Impact of External Permanent Magnets on Balanced Armature Miniaturized Loudspeakers

In this investigation we developed a COMSOL® model with the goal to study the interference of the magnetic flux due to external magnets with the magnetic flux generated by the BA receiver used to displace the armature (metal strip).

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Introduction

Balanced armature (BA) receivers are miniaturized loudspeakers used in hearing aid instruments, earphones, and hearables. A typical design of a BA receiver includes an armature (metal strip) that is placed between two permanent magnets and a coil that is wound around the armature. The armature tip is positioned exactly in the center between the magnets and the magnetic fields in the gaps between the armature and the magnets are equal (hence the name, balanced armature) [1]. Often in many applications, a BA receiver can get close to a strong external magnet. This can happen, for example, when a hearing instrument or an earbud is placed into the charging case. The charging case can contain magnets to guide the inserted device into position. We used COMSOL Multiphysics® to understand what happens when BA receivers are too close to strong permanent magnets. Is there an (ir)reversible effect and what are the underlying physical principles?

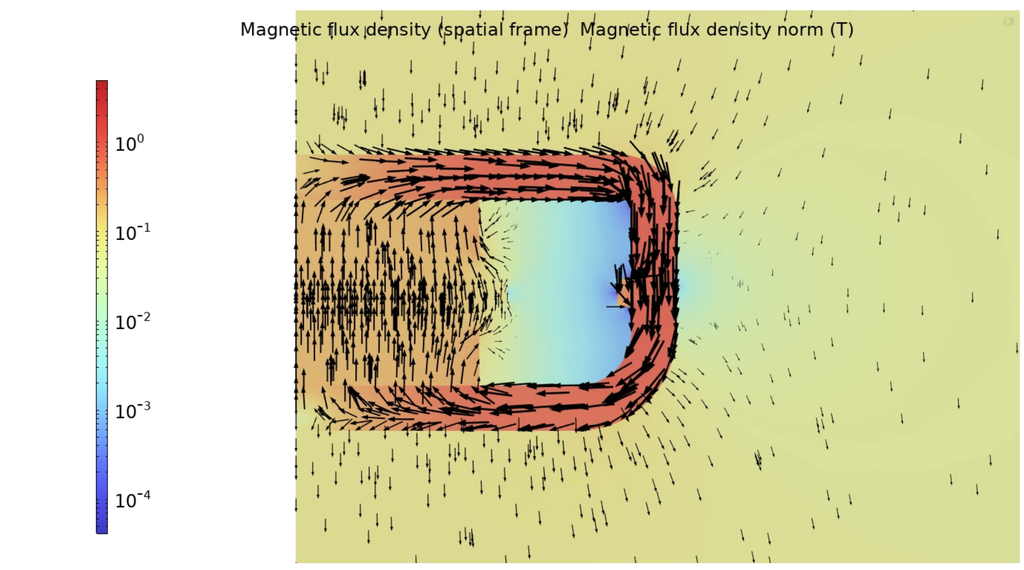

FIGURE 1. Magnetic Flux Density created by both external and internal magnets, including the Balance Armature Receiver.

Methodology

A remanent Flux Density model is used for both internal and external permanent magnets.

$$\boldsymbol{B} = \boldsymbol{\mu_0 \mu_{rec} H} + \boldsymbol{B_r}$$
$$\boldsymbol{B_r} = ||\boldsymbol{B_r}|| \frac{\boldsymbol{e}}{||\boldsymbol{e}||}$$

An Ampere's Law – BH Curve is used to include the non-linearity for Soft Magnetic material of the BA receiver armature.

A multiphysics coupling of Magnetomechanics and Thermoviscous acoustic-structure is used to capture the different physic domains of the fully coupled 3D BA receiver model.

Results

The static magnetic flux created by the external magnet, see figure 1, runs partially via the receiver housing and other internal components of the miniaturized loudspeaker characterized by high magnetic permeability. The simulation results show that the magnetic circuit – that carries the magnetic flux inside a BA receiver (see figure 2) – has a profound impact on the receiver frequency response. When an additional magnetic flux is added by the external magnet to the magnetic path inside a receiver, the magnetic reluctance [2] of the entire magnetic circuit is affected. In particular, the polarity of the external magnets and saturation of the BA receiver casing have a significant impact on the low frequency output.

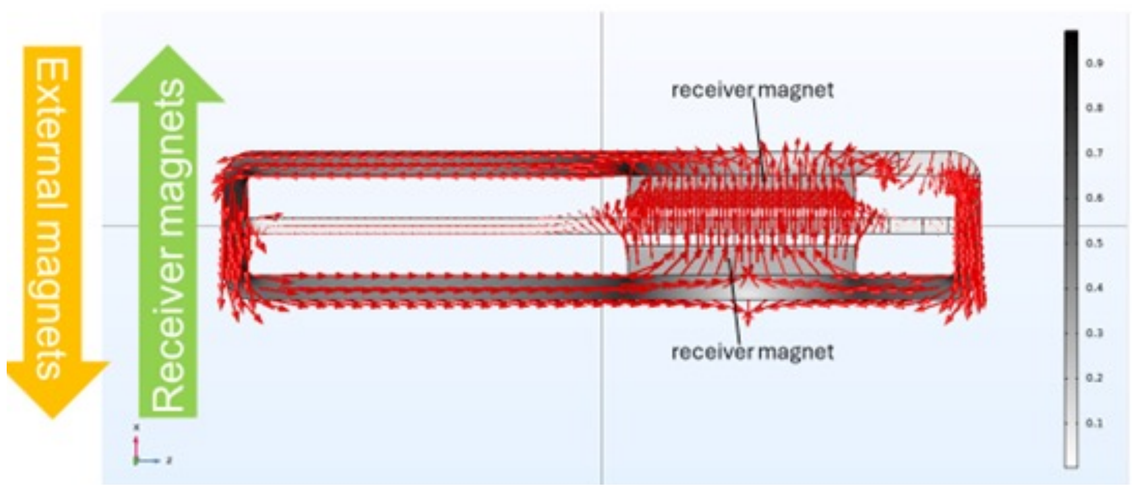

FIGURE 2. Both magnetic flux due to receiver magnets and external magnets flow via the receiver case. Magnetic flux density is shown with arrows.

REFERENCES

1. Jensen, Joe. Nonlinear Distortion Mechanisms and Efficiency of Balanced-Armature Loudspeakers. Technical University of Denmark, Department of Electrical Engineering, 2014.
2. W. Klippel, "Nonlinearities in Balanced Armature Transducers, "J. of the Acoustical Soc. of America 148(1):25- 32, July 2020, DOI: 10.1121/10.0001496

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