APPLICATION FOCUS

Dynamic BGM Systems

It probably hasn't escaped your attention that the retail sector have ratcheted up their efforts somewhat in the last couple of months. First of all their was the Christmas festivities, followed by the New Year Sales and now the impending Chinese New Year Celebrations.

It was during a visit to the shops just before Christmas that the subject for this months Application Focus came to mind – the humble Background Music System.

Undoubtedly it is the most common audio installation you are likely to come across every day. From the system installed at your local gym where you go to prepare for the day (or in my case – the coffee shop), the café down the road from your office that you go to at lunchtime, the supermarket you stop-off at on the way home to pick up all the things you forgot to buy on Saturday or the restaurant you go to for dinner when you can't be bothered to stand in the supermarket queue – each of us is probably exposed to 3 or 4 different BGM systems every day. That's a lot of loudspeakers and amplifiers. The question is though – how many actually sound any good?

Well, it's fair to say that on average - they can be pretty disappointing. In small shops, cafes or restaurants, it tends just to be an iPod dock up on a shelf, or a small pair of home HiFi speakers stretched as far away from the amplifier as the elasticity of copper will allow. Both are only audible above the ambient noise level of the staff putting on their coats at the end of the day. Anything louder and it will be drowned out. In a larger store you may well find a distributed ceiling loudspeaker system - usually designed just for speech. The speakers all probably used to work a long time ago but after one too many late night staff parties or after-hours stock checks that got out of hand, half are distorting and the other half don't work at all.

There is a significant amount of research on the psychology of the consumer in relation to what they are listening too in any given retail outlet. This is probably not the right forum to be discussing consumer psychology so instead, feel free to take a look at this very interesting article published by the Washington School of Business when you have a spare moment which spells out all the best bits and can be found via the link below:

http://faculty.bschool.washington.edu/ryalch/Research/atmosphe.htm

Considering the importance of creating the right "ambience" within the retail sector - it's surprising how often retailers seem to get the audio part wrong. Music being played too loudly or too quietly has just as significant an affect on the atmosphere as the type of music that is played. And it goes without saying that if the music is distorted it will just sound bad regardless of whether its quiet or loud. There is also a very good White Paper written by JBL that can be found via the link below:

http://jblpro.com/ProductAttachments/busmusic.pdf

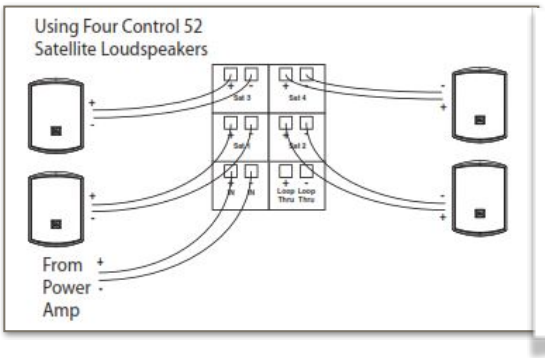
Key things that we are looking for in a good quality BGM system then are good coverage, realistic SPL ability, good tonal balance and good value for money. So let's start off with that last one first.

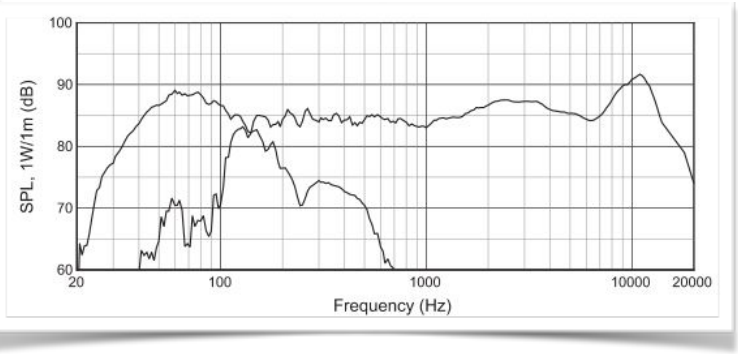
Small Retail Systems

Appreciating that many small businesses don't employ an AV consultant or Integrator to work with them, it's understandable that many of the small cafes and boutique stores simply use whatever they (or most likely their Electrical Contractor) can pick up at the local wholesale store. The JBL Commercial Series was designed to appeal to just that market. The CSMA is a 4 input mixer with a single 120W Drivecore amplifier output. With simple-to-use front panel controls and standard RCA and Euroblock connectors on the rear, even non-audio professionals should have no problems hooking the system up. There is enough inputs to have a dedicated music player permanently connected as well as space for a couple of auxiliary inputs and a mic/line priority input. The unit is small and light enough that it can simply be placed underneath the serving counter. If the customer wishes to locate the amplifier back of house then the CSR- series of wall controls allow remote adjustment from a convenient location with simple wiring.

To achieve the good coverage and tonal balance that we are striving for, the JBL Control50PAK is an elegant way of providing a full range sound in a compact format. Available in white or black the loudspeakers are unobtrusive and can be surface mounted to suit the ID of the space.

Cabling is simplified by having just one link that runs between the amplifier and the Control 50S/T subwoofer. With the subwoofer acting as a Crossover, there are then 4 outputs which power the Control 52 satellite loudspeakers. The end result is a full-range, discrete sound system offering professional quality in a simple to install package.

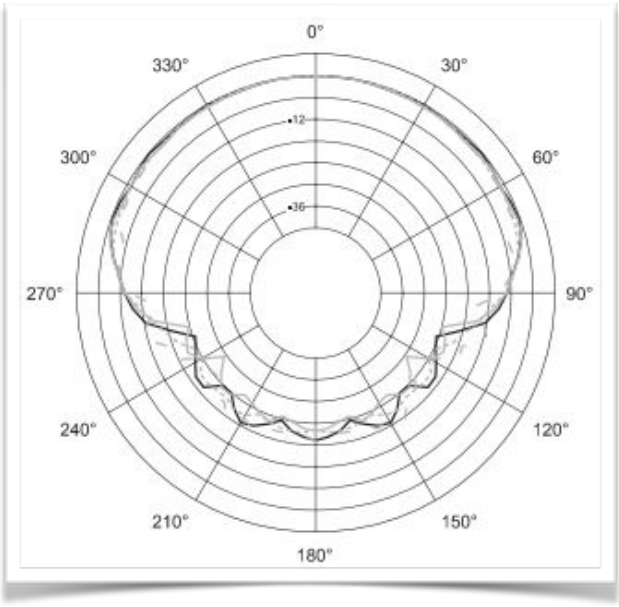




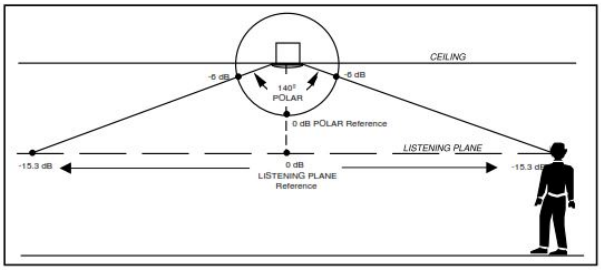
More Application Guides for JBL Commercial Series products can be found at the link below:
http://commercial.jbl.com/en-US/support_downloads#application-guide

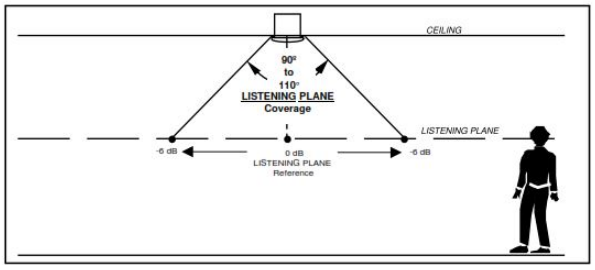
Larger BGM Systems

For larger BGM systems, such as those found in large shopping malls, hotels or casinos for example, designing a system that provides a consistently high-quality experience for the listener is a little bit more involved - for a number of reasons. With larger listening areas to cover, understanding the true coverage area of the proposed ceiling loudspeakers can make a big difference in calculating the correct quantity of loudspeakers required. People often make the mistake of simply taking the published "coverage angle' from a manufacturers data sheet and using that to plot out the conical coverage on the floor below. It's important to understand though that the quoted number is the result of a series of Polar measurements - that is via a microphone orbiting a loudspeaker in an arc and taking multiple measurements. Unfortunately, that is not how a listener experiences the output of a ceiling loudspeaker. Rather, they listen to it from a linear listening plane at various degrees off axis.



This can be more easily illustrated via the two images on the following page. On the left is the "assumed" output of a ceiling loudspeaker with a very-wide 140 degree coverage pattern. On the right is the "actual" coverage pattern once that polar response is unwrapped onto a linear listening plane.





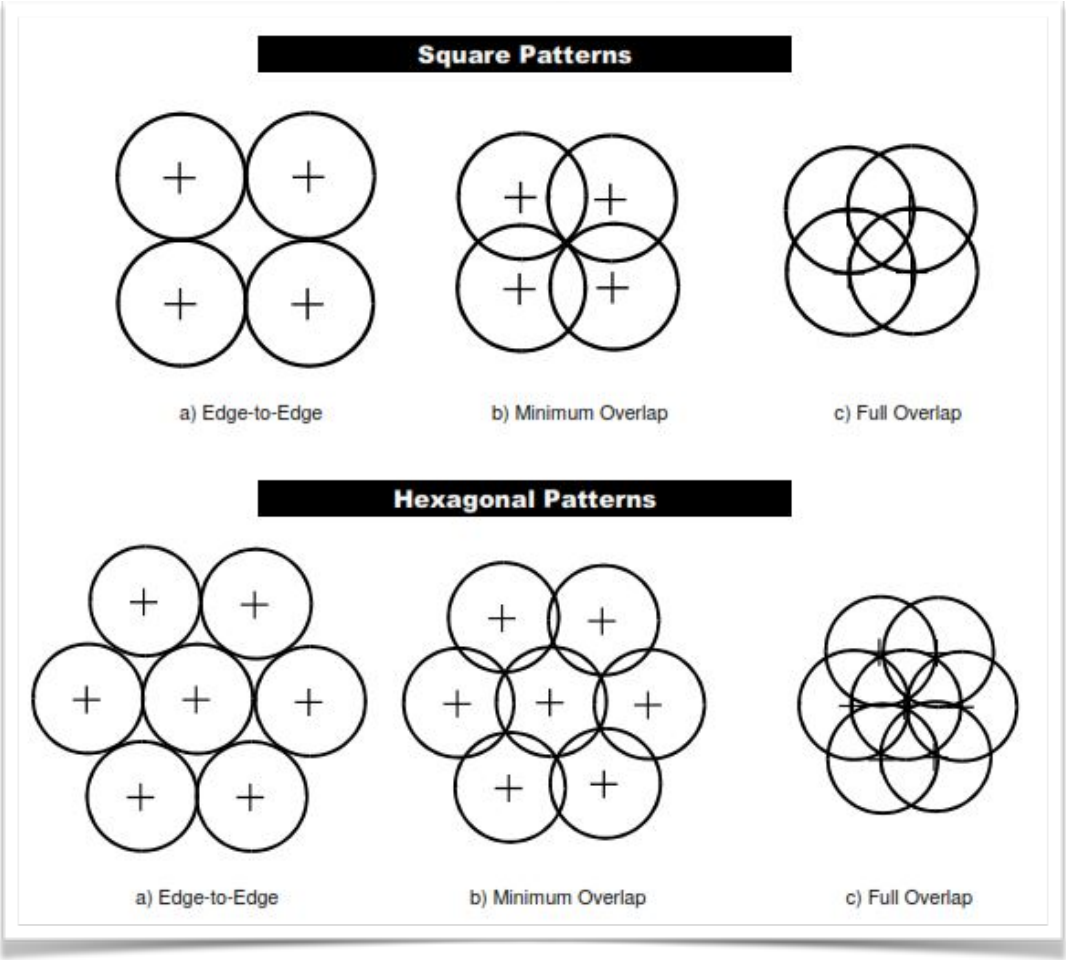
As you can see, there is a significant difference between the "assumed" coverage and the "actual" coverage at this particular mounting height - almost half the coverage area. This "actual" coverage angle is calculated by looking at the published polar patterns on the manufacturers data sheet and identifying at which point the response at a certain frequency and the Delta offset shown on the box below equals -6dB. By averaging the -6dB off axis points at each measured frequency, you are then able to more accurately quote the "actual" or "usable" coverage pattern of the loudspeaker.

Angle Off-Axis	Correction Factor	Angle Off-Axis	Correction Factor
5 Deg	-0.0 dB	45 Deg	-3.0 dB
10 Deg	-0.1 dB	50 Deg	-3.8 dB
15 Deg	-0.3 dB	55 Deg	-4.8 dB
20 Deg	-0.5 dB	60 Deg	-6.0 dB
25 Deg	-0.9 dB	65 Deg	-7.5 dB
30 Deg	-1.3 dB	70 Deg	-9.3 dB
35 Deg	-1.7 dB	75 Deg	-11.7 dB
40 Deg	-2.3 dB	80 Deg	-15.2 dB

If this all sounds too painful (and let's be honest - it does) then fear not as JBL actually have a couple of very useful design calculators that work all of this out for you. The JBL Ceiling Speaker Configurator (CSC) software is a wizard-based application that guides you through the entire process from defining the performance parameters of your system (required SPL and primary function - speech, music or both) and then suggesting several suitable loudspeakers that would fit the application.

The second piece of software available from JBL is the Distributed System Design (DSD) tool. This piece of software requires that you already know which loudspeaker you wish to use, but by adding in the dimensions of the room you are designing for, it allows you to compare different loudspeaker layouts to optimize the design to achieve the required SPL and coverage consistency. Full overlap should be used for the most critical/high quality sound reinforcement systems as this ensures that we achieve the minimal level of SPL variance across the listening plane (1-2dB) .

Budget, of course, may force acceptance of an edge-to-edge or wider spacing when a higher density would be desirable. In this case, the designer should make the client aware of the potential ramifications of this choice before the system is installed.



Layout Pattern & Density	Level Variation Square	Level Variation Hexagonal
Maximum Overlap	-1.4 dB	-1.2 dB
Minimum Overlap	-2.0 dB	-2.6 dB
Edge-to-Edge	-4.4 dB	-5.4 dB
1.4 x Edge-to-Edge	-6.8 dB	-10.2 dB
2 x Edge-to-Edge	-10.4 dB	-17.3 dB

Details of the SPL variances for each design are shown in the table below:

Links to the JBL software below:
http://jblpro.com/ProductAttachments/SetupDSD_V3.5.0.zip

http://jblpro.com/ProductAttachments/CSC_2_1.zip

Using DSP to create a Better Experience

Last month we looked at the way we can use BSS Digital Signal Processing in Distance Conferencing applications. Using some of those same technologies we can apply them to background music systems. In particular we will look at:

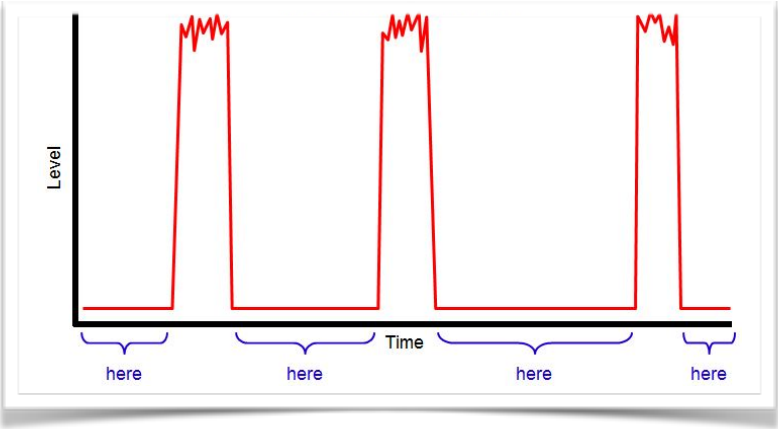
• Ambient Noise Compensation
• Bass Lift Volume Control

Ambient Noise Compensation or ANC addresses one of the most common faults with large BGM systems - Volume. I'm pretty sure we have all had a nice evening at a restaurant spoiled because the music has been so loud you have to shout to the person on the other side of the table to be heard. The opposite can also be true - music which is too quiet can also make the atmosphere feel awkward or uncomfortable - especially if you are on your own - perhaps at a shopping mall or another large space. This problem usually arises because the volume in the venue is discretionarily set by whichever member of staff happens to be nearest the volume control at the time. In a restaurant or coffee shop during peak lunch hours, somebody may turn up the volume of the music so it can be heard above the ambient noise of all the diners tucking into their meals. As most people start to head back to their offices, the restaurant empties, the ambient noise level decreases and now the BGM is too loud for those remaining customers. At the beginning of this article - we spoke about all of the different places that we could find BGM systems. If you think about how all of these environments change over the course of a day or week, setting the "correct" volume is an ever-moving target.

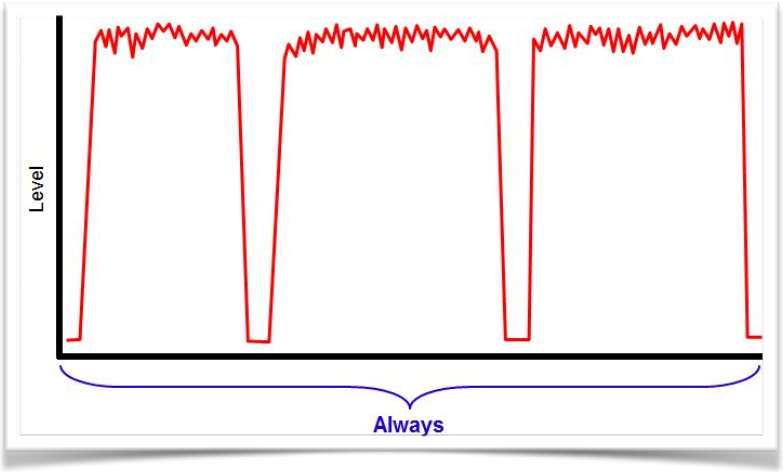
A properly designed BGM system can detect the variances in ambient noise levels - the lunch hour rush, the evening crowd, the weekend surge of shoppers etc and automatically adjust the BGM volume to compensate, creating a constant ambience regardless of how busy or empty it is.

There are two types of ANC objects within BSS London DSP devices - Gap and Non-Gap ANC.

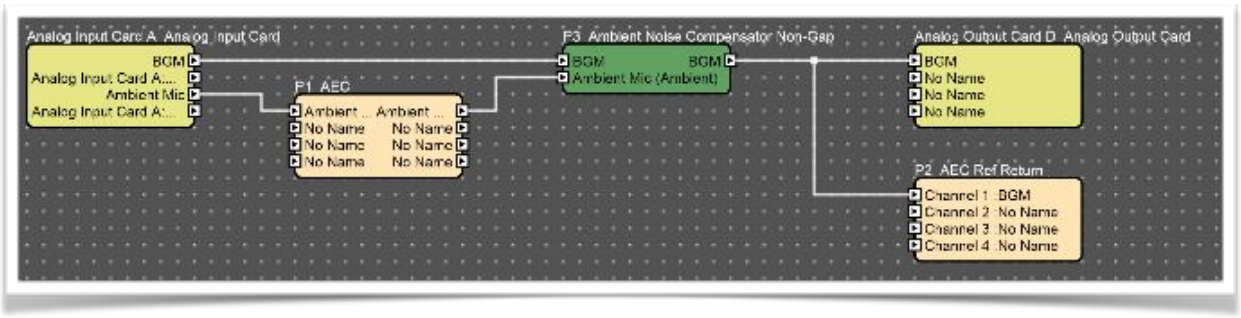
Gap measured ANC, shown on the left, uses a microphone to "listen" to the ambient noise within the space. In order for this to work properly, the loudspeaker cannot be outputting any music or announcements at this time otherwise this would affect the ambient noise measurement. It therefore has to wait for "gaps" in the programs content before calculating what adjustment in volume it has to make. This is perhaps Ok for a Paging system where announcements are only made occasionally with periods of silence in between.



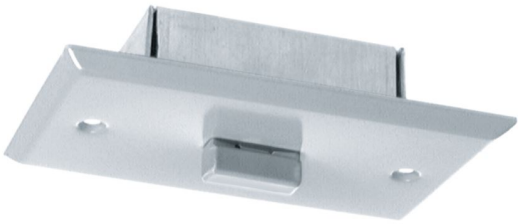
For a BGM system though, where there may be no gaps in the program content for long periods of time we need to use the - you guessed it - Non Gap ANC, which measures the ambient noise all the time, shown below. This way we ensure constant, dynamic, changes in level.



In order for the ANC microphone to listen to just the ambient "noise" within the room and ignore the background music coming from the loudspeakers we need to employ the services of the same Auto Echo Cancellation (AEC) processing object that we used in last months Distance Conferencing example. This time though the AEC will be filtering out the BGM music from the Ambient microphone signal rather than the Near Side audio content being returned from the Far Side caller. Still with us? Here is a simplified schematic from a BLU 101 that has floating AEC and is perfect for this type of application.



Following the signal path from left to right we can see the BGM feed coming into the BLU 101 where it is then routed into the Non-Gap ANC block with the output from this then routed to the physical output of the device. (Note that other loudspeaker gain controls, EQ, compressors etc can all still be included but have been left out of this particular example for clarity.) Lastly, you will see a copy of the output from the Non-Gap ANC block being sent to the first channel of the AEC Reference object. This is how we tell the ambient noise microphone to ignore any of the music signal it may be detecting and only concentrate on the rest of the sound within the space. The ambient sensing microphone is also connected to an input of the BLU 101 and then fed into the AEC processing object before connecting to the Ambient Reference input on the Non-Gap ANC object. What you are left with is a BGM system that will adjust the level up and down by a certain level that can be configured by the user as the ambient noise level increases and decreases.



A good choice of microphone for the ANC application is the AKG PZM11 boundary layer mic (also available in a WR (weather resistant) version for use in outdoor applications. With an integral back box, the microphone can be recess mounted into walls and ceilings making it visually very unobtrusive.

The PZM11 is characterised by a consistent pickup anywhere around the mic. Low frequencies are rolled off to reduce the pickup of heating, ventilation or air-conditioning rumble (HVAC noise). The PZM11 has a mic-level output and is powered by 12-48V phantom power. Electronics on the rear of the plate offer screw terminals, eliminating the need for connectors.

This seems like a good time to talk about another technology recently introduced to the Harman Portfolio - JBL Intellivox. By now, one hopes that everybody is familiar with the concept of both the Beam Steering (DDC) and Beam Shaping (DDS) technology that the Intellivox range of products offer but how can these help in designing a BGM system? Well firstly, the ANC technology and noise sensing microphone are actually already built into every Intellivox Column loudspeaker and can be simply activated via the WinControl Software. For larger applications, for instance where the column loudspeaker is positioned far away from the listening audience, an external ANC microphone can be located above the audience and wired directly back to the Intellivox unit. Each loudspeaker can then autonomously regulate its own volume according to the area it is designed to cover.

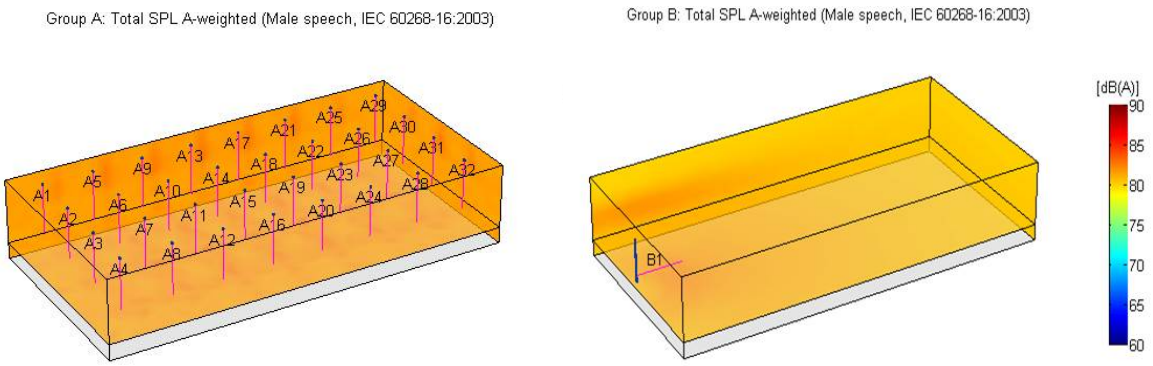
The second advantage of using Intellivox is its obvious ability to achieve consistent coverage whilst reducing unwanted reflections/reverberant sound. If we think about a distributed ceiling speaker design then typically we have a number of loudspeakers located in a ceiling pointing down towards a floor. Now when there are lots of people standing or sitting beneath the speakers then obviously a lot of the acoustic energy is absorbed by the listener with little of it being able to bounce off the floor and begin creating large reflections. When the space is relatively empty though, and the floor area unobstructed, then the speakers are simply going to reflect straight off of the floor. In shopping malls or transit buildings, these floors tend to be very flat and very hard surfaces - great reflectors of sound then!

The whole idea of Intellivox is to only put sound where it is required i.e: at the listeners ears. Correctly positioning the loudspeaker means that neither the floor nor the surrounding walls are acting as reflectors for the loudspeakers. This greatly improves the Direct to Reverberant (D/R) sound ratio and thus greatly improves sound intelligibility (STi) and general audio playback.

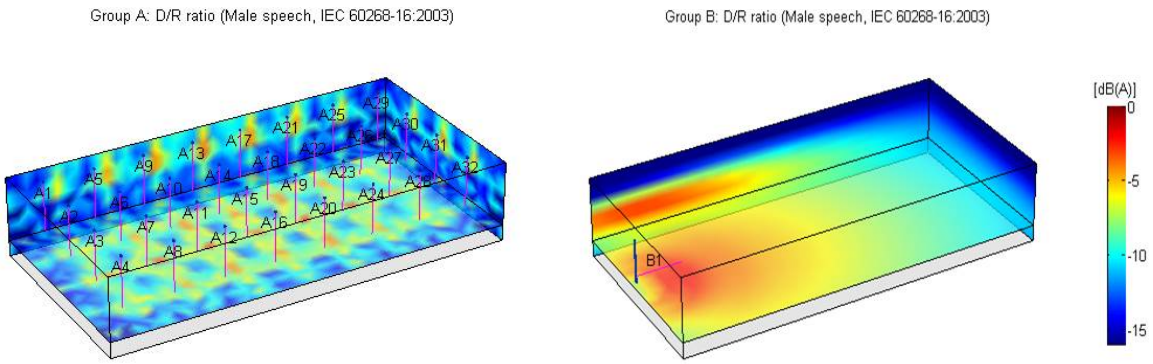
For a high quality BGM solution, particularly in difficult acoustic environments or where architecturally, installing lots of ceiling loudspeakers is not practical, the Intellivox DSX range of loudspeakers is definitely worth looking at.

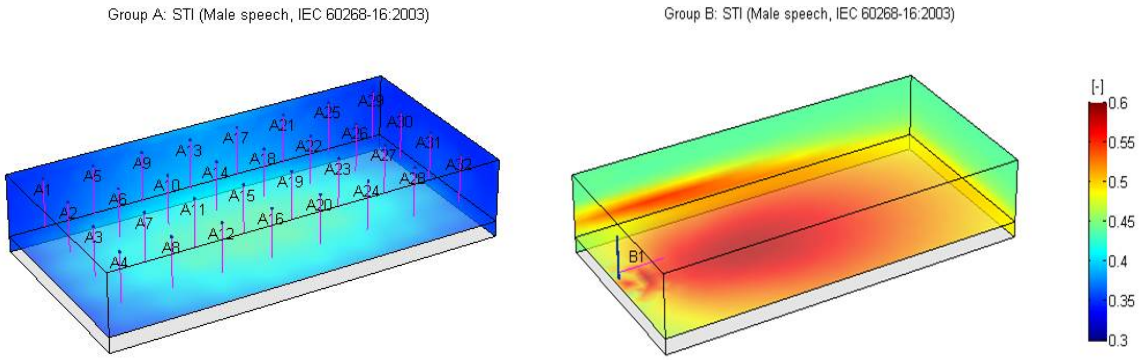
Below are some direct comparisons between a distributed ceiling loudspeaker design comprising of 32 generic loudspeakers versus one JBL Intellivox DSX430 installed in a simulated room of dimensions 20m x 40m x 8m (WxLxH) and with an estimated reverberation time of 2 seconds. Note the desirable increase in D/R and STi by actually using less loudspeakers in this large reflective space.

Total SPL (dBA)



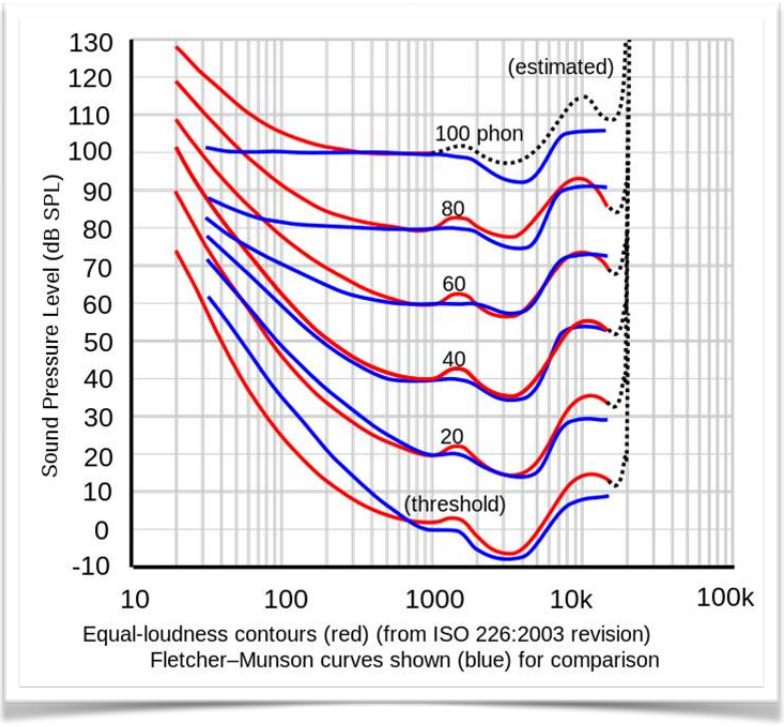
Direct/Reverberant Ratio (dB)





So, with various loudspeaker concepts to work with, we can now have a well designed BGM system that provides great coverage across the entire space and will always be at a suitable level regardless of how busy or empty the space is. What else can we do to ensure a high quality experience?

Well there is one little oddity left that can make a big difference to the overall experience and its related to how your ears function. Theoretically our ears should be able to hear frequencies from 20Hz all the way up to 20 kHz. Unfortunately from day one though we start to lose sensitivity in our ears - particularly at the higher frequencies. This problem is compounded by the fact that our ears are more sensitive to certain frequencies (2kHz - 5kHz usually) than others. This phenomena was first researched by 2 members of the Acoustic Society of America, Harvey Fletcher and Wilden A. Munson, who published their findings in a 1933 paper entitled "Loudness, its definition, measurement and calculation".

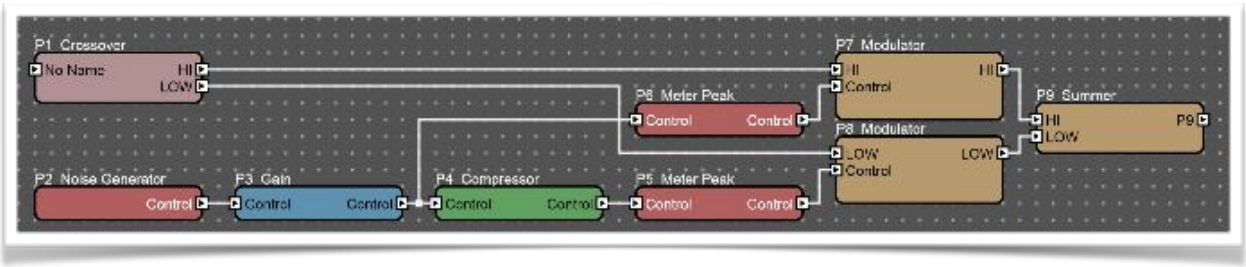


Their research showed that obtaining "equal loudness" of differing frequencies required fairly significant changes in volume - particularly at lower and higher frequencies. Their research was superseded through time until it was finally revised into the ISO 226 standard that we work to today (although they are still often referred to as Fletcher-Munson curves).

As you can see, at relatively low SPL levels, lets say 40dB at 1 kHz, to obtain equal loudness at 100Hz, the lower tone needs to be around 25dB louder and the higher frequencies around 10dB louder. Where as the original Fletcher-Munson tests tended to top-out at 100dB (due to the limitations of the technology they were using during that time), the more modern ISO results show that a similar phenomena exists - albeit to a slightly lesser extent. How does this apply to BGM systems?

Well at low volume levels, music will tend to sound a little bit thinner as the ear struggles to detect the bass and high frequencies. If you EQ your sound system at a lower volume, when you turn it up - it will possible sound overly boomy or bright. Likewise if you EQ your sound system at a high volume, when it is turned down low it will sound as if you are listening to the music through a telephone. Thankfully the Signal Processing within our BSS devices has a solution to this particular problem.

Here is a simplified schematic from a BLU 101 that is perfect for this type of application.



Again following the signal path from left to right, we would feed our BGM signal into the Crossover where the signal is then split into 2 parts - the HI section (everything 100Hz and greater) and the LO section (everything below 100Hz). Where typically we would use a crossover to split one signal to two different speakers, in this particular application, we are simply splitting the sound so that we can independently adjust the LF level at different levels.

To do this we use a Compressor on the LF split that allows lots of bass at low level but when the channel is gradually turned up, the compressor begins to reduce the LF level to keep the tone balanced. Both signals are then summed back together into one signal and can then be routed on through the signal chain to the amplifiers and speakers. It does take a little bit of fine tuning to get the various compressor ratios and LF gain levels working as you need (after all - every loudspeaker installation is slightly different). The end result though is a full frequency range sound whether quiet or loud.

A full Application Note on the Bass Lift set up can be found via the link below:
http://bss.co.uk/en-US/support_downloads

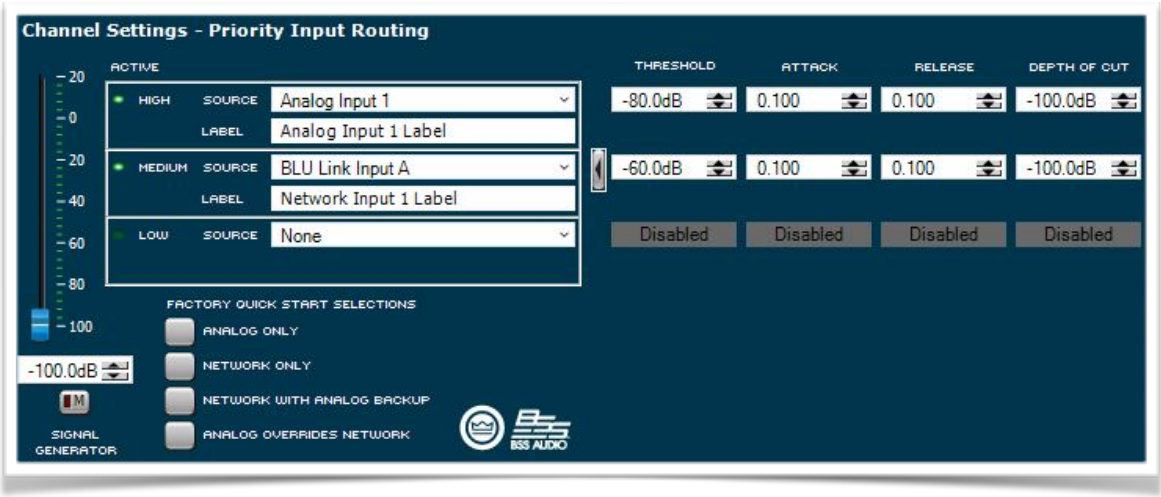
Last but not least.....

So, we have spoken about loudspeakers and we have also spoken about DSP. The missing part of the system then is the amplifiers - and for larger BGM system that utilise the type of BSS DSP technology detailed above, then the Crown DriveCore Install series of amplifiers are perfect.

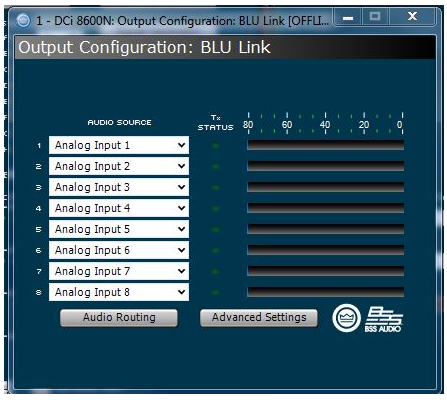
With up to 8 channels of 600W at both low and high (70/100V) impedance available in a 2U chassis, apart from its obvious power density, the patented DriveCore technology also allows us to present a solution to our customers that can actually save them money. By being both electrically and thermally very efficient, the amplifier not only draws less AC from the wall socket to power it, but it also requires less cooling meaning the Air Conditioning in the rack rooms can also be turned down a bit. These "hidden" savings can quickly add up to significant values. The importance of this will certainly not be lost on the operator and should therefore be highlighted to customers - especially those who may be looking at lower cost products.

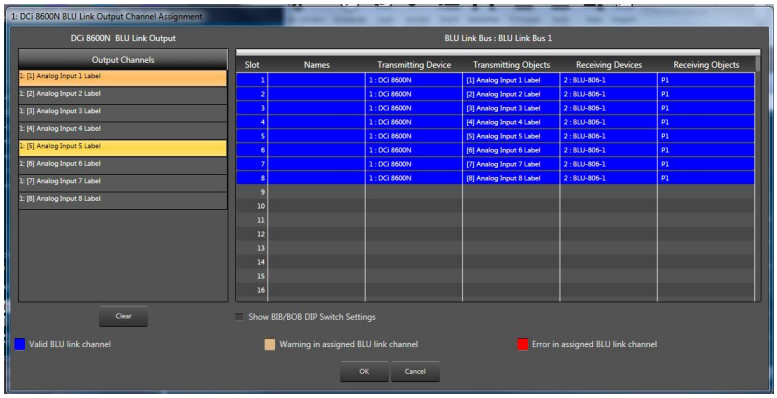
With its own inbuilt DSP and connectivity via BLU Link, it's actually possible to reduce the cost of your design further by taking advantage of the DriveCore Install Network versions digital connectivity. By having lots of DSP in the amplifier to look after loudspeaker and room EQ, as well as a 3 way priority input mixer per channel, you do not need to specify a large standalone DSP to control everything. A smaller DSP that can look after things like AEC and ANC such as the BSS BLU101 can then be linked to a DCI amp via BLU link and a single CAT5 cable. Need more line level inputs for more BGM channels? No need for a BLU BOB, you can actually use the analogue inputs on the back of the amplifier as an on-ramp to the BLU101 using the DCI Networks comprehensive Input/Output routing matrix.

DCI Network, 3 Channel Priority Mixer with Variable Dynamic Control



Integrated GPIO controls on each amplifier mean you can connect physical control objects - such as a potentiometer or button directly to the back of the amplifier so that it can be remotely controlled simply and reliably. The DriveCore Install Network series of amplifiers are also fully implemented into HARMAN Audio Architect software.





DCI Network BLU Link On-Ramp Select and BLU-Link Channel assignment

So there is just a few examples of how HARMAN technology can help create better quality BGM solutions - big or small, regardless of budget. From the JBL Commercial Series - ideal for your day to day retail-type applications to DSP enhanced, networked solutions for larger applications such as shopping malls, hotels, resorts and casinos. The products are there to help you fulfill your customers requirements. Good Luck!

HARMAN Audio Architect software is the subject of an Asia Pacific training program rollout, and discusses various real world scenarios and techniques, some of which are described in this application focus. We hope to see you at one in the near future.

Details on upcoming training sessions in your area and course registration is available via HARMAN's Audio Architect webpages:

http://audioarchitect.harmanpro.com/en-US/audio-architect-training_overview