



Cairo University

# NEW APPROACH FOR MAXIMUM POWER POINT TRACKING IN PHOTOVOLTAIC SYSTEM

By

Eng. AHMED GAMAL EL DIN MOUSA SAIED

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

in  
Electrical Power & Machines Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
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**Title of Thesis:**

New Approach for Maximum Power Point Tracking in Photovoltaic System

**Key Words:**

Maximum power point tracking; perturbation and observation method; Incremental conductance method; renewable energy; photovoltaic

**Summary:**

Any photovoltaic solar generator (PVSG) can be efficiently utilized if it operates at its optimum operating point. Accordingly, many tracking algorithms for maximum power point tracking (MPPT) of photovoltaic (PV) modules had been developed. In the literature, the Perturbation and Observation (P&O) method and the Incremental Conductance (IC) method are the most widely used. Each of them has its advantages and disadvantages.

In this thesis, a MPPT algorithm method based on analysis of the mathematical relationship between the maximum power points and the corresponding currents at different operating conditions is presented. Several simulation results are provided to highlight the performance, effectiveness, advantages and disadvantages of the presented method compared to the conventional P&O and IC methods. Besides, a PV powered water pumping system is presented and discussed as an application of the different given MPPT techniques.

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# Table of Contents

	<b>Page</b>
<b>ACKNOWLEDGMENTS</b> .....	<b>i</b>
<b>TABLE OF CONTENTS</b> .....	<b>ii</b>
<b>LIST OF TABLES</b> .....	<b>v</b>
<b>LIST OF FIGURES</b> .....	<b>vi</b>
<b>LIST OF SYMBOLS AND ABBREVIATIONS</b> .....	<b>x</b>
<b>LIST OF PUBLICATIONS</b> .....	<b>xii</b>
<b>ABSTRACT</b> .....	<b>xiii</b>
<b>CHAPTER (1): INTRODUCTION</b> .....	<b>1</b>
<b>1.1. THESIS OUTLINES</b> .....	<b>2</b>
<b>CHAPTER (2): SOLAR CELL MODELING</b> .....	<b>4</b>
<b>2.1. MODELLING OF PV MODULE</b> .....	<b>4</b>
2.1.1. PV module characteristics .....	<b>4</b>
2.1.2. Equations of PV module .....	<b>5</b>
2.1.3. Presented module .....	<b>5</b>
2.1.4. Photo-light current ( $I_{ph}$ ) .....	<b>6</b>
2.1.5. Reverse saturation current module .....	<b>6</b>
2.1.6. Module saturation current ( $I_s$ ) .....	<b>7</b>
2.1.7. Module shunt current ( $I_{sh}$ ) .....	<b>8</b>
2.1.8. Module output current ( $I$ ) .....	<b>8</b>
2.1.9. Gathering the PV module in one block .....	<b>11</b>
<b>2.2. EFFECT OF VARIATION OF SOLAR IRRADIATION</b> .....	<b>11</b>
<b>2.3. EFFECT OF TEMPERATURE VARIATION</b> .....	<b>12</b>
<b>CHAPTER (3): DC-DC CONVERTERS</b> .....	<b>14</b>
<b>3.1. BOOST CONVERTER</b> .....	<b>14</b>
<b>3.2. MODES OF OPERATION</b> .....	<b>15</b>
3.2.1. Charging mode .....	<b>15</b>
3.2.2. Discharging mode .....	<b>15</b>
<b>3.3. DESIGN OF BOOST CONVERTER</b> .....	<b>15</b>
<b>3.4. CONVERTER SIMULATION</b> .....	<b>16</b>

<b>3.5. OUTPUT WAVEFORMS .....</b>	<b>17</b>
<b>3.6. BUCK CONVERTER .....</b>	<b>18</b>
<b>3.7. MODES OF OPERATION .....</b>	<b>19</b>
<b>3.8. DESIGN OF BUCK CONVERTER .....</b>	<b>20</b>
3.8.1. Filter conductor .....	20
3.8.2. Output capacitor .....	20
3.8.3. Input capacitor .....	20
3.8.4. Switching MOSFET .....	21
<b>3.9. CONVERTER SIMULATION .....</b>	<b>21</b>
<b>3.10. OUTPUT WAVEFORMS .....</b>	<b>22</b>
<b>CHAPTER (4): MAXIMUM POWER POINT TRACKING .....</b>	<b>24</b>
<b>4.1. INTRODUCTION .....</b>	<b>24</b>
<b>4.2. METHODS OF MPPT .....</b>	<b>25</b>
4.2.1. Constant voltage method .....	26
4.2.2. Open circuit voltage $V_{OC}$ method .....	26
4.2.3. Short circuit current method .....	27
4.2.4. Temperature methods .....	28
4.2.5. Fuzzy logic control method .....	29
<b>4.3. COMPARATIVE TECHNIQUES .....</b>	<b>31</b>
4.3.1. The perturb and observe method .....	31
4.3.1.1. Algorithm simulation .....	32
4.3.2. The incremental conductance method .....	32
4.3.2.1. Algorithm simulation .....	34
<b>4.3. SUMMARY .....</b>	<b>35</b>
<b>CHAPTER (5): MAXIMUM POWER POINT TRACKING CASE STUDY...</b>	<b>36</b>
<b>5.1 PROPOSED METHOD .....</b>	<b>36</b>
5.1.1. Algorithm simulation .....	38
<b>5.2. CURVE FITTING .....</b>	<b>38</b>
<b>5.3. MODIFIED ALGORITHM SIMULATION .....</b>	<b>41</b>
<b>5.4. OPTIMUM TUNING OF PI CONTROLLER .....</b>	<b>43</b>
5.4.1. PID controller .....	43
5.4.2. PID parameters affect system dynamics .....	45
5.4.3. Tuning of PID controllers .....	45

5.4.4. Good gain method .....	46
<b>5.5. PROPOSED METHOD USING BUCK CONVERTER .....</b>	<b>48</b>
<b>5.6. SIMULATION RESULTS .....</b>	<b>49</b>
5.6.1. Preliminary assessment of the simulation .....	49
5.6.2. Stationary characteristic tests .....	50
5.6.3. Uniform step change .....	54
5.6.4. Droop and rise test .....	56
5.6.5. Uniform ramp change in photovoltaic irradiance level according to the British standard 50530 .....	58
5.6.5.1. The low – medium irradiance .....	59
5.6.5.2. The medium – high irradiance .....	61
5.6.6. Load variation test .....	64
5.6.6.1. Step down test .....	64
5.6.6.2. Step up test .....	66
5.6.6.3. General load test .....	69
<b>5.7. VALIDATION AND COMPARISON OF THE DIFFERENT ALGORITHM TECHNIQUES .....</b>	<b>72</b>
<b>CHAPTER (6): CASE STUDY WATER PUMPING APPLICATION .....</b>	<b>74</b>
<b>6.1. INTRODUCTION .....</b>	<b>74</b>
<b>6.2. CASE STUDY .....</b>	<b>75</b>
6.2.1. PMDC motor characteristics .....	76
6.2.2. Centrifugal pump model .....	77
6.2.3. Water flow equation .....	77
<b>6.3. WATER PUMPING SYSTEM WITHOUT APPLYING ANY MPPT TECHNIQUES .....</b>	<b>78</b>
6.3.1. Simulation of PV array supply PMDC motor .....	78
6.3.2. Simulation results .....	78
<b>6.4. FLOW RATE AT DIFFERENT IRRADIANCE LEVELS WITH AND WITHOUT MPPT TECHNIQUES .....</b>	<b>80</b>
<b>CHAPTER (7): CONCLUSIONS .....</b>	<b>84</b>
<b>7.1. FUTURE WORK .....</b>	<b>84</b>
<b>7.2. ADVANTAGE AND DISADVANTAGE OF THE STUDIED METHODS .....</b>	<b>84</b>
<b>REFERENCES .....</b>	<b>86</b>
<b>APPENDIX A: Mat-Lab M-file code for PV characteristics .....</b>	<b>90</b>
<b>APPENDIX B: Curve fitting 2nd order equation .....</b>	<b>91</b>
<b>APPENDIX C: Curve fitting M-File code .....</b>	<b>92</b>

## List of Tables

TABLE 2.1	SPECIFICATIONS OF THE SIMULATED PV MODULE, PWX-500 .....	5
TABLE 3.1	COMPONENT VALUES OF DC-TO-DC BOOST CONVERTER .....	16
TABLE 3.2	RESULTS OF DUTY CYCLE VARIATION .....	17
TABLE 3.3	COMPONENT VALUES OF DC-TO-DC BUCK CONVERTER .....	21
TABLE 3.4	RESULTS OF DUTY CYCLE VARIATION .....	22
TABLE 4.1	FUZZY LOGIC CONTROL RULE TABLE .....	30
TABLE 4.2	MAJOR CHARACTERISTICS OF MPPT TECHNIQUES .....	35
TABLE 5.1	VALUES OF THE PV MODULE AT 25C .....	38
TABLE 5.2	VALUES OF THE PV MODULE AT 15C .....	40
TABLE 5.3	VALUES OF THE PV MODULE AT 45C .....	41
TABLE 5.4	LEAST-SQUARE PARABOLAS AND THEIR GOODNESS OF FIT INDICES ..	41
TABLE 5.5	THE EFFECT OF GAIN VALUES ON THE SYSTEM .....	45
TABLE 5.6	ACCEPTED VALUES FOR PV SIMULATION TEST IN THE EUROPEAN STANDARD EN 50530:2010+A1 .....	49
TABLE 5.7	COMPARISON RESULTS OF THE THREE METHODS .....	54
TABLE 5.8	ASSESSMENT OF THE PRESENTED MPPT ALGORITHMS .....	73
TABLE 6.1	SPECIFICATIONS OF THE PMDC MOTOR .....	76
TABLE 6.2	USEFUL POWER AND WATER FLOW RATES WITH AND WITHOUT THE PRESENTED MPPT ALGORITHMS .....	79
TABLE 7.1	CONCISE COMPARED THE ADVANTAGES AND DISADVANTAGES OF EACH SYSTEM .....	84

## List of Figures

Fig. 2.1	PV module characteristics represented as a non-linear curve .....	4
Fig. 2.2	Basic component that formatting the PVG .....	5
Fig. 2.3	PV equivalent circuit .....	6
Fig. 2.4	Photo light current ( $I_{ph}$ ) simulation module .....	6
Fig. 2.5	Reverse saturation current ( $I_{RS}$ ) simulation module .....	7
Fig. 2.6	Saturation Current simulation module .....	8
Fig. 2.7	Shunt current equation simulation module .....	8
Fig. 2.8	Load current equation simulation module .....	9
Fig. 2.9	The diode current simulation module .....	9
Fig. 2.10	The thermal voltage simulation module .....	10
Fig. 2.11	Mat-lab simulation blocks to save the data in work space .....	10
Fig. 2.12	PV simulation module with voltage feed back signal .....	11
Fig. 2.13	Final simulation module after gathering all blocks equations.....	11
Fig. 2.14	Variation of I-V curve with photovoltaic irradiation .....	12
Fig. 2.15	Variation of P-V curve with temperature .....	13
Fig. 2.16	Variation of I-V with temperature .....	13
Fig. 3.1	A boost converter circuit .....	14
Fig. 3.2	Boost Converter Simulation Module .....	16
Fig. 3.3	Boost converter Input & Output voltage at 0.5 duty Cycle Ratio....	17
Fig. 3.4	Boost converter Input & Output Current at 0.5 duty Cycle Ratio ...	18
Fig. 3.5	Boost converter Input & Output Power at 0.5 duty Cycle Ratio.....	18
Fig. 3.6	Buck Converter – Basic Diagram .....	19
Fig. 3.7	Buck Converter Simulation Module .....	21
Fig. 3.8	Buck converter Input & Output voltage at 0.5 duty Cycle Ratio .....	22
Fig. 3.9	Buck converter Input & Output Current at 0.5 duty Cycle Ratio .....	23
Fig. 3.10	Buck converter Input & Output Power at 0.5 duty Cycle Ratio.....	23
Fig. 4.1	PV module's curves characteristics .....	24
Fig. 4.2	PV module systematic diagram .....	25
Fig. 4.3	$V_{OC}$ vs irradiance for indication .....	26
Fig. 4.4	$V_{MP}$ vs illumination (Lux) for Low irradiance .....	27
Fig. 4.5	$I_{MP}$ vs $I_{SC}$ form 200 to 1000 W/m <sup>2</sup> for indication .....	28

Fig. 4.6	V-I characteristics for three different irradiance levels .....	29
Fig. 4.7	V-I characteristics for three different temperatures .....	29
Fig. 4.8	Example of membership functions .....	30
Fig. 4.9	A flow chart of the conventional P&O algorithm .....	31
Fig. 4.10	: P&O system simulation .....	32
Fig. 4.11	P&O subsystem in our simulation for tracking MPP .....	32
Fig. 4.12	The main idea of the IC method .....	33
Fig. 4.13	A flow chart of the conventional IC algorithm .....	34
Fig. 4.14	IC system simulation .....	34
Fig. 4.15	IC subsystem .....	35
Fig. 5.1	The locus curve of maximum power points at different irradiation levels .....	37
Fig. 5.2	Proposed method operating sketch with locus of power at different levels and temperatures .....	37
Fig. 5.3	Proposed method simulation .....	38
Fig. 5.4	Curve fitting equation subsystem for 25°C .....	39
Fig. 5.5	PI controller subsystem .....	39
Fig. 5.6	MPP change in VI curve at different temperature .....	40
Fig. 5.7	Proposed method with temperature signal enhancement .....	42
Fig. 5.8	Related to tables 1, 2, 3 .....	42
Fig. 5.9	Related to tables 1, 2, 3 .....	42
Fig. 5.10	Proposed method flow chart with temperature modification .....	43
Fig. 5.11	the controller system with feedback signal .....	44
Fig. 5.12	controller system in details .....	44
Fig. 5.13	The response speed with different gain values .....	47
Fig. 5.14	Reading off the time between the first overshoot and the first undershoot of the step response with P controller .....	47
Fig. 5.15	Simulation gain values .....	48
Fig. 5.16	Simulation module of the proposed method based on Buck converter .....	48
Fig. 5.17	P&O method performance at 1000W/m <sup>2</sup> .....	51
Fig. 5.18	IC method performance at 1000W/m <sup>2</sup> .....	51
Fig. 5.19	Proposed method performance at 1000W/m <sup>2</sup> .....	52
Fig. 5.20	P&O method performance at 800W/m <sup>2</sup> .....	52
Fig. 5.21	IC method performance at 800W/m <sup>2</sup> .....	53
Fig. 5.22	Proposed method performance at 800W/m <sup>2</sup> .....	53
Fig. 5.23	Zoomed ripple wave in P&O system for indication .....	54

Fig. 5.24	Step change in the irradiance levels .....	54
Fig. 5.25	P&O method performance in different weather conditions .....	55
Fig. 5.26	IC method performance in different weather conditions .....	55
Fig. 5.27	Proposed method performance in different weather conditions.....	56
Fig. 5.28	Random wave signal in Mat Lab for the irradiance level .....	56
Fig. 5.29	Deformation test result with P&O method .....	57
Fig. 5.30	Deformation test result with IC method .....	57
Fig. 5.31	Deformation test result with Proposed method .....	58
Fig. 5.23	change in the solar irradiance level according to the British Standard .....	59
Fig. 5.33	Tested signal in Mat-Lab simulation for the irradiance levels in the first dynamic test .....	59
Fig. 5.34	P&O method performance with dynamic test 1 .....	60
Fig. 5.35	IC method performance with dynamic test1 .....	60
Fig. 5.36	Proposed method performance with dynamic test1 .....	61
Fig. 5.37	Ramp change in the solar irradiance level according to the British Standard.....	62
Fig. 5.38	Tested signal in Mat-Lab simulation for the irradiance levels in the second dynamic test .....	62
Fig. 5.39	P&O method performance with dynamic test 2 .....	63
Fig. 5.40	IC method performance with dynamic test 2 .....	63
Fig. 5.41	Proposed method performance with dynamic test 2 .....	64
Fig. 5.42	Step down load test simulation module for P&O .....	65
Fig. 5.43	Step down load test result for P&O method .....	65
Fig. 5.44	Step down load test result for IC method .....	66
Fig. 5.45	Step down load test result for proposed method .....	66
Fig. 5.46	Step up load test simulation module for P&O .....	67
Fig. 5.47	Step up load test result for P&O method .....	67
Fig. 5.48	up load test Duty Cycle for P&O method .....	67
Fig. 5.49	Step up load test result for IC method .....	68
Fig. 5.50	Step up load test Duty Cycle for IC method .....	68
Fig. 5.51	Step up load test result for proposed method .....	68
Fig. 5.51	Step up load test Duty Cycle for Proposed method .....	69
Fig. 5.52	General Load test simulation module for P&O .....	69
Fig. 5.53	General Load test result for P&O method .....	70
Fig. 5.54	General Load test Duty Cycle for P&O method .....	70

Fig. 5.55	General Load test result for IC method .....	70
Fig. 5.56	General Load test Duty Cycle for IC method .....	71
Fig. 5.57	General Load test result for proposed method .....	71
Fig. 5.58	General Load test Duty Cycle for Proposed method .....	71
Fig. 6.1	Configuration of the system under study .....	75
Fig. 6.2	Systematic of PMDC motor .....	76
Fig. 6.3	Water pumping Simulation Module .....	78
Fig. 6.4	P&O method wave shape on the PMDC motor .....	79
Fig. 6.5	Incremental Conductance method wave shape on the PMDC motor	80
Fig. 6.6	Proposed method wave shape on the PMDC motor .....	80
Fig. 6.7	Flow over irradiance with and without using P&O MPPT system....	81
Fig. 6.8	Flow over irradiance with and without using IC MPPT system.....	81
Fig. 6.9	Flow over irradiance with and without using proposed MPPT system .....	81
Fig. 6.10	Duty cycle ratio using P&O MPPT method .....	82
Fig. 6.11	Duty cycle ratio using IC method .....	82
Fig. 6.12	Duty cycle ratio using the proposed method .....	83

# Nomenclature \*

(\* According to alphabetic order)

<i>AC</i>	Alternative Current
<i>a<sub>MPPT</sub></i>	Accuracy of MPPT in percentage
<i>C</i>	Capacitor
<i>C<sup>\</sup></i>	Proportional factor
<i>C<sub>in</sub></i>	The minimum value for the input decoupling capacitor
<i>D</i>	Duty cycle
<i>DC</i>	Direct Current
<i>ε<sub>MPPT</sub></i>	Relative tracking error in percentage
<i>ε<sub>MPPT,E</sub></i>	MPPT energetic error in percentage
<i>ε<sub>g</sub></i>	Band gap energy of the semiconductor
<i>E</i>	The motor back emf
<i>g</i>	Gravity acceleration
<i>G</i>	Irradiance in W/m <sup>2</sup>
<i>G<sub>reference</sub></i>	Irradiance at 1000 W/m <sup>2</sup>
<i>G</i>	Actual cell Irradiation
<i>G<sub>ref</sub></i>	Standard cell Irradiation
<i>h</i>	Total pumping head in meters
<i>Hz</i>	Hertz
<i>H</i>	High
<i>IC</i>	Incremental conductance method
<i>I<sub>MPP</sub></i>	The current at the maximum power point
<i>I<sub>reference</sub></i>	Reference current calculated from $I_{MPP} = f(P_{max})$ relation of certain power
<i>I<sub>SC</sub></i>	The short circuit current at STC in amperes
<i>IGBT</i>	Insulated Gate Bipolar Transistor
<i>I</i>	Current
<i>I<sub>a</sub></i>	The armature current
<i>I<sub>max</sub></i>	The Maximum Current
<i>I<sub>sh</sub></i>	Shunt current
<i>IC</i>	Incremental Conductance
<i>I<sub>rr</sub></i>	Irradiation Level
<i>I<sub>d</sub></i>	diode current
<i>I<sub>s</sub></i>	reverse saturation current
<i>I<sub>MPP</sub></i>	Current at the Maximum Power Point
<i>I<sub>L</sub></i>	Photo-light current
<i>K</i>	Boltzmann constant
<i>K<sup>\</sup></i>	Proportional factor
<i>k<sub>T</sub></i>	Torque constant in Nm/A
<i>K<sub>E</sub></i>	voltage constant
<i>K<sub>p</sub></i>	Proportional gain
<i>K<sub>I</sub></i>	Integral gain

$K_D$	Derivative gain
$K_i$	short-circuit current/temperature coefficient (A/K)
$L$	Inductor
$MPP$	Maximum Power Point
$MPPT$	Maximum Power Point Tracking
$MOSFET$	Metal Oxide semiconductor Field Effect
$\eta$	Efficiency
$\eta_{MPPT}$	Static efficiency in percentage
$\eta_{MPPT,E}$	MPPT energetic efficiency in percentage
$N_S$	Number of PV cells connected in series
$N_P$	Number of PV cells connected in parallel
$n$	Ideality factor
$P\&O$	Perturb and observe method
$PMDC$	Permanent Magnet DC motor
$P_U$	Useful motor power in watts
$PV$	Photovoltaic
$PVG$	Photovoltaic generator
$PVSG$	Photovoltaic solar generator
$\rho$	Water density in kg/m <sup>3</sup>
$PMDCM$	Permanent Magnet Direct Current Motor
$P$	Power
$PI$	Proportional Integral
$PWM$	Pulse Width Modulation
$P\&O$	Perturb and Observe
$P_{max}$	The Maximum Power
$P_{MPP}$	Power at the Maximum Power Point
$P_U$	Useful or net power applied on the motor
$q$	Electron charge
$Q$	Water flow rate in m <sup>3</sup> /sec
$R_{Load}$	Load resistance in ohms
$R_P$	Parallel resistance in ohms
$R_S$	Series resistance in ohms
$S_i$	Silicon
$SS_E$	Sum of squares due to error
$STC$	Standard test conditions
$S$	The level of the photovoltaic irradiation
$T$	Operating temperature in degree Celsius
$t$	Simulation time in seconds
$T_{dn}$	Ramp down time in seconds
$t_{dwell}$	Dwell time between ramping up and down in seconds
$T_{em}$	Electromagnetic torque of the motor in Nm
$T_f$	Friction torque in Nm
$t_{up}$	Ramp up time in seconds
$T_L$	Load torque in Nm
$T$	Motor shaft torque
$T_f$	Fractional torque
$T_{OP}$	Actual cell temperature
$T_{ref}$	Standard cell temperature