Department of Electronics & Communication Engineering

LAB MANUAL

SUBJECT: ANALOG & DIGITAL COMMUNICATION LAB

B. Tech Year: -3rd Semester: -5th

(Branch: ECE)



Bhubaneswar College of Engineering

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<u>Frequency Division Multiplexing And Demultiplexing</u> <u>Lab Manual</u>

Joacim Rocklöv

Frequency Division Multiplexing And Demultiplexing Lab Manual:

Electrical & Electronics Abstracts ,1997 **Government Reports Announcements & Index**, 1981-07 Abstracts of Photographic Science & Engineering Literature, 1971 INIS Atomindeks ,1980 Aeronautical **NASA SP.** ,1982 Engineering, 1982 A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in Scientific and technical aerospace reports STAR and Wavelength Division Multiplexing Klaus Grobe, Michael Eiselt, 2013-09-12 In this International aerospace abstracts IAA book Optical Wavelength Division Multiplexing WDM is approached from a strictly practical and application oriented point of view Based on the characteristics and constraints of modern fiber optic components transport systems and fibers the text provides relevant rules of thumb and practical hints for technology selection WDM system and link dimensioning and also for network related aspects such as wavelength assignment and resilience mechanisms Actual 10 40 Gb s WDM systems are considered and a preview of the upcoming 100 Gb s systems and technologies for even higher bit rates is given as well Key features Considers WDM from ULH backbone big picture view down to PON access micro view Includes all major telecom and datacom applications Provides the relevant background for state of the art and next gen systems Offers practical The Orthogonal Frequency Division Multiplexing (OFDM). Introduction guidelines for system link engineering and explanation of five different types of techniques Dr. Lokesh Chikkananjaiah, 2021-02-25 Thesis M A from the year 2019 in the subject Electrotechnology grade 9 language English abstract The Orthogonal Frequency Division Multiplexing OFDM is an important aspect of multicarrier digital data transmission system where a single data stream is transmitted into a several number of lower rates subcarrier signals In this thesis there are five different types of the techniques introduced to strengthen the communication quality and capacity This kind of new standard of transmission of data is the first one to perform with OFDM in data packet based communication system In wireless communication network the abstraction of parallel transmission of data symbols is implemented to attain high throughput and effective transmission quality The OFDM is a method to deal with parallel transmission Digital Modulation Techniques Fugin Xiong, 2006 This newly revised and expanded edition of an Artech House classic builds on its success as far and away the most comprehensive guide to digital modulation techniques used in communications today The second edition adds a wealth of up to date critical material including Five new chapters devoted to orthogonal frequency division multiplexing OFDM covering its basics and practical implementation issues peak to average power ratio PAPR reduction synchronization fading channel performance and mitigation methods as well as the newest developments such as wavelet OFDM schemes New modulations for optical communications Enhanced coverage of M ary amplitude shift keying ASK More accurate bit error rate BER equations for quaternary phase shift keying QPSK and quadrature amplitude modulation QAM Enhanced coverage of fading channel mitigation methods such as channel estimate and diversity techniques Fast access comparison of all modulation schemes

New appendixes covering trigonometry identities Fourier transform pairs and properties and O function and error function Frequency Division Multiplexing and Demultiplexing Employing Sampled Data Filtering Techniques Paul McNeel values Orthogonal Frequency Division Multiplexing for Wireless Communications Ye Geoffrey Li, Gordon L. Thrasher.1965 Stuber, 2006-05-31 Orthogonal Frequency Division Multiplexing for Wireless Communications is an edited volume with contributions by leading authorities in the subject of OFDM Its coverage consists of principles important wireless topics e q Synchronization channel estimation etc and techniques Included is information for advancing wireless communication in a multipath environment with an emphasis on implementation of OFDM in base stations Orthogonal Frequency Division Multiplexing for Wireless Communications provides a comprehensive introduction of the theory and practice of OFDM To facilitate the readers extensive subject indices and references are given at the end of the book Even though each chapter is written by different experts symbols and notations in all chapters of the book are consistent **Orthogonal Frequency** Division Multiplexing with Diversity for Future Wireless Systems Khoa N. Le,2012 The book examines several aspects of Orthogonal Frequency Division Multiplexing OFDM employing linear diversity techniques such as inter carrier interference bit error rate peak to average power and inter block interference It should be a useful refe **Reference Manual** Gilbert Held, 1992-12-15 Details the operational characteristics of these data communications devices how to use them effectively and the available features which can be used to assist in the acquisition process Covers the four fundamental types of multiplexers focusing on the statistical and T1 variety Provides readers with insight into an understanding of when and when not to use multiplexers **Applications of Orthogonal Frequency Division** Multiplexing for Long-Haul Optical Transmission Systems Beril Inan, 2014 Frequency Division Multiplexing. 1: Principles of FDM [and] Frequency Division Multiplexing. 2: Implementation of FDM Equipment Degem Electronics, 1979

Orthogonal Frequency Division Multiplexing in Optical Communication Systems. Dr. Ashad Ullah Qureshi,2022-06-01 Optical fiber communication has emerged as a high potential substitute for communication methods such as twisted pair and coaxial wire The main advantage of optical fiber over previous methods is to have higher capacity of data rate transmission The conventional types of modulation and demodulation technique which have been used through optical fiber communication system are Wavelength Division Multiplexing WDM technique and Dense Wavelength Division Multiplexing DWDM technique so far Orthogonal Frequency Division Multiple Access Fundamentals and Applications Tao Jiang, Yan Zhang, Lingyang Song, 2019-08-30 Supported by the expert level advice of pioneering researchers Orthogonal Frequency Division Multiple Access Fundamentals and Applications provides a comprehensive and accessible introduction to the foundations and applications of one of the most promising access technologies for current and future wireless networks It includes authoritative coverage of the history fundamental principles key techniques and critical design issues of OFDM systems Covering various techniques of effective resource management for OFDM OFDMA based

wireless communication systems this cutting edge reference Addresses open problems and supplies possible solutions Provides a concise overview of key techniques for adaptive modulation Investigates radio channel modeling in OFDMA based wireless communication systems Details detection strategies of frequency domain equalization for broadband communications Introduces a novel combination of OFDM and the orbital angular momentum of the electromagnetic field to improve performance Contains extensive treatment of adaptive MIMO beamforming suitable for multiuser access This valuable resource supplies readers with a macro level understanding of OFDMA and its key issues while providing a systematic manual for those whose work is directly related to practical OFDMA and other multiuser communication systems Quadrature Amplitude Modulation Golay Complementary Sequences for Orthogonal Frequency projects **Division Multiplexing** Heekwan Lee, 2005 Multiplexing Somayeh Mohammady, 2019-09-04 Mobile communication has been a critical part of everyday life for the last 30 years As the demand for wireless communications and higher data rates on these links continues its rapid growth engineers scientists and researchers are required to advance the hardware and software needed to deliver systems for 5G Massive multiple input multiple output MIMO and optical backhaul networks Now more than ever before the fundamental concept of multiplexing is at play This book is a unique reference for understanding the concept of multiplexing It provides comprehensive coverage of the practical applications of multiplexing to help the reader better understand its use in these systems It is a great resource especially for engineers working on digital signal processing radio frequency RF antenna design beamforming and network designs The book contains chapters on the following topics History of multiplexing and how it applies to current technologies Different types and applications of multiplexing Multiplexing techniques in wireless networks Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing MIMO OFD Direct Sequence Optical Code Division Multiple Access DS OCDMA Optically multiplexed systems

Orthogonal Frequency-division Multiplexing for Optical Communications Daniel Jose Fernandes Barros, 2011 The drive towards higher spectral efficiency and maximum power efficiency in optical systems has generated renewed interest in the optimization of optical transceivers In this work we study the different optical applications Wide Area Networks WANs Metropolitan Area Networks MANs Local Area Networks LANs and Personal Area Networks PANs In WANs or long haul systems orthogonal frequency division multiplexing OFDM can compensate for linear distortions such as group velocity dispersion GVD and polarization mode dispersion PMD provided the cyclic prefix is sufficiently long Typically GVD is dominant as it requires a longer cyclic prefix Assuming coherent detection we show how to analytically compute the minimum number of subcarriers and cyclic prefix length required to achieve a specified power penalty trading off power penalties from the cyclic prefix and from residual inter symbol interference ISI and inter carrier interference ICI We derive an analytical expression for the power penalty from residual ISI and ICI We also show that when nonlinear effects are present in the fiber single carrier with digital equalization outperforms OFDM for various dispersion maps We also study the

impairments of electrical to optical conversion when using Mach Zehnder MZ modulators OFDM has a high peak to average ratio PAR which can result in low optical power efficiency when modulated through a Mach Zehnder MZ modulator In addition the nonlinear characteristic of the MZ can cause significant distortion on the OFDM signal leading to in band intermodulation products between subcarriers We show that a quadrature MZ with digital pre distortion and hard clipping is able to overcome the previous impairments We consider quantization noise and compute the minimum number of bits required in the digital to analog converter D A Finally we discuss a dual drive MZ as a simpler alternative for the OFDM modulator but our results show that it requires a higher oversampling ratio to achieve the same performance as the quadrature MZ In MANs we discuss the use OFDM for combating GVD effects in amplified direct detection DD systems using single mode fiber We review known direct detection OFDM techniques including asymmetrically clipped optical OFDM ACO OFDM DC clipped OFDM DC OFDM and single sideband OFDM SSB OFDM and derive a linearized channel model for each technique We present an iterative procedure to achieve optimum power allocation for each OFDM technique since there is no closed form solution for amplified DD systems For each technique we minimize the optical power required to transmit at a given bit rate and normalized GVD by iteratively adjusting the bias and optimizing the power allocation among the subcarriers We verify that SSB OFDM has the best optical power efficiency among the different OFDM techniques We compare these OFDM techniques to on off keying OOK with maximum likelihood sequence detection MLSD and show that SSB OFDM can achieve the same optical power efficiency as OOK with MLSD but at the cost of requiring twice the electrical bandwidth and also a complex quadrature modulator We compare the computational complexity of the different techniques and show that SSB OFDM requires fewer operations per bit than OOK with MLSD In LANs we compare the performance of several OFDM schemes to that of OOK in combating modal dispersion in multimode fiber links We review known OFDM techniques using intensity modulation with direct detection IM DD including DC OFDM ACO OFDM and pulse amplitude modulated discrete multitone PAM DMT We describe an iterative procedure to achieve optimal power allocation for DC OFDM and compare analytically the performance of ACO OFDM and PAM DMT We also consider unipolar M ary pulse amplitude modulation M PAM with minimum mean square error decision feedback equalization MMSE DFE For each technique we quantify the optical power required to transmit at a given bit rate in a variety of multimode fibers For a given symbol rate we find that unipolar M PAM with MMSE DFE has a better power performance than all OFDM formats Furthermore we observe that the difference in performance between M PAM and OFDM increases as the spectral efficiency increases We also find that at a spectral efficiency of 1 bit symbol OOK performs better than ACO OFDM using a symbol rate twice that of OOK At higher spectral efficiencies M PAM performs only slightly better than ACO OFDM using twice the symbol rate but requires less electrical bandwidth and can employ analog to digital converters at a speed only 81% of that required for ACO OFDM In PANs we evaluate the performance of the three IM DD OFDM schemes in combating multipath

distortion in indoor optical wireless links comparing them to unipolar M PAM with MMSE DFE For each modulation method we quantify the received electrical SNR required at a given bit rate on a given channel considering an ensemble of 170 indoor wireless channels When using the same symbol rate for all modulation methods M PAM with MMSE DFE has better performance than any OFDM format over a range of spectral efficiencies with the advantage of M PAM increasing at high spectral efficiency ACO OFDM and PAM DMT have practically identical performance at any spectral efficiency They are the best OFDM formats at low spectral efficiency whereas DC OFDM is best at high spectral efficiency When ACO OFDM or PAM DMT are allowed to use twice the symbol rate of M PAM these OFDM formats have better performance than M PAM When channel state information is unavailable at the transmitter however M PAM significantly outperforms all OFDM formats When using the same symbol rate for all modulation methods M PAM requires approximately three times more computational complexity per processor than all OFDM formats and 63% faster analog to digital converters assuming oversampling ratios of 1 23 and 2 for ACO OFDM and M PAM respectively When OFDM uses twice the symbol rate of M PAM OFDM requires 23% faster analog to digital converters than M PAM but OFDM requires approximately 40% less computational complexity than M PAM per processor

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