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A Novel SNR Estimation Technique for OFDM Systems

submitted by

Shahid Manzoor

for the fulfilment of the requirements for the degree of

Masters of Science in Electrical and Electronic Engineering

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UNIVERSITI TEKNOLOGI PETRONAS

A Novel SNR Estimation Technique for OFDM Systems

By

Shahid Manzoor

A THESIS

SUBMITTED TO THE POSTGRADUATE STUDIES PROGRAMME

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BANDAR SERI ISKANDAR,

PERAK

July, 2008

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTP or other institutions.

Signature: _____

Name : Shahid Manzoor

Date : _____

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DEDICATION

To my beloved parents

ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) systems have received a lot of attention because of their robust performance in frequency dispersive channels. Further performance improvement is achieved by employing more sophisticated receiver techniques that often require the knowledge of signal-to-noise ratio (SNR) - broadly defined as the ratio of the desired signal power to the unwanted noise power. For example, noise variance and, hence, signal to noise ratio (SNR) estimates of the received signal are very important for the channel quality control in communication systems. Similarly, in advanced communication systems, SNR estimation is used for adaptive algorithms for modulation, power control and coding.

The objective of the work undertaken in this thesis is to design a front-end noise power estimator and, thence, SNR estimator. The proposed SNR estimator utilizes the OFDM preamble signal – the preamble used for synchronization. The estimation is achieved by auto correlating the preamble and it is deployed right at the front-end of the receiver. Noise power and, hence, signal power is estimated from the correlation results. The technique is also extended to obtaining noise power estimates of colored noise using wavelet-packet based filter bank analysis of the noise.

In order to benchmark the proposed noise power and SNR estimation technique, a complete end-to-end fixed-broadband-wireless-access-system (IEEE 802.16d) simulation has been developed and the results are compared with other works reported in the literature. The simulations are conducted in both frequency non-dispersive and dispersive channels with real additive white Gaussian noise (AWGN) and also colored noise. It is observed that the proposed estimator gives better SNR estimates. The proposed estimator is also checked with WiMAX systems (IEEE802.16d, 2004) using SUI multipath channels and with Wi-Fi systems (IEEE802.11a) with indoor channel models. The estimator performs SNR estimation at front-end of the receiver unlike all other estimators which perform SNR estimation at back-end of the receiver. Furthermore, the proposed estimator has relatively low computational complexity; for it makes use of only one

OFDM preamble signal to find the SNR estimates. The criteria of good SNR estimator are accuracy of estimates, low complexity and easy to implement. The results show that the proposed estimator fulfills these criteria successfully.

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LIST OF ABBREVIATIONS

AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BS	Base Station
CCI	Co-Channel Interference
CIR	Channel Impulse Response
CPE	Customer Premises Equipment
CSI	Channel State Information
DA	Data Aided
DFT	Discrete Fourier Transform
DVB	Digital Video Broadcasting
FBWA	Fixed Broadband Wireless Access
FDM	Frequency Division Multiplexing
FFT	Fast Fourier Transform
ICI	Inter-carrier Interference
IDFT	Inverse Discrete Fourier Transform
IFFT	Inverse Fast Fourier Transform
ISI	Intersymbol Interference
LAN	Local Area Network
LOS	Line-Of-Sight
MAN	Metropolitan Area Networks
MDL	Minimum Descriptive Length
MF	Matched Filter
ML	Maximum Likelihood
MLSE	Maximum-Likelihood Sequence Estimation
MRC	Maximum Ratio Combining
MSE	Mean Squared Error
NLOS	Non-Line-Of-Sight

NMSE	Normalized Mean-Squared-Error
OFDM	Orthogonal Frequency Division Multiplexing
PAPR	Peak to Average Power Ratio
Pdf	Power Density Function
PN	Pseudorandom Noise
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RMS	Root-Mean-Squared
SINR	Signal to Interference + Noise Ratio
SIR	Signal-to-Interference-Ratio
SNR	Signal to Noise Ratio
SS	Subscriber Station
SSME	Split Symbol Moment Estimator
SUI	Stanford University Interim
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WP	Wavelet Packet
WSSUS	Wide-Sense Stationary and Uncorrelated Scattering