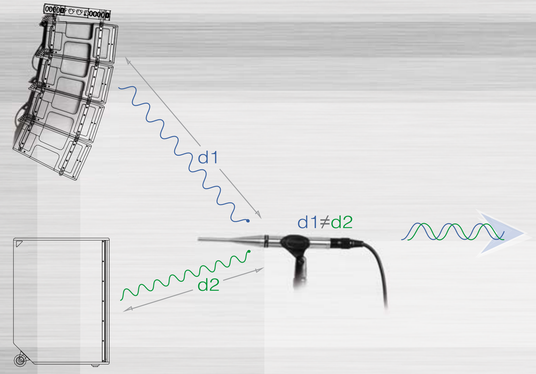
Time Alignment of subwoofers in large PA Systems. Introducing a downscaled model.

Joan Amate & Natàlia Milan - Master Audio - Terrassa, Barcelona (Spain)
130th AES Convention, London, UK - 2011, May 13

1 Abstract

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.



Interference
Loss of performance
Uneven sound

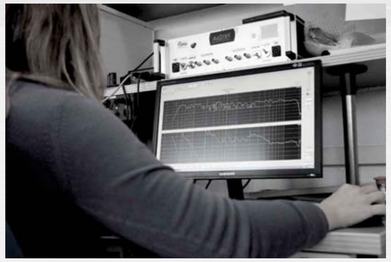
Downscaling

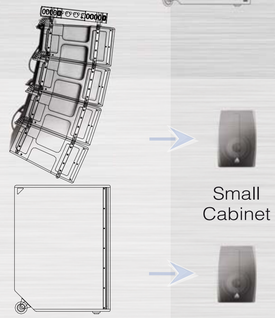
2 The Idea

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.

Anechoic Environment

FFT Measurement System



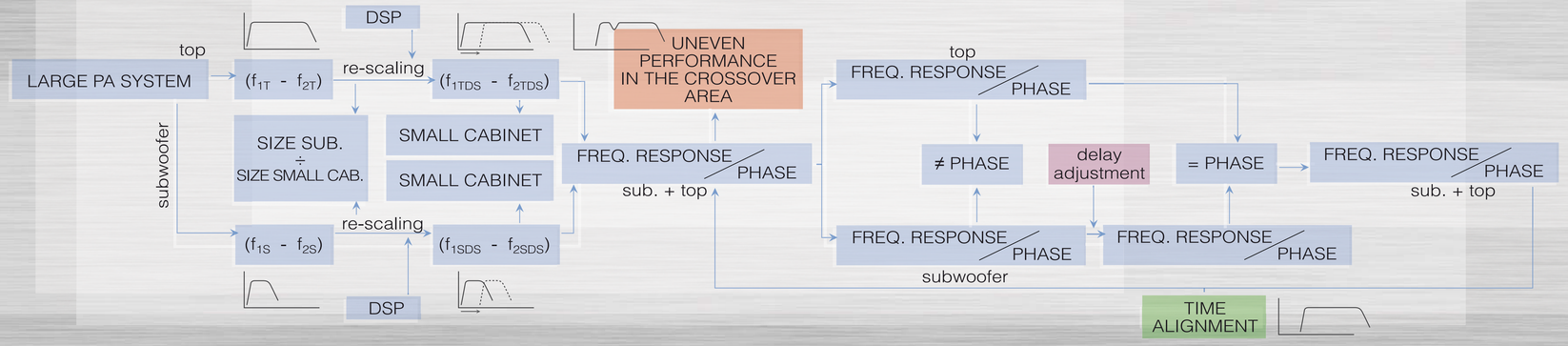


Small Cabinet

3 The Process

The downscaled setup was based on two Master Audio B6® units. The first unit roled as a subwoofer while the second unit roled as the mid-high source. The second unit was placed above the first unit, with a slight physical delay between cabinets. In this way we ensured that the two units were temporarily out of alignment.

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.



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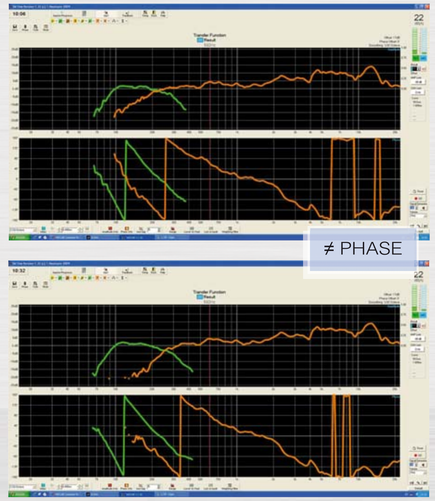
4 The Results

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 was noticed on the frequency range being shared by both cabinets (200-300Hz) or at the Xover frequency (270Hz). We needed to add or subtract delay from the subwoofer unit until both phase curves overlaped on the frequency range being shared by both cabinets (200-300Hz) or at the Xover frequency (270Hz). Finally we compared the amplitude of both the unaligned and aligned complete system.A flatter response was obtained through the correct alignment of the system.

Overlap

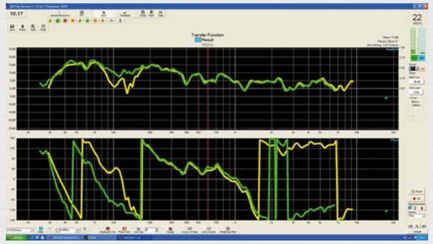
Same Crossover Frequency



5 The Field 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.

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.



Initial Frequency Response
Frequency Response After Time Alignment

6 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.