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- In the hi-tech-equipment of the Diskothek **JollyTime**®, Brunswick
- In the installation of the Escape 3D Cinema **Sunbeam**, Hongkong
- In the monitor loudspeakers of **MBS Film Studios**, Hongkong
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MUNDORF®

MUNDORF EB GMBH
Liebigstr. 110
50823 Cologne
GERMANY
mundorf.com
info@mundorf.com

MUNDORF® AMT®

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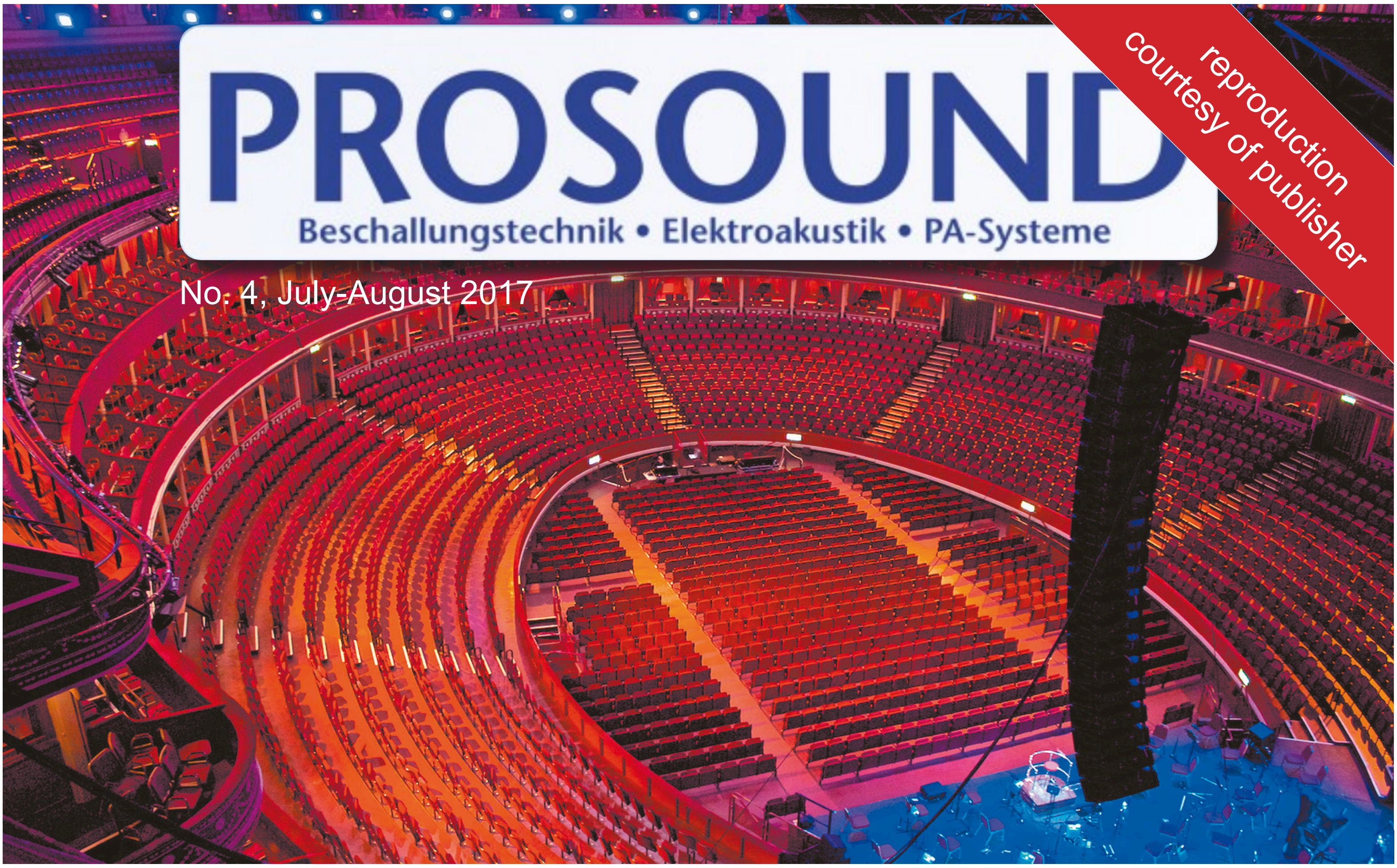


Natural Sound

Sound Reinforcement for the Royal Albert Hall with Mundorf ProAMT

Dieter Michel

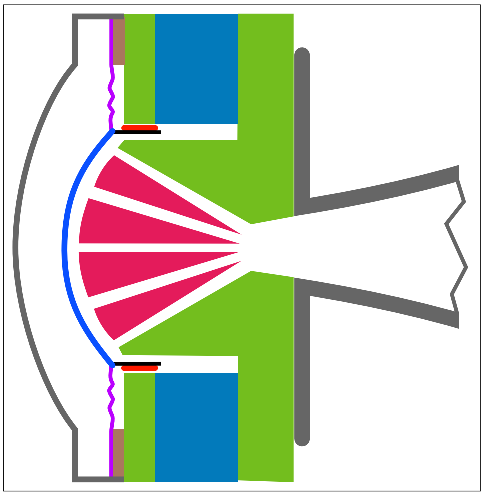
One of the greatest challenges for modern sound reinforcement technology is to make everything sound natural, even if the acoustic conditions of the venue conflict this objective more or less strongly. At its best, listeners asked about their impression of the sound will have found everything completely normal and inconspicuous and perhaps even be surprised about the question. Perhaps they will assign positive impressions about the sound to the artists involved, the orchestra or the choir - even though these would be virtually unheard without electro-acoustic support. In addition, there are of course also concert venues, which live on the characteristic sound of the sound system - for example, rock concerts, where, apart from the voice, acoustic instruments are virtually unused and from which a real large-scale PA sound is expected. However, this article deals with a sound system concept for venues of the aforementioned type, for which the priority is to provide support that is as natural and undistorted as possible for human voices, acoustic instruments and orchestras. The trigger for the following report was a visit to the ProLight+Sound trade fair stand of Mundorf and the opportunity to gain a personal impression of the sound quality of the professional version of the Mundorf Air Motion Transformer (ProAMT) at a performance of "Swan Lake" with the English National Ballet and its orchestra.

A natural reproduction of the human voice and acoustic musical instruments with loudspeakers is absolutely feasible. Manufacturers of studio monitors are happy to confirm that while the development and construction of loudspeakers that sound really neutral is not a walk in the park, neither is it impossible. Users will also agree, at least as long as the tasks is to provide that sound for a only a handful of people in a control room with carefully planned acoustics. But if it is 5000 people, not five, and the room is not actually built to provide electro-acoustic support, then things look very different. Firstly, the loudspeakers used for such a purpose must provide enough acoustic power to be able to sufficiently serve the public. Secondly, they must radiate the sound in a defined way to avoid any undesired stimulation of acoustically unfavourable room structures.

As a minimum standard, most professional sound systems use horn systems for the mid and high ranges and are often used nowadays in the form of line arrays. While these are not universal tools, they have proven their worth in many theatres and venue halls.

Modern horn/driver combinations have the advantage of both a high degree of efficiency and a defined radiation pattern, which can be designed to meet the requirements of the application using modern horn constructions. So, everything's ok then?

The problem is that even with a good horn system, you can sometimes hear that a loudspeaker is being used during the reproduction of voices and acoustic instruments. That is in no way to say that the sound is poor in any way, or that anything can be criticised really. On the contrary, the sound can actually be considered good it is only that you can hear that a loudspeaker is being used.

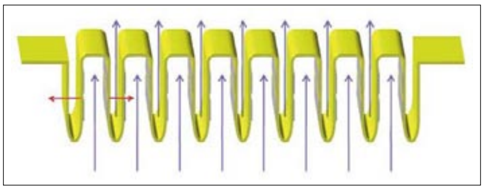


Cross-section of a typical compression driver with flange-mounted horn

For a lot of venues even very demanding ones this is ok. It's also not like that sound designers and sound engineers would complain continually about the imperfect quality of the loudspeaker system. However, there are events, for which the natural sound of voices and acoustic musical instruments is very important, during which you would not want to hear that a loudspeaker is being used.
Among others, critical events include classical concerts with large orchestras or a lower number of individual acoustic instruments. In a classical concert hall or opera house, electro-acoustic support would naturally be unnecessary because the built-in acoustics will provide a good sound. But when the concert is taking place in a room, which is too large or unsuitable for a purely acoustic orchestra, there is often no way round using a loudspeaker. However, when the demand for naturalness is very high, it can be difficult to avoid a to put it bluntly "loudspeaker sound" with conventional PA equipment. This can be partly down to the fact that modern sound systems work with compression drivers, which have part of the set of promlems discussed here virtually built-in in principle.

Compression Driver

A normal compression driver gains its high degree of efficiency from the said "compression". It has a diaphragm with a diameter of perhaps 10cm, which is comparably large for a tweeter, but does not radiate the sound directly. Instead, it works into

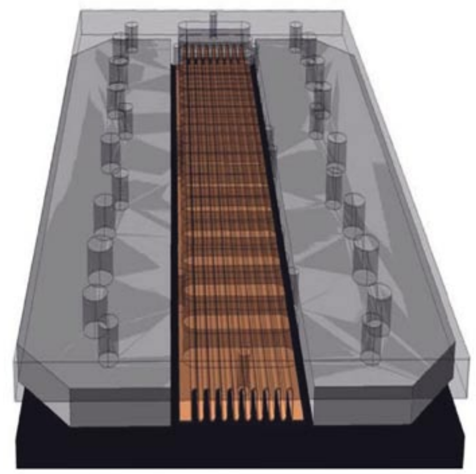


Cross-sectional view of the folded membrane of an AMT: the Lorentz force caused by the current flow (here vertical to the paper level) and the (vertical in this top view) effective magnetic field moves the membrane folds in a horizontal direction the flanks are pressed together and away from each other alternately (red arrows) thus creating an air movement (black arrows).

a pressure chamber, which has a significantly smaller sound exit opening, typically 1" (25.4mm) but often now also 1.4" (35.6mm) because this is far more suitable for shaping the radiation pattern properly together with the adjoining horn than a large diaphragm radiating directly into the horn. As the diaphragm in the high frequency range is no longer small in comparison with the wavelength, the pressure chamber is filled with a phase plug, which only enables defined sound paths to the sound exit opening, for example in the form of circular channels. The diaphragm is almost in direct contact to the phase plug the air gap may be only 1 mm. The channels in the phase plug have a considerably smaller opening than the surface of the diaphragm. This means that a given diaphragm velocity leads to a higher sound particle velocity in the phase plug (velocity transformer). It is higher by a factor, which corresponds to the area ratio of the membrane surface to the opening of the channel in the phase plug and is termed "compression ratio". With a 1.4" driver, the compression ratio is normally in the range of 7:1.
The advantage of this compression is that the driver membrane "sees" a considerably higher radiation resistance as compared to direct radiation into a horn which in turn means a high degree of efficiency. In theory, this can amount to up to 50% - in practice, the achievable efficiency is lower, more around 30%.

No Light without Shadows?
No Light without Shadows!

Unfortunately, this operating principle is not completely without problems. One of



Structure of the Mundorf ProAMT the top pole plate is drawn transparent to make the installation of the membrane clearer.

the potential problems is extremely fundamental and is caused by thermodynamics. In the compression chamber, the air is very rapidly compressed and expanded by the diaphragm this is known as an adiabatic change of state. Now, the fact is one has to say: unfortunately that the relationship between pressure p and volume V in the case of adiabatic change of state is not linear. Instead, the following relationship is valid:

$$p \cdot V^{\kappa} = \text{const.}$$

Even a sinusoidal change in volume, created by the membrane in the compression chamber, does not lead to a sinusoidal pressure course at the sound exit opening, because the air itself is not linear.
In the case of small pressure deviations, the effect is a lot smaller than with large deviations, meaning that other non-linearities come to the fore with a loudspeaker which radiates directly. In the compression chamber of a compression driver, very high acoustic pressures occur, meaning the non-linearity of the air is practically the main source of non-linear distortions. With drivers with lower compression ratios and horns with a greater flare rate, the zone of high acoustic pressure is smaller and the distortions are lower.
However, there is a conflict of objectives when it comes to system design, as a low compression ratio and high lower limit frequency naturally collide with the aim of

covering the largest possible range of frequencies with a high level of efficiency. So a compromise must always be found.
Speaking of a large frequency range: another potential problem in compression drivers, which can sometimes be dealt with using suitable materials and constructions, is the fact that it is actually a mid range speaker.
The diaphragm of a compression driver is normally low tuned. This means the resonance frequency is below the operating frequency range. This means that the vibration characteristics of the diaphragm are predominantly defined by the membrane mass known as mass control or mass breakup. With a loudspeaker, that emits directly, this means the diaphragm can decreasingly follow the driving force due to its mass inertia the higher the frequency is - this results in a decreasing membrane excursion with increasing frequency. With a direct radiator, this effect is compensated by the radiation resistance increasing in reverse with the frequency, so that the frequency response remains more or less constant in the frequency range of operation.

However, due to the flange-mounted horn, a compression driver works onto a more or less constant radiation resistance, which no longer compensates the frequency-dependent influence of the diaphragm mass. Due to the strong damping effect caused by the high radiation resistance, the frequency response in the mid range is reasonably flat. However, in principle, a 1st order low pass is created. Its cut-off frequency is defined by the diaphragm mass and the strength of the drive and will be located around 3.5 kHz in the case of modern drivers. You can either use electronic equalisation here or devise measures to at least alleviate the effect of mass breakup. Expanding the frequency response is part of the high art of driver development. Normally, developers move towards using at least an overtone of the driver diaphragm and/or suspension to expand the frequency response. Another solution is to divide the frequency range and emit the sound from two membranes in a co-axial driver configuration.
The bottom line is that with compression drivers, you will always have to deal with

Mundorf ProAMT with backward chamber and without horn

non-linear distortions in the compression chamber due to the principal non-linearity of the air and with bandwidth limitation. Unfortunately, there is another effect of driver diaphragm size: the sound emitted by the diaphragm does not pass completely through the nearest channel of the phase plug. Instead, it propagates in the gap between the phase-plug and the diaphragm. As a result, sound propagation paths of different lengths are created, which express themselves in a certain smearing of the impulse response and cannot be completely removed by an equalising filter (also FIR) [1].
All these effects can be alleviated by a sophisticated construction, but not completely eliminated. This is the point at which other concepts for high frequency sound production take up which claim not to have these previously mentioned potential problem zones and can, for this reason, supply a natural high frequency reproduction.
One such concept is the Air Motion Transformer (AMT). Its operating principle is similar to that of a magnetostat, while having special construction characteristics which should provide the AMT with a high degree of efficiency and power handling capability.
As a matter of fact, a presentation by Cologne-based company Mundorf at the

Diaphragm assembly of a ProAMT - the folded film can be seen clearly.

ProLight+Sound provided the incentive for this article. With the ProAMT, Mundorf presented an Air Motion Transformer for professional use and proved a power handling capacity of 60W during a live exhibit before the trade public.

Air Motion Transformer

The diagram shows the structure of an Air Motion Transformer. The core is a Kapton film, on which a thin aluminium conductor path is laminated in a winding pattern. The film is placed in S-shaped creases during installation, so that the conductor paths are on the edges of the folds (see diagram) when installed. The magnetic structure of an AMT consists of two pole plates, of which at least the front one has sound exit openings. The magnetic flow causes the folded membrane to be permeated vertically by an almost homogeneous magnetic field.
A current flow through the laminated conductor path now causes a force to be effected on the membrane, which stands vertically to the magnetic flux lines and to the direction of current flow. As the magnetic field is parallel to the main direction of radiation and the current flows in a vertical direction the force acts in a horizontal direction. The membrane does not move forwards and backwards. Instead neighbouring edges of the creases are pressed to-

Raymond Gubbay and the Royal Albert Hall 2013 Production von "Swan Lake", June 2013

Raimund Mundorf and Ed Kinsella in front of the Royal Albert Hall

gether and away from each other through the Lorentz force. Sound is created when the folded membrane of the AMT, following the electrical excitation signal, presses and sucks in the air from the creases. The principle is similar to that of a magnetostat, but has the advantage that the effective sound radiating area is greater than the front of the diaphragm construction.
So, this is a loudspeaker which has a comparatively high effective radiating area , but which is very light and is driven directly and in comparison with a driver diaphragm - in an equiphase manner by the magnetic field at all points of the moving surface. For this reason, it is possible to assume that a coherent acoustic wave is created in the sound exit plane. In turn, these are very favourable starting conditions for use as a tweeter in a line array, as the small wave lengths in the high frequency range cause the greatest problems in ensuring a coherent coupling between the array elements. With the AMT, there is automatically a rectangular sound exit plane and in-phase sound production over the entire membrane caused by the direct drive.
In comparison with a compression driver, the AMT principle has the advantage of working without a compression chamber, meaning the thermodynamic non-linearities due to the high acoustic pressures play no noteworthy role. In addition, the AMT membrane is very light and does not have to move piston-like in one piece. This means the AMT can work up to the limits of the operationg frequency range and exhibit a very good impulse response behaviour.
Because there is no compression chamber in the AMT principle, the level of efficiency is naturally not as high as with a compression driver. However, the conductor paths on the AMT diaphragm have a considerably larger surface than the voice coil of a driver diaphragm, meaning that heat can be better be dissipated. You can even use a ventilator to do this, which is fed from the audio signal. This means it only operates when it is really loud.
There are constructive differences among the various AMT designs, e.g. in the design of the area behind the membrane. If the rear pole plate is closed, there is a higher power handling capacity and a higher lower cut-off frequency. If you open the pole plate into a more or less large chamber, then the frequency range expands to include lower frequencies. However, the maximum sound pressure level falls as a result.
As interesting as a single component such as the ProAMT is in technical terms, complete systems are naturally of more practical significance for the professional PA market, as these can be easily purchased and used by an event technology service provider.
Among the ProAMT customers a manufacturer in the professional PA market could relatively easily be found, the British company EM Acoustics, whose range includes a line array system (the Halo Compact) with a special constructive approach which stands for a particularly natural sounding reproduction.
At the time of this contact, the sound reinforcement for "Swan Lake" at the Royal Albert Hall with the English National Ballet and its orchestra was provided with the Halo Compact system by EM Acoustics. This meant there was a last-minute opportunity to hear the Mundorf ProAMT in use in a very typical, but very demanding application.
But first to the Halo Compact: it is a compact line array system, whose elements are equipped with an 8" mid/bass unit and a 19.7cm high ProAMT both with a Neodymium drive unit. The frequency response ranges from 75Hz to 20kHz. The Halo CS Subbass is responsible for frequencies below 75Hz and can be flown in the array as well. The array elements offer two special features: firstly, the high frequency range is covered up to the upper cut-off frequency without compression distortions and secondly, the system is designed in a purely passive way.
Ed Kinsella, R&D Director at EM Acoustics, naturally had something to say about this somewhat unusual concept at our meeting in London. The core component is, of course, the Air Motion Transformer, because it does not have the potential problems of a compression driver. According to Kinsella, it goes without saying that you

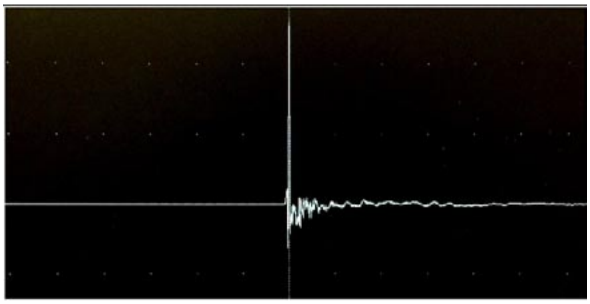


Diagram: EM Acoustics

HALO Compact Arrayelement

can get more sound pressure from a compression driver but it doesn't sound as good at high output levels. The AMT principle means the impulse response is better than that of a compression driver, so that your sense of hearing does not become fatigued during longer periods of listening and it is also seemingly easier to evaluate the information on offer. The audience no longer notices the loudspeaker. Instead, they can concentrate better on the music. Unfortunately, it is difficult to record such properties in a data sheet.

Royal Albert Hall

The Royal Albert Hall in London is a world-class venue, which opened back in 1871 and is not just a performance venue for classical music concerts. Architecturally, the Royal Albert Hall is based on the design of a Roman amphitheatre and has an oval layout. At the northern end of the oval, there is the orchestra podium, the large organ and the seating area for the choir. The central performance area is used as a dance floor for ballet (as is the case for Swan Lake) or other performances. Seats can also be placed here. On the parquet flooring, the public is seated almost 270ø around the central performance area. Three rows of boxes surround the parquet and are complemented by a three-quarter circle of seating on the top tier. In this way, the Royal Albert Hall offers space for up to 5,272 visitors on regular seating. This is normal for an arena or multi-purpose hall, but actually considerably too large for a classic concert hall. In fact, the Royal Albert Hall is constructed more as a large ballroom than a classic concert hall singly by the basic room geometry. A large orchestra can no longer fill this large room purely acoustically, especially as its acoustic conditions are not designed so that the sound from the podium is distributed to all public spaces in such a way that the audience receives a good impression of the sound. During classical concerts, opera and ballet, electro-acoustic support is required. In a hall of international reputation, it goes without saying that the sound system must not only be loud enough but also fulfil the highest demands on the naturalness of the sound. Ideally, the public should forget that electro-acoustic support is being used at all.
The Royal Albert Hall offers a requirement profile that can be fulfilled with a ProAMT-based sound system. For this reason, EM Acoustics sound systems have already been used for various productions in the Royal Albert Hall, including the production of "Swan Lake" I saw. For this production, Ed Kinsella planned a sound system consisting of a total of four line arrays based on the Halo Compact System, which is suspended above and somewhat in front of the orchestra podium. The arrays are each equipped with 15 Halo Compact elements. The wide emission range of the line arrays supports the even coverage of the relatively large angle range of almost 270°. The central area is naturally used as a dance floor for Swan Lake and does not need to be provided with sound. The curving of the arrays was designed in such a way that the systems cover all the public spaces from the parquet flooring to the top tiers. It is interesting that it is very easy to control the entire sound system due to the passive construction of the array elements including system equalisation. All the electronics for the sound system are in a really tiny rack unit. AQ-10 four-channel amplifiers are used for the power unit, which were designed by MC2 and supply four array elements per channel (3.2kW@2Ohm). For each array, only one amplifier is needed, and a further one for the sub-basses i.e. just five amplifiers for the entire system plus an XTA controller to control the amplifiers. In total, this is just 11(!) rack units for the entire Royal Albert Hall!

Sound

In terms of a personal impression of the sound during the performance, all that can actually be said is that the sound system described here is not noticed either in terms of its appearance or it's sound. This is not only meant in the sense that it is not acoustically at the forefront this would be absolutely undesirable during this performance. It is also unnoticeable in that you do not have the impression of a loudspeaker system being used at all it is simply just loud enough and sounds naturally and this has definitely been the aim of using this very system.
In the case of the Royal Albert Hall, the acoustic result is very natural and harmonious inconspicuous in the most positive sense of the word. With some experience in the field, you would perhaps wonder how the sound could be so normal and natural in such a large hall, which was not designed as a concert hall. However, this would be a conclusion arrived at through explicit reflection when you are simply listening, this insight does not arise. Even during the solo of a single violin, the acoustic impression was normal, although it must rationally be clear that a single violin cannot naturally fill a 5000-person hall with the sufficient volume.
To this extent, I am able to draw an extremely positive conclusion from this first contact with the ProAMT during a very demanding event. Definitely reason enough to look more closely at the Halo compact systems in one of the next editions.

[1] David W. Gunness, Improving Loudspeaker Transient Response with Digital Signal Processing, 2005, 119. AES Convention, NY

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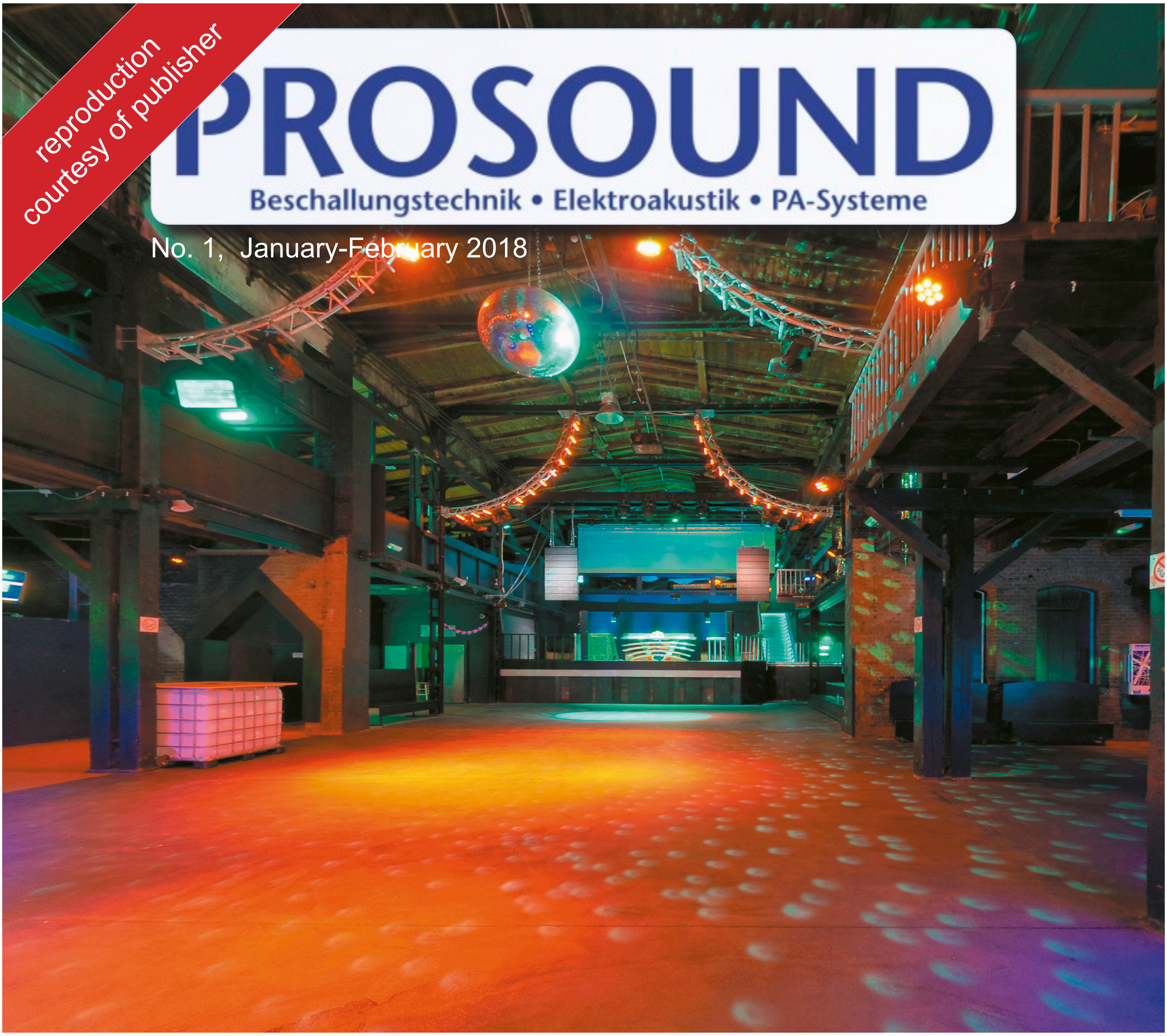


Hightech Disco sound reinforcement at JollyTime® in Brunswick

Pan Acoustics is implementing Beam Steering with ProAMT in an innovative Line Array

Dieter Michel

JollyTime® in Braunschweig is a large disco which is preceded by decades of tradition true to its name. First opened in 1984, the building re-opened in the spring of last year after a five-year break. Along with other structural/technical modernization work, the disco also obtained a new sound reinforcement system from the Wolfenbüttel-based speaker manufacturer Pan Acoustics, with technical refinements which make the sound reinforcement system very interesting even beyond disco sound reinforcement.

Jolly Time is located in a former factory hall. For this reason, the basic layout of the interior is not so drastically different from that of an event hall. In fact, the rooms can also be used for guest events, private parties and industry presentations. The audience areas consist, on the one hand, of the hall area on the ground floor, which is practically always used as a dance floor. To the side there are bars and seating areas, and on the first

View of the stage from the dance floor

floor there is an all-round gallery with more bars and quieter areas. A stage is installed on one front, where the DJ stand is normally set up. This also gives Jolly Time a basic multipurpose hall-like layout. This isn't so striking visually, but it naturally affects the possible uses and the acoustic constraints.

In the run-up to the conversion and the new opening, the new operator contacted the speaker manufacturer Pan Acoustics from the nearby Wolfenbüttel, as this has the reputation of being able to design and create innovative sound reinforcement solutions. It also benefited the existing project that Pan Acoustics doesn't work with standard components, but is prepared to create innovative solutions also in detail, if this results in new technical possibilities for sound reinforcement.

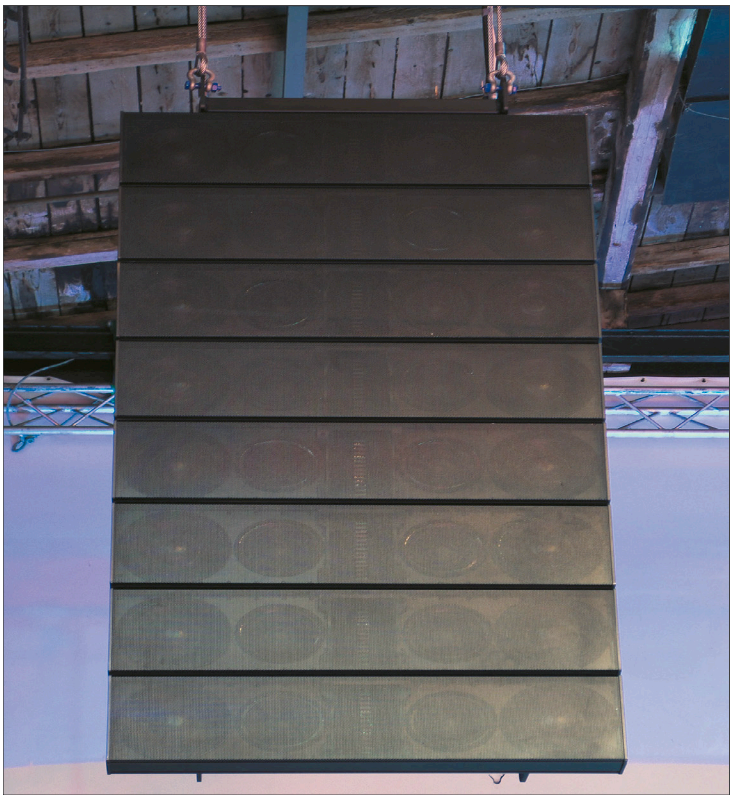
In this case, the customer naturally wanted the best possible sound on the entire dance floor combined with a design for the quieter areas also of the best quality, but with a usage profile of sound pressure levels adjusted to the respective areas. Of course, good sound is, just after the DJs - and therefore the quality, compilation and presentation of the music -, the flagship of a disco. It is therefore understandable that the new operators set great store by a first-rate sound reinforcement system.

Due to the layout of the dance floor, they steered clear of traditional solutions from the outset - such as a fourpoint sound reinforcement from the corners of a mostly square dance floor. The new sound reinforcement system would integrate well into the building structure, as there is no separate engineering room for any controller or power amplifier electronics and the like, and the space required for the speakers themselves had to be contained.

Pan Acoustics has now had 12 years of experience in the conception, development and production of beam-steering and beamforming speaker systems. For this reason, incorporating a speaker system with DSP-controlled beam control into the conception of the new sound reinforcement system for Jolly Time posed no problem for the Wolfenbüttel team.

In fact, this kind of concept proves to be a very viable solution, especially when it comes to meeting the highest quality standards. With conventional line array systems, this is also possible up to a certain level of quality, but the fewer individually controllable speakers are available, the fewer parameters you have to guarantee an equal high-quality supply for the audience areas.

For a good sound quality in all audience areas, a sound supply which is equal and as targeted as possible is naturally an important factor. Another important factor is the audio quality of the speakers, as it should not be about only guaranteeing an equal sound supply, and then settling for a moderate sound quality.



Front view of one of JollyTime's Pan Beam Line-Arrays

The quality of the speaker components play an important role here - combined with the fact that one should be able to optimally control it with the help of an integrated DSP technology. As far as the quality of the components is concerned, Pan Acoustics founder and manager Udo Borgmann got in touch with the Cologne-based speaker manufacturer Mundorf some time ago, which, along with the crossover components of the highest quality with ProAMT, is also planning a high-range system of very high quality and also of a suitable level for PA purposes, which we have already discussed in Prosound.

*Pro*AMT technology

A quick reminder: the abbreviation AMT stands for Air Motion Transformer. This is a speaker design which resembles the magnetostatic speaker but which works a little differently. In magnetostats, a meander-shaped conductor path is applied on a flat film membrane. When you bring this into a homogenous magnetic field that runs parallel to the film and vertically to the conductor path, in case of current flow the membrane is pushed vertically by the Lorentz force towards the film, thus swinging back and forth. In the Air Motion Transformer, there is also a similar membrane with an applied meander-shaped conductor path. But the film is folded lengthways, and the geometry is designed in such a way that the conductor paths are each placed on the edges of the folds. In the AMT, the magnetic field does not run parallel to the membrane level, but perpendicular, i.e. principally in the direction of sound radiation. The current flow through the conductor path then ensures that the edges of the folds, pushed by the Lorentz force, converge and move away from each other. There is therefore no membrane movement in the direction of sound radiation here, and sound radiation rather takes place in a way that air is pressed or sucked out of the folds. With an appropriate geometry of the folded membrane,a higher degree of efficiency is created by this function principle than in traditional magnetostats - and that is exactly what is aimed for when using magnetostatic operating principle in PA application.

Mundorf distributes the high-performance variant under the name ProAMT, whereby a special design is used for the Pan Acoustics system. More on this later.

For an array element, Pan Acoustics developers combined a ProAMT and two 8" midrange speakers and two 10" woofers each in d'Appolito-like arrangement in a housing 0.90 m wide and approx. 25 cm high. Each speaker is individually controlled by a DSP and its own power amplifier channel according to magnitude and phase, from which the extensive possibilities of beam-steering result - a concept with which Pan Acoustics has a lot of experience.

A benefit of this concept is the fact that no complicated and expensive rigging mechanism is needed, as the array elements don't need to be swiveled mechanically against one another to reach the desired level distribution in the room through the emerging curving of the array.

DJ workplace with Pan Beam monitor system

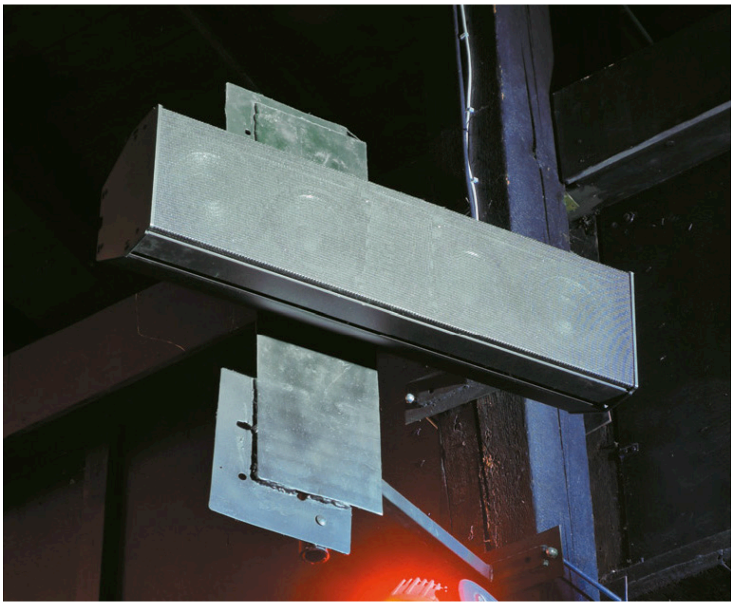
But with the beam-steering concept, it is important to know that the acoustic pressure and the frequency response in any point of the audience area consists of the contribution of all speakers - here: the whole array. However, this means that the sound radiated from all the speakers must in fact be able to reach the point in question in the audience area.

During my on-site visit in Brunswick, for a moment it wasn't clear to me how this requirement would be observed in the high-range speaker fitted with ProAMT. The ProAMT installed here has a sound outlet area almost 25 cm high at the mouth of the short attachment horn; the membrane is around 20 cm long. This should lead to a noticeable concentration in the high-frequency range. A closer look at the data sheets of the Mundorf 8" ProAMT with short horn shows that you can expect a vertical beam angle of 30° for instance at 5 kHz.

At Jolly Time, the line arrays of the front sound reinforcement are configured with an even front, i.e. flown without angling the elements against one another. The main radiation direction without beam-steering thus runs parallel to the floor area. In this configuration, you would therefore expect in the high-frequency range that at least the area near the stage would no longer be reached by all the tweeters through the noticeable concentration of the 8"-high membrane, and an effective beam-steering would no longer be possible there.

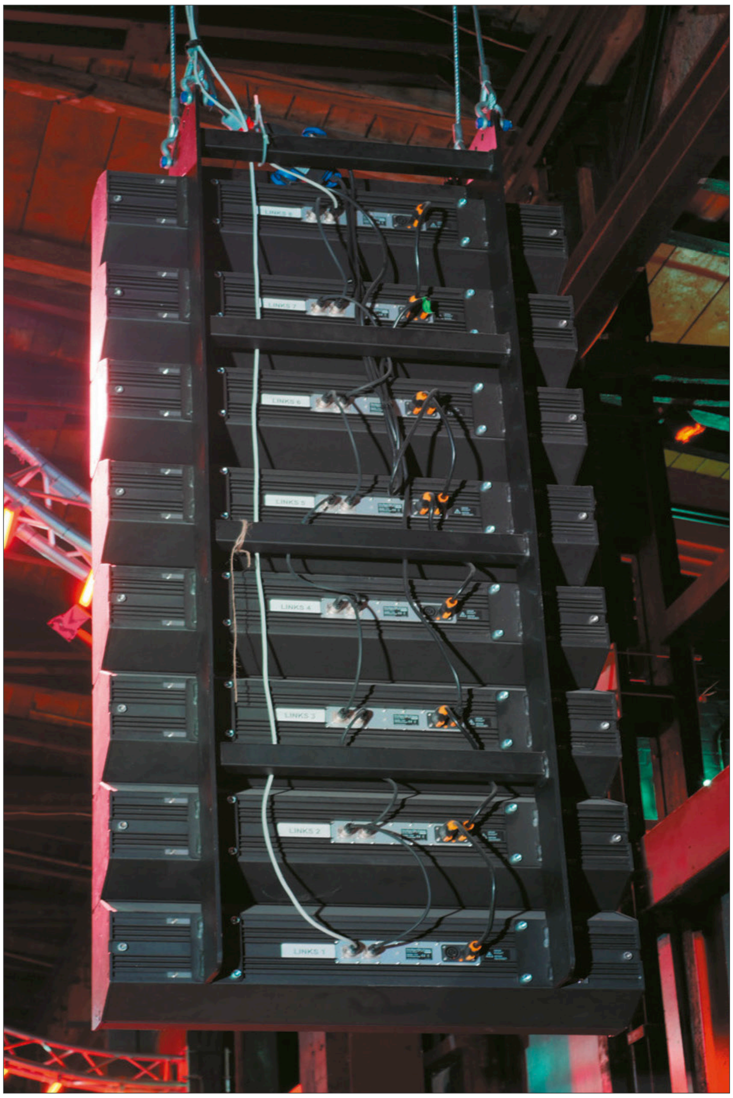
In fact, this effect naturally became clear to the Pan Acoustics developers, and they were able to find a solution which only works by having a very direct and cooperative contact with the ProAMT manufacturer Mundorf. In this way, various ProMAT construction parameters in particular could be adjusted according to customer requirements in order to be able to adapt the high-frequency system to the acoustic concept of the speaker developer. In the present case, the requirement was: we need a high-frequency system with an acoustically efficient construction height of 25cm, but which still ideally radiates like a spotlight in the vertical axis. Mundorf also has these spotlights in the AMT programme, but these use a membrane only 2 inches high. These apparent conflicting goals could be resolved in the present case by separating the membrane of the 8" ProAMT into three areas electrically and mechanically. In fact, the membrane consists of a continuous piece of Kapton film which is however separated into three oscillatory sections by additional supporting points. Instead of a single conductor path there are three, one for each section, so that each section can be individually controlled (see image). Since the separating supporting points steadily make the membrane decelerate or cushion it in its direct surroundings, the oscillatory part should probably be even a little smaller than in the regular 2" AMT, which at 5000Hz has a vertical beam angle of around 90° according to the data sheet. In this way, each of the three individual sections of the 8" ProAMT with this frequency should probably ultimately have a vertical beam angle of over 100°, so that the sound radiated by them can also reach the nearby area in front of the array. This, in turn, is the requirement for beam-forming

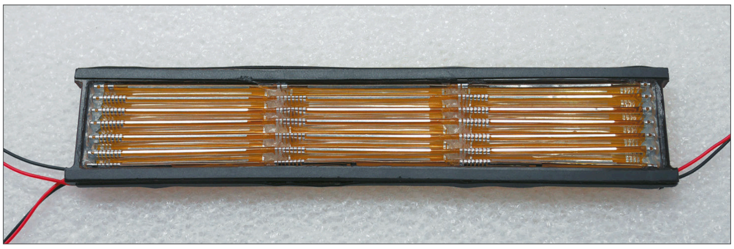
Pan Beam PB 224 as DJ monitor



Single Pan Beam Array unit as delay system to work well also in the high-range area in the front part of the audience area.This ProAMT high-range unit is a custom-made product for Pan Acoustics which generally enables to carry out beam steering in the high-range area with a single array element.

A total of seven speakers can be individually controlled per array element, of which two for a woofer and mid-range speaker and three for the ProMAT. On each side, arrays made of eight elements each are flown, making 56 speakers per side or 112 in total. The front sound reinforcement is therefore controlled via 112 individual DSP channels, thus guaranteeing very high fine tuning. This reaches very good beam forming which concentrates the sound very precisely on the dance floor, so that areas planned to be quieter, such as the bars, respectively receive less sound pressure level. In the rear area of the hall, an array element is installed again on each side to refresh high-range frequencies in particular, which lose some level through air absorption. It helps here to already be able to create an active beam control in the high-range area with an array element.





In the above ProAMT membrane, the three individually cotrollable areas can be easily identified.

Very good sound quality is also required in the galleries, but with less sound pressure level for people to be able to have a conversation. The direct sound level of the front systems above is comparatively low, as desired, due to the precise beam steering. For this reason, Pan Beam line array speakers of type PB 04 and PB 08 are installed here to specifically guarantee the desired sound pressure levels with very good sound quality in the various areas. These systems are respectively controlled in a delayed manner so that no irritating delay effects are created when moving from the supply area of the main sound reinforcement to the nearby areas.

Sound

But all theory is grey - it's better to just listen. During our visit in Braunschweig, we proceeded by first listening to the system with various music pieces, club-like material as well as rock and individual male and female singing

The Pan Acoustics system at Jolly Time is set up in such a way that the entire audience area, from the area near the stage to, in principle, the end of the hall, is covered. Here, the beam is aligned in such a way that it roughly reaches ear height just before the end of the audience area. This should ensure that the complete direct sound is absorbed by the audience and ideally that reflections are not triggered on the rear wall. This even works when the room is empty - there are no direct rear wall reflections, and reflections on the ground reach the listener - so to speak - indirectly; they are therefore reflections of a higher order which respectively reach the listener later. The latter reflections can only be heard in an empty room, and not at all during normal operation, because the audience then provides sufficient absorption. The recording of pure singing voices also created an interesting "aha moment": we had previously recorded a few typical club titles with a higher sound pressure level. When playing the first pure vocal recording, my very first auditory impression was: "if it hadn't been a little too loud, I would have thought that the singer was standing on the stage here, singing only acoustically, without PA".

It must be said that this is the editors' own recording, which was produced without compression and other signal processing, which is potentially used in modern sound productions.

Note: this is not a sort of spectacular sound, but, on the contrary, it is the impression of hearing a natural voice. The sound of a speaker is of course always the overall result of all the design choices made by the speaker developer and also of component quality. But, as I once heard a similar effect with a ProAMT-equipped sound reinforcement system in the Royal Albert Hall, I would like to cautiously speculate that this component contributes significantly to the fact that natural sound sources and especially voices are perceived as natural. In electronic music, which is also common in clubs, this benefit cannot be heard so directly because there is no natural "original" sound.

However, you can hear a very good, clear sound quality, thanks to which the song can be heard on the dancefloor exactly as the artists had imagined. The new system at Jolly Time does not lack pressure or level reserves. These are provided by 16 18" subwoofers of type PB S 118 alone, which are placed under the stage. As the main sound reinforcement from the two Pan Acoustics arrays radiates very precisely onto the dancefloor, it is comparatively quiet on the stage and behind the front systems in general. For this reason, it is necessary to plan separate monitor speakers for the DJ. These are also Pan Acoustics systems, of type PB 224. These are installed diagonally on the left and right in the front of the DJ stand on profile housing and prolong the elongate of the actual speaker downwards, so that it gives the impression of a homogenous pillar reaching the stage floor.

All the speaker systems of Pan Acoustics are active and are digitally controlled via their AES/EBU interface. This has the advantage that, on the one hand, it requires no separate engineering room for power amplifiers and the like; on the other hand, the system can't overdrive if the transfer from the output of the disco mixer to the AES/EBU interface of the sound reinforcement system is set correctly. This is naturally also the case for guest events where people bring their own sound technology - even here the correct level must be set only in one point, unless it can be directly transferred from the mixer to the in-house system digitally. The arrays of the sound reinforcement system at Jolly Time are flat and uncurved. They therefore have an installation depth of only around 25 cm. This is of course a dream for installations of a very different kind, for example in theatres with little room in the proscenium arch or in projects in general where visually obtrusive and extensive speaker installations are not desirable from an architect's point of view.

In terms of sound, I have already referred to the naturalness of the reproduction, which is of course also very interesting for theatre installations and other projects where you shouldn't be aware of the speakers at all - which boils down to a natural, clear reproduction without compromising on level stability.

Pan Beam line array speaker type PB 04 and PB 08 are used on the gallery as supporting or delay systems.

Pan Acoustics team with founder and owner Udo Borgmann (3rd from left) and Jolly Time manager Turgay Araz (right)

The MUNDORF *Pro*AMT25 Cinema in various Movie Theater applications

The newly opened Escape3D SUNBEAM movie theater in Hongkong

In July 2015, Hongkong MBS Studios asked their chief developer to develop a new monitor and film-theater loudspeaker series „from first scratch“! Then, the expressed requirement of MBS-Studios was to use AMT (Air Motion Transformer) tweeters. With this advice, the chief developer also got some brochures of different AMT manufacturers, including Mundorf‘s Pro-AMT brochure. Shortly thereafter, MBS-Studios‘ chief developer contacted Mundorf company for to discuss the special requirements and possible solutions for an AMT integration. After all, we mutually decided to try our *Pro*AMT25Cinema for the related projects and, after some minor changes, Mundorf *Pro*AMT25C model was fully approved by MBS Studios.

Zhongshan Film University AURO 3D theater

In March 2016, MBS Studios invited Mundorf company to Hongkong for to listen to the final state. MBS Studios‘ and our general view on loudspeakers is quite equal: Loudspeakers should be able to transmit the emotional energy of acoustical occurrences right into the hearts of the audience. Thus, they should stress the images‘ message or help to better sense the music‘s meaning, as in both movies and music, sound is meant for to create sensations. Obviously, our AMTs are very suitable for that task, since quite a few hi-end loudspeaker manufacturers use them and, for long. But, in terms of sound processing, theater audio is more complex than HiFi-Audio and more challenging in its required technology, too!

Shanghai Rui Chuang Commercial Rehearsal cinema and recording room

Status Quo: All MBS Studios‘ sound-mixer and rehearsal studios now use monitors with Mundorf *Pro*-AMT25C. In Hongkong, the world‘s first Barco Escape 3D cinema with K4 digital projectors opened in late 2017: The SUNBEAM movie theater. Its sound system consists of 62 units with Mundorf *Pro*AMT25C installed. In Shanghai, MBS Studios also operates a cinema for Shanghai Rui Chuang Film and Television Co., Ltd., for commercial rehearsal, equipped with 48 *Pro*AMT25C. In Zhongshan, the Film University is equipped with both a Dolby Full View Hybrid Theater with 48 *Pro*AMT25C and an AURO 3D Audio-Visual theater equipped with 22 *Pro*AMT25C, alongside a recording studio with 2 monitors performing Mundorf *Pro*AMT25C.

Zhong Le Video+Music Co., Ltd. and Mundorf first met in March 2016. Since then we have developed a strong relationship resulting in +600 sold *Pro*AMT25, up to date. Located in Shenzhen, the company belongs to the top suppliers of high-end home theaters throughout China with installments of up to 48 speaker systems with *Pro*AMT25C alongside various sub-woofers.

Zhongshan Dolby Full View Hybrid Theater

Zhong Le Video+Music Co Shenzhen one of various demo home theaters equipped with 32 speaker units employing Mundorf *Pro*AMT25C and 4 sub-woofers!

Zhong Le Video+Music demo home theater

Rehearsal + Recording in Zhongshan Film University

MUNDORF EB GMBH
Liebigstr. 110
50823 Cologne
GERMANY
mundorf.com
info@mundorf.com

MUNDORF EB GMBH
Liebigstr. 110
50823 Cologne
GERMANY
mundorf.com
info@mundorf.com

MUNDORF®