Jaap van Loon, August 2024

Different drivers in common inner housing

Summary

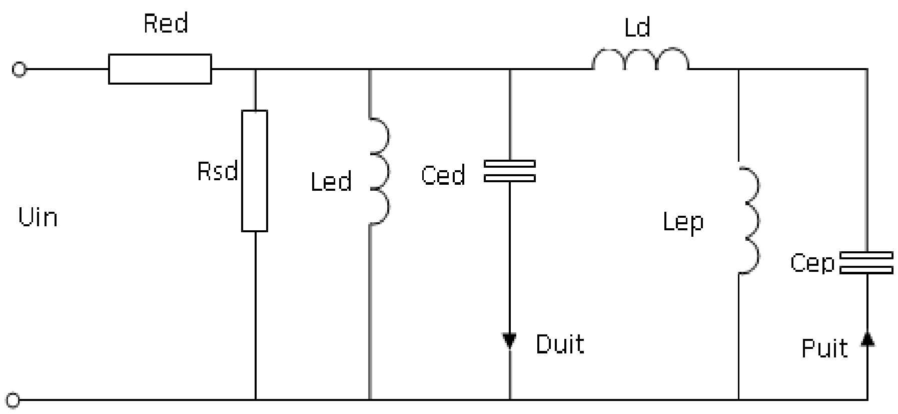
In this document, a method is proposed to simulate the behavior of a system with two different drivers together in one closed enclosure.

The method works as follows: Take a system of 1 driver (A) plus 1 passive radiator (B). The behavior of such a system is well known (see, the pdf by Richard Small [1)]).
I suspect, and this is the essence, that the passive radiator can be replaced by a normal, but now shorted, driver. The addition of the situations "driver A" actuated, "driver B" shorted plus the situation "driver B" actuated, "driver A" short-circuited then gives the total behavior of the system.

A Simulation spreadsheet has been implemented using the above method[1)].
The electrical equivalent of the two-driver configuration, whose properties expressed in T/S parameters, has been simulated.
It turned out that this superposition method works (at least in the simulation). In many cases, two drivers can be replaced by a single virtual driver whose T/S parameters are easy to calculate.

Passive radiator equivalent circuit

The following circuit gives a simplified electrical equivalent for a passive radiator system according to R. Small [2)]:



Where:

Uin = input voltage [V]

Red = dc resistance of the drivers voice coil [ohm]

Rsd = electrical resistance representing the drivers mechanische resistance

$$Rs = Qms.Re.Qes^{-1} \text{ [ohm]}$$

Led = electrical inductance representing the compliance of drivers suspension

$$Le = Re.Qes^{-1}.Ws^{-1} \text{ [H]}$$

Ced = electrical capacitance representing the drivers cone mass

$Ce = Qes.Ws^{-1}.Re^{-1}$ [F]

Ld = electrical inductance representing the compliance of the air mass in de box

$Lb = Vbox.Bl^{2}.rho^{-1}.c^{-2}.Sd^{-2}$ [H] (Bl-product and cone surface are those of the driver)

Lep = electrical inductance representing the compliance of the passive radiator suspension

$Le = Re.Qes^{-1}.Ws^{-1}$ [H]

Cep = electrical capacitance representing the mass of the passive radiator cons

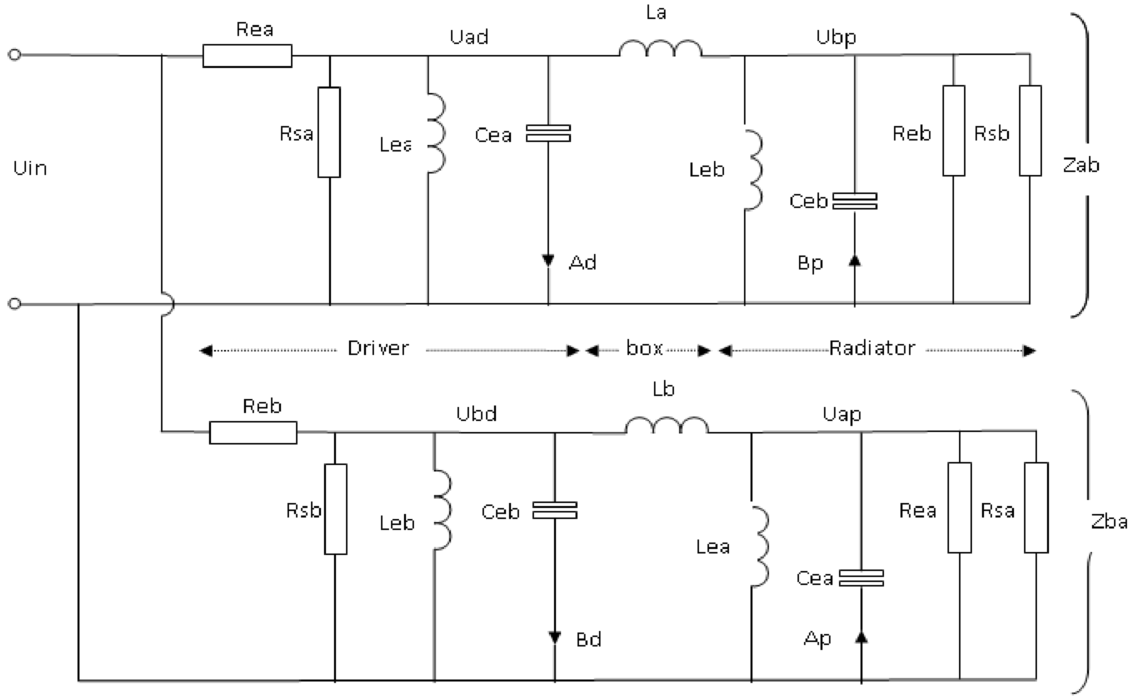
$Ce = Qes.Ws^{-1}.Re^{-1}$ [F]

Duit = electrical current representing the acoustical output of the driver

Puit = electrical current representing the acoustical output of the passive radiator

Simulation set-up for drivers in parallel

In the following circuit, the passive radiator has been replaced by a normal, but now shorted, driver. The drivers play the role of both driver and passive radiator.



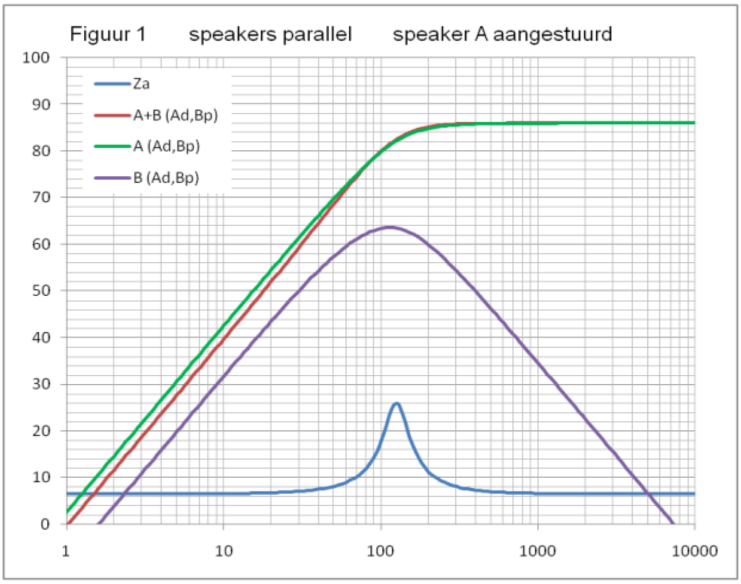
The following drivers were simulated:

Scan Speak 10F/8414G10 as driver A with

Scan Speak 15W/8434G10 as driver B Of these drivers, the T/S parameters, spl, Bl product and cone surface were used in the simulation. The self-inductance of the voice coils was ignored.

Simulated was a closed box with a Qtb of 0.7 for the total system. Apart from the driver parameters, the box volume was the only freely chosen parameter in the simulation.

<u>Results of the simulation</u>

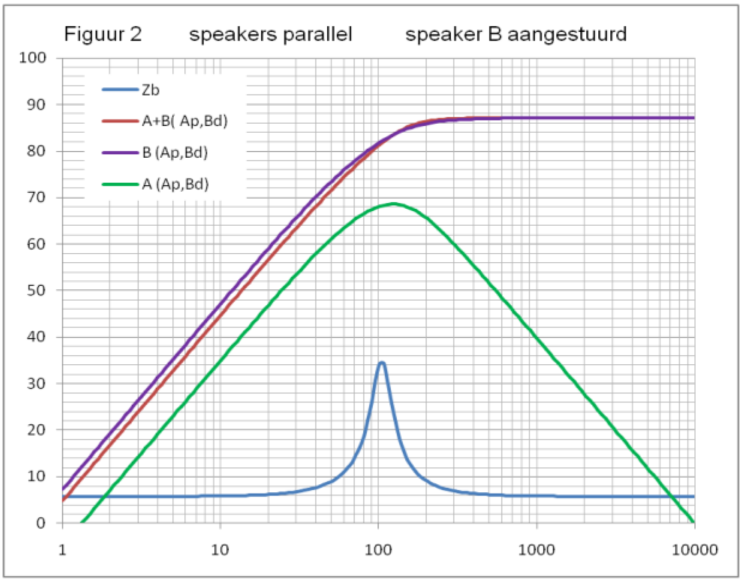


In the first simulation, driver A is actuated (A<u>d</u>) while driver B is shorted (B<u>p</u>).

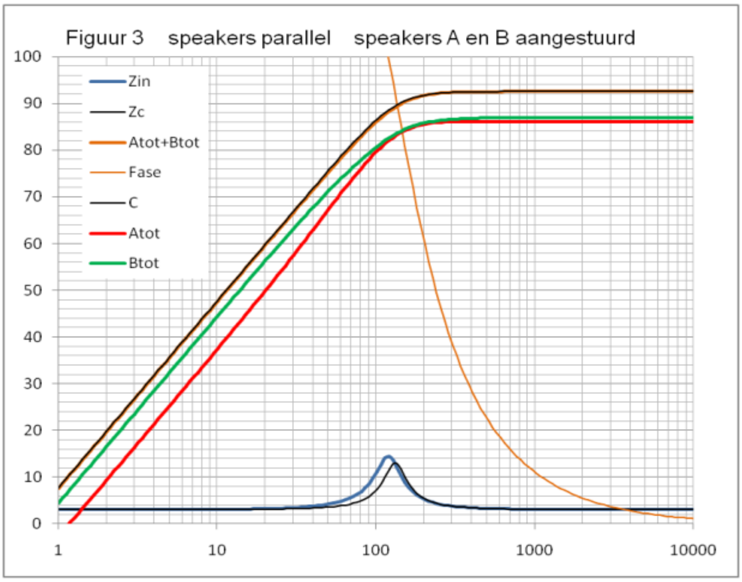
Green is the output of driver A Purple the output of driver B Blue is the electrical impedance of driver A.

Red gives the combined output of A plus B

Note that the combined output at low frequencies is somewhat lower than driver A alone. This is because the passive driver B is out of phase with driver A.



The second simulation is analogous to the first. Now, however, driver B is actuated (Bd) while driver A is shorted (Ap).
Blue is the electrical impedance of driver B



The third graph shows the summation of the results of simulations 1 and 2, so both drivers actuated.

It turned out that in this combinations of drivers, the whole (Atot+Btot) behaves practically as if it was one driver (C).

Surprisingly, the "out off phase" of the passive drivers is apparently compensated. I don't know exactly how this works, but it is in line with the limit case of two identical drivers in one enclosure where you instinctively expect this result.

The parameters of the virtual driver C must be chosen as follows:
Vas and Sd are the sum of those parameters of drivers A and B.
Fs, Qm, Qe and Bl are the geometric mean (root from A*B) of that parameters of A and B.
Re is parallel resistance of A and B.

Incidentally, this has been proposed before[3)], although to my knowledge without justification.

If one is only interested in the total output, this is easy to predict the performance of two different drivers in the same box without simulating. However, if you want to know the output of both drivers separately, a full simulation is required.

Conclusions

Adding both states (A-to, B-short plus A-short, B-on) seems to work. This makes it possible to predict the behavior of systems with two different drivers in the same enclosure.

From the parameters of two drivers, the parameters of the virtual replacement driver are easy to calculate. This approach is not 100% correct but seems good enough as a rule of thumb.

Measurements, preferably acoustic, are necessary to confirm the correctness of this simulation method. I don’t know if this approach works for vented boxes.

1) Combineren van luidsprekers.xlsx

2) Passive-Radiator Louddriver Systems Parts 1—2.pdf by Richard Small
https://sdlabo.jp/archives/Passive-Radiator%20Louddriver%20Systems%20Parts%201--2.pdf

3) the "Compound Driver" approach
http://community.fortunecity.ws/rivendell/xentar/1179/theory/dddllqd/dddllqd.html.