BOUNDARY CANCELLATION

AND

WOOFER PLACEMENT, KICK DRUM EQ, AUX FED SUBS AND OTHER INFO

How to eliminate low frequency bass cancellation with proper woofer placement

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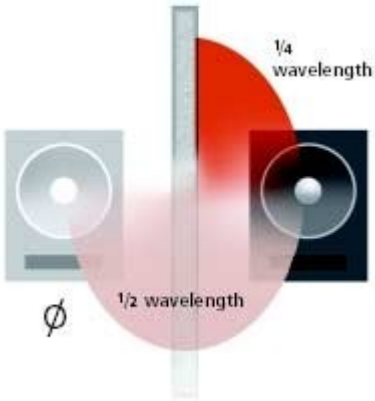
Many local bands and sound companies are unknowingly victims of a type of low frequency cancellation known as boundary cancellation. This phenomenon occurs when a loudspeaker is 1/4 of a wavelength away from a boundary. Assuming that the boundary (like most walls or floors) absorbs little or no energy, the reflection off of the boundary plays against the energy still coming from the speaker source.

Here is a thought experiment that is a good analogy. Imagine a subwoofer that is placed 1/2 of a wavelength, at a certain frequency, away from another sub, and the second sub has had its polarity reversed. It is easy to imagine that the loudspeakers will be opposing each other because one will be moving inward while the other moves outward, causing mutual cancellation due to the 180 degrees of difference in phase.. A similar thing occurs when a loudspeaker is placed 1/4 of a wavelength away from a boundary. It is as if the boundary is not there, but instead there is a phantom loudspeaker 1/2 of a wavelength away that has had its polarity inverted.



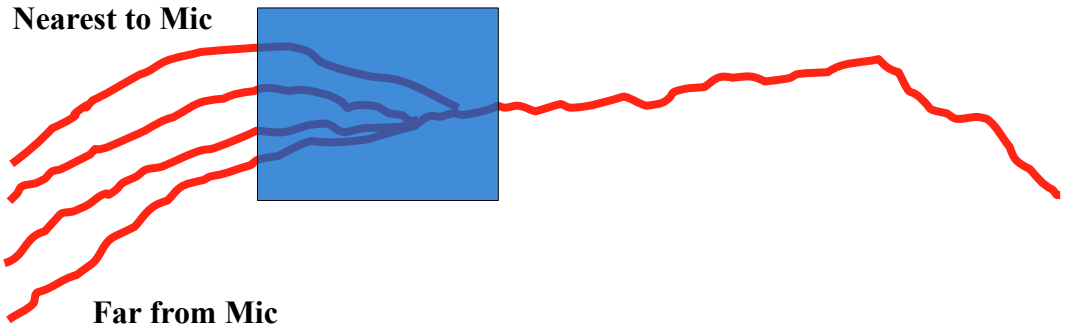
Now lets investigate where and why many people unknowingly have a problem at a very critical frequency. The kick drum frequency can be a fundamental problem for many people as they have a misconception as to where this frequency actually is. I will not say that the fundamental frequency is exactly at 80 Hz, but usually the 80 Hz, 1/3 octave equalizer control, will bring more of the kicks thump out than say 50 Hz, 63 Hz or 100 Hz. Usually, this fundamental is somewhere between about 72 and 80 Hz. \

It is not always easy to get a great sound from a kick drum; however, most people are looking to reinforce or reproduce the characteristic kick drum sound established in an LA studio by New York drummer, Steve Gadd. You can hear similar kick drum tunings in most genres of music today, and the reason is very simple. It fits, and it does not step on the vocalist or rhythm instruments. The sound consists of the fundamental frequency and the harmonic that is one octave above, but subsequent harmonics above are suppressed. This is what the proper use of the pillow in the kick drum results in. (If you would recall the early sound of John Bonham´s kick drum sound in Led Zeppelin. It rang quite a bit, and just wasn't tight by today's standards). Later Led Zeppling recordings captured a tighter sounding kick drum.

Many people are hung up on using a certain particular microphone models as the only way to get "**The**" proper Kick drum sound. Yes there are some models that are preferred for the Bass Drum, but it all starts with the tuning. If the drum is tuned properly then a great microphone can accurately reproduce that tuning. But if the Kick drum has the tone of someone slamming a screen door on your back porch, then that is what that "great Mic" will reproduce. In the early seventies, drummers began putting a blanket or pillow in the kick drum and pushed it up against the rear head in order to attenuate some of the overtones of the drum that would ring out or sustain much longer than the fundamental. There are drummers to this day (usually of the Jazz genre) that will not use any blanket or pillow in their bass drum. But these drummers usually play very quietly with little or no reinforcement.

When ever you put **any** directional microphone close to a sound source, you will introduce some coloration that is caused by the proximity effect of the microphone. The proximity effect is an increase in the bass or low frequency response that occurs when a directional microphone is close to the source of the sound. The closer the source is to the microphone, then the more the low bass frequency response will be apparent.

Proximity Effect



It is not the lowest of boosted frequencies that are a problem, but the accentuation of the higher low-mid frequencies is what can add to the the sustained ringing of the kick drum overtones in a reinforcement situation. This area from about 200 to 400 Hz is also a problem for vocals and can contribute to a certain "honkyness", more so with some microphones than others.

We used to have a product called the Electric Pillow, which was a kick drum conditioning filter, that employed a special filter attenuating the region where most of the ring came from. This filter can be simulated via an 1/3 octave graphic equalizer that is employed and connected via the insert feature on **just** the kick drum channel. If you would like to dry up and tighten a kick drum in a mix, insert an equalizer into the kick channel, roll it off below 40 Hz; boost it +4 to +6 dB at 80 Hz; and leave 100, 125, and 160 Hz flat (0 dB). Set 200 Hz to -3 dB, 250 Hz to -6 dB. Cut 315 Hz through 500 Hz completely (-15 dB). Set 800 Hz to -6 dB, and leave 1 kHz through 5 kHz flat. Then cut 6.3 kHz to -4 dB, 8 kHz to -8 dB, and cut 10 kHz, 12.5 kHz and 16 kHz all the way (-15 dB). This equalization curve can help when wanting more punch out of your kick drum in a mix, but other problems may arise when you choose where to place the loudspeaker.

Here is an example of conditions where the kick drum can be diminished due to boundary cancellation. Lets assume that a typical stage is 3 1/2 ft. high (42 in. or 1.07 m), and the subs are placed on the corners of the stage. If we divide the speed of sound by a given frequency, we get the wavelength or physical size of that wave form in air. In most warm rooms, the speed of sound is 1130 ft. per second (344.5 m). 1130 / 80 = 14.125 ft. (4.3 m). One-fourth of this dimension is 3.53 ft or 42.4 in. (1.08 m)

Guess what? This height of the stage (42 inches above the floor), is canceling half the energy of the fundamental kick drum frequency. This is very common occurance, yet unrecognized by most. If you move the sub closer to the floor or boundary, you raise the frequency of cancellation. And of course if you move it further away from the boundary, you lower the frequency of cancellation. No one is really the wiser if the note of cancellation is in some key in the bass players domain because he doesn't play the same note over and over. However, in the case of the kick drum, you decide.

A Worst Case Scenario of Boundary Cancellation

In the early 70s, in a club in McKeesport, Pennsylvania, I was mixing for a band that played this room for the first time. The stage was 3 1/2 feet from the corner, and it was also about 3 1/2 feet above the floor, and yep, only about 3 1/2 feet deep. We lost a woofer on the left-hand side, halfway through the first set. Trying to compensate on the EQ, I only succeeded in trashing the woofer on the right side before the set was finished.

We decided to put two woofers together in the center of the dance floor and plug them in. Back then I had heard about center floor coupled woofers before but never tried them myself.

When the band began the next set, I had an incredible mount of kick drum with the current EQ setting. In fact, I had to turn it DOWN and change the EQ. Below is the math.

Boundary cancellation was occurring in five places, so here are the losses:

Left Woofer	Right Woofer
-3 dB off of floor	-3 dB off of floor
-3 dB off of side wall	-3 dB off of rear wall
-3 dB off of rear wall	

Total loss due to boundary cancellation = **-15 dB**.

By placing the two subs on the floor, we gain +3 dB. Because they were placed together and mutually coupled, and were thus coincident, we gain an additional +6 dB of performance for a total of +9 dB. The difference between -15 dB and + 9 dB is a 24 dB margin. Now you can see why the kick drum was so pronounced when we made the change.

For some reason, this woofer placement became a default arrangement by most bands that played this room. No one knew why it worked so well at the time, but the thump on the dance floor was incredible when we did it this way. (Alas though, one night the club mysteriously caught fire in several places at once and burned to the ground).

Several years later when I attended a Don Davis Syn-Aud-Com seminar, Don explained the math involved with boundary cancellation. Many common stages unfortunately present this case of boundary cancellation at the kick drum frequency. Should the woofers therefore go on the ground? It depends on the crossover frequency. If crossed over low enough (<125 Hz) the woofers can be centered on the floor or ground in front of the stage.

In a permanent installation, the sub can be placed under the stage, however, when placed under the stage, care should be taken to insure that any gap is sealed. Some stages can benefit from a back box that further isolates the woofer from coupling with the cavity underneath the stage. It is also a good idea to put absorption material on the top, sides and back of the enclosure. All of this is necessary to prevent the subwoofer from driving the stage itself. If this is not addressed, the cavity under the stage becomes a massive Helmholtz resonator (a type of acoustical resonator with an enclosed volume of air connected to the acoustical environment by a much smaller opening). With front-loaded, direct radiating woofers, the loudspeakers can be serviced or replaced without removing the enclosure from under the stage.

Many three-way systems that are crossed over between 200 and 300 Hz will have a problem with an octave or more of information being muddied due to some blockage by the audience if the subs are placed on the floor. The best crossover frequency for a separated woofer is below 125 Hz. The audience can NOT really block the low frequencies below 125 Hz. The wavelengths are simply too large.

Aux Fed Mix

Today you will often find center placed subwoofer systems that are fed from their own special or separate mix from one of the FOH consoles auxiliary mixing buses. This technique is usually referred to a an “Aux Fed Mix.” Aux fed mixes make sense, as this gives the system operator the ability to control the low end of the performance in a manner that will allow for all of the low frequency emphasis necessary to make the show as dynamic as possible, without necessarily detracting from other aspects. What do I mean by this? Well, some sound people in their quest for the ultimate “Arena” Kick drum sound, will put so much bass lift in the EQ to the left and right FOH loudspeaker systems, that they seem to be unaware of how it affects other instruments and voices particularly. I submit that when there is so much bass boost (lift) in the EQ of the system, that when a 110 lb. Female singer then sounds like Godzilla running through the alley, that their “Bass Lift” is over the top.

Excessive bass lift on the mains make acoustic instruments sound unnatural as well. The Aux Fed Sub should be low passed (high cut) at 90 to 100 Hz. The beauty of Aux Fed Subs is that they only receive a special mix of the Kick Drum, Floor Tom and Bass Guitar (and possibly a keyboard or any other instrument with content below 100 Hz). The operator can then even get a little "Bass Stupid" about driving these Subs, but he does not muck up the rest of the FOH mix. Now it is important to recognize that these same channels that are sent to the Aux fed subs, still need to be routed to the FOH mix, as the information above 100Hz is still important to the character of these instruments. But the desired low frequency emphasis that can be employed for crescendos or song endings can be controlled better via of the Aux fed sub method.

I hope this article will help you understand the acoustic principles involved and perhaps when you apply this information, you will get an even better sound from your performances.