



**HAL**  
open science

## Sound insulation performance of plate with interconnected distributed piezoelectric patches

Kaijun Yi, Lin Li, Manuel Collet, Mohamed Ichchou

► **To cite this version:**

Kaijun Yi, Lin Li, Manuel Collet, Mohamed Ichchou. Sound insulation performance of plate with interconnected distributed piezoelectric patches. CFM 2015 - 22ème Congrès Français de Mécanique, Aug 2015, Lyon, France. hal-03444740

**HAL Id: hal-03444740**

**<https://hal.science/hal-03444740>**

Submitted on 23 Nov 2021

**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.

# Sound insulation performance of plate with interconnected distributed piezoelectric patches

K. J. Yi <sup>a</sup>, L. Li <sup>b</sup>, M. Collet <sup>a</sup>, M. N. Ichchou <sup>a</sup>

<sup>a</sup> LTDS UMR5513 Ecole Centrale de Lyon, 36 Avenue Guy de Collongue, 69130 Ecully, France

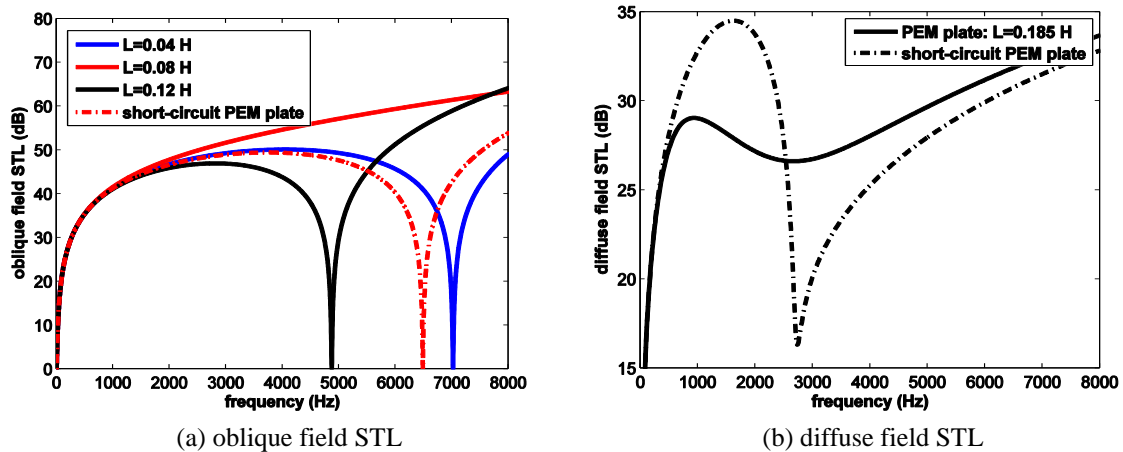
<sup>b</sup> School of Energy and Power Engineering, Beihang University - 18, Xueyuan Road, 100083 Beijing, China

## Abstract

*The intensive use of light plate-like structures in aircraft industry and transport industry result in more serious vibration and noise issues for their higher dynamical sensitivities. To deal with these problems, techniques based on piezoelectric materials have been proposed and numerous papers have contributed to their development and application<sup>[1-7]</sup>. In these applications, periodically distributed piezoelectric control strategies<sup>[4-7]</sup> attracted many researchers for their abilities to modify the equivalent dynamical parameters of the piezo-mechanical system to obtain new desired vibro-acoustic functionalities, i.e., materializing “integrated smart structure” or “metacomposite”<sup>[8]</sup>. However, previous works who used the periodically distributed piezoelectric techniques mainly focused on controlling vibration, associated sound radiation<sup>[9]</sup> or wave propagation on the structures, few of research concerns control sound transmission.*

*In our work, wave propagation properties and sound insulation performance of a thin plate with interconnected distributed piezoelectric patches via an inductive circuit network were studied. Firstly, analytical dynamical equations for this piezo-electromechanical plate (PEM plate for short) were established by using homogenization method under sub-wavelength assumption. Then, dispersion relationships and energy density of the wave modes propagating in PEM plate were analyzed. At last, the coincidence frequency as well as the sound transmission loss (STL) were studied. The results obtained lead to the following conclusions:*

- (1) Two free bending waves exist in PEM plate with different wave speeds and translate energy both in mechanical field and in electric field.*
- (2) There exists a region for the incident angle of sound wave of PEM plate, if the incident angle of sound wave lies in the region then there is not the coincidence frequency around where the insulation effect is worst.*
- (3) The disappearance of coincidence frequency can be used to optimize the value of inductance to considerably improve the sound insulation performance of PEM plate in coincidence region as illustrated in figure 1.*



(a) oblique field STL

(b) diffuse field STL

Figure 1 STL of PEM plates and short-circuit PEM plate

## References

- [1] Hagood N W, von Flotow A. Damping of structural vibrations with piezoelectric materials and passive electrical networks[J]. *Journal of Sound and Vibration*, 1991, 146(2): 243-268.
- [2] Livet S, Collet M, Berthillier M, et al. Structural multi-modal damping by optimizing shunted piezoelectric transducers[J]. *European Journal of Computational Mechanics/Revue Européenne de Mécanique Numérique*, 2011, 20(1-4): 73-102.
- [3] Huang T L, Ichchou M N, Bareille O A, et al. Traveling wave control in thin-walled structures through shunted piezoelectric patches[J]. *Mechanical Systems and Signal Processing*, 2013, 39(1): 59-79.
- [4] Vidoli S, Dell'Isola F. Vibration control in plates by uniformly distributed PZT actuators interconnected via electric networks[J]. *European Journal of Mechanics-A/Solids*, 2001, 20(3): 435-456.
- [5] Alessandrini S, Andreus U, Dell'Isola F, et al. A passive electric controller for multimodal vibrations of thin plates[J]. *Computers & structures*, 2005, 83(15): 1236-1250.
- [6] Collet M, Ouisse M, Ichchou M N. Structural energy flow optimization through adaptive shunted piezoelectric metacomposites[J]. *Journal of Intelligent Material Systems and Structures*, 2012, 23(15): 1661-1677.
- [7] Tateo F, Collet M, Ouisse M, et al. Experimental characterization of a bi-dimensional array of negative capacitance piezo-patches for vibroacoustic control[J]. *Journal of Intelligent Material Systems and Structures*, 2014: 1045389X14536006.
- [8] Collet M, Ouisse M, Tateo F. Adaptive Metacomposites for Vibroacoustic Control Applications[J]. *Sensors Journal, IEEE*, 2014, 14(7): 2145-2152.
- [9] Casadei F, Dozio L, Ruzzene M, et al. Periodic shunted arrays for the control of noise radiation in an enclosure[J]. *Journal of sound and vibration*, 2010, 329(18): 3632-3646.