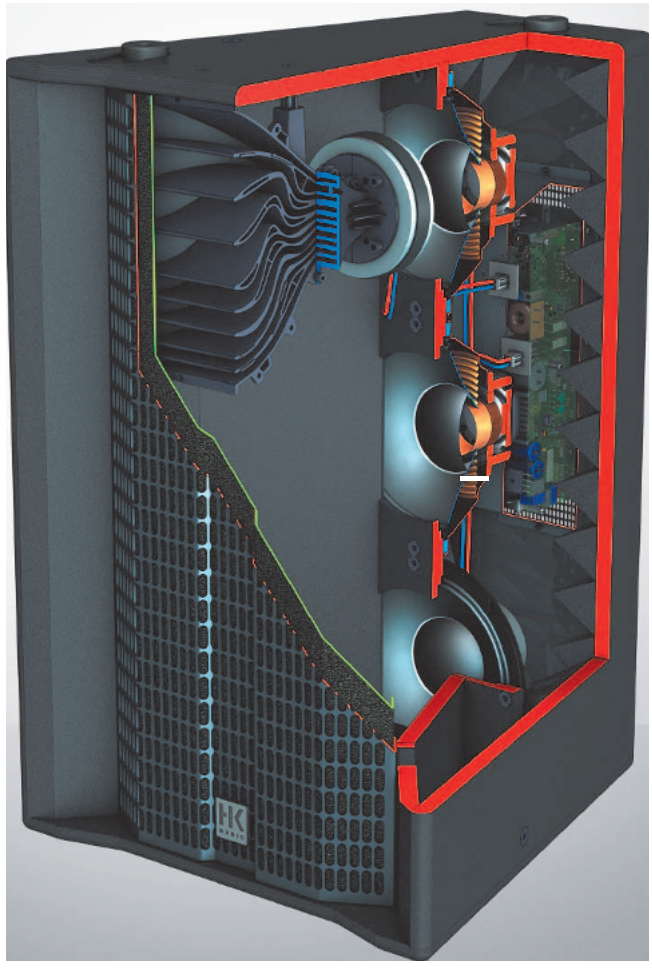
Line arrays now dominate the PA market in all size categories. This is mainly attributable to their great flexibility and the good directivity that is to be achieved when they are handled properly.However, 'classic' horn-loaded PA systems still hold their ground alongside these “speakers hung on their sides”, and they undeniably have their advantages: Very direct and dynamic response and generally easy handling that doesn't require rigging hardware are just some of the arguments in favor of the horn-based PA. HK Audio from St. Wendel has plenty of experience with sound systems, from small club systems to the large stadium PA, based on both concepts.

The design of the new LTS system, sort of a hybrid of a line array and a horn-loaded top unit, is said to have been inspired by the needs of users: Three 8" woofers form a vertical array and are equipped with a sizable horn whose duct spans the cab's entire front face. The tweeter is centered at the top end of the horn aperture. A 1" compression driver first pipes the signal through a short waveformer to create a uniform wave front, which in turn flows into a Multicell Transformer. It behaves like a small curved tweeter array to produce +5 to -25° asymmetrical vertical directivity. This rather unusual combination is supposed to combine the advantages of both worlds: line arrays and horn-based PAs. Is that

Configuration *determined on the back of the LTS A according to the top unit's position.*

LTS A top unit *with three 8" drivers in vertical array with a horn and Multicell Transformer-loaded tweeter. Four bass reflex ports for the 8" drivers are on the horn's surfaces (the top two are obscured by the tweeter).*



A look inside *an LTS A*

even possible and what kind of performance can this system deliver? That is to be clarified in this test report.

Let us first take a quick look at the HK Audio Linear 5 series: It is comprised of two direct radiating top units, the 112 and 115 models, with diverse options for the tweeter. Both are available in active and passive versions.

Matching subwoofers come in 2 × 10" and 2 × 12" formats, which can also be active or passive. The two speakers presented here, the LTS A (top unit) and Linear SUB 4000 A (subwoofer), were added to the series in 2015, the active versions of which were available at the time of testing. Passive versions are to follow. The Linear SUB 4000 A can be combined directly with all tops, or serve as a sub-low-extension to add a fourth channel to combinations of a top unit and smaller subwoofer.

The LTS A top unit

At first glance, the LTS A appears to be a regular top unit, as if it were loaded with 2 × 12" or 2 × 15" speakers. Its dimensions are 44 × 68 × 46 cm; it weighs 24.7 kg. The cab is easy to handle thanks to the two rather large grips on the sides. The front is covered by a solid grille backed with foam. The grille, appropriately shaped to make it exceptionally stable,

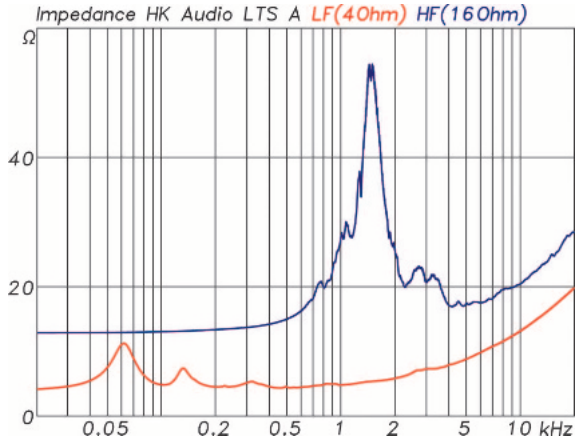
offers real protection against damage in transit. The grille is likely to withstand the famous (and strictly standardized) ball-toss test unharmed. Additional features include a 0° tilt pole mount, five M8 rigging points, as well as multiple feet and milled indentations for safe setup.

A protective cover, tilt bracket and head stack bracket are available as accessories. The term 'head stack' denotes a vertical placement option for the LTS where the top cab is set upside down on the bottom cab to move the two tweeters closer together. With the benefit of their asymmetrical directivity, the two tweeters combine to create a single source. The housings' top and bottom panels are equipped with feet and matching indentations, so the cabinets can be stacked safely. The two housings can also be locked down in this position with side-mounted, sliding sheet metal latches. In addition to the vertical stack, the LTS may also be combined in pairs to set up a horizontal cluster. Given the right splay, this results in a horizontal beam angle of 140°, which is also good for covering wide areas. The Linear SUB 4000 A subwoofer's top panel is also equipped with milled indentations that accept the top units' feet so the enclosures can be safely clustered. The largest configuration of top units would then consist of four clustered cabs with two head stacks.

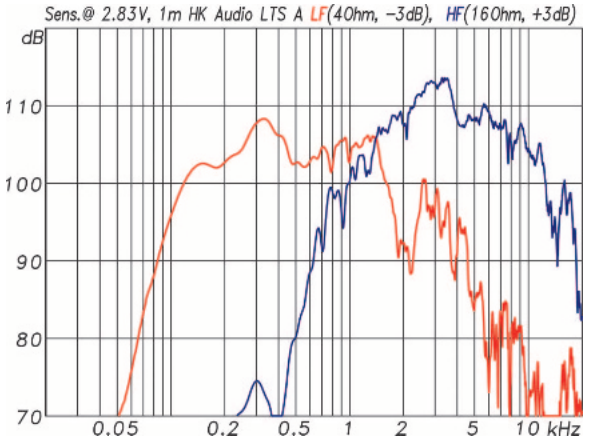
The CAD cutaway image shows what an LTS A looks like on the inside: The three 8" drivers are situated at the rear of the housing and radiate directly into the large horn with practically no compression. This sectional view also shows the interesting interior of the Multicell Transformer developed by HK Audio; its channels are curved in the middle to generate a uniform wave front at the exit. The active electronics with a DSP system and two class-D amplifiers are located at the back of the housing under a metal cover.

Baseline values

Some speaker developments could be described with the words, "it's all down to the DSP." A glance at the big picture does not necessarily reveal if a speaker's qualities are based



Impedance *of the 16-ohm tweeter (blue) and the 4-ohm bass woofer (red), (Fig. 1)*



Frequency response without filters *of the two channels in the top unit measured directly. In both cases, sensitivity is indicated in reference to 2.83 V/1 m. Subtract 3 dB from the woofer's value and add 3 dB to the tweeter's to arrive at the 1 W/1 m value. (Fig. 2)*

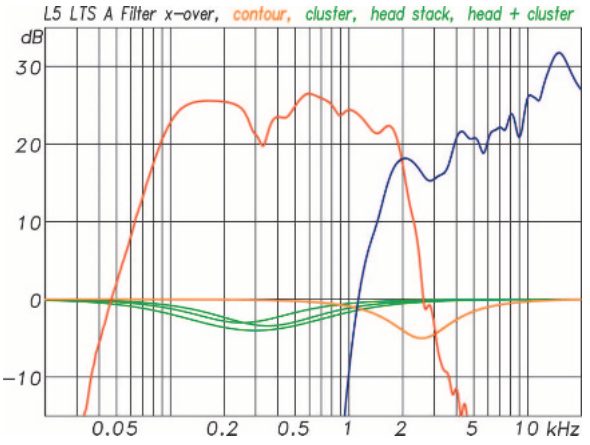
on good drivers and a fundamentally good design, or on the vigorous intervention of filters. This is why we measure the individual channels without the connected electronics for our test reports whenever we can, even for fully active loudspeakers, to see more clearly what the speakers themselves can do. This includes measuring electrical impedance and frequency response with a concrete indication of the axial sensitivity at 1 W/1 m or 2.83 V/1 m.

The LTS A's impedance curves show the responses of one 4-ohm bass channel and one 16-ohm tweeter. As the two local peaks of the curve at low frequencies would indicate, the subwoofer's housing is designed as a bass reflex enclosure tuned to around 100 Hz. The four accompanying bass reflex ports sit at the top and bottom of the horn's surface. The horn driver-based woofers' small housings don't actually allow for any bass response, so the bass reflex resonators provide some low-end boost. The principle behind this type of mid-bass horn has long been known, and is reminiscent of the very successful JBL classic, the 4560. This goes to show that an attempt to apply new technology to classic designs can be quite promising.

The frequency responses of the two channels in Fig. 2 indicate at first glance that these speakers' sensitivity is high. The reading for the woofer is 102 to 108 dB at 2.83 V, and the tweeters range broadly in the vicinity of the 110-dB line. The woofers are a 4-ohm system and the tweeter is a 16-ohm system, so 3 dB have to be subtracted (woofer) or added (tweeter) to obtain the 1 W/1 m figures. The bass channel ranges to approximately 1.5 kHz, at which point the curve begins to dip sharply. The tweeter is able to keep up rather well, so it's easy to separate or combine the two channels. The transition takes place at 1.7 kHz when the crossover and speaker are measured together, whereby a FIR filter with a steep slope is used in the LTS A to achieve a linear-phase separation between the two channels. FIR filters have a long tradition at HK Audio, where they were used as many as 20 years ago in the legendary R-Series.

User filters and cluster setups

Fig. 3 shows the associated filtering functions. The FIR filters are evident here in the curves' steep slopes and the fine structure. Latency is a somewhat critical issue with FIR filters, but that problem is quickly negated here, as the overall latency of the DSP system in the LTS A is just 2.4 ms. Filters for the various array or cluster setups (green curves) and a so-called Contour filter (orange curve) are user-adjustable. The



Three filter curves for various cluster variants *(green) and the Contour filter (orange); internal filter frequency responses in the top unit for the LF channel (red) and the HF channel (blue), (Fig. 3)*

Contour filter attenuates the 2-to-3 kHz range by around 4 dB. This usually sounds a tad more pleasant and less aggressive at high volumes.

Fig. 4 illustrates the combined action of the speakers and filters. The curve speaks for itself. The filter curves also go to show that this linear response is accomplished without serious intervention on the part of the filters. The cab opts out at the bottom end at around 120 Hz, which is a quite sensible approach. This is entirely sufficient for many applications and, in any event, an added subwoofer would always be required to render powerful music. Of course, the LTS could have been given another half an octave or more low end via the filters, but this would have been detrimental to the speaker's ability to handle high levels in solo mode, and would probably have created more problems than benefits.

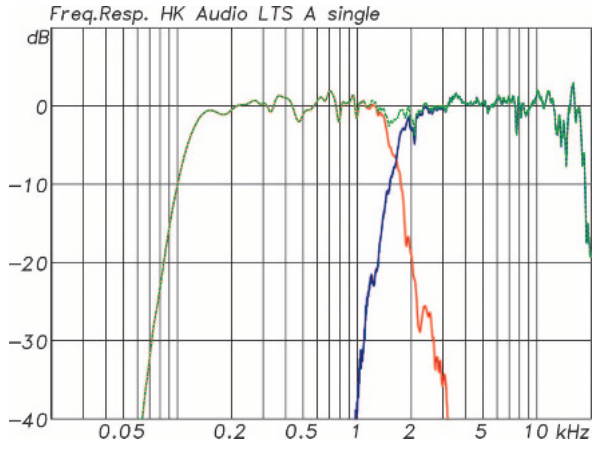
Some narrow resonances ranging up to 2 kHz can be seen in the spectrogram in Figure 5; they are attributable to housing modes and the woofers' horn, and can never be ruled out entirely. The tweeter, in tandem with its Multicell Transformer, demonstrates its qualities in the range above 2 kHz.

Linear SUB 4000 A *with the grille removed: The band-pass system works with an 18" driver in two generously sized resonator chambers.*

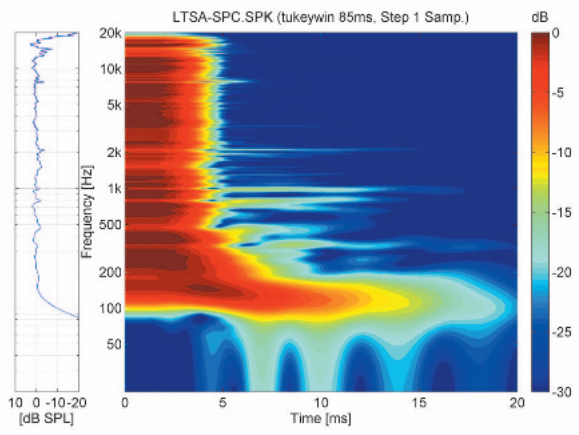
Application-oriented directivity

The HK Audio datasheet specifies that the LTS system's directivity comes to 60 × 30 degrees, whereby the vertical plane exhibits an asymmetrical + 5° by -25° pattern. The main axis is not centered within this area; it is inclined just slightly, at -3°. The rationale behind this is clear enough: The cab sits at a height just above head level and its slightly inclined main axis radiates towards the distant back rows. The longer throw range requires a higher volume level, so this is a good fit. There is a larger coverage pattern below this main axis, where the level gradually drops off to address listeners situated closer to the speakers. The Multicell Transformer channels' special shaping and layout create this asymmetrical pattern.

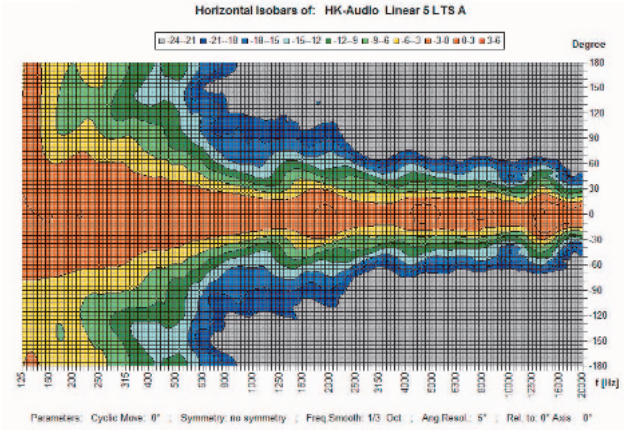
The mid-low unit is a good match for this narrow vertical directivity. Sharply focused directionality is already achieved simply because of its dimensions, and it remains intact and clearly perceptible in the lower frequencies. This type of pattern is an advantage especially in reverberant rooms because the room's resonance modes are excited to a lesser degree. The cab projects symmetrically at a 60° angle along the horizontal plane. This is achieved for the line of 8" drivers by means of the horn function. The 60° are maintained, smoothly and uniformly, from 1 kHz upwards. The isobars open up slowly below that point, so the benefits of the directional pattern are still to be had here. A look at the LTS with its front grille removed reveals a top-mounted tweeter, suspended in front of the top 8" driver. This position serves to incline the mid-low array's directivity pattern. In summary,



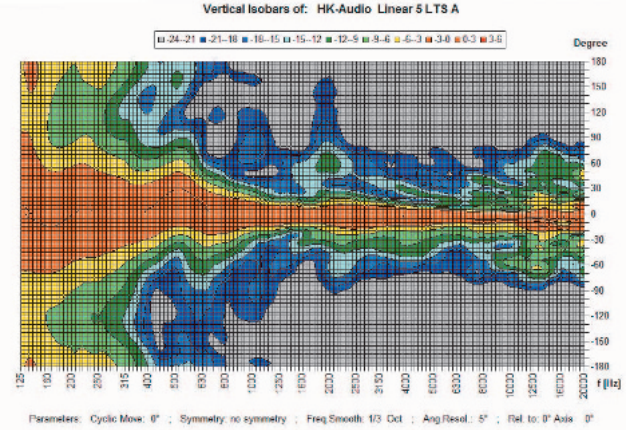
Strictly a top unit, *but also deployable in solo mode; however a subwoofer is required for powerful music. LF channel (red), HF channel (blue) and the composite function (green), (Fig. 4)*



Spectrogram of the LTS A: *Several narrow resonances can be seen up to 2 kHz, which can never be ruled out altogether in such complex setups, (Fig. 5)*



Horizontal isobars *of the nominal 60° systems, which are sustained well from around 1 kHz upwards, (Fig. 6)*



Vertical isobars *with asymmetrical directivity of + 5° upwards to -25° downwards, (Fig. 8)*

it can be said that the HK Audio LTS' directivity specifications are not just figures in a datasheet; they can be reproduced in the real world across a very wide frequency range.

Subwoofer Linear SUB 4000 A

The LTS is designed to be a 'real' top unit with no ambitions in the way of fullrange capabilities. Of course, this immediately gives rises to questions about a matching subwoofer.

Combinations resulting in 3- or 4-channel systems are possible with all active Linear series subs. The Linear SUB 4000 A lends itself to classic PA setups. As an 18" system with a large housing, it can handle plenty of volume and its response ranges very low. The bottom cutoff frequency is specified as 39 Hz (-3 dB), which our measurements confirmed.

The Linear SUB 4000 A is constructed as a band-pass enclosure with two chambers, both of which radiate outwards. The

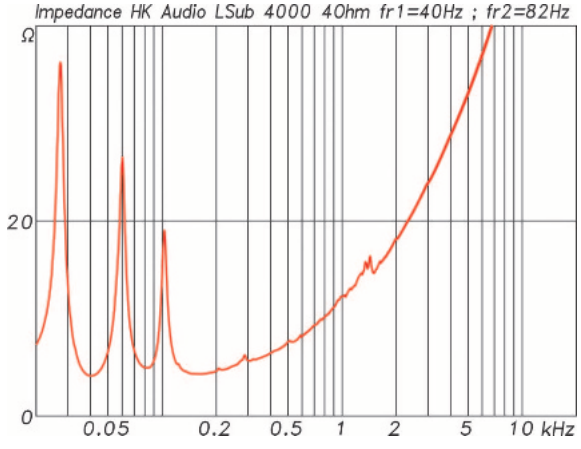
The LTS A's wave former *with a Celestion 1" driver*

In/Out *and subwoofer configuration*

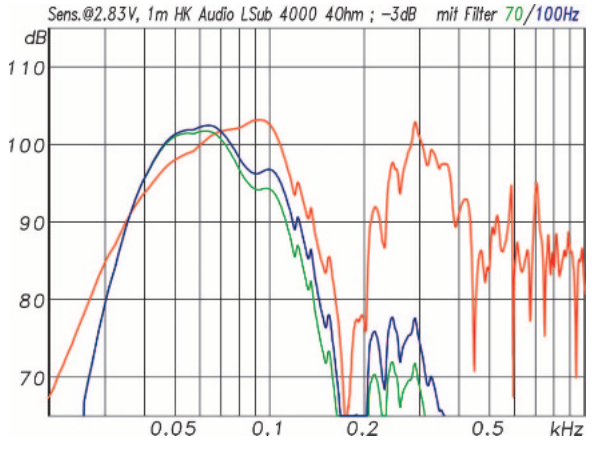
front of the driver radiates into chamber that is tuned higher, to a resonant frequency of 82 Hz, and the back radiates into a chamber tuned to 40 Hz. The enclosure's volume and openings are generously sized, which is still the best way of achieving good bass response.

The electronic module is equipped with a class-D amplifier providing 1.2 kW, all of which can be tapped with the 4-ohm driver. The loudspeaker measured on its own without the electronics results in the response illustrated by the red curve in Fig. 10. The two resonators help the Linear SUB 4000 A to achieve a remarkable level of sensitivity, 100 dB on average between 40 and 100 Hz. However, this figure is referenced to 2.83 V/1 m for a 4-ohm system; 3 dB must be subtracted to obtain the figure at 1 W/1 m.

The first modes generated by the band-pass chambers don't pop up until points beyond 200 Hz, so they're far enough



The band-pass subwoofer's impedance curve *with a profile typical of two resonators, here at 40 Hz and 82 Hz, (Fig. 9)*



Subwoofer *frequency response and sensitivity in isolation (red) and with filtering for the crossover to the top unit at 100 Hz (blue) and 70 Hz (green), (Fig. 10)*

away from the speaker's working range. The blue and green curves were measured for crossover frequencies of 70 Hz and 100 Hz with the built-in electronics activated.

The 70-Hz option is to be used when the Linear SUB 4000 A serves as a low-frequency extension in combination with a Sub 1200 or Sub 2000. The cutoff is 100 Hz when it is used with the LTS top unit. The Linear SUB 4000 A routes an appropriately filtered high-pass signal straight to its Mid/High Line Out port.

The interaction between the top unit and subwoofer

The critical frequency range for top unit/subwoofer combinations is usually the crossover between the two systems. The two channels' relative phase positions can change from setup to setup, so the result also depends on the configuration.

If the top unit is placed on the subwoofers, either directly or on a speaker pole, then there's not much delay between the two channels for listeners to perceive, and the situation is advantageous. Fig. 11 shows the frequency responses of the Linear SUB 4000 A with the LTS top unit measured in this way. The two channels complement each other well. The minor 2 dB dip in the curve between 80 and 200 Hz is not attributable to phase-shifting; it is caused by a slight drop in level that occurs on both sides.

The red curve in Fig. 12 shows the phase response of the entire combination (the curve for just the top unit is blue). The linear phase progression in the middle and upper frequency range, including the crossover from the midrange woofer to the tweeter in the top unit, merits special mention. It is accomplished by means of FIR filters that are able to correct the phase, which is to say that they enable linear phase filtering. This is no longer possible at lower frequencies because a linear phase response would result in too much latency.

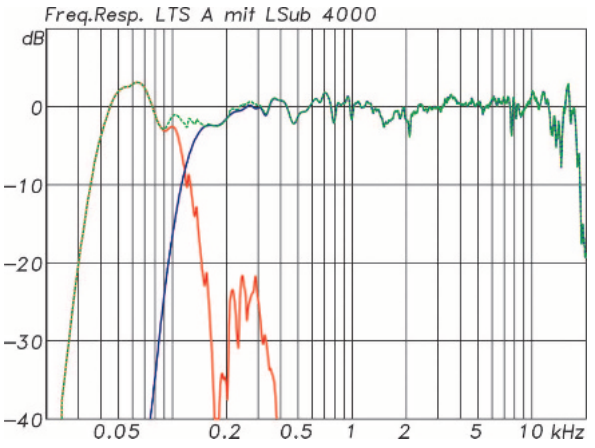
How high can it go? Peak levels and distortion

To find out how high the system's peak levels can go, let's first look at the measurement with sine bursts for distortion thresholds of 3% and 10%: The measurement algorithm increases the level until a distortion level of 3% or 10% is reached, or until a limiter is detected in the signal. Protective limiting is evident when the input level is steadily increased without the output level or distortion rising; the two 3% and 10% distortion curves then coincide (10% distortion is actually unattainable here). This is the case for nearly all of the working range of the LTS top unit's 8" drivers: They are protected internally to prevent them from reaching this load range. In the main, the curve also reflects the axial sensitivity. The 3% curve and the 10% curve clearly diverge at 1.5 kHz, which is the point at which the high-frequency driver kicks in. This response is typical for the k2-dominated distortion of compression drivers. A look at the bottom end of the frequency range reveals that the subwoofer makes a good match here. And with that, a 1:1 combination looks to be a very good idea. Deviations in one or the other direction are of course possible, depending on the type of application. If we consider the mean of the curves, then the SPL readings obtained with this type of measurement range between 125 and 130 dB.

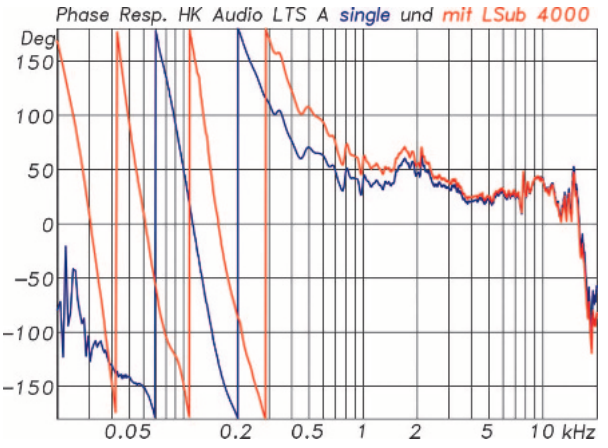
What is just as important as these figures is the insight that there are no weak points in the response and that the system is well tuned.

»The enclosure's volume and openings are generously sized, which is still the best way of achieving good bass response.«

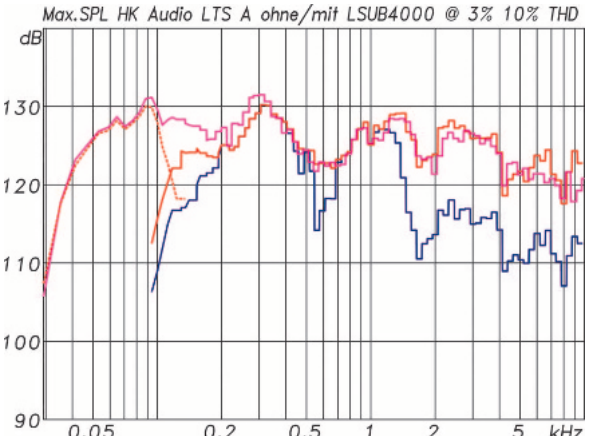
A comment on the design of the band-pass subwoofer HK Audio Linear SUB 4000 A



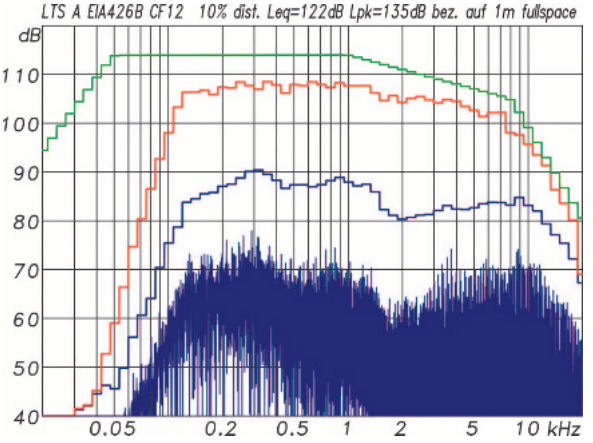
Combination *of the subwoofer (red) and top unit (blue) and the composite (green). The two systems complement each other very well indeed. In a 1:1 combination, the subwoofer is operated in the -6 dB setting. (Fig. 11)*



The LTS A top unit's phase response *with a subwoofer (red) and solo (blue), (Fig. 12)*



The LTS A's maximum level *measured with 185 ms sine bursts. Solo (blue) for 3% max. distortion, red for 10% max. distortion. Red dashes for the Linear SUB 4000 A for 10% max. distortion, pink for the 1: 1 top unit + subwoofer combo for 10% max. distortion, (Fig. 13)*



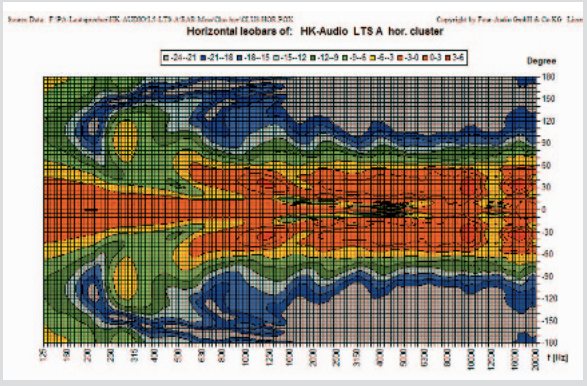
The LTS A's intermodulation distortion: *At 10% distortion, 122 dB continuous SPL and 135 dB peak, relative to 1 m distance, are achieved under full-space conditions, (Fig. 14)*

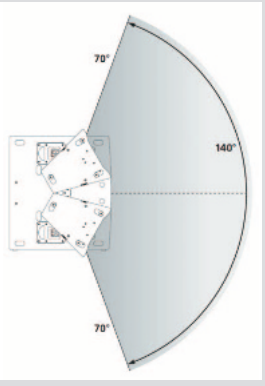
The multisine measurement is more relevant in practical terms: In this case, 60 sinusoidal signals with a random phase and frequency weighting according to EIA-426B generated a signal with a 12 dB crest factor, thereby creating a realistic load condition. This measurement assesses all harmonic distortion components as well as intermodulation distortion.

If we also deem a distortion threshold of more than 10% of the signal to be appropriate here as well, then the highest level that the speaker is able to deliver in practice can be deduced directly from the measurement. This comes to 122 dB SPL on average and 135 dB peak for the LTS top unit in solo mode, both referenced to 1 m distance under free-field, full-space conditions. The LTS datasheet specifies 141 dB under

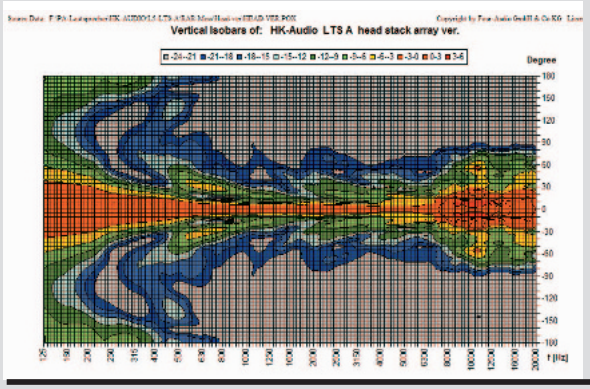
How does stacking work?

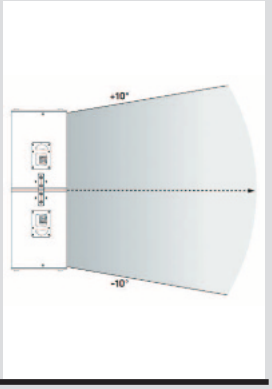
The consensus is that clusters and arrays with conventional speakers can be troublesome to set up. When several speakers are combined in a cluster, inconsistencies in their directivities result in lot of interference and cabinets that are placed side by side deliver a patchy overall sound. This is why the following holds true: The more uniform each cab's directivity, the better the combination of multiple systems will sound. With its large midrange horn and line array-like vertical layout, the LTS A would appear to be predestined for forming clusters. The speaker even provides the appropriate presets for vertical head stacks and horizontal clusters. We looked at both combinations from every angle. The horizontal cluster consists of two cabinets with 30° of splay between the inside panels. According to the datasheet, this results in a cluster with a beam width of 140°.





120° cluster *made up of two HK Audio LTS As side by side; horizontal isobars*





Head stack *made up of two LTS As, vertical isobars*

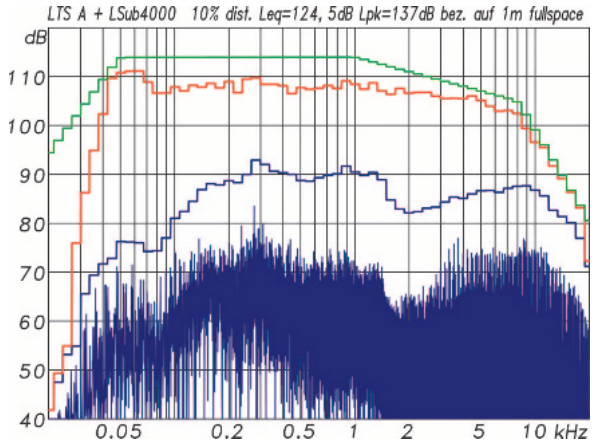
Our isobar measurement confirms the accuracy of this specification: Starting as low as around 500 Hz, the isobars extend upward at about ± 70° as if drawn with a ruler. There are a few small gaps on the central axis that could be prevented with a slighter tighter formation, but then again, this could result in inconsistencies at the far reaches.

Head to head

Apart from line arrays, vertical stacking is widely held to be tricky business: Either the speakers are placed so far apart that they operate as two independent sources, or they are arrayed with the tweeters, especially, placed as close together as possible. This is the approach used for head stacks. The HK Audio LTS system is ready for this option because the tweeter sits at the very top end of the housing. The hardware, which makes it easy to connect two cabinets head to head, is also geared for head stacks. When the two are connected, the two tweeters are then arrayed head to head so that they merge acoustically into one system. The same goes for the midrange woofer's line sources, and their length doubles when cabinets are stacked.

This results in a sort of line array with a straight midrange stack and a slightly curved tweeter array. The datasheet specifies ± 10° beam width, which is well suited for long-throw applications where the audience area is level. The isobar measurement confirmed this value across a wide frequency range. Above 6 kHz, the tweeter unit's signal starts to fray somewhat so that the precision of a well-made, 'proper' line array can no longer be fully matched.

This combination nevertheless achieves excellent results. And that makes the LTS suitable for further applications as a horizontal cluster or stacked array for large audience areas or for venues with acoustically challenging conditions.



In combination with the subwoofer, *the level increases by approximately 2 dB, but the subwoofer has a lot more headroom beyond that. (Fig. 15)*

half-space conditions, which coincides perfectly with our findings. Specifying a level under half-space conditions for a top unit is not as useful, but HK does this to enable comparisons.

Fig. 15 shows the same measurement taken for the top and subwoofer combined. This increases the achievable level by 2 dB. Of course, the frequency range is also extended by around 1.5 octaves downwards. The red curves in Fig. 14 and 15 show the overall signal in 1/6 octave steps. Continuous SPL for the duration of the measurement can be obtained by adding all these figures up. The blue curves and blue spectral lines represent the extrapolated distortion components. And if all these figures are added up and brought into the proper ratio with the overall signal, then we get 10% or -20 dB distortion. The frequency-selective spacing between the two curves shows the amount of distortion as a function of frequency. Fig. 15 tells us that the tweeter is clearly working at the limit, and that the subwoofer still has some headroom available.

Audition and prices

A stereo set consisting of the LTS and Linear SUB 4000 A was set up in an anechoic chamber for the audition. In the first go-round, the top unit was operated without the support of the subwoofer. The tops are not suitable for real bass signals, but then no one would expect them to be in any event. Even so, they do not sound thin or obtrusive. Vocals and speech are rendered near to the point of perfection, and with extraordinary punch and reach. The combination of LTS A and Linear SUB 4000 A creates a full-fledged PA.

With its level attenuated by 6 dB, the subwoofer plays very well indeed with the top units in a 1:1 ratio. It soon becomes clear that the Linear SUB 4000 A defies commonly held preconceptions about band-pass enclosures: On the contrary, the bass is unusually tight and precise, even when the unit is pushed to the limit. This small combination already sounds very much like a big PA. The notion of a large combination with four subs and top units per side and a room that holds an audience 3,000 as described on the HK Audio website is certainly not unreasonable.

According to HK Audio, the manufacturer's suggested retail price including sales tax is around €1,784 for a Linear 5 LTS A, while a Linear Sub 4000 A costs around €2,379.

Conclusion

It can be confirmed without hesitation that HK Audio has landed a big hit with the Linear Series LTS A and Linear SUB 4000 A: The fully active system comprised of a top unit and subwoofer comes equipped with highly professional features and is constructed to highly professional standards. Its acoustical properties – the tight vertical directivity, high SPL and low distortion – are a perfect fit for the needs of many users. Add to this the versatile application options, with combinations ranging from a top unit in solo mode to a midsize PA with four top units and the corresponding number of subwoofers in each stack. If that is not persuasive for you, we recommend an audition, where the Linear system lives up to its name. However, the system doesn't just sound really good; it also gets mighty loud with its good properties remaining intact.