Technical news
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R&D News

Time alignment of subwoofers in large PA systems

Doing the correct set-up of a large PA system is not an easy task.

In common PA systems the frequency range is divided into different ranges that are reproduced using different cabinets (subwoofers for the bass range and top cabinets for the mid range). This means different locations and positions of the sound sources and therefore destructive or constructive interferences in the crossover range. Time alignment is needed to adjust the arrival time of frequencies in the crossover area.

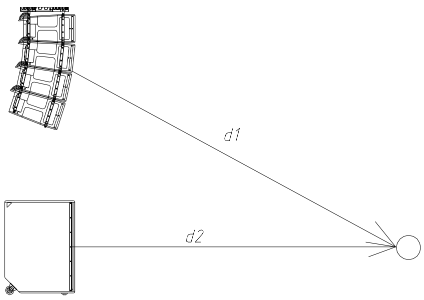


Fig.1.This system is not completely aligned because d1 and d2 are not equal.

Typically, the "rule-of-thumb" of delaying the subwoofers with the distance difference (d1-d2) has been used, but this is not always the best approach. At crossover frequencies the phase is modified by the effect of the filters applied, so it is not just a matter of distance.

This brief studies how to properly align a system of this kind. First, a downscaled model has been used in order to fit it inside an anechoic room and study the different situations. Then the alignment process obtained is applied and validated in a larger PA system.

Measurement equipment

Having an anechoic room with absorbent walls, ceiling and floor will drive us to some "pure" measurements, free of problems on the phase recording. The anechoic room used is located at Master Audio's facilities, with a volume of 400m^3 and a RT<0,2s down to 200Hz.

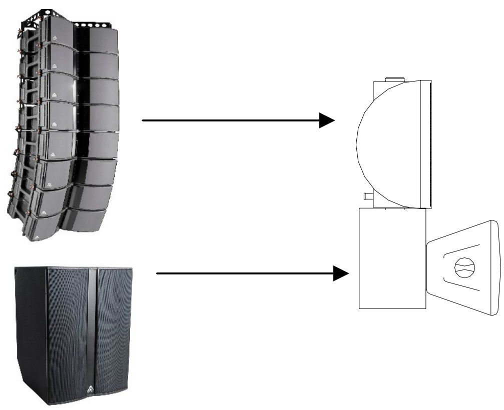
A powerful measurement system based on the Fast Fourier Transform (FFT) will be needed in order to get both amplitude and phase response. As a sound source, some small cabinets from Master Audio® (B6® model) have been chosen. These cabinets will act as the downscaled model of the big PA system.

With a downscaled model we are able to notice how the real system will perform in real life. Downscaled measurements never replace those in a real application but they can help us a lot before doing the final set-up in a live performance. The knowledge of these techniques in the laboratory will greatly help us in our daily work on the stage.

Fig.2. Elements involved with downscaled measurements

Measurement process

We will setup an example based on two B6® units. The first unit will role as a subwoofer (cutting its frequency range with an external crossover) and will be placed on the basis of the measurement platform. The second unit will role as the mid-high enclosure and will be placed above the first unit, with a slight physical delay between cabinets. In this way we ensure that the two units are temporarily out of alignment, as it will happen when a big PA system is hung above some subwoofers.



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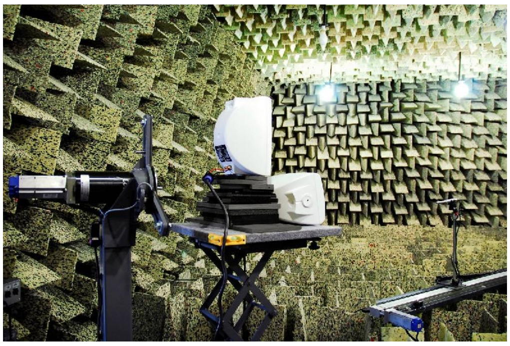

Fig.3.From big scale to small scale

By measuring the transfer function of the downscaled model and by applying phase alignment through delay correction it is possible to avoid the feared destructive interferences caused by the performance of both cabinets at the same time.

What happens when there is an overlapped frequency response between both sources?

Measurements of both the first unit (subwoofer) and the second unit (top cabinet) were recorded on the same screen.
When comparing the phase and amplitude of both units a phase difference is noticed on the frequency range being shared by both cabinets (200-300Hz).

Fig.4.Comparison of subwoofer and top unit

We need to add or subtract delay from the subwoofer unit until both phase curves overlap on the frequency range being shared by both cabinets (200-300Hz).

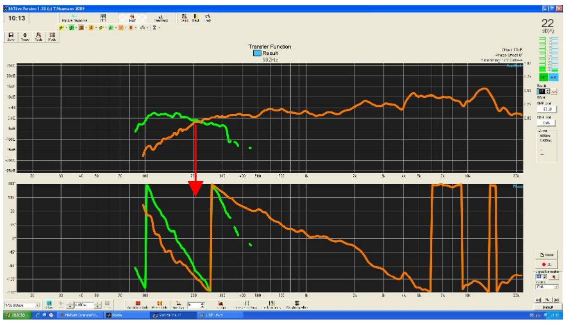

Fig.5.Phase alignment between subwoofer and top unit

Finally we compare the amplitude of both the unaligned and aligned complete system. A flatter response is obtained through the correct alignment of the system.

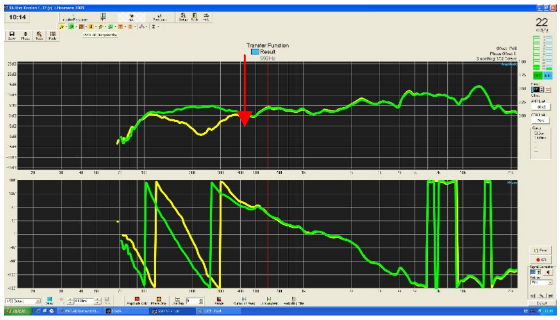

Fig.6.Aligned (green) and unaligned (yellow) system

What happens when both sources share the same crossover frequency?

As in the previous example we take a measurement of both the first unit (subwoofer) and the second unit (top cabinet). When comparing the phase and amplitude of both units a phase difference is noticed at the crossover frequency (270Hz).

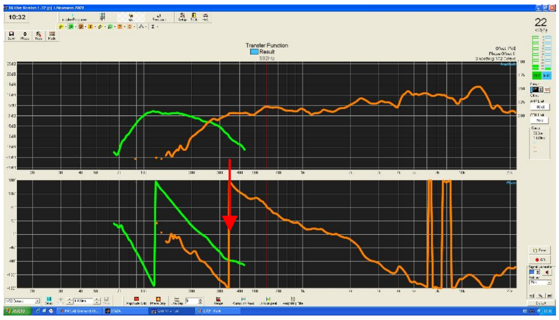

Fig.7.Comparison of subwoofer and top unit

Adding or subtracting delay from the subwoofer will drive us to the same phase at the crossover frequency (270Hz).

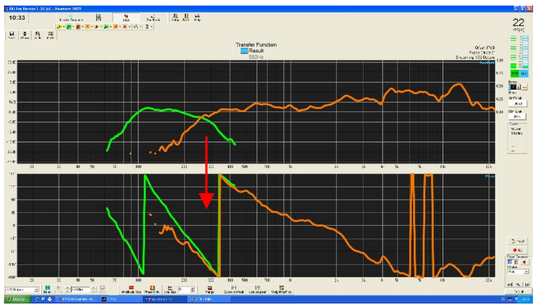

Fig.8.Phase alignment between subwoofer and top unit

In this example the improvement is not as obvious as it was in the previous example.

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In any case a better response is got with the system's alignment.

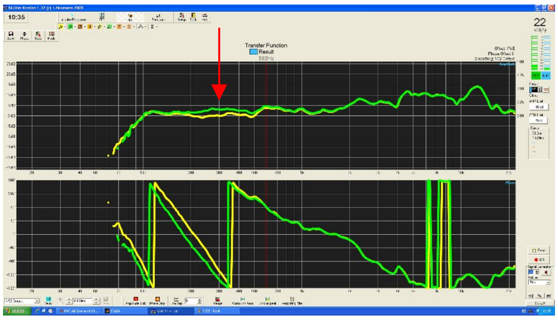

Fig.9.Aligned (green) and unaligned (yellow) system

Field R&D Test work

A 4-box (Master Audio X210®) array was set up to cover the test area. One subwoofer (Master Audio X218W®) was then placed below the main system and the response measured.

Fig.10.System for test

The initial response of the whole system was saved and observed and then some phase adjustment (same process as we did in the laboratory) was made to the subwoofer unit. This made a significant difference. When this was corrected an even frequency response was obtained.

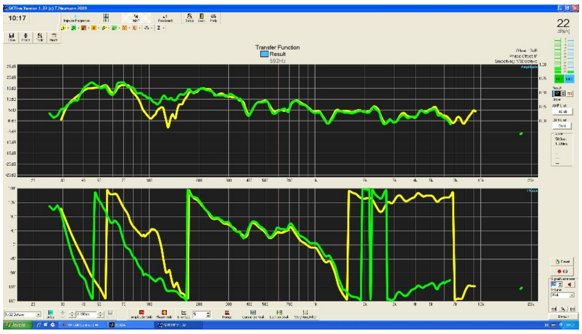

Fig.11.Aligned (green) and unaligned (yellow) system in real test

Some differences were found to downscaled measurements. In a field measurement, the phase curves may show some irregularities due to the loss of coherence at certain frequencies. We should be capable to notice and recognise the real phase shape.

Conclusions

Appropriated time alignment of PA systems such as line arrays is crucial for an optimum performance. When using subwoofers, the problem of phase-shift may drive to a dramatic loss of performance on the crossover range between sources.

A downscaled model was tested in an anechoic environment in order to predict the behaviour of the system before going to a real live application.

Time alignment of subwoofers is best achieved by using practical phase measurements. The overall system response is clearly improved by correcting the phase shift measured at the crossover frequencies.

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