

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Motivation . . . . .	4
1.2	Objectives . . . . .	5
1.3	Materials and Methods . . . . .	6
1.3.1	Computational Methods . . . . .	7
1.4	Major Contribution of the thesis . . . . .	9
1.5	Organization of the Thesis . . . . .	10
<b>2</b>	<b>Literature Review</b>	<b>12</b>
2.1	Introduction . . . . .	12
2.2	Metaheuristic Algorithms . . . . .	13
2.2.1	Swarm Intelligence Based Algorithms . . . . .	14
2.2.1.1	Sine Cosine Algorithm (SCA) . . . . .	14
2.2.1.2	Ant Lion Algorithm (ALO) . . . . .	15
2.2.1.3	Dragonfly Algorithm (DFA) . . . . .	16
2.2.1.4	Artificial Bee Colony (ABC) . . . . .	16
2.2.1.5	Harris Hawk's Optimization (HHO) . . . . .	17
2.2.1.6	Salp Swarm Algorithm (SSA) . . . . .	18

## **Contents**

---

2.2.1.7	Marine Predator Algorithm (MPA) . . . . .	18
2.2.1.8	Artificial Hummingbird Algorithm (AHA) . . . . .	19
2.2.1.9	Grey Wolf Optimizer (GWO) . . . . .	20
2.2.1.10	Improved Grey Wolf Optimizer (IGWO) . . . . .	22
2.2.1.11	Moth Flame Optimization (MFO) . . . . .	23
2.2.1.12	Particle Swarm Optimization (PSO) . . . . .	24
2.2.1.13	Firefly Algorithm (FFA) . . . . .	25
2.2.1.14	Whale Optimization Algorithm (WOA) . . . . .	26
2.2.2	Physics Inspired Algorithms . . . . .	27
2.2.2.1	Equilibrium Optimizer (EO) . . . . .	28
2.2.2.2	Artificial Electric Field Algorithm (AEFA) . . . . .	28
2.2.2.3	Flow Direction Algorithm (FDA) . . . . .	28
2.2.2.4	Atom Search Optimization (ASO) . . . . .	29
2.2.2.5	Multi-Verse Optimizer (MVO) . . . . .	29
2.2.2.6	Big Bang-Big Crunch Algorithm (BB-BC) . . . . .	29
2.2.3	Other Algorithms . . . . .	30
2.2.3.1	Teaching-Learning-Based Optimization Algorithm (TLBO) . . . . .	30
2.2.3.2	Genetic Algorithm (GA) . . . . .	31
2.2.3.3	Arithmetic Optimization Algorithm (AOA) . . . . .	32
2.2.4	Hybridization of Metaheuristic Algorithms . . . . .	33
2.3	Optimal Design of DC-DC power converters . . . . .	34
2.4	DC-DC converters for maximum power point tracking in PV applications . . . . .	36

## Contents

---

2.4.1	DC-DC converters as PPU's in PV systems for MPPT application . . . . .	37
2.4.2	MPPT Algorithms and DC-DC Converters . . . . .	38
2.5	Optimization of Hybrid Renewable Energy Systems (HRES) . . . . .	41
2.5.1	Applications of Optimization Algorithms . . . . .	43
2.6	Discussion . . . . .	44
2.7	Summary . . . . .	46
<b>3</b>	<b>Optimal design of DC-DC converter for MPPT applications</b>	<b>48</b>
3.1	Introduction . . . . .	48
3.2	Steady State Space Model of DC-DC Boost Converter . . . . .	48
3.3	Mathematical formulation of the Design optimization Problem . . . . .	51
3.4	Design optimization of DC-DC Boost converter . . . . .	52
3.5	DC-DC Boost converter optimal design based MPPT tracking of standalone PV systems . . . . .	59
3.5.1	Optimal Design of the DC-DC Boost Converter for MPPT tracking of standalone PV systems . . . . .	61
3.5.2	MPPT tracking of PV standalone system using optimized DC-DC Converter . . . . .	63
3.6	Discussion . . . . .	69
3.7	Summary . . . . .	71
<b>4</b>	<b>Optimal sizing of the Hybrid Renewable Energy System (HRES)</b>	<b>72</b>
4.1	Introduction . . . . .	72
4.2	Developing an effective mathematical model for PV Hydro Hybrid Renewable Energy System(HRES) . . . . .	72
4.2.1	Study Area and Load Profile . . . . .	76

## Contents

---

4.2.2	Load Assessment . . . . .	78
4.2.3	Assessment of study's area Meteorological data . . . . .	79
4.3	Optimal Sizing of Hybrid PV Hydro Renewable Energy System using Metaheuristic Algorithms . . . . .	83
4.4	Discussion . . . . .	88
4.5	Summary . . . . .	88
<b>5</b>	<b>Development and Comparative Assessment of a Hybrid Optimization Algorithm</b>	<b>90</b>
5.1	Introduction . . . . .	90
5.2	Design and development of a Hybrid Metaheuristic Algorithm (GWOSCAPSO) . . . . .	90
5.3	Performance evaluation of the developed GWOSCAPSO optimization algorithm . . . . .	92
5.3.1	Time Complexity . . . . .	93
5.3.2	Statistical Performance Analysis . . . . .	93
5.3.2.1	Friedman's Test . . . . .	94
5.3.3	Benchmark Functions . . . . .	94
5.4	Application of hybrid GWOSCAPSO for solving Renewable Energy Optimization Problems . . . . .	98
5.4.1	Design Optimization of DC-DC Boost Converter using GWOSCAPSO . . . . .	98
5.4.2	Optimized design of the Boost Converter for MPPT applications for standalone PV systems using GWOSCAPSO . . . . .	100
5.4.3	Optimal Sizing of Hybrid PV Hydro Renewable Energy System(HRES) using GWOSCAPSO . . . . .	102
5.5	Discussion . . . . .	104

## **Contents**

---

5.6 Summary . . . . .	107
-----------------------	-----

<b>6 Conclusion and Future Directions</b>	<b>108</b>
---	------------

6.1 Conclusion . . . . .	108
--------------------------	-----

6.1.1 DC-DC converter design optimization for MPPT application	109
--	-----

6.1.2 Optimal Sizing of a Hybrid PV-Hydro based HRES . . . . .	109
--	-----

6.1.3 Hybrid GWOSCAPSO algorithm . . . . .	110
--	-----

6.2 Limitations of the current study . . . . .	110
--	-----

6.3 Directions for Future works . . . . .	111
---	-----

<b>Bibliography</b>	<b>113</b>
---------------------	------------

<b>Publications based on thesis works</b>	<b>140</b>
---	------------