What´s Up With Those Animas?

By Joachim Gerhard

People ask me a lot of questions about the Anima.
Why does the bass go so deep and why is it so tight and clean?
Why does it produce such a big soundstage?
Why does it not sound “hard” even though it uses metal drivers?
Why does it sound so “fast” and clean without coloration?
Why can I “hear through the mix” even at low volumes?
And so it goes.

To answer these questions, we have two understand two things:

What makes a good loudspeaker?
How does the human ear work?

To answer the first question regarding a dynamic loudspeaker, we first need to establish a definition for the device. It was Chester Rice and Edward Kellogg who did the pioneering work on dynamic driver technology at General Electric in the early 1920s. A dynamic driver consists of a membrane (the cone in a dynamic driver), a voice coil, a suspension, a magnet (in those days often a field-coil magnet, but today it is a permanent magnet with ferrite and neodymium as common materials) and a basket (stamped or cast in better models).

The stiffness of the suspension and the moving elements (the membrane and the voice coil) act like a weight on a damped spring. A concept that many of us know from taking physics in school is that many objects resonate at a certain frequency. This inherent resonant frequency more or less defines the deepest frequency that a particular driver can reproduce. If you simply play the driver in open air without an enclosure, a lot of the lower-frequency energy produced by the driver would be “wasted” because without an enclosure, pressure cannot build up. The air around the driver is moved back and forth with, say a frequency of 50Hz, but we cannot hear that tone. Some containment is necessary, in the simplest case a flat baffle that the driver is mounted on that supports that pressure created by the driver until it ultimately bends around the edge. This was also the Rice and Kellogg solution. They used foamed bronze baffles of considerable dimensions. However, for a tone to be audible at 50Hz without much loss, the baffle has to be wider then two meters or about six and a half feet. (You can find a lot of good information on the Internet about the advantages and tradeoffs of using baffles, also called dipoles. I recommend looking at the Linkwitzlab website, www.linkwitzlab.com or Music and Design, www.musicanddesign.com which is John Kreskovsky's website.)

However, for almost every application, this type of design is ruled out because the speaker would be too big. For this reason, two types of enclosure designs have become popular for their ability to shrink the size of the speaker without much compromise on sound quality or quantity: the sealed enclosure and the reflex (or ported) enclosure.

Until the mid 1950s and the introduction of the first Acoustic Research (AR) loudspeaker, most speakers where based on the bass-reflex design. They were mostly designed and tuned by ear or the engineer's experience, because mathematical treatment of the various factors involved in enclosure design was not yet perfected. The result was usually loudspeakers with enclosures that were too big and not optimally matched with respect to the drivers, the size of the port and the size of the enclosure. Because bass sells, many manufacturers overdid it and boomy bass was the order of the day.

When the first Acoustic Research sealed-enclosure, or acoustic suspension loudspeaker, came along, it was quite a shock. The closed cabinet sounded tighter and was much smaller. However, the smaller size and acoustic suspension design came with a tradeoff: low sensitivity (meaning that they would not play as loud as a higher-sensitivity reflex-type speaker for a given amount of amplifier power).

AR's timing was good, however, because by the end of the 1960s, transistorized amplifiers with much more power output then the older tube units became available and the prices went down because the new transistor technology did not need the expensive "iron" – transformers – and components required by tube amplifiers. Historically, the mid-1950s through the 1960s, 1970s and 1980s could be seen as a Golden Age of high fidelity as it became a popular leisure time activity. (It took the Internet, portable music players, digital music streaming and certain other factors to change that. If casually listening to compressed audio on the go is a better way of life then listening carefully to music and making it a special occasion, that has to be questioned, but I will leave that for others as I am no philosopher and neither a politician nor a priest.)

What has this all to do with the Anima? A lot, I think. Our lifestyle has changed. We live faster and want our technology to be compact, pretty and convenient. I saw the need to design a speaker that was small but did not give up much in terms of objective sound quality and full enjoyment of the music. Because bass is the foundation of the music, I came back to the older reflex design, this time armed with a lot of modern tools that allow a much better understanding of what is going on physically in the design. I could talk about the proprietary computer programs that I designed and use, but that would be boring. I'll just say that my work is based on a mathematical model by Don Keele. His work is based on work done by Thiele and Small. Even those giants have forerunners like Ted Jordan and Dr. Harry Olsen – all this work did not come easy in one stroke of genius.

Whereas Thiele and Small "paint with a wider brush" in terms of their design parameters, Keele narrowed the choices considerably so that a pattern appeared with optimum parameters that could be readily determined and graphed. The alignment, or tuning, I use is called QB3. It is rather over-damped and comes closer to the way a closed box behaves but goes deeper and delivers less-distorted bass than other alignments. It is done by tuning the reflex port deeper than usual, which suppresses cone movement by the air load of the port. It also takes advantage of the fact that small rooms have gain in the bass – they tend to produce exaggerated bass response. A medium-sized room by European standards has around 700 cubic feet. A room like that has a gain of 9dB at 20Hz with rise of about 4 - 6dB per octave under 200Hz. If the speaker produces a tone of 20Hz that would read 80dB as measured at 2m in the free field (on a high stand, far away from any boundaries) and was then measured at 2m but in the above listening room at the listening seat, we would measure 89dB.

So, taking room response into account is one reason for the astounding bass the Anima is capable of from its modestly sized enclosure. It's the result of a particular, deliberately designed combination of driver parameters, enclosure volume and port design that leaves no room for guessing.

Another reason for the Anima's bass quality has to do with how we hear.

Did you know that an upright bass suppresses its deep E tone (41 Hz) by 30dB? Still you can clearly hear the 41Hz tone. This is because we hear the overtones and the brain adds the fundamental. It is a phenomenon called "residuum" in German, which does not translate well into English, but refers to "hidden" data retrieval the brain and ear can extract when overtones are precisely reproduced. If a speaker is able to reproduce the overtones correctly, then we hear the fundamental too, even if the speaker isn't actually producing a lot of it. This subject goes into the area of pattern recognition, a discipline that is drawing a lot of attention at the moment in artificial intelligence research.

However, it is important to mention that this is not just a phenomenon that occurs in the brain; there is a biomechanical aspect to this as well. The cochlea in the inner ear also reacts in such a way that it too is "responsible" for the way our brain is retrieving the "hidden" data found in the sound being produced by the speaker. We can make a model of the cochlea to demonstrate this effect. It would look like a long stretched ribbon that is wider at one end than the other, where the narrow end of the ribbon is attached to a very hard connection and the wide end is attached to a soft and "forgiving" connection. If this ribbon were excited at 82Hz, a wave would move through the ribbon at the fundamental 82Hz, but a lower amplitude wave, exactly double that length (41Hz) would also be present. The cochlea behaves the same way and is producing sub-harmonic information of fundamental tones for the brain to process, which further enhances the pattern recognition mechanism already at work. In short, our mind isn't just "making up" the sound, but is translating the data from the input of what we do hear into something meaningful that we perceive as being present in the sound from the loudspeaker.

The use of bamboo as a cabinet material in Canalis loudspeakers also plays a big role in the overall sound of the speakers. These bamboo cabinets have a much more natural tone than cabinets made from other materials like MDF (the glue used to bind the wood imparts a sonic signature), not to mention artificial materials like Corian, metal or phenolic. The construction of the bamboo ply makes for a very well damped and "quiet" cabinet.

Another important element is the very stiff driver cone material we use in the Anima. They are made from metal – deep-anodized aluminum for the woofers and midrange drivers and an aluminum-magnesium alloy for the tweeters. At first sight, this looks like it contradicts our choice of cabinet material – natural bamboo for the cabinets and artificially "hard" metal composites and alloys for the driver cones?

To clarify, we need to take a step back and talk about active vs. passive radiation in loudspeakers. Whereas the driver cones send out sound actively, the sound that comes from the cabinets comes to the ears dispersed and delayed much later than the sound from the drivers.

The use of metal driver membranes is not new. They where used by Western Electric in the 1930s, and later in the 1950s the General Electric Company of England made drivers that were quite good at the time. The first high fidelity metal-membrane drivers were made by Ted Jordan in England in the 1960s and were based on the positive sonic impression he got from the GEC drivers. His idea was to use a rather soft alloy and shape the cone in such a way that it would break up in a controlled manner, so that when reproducing high frequencies only the inner part of the membrane would move. Using this approach, he was able to make a rather wideband one-way speaker called the Jordan-Watts module, which attained quite a bit of fame for its superior performance.

I had these speakers when I was 15, as well as his later 50mm Module. What struck me at the time was the good detail resolution and the three-dimensional soundstage the drivers where capable of. On the other hand, there was still a small but ultimate frustrating metal “zing” imparted to all treble material, even when the musical instrument on the recording was not made from metal. I ended up with an active 3-way system that had KEF B139 bass drivers, a Jordan 50mm Module and a Technics T1000 ribbon tweeter. That sounded really nice because the Jordan could work in its optimum range where it did not break up into ringing.

For many years, I forgot about all of this and built more or less conventional speakers with the then (early 1980s) popular polypropylene cones and soft dome tweeters. These soft cones had the advantage of low coloration, but there was something sonically amiss: that sense of transparency, micro detailing and dynamics I knew from metal cone drivers. The reason is that soft membranes deform easy under stress, especially in the bass where is much acceleration. This gives rise to plastic deformation. This hysteresis effect swallows detail that is responsible for transferring important acoustic information. It also produces harmonic distortion that is somewhat benign but results in a loss of transparency because artificial overtones are mixed in.

When driver manufacturer SEAS introduced their magnesium cones in the 1990s, it was time to look again at the possibilities of metal-cone and metal-dome drivers. The Audio Physic Avanti 3 was the first speaker I designed that had a metal (magnesium) midrange cone, along with a metal-membrane tweeter and hard-paper woofers in a closed cabinet. To make that work I had to equalize the SEAS quite drastically because the first batch had a complex double resonance over 3kHz and above. I made it work satisfactorily and that speaker was a success despite a somewhat dry presentation. The detail was back and so were the dynamics, at least from 50Hz up, provided you had a powerful transistor amp that did not sound too sharp. The heavy cast-magnesium cones had low sensitivity, maybe around 86dB. Also the closed cabinet had somewhat restricted low-frequency extension and in the desire to erase the least bit of boom I may have over-damped the box a bit. (I designed a subwoofer that came to the rescue here and many listeners still treasure their old Avantis today.)

When I founded Sonics by Joachim Gerhard in 2004, I had a new opportunity to try metal as a membrane material again. SEAS makes woofers and midranges from much thinner and lighter aluminum and the cones were shaped in such a way that stiffness was at its maximum without causing the drivers to break up horribly.

I used a conical profile at the time, as geometrically a cone has the best stiffness of all shapes. The angle of the cone is designed in such a way that the sound that emerges around the voice coil reaches the front baffle at the exactly the same time that it takes the sound to travel through the cone so that theoretically we have a flat wave that is in-phase over the designed frequency spectrum. This is possible because the speed of sound in solid material is faster then it is traveling in air, and by the time the sound from the inner part of the cone near the voice coil and the sound from the outer part of the cone travel through the cone, they get to your ears at the same time. We only have to know the Young's Modulus (a measure of the stiffness of a material) of the membrane material and off we go…theoretically!

For even greater stiffness, these aluminum membranes are deep anodized on both sides. Aluminum oxide is the same material from which gemstones like sapphire and ruby are made. It is the second-hardest material on earth after diamond. With this anodizing technique, a very stiff and light membrane is produced (even better then carbon fiber in woven or nanotube form).

The trick (or call it engineering) is now to use the driver only in the range where it does not break up. The loudspeaker crossover now comes into play. I use what I call a transitional filter that is able to suppress the output at the cone resonance (the 5-inch driver in the Anima has a resonant frequency at over 5kHz) completely, without having too many components in the crossover (which could degrade sonic purity and have other sonically unwanted effects).

This is only one job the crossover has to accomplish. The crossover also has to establish the transition from the woofer to the tweeter and compensate for the so-called "baffle step." The baffle step phenomenon is related to the effect a baffle has on the driver's output, alluding to what I was discussing at the beginning of this article. Under 1kHz the sound that emerges from the cone is affected less and less by the baffle because the length of the wave gets longer as its frequency gets lower. One 360° revolution of a 100Hz tone has a wavelength of approximately 3.3m (about 6-1/2 feet) for example, and 1kHz is approximately 33cm (a little over a foot). Ultimately, the sound wave bends around the edges of the cabinet, which would leave us having a very lightsounding bass-shy speaker if the crossover did not compensate for this phenomenon.

The good news is that I have come up with solutions for these considerations with only three very-high-quality crossover components, which are made for Canalis in the United States. Thank you to Allen and others at Canalis for your choices in picking the best of the best for these parts.

I was further aided in my ability to solve all the potential sonic problems because SEAS designs the drivers exactly the way I need them.

I know because I helped to develop them. I have worked together with SEAS since 1981, so you could say that in a sense I am their oldest employee! I spend countless hours in their lab and have excellent communication with their young and eager team. We use a Klippel analyzer extensively and this gives us the same consistency of meter readings whether taking driver measurements at the SEAS facilities or in my own lab in Brilon, Germany.

The crossover frequency in the Anima is unusually low, under 2kHz. Here, I go my own way, very different of what English loudspeaker engineers usually do for example. They prefer a crossover frequency of 5kHz and up, and the argument is that they stay out of the 4kHz range where the ear is most sensitive (referencing the Fletcher-Munson loudness curves). I go under that range because the metal cones used in the Anima mid-woofer will not work there very well. Another advantage of my decision is that I stay out of the frequency range where the woofer cone gets directional, and the range where the ear is most sensitive is reproduced better by the much faster and lighter tweeter. The three-dimensional radiation pattern is greatly improved and sitting off-axis is much less critical because the tonal balance in the midrange stays the same over a very wide horizontal angle.

For the tweeter, I use a 3/4-inch dome with a wide cloth surround. The tweeter dome is made from a very light and stiff magnesium-aluminum alloy. For this driver we do not have to worry about audible breakup – the driver's breakup mode is at 39kHz, totally inaudible, on a par with the best beryllium or diamond-diaphragm 1-inch drivers. The wide surround damps that resonance optimally to ensure minimal ringing, and extends the tweeter's frequency response in the lower range so that the lower than usual crossover frequency of the Anima is possible without causing dynamic constraint. Quite a miracle of engineering, I must say.

In the high frequencies the cabinet has another negative effect. When the sound of the tweeter reaches the front edges of the cabinet, another wave is launched, (as per Huygens' principle), which is unfortunately out of phase with the driver. As an example, if you look carefully at the on-axis frequency response measurements of various loudspeakers taken by *Stereophile* (done very consistently for many years by the indisputable John Atkinson) you often see a "hole" at around 5 to 7kHz. Unfortunately, that frequency, especially at 7kHz, is where a lot of "height" information is decoded by the listener (Blauert et al).

I thought long and hard how to solve that problem without resorting to the usual solutions of rounding the baffle edges or even building the speakers into an egg- or ball-shaped cabinet that would bring the cost of manufacturing the speaker up tremendously and which do not look appealing to my eyes. My solution is the use of the Anima's DC Module in the crossover. For any minimum-phase (causal) interference, such as what is created because of the cabinet edges, an opposite filter can be employed that cancels the effect to 100 percent. The DC Module has that filter on board, which I call the Omni-shape filter, and it allows me to use hard cabinet edges in the design of the Anima and other Canalis loudspeakers, without their adverse sonic effects.

I trust this explanation will help you better understand why the Anima sounds the way it does. I hope that you enjoy it. I do.