Active acoustic absorption

General presentation - applications

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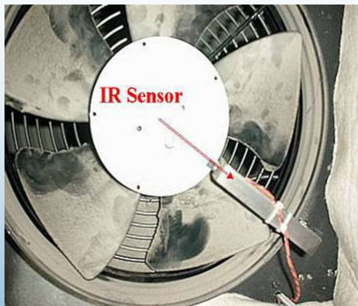
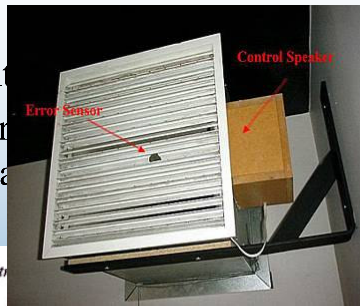
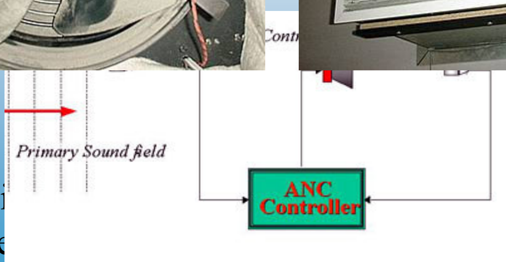
Introduction: ANC

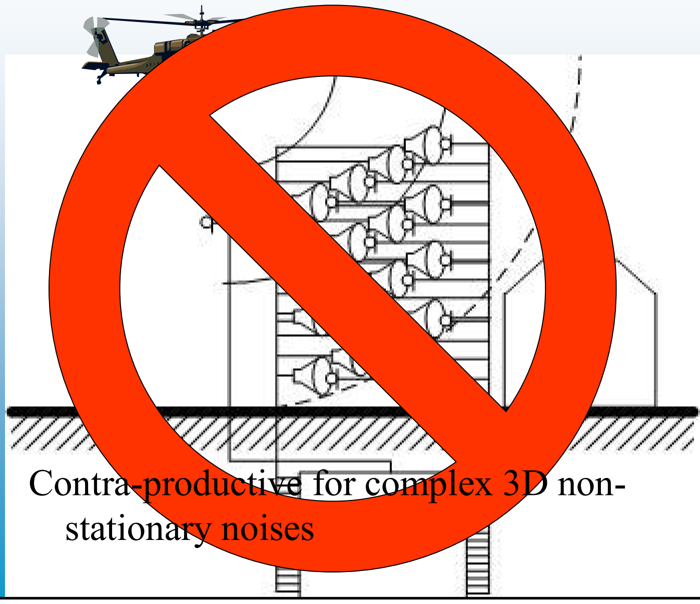






Effic … opagation,
eve

Introduction: 3D ANC



Contra-productive for complex 3D non-stationary noises

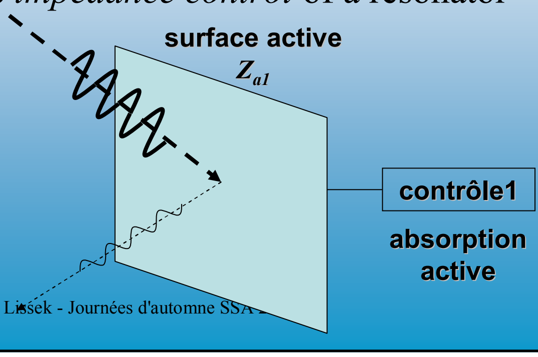
Introduction: Active absorber

Aim of this research:

design a *broadband acoustic absorber*

Principle:

active *impedance control* of a resonator



Introduction: Active absorber

Aim of this research:

design a *broadband acoustic absorber*

Principle:

active *impedance control* of a resonator

Assessed applications:

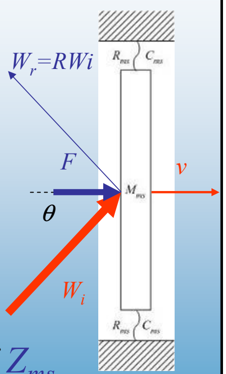
room acoustics

active noise attenuation (harmonic noise sources)

low frequency control, modal control

Building acoustics: room acoustics

$$\underline{Z}_{ms}(\omega) = \frac{\underline{F}}{\underline{v}} = \underbrace{\underbrace{R_{ms}}_{losses} + \underbrace{i\omega M_{ms}}_{mass} + \underbrace{\frac{1}{i\omega C_{ms}}}_{compliance}}_{\text{material mechanical properties}}$$



Reflection coefficient r function of Z_{ms}

Reflection factor R function of Z_{ms}

Absorption factor α function of r (R), then of Z_{ms}

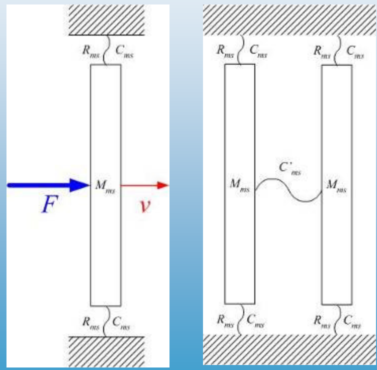
Building acoustics: sound insulation

Mechanical impedance of the material:

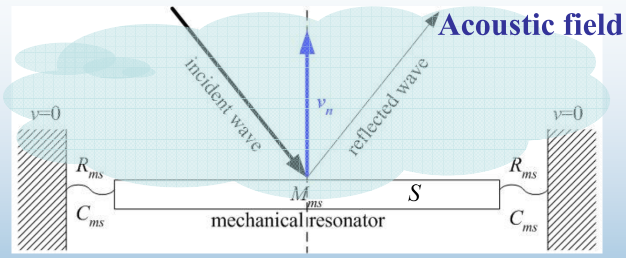
$$\underline{Z}_{ms}(\omega) = \frac{\underline{F}}{\underline{v}} = \underbrace{\underbrace{R_{ms}}_{losses} + i\omega \underbrace{M_{ms}}_{mass} + \underbrace{\frac{1}{i\omega C_{ms}}}_{compliance}}_{\text{material properties}}$$

Sound insulation depends on Z_{ms}

$$R = 10\log_{10}\left(\frac{W_1}{W_2}\right)$$



Principle of ***passive*** damping



param of absorption

S (absorbing area)

M_{ms} *(material mass)*

C_{ms} *(material suspension)*

R_{ms} *(losses)*

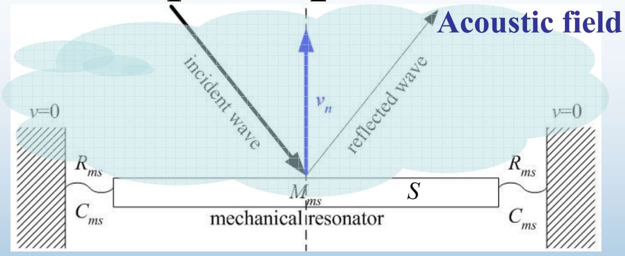
Acoustic impedance @ interface :

$Z_a(\omega)= (R_{ms} + j\omega M_{ms} + (j\omega C_{ms})^{-1})/S$ (R,M,C system, ω = pulsation)

@ resonance ($f_r = \dfrac{1}{2\pi\sqrt{M_{ms}.C_{ms}}}$):

$Z_a(\omega_r)= R_{ms}/S$ proportional to $Z_c = \rho.c$ (characteristic impedance)

Principle of ***passive*** absorption



factors of absorption

S (absorbing area)

M_{ms} *(material mass)*

C_{ms} *(material suspension)*

R_{ms} *(losses)*

@ resonance ($f_r = \dfrac{1}{2\pi\sqrt{M_{ms}.C_{ms}}}$):

$Z_a(\omega_r) = \boldsymbol{R_{ms}}/S$ proportional to $Z_c = \rho.c$ (characteristic impedance)

Note: when $Z_a = Z_c$ (impedance matching)

➔ transparency : the material is totally absorbent

Specifications of active acoustic absorbers

Acoustic resonator

➔ resonance: frequency f_r , quality factor Q

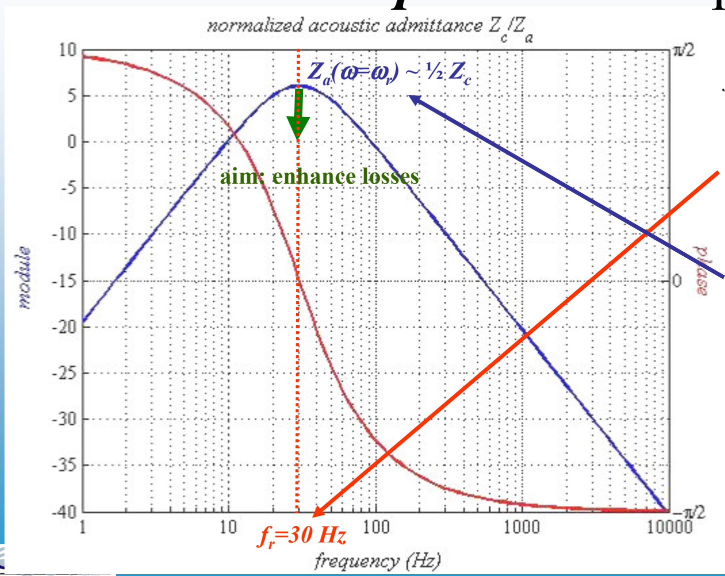
The aim of active absorption:

allow the modification of f_r and Q, by way of simple (electric) control

➔ modification of the properties of the absorber:

- make it more absorbent at resonance (acoustic impedance Z_a to match characteristic impedance Z_c of the medium)
- make it absorbent over a wider frequency range
- possibility to shift the resonance frequency

behaviour of ***passive*** absorption



factors of absorption

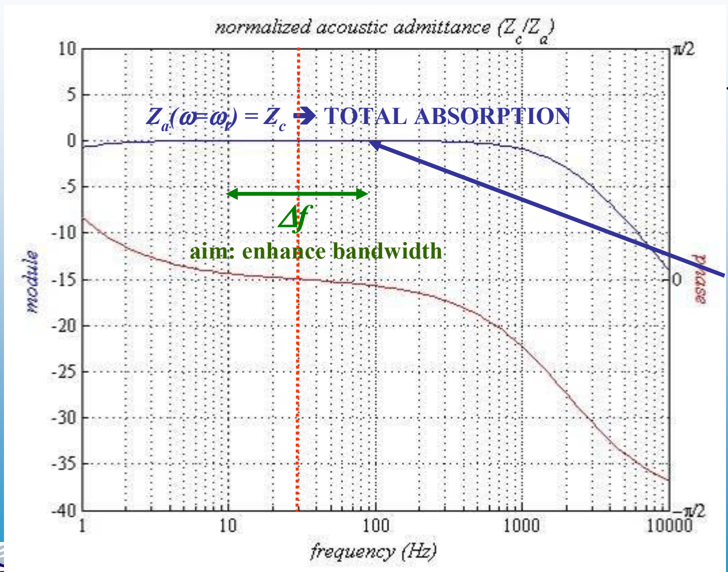
S (absorbing area)

M_{ms} *(material mass)*

C_{ms} *(material suspension)*

R_{ms} *(losses)*

Ideal behaviour of ***active*** absorption



factors of absorption

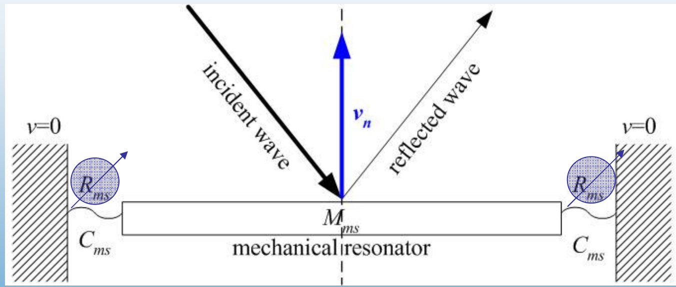
S (absorbing area)

M_{ms} *(material mass)*

C_{ms} *(material suspension)*

variable R_{ms}

Principle of ***active*** absorption

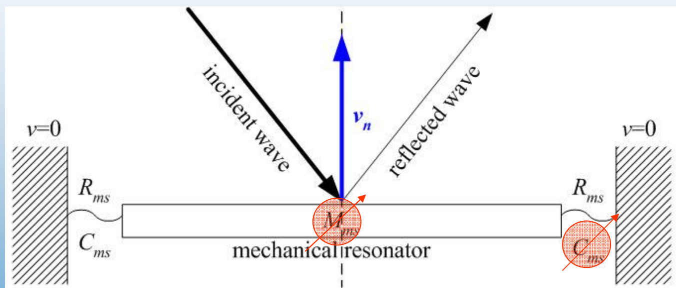


GOAL:

Active control : modification of R_{ms}

$$Z_a(\omega) = (\boldsymbol{R_{ms}}\ \textbf{(controlled)} + j\omega M_{ms} + (j\omega C_{ms})^{-1})/S^2 = Z_c$$

Principle of ***active*** resonance shift



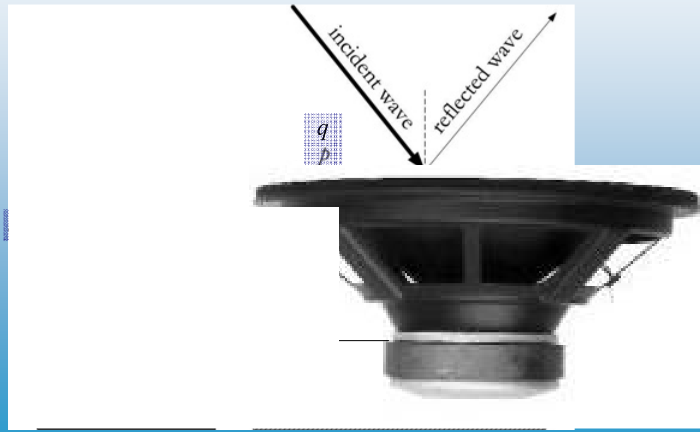
GOAL:

Active control : modification of f_r

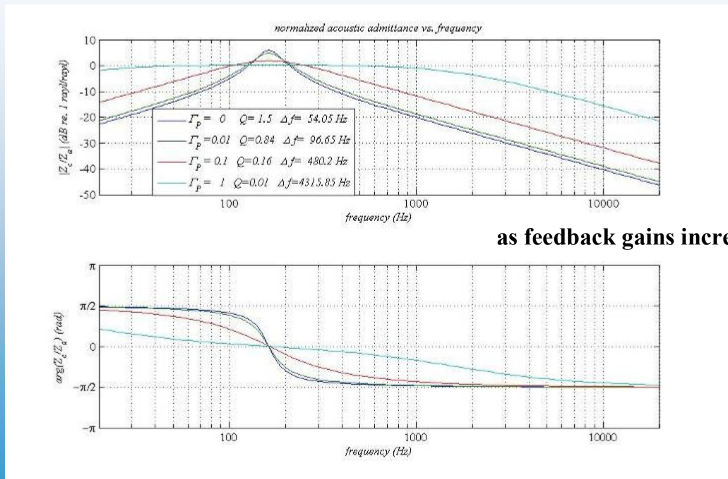
$$Z_a(\omega) = (\boldsymbol{R_{ms}} + j\omega M_{ms}\text{(controlled)} + (j\omega C_{ms}\text{(controlled)})^{-1})/S^2$$

Application: « active materials »

"Resonator" = electrodynamic loudspeaker

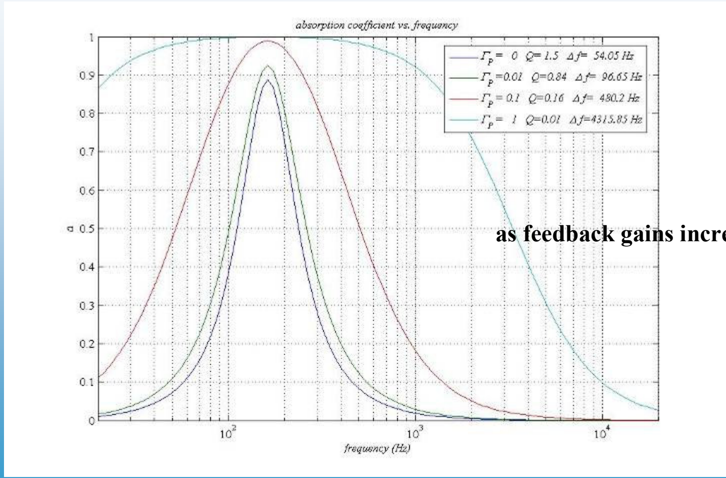


Calculations
normalized acoustic admittance (Z_c/Z_a)

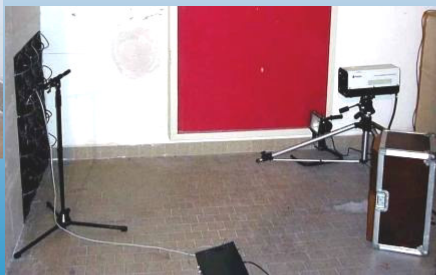


as feedback gains increase

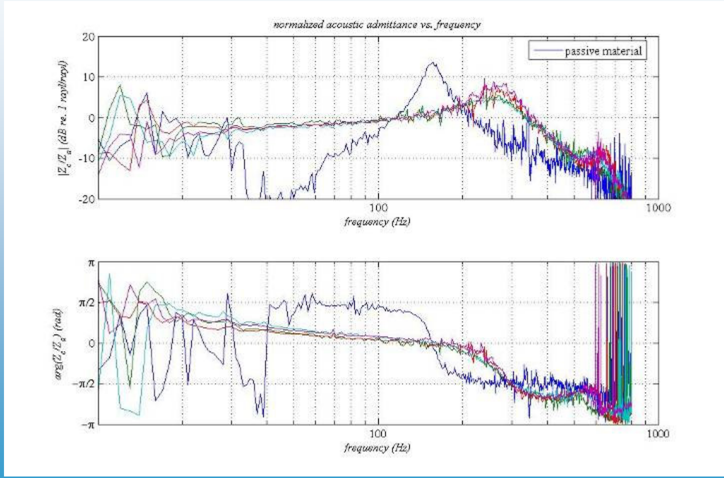
Calculations
absorption coefficient ($\alpha = f^{\circ}(Z_a)$)



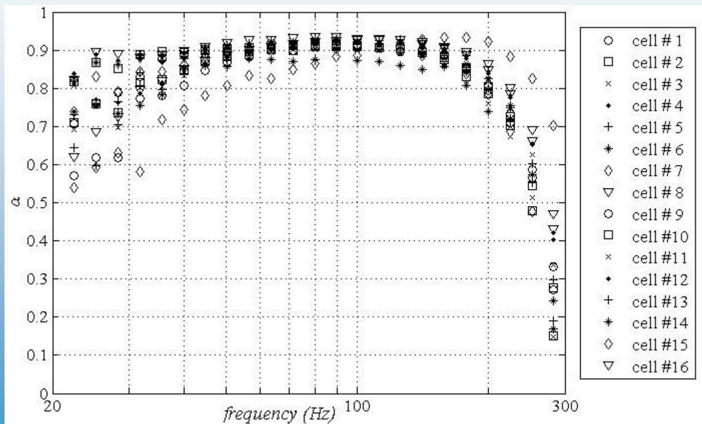
Experimental results



Experimental results
measured normalized admittance



Experimental results
measured absorption coefficients



Conclusion

Validation of the concept of active materials:

- ✓calculations promise good performances, even without specific transducer (usual loudspeaker)
- ✓experimental results show good tendency
- ✓not much expensive in regards with the acoustic gains:
  - ✓cheap actuators (usual loudspeakers)
  - ✓cheap sensors (back-electret microphones)
  - ✓simple electric control (discrete components)

Perspectives

Optimization in progress :

- ✓ dedicated transducers
- ✓ enhanced control
- ✓ assess energy transfer

Potential transfer of technology: industries concerned with non-stationary broadband or narrow band noises

➔optimize the concept within applied frameworks

- ✓ **aircraft engines (SNECMA)**
- ✓ electric industry
- ✓ railway industry
- ✓ buildings
- ✓ etc...

EUROPEAN COMMISSION
Community Research

X3-NOISE

Aircraft External Noise Network and Coordination

Snecma (F, Co-ordinator), Airbus Central Entity (F), Rolls-Royce (UK), ANOTEC(E), Airbus UK (UK), NLR (NL), Free Field Technologies (B), Manchester Metropolitan University (UK), DLR (D), ZWS (F), Airbus France (F), A2 Acoustics (S), FOI (S), TO70 (NL), GFIC (F), Alenia (I), EADS CRC (D), ISVR (UK), ONERA (F), Institute of Aviation (P), INASCO (HE), COMOTI (RO), Budapest University of Technology and Economics (HU), Czech Technical University (CZ), Vilnius Gediminas Technical University (LT), Trinity College Dublin (IE), Instituto Superior Tecnico (P), Ecole Polytechnique Fédérale de Lausanne (CH)

2006 – 2010

Objectives of the X3-NOISE Coordination Action

1. Evaluation of EC-funded projects and assessment of their contribution to the state-of-the-art.
2. Formulation of priorities and key topics for future technology projects through development of common strategies, identification of required infrastructures, benchmarking against competing countries and complementarity with national activities.
3. Formulation of research strategy for the development of tools / instruments aimed at supporting the management of airport environmental capacity within the frame of ICAO Balanced Approach and EC Environmental Noise Directive.
4. Identification of potential reinforcement of future project partnerships through expertise mapping to foster new collaborations and promote novel ideas.
5. Optimum exploitation of anticipated breakthroughs in Aircraft Noise research by the scientific community, SME's interested in aeronautics applications and other noise engineering areas.
6. Appropriate communication and feedback strategy to inform on progress made in aircraft noise research, including the development of technical information aimed at Regulatory Bodies and Policymaking Agencies on the basis of state-of-the-art, demonstrated technology and operational capabilities of future aircraft.
7. Improved integration of the European Aircraft Noise Research Community through a network of National Focal Points (NFPs), including the structured development of local networks in new EU member states in order to foster participation in future projects.

Project Coordinator:
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THANK YOU FOR YOUR ATTENTION

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