musikelectronic geithain

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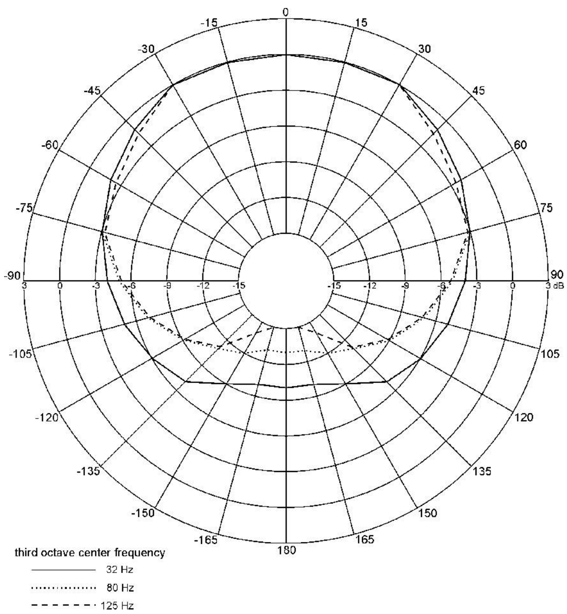
The first of its kind: studio monitor RL 901k with a cardioid radiation at low frequencies.

The acoustic delay lines on the left and right side of the back of the RL 901k are hardly conspicuous.

Controlling low frequencies

Active Studio-Monitors with low frequency cardioid characteristic made by musikelectronic geithain

Generations of loudspeaker developers had had to accept an apparently irrefutable fact: Controlling radiation characteristics in practice is easy in the high and in the mid, but not at all in the low frequency range. Anyway it is taught in every physics book that low-frequency waves with a length extending in the range of meters, i.e. below 300 Hz, know how to elegantly diffract around obstacles, which are smaller than them. So they escape all measures to influence the directivity as they e.g. lead to success for hyper-cardioid microphones, by skillfully produced delays and phase cancellations – indeed only above the low frequencies. That it is, also possible to control long wave energy – if you know the “trick” with the phase - is proofed by the studio monitor RL 901K of the manufacturer Musikelectronic Geithain (ME-Geithain). The box with themeasurements 550 × 500 × 430 mm (h × w × d) shows a distinctive cardioid characteristic, which is effectivebelow approx. 300 down to 30 Hz.The free-field diagram illustrates how strong the lowfrequency energy emitted in the “wrong” direction getsrestrained. After all the decay at 80 Hz is at least 8 dBin the rear area from 130 degrees and more than 10 dBin the segments at ± 45 degrees around the back middle axis.



The free field diagram of the RL 901K shows the reduction of the backward emitted energy; it is effective till below 30 Hz.

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How this directional characteristics has been achieved and what consequences result for audio control rooms, graduate engineer Dieter Thomsen talked about it to Jochen Kiesler, owner and chief developer of ME-Geithain. The company, which is located close to Leipzig, was known already before the German reunion for the production of studio monitors with special coaxial arranged high- and mid-frequency transducers, satisfying highest professional demands. Without great PR activities they now start to conquer one of the front ranks in the high-end consumer segment.

Mr. Kiesler, how do you achieve cancellation of waves with wavelength in meter range, and this not only for a few discreet Hz but within a 1:10 bandwidth? After all, we talk about wavelength, which extend between 1 and 10 meters.

Well, for sure not by deceiving physics. That won't do. To sum it up, the trick was to attach an acoustic phase-rotation line at the back of a loudspeaker which produces a phase-shift of 160 degrees. Thereby both, the phase and the amplitude must be kept constant within 5 degrees and – this is the biggest problem – irrespective of pressure conditions. After all, the range of pressure inside the box differs from 25 to 125 dB and for all that, the specific flow resistance has to be the same.

In other words, the flow resistance causes a wideband delay?

You could say so. We use a combination of several materials which I would not like to discuss in detail now. Inside the loudspeaker box RL 901K there are two separated cabinets which close up with these flow resistances in their back. The dimensions of the flow resistance and of the membrane correspond to each other and if you choose the correct combination, it works for frequencies down to 30 Hz.

Jochen Kiesler:
The cardioid characteristic helps us a lot to control the mutual dependences of loudspeaker and room.

Why hasn't anybody come up with this idea before?

Well, there has not been any lack of attempts. Some approaches use two subwoofer set up against each other – actually a plausible idea. In practice however, you would need two high-quality low frequency drivers with an amplifier and the matching enclosure for each. Therefore it never became a commercial product. Whereas we have some experience with constructing loudspeakers which emit a cardioid characteristic down to 100 Hz from working with PA-systems. One day we asked ourselves if we could extend this principle to still lower frequencies even if there was no theoretical basis for it.

Delay actually implies that the sound velocity is reduced in the acoustic line. Is this really true?

Yes. It is reduced from the usual 330 m/s down to approximately 310 to 220 m/s. This can be determined indirectly by a phase measurement.

How were the transfer function for the cardioid- and the omni-directional characteristics measured and what do they mean in detail?

We have used the same specimen of loudspeaker in the same room – which is an audio control room of a radio station – and averaged five measurements at the monitoring spot. The distance from the wall was about 1 meter. For the omnidirectivity we have sealed the rear radiation-inlets pressure-tight. The left channel shows the differences most clearly, because of a window which was located on the left side of the control room and its acoustically hardness down to low frequencies. Besides the room had a small depths which made the situation even worse. The notch between 70 to 100 Hz, which you can see on the chart, is typical for a multitude of small audio control rooms as they can usually be found today. If there are now 10 db less sound level behind the loudspeaker, there is also a smaller superposition-effect for the formation of wavemodes. This leads to less ripple on the characteristics of the operational sound level, as one can see at the curve for the "cardioid". I emphasize again, however, that the shown curves are only valid for a specific room. Unlike this, the recordings of directivity are generally applicable. They were measured in a free-field situation with a measuring microphone in standard height of 1,40 meter so that the ground reflections were included. And they also influence the energy behind the

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speaker by sort of "crosstalking". If they weren't taken into account, the measurement would be unrealistic. By the way: not even in an anechoic room you obtain the required accuracy, because already the spacing between the wedges of the acoustic insulation leads to falsifications.

Can you assume that an ideal exists there, so to speak a predetermined room-position for the RL 901K

No, an optimization for the room position can only be found by trying out. And I also could only give advice against simulation-programs, which lead you to expect reliable statements about the sound of a room, after entering only a few parameters like room dimensions and specifications of the loudspeakers. Besides, I believe digital correction is likewise only partly suitable. Selective notches in a transfer function at the monitoring spot can't either be compensated without any damages by this technique.

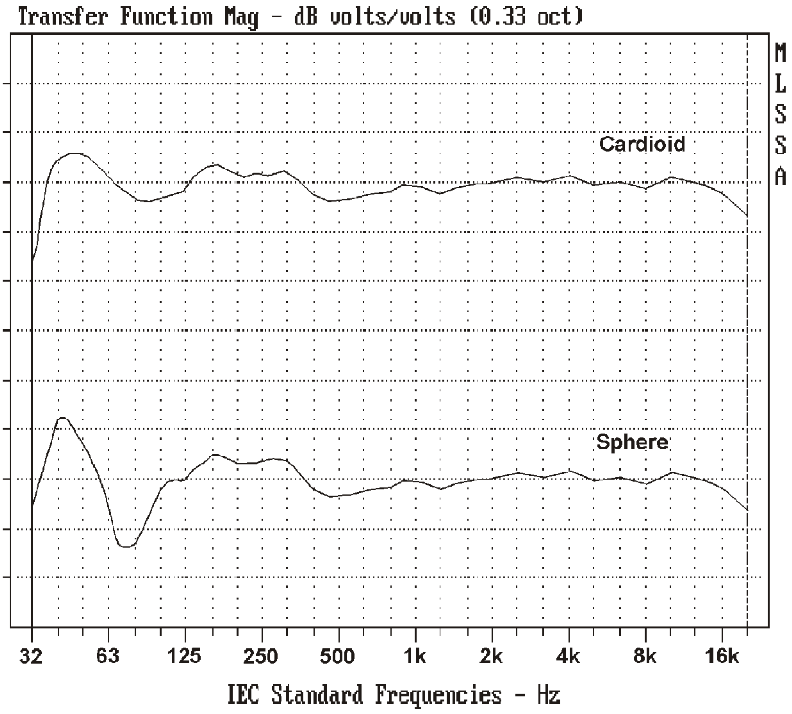
If an active loudspeaker emits a particular power, does it get less because of the cancellation?

Concerning this one should not make a mistake; the acoustically effective power in the complete system remains unchanged.

Till now both, the RL 901 and the RL 901K are in the product catalog. Will you offer the k-version exclusively in the future? Is there a possibility to modify non-K-versions and are other MEGeithain-models also upgradeable?

The 901 was favorable for the modification because of its suitable inside construction; it had enough space for installing the flow resistance and the inlets on its back. All the other loudspeaker boxes require a new design. But the modification does only make sense for active monitors.

To conclude, how does the cardioid radiation influence the sound in practice?



Control room 4 · RL 901 Cardioid /Sphere · left side · 12.02.2002

Sound pressure level of the RL 901 for cardiod- and omnidirectional radiation, averaged over five points, measured in a small audio control room. The linearization between 70 and 100 Hz is clearly shown in the upper curve of the diagram.

The result would be a more balanced sound impression for low frequencies if there had been notches in the transfer function of the omnidirectional radiation. In addition, an optimization for the positioning of the loudspeaker at a specific point in a room and for a defined low frequency band becomes easier. For little damped room characteristic modes excitation, resulting from loudspeakers' set up, gets reduced and therefore the time of ringing, too. But this does not mean that the acoustic design of a room is no more or a little less important; this is also a proper measure for optimizing the overall sound quality. Besides, one thing must be kept in mind: The room is always first there and we expect of the loudspeaker which is set up afterwards that it renders high quality services. And the cardioid characteristic helps us a lot to control the mutual dependences of loudspeaker and room.

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VISUALIZATION OF MODES

Any room with its acoustic characteristics can be regarded a complex system – this becomes obvious when loudspeakers are to fulfil their assignment, which is to reproduce i.e. any acoustic environment to a large extent without any coloration. Often the result is disappointing in the first place – especially when highly optimized professional products are used with high expectations regarding the results.

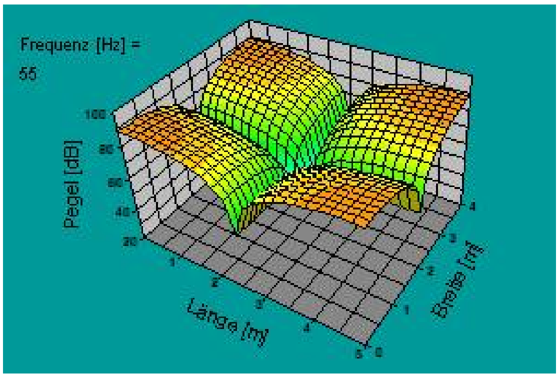
Since a major focus lies on the interference of the "hearing environment "with the "loudspeaker-system", optimization measurement would be necessary actually at both of the two components. Optimization of the hearing environment seldom has priority, though: But acoustics always has its price. So, in case of the stereo reproduction a compromise usually consists in improving the sound by variation of the loudspeaker position.

The main purpose would be to get a balanced, clearly drawing low frequency reproduction - the often quoted Sweet Spot with its neutral impression.

The arch enemy of any linear low frequency reproduction are standing waves, which arise after the inexorable law of the multiples of the half wavelength between two reflecting surfaces. The resonance peak absolutely can reach 15 dB at an antinode of such standing waves. Since there merely exist any real sound-hard-boundaries for lowest frequencies, the resonance peak stays mostly below this value. Conditions become more complicated in practice by standing waves, which do not only arise axially between two parallel walls with sufficient expansion, but also diagonally and tangential.

It would be nice, if such effects could be compensated by a pre-equalization in the power amplifier; but the stationary character of such overlapping resonances which are all together called modes already make any approach ineffective from the start. Different modes arise in each fraction of a second stimulated by the speaker membrane in new forms. Their decay time does not all follow the course of the stimulating energy, but usually takes much longer – a phenomenon, which can give a room this well-known sponge like / bouncing character, but isn't traceable by obvious investigation. On the other hand the listener needs a certain mixture of resonances and reflections, in order to orient himself in an acoustic environment and to feel the sound lively. Only a visualization can show the dynamics unfold by the non stationary energy movements. An example of a good visualization can be downloaded as an avi-file on the web page "the platform for innovative acoustics" of the "Fraunhofer Institut für Bauphysik" (PIA) [1]. The picture taken from the animation, which shows the whole process from 20 Hz to 100 Hz in steps of 0,5 Hz, can only show a snapshot.

In addition for better understanding of the



Only a visualization is able to illustrate the short-time processes at the arise and superposition of room modes first.

topic a paper of Dr. Horst Wollherr and Sebastian Goossens (IRT) is recommended, held on the "Tonmeistertagung " 1998 [2]. In a formula for the radiation, stated in this paper sound velocity appears as a relevant size; it plays an important role in the context with the cardioid-monitor RL901K from ME-Geitain. The sum of the aspects addressed in the lecture certainly exceeds the framework of this contribution.

No doubt: The best way to get linear reproduction without resonance peaks is to avoid the excitation of the modes at all. If financial aspects are of minor importance, you could design a pretty useful 2-pi-radiator by installing the loudspeaker, which has a omni-directional characteristic at low frequencies (4- pi - radiator), pressure-tight into the wall. Apart from the necessary efforts for the construction of this solution it is hardly suitable for every monitoring room; in addition even small control monitors, e.g. set up directly in front of the mixer, are expected to provide the highest possible linearity within the low frequency range. Acoustically almost "malicious" is such a fixed 5.1- reproduction installation, as Jochen Kiesler said, because a significant amount of energy gets through by the surround-speakers upon the surface in front of the listener.

The superiority of the ME-Geithain solution exists in the fact that it permits to separate the characteristics of the room from that of the system loudspeaker - also if the cardioid-box thereby does not become an ideal 2-ð radiator, the floor still is another interference factor. Not without reason do the "Geithain"-people optionally offer a stable-rack for each of their product series. It rises up the loudspeaker to a height of 1.4 meter and is built asymmetrically: Unwanted, downward-targeting low frequency energy is already suppressed to a large extent by the construction.

If now a way to control low frequency radiation has been found, the only thing missing to get the ideal transducer is the one "trick": to succeed over the air compressibility. Because this is what robs the attack of every fast impulse, before it reaches the listener, even if the highest quality high-frequency-transducers were used. The development, however, keeps on going ...

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