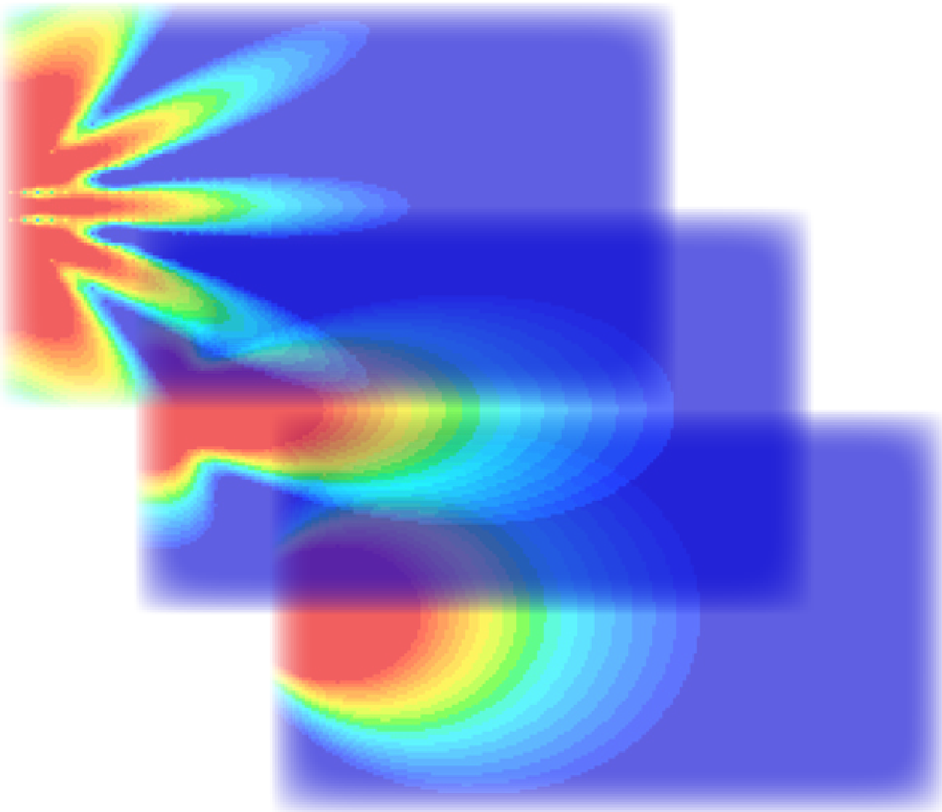
System Planning For Dance Venues

by Rog Mogale

Produced in conjunction with Void Acoustics LTD



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I produced this paper with the aim of helping system installers and venue designers locate suitable locations for loudspeaker placement. The majority of the analysis has been based around low frequency placement as the effects of incorrectly positioned bass enclosures can lead to uneven coverage and increased sound levels emanating from the building. The deployment of mid top loudspeakers is a slightly easier task due to the controlled dispersion and predictable behaviour patterns of known array configurations.

The room used for the simulations and analysis is 25 meters long x 15 meters wide. This would be a fairly typical size for a medium to large type venue. The floor can be considered to be flat and on one level, as this makes it easier to see the effects of any cancellations. The bass enclosures used for the simulation contained 2 x 18" drivers with a cabinet size of 1200 mm wide x 636 mm high x 800 mm deep. Multiples of this size cabinet would be typical in a medium to large size venue. An arrow in front of each enclosure is depicted to show the direction of radiation. Simulations were produced with a single enclosure high (636 mm high) and with two enclosures high (1272 mm high). Little difference apart from the increase in SPL was observed whilst simulating single or double height stacks, so both stack heights can be used when it comes to planning the LF layout with only the final SPL required dictating whether to use a single or double height stack in each position. Three and four high stacks were not simulated as it was thought that a venue this size would not require so many LF enclosures to achieve adequate SPL's.

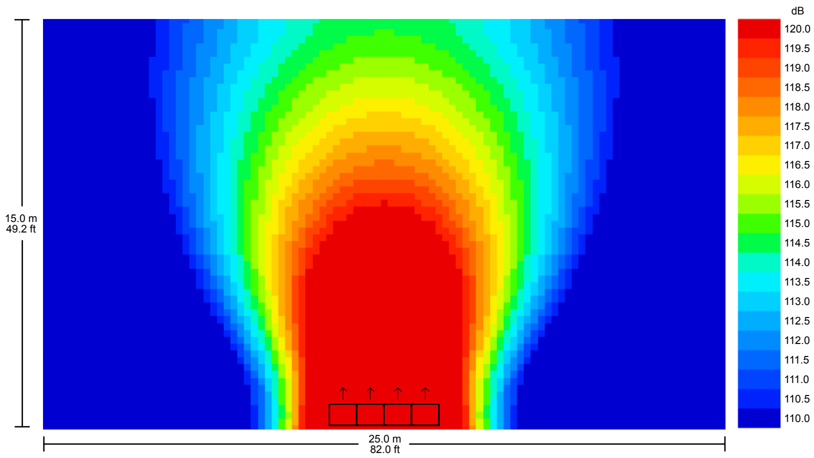

fig 1. four single height LF enclosures

fig 1. shows the layout of the venue. All further simulations were produced in the same 25 x 15 meter sized area. The SPL range depicted covers 10dB with red representing 120dB and blue representing 110dB. It is likely, especially with double height stacks that SPL's over 120dB would exist near the enclosures, but to make it easier to view the simulations a reduced range of SPL's are depicted. The 110 to 120dB range would also be a good target SPL to try and obtain in dance areas.

The last paper I wrote about bass arraying showed different configurations at frequencies of 50 and 100Hz. This paper will not go into such depth and an averaging technique has been used instead of showing the effect at different frequencies within the LF range. The averaging took 8 spot frequencies between 31.5Hz and 120Hz and spliced them to give an overall view of the LF radiation pattern. Using averaging has led to an easier to view simulation and a far more informative display than if a single middle ground frequency of say 63Hz were used.

Layout Considerations

I think one fo the first things that needs to be thought of is how the audience will interact with the DJ. Do you want the DJ to be the focus of the club, do you want there to be even coverage or more SPL in front of the DJ booth. Only when questions like these can be answered can you really start to plan the location and type of system to be installed. A club that uses the DJ to supply music to drink to will need uniform coverage with lower sound levels. An out and out dance club bringing in named DJ's will need the DJ to be close to the audience with higher levels on the dance floor with lower levels in bar and rest areas. In this situation there are some good reasons to locate the LF enclosures under or in the DJ booth. The booth will normally be on or near the dance floor, so this puts the bass right where the action is. You can get high levels on the dance floor with fewer enclosures as they are close to the audience. Lower levels in the venue also means lower levels outside the venue. The other advantage is that you have a single location for the bass enclosures, which as we will see, reduces the likelihood of cancellations. Booth located bass stacks will normally mean higher bass levels where the DJ is mixing. Its an advantage as there are reduced distances, hence timing issues between the bass stack and DJ, but good monitoring will be required to keep up with the elevated LF levels in the booth.

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by Rog Mogale

Booth Simulations

The first set of simulations show how different configurations of four LF enclosures effect the coverage. Fig 2 shows what happens when you array four LF enclosures two wide by two high. The enclosures are set flush with the front of the DJ booth and the front of the booth is 2.6 meters from the rear wall. As can be seen this configuration would give good coverage over most of the dance floor, which has been shaded in these simulations. The rear of the dance floor would have less SPL, but this could be advantageous if bars and seating areas were located near the far corners from the booth. Fig 3 also depicts the same four LF enclosures, but this time they are single height with two positioned facing from the sides of the booth. All four enclosures are fed the same signal in this configuration. Adding the side facing enclosures has had the effect of narrowing the radiation pattern. This has happened because the array is now wider than in the previous configuration. As can be seen, the back of the dance floor is now seeing a higher SPL. This configuration would give very uniform coverage over the entire dance floor with zero cancellations and a useful reduction in SPL at the sides of the room for bars and seating areas.

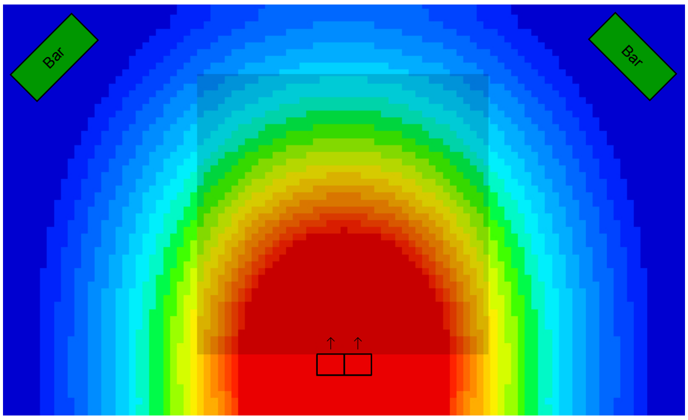

fig 2. four double height LF enclosures under a DJ booth

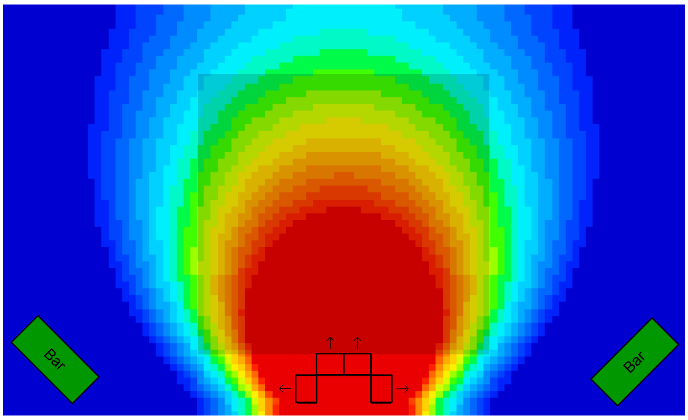

fig 3. four single height LF enclosures under a DJ booth

If an even greater amount of side reduction or throw is required, move the side facing enclosures so they are flush with the front facing enclosures. Fig 4 shows the radiation pattern for this configuration. The back of the dance floor is now receiving high SPL's and the side attenuation has increased. This configuration would also work very well if the whole layout was turned 90 degrees, with the DJ booth facing down the length of the room instead of across it. If the dance floor is wide but not so deep, then the configuration in fig 5 would be suitable. The two side facing enclosures A and D, have had 2ms of delay added. As in all the other configurations on this page, all four enclosures are receiving the same signal at the same power level, just A and D have 2ms of delay in fig 5.

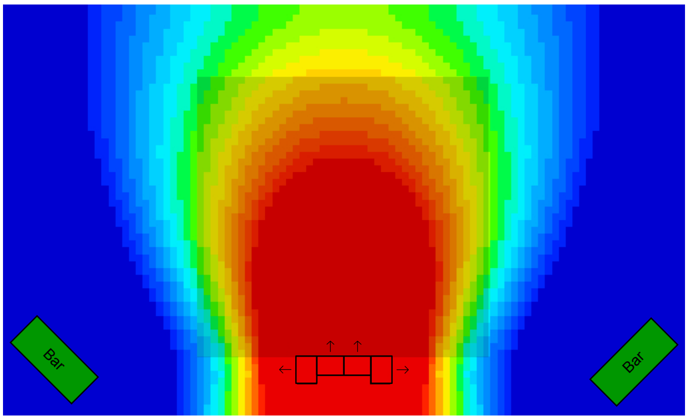

fig 4. four single height LF enclosures under a DJ booth

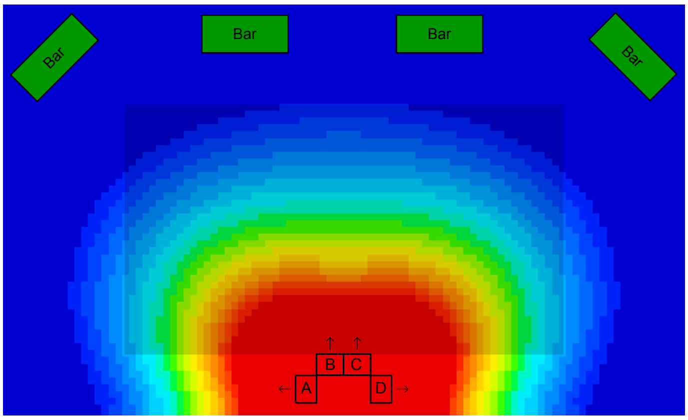

fig 5. four single height LF enclosures, sides delayed by 2ms

System Planning For Dance Venues

by Rog Mogale

For even larger dance floors the configurations in fig 6 and 7 maybe more suitable. Fig 6 shows four single height LF enclosures with the two outer enclosures A and D facing the side. Enclosures A and D have 5ms of delay applied and the distance from the rear of enclosure A to the rear of enclosure D is 5 meters. Fig 7 shows the same configuration expect that enclosures A and D have been moved forwards so they are flush with the forward facing enclosures B and C. The delay time for enclosures A and D has been increased to 7ms in this configuration. As can be seen the configuration in fig 7 would give uniform SPL's at high levels over the entire dance floor. There are no cancellations and the area just in front of the DJ booth would receive very high sound levels over a wide area. This size and shape of dance floor could also be covered with the configuration in fig 4, if the layout was turned 90 degrees with the DJ booth firing down the length of the room. I'm not convinced the configuration in fig 4 would maintain high SPL's right to the back of the dance floor as well as fig 7 does for a dance floor this long and it would be easier to get better coverage with mid hi loudspeakers with the configuration in fig 7.

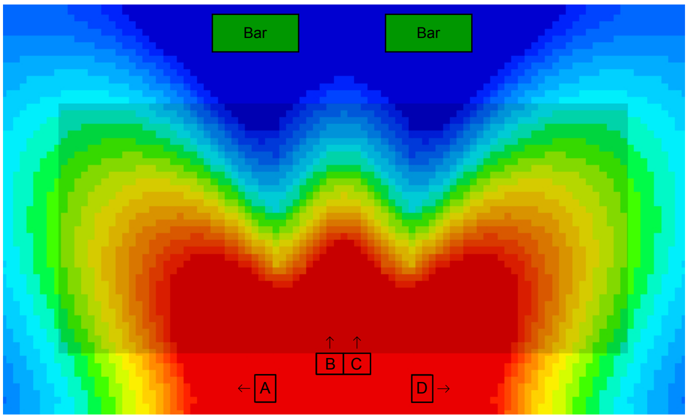

fig 6. four single height LF enclosures, sides spaced and delayed by 5ms

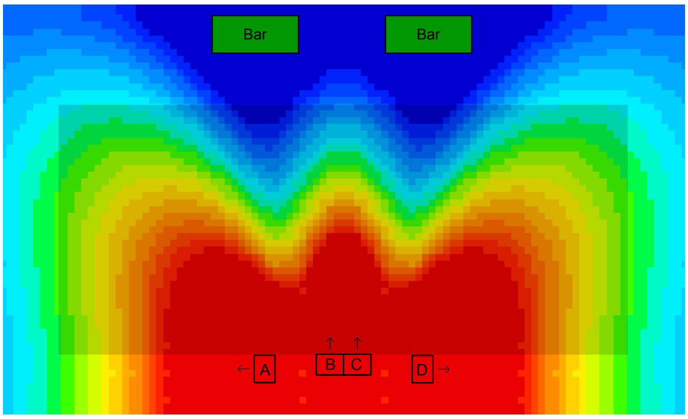

fig 7. four single height LF enclosures, sides spaced and delayed by 7ms

Multiple Stacks

It might be thought that breaking the bass system into smaller parts and locating them in different positions around the room could be a better way of getting uniform coverage. The next simulations show just what happens when multiple LF stacks are employed around our venue. Fig 8 the shows the radiation pattern of two stacks, each stack is two enclosures high. The distance between the stacks is 5 meters and because the distance between the stacks is now so great, the bass system has stopped working as a whole. Some of the other configurations shown previously had outer enclosures spaced 5 meters apart, but because of the other enclosures between them the distance from any two enclosures was small enough for it to work as a single array. Fig 8 shows what is known as the power ally effect and if a single frequency above 80Hz were depicted the effect would look a lot worse. Fig 9 is a simulation of four stacks of two enclosures. It might be popular to position a bass stack on each corner of a dance floor, but as can be seen its probably the worse LF configuration you can employ. The cancellation is very severe and there is little bass where you really need it.

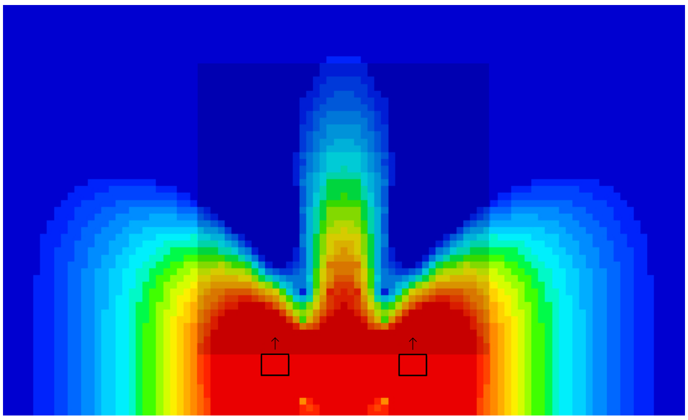

fig 8. two stacks of double height LF enclosures 5 meters apart

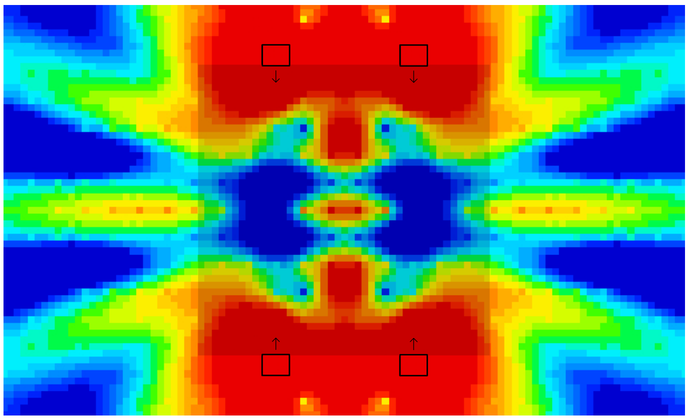

fig 9. four stacks of double height LF enclosures 5 meters apart

System Planning For Dance Venues

by Rog Mogale

Continuing with multiple stacks, fig 10 shows the radiation pattern of two opposing stacks with four LF enclosures in each stack. This configuration results is severe cancellations with the sides of the venue experiencing very bad coverage. Fig 11 expands on the four stack configuration with two LF enclosures in each stack. Each stack is in a corner location and the results while pleasing to the eye in this simulation would not sound good. If you were stood within 2 meters of a stack you would experience bass, but anywhere else in the room and it would be hit or miss if you felt some bass. As can be seen, it would only take a sideways step in most of the room and you could experience over a 20dB drop in level.

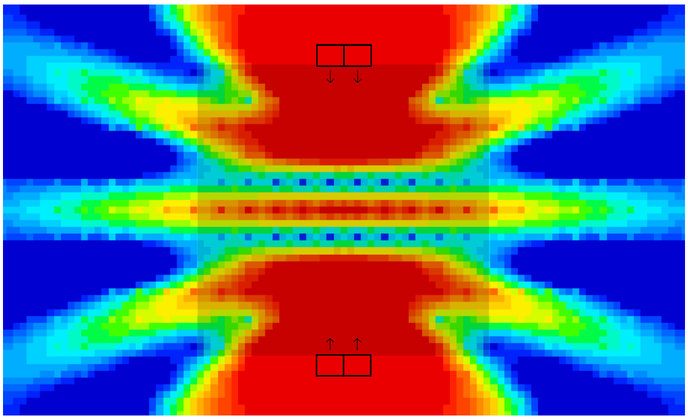

fig 10. two opposing stacks of four LF enclosures

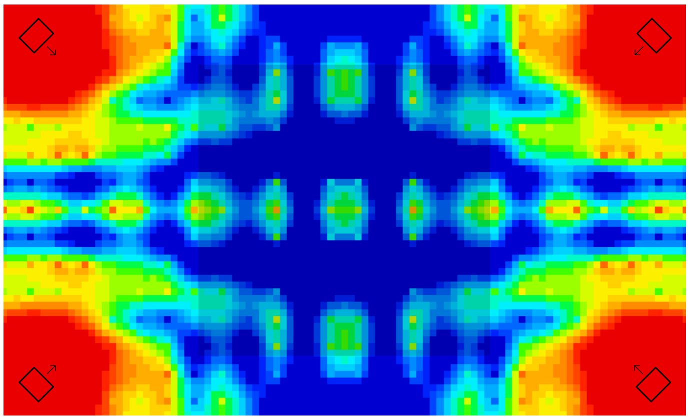

fig 11. four stacks of double height LF enclosures, corner placement

Boundary Placement

In situations where bass enclosures are not installed in a DJ booth, boundary or on the floor against a wall placement has advantages. The bass array will now be radiating into one quarter space so an increase in efficiency can be expected and reflection cancellations will be minimised as the distance from the enclosure to rear wall is small. When an enclosure is placed at some distance from a rear wall cancellations and reinforcements take place at specific frequencies relative to the distance from the wall to enclosure. Positioning LF enclosures very near to a rear wall helps to reduce these reflection effects as cancellations will be at higher frequencies so out of band. Fig 12 shows the radiation pattern of four single height LF enclosures positioned against a wall. For situations where you need the LF to extend out a long way with good attenuation at the sides this configuration can be recommended. If a broader more localised radiation pattern with less throw is required, then adding delay to the outermost enclosures will accomplish this. Fig 13 shows the same four LF enclosures as fig 12, but enclosures A and D have 4ms of delay applied to them. Altering the delay time from 0ms to 4ms will cause the radiation pattern to change from how it looks in fig 12 (0ms) to fig 13 (4ms). If SPL measurements are taken at different locations around the venue or dance floor whilst altering the amount of delay, it should be possible to tailor the radiation pattern to fit the area.

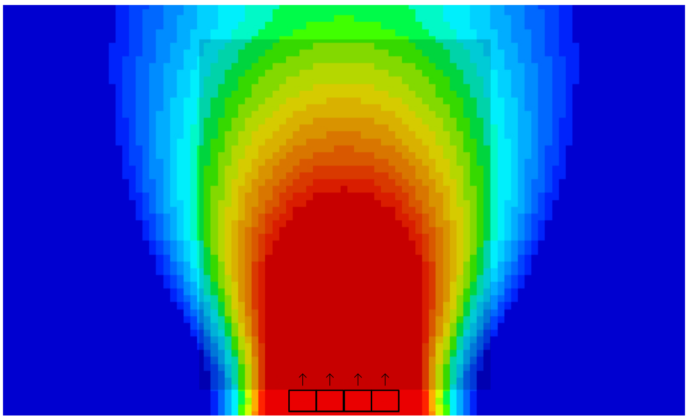

fig 12. four single height LF enclosures

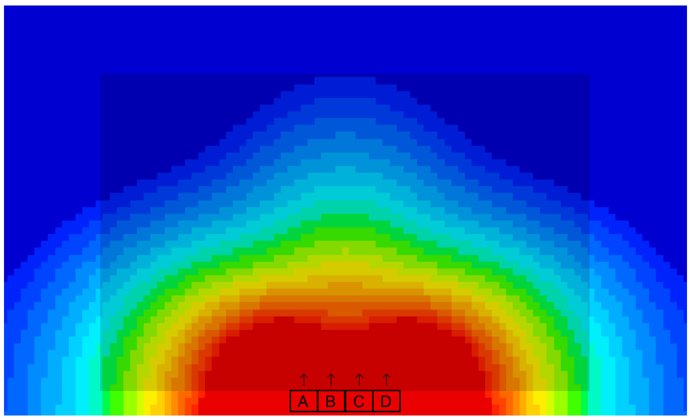

fig 13. four single height LF enclosures, 4ms delay on outer enclosures

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System Planning For Dance Venues

by Rog Mogale

If extreme side attenuation with increased long distance SPL's are required then adding space between the LF enclosures will achieve this. Fig 14 shows the radiation pattern of four LF enclosures that have been spaced. The distance from the centre of one enclosure to the centre of the adjacent enclosure is 2 meters in this simulation. If the distance between enclosures is increased to 3 meters, the radiation pattern will be as depicted in fig 15. Cancellations can be seen forming as the array no longer combines as a whole. At frequencies below 80Hz this spacing distance would not cause too many cancellations and summing will occur, but above 80Hz considerable interference would take place.

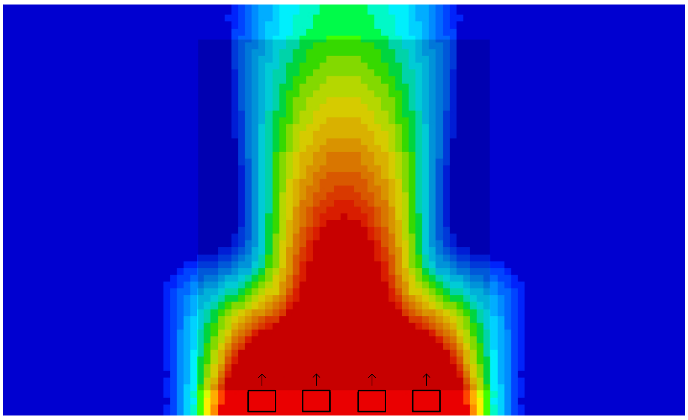

fig 14. four single height LF enclosures spaced 2 meters apart

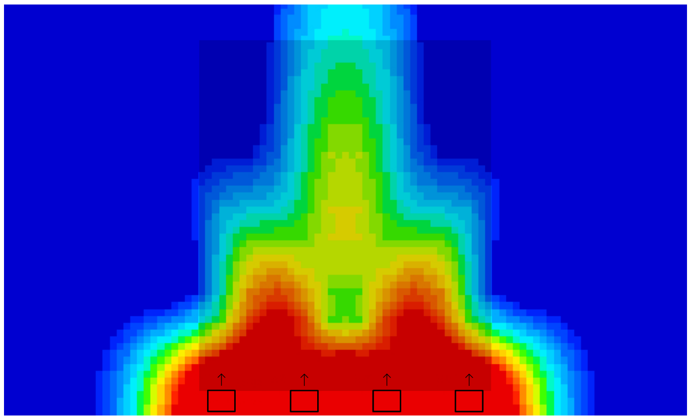

fig 15. four single height LF enclosures spaced 3 meters apart

Central Placement

One often overlooked deployment is the 360 degree central array. This involves positioning the LF enclosures under and facing out on all sides from a central DJ booth or dance podium. As will be seen, this configuration has many advantages when it comes to sound coverage and audience interaction with the DJ. Fig 16 shows the radiation pattern of eight enclosures. Each pole, N, S, W and E contain two LF enclosures, all are fed the same signal and power levels. Its important with this configuration to ensure the rear edges of each enclosure are touching the adjacent enclosures rear edges. In our example using enclosures that are 800 mm deep, the total dimension of the array would be 2.8 meters x 2.8 meters x 1272 mm high, with a central clear space of 1200 mm x 1200 mm. The resulting radiation pattern is very impressive with wide and uniform coverage. There are no cancellations or interference whatsoever. In a square shaped room the configuration shown in fig 16 would be about as good as could ever be possible. In a rectangular shaped room, such as our venue, the circular radiation pattern would mean excessive SPL's along the middle sides of the narrowest part of the room. However this can be rectified by power shading and steering the array, allowing the radiation pattern to perfectly fit the room. Fig 17 shows the same configuration that has had power shading applied. All the enclosures are fed the same signal with no delay differences, what's changed are the power levels that are fed to some of the poles in the array. To get the radiation pattern shown in fig 17, the W and E poles had there levels reduced by 8dB compared to the N and S poles, which receive the same power levels as in fig 16. This sounds like the opposite of what you should do as we want more sound level in the W and E directions, but strangely enough you have to reduce the levels going to the enclosures that are facing the way you want an increase in SPL.

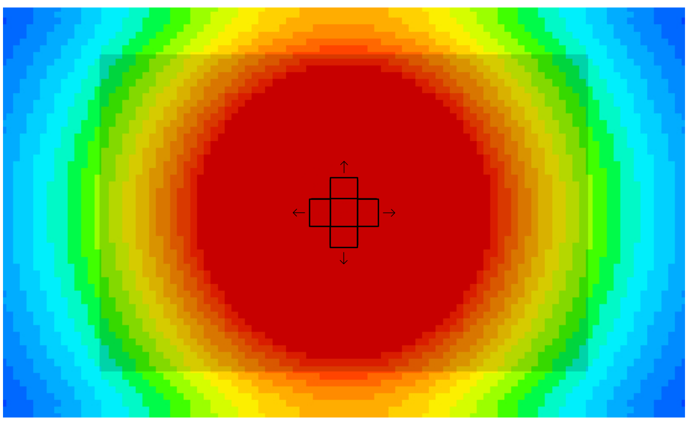

fig 16. double height 360 degree central array

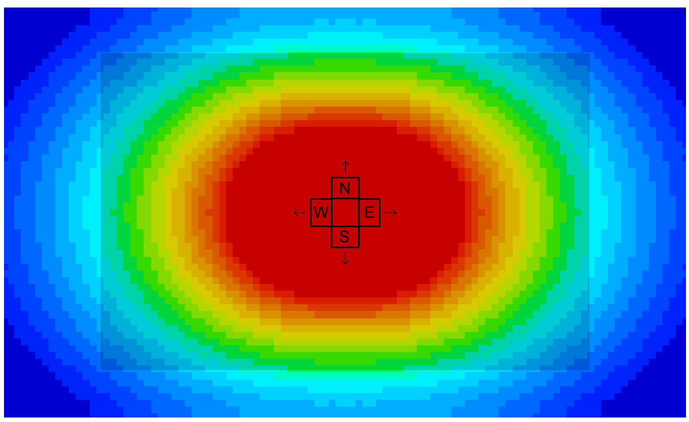

fig 17. double height 360 degree central array with power shading

The configurations in fig 16 and 17 used 8 LF enclosures with each pole containing two enclosures. If we take the same 8 LF enclosures but scale up the 360 degree central array so that it is now single height with two side by side enclosures for each pole, we get the radiation pattern shown in fig 18. The radiation pattern is almost exactly the same as in fig 16. The dimensions of the scaled up central array are now 4 meters x 4 meters x 636 mm high. The central clear space is 2.4 meters x 2.4 meters. As long as the rear edges are always in contact with the adjacent enclosures rear edges then its possible to keep scaling up the array in size and maintain the same radiation pattern. Fig 19 shows the effect of moving each enclosure of the array forwards by 500 mm. The result is a huge reduction in SPL in all directions due to the destructive interference exhibited by multiple enclosures suffering from incomplete summing.

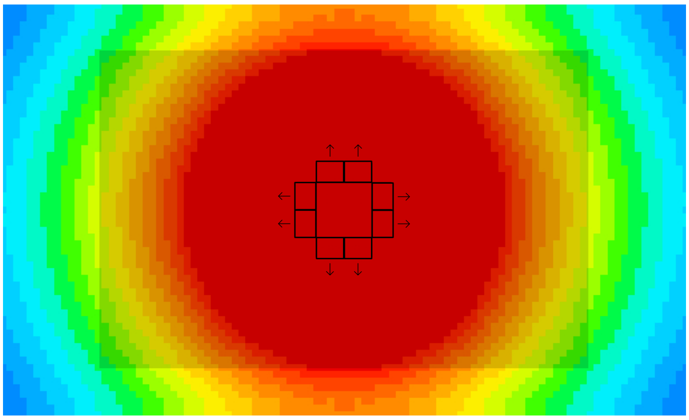

fig 18. single height 360 degree central array, no power shading

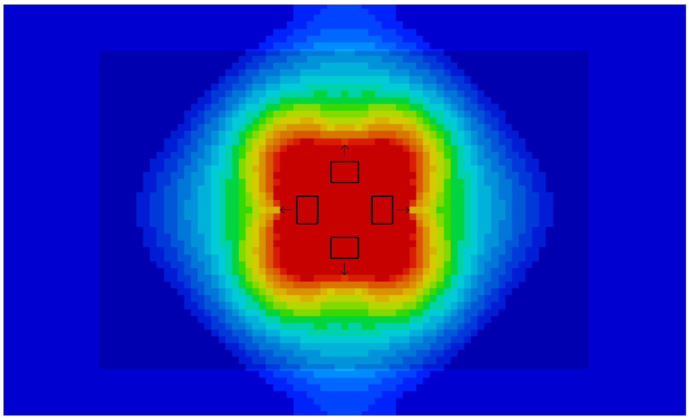

fig 19. double height 360 degree central array, spaced by 50 cm

Mid Top Integration

The successful deployment of the mid top loudspeakers in the system has to be very well thought out and planned long before the installation process commences. The key to good system performance is the integration between the bass and mid top elements. When bass enclosures are crossed over to mid top loudspeakers around the 110Hz to 150Hz range the positioning of the mid tops in relation to the bass enclosures is vital if optimum integration is to take place. The rule here is distance. If the mid top loudspeakers can be positioned above or very near to the bass stack/s then good integration should take place.

In this paper I will show three different system layouts for bass and mid top placement for our venue. Layout 1 consists of the bass configuration from fig 2, which is four LF enclosures, two wide by two high under the DJ booth and is shown again in fig 21. And four mid tops, each with a dispersion of 60 degrees horizontal x 50 degrees vertical. Fig 20 shows that when each mid top is positioned at each corner of the dance floor the coverage would be fairly uniform. Each mid top was 5 meters above the ground, was tilted down by 40 degrees and were toed in by 25 degrees. I have referenced the toe in angle as 0 degrees when two mid tops are facing each other down the longest dimension of the dance floor. As with the LF simulations, an averaging technique has been applied to aid reading the simulations. An emphasis to frequencies over 600Hz was applied to the averaging as it is in this range where interference is more likely to be problematic.

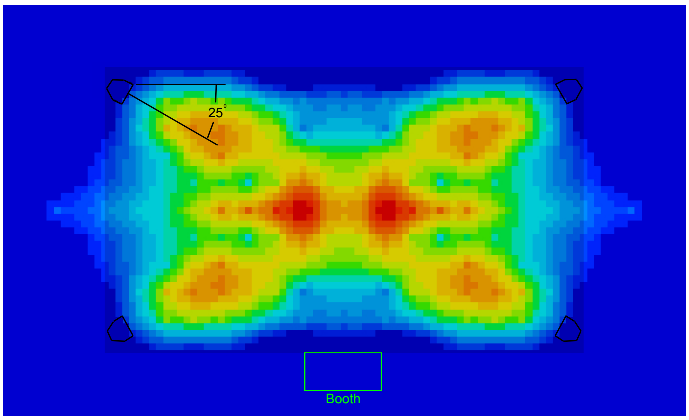

fig 20. (layout 1) four corner positioned mid tops

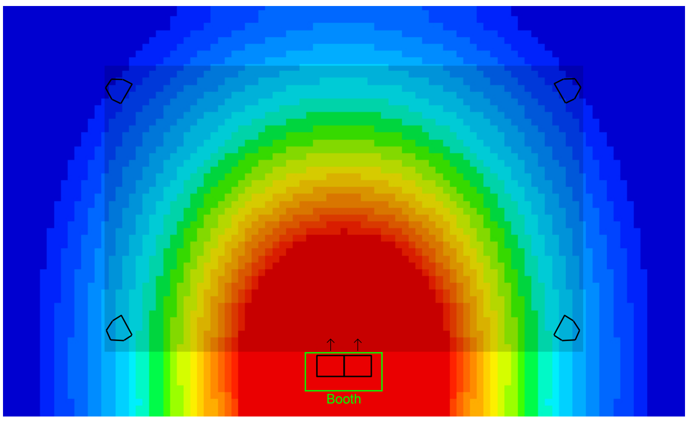

fig 21. (layout 1) four double height LF enclosures under a DJ booth

System Planning For Dance Venues

by Rog Mogale

Continuing with layout 1, fig 22 shows a composite of the radiation patterns from both the bass and mid top sections. It would appear that the dance floor would receive a fairly uniform coverage of bass and mid top. The area just in front of the DJ booth would have greater levels of bass to mid top, so the frequency balance at that location would not be correct. But the main worry would be that the mid top loudspeakers are no where near the bass stack in this layout. If a 110Hz to 140Hz crossover frequency were used between bass and mid top, then the integration would be very poor. It would be quite obvious that the bass was coming from a different place than the mid top and the upper bass to lower mid frequencies would lack definition. However, if mid tops that had an extended LF response were used so more of the vital kick frequencies came from them instead of the bass stack, this layout could work. A crossover frequency no higher than 75Hz would be required to make this layout integrate well, which would rule out many of the high output horn loaded mid tops available.

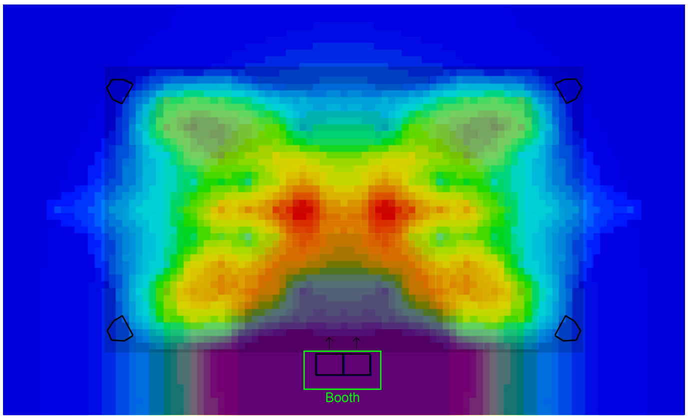

fig 22. composite radiation patterns of layout 1

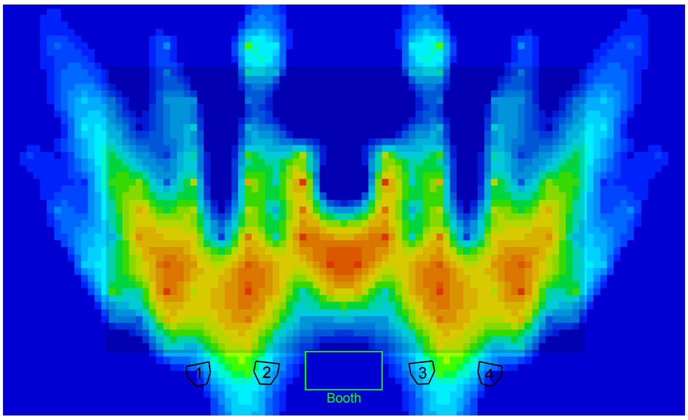

fig 23. four spaced front mid tops (layout 2)

Layout 2

Fig 23 shows the first stage of layout 2. The mid tops used are the same 60 h x 50 v as used in layout 1. Mid tops 2 and 3 have a distance of 5 meters between them, whilst the distance between 1 and 2 or 3 and 4 is 2 meters. All the mid tops have been tilted down by 35 degrees and receive the same power levels. 1 and 2 are paralleled up and are the systems right channel whilst 3 and 4 are paralleled up and are the systems left channel. The bass system used for layout 2 is the same as layout 1. Layout 2 would have good integration if crossed over in the 110Hz to 140Hz range and there is now more sound level in front of the DJ booth. The coverage at the front of the dance floor is even, but the rear has less SPL, so to rectify this another 3 mid tops have been added for fig 24. When the fills are added the whole dance floor receives mid top levels that are within 6dB.

Mid top 5 is fed the same signal as 1 and 2, but with -2dB of gain. It is also delayed with respect to mid tops 1 and 2. Mid top 6 is also fed the same signal as 3 and 4 with -2dB of gain. Its delay setting would be the same as for mid top 5. Mid top 7 is a mono sum of the left and right channels and is it at -3dB of gain. Its delay time would be slightly longer than mid tops 5 and 6. Its a complex setup that requires 5 channels of processing just for the mid tops. If an 8 output processor was used, then the another output could be used to fed the mono bass stack. If active mid tops were used then many more processor channels would be required.

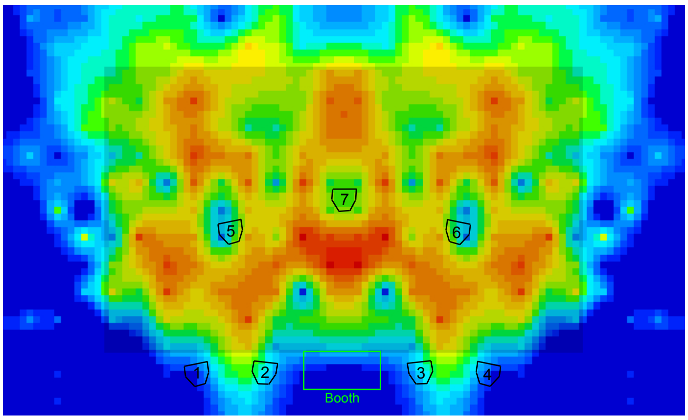

fig 24. four front mid tops with three delayed fills (layout 2)

I have setup a few clubs with this layout and the sound is very always very coherent. As all the mid tops face one way and are delayed back from the bass stack, it feels like all the sound is coming from the front, making you feel closer to the DJ booth. Another advantage of using delayed fills that point away from the booth is that you can apply greater downward tilt as you don't need so much coverage from each mid top. This helps keep the sound reflecting off the ceiling, which would lead to multiple sound paths reaching the listener.

System Planning For Dance Venues

by Rog Mogale

Layout 3

The final system layout we will look at uses the 360 degree central array in fig 18 for bass but with power shading to alter the radiation pattern to fit our room. This layout can either have the DJ booth centrally mounted over the bass enclosures, or have a DJ booth at another position looking over the dance floor. Fig 25 shows the radiation pattern of four 60 h x 50 v mid tops and have been positioned at 90 degrees from each other. Its not surprising to see that there are massive gaps in the coverage as the dispersion of each mid top is too narrow to fill the entire area. The use of 90 degree dispersion mid tops would go a long way in filling the gaps, but I'm still not sure because of HF beaming at higher frequencies that the coverage would be that uniform. Another way to get better coverage from a central cluster would be to use six 60 degree dispersion mid tops. This would give a combined dispersion of 360 degrees, which is exactly what we are looking for. The use of 60 degree dispersion mid tops also means that HF beaming will be reduced, as we are not asking for too wide a dispersion form any single mid top.

Fig 26 shows the radiation pattern of six 60 degree mid tops that have been positioned with a 60 degree angle between enclosures. A downward tilt of 40 degrees was applied to each mid top. Apart from the very corners of the dance floor, the coverage is even and as the mid tops are sitting above the bass enclosures, the integration would be very good.

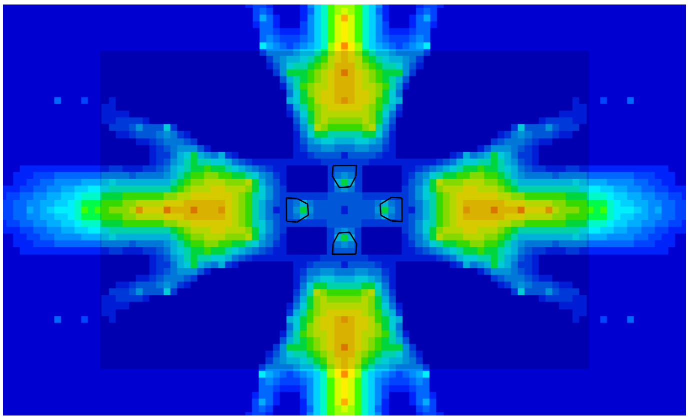

fig 25. four 60 degree centrally placed mid tops (layout 3)

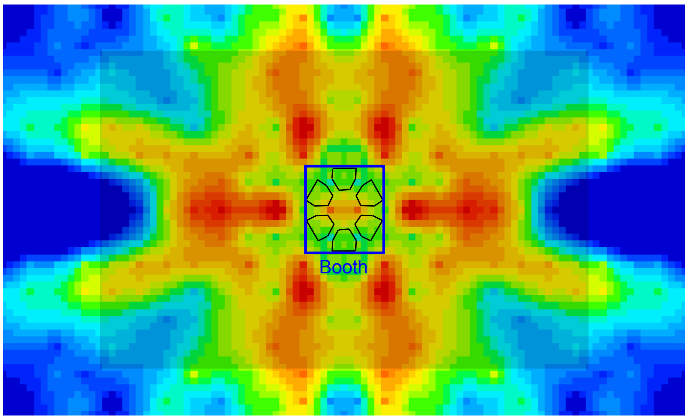

fig 26. six 60 degree centrally placed mid tops (layout 3)

The only delay required on the system in layout 3 would be the offset between the bass enclosures and the mid tops. The bass enclosures would all have zero delay and all the mid tops would receive the same amount of delay. All that's needed to be worked out with an RTA is the delay required for a mid top to have the correct phase and amplitude response though the crossover point.

Conclusion

I hope this paper has given you another perspective on planning a sound system for a dance venue. Its become quite evident that single bass stacks close to a dance floor overcome all the problems of interference and cancellations associated with multiple bass stacks. Its also clear that mid top loudspeakers placed close to a bass stack improve integration. Fills are very helpful for getting an even coverage, but the positions, orientation and delay times required all needs careful planning at an early stage. I'm starting to believe that for a venue that has its booth at one end, you should only ever see the back of the mid top loudspeakers as you look down the club. Anything that points back towards the booth will upset the coverage as you are listening to a loudspeaker with a inappropriate delay setting for that area.

For a club that has a large open area and has top named DJ's, layout 3 with a central booth would look like the best option for both sound and audience interaction with the DJ. For a venue that wants a DJ booth along one side of a wall, layout 2 with fills looks like a safe bet. To end where I started, no system can be planned before great consideration into the theme and layout of the club has be decided on. Only then can a layout be devised to suit the venues size, its acoustic properties and its philosophy on entertainment.