AINO GRADIENT

Neo83

by Juhazi

Painting by Martti Innanen

19.12.2015

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- **Active 4-way dipole loudspeaker**
- DSP controlled – MiniDSP 4x10HD
- B&O ICEPower 125+50 amplifiers (D-class)

- **DIY audio project** by Juha Sirkka aka ”Juhazi”
  - *www.diyaudio.com/forums/multi-way/231353-aino-gradient-collaborative-speaker-project.html#post3395680*

- Woodwork by Puusepäliike Tommi Koivisto
- Inspiration from Gradient 1.3 designed by Jorma Salmi of Gradient OY
- Measurements with MiniDSP UMIK-1 and RoomEQWizard analyzing software
- *Notice! Measurements are from various versions, indoor with some room reflections!*

Version history:
Prototype, May 2013
AINOgradient, Aug.2013
AINOgradient Neo, Dec. 2013
AINOgradient NeoB, Jan. 2014
AINOgradient Neo83, Jan. 2015

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Project foundation

- I have been interested in audio all my life, inspired by my uncles. I built my first kit speakers at age of 13 (1973), second pair at 22. The diy aspect was revitalized in 2007 when kids were older and I started reading web pages and forums about diy audio. I don't have any school education in electronics, audio or music - this is just one of my hobbies.
- I have always admired the famous and unique Gradient 1. series loudspeakers by Jorma Salmi, but have never owned a pair. All my previous diy-speakers are kits or projects designed by someone else and are monopoles. I started studying dipole speaker related topics at web forums and the very informative web pages of Siegfried Linkwitz and John Kreskowsky, whose latest speakers are active 4-way dipoles. Rudolf Finke gave me valuable guidance himself.
- Dipole function requires heavy equalizing and limited passbands leading to a 4-way design to get **controlled and high horizontal and vertical directivity at wide range**, which was my main goal. DSP-technology of miniDSP gives easy software-based way to do equalizing and crossovers. The new speakers will be part of a 5.1 AV-system in the living room, but most of music is listened in 2.0 stereo.
- I started a thread at www.diyaudio.com Multi-way forum in March 2013. I got help from many forum members. I determined the design to have a monopole/omnipole woofer (like Gradient 1.n), dipole midrange and a ribbon-tweeter. Directivity and power handling issues lead me to choose a PA 12" for lower mid and a 4" mtm upper mid-tweeter with a waveguide/horn. Lots of choices and compromises were suggested and considered, including planars. I also decided not to use extra rear projection tweeters, unlike SL and JK do in many of their designs.
- The woofer box got it's shape from a drinking glass designed by Ms Aino Aalto, the Aino-glass. She and husband Alvar Aalto were architects and designers who had their first office in my home town Jyväskylä, Finland. Now we have their museum here. Also the wife of composer Jean Sibelius was Aino! My grandmother and my youngest daughter are named Aino.

My daughter, 6y

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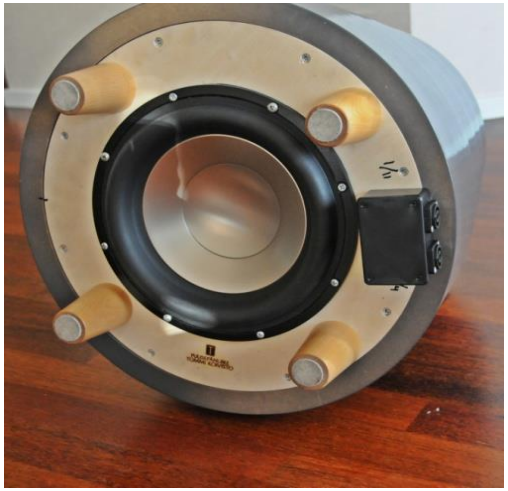

- **Transducers:**

- W Seas L26ROY (25L sealed)
- LM Beyma 12MWNd (tilted dipole)
- ~~HM Peerless NE95W-04 (2 series, dipole)~~
- ~~T Fountek NeoCD3.5H, (serial capasitor)~~
- HM B&G Neo8-PDR (dipole, production ceased)
- T B&G Neo3-PDR (dipole, production ceased)

•Enclosure/body made by Tommi Koivisto:

- woofer box - mdf slices glued to stacks, pentagonic hole, automotive paint
- pole - solid birch, Tung oil coating
- MT frame - Finnish birch plywood, OSMOwax coating
- two 2-ch Speakon connectors to amplifier
- amplifiers and dsp are external
- weight of a speaker is 42kg, height 120cm

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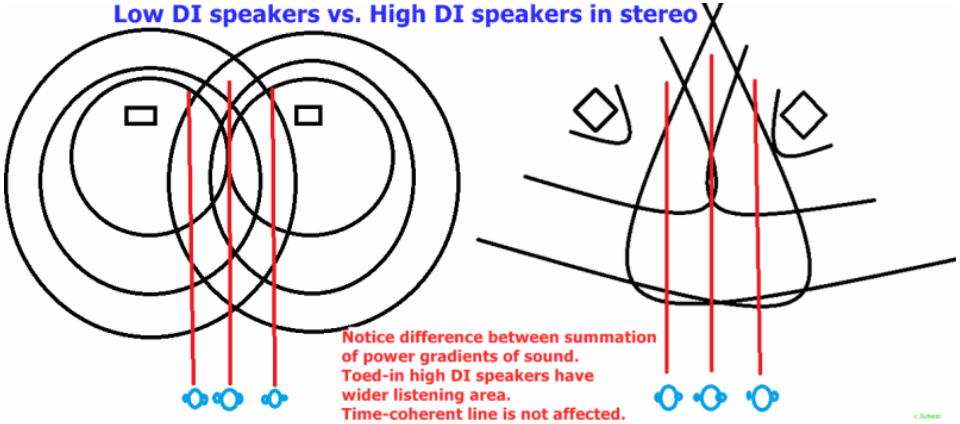
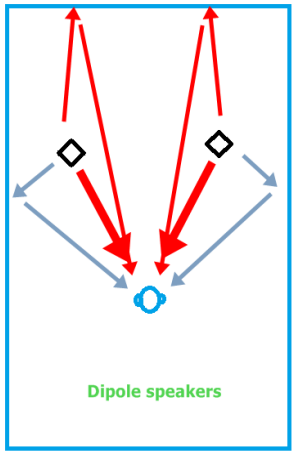
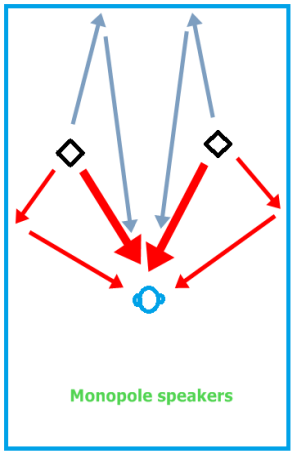
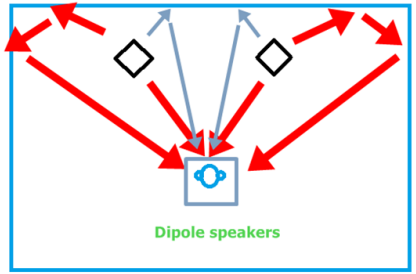
Why dipole?

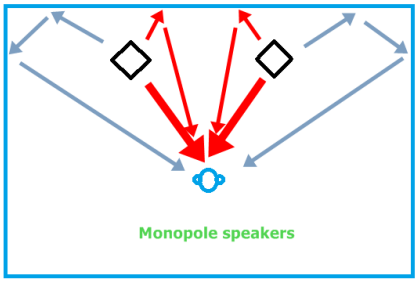
- A dipole transducer has the radiation pattern of second order gradient (~parabolic)
- Setting a pair of dipole **speakers toed-in** in a room creates wide listening area and minimizes early sidewall reflections











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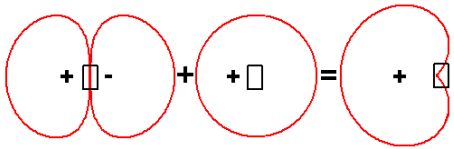
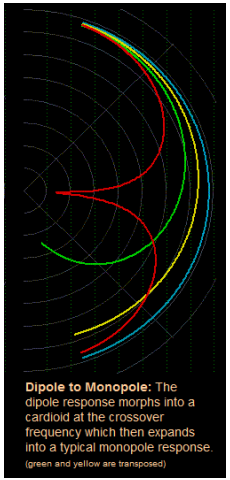
Dipole+monopole=cardioid

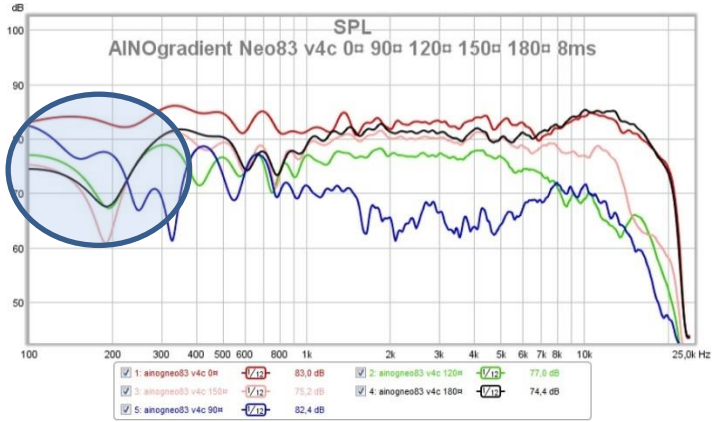
- The bass/woofer of AINOgradient is a downfiring sealed speaker and it radiates evenly to all directions
- When we cross a dipole with a monopole, the result is cardioid radiation pattern at crossover area
- By changing the crossover frequency of W/LM crossover and it's steepness (LR2 or LR4), we can manage the amount of frontwall reflections and room mode excitations in the range of 50Hz to 300Hz. This has a very much different effect to the perceived sound than doing just equalization of room response!
- Graphics from [Rudolf Finke]



- [John Kreskowsky]



v4c - W to LM xo 150Hz LR2, cardioid area pale blue:



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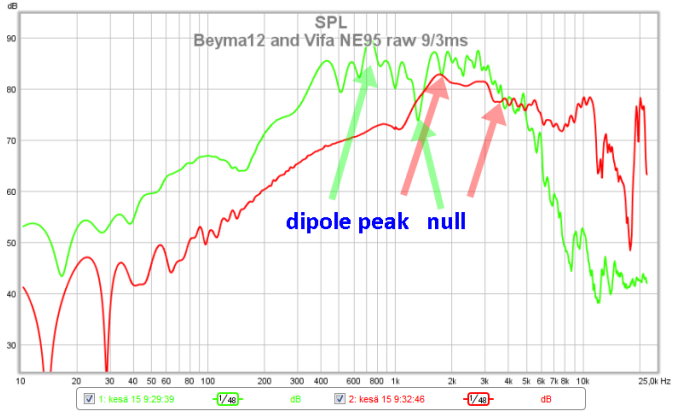
About dipole equalization

- A nude, circular dipole trandsducer has characteristical response curve with dipole rolloff 6dB/oct, dipole peak and null. Above the null there is lots of lobing and directivity is lost. Peak is determined by the diameter of the transducer or baffle. Mellow and Kärkkäinen paper
- Measured raw responses of the dipole midranges of AINOgradient (HM as a pair CtC 190mm) *(upper picture)*
- Usable range of a nude dipole is very limited because roll-off can be equalized only for max. 3 oct and range above the peak should be lowpassed /crossed
- Rudolf Finke has a suggestion for a smart 3-way dipole *(lower picture)*. A common problem with existing 3-way dipoles is loss of directivity above 1kHz, because of a single mid driver in a too wide baffle.
- Lately many 4-way (partly) dipole speakers have been introduced, eg. Linkwitz's LX521, Kreskowsky's NaO Note and Gainphile's S19. All these have active/dsp crossovers
- With digital equalizing we must be careful not to generate digital clipping!



Passive crossovers don't allow any boost of frequency ranges - only attenuation. In this case a combination of three first dipole peaks, together covering a large part of the hearing range, lends itself to a smart 3-way dipole system:

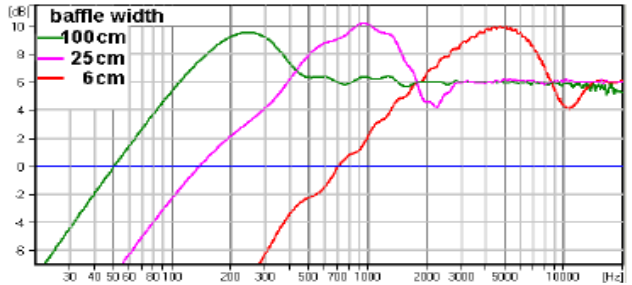


Fig. 3.14

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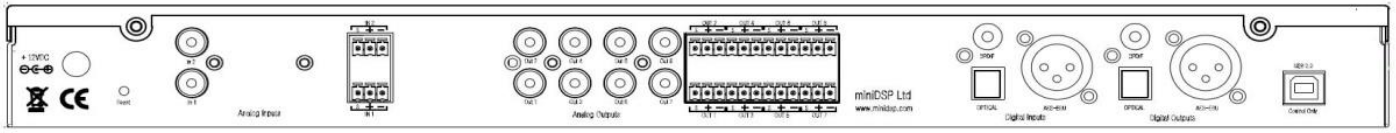
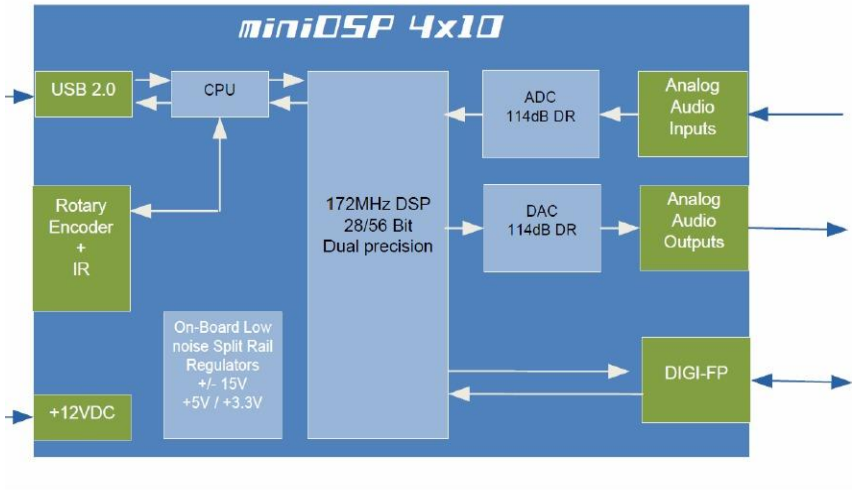
DSP



miniDSP 4x10 System Diagram

- **MiniDSP 4x10Hd technical specifications**

- 28/56bit DSP Engine, 24 bit ADC/DAC IC with 114dB SNR, 48/96kHz sampling rate depending on plug-in
- Digital (2 x IN, 2 x OUT over SPDIF/Toslink/AES-EBU) and Analog (2 x IN, 8xOUT balanced and unbalanced) connectivity
- Front panel rotary encoder and learning IR control, memory slots for 4 configurations, Plug&Play USB driver and Software configurable for real time configuration by miniDSP plug-ins from Mac/Windows
- L andR channel inputs – level and 5 eq setting each (Fq, Gain, Q)
- 8 output channels – 5 eq settings, HP&LP, level, delay, polarity. It is possible to use biquad programming.



miniDSP Ltd - www.minidsp.com
Features and Specifications are subject to change without prior notice

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MiniDSP settings

a glimpse at xo and PEQ, not final versions

Notice! Minidsp settings and acoustic response are not equal!

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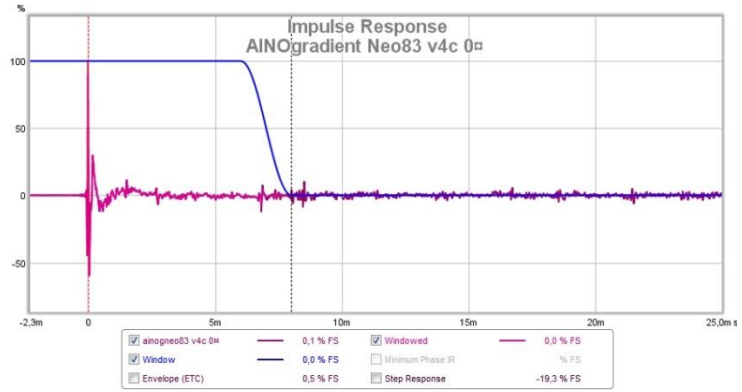
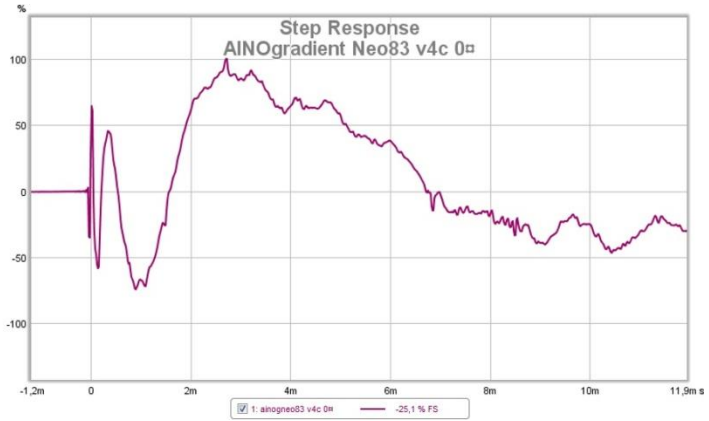
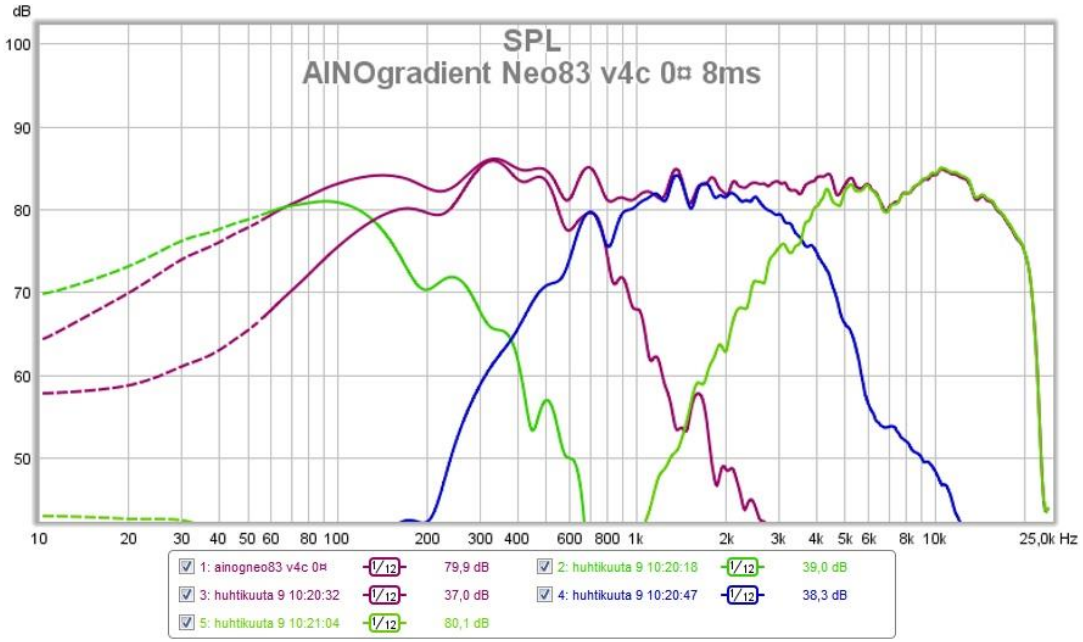
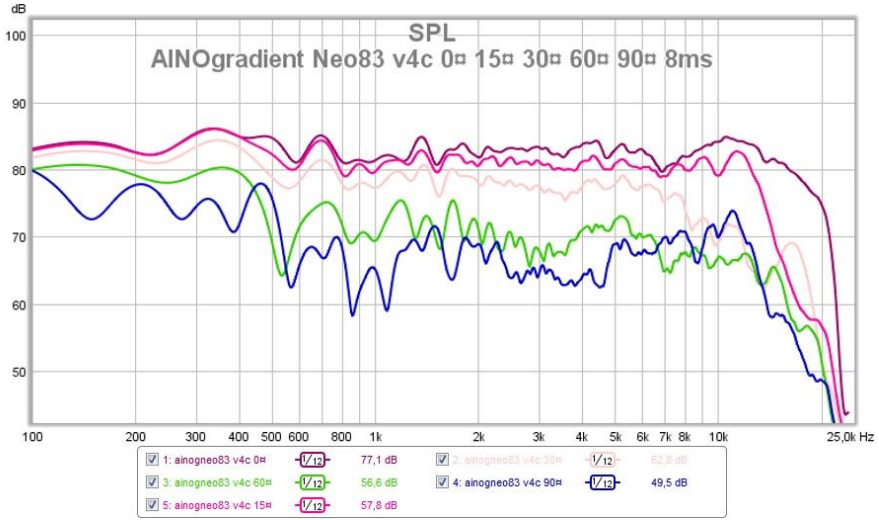
Measurements (indoor)



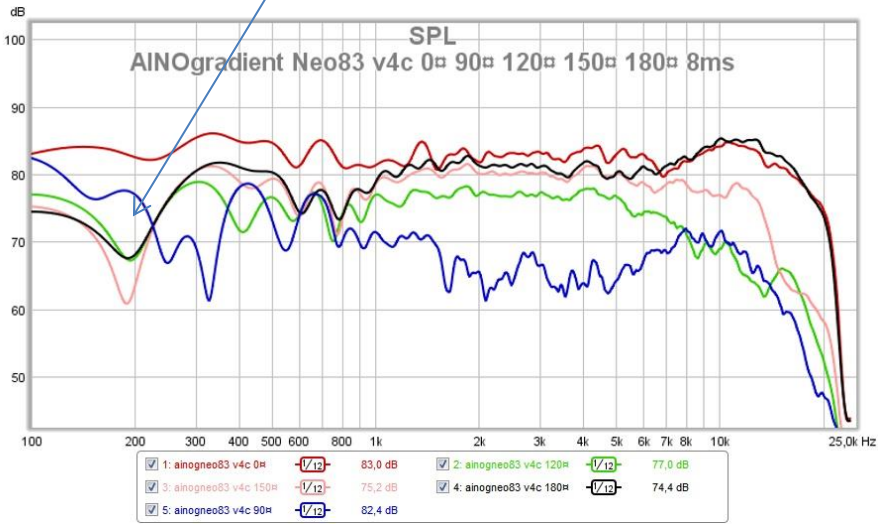


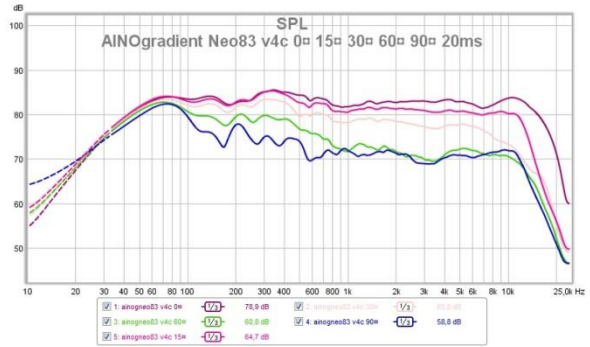


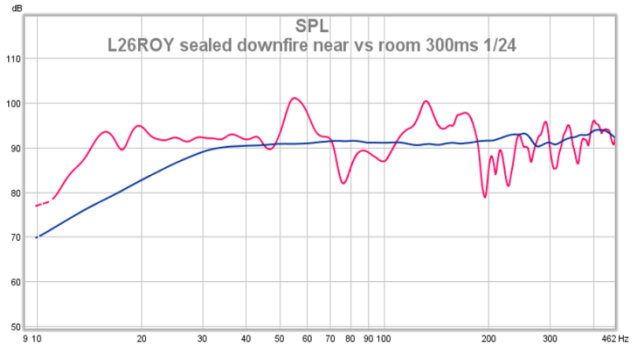
Directivity, measured at 1,5m



Cardioid response!







Bass response gets boosted due to downfiring placement of the woofer!

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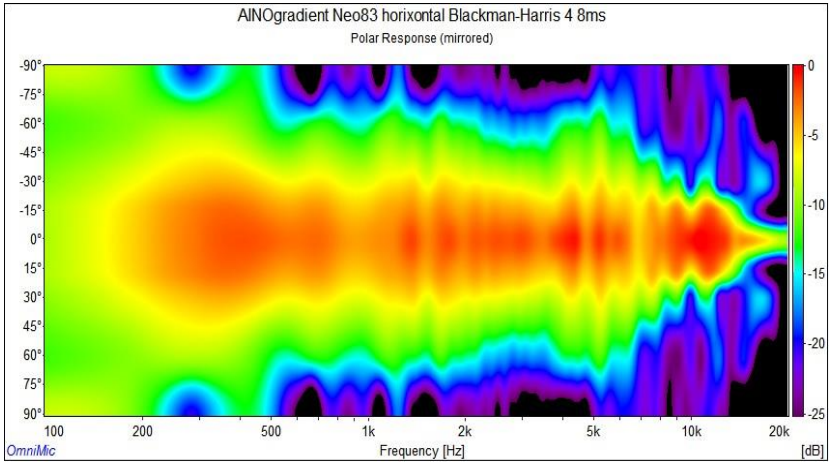
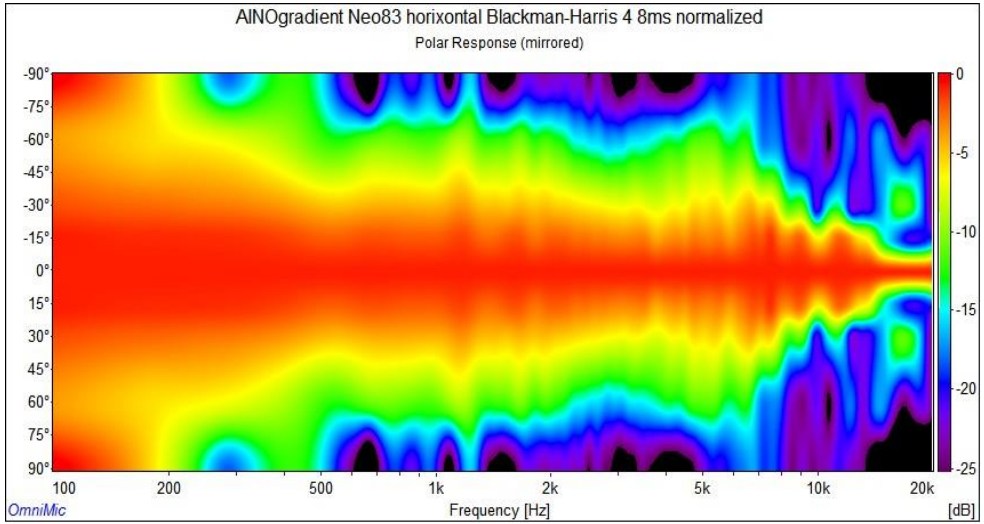
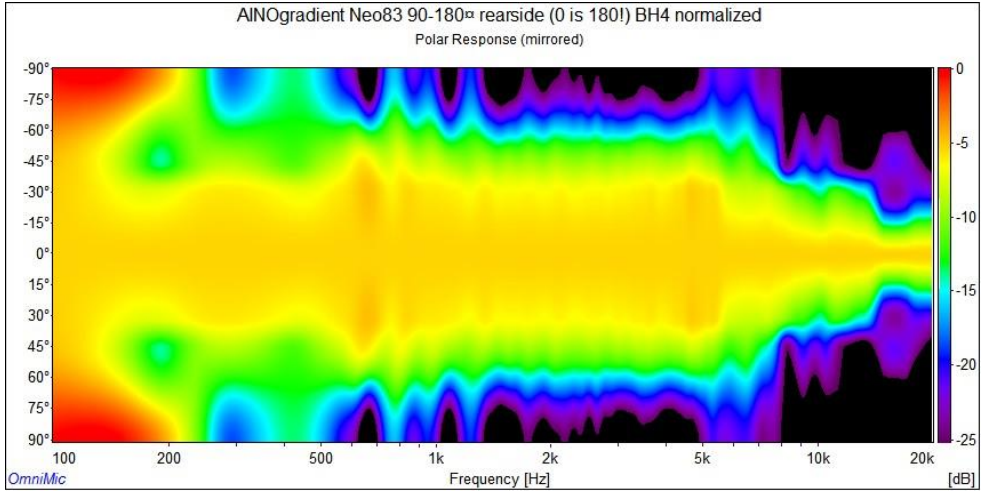
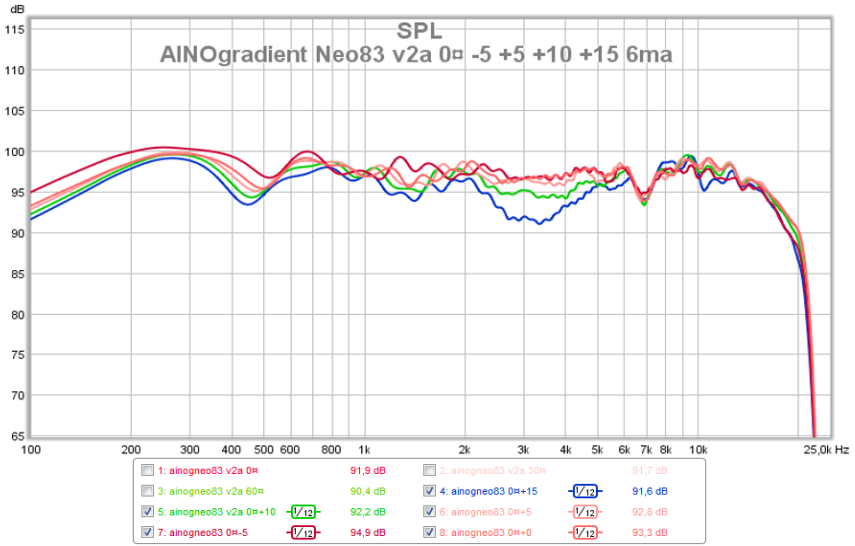




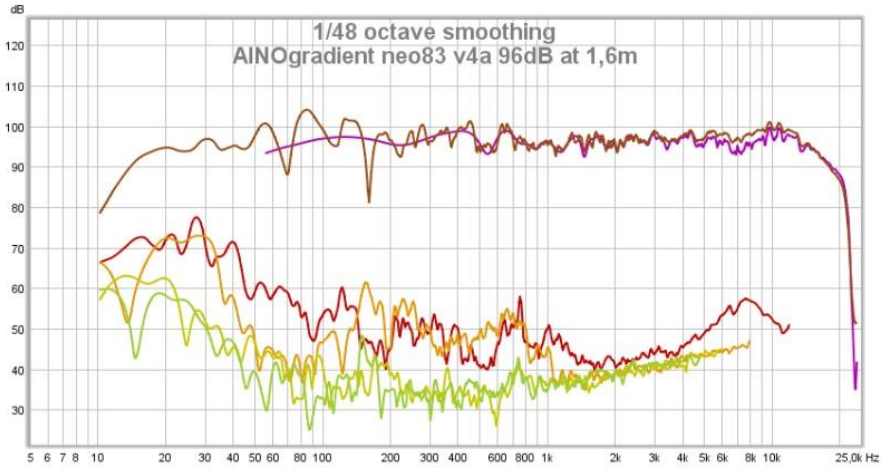
Polar graphics done with Dayton [Omnimic V2](), from REW measurements



Vertical directivity



Distortion



Step responses
v4a2 – LR2/LR2/LR2
v4c – LR2/LR4/LR4

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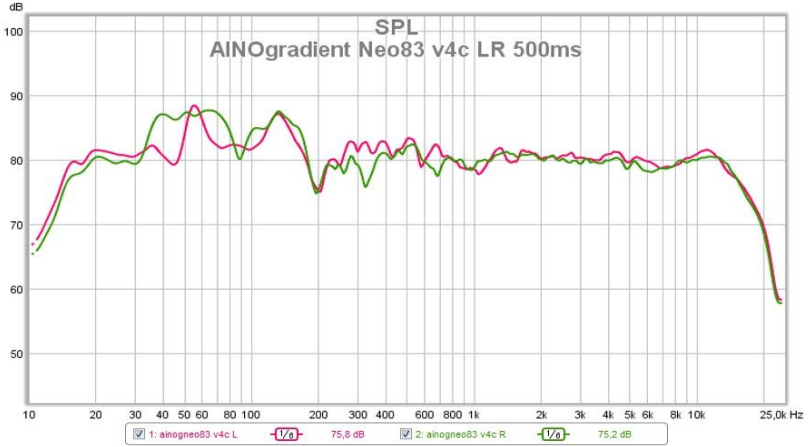
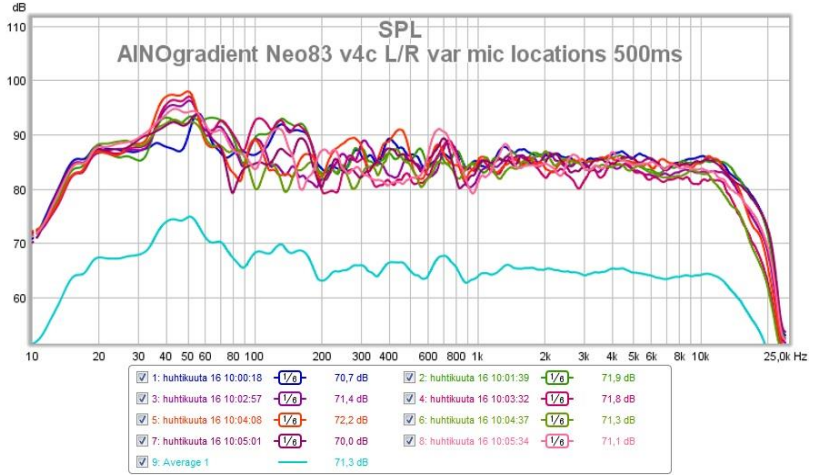
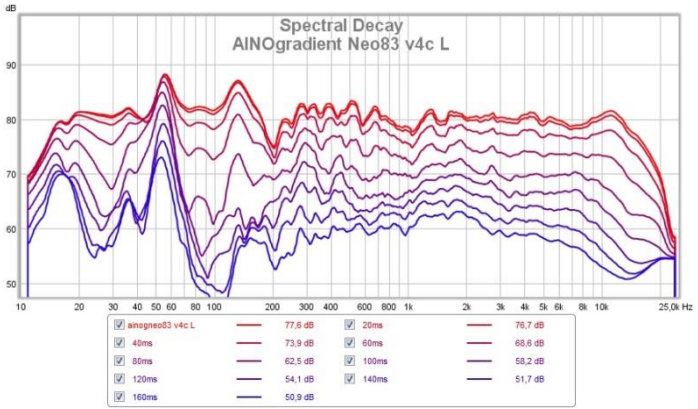
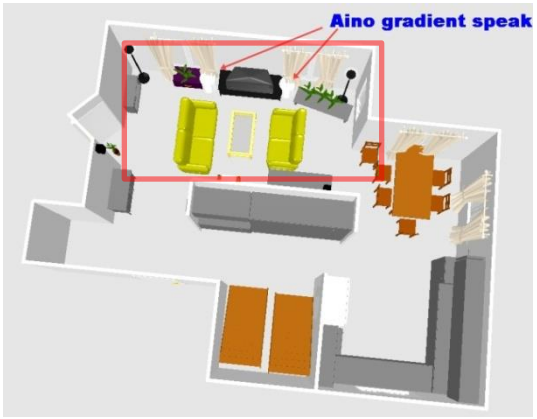
AINOgradient in my living room









- Room size 6m x 3,5m
- tilted wooden ceiling 2,6–4m height
- gypsum board / wood frame walls with insulation

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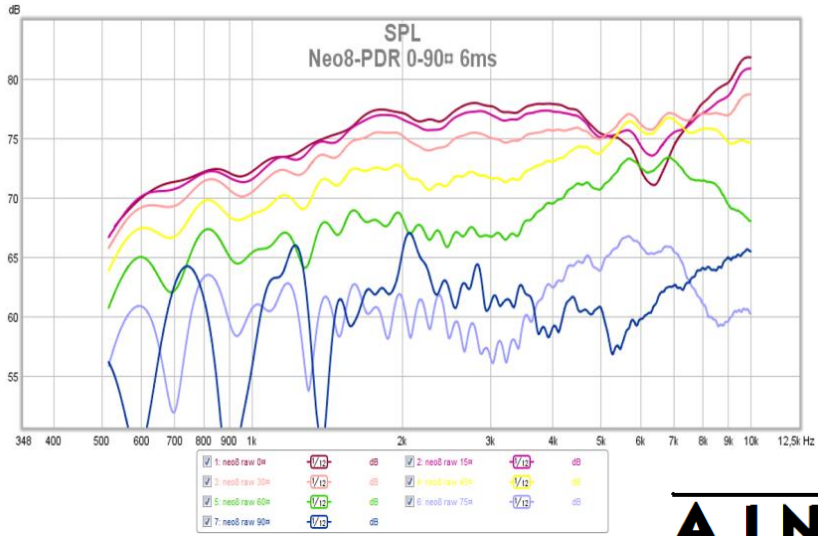
AINOgradient Neo(B) and Neo83

- Problems with loosing directivity of Peerless NE95W mids around 2kHz (cone cavity problem?) was solved in December 2013 in **Neo** by using B&G Neo8-PDR planar electromagnetic ribbon driver (neodymium). **NeoB** version had also a rear mount dome tweeter
- Active membrane of Neo8 is only 35mm wide and 150mm tall and frame width is 90mm, this gives a very high dipole peak and some baffle gain below it – a very nice dipole mid! Edge simulation proved to sync well with reality, because the driver is planar as simulation proposes.
- Neo3-PDR tweeter was added Jan. 2015, **Neo83**



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Summary and my thoughts

- Horizontal directivity of active miniDSP-controlled **AINOgradient** dipole speaker is extremely even and strong – minimizing early reflections from side walls. Vertical directivity is likewise high to reduce floor and ceiling reflections. My preferred room (power) response is just slightly declining towards highest frequencies.
- Bass level and room response can be adjusted with miniDSP 4x10HD and verified with REW analysis
- 8 amplifier channels are required for stereo, B&O ICEpower modules are used in two cases
- Sound is very good and balanced, stereo imaging in my living room is better than a 2-way pair with waveguides + sub, but still more ”lively and lifelike”
- **AINOgradient Neo83** loudspeaker system was voted for having ”Best Sound in Show” at the Finnish DIY-audio event in May 2015!

Version history:
AINOgradient, Aug. 2013
AINOgradient Neo, Dec. 2013
AINOgradient NeoB, Jan. 2014
AINOgradient Neo83, Jan. 2015

• This project will never end! The parts of the speaker can be changed individually by making new frame parts and adjusting dsp!

• **Most sincere regards and respect to Mr Jorma Salmi for the original concept and inspiration!**

• Further info and contacts
- •Email juha.sirkka@fimnet.fi
- •Diyaudio.com forum username Juhazi, AINO-thread
- •Jyväskylä, Finland

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