

Active control of sound in a small single engine aircraft cabin with virtual error sensors

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Abstract

The harmful effects of aircraft noise, with respect to both comfort and occupational health, have long since been recognised, with many examples of sound control now implemented in commercial aircraft. However, the single engine light aircraft cabin is still an extremely noisy environment, which apparently has been side-lined by both cost and weight constraints, especially with respect to low frequency sound reduction. Consequently, pilots and passengers of these aircraft are still exposed to potentially damaging noise levels and hearing damage can only be avoided by the proper use of ear defenders. Minimisation of the noise around the occupants of the aircraft reduces the dependency of personal ear defenders and is conducive to a more comfortable, hygienic and less stressful environment. This thesis describes the basis of a theoretical and experimental project, directed at the design and evaluation of a practical active noise control (ANC) system suitable for a single engine light aircraft.

Results from initial experiments conducted in a single engine aircraft demonstrated the viability of ANC for this application. However, the extreme noise, the highly damped cabin, the multiple tone excitation, the severe weight limitations and the requirement of air worthiness certification severely complicated the problem of achieving noise reduction throughout the entire aircraft cabin. Compromising the objective to only achieving local control around the occupants still presented difficulties because the region of attenuated noise around the error sensors was so small that a nearby observer experienced no sound level reduction whatsoever.

The objective was therefore to move the control zone away from the error sensor and place a broad envelope of noise reduction immediately around the occupant's head, through the use of "virtual sensors", thus creating the *perception* of global noise control.

While "virtual sensors" are not new (Garcia-Bonito et al. (1996)), they are currently limited to acoustic pressure estimation (virtual microphones) via the initial measurement of an observer / sensor transfer function. In this research, new virtual sensor algorithms have been developed to:

1. minimise the sound level at the observer location
2. broaden the control region,
3. adapt to any physical system changes and
4. produce a control zone that may ultimately follow an observer's head

The performance of the virtual sensors were evaluated both analytically and experimentally in progressively more complex environments to identify their capabilities and limitations. It was found that the use of virtual sensors would, in general, attenuate the noise at the observer location more effectively than when using conventional remotely placed error sensors. Such a control strategy was considered to be ideal for a light single engine aircraft, because it would only require small light speakers (possibly fitted into a head-rest) to achieve a broad control zone that envelopes the region around the occupants' heads.

Statement of originality

To the best of my knowledge, except where otherwise referenced and cited, everything that is presented in this thesis is my own original work and has not been presented previously for the award of any other degree or diploma in any University. If accepted for the award of the degree of Ph.D. in Mechanical Engineering, I consent that this thesis be made available for loan and photocopying.

Colin D. Kestell.

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