

Contents

<i>Preface</i>	xii
<i>Nomenclature</i>	xv
1 Aircraft Noise Control	1
1.1 Introduction	1
1.2 Active Noise Control and Active Structural Acoustic Control	7
1.2.1 Active noise control applications in aircraft	9
1.3 Book Overview	12
2 Fundamentals in Structural Acoustics	17
2.1 Introduction	17
2.2 Metrics of Sound Transmission	19
2.2.1 Sound pressure level	20
2.2.2 Sound insertion loss	21
2.2.3 Sound transmission loss	22
2.3 Transmission Loss Experiments	23
2.4 Experimental Modal Analysis	25
2.4.1 Basics in structural dynamics	26
2.4.2 Modal parameter estimation algorithms	28
2.5 The Acoustic Wave Equation and the Helmholtz Equation	29
2.5.1 The inhomogeneous wave equation	31
2.5.2 The solution to the inhomogeneous wave equation	31

2.5.3	Free space sound radiation	33
2.5.4	The Kirchoff-Helmholtz integral equation	34
2.6	Sound Radiation from Vibrating Flat Panels	34
2.6.1	Sound power radiation	37
2.6.2	Elemental radiators	39
2.6.3	Radiation modes	41
2.6.4	Sound radiation efficiency	42
2.7	Finite Element Method for Interior Problems	44
2.8	Coupled FE Formulation for Interior Vibro-Acoustic Systems	49
2.9	Summary	51
3	Transmission of Sound through Multiple Partitions	53
3.1	Introduction	53
3.2	Analytical Modelling of Multi-Panel Partitions	55
3.2.1	Infinite panels	55
3.2.2	Modal coupling theory	59
3.2.3	Structure-acoustic modal coupling in triple-panel partitions	63
3.3	Sound Transmission Through Infinite Triple Partitions	69
3.3.1	Analysis of the derived equations	73
3.4	Sound Transmission Simulation	79
3.4.1	Diffuse acoustic excitation model	81
3.4.2	Benchmark examples	82
3.5	Summary	91
4	Adaptive Control of Sound Radiation	93
4.1	Introduction	93
4.2	Control of Sound Radiation by Structural Actuators	97
4.3	Control Strategies	101
4.3.1	Feedforward control	101
4.3.2	Feedback control	102
4.3.3	Feedforward vs. feedback control	104
4.4	Steepest-Descent Algorithm	105
4.5	Adaptive Digital Filters	107
4.6	Filtered-X LMS Algorithm	110
4.7	Multi-Channel Adaptive Algorithms	111

4.8	Experimental System Identification	111
4.9	Numerical Simulations	118
4.9.1	Harmonic primary noise	122
4.9.2	Random primary noise	125
4.9.3	Narrow-band primary noise	130
4.10	Summary	135
5	Noise-Reducing Smart Windows	139
5.1	Introduction	139
5.2	Literature Survey	143
5.2.1	Control of sound transmission through multi-wall partitions: panel control	146
5.2.2	Control of sound transmission through multi-wall partitions: cavity control	148
5.3	Piezoelectricity	151
5.4	Smart Window Design	156
5.4.1	Scope	158
5.4.2	Numerical modelling	160
5.4.3	Structural control actuators	165
5.5	Smart Window Test-Bed	172
5.5.1	Experimental modal analysis	174
5.5.2	Control actuators set-up	177
5.6	Transmission Loss Predictions	186
5.7	Summary	187
6	Active Noise Control Experiments	189
6.1	Introduction	189
6.2	Experimental Set-Up	191
6.3	Instrumentation	195
6.4	Imperfections in the Experimental Set-Up	196
6.4.1	Coupled vibro-acoustic model of the sending room	198
6.4.2	Experimental validation	202
6.5	Real-Time DSP Implementation of Active Noise Control	206
6.5.1	The real-time controller	207
6.5.2	Experimental results	211

6.6	Sound Intensity Measurements	231
6.6.1	Experimental results	233
6.7	Passenger Comfort Estimation	239
6.7.1	Subjective noise perception	239
6.7.2	Virtual Passenger Model	241
6.8	Summary	243
A	Benchmark Examples	245
A.1	Introduction	245
A.2	Laminar Piezoelectric Sensor	245
A.3	Cantilever Piezoelectric Plate	247
A.3.1	Static analysis	247
A.3.2	Dynamic analysis	249
B	Sound Power Simulations	253
B.1	Radiation Efficiency	253
B.2	Radiation Efficiency of the Window Test-Bed	255
C	Preliminary Experimental Studies	259
<i>Bibliography</i>		263
<i>Index</i>		279