INDOOR SIGNAL PROPAGATION

– A CASE STUDY FOR SRI LANKA –

INDOOR SIGNAL PROPAGATION

– A CASE STUDY FOR SRI LANKA –

This dissertation was submitted to the Department of Electronic & Telecommunication Engineering, University of Moratuwa in partial fulfillment of the requirements for the Degree of M. Sc. in Telecommunications

Department of Electronic & Telecommunication Engineering
University of Moratuwa

UOM Verified Signature

(Eng. A. T. L. K. Samarasinghe)

G. L. Roshan Chandraguptha
Admission Number - 05/8371
January 2009

Declaration

I certify that this dissertation does not incorporate without acknowledgement any material previously submitted for a degree in any University to the best of my knowledge and believe that it does not contain any material previously published, written or orally communicated by another person or myself except where due reference is made in the text. I also hereby give consent for my dissertation, if accepted, to be made available for photocopying and for inter-library loans, and for the title and summary to be made available to outside organizations.

UOM Verified Signature

Signature of the Candidate

(G. L. Roshan Chandraguptha)

Date: 20th Jan 2009

To the best of my knowledge, the above particulars are correct.

UOM Verified Signature

Supervisor

(Eng. A. T. L. K. Samarasinghe)

A. T. L. K. Samarasinghe
Head
Department of Electronic &
Telecommunication Engineering
University of Moratuwa, Sri Lanka

Acknowledgement

I would like to thank the Department of Electronic and Telecommunication Engineering for giving me the opportunity to carry out research project, 'Indoor Signal Propagation – A Case Study for Sri Lanka'.

First and foremost I would like to thank Dr. Priyantha Thilakumara and Dr. Ajith Pasqual, course coordinators of M. Sc. in Telecommunications 2005/2006, for the guidance given during the course.

Secondly I would like to thank specially Eng. Kithsiri Samarasinghe being the supervisor of the project for guiding me and enriching me on the subject matters. Mostly the time spent on discussion regarding the project work and achieving set goals in order to complete the research were very important during the project. Thank you very much sir. I appreciate your guidance very much.

Also I would like to thank Eng. Samantha Epa and Eng. Dinesh Thamotharam of Dialog Telecom (PLC) for providing me the equipment and other necessary technical details from the service provider.

Finally to all those who help me in various ways to complete research project successfully.

Abstract

Mobile communication radio channel varies very rapidly at times and causes very hard to predict its behavior and characteristics. Even if the channel does not explicitly change, speed of the mobile user and the surrounding will contribute to these variations causing many problems for mobile communication. Therefore study of Indoor signal propagation is an important factor in arriving at a good mobile network design.

Most of the work carried out in this area is specific for a particular country, region or area as evident by previous researches. Research specific to an area is essential since deals with surrounding buildings, environment and especially in the case of indoor propagation building material used for construction.

In this research the radio signal strengths inside a building were measured for two cases; one where the transmitter is an outdoor antenna installation and the other where the transmitter is an indoor antenna installation. Literature surveyed propagation models, equations and other graphs were used to map the measured and analyzed signal strength values, attenuation characteristics, propagation characteristics.

Principal objectives of the research were to determine how these parameters fit into best model(s) and determine the parameters appropriately to suit the conditions in Sri Lankan context. The parameters obtained are of similar range with other literature surveyed values such as path loss exponent, floor attenuation factor and partition attenuation factor values.

The parameters obtained can be used for any commercial software used in indoor signal strength estimations as the starting values for signal strength optimization and in order to obtain better results in terms of optimum signal coverage and optimum antenna placement. Generalization of these parameters for Sri Lankan context can be done once similar type of analysis is carried out in many buildings in Sri Lanka.

Table of Content

CHAPTER 1 1

1. INTRODUCTION 1

1.1. RESEARCH OBJECTIVES 1

1.2. LITERATURE REVIEW ON SIMILAR WORK DONE ELSEWHERE 2

1.2.1. Work done by Molkdar D. 2

1.2.2. Work done by Seidel Scott 2

1.2.3. Work done by Turkmani A. M. D. and Toledo A. F. 3

1.2.4. Work done by Hashemi H 4

1.3. BASICS OF RADIO WAVE SIGNAL PROPAGATION 4

1.4. RADIO WAVE PROPAGATION MECHANISMS 5

1.5. FADING 6

1.5.1. Small scale fading 6

1.5.2 Factors influencing small-scale fading 7

1.5.3. Large-scale fading 8

1.5.4. Path loss 8

1.5.5. Two ray model 9

1.5.6. Diffraction 12

1.5.7. Knife-edge diffraction model 13

1.5.8. Scattering 14

1.6. OUTDOOR PROPAGATION MODELS 15

1.6.1. Okumara model 15

1.6.2. Hata model 16

1.7. INDOOR PROPAGATION MODEL 18

1.7.1. Partition losses (same floor) 18

1.7.2. Partition losses (between floors) 19

1.8. DOPPLER SHIFT 20

CHAPTER 2 21

2. METHODOLOGY 21

2.1. RESOURCE REQUIREMENT 22

2.1.1. Outdoor installation measurements 22

2.1.2. Indoor installation measurements 23

CHAPTER 3 24

3. MEASUREMENTS AND OBSERVATIONS 24

3.1. INDOOR SIGNAL STRENGTH MEASUREMENTS FOR AN OUTDOOR ANTENNA INSTALLATION 24

3.2. INDOOR SIGNAL STRENGTH MEASUREMENTS FOR AN INDOOR ANTENNA INSTALLATION 26

CHAPTER 4 28

4. ANALYSIS 28

4.1. OUTDOOR INSTALLATION, FLOOR ATTENUATION FACTOR AND PATH LOSS EXPONENT ANALYSIS 28

4.1.1. Analysis with literature surveyed model parameters *28*

4.1.2. Optimizing the parameters *29*

4.1.3. Comparison of results *30*

4.2. INDOOR INSTALLATION, PARTITION ATTENUATION FACTOR AND PATH LOSS EXPONENT ANALYSIS 31

4.2.1. Analysis with literature surveyed model parameters *31*

4.2.2. Optimizing the parameters *34*

4.2.3. Comparison of results *38*

CHAPTER 5 40

5. CONCLUSION 40

6. RECOMMENDATIONS 41

6.1. IMPROVEMENTS AND FUTURE WORK 41

6.1.1. Graphical analysis *41*

6.1.2. Starting value for the signal strength predicting software *42*

List of Figures

FIGURE 1: SMALL-SCALE AND LARGE-SCALE FADING 7
FIGURE 2: TWO RAY MODEL 10
FIGURE 3: VECTOR SUM 11
FIGURE 4: FRESNEL ZONE GEOMETRY 12
FIGURE 5: KNIFE-EDGE DIFFRACTION MODEL. 13
FIGURE 6: MEDIAN ATTENUATION RELATIVE TO THE FREE SPACE ($A_{MU}(F, D)$) 15
FIGURE 7: CORRECTION FACTOR, G_{AREA} FOR DIFFERENT TYPES OF TERRAINS. 16
FIGURE 8: DOPPLER SHIFT 20
FIGURE 9: CROSS SECTION OF THE BUILDING AND MEASUREMENT LOCATIONS 25
FIGURE 10: FLOOR PLAN OF SIGNAL STRENGTH MEASURED LOCATIONS 26

List of Tables

TABLE 1: SIGNAL STRENGTH MEASUREMENT AT DIFFERENT FLOORS (BCCH =121, BS=70) 25

TABLE 2: SIGNAL STRENGTH MEASUREMENT AT 20 LOCATIONS 27

TABLE 3: CALCULATION WITH VALUES FROM LITERATURE 29

TABLE 4: MINIMIZING THE MEAN OF DIFFERENCE BETWEEN THEORETICAL AND MEASURED VALUES. 30

TABLE 5: COMPARISON OF PATH LOSS EXPONENT AND FLOOR ATTENUATION FACTORS 30

TABLE 6: SAME FLOOR, SIGNAL STRENGTH MEASUREMENT DUE TO EACH ANTENNA WITH TYPICAL VALUES 31

TABLE 7: MEAN OF DIFFERENCES AND STANDARD DEVIATIONS 34

TABLE 8: RESULTS OF THE OPTIMUM PATH LOSS EXPONENT AND PARTITION ATTENUATION FACTOR. 35

TABLE 9: MEAN OF DIFFERENCE AND THE STANDARD DEVIATION 38

TABLE 10: COMPARISON OF PATH LOSS EXPONENT AND PARTITION ATTENUATION FACTORS 38

TABLE 11: COMPARISON OF RECEIVE SIGNAL STRENGTH AND CALCULATED WITH RESEARCHED PARAMETERS 39

Abbreviations

GSM – Global System for Mobile communication

BCCH – Broadcast Control Channel

BS – Base Station

FAF – Floor Attenuation Factor

PAF – Partition Attenuation Factor

AFM – Attenuation Factor Model

LOS – Line of sight

NLOS – Non line of sight

PCS – Personal Communication Systems

CW – Continuous Wave