

Advanced Detection Schemes of Digital Signals in Impulse Noise

by

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of the requirements for the degree of

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in Electrical Engineering**

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Abstract

In this thesis, we investigate the optimum approach to mitigate the effects of impulse noise in wireless communication channels. First, we present a measurement campaign to verify the statistical properties of a Middleton Class-A (MCA) model for impulse noise. This campaign measures wireless interference that corrupted a 2.4 GHz industrial, scientific, and medical (ISM) band. We extend this verification to characterize the spatial coupling and correlation of impulse noise for multiple antenna systems.

We then investigate the optimum detector for binary signals corrupted by MCA noise. We approximate the MCA model to a single weighted Gaussian density such that the nonlinearities of the optimum detector can be evaluated in a closed-form expression. The approximate MCA model discriminates the noise probability density function (PDF) of Gaussian and impulsive events using a threshold detection scheme. By means of such approximations, we provide a precise analysis for the behaviors of optimum nonlinearities in reducing the effects of impulse noise. We also introduce a decision boundary analysis to justify and analyze the performance of the optimum detector in different MCA noise environments. We also approximate the nonlinearities to investigate the behaviors of the other suboptimum detectors such as a locally optimum detector (LOD) and a clipping detector. As a suboptimum approach, we further approximate the optimum nonlinearities using linear segments to introduce new suboptimum detectors such as a piecewise linear detector and a clipping-like detector.

Next, we extend the approximate MCA model to derive the optimum combining schemes for time and space diversity in the presence of fading and impulse noise. We assume perfect knowledge of noise states to evaluate the analytical performances of the optimum combining schemes for time, receive, and transmit/receive diversity in Rayleigh fading and MCA noise. Although this assumption is unrealistic, it leads to a tight performance bound for the optimum combining schemes in impulse noise. These evaluations allow us to study the performance loss of spatial diversity with respect to the number of transmit and receive antennas.

Finally, we utilize the spectral dimensions in the mitigation problem of impulse noise for orthogonal frequency division multiplexing (OFDM) systems. We start with the receiver design of OFDM systems applied to fading channels with MCA noise, such as the optimum receiver and a conventional OFDM detector. We then evaluate an upper performance bound for the optimum receiver in flat fading with MCA noise. This analysis indicates a significant performance improvement of the optimum detector over a conventional OFDM detector in impulse noise. We finally develop a sphere decoding along with sparse Bayesian learning (SBL) to realize the optimum OFDM detector in MCA noise.

Acknowledgment

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Statutory Declaration

(on Authorship of a Dissertation)

I, Khodr Ahmad Saaifan hereby declare that I have written this PhD thesis independently, unless where clearly stated otherwise. I have used only the sources, the data and the support that I have clearly mentioned. This PhD thesis has not been submitted for conferral of degree elsewhere.

I confirm that no rights of third parties will be infringed by the publication of this thesis.

Bremen, June 30, 2015

Signature _____

Dedication

To my late father, my mother, and my wife Inas

Contents

Abstract	I
Acknowledgment	III
Statutory Declaration	V
Contents	IX
List of Figures	XIII
1 Introduction	1
1.1 Statistical Models of Impulse Noise	2
1.1.1 The Middleton's Class-A Model	2
1.1.2 The Symmetric Alpha-Stable Model	4
1.1.3 The ε -Mixture Model	5
1.1.4 Generalized Gaussian Distributions	6
1.2 Signal Detection in Impulse Noise	7
1.2.1 Optimum Detector	8
1.2.2 Suboptimum Detectors	8
1.3 Impulse Noise Mitigation Across Time, Space, and Frequency	10
1.3.1 Time Diversity	11
1.3.2 Spatial Diversity	13
1.3.3 OFDM Signals	17
1.4 Outline of the Thesis	20
2 Impulse Noise Measurements	23
2.1 Statistical Properties of MCA Interference	23
2.1.1 Temporal Dependence and Correlation	28
2.1.2 Spatial Dependence and Correlation	29
2.2 Measurement Campaign and Setup	30
2.2.1 Measurement Receiver	30
2.2.2 Measurement Results	31

2.3	Model Verification	32
2.3.1	MCA Model for Measured Interference	34
2.3.2	Model Extension for Multi-antenna Systems	37
2.4	Conclusion	38
3	Signal Detection in MCA Noise	41
3.1	Approximate Optimum Nonlinearity	41
3.1.1	A Simplified Model of MCA Noise	42
3.1.2	Near Optimum Nonlinearities	43
3.2	Decision Regions in MCA Noise	46
3.2.1	Decision Boundary Evaluation	46
3.2.2	Decision Boundary Analysis	48
3.3	Suboptimum Detectors in MCA Noise	49
3.3.1	Nonlinearities of Suboptimum Detectors	51
3.3.2	Piecewise Linear Detector	51
3.4	Performance Evaluation and Simulation Results	55
3.4.1	The Performance of the Optimum Detector	56
3.4.2	Performances of the Suboptimum Detectors	58
3.5	Conclusion	59
4	Diversity Schemes for Impulse Noise Mitigation	61
4.1	Time-Diversity Scheme	61
4.1.1	Asymptotic Upper Performance Bound	62
4.1.2	Nonlinear Diversity Combining	66
4.2	Spatial Diversity Reception	70
4.2.1	Asymptotic Upper Performance Bound	71
4.2.2	Spatial Diversity Combining	74
4.3	Space-Time Coding	78
4.3.1	Asymptotic Pairwise Error Probability	80
4.3.2	Approximately Optimum Receiver Metrics	84
4.4	Conclusion	85
5	Multicarrier Systems in Impulse Noise	87
5.1	Detection Techniques	87
5.1.1	The Optimum Detector	88
5.1.2	Suboptimum Detectors	89
5.2	Performance Analysis of the Optimum Detector	90
5.2.1	Pairwise Error Probability	92
5.2.2	Upper Performance Bound	94

5.3	Optimum Detector Using Lattice Decoding	98
5.3.1	Lattice Sphere Decoding	98
5.3.2	Noise Covariance Estimation	101
5.4	Conclusion	104
6	Concluding Remarks	105
	Own Publications	111
	Bibliography	113