# Shape And Topology Optimization Of Loudspeaker Drivers

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## Abstract

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This paper illustrates the use of formal mathematical optimization techniques for engineering solutions focused towards loudspeaker drivers. Both shape and topology optimization techniques are applied, with the physics ranging from acoustics, structural mechanics, coupled vibroacoustics, and magnetics. It is demonstrated how engineering solutions can be found that are not necessarily found via conventional methods for both tweeters, woofers, and compression drivers.

The problems are setup using the in-built shape and topology optimization nodes in COMSOL Multiphysics® along with the accompanying physics for each case in question. For the topology optimization, additional interpolation schemes as well as filtering techniques are applied.

The cases considered are:
• Acoustic shape optimization of a compression driver
• Vibroacoustic shape optimization of woofer surround
• Magnetic shape optimization of a magnet system
• Structural mechanics topology optimization of woofer basket
• Structural mechanics shape optimization of woofer basket
• Acoustic topology optimization of tweeter phase plug

The magnet system example is based on an Application Gallery model, while all other models were made completely from the ground up.

A few examples are shown in the attached pictures. The shape optimization of the magnet system, Figure 1, results in a shape similar to that of the topology optimization in the Application Gallery model, only the objective (maximize the Bl-factor) is better met with the current shape optimization than the original topology optimization. Also, a shape optimized compression driver has been found with resulting shape indicated in Figure 2. The objective here was to have a smooth output sound pressure across the entire audible frequency range.

For most, if not all, cases considered, the resulting optimized geometries could not have been obtained with more conventional trial-and-error methods, as a pure combinatorics approach would present to large a solution space. Instead, with formal optimization, sensitivities are calculated, which guide the solution towards a (at least local) minimum.

The COMSOL Multiphysics® modules used are as follows: AC/DC Module, Acoustics Module, Optimization Module, and the Structural Mechanics Module. For each case at least the Optimization Module was used alongside one or two more physics.

## Figures used in the abstract

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**Figure 1** : Figure 1: Shape optimized magnet system with magnetic flux density color map and magnetic field contour lines.



**Figure 2** : Figure 2: Shape optimized compression driver.