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CONSTANT-CURVATURE-ARRAY

Martin Audio Torus

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Martin Audio Torus

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CONSTANT-CURVATURE-ARRAY

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With a vertical opening angle of 15 or 30 degrees, the T1215 and T1230 from Martin Audio can be adjusted horizontally to 60, 75 or 90 degrees thanks to a sophisticated mechanism. They are suitable not only for horizontal or vertical arrays, but can also be deployed as single systems in stand-alones.

Copy and measurements: Anselm Goertz | Images: Anselm Goertz, Martin Audio

Martin Audio, founded in 1971 by Dave Martin in London, is without question one of the most traditional manufacturers in the pro audio industry. Its legendary and then often copied “bass bins” as well as its “Philishaves” are not only part of Martin Audio’s history, they are milestones of sound reinforcement technology. Numerous well-known bands including Pink Floyd and the Dire Straits relied on equipment from Martin Audio for their major tours. However, the company has by no means rested on the laurels of the past. With ever new and better products, Martin Audio has now been one of the premium manufacturers of professional sound reinforcement technology for 50 years. Products such as the F2, the W8L line array or, more recently, developments regarding beamforming optimisation with the MLA systems and the display software underline the company’s position on the international market. Today, Martin Audio is part of the Focusrite Group, which, in addition to the Focusrite brand, also includes companies such as Berlin-based monitor manufacturer ADAM Audio and Optimal Audio.

12“ woofer with large phase plug; on the right, the tweeter unit with its adjustable opening angle

Two Torus systems The LED on the speaker on the right side is light. This LED can be activated using the Vu-NET software for quick detection of which speakers are connected to the relevant channel

Constant curvature array

At the end of 2021, Martin Audio presented its latest development: the Torus system, at the core of which are the two T1215 and T1230 top speakers, which are complemented by various subwoofers, two system power amplifiers and the corresponding software. The two tops are designed as array components with a fixed angle, hence the designation “constant curvature array”. The motivation for this principle lies in the fact that the constant curvature array is a good middle ground between simple point source loudspeakers and line arrays for sound reinforcement over medium distances. This is exactly what Martin Audio has recognised and the company has therefore widened its portfolio accordingly. Users can create both vertical and horizontal arrays using the two Torus components with their fixed vertical opening and cabinet angle of 15° or 30° – which in turn makes flexible deployment of the system possible. In addition to short vertical arrays for distances up to 30 m, the Torus system can also be configured as a horizontal array for sidefill and monitor applications or as a single system with or without subwoofers.

In addition to the selection of the vertical dispersion angle of 15° or 30° via the speaker type, the Torus also offers the option of setting the horizontal dispersion angle. The tweeter waveguide’s horizontal contour can be adjusted via two knurled wheels each, which can be accessed directly even with the front grille in place.

Users can choose between 30° or 45° for each side respectively, so that angles of ±30°, +30°/-45°, +45°/-30° and ±45° are possible over all. The dispersion angle's asymmetrical settings allow users, for example, to set a larger opening angle towards the inside for audiences located close to the stage. The mechanics on the flying frame are designed in such a way that the overall construction can be symmetrical on the inside with the tweeters on both sides.

Unscrewing the Torus' solid front grille reveals a completely covered front, containing the 12" woofer and two bass reflex ports in addition to the large tweeter unit on the remaining surface. A phase plug has been added to the 12" driver to increase sensitivity in the mid-range, allowing a continuous transition from the woofer to the tweeter unit. A closer look reveals another small detail: there is a white field in a corner between the woofer and tweeter behind which an LED is hidden. This LED can be switched on via the Vu-NET software so that users can immediately see which speakers are connected to which the controller amp's outputs. This display is clearly visible even through the grille.

Torus mechanics and rigging accessories

The basis of the Torus is a wooden enclosure that supports all internal components such as drivers, waveguides, the passive crossover and the connection panel. The plastic phase plug for the woofer and the front part of the tweeter waveguide with the mechanism for adjusting the dispersion angle are mounted on the front. The 2-point flying mechanism is flush-mounted with both sides of the enclosure and can be set by simply folding down the links and then sliding in the rigging pins. Due to the fixed angles, the enclosures are always tightly arranged to each other, so that no third connection point is needed for angle adjustment. The enclosures is 650 mm wide with a height at the front of 369 mm and 350 mm respectively. The T1215 weighs 31 kg, while the T1230 weighs 26 kg.

Martin Audio offers a wide range of accessories for setting up and mounting the Torus. The large T12GRID flying frame can carry up to six Torus units as a vertical

Torus T1215 with integrated flight mechanics

The **opening angle** can be set individually for each side to 30° or 45° degrees via knurled wheels (can also be operated with the grille in place), thus angles of ±30°, ±45° and +45°/-30° as well as +30°/-45° are possible array, while up to three Torus can be operated as a horizontal array by deploying the T12HRIG. For a horizontal array with six units, users therefore need two T12HRIGs. The T12POLERIG allows users to set up a single Torus on a tripod, while the SBAR holder allows flying mounting of a single transversely hanging Torus. For a combination with suspended subwoofers or as a ground stack, users can purchase the T12TRIG transition grid or the T12GSRIG.

The Torus' electrical connection takes place via NL4 connectors with link connection and a switch for selecting the tap on pins 1± or 2±, so that two speakers can be controlled independently of each other via a four-wire cable.

Electronics: iK42/iK81 controller amps

The Torus comes with two controller amps, the iK42 and iK81, which offer four and eight channels respectively. The iK42 supplied for review is rated with 4 × 5 kW at 2 Ω, while the iK81 is rated with 8 × 1.25 kW at 8, 4 and 2 Ω. Both amplifiers originate from Linear Research, where they trade as 44M20 and 48M10. A detailed review of the Linea Research 44M20 can be found in Production Partner issue 4/2016. The iK power amplifiers' integrated controllers feature a large number of input and output filters as well as various limiter functions for RMS, peak and excursion. The limiters can additionally be split into two bands, so that passively separated 2-way systems can also be safely protected. All outputs also feature FIR filters with a maximum of 1000 taps that can be used for system equalisation. However, these are not yet used in the Torus. Power is supplied via a Powercon connection (32 A), whose current consumption can be limited by a current limiter (external breaker protection) for weaker power supplies.

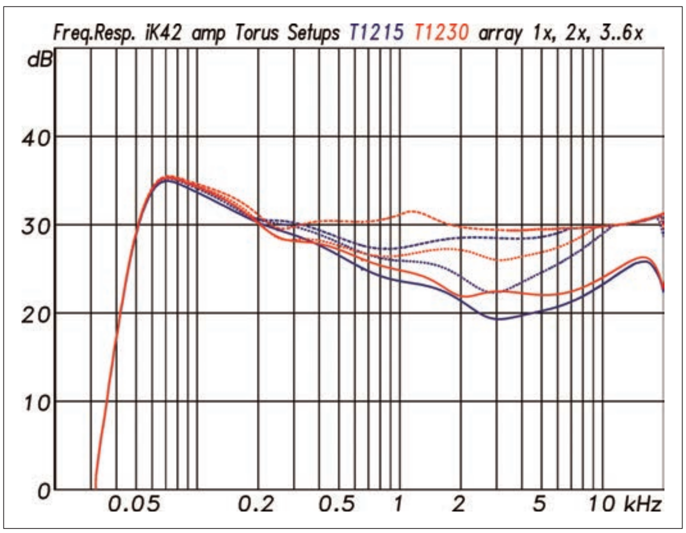
In terms of signal feed, the amplifier offers four analogue inputs, two inputs in AES3 format and Dante with automatic failover. However, due to the current chip shortage, the Martin Audio homepage pointed out at the beginning of 2022 that the iK amps cannot currently be equipped with a standard Dante interface.

For the Torus systems, the controller setups include settings for the T1230 and T1215 (each as a single speaker), for two speakers and for arrays of three to six units (Fig. 1). Per output, the iK42 can drive up to four Torus connected in parallel, however the 2-Ω-immanent problems concerning the cable lengths then have to be kept in mind.

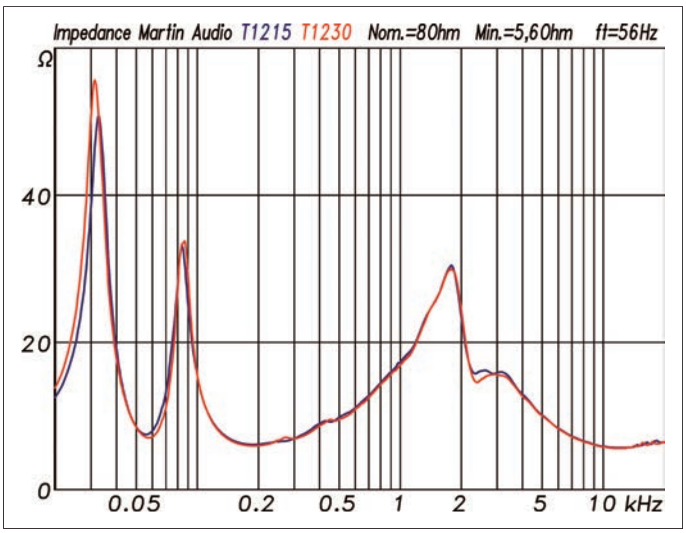
Torus' measurement values

When it comes to measurements, let us first take a look at the Torus without bringing the controller amp into play. Fig. 2 shows the two nominal 8-Ω systems' impedance curves. The impedance minimum is 5.6 Ω, while the tuning frequency is 56 Hz.

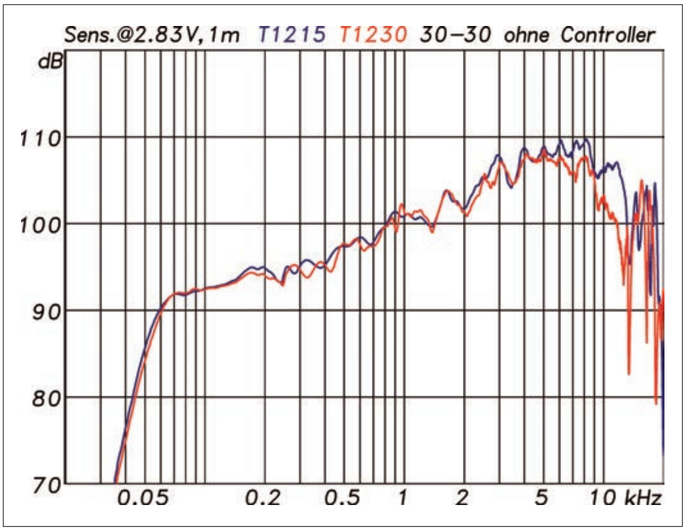
The frequency responses with the sensitivity referred to



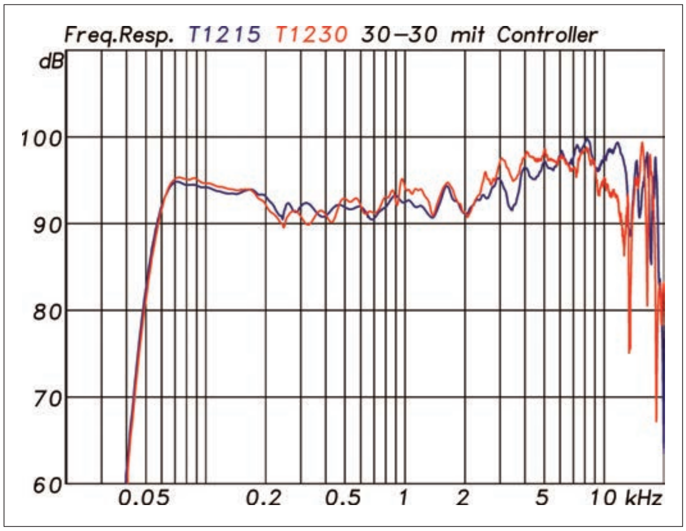
Frequency responses controller amps iK42 for arrays with one (--), two (···) or three to six (---) Torus units, blue = T1215 and red = T1230 (Fig. 1)



Impedance curves of the T1215 (blue) and T1230 (red). The nominal 8-Ω system has an impedance minimum of 5.6 Ω. The bass reflex cabinet's tuning frequency is 56 Hz (Fig. 2



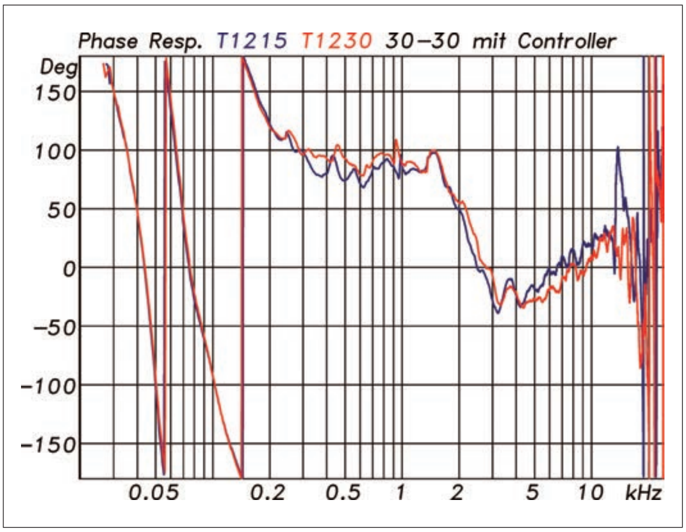
Frequency response and sensitivity of the T1215 (blue) and T1230 (red). The internal passive filter is limited to the pure X-Over function. Further filtering is carried out via the controller (Fig. 3)



Frequency responses of the Torus measured as single systems with controller (Fig. 4)

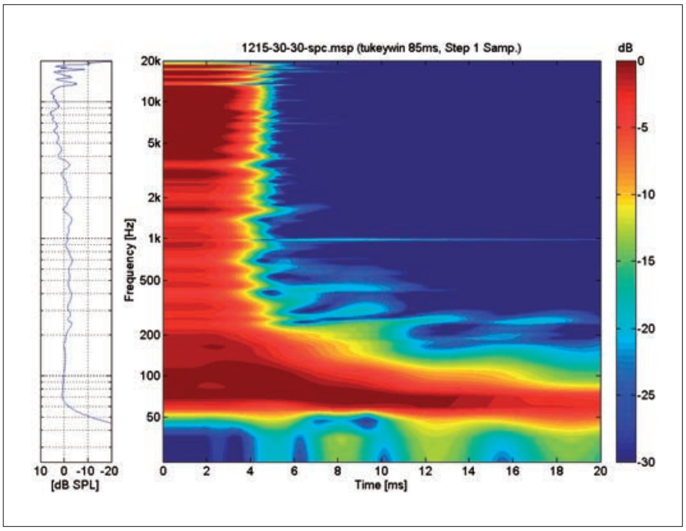
2.83 V/1 m in Fig. 2 show that the internal passive filter is used exclusively for the X-over function and does not perform any further equalisation. The transition from the woofer to the tweeters at about 1.5 kHz is smooth, so that the overall frequency response rises evenly. This is also achieved by the phase plug in front of the woofer, which adapts better to the tweeters' high sensitivity.

Together with the controller amp and the setting for a single speaker, the frequency responses for the two Torus models are as shown in Fig. 4. Overall, there is a slight boost at the edges of the transmission range, which was probably chosen on the basis of a tonal balance. If one prefers a somewhat flatter curve, this can be quickly achieved by a small change to the input EQ. First of all, the corresponding phase response in Fig. 5 shows that the T1215 and T1230 are virtually congruent in this respect, thereby fulfilling an important prerequisite for joint use in an array. At the lower end



Phase responses of the Torus measured as single systems with controller; due to the electrical and acoustic high-pass function, strong phase rotations occur at the lower end of the transmission range (Fig. 5)

Torus T1215 with 12" driver, the phase plug in front and the passive crossover, which contains the components for the high-pass and low-pass filter as well as the small circuit to drive the LED on the front



Spectrogram of the T1215 with an almost resonance-free oscillation (Fig. 6)

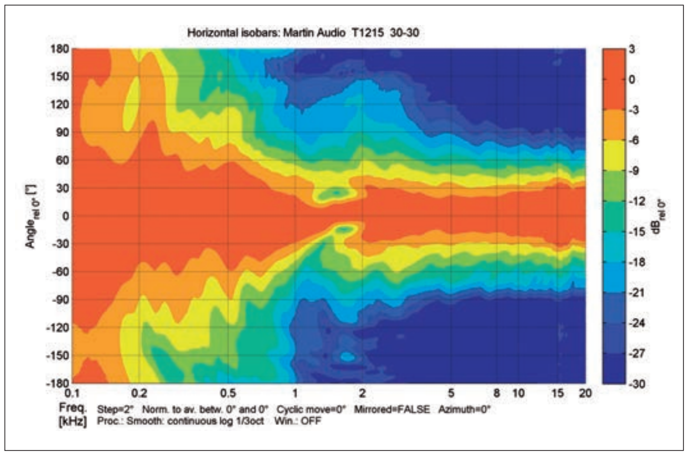
Tweeter unit of the T1215 with three drivers and Y-waveguides

of the frequency range, one can see the unavoidable phase shift caused by the acoustic high-pass filter (bass reflex cabinet) and the additional, with 8th order very steep high-pass filter in the controller. Towards the higher frequencies, the phase response is largely constant, with the exception of the transition from the woofer to the tweeters. Product Manager Dan Orton told us in spring 2022 that the team is currently working on new controller setups in which the FIR filters in the controller's outputs are to correct the phase response at this point.

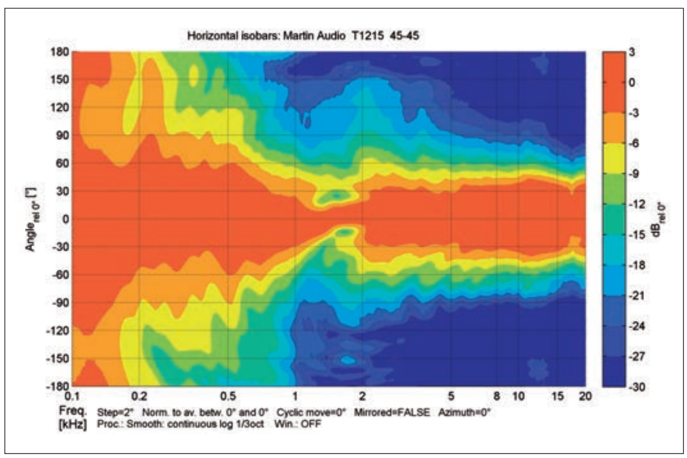
The Torus T1215's spectrogram in Fig. 6 is almost flawless. No relevant resonances can be detected in the oscillation. Only the T1215's spectrogram is shown here as an example for both models.

Variable directivity horizontally/vertically

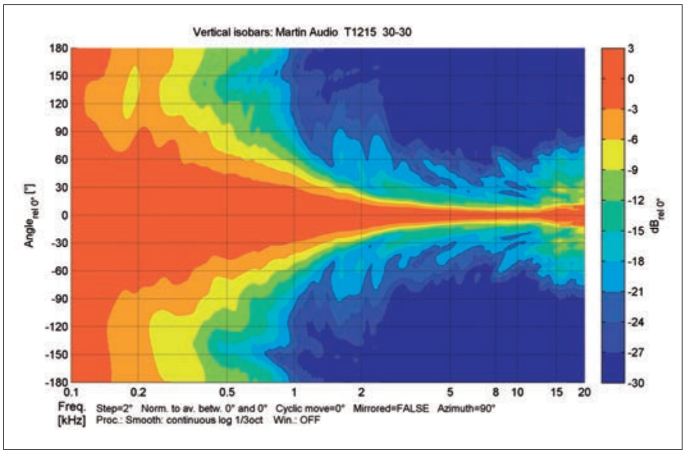
Up to this point, we have only discussed "normal" loudspeaker data, but things get interesting when it comes to directivity, as the Torus system is designed as a line array with fixed curving and also offers variable adjustment of the horizontal dispersion angle. As the two Torus models are suitable for both vertical and horizontal arrays, the first thing that needs to be done when discussing directivity is to determine which plane is the horizontal and which is the vertical. For the following isobar diagrams, we always refer to the speaker in a transverse position in which the woofer is located on the left side and the tweeter on the right side when



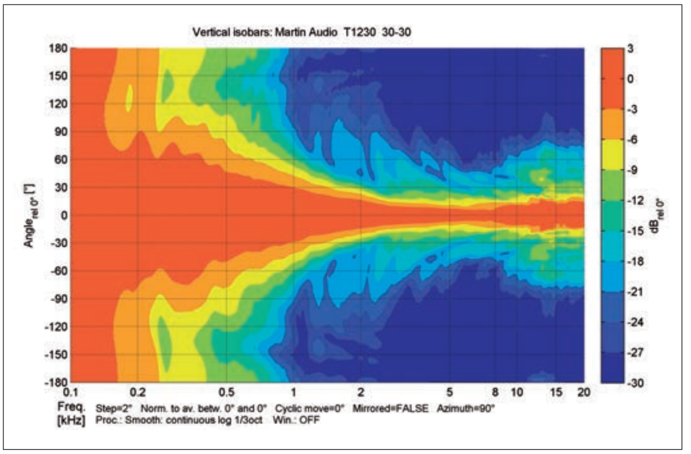
Horizontal isobars of the T1215 in the ±30° setting (Fig. 7)



Horizontal isobars of the T1215 in the ±45° setting (Fig. 8)



Vertical isobars of the T1215 with the narrow 15° opening angle at high frequencies (Fig. 9)



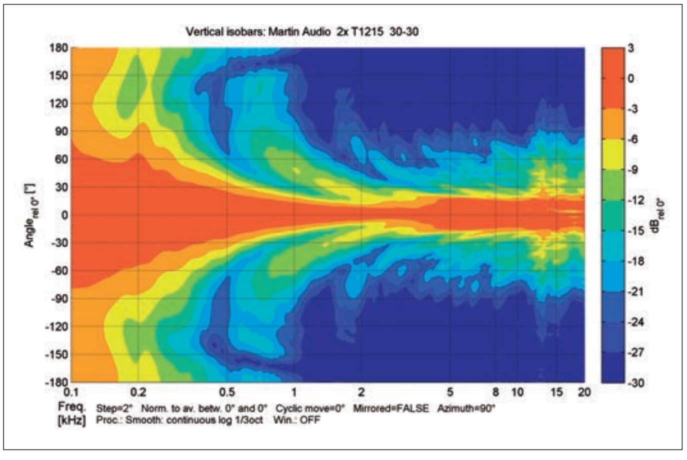
Vertical isobars of the T1230 with an opening angle of 30° (Fig. 10)

viewed from the front. The Torus' tweeter unit operates with three 1" neodymium-driven drivers, each of which initially radiates into a classic Y-waveguide. Arranged one above the other, their exit surfaces then form the line source, whose wavefront is curved to a greater or lesser extent in accordance with the vertical dispersion angle of 15° for the T1215 or 30° for the T1230. The line source then hands over to the horizontal waveguide with its adjustable dispersion angle.

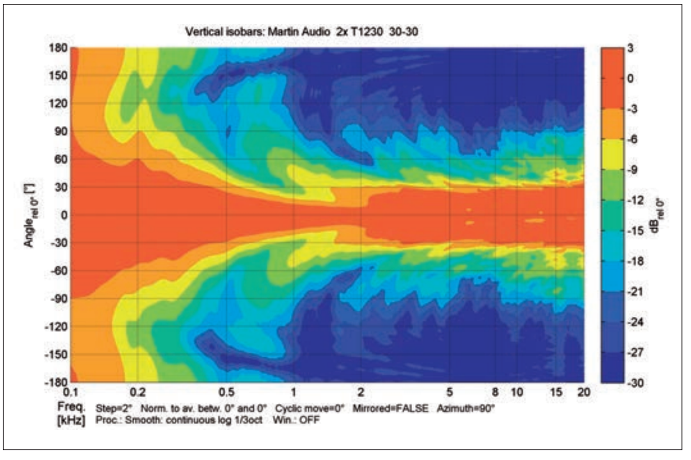
In a first series of measurements, the T1215 was initially measured in the horizontal plane for each of the four possible angle settings of ±30°, +30°/-45°, +45°/-30° and ±45°. Shown are the measurements for ±30° (Fig. 7) and for ±45° (Fig. 8): in both settings, the set dispersion angles are perfectly maintained for the tweeter's entire working range. The same is the case for the asymmetrical settings, which are not shown here. Vertically, the aim is comparable to that of a conventional line array component, in other words, the isobars constrict more and more from the low to the high frequencies – comparable to the point of a needle.

The difference, however, is that in a constant curvature array, the isobars do not peak arbitrarily, but converge to the specified opening angle. For the T1215, this is ±7.5°, while it is ±15° for the TS1230.
The respective isobar curves can be found in Fig. 9 and Fig. 10. In both cases, the desired behaviour is precisely achieved.

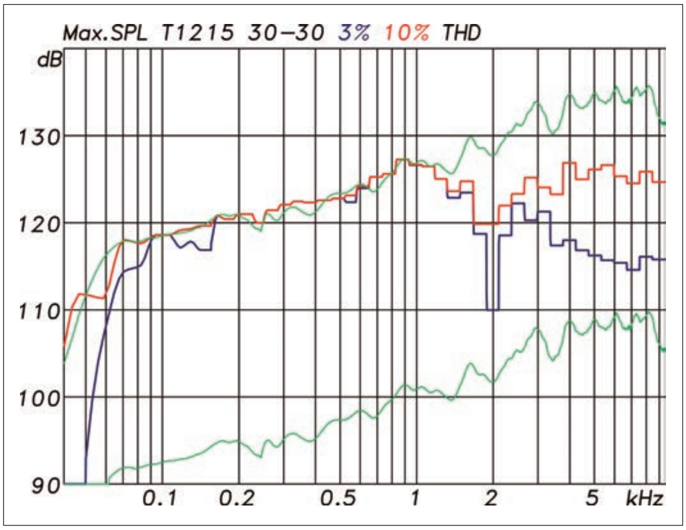
After measuring the single speakers, the question of their behaviour in an array remains – regardless of whether they are operated in a horizontal or a vertical position. For this purpose, two T1215s or two T1230s were



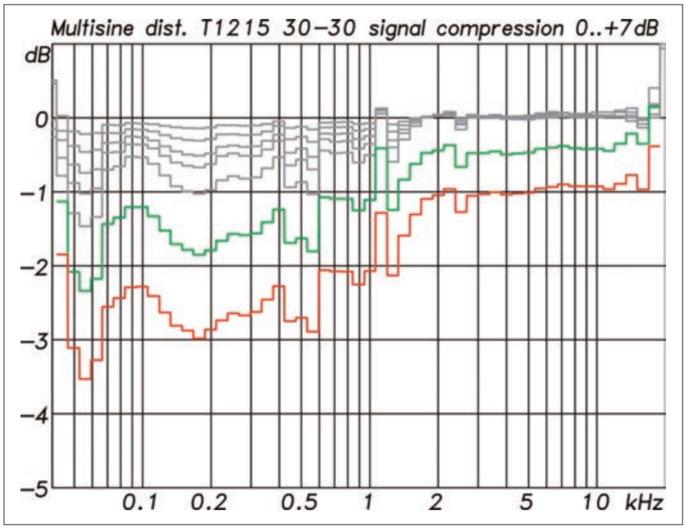
Vertical isobars of an array consisting of two T1215s that together cover an angle of 30° (Fig. 11)



Vertical isobars of an array consisting of two T1230s that together perfectly cover an angle of 60° (Fig. 12)



Maximum level measurement of the T1215 with sine burst signals for a maximum of 3% THD (blue) and for a maximum of 10% (red) THD. The green curves show the T1215's sensitivity at 1 W at 8 Ω and extrapolated also for 400 W (+26 dB) (Fig. 13)



Power compression measured with a multitone signal with an EIA-426B spectrum starting at an average level Leq of 113.8 dB. Based on this reference measurement, the input level was increased in steps of 1 dB up to +7 dB. The green curve shows the progression at +6 dB and the red curve at +7 dB. If a broadband power compression of a maximum of 2 dB is permitted, the green curve is the limit. The graph in Fig. 15 was derived from the measurement for the green curve (Fig. 14)

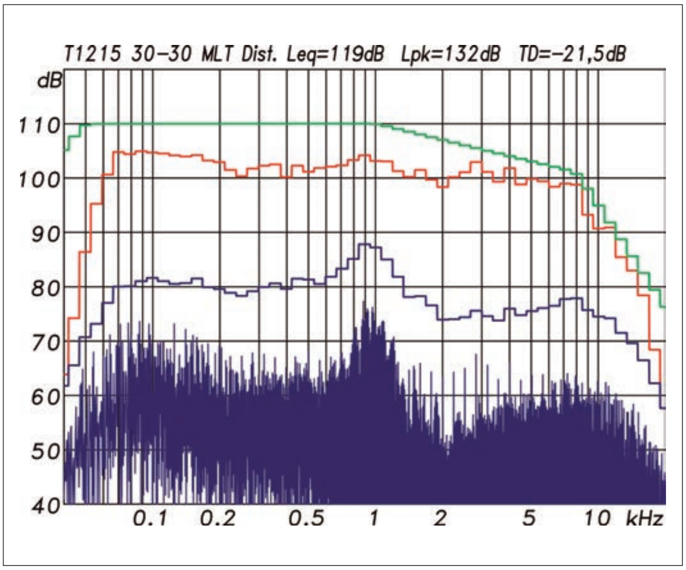
placed on the turntable as a mini-array. The resulting isobars can be found in Fig. 11 and Fig. 12. The tweeter units also interact perfectly in the array. In Fig. 12 for the T1230 array, however, one can already recognise a basic problem, namely that the woofers start to develop increased directivity in the array. This behaviour becomes even more pronounced in larger arrays, where the tweeters cover an increasingly larger range and the woofers simultaneously bundle more and more. The result is a so-called "low mid boom". To prevent this from occurring, it is necessary to control and filter each speaker separately or in pairs symmetrical to the array's centre axis. With the appropriate filtering, a kind of beamforming optimisation can then be carried out for the affected frequency range in order to widen the dispersion angle again. Martin Audio is working on implementing this low-mid beamforming for the Torus system in the display software.

Maximum level

For the maximum level measurements, we initially used the method with sine burst signals. Slightly deviating from the previous procedure, 683 ms long burst signals were used for the frequency range up to 400 Hz and 171 ms long burst signals were used for the frequency range above 400 Hz. The rationale for the longer bursts at low frequencies was the higher resolution with a longer FFT length (fourfold). Fig. 13 shows the result for a maximum of 3% (blue) and 10% (red) distortions. The two curves are largely congruent, which is due to the fact that the 10% THD was not reached, as a limiter in the controller already intervened. Where the tweeter enters, the curves separate, as compression drivers – with their relatively high 2nd order distortion (k2) – reach the 10% THD before a limiter intervenes. At low frequencies, the 10% curve is again significantly higher than the 3% curve, as the greater diaphragm excursion causes greater distortion.

The two additional green curves show the T1215's sensitivity at 1 W at 8 Ω and the extrapolated curve for 400 W (+26 dB). The 400 W value, corresponding to the continuous power rating according to AES specified in the data sheet, was chosen here because the RMS limiter set to this value usually takes effect with sinusoidal signals that are present for longer periods of time. The curve for the achieved maximum level then also largely corresponds to the curve calculated for 400 W. The deviation is greater when it comes to the tweeter, as the limiter has to intervene earlier here due to the lower power handling.

Fig. 15 shows the second maximum level measurement with a multisine signal that has a spectral distribution



Intermodulation distortion of the T1215 with a multitone signal with an EIA-426B spectrum and a 12 dB crest factor for a maximum of 2 dB power compression. In relation to 1 m in the free field, a level of 119 dB as Leq and 132 dB as Lpk were achieved (Fig. 15)

according to EIA-426B for a medium music signal (green curve) and a crest factor of 12 dB. This type of measurement thus reflects a very realistic load. The distortion value measured here includes both the total harmonic distortions (THD) and the intermodulation distortions (IMD) created with this signal. Together, these are referred to as Total Distortions TD = THD + IMD. At 1 m in the free field, the T1215 achieves an average level Leq of 119 dB and peak level Lpk of 132 dB.

In addition to a limit value for the TD, this measurement can also be evaluated based on power compression as a limiting criterion. To do this, one starts a series of measurements with a low level in the loudspeaker's linear working range, at which no power compression occurs. From this value, the level is then increased in steps of 1 dB. At some point, the loudspeaker will no longer follow these level increases, either broadband or only in individual frequency bands. For this measurement, the limits for power compression were defined as not more than 2 dB in broadband and not more than 3 dB in individual frequency bands. Fig. 14 shows the T1215's curves measured and calculated in this way. The grey curves show the deviations from the linear curve that increase as the level increases and then increase rapidly after the onset of the limiter. For the woofer, the 2 dB limit is already exceeded in wide ranges at +7 dB (red curve) compared to the start value. The last measurement result (green curve) that still just complied with the limit was therefore used to determine the maximum level in Fig. 15. The distortion component in this measurement was -21.5 dB. The two limiting criteria with a maximum of -20 dB total distortion or a maximum of 2 dB broadband deviation from linear behaviour coincide very closely here, as is often observed elsewhere too.

All maximum level measurements refer to the T1215. The T1230's results are comparable in principle, but are 1-2 dB lower due to the larger dispersion angle.

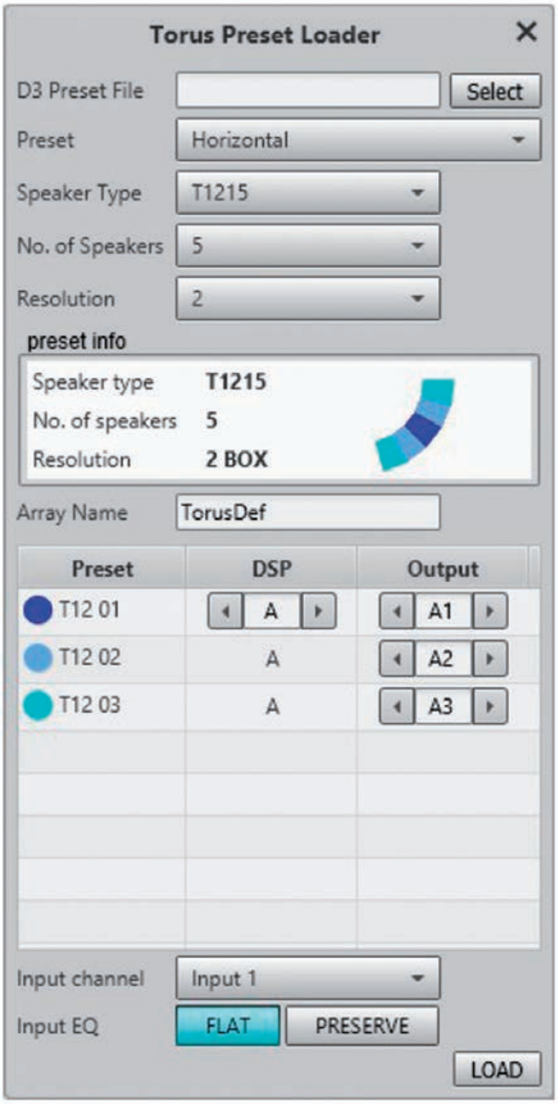
Subwoofer

There are no dedicated subwoofers for the Torus series. From its own extensive range, Martin Audio recommends the SXCF118 cardioid subwoofer to go with the Torus. It contains an 18″ and a 14″ driver and is actively driven via two amplifier channels. The SXCF118 is flyable and has a width of 650 mm, which matches the Torus. The Torus system can be flown directly below the subwoofers using the T12TRIG transition frame. In the case of a ground stack, the SXCF118 can also be used as a base on which arrays with a maximum of three Torus units can be built using the T12GSRIG frame. A detailed review including measurements of the SXC118 (the non-flyable version of the SXCF118) was published in Production Partner issue 2/2020. Other subwoofers for possible combination with the Torus series are the SX118 and the SX218 with conventional 1 × 18″ or 2 × 18″ configurations.

Vu-NET and Display software

The Torus system comes with two powerful software packages: the Vu-NET and the Display software. These can be used not only to operate and plan the Torus system, they are also suitable for further Martin Audio products. Vu-NET is the software belonging to the controller amps, with which users can load and operate the appropriate configurations into the amplifier. The setups are managed via drive modules and above that in module groups.

The Display software has been available for planning Martin Audio systems for quite some time, and is currently available in its third generation as Display 3. Version 2.3.3, which was presented in Production Partner issue 2/2020, has been extended to now include a threedimensional display in version 3, so that the level distributions over the complete audience areas can also be calculated three-dimensionally. A detailed description of the new Display 3 software would, however, go beyond the scope of this article and will be covered in a separate article. As of spring 2022, Martin Audio intends to add the option for EASE data to export an XGLC file from D3 for a generic Torus GLL. Unfortunately, this was not yet been implemented at the time of writing, but Martin Audio is working on this function for a future D3 update. Internally, a beta GLL with all configurations is available. While it is not yet 100% precise, it does allow Martin Audio to work on projects if needed.



Pre-set example Vu-NET for operation of a horizontal array consisting of five T1215s that are controlled via three power amplifier channels (Fig. 16)

Prices

T1215 bw or wb	3,510 €
T1230 bw or wb	3,510 €
IK42-Dante 4 Ch power amplifier	7,605 €
IK81-Dante 8 Ch power amplifier	8,991 €
SX118 1 × 18″ subwoofer	1,872 €
SXC118 1 × 18″ 1 × 14″ cardioid subwoofer	3,475 €
SXCF118 SXC118 flyable	4,973 €
SX218 2 × 18″ subwoofer	3,101 €
T12GRID for max. 6 Torus ver.	1,404 €
T12GSRIG max. 3 Torus ground stack	1,404 €
T12TRIG transition frame ver.	936 €
T12PB pull-back ver.	585 €
T12HRIG for max. 3 Torus hor.	234 €
T12SBAR 1 × Torus landscape	176 €
T12POLERIG 1 × Torus stand	257 €
T12FC Flight Case 2 × Torus	1,463 €

Summary

With the Torus series as a constant curvature array, Martin Audio complements its portfolio and thus closes an existing small gap in its range between its classic point-source models and its line arrays. In order to be able to use the Torus system as flexibly as possible for horizontal and vertical arrays, as a single system or in a ground stack, a wide range of easy-to-use accessories have been designed and the loudspeaker itself has been developed in two versions as a 15° and 30° system. Furthermore, the horizontal dispersion angle can be quickly and easily adjusted to 60°, 90° and asymmetrical 75° via two knurled wheels on the front. In addition, the Torus features a number of other practical details, such as recognition of speakers assigned to an amplifier output via LEDs in the speakers or the NL4 sockets' switchable pin assignments. The flight mechanics are fully integrated and elegantly implemented flush with the sides. The operation of the flight mechanics is just as easy. Complementing the speakers are the well-equipped and powerful iK controller amps with the associated Vu-NET software for system management and the Display 3 software for system planning. All in all, this is a well-rounded package that offers users all the necessary tools at a fair price. ■