Chapter II.1

Historical background of active noise control

Advanced audio engineering for active noise control
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Introduction

• Active noise control involves the electro-acoustic generation of a sound field to cancel or lower an unwanted primary field.
• It is basically derived from the principle of superposition of sound fields, which comprises the acoustic interferences principle.

• An usual single-channel active noise control system comprise:
  • a reference sensor (e.g. microphone) for sensing a parameter of the noise to be cancelled
  • an electronic control disposal to process the reference signal and the control signal
  • an actuator (loudspeaker) driven by the control signal to generate the cancelling disturbance
  • an error sensor to provide the controller with information so that it can adjust itself to minimize the resulting sound field
Introduction
Introduction

• This standard system is "adaptive":
  • it adapts itself to variations of the primary noise
  • it adapts to changing environmental conditions
  • error and reference sensing provide the input of the adaptation
Brief story: the early years

• 1878: presumptions made by Lord Rayleigh on the basis of electromagnetics experiments
  ➔ Points of Silence

• 1878: Thompson observes sound cancellation from two Bell telephones

• 1930: H. Coanda patented the idea of sound cancellation by destructive interferences
  • Electroacoustic system to generate a signal of opposite phase to the unwanted sound

• 1933: P. Lueg described and patented the use of active sound cancellation as an alternative to passive control for low frequency sound in a duct
Brief story: the early years

Lueg patent
Brief story: the early years

• 1953: Olson develops active sound cancellation in rooms, in ducts and in headsets and earmuffs using feedback control
  • very limited attenuation over limited frequency band
  • instability due to high frequency noise with phase delay >180 °
  • limitations due to poor electronic availability
Brief story: the early years

• 1956: Conover demonstrated an active noise cancellation system for transformer noise
  • need to be adjusted in time by operator
  • noise reduction in a very narrow angle from the loudspeaker axis, localized area of efficiency, low acoustic benefits
  • even though 20 dB attenuation is possible at the error sensor ➔ impractical
  • concludes to the difficulty to “fight noise with noise”
Brief story: the early years

• 1972: Jessel obtained good results on the Olson system basis
  • enhancement of secondary sources, use of multiple sources, application of Huygens principle
  ➔ shall use numerous, directive, loudspeaker

• 1973: Swinbanks developed an active dipole (2 active noise loudspeakers at each extremity of a duct, and an electronic delay) with the aim of lowering exhaust noise

• 10 years after …
Brief story: from theory to practice

• Transition from laboratory to production took a long time:
  • time to develop sufficiently powerful signal processing electronics,
  • understanding of the physical principles involved
  • multi-disciplinary nature of the technology
    • control,
    • signal processing,
    • electronics,
    • acoustics and vibration.

• It was not until the early 1990s that regular implementations of active noise cancellation outside of the laboratory were reported (Ericksson, 1990, 1991) and Wise et al. (1992).
• Since that time numerous practical implementations have been reported, including systems for reducing helicopter and aircraft cabin noise.
Brief story: from theory to practice

Patents:
- interest in the technology ➔ exponentially increasing number of research publications on active control
- number of technical papers published since the 1930s increased from:
  - approximately 240 before 1970
  - 850 in the 1970s
  - 2,200 in the 1980s,
  - over 4,000 in the 1990s.
Brief story: from theory to practice

- Exhaustive list of patents:
  - see Guicking’s Online Reference Bibliography on Active Noise Control (GORBI 1.1), available on CD-ROM and booklet
  - More than 8’300 patent references !!!
The Energy Objection

• Where does the energy go?
  • In the interference theory, the cancellation of noise in one point leads to doubling noise elsewhere. Global energy conservation.

• But in the more general case: reveals that secondary sources can absorb the primary energy: the energy transfer is then to be accurately investigated... (see later chapters...)
References


• M. Rossi, Collection “Electricité” - Audio, PPUR, Lausanne 2007


• D. Guicking, Patents on Active Control of Sound and Vibration – an overview, edited by the author, Göttingen 2005