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HK Audio Elements

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A modular mini line array for small stages and applications requiring inconspicuous visuals, good intelligibility, and a relatively long throw

HK Audio is blazing a new trail in sound reinforcement for small stages and clubs with the Elements system. "Blazing a new trail" may seem a bit over the top and overused in this context, but upon closer examination, this is not far off mark when it comes to the Elements system. So, what gives?

As the name would indicate, it is indeed a system comprised of six elements that configure flexibly to set up PA systems. The six elements are an active subwoofer, a passive subwoofer housed in the same type of chassis, a passive line-array mid/high unit, a power amp module sharing the mid/high unit's enclosure design, a special speaker pole, and a base. Featuring four 3.5" wide-range speakers aligned in a short array, the mid/high units may be stacked in columns comprising up to four units with 16 drivers in total. Both the mid/high units and optional subwoofers are highly scalable, from the smallest combination consisting of one mid/high unit with a power amp up to the largest permutation with eight subwoofers and eight mid/high units, which is called Big Elements. These wide-range loudspeakers may be reminiscent of the classic speaker columns found in churches, but they are a breed apart.

Modern wide-range chassis such as the 3.5" neodymium speakers used here are real high-performance drivers with high sensi-

tivity, considerable load-handling capacity, and frequency response ranging down to 20 kHz. This small high-tech driver was developed at the English speaker specialist Celestion in collaboration with HK Audio. Configured as line sources, the Elements mid/high units provide excellent vertical directivity, which facilitates deployment in acoustically challenging environments. For example, a column of four mid/high units plus a power amp module and base could provide speech reinforcement in boomy or cavernous rooms. The column may be aligned to the audience to achieve a clean signal without eliciting undue reverberation from the room. This brings us back to the principle behind the classic speaker column in churches, which was configured specifically to create a wide horizontal and narrow vertical pattern of throw. This principle lives on in Elements, although in an optimized form with modern drivers and a scalable, modular design. In terms of room acoustics, this simply means that the sources deliver a lot of direct sound and little diffuse and/or room sound to the listener, which ensures good speech intelligibility and clarity for music. Combining many small wide-range systems to form a line array has the added and very welcome advantage of frequency coupling, which is particularly beneficial for frequencies in the lower range. Given the same voltage at the terminals, doubling the number of drivers boosts the level by 6 dB. The same goes for the subwoofers: On demand, 10" systems may be combined to create quite powerful small arrays.

Connecting modules via E-Connect

So much for the acoustical aspects and advantages of the Elements system. But practical concerns often play an important role in day-to-day use. Having crafted speaker cabinets for 30 years, HK Audio has plenty of experience and is well aware of the problems that can arise in the daily application of sound reinforcement equipment, so the company redoubled its focus on matters of setup, cabling, and transport. Elements' E-Connect system addresses the two first issues. The mid/high units, subwoofers, and power amp modules are all equipped with mechanical connectors much like those found on tripod systems. These connectors also hold the electrical wiring. Apart from the speaker pole, all E-Connect components are integrated into the speaker enclosures, where they cannot be left behind and are out of harm's way. A robust ¼" jack plug that is largely relieved of mechanical stress by the connector's sleeve provides the electrical connection.

The mid/high units connect to one another, to the speaker pole, and directly to the amp module or subwoofer both mechanically and electrically via E-Connect. However, a short Speakon-equipped cord is required to connect the passive subwoofer to the amp module (or to the active sub). Housed in a separate module or integrated in the subwoofer, the amp delivers 600 W to drive two subs or four mid/high units or one sub and two mid/high units.

The EA600 amp module's electronic circuitry resides in the same type of enclosure as that of the mid/high units so the amp may serve as the bottom module of a column. One power amp drives the subs and mid/high units in parallel, which tells us that frequency crossover is controlled by passive components. We tested a set of two columns comprising one each active E110 Sub A subwoofer with a speaker pole and two each E435mid/high units. Also called a Basic System, this is an archetypal mini PA for a soloist that may be conveniently transported in any compact car. The optional accessories for transport are a protective cover for the subwoofer and padded bags for four mid/high units or amp modules each, or a combination of the two plus a speaker pole. A padded bag is also available for the base. Apart from the two sub-

woofers, the entire Basic System – four mid/high units, two speaker poles, and the mains cords – may be packed and readily carried in a single gig bag.

Elements may also be configured as a typical DJ rig with several subwoofers on each side, or used without subwoofers for a cappella gigs. It could also quite conceivably serve as a side-fill monitor on larger stages or as a DJ monitor rig. This line array's special properties, particularly its resistance to feedback, also enable deployment as a personalized PA system where every musician sets up his or her backline column for use as both a PA and monitor. Courtesy of their exceptionally slim silhouette, all variants of Elements may be sited very inconspicuously and are well suited for posh industry and gala dress events. Now let us take a closer look at the key modules of Elements.

E435 Mid/High Unit

The E435 mid/high unit comprises four 3.5" wide-range speakers arrayed in line and wired in series as one 16-ohm unit. The entire unit is addressed via a capacitor connected upstream. Serving as a passive high-pass filter of the first order, it operates at about 140 Hz. When installed in a closed housing, the speaker itself behaves like an acoustical second-order high-pass, which in aggregate creates a third-order high-pass. The dimensions of the aluminum frame enclosure are 11 x 38 x 12 cm (W x H x D), with the drivers spaced about 9.5 cm apart. The weight comes to a very manageable 2.35 kg. The electrical connection is provided exclusively by the E-Connect system.

A line array's efficiency depends primarily on the installed components, particularly the drivers' capabilities. The E435 is equipped with just one type of driver in its archetypal form – that is, without a horn or waveguide – which made it easy for us to assess the unit's performance. To this end, we first measured the E435 mid/high units individually, then in paired configurations, and finally in a set of four, all without controllers and matching outboard amp. Figure 1 shows the frequency response curves and sensitivity at 4 V terminal voltage. This is equivalent to a value of 1 W/1 m for a single E435, which is nominally a 16-ohm system. The E435 kicks off at 87 dB, ascending to a rather impressive 95 dB in the mid-range. At 4V terminal voltage, sensitivity increases by 6 dB every time the number of speakers doubles. Doubling the number of drivers also increases power consumption twofold, which provides an initial 3 dB boost in signal level.

Is HK Audio Elements a line array?

Faced with the Element E435 mid/high units, the skeptic is bound to ask two questions:

– Is the column – particularly in small setups – too short to be a proper line array?
– If it is indeed a line array, then what's up with the distance between drivers at high frequencies?

The answer to the first question is that, strictly speaking, any in-line configuration no matter how short is a line array. Whether or not this has any effect on the pattern of throw depends on the frequency. The same goes for the extended near field, where the wave propagates in cylindrical form with a 3 dB loss in level as the distance doubles. Once the wave crosses over to the far field, the level loss is 6 dB. This transition can be approximated mathematically using the frequency f in Hz and the array length l (speed of sound c = of 340 m/s).

$$r = \frac{l^2 \cdot f}{2c}$$

The near-field effect – a 21-cm extension at 1 kHz – is of no great consequence when using a single E435 mid/high unit. After the wave crosses over into the far field, the more or less uniform cylindrical wave front transitions into a spherical wave front whose beam width (BW) again depends on the source's length. This can also be calculated using a formula - or surmised directly from our isobar diagram in figure 13. It indicates very clearly that the vertical convergence effect is quite strong even with a short line array. At 1 kHz and –6 dB, a single E435 has a beam width of 60°, and 6° at 10 kHz. Unlike with an HF horn, the beam's focus grows even tighter with increasing frequency. This property has to be kept in mind when aligning the source because the high frequencies may miss some of the audience. The best option is to place such a small line array lacking any further curvature just above the audience's ear level. A taller column, for example, a 1.5 m setup with four E435 units, simplifies matters because of the extended near field and the height of the radiated cylindrical wave. A fourfold increase in the array's length extends the near field to the power of two - that is, by a factor of 16. It extends to 3.2 m at 1 kHz, and to 16 m at 5 kHz. So an Elements array comprising four units is best set up so that the top unit sits above the heads of the audience.

$$BW_{-6dB} \approx 2 \cdot \sin^{-1}\left(\frac{1{,}9}{\pi} \cdot \frac{c}{l \cdot f}\right)$$

Now let us address the second question concerning the distance between drivers. It is exactly 9.5 cm. Side lobes appear at about 1.8 kHz and new parasitic main lobes begin forming at 3.6 kHz. Initially, this does not sound like good news, but there is a bright side: The overall column's beam, created by point sources spaced 9.5 cm apart, is overlapped by the beam of the individual driver, whose directivity is quite pronounced at 3.6 kHz and thereby reduces the unintended side lobes. The isobar curves in figure 13 show the side lobes at 4 kHz starting at ±60° with a level of –6 dB in relation to the 0°axis.

The value increases by another 3 dB in the low frequencies due to the greater acoustical resistance: A second neighboring loudspeaker addressed by the same signal creates more favorable conditions for the first driver to convert the speaker cone's mechanical action into airborne sound. The improved response results in a 3-dB gain in signal level. This effect occurs only when speakers are spaced is close enough together in relation to the wavelength. This is precisely what can be seen in figure 1, where the gain is limited to the lower frequencies when the number of speakers is doubled for the second time. Higher frequencies do not benefit from this gain, and another effect is added to the equation: The column of four E435s has grown to a height of 1.5 m and its near field for higher frequencies has been extended to the point where the measuring spot is actually still within the near field. Weaker and stronger interference in the frequency response may be encountered, the intensity of which varies greatly from one position to the next. The mid/high units' impedance curve in figure 2 indicates a marked increase towards the low frequencies caused by the passive, second-order high-pass filter that has been integrated, upstream. The driver's resonant frequency in the sealed enclosure lies just below 200 Hz.

E110-Sub

A line array equipped with 3.5" wide-range speakers cannot do without the support of a subwoofer when it comes rendering music. To this end, Elements offers the E110 Sub equipped with a 10" woofer in a bass reflex housing. The unit comes in a passive and a powered version. The active model's power amp delivers 600 W max to its 10" driver, and can also drive a second passive subwoofer or, alternatively, two mid/high units. The latter may be placed right on top of the subwoofer or on a speaker pole and connected via the E-Connect system. The E110's housing measures 30 x 48 x 46 cm (W x H x D) and the active version weighs 19 kg. This makes it a very compact and handy enclosure that one person can easily carry and set up using the grip set into the top panel. An XLR port with a link for the audio signal furnishes the electrical connection. A locking IEC mains socket provides the mains connection. Although it is not quite as rugged as a PowerCon socket, it does have the distinct advantage that a suitable cord is readily found if the original is left behind; which is not easily done with PowerCon cords.

Sited next to the mains switch on the power amp module is another switch that controls input sensitivity and the controller's filter function. The subwoofer's built-in circuitry offers filters for one or two mid/high units and one, two, three, and four EA600 power amp modules. Figure 5 shows the filter functions for one and two mid/high units. Let us look at the E435 by gauging the loudspeaker without controllers and without passive filters. The red curve in figure 3 shows the bass reflex enclosure in isolation, the green curve indicates the integrated passive crossover's filter function, and the blue curve represents the enclosure with a crossover. Figure 4 shows the corresponding impedance curve and the bass reflex enclosure's tuning frequency of 50 Hz.

A subwoofer of this size is, of course, not a system with ultra low bass response. More a supplement for the small mid/high units, it provides a fitting bass foundation for the usual applications. And the fit is very good as figure 6 attests. The E110 picks up precisely where the E435 leaves off, extending the frequency range by about two octaves. The light blue composite curve for a subwoofer and two mid/high units illustrates the successful crossover at about 140 Hz.

The controller amp increases the level at 66 Hz by around 7 dB to extend the low end

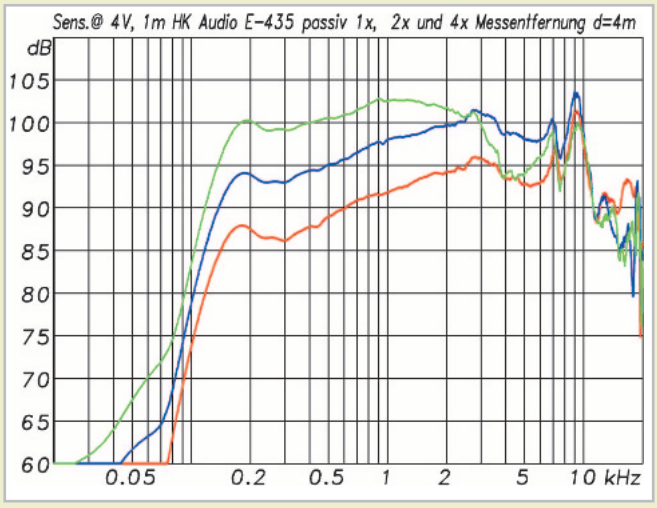

Fig. 1: The Elements mid/high units' frequency response curves for a single system (red), two units (blue), and four units (green). All measurements pertain to 4 V/1 m. A look at the low frequencies clearly shows that sensitivity increases 6 dB every time the column is doubled up.

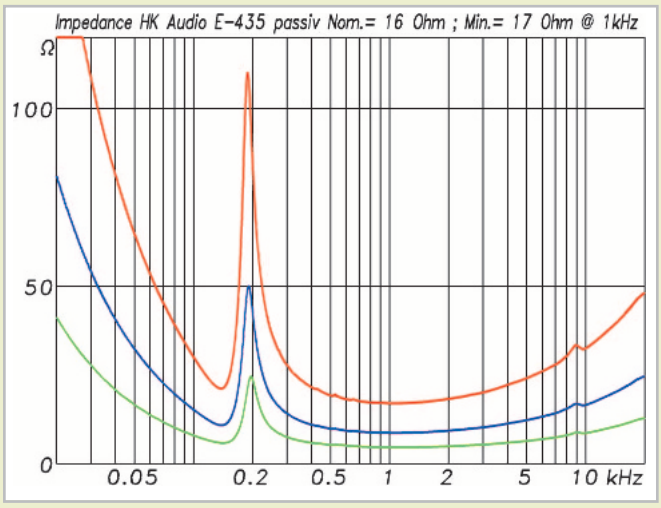

Fig. 2: The Elements mid/high units' impedance curves for a single system (red), two units (blue), and four units (green). At a minimum impedance of 17 ohms, the nominal 16-ohm systems are very accommodating to the amp that powers them. The impedance peak at just below 200 Hz indicates the resonant frequency of the small wide-range speakers in the sealed enclosure.

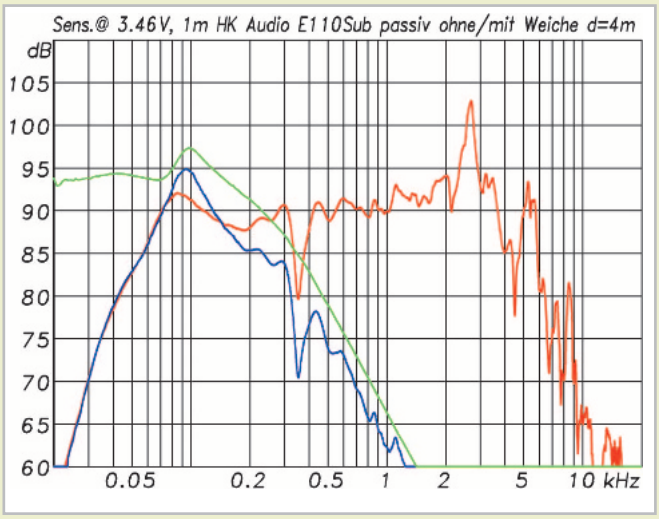

Fig. 3: The E110 subwoofer. Red indicates the subwoofer without its passive crossover. Green shows the integrated passive crossover's filter function, and blue the subwoofer with crossover. This well-conceived crossover provides the desired low-pass filtering effect and couples the sub to the mid/high units.

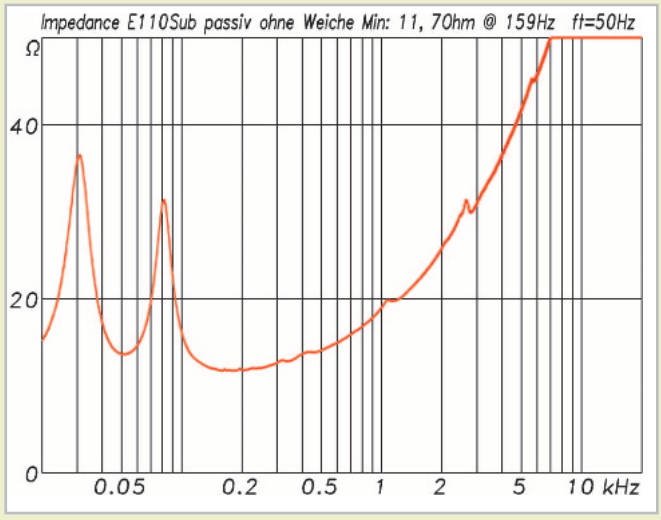

Fig. 4: The impedance curve of an E110 Sub without a crossover. The tuning frequency of the bass reflex resonator is 50 Hz.

somewhat further. With its bass reflex resonator tuned to a frequency of 50 Hz, the subwoofer is easily able to handle this boost.

Active...passive?

Now that we have reviewed the active and passive components, controller functions, and passive filters, let it be emphasized that Elements is a self-powered system. Although it separates the signal entirely passively, it is nonetheless equipped with on-board amps. A filter in the controller amp performs all the equalization. This combination is the only way to drive both mid/high units and subs simultaneously via a single power amp channel.

Experience teaches that cutting off at the frequency for subwoofers with passive components is not some trivial exercise because the strong impedance fluctuations on both sides of the typical cutoff band make life difficult for passive filters. But HK Audio certainly solved this problem with aplomb. Figure 7 shows the overall response of an E110 subwoofer with one and two E435 mid/high units operated with the corresponding controller amp and appropriate filtering. The crossover from the subwoofer to the mid/high units is a rousing success.

Looking at the big picture, the curve indicates an additional boost of several dB at

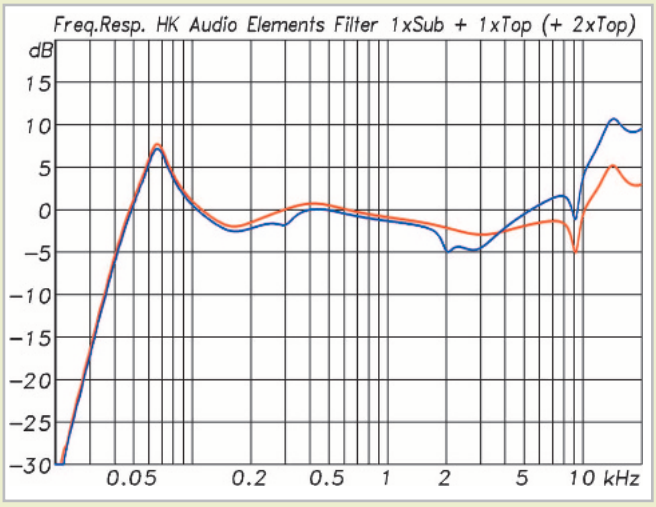

Fig. 5: The filter function in the power amp that addresses one subwoofer in combination with one (red) and two (blue) mid/high units.

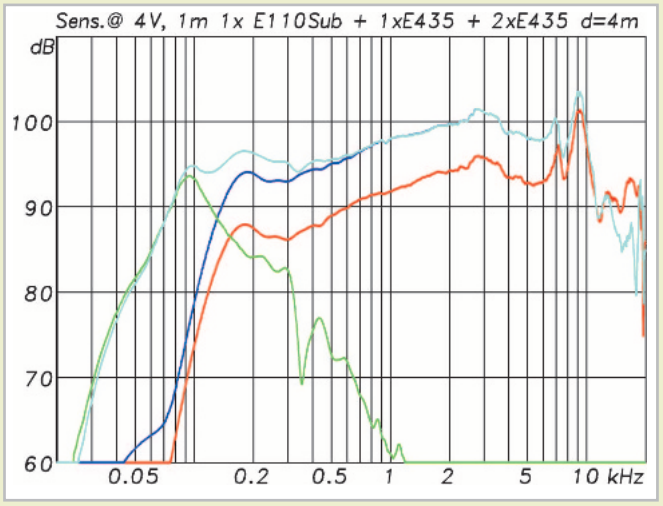

Fig. 6: The frequency response curves of an E110 subwoofer without a controller (green) and of one (red) or two (blue) mid/high units. Light blue indicates the composite of a subwoofer and two mid/high units.

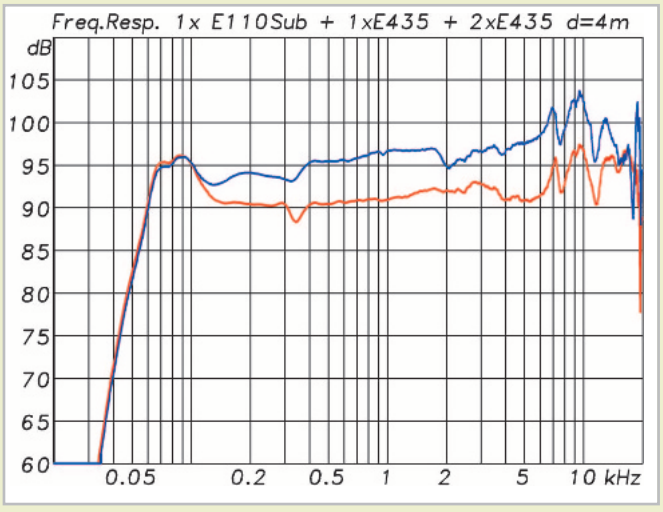

Fig. 7: The frequency response curves of combinations of one subwoofer with one (red) and two (blue) mid/high units operated via the internal active circuitry. The overall result is a linear frequency response curve with the desired boosts at the edges. The transition between the mid/high units and subwoofer is excellent.

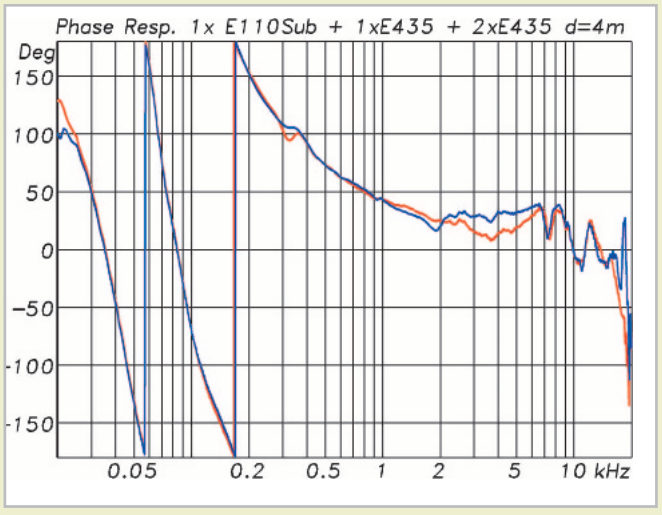

Fig. 8: The phase response curves of combinations of one subwoofer with one (red) and two (blue) mid/high units.

both ends, which was certainly intended. Figure 8 presents the corresponding phase response curves; figure 9 the resultant group delays. There is no phase shifting of any consequence in the middle and high frequencies thanks to the wide-range speakers used sans crossover. The phase reverses 360°several times in the lower frequencies, which is attributable to signal being split and routed to the subs and mid/high units, the subwoofer bass reflex housing's acoustic high-pass filtering function, and the added electrical high-pass filter of the fourth order in the controller amp. The delay curve rises accordingly. The only way to reduce this phase shifting is to use less steep high-pass filters, which is not feasible given the load this would place on the loudspeakers. What's more, opting for more moderate high-pass functions at the cost of diminished operating reliability is not an advisable trade-off. The reduction in phase shifting would hardly be detectable in practical applications and only with great difficulty under laboratory conditions – in marked contrast to a driver destroyed by an overload.

Peak levels and directivity

A look at the curves indicating peak level in figure 10 reveals a very uniform response. What's more, at frequencies above 200 Hz,

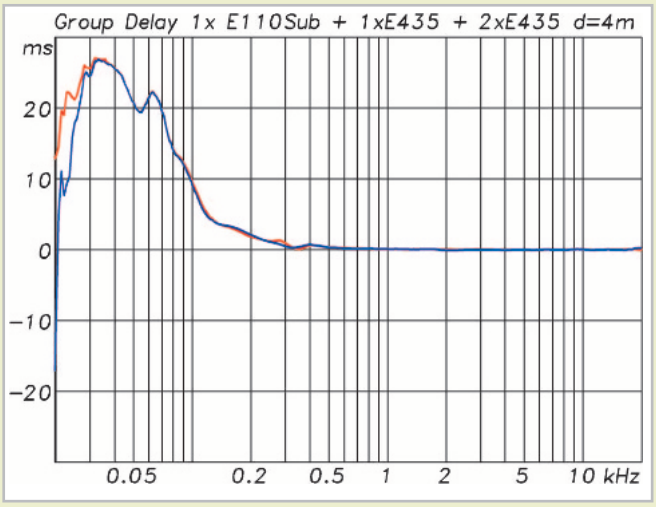

Fig. 9: The delay times associated with the phase response curves in fig. 8. The steep acoustical and electrical high-pass filtering causes a marked increase in low frequencies' delay.

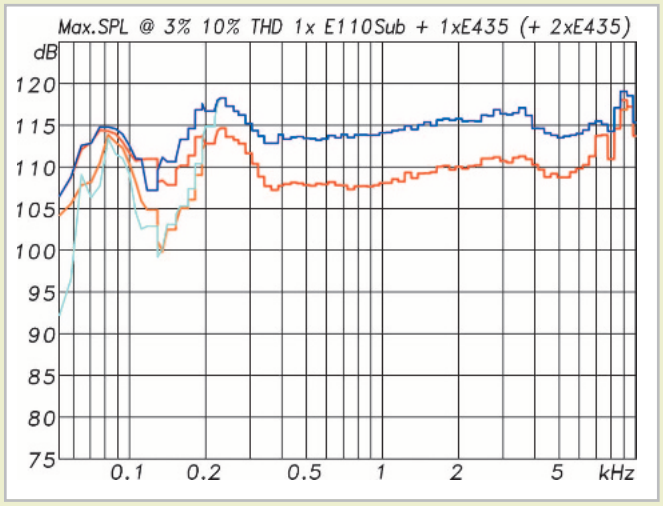

Fig. 10: The peak level at 1 m distance and 3% (orange and light blue) and 10% (red and dark blue) maximum distortion for a subwoofer with one (top) and two (bottom) mid/high units.

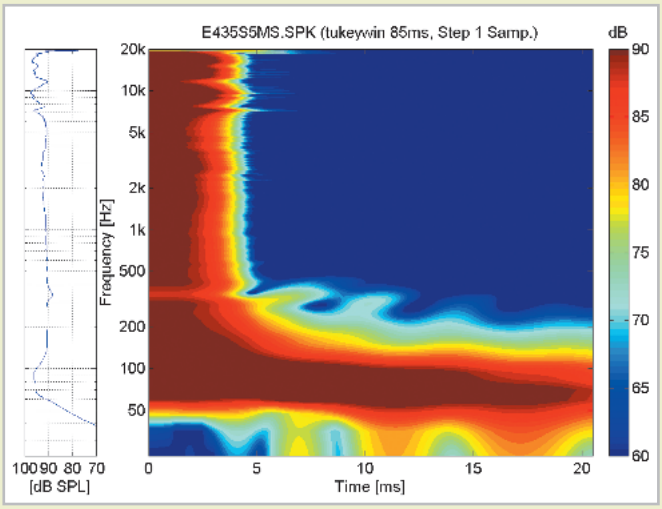

Fig. 11: A spectrogram showing the E435 with an E110 subwoofer. The small wide-range speakers' response is excellent. The lengthy post-pulse oscillation below 100 Hz is due to the extended delay time or rather the filtering.

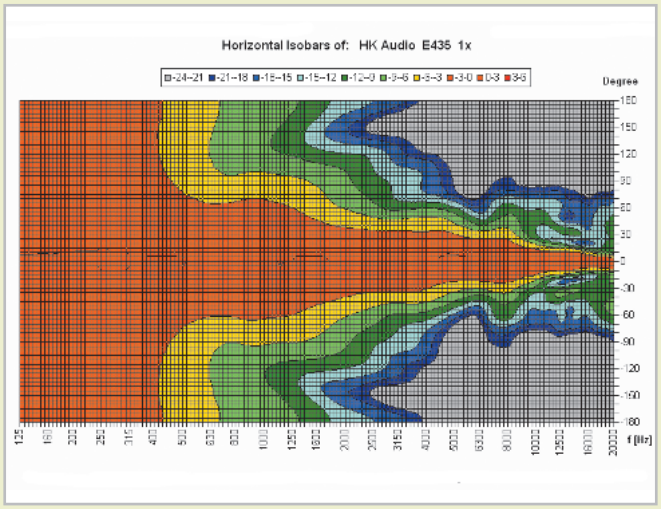

Fig. 12: Horizontal isobars of the E435: The beam narrows towards the high frequencies, which is typical for wide-range speakers.

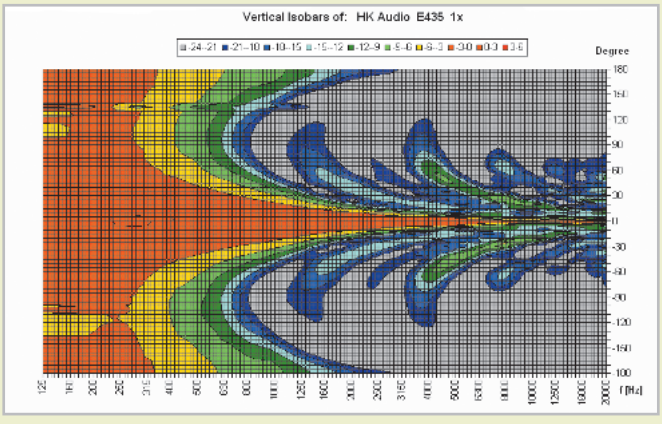

Fig. 13: Vertical isobars of an E435 unit. The small side lobes starting at 4 kHz are attributable to the spacing between drivers.

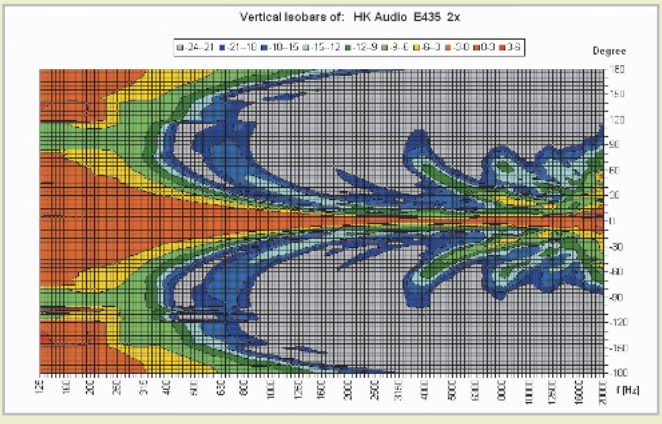

Fig. 14: Vertical isobars of two E435 units

the 3% and 10% curves subside continuously, which means that the 10% threshold has not been reached and a limiter is preventing any further increases in level. Calculations based on the input sensitivity values and the amp's power output would lead us to expect the curve to be sited about 3 to 5 dB higher than it is. According to the manual, Elements amps are equipped with a pure RMS limiter. In all probability, it intervenes relatively early when taking this type of measurement to limit power output. In closing, let us venture a quick glance at the isobar diagrams in figures 12 to 14. A line array's vertical directivity always draws immediate attention; the fact that it also has a horizontal directivity is often overlooked. Here the E435 behaves like a typical wide-range speaker where the beam's width converges at an increasingly narrower angle. This is because the membrane surface area always remains the same regardless of frequency and the pattern of throw narrows with increasing frequency. At 8 kHz, roughly 70° is achieved for the –6 dB isobar, which is definitely a value well-suited for practical applications.

Figures 13 and 14 show the vertical isobars for one and two E435s. The main difference is that in the longer array, the convergent effect is more pronounced even in the low frequencies. This means that in venues with challenging acoustics (long reverberation time), the tallest possible column should be set up to achieve significant directivity in the lower frequencies even if the application does not require high sound pressure levels!

The upshot

Elements makes a good impression all around. Some of things these small wide-range speakers can do are astonishing indeed. The transition from subs to mid/high units works remarkably well despite the passive crossover. Deployed properly, Elements is a handy problem-solver for many applications. A E435 mid/high unit costs around 335.00 euros; a E110 Sub A goes for about 949.00 euros. The EA600 power amp featuring the same design is available for around 510.00 euros and the passive E110 Sub for about 619.00 euros.

Text and measurements: Anselm Goertz
Photographs: Dieter Stork, HK Audio (1)