



**HAL**  
open science

## 3D Printing of an Electrodynamics Loudspeaker Driver

Victor Hamonet, Thibaut Julienne, Pierre Lecomte, Manuel Melon

► **To cite this version:**

Victor Hamonet, Thibaut Julienne, Pierre Lecomte, Manuel Melon. 3D Printing of an Electrodynamics Loudspeaker Driver. JJCAAS 2019, Jun 2019, Le Mans, France. hal-02983058

**HAL Id: hal-02983058**

**<https://hal.science/hal-02983058>**

Submitted on 29 Oct 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# 3D Printing of an Electrodynamics Loudspeaker Driver

Victor Hamonet<sup>1</sup>, Thibaut Julienne<sup>1</sup>, Pierre Lecomte<sup>2</sup>, Manuel Melon<sup>2</sup>

<sup>1</sup> IMDEA, Le Mans University, Le Mans, France

<sup>2</sup> LAUM, UMR 6613, Le Mans University, Le Mans, France  
firstname.lastname@univ-lemans.fr



## INTRODUCTION

**Context** 3D printing with Fused Deposition Modelling (FDM) [1] is a mature and affordable manufacturing process for rapid prototyping.

**Idea** Explore the possibilities to 3D print an electrodynamic loudspeaker using an FDM thermoplastic printer and minimum extra parts.

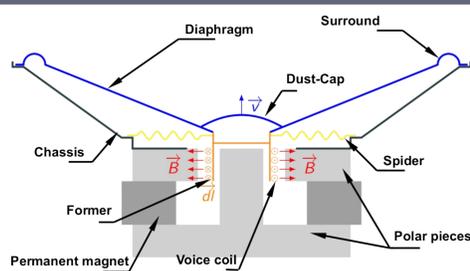
**Goal** Propose a possibility to build "at home" a transducer with acceptable acoustic performance at a minimal cost.

**Interests** Do It Yourself (DIY), Educational, Economic

**Challenges** Typical designs of electrodynamic loudspeakers are reconsidered to be built with FDM.

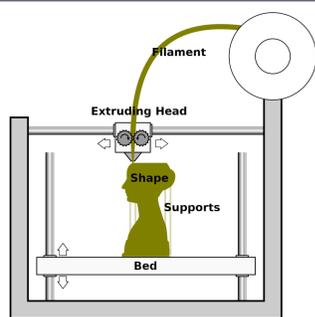
**Background** Some attempts for 3D printed loudspeaker [2][3][4].

## ELECTRODYNAMIC LOUDSPEAKER [5]



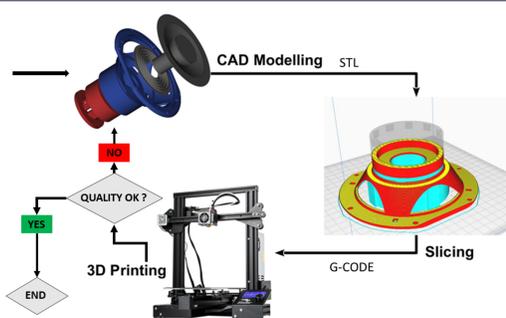
- A permanent radial magnetic field  $\vec{B}$  is applied on a cylindrical voice coil.
- When a current  $i$  flows through the coil of length  $L$ , an axial Laplace force is generated:  $F = B * L * i$ .
- Mechanical motion is induced to the diaphragm:  $\vec{v}$
- Pressure  $p$  is radiated, ideally proportional to  $i$ .

## FUSED DEPOSITION MODELLING [1]



- A thermoplastic filament is fused in an extruding head.
- It is deposited layer by layer to build the desired shape.
- At each layer, the bed (or the extruding head) is translated vertically from a layer height.
- Strong overhangs require removable supports, printed together with the part.
- Supports can be hard to remove and compromise the part final appearance.
- The print quality depends on many factors: material, printing speed, layer height, etc.

## WORKFLOW



- Each part is drawn using a Computer Aided Design (CAD) software (in this work, FreeCAD 0.18).
  - ▷ During the drawing, overhangs are limited to reduce the use of supports.
  - ▷ The resulting solid model is exported using STereoLitography (STL) format.
- The STL file is prepared using a slicing software (in this work, Cura 4.0)
  - ▷ The solid shell and inner volume are considered separately.
  - ▷ Many parameters are adjusted : nozzle size, layer heights, wall thickness, printing temperature, etc.
  - ▷ The result is exported as G-CODE instruction file.
- The 3D printer (in this work, Creality Ender-3) runs the instructions and print the part.
- If the physical part meets the requirements, the process ends. Otherwise, CAD and slicing processes are adjusted.

## PARTS FEATURES

Each part requires specific mechanical properties. It is associated with specific printing parameters and material:

**Chassis** printed in Polyactic Acid (PLA) or Acrylonitrile Butadiene Styrene (ABS) with thick shell and infill to improve stiffness and limit vibrations.

**Surround** printed flat at low speed in Thermoplastic polyurethane (TPU) flexible filament. Brim for the moving mass part.

**Diaphragm** printed in PLA, using a Cura's "Spiralize Outer Contour" mode.

**Dust Cap** printed with PLA, flat design.

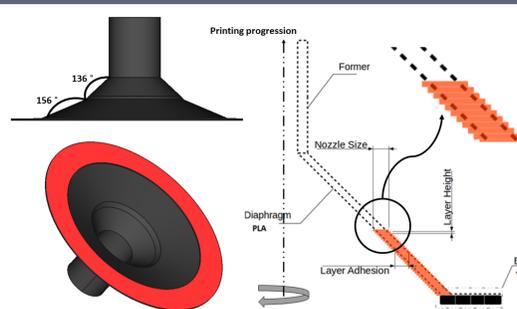
**Spider** suspension printed in TPU at low speed.

**Former** printed in PLA as part of the moving mass design.

**Coil** not printed. Made of a few meters of metal wire.

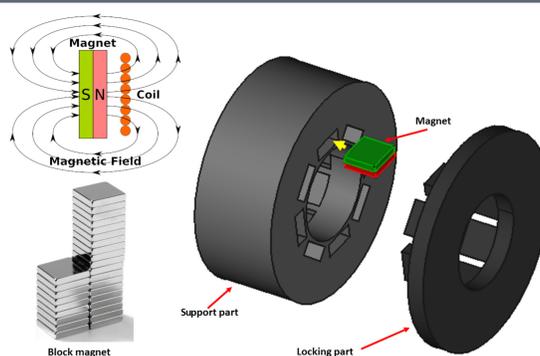
**Magnetic motor:** Specific ironless design printed in PLA. Requires several small permanent magnets.

## MOVING MASS DESIGN



- Cura's "Spiralize Outer Contour" mode: empties the solid and prints only the outer edge as a spiral with increasing altitude.
- Nozzle diameter, layer height, and overhang angles are crucial parameters for a good layer adhesion.
- Result: light and air-tight part with smooth surface.
- Surround, diaphragm and former are printed together as a unique part.
- Surround is printed in TPU as a brim of the diaphragm, printed in PLA.
- Filament material is changed manually during printing.
- Neither glue, nor part centering procedure required.

## IRONLESS MOTOR DESIGN



- Printing polar circuit parts is a demanding procedure [2].
- Ironless design: create a permanent radial magnetic field by using several block magnets.
- The magnets are arranged in a circular pattern with their polarity directed towards the center.
- Holding frame designed and printed in PLA.

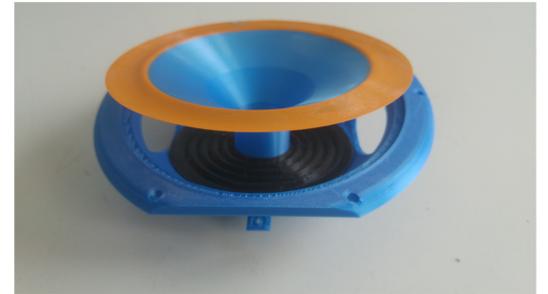
## CONCLUSION & FUTURES WORKS

- Functional prototype shows promising results for a very low budget project ( $\leq 15$  €).
- Magnetic motor improvements: higher block magnets to reduce magnetic field short-circuits.
- Parts design improvement: CAD designs allowing to get rid of the supports during printing and glue during assembly.
- Mechanical properties improvements: Use of composite filaments such as PLA-carbon fiber.
- All the CAD files, assembly instructions and documentation are available online: <https://github.com/dr-mxusse/3d.printed.loudspeaker>

## REFERENCES

- [1] P. Chennakesava and Y. S. Narayan, "Fused deposition modeling-insights," in *Proceedings of the International Conference on Advances in Design and Manufacturing ICAD&M*, vol. 14, 2014, pp. 1345-1350.
- [2] A. Kiran, R. MacCurdy, and H. Lipson, "Fully functional loudspeaker is 3-D printed," 2013, Cornell University, Ithaca, NY. [Online]. Available: <https://news.cornell.edu/stories/2013/12/fully-functional-loudspeaker-3-d-printed> (Accessed 2019-06-24).
- [3] J. Prusa, "3D Printed Speaker," 2013. [Online]. Available: <https://youtu.be/Xo2EJwZpXSE> (Accessed 2019-06-24).
- [4] Y. Ishiguro and I. Poupyrev, "3D printed interactive speakers," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2014, pp. 1733-1742.
- [5] J. Borwick, *Loudspeaker and Headphone Handbook*, 3rd ed. Focal Press, 2012.
- [6] R. Scopigno, P. Cignoni, N. Pietroni, M. Callieri, and M. Dellepiane, "Digital fabrication techniques for cultural heritage: A survey," in *Computer Graphics Forum*, vol. 36. Wiley Online Library, 2017, pp. 6-21.

## ASSEMBLY



- The surround is glued to the chassis.
- The spider is glued to the former and to the chassis.
- The voice coil is wound on the former with a winding machine.
- A wooden cabinet is built for the prototype.



## FIRST PROTOTYPE MEASUREMENTS

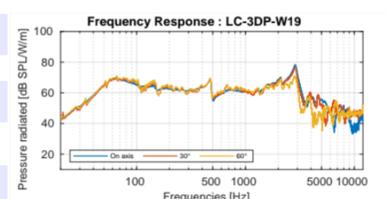
- Thiele & Small parameters estimated.
- Frequency response measured on axis and at 30°, 60°.

### LC-3DP-W19: 3D Printed Loudspeaker



### General Specifications

Nominal Impedance	8 Ω
Sensitivity	61 dB/W/m @ 1kHz
Bandwidth	[40-3k] @ 6 dB
Voice coil inner diameter	24 mm
Voice coil material	Aluminum (ø 0.214 mm)
Diaphragm material	Polyactic Acid
Surround / Spider material	TPU
Total mass	149 g



### Thiele and Small Parameters

$S_d$	95 cm <sup>2</sup>	$f_s$	66.5 Hz
$M_{ms}$	17 g	$Q_{es}$	103
$C_{ms}$	3.37x10 <sup>-4</sup> m/M	$Q_{ms}$	2.25
$R_{ms}$	3.15 N.s/m	$Q_{ts}$	2.2
$L_e$	0.485 mH	$V_{as}$	4.3 L
$R_e$	9.5 Ω	$\eta_0$	1.2 %
$Bl$	0.8 T.m		

