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Index Modulation for OFDM Communications Systems

Springer

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Preface

The unprecedented surge of mobile data traffic requires future wireless networks to support both high spectral efficiency and energy efficiency. The currently employed orthogonal frequency division multiplexing (OFDM) technique, unfortunately, is not capable of satisfying such requirements. The OFDM modulation is prone to Doppler-induced intercarrier interference. Its inherent high peak-to-average power ratio also necessitates expensive power amplifiers. In this context, novel advanced modulation techniques are therefore very much needed. Among these, the recently emerging index modulation has attracted significant interest. Index modulation refers to a family of modulation techniques that leverage upon the on–off state of the transmission entities such as antenna, signal constellation, spreading code, and pilot to convey information. A prominent feature of index modulation is that the additional information is implicitly transmitted over the emitted signal at the cost of little or even no power, achieving significant benefits in terms of spectral efficiency and energy efficiency. The recent standardization that OFDM is deemed as both uplink and downlink waveforms of the fifth-generation wireless networks sets off a new wave of development of index modulation techniques for OFDM communications systems.

This monograph includes transceiver design, system optimization, and performance analysis of index modulation techniques based on constellation, code, and pilot resources for OFDM communications systems. The chapters of this monograph are relatively independent of each other. The readers can go directly to the chapter(s) of interest. In Chap. 1, the motivation of this monograph and a brief review of index modulation techniques are introduced. In Chap. 2, constellation-based index modulation that uses a combinatorial approach is presented. In Chap. 3, constellation-based index modulation that uses a permutational approach is studied, including the basic, generalized, and diversity-enhancing forms. In Chap. 4, code-based index modulation that exploits the indices of spreading codes to convey additional information is investigated, followed by two extensions. In Chap. 5, pilot-based index modulation that applies the positions of pilots for information transfer is proposed, including the applications to carrier phase tracking and channel

estimation. Finally, in Chap. 6, some open problems and discussions about the future research directions are highlighted.

This monograph is designed for researchers in the field of wireless communications.

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Contents

Acronyms

ABEP	Average bit error probability
APM	Amplitude phase modulation
AWGN	Additive white Gaussian noise
BER	Bit error rate
CFO	Carrier frequency offset
CGD	Coding gain distance
CIR	Channel impulse response
CP	Cyclic prefix
CSI	Channel state information
DF	Decode-and-forward
DFT	Discrete Fourier transform
DM-OFDM	Dual-mode aided OFDM
DSM	Differential spatial modulation
FFT	Fast Fourier transform
GSM	Generalized spatial modulation
ICI	Intercarrier interference
ICT	Information and communication technology
IDFT	Inverse discrete Fourier transform
IFFT	Inverse fast Fourier transform
IM-OFDM-SS	Index modulated OFDM spread spectrum
LLR	Log-likelihood ratio
MIMO	Multiple-input multiple-output
ML	Maximum-likelihood
MM-OFDM-IM	Multiple-mode OFDM with index modulation
MRC	Maximal ratio combining
NOMA	Non-orthogonal multiple access
OFDM	Orthogonal frequency division multiplexing
OFDM-IM	OFDM with index modulation
PAM	Pulse amplitude modulation
PAPR	Peak-to-average power ratio
PDF	Probability density function

PEP	Pairwise error probability
PPD	Pilot position detection
PPS	Pilot position selection
PSK	Phase shift keying
QAM	Quadrature amplitude modulation
RF	Radio frequency
SAP	Subcarrier activation pattern
SE	Spectral efficiency
SM	Spatial modulation
SNR	Signal-to-noise ratio
WLAN	Wireless local area network