

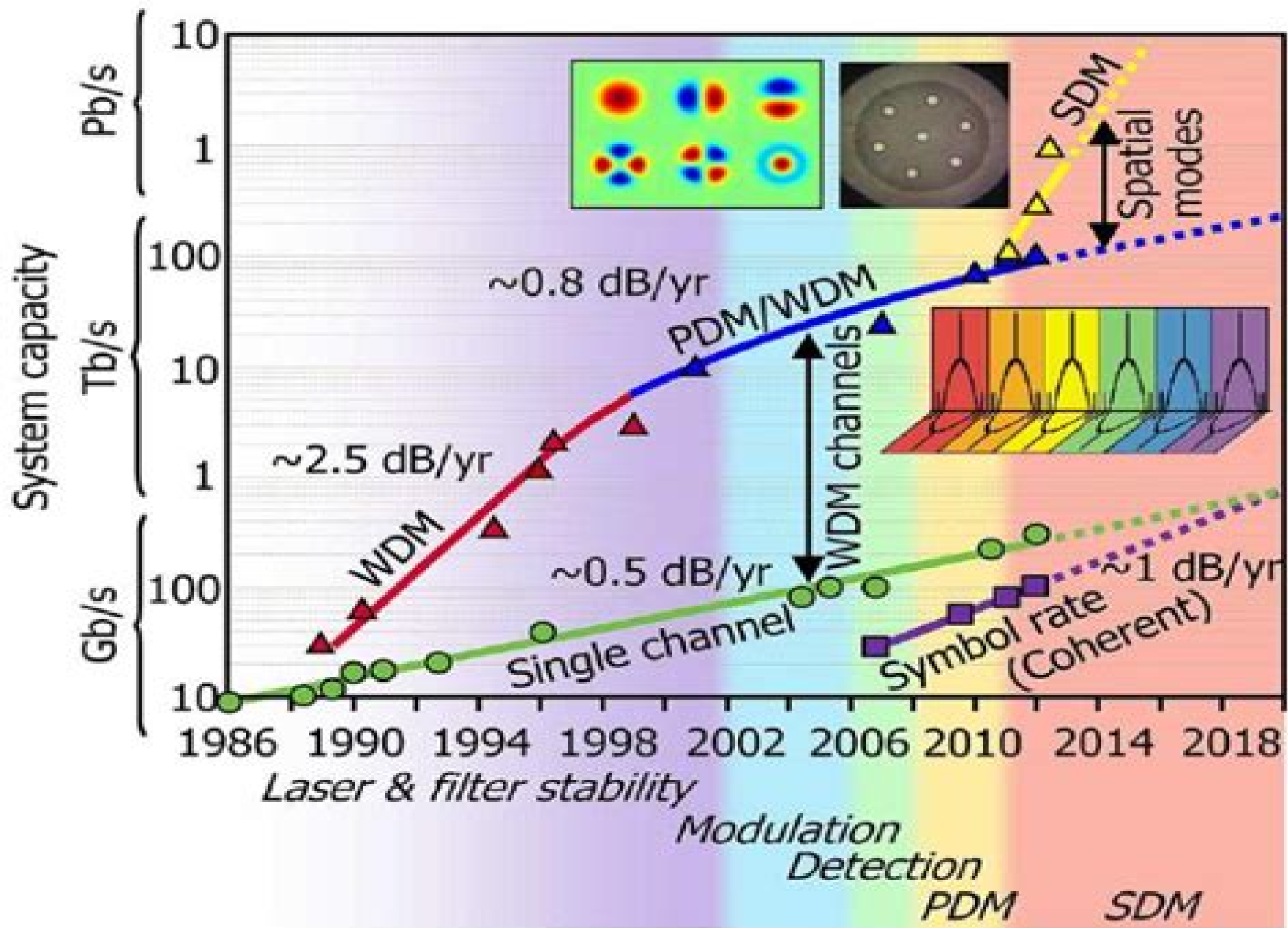


Fig. 1 Evolution of single channel capacity during the last two decades and

Advanced Digital Signal Processing In Coherent Optical Systems

Jianjun Yu,Xinying Li,Junwen Zhang



Advanced Digital Signal Processing In Coherent Optical Systems:

Advanced Digital Signal Processing for Next-generation Coherent Optical Communication Systems Meng Qiu, 2017

Coherent detection combined with digital signal processing DSP has been widely adopted in modern fiber optic transport for long haul and medium reach applications Compared with direct detection systems coherent communication systems can significantly improve the receiver sensitivity and increase the transmission capacity The ever increasing demand for greater transport network capacity necessitates continuous upgrade of future fiber transmission systems In such context novel advanced DSP schemes are necessary to satisfy the requirements of next generation coherent optical communication systems In this thesis we present several advanced DSP techniques to cope with both linear and nonlinear impairments in coherent optical communication systems with data rates of 100 Gb/s and beyond First two effective low complexity algorithms for carrier recovery in single carrier coherent systems are presented Specifically we describe a frequency offset FO tracking algorithm that can dynamically compensate the FO in intradyne coherent systems to avoid potential performance degradation caused by stochastic frequency drift of lasers In addition we demonstrate a format transparent carrier phase recovery CPR algorithm based on interleaved superscalar parallelization which can be economically implemented in practice because it can minimize the required pilot symbol overhead and buffer size in the superscalar parallelization structure Second we explore the digital subcarrier multiplexing SCM technique and discuss its benefits Specifically we employ SCM signals in a long haul transmission scenario to demonstrate the improved tolerance to both fiber nonlinearity and laser linewidth when the number of subcarriers is optimized Furthermore we explore the enhanced flexibility of the DSP design in SCM systems and propose a novel joint CPR algorithm for the correction of cycle slips CS Finally we conduct studies on a low cost solution for medium reach transmission namely the Stokes vector direct detection SV DD systems We demonstrate that the laser linewidth tolerance of SV DD systems is limited by equalization enhanced phase noise EEPN and verify that the EEPN induced performance degradation can be mitigated by a simple maximum likelihood ML phase recovery stage All the aforementioned DSP techniques have been demonstrated by simulations and experiments based on our leading edge coherent optical transmission testbed

Digital Signal Processing For High-speed Optical Communication Jianjun Yu, Xinying Li, Junwen Zhang, 2018-03-09

There is an increasing tendency to integrate optical communication with wireless communication to satisfy continuously emerging new data communication demands Thus optical wireless integrated access networks and transmission systems as well as LED based visible light communication are attracting ever increasing research interest Digital signal processing DSP is one new technology for optical transmission As such this book is designed to pave the way to the better understanding of the deployment of DSP in optical fiber communication systems Digital Signal Processing for High Speed Optical Communication covers a wide area of DSP topics in optical communications and describes state of the art digital signal processing techniques for high speed optical communication In this book numerous advanced

digital signal processing techniques aiming at the promotion of the capacity increase and performance improvement of optical or optical wireless communication systems and networks are presented and explained Coverage includes new technologies optical filter with MLSE and new pre coding and pre equalization applicable to single carrier and multi carrier direct detection and coherent detection optical commutation systems and networks Digital Coherent Optical Systems Darli Augusto de Arruda Mello,Fabio Aparecido Barbosa,2021-03-08 This textbook details the architecture of a digital coherent optical system and describes its main digital signal processing DSP algorithms The authors first show how the combination of advanced modulation techniques DSP and coherent detection has led to significant gains in capacity and ease of operation The authors follow the path of the information from its generation in the transmitter to propagation through the fiber and processing by the DSP algorithms in the receiver The work summarizes academic results and presents them in a didactic way to students and practitioners working on the area of optical communications A full suite of classroom materials is included for easy integration into a curriculum containing theoretic and simulation problems and off the shelf Matlab Octave functions *Advanced DSP Techniques for High-Capacity and Energy-Efficient Optical Fiber Communications* Zhongqi Pan,Yang Yue,2019-12-03 The rapid proliferation of the Internet has been driving communication networks closer and closer to their limits while available bandwidth is disappearing due to an ever increasing network load Over the past decade optical fiber communication technology has increased per fiber data rate from 10 Tb/s to exceeding 10 Pb/s The major explosion came after the maturity of coherent detection and advanced digital signal processing DSP DSP has played a critical role in accommodating channel impairments mitigation enabling advanced modulation formats for spectral efficiency transmission and realizing flexible bandwidth This book aims to explore novel advanced DSP techniques to enable multi Tb/s channel optical transmission to address pressing bandwidth and power efficiency demands It provides state of the art advances and future perspectives of DSP as well *Advanced Digital Signal Processing for Next-generation Flexible Optical Networks* Xiang Lin,2020 To keep pace with the rapid expansion in data exchange traffic around the world optical networks are anticipated to provide flexibility to maximize utilization of the deployed optical fiber resources On the other hand digital signal processing DSP has been employed in coherent optical systems to enable 100G and beyond optical fiber networks The goal of the thesis is to develop advanced DSP techniques for the flexible optical networks With the reconfigured modulation formats in the systems modulation classification MC is essential in the DSP to facilitate the sequential compensation modules which are modulation format dependent Based on the cumulative distribution function CDF of received signal's amplitude an MC algorithm for M-ary quadrature amplitude modulation M-QAM formats with M=4,8,16,32 and 64 is proposed Results show that the proposed algorithm achieves accurate classification at optical signal to noise ratio OSNR of interest and is robust to frequency offset and laser phase noise Relying on the CDF of received signal's amplitude a non data aided NDA OSNR estimation algorithm is developed for coherent optical systems employing multilevel constellations It outperforms the state of

the art NDA algorithm in terms of performance and complexity Furthermore a joint OSNR estimation and MC algorithm enabled by support vector machine is designed Compared to deep neural network based joint estimation approach the proposed algorithm achieves better performance with comparable complexity In addition a low complexity two stage carrier phase estimation algorithm is proposed for coherent optical systems with 16 QAM format The proposed algorithm exploits the second power operation instead of the conventional fourth power to remove the modulation phase which is enabled by constellation partition and rotation Optical back to back experiments and numerical simulations are carried out to evaluate the performance of the algorithm Results show that compared with the conventional fourth power based CPE algorithm the proposed algorithm provides comparable tolerance to the carrier phase noise with reduced complexity Lastly a novel transmission scheme is investigated for the open and disaggregated metro coherent optical networks which impose the requirements for multiple user connectivities on the limited orthogonal frequency resources Thus it is desirable to provide connections simultaneously to various users in a non orthogonal way A transmission scheme based on the non orthogonal sparse code multiple access in a digital subcarrier multiplexing is proposed Compared to power domain based counterpart the proposed scheme supports more than 2 users without user pairing and clustering The feasibility of the proposed scheme is verified through numerical simulations Three scenarios with 2 4 and 6 users over 1 2 and 4 subcarriers respectively are considered Performance evaluations show that in all scenarios the proposed scheme attains bit error ratio lower than the forward error correction limits with the transmission ranges of interest in metro applications

Digital Signal Processing In High-Speed Optical Fiber Communication Principle and Application Jianjun Yu, Nan Chi, 2020-07-06 This book presents the principles and applications of optical fiber communication based on digital signal processing DSP for both single and multi carrier modulation signals In the context of single carrier modulation it describes DSP for linear and nonlinear optical fiber communication systems discussing all optical Nyquist modulation signal generation and processing and how to use probabilistic and geometrical shaping to improve the transmission performance For multi carrier modulation it examines DSP based OFDM signal generation and detection and presents 4D and high order modulation formats Lastly it demonstrates how to use artificial intelligence in optical fiber communication As such it is a useful resource for students researches and engineers in the field of optical fiber communication

Advanced Digital Signal Processing in Coherent Fiber Optic Communication Systems Mahdi Malekiha, 2017 To satisfy the explosive growth in global Internet traffic the development of transmission links that not only have high capacity but are also flexible reconfigurable and adaptive is imperative The advents of high speed digital to analog and analog to digital converters and recent progress in complementary metal oxide semiconductor CMOS technology has facilitated the development of optical transceivers relying on coherent detection and digital signal processing DSP for the compensation of fiber impairments Next generation coherent optical networks are anticipated to further approach the Shannon limit and deliver 400 Gb/s or 1 Tb/s data rates per channel while providing

flexibility and agility to maximize the utilization of the network resources This thesis explores novel system architectures and advanced DSP algorithms to fulfill these design targets Currently chromatic dispersion CD compensation and forward error correction FEC decoders are the major power consuming more than 50% blocks of a conventional transceiver application specific integrated circuit ASIC This thesis presents the concepts and architectures of multi sub band MSB signaling for mitigation of CD and eliminating the need for a CD compensating equalizer in reduced guard interval RGI orthogonal frequency division multiplexing OFDM and single carrier systems The performance of the proposed techniques are experimentally evaluated using a leading edge optical long haul transmission test bed It is shown that the MSB technique in addition to the evidently lower computational complexity allows for a highly efficient adaptive rate smart transceiver implementation with lower system overhead and simplified parallelism while attaining the same or better transmission reach and performance as the conventional transceiver This is due to its higher tolerance to fiber nonlinearity With coherent technology and advanced FEC it is known that the capacity of current fiber optic transmission systems is fundamentally limited by fiber nonlinearities We have optimized the perturbation based nonlinearity compensation PB NLC equalization scheme and proposed a novel adaptive nonlinear equalizer The performances of the aforementioned DSP equalization schemes are numerically and experimentally studied It is found that the optimized technique demonstrates lower computational complexity over conventional PB NLC In addition the proposed adaptive nonlinear equalizer does not require prior calculations of perturbation coefficients and detailed knowledge of the transmission link parameters It achieves comparable performance to the PB NLC Unlike previously studied adaptive nonlinear equalization techniques our algorithm takes advantage of common symmetries avoids replication of operations and only uses a few adaptive nonlinear coefficients Finally its computational complexity is smaller than previously proposed adaptive nonlinear equalization schemes which meets the requirements of next generation optical networks

Advanced Digital Optical Communications Le Nguyen

Binh, 2017-11-22 This second edition of Digital Optical Communications provides a comprehensive treatment of the modern aspects of coherent homodyne and self coherent reception techniques using algorithms incorporated in digital signal processing DSP systems and DSP based transmitters to overcome several linear and nonlinear transmission impairments and frequency mismatching between the local oscillator and the carrier as well as clock recovery and cycle slips These modern transmission systems have emerged as the core technology for Tera bits per second bps and Peta bps optical Internet for the near future Featuring extensive updates to all existing chapters Advanced Digital Optical Communications Second Edition Contains new chapters on optical fiber structures and propagation optical coherent receivers DSP equalizer algorithms and high order spectral DSP receivers Examines theoretical foundations practical case studies and MATLAB and Simulink models for simulation transmissions Includes new end of chapter practice problems and useful appendices to supplement technical information Downloadable content available with qualifying course adoption Advanced Digital Optical Communications

Second Edition supplies a fundamental understanding of digital communication applications in optical communication technologies emphasizing operation principles versus heavy mathematical analysis It is an ideal text for aspiring engineers and a valuable professional reference for those involved in optics telecommunications electronics photonics and digital signal processing

Handbook of Radio and Optical Networks Convergence Tetsuya Kawanishi, 2024-10-02 This handbook provides comprehensive knowledge on device and system technologies for seamlessly integrated networks of various types of transmission media such as optical fibers and millimeter and THz waves to offer super high speed data link service everywhere The seamless integration of the knowledge of radio and optical technologies is needed to construct wired and wireless seamless networks High frequency bands such as millimeter wave and THz wave bands where super wideband spectra are available can offer high speed data transmission and high resolution sensing However the expected coverage is limited due to large wave propagation loss Thus convergence of radio and optical links is indispensable to construct worldwide networks The radio and optical technologies share the same physics and are closely related to each other but have been developed independently Therefore there is a big gap between these two fields Bridging the two fields this handbook is also intended as a common platform to design integrated networks consisting of wireless and wired links Full coverage of wireless and wired convergence fields ranging from basics of device and transmission media to applications allows the reader to efficiently access all the important references in this single handbook Further it also showcases state of the art technology and cases of its use

Springer Handbook of Optical Networks Biswanath Mukherjee, Ioannis Tomkos, Massimo Tornatore, Peter Winzer, Yongli Zhao, 2020-10-15 This handbook is an authoritative comprehensive reference on optical networks the backbone of today's communication and information society The book reviews the many underlying technologies that enable the global optical communications infrastructure but also explains current research trends targeted towards continued capacity scaling and enhanced networking flexibility in support of an unabated traffic growth fueled by ever emerging new applications The book is divided into four parts Optical Subsystems for Transmission and Switching Core Networks Datacenter and Super Computer Networking and Optical Access and Wireless Networks Each chapter is written by world renown experts that represent academia industry and international government and regulatory agencies Every chapter provides a complete picture of its field from entry level information to a snapshot of the respective state of the art technologies to emerging research trends providing something useful for the novice who wants to get familiar with the field to the expert who wants to get a concise view of future trends

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Wireless Communications Sushank Chaudhary, Amir Parnianifard, Abhishek Sharma, 2025-05-09 This edited volume brings together diverse perspectives on machine learning and AI applications in optical and wireless systems offering a structured and comprehensive resource for researchers and professionals It explores advancements driven by 5G IoT and the increasing demand for high speed reliable communication Covering optical fiber systems wireless networks and AI driven optimizations the book provides insights into real world applications impacting telecommunications healthcare and transportation The contributing authors discuss key topics such as signal processing techniques optimization algorithms and deep learning models applied to optical and wireless networks The volume also highlights emerging challenges security concerns and future trends in AI powered communication systems This resource is essential for professionals in electrical and computer engineering telecommunications and computer science helping them stay ahead in these rapidly evolving technologies

Fiber Optics Fundamentals and Advances in Optical Communications Gp Capt KS Mathur (Retd.), 2021-02-10 Your comprehensive guide to Fiber Optics Fundamentals and advancements taking place in this field Synopsis This book provides solid base in fiber optics communications for B Tech and M Tech students and also for practicing engineers and research scholars in this field The book contains more than 650 illustrations which give a comprehensive coverage of the technology involved in the fiber optics communications This book gives an in depth coverage of Telecommunications fundamentals optical fiber transmission characteristics optical fiber manufacturing and cables Signal degradation distortion in optical fibers optical fiber nonlinearities and their management optical sources and receivers optical amplifiers SONET SDH OTN DWDM OFDM and Super Channels connectors and couplers fiber optic link design optical networks and cloud computing review of fiber optic sensors and their applications Fiber optics sensors are altogether a different field in latest sensor technology Advance technologies in fiber optics communications covering FTTH technologies OTDR Nanophotonics Low signal latency in optical fibers and fabrication and simulation of optical fibers and their optical parameters by Opti Wave software Optical Network Communications :An Engineer's Perspective Sanjay Yadav, 2025-01-06 Optical Network Communications An Engineer s Perspective Bridge the Gap Between Theory and Practice in Optical Networking Are you an engineer looking to master the practical aspects of optical network communications Written by an industry veteran this

comprehensive guide delivers what traditional textbooks often miss real world insights and hands on knowledge essential for working professionals About the Author Meet Sanjay Yadav an accomplished Optical Networking Professional with nearly two decades of experience across diverse optical networking technologies His expertise spans product and service development network design and operations automation and tooling With a rich background in technical support customer handling system engineering and software testing Sanjay brings a unique perspective to optical networking challenges His philosophy of Share Explore and Inspire with the Tech Inside You drives his passion for knowledge sharing and technological innovation Why This Book Is Different Unlike traditional academic texts this book focuses on the operational maintenance and development aspects of optical networks that engineers encounter daily Drawing from extensive industry experience it provides practical solutions and insider knowledge that you can apply immediately in your work Inside You ll Discover Practical implementations of optical network technologies in telecom networks data centers and submarine communications Essential operational guidelines for running and maintaining optical networks Real world troubleshooting techniques and best practices Industry tested tools and methodologies for network optimization Valuable tables charts and reference materials designed for practicing engineers Learning Path The book follows a structured approach guiding readers from fundamental concepts to advanced applications Each chapter builds upon previous knowledge while incorporating practical examples and industry scenarios Industry Applications Detailed coverage of emerging technologies in 5G 6G optical networks Practical insights into coherent optical communications Real world implementation of ROADM and DWDM systems Cost effective network design strategies Performance optimization techniques for modern data centers Submarine cable system operations and maintenance Perfect For Network engineers seeking practical knowledge Professionals transitioning into optical communications Experienced engineers looking to expand their expertise Technical managers overseeing optical network operations Students wanting to supplement theoretical knowledge with practical applications Professional Development Beyond technical content the book includes Skills assessment and development roadmaps Industry certification preparation tips Project management best practices Team collaboration and leadership insights Innovation and research opportunities

Adaptive Optics Theory and Its Application in Optical Wireless Communication Xizheng Ke, Pengfei Wu, 2022-03-23 This book introduces in detail the theory of adaptive optics and its correction technology for light wave distortion in wireless optical communication It discusses the adaptive control algorithm of wavefront distortion proportional integral control algorithm and iterative control algorithm and double fuzzy adaptive PID control algorithm It also covers the SPGD algorithm of adaptive optics correction deformable mirrors eigenmode method of wavefront aberration correction vortex beam wavefront detecting wavefront aberration correction liquid crystal spatial light modulator wavefront correction different wavelengths of Gaussian beam transmission wavefront differences in the atmospheric turbulence and correction and with wavefront tilt correction adaptive optics wavefront aberration correction Various distortion correction methods are

verified by experiments and the experimental results are analyzed This book is suitable for engineering and technical personnel engaged in wireless optical communication college teachers graduate students and senior undergraduate students

Optical and Wireless Convergence for 5G Networks Abdelgader M. Abdalla,Jonathan Rodriguez,Issa Elfergani,Antonio Teixeira,2019-10-07 The mobile market has experienced unprecedented growth over the last few decades Consumer trends have shifted towards mobile internet services supported by 3G and 4G networks worldwide Inherent to existing networks are problems such as lack of spectrum high energy consumption and inter cell interference These limitations have led to the emergence of 5G technology It is clear that any 5G system will integrate optical communications which is already a mainstay of wide area networks Using an optical core to route 5G data raises significant questions of how wireless and optical can coexist in synergy to provide smooth end to end communication pathways Optical and Wireless Convergence for 5G Networks explores new emerging technologies concepts and approaches for seamlessly integrating optical wireless for 5G and beyond Considering both fronthaul and backhaul perspectives this timely book provides insights on managing an ecosystem of mixed and multiple access network communications focused on optical wireless convergence Topics include Fiber Wireless FiWi Hybrid Fiber Wireless HFW Visible Light Communication VLC 5G optical sensing technologies approaches to real time IoT applications Tactile Internet Fog Computing FC Network Functions Virtualization NFV Software Defined Networking SDN and many others This book aims to provide an inclusive survey of 5G optical wireless requirements architecture developments and technological solutions

Chaos and Its Applications Yuncaai Wang,2025-07-04 This book highlights the applications of optoelectronic chaotic signals in various fields including lidars radars sensors secure communication and millimeter terahertz noise generation It covers the following topics In lidar radar detection the book discusses chaotic lidars chaotic through wall life detection radars and chaotic ground penetrating radars Regarding optical fiber measurement and sensing it provides a detailed examination of chaotic time domain reflection measurement and chaotic distributed fiber sensing technologies In the realm of secure communication the book reviews optical chaos synchronization chaotic secure optical communication physical random number generators and secure key distribution based on chaotic synchronization For noise generation it summarizes the millimeter terahertz noise generation mechanism and noise source prototypes that utilize photo mixing chaotic lights This book is a valuable resource for professionals educators graduate students and advanced undergraduates involved in fields such as radar detection laser technology fiber optic sensing optical communication and testing and measurement technology and instruments

Theory and Design of Terabit Optical Fiber Transmission Systems Stefano Bottacchi,2014-10-02 This comprehensive modular treatment of the challenging issues involved in very high speed optical transmission systems contains all the theory and practical design criteria required to optimise transmission system design Each chapter covers the theoretical modelling of a given system chapters are well supported by real world worked examples and accompanied by MATLAB code and receiver design examples Critical analysis

and comparison of engineering solutions is presented to make clear the principles underlying system performance optimisation and a broad range of transmission systems is discussed including the status and performance demands of the Terabit systems now entering the next generation market Blending theoretical and practical considerations for high speed fibre optic systems design this is an indispensable reference for all forward looking professionals and researchers in optical communications

Research and Technology Program Digest Flash Index ,1967 *Communications, Signal Processing, and Systems* Qilian Liang,Wei Wang,Xin Liu,Zhenyu Na,Min Jia,Baoju Zhang,2020-04-04 This book brings together papers from the 2019 International Conference on Communications Signal Processing and Systems which was held in Urumqi China on July 20 22 2019 Presenting the latest developments and discussing the interactions and links between these multidisciplinary fields the book spans topics ranging from communications to signal processing and systems It is chiefly intended for undergraduate and graduate students in electrical engineering computer science and mathematics researchers and engineers from academia and industry as well as government employees

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