Sound Principles by DALI

[Amplifier Optimized]

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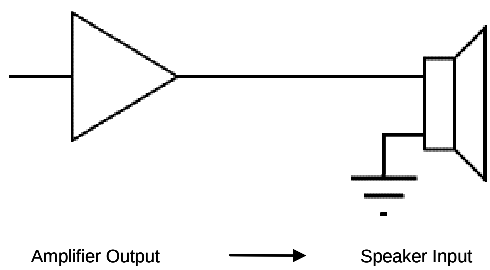
1. Why do we care about optimizing our loudspeakers for the amplifier?

The overall purpose is to provide optimum working conditions for the amplifier. This is achieved by making the load of loudspeaker “amplifier friendly”.

Any playback chain – from source to sound - is no better than the weakest of the links. But often it is forgotten - yet extremely important - to look at how the links are interacting and thereby affecting each others behaviour. Most critical is the relationship between amplifier and loudspeaker.

The loudspeaker pose a significant loading of the power amplifier’s output stage. This load is draining power from the amplifier – the same power the speaker is meant to transfer into useful acoustical output.



In the ideal world the amplifier is a voltage source meaning that it will always ensure a fixed, well-defined amplification of its input signal - no matter which load impedance is used (within certain limits). In order to make the amplifier as stable and accurate as possible most manufacturers make use of significant negative feedback in their amplifier designs.

The terms for interfacing between power amplifiers and loudspeakers are most often described by a simple number, e.g. "8 ohms". But in reality this description is severely simplified, and does not tell a lot about the actual working conditions for the amplifier. Apparently very little effort is made, across the audio industry, to implement standards and to secure compliance to these for this crucial interfacing.

To make the amplifier and its feedback systems operate as ideal and accurate as possible the loudspeaker load should be constant at every frequency. So a 4 ohm amplifier load should – ideally – be 4.0 ohms within the 20 - 20.000 Hz region (the audio frequency band).

In reality, however, for various reasons related to the practical aspects of loudspeaker design, this is **never** the case.

When looking at the typical design of an amplifier it is obvious that the need for stable impedance increases at higher frequencies. This is mainly because the risk of creating instability within the feedback loop increases as the upper bandwidth limit of the amplifier is approached.

By defining a target - as we do at DALI – we strive to reach this ideal. Our goal is to improve the total sound quality of the playback chain.

2. The meaning of "Amplifier Optimization"

By defining the term "Amplifier Optimized" DALI is prioritizing the most critical aspects of the loudspeaker loading the amplifier. From many years of critical analysis of responses from customers, service departments and even from amplifier designers - combined with our own laboratory research on the interfacing between loudspeakers and commercially widespread amplifiers, we have set up the following guidelines for input impedance when it comes to the design of a DALI speaker:

1. The impedance of a loudspeaker must be as flat (linear) as possible from 200 Hz and up (the higher the frequency - the more important).
2. In the region above 200 Hz any impedance peaks of more than twice the nominal impedance should be avoided.
3. No additional global "impedance correction circuits" in the loudspeaker's crossover circuit are allowed in the design.
4. Any impedance dips surpassing 20% below the rated, nominal impedance should be avoided. In general impedance below 3.2 Ohms must be avoided.
   Example: 4 ohms nominal impedance -20% equals 3.2 ohms as acceptable minimum impedance.

3. Why amplifier optimization improves the sound quality

- An uneven impedance introduces reactive behaviour at higher frequencies, making the feedback of the amplifier stressed and unstable.

- The sound quality of any amplifier will improve when it is loaded by a well-defined, stable impedance as opposed to a heavily fluctuating frequency-dependant impedance.

- The improvement will be most significant on ”inexpensive” amps, A/V receivers, digital amplifiers and tube amps. In reality, however, it will improve performance from all types of amplifiers.

- The positive advantages of amplifier optimization will increase with the frequency – especially around and above clipping level. This is where feedback becomes inactive or even unstable, causing “ringing” and other non-musical artefacts.

- Amplifier optimization will reduce - and in some cases eliminate - the risk of damage to amplifier outputs.

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4. In detail - How does this affect the design of DALI speakers ?

This is where the real challenge lies as there are no simple “tricks” to implement. The challenge of combining a well-integrated and well-balanced sound in a passive loudspeaker with a smooth input impedance response is a primary design target from the very beginning of the concept phase. This means it goes back all the way to the design and selection of components, not least the loudspeaker drivers.

The drivers can - to a large extent - be designed to work better in amplifier optimized crossovers. A few examples of a driver being able to work well in such designs are:

a. Drivers with a wide frequency bandwidth, securing a large “overlap” between two drivers crossing over.

b. Drivers with a smooth, wide dispersion at higher frequencies, generating sufficient radiated energy at higher frequencies - even at very off-axis angles.

c. Drivers with a relative smooth impedance response of their own (only subtle increase in impedance when frequency is increased), and in best case having a flat impedance response from 150-200 Hz and up (woofers), app. 500 Hz and up (midranges) and app. 2 kHz and up (tweeters).

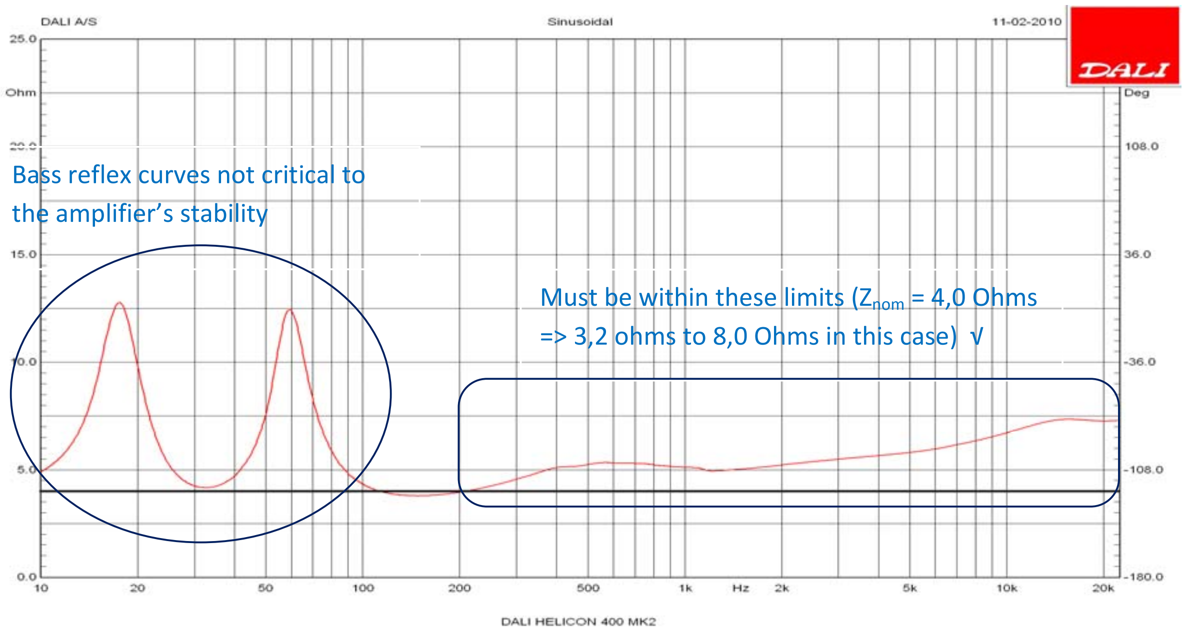
Looking at the crossover design all iterations of the individual crossover channels are made with the clear objective of having the induced energy per channel reflecting the radiated energy per channel.

In many speaker designs this is not at all the case. These speakers may have a quite uniform frequency response, at least measured on-axis. But when you see the impedance response a significant peak will be dominating, typically where the drivers are overlapping (see Appendix b). In many cases this increase is so steep (high Q) that it can be considered as a resonator at the particular peak frequency.

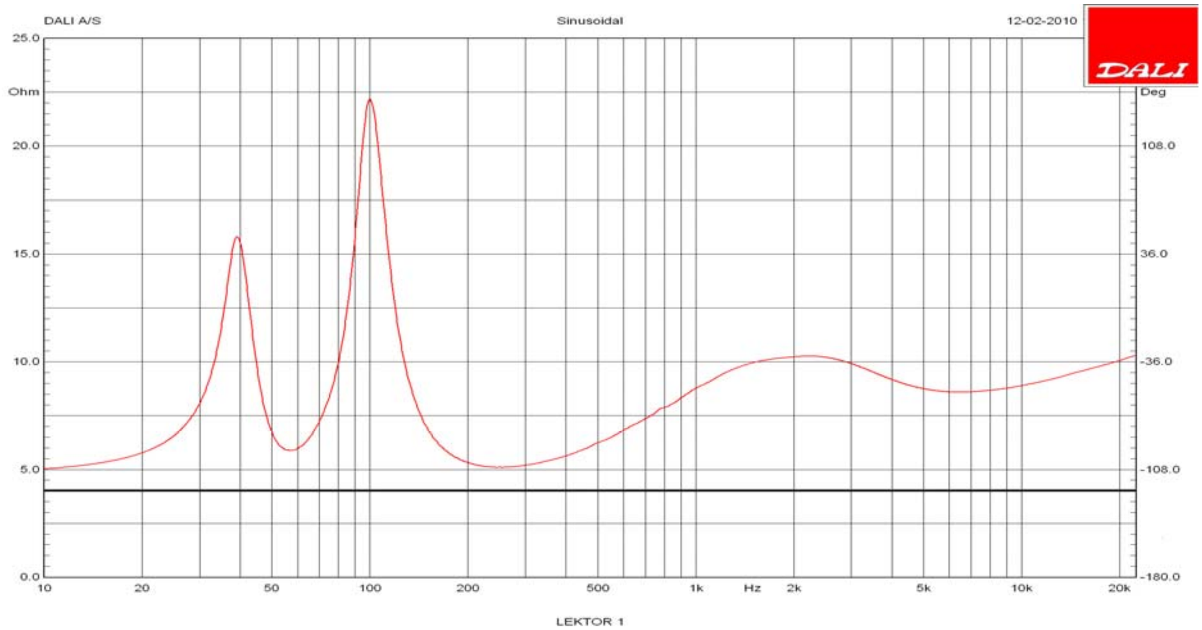
It is commonly agreed between many conscious designers that such resonance effects within the audio chain **will** in fact leave audible colorations affecting the total perceived sound quality. And though this negative effect is not generated by the sound response from the loudspeaker itself, when connected to a "perfect" sound signal - it is still affecting the ability of the amplifier to deliver "a perfect signal" - thereby degrading the signal itself. At the end of the day this will result in a less perfect performance. So we can add to the old saying….:

"No chain is stronger than the interaction between the links"

An example and explanation of the impedance response of an amplifier optimized loudspeaker:

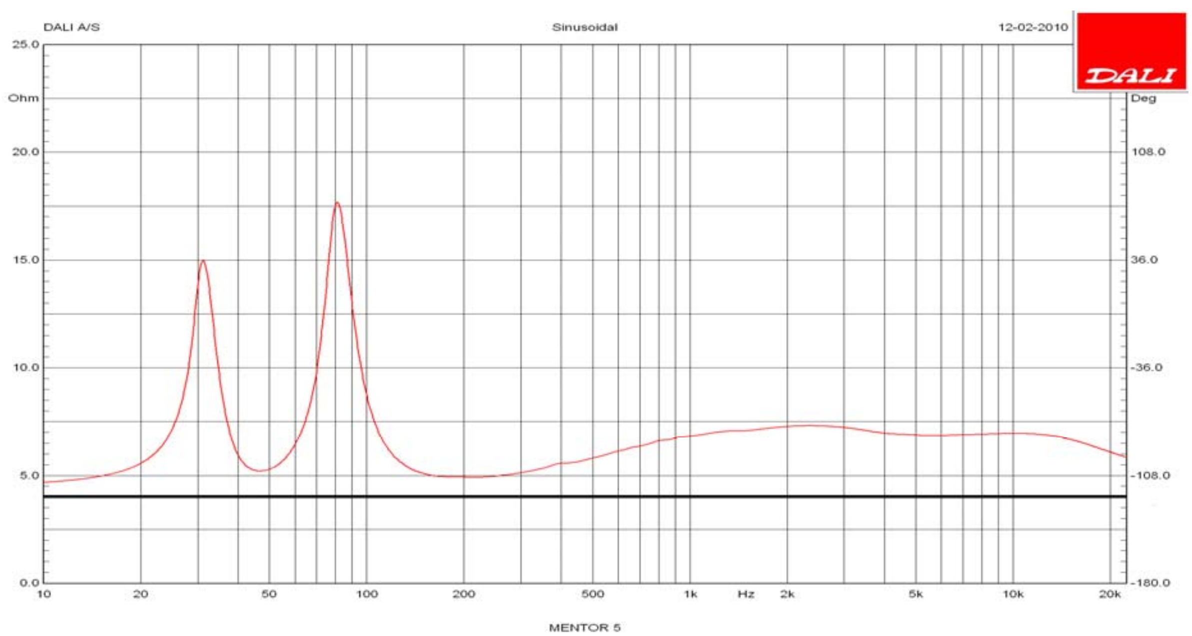


Appendix A: Impedance curves for various DALI models / series:



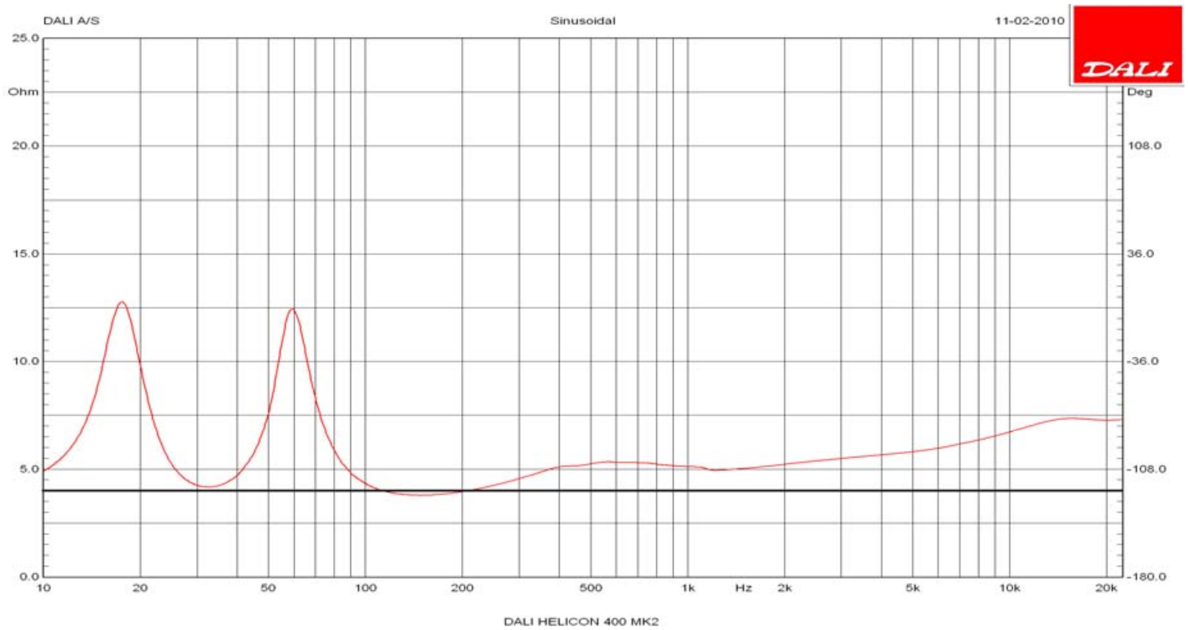
Above: DALI LEKTOR 1

Smooth impedance above 200 Hz and overall high impedance (gentle amplifier load, never getting near the 4 ohm line, in fact always above 5 ohms).



Above: DALI MENTOR 5

Very smooth impedance above 200 Hz

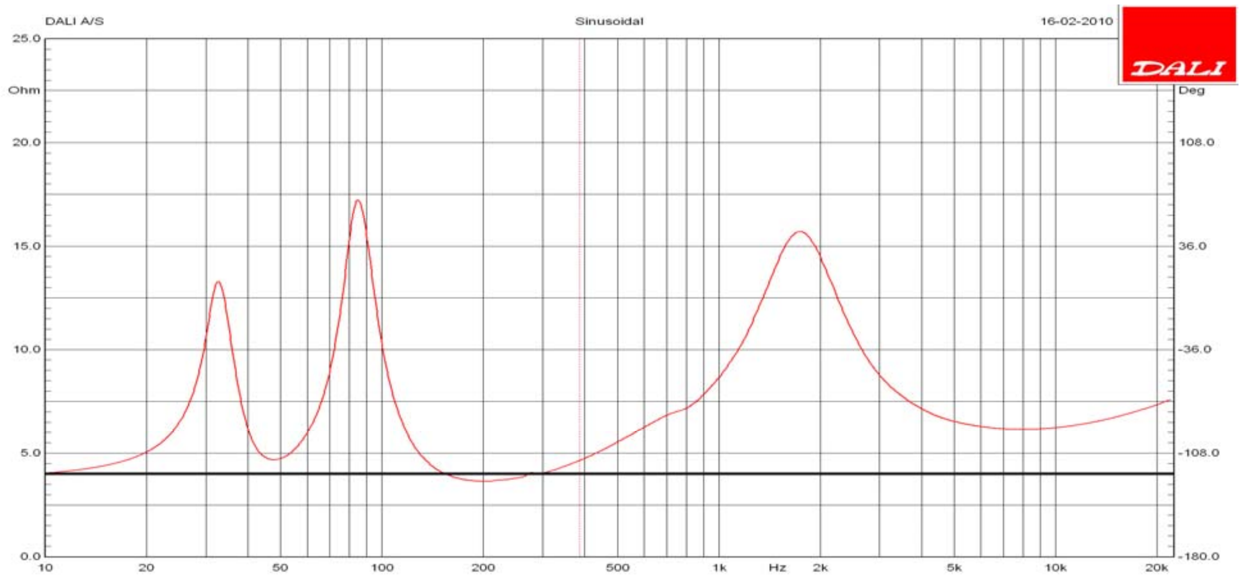


Above: DALI HELICON 400 MK2

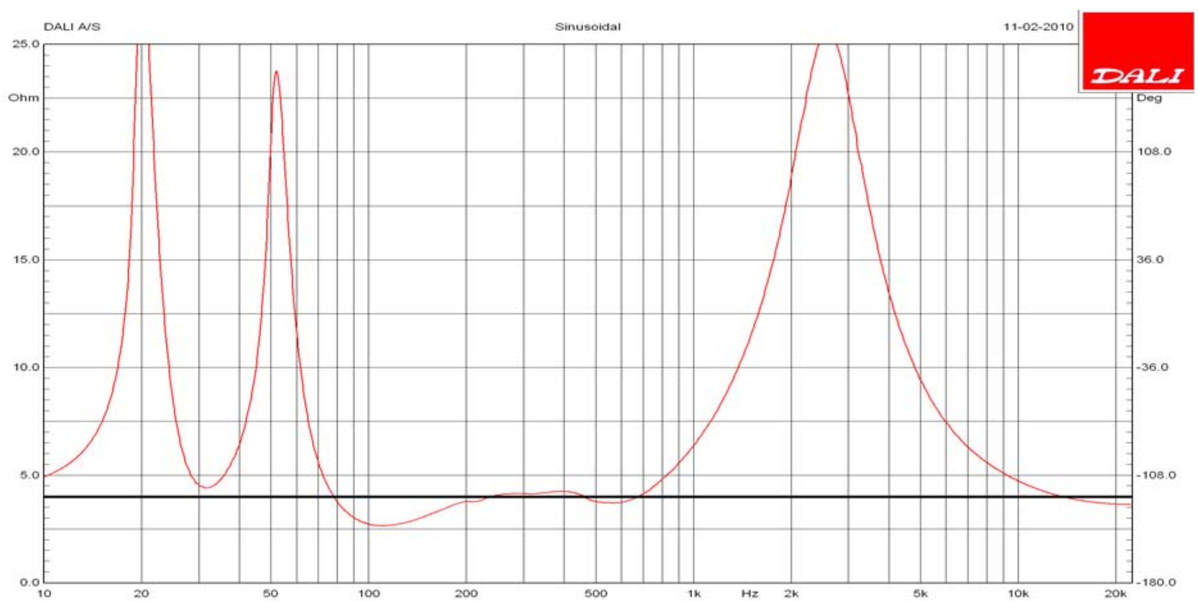
Very smooth impedance over the entire midrange band.

Minimum impedance = 3.85 ohms @ 150 Hz (still easily within IEC-268-5).

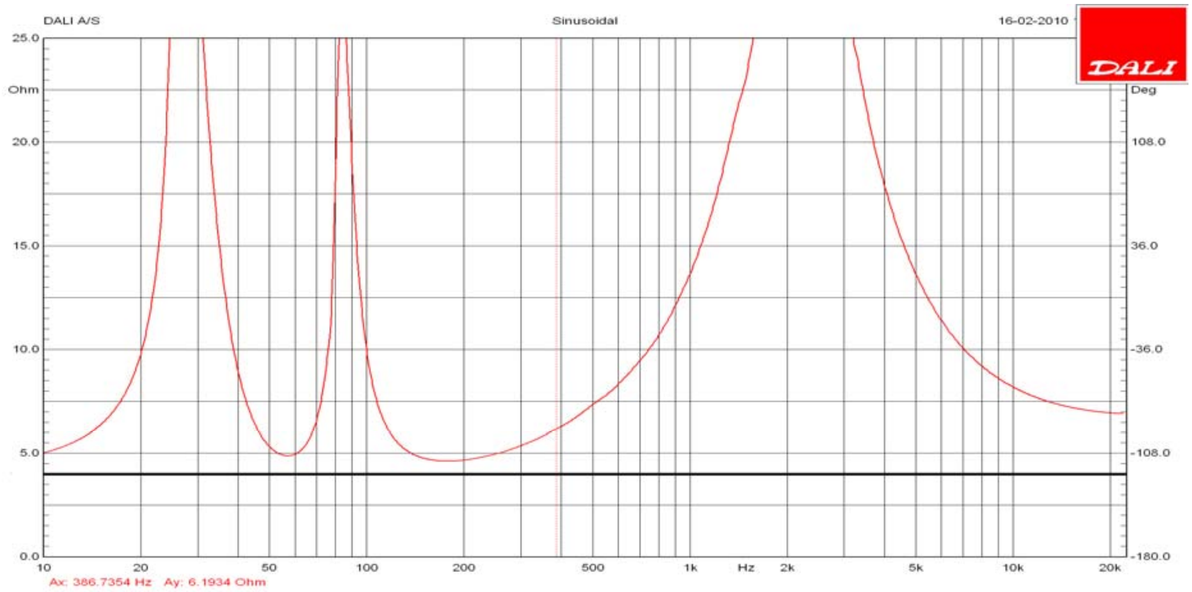
Appendix B: Competitor products without amplifier optimization:



Above: Competitor product in 120 EURO/each retail price class.
Extremely uneven midrange impedance response.
Impedance drops to 3.5 ohms @ 205 Hz, but speaker is rated 8 ohms!



Above: Competitor product in 700 EURO/each retail price class.
Very uneven midrange impedance response.
Impedance drops to as low as 2.7 ohms @ 120 Hz , but speaker is rated 8 ohms!



Above: Competitor product in 475 EURO/each retail price class.

Extremely uneven midrange impedance response.

Impedance drops to 4.6 ohms @ 180 Hz, but speaker is rated 8 ohms.