

Contents

1. Introduction. By A. A. Oliner (With 2 Figures)	1
1.1 An Overview of the Field	2
1.2 The Organization of This Book	5
References	11
2. Types and Properties of Surface Waves. By G. W. Farnell (With 26 Figures)	13
2.1 The Wave Equations	14
2.2 Surface Wave Characteristics	17
2.2.1 Isotropic Substrates	20
2.3 Plate Modes	22
2.4 Anisotropy	24
2.4.1 Basal Plane of Cubic Crystals	26
2.4.2 (110) Plane of Cubic Crystals	29
2.4.3 (111) Plane of Cubic Crystals	30
2.5 Power Flow	31
2.6 Piezoelectricity	35
2.6.1 Stiffened Rayleigh Waves	36
2.6.2 Bleustein-Gulyaev Wave	39
2.7 Propagation in Thin Layers	41
2.7.1 Rayleigh-Type Waves	41
2.7.2 Love Waves	47
2.7.3 Anisotropy	48
2.8 Reflections	49
2.9 Diffraction	54
References	59
3. Principles of Surface Wave Filter Design. By H. M. Gerard (With 26 Figures)	61
3.1 Historical Background	61
3.1.1 The Interdigital (ID) Transducer	62
3.1.2 The Surface Wave Filter	62
3.2 Basic Design Principles	64
3.2.1 Review of General Fourier Synthesis (Transversal Filter Theory)	64

3.2.2	The Interdigital (ID) Transducer as a Transversal Filter . . .	66
3.2.3	Surface Wave Filter Design Prescription	68
3.3	Equivalent Circuit Model	72
3.3.1	The Crossed-Field Model	72
3.3.2	Delta Function Representation	76
3.3.3	Acoustic/Electric Transfer Function	76
3.3.4	The Apodization Law	80
3.4	Transducer Performance Characteristics	81
3.4.1	Design Trade-Off Relationships	81
3.4.2	Filter Error Characteristics	86
3.4.3	Other Trade-Offs	88
3.5	Summary and Examples	89
3.5.1	Examples	91
	Appendices	93
	References	96

4. Fundamentals of Signal Processing Devices. By E. A. Ash

(With 54 Figures)	97
4.1	Introduction	97
4.2	Delay Lines	99
4.2.1	Insertion and Spurious Signals	99
4.2.2	Delay Line Bandwidth	101
4.2.3	Temperature Stability	102
4.2.4	Long Delay Lines	103
4.3	Acoustic Surface Wave Resonators	107
4.3.1	Surface Wave Reflectors and Transmission Cavities	109
4.3.2	The Loaded Surface Wave Resonator	112
4.4	SAW Delay Line Oscillators	117
4.4.1	Mode Control for Single-Frequency Operation	118
4.4.2	Oscillator Stability	119
4.4.3	Tuning and FM Capability	124
4.4.4	Multifrequency Operation	125
4.5	Coded "Time-Domain" Structures	128
4.5.1	Pulse Compression Filters for Chirp Radar	129
4.5.2	Phase-Coded Transducers	137
4.5.3	Signal Processing and Linear Chirp Filters	143
4.6	Nonlinear Signal Processing	149
4.6.1	The Piezoelectric Convolver	153
4.6.2	Acoustoelectric Nonlinear Signal Processing	158
4.6.3	Acoustoelectric Processing with Inherent Memory	163
4.7	Multipoint Acoustic Devices	167
4.7.1	Multistrip Coupler — Basis of Operation	169
4.7.2	Full Transfer Multistrip Coupler	173
4.7.3	Partial Transfer Multistrip Coupler	174

4.7.4	Asymmetrical Multistrip Coupler for Beam Compression	177
4.7.5	Acoustic Surface Wave Multiplexers	178
References		182
5.	Waveguides for Surface Waves. By A. A. Oliner (With 15 Figures)	187
5.1	Background and General Considerations	187
5.1.1	Why Waveguides?	187
5.1.2	Types of Waveguide	189
5.2	Flat Overlay Waveguides	192
5.2.1	The Strip Waveguide	192
5.2.2	The Shorting-Strip (or $\Delta v/v$) Waveguide	197
5.2.3	The Slot Waveguide	198
5.3	Topographic Waveguides	200
5.3.1	The Antisymmetric, or Flexural, Mode of the Rectangular Ridge Waveguide	201
5.3.2	The Symmetric, or Pseudo-Rayleigh, Mode of the Rectangular Ridge Waveguide	204
5.3.3	Waves Guided by a Plate Edge	206
5.3.4	The Wedge Waveguide	211
5.4	Other Types of Waveguide	213
5.4.1	In-Diffused Waveguides	213
5.4.2	Rectangular Overlay Waveguides	214
5.4.3	Circular Fiber Waveguides	215
5.5	Summary and Conclusions	217
5.5.1	Summary of Waveguide Properties	217
5.5.2	Applications: Actual and Potential	219
References		221
6.	Materials and Their Influence on Performance. By A. J. Slobodnik, Jr. (With 67 Figures)	225
6.1	The Laser Probe as a Basic Measurement Tool	225
6.1.1	Description of the Laser Probe	226
6.1.2	Laser Probe Applications and Introduction to Attenuation, Beam Steering, and Diffraction	228
6.2	Propagation Loss	229
6.2.1	Room-Temperature Attenuation	230
6.2.2	Temperature Dependence of Attenuation	232
6.2.3	Air and Gas Loading	237
6.2.4	Frequency and Material Dependence of Propagation Loss	242
6.2.5	The Effect of Surface Quality on Attenuation	244
6.3	Diffraction and Beam Steering	251
6.3.1	Review of the Theories	251
6.3.2	Limitations to the Parabolic Theory	254
6.3.3	Limitations in Using the Angular Spectrum of Waves Theory	257

6.3.4 Material Dependence of Diffraction and Beam Steering . . . 259

6.3.5 Minimal Diffraction Cuts 267

6.4 Optimum Transducer Design in the Presence of Material Limitations 273

6.5 Diffraction Compensation in Periodic SAW Filters 279

6.5.1 Introduction 279

6.5.2 Basic Theory 280

6.5.3 Correction for Diffraction 281

6.5.4 Experimental Investigation 283

6.6 Coupling Efficiency and Temperature Coefficients 285

6.6.1 Introduction 285

6.6.2 Temperature Coefficient Computations 287

6.6.3 Temperature Coefficient, Coupling Trade-Offs, and Conclusions 289

6.7 Nonlinear Effects 289

6.7.1 Introduction 289

6.7.2 Nonlinear Effects in the Fundamental Frequency Wave . . . 290

6.7.3 Harmonic Generation 290

6.7.4 Detailed Power Dependence 294

6.7.5 Mixing 298

6.7.6 Summary and Conclusions Concerning Nonlinear Effects . . 298

6.8 Summary and Properties of Materials 298

References 301

7. Fabrication Techniques for Surface Wave Devices. By H. I. Smith (With 8 Figures) 305

7.1 Techniques for Exposing Patterns in Polymer Films 305

7.1.1 Optical Projection Printing 306

7.1.2 Conventional Contact Printing 306

7.1.3 Conformable-Photomask Contact Printing 307

7.1.4 Holographic Recording 310

7.1.5 Scanning Electron Beam Lithography 311

7.1.6 Projection Electron Lithography 313

7.1.7 X-Ray Lithography 314

7.2 Techniques for Patterning the Substrate 314

7.2.1 Aqueous Chemical Etching 316

7.2.2 Plasma Etching 317

7.2.3 Ion Bombardment Etching 318

7.2.4 Doping 320

7.2.5 The Liftoff Technique 320

7.3 Conclusions 321

References 322

Subject Index 325