

# ANTENNAS AND PROPAGATION

*Modeling, Simulation & Measurements*

Edited by

**MD. RAFIQUUL ISLAM** B.Sc., M.Sc., Ph.D., MIEEE  
International Islamic University Malaysia

**JALEL CHEBIL** B.Sc., M.Sc., Ph.D., MIEEE  
International Islamic University Malaysia



IIUM PRESS

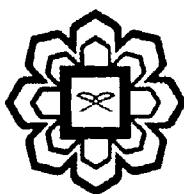
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

**ANTENNAS**  
**AND**  
**PROPAGATION:**  
*Modeling, Simulation & Measurements*

Edited by

**MD. RAFIQUL ISLAM** B.Sc.,M.Sc.,Ph.D.,MIEEE  
International Islamic University Malaysia

**JALEL CHEBIL** B.Sc.,M.Sc.,Ph.D.,MIEEE  
International Islamic University Malaysia



**IIUM Press**

Published by:  
IIUM Press  
International Islamic University Malaysia

First Edition, 2011  
©IIUM Press, IIUM

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without any prior written permission of the publisher.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

Md. Rafiqul Islam & Jalel chebil: Antennas and Propagation: Modeling, Simulation & Measurements

Bibliography p.  
Includes Index  
ISBN

ISBN: 978-967-418-138-3

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM  
(Malaysian Scholarly Publishing Council)

**Printed By:**  
**IIUM PRINTING SDN.BHD.**  
NO. 1, JALAN INDUSTRI BATU CAVES 1/3  
TAMAN PERINDUSTRIAN BATU CAVES  
BATU CAVES CENTRE POINT  
68100 BATU CAVES  
SELANGOR DARUL EHSAN  
TEL: +603-6188 1542 / 44 / 45 FAX: +603-6188 1543  
EMAIL: iiumprinting@yahoo.com

# Table of Content

Preface

<b>Part I</b>	<b>Microstrip Antenna Design</b>	<b>Page</b>
Chapter 1	Ultra Wideband Antennas <i>Muhammad Feroze Akbar J. Khan, Shaker MM. Al-Karaki, Md. Rafiqul Islam</i>	1
Chapter 2	Patch Antenna Parameters For Ultra Wideband Design <i>Muhammad Feroze Akbar J. Khan, Shaker MM. Al-Karaki, Md. Rafiqul Islam</i>	6
Chapter 3	Design Procedure for Microstrip Patch Antenna <i>Shaker MM. Al-Karaki, Muhammad Feroze Akbar J. Khan, Md. Rafiqul Islam</i>	13
Chapter 4	Design of Symmetrical Fed Patch UWB Antenna Using Partial Ground and Stairs <i>Md. Rafiqul Islam, AHM Zahirul Alam, Muhammad Feroze Akbar J. Khan and Shaker MM. Al-Karaki</i>	22
Chapter 5	Design of Symmetrical Fed Patch UWB Antenna Using Slotted Partial Ground And Stairs <i>Md. Rafiqul Islam, AHM Zahirul Alam, Muhammad Feroze Akbar J. Khan and Shaker MM. Al-Karaki</i>	33
Chapter 6	Design of Symmetrical Fed Patch UWB Antenna With Tuning Stub And Symmetrical Slotted Ground <i>Md. Rafiqul Islam, AHM Zahirul Alam, Muhammad Feroze Akbar J. Khan and Shaker MM. Al-Karaki</i>	40
Chapter 7	Design of Unsymmetrical Fed Patch UWB Antenna With Unsymmetrical Slotted Ground <i>Md. Rafiqul Islam, AHM Zahirul Alam, Shaker MM. Al-Karaki and Muhammad Feroze Akbar J. Khan</i>	49
Chapter 8	Ultra Wideband Antenna With Band Notch Using Asymmetrical Feedline <i>AHM Zahirul Alam and Md. Rafiqul Islam</i>	56
Chapter 9	Multi-Band Reconfigurable Antenna Using RF MEMS Switch <i>AHM Zahirul Alam and Md. Rafiqul Islam</i>	63
Chapter 10	Multi-Band Planar Patch Antenna <i>AHM Zahirul Alam and Md. Rafiqul Islam</i>	69
Chapter 11	Tuning Fork Type Planar Antenna <i>AHM Zahirul Alam and Md. Rafiqul Islam</i>	76
Chapter 12	Leaky-Wave Array Antenna <i>Mimi Aminah Wan Nordin, Hany E. Abd El-Raouf, AHM Zahirul Alam, Md. Rafiqul Islam</i>	83

Chapter 13	Overview of Smart Antenna System <i>Ibrahim A. Haji, Md. Rafiqul Islam, A.H. M. Zahirul Alam, Othman O. Khalifa Khaizuran Abdullah,</i>	
Chapter 14	Direction of Arrival Algorithms For Array Antenna Design <i>Ibrahim A. Haji, Md. Rafiqul Islam, A.H. M Zahirul Alam, Othman O. Khalifa, Khaizuran Abdullah</i>	97
Chapter 15	Analysis of Beamforming Algorithms <i>Ibrahim A. Haji, Md. Rafiqul Islam, A.H. M Zahirul Alam, Othman O. Khalifa and Khaizuran Abdullah</i>	108
Chapter 16	Design of Linear Array Antenna For Smart Antenna Application <i>Md. Rafiqul Islam, A.H. M Zahirul Alam, Othman O. Khalifa, Khaizuran Abdullah, Ibrahim A. Haji</i>	121

## **Part II Propagation Measurements and Modeling**

Chapter 17	Propagation Path Loss Modeling For Wireless Applications <i>Ali Khadim, Jalel Chebil and Md Rafiqul Islam</i>	137
Chapter 18	Comparison between Measured and Predicted Path Loss For Mobile Communication in Malaysia <i>Jalel Chebil, Md Rafiqul Islam and Ali Khadim</i>	152
Chapter 19	Proposed Path Loss Models For Suburban Area in Kuala Lumpur <i>Jalel Chebil, Md Rafiqul Islam and Ali Khadim</i>	157
Chapter 20	Rain Rate Distribution For Microwave Link Design in Malaysia <i>Jalel Chebil and Tharek Abd. Rahman</i>	164
Chapter 21	Rain Rate Conversion Factor in Malaysia <i>Jalel Chebil and Tharek Abd. Rahman</i>	171
Chapter 22	A Matlab Program for Prediction of Rain Rate and Rain Attenuation Distributions in Malaysia <i>Jalel Chebil and Tharek Abd. Rahman</i>	180
Chapter 23	Time-Delay Neural Network For Rainfall Forecasting <i>Kyaw Kyaw Htike, Othman O. Khalifa and Md. Rafiqul Islam</i>	186
Chapter 24	Development of One-Minute Rain Rate Contour Maps For Radiowave Propagation in Malaysia <i>Jalel Chebil and Tharek Abd. Rahman</i>	193
Chapter 25	Rain Attenuation Measurements in Malaysia <i>Jalel Chebil and Tharek Abd. Rahman</i>	201
Chapter 26	Propagation Study on Rain Attenuation at 18 GHz in Malaysia <i>Jalel Chebil and Tharek Abd. Rahman</i>	206
Chapter 27	Investigation Of Rain Attenuation At 38 GHz	214

	<i>Ahmad Fadzil Ismail and Khairayu Badron</i>	220
Chapter 28	Rain Attenuation Prediction Models For Earth-Space Link <i>Ahmad Fadzil Ismail and Khairayu Badron</i>	
Chapter 29	Development of A Modified Rain Attenuation Prediction Model <i>Ahmad Fadzil Ismail and Khairayu Badron</i>	226
Chapter 30	Antenna Losses Due To Rainfall And Its Effect On The Rain Attenuation Measurements <i>Jalel Chebil and Tharek Abd. Rahman</i>	233
Chapter 31	Modeling Of Wet Antenna Losses For Frequencies 15-38 GHz <i>Md. Rafiqul Islam, Jalel Chebil and Tharek Abdul Rahman</i>	239
Chapter 32	Path Length Reduction Factor For Rain Attenuation Prediction In Malaysia <i>Md. Rafiqul Islam, Jalel Chebil, Ahmad Fadzil Ismail and Tharek Abdul Rahman</i>	248
Chapter 33	Frequency Scaling Methods For Rain Attenuation Prediction <i>Md. Rafiqul Islam, Jalel Chebil, Ahmad Fadzil Ismail and Tharek Abdul Rahman</i>	256
Chapter 34	Proposed Frequency Scaling Method Based On Measured Rain Attenuation Data <i>Md. Rafiqul Islam, Jalel Chebil and Tharek Abdul Rahman</i>	269
Chapter 35	Analyses Of Rain Fade Characteristics For A 38 GHz Link In The Tropics <i>Ahmad Fadzil Ismail and Khairayu Badron</i>	278
Chapter 36	Worst-Month Statistics Modeling Based on Measured Data <i>Md. Rafiqul Islam, Jalel Chebil and Tharek Abdul Rahman</i>	285
Chapter 37	Worst-Month Rain Fade Statistics at 38 GHz <i>Ahmad Fadzil Ismail and Khairayu Badron</i>	298
Chapter 38	Rain Fade Slope Prediction Model Based On Satellite Data Measured In Malaysia <i>Md. Rafiqul Islam, Khalid Al-Khateeb, Sheroz Khan and Hassan Dao</i>	303
Chapter 39	Effects Of Rain On Free Space Optical Propagation <i>Suriza A.Z., Md. Rafiqul Islam, Wajdi Al-Khateeb and A.W. Naji</i>	310
Chapter 40	Investigation Of Solar Environment Effects On Space Assets & Satellite Signals <i>Othman O. Khalifa, Md. Rafiqul Islam, Jalel Chebil, Saad Bashir and Sivamohan A/L V.Shunmugam</i>	318

## Chapter 37

# Worst-Month Rain Fade Statistics at 38 GHz

Ahmad Fadzil Ismail<sup>1</sup> and Khairayu Badron<sup>1</sup>

### 37.1 Introduction

In situations when system planning requires the critical attenuation value exceeded for a time percentage  $p_w$  of the worst month, a procedure in Recommendations ITU-R P.618-10 [1] can be used to estimate the attenuation exceeded for a specified percentage based on the average year probability  $p$ . The ‘worst month’ can be identified by comparing individual monthly distribution of the rain fades. ITU-R P.581-2 [2] proposes that the fraction of time during which a pre-selected threshold is exceeded in the worst month of a year is referred to as ‘the annual worst-month time fraction of excess’. In other words, the probability distribution  $P_{wm} = \text{probability that } s > s \text{ in the worst month period of the average year}$ . In the ITU-R definition of ‘average annual worst month’,  $s$  is the random variable in question such as rain intensity or attenuation and  $s$  is a chosen threshold for exceedance measurement. The origin of the ‘worst month’ concept was initiated by condition where it has always been recognised by ITU that the average yearly exceedance of cumulative distribution may be irrelevant in illustrating the variability of attenuation from month to month, season to season or year to year. Hence, it is apparently worthwhile to take into account the occurrence of pronounced monthly or seasonality of a specific region.

The study of the worst-month rain induced attenuation statistics for tropical environment at V-band is a continuation from the previous analyses of the associated annual and monthly variability [3, 4]. In the study, the signal attenuation measurements at 1 second integration time were acquired using Ericsson MINI-LINKS terminals [5]. The data were utilised to derive the annual worst-month statistics and its relationship with the average annual distribution. The relationship between the measured worst month and the yearly probabilities was explored and evaluations were made against the ITU-R model. New values for the parameters  $Q_1$  and  $\beta$  are proposed based on measurements in Johor Bahru, Malaysia.

### 37.2 Monthly Cumulative Distributions

The annual worst month for a pre-selected threshold is defined as the month with the highest probability of exceeding that threshold within the period of 12 consecutive months. A worst month can therefore be recognized for each threshold level. As can be observed in Figure 1; at probability exceeding 0.1 and 0.01 time percentage, the month of October 1999 is the worst month for the period from January 1999 to December 1999. The envelope of the highest monthly probability value of all the monthly cumulative

---

<sup>1</sup> *Department of Electrical and Computer Engineering, Kulliyah of Engineering International Islamic University Malaysia (IIUM)*