1 INTRODUCTION

The LA amplified controllers provide libraries of presets dedicated for use of L-ACOUSTICS® products. A factory preset combines the control of speaker parameters and the application targets of the speaker. As a result, a preset allows the loudspeaker to match a given application when arranged into a given configuration. Multiple configurations exist from single distributed to line source array systems.

However, as the number of available factory presets is not infinite, the frequency response of the system in use does not exactly match each configuration and may need reshaping. This operation is easy to apply for distributed systems by using discrete preset settings for each loudspeaker.

On the contrary, it remains harder to reshape a line source response which changes much with various configurations. As preset parameters do not compensate for the laws of physics in array coupling, System Engineers have to re-tune the tonal balance of their systems with no guidance.

As early as 1992, L-ACOUSTICS® identified the multiple factors governing the changes in the frequency response of a WST® line source design [1-3]. With the evolution of DSP technology, L-ACOUSTICS® has now developed the new exclusive ARRAY MORPHING tool. This latest part of the LA NETWORK MANAGER software (version 1.2 and latest) allows quick, accurate, and predictable global settings for any L-ACOUSTICS® WST® system.

2 PRESET CONSTRUCTION

2.1 Fundamentals

The final frequency response of a loudspeaker not only depends on the enclosure and transducer characteristics but also on the preset which is the final electronic transducer optimization.

The preset contains the DSP parameters for controlling the bandwidth (shelving and X-over filtering) and power resources for each frequency section. The goal is to optimize resources for each section by ensuring individual transducer thermal and mechanical protection as well as offering the user the desired frequency contour for a given application.

In this way, the preset contributes to the acoustic performance of the loudspeaker. These can be compared to the motor of a car: this organ develops power. But a question remains: which envelope to choose to make the car attractive and suitable for practical use?

While transducers and amplification define the power and the bandwidth abilities of the speaker system, the enclosure design and the preset parameters optimize the acoustic performance. In addition, the preset includes complementary EQ to provide the sonic signature of the loudspeaker (typically the sonic envelope for the application).

As a result, a preset construction addresses the acoustic performance as well as the sonic signature of a loudspeaker. Both aspects are independent, since a speaker may yield excellent acoustic performance and poor sonic signature. The contrary is also possible.

To obtain excellent results, it is necessary to take into account all the parameters governing the acoustics of a loudspeaker system. These parameters are different for each system type, configuration and use. These parameters have been identified and classified by L-ACOUSTICS® in the case of line source array systems.

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2.2 Line source array parameters

The transfer function of a line source array (denoted $\mathcal{T}_{\text{array}}$) is governed by three sets of parameters respectively linked to the system application, environmental conditions and array geometry (array size, array curvature, and listening distance) as it is shown in the following formula:

$$\mathcal{T}_{\text{array}} = \mathcal{T}_{\text{env}} \times \mathcal{T}_{\text{app}} \times \left[\mathcal{T}_{\text{size}} \times \mathcal{T}_{\text{curv}} \times \mathcal{T}_{\text{dist}}\right]$$

$\mathcal{T}_{\text{env}}$ denotes the environmental influence due to room acoustics and air absorption. These effects may be compensated using the integrated CONTOUR EQ setting tool in the Network Manager or an external EQ STATION.

$\mathcal{T}_{\text{app}}$ is a function of the product type, system configuration, and preset that have been selected to match a particular application. As an example, the frequency responses of three different systems are given in Figure 1 (after SPL rescaling to make the comparisons easier). They have been obtained by successively applying the $\mathcal{T}_{\text{app}}$ transfer function of each system to a pink noise signal:

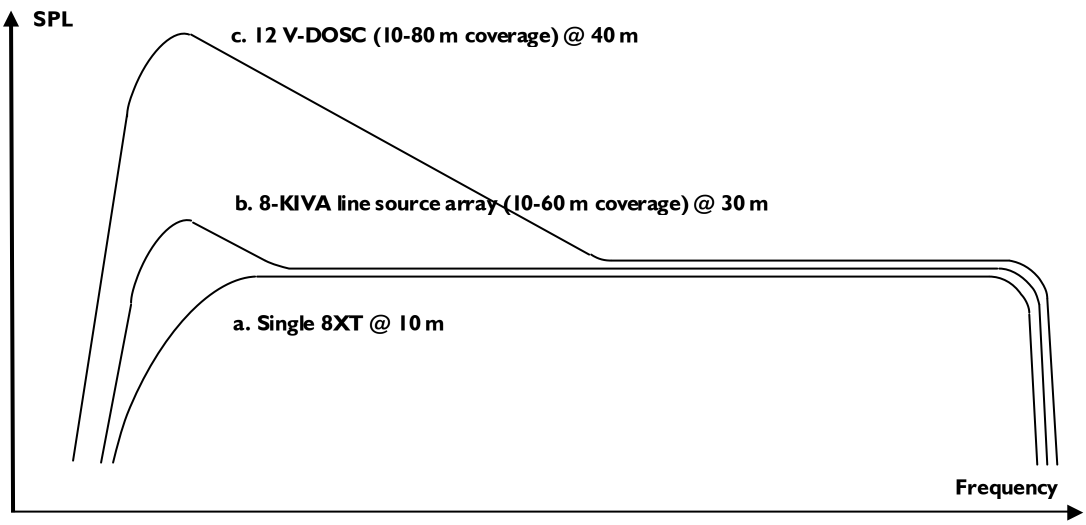

Figure 1: Three representative system frequency responses

- **a.** Single coaxial speakers (or 2-KIVA or 2-dV-DOSC fill line source arrays) for distributed applications. The [FILL] preset has been selected to obtain a "flat" response in free field conditions. Two other presets are available: [FRONT] for FOH application and [MONITOR] to match half-space conditions (last for coaxial only).
- **b.** KIVA (or dV-DOSC) line source array without low frequency extension (KILO or dV-SUB). The low frequency response can be from "flat" to slightly enhanced. Such a system is modular as it can match different applications (theatre, arena, stadium) for all sized audiences.
- **c.** V-DOSC (or K1 or KUDO) line source array for concert-touring applications with large audiences. The low frequency response is enhanced to satisfy near-field experience at any distance. The presets used to obtain such a response are based on the "12 V-DOSC (10-80 m coverage) @ 40 m" response curve that has become the L-ACOUSTICS® reference over 15 years of international feedback experience.

$\mathcal{T}_{\text{size}}$, $\mathcal{T}_{\text{curv}}$, and $\mathcal{T}_{\text{dist}}$ are respectively linked to the array size, array curvature, and listening distance. Their influence will be discussed in the following section.

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3 LINE SOURCE ARRAY CONTOUR RECALL

For more detail on this subject, please refer to [1] or [2], or attend a WST® training course.

Any line source array provides a wave propagation mode yielding a -3 dB SPL decrease per doubling of distance in the HF frequency domain and -6 dB in the LF domain. The frequency of transition depends on the size of the line source. For example, the Figure 2a shows the evolution of the frequency response of a 12-V-DOSC system when doubling the listening distance three times (d, 2d, 4d, and 8d).

If we now rescale the SPL level to offset the -3 dB loss in the HF region, we obtain the four curves of Figure 2b. We observe that the **LF domain** contribution is enhanced as the **observation distance decreases** from far to close.

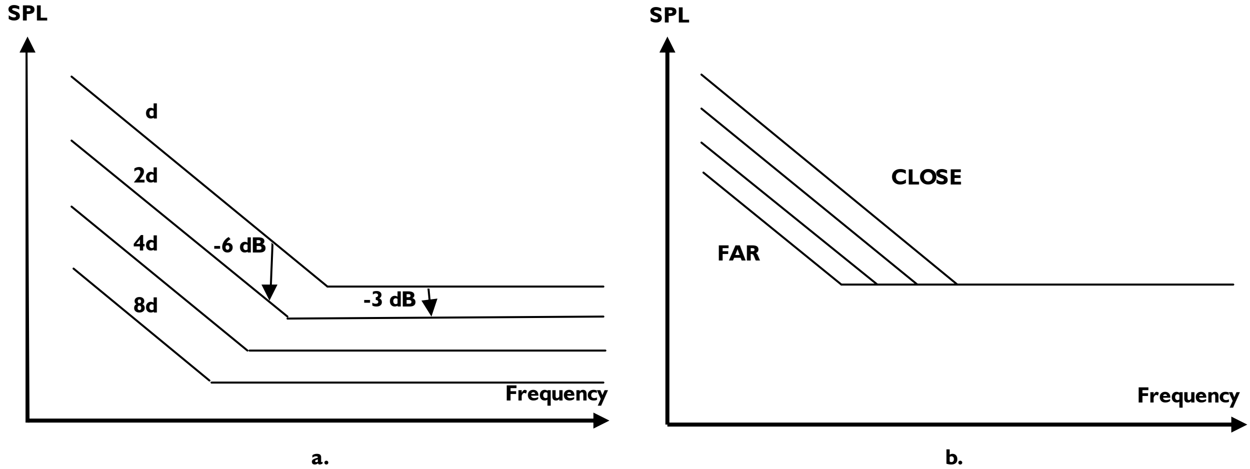

Figure 2: 12-V-DOSC array contour versus observation distance

In the same way we can observe that the LF domain contribution is enhanced as the **array size** (number of enclosures) or **curvature** (inter-enclosure angles) **increases**, as it is respectively shown in Figure 3a and Figure 3b.

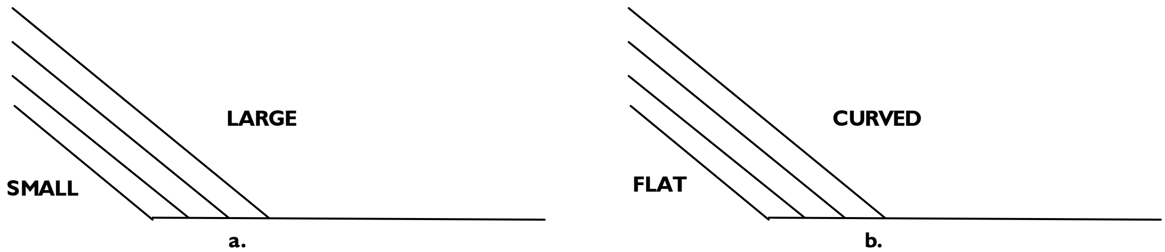

Figure 3: 12-V-DOSC array contour versus size and curvature

As shown in the above diagrams, it can be demonstrated that the three geometrical factors governing the frequency response of a line source array induce similar effects. As a size increase acts like a curvature increase or a distance reduction we conclude that these three factors are linked and can virtually be addressed by the same action.

Based on this original observation which results from the physics of line sources, L-ACOUSTICS® has developed the first frequency response setting tool for line source arrays. This tool is called ARRAY MORPHING and will allow the System Engineer to easily achieve the same tonal balance for different geometry line source arrays and combine different line source speakers in the same installation while offering the same sonic signature.

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4 ARRAY MORPHING

4.1 Overview

The ARRAY MORPHING tool is part of the new CONTOUR EQ shown in Figure 4. It is composed of two parameters called ZOOM FACTOR and LF CONTOUR which will allow the modification of the frequency response curve displayed on the left side of Figure 4.

This latest represents the unscaled frequency response curve of the system in use when no correction is applied (ZOOM FACTOR and LF CONTOUR turned off). The fact that any system frequency response can be represented by this curve is justified by both following points:

- All L-ACOUSTICS® presets have been created using the same approach.
- Unscaling makes possible the use of the same display for all speakers.

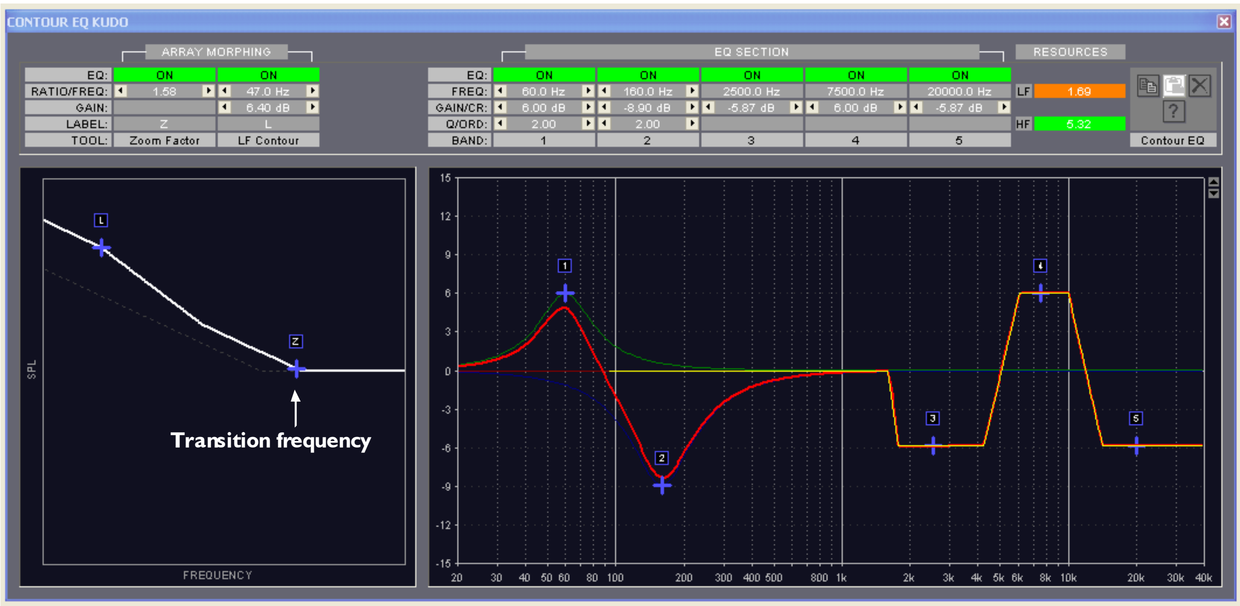

Figure 4: The CONTOUR EQ window

Note 1: The reference presets for concert-touring systems offer a contour as described in Figure 1c. The reference preset for a modular line source offers a contour as described in Figure 1b.

Note 2: The ARRAY MORPHING tool does not apply to single distribution speakers, except for “art” effects.

Note 3: The EQ SECTION on the right side of the screen is composed of 2 parametric IIR filters (#1-2) for room acoustic equalization and 3 constant phase FIR plateau brick-wall filters (#3-5) for air absorption compensation. The associated curves are transfer function curves.

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4.2 ZOOM FACTOR setting

The ZOOM FACTOR is a single parameter which literally allows the line source to sound either bigger (inv. thinner) or closer (inv. further away) with a ten fold zoom magnitude. Values for Z (ZOOM FACTOR) are comprised between 0.32 and 3.16.

- Z=1 is the neutral setting and has no effect on the frequency response curve (dotted line on Figure 5).
- Z > 1 acts as a telephoto lens (array looks bigger, inter-enclosure angles appear larger, listening distance looks shorter). The corresponding response curve has transition frequency shifted towards right (Figure 5a). This setting will enhance the LF contribution and is useful for additional LF contour when using an ultra-compact system.
- Z < 1 acts as a wide angle photo lens (array looks shorter, inter-enclosure angles appear smaller, listening distance looks longer). The corresponding response curve has transition frequency shifted towards left (Figure 5b). This setting will "flatten" the frequency response curve and is useful for classical or corporate applications when using a large format system.

IMPORTANT

ALWAYS apply the ARRAY MORPHING tools to ALL enclosures in the array to avoid poor acoustic results.
For that, check that all corresponding amplified controllers are part of the group for which the current CONTOUR EQ applies (see the **"LA NETWORK MANAGER – User Manual"**).

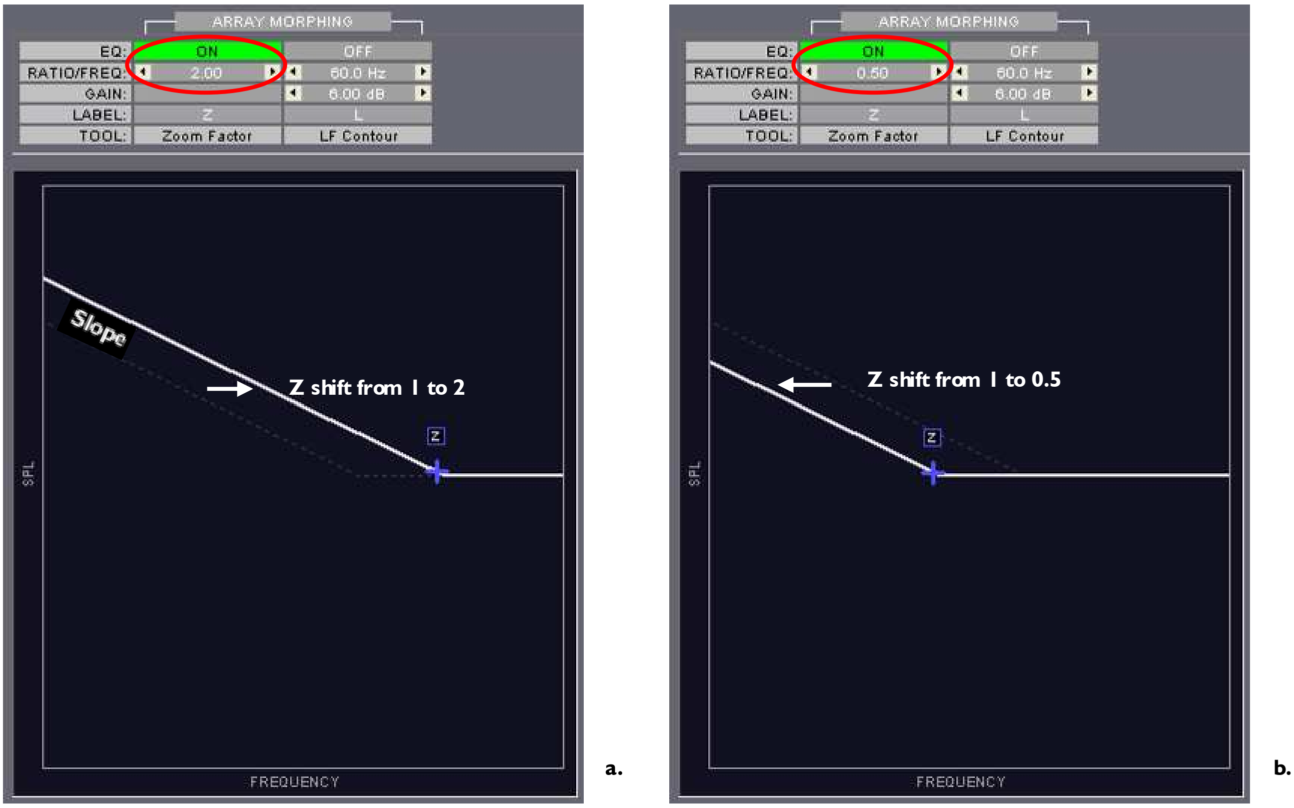

Figure 5: ZOOM FACTOR setting

The ZOOM FACTOR uses a realistic multiplier scale indicating that if the operator selects Z = 2, the effect on the EQ Contour is to virtually multiply the array size by 2 or divide the observation distance by 2, or as doubling the vertical coverage. Inversely, setting Z = 0.5 (the inverse of 2) will divide the array size by 2 or multiply the observation distance by 2, or divide the vertical coverage by 2.

Setting Z > 1 will reduce the LF power headroom for all enclosures pertaining to the group for which the modifications apply (see the **"LA NETWORK MANAGER – User Manual"**). For example, setting Z = 2 will induce a 6 dB headroom reduction. Inversely, setting Z < 1 will enhance the LF power headroom for all enclosures pertaining to the same group.

Note: The exact headroom display is available in the CONTOUR EQ window (in the top right part of Figure 4).

CAUTION

ALWAYS verify that the headroom is in a safe range for all enclosures (see the **"LA NETWORK MANAGER – User Manual"**).

4.3 LF CONTOUR setting

LF CONTOUR is a single low frequency shelving tool. The **frequency** can be set between 35 and 180 Hz and the **gain** between -15 and +10 dB.

CAUTION

Due to its large magnitude, the gain parameter must be used very carefully in order to avoid severe system headroom reduction.

Exhaustive presentation of the LF CONTOUR tool will not be developed here as the setting possibilities are numerous. However, it is highly recommended to follow one of both following guidelines:

LF CONTOUR used as an additional refinement of the ZOOM FACTOR settings

After the most suitable ZOOM FACTOR value has been selected, set both LF CONTOUR parameters. It is recommended to start with the lowest frequency value (FREQ = 35 Hz) and monitor the GAIN setting effects on the response curve. The FREQ value can then be adjusted to shape the desired LF response of the line source array.

- GAIN > 0 and FREQ = 35 Hz settings will allow recovering more LF level especially with the Z < 1 setting (see Figure 6a).
- Set larger frequency value (near 180 Hz) to recover larger domain, even up to the entire sub-low-mid original response (Figure 6b).
- GAIN < 0 will allow reaching a "flat" frequency response (see Figure 7) when using a concert-touring system.

LF CONTOUR used as an alternate way to address the LF response of a line source array

The LF CONTOUR tool can be used with the ZOOM FACTOR tool inactive (turned off or Z = 1). Both FREQ and GAIN parameters, respectively addressing the frequency and gain settings, can be adjusted to obtain the desired frequency response curve.

IMPORTANT

ALWAYS apply the ARRAY MORPHING tools to ALL enclosures in the array to avoid poor acoustic results.
For that, check that all corresponding amplified controllers are part of the group for which the current CONTOUR EQ applies (see the **"LA NETWORK MANAGER – User Manual"**).

Setting GAIN > 0 will reduce the LF power headroom for all enclosures pertaining to the group for which the modifications apply (see the **"LA NETWORK MANAGER – User Manual"**).

Note: The exact headroom display is available in the CONTOUR EQ window (in the top right part of Figure 4).

CAUTION

ALWAYS verify that the headroom is in a safe range for all enclosures (see the **"LA NETWORK MANAGER – User Manual"**).

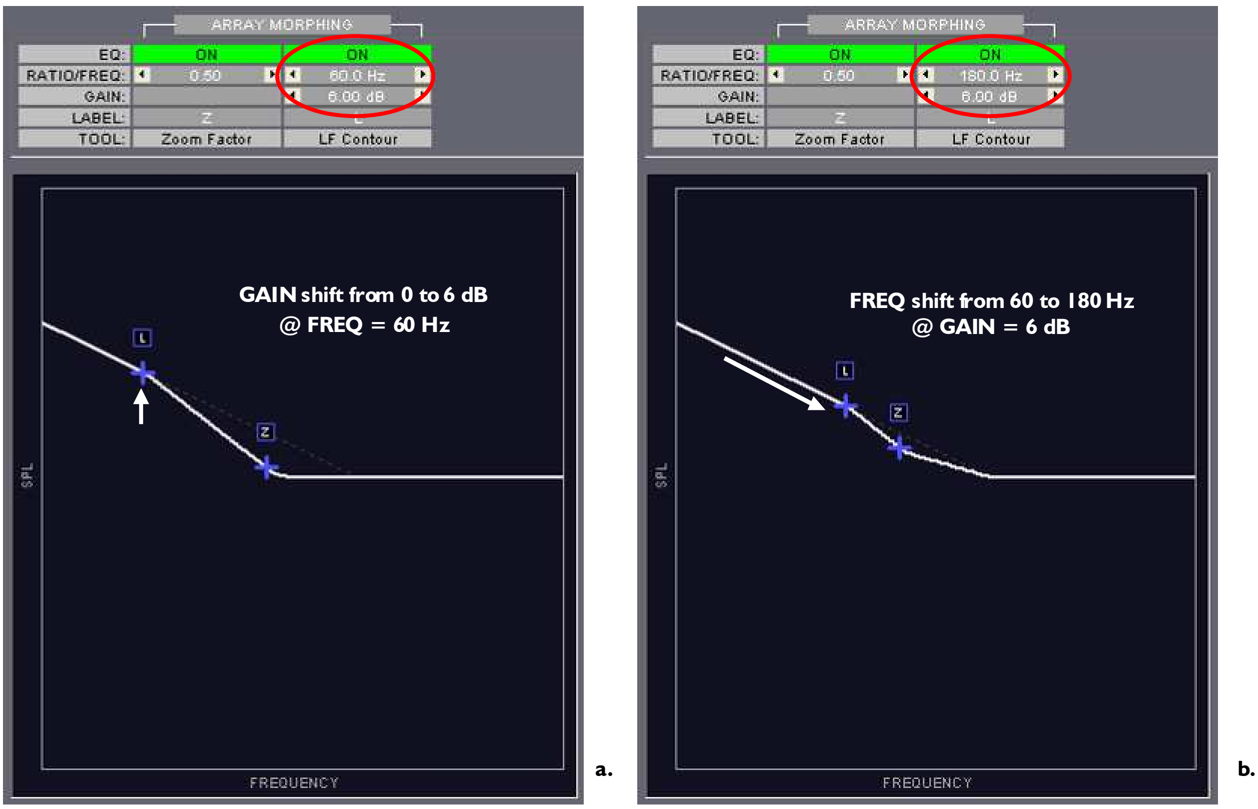

Figure 6: Setting the FREQUENCY and GAIN parameters

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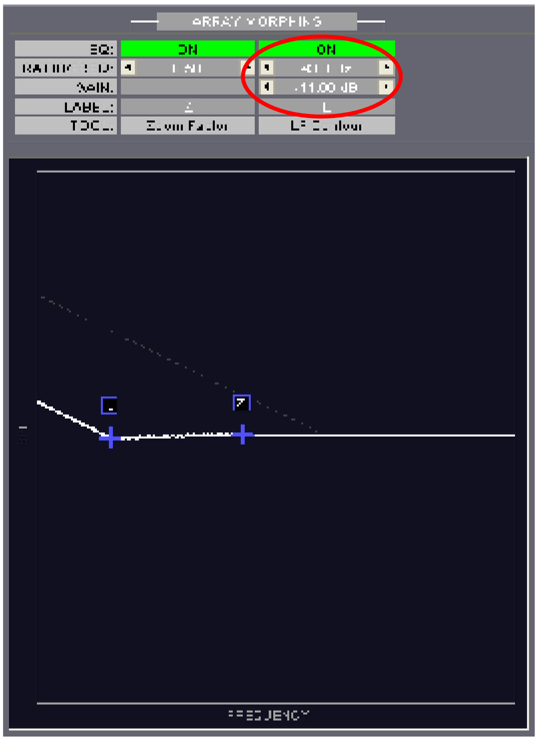

Figure 7: Setting a quite flat frequency response

5 CONCLUSION

ARRAY MORPHING is the first frequency response setting tool addressed to line source arrays. Used along with a factory preset of the LA4 or LA8 preset libraries (see the **"Preset Libraries – User Manual"**) it allows the Sound System Engineer to virtually re-dimension any array (within the limits of the power resources) and specifically addresses the following:

- Smoothly adjust the frequency response of a line source array and compensate for different array geometries and conditions of use.
- Provide the same sonic signature to all L-ACOUSTICS® line source systems used in the same installation, and approach a reference standardized frequency response when desirable.
- Offer frequency response flexibility to adapt to various applications: from speech & classical music ("flat" response) to live rock music ("enhanced LF response").

6 REFERENCES

[1] M. Urban, C. Heil and P. Bauman, "Wavefront Sculpture Technology", *J. Audio Eng. Soc.*, Vol. 51, No. 10, 2003 October.

[2] M. Urban, C. Heil and P. Bauman, "Wavefront Sculpture Technology", Convention Paper, presented at the 111th Convention of the Audio Engineering Society, New York, September 21-24, 2001, preprint 5488.

[3] C. Heil and M. Urban, "Sound Fields Radiated by Multiple Sound Source Arrays", 92nd Convention of the Audio Engineering Society, *J. Audio Eng. Soc. (Abstracts)*, vol. 40, p. 440 (1992 May), preprint 3269.