Ain Shams University
Faculty of Engineering
Electronics and Communications Engineering Department

Performance Evaluation of OFDM System Subjected to Frequency Offsets in General Fading Channels

A Thesis
Submitted in partial fulfillment for the requirements
Of the degree of Master of Science in Electrical Engineering
(Electronics and Communications Engineering)

Submitted by

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Statement

This dissertation is submitted to Ain Shams University in partial fulfillment of the degree of Master of Science in Electrical Engineering (Electronics and Communications Engineering).

The work included in this thesis was carried out by the author at the department of Electronics and Communications Engineering, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or qualifications at any other university or institution.

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Thesis Abstract

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Orthogonal frequency division multiplexing (OFDM) is a multi-carrier transmission technique that has been recently recognized as an excellent method for high speed bi-directional wireless communications. It provides a good performance against the most severe multi-path propagation conditions.

OFDM is sensitive to frequency synchronization errors, which results in inter-carrier interference (ICI) and degrades system's performance.

This research work aims to investigate the combined effects of carrier frequency offset (CFO) and fading conditions on system's performance. Nakagami-m fading channel is used as a multi-path propagation model for its ability to emulate fading channels whose conditions are either less severe than, the same as, or more severe than the Rayleigh fading model.

Closed form expressions of BER/SER for OFDM system subjected to CFO over Nakagami-m fading channel are developed. The impact of CFO and severe fading conditions on performance is revealed.

CFO mitigation techniques are introduced to improve system's performance when subjected to CFO. Closed form BER/SER expressions are developed for polynomial cancelation coding (PCC)-OFDM and the ameliorated ICI cancelation OFDM when subjected to CFO in Nakagami-m fading channel, and system improvement is emphasized.

To combat the severe fading conditions, diversity reception is applied. Space diversity reception is employed at the receiver and maximum ratio combining (MRC) is used. The effect of correlation among diversity branches is considered. Expressions of BER/SER for PCC-OFDM subjected to CFO with diversity reception over Nakagami-m fading channel are developed, and in some cases expressions result in a closed form.

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CONTENTS

LIST OF FIGURES

LIST OF SYMBOLS

N	Number of SCs
τ_{RMS}	RMS Delay Spread
f_d	Doppler Frequency Shift
m	Nakagami-m Parameter
ε	Normalized CFO
$S(i)$	ICI Coefficient
P_{be}	Bit Error Probability
P_{se}	Symbol Error Probability
γ	E_b/N_o (Bit Energy to Noise Spectral Density)
$M_{\gamma}(x)$	Moment Generating Function of γ
$Q(x)$	Gaussian Q Function
$n(k)$	Additive White Gaussian Noise
$\phi(\omega)$	Characteristic Function
σ^2	Noise Variance
$\Gamma(x)$	Gamma Function
${}_2F_1(a,b;c;d)$	Guasshypergeometric Function
L	Number of Diversity Branches
ρ	Correlation Coefficient

LIST OF ABBREVIATIONS

ADSL	Asymmetric Digital Subscriber Line
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
CDMA	Code Division Multiple Access
CFO	Carrier Frequency Offset
CHF	Characteristic Function
DAB	Digital Audio Broadcasting
DFT	Discrete Fourier Transform
DVB	Digital Video Broadcasting
EGC	Equal Gain Combining
FDM	Frequency Division Multiplexing
FFT	Fast Fourier Transform
GA	Gaussian Approximation
GSC	Generalized Switched Combining
ICI	Inter-Carrier Interference
IDFT	Inverse Discrete Fourier Transform
IFFT	Inverse Fast Fourier Transform
ISI	Inter-Symbol Interference
LOCZ	Location of Channel Zeros
LOS	Line of Sight
MGF	Moment Generating Function
MLE	Maximum Likelihood Estimation
MRC	Maximum Ratio Combining
NSCs	Null Subcarriers
OFDM	Orthogonal Frequency Division Multiplexing
PAPR	Peak to Average Power Ratio
PCC	Polynomial Cancelation Coding
Pdf	Probability Density Function
PSAM	Pilot Symbol Assisted Modulation
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RMS	Root Mean Square
SCs	Subcarriers
SCC	Symmetric Cancelation Coding
SER	Symbol Error Rate
SINR	Signal to Interference plus Noise Ratio