



Reinhold Noé

Essentials of Modern Optical Fiber Communication



Springer

Contents

1	Introduction.....	1
2	Optical Waves in Fibers and Components.....	3
2.1	Electromagnetic Fundamentals.....	3
2.1.1	Maxwell's Equations	3
2.1.2	Boundary Conditions	6
2.1.3	Wave Equation.....	8
2.1.4	Homogeneous Plane Wave in Isotropic Homogeneous Medium.....	9
2.1.5	Power and Energy	13
2.2	Dielectric Waveguides.....	18
2.2.1	Dielectric Slab Waveguide	18
2.2.2	Cylindrical Dielectric Waveguide.....	26
2.3	Polarization.....	40
2.3.1	Representing States-of-Polarization.....	40
2.3.2	Anisotropy, Index Ellipsoid	45
2.3.3	Jones Matrices, Müller Matrices	52
2.3.4	Monochromatic Polarization Transmission	64
2.3.5	Polarization Mode Dispersion.....	71
2.4	Linear Electrooptic Effect.....	80
2.4.1	Phase Modulation	80
2.4.2	Soleil-Babinet Compensator	84
2.5	Mode Coupling	88
2.5.1	Mode Orthogonality	88
2.5.2	Mode Coupling Theory.....	93
2.5.3	Codirectional Coupling in Anisotropic Waveguide	95
2.5.4	Codirectional Coupling of Two Waveguide	100
2.5.5	Periodic Codirectional Coupling.....	106
2.5.6	Periodic Counterdirectional Coupling	110
2.6	Mode Coupling for Dispersion Compensation	114

2.6.1	Mode Coupling and Differential Group Delay Profiles	114
2.6.2	Polarization Mode Dispersion Compensation.....	118
2.6.3	Chromatic Dispersion Compensation	123
2.6.4	Fourier Expansion of Mode Coupling	130
2.7	Nonlinearities in Optical Fibers	136
2.7.1	Self Phase Modulation	136
2.7.2	Cross Phase Modulation	146
2.7.3	Four Wave Mixing	148
3	Optical Fiber Communication Systems.....	153
3.1	Standard Systems with Direct Optical Detection.....	153
3.1.1	Signal Generation, Transmission, and Detection	153
3.1.2	Regeneration of Binary Signals	165
3.1.3	Circuits and Clock Recovery	174
3.2	Optical Amplifiers in Systems with Direct Detection.....	182
3.2.1	Photon Distributions	182
3.2.2	Noise Figure.....	187
3.2.3	Intensity Distribution	190
3.2.4	Receivers for Amplitude Shift Keying.....	195
3.2.5	Receivers for Differential Phase Shift Keying.....	200
3.3	Coherent Optical Transmission	212
3.3.1	Receivers with Synchronous Demodulation	212
3.3.2	Carrier Recovery	221
3.3.3	Receivers with Asynchronous Demodulation.....	231
3.3.4	Laser Linewidth Requirements	236
3.3.5	Digital Coherent QPSK Receiver	243
3.3.6	Digital Coherent QAM Receiver	255
References	275	
Index.....	281	