HIGH PERFORMANCE FULL-RANGE LOUDSPEAKER SYSTEM WITH CARDIOID DIRECTIVITY FOR DIFFICULT ACOUSTIC ENVIRONMENTS

43.55.FW ELI -ELEKTRO-ACOUSTICS AND INSTRUMENTATION

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ABSTRACT

Nowadays the demand to sound reinforcement used in cathedrals, churches, halls and other difficult acoustic enviroments are much more higher than less years before. High performance reproduction of both speech and (live) music with high level of natural intelligibility is wanted by the audience. Based on acoustical and physical laws loudspeakers with a high-Q are needed. Ordinary sound solutions are unexcepted by architects and consultans because of their dimensions. FOHHN Audio AG/ Germany developed a compact full-range loudspeaker with extra ordinary front-to-rear damping below to 70 Hz. This prevents acoustical spill. Cathedral Nuertingen is an example of use to explain the cardioid technology.

INTRODUCTION

With the example of the sound reinforcement system in the Cathedral of Nuertingen will be demonstrate how to get a well accepted system. In this situation it is not practical to use a mobile loadspeakersystem at special events. A permanent installed speaker system is needed to reproduce natural sound, speach and even live music itsself.
In this project and this article we will give an impression how to give a solution of speach and music with the same speakersystem in a very difficultly acoustic environment.

HISTORICAL NOTES

The Cathedral of Nuertingen was built in 1024 or former and destroyed in 1286 by Rudolf von Habsburg. In 1509 the building of the present cathedral was finished. The first organ was built in 1530. A second organ in baroque style was added in 1724 in the choir and replaced in

1885/6 by an organ in an newgothic style. The first extensive renovation was in 1895/6. In 1936, a new organ was built on the westgallery. During the second extensive renovation in 1964 the original galleries around the cathedral have been taken out. This causes a dramatically deterioration of the acoustical environment. In 1973 a new organ has been built on the westgallery [1]. In the Year 2000 a big fire has disturbed the interior of the house, the organ, and the public-address-system [2]. All these renovations and changes, motivated by mainly optical interests, have modified the acoustical situation. So there are reasons for the assumption this situation before 1964 with the wooden galleries would have had a better acoustic situation than the situation afterwards. Wooden Installations often work as absorbing elements for deep frequencies.

SITUATION

The old public-address-system was destroyed by fire. For selection and planning the public-address-system, roomacoustical measurements have been necessary [2)]. The communitiy wanted to have a better integration of modern musical elements and integration of electonically added equipment. Also elctronical piano and keyboards should be integrated into the church service. In the community exits a young team of musicians who are celebrating there own kind of church services and concerts.

THE PUBLIC-ADDRESS-SYSTEM

The public-address-system should not stimulate the diffuse sound field. So a high directivity –especially at deep frequencies - is profitable. The loudspeakers should be placed near the audience. By using many loudspeakers a signal-managing-system is needed to avoid differences in sound travel time. The selected loudspeakers should fulfil the requirements[2)].

PRODUCT REQUIREMENT SPECIFICATIONS

1st: A frequency range from 70Hz up to 20.000Hz at a maximum of ripple less than +/- 3 dB is needed. 2nd: Sound pressure level in all seats and listener positions of more than 85 dBs are needed to get enough dynamic for music programs and live music or bringing in from external audio equipment. To get a good dynamic and sound pressure headroom the maximum level can be more than 10 dB above. 3rd: A back absorption of more than 20dB all over the complete frequency resonse is needed to reduce unwanted acoustic radiation (spill). This will reduce unwanted reflexions in this very reverberant environment especially in the Cathedral of Nuertingen.

DEMANDED MECHANICAL DIMENSIONS OF THE SPEAKER SYSTEMS

Dependent on the wavelength of the lowest frequency the dimensions of oridinary speakers are very large if we would use ordinary horn loaded speaker design. But for use in churches and cathedralds the mechanical dimensions of full range horns are much too large.
At 100Hz for exmaple the wavelength is about 3 meters long which means a construction of very lage horn with very uncomfortable dimensions. In this case it was very difficult to find the best solution without any compromise.

PROBLEMS OF THE MECHANICAL DIMENSIONS

To reach best performance at a minimum of size of cabinets we decided to develop loudspeakers with a similarly acoustic design like acoustic design of directional microphones. This offers dimensions as small as possible and a good directivity at bass and low-mid frequencies. There is no need to do the same in the radiation of high frequencies. At frequencies above 2000Hz it is much more easier to get a closer directivity becasue of the

mechanical dimensions. The well known effects of columns by stacking and building vertical ”line arrays” brings a good improvement at short wavelengths. Very high frequencies (above 4kHz) can be radiated with small horn tweeter systems.

SUBWOOFERS

Ordinary subwoofers should not be practical because of their onmidirectional directivity. The complete sound preasure in the low frequencies (below 100Hz) only should go out from four pieces of speakercabinets in the main area of the church. Important is the direction of the radiation especially in the lower frequency spectrum. Additionally the distance to the listener position must be as short as possibel. Therefore we could reach enough sound preasure level

IMPLEMENTATION

At different places and different listener positions inside the Cathedral of Nuertingen the architecturally acceptance because of the size of a public adress speaker system is necessary. So we decided to use the smallest cabinets as possible in some sections of the cathedral. Therefore three different models of speaker cabinets must be used. Because of the acoustic environment only speakersystems with cardioidial directivity could be used. In assortment of Fohhn Audio AG, a speaker manufactorer company, we find some models which can perform the acoustical in different mechanical sizes an powerful sound performance.

SELECTION OF SPEAKER MODELS

In the choir area of the cathedral four pieces of the model „FN-3” could be installed. Below the loft (under balcony) also the very small sized model „FN-3” is used. All nearfield sections also the model „FN-3” should be recommended. The side ranks and the loft the speaker model FTS -3 is recommended. The main section in the church ship four pieces of the larger sized models „FTS-4” must be used because of better extension of the lower frequencies. Especially the model „FTS-4” offers a ratio from front to the rear side of more than 20dBs even in the frequencies below 500 Hz. Please remark: only the Model FTS-4 offers an extendes frequency reponse below 70Hz.
The mechanical datas of the selectes speakers see below:

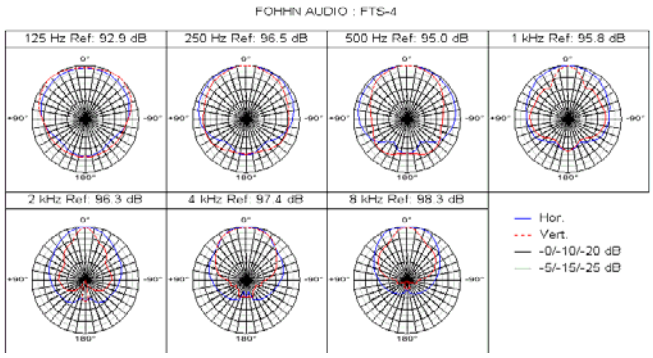
MECHANICAL DIMENSIONS*:*

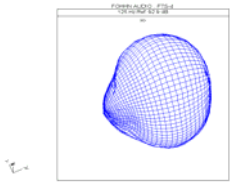
FN-3: (WxHxD) 15 x 15 x 16cm more technical Datas: http://www.fohhn.com/php/?pid=107
FTS-3: (WxHxD) 15 x 60 x 14 cm more technical Datas: http://www.fohhn.com/php/?pid=108
FTS-4: (WxHxD) 21 x 95,5 x 22 cm more technical Datas: http://www.fohhn.com/php/?pid=109

DIAGRAMS

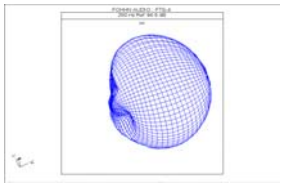
The following diagrams show the directivity and polar pattern of the selected speaker model Fohhn „FTS-4” (http://www.fohhn.com/php/?pid=109)

Polar pattern of Fohhn Audio AG model FTS-4.

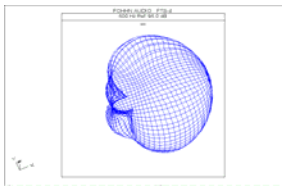




3-D baloon of FTS-4 at 125Hz band



3-D baloon of FTS-4 at 250Hz band



3-D baloon of FTS-4 at 500Hz band

DESCRIPTION OF FUNCTION

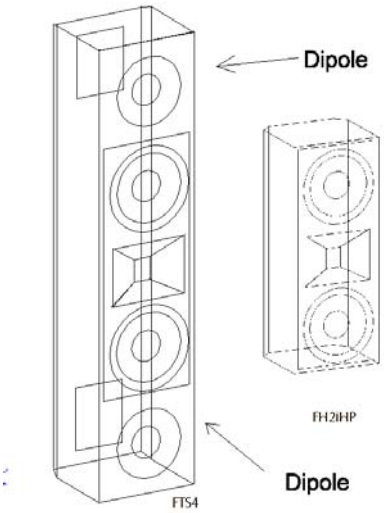
By overlaying two independent sound radiations we get a new polar pattern of sound radiation. This means overlaying of the omnidirectional radiation part of the loudspeaker box and the dipole section of the loudspeaker box. The result is a summarizing of sound pressure on the front side of the loudspeaker cabinet and an extinction of the sound pressure on the rear side of the loudspeaker box. The principle is similar to a the principle of a directional microfone. The geometrical form seems like a carioide. By adding more speaker systems as a column we get in the vertical area a narrowly limited polar pattern and in the horizontally area like a carioidical polar pattern.

SOLUTION

The speaker is using separate loudspeakers to the front and the rear side. All speakers are producing pressure to the front side. Two loudspeakers are producing pressure to the front side and the same time invers pressure (out of phase to the front) to the rear side of the cabinet. This means extinction of the sound level at the rear side of the cabinet. An electronical circuit

can control the dipole speakers. The loudspeakers at the top and the bottom of the cabinet are working like acoustic dipoles. Because of the consistent symmetrically acoustic design the system will work down to low frequencies. An especially solution is to use a seaparate limiter system inside the FTS-4 only for the dipole speakers (gradient radators) and a phase shifting network to optimize the overlay at the back side of the cabinet.

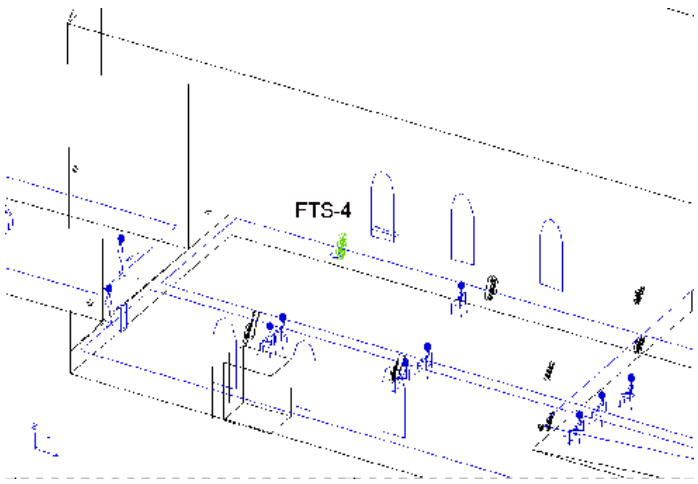
Picture No.1 Picture No.2



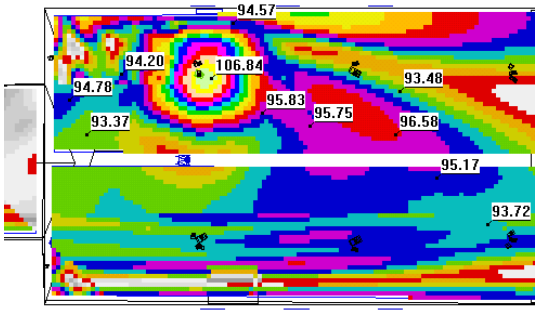
FTS-4 COMPARED TO ORDINARY SPEAKERS

Picture No.3

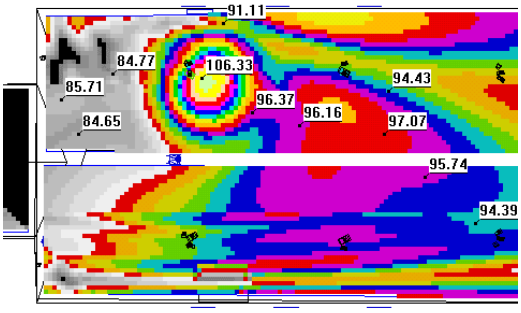
Picture No.4



Picture No.5



Picture No.6



Picture No 3 will show the speakers mounted in the Cathedral in Nürtingen. In picutre No.4 we see the model of the CAAD (computer aided acoutic design) simulation. It was created with the software ULYSSES *. Let´s show the difference to ordinary speaker systems in this sample. The pictures No 5 and No. 6 shows the interaction in the direct sound field (PC calculation). Only one speaker (FTS-4) is switched on. In picture No.5 the model FTS-4 is substituded by the speaker model FH2iHP (oridinary dircectivity). This model is almost simular to the FTS-4 model. The difference to the FTS-4 cordioide type is that there are no additional dipoles included - also see in the drawing at picture No.1 and No.2. The result of the calculation was done in the 125Hz band and shows a significant difference and a reduction of the sound preasure in the unwanted areas of the room. Therefore less than 11 dB of unwanted sound energy will be brought into the acoustic environment.

*www.ifbsoft.de

CONCLUSION

Consequent use of speaker systems with cardioid pattern characteristics allows to reproduce music and even wideband sound signals in reverberant environmets at a high sound quality and a high intelligibilty. This can not subtitude acousitcal measures of the room but can support it.

REFERENCES

[1] Die Stadtkirche in Nürtingen, Johannes Kiefer, Studiodruck Brändle, Nürtingen-Raidwangen

[2] Neues Leben in alten Mauern, Festschrift zur Wiedereinweihung der Stadtkirche St Lautentius Nürtingen, 2001

[3] A.Egenter, Clear-Sound-Acoustics Acoustical measures in historical buildings at the example of the Cathedral of Nürtingen
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[4] Neuer Klang in altern Mauern Page 76 - 80 Professional System 2/2000 März/ April