Synthesis Lectures on Communications

SYNTHESIS
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Xin Lin

Visible Light Communications

Springer

Synthesis Lectures on Communications

This series of short books cover a wide array of topics, current issues, and advances in key areas of wireless, optical, and wired communications. The series also focuses on fundamentals and tutorial surveys to enhance an understanding of communication theory and applications for engineers.

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To my family

Preface

Visible light is an electromagnetic wave with wavelengths in a region of the spectrum from about 380 to 780 nm. The developments of visible lightwave technology, such as lightwave propagation, detection, and switching have found ever-increasing applications in optical communications, signal processing, computing, and sensing.

Visible light communication (VLC) as one of lightwave technology is a novel wireless communication technology developed along with LED lighting. One of its most important features is the ability to use the ubiquitous lighting to transmit information around the users, and this makes VLC one of the best techniques to realize ubiquitous information services, such as indoor short-range communications, Li-Fi (Light Fidelity) systems, IoT (Internet of Things) systems, underwater optical wireless communication systems and so on. Thus, it can also be referred to as illumination light communication (ILC), it is a modern and interesting technique related with the daily life of people.

The purpose of this book is to help readers understand the fundamentals that are related with this emerging technology, and its best application areas. Subject matter of this book has been chosen with two general aims in mind. The first is to give readers enough of the basic principles behind practical optical components and systems so that they can do effective research and laboratory works. The second aim is for readers to know the essence of VLC so they can find and build new applications.

This book, apart from emphasizing the basics and applications of VLC, also incorporates many of the recent developments, such as visible-light wireless LAN, underwater optical wireless sensor network, optical metamaterials, Optical multiple-access techniques, new VLC standards, and techniques of combining VLC with art. The book includes author's worked examples of the research and developments and a wealth of references. Depending on the requirement, topics in the book can as a research or

development material for researchers and engineers in optical engineering or optical communication fields. And it also can provide an important reference material for either an introductory or a more advanced course to science students.

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Contents

Acronyms

ACO-OFDM	Asymmetrically Clipped Optical OFDM
ADC	Analog to Digital Conversion
AEL	Allowable Exposure Limit
AM	Amplitude Modulation
APD	Avalanche Photodiode
ARIB	Association of Radio Industries and Businesses
ASK	Amplitude Shift Keying
AUV	Autonomous Underwater Vehicle
B	Blue
BCSK	Binary CSK
BER	Bit Error Rate
BIM	Baseband Intensity Modulation
C	Cyan
CC	Convolutional Codes
CCD	Charge-Coupled Device
CD	Coherent Detection
CDM	Code Division Multiplexing
CIE	Commission Internationale de l'Éclairage (International Commission on Illumination)
CMOS	Complementary Metal Oxide Semiconductor
CMY	Cyan, Magenta, and Yellow
CRC	Cyclic Redundancy Checks
CRI	Color Rendering Index
CRT	Cathode Ray Tube
CSK	Color-Shift Keying
CSML	Color-Separation Metalens
CSS	Carrier Signal Source
D/A	Digital-to-Analog

DBM	Duobinary Modulation
DBR	Distributed Bragg Reflector
DC	Direct Current
DCO-OFDM	Direct Current Biased Optical OFDM
DD	Direct Detection
DEMUX	Demultiplexer
DLL	Data Link Layer
DMT	Discrete Multitone
DSOC	Deep Space Optical Communication
DSP	Digital Signal Processing
E/O	Electro-Optic Conversion
EEL	Edge-Emitting Laser
ELF	Extremely Low Frequency
EMC	Electromagnetic Compatibility
EPE	External Photoelectric Effect
FDM	Frequency Division Multiplexing
FEC	Forward Error Correction
FM	Frequency Modulation
FOC	Fiber Optic Communication
FOV	Field of View
FSK	Frequency Shift Keying
FSO	Free-Space Optics
FWHM	Full Width at Half Maximum
G	Green
GPS	Global Positioning System
HD	Heterodyne Detection
IC	Integrated Circuit
ID	Identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFFT	Inverse Fast Fourier Transform
ILC	Illumination Light Communication
IM	Intensity Modulation
IM/DD	Intensity Modulation with Direct Detection
IoT	Internet of Things
IPE	Internal Photoelectric Effect
IR/Ir	Infrared
IrDA	Infrared Data Association
IS	Image Sensor
ISC	Image Sensor Communication
ISS	Information Signal Source