AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

ELECTRICAL POWER AND MACHINES DEPARTMENT

MICROCOMPUTER BASED ARTIFICIAL INTELLIGENT CONTROL STRATEGIES FOR WIND AND PHOTOVOLTAIC SOLAR ENERGY CONVERSION AND UTILITY INTERFACE SCHEMES

A Thesis Submitted in Fulfilment for the Requirement
of the Degree of Doctor of Philosophy
in
Electrical Power and Machines
To Ain Shams University, Faculty of Engineering,
Elect. Power & Machines Dept.

BY

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بسم الله الرحمن الرحيم

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in Electrical Engineering.

The work included in this thesis is carried out by the author in the Department of Electrical Power and Machines, Faculty of Engineering, Ain Shams University, Egypt from January, 1991 to May, 1992 and in the Department of Electrical Engineering, University of New Brunswick, Canada from June, 1992 to June 1994.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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The author acknowledges the Dept. of Electrical Power and Machines, Faculty of Engineering, Ain Shams University. Acknowledgement is dedicated to Eng. M. Yousef El-Sharkh for helping the author in the thesis writing.

I gratefully acknowledge my parents for their patience and understanding. I would like to thank my wife for her patience, hard working and encouragement during the research period.

ABSTRACT

The thesis presents novel artificial intelligent controllers for two renewable energy schemes interfaced to the utility grid. The proposed schemes are the photovoltaic-utility scheme and the wind driven induction generator-utility scheme. The proposed artificial intelligent based controllers are Fuzzy logic and artificial neural networks. The control objective is to utilize and track the reference power in the renewable energy schemes.

The main feature of the artificial intelligent controllers is to design a system with acceptable performance with presence of system uncertainties and nonlinearity. These controllers are model free design techniques, they need system heuristic data and system operator expertise.

The stochastic variations of solar insolation and wind velocity make difficulties for the renewable energy sources to commit firm supply of electricity. So some form of energy storage is required. In this thesis a renewable energy-utility interfacing technique is proposed in which the utility works as an energy storage with infinite capacity.

In wind energy schemes, a DC link is used to interface the induction generator power to the utility grid. The induction generator output is a variable voltage variable frequency. This output is rectified through a 3-phase uncontrolled bridge rectifier. Then injected to the utility grid through a smoothing reactor and a line commutated thyristor inverter. The injected power to the grid is regulated by varying the inverter firing angle. A d-q synchronously rotating frame model of the induction generator with the self excitation capacitor is utilized

in the simulation study.

In the solar energy scheme, a model of the photovoltaic solar array is utilized in the digital computer with its data acquisition card to emulate the PV array performance characteristics using a power amplifier. The output power from this PV emulator is injected to the grid through a smoothing reactor and a line commutated inverter.

Extensive digital simulations are carried out and a laboratory setup (based on microcomputer with its data acquisition card) of these schemes are implemented. The objective is to study the schemes performance with the supervision of the proposed fuzzy logic and artificial neural network controllers under wind velocity and solar insolation variations. Both simulation and experimental results confirm a robust and satisfactory performance in a wide range of operating conditions. The proposed controllers give superior performance over the conventional PI controller for the renewable energy schemes.

CONTENTS

	Page
ACKNOWLEDGEMENT	i
ABSTRACT	iii
LIST OF FIGURES	viii
LIST OF SYMBOLS	xiv
CHAPTER I INTRODUCTION	1
1.1 GENERAL	1
1.2 RENEWABLE ENERGY	1
1.2.1 Photovoltaic Solar Energy	2
1.2.2 Wind Energy	4
1.3 ARTIFICIAL INTELLIGENCE (AI)	6
1.3.1 Expert Systems (ES)	8
1.3.2 Fuzzy Logic (FL)	8
1.3.3 Artificial Neural Networks (ANN)	9
1.3.4 AI Controllers Implementation Requirements	10
1.4 PREVIOUS WORK	10
1.4.1 PV-Utility Scheme	10
1.4.2 Wind Energy: Wind Driven Induction Generator	13
1.4.3 Fuzzy Logic (FL)	19
1.4.4 Artificial Neural Networks (ANN)	21
1.5 THESIS OBJECTIVE	26
1.6 THESIS OUTLINE	28
CHAPTER II FUZZY LOGIC FOR PROCESS CONTROL	30
2.1 GENERAL	30
2.2 FUZZY SETS	30
2.3 FUZZY LOGIC CONTROLLER	35
2.4 FLC FOR CONTROLLING THE INJECTED POWER TO THE GRID	36
2.4.1 Fuzzificattion Process	37
2.4.2 Knowledge Base	38
2.4.3 Decision Making	41
2.4.4 Defuzzification Process	44
2.5 FLC ADVANTAGES	45
2.6 FLC LIMITATIONS	45
2.7 WHEN FLC CAN BE USED	46
CHAPTER III ARTIFICIAL NEURAL NETWORKS	47
3.1 GENERAL	47
3.2 BIOLOGICAL AND ARTIFICIAL NEURAL NETWORK	47
3.3 ARTIFICIAL NEURONS	47
3.4 ACTIVATION FUNCTIONS	49
3.5 NEURAL NETWORK TOPOLOGY	51

3.5.1 Feed-Forward Networks 52
3.5.2 Recurrent Networks 53
3.6 ARTIFICIAL NEURAL NETWORKS TRAINING 53
3.6.1 Supervised Learning 55
3.6.2 Unsupervised Learning 55
3.7 MULTI-LAYER FEED-FORWARD NETWORK LEARNING ALGORITHM 55
3.7.1 The Generalized Delta Rule 56
3.7.2 Back-Propagation Algorithm 61
3.8 ANN STRUCTURE DESIGN 62
3.9 NEURAL NETWORKS IN CONTROL SYSTEMS 64
3.9.1 Identification of Systems Models 65
3.9.2 Direct Inverse Control 66
3.9.3 Direct Adaptive Control 72
3.9.4 On-Line Training Algorithm 73
3.10 OFF-LINE TRAINING WITH MATLAB 76

CHAPTER IV PHOTOVOLTAIC-UTILITY INTERFACING SCHEME WITH AI-BASED CONTROLLERS 81

4.1 GENERAL 81
4.2 PV-SOLAR ARRAY MODELLING 81
4.3 PHOTOVOLTAIC-UTILITY INTERFACING SCHEME 86
4.4 DYNAMIC MODELLING OF PV-UTILITY SCHEME 88
4.4.1 Model of the PV Array 88
4.4.2 Models of the DC Link and Inverter 88
4.5 FUZZY LOGIC CONTROLLER FOR THE PV SCHEME 89
4.5.1 Numerical Simulation 89
4.5.2 Experimental Implementation 93
4.6 ARTIFICIAL NEURAL NETWORKS CONTROLLERS 99
4.6.1 Numerical Simulation 102
4.6.2 Experimental Implementation 102

CHAPTER V INDUCTION GENERATOR-UTILITY INTERFACING SCHEME WITH AI-BASED CONTROLLERS 111

5.1 GENERAL 111
5.2 THE PROCESS OF SELF EXCITATION IN INDUCTION GENERATOR 111
5.3 INDUCTION GENERATOR DYNAMIC MODELLING 112
5.3.1 Axes Transformation 112
5.3.2 Preferred Reference Frames 114
5.3.3 Induction Generator Voltage Equations 115
5.3.4 Voltage Equations in the Synchronously Rotating Frame 115
5.3.5 Self Excitation Capacitor Model 121
5.4 DYNAMIC MODELLING OF THE INTERFACING SCHEME 123
5.5 FUZZY LOGIC CONTROLLER 128
5.5.1 Numerical Simulation 128
5.5.2 Experimental Implementation 135
5.6 ARTIFICIAL NEURAL NETWORKS CONTROLLERS 143

	5.6.1 Numerical Simulation	148
	5.6.2 Experimental Implementation	149
CHAPTER VI	**CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH**	160
REFERENCES		163
PUBLICATIONS		170
APPENDIX I	**SCHEMES PARAMETERS**	171
APPENDIX II	**STEADY-STATE ANALYSIS OF STAND ALONE INDUCTION GENERATOR**	175
APPENDIX III	**SOFTWARE LISTING**	186

LIST OF FIGURES

Figure No. **Page**

Figure No.		Page
Fig. 2.1	Diagrammatic representation of a crisp set.	32
Fig. 2.2	Diagrammatic representation of a fuzzy set.	32
Fig. 2.3	Basic operations of two fuzzy sets.	34
	(a) Defined fuzzy sets A and B.	
	(b) Union of A and B.	
	(c) Intersection of A and B.	
	(d) Complement of A.	
Fig. 2.4	Fuzzy controller structure.	39
Fig. 2.5	Diagrammatic representation of the fuzzy sets.	39
Fig. 2.6	Rules lock up table in the PE-CPE space.	42
Fig. 2.7	Processing of rules 1 and 2 in the FLC.	43
Fig. 3.1	Biological neuron.	48
Fig. 3.2	Basic processing unit in an ANN (neuron).	48
Fig. 3.3	Neurons activation functions.	50
Fig. 3.4	Two-layer feed-forward network.	54
Fig. 3.5	A single-layer recurrent network.	54
Fig. 3.6	Multi-layer feed-forward ANN with the error back-propagation.	57
Fig. 3.7	Flow chart of the back-propagation training algorithm.	63
Fig. 3.8	Identification of a plant model.	67
Fig. 3.9	Identification of a plant inverse dynamic model.	67
Fig. 3.10	Power plant inverse dynamic model identification.	69
Fig. 3.11	Direct inverse control (no weights updating) and Direct adaptive on-line control with weights updating.	70
Fig. 3.12	Multi-layer feed-forward network.	71
Fig. 3.13	PV time series function learning (# of iterations=10000 & learning rate=1.0e-5).	78
Fig. 3.14	Output vector errors (# of iterations=10000 & learning rate=1.0e-5).	79
Fig. 3.15	PV time series function learning (# of iterations=50000 & learning rate=1.0e-4).	80
Fig. 4.1	Solar Cell equivalent circuit.	83
Fig. 4.2	PV array voltage-current characteristics at different S_r and T=301k°.	85
Fig. 4.3	PV array power-current characteristics at different S_r and T=301k°.	85
Fig. 4.4	Photovoltaic-utility interfacing scheme.	87
Fig. 4.5	PV scheme simulation performance with the FLC.	91
	(a) PV array power P_{pv}.	
	(b) Inverter control voltage V_c and PV array current I_{pv}.	
	(c) Unit step disturbance in the solar insolation level S_r.	
	(d) PV array voltage V_{pv}.	
Fig. 4.6	PV scheme simulation performance with the PI controller.	92
	(a) PV array power P_{pv}.	
	(b) Inverter control voltage V_c and PV array current I_{pv}.	
	(c) Solar insolation level S_r.	
	(d) PV array voltage V_{pv}.	
Fig. 4.7	Experimental setup of the PV-utility interfacing scheme.	94

Fig. 4.8 Line commutated inverter DC voltage waveform. 96
Fig. 4.9 PV array voltage waveform. 96
Fig. 4.10 PV scheme experimental performance with the FLC. 97
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.11 PV scheme experimental performance with the PI controller. 98
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.12 PV scheme experimental performance with the FLC for a step change of S_r from 0.04 to 0.09 to 0.04 W/Cm^2. 100
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.13 Learning of the inverse dynamic model of the PV scheme (input-output patterns are generated by the FLC as time passes with a rate of 20 pattern/second). 101
Fig. 4.14 PV scheme simulation performance with the direct adaptive ANN controller for a step change of S_r from 0.04 to 0.08 to 0.04 W/Cm^2. 103
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.15 On-line weights and biases adaptation of the PV scheme with the direct adaptive ANN controller. 104
(a) Hidden layer bias.
(b) Output layer bias.
(c) Typical weight from input to hidden layer.
(d) Typical weight from hidden to output layer.
Fig. 4.16 PV scheme experimental performance with the direct inverse ANN controller for a step change of S_r from 0.04 to 0.09 to 0.04 W/Cm^2. 106
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.17 PV scheme experimental performance with the direct inverse ANN controller for a step change of S_r from 0.025 to 0.09 to 0.025 W/Cm^2. 107
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.18 PV scheme experimental performance with the direct adaptive ANN controller for a step change of S_r from 0.04 to 0.09 to 0.04 W/Cm^2. 108
(a) PV array power P_{pv}.

(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 4.19 PV scheme experimental performance with the direct adaptive ANN controller for a step change of S_r from 0.025 to 0.09 to 0.025 W/Cm^2. 109
(a) PV array power P_{pv}.
(b) Inverter control voltage V_c and PV array current I_{pv}.
(c) Solar insolation level S_r.
(d) PV array voltage V_{pv}.
Fig. 5.1 Arbitrary a-b-c to d-q axes transformation. 113
Fig. 5.2 Induction generator d-q equivalent circuits at synchronously rotating frame. 117
(a) q^e-axis circuit.
(b) d^e-axis circuit.
Fig. 5.3 Self excitation capacitor in the a-b-c axes frame. 122
Fig. 5.4 Equivalent circuit of self excitation capacitor in the d-q axes frame. 122
(a) d-axis circuit.
(b) q-axis circuit.
Fig. 5.5 Simulation building up of the phase voltage V_a and the stator q axis voltage V_{qs}. 124
Fig. 5.6 Experimental building up of the phase voltage V_a. 124
Fig. 5.7 Induction Generator-utility interfacing scheme. 126
Fig. 5.8 Simulation results of the induction generator scheme with the FLC. 130
(a) DC link power P_{DC}.
(b) Shaft torque T_L disturbance.
(c) Bridge rectifier DC voltage side V_R.
(d) Line commutated inverter DC voltage side V_I.
Fig. 5.9 Simulation results of the induction generator scheme with the FLC. 131
(a) Electromagnetic torque T_e.
(b) Shaft torque T_L.
(c) Rotor electrical speed w_r.
(d) Stator frequency w_s.
Fig. 5.10 Simulation results of the induction generator scheme with the FLC. 132
(a) Inverter control voltage V_C.
(b) Inverter firing angle α_I.
(c) DC link current I_{DC}.
(d) Phase A voltage V_a.
Fig. 5.11 Simulation results of the induction generator scheme with the FLC. 133
(a) Stator q-axis current i_{qs}.
(b) Stator d-axis current i_{ds}.
(c) Rotor q-axis current i_{qr}.
(d) Rotor d-axis current i_{dr}.
Fig. 5.12 Simulation results of the induction generator scheme with the FLC. 134
(a) Stator q-axis flux linkage Ψqs.
(b) Stator d-axis flux linkage Ψds.
(c) Rotor q-axis flux linkage Ψqr.
(d) Rotor d-axis flux linkage Ψdr.
Fig. 5.13 Oscillogram of the induction generator line to line voltage. 137

Fig. 5.14 Oscillogram of the induction generator scheme DC link voltage V_R. 137
Fig. 5.15 Oscillogram of the induction generator scheme DC link current I_{DC}. 138
Fig. 5.16 Oscillogram of the induction generator scheme inverter DC voltage V_I. 138
Fig. 5.17 Induction generator scheme experimental performance for a change in shaft speed from 1247 to 1342 (rpm) with the FLC. 139
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.18 Induction generator scheme experimental performance for a change in shaft speed from 1217 to 1312 (rpm) with the FLC. 140
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.19 Induction generator scheme experimental performance for a change in shaft speed from 1203 to 1293 (rpm) with the FLC. 141
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.20 Induction generator scheme experimental performance for a change in shaft speed from 1247 to 1342 (rpm) with the FLC. 142
(a) DC link voltage V_R.
(b) Inverter firing angle α_I.
Fig. 5.21 Induction generator scheme experimental performance for a change in shaft speed from 1247 to 1342 (rpm) with the PI controller. 144
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.22 Induction generator scheme experimental performance for a change in shaft speed from 1217 to 1312 (rpm) with the PI controller. 145
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.23 Induction generator scheme experimental performance for a change in shaft speed from 1203 to 1293 (rpm) with the PI controller. 146
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.24 Results of the off-line identification of the inverse dynamic model of the induction generator scheme (input-output patterns are generated by the FLC as time passes with a rate of 20 pattern/second). 147
Fig. 5.25 Simulation results of the induction generator scheme with the direct adaptive ANN controller. 151
(a) DC link power P_{DC}.
(b) Shaft torque T_L.
(c) Bridge rectifier DC voltage side V_R.
(d) Line commutated inverter DC voltage side V_I.
Fig. 5.26 Simulation results of the induction generator scheme with the direct adaptive ANN controller. 152
(a) Electromagnetic torque T_e.
(b) Shaft torque T_L.
(c) Rotor electrical speed w_r.
(d) Stator frequency w_s.
Fig. 5.27 Simulation results of the induction generator scheme with the direct adaptive ANN controller. 153

(a) Inverter control voltage V_C.
(b) Inverter firing angle α_I.
(c) DC link current I_{DC}.

Fig. 5.28 On-line network weights and biases adaptation for the induction generator scheme with the direct adaptive ANN controller. 154
(a) Hidden layer bias.
(b) Output layer bias.
(c) Typical weight from input to hidden layer.
(d) Typical weight from hidden to output layer.
Fig. 5.29 Induction generator scheme experimental performance for a change in shaft speed from 1247 to 1342 (rpm) with the direct inverse ANN controller. 155
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.30 Induction generator scheme experimental performance for a change in shaft speed from 1217 to 1312 (rpm) with the direct inverse ANN controller. 156
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.31 Induction generator scheme experimental performance for a change in shaft speed from 1247 to 1342 (rpm) with the direct adaptive ANN controller. 157
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.32 Induction generator scheme experimental performance for a change in shaft speed from 1217 to 1312 (rpm) with the direct adaptive ANN controller. 158
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. 5.33 Induction generator scheme experimental performance for a change in shaft speed from 1203 to 1293 (rpm) with the direct adaptive ANN controller. 159
(a) DC link power P_{DC}.
(b) DC link current I_{DC}.
Fig. A.1 Experimental setup photograph. 174
Fig. A.2 Equivalent circuit of capacitor self excited induction generator with local load. 179
Fig. A.3 Variations of V_g / F with X_m. 179
Fig. A.4 Induction generator no-load equivalent circuit. 181
Fig. A.5 Induction generator steady state performance at no load. 181
(a) Phase voltage versus rotor speed.
(b) Stator frequency versus rotor speed.
Fig. A.6 Induction generator steady state performance with resistive load R_L=63 Ω. 184
(a) Phase voltage versus rotor speed.
(b) Output power versus rotor speed.
(c) Phase voltage versus output power.