



University of Moratuwa

UNIVERSITY OF MORATUWA
LIBRARY

**WAVELET PACKET BASED
ANTENNA RADIATION PATTERN
ANALYSER**

**Submitted in partial fulfilment for the degree of Master of Engineering in
Electronics & Telecommunication Engineering**

University of Moratuwa



82720

Wipula Wimalshanthi

621.38 "05"
621.38(048)

Thesis

82720

January 2005

82720

The work presented in this dissertation has not been submitted for the fulfillment of any other degree.



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

UOM Verified Signature

W Wimalshanthi

(Candidate)

UOM Verified Signature

Prof. J A K S Jayasinghe

(Supervisor)



ABSTRACT

Analysis of antenna radiation patterns, especially in respect of antennas with complex shapes and sizes, require the adoption of numerical methods of obtaining solutions to electro-magnetic equations. Method of Moments (MoM) being one of such proven methods, still poses the problem of manipulation of large matrices.

Objective of this exercise is to investigate the possibility of using wavelet transform techniques in obtaining fast solutions for the matrix equations resulting from MoM method. Specific attention has been given to Discrete Wavelet Transform (DWT) and Discrete Wavelet Packet (DWP) transform methods in order to sparsify the large impedance matrices generated by MoM method.

Wavelet transform being a recently developed technique, the mathematical background and related theoretical aspects have been illustrated prior to analysing several examples of thin wire centre fed antennas.

Examples have been selected to demonstrate effective adaptation of Discrete Wavelet Transform and Discrete Wavelet Packet Transform techniques in obtaining solutions for the matrix equations in the analysis of thin wire antennas. Comparisons have been made with the conventional method of solving these matrix equations illustrating the improvement in the computation times as a result of sparsification of matrices using Wavelet transform methods with the extensive assistance of MatLab Wavelet Tool Box.

Having indicated the advantages of wavelet transform techniques over the conventional methods of solving large matrix equations, several suggestions have been made towards optimising the results obtained to be taken up as further research work.

LIST OF FIGURES

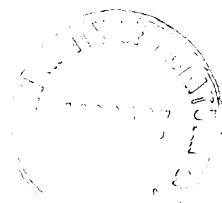
No.	Title	Page
2.1	Cylindrical conductor of radius a , with current density measured along its perimeter $K(Am^{-1})$	02
2.2	Conductor replaced by current filament $I = 2\pi aK (A)$ at a distance a from the z -axis	03
2.3	Source point on current filament with field dE , at a distance r on the z -axis	04
2.4	Segmentation of wire-antenna	07
2.5	Illustration of Fourier Analysis	09
2.6	Illustration of Short-Time Fourier Analysis	10
2.7	Illustration of Wavelet Analysis	11
2.8	Comparison of Wavelet Analysis with other Signal Analysis techniques	11
2.9	Comparison of a sine wave and a wavelet	12
2.10	Illustration of 'Mexican hat' wavelet	12
2.11	Illustration of Continuous Wavelet Transform	13
2.12	Scaling of a Wavelet	14
2.13	Illustration of shifting of Wavelet function	14
2.14	Step-by-Step illustration of CWT	15
2.15	A plot of the Wavelet Transform Coefficients vs Time	16
2.16	Decomposition of Signal in DWT	17
2.17	Single stage DWT of a Noisy Sine wave	18
2.18	Wavelet Decomposition Tree	18
2.19	Two Dimensional DWT Decomposition	19
2.20	Wavelet Reconstruction in IDWT	20
2.21	Decomposition and Reconstruction Filters	20
2.22	Reconstruction of First Level Approximation (A_1)	21
2.23	Reconstruction of First Level Detail (D_1)	21
2.24	Reconstruction of Signal from Multilevel Details and Approximations	22
2.25	Two-Dimensional Inverse DWT Reconstruction	23
2.26	Wavelet Packet Decomposition Tree	24
3.1	Multistage Decomposition and Reconstruction of the signal $X(n)$	25
4.1	Segmentation of short thin-wire antenna	29
4.2	Current distribution plots of Example (4.1.a) using $db1$ Wavelet with moderate thresholding	31
4.3	Current distribution plots of Example (4.1.b) using $db2$ Wavelet with moderate thresholding	33
4.4	Current distribution plots of Example (4.1.c) using $db2$ Wavelet with excessive thresholding	35
4.5	Segmentation of Thin-wire antenna	37
4.6	Current distribution plots of Example (4.2.a)	39

LIST OF FIGURES (Continued)

4.7	Comparison of computation times between conventional and DWP methods	40
4.8	Current distribution plots of Example (4.2.b)	41
4.9	Current distribution plots of Example (4.2.c)	43
B.1	Graphical illustration of 'db1' and 'db2' wavelets	67
B.2	Graphical illustration of four filters of 'db1' wavelet	67
B.3	Graphical illustration of four filters of 'db2' wavelet	68



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



LIST OF ABBREVIATIONS USED

AIM	Adaptive Integral Method
CWT	Continuous Wavelet Transform
DWP	Discrete Wavelet Packets
DWT	Discrete Wavelet Transform
FMM	Fast Multipole Method
FT	Fourier Transform
IDWT	Inverse Discrete Wavelet Transform
IML	Impedance Matrix Localization Method
MoM	Method of Moments
MVM	Matrix Vector Multiplication
STFT	Short Time Fourier Transform
WT	Wavelet Transform



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

CONTENTS

Abstract	i
1. Introduction	01
2. Relevant Concepts	02
2.1 Method of Moments Developed for a Wire Antenna	02
2.2 Wavelet Transform	08
2.2.1 Introduction to Wavelets	08
2.2.2 Wavelet Analysis in Comparison with several other Signal Analysis methods [7]	09
2.2.2.1 Fourier Analysis	09
2.2.2.2 Short-Time Fourier Analysis	10
2.2.2.3 Wavelet Analysis	10
2.2.3 Wavelet Transform techniques	11
2.2.3.1 An Example of a Wavelet	12
2.2.3.2 Continuous Wavelet Transform [7]	13
2.2.3.2.1 Scaling	14
2.2.3.2.2 Shifting	14
2.2.3.2.3 Steps involved in Continuous Wavelet Transform (Figure 2.14)	15
2.2.3.3 Discrete Wavelet Transform [7]	16
2.2.3.3.1 Multiple-level Decomposition	18
2.2.3.3.2 2-Dimensional DWT	19
2.2.3.3.3 Wavelet Reconstruction	19
2.2.3.3.3.1 Reconstruction Filters	20
2.2.3.3.3.2 Reconstructing Approximations and Details	20
2.2.3.3.4 2-Dimensional Inverse DWT	23
2.2.3.4 Discrete Wavelet Packet Transform	24
3. Mathematical Analysis	25
3.1 Application of Discrete Wavelet Transform in Solving Large Matrix Equations	25
4. Numerical Examples	29
4.1 Computation of Current Distribution along a Centre-fed thin-wire Antenna	29
4.1.1 Using MoM method and assuming uniform current distribution per segment	29
4.1.2 Using MoM method and assuming piecewise uniform current distribution per segment for improved accuracy	37
5. Discussion, Conclusions and Suggestions for further research work	45
5.1 Discussion	45
5.2 Conclusions and Suggestions for future research work	46
5.3 Acknowledgements	47

CONTENTS (Continued)

List of References	48
ANNEX – (A) MatLab Program Listings	49
ANNEX – (B) Description of Specific MatLab Commands and Wavelets used	65



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

