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MAXXBASS® APPLICATIONS IN SUBWOOFER DESIGN

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ABSTRACT
MaxxBass® psychoacoustic bass enhancement offers loudspeaker system engineers a new way to improve subwoofer performance by using signal processing technology. Waves has developed a reference design for a home theater quality subwoofer that provides the same deep bass response as large, high quality subwoofers at a fraction of the size: the MiniWoofer is a seven-inch cube weighing less than six pounds. This product will be demonstrated, and the system design will be discussed including how this design can also be optimized for automotive and other applications.

1 INTRODUCTION

Accurately reproducing bass frequencies is the most difficult and expensive part of loudspeaker design.[1] CDs, DVDs, and other compressed audio formats are dramatically improving audio media quality, but bass frequency performance is lagging behind since subwoofers still require large enclosures with powerful amplifiers to generate loud and deep bass. Furthermore, many system designers have reduced bass frequency response due to competitive market pressures for products which are less expensive, smaller and use less power. However, MaxxBass offers an opportunity to dramatically improve loudspeaker bass performance by utilizing the latest in the science of auditory perception without altering the physics of acoustic bass reproduction.

2 BRIEF HISTORY OF BASS

People have always liked the sound of deep, rich bass, and they have been listening to it well before today's electric bass guitars, car audio systems and home theater subwoofers. In prehistoric times, bass was generated by playing drums made of stretched animal skins and sticks. Drums, horns, woodwinds and string instruments all have versions designed primarily for playing bass frequencies. In the Middle Ages, large pipe organs installed in cathedrals used pipes up to 40 feet long to create low

petal tones that drew crowds to church services to feel the bass, which helped generate emotion as they listened to spiritual messages.[2]

3 PHENOMENON OF THE MISSING FUNDAMENTAL

In the early 1700s, some pipe organ music composers found that they could trick the listener into hearing low bass tones that weren't really there if they played a certain combination of notes that were higher than the low tone or "fundamental" that they wanted heard. For example, if they wanted the listener to hear a low C then they could play a C an octave higher and a G above that, and the low C would magically be heard in the listener's head.[3]

The Phenomenon of the Missing Fundamental has also been studied and proven by many distinguished audio scientists such as Helmholtz, who discovered how vented ports and vents operate. The perceived pitch of a combination of tones spaced equally in frequency is usually not that of the mean frequency, but rather that of the constant difference frequency,[4] which is the missing fundamental.

4 MAXXBASS

Meir Shashoua, the CTO of Waves, developed a theory on how the Phenomenon of the Missing Fundamental could be applied to loudspeaker reproduction limitations. Waves, the leader in audio signal processing plug-in tools for the professional audio market, improved and sharpened this psychoacoustic effect. This technology, called MaxxBass was patented in 1999.

Waves MaxxBass and second generation Renaissance Bass plug-ins utilize this technology and in the past few years, have become standard tools in creating much of the world's most popular music. These software tools are used to improve bass punch on bass limited systems, which is important for playing music on everything from dance floors with subwoofer arrays to small portable systems with severely limited bass capability. Christina Aguilera's "Lady Marmalade" is just one example of today's popular music that is mixed with MaxxBass technology.

Since MaxxBass can be tuned to specific loudspeaker parameters, it is even more effective when implemented directly in consumer audio reproduction systems. This is now possible due to a cost-effective MX3000AS ASIC (Application Specific Integrated Circuit) as well as DSP software licensing from Waves.

Another advantage of implementing MaxxBass in consumer audio equipment is that it includes a high pass filter (HPF) which removes the original bass frequencies that cannot be reproduced by the loudspeaker and which are no longer needed since MaxxBass reproduces these through psychoacoustics. The HPF eliminates damaging speaker excursion, unnecessary power consumption and undesirable intermodulation distortion in the loudspeaker.

5 APPLICATION TO SUBWOOFER DESIGN

Boosting the low-frequency performance of a speaker by up to 1.5 octaves requires increased headroom in the amplifier, increased excursion in the driver, and extra Bl to maintain control at high excursion, all of which are substantially more expensive than

implementing MaxxBass.[5] MaxxBass technology is a powerful and cost-effective way for audio system designers to improve bass response.

MaxxBass enables an entirely new alignment and acoustic design of subwoofer systems. For the driver, the higher *fc* enables a lighter, more efficient cone, while the new alignment allows for a much more compact enclosure. In addition, the raised sensitivity potentially allows for a higher maximum sound level before the onset of audible distortion. [6]

6 HOME MINIWOOFER

The Home MiniWoofer is an example of how MaxxBass can dramatically shrink the size of a traditional subwoofer without sacrificing sound quality. The Home MiniWoofer was designed to provide the acoustic performance of a typical home theater subwoofer, while shrinking the size of the enclosure as much as possible without increasing overall system costs. The result is a Home MiniWoofer that is a seven-inch cube weighing less than six pounds. In addition to providing an attractive option for home theater customers who don't want a subwoofer that takes up a lot of space, the MiniWoofer can also be designed in a variety of forms ranging from a small subwoofer that fits under a car seat or on a door panel to a three-inch thick flat panel subwoofer that can hang on a wall under a plasma TV.

Table 1 compares several parameters of a typical home theater subwoofer to the Home MiniWoofer. An extensive evaluation study determined that a 90Hz f3 and a 60Hz MaxxBass Frequency with a sealed enclosure were optimal for size reduction, while meeting the same perceived bass range (40Hz) as the original system. Further increasing f3 started to degrade sound quality. The full reference design including Teal/Small parameters of the final design are available at www.maxx.com.

Table 1 Comparison of Home MiniWoofer to Home Theater Subwoofer

	Typical Home Theater Subwoofer	**Home MiniWoofer**
Performance		
Physical Low Freq Roll-Off	40 Hz	90 Hz
Perceived Low Freq Roll-Off	40 Hz	< 40 Hz
Loudness (SPL 1m C-weight)	>100 dB	>100 dB
Specifications		
Enclosure Dimensions	12 x 8 x 14 inches	7 x 7 x 7 inches
Enclosure Volume	0.4 ft3	0.1 ft3
Enclosure Type	ported	sealed
Driver Size	8 inches	6.5 inches
Magnet Weight	18.7 oz	10 oz
Voice Coil	1.5 inches	1.0 inch
Maximum Power	100 Watt	50 Watt

7 FURTHER DESIGN OPTIMIZATIONS

The MaxxBass MiniWoofer can be further optimized to enable a wide range of new subwoofer designs.

In automotive applications, the power supply would be modified from the current 15VDC to a standard 12.0 to 14.4V automotive supply. Obtaining maximum power transfer can be achieved by using a 4 ohm impedance instead of 8 ohms. For an OEM automotive subwoofer, this would allow a ~80Watt peak subwoofer to provide big bass sound with a modest 6.5" to 8" driver size without an expensive DC-DC converter. For a higher performance aftermarket product, an 8" driver with 200 Watts of power would allow a competition quality subwoofer to be delivered in a small package.

For LCD and plasma TVs, the MiniWoofer can be easily redesigned to allow a thin profile subwoofer with the same volume to be wall mounted below a flat panel TV.

Since MaxxBass substantially reduces power consumption, the MiniWoofer could even be used in portable audio electronic products to dramatically enhance sound quality.

References

1. Colloms, Martin and Ben-Tzur, Daniel - "The Effect of MaxxBass Psychoacoustic Bass Enhancement System on Loudspeaker Design", Audio Engineering Society, 1998.
2. Turnmire, Patrick – "Wave Technology," *Car Audio and Electronics*, June 2002.
3. Ibid.
4. Beranek, Leo - "Acoustics", Acoustical Society of America, 1993.
5. Dickason, Vance - *VoiceCoil*, April 2002.
6. Colloms, Martin and Ben-Tzur, Daniel - "The Effect of MaxxBass Psychoacoustic Bass Enhancement System on Loudspeaker Design", Audio Engineering Society, 1998.

Photo of Home MiniWoofer

Home Theater Review of Home MiniWoofer

http://hometheater.about.com/cs/loudspeakers/fr/aaminiwooffull.htm

Product Description

Guide Rating - ★★★★☆

The Maxx home MiniWoofer is a very compact 7x7x7 inch cube, weighing less than 7 pounds, with a 57 watt (peak power) built-in amplfier. The MiniWoofer has two input options, a dedicated subwoofer line input and a set of stereo line inputs. Level controls for matching audio levels with main system speakers are provided. The MiniWoofer does not use traditional bass-boost techniques, instead a patented system based on psychoacoustics can deliver a perceived low frequency response below 40HZ.

Setup of the Maxx MiniWoofer

Setting up the Maxx MiniWoofer is very easy. If you have a television or compact audio system with a subwoofer pre-out, just hook it up directly to the MiniWoofer's subwoofer input. However, if you don't have a subwoofer output, you can use an RCA Y-adapter to split the audio from a L/R output of a CD, Cassette, or DVD player, with the one set of L/R connections going to the audio inputs of your stereo receiver or TV and the other set going to the MiniWoofer. Controls on the back of the MiniWoofer allow the volume and intensity of the bass output to be adjusted to one's taste.

Test Number One

First, I combined the MiniWoofer with a Sony CDP-261 CD player, TE-KC500S Audio Cassette Deck, and Yamaha CR-220 stereo receiver using Radio Shack Minimus-7's as main speakers. The Minimus 7's provide very good mid-range and high frequency response, but lack good bass response. The addition of the MiniWoofer provided the right touch of bass that the system previously lacked.

During a portion of the test, I shut off the Minimus-7's in order to hear just the MiniWoofer. I was pleased to find that only the bass portion of the music (bass guitar and bass drums), was present. There was no leakage of higher frequency material, such as vocals and other instruments, even though MiniWoofer was receiving the full bandwidth of the audio signal. This meant both the crossover and lowpass filter were working as they were supposed to. The CD tracks used in this portion of the test included "Sunrise" and "Those Sweet Words" by Norah Jones, and "Magic Man" by Heart.

The only tricky part was matching the level of the MiniWoofer to that the CR220/Minimus 7's, since the MiniWoofer were connected to the line outputs of the CD player and Audio Cassette Deck. Changing the volume of the CR220 meant recalibrating the output levels of the miniwoofer.

Test Number Two

I also connected the MiniWoofer to the dedicated subwoofer output of an Olevia LT30HV 30-inch LCD TV that also has a built-in amp with side mounted speakers. Although the speakers of the Olevia actually provide good response (for TV speaker systems), adding the MiniWoofer really enhanced the bass response from TV shows and analog DVD and VCR sources. In addition, since the MiniWoofer was connected via the Olevia's dedicated subwoofer output, it was easier to match the volume and intensity level of the MiniWoofer to that of the TV, since changing the sound level of the main speakers also changed the level of the subwoofer (once the initial TV/MiniWoofer levels were matched).

Positives / Negatives - And The Bottom Line

The Maxx home MiniWoofer is very compact, which is perfect for small rooms or use with compact audio setups. Initial setup and operation is easy. In addition, the MiniWoofer uses an auto-power system that operates only when low frequency input signals are detected. In addition, the sound quality is very good, especially when considering the light weight and small size of the miniWoofer.

However, because of its modest amplifier and driver size, the MiniWoofer would not be the best choice for large home theater system. Adjustment of volume and intensity can be tricky when used with stereo input option. Although the MiniWoofer provides good bass, the bass is not quite as tight as that on higher-end subs.
However, despite these modest negatives, the MAXX Home MiniWoofer is a great addition to a compact audio system or television (with audio outputs). With the MiniWoofer, you can experience a much fuller sound from your CDs, Cassettes, DVDs, and television programs. Although the MiniWoofer is not as powerful as those one might need for a large home theater system, for those seeking better bass with their built-in television audio systems or compact audio systems, this product is definitely worth the listen and consideration.