

Contents:

1	Introduction.....	1
1.1	Motivation.....	1
1.2	Research Objectives.....	3
1.3	Approach.....	3
1.4	Outline.....	4
2	Background.....	6
2.1	Piezoelectric Background and Theory.....	6
2.2	Literature Review.....	9
2.2.1	Control of Structural Vibrations with Smart Materials.....	10
2.2.2	Passive and Semi-Active Control Strategies for Vibration Suppression.....	11
2.2.3	Active Control Strategies for Vibration Suppression.....	15
2.3	Shunt Circuit Design.....	21
2.4	Shunt Circuit Tuning Method.....	23
2.5	PPF Controller Design.....	24
2.5.1	Digital Positive Position Feedback.....	25
2.5.2	PPF Controller Tuning Method.....	26
2.6	Summary.....	27
3	Experimental Setup.....	29
3.1	Test Stand Design.....	29
3.1.1	Bottom Box Enclosure.....	31
3.1.2	Top Box Enclosure.....	33
3.1.3	Excitation Frame.....	34
3.1.4	Electromagnetic Shaker.....	37
3.1.5	Total Test Stand Assembly.....	37
3.2	Test Setup.....	38
3.2.1	Test Plate Setup.....	39
3.2.2	Transducer Arrangement for RLC Shunt Circuit Tests.....	40
3.2.3	Transducer Arrangement for Active PZT Tests.....	41

	3.2.4	Data Acquisition System.....	41
	3.3	Validation Tests.....	43
	3.3.1	Vibration Response Validation.....	43
	3.3.2	Repeatability and Linearity.....	46
	3.4	Summary.....	48
4		Experimental Test Results.....	49
	4.1	Smart Test Plate Development.....	49
	4.1.1	Baseline Test Results.....	49
	4.1.1.1	Test Plate Resonant Frequencies.....	50
	4.1.1.2	Test Plate Mode Shapes.....	52
	4.1.2	PZT Placement and Application.....	54
	4.1.3	Smart Plate Test Setup for Shunted PZT Tests.....	58
	4.1.4	Smart Plate Test Setup for Active PZT Tests.....	59
	4.2	Shunted PZT Testing Procedure and Results.....	62
	4.3	Positive Position Feedback (PPF).....	65
	4.3.1	PPF Filter Frequency Selection.....	66
	4.3.2	PPF Filter Damping and Sampling Time Selection.....	67
	4.3.3	PPF Filter Gain Selection.....	68
	4.4	Active Control Testing and Results.....	69
	4.4.1	dSPACE and Simulink Block Diagram.....	69
	4.4.2	Active PZT Test Results.....	72
	4.5	Impedance-based Health Monitoring Technique.....	80
	4.5.1	Impedance Method.....	80
	4.5.2	Implementing the NDE in the Test Setup.....	82
	4.5.3	Health Monitoring Results.....	83
	4.6	Vibration Testing Under Varied Temperatures.....	86
	4.6.1	Test Setup.....	86
	4.6.2	Results.....	84
	4.7	Summary.....	90
5		Comparison Between Shunted PZTs and Active Control with Positive Position Feedback.....	91

5.1	Results for Comparison.....	91
5.2	Narrowband Frequency Reductions.....	94
5.3	Broadband Frequency Reductions.....	97
5.4	Comparison: Actuator Size to Performance.....	102
5.5	Summary.....	109
6	Conclusions.....	110
6.1	Summary.....	110
6.2	Recommendations for Future Research.....	112
	References.....	114
	Appendix A (Matlab File for Calculating Resistor Values).....	A1
	Appendix B (Fine-Tuning the Shunt Resistors with Testing).....	B1
	Appendix C (Matlab File for Building PPF Controller).....	C1
	Appendix D (Information on Piezoelectric Materials).....	D1
	Vita.....	