

MODELING AND SIMULATION OF A LAND MOBILE SATELLITE LINK

By

Eng. Heba-t-Allah Farouk Koraitim



A Thesis

**Submitted in partial fulfillment of the Master Degree in
Electrical Engineering
Electronics and Communications Department**

621.3825
H. F.

**Under the supervision
of**

u8554

Prof. Dr. Hadia El-Hennawy
Ain Shams University

Prof. Dr. Osman L. El-Sayed
Cairo University

Dr. Refaat El-Zanfally
National Telecommunications Institute

Cairo-1993



بسم الله الرحمن الرحيم



*To my family,
and all my friends...*

ACKNOWLEDGMENT

No words can ever express my sincere gratitude to all the people who contributed to the fulfillment of this work.

My deepest thanks go to Professor Dr. Hadia El Hennawy, Ain Shams University, for her caring guidance, helpful suggestions, and positive support throughout the work. Her continuous encouragement and dedicated time during all the steps of this study enabled it to progress and develop.

I was honoured to work under the supervision of Professor Dr. Osman L. El-Sayed, Cairo University, whose wide knowledge and experience guided me throughout the work. Without his confidence, support, and constructive discussions, the work could have never been achieved in this way.

I wish also to express my thanks to Dr. Refaat El-Zanfally for the useful discussions and continuous encouragement, and for providing the basic simulation software which formed the starting point of this study.

My thanks go to Professor Dr. A. Y. Bilal, Cairo University, Director of the National Telecommunication Institute, for his encouraging support and assistance.

An acknowledgment is due to all the friends who offered me their valuable help and encouragement. Particular thanks go to Dr. Hany Ghali, Ain Shams University, for his efforts and care in assisting me to present this work in its final form. I would also like to express my thanks to all my colleagues at the National Telecommunication

Institute, especially Engineer Nagy Fathy, Computer department, and Engineer Mohamed Afifi, Network Planning department for their helpful discussions, useful comments and technical assistance throughout the course of this work. I would like to thank my colleagues in the Transmission department for their understanding, support and encouragement.

Lastly, I would like to mention the major role of my family and all my friends in providing the greatest care, patience, and encouragement during the study period.

Examiners Committee

Name, Title and Affiliation

Signature

1 - Prof. Dr. M. Fekry Mohamed Ragay
Communications Engineering Dept.,
Cairo University



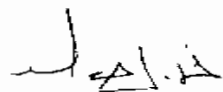
2 - Prof. Dr. M. Nabil Saleh
Dean, Faculty of Engineering,
Ain Shams University

M. N. Saleh

3 - Prof. Dr. Hadia El-Hennawy
Electronics and Communications Engineering Dept.,
Ain Shams University

H. El Hennawy

4 - Prof. Dr. O. Lotfy El-Sayed
Communications Engineering Dept.,
Cairo University



STATEMENT

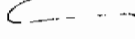
This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering.

The work included in this thesis was carried out by the author in the National Telecommunication Institute, Transmission department, from December 1990 to December 1993

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

Name : Heba-t-Allah Farouk Koraitim

Signature : 

Date : 30.12.1993 

Ain Shams University
Faculty of Engineering

Curriculum Vita (C.V.)

Student Name : Heba-t-Allah Farouk Koraitim

Date of Birth : 24-12-1966

Place of Birth : Cairo

First University Degree :

B.Sc. Electrical Engineering, Electronics and Communications Department, Ain Shams University, June 1989.

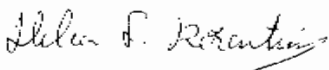
Previous Experience :


Teaching and research assistant at the National Telecommunication Institute, Transmission department, 1989-1993.

Present Job :

Teaching and research assistant at the National Telecommunication Institute, Transmission department.

Name : Heba-t-Allah Farouk Koraitim

Signature : 

Date : 30-12-1993 

Abstract

The objective of this thesis is evaluating the performance of a digital land mobile satellite link under some of the main impairments to which the signal is subjected. The considered system impairments include the land mobile propagation channel, in addition to the transponder travelling-wave tube amplifier. For this purpose, a simulation package is developed to analyze the link performance under the effect of multipath and shadowing phenomena of the mobile propagation channel. The nonlinearities encountered in the satellite transponder amplifier are also added in the simulation and the performance of the link is evaluated in a Gaussian noise environment.

Table of Contents

Chapter 1 : General Introduction	1
Chapter 2 : Mobile Satellite Communications	6
2.1 Introduction	6
2.2 Evolution of Satellite Communications	7
2.3 Geostationary Satellite Systems	12
2.4 Mobile Satellite Communications Systems	14
2.5 Network Configuration	17
2.5.1 Multiple Access Techniques	20
2.5.2 Link Model	26
2.6 Frequency Allocation	29
2.7 Mobile System Features	33
2.7.1 Modulation Techniques	34
2.7.2 Concept of Error Control	35
2.8 Low Earth-Orbiting (LEO) Satellite Systems	37
2.8.1 Frequency Band for LEO Systems	38
2.8.2 Geostationary Versus LEO Systems	38
2.8.3 LEO Satellite Systems Versus	
Mobile Cellular Systems	40
Chapter 3 : The Land Mobile Propagation Channel	41
3.1 Introduction	41
3.2 Mobile Propagation Channels	42
3.3 Characterization of the Multipath Phenomenon	47
3.3.1 Multipath Models	48

3.3.2 The Scattering Model	52
3.3.3 Signal Envelope	55
3.3.4 Signal Phase	56
3.3.5 Power Spectrum of the Fading Signal	57
3.3.6 Level Crossing Rate and Average Fade Duration	58
3.4 Shadowing	61
3.5 Channel Modeling Techniques	62
3.6 Probability Distribution Models	64
3.6.1 Loo's Statistical Model	67
3.6.2 Total Shadowing Model	71
3.6.3 Lognormal Shadowing Model	73
3.6.4 Markov Transition Models	75

Chapter 4 : Performance Analysis

of a Land Mobile Satellite Link	78
4.1 Introduction	78
4.2 Simulation Model of a Digital Land Mobile Satellite Link	82
4.3 Mobile Satellite Channel Simulation	84
4.3.1 Model for Simulating the Rayleigh Multipath Phenomenon	84
4.3.2 Mathematical Realization of the Rayleigh Model	87
4.3.3 Practical Implementation	89
4.3.4 Simulation of Rician Shadowed Mobile Channels	93
4.4 Link Simulation	103

4.4.1 Signal Generation	103
4.4.2 Noise in Land Mobile Satellite Systems	107
4.4.3 Transponder Nonlinearities	110
4.4.4 Signal Detection	119
4.5 Case Studies	121
4.5.1 Introduction	121
4.5.2 Simulation Features and Parameters	121
 Case Study I : Satellite Link Performance under Transponder TWTA Nonlinearity and Additive White Gaussian Noise	 126
 Case Study II : Land Mobile Channel Performance	 140
 Case Study III : Land Mobile Satellite Link Performance under the Combined Effect of Transponder Nonlinearity and Propagation Channel in a Gaussian Noise Environment	 147
 Chapter 5 : Conclusion and Perspective	 157
 Appendix A : Frequency Allocations of the 1992 World Administrative Radio Conference	 160
 References	 166

Chapter 1

General Introduction

In the ever-growing field of telecommunications, new services are continuously offered, supported by the rapidly growing technological development. Presently, satellite systems constitute one of the major telecommunications fields experiencing tremendous evolution. Satellite services are no longer confined to organizations, or large groups of users, rather it is extending to satisfy individual demands all over the world. Nowadays, it has become possible for a user, wherever located, whether stationary or travelling, to communicate in a relatively efficient, cost-effective manner, with any desired, remotely located destination. The global coverage and high communications capacity of satellite systems facilitated the realization of such advanced services on a personal need basis.

Land mobile satellite communications is a recently introduced service, offering wide range of speech and data communications. Researchers and system designers are directing their efforts towards improving the present system performance and developing new services to satisfy future demands.