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HK Audio SI Series

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The P10i (front) and P10j (back) without front grille

HK Audio SI Series

System integrator models from HK Audio with column speakers and subwoofers in weatherproof IP66 design, with EN54-24 certification and optional 100-volt transformers.

Copy and measurements: Anselm Goertz | Images: Anselm Goertz

The new SI Series loudspeaker models from HK Audio, located in St. Wendel in the German Saarland region, were developed specifically for the installation market and not, as is often the case, derived from the models of a rental series. Prior to their development, planners and installers were involved as advisors. The most common requirements in the day-to-day planning business are:

- a radiation pattern that is adapted to difficult room acoustic conditions, so that areas with an audience can be selectively sounded without causing too much reverberation in the surrounding room
- a sufficient maximum level sound pressure so users can achieve a sufficient signal-to-noise ratio even at a high noise level
- EN54-24 certification for use in voice alarm systems
- weatherproof for outdoor use
- in addition: aspects regarding mounting and colour matching to the surroundings as well as several special requirements, such as ball impact safety for use in sports halls.

The first two points aim at sufficient speech intelligibility, which is primarily determined by a room's acoustic conditions and a possible noise level. A long reverberation time and high noise level often occur in combination, which further complicates the situation. Examples that almost everyone knows from their own experience are sports halls (for example handball, ice hockey, or other sports), railway stations or exhibition halls. The situation is similarly difficult when it comes to houses of worship, museums or the large foyers of modern buildings, where the noise level is usually not a relevant issue, but the room acoustic conditions and widely distributed spatial areas also create difficult conditions.

HK Audio P10 – why columns?

Everyone is familiar with the effect of live rooms in which one can hear a conversation partner sufficiently loud enough over a distance of 10 m, but cannot understand anything because the reverberation covers up all the important features for good speech intelligibility. The ideal when it comes to speech intelligibility would be to hear only the direct sound coming from the source to the receiver via the shortest path. However, as long as one is not outdoors, there will always be a more or less pronounced amount of reflections and diffuse sound caused by reverberation of the room. While reflections, if they arrive at the listener within the first 50 ms after the direct sound has done so, can also have a positive effect on speech intelligibility, diffuse sound is always counterproductive regarding the speech intelligibility. For other applications, however, a more pronounced diffuse sound field may be desired. The atmosphere in a sports hall, for example, depends in large part on the noise of the fans, a concert hall needs diffuse sound so that the feeling of enveloping sound can develop, and a church's organ and choir would sound featureless and dull without long reverberation. Even these simple examples show that intelligent solutions and compromises are necessary to meet all requirements. Let us take a large hall with a long reverberation time and flexible use as an example. For announcements and voice alarms, sufficient speech intelligibility should or even must be achieved. However, room acoustic measures to reduce reverberation are not possible. In such a case, it is still necessary to achieve sufficient speech intelligibility with the help of suitable loudspeakers. The term "suitable" refers primarily to the speakers' directivity. It is important to emphasise again that directivity is not about good or bad, but about suitable or unsuitable for a particular application. In live rooms, this means that the loudspeaker should radiate the sound as much as possible to where the listeners are located and as little as possible into the remaining areas, so that as much direct sound as possible reaches these listeners and at the same time the reverberation is stimulated as little as possible. If the audience is located on one or more levels, then column array loudspeakers achieve this relatively well – as one knows from installations in houses of worship. Idealised as a line source, the column radiates broadly horizontally and very narrowly vertically, so that a large audience area can be well covered in one plane.

Fortunately, this means a lot more than the usually very thin and weak-sounding old column speakers that may directly come to mind in this context. Compared to older models, modern broadband drivers offer a significantly extended frequency range and higher power capacity. The concept of a column loudspeaker is further enhanced by DSP-controlled speakers whose directivity can be adjusted even more precisely to the surrounding conditions by means of purely electronic filters. However, this is offset by a considerable technical effort in hardware and, above all, in software, which makes DSP-controlled speakers too expensive for many applications. Added to this is the aspect of EN54 certification, which is currently not yet possible for active loudspeakers, so that individual approval is required for use in voice alarm systems. In the medium term, however, there is the prospect that – derived from the pre-standard DIN VDE V 0833-4-1 that already exists in Germany – there will also be a possibility of certifying active loudspeakers.
If one still wants to optimise or adjust a column speaker's radiation pattern a little without active technology, it is possible to do this using passive filters in the column or mechanically by curving the column. This approach is familiar on a larger scale when it comes to line arrays that hang more or less straight at the top of the line and then curve further down to reach the front rows of the audience as well. The curvature increases the radiation angle and reduces the intensity, which is compensated for by the shorter distance to the audience, resulting in a largely uniform level of distribution over all.

Multiple column versions by HK Audio

Building on extensive experience in the development of line arrays, HK Audio has taken up precisely this idea for column speakers as well: in addition to the straight P10i, the SI Series also includes the P10j curved version. Both P10 models are also available in a Low-Z version with 16 Ω nominal impedance and with transformers for 100 volt systems with taps for 150, 75 and 37.5 W. In the following, however, we will focus solely on the Low-Z version. ➔

The S210 P without bass reflex port, but including two passive radiators on the rear

All P10 models are equipped with ten 3" full range dri-vers each, working on a closed cabinet. The full-range drivers are driven by a 0.8" voice coil together with a powerful ferrite magnet that is almost the size of the rest of the driver. The cabinet itself is 820 mm high, 120 mm wide and 165 mm deep and weighs 10.4 kg. In the j model, the depth of the cabinet is reduced to 119 mm at the lower end due to the baffle's curvature. The cabinet is made of solid multiplex and coated with a waterproof two-component varnish. The front is protected by a steel grille, the quality of which is proven by a ball impact safety certificate according to DIN 18032-3. Also verified by tests are the IP66 protection class and the EN54-24 type B certificate for outdoor use. The loudspeakers can therefore be permanently installed in unroofed and unprotected outdoor areas.
Despite this robust design, the slim cabinet remains visually pleasing, as the entire front is covered with an impregnated fabric that is still pulled far over the edges, so that neither the front grille nor the drivers are visible. Additionally, there are plenty of accessories for mounting the speakers. In detail, these are a U-bracket, a swivel and tilt bracket for wall mounting or alternatively for ceiling mounting and a pole mount. If two P10s are to be operated as one unit, they are screwed together using lateral connector plates.

Measurements P10

A first quick impedance measurement (FIG. 1) confirms the 16-Ω nominal value with an uncritical minimum of 15.6 Ω for both P10 models in the Low-Z version. The drivers' resonance frequency in the cabinet is 198 Hz. The P10's frequency response and sensitivity from FIG. 2 were initially measured without a controller directly at the measuring amplifier. For sensitivity, it should be noted that the curves are related to 2.83 V/1 m. With a 16-Ω system, the 1 W/1 m value is 3 dB higher, so that on average between 200 Hz and 10 kHz one arrives at a 1 W/1 m value of 97(i) or 96(j) dB. Below the resonance frequency of 198 Hz, the level decreases slowly with 12 dB/ oct, which is typical for a closed cabinet. With bass reflex tuning, one could achieve a lower cut-off frequency; however below that, the curve would then decrease with 24 dB/oct.
Which cabinet concept is better depends on the application. For the P10, however, in addition to the acoustic aspects, protection against the ingress of water and dust is of course also an argument in favour of the closed cabinet.
The P10's raw measurements thus show, first of all, that high-quality speech reproduction is already possible with slight equalisation. A subwoofer would only be necessary if one would want to cover the frequency range below 150 Hz with an adequate level for music.

Directivity

Almost more important than the frequency response is a speaker's directivity, as this cannot be changed by an upstream controller. For this purpose, a P10i and a P10j each were measured in the horizontal and vertical plane. FIG. 3 to 6 show the isobars determined in this way. The horizontal curves in FIG. 3 and FIG. 4 also directly reveal the cause of the jump in the frequency response at 1 kHz. Here, radiation pattern also narrows abrupt ly, causing the level on the centre axis to rise. This effect is also called "baffle step" and occurs when the emission passes from full space to half space due to the dimension of the baffle. If one compares the P10i's and P10j's horizontal isobars, one notices that the curved P10j radiates somewhat wider and more evenly. This is also

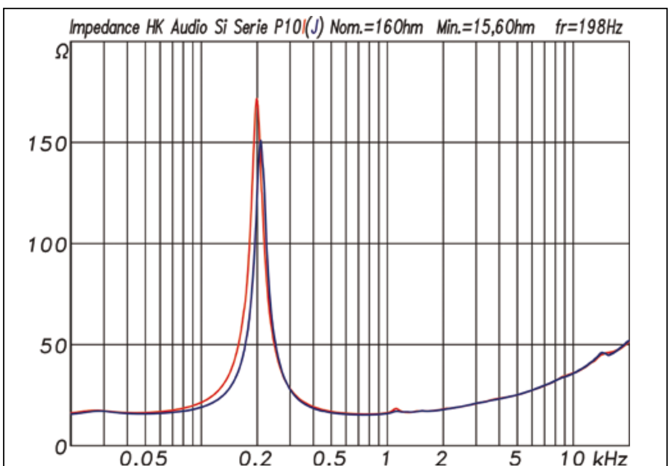

Fig. 1: The two P10 models' impedance curves. The nominal impedance in the low impedance version is 16 Ω. The minimum is an uncritical 15.6 Ω. The drivers' resonance frequency in the cabinet is 198 Hz.

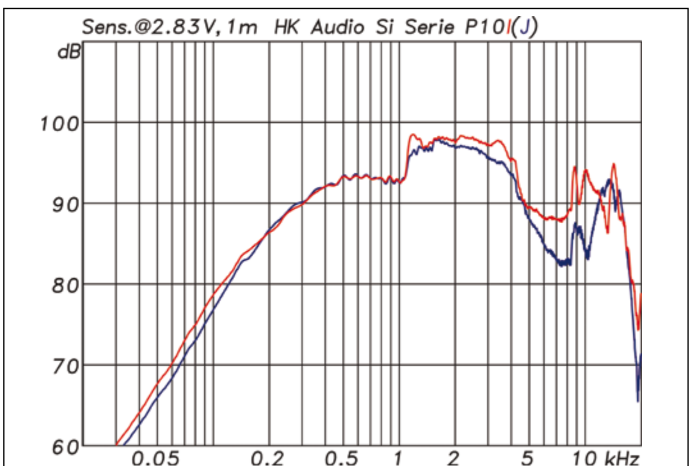

Fig. 2: The two P10 models' frequency response and sensitivity. In the j version, the highs drop slightly compared to the i model.

The two S210 versions as seen from behind; the S210 P includes two passive radiators (above) and the S210 V (below).

exactly what is stated in the data sheet, which specifies 100° for the P10i and 120° for the P10j. Above 8 kHz, the horizontal isobars then narrow to about 40° for both models.
The vertical plane in FIG. 5 and FIG. 6 is more interesting with the P10i showing the typical behaviour with a straight line that continuously narrows towards high frequencies. Due to the distance between the individual sources, weak secondary maxima occur above 5 kHz. In the j version, the vertical opening angle is somewhat wider and, above all, more constant. The system opens downwards to about –10°. Overall, the main radiation axis is approximately 15° wide, so that the front audience areas can still be easily reached with the P10j if its lower edge is mounted with just above head height.

Simulation data

To plan public address systems comprising P10s, HK Audio provides an EASE-GLL that can be used in EASE and also in EASE Focus. Due to the column's length, the near field is much wider than that of point source loudspeakers, so that large parts of the audience are in the near field at medium and high frequencies. This can only be calculated correctly by the GLL if – as in the P10 GLL – each source (i.e. each driver) is mapped as a separate source with its own balloon at its respective position (see FIG. 7). If one were to capture a complete P10 with one balloon, then the calculations would be valid for the far field, but not for the near field.

S210 subwoofer

As part of the SI Series, HK Audio offers two subwoofers to go with the P10 speakers: the S210 V and the S210 P, with the V standing for "vented" and the P for "passive radiator". Externally, the two subs with identical dimensions of 70 × 29.7 × 55 cm can hardly be distinguished. It is only on the rear that the S210 P with two fabric-covered surfaces differs from the S210 V with a solid wooden panel.
If, however, one removes the front and rear covers, the difference becomes clear: the S210 V is a classic bass reflex port on the front, whereas the S210 P has no port ➔

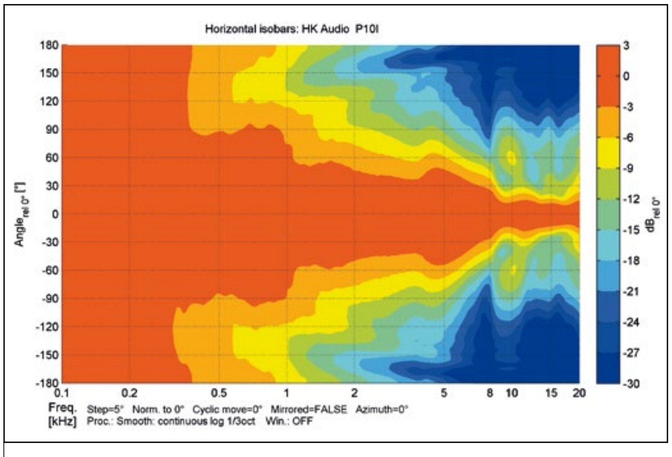

Fig. 3: The i model's horizontal isobars. The opening angle narrows above 8 kHz.

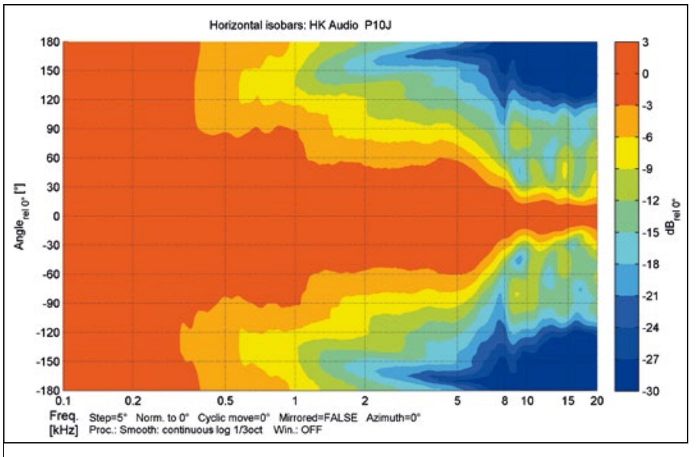

Fig. 4: The j model's horizontal isobars

Side view of the two P10 versions

but rather two passive radiators on the rear. In principle, a passive radiator works in a similar way to a bass reflex port. A mass consisting of either the passive radiator or the air mass in the bass reflex port is driven from the rear of the drivers' membranes via the air volume in the cabinet, which here acts as a spring. This creates a spring-mass system that oscillates strongly at its resonance frequency and performs an oscillation in phase opposition to the drive, in other words to the back of the membrane. The resonator's oscillation is then in phase towards the front of the membrane, so that the resonator constructively complements the sound radiation of the membranes. This in turn leads to increased bass reproduction. However, this only works in a narrow frequency range – namely, around the resonance frequency. For higher frequencies, the resonator is no longer excited. For lower frequencies, the resonator's oscillation changes to a course in phase with the back of the membrane, where the sound radiation then has a destructive effect on the membrane. As a result, the level of a bass reflex cabinet decreases below the resonance frequency with 24 dB/oct towards low frequencies in contrast to the 12 dB/oct of a closed cabinet. As the driver in the bass reflex cabinet runs visibly undamped below the resonance frequency and dangerous excursions can occur at high levels, a bass reflex cabinet should be always operated with an upstream 2nd or 4th order electrical high-pass filter for protection.

If we look at the two subwoofers' impedance curves in FIG. 8, we can see that they are almost identical. In principle, both subs are designed as bass reflex systems and are tuned to a resonance frequency of about 50 Hz. The only difference lies in the design of the resonator's vibrating mass as an air mass in the port or as a passive radiator. As the further curves in FIG. 8 show, the subs can be operated in 16-Ω or 4-Ω mode, with the

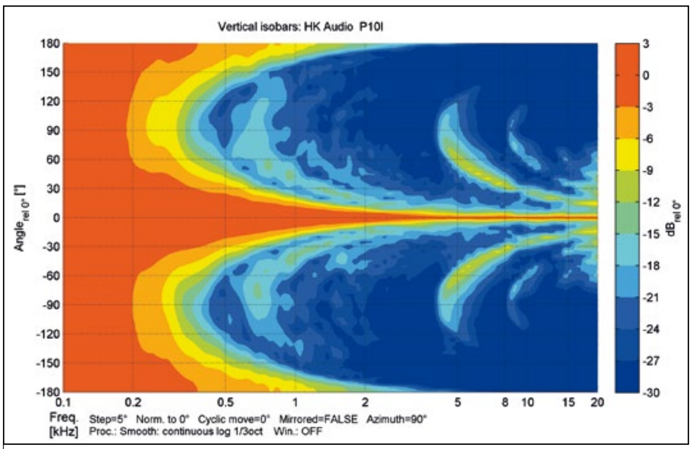

Fig. 5: The i model's vertical isobars with the very narrow radiation angle typical of a straight column, which narrows continuously towards high frequencies. Due to the distance between the individual sources, weak side maxima occur above 5 kHz.

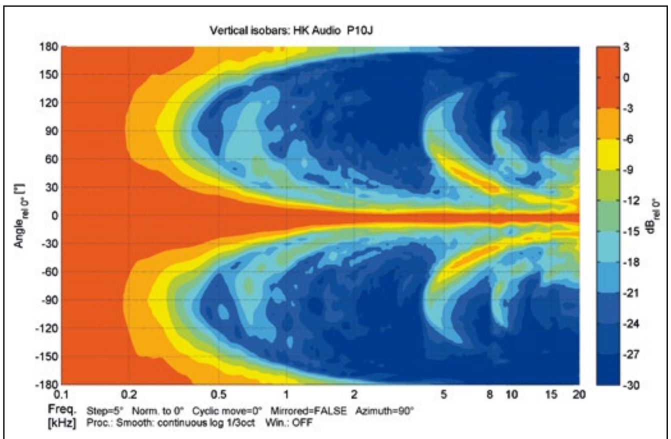

Fig. 6: In the j version, the vertical opening angle is somewhat wider and more constant. The system opens downwards to approximately –10°.

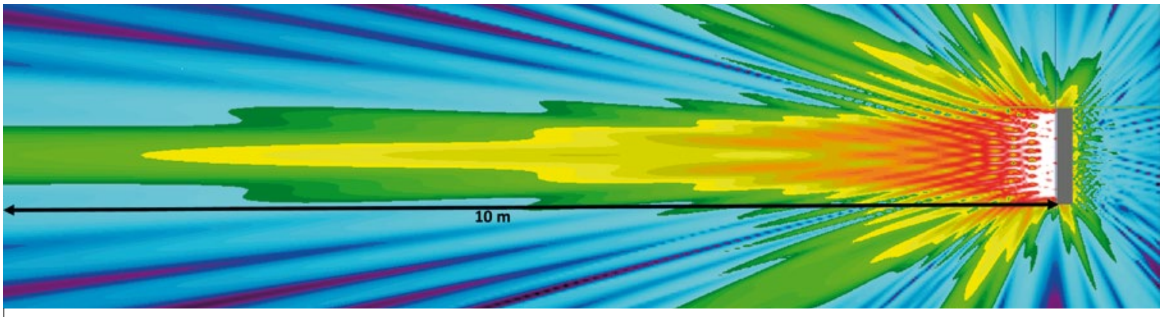

Fig. 7: Display of a P10i's sound field in EASE. Every single driver must be recognisable for correct representation of the near field, as shown here in the sectional view. The calculation was made for a P10i at a frequency of 10 kHz.

two drivers being operated either in series or in parallel via the slide switch on the rear panel, thus facilitating adaptation to different power amplifiers.
The differences in the two subwoofers' frequency responses are clearly more pronounced in FIG. 9. The S210 P with passive radiators is 3-6 dB quieter in the relevant frequency range compared to the S210 V, which in turn has a much more unstable response above 300 Hz.
The reason for this lies in cabinet resonances, which can penetrate more strongly to the outside through the open port. In the end, however, this does not matter as the subs are only operated up to a maximum of 200 Hz.
The S210 V has an IP44 protection class, while the S210 P even has IP66. The difference comes from the S210 V's open ports, which are avoided by the passive radiators.

Electronics and setups

When it comes to controllers and power amplifiers, HK Audio offers several options: ready-to-run setups for the SI Series are available for the LAB Gruppen power amplifiers IPD and PLM with Lake controller, for Powersoft power amplifiers with Armonia+ DSP, for the QSC Q-SYS system and in the form of tables with parameters for filters and limiters if users want to use a product other than the three mentioned above. This offers customers every conceivable option. Especially when it comes to use in voice alarm systems, the free parameters for filters and limiters are mainly important, because in this context a technology for voice alarm control and indicating equipment (VACIE) certified according to EN 54-16 shall be used, for which ready-made setups are not available. A LAB Gruppen PLM 12K44 power amplifier with integrated Lake controller was supplied for the test and thus the top product available for the SI Series.
In addition to an output power of almost 4,000 W at 4 Ω, the PLM power amplifier offers a whole range of additional features: these include the Rational Power Management (RPM) – where the available power of the power supply can be distributed to the four power amplifiers as required, so that active multi-way systems can be optimally utilized – and of course the integrated Lake controller. With its special MESA EQ filters as ➔

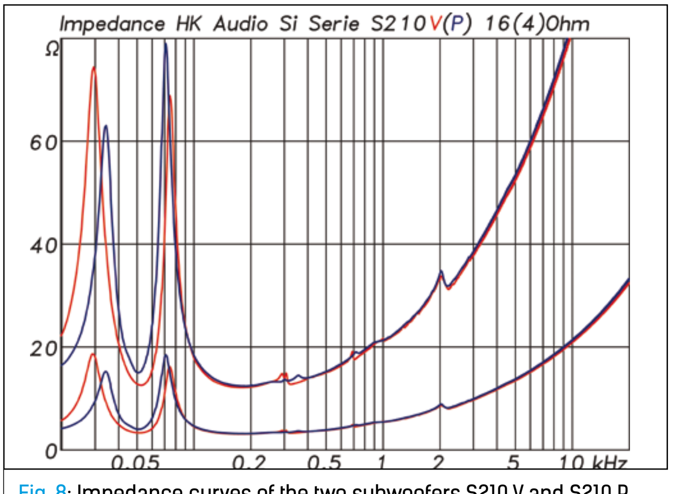

Fig. 8: Impedance curves of the two subwoofers S210 V and S210 P, each in the setting for 4 Ω and 16 Ω nominal impedance. The tuning frequency for both models is approx. 50 Hz.

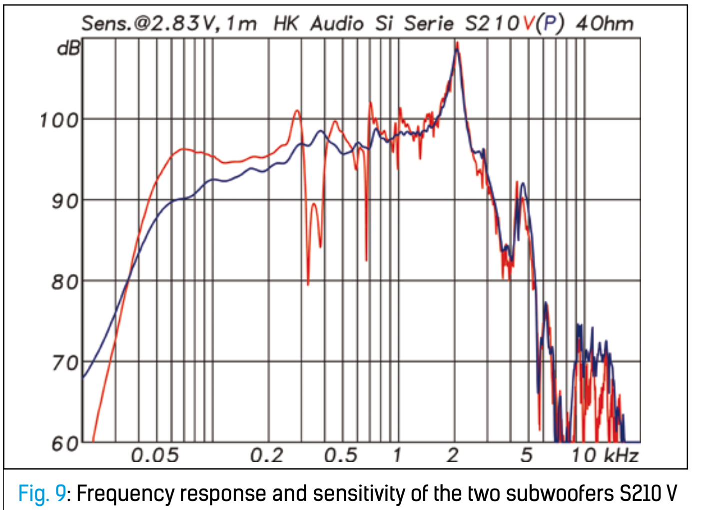

Fig. 9: Frequency response and sensitivity of the two subwoofers S210 V and S210 P in the setting for 4 Ω nominal impedance. The V model with a bass reflex port is clearly louder at low frequencies with an overall somewhat more unstable frequency response.

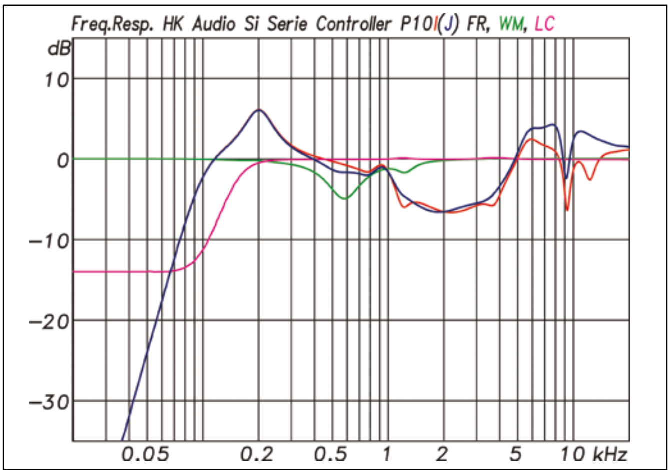

Fig. 10: Frequency responses of the associated Lake controller for the P10 in both versions and additional filters for wall mount (WM) as well as low cut (LC).

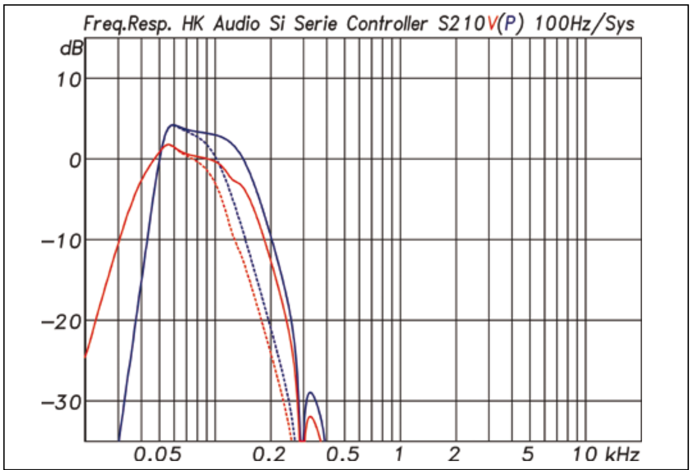

Fig. 11: Frequency responses of the associated Lake controller for the S210 V and S210 P subwoofers

well as classic IIR and FIR filters, this controller offers everything users could wish for in terms of filters.
The power amplifiers themselves operate with a so-called Class-TD circuit.
This is a Class AB power amplifier that does not operate with a multi-stepped supply voltage (Class H circuit), as is usually the case with high-power amplifiers, but is instead supplied with a voltage that is regulated to match the current demand. This regulated voltage in turn comes from a Class D amplifier. Conventional Class AB power amplifiers deliver the best audio quality, but generate considerable losses depending on the load, which can be optimised within limits using Class H technology with stepped supply voltage.
A Class D circuit with so-called pulse width modulation is the best when considering the lowest possible power dissipation, however it has various disadvantages in terms of audio quality. The Class TD circuit patented by Lab Gruppen combines the advantages of Class AB and Class D circuitry while avoiding its disadvantages. A Class D power amplifier operates as a kind of regulated power supply for the actual power amplifier built in Class AB technology, which then processes the audio signal.
As the upstream Class D amplifier provides the downstream Class AB with an optimally suitable supply voltage just above the minimum required value, it always runs at a favourable operating point with low power loss. With this circuitry, the audio signal remains unaffected by the Class D stage.
The PLM 12K44 provides analogue symmetrical inputs with the typical Lake iso-float ground, two digital inputs in AES3 format and a redundant connection for a Dante audio network. A priority list for the inputs can be created using the Lake software so that, for example, the analogue signals can be used as an automatic fallback for the digital signals in the event of a malfunction. The

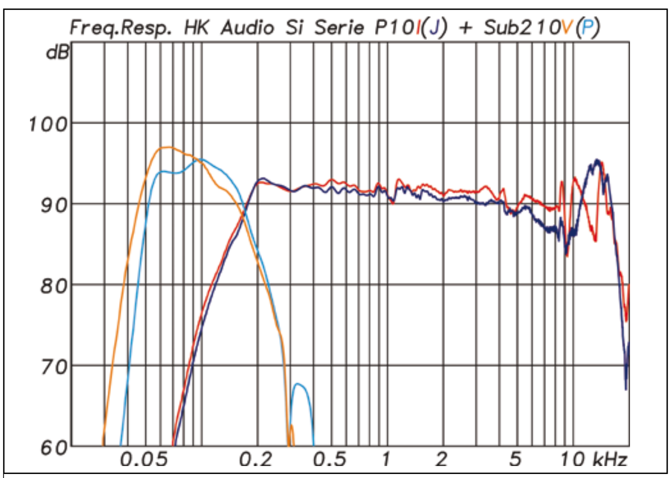

Fig. 12: Subwoofer and tops measured with controller

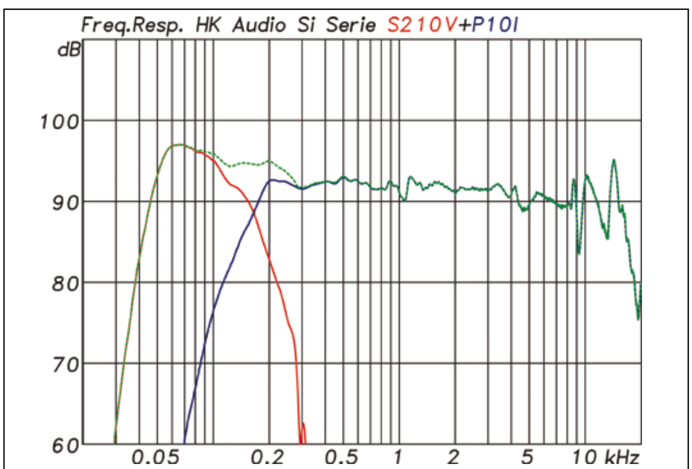

Fig. 13: Interplay of subwoofer and top unit using the example of the P10i and the S210 V

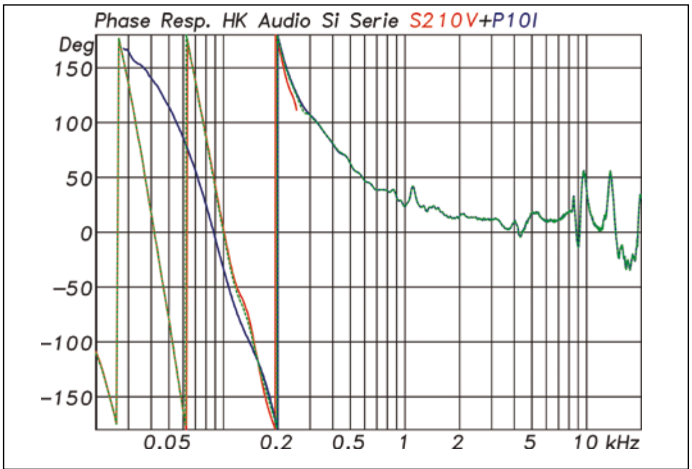

Fig. 14: Phase responses of the combination of P10i and S210 V. In the transition area, the phase position matches exactly.

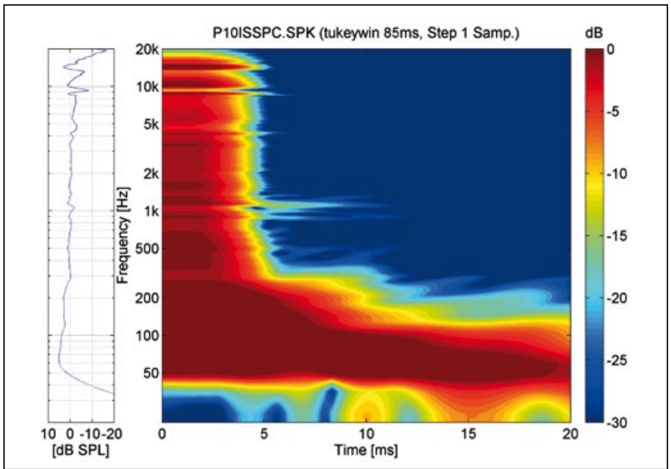

Fig. 15: Spectrogram of the combination of P10i and S210 V. A small resonance appears at 1 kHz. The longer resonance towards the low frequencies is caused by the phase rotation of the X-over and high-pass filters.

network connection between the power amplifiers can be carried out as a star or also via daisy chain. If the Dante network is to be redundant, then double star networking is required.
On the Lake controller, the setups for the SI Series are located in so-called frames, in which complete system setups can be defined. For the P10, filters are available for the i and j version for full range (FR), wall mount (WM) and low cut (LC) respectively. The corresponding measured frequency responses can be found in FIG. 10. There are only slight differences between the setups for the i and j versions above 5 kHz, where the curved P10j needs a little more level in the treble. The wall mount setting lowers the level slightly at 600 Hz, where the proximity of a boundary surface creates an exaggeration. Two customised setups are also available for the two S210 subwoofer versions. FIG. 11 shows the corresponding frequency responses for the V and P versions, each in the "100 Hz" and "Sys" (system) settings. The 100 Hz setup is intended as a universal low-pass filter for combination with any other tops, while the Sys setup with the low-pass filter's corner frequency of 140 Hz is intended for combination with the P10 tops. The differences between the S210 V and S210 P setups can be found primarily below 50 Hz, where the P version with the passive resonators requires a steeper high-pass filtering.

Interaction

FIG. 12 shows how the subwoofers and tops interact with the PLM 12K44 power amplifier, with the frequency responses of the two tops and subwoofers measured via the power amplifier with filtering. The P10 tops are precisely straightened in their course by the filters. There is now only a small deviation for the P10j at high frequencies, where the level drops by about 3 dB in the range around 9 kHz. The cause could also lie in the choice of measurement position, as no clearly defined centre axis can be determined for the curved version.
A slightly different angle can then quickly lead to deviation at high frequencies.
An important aspect of top/subwoofer combina- →

The P10's connection panels in the Low-Z version with Phoenix connections and link socket. After connecting the cables, jet-proof cover plates with two cable glands are fitted.

All P10 and S210 versions (subwoofer here without front grille)

tions is the interaction in the transition area. Both the level ratios and the phase positions must match here, otherwise cancellations will occur in the transition area. FIG. 13 and FIG. 14 show examples of how the two ways complement each other in terms of amplitude and phase characteristics when a P10i is combined with an S210 V subwoofer. The top's and the subwoofer's characteristics intersect at about 160 Hz in this setting. If the subwoofer's level were to be lowered a little, the intersection point in the graph would also be a little lower. The green cumulative curve already indicates that the phase curves will also match in the transition area, which is directly confirmed by the top's and the subwoofer's matching phase curves in the transition area in FIG. 14. In practice, however, one should keep in mind that the phase positions can shift noticeably depending on the placement and position of the top unit and subwoofer in relation to each other. Using delay settings as well as all-pass filters, a correction with metrological support is possible. However, this can be difficult depending on the environment if room resonances also fall into this frequency range.

Whether such a phase adjustment is correct can be tested by simply turning the phase of one of the two ways once. This should result in a deep dip in the frequency response at the crossover frequency.

Accessories and costs

P10i/j Low-Z	849.00 €
P10i/j TR 100V	949.00 €
S210 V	1,199.00 €
S210 P	1,399.00 €
U-bracket for one P10 (incl.)	
Connector plates for two P10s each	40.00 €
Swivel and tilt bracket for one P10	125.00 €
Swivel and tilt bracket for two P10s	315.00 €
Rigging rail for max. three P10s	215.00 €
Pole support	65.00 €
Ceiling mount for max. two P10s	215.00 €
U-bracket for one or two S210s	99.00 €
Connector plates for two S210 each	19.00 €

All prices net plus VAT.

WHAT DOES THE SPECIFICATION OF THE ACHIEVABLE MAXIMUM LEVEL MEAN IN PRACTICE?

When measuring loudspeakers, most positions are more or less clearly defined: impedance, frequency and phase response or even the radiation angle contain clear information and can thus be compared directly with each other. However, the maximum level

Summary

With the new SI Series, HK Audio offers a loudspeaker set specialised for fixed installations. With their directivity, the two top speakers, which are designed as columns with full-range drivers, are also suitable for difficult room acoustic conditions. Their EN54-24 certification additionally allows unrestricted use in voice alarm systems, both indoors and outdoors. A claim that the IP66 protection class classification underlines. To complement the bass range when used for music reproduction, the SI Series includes two almost identical 2 × 10" subwoofers that differ primarily in their IP44 or IP66 protection class. The latter is achieved by using passive radiators instead of a conventional bass reflex cabinet. The SI Series is therefore not only suitable for difficult rooms, but also for outdoor installations in amusement parks, sports facilities and many applications more, where speakers are exposed to the weather all year round. When it comes to the measurements and manufacturing quality, the SI Series plays on an unrestrictedly professional level, a fact that is also reflected in the selection of supplementary electronics from LAB Gruppen, Powersoft or QSC. The SI Series' price list also has a few further pleasant surprises in store: at 849 € net for a P10 and 1,199 € net for an S210 V subwoofer, users will get a lot of solid, high-quality technology for their money – a fact that also applies to the abundant accessories for speaker mounting. •

The SI System with two subwoofers and two tops; below, the S210 P includes the passive radiators behind the covers on the back.

is rather difficult, as this is often specified as an undefined single-number parameter and is therefore difficult to interpret. Additionally, there seems to be a race for ever higher values, which leads to many a dubious numerical value.

For a reproducible determination of the maximum level that is also comparable under practical conditions, we therefore rely on two proven measurement methods for our reviews: firstly, the measurement with sine burst signals and, secondly, the multitone measurement. The first measurement method with sine bursts could be described as a typical developer or laboratory measurement. In this measurement, the level for a frequency is increased with a sine signal until a certain percentage of distortion, typically 3% or 10%, is reached. The sound pressure measured as an average level for the duration of the measurement is recorded as a measured value. This measurement is carried out over a sensibly defined frequency range. Via FFT, the mono-frequency measurement signal enables direct evaluation of the resulting total harmonic distortions (THD). The length of the burst signal can have an influence on the

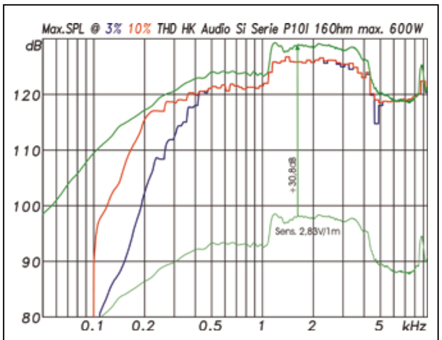

Fig. 16: The P10i's maximum level measurement for a maximum distortion of 3 % and 10 % with sine burst signals. For a maximum of 600 W power at 16 Ω, the sensitivity at 2.83 V results in the green curve indicating the calculated maximum level by a shift of the curve by 30.8 dB.

measurement result if limiters or other protective circuits are involved and intervene within the measurement duration of a burst. On the other hand, in order to evaluate the distortions, the sine bursts need to have a certain length. The lower the sine's frequency, the longer the burst must be to enable a THD evaluation via FFT. For a typical measuring range starting at 40 Hz, a 14-degree FFT has proven itself for evaluation. At a sample rate of 48 kHz with a burst, this results in a total length of 683 ms. If tweeters were measured with this burst length, the limiters could already intervene or, if they do not exist, the driver could be damaged. Therefore, the burst measurement is carried out with adjusted lengths from 683 ms to 43 ms depending on the frequency.

For the curves in Fig. 16 and Fig. 17, this type of measurement was carried out separately for a P10i and for a S210 V respectively. The measured levels are average levels for the duration of the burst signal related to 1 m distance. As a sine signal is used for measurement, the peak level in this case is only 3 dB higher. The measurements were carried out at a distance of 4 m and then calculated back to 1 m according to the 1/r law (-6 dB per doubling of distance). For the subwoofer, an additional correction function was used to compensate for room influences below 100

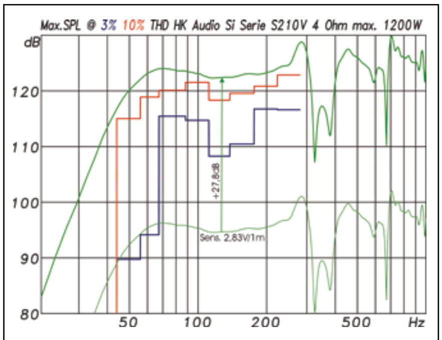

Fig. 17: The S210 V subwoofer's maximum level measurement for a maximum distortion of 3 % and 10 % with sine burst signals. For a maximum of 1,200 W power at 4 Ω, the sensitivity at 2.83 V results in the green curve indicating the calculated maximum level by a shift of the curve by 27.8 dB.

Hz, since the anechoic room no longer functions perfectly here. The limits for the permissible maximum distortion of 3 % and 10 % THD are typical values for loudspeakers, where frequency-dependent weaknesses can be easily recognised. If the two curves for 3 % and 10 % coincide over wide ranges, as is the case in Fig. 16, this means that the limit value was not reached before a limiter or a defined power limit stopped the measurement. The curves' behaviour towards low frequencies is also quite typical. They clearly separate here, as more distortion is created due to the greater membrane excursion. The situation is similar for loudspeakers with compression drivers as tweeters, as the compression chamber causes an increase in distortion quite early on. The latter cannot be observed with the P10, as it is completely equipped with full-range drivers.

So, what do the sine burst measurements tell us? Dips in the curves indicate partial weak points, which do not exist for either the P10i or the S210 V. Furthermore, the sensitivity and the permissible power can be used to calculate how close one is to approaching the mathematically possible maximum level. The figure's two green curves each show the sensitivity curve for 2.83 V and, with the corresponding shift, the resulting calculated curve at maximum power. For the P10i, the maximum power of 600 W at 16 Ω means a voltage of 98 V corresponding to +30.8 dB compared to the 2.83 V. For the S210 V, it is 69.3 V at 4 Ω corresponding to +27.8 dB to the 2.83 V for the sensitivity. If one would like to derive a single value from these curves, then one could specify 120 dB for the S210 V and 123 dB for the P10i.

More relevant in practice is the second method of measuring the maximum level with a multitone signal. The measurement signal used for this purpose consists of 60 sine signals with random phase and an EIA-426B weighting. Depending on the application, other spectral weightings can also be used, for example for a speech signal. The crest factor of the measurement signal synthesised in this way is a practical value of 4 corresponding to 12 dB. A great advantage of this measuring method is the possibility of measuring synchronously and obtaining the signal spectrum directly via FFT, from which all newly added distortion components can be easily analysed. This applies to the total harmonic distortions (THD) as well as to all intermodulation distortions (IMD). The sum of all distortions is then called total distortions (TD). As with the sine burst measurement, a distortion value can also be defined as a limit value for the multitone measurement.

In addition to the distortion components, the power compression can also be evaluated as a second criterion with this measurement. To do this, one starts the measurement series with a low level in the loudspeaker's linear working range, a point at which no power compression occurs. Starting from this value, the level is further increased first in 2 dB steps and later in 1 dB steps. At some point, the loudspeaker will no longer follow these level increases, either in broadband or only in individual frequency bands. The limit value for the power compression was defined as not more than 2 dB in broadband and not more than 3 dB in individual frequency bands.

Fig. 18 shows the evaluation of the P10i's power compression. Starting from the initial value with an average level of 101 dB, the limit value for power compression was reached at +14 dB (green curve in Fig. 18). The spectra measured in the process can be found in Fig. 19. The average level Leq measured in this way is 113.7 dB, while the peak level is 126 dB with -19 dB (11 %) total distortion. Mathematically, without power compression, an Leq of 115 dB would have been expected, which is reduced by 1.3 dB over a wide frequency range due to the 1-2 dB compression.

Based on this measurement series, a complete specification of the maximum level could be: 126 dB peak and 114 dB average level for a typical music signal with EIA-426B spectrum and a crest factor of 12 dB. In short, one could also speak of a peak value of 126 dB. Especially when it comes to voice alarms, the level to be achieved is defined as the average level for a test signal with speech spectrum and a crest factor of 12 dB. A maximum of 3 dB compres-sion has proven to be acceptable.

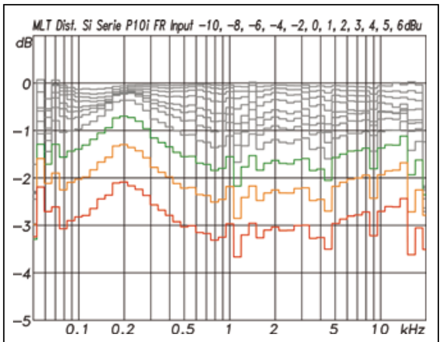

Fig. 18: The P10i's power compression measurement with a multitone signal with EIA462B spectrum and a crest factor of 12 dB. The green curve just fulfils the criterion of no more than 2 dB power compression in several adjacent frequency bands.

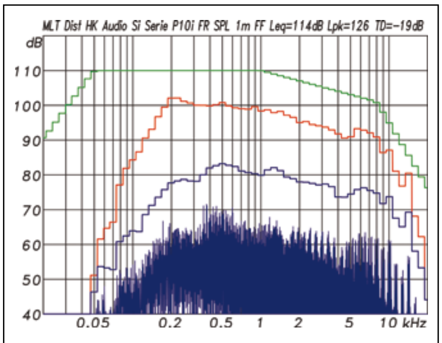

Fig. 19: Spectra derived from the measurement of the green curve in Fig.18 for the total signal (red) and for all distortion components (blue). The green curve shows the multisine signal's spectral composition. The average level Leq measured in this way is 114 dB, while the peak level Lpk is 126 dB. The distortion component is -19 dB (11 %).

Finally, the topic of maximum level raises the important question of how to predict the achievable level with a defined signal, such as speech or music, already in the planning process. Let us again take the P10i and a signal with an EIA-426B spectrum with a crest factor of 12 dB as an example. Fig. 20 shows the maximum level calculated with the EASE-GLL, which is just under 118.8 dB. The GLL's system information states that a maximum voltage of 69 Vrms is permitted for the P10i's Low-Z version. Attention: The 40 Vrms value stated as input voltage in the GLL does not correspond to this, because the controller's filters follow only afterwards in the calculation – and this changes the voltage value.

In concrete terms, this means that if one wants to measure an average level of 118.8 dB, then the amplifier must provide an output voltage of 69 Vrms. For a sine signal, this would not be a problem for the PLM12K44 power amplifier. However, if one has a signal with a much higher crest factor, for example a speech signal or the STIPA test signal with a crest factor of 12 dB, then the amplifier would have to deliver peak values four times as high, namely 276 Vpk. However, not even this power amplifier can do that. The maximum output voltage is 188 Vpk. This means that if one wants to keep the 12 dB crest factor uncompressed, one will not achieve 118.8 dB as the average level, but rather only 115.5 dB. Alternatively, one can accept a signal compression of 3.3 dB in the peaks and can then achieve an Leq of 118.8 dB. However, this calculation does not take into account power compression by limiters, drivers, power amplifiers or the like into account. The previously shown multitone measurement with exactly this signal delivered a maximum of 114 dB as average level, where the 1.5 dB loss due to the power compression is reflected compared to the calculated 115.5 dB.

This all sounds complicated and perhaps a little confusing at first. It is however easy to

Fig. 20: Maximum level of 118 dB calculated with the associated EASE-GLL

understand if one knows the voltage value stored in the EASE GLL as the rms voltage, multiplies this by a factor of 4 to arrive at the peak voltage value required, and then compares this with the power amplifier's actually possible maximum output voltage, also as the peak voltage.

Applied to the P10, this means: one knows the value of 69 Vrms, from this follows a peak value of 276 Vpk. However, the amplifier is only capable of 188 Vpk, which is 3.3 dB too little to transmit the signal uncompressed. Accordingly, one loses 3.3 dB compared to the calculation, from which one subtracts another 1-2 dB to take power compression into account. And the result is the desired value, which should also be achieved in practice. The decisive point here is the amplifier, whose maximum output voltage must be observed and included in the calculation. If, for example, one was to use an IPD2400, which delivers a maximum of 100 Vpk, instead of the large PLM12K44, then the level reduction compared to the calculated value from the GLL would not be 3.3 dB, but rather 8.8 dB.