My Life's Journey through "Audioland"

A call for an open source loudspeaker project

Early Childhood

In the fall of 1945 my mother moved from Ostrava to Vienna with four little children. I was the oldest one, and my father had become a prisoner of war in Russia.

Even though it was a difficult time, as far as music was concerned, it was a most wonderful time for me. We did not have enough money to even have a radio. But I was fortunate enough to receive free concert and opera tickets from our school. So my first exposure to classical music was in the form of live music, from some of the best orchestras in the world. My first opera was Beethoven's Fidelio, performed in the "Theater an der Wien", where it also had its premiere on November 20th, 1805. The main opera house at that time was still not rebuilt. I also remember several concerts in the "Musikverein", the house where the Vienna Philharmonic plays.

During this time, the sister of my grandfather, Paula, gave me a very old crystal detector radio, which triggered my interest in electrical engineering.

I wanted to learn to play an instrument. An aunt gave me a violin, but we did not have enough money for me to have lessons.

Electrical Engineering in Germany

In 1952 we moved to Germany near Darmstadt, after my father had come back from Russia.
Later I studied Electrical Engineering at the Technical University in Darmstadt. In 1961, just before graduation, I became interested to spend some time in the United States for further education in my field. I was able to get a job with Hewlett Packard in Palo Alto, California.

The years at Hewlett Packard

I knew, that Siegfried Linkwitz also got a job at HP, he joined in August 1961 and I joined in February 1962.

Both Siegfried and I ended up in the Microwave Division, in the same lab.

Finally making some money, my interest in music could be realized. Initially I built some Heathkits.

The work at HP at that time was extremely exciting. I worked with some very talented engineers. Since we worked i.e. on frequency synthesizers, we learned about phase-lock loops, root locus, the s-plane. Several us were interested in what we called Hi-Fi and wanted to design our own equipment, from

the FM tuner to the amplifier, and even the loudspeaker. One of the very gifted engineers, Russ Riley, designed the FM tuner, I believe John Paige designed a transistor power amplifier. We also needed a stereo decoder. The first ones used tuned circuits with coils. Since I had learned about phase-lock loops, I tried a design using these. I was successful in building the first prototype. I showed the design to Russ, and some time later he came back to me with a superb finished design.
We had a printed circuit board done, and it performed beautifully.

During this time Signetics came out with some linear ICs, and also with a phase-lock loop chip. I contacted Hans Camenzind at Signetics, we arranged for a meeting and I showed him the stereo decoder. He asked me, if he could borrow it for a while. Some time later I noticed, that Signetics had come out with a stereo decoder chip. Since I did not have patent protection, nor did I publish the design, only very few people know, that the initial prototype was my idea. This is the ignorance of a young engineer in a foreign country.

At HP I ended up working on several system designs, so my focus was more on systems, rather than individual units.

Intel had come out with the first microprocessor, the 4004. I became very much interested in it, designed a unit at HP labs using this chip. During this time I also heard about the homebrew computer club. We

would meet at regular intervals. It was a very exciting time for the birth of the personal computer. I met the two Steve's, I was in the Byte computer store in Mountain View, when Steve Jobs came in and presented the Apple 1 to the storeowner. The rest is history, the beginning of Apple.

We had a very open environment of free sharing of ideas. I had designed my own little computer using the Intel 8080 chip. Li-Chen Wang had written a basic interpreter, and adopted it for my computer. I changed the source code to Intel mnemonics, and it was published.

The interesting thing about it was, that at first Li-Chen and later I introduced the term: copy left. In todays terms it would be the equivalent to an open source project.

While I was working in the Frequency and Time Division of HP, I was project leader of a test system for the telephone industry (5453A/5468A), using the FFT analyzer and the 2115 HP computer. It was way ahead of its time, because later, with the use of microprocessors, the cost had come done tremendously; it was a pioneering effort. During this time one of the engineers, Ron Potter, had used the 5450A FFT analyzer for his own design of a loudspeaker. Then I heard that the R&D manager from KEF in England was interested in the HP FFT analyzer and came to visit. I informed Lyman Miller and Siegfried Linkwitz about this, they came to us and were introduced to Laurie Fincham.

During one of my business trips to England, I visited KEF in Kent, and also spent a night at Laurie's home.

Siegfried became exclusively interested in loudspeakers, while I, since due to an injury on my head, while living in Vienna, my hearing, especially my left ear is severely handicapped, I became interested in developing test equipment for audio testing. I had developed a tuning 1/3 octave analyzer.

Leaving Hewlett Packard

I became somewhat frustrated at HP, and knew about Sound Technology, which had been formed by two former HP engineers, who I had known, when they were still at HP. They had come out with the best distortion analyzer in the world at that time. I showed them my prototype, and they responded that they were not interested in my design, but wanted to hire me. Therefore I decided to leave HP and started to work on a project utilizing FFT technology.

After one year the President decided to cancel the project, while I was on vacation in Germany, and informed me on my return. I immediately resigned on the spot.

This was the end of any active pursuit in the field of audio. Privately off course, I ended up purchasing different commercial products, i.e. KLH 6 loudspeakers, etc.

I knew of Siegfried's efforts in the field of loudspeakers, the design of the Beethoven at Audio Artistry, and so on.

Occasionally I would come and visit him, and he would always have me listen to his latest version of a loudspeaker design.

Building Orions

In 2000 my wife died, I ended up selling my house in Palo Alto, and had some extra money, so I decided to build the Orion. In 2003 I moved to Italy and took the Orion's with me, a second pair in components. I had both ATI6012 amplifiers modified at the factory for 230 volts.

I ended up buying a fairly big house in Italy, did some remodeling and ended up with a huge living room of 1000 square feet under the roof.

In 2007 I decided to leave Italy, wanted to move to the Black Forest in Germany, took the two pairs of Orion's with me, now in a much smaller living room. After two months I found out that I could not stay in Germany as a permanent resident, and decided to move back to California. Since the Orion's were adapted for Europe, I ended up selling one pair, and had to dismantle the second pair.

Building Plutos

In California, I moved close to Aptos, and had a very small living room. By this time Siegfried had come out with the Pluto, and I ended up building one at first, later trying out several versions, sometimes with my own design modifications.

My children had all moved to the East coast, so after a year, I decided to move closer to my family, first moving to Virginia. I rented a house with a medium size living room with an octagon shape. The Pluto's, which I had brought with me, sounded so terrible in this room that I ended up not listening to loudspeakers anymore, since I had no other room suitable for listening.

After 15 months, I moved closer to my oldest daughter in New Jersey close to Princeton. There I had another shape of living room, and had to do some more engineering work to find a satisfactory solution to my speaker problems. I actually ended up buying the KEF Q100 speakers, removing the Uni-Q© drivers and crossovers and mounting them in a 4" plastic tube. I built two woofers using the 5inch drivers from Pluto. I also found the KRK Ergo for room correction, and this system gave me at least some satisfaction.

Moving to Spain, first speaker comparison

In April 2012 I obtained a residency visa for Spain and moved to San Lorenzo de El Escorial.

I now live in a very beautiful apartment with a good size listening room (3.42 m high, 3.83 m wide, 10.72 m deep).

In the beginning of 2013, I decided that I really wanted to find out, what kind of loudspeaker gives the best listening results, not being satisfied with the opinions of others, but wanting to find out for myself. I did quite a bit of research on the Internet. Siegfried in the meantime had come out with the LX521, so I also wanted to build that one. In addition I purchased an omnidirectional speaker, the Venus from Duevel. The others of interest were the NaO Note II RS from John Kreskovsky and the Nathan from Gedlee. I spent quite a bit of time, effort and resources, but really wanted to find out for myself.

My conclusion at that time was the following:

The omnidirectional speaker did not live up to its claim. Even though it created a very uniform 360 degree sound field, it encounters more reflections in the room. The argument, that sound is traveling in a 360 degree mode, when an instrument plays, or somebody sings, is only true for an infinitely large environment. It does not hold true in a smaller room, even in concert halls, acoustic treatment is many times necessary.

So the main comparison ended up between the LX521 and the NaO. Both loudspeakers were very close, I preferred the NaO a bit for its musicality, and the LX521 was superior in the bass and at higher volume levels, even too high for my ears.

I am lucky to have a local woodworking shop with an NC machine and very precise cutting machine.
After this first experiment, I shifted my focus to more important things. I met a young musician and sound engineer, and ended up giving him the NaO speakers. I also gave him a lot of my surplus drivers, electronics, parts of Nathan, etc.

Additional Experiments

About two months ago, I had more extra time, so I wanted to go back and investigate speakers again.

I pretty much built another NaO Note II RS speaker pair.

One time, when I listened to the LX521, I noticed that the bass was not as strong as the size of the woofers and all the amplifiers would suggest.

Since I had used the KRK Ergo for room correction before, and had also acquired the RP1 from Lyngdorf, I calibrated the room, and sure enough, it was a tremendous improvement. Since the top is easy to separate from the woofer section, I built two stands, put the LX521 tops on top of them and used subwoofers in the front corners, a la Lyngdorf. This also gave me very good results.

Here are my present conclusions and assessments:

Let me first quote from Dirac Research:

What is Dirac Live? Loudspeakers and rooms in which they are placed inevitably introduce coloration on the reproduced sound. These colorations are sometimes very difficult or impossible to remove with traditional hardware design and room treatments.

Dirac Live® is advanced patented software technology that analyzes the speakers as well as the room and corrects these colorations with the purpose of achieving a better sound. We call this "room correction."

How does Dirac Live work? The audio system and room are analyzed with a microphone connected to Dirac's computer software. The software then builds an acoustical model of the room and detects the deficiencies. After careful analysis the Dirac Live technology makes a correction of the colorations in the sound. The technology handles both the timing and amplitude aspects of the coloration, or on a more technical level, the impulse response and the frequency response.

What are the benefits of Dirac Live? In short, the speakers become better and negative room effects are reduced. However these are some of the more specific benefits that can be experienced: - Improved staging (localization of sound events) - Better clarity and intelligibility in music and vocals - A deeper and tighter bass without resonances.

Most rooms are different from any other room. My own experience, of having lived in eight different living rooms in the last 14 years is a testimony to it.

Also the argument that a woofer in the corners will excite all room modes, can also be turned around, because it is the place where one has the greatest control. Plus it enhances the output of a sub, requiring smaller subs.

So in my mind, room correction and calibration is a must. Rather than first designing a speaker for flat frequency response in free air, and then having the dilemma where to put the speakers in the room, fitting with the rest of the furniture, etc., it is better to calibrate each room, because each one is different.

It is important to have the speakers in a room both frequency and time aligned. Using many different kinds of compensation, like shelving and several notch filters and crossovers, may actually do more harm to the impulse response. Music is not a series of sine waves, but rather a series of impulses, and proper time alignment is important, besides constant directivity in order to avoid coloration from reflections.

A new paradigm in speaker design could be as follows:

1.) pay attention to linear phase (time alignment) of the drivers.
2.) find an optimum shape of the open baffle.
3.) Use modern dsp technology and software for time and frequency alignment in a room under calibration.

This actually simplifies the design process, except possibly for number 2. But the dsp processor just in front of the amplifiers only needs to do correction for the baffle and crossovers. The processor in front of this in the signal chain will do the time and frequency alignment (i.e. the Dirac miniDSP DDRC-22D unit).

I wanted to take a modular design approach, and initially focused on the least expensive, but still full frequency spectrum solution. The baffle shape of the LX521 is the one I used initially. This is probably the greatest contribution in the design of the LX521 by Siegfried Linkwitz. It works quite well. If there is a better shape than this one, I do not know, may well be, but I do not have the equipment nor the time to do this myself. You also need to realize, that SL spent quite a bit of effort in the design of this baffle, considers it to be proprietary, so if you want to use this shape for your design, you have to purchase the construction plans from Linkwitz Labs, as I have done.

Open Source Project

So finally, after such a long history, I come to the main point:

Siegfried Linkwitz put out a design challenge to the DIY community and to the general loudspeaker community: Design the right speaker!
In the process he is proposing the LXmini as a starting point and comparison.

I personally used the building and comparisons of different designs as a starting point. So far I implemented the least expensive version of the modular design approach, based on the LX521 baffle shape.

True to the spirit of "copy left" I would like to propose the opening of an open source project. The outcome would be a design that is available to anyone free of charge, or based on donations. There would be no proprietary component in this. Rather than competing with each other, in order to get the ego satisfaction of coming up with the worlds best design, I would like to work as a group working together for a common goal, deriving not ego satisfaction, but something possibly much more satisfying in the end, the knowledge of having contributed to the common good. This may enable a broader section of society being able to enjoy listening to pure music for their own healing and benefit, rather than satisfying the upper 1% of society, being able to afford ever-increasing prices for audio equipment.

Modular Design Approach

Based on an optimum baffle shape (not the proprietary LX521 shape), one can have the following combinations:

1.) 3-way with dipole woofer as a unit
2.) 3-way hybrid with dipole woofer as a unit
3.) 3-way with subwoofers in front corners
4.) 3-way hybrid with subwoofers in front corners
5.) 2-way with subwoofers in front corners
6.) 2-way hybrid with subwoofers in front corners
7.) 2-way hybrid with absorber panels behind baffle for mounting against the wall and subwoofers against the wall, possibly to be used with a television flat screen.

The complete system electronics would consist of:

PC or Apple computer with music server software

USB streamer for optical output

DDRC-22D for room correction (volume control)

DSP unit for crossovers and basic shelving (optical in, analog out)

Power amplifiers with fixed gain:
From two for the 2-way hybrid (6&7)
Up to 5 for the full 3-way with dipole woofer, requiring two amps for the woofers.

Project Goals

1. Design and testing of an optimum baffle for both 2-way and 3-way
2. Selection of driver units
3. DSP programming
4. Esthetic design for WAF
5. Write-up of construction plans
6. Demo units
7. Publication

The project participants would donate their time for free. The communication between selected team members would be private exchange of emails. No communication in forums (too much energy would be wasted in arguing about specific points).

Team members must be convinced that the proposed approach has merit and also has a chance to give very good results at moderate cost, suited for all kinds of living environments and room sizes.

The project should be geared toward a DIY approach. Any commercialization later on would need the approval of the team. Any selected products must be of reasonable cost and high quality at the same time.

My personal favorite so far:

The pictured 2-way hybrid below.

It only requires two amplifiers and still gives a very good full frequency spectrum sound.

Other observation:

Even though, like I mentioned before, my hearing is not very good, especially in the left ear, and as I get older, when testing with sine waves, more and more higher frequencies are lost. But I believe, since we listen mostly to impulses, I can still notice a loss in "sharpness", if the high frequencies from the loudspeaker are missing.

My own Test System

I personally prefer the ARTA test software, even though you have to pay a small amount for it.

I use an HP Pavilion computer, with a Steinberg UR22 USB Audio Interface. I also built the ARTA loudspeaker test box for impedance measurements.

I use the test microphone from the Lyngdorf RP1.

Picture Gallery:

Setup in New Jersey: KEF Uni-Q© on 4” tubes with two dual 5” subwoofers underneath against the wall.

I could never really explain, why this gave me such good sound, even though I did not use a reflector on top. I discussed this with the engineering department at KEF. I would not propose this as a solution, because it does not make long-range sense, having to purchase and dismantle KEF Q100’s, even though this is what I ended up doing.

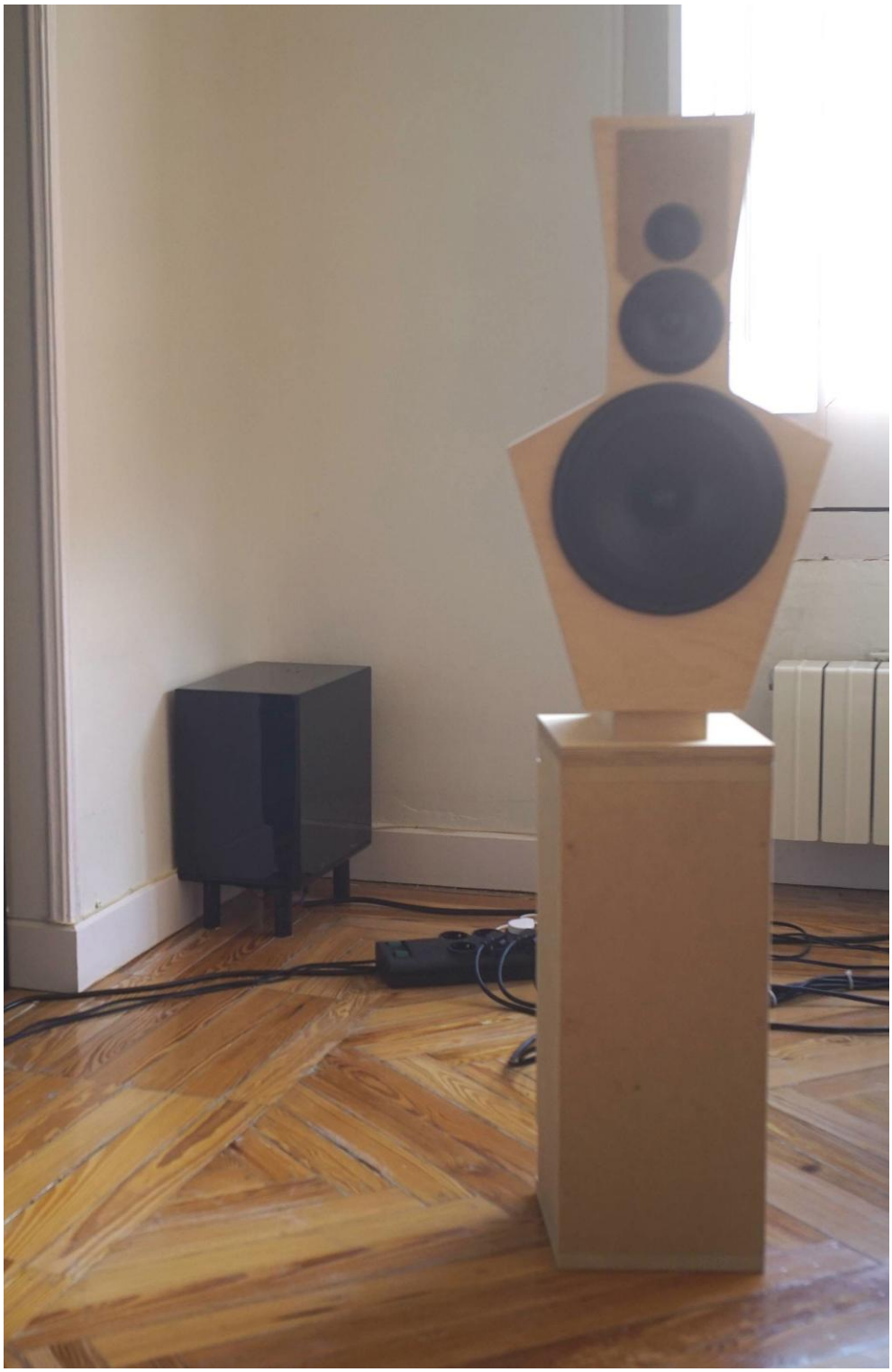
All three test subjects of the first experiment (Venus, NaO Note II RS, LX521)

Plus my own version of a full range mini (octagon), Preceding SL’s design of the LXmini.

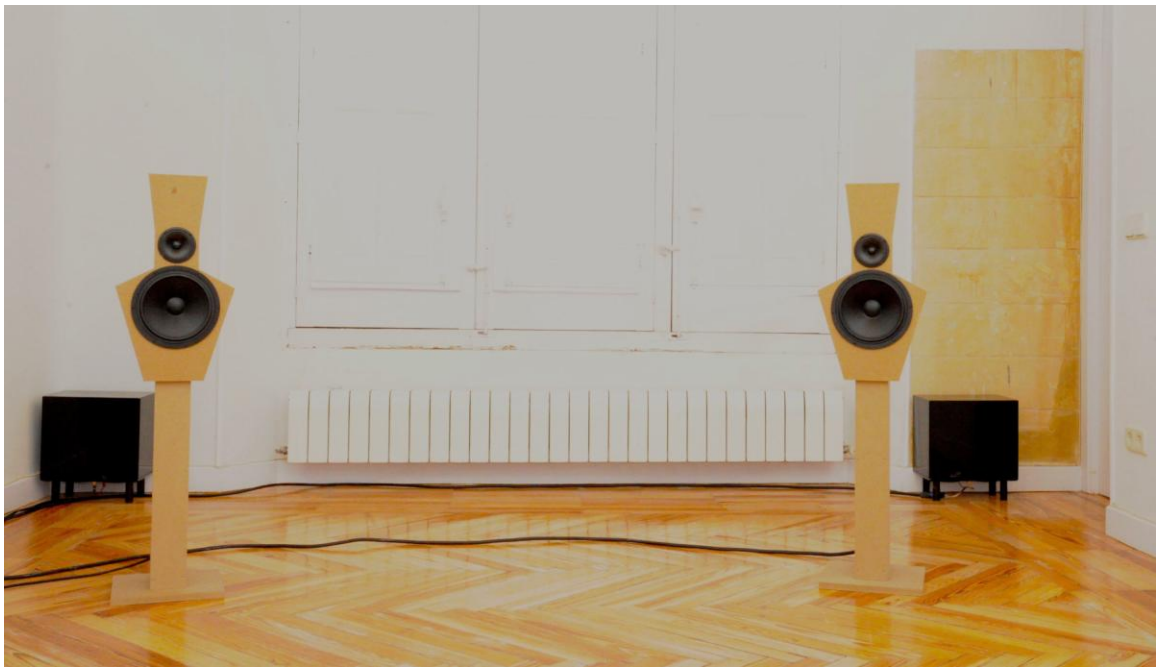
NaO Note II RS at the young musician’s home

Dual 5” subwoofer, viewed from below.

My original test units, slightly modified, at present time (plus a very old phonograph)



LX521 top on stand with dual 5” subwoofers in front corners



LX shaped 2-way hybrid with dual 5” subwoofers in front corners

This is my favorite so far.