Placement for best performance

Generally, the construction of a subwoofer system generates omnidirectional sound dispersion, incorrect placement of subwoofer systems can generate undesirable effects on sound dispersion, such as cancellations (passages), excessive summation in the rear, poor coverage in the public area, etc.

The correct placement of the subwoofer systems depends on the characteristics of the place to be provided with sound, which is a key point to guarantee the success of the event. You will find some examples down below.

In summary:

- **In-Block** and **L & R stack** configurations; create a lot in the control area and also create the famous “passages” or cancellations in the public area.

- **Reversed stack** and **In-line cardioid** configurations; create a significant decrease in level on the stage and a slight decrease in pressure in the audience area.

- With **In-line horizontal configuration**; we will obtain a narrow and long coverage, with a sufficient level on the stage and a homogeneous response in the audience area.

- **End-Fired** configuration; produces homogeneous coverage and a fairly significant level reduction on the stage.

- With **In-arch configuration**; the response remains homogeneous, expanding the coverage and reducing the rear level.

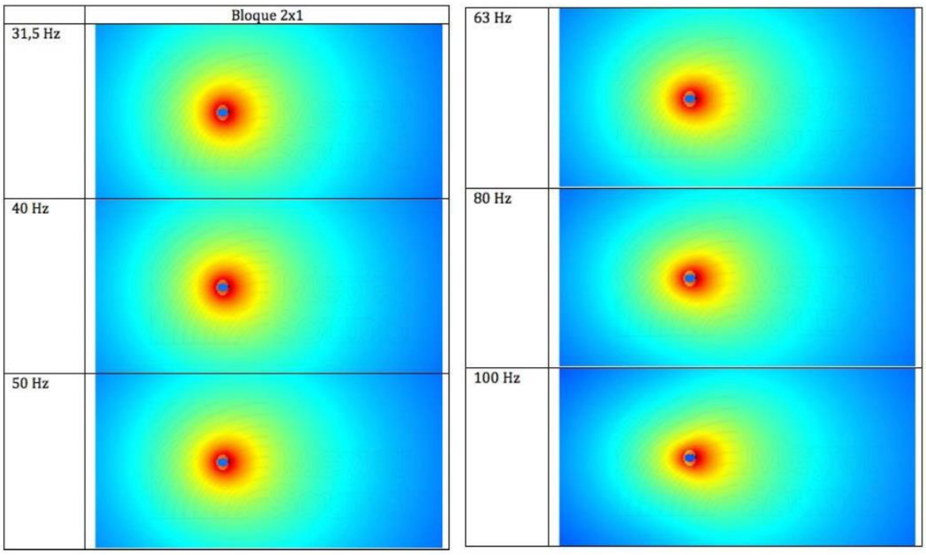
In-Block subwoofers configuration

Using two in-line subwoofers.

Two sources fed with the same signal, time, level and polarity.

This configuration generates omnidirectional sound dispersion throughout virtually the entire operating frequency range.

The pressure level is +1.5 dB compared to the configuration of two subwoofers stacked on top of each other.



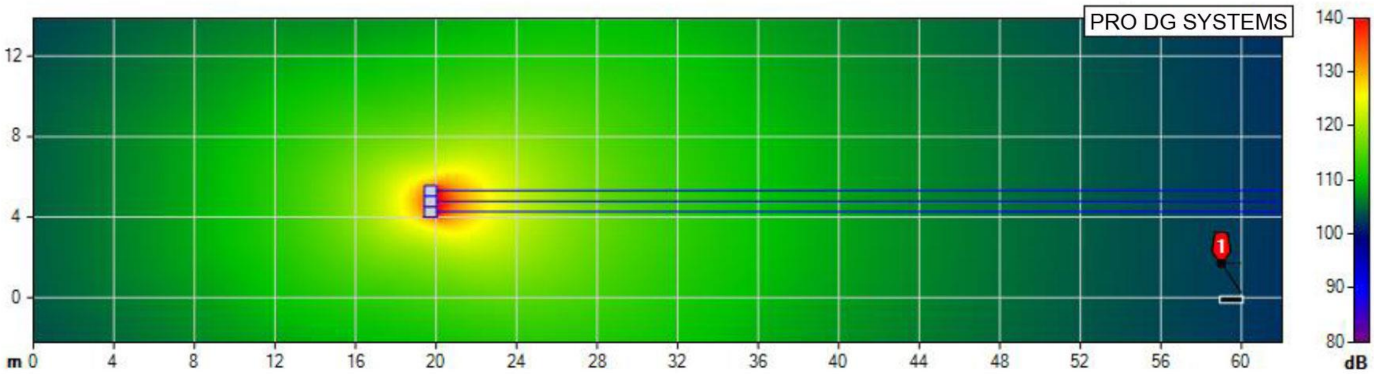
L & R stack subwoofers configuration

Using 3 subwoofers in stack format

The results are very similar to those obtained with the block configuration are obtained.

We gain some dB, but still had no control at the rear.

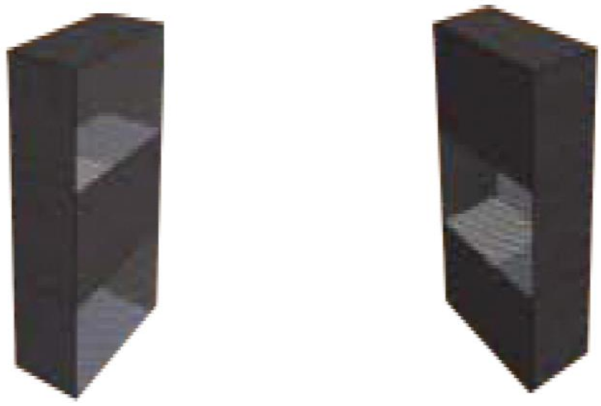
Not having control over the rear generates more dB in the audience area, but it will bother your stage colleagues.



Reversed stack configuration

Placing three subwoofers in a stack format, with one of its units reversed.

Next, we will place the measurement microphone on the back, with the subwoofer in reversed position disconnected and the other two subwoofers on work, we will take a phase reference.



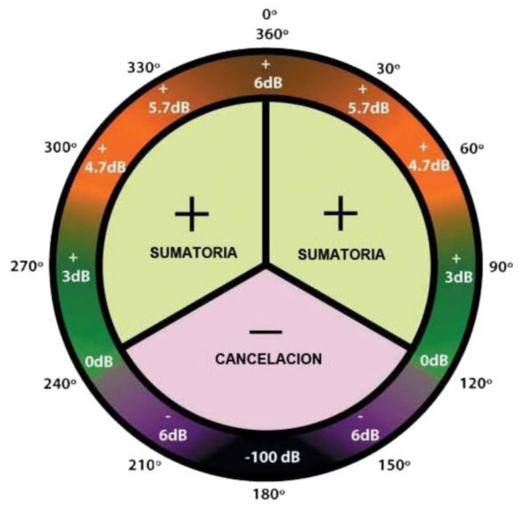
Front view **Rear view**

Then we connect the subwoofer in the reversed position and disconnect the other two subwoofers, we will take another reference and adjust it in phase by applying the corresponding delay (approximately 3ms), finally, we will apply a polarity change to the subwoofer in the reversed position.

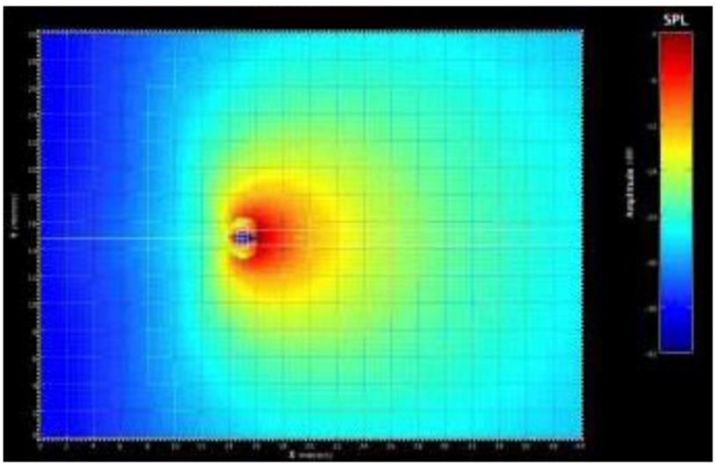
What happen?

We will create interferences or constructive frequencies in the front, and destructive frequencies in the back.

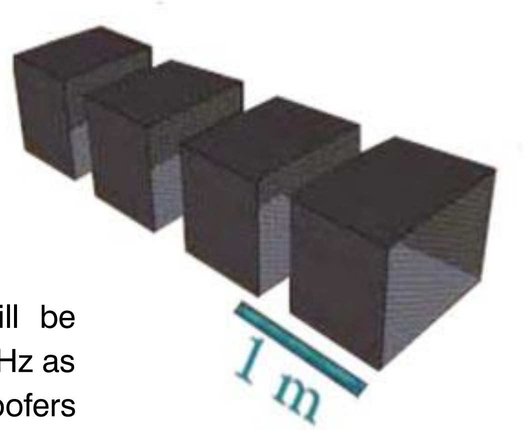
That is, we will achieve a significant decrease in level on the stage and a slight decrease in pressure in the audience area.



Example of dispersion at 70 Hz:



End-Fired configuration



Placing four in-line subwoofers, one after the other.

Although it is not a cardioid configuration, it is directional, producing attenuation in the rear and quite a bit in the front.

The physical separation distance between subwoofers will be determined by the key frequency. If, for example, we take 85 Hz as the key frequency, the separation distance between subwoofers will be 1m:

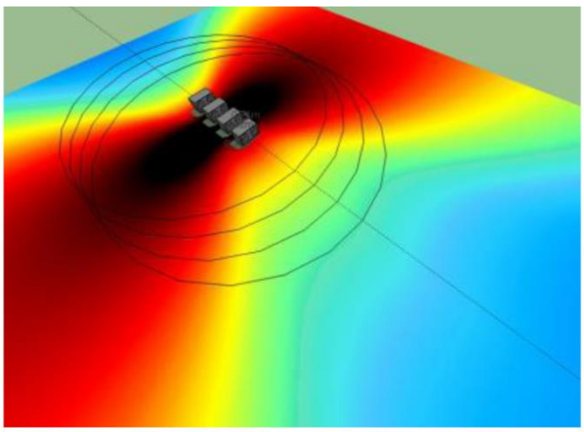
We must obtain the **λ** wavelength (lambda).

λ= V/F = m V: speed of sound; 340 meters per second. F: frequency in Hz.

340m x sec / 85 Hz = 4m. / 4 (1/4 of the desired wavelength) = 1 m

Once the subwoofers are physically located, it will be necessary to apply delay to generate the necessary separation electronically, the objective is to make the four units behave as one.

This is what happens if we do not apply electronic delay:

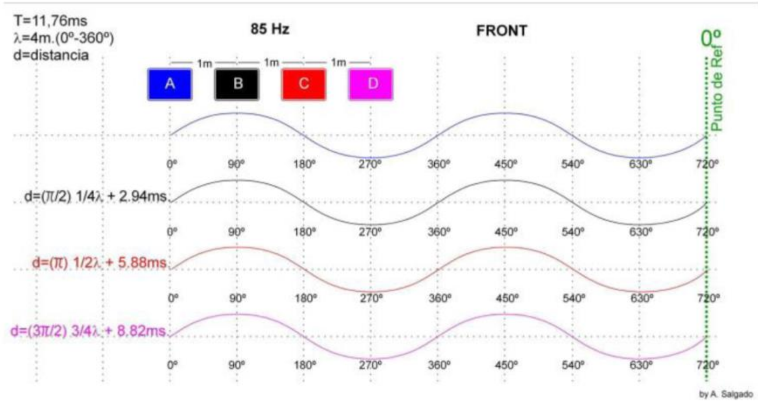


The delay that we must apply will be determined by the following formula:

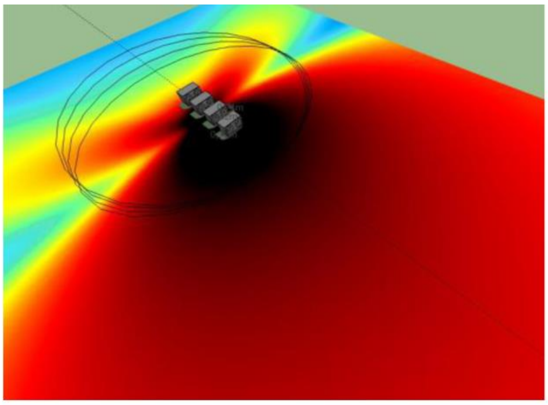
T= 1 / **F**; 1 / 85 Hz = 0,01176 sec / 4 (1/4 of a cycle) = 0,00294 sec x 1000 = 2,94 ms

Therefore;

- Subwoofer 1. Delay; 0 ms (It is understood that it is the closest unit to the stage)
- Subwoofer 2. Delay; 2,94 ms
- Subwoofer 3. Delay; 5,88 ms
- Subwoofer 4. Delay; 8,82 ms



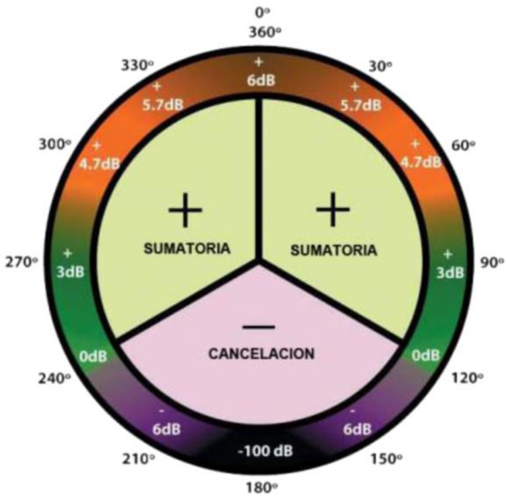
Result of our configuration.
Completely matched in phase



Lobe behavior after applying the electronic delay

As a result, in the rear part we obtain a large sum of constructive frequencies as all the sources are in 90º phase (summation), on the contrary in the rear part we have the four units in 180º push-phase (cancellation).

Therefore, we can consider that this configuration is not cardioid and is directional.



In-line cardioid configuration

Using two in-line subwoofers.

This configuration is formed with two sources spaced ¼ of the wavelength of the key frequency that we select. It is necessary to be clear about this concept; two parallel signals but with different paths, at the same point produce comb filters.

1/8 above the chosen key frequency, producing the first destructive frequency and the first cancellation.

Example: if we choose 40 Hz as the key frequency, we will have the first cancellation at 80 Hz (or what is the same in its first octave), which is not appropriate, because it destroys the frequency response of our configuration. And the same thing will happen with each odd multiple (80 x 3 = 240 Hz, 80 x 5 = 400 Hz, etc).

If we choose 85 Hz as the key frequency; We must obtain the **λ** wavelength (lambda).

λ= V/F = m V: speed of sound; 340 meters per second. F: frequency in Hz.

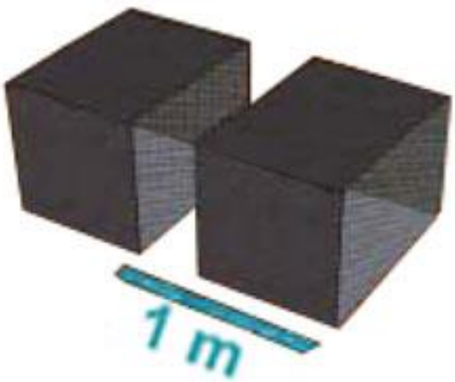
340m x sec / 85 Hz = 4m. / 4 (1/4 of the desired wavelength) = 1 m

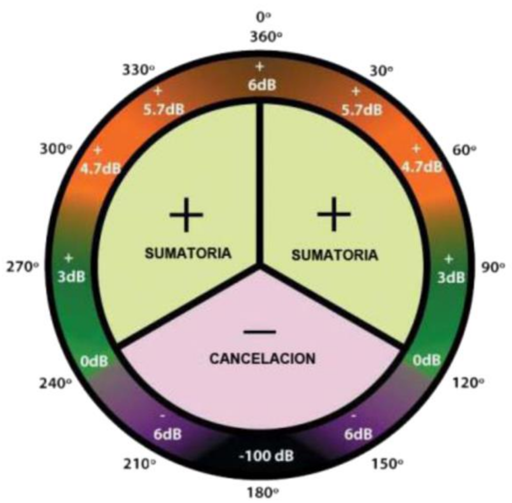
We can know that the physical distance between subwoofers will be 1 m

We have physically separated the subs 90º at 85 Hz, now we are going to electronically separate the rear sub another 90º, for this we convert 90º at 85 Hz in time.

T= 1 / F; 1 / 85 Hz = 0,01176 sec / 4 (1/4 of a cycle) = 0,00294 seg x 1000 = 2,94 ms.

In this way we will have the rear sub separated by 90º physically (with respect to the front) and another 90º electronically; 90º + 90º = 180º



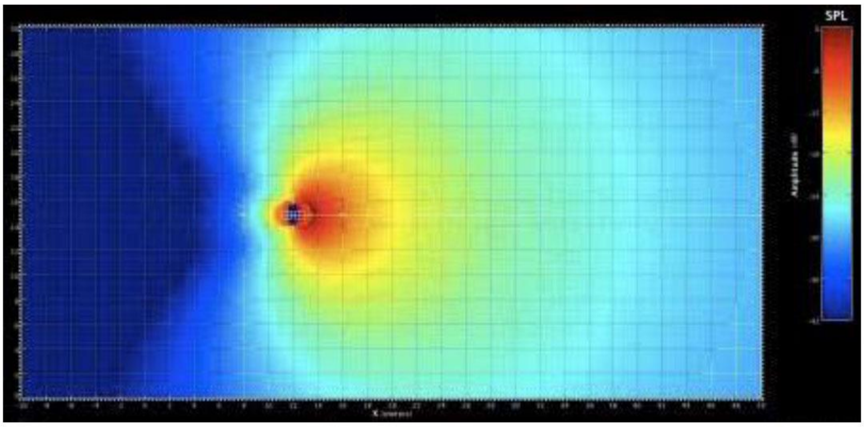


What happen?

Total cancellation of destructive frequencies. By simply reversing the polarity of the rear sub we once again have summation or constructive frequencies on the front.

Since the rear sub is physically distanced 90º from the front and another 90º electronically; 90º - 90º = 0 constructive frequencies. But since it is inverted in polarity we obtain cancellation in the rear part (stage) and summation in the front part (audience area).

Example of dispersion at 70 Hz:



With this configuration we lose 1.5 dB compared to an in-block configuration of two subwoofers, but we will let our monitor colleagues work.

In-line horizontal configuration

Placing eight subwoofers besides to each other.

This configuration is based on the theory of Harry F. Olson published in his book "Acoustical Engineering" in which it is mentioned that; *placing two speakers at a distance equal to or less than half the wavelength of the upper cut-off frequency will create a highly directional forward lobe of energy.*

As we know, a standard L & R subwoofers configuration produces summation and cancellation zones dependent on the physical separation and, therefore, the wavelength of the frequency, appearing the typical "corridors".

To avoid these effects we are going to create a central line of subwoofers and reduce the distance between the elements, so that their separation is not greater than half their wavelength of the maximum frequency to be reproduced.;

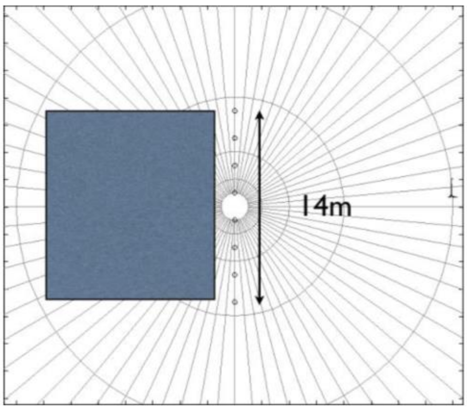
λ Wavelength (lambda).

λ= V/F = m V: speed of sound; 340 meters per second.   F: frequency in Hz.

Choosing 100 Hz as example of maximum frequency, the result will be;

340m x sec / 100 Hz = 3,4m / 2 = 1,70 m (distance between subwoofers that we should not exceed).

As an example, we will make a configuration covering 14 m long and placing the subwoofers at a distance of 1.70 m from each other.



Once the subs are placed 1.70 m from each other, we will see the behavior of different frequencies to different degrees, taking the central axis as a reference. To observe the existing phase relationship in degrees we will use the formula;

$D \times F \times 360 / 340$ D; separation distance. F; Frequency.

360 a complete cycle and 340 the speed of sound.

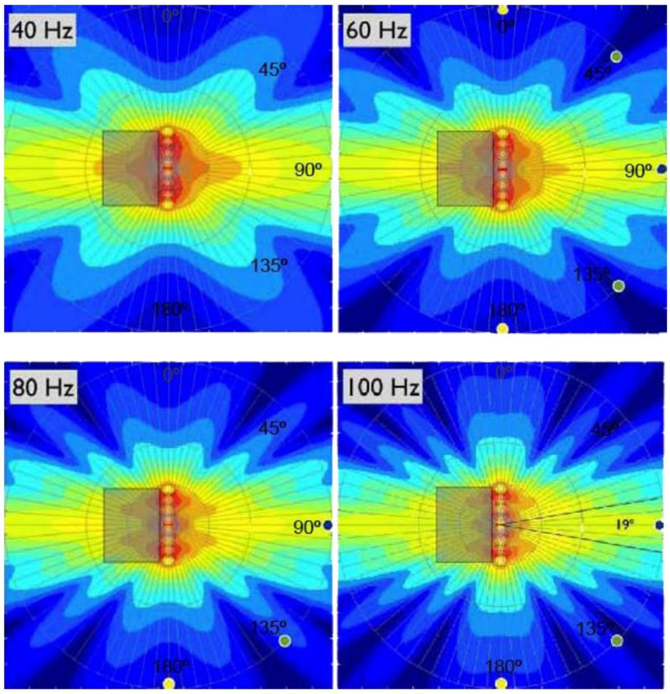
We take as example a phase relationship in degrees for 100 Hz;

$1{,}70 \times 100 \text{ Hz} \times 360 / 340 = 180^{\circ}$

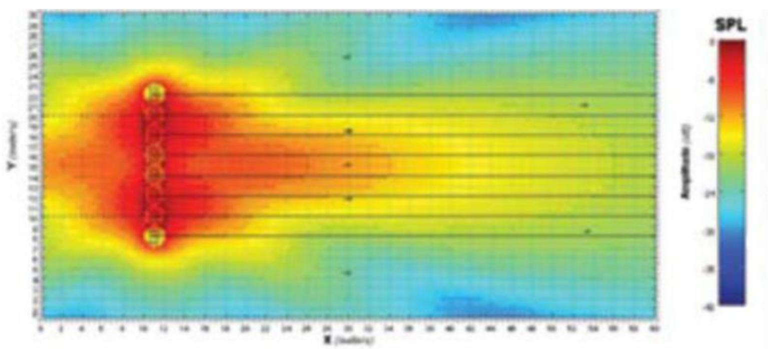
As we can see, the pattern narrows as we increase the frequency.

Conclusions: we should not separate the subwoofers more than 240º from the maximum frequency to be played, if we do so cancellations and the famous “passages” will appear.

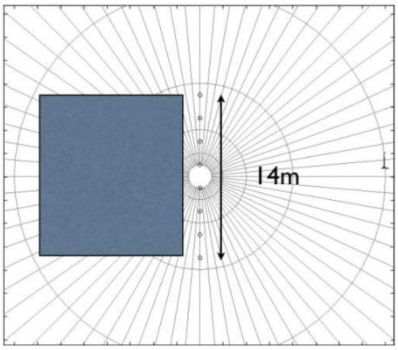
This configuration is designed to work in closed spaces where we have side walls and we should not place the sub closest to the wall more than 120º from the maximum frequency to be reproduced.



This configuration has a fairly narrow and long pattern, as a limit of coverage we will have the subwoofers placed in the extreme and in the stage part we will also have a lot of energy, which can be annoying for the monitor colleagues.



In-arc configuration

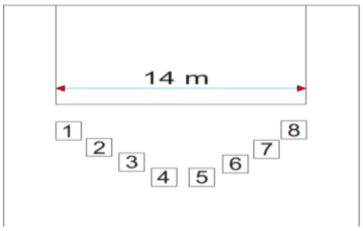


As with the configuration of eight subwoofers in-line horizontal, the difference is that we are going to sacrifice pressure in the central part, in exchange for gaining general coverage and reducing the pressure level on the stage.

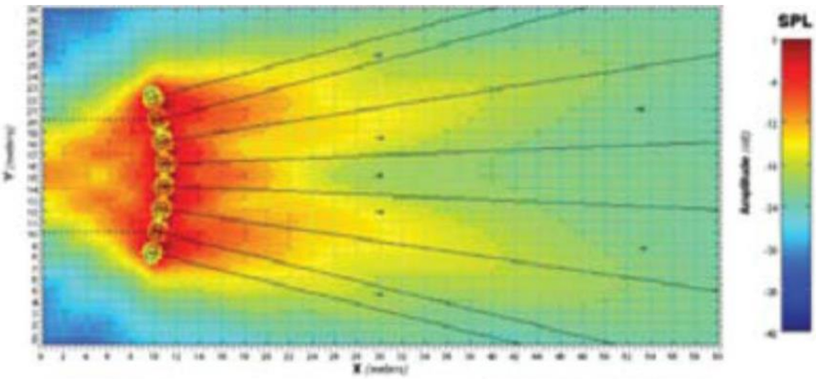
Taking the previous example as a starting point; we place the subwoofers at a distance of 1.70 m from each other and apply the following delays;

- Subs nº 4 and 5; 0 ms - Subs nº 3 and 6; 1,50 ms - Subs nº 2 and 7; 3 ms - Subs nº 1 and 8; 4,50 ms

The lobe behavior will be as follows:



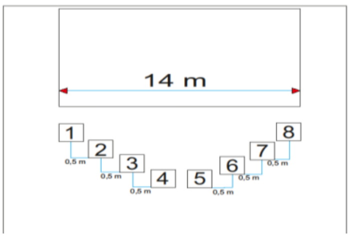
Virtual arch



As we can see, we have gained general coverage with respect to the in-line horizontal configuration, but we have a slight reduction in level in the central area, this can be solved by placing a subwoofer above sub No. 4 and another above sub No. 5, thus recovering the level in the central zone.

If there is not enough processing available, we can make a physical arc by placing the subs in the following way:

- Subs nº 1 and 8; 0 m
- Subs nº 2 and 7; 0,5 m regarding sub 1 and 8
- Subs nº 3 and 6; 0,5 m regarding sub 2 and 7
- Subs nº 4 and 5; 0,5 m regarding sub 3 and 6



Physical arch

This configuration is increasingly used, it achieves a very homogeneous coverage, a good level in the audience area and a significant reduction in the stage area, its performance is very good in combination with Line Array systems.