NOVEL RESULTS FOR THE PERFORMANCE OF AMPLIFY AND FORWARD AND COGNITIVE RADIO SYSTEMS THROUGH VARIOUS COMMUNICATION CHANNEL SCENARIOS

By

Ebtehal Hassan Abdel Fattah El-Bahaie

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
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Title of Thesis:

Novel Results For The Performance Of Amplify And Forward And Cognitive Radio Systems Through Various Communication Channel Scenarios

Key Words:
Amplify and Forward; Nakagmai fading ; Lognormal shadowing; Gauss Hermite polynomial; Cognitive Radio

Summary:
This thesis includes three contributions. The first is accurate numerical results for the BER of a dual hop AF system with independent or correlated interferer in Nakagami fading channels. The second contribution is the evaluation of the BER and ergodic capacity for a dual hop AF system in a Nakagami fading plus Lognormal shadowing environment. Lognormal shadowing is represented by the Hermite polynomial. The third contribution is the exact analytical results for a cognitive radio system for two cases when the secondary users (SUs) are directly connected to the fusion centre and when the SUs are far from the fusion centre in Nakgami fading and Lognormal shadowing channels.

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I would like to thank my supervisor Prof. Emad Al-Hussaini for his continuous support and dedication throughout this research.

I would like to thank my husband and my family for their encouragement to complete this thesis.

Dedication

To my mother

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1- Ebtehal H. El-Bahaie, Emad K. Al-Hussaini, "Performance of Dual Hop Relay System in the Presence of a Correlated Interferer Through Nakagami Fading Channel ", Wireless Personal Communication, vol. 84, no. 2, 2015, pp: 1401-1415

2- Ebtehal H. El-Bahaie, Emad K. Al-Hussaini , "Novel results for the performance of single and double stages cognitive radio systems through Nakagami *m* fading and log-normal shadowing ", Telecommunication systems, 2017, pp: 1-9

List of Abbreviations

AF	Amplify and Forward
AWGN	Additive white Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase shift keying
CAF	Cyclic autocorrelation function
CDF	Cumulative Distribution function
CF	Compress and Forward
CR	Cognitive Radio
CSD	Cyclic spectral density
CSI	Channel state information
D	Destination node
DF	Decode and Forward
FCC	Federal Communications Commission
FDM	Frequency division multiplexing
IM	Inter-modultion
ISI	Inter symbol interference
MAI	Multiple access interference
MRC	Maximal Ratio Combining
PDF	Probability density function
PSD	Power Spectral Density
PU	Primary Use
R	Relay node
S	Source node
SDR	Software defined radio

SU	Secondary User
SNR	Signal to noise ratio
WSS	Wide sense stationary
VF	Voice frequency

List of symbols

a	modulation parameter
d	distance traveled by the radio wave
$E\{\}$	Expected value
E_1	The energy of the transmitted signal at the source
E_2	The energy of the transmitted signal at the relay
E_{h_I}	The energy of the interferer at the first hop (link)
E_{g_I}	The energy of the interferer at the second hop (link)
$F_{\gamma_t}(.)$	Cumulative distribution function of γ_t
$f_{\gamma_t}(.)$	Probability density function of γ_t
${}_1F_1(.,.,.)$	Confluent hyper-geometric function
G	The amplification factor at the relay
g_k	Fading gain of the interferer $'k'$
H_0	The hypothesis problem that indicates signal absence
H_1	The hypothesis problem that indicates signal presence
h_j	Fading gain of the interferer $'j'$
h_{kl}	Channel gain k and l
h_k	Composite Nakagami fading-lognormal shadowing coefficient
$I_0(.)$	Modified Bessel function of order zero
$I_v(.)$	Modified Bessel function of the first kind of order v
K_i	Order of the Hermite polynomial for the i^{th} link
$K_0(.)$	Zero order modified Bessel function of the 2^{nd} kind.
$K_v(.)$	v^{th} order modified Bessel function of the 2^{nd} kind
L	Number of interferers at the first link
L_k	Laguerre polynomial of degree k

M	Number of secondary users
m	fading depth
m_h	Fading parameters for the desired signal at the first hop (link)
m_{h_I}	Fading parameter for the interfering signal at the first hop (link)
m_g	Fading parameter for the desired signal at the second hop
m_{g_I}	Fading parameter for the interfering signal at the second hop
m_i	Nakagmi fading parameter at the i^{th} link
m_{s_i}	Shadowing severity parameter for the i^{th}link
N	Number of interferers at the second link
N_d	Number of antennas at the destination node
N_r	Number of antennas at the relay node
N_s	Number of samples of the received signal
N_{0_i}	Variance of the zero mean AWGN at the i^{th} node
$n_{kl}(t)$	AWGN process with zero mean and one-sided power spectral density N_0
n_k	Gaussian distributed noise with zero mean and variance ${\sigma_n}^2$
P_d	Probability of detection
$P_{d_{M1}} = P_{d_1}$	Probability of detection at the secondary user
$P_{d_{NL_1}}$	Average probability of detection for the composite Nakagami lognormal (NL) channel at the end of the first link and at each SU
$P_{d_{NL_2}}$	Average Probability of detection for each SU at the end of the second faded and shadowed link
P_e	The average bit error rate
P_f	Probability of false alarm
$P_{f_{M1}} = P_{f_1}$	Probability of false alarm at the secondary user
$P_{f_{NL_2}}$	Probability of false alarm for each SU at the end of the second faded and shadowed link
P_D	Overall probability of detection at the fusion centre