



Cairo University

**OPTIMAL DESIGN OF PHOTONIC CRYSTAL FIBER
STRUCTURES AND EM-BASED SYSTEMS USING
MODIFIED TRUST REGION OPTIMIZATION
ALGORITHMS**

By

Eng. Ahmed Essam Hammad Haggag Ahmed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in

ENGINEERING MATHEMATICS

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

Optimal designs of photonic crystal fiber structures and EM-based systems using modified trust region optimization algorithms.

Key Words:

Trust region; Design centering; Box constrained optimization; photonic crystal fiber; yield optimization.

Summary:

Two modified derivative free trust region algorithms have been proposed. The first is an unconstrained trust region (UTR) algorithm, while the other is a constrained trust region (CTR) algorithm. Both algorithms use quadratic surrogate models as a function approximation. The accuracy of the two modified algorithms is measured by applying them to some bench-mark and test functions. The CTR is used to obtain an optimal design for a photonic crystal fiber (PCF) polarization rotator. Further, the UTR algorithm has been employed in the optimization of the PCF dispersion and some practical polarization devices for the (PCFs) and EM-based systems.

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Table of Contents

ACKNOWLEDGMENTS.....	I
TABLE OF CONTENTS	II
LIST OF TABLES	V
LIST OF FIGURES	VI
LIST OF ABBREVIATIONS	X
ABSTRACT.....	XII
CHAPTER 1 : INTRODUCTION.....	1
1.1 OPTIMAL DESIGN	1
1.2 MOTIVATION OF THE WORK	2
1.3 DERIVATIVE FREE OPTIMIZATION	3
1.4 TRUST REGION OPTIMIZATION.....	4
1.4.1 Historical Background.....	5
1.4.2 The Trust Region Framework.....	5
1.4.3 Trust Region Methods For Unconstrained Optimization.....	7
1.4.4 Trust Region Methods For constrained Optimization.....	9
1.4.5 Trust Region Methods For Nonlinear Equations and Nonlinear Least Squares.....	10
1.4.6 Trust Region Methods For Multi-objective Optimization.....	11
1.5 PHOTONIC CRYSTAL FIBERS (PCFS).....	12
1.6 EM-BASED SYSTEMS.....	13
1.7 THESIS OUTLINES.....	14
CHAPTER 2: THE PROPOSED MODIFIED TRUST REGION ALGORITHMS..	15
2.1 INTRODUCTION.....	15
2.2 AN OUTLINE OF THE BASIC STEPS OF THE PROPOSED MODIFIED TRUST REGION ALGORITHMS.....	16
2.3 THE INITIAL MODEL.....	20
2.4 THE TRUST REGION SUB-PROBLEM.....	20
2.4.1 The Modified UTR Algorithm.....	21
2.4.2 The CTR Algorithm.....	24

2.5 THE UPDATING PROCEDURE FOR THE MODEL AND THE TRUST REGION PARAMETERS.....	25
2.5.1 The Trust Region Size and Center Update For The Modified Trust Region Algorithms.....	25
2.5.2 The Model Updating Procedure.....	26
2.6 THE COMPLETE ALGORITHM.....	27
2.7 SOME BENCH-MARK TEST FUNCTIONS.....	29
2.7.1 The 2D Beale Fuction.....	29
2.7.2 The 2D Cube Fuction.....	31
2.7.3 The 3D Box Fuction.....	32
2.7.4 The 6D Watson Fuction.....	33
2.7.5 The 10D Hilbert Fuction.....	34
2.7.6 Box Constrained Numerical Example.....	35
2.8 THE CONVERGENCE ANALYSIS FOR THE MODIFIED UTR ALGORITHM.....	35
2.9 CONCLUSIONS.....	38
CHAPTER 3: NUMERICAL TECHNIQUES FOR MODELING PHOTONIC CRYSTAL FIBER DEVICES	39
3.1 INTRODUCTION.....	39
3.2 FULL VECTORIAL FINITE DIFFERENCE METHOD (FVFDM).....	40
3.2.1 Maxwell's Equations.....	40
3.2.2 Formulation of the FVFDM.....	41
3.2.3 Boundary Conditions.....	42
3.3 FULL VECTORIAL FINITE DIFFERENCE BEAM PROPAGATION METHOD (FVFD-BPM).....	43
3.3.1 Introduction.....	43
3.3.2 Formulation of the FVFD-BPM.....	44
3.4 SUMMARY	46
CHAPTER 4: DISPERSION OPTIMIZATION OF PHOTONIC CRYSTAL FIBERS.....	47
4.1INTRODUCTION.....	47
4.2 DESIGN OF ULTRA-FLATTENED ZERO DISPERSION PCF.....	50
4.3 DISPERSION OPTIMIZATION OF SELECTIVELY FILLED NLC-PCF.....	54
4.3.1 Nearly-Zero-Flattened-Dispersion.....	54

4.3.2 Photonic Crystal Fiber for Dispersion Compensation.....	60
4.3.2.1 Design centering optimization technique.....	60
4.3.2.2 Numerical results.....	62
4.4 SUMMARY.....	64
CHAPTER 5: OPTIMAL DESIGNS OF POLARIZATION HANDLING DEVICES	65
5.1 INTRODUCTION.....	65
5.2 OVERVIEW OF POLARIZATION HANDLING DEVICES.....	65
5.3 DESIGN OF A PASSIVE POLARIZATION ROTATOR.....	67
5.4 DESIGN OF A NLC POLARIZATION SPLITTER.....	74
5.5 DESIGN OF A POLARIZATION INDEPENDENT MULTIPLEXER-DEMULTIPLEXER.....	79
5.6 SUMMARY.....	82
CHAPTER 6: OPTIMAL DESIGN OF EM-BASED SYSTEMS.....	83
6.1 INTRODUCTION.....	83
6.2 OPTIMAL DESIGN OF RF CAVITY.....	83
6.3 THE RE-ENTRANT RF CAVITY FOR KLYSTRON AMPLIFIER.....	88
6.4 DESIGN CENTERING PRACTICAL EXAMPLES.....	92
6.4.1 Design Centering of RF Cavity.....	93
6.4.2 Design Centering of Microwave Circuits.....	97
6.4.2.1 Generalized space mapping (GSM).....	97
6.4.2.2 Six-section H-plane waveguide filter.....	98
6.4.2.3 Bandstop microstrip filter with open stubs.....	101
6.4.2.4 Ultra-wideband (UWB) multiple-input-multiple-output (MIMO) antenna	103
6.5 SUMMARY.....	105
CHAPTER 7: CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK..	107
APPENDIX A.....	109
REFERENCES.....	113

List of Tables

Table 2.1: The 2D Beale function Results	30
Table 2.2: The 2D Cube function Results	31
Table 2.3: Results of the 3D Box function.....	32
Table 2.4: Results of the 6D Watson function.....	33
Table 2.5: Results of the 10D Hilbert function.....	34
Table 4.1: Results of the dispersion sum using the original [9] and the modified trust region algorithms	53
Table 4.2: A comparison between the original trust region (OTR) [9] and the modified unconstrained trust region (UTR) algorithms, PSO [23], CFO [23], RBF-ANN [22], GA [24], GA [25].....	54
Table 4.3: Results of the nearly-flattened zero dispersion using the NLC-PCF of type 1, Type 2, Type 3, Type 4	57
Table 4.4: Results of the dispersion compensation of the quasi TM mode using the NLC-PCF of Type 5	64
Table 5.1: The initial and final design parameter values for the polarization rotator device	68
Table 6.1: The RF Cavity Results using the modified algorithm compared with the original algorithm and NEWUOA [9]	86
Table 6.2: A comparison between the original [9], the modified (UTR) algorithms and previous design [186] for Re-entrant RF Cavity in Klystron Amplifier.....	90
Table 6.3: Results of RF cavity design centering using the original and the modified (UTR) algorithms.....	95
Table 6.4: Yield values of RF Cavity using the modified algorithm compared with the original algorithm.....	96
Table 6.5: Results of the six-section H-plane waveguide filter (independent case)....	100
Table 6.6: Results of the six-section H-plane waveguide filter (correlated case)	100
Table 6.7: Results of the UWB MIMO antenna using the modified (UTR) algorithm	104

List of Figures

Figure 1.1: Example on (a) one dimensional (b) two dimensional (c) three dimensional Phc structure.	12
Figure 2.1: Geometry improvement of the available points.	18
Figure 2.2: A flow chart for the basic steps of the proposed modified algorithms	19
Figure 2.3: Results of the 2D Beale function	30
Figure 2.4: Results of the 2D Cube function.....	31
Figure 2.5: Results of the 3D Box function.....	33
Figure 2.6: Results of the 6D Watson function	34
Figure 2.7: Results of the 10D Hilbert function	35
Figure 3.1: The scanning electron microscope images of (a) index guiding PCF [93] and (b) photonic bandgap guiding fiber [94].....	39
Figure 3.2: Propagation of an initial field distribution along the axial direction	43
Figure 3.3: Envelope of the transverse magnetic field component.....	45
Figure 4.1: The optical fiber structure [147]	47
Figure 4.2: A broadened output pulse at the end of the fiber results from non-monochromatic excitation source with a spectrum, $\Delta\lambda$, of wavelengths [147].....	47
Figure 4.3: The extension of the electric field into the cladding region [147].	49
Figure 4.4: Schematic diagram of the PCF structure [10].....	51
Figure 4.5: (a) Dispersion of the quasi TE mode calculated by the original, modified trust region algorithms, the genetic algorithms and the metaheuristic algorithms[10]..	52
Figure 4.5: (b) Comparison of the objective function values for the original and the modified algorithms versus the number of function evaluations [10]	52
Figure 4.6: Cross section of the NLC-PCF whose cladding holes are selectively infiltrated (grey area) by a NLC of type E7 and are arranged in a soft glass background material of (a) Type 1, (b) Type 2, (c) Type 3, (d) Type 4, and (e) Type 5 [10].....	55
Figure 4.7: Variation of n_o and n_e of the E7 material with the wavelength at different temperatures T from 15° C to 50° C with a step of 5° C. The solid line with closed circles represents the variation of the refractive index of the SF57 material n_{SF57} with the wavelength [151].....	56

Figure 4.8: (a) Dispersion of the quasi TM, and quasi TE modes using the NLC-PCF of type1 and dispersion of the quasi TM mode using the NLC-PCF of type2, type3, and type4. (b) The corresponding objective function values calculated by the modified algorithms versus the number of function evaluations of the studied cases [10].	58
Figure 4.9: Variation of the birefringence with the wavelength using the NLC-PCF of type1 type2, type3, type4, and type5 at their optimized geometrical parameters compared to the PCF with cladding air holes at the same geometrical parameters of the NLC-PCF of type 5 [10].	59
Figure 4.10: (a) Dispersion compensation of the quasi TM mode using NLC-PCF of type5 [10].	63
Figure 4.10: (b) The variation of the objective function values with the number of function evaluations of the quasi TM mode of the studied NLC-PCF of type5 [10]. ...	63
Figure 5.1: Cross section of the suggested rectangular PCF PR with an extra air hole.	68
Figure 5.2: Contour plot of the nondominant H_x and the dominant H_y field profiles of the fundamental quasi- TE mode for (a), (b) the initial parameters and for (c), (d) the final parameters of the suggested PCF.	69
Figure 5.3: Evolution of the quasi TE and TM powers for the TE excitation along the propagation direction at the final parameters.	70
Figure 5.4: Contour plot of H_y , H_x and field profiles at different propagation lengths= $0, L_\pi/2$ and L_π	71
Figure 5.5: (a) Cross section of the suggested rectangular PCF PR using the initial parameters.	71
Figure 5.5: (b) Cross section of the suggested rectangular PCF PR using the final parameters.	72
Figure 5.6: The objective function values versus the number of function evaluations..	73
Figure 5.7: Evolution of the TE and TM powers for the TE excitation along the propagation direction at the final parameters.	73
Figure 5.8: Contour plot of H_y , and H_x field profiles at different propagation lengths= $0, L_\pi/2$ and L_π	74
Figure 5.9: Cross-section of the NLC-PCF coupler between two electrodes. The director of the NLC with a rotation angle ϕ is shown at the right.	75

Figure 5.10: Three dimension mode field profile of the fundamental component H_y of the (a) even and (b) odd TE modes at the operating wavelength $\lambda = 1.55 \mu\text{m}$	76
Figure 5.11: Field contour patterns for H_y , and H_x of the quasi TE and TM modes, respectively, at (a, b) $z=0$, (c, d) $z=190 \mu\text{m}$, and (e, f) $z=380 \mu\text{m}$ at $\lambda = 1.55 \mu\text{m}$	78
Figure 5.12: Evolution of the normalized powers at the left core for the quasi TE and quasi TM modes at the operating wavelength of $1.55 \mu\text{m}$ along the propagation direction.....	79
Figure 5.13: Evolution of the normalized powers at the left core for the quasi TM modes at the wavelengths 1.3 and $1.55 \mu\text{m}$ along the propagation direction at $\varphi = 0^\circ$	81
Figure 5.14: Evolution of the normalized powers at the left core for the quasi TE modes at the wavelengths 1.3 and $1.55 \mu\text{m}$ along the propagation direction at $\varphi = 90^\circ$	81
Figure 6.1: The RF cavity structure.....	85
Figure 6.2: Results of the effective shunt impedance per unit length in MOhm/m for the RF Cavity using the modified algorithm compared with the original algorithm and NEWUOA.....	86
Figure 6.3: The initial RF cavity structure.....	87
Figure 6.4: The optimal RF cavity structure (using the modified (UTR) algorithm)....	87
Figure 6.5: The optimal RF cavity structure (using the original algorithm) [9].....	88
Figure 6.6: The optimal RF cavity structure (using the NEWUOA) [9].....	88
Figure 6.7: The re-entrant cavity structure.....	89
Figure 6.8: The initial re-entrant cavity structure.....	90
Figure 6.9: The optimal re-entrant cavity structure (using the original algorithm [9]).	91
Figure 6.10: The optimal re-entrant cavity structure (using the modified (UTR) algorithm).....	91
Figure 6.11: Results of the r_s/Q in Ohm for the RF Cavity of Klystron Amplifier using the modified (UTR) algorithm compared with the original algorithm [9].....	92
Figure 6.12: Proposed structure for RF cavity design centering.....	94
Figure 6.13: The final shape of RF cavity using the original algorithm with shunt impedance= 114.235 MOhm/m	95

Figure 6.14: The final shape of RF cavity using the modified (UTR) algorithm with shunt impedance=114.718 MOhm/m.....	96
Figure 6.15: The Results of the yield function of RF Cavity using the modified compared with the original algorithm.....	97
Figure 6.16: (a) Six-section H-plane waveguide filter.....	99
Figure 6.16: (b) The equivalent empirical circuit model [189].....	99
Figure 6.17: Yield values at the initial and final points with parameter spread $\sigma/2$	100
Figure 6.18: The structure of the bandstop microstrip filter.....	102
Figure 6.19: (a) The initial yield of the bandstop filter.....	102
Figure 6.19: (b) The final yield of the bandstop filter.....	103
Figure 6.20: The structure of the proposed antenna.....	104
Figure 6.21: The S-parameters at the initial and final centers.....	105

List of Abbreviations

PCF	Photonic Crystal Fiber
EM	Electromagnetic
LHS	Latin Hyber-cube Sampling
GSM	Generalized Space Mapping
DFO	Derivative Free Optimization
MCS	Multilevel Coordinate Search
RSMs	Response Surface Methods
SMF	Surrogate Management Framework
NEWUOA	New Unconstrained Optimization Algorithm
BOBYQA	Bound Constrained Optimization by Quadratic Approximation
Phcs	Photonic Crystals
LC	Liquid Crystal
PRs	Polarization Rotators
MUX-DEMUX	Multiplexer-Demultiplexer
FVFDM	Full Vectorial Finite Difference Method
FVFD BPM	Full Vectorial Finite Difference Beam Propagation Method
NLC-PCF	Nematic Liquid Crystal PCF
UTR	Unconstrained Trust Region
CTR	Constrained Trust Region
TIR	Total Internal Reflection
PBG	Photonic Bandgap Guiding
BPMs	Beam Propagation Methods
FDM	Finite Difference Method
MM	Mode Matching

FVBPM	Full Vectorial Beam Propagation Method
PML	Perfect Matched Layer
FFTBPM	Fast Fourier Transform Beam Propagation Method
TE	Transverse Electric
TM	Transverse Magnetic
DC-PCF	Dispersion Compensating PCF
DCCFs	Dual Concentric Core Fibers
CT	Cross Talk
SM	Space Mapping
LINACs	Linear Accelerators
UWB	Ultra-Wideband
MIMO	Multiple-Input- Multiple-Output
PM	Planar Monopole