DEPARTMENTS

BOOK REVIEWS

Fundamentals of Optical Fiber Communications

Wim Van Etten and Jan Van der Plaats, 415 pages, index, references, appendices, problems. ISBN 0-13-717513-2. Prentice Hall International, 66 Wood Lene End, Hemel Hemstead, Hertfordshire HP24RG (1991) $80 hardbound.

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This book is a compilation from courses on fiber optic communications taught by the authors to undergraduate and postgraduate students at Eindhoven University of Technology. Therefore, the book may serve as a comprehensive introduction to this field and even provide nonspecialists with an excellent opportunity for study both in system components (fibers, lasers, detectors, etc.) and in fiber optic systems in general (transfer functions, noises, coherent communication principles). Numerous illustrations (239 figures) and problems (96) help achieve clear understanding of the material given. In addition, the book is not only a popular textbook, but consistently presents the contemporary state of the art in a new field of applied physics.

The book consists of 16 chapters and 6 appendices. The introduction briefly touches on the highlights of subjects elaborated further on. Three groups of issues should be mentioned, namely, light propagation in fibers and fiber optic elements (Chaps. 2 through 7, 12, and 15), light sources and detectors (Chaps. 8, 9, and 13), and general fiber optic systems analysis (Chaps. 10, 12, 14, and 16). The appendices contain some auxiliary data on Bessell functions, Poisson processes, and the values of the main physical constants. Also, the transmission of modulated signals via bandpass systems and free space is considered.

The second chapter contains a traditional description of a light field in a slab waveguide. The concepts of the propagation constants and cutoff frequency are introduced.

Chapter 3 presents a theoretical investigation of step-index fibers. The wave equation is solved, and the properties of transverse and hybrid modes are analyzed. Finally, the light field in a waveguide is treated under the linearly polarized modes approximation. This treatment radically simplifies the problem and at the same time is well suited for most real fibers.

Chapter 4 supplements Chap. 3 with attention focused on dispersion phenomena in step-index fibers. Phase and group delays are defined. Simple examples illustrate the consequences of the phase (group) velocity-wavelength relationship. Finally, three main mechanisms responsible for dispersion are discussed: material, waveguide, and multimode dispersion.

Chapter 5 deals with the propagation of light in a single-mode waveguide, in particular the basic mode light field distribution. Numerous illustrations give a clear notion of the behavior of light in a fiber. Dispersion in single-mode waveguides is also taken into consideration, especially the material dispersion of quartz glasses doped by GeO_2. The possibility of manufacturing fibers with pregiven dispersion is also briefly discussed.

Chapters 6 and 7 are devoted to multimode graded index fibers. The ray model is applied for evaluation of the trajectories of light beams inside parabolic and self-focusing fibers. A group of issues that center around the aperture of the waveguide is analyzed. Chapter 7 covers dispersion in graded index fibers. Both ray and mode models are implemented.

Though Chapters 2 through 7 pay essential attention to the physical content of the phenomena involved and utilize good mathematics, the analysis is restricted to the linear approximation only. However, current trends indicate a rapid growth of interest in nonlinear phenomena. Therefore, one may regret the lack of commentary on the applications of optical solitons to communication and on stimulated Brillouin scattering, stimulated Raman scattering, and the Kerr effect. These phenomena may not only limit the possibilities of fiber optic communication systems, but serve for their improvement as well.

Chapters 8 and 9 treat optoelectronic and electro-optical devices widely used in fiber optic communication systems as light sources and receivers. Chapter 8 includes a short survey of the main types of light-emitting diodes (LEDs, both surface emitter and edge emitter), laser diodes (LD), and photodiodes (PD). Semiconductor LEDs that ensure operation in the 800- to 900-nm and 1000- to 1300-nm ranges are considered. The concept of the coherence function provides the basis for the investigation of the spatial and spectral characteristics of LEDs. A special section contains a description of the main types of LDs—double channel planar buried heterostructure LDs and distributed feedback LDs. The comparison of LEDs and LDs reveals the spheres of their primary application. The choice is strongly affected by the modulation bandwidth required and the length of the communication link. The p-i-n photodiode and internal gain photodiode principles are also analyzed. Recommendations on Ge- and Si-photodiode employment, based on their quantum efficiency, are given.

A simple version of laser diode theory is described in Chap. 9. The theory utilizes a set of rate equations supplemented by a number of simplifying assumptions. These equations yield the laser condition and allow the stationary regime to be investigated thoroughly. The possibility of modulation of a laser by small signals is also analyzed.

Chapter 10 assumes that the communication system consists of a directly modulated light source, a fiber (single or multimode), and a photodiode. The transfer function and temporal response are obtained. Three special cases are of particular interest: coherent light sources, partially coherent light sources, and polychromatic sources. These cases can be associated with single-mode LDs, single-mode LEDs, and multilongitudinal-mode LDs, respectively. Other cases involved are strong and negligible mode coupling.

The previous sections provide the foundation for Chap. 11, which introduces the application of wave theory to launching light from LEDs or LDs into a single-mode fiber. Single-mode fiber–fiber coupling and other practical problems that may reduce the efficiency of optical communication systems are considered. The same problems for multimode fibers are analyzed under the ray approximation. The concept of phased space, widely used when considering sources and detectors in geometrical optics, is introduced. The results of the chapter enable the estimation of losses in optical elements.

Chapters 12 and 13 cover the ultimate principles of photodetectors and their characteristics and approaches to the optimization of both analog and digital receivers. The peculiarities of the field that affect input stage and bipolar input stage receivers are considered in Chap. 12, with attention drawn to noise characteristics (equivalent circuits, statistics of noise, optimization, etc.).

Chapter 14 superficially touches upon the noise characteristics of all the elements that make up a communication system. Not only are light sources and detectors taken into consideration, but also the fiber itself. Signal-to-noise ratio reduction is mainly due to mode interference in multimode fibers.

Chapter 15 briefly covers fiber optic system components and system design. The central issues considered are the comparison of optical fibers and copper cables, splices and connectors, polarization-maintaining fibers, etc. Some aspects of communication systems in general are also discussed, such as repeater distance and line coding.

Finally, the last chapter deals with coherent fiber optic communication systems with phase and frequency modulation. The signal-to-noise ratio is analyzed, and confident PM or FM reception is shown to require much less powerful sources than AM reception. Possible approaches to coherent receivers are also discussed.

This book will be of much interest to a wide range of readers. First among them are postgraduate and undergraduate students and researchers not previously involved in the field. Those more experienced in the field also may easily find a number of useful remarks, problems, and mathematical data. The authors' style makes reading the book not only a useful occupation, but also a pleasant one.

Fiber Optic Sensors: An Introduction for Engineers and Scientists

Eric Udd, Ed., 476 pages, illus., index, references, Wiley Series in Pure and Applied Optics. ISBN 0-471-83007-0. John Wiley and Sons, New York (1991) $69.95 hardbound.

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Fiber optic sensors have been a popular research topic for the past 15 years, and they now are a fast-growing industry featuring numerous small start-up enterprises. Yet in some ways the technology is still a solution looking for a problem, as products that address large-dollar-volume markets on the horizon have not yet found their way into production.

This edited text covers the most important topics in the field, and the material is organized in a sensible manner. Chapter 1 is a brief but useful overview by the editor. The next four chapters are devoted to components used in the sensors; the following seven chapters are on transduction mechanisms and sensor configurations; and the last two chapters cover applications. Chapter 2 on optical fibers treats the theory of propagation in fibers and fabrication methods. Descriptive information and illustrations on LP modes, dispersion curves, and mode field distributions would have been useful additions here, as would references to recent review articles and books on fibers. Chapters 3 and 4 are reasonably useful discussions of light sources and photodetectors. Chapter 3 would have benefited from a more extensive treatment of semiconductor materials (GaAlAs and InGaAsP), short- and long-wavelength regions, and the merits of each. Light source reliability and low-frequency 1/f noise could also have been covered here. Recent literature references are sparse in both Chaps. 3 and 4. Chapter 5, by L. M. Johnson, is a nicely done overview of integrated optic modulators. The multifunction chip of Fig. 5.9 represents possibly the most important fiber sensor application of integrated optics at present.

The discussion of specific sensor configurations begins with a very readable discussion of several sensor types in Chap. 6, by G. L. Mitchell. Band-edge temperature sensors, encoder-based sensors, and Fabry-Perot sensors are covered here. Chapters 7 and 8, both by W. B. Spillman, Jr., are devoted to multimode grating and polarization sensors. These chapters are quite comprehensive, but discerning where these sensors might find practical application is difficult for the reader. Chapter 9, by E. Udd, covers the fiber gyro and other Sagnac sensors. This chapter, which discusses interferometric and resonator approaches to rotation rate measurement as well as signal processing schemes, is a highlight of the book. Chapter 10, by A. Dandridge, tells everything you would want to know about fiber-based Mach-Zehnder and Michelson interferometers—an excellent chapter! Chapter 11 on sensor multiplexing, by A. Kersey, and Chap. 12 on magnetic field sensors, by F. Buchholz, are also comprehensive. Both of these chapters would have benefited from a concluding assessment on which of the many approaches and configurations are likely to be of practical value and which are falling by the wayside.

Turning to applications, Chap. 13, by J. W. Berthold III, covers a wide range of industrial uses of fiber sensors. This chapter has my vote for the most down-to-earth chapter in the book and one of the most interesting and readable. Chapter 14, by E. Udd on smart structures, is a valuable introduction to an emerging application area of considerable interest in the engineering community.

In some respects, the book under review complements an earlier edited text in the field, *Optical Fiber Sensors: Principles and Components* (J. Dakin and B. Culshaw, Eds., Artech House, Boston, 1988, 2 vol.). Even though much overlap exists in the topics covered in these two books, the reader of both will benefit from points of view that are generally quite different. These texts are both highly recommended for engineers engaged in the development of fiber sensors and for engineers and scientists interested in applying them.

BOOKS RECEIVED

Introduction to Nonlinear Optical Effects in Molecules & Polymers, edited by Paras N. Prasad and David J. Williams. 307 pp., illus., references. ISBN 0-471-51562-0. John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875-1272 (1991) 49.95 hardbound. Covers basis and formulation of nonlinear optics, origin of microscopic nonlinearity in organic systems, bulk nonlinear optical susceptibility, second-order nonlinear optical processes, measurement techniques for second-order nonlinear optical effects, nonlinear optics in optical waveguides and fibers, device concepts, and issues and future directions.

Coherence, Amplification, and Quantum Effects in Semiconductor Lasers, edited by Yoshihisa Yamamoto. 646 pp., illus., references. ISBN 0-471-51249-4. John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875-1272 (1991) $74.95 hardbound. Covers line broadening of semiconductor lasers, modulation and noise spectra of complicated laser structures, frequency tunability, frequency modulation and spectral linewidth of complicated structure lasers, spectroscopy by semiconductor lasers, coherent detection using semiconductor lasers, traveling-wave semiconductor laser amplifiers, injection-locked semiconductor laser amplifiers, photon statistics and mode partition noise of semiconductor lasers, squeezed-state generation by semiconductor lasers, generation of photon-number-squeezed light by semiconductor incoherent light sources, and controlled spontaneous emission in microcavity semiconductor lasers.