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3-WAY COLUMN LOUDSPEAKER

# Kling & Freitag PIA M

Photo: Kling & Freitag

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# Kling & Freitag PIA M

It's more than just a column loudspeaker: the PIA M's midrange and low frequency ways can be switched to a cardioid dispersion behaviour in a very analogue way. With vertical dispersion angles of 5° to 25°, the tweeter too relies on a budget-friendly method: here, again, a clever mechanism is at work.

Copy and measurements: Anselm Goertz
Images: Anselm Goertz, Kling & Freitag (1)

There are many different types of column loudspeakers on the market. Ranging from simple passive column loudspeakers with broadband chassis to high-tech DSP column loudspeakers, the range of products is wide – a fact that is reflected both in their respective technical design and price.
As experience shows, one of the most important characteristics that determine whether a sound reinforcement task is successful or fails is not necessarily a loudspeaker's design, but rather its directivity. What all column loudspeakers have in common is their horizontally wide and vertically narrow dispersion angle. But this is pretty much where the commonalities end. Instead one can find simple models with lined-up small drivers as well as DSP-controlled column loudspeakers that, with a lot of technical effort and associated software, can be modified according to the given acoustic conditions. The devices' price range is equally large, ranging from a few hundred euros to sums well into five figures.
Although the advantages of DSP-controlled column loudspeakers, often featuring multi-way technology, are obvious, high costs often present a problem. In the case of fixed installations, one also needs to consider the at times difficult requirements regarding power and network connections.
Kling & Freitag is also familiar with this problem. With the VIDA, the loudspeaker manufacturer's portfolio includes a large and highly complex DSP column loudspeaker. However, the thought arose whether it would not be possible to find a passive solution. While this may not be as flexible overall, it could be suitable for a majority of applications and would accommodate users who do not necessarily need (or cannot install) a DSP version.

## PIA: passive intelligent array

The consequence of these considerations is the PIA M. The "I" in Passive Intelligent Array probably refers less to the loudspeaker in the sense of AI (artificial intelligence) and rather to the development with NI – "natural intelligence". Using the latter, Kling & Freitag's development team has combined all important features needed for good sound reinforcement in the PIA M, even those for acoustically difficult environments.


**Display sample to illustrate the inner** workings with passive crossover (top/bottom) and the central lever on the rear that mechanically shifts the cells of the tweeter module in the dispersion angle

As the "M" behind the PIA type designation already indicates, other sizes such as "S" or "L" will probably be available in the near future.

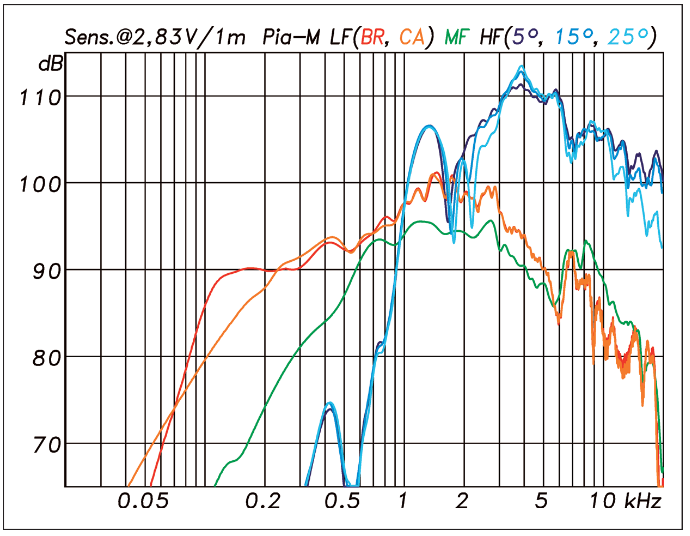
The PIA M is a 3-way system with four woofers, two midrange drivers and four tweeters with passive separation. Each way also has a special feature: the woofers can be operated either as a bass reflex or as a cardioid system, the midrange drivers are also cardioid, and the curve of the small tweeter array with four drivers and waveguides can be mechanically adjusted to allow an asymmetrical dispersion angle of 5°, 15° or 25°. The design of the drivers on the front – with the woofers located on the outside and a midrange/tweeter unit located in the middle – makes it possible to realise the vertically narrow dispersion characteristics over a wide frequency range. The cardioid dispersion of the woofers and midrange drivers also ensures that there is still pronounced directivity at low frequencies even in the horizontal plane. This brings clear advantages especially in reverberant rooms and when a lot of microphones are used on stage.

**Midrange driver with lateral dispersion from its rear side** through a layer of Basotect. The result is a cardioid radiation pattern (image of a prototype sample)

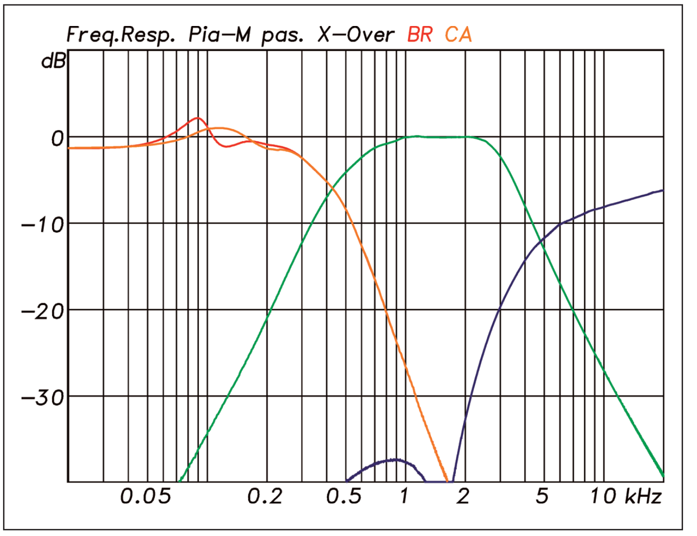
All this is contained in a 1.2 m long, slim column loudspeaker that weighs only 12 kg and that features the very decisive advantage of a purely passive operation. In principle, the PIA M can therefore be operated with any amplifier and, if required, also with a 100 V transformer. However, Kling & Freitag strongly recommends using one of the recommended system amplifiers, as these have already been equipped with suitable setups for the PIA M's various configuration options. The Kling & Freitag's system amplifiers come from the Swedish manufacturer Lab.gruppen, where the PLM+, D and IPX series models are available as K&F versions. Matching the PIA M's power handling capacity and the desired level, the IPX models are likely to be the preferred choice. All this is available in a road-ready version for a pleasingly low list price of €2,680 net. This raises the question of what the PIA M cannot do when compared to a DSP column loudspeaker. For a fair comparison, one should therefore not conceal the fact that the PIA M cannot be cascaded, is not quite as flexible and perfect in beamforming and, of course, cannot form multiple beams. However, for 90% of the usual sound reinforcement tasks with ranges of up to 25 m and a largely flat audience area, the PIA M offers all the desired characteristics.

## Detailed measurements of the three ways

In the measurement lab, we first examined the PIA M's ways separately. For this purpose, the passive crossover was disconnected so that the measuring amplifier could be connected directly to the low, mid and high frequency ways. The ways that were not measured were short-circuited during this measurement, as they would otherwise have acted as resonance absorbers. Fig. 1 shows the frequency responses measured in this way with an indication of the sensitivity referred to 2.83 V / 1 m. The woofers were measured in both modes; it is easy to see that the cardioid mode (orange curve) is accompanied by a noticeable loss in sensitivity below 200 Hz. The midrange unit, also a cardioid system, evenly covers the frequency range from 500 Hz to 5 kHz and achieves an average sensitivity of 93 dB between 600 Hz and 3 kHz. The tweeter consisting of four tweeters was measured for its three settings with dispersion angles of 5°, 15° and 25°. Due to the asymmetrical directivity, the frequency responses shown were measured at angles of 0°, -6° and -10°. At its maximum between 3 and 6 kHz, the tweeter reaches a remarkable sensitivity of over 110 dB,




**The PIA M's frequency response and sensitivity of the three ways;** for the LF way, there are the bass reflex or cardioid options; for the HF, there are vertical dispersion angles of 5°, 15° or 25° (Fig. 1)

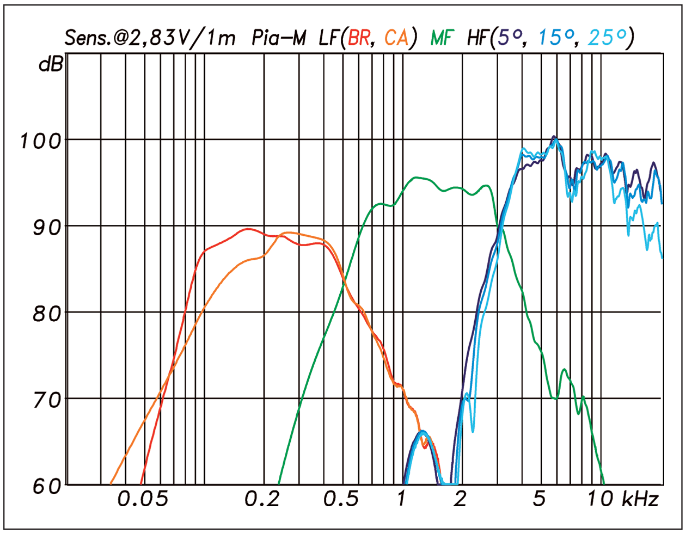



**The filter functions** of the internal passive crossover for the three ways. In the LF path, the impedance feedback causes a small difference in the curves for the bass reflex and cardioid versions (Fig. 2)

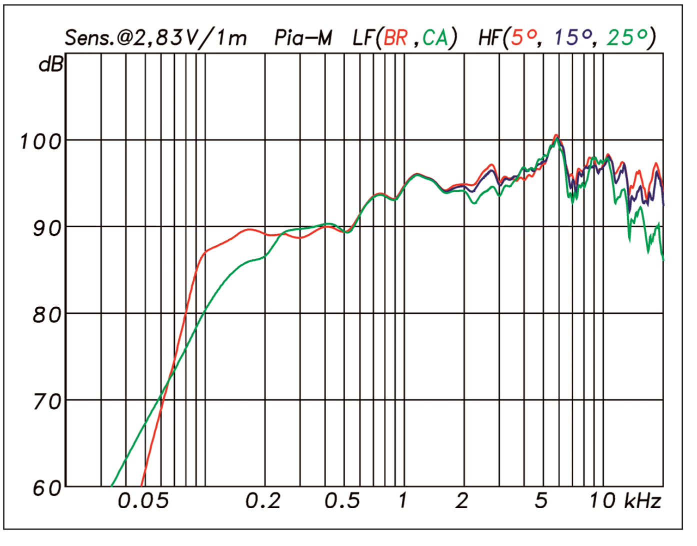
which then drops off more or less evenly towards higher frequencies to 100 dB at 20 kHz.

The PIA M's passive filter is primarily limited to the function of the high-pass and low-pass filters (Fig. 2), without any further equalisation of the individual ways. For the whole system, this is carried out in the system amplifier on the active side.

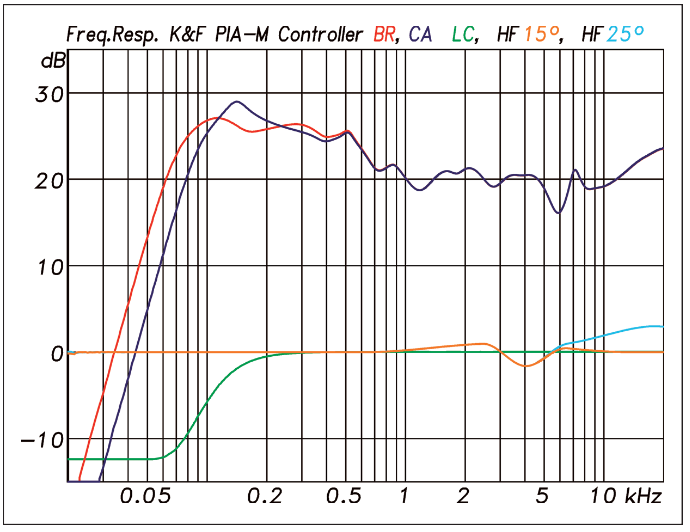
The three ways together with the internal passive filters result in the curves shown in Fig. 3. The crossover frequencies can be found at 500 Hz and at 3 kHz. The sum of the three ways are the overall frequency responses shown in Fig. 4, which shows the curves for the bass reflex and cardioid modes as well as for the tweeter's three settings. Without knowledge of the previous graphs, it would not be possible to identify the crossover frequencies based on the total frequency responses. This is a good indication that the three ways are in phase in the crossover area and add up without cancellations.



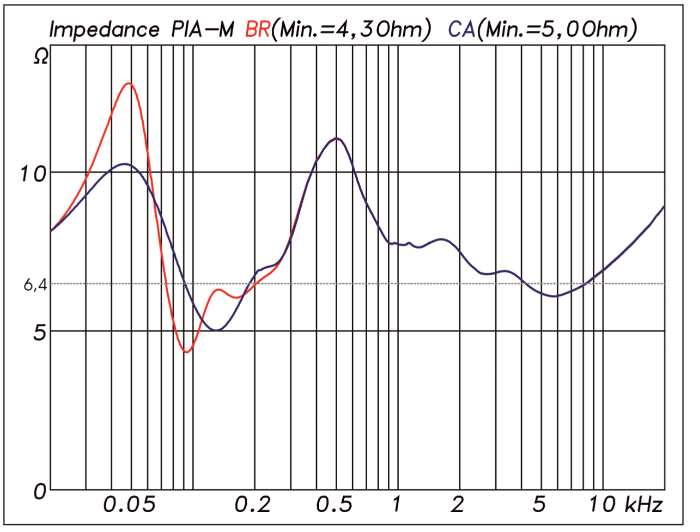

**With internal passive filters** Frequency responses and sensitivity of the three ways measured in the PIA M (Fig. 3)




**The PIA M's overall frequency response** and sensitivity for the bass reflex and cardioid versions and for settings of the tweeter to 5°, 15° and 25° (Fig. 4)




**Filter functions for the associated amplifier** with controller (Fig. 5)



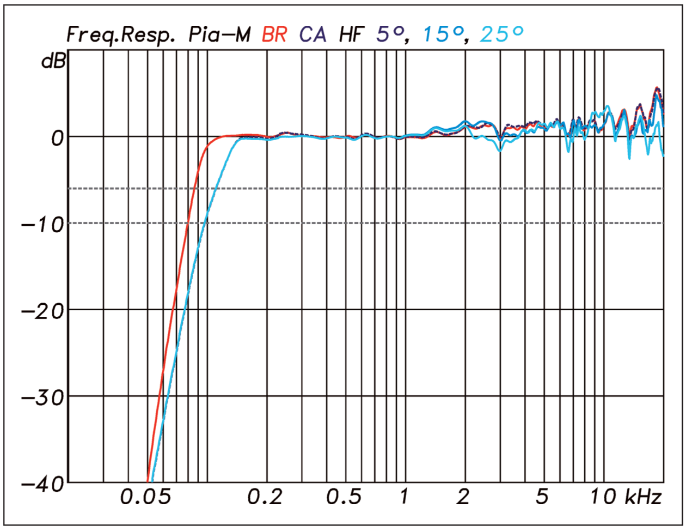

**The PIA M's impedance curves** in the bass reflex and cardioid modes; the relatively low impedance minimum of 4.3 and 5 Ω respectively must be taken into account for parallel connections (Fig. 6).

## Controller and amping

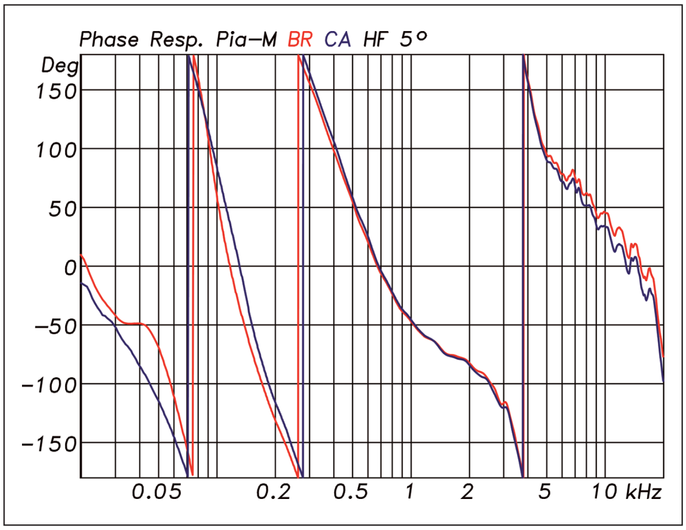
On the associated system amplifiers, there are two basic types of set-ups for the PIA M, one for the bass reflex and one for the cardioid mode. For both setups, there is also the low-cut option, which can be selected in combination with a subwoofer. In addition, overlays can be set in all versions, allowing adjustment in the high-frequency range depending on the respective dispersion angle. Fig. 5 shows the filters included in the controller. The filter for the cardioid mode (blue curve) partially compensates for the level loss at low frequencies, but it also has to kick-in a little earlier for the high-pass filtering to protect the drivers. The low-cut filter (green curve) is a low shelf filter used as an overlay with a -6 dB point at 100 Hz and a maximum low frequency cut of 12 dB. Depending on the dispersion angle, only slight corrections of 2-3 dB maximum are required to adjust the tweeter.

Kling & Freitag recommends operating a maximum of two PIA M in parallel at one output when using the IPX series' smaller system amplifiers and a maximum of three devices with the larger PLM models. Depending on the operating mode, the speaker, nominally specified as an 8 Ω system, shows a minimum of 4.3 Ω or 5 Ω in the impedance measurement in the range around 100 Hz, which – strictly speaking – is not permissible with a nominal impedance of


**Bass reflex system or cardioid** Rotatable cover plate on the rear allows selection of the woofers' operating mode




**Frequency response** measured with controller in the bass reflex and cardioid modes and for tweeter settings of 5°, 15° and 25° (Fig. 7)




**Phase responses with controller** measured in the bass reflex and cardioid modes (Fig. 8)

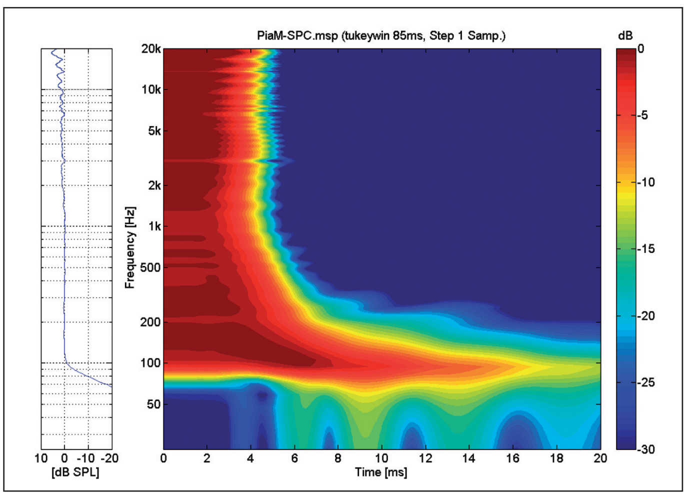
8 Ω. However, it is put into perspective again, as the frequency range where the permissible minimum value of 6.4 Ω is undercut is rather narrow. Nevertheless, this should be kept in mind.

The PIA M is connected either via one of two NL4 Speakon or alternatively via Phoenix connectors.

## Overall measurements

While the discussions above regarding the measurements of the individual ways and their filters were of a rather academic nature, the focus now is on the measurements of the PIA M system as a whole, as experienced by the user. Fig. 7 shows the frequency responses for the two bass reflex and cardioid modes, each with the tweeter set to 5°, 15° or 25°. With an overall very straight line, the lower corner frequency (-10dB) is at 80 Hz or 97 Hz. There is a slight increase of the curves by 2-3 dB towards the high frequencies, which fits well with regard to the expected sound reinforcement distances and the air attenuation at high frequencies.

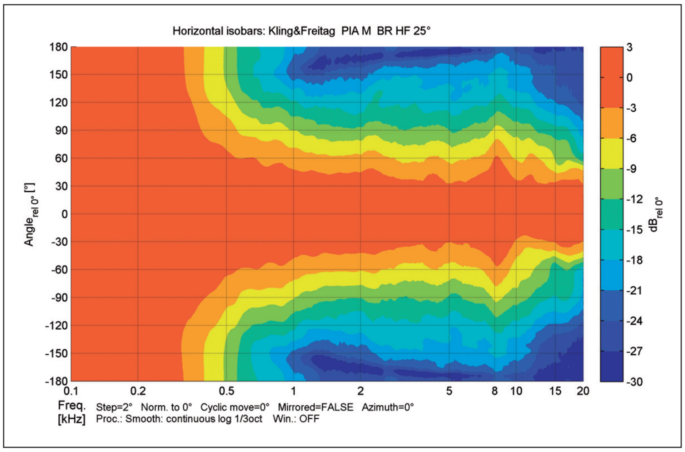
The corresponding phase responses from Fig. 8 show a phase rotation of 3 × 360° over the entire frequency range, which should correspond to the minimum phase component of the filters used. FIR filters, which could also be used to equalise the phase response of the loudspeaker as a whole, were not included in the first development step. However, as the system amplifiers are capable of calculating FIR filters, an implementation with linear-phase modules can be expected in the future. Nevertheless, a look at the spectrogram in Fig. 9 shows that the PIA M achieves almost perfect decay even without phase equalisation. No resonance, no matter how small, can be detected over the entire frequency range. The longer reverberation at low frequencies is caused by the increase in group delay that inevitably accompanies the acoustic and electrical high-pass functions.



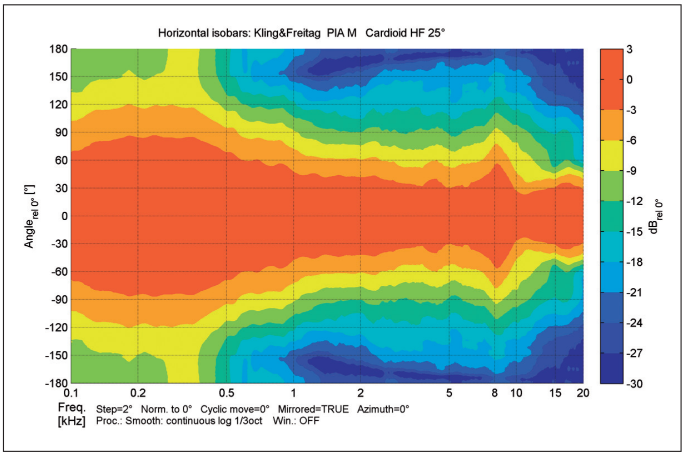

**The PIA M's spectrogram** in the bass reflex mode; the diagram shows perfect decay without any discernible resonances (Fig. 9)

## Horizontal directivity

Let us move on to the topic of directivity, one of the PIA M's most important disciplines. The data sheet specifies a nominal dispersion angle of 100° × 5°-25° (asymmetrical,




**The PIA M's horizontal isobars** in the bass reflex mode (Fig. 10)




**The PIA M's horizontal isobars** now in the cardioid mode; below 500 Hz, the effect of the cardioid principle can be seen very well in comparison to Fig. 10 (Fig. 11)

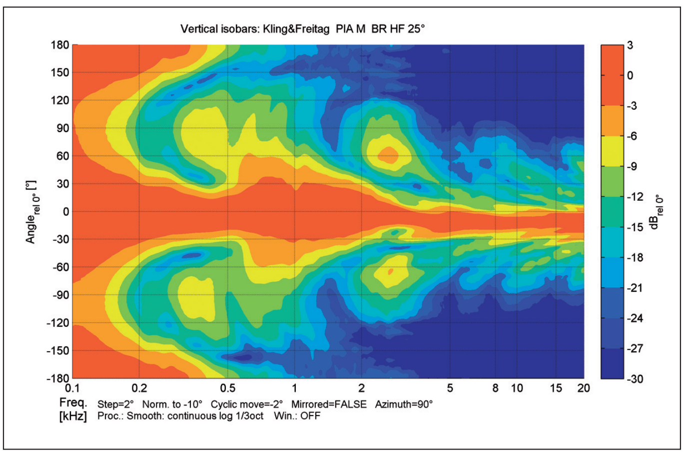
adjustable), which is described in more detail by four graphs with isobars.

In our lab, the isobars for both modes were measured with all of the tweeters' dispersion angles at a measuring distance of 8 m with 2° resolution in high precision. Figs. 10 and 11 display the isobars for the horizontal directivity as a bass reflex system and in cardioid mode, respectively.

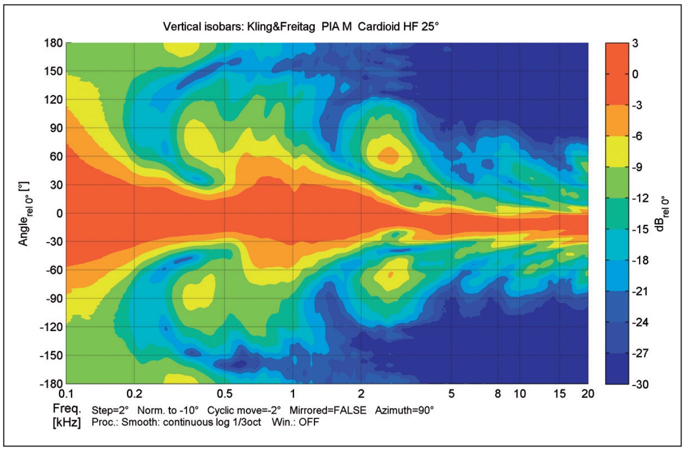
Above 500 Hz, the isobars of both versions are almost identical, as the woofer's mode has no effect here. The midrange unit operates as a cardioid system and the tweeters' horizontal dispersion is defined by their waveguides. If one takes a look at the very even -6 dB isobar lines, one could describe the horizontal dispersion angle as 120° or, further averaged, as 100°, depending on one's point of view. Major differences between the two modes can be identified below 500 Hz, where the dispersion angle widens to 360° in the usual way in the bass reflex version. When operated as a cardioid system, the isobars are clearly different and only widen to a maximum of ±120° even at low frequencies. The rear dispersion at 180° is now attenuated by 12 dB compared to the front, which results in great advantages in acoustically difficult rooms and regarding the tendency for feedback.

## Vertical directivity

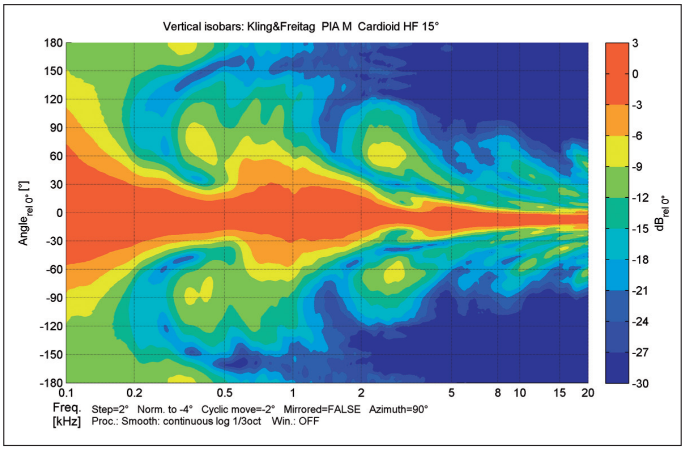
In the vertical plane, the two modes are similar, but not in such a pronounced form. Here, due to the column loudspeaker's length of 1.20 m, there is already a clearly more pronounced directional effect, which is superimposed on the cardioid behaviour. Figs. 12 and 13 show the measurements for both modes in the vertical plane. The differences are most obvious at 180°, where again approximately 12 dB of attenuation can be identified for the cardioid mode. With 60° to 100°, the midrange unit opens a little wider vertically than the woofers and tweeter. Above 3 kHz, the tweeters determine the dispersion angle, which can be adjusted using a small mechanism on the back of the speaker. The pre-set angles are 5°, 15° and 25°. The variable adjustment is made possible by the fact that the four tweeters with their waveguides are constructed similar to a mini line array and their curving can be adjusted via the small mechanism inside the speaker. Kling & Freitag has applied for a patent for this simple, well-functioning method. The graphs with the isobars from Figs. 13



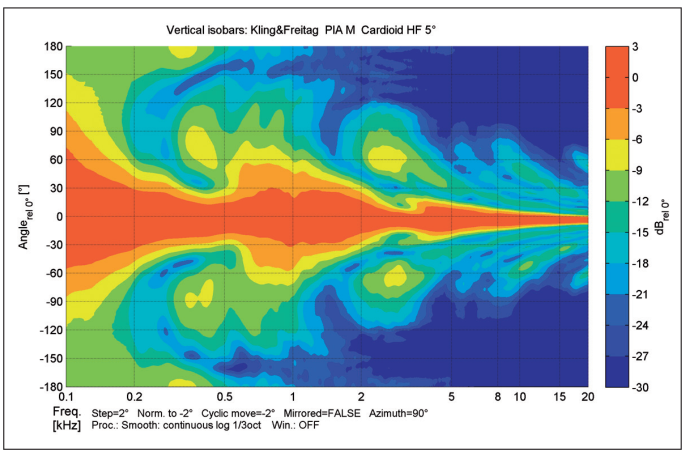

**The PIA M's vertical isobars** in the bass reflex mode with the tweeter's dispersion angle set to 25° (Fig. 12)




**The PIA M's vertical isobars** in the cardioid mode with the tweeter's dispersion angle set to 25° (Fig. 13)




**The PIA M's vertical isobars** in the cardioid mode with the tweeter's dispersion angle set to 15° (Fig. 14)



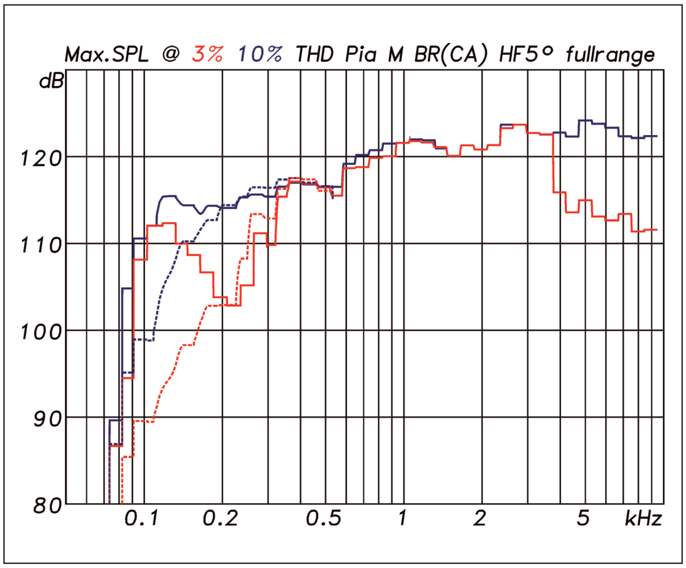

**The PIA M's vertical isobars** in the cardioid mode with the tweeter's dispersion angle set to 5° (Fig. 15)

to 15 show the measurements for tweeter settings of 25°, 15° and 5°, which can be easily reproduced here.

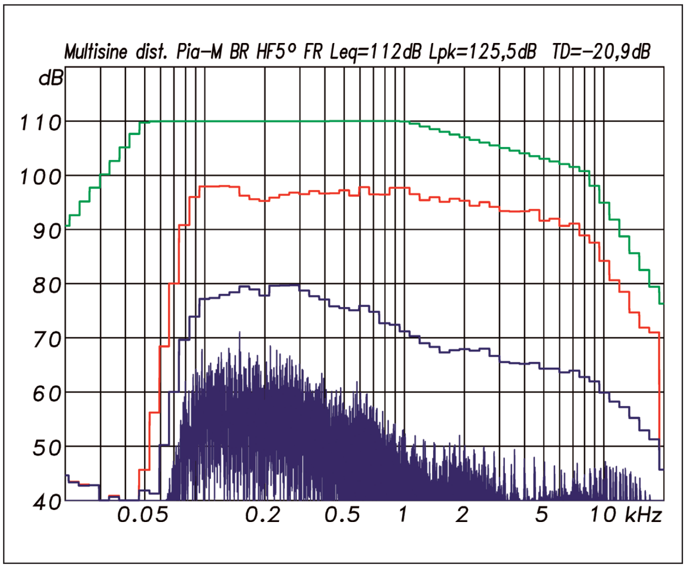
## Maximum level

The first measurements regarding the maximum level were carried out using the sinus burst method. In this measurement, sine bursts with a length of 171 ms to 683 ms are sent to the loudspeaker and the measured sound pressure level is then evaluated for its distortion components. The level and the total harmonic distortions (THD) can be derived from the measurement signal transferred into the frequency range via FFT. The measurement covers the loudspeaker's entire frequency range in 1/6 octave steps, defined here as 70 Hz to 10 kHz. Above said 10 kHz, no more evaluation takes place, as all harmonic distortion components are already outside the audible frequency range then. A burst measurement such as this is a typical lab measurement with which frequency-dependent weaknesses can be easily identified. For the measurement, the measuring system increases the level in 1 dB steps until a defined distortion limit is reached. This is where the sound pressure level is then recorded as a measured value. In our reviews, the distortion limits for this measurement are defined as 3% and 10% for sound reinforcement speakers. The detection of a limiter or a maximum power value can be set as further termination criteria. Fig. 16 shows the sinus burst measurement for the PIA M as a bass reflex and as a cardioid system. In this type of measurement, the PIA M achieves values between 115 and 120 dB in a wide frequency range with an overall balanced curve without weak points. As expected, there are significant differences between the two modes in the low frequencies. Below 200 Hz, the cardioid system's lower sensitivity is also reflected in the maximum level curve. Above 300 Hz, both curves coincide for a maximum of 3% and a maximum of 10% distortion, which is a clear indication that a limiter intervenes and it is not the distortion that determines the value. Where the tweeter sets in, the two curves for 3% and 10% THD diverge significantly again, since typically for compression drivers a high $k_2$ component in the harmonic distortion causes the 10 dB difference. A level increase of 10 dB causes the $k_2$ components to increase by 20 dB.

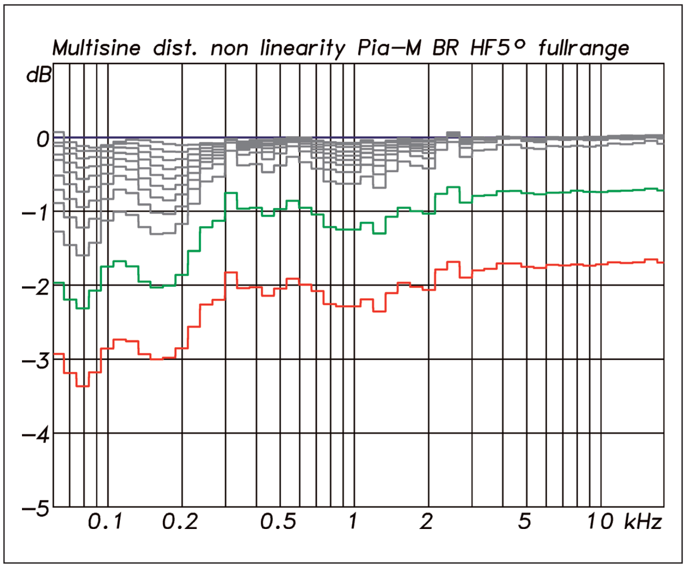
A multi-tone measurement was carried out as a second distortion measurement series for both operating modes. Using a multi-tone signal that has a spectral distribution and a crest factor comparable to an average music signal




**Maximum level** measured with sine burst signals for a maximum of 3% THD (red) and for a maximum of 10% THD (blue). The dashed curves show the cardioid mode (Fig. 16)



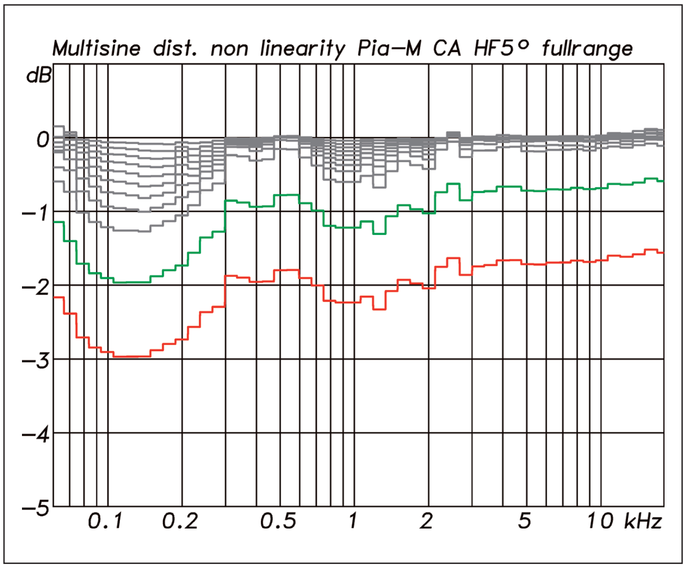

**The PIA M's intermodulation distortion** in the bass reflex mode with a multi-tone signal with an EIA-426B spectrum and a crest factor of 12 dB for a maximum power compression of 2 dB or a maximum of 10% total distortion. A level of 112 dB as $L_{eq}$ and 125.5 dB as $L_{pk}$ is achieved in relation to 1 m in the free field (Fig. 18)



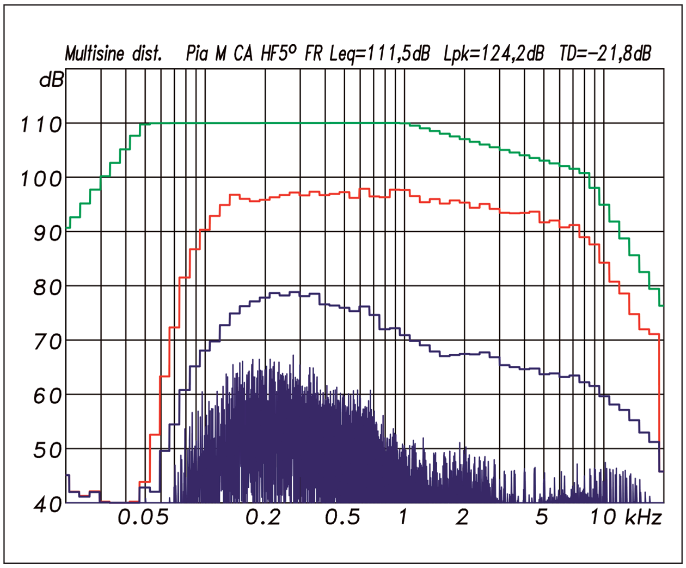

**The PIA M's power compression** in the bass reflex mode measured with a multi-tone signal with an EIA-426B spectrum starting at an average level $L_{eq}$ of 103.1 dB. Based on this reference measurement, the input level was increased by a total of 11 dB in steps of 1 dB. The green curve shows the progression at +10 dB, the red curve at +11 dB. If one allows a broadband power compression of a maximum of 2 dB, then the green curve is the limit. The second termination criterion of a maximum of 10% total distortions is also achieved here. The graph in Fig. 18 was derived from the measurement for the green curve (Fig. 17)

(green curve in Figs. 18 and 20) and starting in the linear working range at just under 103 dB, the loudspeaker is driven at an increasingly higher level, whereby the distortions and the level loss (power compression) are evaluated depending on the frequency. Fig. 17 and 19 show the level loss compared to the calculated value, which results from the starting value plus the level increase. The termination criterion for this measurement is either a power compression of more than 2 dB in several contiguous frequency bands, more than 3 dB in individual frequency bands or a distortion of 10%. Distortions are all components in the measured signal that are not part of the excitation signal. These are total harmonic distortions (THD) as well as all intermodulation distortions (IMD) caused by the multitone signal. Using this measuring method, the PIA M as a bass reflex system achieves an average level $L_{eq}$ of 112 dB and a peak level $L_{pk}$ of 125.5 dB at -20.9 dB total distortion referred to 1 m in the full room. In cardioid mode, the values are slightly lower, however with the somewhat reduced transmission range to the low frequencies.

Fig. 17 and 19 show that the final level limiting is done broadband by a limiter in the amplifier. From the green to the red curve, the input level was increased by 1 dB, which was in turn compensated by the limiter over the entire frequency range.




**The PIA M's power compression** measured in the cardioid mode. The measurement conditions correspond to those in Fig. 17. The graph in Fig. 20 was derived from the measurement for the green curve (Fig. 19).




**The PIA M's intermodulation distortions** in the cardioid mode with a multi-tone signal with an EIA-426B spectrum and crest factor of 12 dB for a maximum power compression of 2 dB or a maximum of 10% total distortion. A level of 111.5 dB as $L_{eq}$ and 124.2 dB as $L_{pk}$ is achieved in relation to 1 m in the free field (Fig. 20)

**Tweeter** as mini line array with mechanically adjustable dispersion angles of 5°, 15° or 25° (image of a prototype sample)

## Audio test

For the audio test, the PIA M was set up in the warehouse located next to the measurement lab. In this realistic environment, it is possible to listen at distances of up to 18 m and, when the roller shutter is open, from even further away. For this purpose, the PIA M was placed freely on a tripod with the lower edge 2 m above the floor and with the tweeter set to 5°. We listened to this set-up in the bass reflex and in the cardioid mode combined with the supplied PLM amplifier set to the respective set-ups.

What was already indicated in the measurement results was fully confirmed in the audio test: the PIA M is sonically excellent – both with regard to speech and to music. It may

**Audio test** and size comparison in the warehouse with a PIA M placed at a height of 2 m (lower edge) above the floor

not have a deep and loud bass, however one does not have the feeling that something is missing, a fact that speaks for a good tuning as a whole. Level and range are very large for a speaker of this size, giving a direct response even at a distance of 15 m. Only at 25 m does the level begin to drop noticeably. In the set-up mentioned here, the PIA M fully covered a range of 2 m to 20 m when viewed from the loudspeaker, and was still deployable up to 25 m. The reproduction remained tonally balanced over the entire length of the room. What is not immediately noticeable at first glance, but therefore remarkable, was the pleasant and precise high-frequency reproduction. Not at any point did it seem unbalanced or intrusive. If one switched the PIA M to cardioid mode, one entered a kind of quiet zone at the height of the box. At the same time, the reproduction in the listening area in front of the speaker became even more precise, as the low-frequency diffuse field in the room was less excited. This behaviour has a very favourable effect especially in reverberant rooms or with critical miking on stage. Overall, the low-frequency reproduction was somewhat weaker in cardioid mode, but was still sufficient for speech and music with little bass.

The listening test, to sum it up briefly, exceeded expectations. The PIA M passed with flying colours.

## Accessories and prices

| | |
|---|---|
| PIA M Low-Z bw or wb | 2,680.00 |
| PIA M 100V sw or ws | 2,895.00 |
| Wall mount | 79.00 |
| Truss adapter set (2 × half coupler) | 65.00 |
| Stand socket M10 | 34.00 |
| Pipe clamp for TV spigot | 219.00 |
| TV spigot | 36.00 |

**(all prices net plus VAT)**

## Summary

When it comes to Kling & Freitag's PIA M, the measured values and the audio test give a consistent impression. This speaker is a successful product in every respect and is also well tailored to the needs of the mobile and fixed installation markets. As a medium-sized column loudspeaker with optional cardioid directivity, the PIA M is suitable for acoustically difficult tasks and – thanks to the wide range of mounting accessories – can be deployed very flexibly. The passive 3-way concept not only offers good sound characteristics, but also enables cost-effective deployment with only one amplifier channel. For the PIA M, the current Kling & Freitag price list lists an amount of € 2,680 net. This should be a good compromise in terms of price and technology between simple column loudspeakers with broadband systems and the DSP-controlled models and it will probably meet the requirements of many potential users. ■