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Review
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Based in Nürtingen, Europe's largest IOSONO 3D demo facility

3D Sound in the Fohhn SoundLab



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Visitors to the Fohhn SoundLab in Nürtingen will be treated to a rather unusual sight: 24 Fohhn LX-100 line source loudspeakers are arranged in a circle, while overhead at a height of 5.10m above the listening area, 18 Fohhn LX-10 compact loudspeakers are suspended from the ceiling. Four Fohhn long excursion subwoofers are also used to expand the system.

One of the first clues to this slightly unconventional set-up can be found by taking a closer look at the amplifier rack. In addition to the usual Fohhn amplifiers, there's an IOSONO CORE processor (www.iosono.com) occupying a central position next to some AD/DA convertors. Those who are familiar with surround sound in general, and wave field synthesis (WFS) in particular, may have twigged by now. This exotic looking loud-speaker set-up (in combination with the IOSONO processor) forms the basis of a surround system that, in many ways, has developed from WFS.

WFS reloaded

At IOSONO, one of the WFS-based algorithms developed in recent years has enabled individual loudspeakers to be positioned with relatively large distances between them: In the Fohhn SoundLab, the 24 LX-100 speakers are placed nearly 2 metres apart. This is in contrast to the standard theoretical principles of WFS in which the smallest possible distance between any number of speakers is advocated. Also possible – and there has previously been no provision for this in WFS – is the integration of ceiling speakers, an effective approach to achieving true 3D sound. The listener not only experiences a horizontal sound plane, as is the case with stereo or 5.1 systems, but also finds him/herself, through the integration of the vertical aspect, in a complete 3D sound space. The listening area can also be made to appear larger than the actual room as the relevant algorithm enables sound sources to be placed outside the room boundaries. Using this system, the “sweet spot” can be made to extend more or less throughout the entire room.

In the past, IOSONO has successfully implemented a significant number of projects, gradually developing into one of the leading suppliers of 3D sound systems. However, on the occasion of one particularly large-scale project, the company sought a reliable partner from the sound reinforce-

ment industry and, last year, organized a “shoot out” to which half a dozen major players, including Fohhn, were invited.

Enter Fohhn

During the shoot-out, the IOSONO team were able to evaluate the entire Fohhn product range (www.fohhn.com). From both a measurement and subjective listening perspective, the Fohhn systems made an excellent impression on the IOSONO team - not least the broad horizontal beam width of the LX-100, regarded as highly advantageous.

According to Stephan Maurer from IOSONO, Fohhn's loudspeaker technology was as near to an ideal solution as could be wished. The comparatively straightforward integration of the line arrays into virtually any type of architecture was also a significant factor in the decision to go with Fohhn – alongside the compelling sound characteristics of course.

A further factor influencing IOSONO's decision lay in the straightforward communication paths to both the Fohhn management and developers. This enabled any special requirements from IOSONO's side to be quickly and easily addressed without the need to go through layers of bureaucracy – something that has also proved highly advantageous during the actual project implementation.

From Fohhn's side, everyone had been very taken with the acoustic results afforded by the IOSONO algorithm. This led to interest in collaborating on the planned project. In the past, Fohhn had been extremely active in the cinema market, having also had an interest in surround sound from its outset. In addition, the company was familiar with WFS, seeing both line array technology and beam steering as feasible offshoots of WFS development (see insert “Loudspeakers for 3D sound systems”).

IOSONO in the Fohhn SoundLab

Initial collaboration between the two companies resulted in the setting up of Europe's largest 3D audio demo facility at the Fohhn SoundLab in Nürtingen, near Stuttgart. Meanwhile, IOSONO's own demo room has also been equipped with Fohhn loudspeakers and further projects are planned.

Since March it has been possible to go and experience the opportunities presented by the surround system and the Fohhn loudspeakers. The results are indeed compelling with listeners exposed to a spectacular world of sound. Instead of merely being confined to a "sweet spot", the prime listening area within this extremely stable sound field extends throughout the entire room, regardless of where the listener is positioned. It also enables the listener to move around freely without any reduction in the quality of sound experience. This makes the system potentially interesting for use in cinemas and museums, as well as for exhibitions, presentations, events of various kinds, theatres and theme parks.

Sound sources of all kinds – whether live or pre-recorded audio – can be easily moved and positioned in the room in real time. Use of a mouse, keyboard, joystick or other designated controller provides easy, user-friendly control possibilities.

The use of ceiling speakers greatly enhances the spatial effect. Not only is the sound experienced on a horizontal plane (as is typically the case with stereo, 5.1 or 7.1), it also delivers on a vertical level so that the listener is "enveloped", in every sense of the word, and finds him/herself at the heart of the acoustic scenario.

This sound experience is guaranteed to impress across the board, as Fohhn loudspeakers turn the possibilities offered by the IOSONO system into reality. With some projects already in the planning stages and others in the pipeline, the future of this team effort looks assured. All prospective clients (architects, planners, sound designers, exhibition organisers, theatrical and musical decision makers etc) are recommended to head to Nürtingen for a bespoke demonstration of the system. As previously mentioned, communication channels are easy to navigate and Fohhn is always happy to welcome visitors to the SoundLab. Präsentation des Systems zu ermöglichen.

Interview with Stephan Mauer (IOSONO) and Uli Haug (Fohhn)

Professional System: IOSONO has emerged as a spin-off from Fraunhofer's Wave Field Synthesis. Can you explain to our readers how your algorithm differs from the original one? And, in this respect, how is it unique?

Loudspeakers for 3D sound systems

Beam steering, wave field synthesis, 3D sound: The basis of these applications involves the linking or superimposition of a range of sources, which in practical electro-acoustic terms means using a number of loudspeakers.

For use in a 3D sound system, the designated loudspeakers need to fulfil all the basic requirements found in any sound reinforcement system: in addition to precise directivity and even coverage, quick recovery from "peaks" i.e. the least possible distortion at high levels is also a necessity. Elsewhere, for example in the cinema world with WFS and 3D sound, it's not as necessary to determine a preferential direction in the same way as for LCR or effect loudspeakers. When sound events are located nearer to the loudspeaker positions, fewer systems may be used for playback. In this instance, each loudspeaker must be able to send high sound levels to every listening position.

To achieve really good dynamics with 2D and 3D systems, it's often preferable to use multi-way loudspeakers with compression drivers in the high frequency range. The improved results regarding intermodulation distortion also make a case for this type of solution.

With completely controlled signal flow and opportunity for equalization, the on axis frequency response of each loudspeaker is not the main concern here, although for good headroom the frequency response range offered by a combination with sub-woofers should be possible to achieve without huge filter gains. Instead, the most important characteristic of these loudspeakers is their directivity. Here you have to distinguish between speaker systems located in the audience area (2D) and ceiling mounted systems (3D). In both cases, based on WFS criteria, there is a demand for identical sound source levels at the point of listening. For ceiling speakers that radiate sound vertically from above, this ideally entails broad, even sound dispersion on all axes and a significant reduction in the sound field outside the nominal dispersion angle to avoid reverberant sound produced by reflections from external structures. For this purpose, loudspeakers with a small radiating surface and high excursion drivers are the best choice.

Even more precise are the requirements for the loudspeakers at listening level. Horizontal directivity requirements are similar to those of the ceiling speakers; the vertical beam width however needs to be relatively narrow in order to minimize strong reflections from the floor, which is a critical factor in the acoustic location.

High performance multi-way loudspeakers such as the Linea LX systems have all these features and are already proving highly suitable as main systems in a 3D sound setup. Another possibility is afforded by the Linea Focus systems, which enable the required parameters to be adjusted via beam steering.

Stephan Mauer: Ok, well the IOSONO algorithm stems from pure wave field synthesis (WFS), but in the event it is optimized so that the well known WFS perceptive characteristics can be produced using just a small series of loudspeakers that do not have to be positioned side by side without gaps, which would confine the sound characteristics to a particular position or direction for everyone within the listening area. The IOSONO algorithm uses a range of technologies and concepts that enable optimal control of various loudspeaker configurations. It also means that we can control three-dimensional speaker configurations, which, when using pure WFS is impractical.

PS: And the similarities?

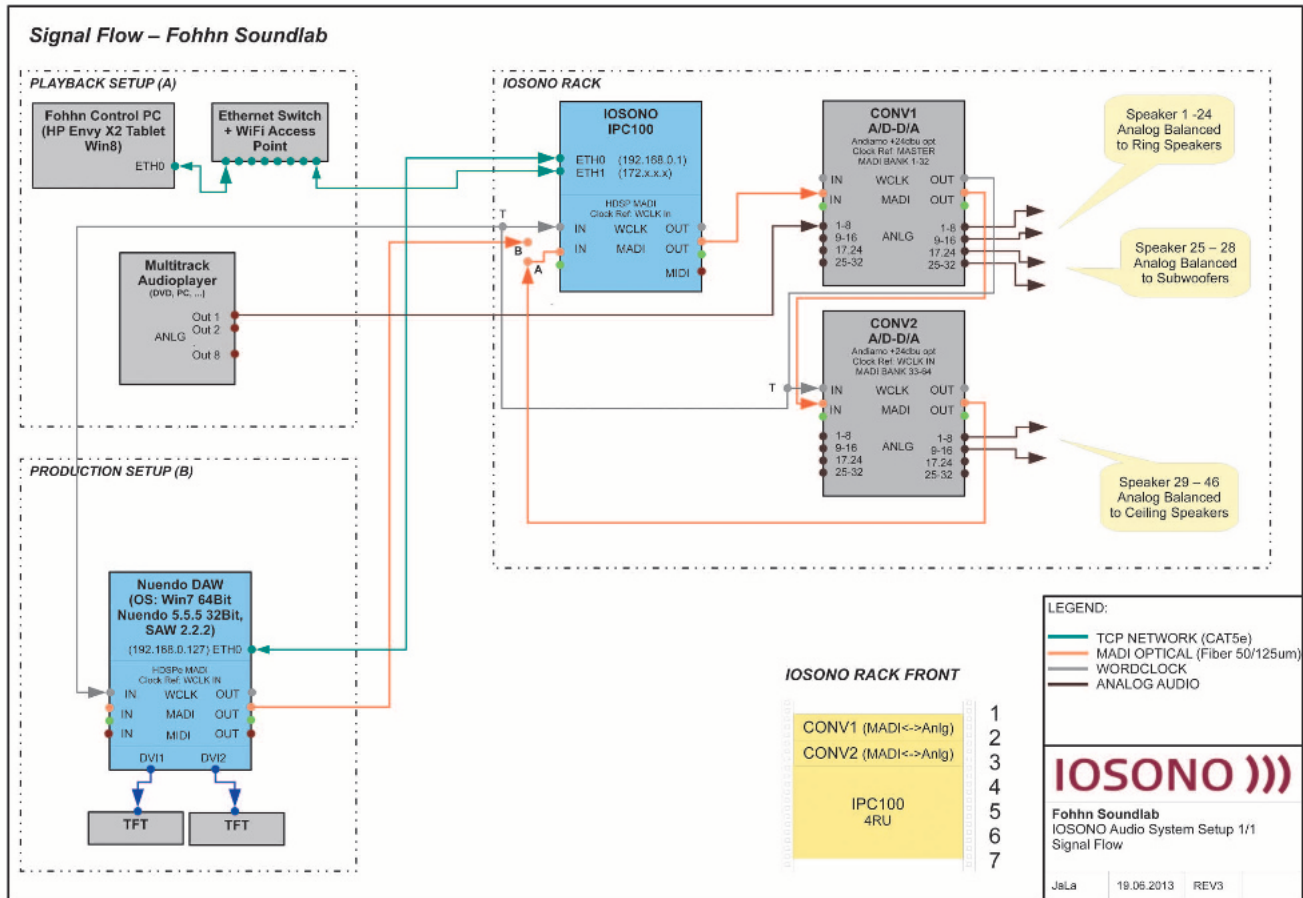
Stephan Mauer: For most people, the more noticeable parameters such as focus and stability of image appear very similar, as they do to us when using fewer loudspeakers. When using a continuous loudspeaker configuration without gaps, which is necessary with pure WFS, our

algorithm also works with pure WFS. The smaller the gap between loudspeakers, the closer you come to this situation. And of course both algorithms are partly based on similar concepts such as the Huygen'schen Principle.

PS: The circular arrangement of loudspeakers in the Fohhn SoundLab involves unusually large gaps between the individual speakers – I'd estimate around 2 metres – something of a departure from the WFS rule of thumb. Are phantom sound sources also involved here?

Stephan Mauer: That's basically correct. At this kind of distance, waveforms for the majority of the audio spectrum can't be successfully reproduced. But that's not what we're aiming for here. The required result is generated using a combination of WFS-based approaches and phantom sound sources in line with amplitude panning.

PS: To what extent is the distance between the loudspeakers determined by the size of the lis-



Signal flow diagram of the SoundLab's 3D installation.

tening area and the shortest distance between the listeners and the loudspeakers etc? What would be the advantage of reducing the distance between speakers? And what kind of unwanted effects might occur if the distance is too large?

Stephan Mauer: Imagine you have a very small group of loudspeakers in a circle, like 5.1 Surround for example. There's usually just one "sweet spot" at which the spatial effect of the mix is exactly as you'd want it. The closer that neighbouring loudspeakers are moved together, the larger the listening area appears within the spatial set-up. As a general rule of thumb, listeners should be at least the same distance away from the speakers as the speakers are from each other. If the listener is any nearer to the loudspeakers, he/she approaches a stereo situation with its associated problems such as incorrect sound localization.

PS: The other obvious difference to address in relation to original wave field synthesis is the use of compact ceiling-mounted loudspeakers. Does this make the production of actual 3D sound possible, involving not only horizontal but also vertical sound distribution?

Stephan Mauer: Yes indeed. Most of our projects over the last two years, as well as our current ones, have involved three dimensional loudspeaker configurations. This enables the creation of acoustic images that are so much more realistic and totally enveloping. When I have loudspeakers on different levels like here on the ceiling, it allows me to move and position sound objects vertically. This also works on the ceiling itself. As a sound designer you have total freedom to create or emulate an actual piece of reality.

PS: During the presentation you mentioned the term "object oriented mixing" several times. What can we understand from that?

Stephan Mauer: Conventional audio formats like stereo or 5.1 are channel based. In other words, during the mix process you determine which signal is reproduced by which loudspeaker, as well as the audio channel via which it will be distributed. These audio formats can also be manipulated, which means that we work either object based or object oriented. This involves objects, or virtual sound sources, that can be displayed on a computer desktop. These objects are associated with metadata such as volume, source type, position and an

audio signal. The entire collection of metadata is referred to as a scene description. The source of the audio signal can be a single microphone, a mix buss or the left channel of an audio CD for example. During the mix process I can specify exactly what I hear, where and with which parameters.

This package of scene metadata and the audio signal is sent to the IOSONO processor that calculates in real time what every loudspeaker in the system must contribute in order to generate the required result.

PS: How do you determine the required number of loudspeakers for a specific room? Is there a fixed formula? Or is it a case of "trial and error" and practical experience?

Stephan Mauer: This is one of the key factors we encounter when involved with system design, or where we are supporting customers. Firstly we have to identify what is going to happen in the room, or with the system. Is there a preferred direction? Is the spatial orientation in one particular direction more important than in others? Does the spatial image need to be equally good in all directions? – I may not be familiar with the actual content at that point. Where and how big should the listening area



LX-10 compact loudspeakers suspended at a height of 5.10 metres above the listening area.

be? For a spatial reproduction involving a 360° panorama, covering a much greater area than just a "sweet spot", around 20 loudspeakers need to be arranged in a circle. If the listeners are to experience no loss in quality when sitting or standing near the loudspeakers, the earlier rough calculation formula comes into use.

If you use systems that all have a similar type of focus, you usually find that the number of speakers doesn't vary that much. In the 50 or so systems installed up to now, we've learned where we can save on cost without compromising on quality, and where we can't. Most of the challenges we have to solve are concerned with selecting the correct sound systems.

PS: Which Fohhn systems are used here in the SoundLab? Are other Fohhn systems also suitable for use with IOSONO?

Stephan Mauer: We principally expect the systems to generate both high performance sound and a broad horizontal coverage. In the case of the ceiling speakers, both horizontal and vertical coverage is required. For this reason 24 Fohhn LX-100 systems have been arranged in a circle at ear height and 18 Fohhn LX-10 systems suspended from the ceiling. In addition, 4 Fohhn subwoofers have also been

evenly placed within the system, enabling low frequency sound images to be generated in different directions.

Uli Haug: The main loudspeaker system comprises 24 LX-100 hybrid line source systems arranged in a circle. The distance between each loudspeaker is 1.95 metres. The LX-100 is equipped with 8 x 4" high performance speakers and a 1" compression driver with Waveguide. With a general SPL of 94dB, each system can deliver a peak SPL of around 106dB across the whole listening area. Special housing and floor stands have been developed for the LX-100 systems so that all cabling can be hidden from view. 18 high performance LX-10 compact loudspeakers, equipped with 4"/0.75" drivers that have a coaxial construction, are suspended from the ceiling at a height of 5.10 metres using a special bracket. In each of the four corners, one 18" long excursion subwoofer has been carefully positioned to provide the necessary power in the low frequency range.

Other Fohhn loudspeakers are also suitable for use in the IOSONO/FOHNN 3D system, as long as they can fulfil all the necessary parameters within the circular set-up. Appropriate systems could include the hybrid line source LX-

150, LX-501 or LX-601, as well as our Linea Focus and Focus Modular series with beam steering.

PS: Is the IOSONO system suitable for use in combination with conventional sound reinforcement solutions such as a line array system or various point source speakers, or are there limitations for the user? For example is the idea of combining a conventional FOH system with a surround system conceivable, or even sensible?

Stephan Mauer: In general, if the loudspeakers sound good, the SPL is sufficient and I can achieve a balanced coverage of the listening area, then I would advocate it. And yes, depending on the particular application, you can combine a stereo PA with a surround circle or ceiling loudspeakers. On the other hand we've also successfully implemented a high resolution front-of-house set-up with several loudspeakers above or in front of the stage, without adding surround or ceiling systems. During the system design, it generally boils down to the requirements of the system itself.

However, if it's a case of multi-directional coverage i.e. surround, then we're concerned with changing SPL levels over distance, which is very important. At distances of over 25 or 30 metres,

line source or line array systems are very helpful in providing a homogenous coverage. If this isn't addressed, then the resulting sound and effectiveness of the mix, depending on where you are standing, can be completely out of balance.

PS: In addition to the loudspeakers, the system has a range of other components. Could you explain to our readers how the system is put together? The Core Processor occupies an extremely compact 4 rack units of space. Is that all the necessary hardware, or are other components hidden away somewhere? What software is used?

Stephan Mauer: The IOSONO CORE lies at the heart of each IOSONO system. It calculates the loudspeaker signals for the system in real time and can be fed with multiple sound sources. In a production environment it gets audio signals and scene data from a DAW-PC running Nuendo and our mixing tool the Spatial Audio Workstation (SAW). For playing back pre-recorded audio, the files can be read directly from the internal hard drive. In a live situation audio signals are often coming from the mixing console, the scene data is directly generated within the processor and controlled via a computer.

The IOSONO CORE has a choice of MADI or AES connectors for digital in-and output signals that can be converted according to the particular requirement. For this purpose, two optical Andiamo 32-channel MADI-Analogue/Analogue-MADI converters from d.o.TEC are pressed into action. Their analogue multi-pin outputs are directly connected to the Fohhn amplifiers, which in turn drive the relevant loudspeakers. The basic functionality of the IOSONO CORE can be controlled via touch display on the front of the unit. Configuration and more detailed functions can be remotely controlled via software on a Windows PC.

PS: With regard to content production, what happens for example to content producers who are not working with Nuendo. That could be quite a number ... Can you explain a bit more about the interface situation?

Stephan Mauer: Currently, object-based IOSONO content can be created using Nuendo with the IOSONO Spatial Audio Workstation (SAW). SAW is a core plug-in that is also very tightly integrated with Nuendo and goes deep into its structure. This is one of the reasons why SAW isn't available for use with all DAWs – not every manufacturer wants to release the details that are necessary for us to do this.

Regarding workflow: While audio processing functions such as gain, EQ and dynamics can be found in Nuendo, SAW enables the mix to be shaped spatially, with virtual sound sources positioned and automated. Its graphic interface is similar to a desktop with icons, enabling sound sources to be freely positioned.

In order to use IOSONO content with another DAW, we simply synchronise the DAW in which the processing is based with the Nuendo/SAW-PC and loop the audio through the Nuendo/SAW-PC. The sound will then be generated by the chosen DAW, while the spatial mixing remains in SAW. Using this method, we've successfully worked on a range of projects with a number of our customers.

At the moment we have no plans to clone SAW for use with other systems, but SAW does have a powerful little brother Anymix Pro, a VST/RTAS plug-in from IOSONO for surround mixing. This enables up- and down mixes for spatial projects to be easily and efficiently implemented, and artistically shaped.

PS: So, to go right back to the start of the project at this point: How did the collaboration between IOSONO and Fohhn start? What provided the impetus for this and where is this joint venture heading, in other words, what other projects are on the table? What synergies do you see as partners?

Stephan Mauer: Fohhn loudspeakers bring three important elements to the table. In addition to their sound quality, they are remarkable for their broad horizontal beam characteristics produced from speaker chassis with relatively small diameters, their typical (for line arrays) reduction of just 3dB in sound pressure levels with distance doubling and, last but not least, their aesthetic qualities. If you want to install 60 or more loudspeakers in a room, line source/line array speakers appear less intrusive than 12" loudspeakers. For this reason, we'd been interested in Fohhn products for a while. At an audio shoot-out for an extremely large project, Fohhn's LX series stood out among systems from other participants. For a better mutual understanding, we also demonstrated our system to colleagues at Fohhn in order to satisfy them before embarking on the project. The Fohhn SoundLab is a first result of this energetic and innovative collaboration between IOSONO and Fohhn.

In addition to the aforementioned project and the Fohhn SoundLab, further projects are also in preparation. For IOSONO, a very important project is the new IOSONO showroom at our offices in Erfurt, where we will be installing the new Fohhn FIAD system with LX-11 loudspeakers. As a supplier of processors for spatial audio we rely all the time on electro-acoustics and solutions. This direct and motivated collaboration with Fohhn is extremely convenient for the joint development of system solutions as it increases our flexibility and expertise. It also creates synergy with regard to expanding markets and making contacts.

Uli Haug: During the Autumn of last year we received a call from an audio specialist who was responsible for planning a state-of-the-art cinema complex in Switzerland. During his search for an optimum 3D audio system, we

were asked, along with six other manufacturers, to take part in a shoot-out over several days. At the event both conventional loudspeakers and line arrays were represented. From the tests it became clear that our hybrid line source LX-100 loudspeakers, in combination with a Fohhn DSP-controlled Class D amplifier, had fulfilled the required criteria most effectively. These criteria principally included low distortion, solid SPLs, broad and even horizontal beams, narrow directional vertical beams, long reach and decent appearance. In order to offer prospective customers outside the cinema market the opportunity to experience the IOSONO/FOHNN 3D system, we decided to equip the Fohhn SoundLab in Nürtingen with a system comprising an IOSONO IPC-100 Spatial Audio Processor, 46 Fohhn loudspeakers and 12 Fohhn 4-channel DSP amps. The system has garnered the highest praise. Customers from both Germany and abroad are visiting the SoundLab on a weekly basis in order to personally evaluate the system's performance capability. Because of its excellent three-dimensional sound capability, its quality and elegant appearance, we believe the system is suitable for a range of mobile and fixed installation projects. We've already had enquiries from the automobile industry, from theatres, cinemas, music producers, DJs and exhibition booth contractors. 3D sound is in its early stages and is set to become well established in the future. On the subject of synergy: we believe that synergy automatically occurs on both technical and business levels when two innovative, focussed companies aim to accomplish something new; opening up new markets and constantly striving to improve while delivering the best possible quality.

PS: In the cinema world, everyone is familiar with 5.1 and 7.1 systems – these are geared towards a spatially limited "sweet spot". But with your system there's no sweet spot in the conventional sense, in other words the whole room becomes the sweet spot. That opens up the IOSONO/Fohhn combination for use in projects outside this market. Where do you see the potential opportunities?

Stephan Mauer: IOSONO isn't only active in the cinema market, the technology actually offers a whole range of possibilities. In the past we've installed a number of systems in the live and event sector, for example at the opera in Sydney, or at corporate events. There are also opportunities in planetariums, museums and showrooms. Because Fohhn loudspeakers are also very versatile in their applications, an IOSONO/Fohhn combination could work in all these various scenarios.

Uli Haug: We see the possibilities of creative sound design for performances in theatres, opera houses and concert halls, as well as for reproducing sound backdrops or effective acoustic portrayals of visual affects in theme



In addition to Fohhn amplifiers, the rack also contains an IOSONO CORE processor, along with AD/DA converters.

parks, on exhibition booths or in museums. At live music events or in clubs this also presents some completely new possibilities for sound mixing.

PS: People's experience with these systems is still quite limited, although you have acquired

quite a reputation with planners, users and installers. Will you also become involved in planning, in other words, how will you work with future users or planning specialists on the route from idea to implementation?

Stephan Maurer: As well as developers and administrators, we also have a team of both em-

ployed and freelance engineers whose job is to support customers and prospective users in this area, which naturally raises some very different questions from working with stereo or 5.1.

We have the theoretical knowledge and practical experience and will often guide a project from the start, planning or assisting with planning, advising on choice of components and dealing with acoustic queries. When the systems are delivered, we calibrate and tune them and hold seminars and workshops for colleagues at the venue. We also take care of the technical support for these systems, with valuable help from our international network of trained and experienced distributors, installers, studios and system technicians.

Aside from specific projects, we often take part in seminars, workshops and conferences, or offer our own workshops. For example at the end of 2013 there's a workshop on our new IOSONO CORE processor, which will equip customers and other interested parties with the necessary tools for planning and use.

PS: How complicated will system handling be for future users and how "deep" into the system can the user actually go? Experience has shown that, in the fixed installation sector, having a "staff operating" mode is an advantage as there isn't always a qualified operator available.

Stephan Maurer: Yes, of course there's a "staff operating" mode! The IOSONO CORE functions that are required on a daily basis can all be accessed via the touch display. This is fine for straightforward daily use in an installation, in a studio or a museum. For those who want to explore the system in more depth, we offer training. It takes one or two days to acquire the basic working knowledge. However we have also learnt that it needs a "learning by doing" approach and that's what happens in our training facility. In the initial stages, there's a qualified engineer on hand. After that we support our customers via email and telephone.

PS: Thank you very much for both the interesting demonstration and the chat.

Text: Thomas Zahn

Photos: Thomas Zahn, Fohhn