CONTENTS

Foreword		۷
Selected Bit	oliography (books)	ix
Chapter I.	EQUATIONS OF NONLINEAR THERMOPIEZOELECTRICITY	
1.0	Introduction	1
1.1	Motion and Deformation of a Solid A. Deformation and convection B. Polar decomposition C. Infinitesimal strains D. Strain rates E. Singular surfaces	4 7 7 8 11
1.2	Balance Laws A. Mechanical forces B. Electric forces C. Maxwell's equations in the quasistatic approximation D. Mass and momentum balance laws E. Energy and thermodynamics	12 12 12 13 14 15
1.3	Constitutive Equations	17
1.4	Propagation Equations in the Reference Frame A. Piola-Kirchhoff stress B. Material electric field C. Expressions in terms of mechanical displacements	20 20 21
	 and electric potential D. Simple special cases Classical piezoelectricity, classical electrostruction, biased piezoelectricity 	22 24 24
	electrostriction, plased plezoelectricity	24

xi

Append	lices of	Chapter I		
	I.A.1	Material Coefficients for Various Materials (Crystals)	26	
	I.A.2 1.	Isotropic and Cubic Materials Murnaghan's isotropic elasticity	34 34	
	۲. ۲	Longitudinal wave generation by transverse waves Propagation equations for nonlinear cubic	36	
	5.	crystals	37	
Chapter II.	BULK WA	VES FOR ONE-DIMENSIONAL MOTIONS		
2.1	One-dimensional Linear and Nonlinear Motions A. Linear equation B. Nonlinear equation			
2.2	Solutio Simpl	n by Means of the Method of Characteristics: e Waves etc.	45	
	A. Cha B. Nea	racteristics of the nonlinear wave equation r-field solution	45 49	
	C. Cas D. Far	e of a sinusoidal excitation -field solution	50 51	
2.3	Solutio A. Per	ns by Means of Approximation Methods turbation method of Poincaré (straightforward	53	
	e B. The	xpansion) multiple-scale technique	53 54	
	C. The	method of coupled-amplitude equations	56	
2.4	Nonline	ar Vibrations of Resonators	59 59	
	B. Exp	erimental results concerning quartz	62	
	C. Int	ermodulation	65	
Appen	dices of	Chapter II		
	II.A.1	Nonlinear Coupling between Crystal and Predeformation	69	
	1.	Linearization of the modified elasticity coefficients	72	
	2.	Solution by means of a polynomial approximation	73	
	3.	Solution by means of a perturbation method	74	
	II.A.2	A Simple Nonlinear Hyperbolic Equation for Elastic Waves	76	
	1.	Straightforward expansion and harmonic	76	
	2.	The multiple-scale technique	78	
	3.	steepening of an initially sinusoidal strain wave	81	

xii

	4. 5.	Forced excitations (Problem treated by way of exercise) The Galerkin method	84 84
	11.A.3 1. 2. 3.	Compensation between Nonlinearity and Dispersion A lattice model, the Boussinesq equation Solitary waves Korteweg-de Vries equation	89 89 92 93
	II.A.4	Integration of Coupled-Amplitude Equations	96
	II.A.5	Piezoelectrically Excited Resonators	98
Chapter III.	RAYLEIG	H SURFACE WAVES	

104 3.0 Introduction 3.1 Excitation and Detection by Means of Interdigitated Transducers 105 A. Potential distribution created by the 106 transducer B. Emitted elastic waves 108 C. Detection 112 3.2 Nonlinear Propagation 114 A. Near-field solution, anisochronism of 114 surface waves B. Far-field solution (Schematic in 127 Table III.3) Appendices of Chapter III III.A.1 The Classical Rayleigh Wave 134 III.A.2 Nonlinear Coupling between Crystal and Predeformation for Surface Waves 142 Chapter IV. AN EXAMPLE OF APPLICATION: THE WAVE-GUIDE 146 CONVOLVER 146 4.1 Working Principle of the Convolver 150 4.2 Variational Method 151 4.3 Linear and Nonlinear Theory A. Linear theory 152 B. Nonlinear study 154 4.4 Numerical Results 158

xiii