

**EVALUATION OF EM EXPOSURE FROM
WIRELESS COMMUNICATION DEVICES
IN A HOUSEHOLD ENVIRONMENT**

T.R.C.O. Ariyaratne

(8353)



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Degree of Master of Science



UNIVERSITY OF MORATUWA
LIBRARY

THESES & DISSERTATIONS

Electronic and Telecommunication Engineering

University of Moratuwa
Sri Lanka

621.39(043)

108945

January 2013

LB/DON/44/2015

**EVALUATION OF EM EXPOSURE FROM
WIRELESS COMMUNICATION DEVICES
IN A HOUSEHOLD ENVIRONMENT**

T.R.C.O. Ariyaratne

(8353)



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Thesis submitted in partial fulfilment of the requirements for the degree

Master of Science in Telecommunications.

Department of Electronic and Telecommunication Engineering

University of Moratuwa

Sri Lanka

January 2013

University of Moratuwa



108945

108945

621.38 "13"

621.39 (0+3)

108945

DECLARATION

This is to certify that to the best of my knowledge, this dissertation does not incorporate any material previously published without acknowledgment.



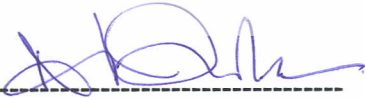
T.R.C.O. Ariyaratne

(Candidate)

Date:



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



Eng. A.T.L.K. Samarasinghe

(Supervisor)

Date:



ABSTRACT

With the increasing usage of wireless devices in households, the magnitude of exposure is explored when multiple such devices are used simultaneously. Out of many wireless devices found in a typical house, the study is limited to three common applications: Mobile Communication (GSM 900 MHz, GSM 1800 MHz and WCDMA 2100 MHz), Wi-Fi Communication (2400 MHz) and Cordless System Communication (1900 MHz).

The necessary data samples were collected from a household environment and SAR calculations were performed. An indoor wireless propagation simulation was carried out to visualize the existing radio environment under wireless transmission. It is shown that effects of simultaneous exposure can increase the level of harmfulness.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my project supervisor Eng. A.T.L.K. Samarasinghe for the insight provided to shape this research project and for the assistance extended providing guidance, advice and encouragement throughout the study.

I also convey my sincere gratitude for the course supervisors Dr. Ajith A. Pasqual and Dr. K.C.B. Wavegedara for the advice and support extended during the progress of the project.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

CONTENTS

DECLARATION.....	ii
ABSTRACT.....	iii
ACKNOWLEDGEMENT.....	iv
CONTENTS.....	v
LIST OF FIGURES.....	vii
LIST OF TABLES.....	viii
LIST OF ABBREVIATIONS.....	ix
CHAPTER 1 - Introduction	10
1.1 Research Objectives	10
1.2 Research Outline	12
CHAPTER 2 – Electromagnetic Radiation	13
2.1 Introduction	13
2.2 Specific Absorption Rate (SAR)	13
2.3 Safety Standards	14
2.3.1 Health Safety	14
2.3.2 Product Standards	14
2.3.3 Compatibility Standards.....	14
2.4 Exposure Standards	15
2.4.1 Population Groups.....	15
2.4.2 Basic Restrictions.....	15
2.5 Communication Standards	16
2.5.1 Mobile Communication	16
2.5.2 Wi-Fi Communication	18
2.5.3 Cordless System Communication	19
2.6 Previous Work.....	20
CHAPTER 3 – Sample Data Collection	21
3.1 Data Collection Tools.....	21

3.1.1	Mobile Signals	21
3.1.2	Wi-Fi Signals	22
3.2	Previous Work	22
3.2.1	Experiment	23
3.2.2	Results	24
3.3	GSM 900MHz Data Collection	25
3.4	GSM 1800MHz Data Collection	28
3.5	WCDMA 2100MHz Data Collection	29
3.6	Wi-Fi Data Collection	30
CHAPTER 4 – Simulation Design.....		31
4.1	Simulation Tool	31
4.2	Creating a 3D Model	32
4.3	Calibration of Material and Prediction Properties.....	34
4.4	Prediction Result	35
CHAPTER 5 – Calculations and Results		36
5.1	RF Source and Human Head Modeling	36
5.2	SAR Calculation	38
5.2.1	Mobile Phones.....	40
5.2.2	Wi-Fi 2400MHz	45
5.2.3	DECT 1900MHz	46
5.2.4	Simultaneous Exposure	48
CHAPTER 6 - Conclusion		50
6.1	Enclosed Areas	50
6.2	Household Radio Environment	50
6.3	Future Developments	52
REFERENCES.....		53



University of Moratuwa, Sri Lanka
 Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF FIGURES

		Page
Figure 1.1	A typical test Scenario of the study	10
Figure 3.1	TEMS Investigation drive test tool	20
Figure 3.2	PassMark WirelessMon software tool	21
Figure 3.3	Test setup	22
Figure 3.4	Mobile test transmitter placement	23
Figure 3.5	Received levels	23
Figure 3.6	Simulation Results	24
Figure 3.7	GSM 900MHz Existing Radio Environment	25
Figure 3.8	GSM 900MHz Transmit Levels during a Call	26
Figure 3.9	GSM 1800MHz Transmit Levels during a Call	27
Figure 3.10	WCDMA 2100MHz Transmit Levels during a Call	28
Figure 3.11	Wi-Fi 2400MHz Radio Environment	29
Figure 4.1	iBwave Design Planning Tool	31
Figure 4.2	3D Model for simulation	32
Figure 4.3	Wi-Fi RF Source Design Parameters	33
Figure 4.4	Prediction and Calibration Settings	34
Figure 4.5	Wi-Fi Router Coverage Prediction	35
Figure 5.1	Human Exposure Evaluation Model	36
Figure 6.1	Variation of Received Levels with distance	49

LIST OF TABLES

		Page
Table 2.1	Basic restrictions for time varying EM fields	10
Table 2.2	802.11 protocol specifications	18
Table 4.1	Calibration Results of Propagation Module and Materials	34
Table 5.1	Human Head Tissue Properties	36
Table 6.1	Summary of SAR Exposure Levels	50



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF ABBREVIATIONS

2G	Second Generation mobile communication-systems
3G	Third Generation mobile communication systems
ARFCN	Absolute Radio Frequency Channel Number
BCCH	Broadcast Control Channel
BTS	Base Station Transceiver
DCS	Digital Cellular Services
DECT	Digital Enhanced Cordless Telecommunications
EM	Electromagnetic
GSM	Global System for Mobile Commination
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
MAC	Media Access Control
MCC	Mobile Country Code
MNC	Mobile Network Code
PBX	Private Branch Exchange
SAR	Specific Absorption Rate
TDD	Time Division Duplexing
WCDMA	Wideband Code-Division Multiple-Access
WLAN	Wireless Local Area Networks