**Active Control of Noise and Vibration, Second Edition**

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In the preface to the first edition (1997) of this work, the authors (Hansen and Snyder) made a case for meeting the goal of "including the most recent theoretical and practical developments" pertaining to the fast growing field of active control of sound and vibration, and they bolstered the argument by mentioning that, at that time, the number of published research papers has been doubling every year over a decade and that "each year more researchers [were] becoming involved in this fascinating subject." The authors could have produced great work by simply concentrating on the most current developments in the field but they also wanted to ensure that the fundamental mathematical and physical principles associated with active noise and vibration control (ANVC) were covered in great depth, as these could be expected to remain time-invariant. The result was a tome of 1288 pages, which was praised by experts as a superb reference when dealing with the various topics associated with ANVC.

The second edition (2011) added three extra authors and quite a few extra pages (1528 pages plus 9 pages for the index) but the goal remained the same. The differences between the editions are the in-depth coverage of algorithms, hardware options for digital signal processing, as well as a broad (and yet focused) look at specific applications. What has not changed is the level of depth in the treatment of the topics, the ample derivations whenever they are required to ease the comprehension of the material, the clarity of the tables and figures, and the outstanding layout of the text.

Chapter 1 ("Background") provides a refreshing look at applications of ANVC from the perspective of how many patents worldwide have been applied for since 1987. Starting with less than five in 1987, the curve goes up steadily until 2007 where the aggregate of applications exceeds 250, but then it falls drastically to less than 80 worldwide, with just a handful of applications from the US and Korea, the two leaders in the field. Could this be showing that the Hansen and Snyder were prescient, when 14 years before, they wrote the following in the preface to the first edition?

> So far, it seems that lawyers and judges have made more money from active control than any engineering company and they do not even own any patents! It is also of interest to ponder upon the number of patents which are granted that closely describe an aspect of active noise and vibration control which has been patented previously. All we can do here is try to appeal to some sense of reason as the results of too much litigation of this type will stifle research, slow down new product development and create a wealthy legal profession, all of which we would be better off without.

The chapter closes with a very concise and precise overview of the fundamentals of ANVC that apply to all the industry sectors identified by the authors. Materials from this portion could even be used to create the foundation to an "executive summary" for readers who have a reasonable grasp of general engineering control issues.

Chapter 2 delves deeply (173 pages) into the "Foundations of Acoustics and Vibration" and it is a full text by itself, suitable for upper-undergraduate and graduate reference work. The derivations are clear (thanks to examples) and almost 40 pages are dedicated to sound intensity and sound power, with an emphasis on structure-borne vibrational energy.

Chapters 3 and 4 ("Spectral Analysis" and "Modal Analysis") are also reference texts in their own right. Although the material may seem fundamental at first, it is very clear that the authors are always trying to present it in the context of ANVC. The result is a very "comforting guided walk" through the topic, always with excellent and easy-to-follow graphs and derivations.

Chapter 5 ("Modern Control Review") is a standard and clear text on control theory; however, the bar is being raised by the introduction of ANVC-specific elements such as forgetting factors and stochastic gradients. The reader is always brought back to ANVC through clear and effective examples. Chapter 6 takes over and immerses the reader *into* "Feed-Forward Control System Design" with an in-depth presentation (329 pages) of the topic, supported by detailed coverage of applicable algorithms. This is a "recipe book" for anyone looking at coding ANVC applications because the presentation of the various algorithms is accompanied by clear and well-referenced block diagrams.

Chapter 7 breaks from the theoretical fundamentals by dwelling into a very specific topic: "Control of Noise Propagating in Ducts" where the authors take the reader by the hand to guide her/him through the challenges associated with this application of ANVC. Once again, derivations are well-supported by clear figures and illustrations, and the 125 pages associated with the topic are by themselves a reference.

In Chapter 8, the authors take us from the confines of a duct into free space. "Active Control of Free-Field Sound Radiation" (159 pages) was my favorite chapter. The clarity

of the presentation is outstanding because the authors use an almost surgical approach to each topic. For example, section 8.6 "Reference Sensor Location Considerations" is broken down into three detailed subsections ("Problem Formulation," "Gain Margin," and "Phase Margin"), each using figures and derivations as needed. The clarity is simply outstanding.

Chapter 9 takes the reader back "indoors." We went into a duct (no fun), moved to the great outdoors (fun), and now we find ourselves in a middle-ground: planes, trains, and automobiles, these wonderful environments that travel with us but add noise along the way. "Control of Enclosed Sound Fields" is where vibration and airborne sound generation interact with each other to create some extremely complex issues as the spaces are relatively small (i.e. modal effects will yield large errors depending upon the placement of the sources and sensors) and the structural parameters of the enclosures add substantial complexity to the models. The chapter offers a nice range of references pertaining to ANVC applications in propeller-driven aircrafts and automobile.

Chapters 10 and 11 ("Feed-Forward Control of Vibration in Beams and Plates" and "Feedback Control of Flexible Structures") take the reader back to Chapter 6 with applications specific to solid 1-D and 2-D environments. Once again, the presentation of the materials is balanced between solidly referenced presentation of foundation material, derivation as needed, and examples.

Chapter 12 is a wonderful 136-page text on "Vibration Isolation" and this comes as no surprise considering Hansen's background and past writings on the topic. It is clear and perfectly organized, and it raises the complexity associated with the topic, especially when it comes to the implementation of effective models. The references are outstanding.

Chapter 13 ("Control System Implementation") brings a welcome "break" in terms of complexity associated with foundational material. My first impression was that this chapter should have been placed earlier in the tome, but then I realized that this may have been the choice of clever authors and editors. It works where it is because over the course of only 26 pages, the chapter brings back fundamentals in a refreshing fashion. It works so leave it there!

Chapter 14 deals with "Sound Sources and Sound Sensors" and it is a very good presentation of the relevant parameters and variables associated with loudspeakers and microphones in the context of ANVC. The authors did an excellent job on covering the directionality parameters associated with both transducers and the references are superb.

Following in the tradition of "airborne noise first, then vibration", Chapter 15 deals with "Vibration Sources and Vibration Sensors" and it echoes the model of the previous chapter: fundamentals are clearly presented with excellent figures and well-laid-out text, comments are focused and effective, and most impressive are the depth and breadth of references at the time of the writing.

To say that the 2nd edition of *Active Control of Noise and Vibration* is anything less than the reference in the topic of ANVC should be considered a crime (OK, OK, a misdemeanor). Some may even raise the question that the work was first published in 2011 (my review copy was dated 2013), so is there anything newer out there? The answer is "not really." Yes, there are a few more recent entries in very specialized areas (aircraft cabin noise and smart materials actuators), but the fact is that there is not one work that is as comprehensive and detailed as this one in the realm of ANVC. Anyone considering fundamental or applied research work in this field must take the plunge and buy this outstanding reference.

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