



# Thrax

Basus Motional Feedback Bass System The Basus subwoofer system consists of a bass driver with motional feedback in a sealed metal enclosure, a 1 kilowatt power amplifier, and an active crossover system with switch selectable preset frequencies. The active crossover system allows the Basus system to be used with any speaker/amplifier combination.

The Basus subwoofer project was started as a bass extension unit for the Lyra speaker that evolved in the ultimate universal woofer, for that we provide a matching stand to mount the Lyra on top of the Basus making it one system visually. The Lyra/Basus/Teres combination creates an active speaker system with unmatched synergy and visceral impact. Undistorted bass at high enough levels creates a different perception of the music. When the group delay is very low pulses and percussive instruments become solid and with well defined bodies cleaning up the murkiness in the soundstage creating a see through effect allowing one to hear the reverb and reflections in the back of the sound stage. You don't hear more bass but more music!



Basus and the need for better bass

In Music school you are taught music has three main elements; rhythm, harmony, and melody. The bass notes lay the foundation for two of these three elements; Rhythm and Harmony. Numerous studies confirm that people react to low frequency beats and can detect timing errors in a low frequency beat more accurately than in mid and high frequency ranges. Bass is not rumbling noise associated with a passing starship, but the foundation of a musical passage. It is the lowest note that defines the harmonic structure in frequencies above it. It can make music sound Sad or Bright, or Mellow. Music contains two very different types of bass; one that is continuous and sustained, and the other pulsed and very short (percussive). Proper phase alignment in sustained bass creates the right waveform allowing you to identify the instrument and to enjoy its sound texture. The pulsed bass gives you the beat and timing of the piece. Any delay there and the sound is ever so slightly off beat making the music less enjoyable. Small ported speakers and home cinema subwoofers exhibits very large group delay giving meaning to the term "murky bass". Large ported enclosures behave better having this problem only in the very low bass. The best overall performance is achievable with sealed enclosures and especially large sealed enclosures. In large sealed enclosures the group delay is the lowest and less obtrusive. Unfortunately, the efficiency of sealed box systems is very low. For any given cut-off frequency, the box size will have to double for each 3dB higher efficiency. Now you can understand which manufacturers "misinform" you. Below are the maximum theoretically possible efficiencies for sealed box speakers expressed as SPL per watt:

- 2 cu ft 30hz = 84dB
- 4 cu ft 30hz = 87dB
- 8 cu ft 30hz = 90dB
- 16 cu ft 30hz = 93dB
- 32 cu ft 30hz = 96dB

The conclusion is that to have deep bass at high levels you need large speakers and a lot of power

Cabinet's re-radiated energy- think of a drum, vibraphone or an organ pipe. The speaker enclosure is a resonator in its own right. If you create a pulse at its opening in a bit it will respond with its own voice - like an echo in the mountains. Containing this unwanted sonic signature of the box in the box and not letting it escape the enclosure is a difficult task. Heavy boxes with thick walls still leave just a thin diaphragm between you and the inner rumblings of the box. A heavier stiffer membrane and hard surround are used extensively in the more powerful subwoofers. The box resonances, inherently creates delays, and out of time tone bursts making the bass sound murky or boxy.

Harmonic distortion in the bass region seems to be so widely accepted that on the order of 5-10% that people complain about its absence, when it is not present. Putting this in the context of audibility thresholds means that in many systems you hear the "newly created" harmonic structure of a bass note without hearing the note itself. (bose acoustimass, laptops, tvsets).

Modulation effect of bass on rest of music. The human ear is known to produce a fair bit of harmonic distortion itself leading to the production of intermodulation products. What does it mean? Illustrated for a simple explanation if you listen to a clean tone - an opera singer and you add a low frequency signal with appropriate but still unobtrusive level, meaning you don't notice it, you will notice in fact a change in the tone of the voice. The voice will be modulated. A clean 3k signal will sound like a few 3k signals. This is some of the Basus of music creation. A bass tone modulates a higher pitch tone giving it its beat and coloring it, so in a solo an off beat note is accentuated by having a different character as not being modulated by the bass burst. Interesting.



### Noise and signal to noise

Up to now we discuss about how good it is to have bass modulating the upper tones and how it creates music, but when this is done ad hoc without being related to the music we could classify it as noise and distortion. the level of these artifacts relative to the level of the reproduced signal will define the speaker signal to noise ratio. It varies with amplitude and spectral content and this is one of the reasons for not being able to quantify, but once experienced everyone can distinguish between various speaker systems.

One means of reducing those artifacts is to make sure they are not created in the first place. The use of feedback has been widely discussed and is the principle behind 99% of the amplifiers in use today. Why is it not applied to speakers? Not as easy and well understood or maybe too complex and with limited commercial value to be worth the effort, we won't know for sure. Speaker drivers are linear electric motors, much like the one spinning a fan or lately the wheels of your Tesla. Those same motors are used in CNC machines and everywhere in our daily life. To make them do what we want we need to know what they do. The PC on which you are reading this has a fan mounted on the CPU that adjusts its speed according to the temperature of the CPU. This is just one example of a feedback system. You start playing a computer game and your CPU load increases dramatically, a bit later the fan starts spinning much faster trying to cool the CPU. The time it takes for the CPU to heat up so the fan speeds up and then restores the CPU temperature is called latency. Every feedback system has such a thing.



Now apply this to speakers. You have a bass driver and you apply a signal to it. The current running through the coil creates a driving force accelerating the speaker cone - (voltage is not present in formulas for force driving the cone - only current) the acceleration creates a sound wave, but when you stop the signal the cone is still moving. It does not accelerate anymore so it does not produce sound anymore right? Not quite, now you have the cone mass, surround and spider forming a resonant system that damps the excitation. This system has its own "deceleration force acting on the cone (producing sound not related to our signal) and last but not least the magnetic motor generates EMF that when run through a load (the crossover and amplifier output) again creates current accelerating the cone in some unpredictable direction. It is a bit like beating a drum and trying to control the sound with the sticks.

Introducing a system that measures the acceleration and velocity of the cone and comparing it to the input signal gives us the ability to create a control signal forcing the cone to start and stop as does the input signal and not as the resonant system it comprises.

As described earlier all feedback systems have latency and a number of other limitations allowing us to apply only a certain amount of correction in a limited frequency band. In other terms, the sound can never be made perfect but over a limited frequency range it can improve performance more than 10 times!!! With the implemented feedback system we are able to control (lower) the resonance of the mechanical system in the box and the total Q of the system. Taking advantage of the fact that speaker drivers operating above their resonant frequency have much lower phase shift.

To handle the 1kW of power and the high pressures and mechanical stress we built it in a all metal enclosure capable of withstanding the high sound pressures. 1kW? What for? At resonance the impedance of a bass driver can rise more than 10 times. to put this in perspective means that the power going to it is 10 times less. So your favorite 100W class A amp that can pump 30Amps in a speaker in reality can't deliver more than 10watts to the bass driver!! Yet once we go to a higher frequency with very reactive part of the impedance it can pump a few hundred watts in it for no reason what so ever charging and discharging some

Mass and its effect - a myth that large heavy cones make bass is just not true. The heavier the cone the more force and time is needed to accelerate it and to stop it. Heavier units are more robust and can take more power to compensate for the lower efficiency, so with a powerful amp you can make them sound just as loud as the lighter ones. It makes no sense but sells more speakers ;-). Anyone that studied acoustics will know that the formula for sealed speaker efficiency and extension there is a corresponding volume of the enclosure, but there is no mention about driver size, weight and shape. It is irrelevant. Only practical manufacturing reasons will define the size and weight of the driver.

Matching an active bass unit to an existing system requires removing the frequency band from the main speakers and level matching the two. We have built a crossover system in the Basus allowing for multiple interface types and level adjustments to suit every system. You always wanted that 20W SET amp to power the mid/highs and have thunderous bass at the same time, now is your chance. With its i/o flexibility Basus allows for balanced and unbalanced signals as well as 6 predefined crossover frequencies. amplifier damping illustrated - monkey phase shift around resonance (imaginary component illustrated).

Why no one else does and says this? Well not quite true. The principle we use where developed by Philips in the 60's and 70's and thousands of studio monitoring speakers have used it over the last 35 years. Unfortunately, most of the development effort was directed to making a small box sound like a large one and no one ever considered building commercially a big system. You can say that we have scaled, hot-rodged and turbocharged the concept, by developing a custom drive unit, drive electronics and bomb proof enclosure.. Is it that good? and then some!

TECHNICAL SPECIFICATION  
Built in Amplifier Power 1000W  
Dimensions 450W x 450D x 800H mm  
Frequency band 25~250Hz  
Weight 130Kg

