AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electrical Power and Machines Engineering

Optimized Controller for Converter Based DG

A Thesis submitted in partial fulfilment of the requirements of the degree
of
Master of Science in Electrical Engineering
(Electrical Power and Machines Engineering)

by

Ahmed Haitham EL-Ebiary
Bachelor of Science in Electrical Engineering
(Electrical Power and Machines Engineering)
Faculty of Engineering, University, 2016

Supervised By

Prof. Dr. Mostafa Ibrahim Mohamed Marei

Dr. Mahmoud Abdallah Attia Ibrahim

Cairo - (2020)

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. Date:17 January 2020

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Statement

This thesis is submitted to Faculty of Engineering, Ain shams University as a partial fulfilment of Master of Science in Electrical Engineering . The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Abstract

Most of Distributed Generators (DGs) use Voltage Source Inverter (VSI) for the purpose of interfacing DG with the grid and producing electricity at the desired voltage and frequency. By applying different control strategies for the inverter, we can control the DG as a current source or as a voltage source depending on the controlled variable in the control strategy.

DG is controlled as a current source in the grid connected mode and the controlled variable in this mode is the grid current to control the active and reactive power injected to the grid. In contrast, DG is operated as a voltage source in the islanded mode, and the controlled variable will be the voltage across the local load to keep its amplitude and frequency within the allowable limits. Therefore, the DG operates in two steady state modes: grid connected mode and islanded mode, and two transient modes: transition from grid connected to islanded, and from islanded to grid connected. During these transient modes, the voltage and current of the critical local load connected to the DG suffer from destructive spikes, as we need to switch the control strategy of the inverter. To solve this problem a seamless control strategy for the inverter of the DG is used with no need for switching between different control schemes. The strategy is called the “Unified Control Strategy". The strategy is implemented in the Synchronously Rotating reference Frame (SRF), where AC quantities, that need to be regulated, are converted to DC quantities in this frame so conventional Proportional Integral (PI) controllers can be used which are simple and can achieve zero steady state error.

Hysteresis Current Controller (HCC) is used for generating the gate signals for the inverter switches which is based on comparing output currents of the inverter with their reference values, and then the error signals pass into Hysteresis comparator to decide which switch that will be given a signal on its gate to operate, so the controlling variable is always the inverter output current.

In this thesis, a seamless control strategy in the SRF is applied for the inverter to achieve smooth transition between different modes of operation and to improve the power quality. The same control structure is used for all modes, and there is no need for transition between different control structures. The DG is controlled as a current source in the case of grid connected mode by the means of current loop to control active and reactive power injected to the grid, and as a voltage source in the islanded mode by the means of voltage loop to control the voltage of local critical load . The

controller proposed in the strategy is the Set Membership Affine Projection Algorithm (SMAPA) based Proportional Integral (PI) controller whose proportional gain (Kp), and integral gain (Ki) are chosen based on optimization technique to get the better dynamic performance during transitions.
The proposed control strategy is tested using PSCAD/EMTDC simulation environment under different loading conditions, and different types of loads linear, and non-linear loads. Simulations show the effectiveness of the control strategy during different modes of operation. The superiority of the proposed method is achieved through comparison with another method based on PWM technique.

Key words: Distributed generation, Seamless transfer, Set membership affine projection algorithm, Voltage source inverter, Grid connected, Islanding.

Acknowledgment

I would like to thank my supervisors: Professor. Mostafa Ibrahim Marei and Dr. Mahmoud Abdallah Attia for their effort, and support during the research, they guided me & encouraged me untill the end of this research. Also I would like to thank Dr.Mohamed Moukhtar and Eng. Abdallah Alaa for their guidance , and discussions.

Ahmed Haitham EL-Ebiary

January 2020

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List of Abbreviations

DG	Distributed Generator.
VSI	Voltage Source Inverter.
CSI	Current Source Inverter.
HCC	Hysteresis Current Controller.
AC	Alternating Current.
DC	Direct Current.
PI	Proportional Integral.
SRF	Synchronously Rotating Frame.
SMAPA	Set-Membership Affine Projection Algorithm.
UPS	Uninterruptable Power Supply.
PCC	Point of Common Coupling.
PWM	Pulse Width Modulation.
PR	Proportional Resonant.
MRAC	Model Reference Adaptive Controller.
NN	Neural Networks.
LMS	Least Mean Square.
RLMS	Recursive Least Mean Square.
SMF	Set Membership Filtering.
APA	Affine Projection Algorithm.
NLMS	Normalized Least Mean Square.
IP	Performance Index.
CV	Controlled Variables.
PLL	Phase Locked Loop.

List of Symbols

$d(k)$	*Desired Signal Vector of Adaptive Filter.*
$X(k)$	*Input Vector of Adaptive Filter.*
$Y(k)$.	*Output Vector of Adaptive Filter.*
W	*Weight Vector.*
Θ	*Feasibility set.*
γ	*Error Tolerance.*
H_k	*Constraint Set.*
ψ_k	*Membership Set.*
λ_k	*Vector of Lagrangian multipliers.*
$g(k)$	*Posteriori error with new weight vector.*
$\alpha(k)$	*Learning/ Updating rate.*
$m(k)$	*Pi controller action.*
Kp	*Pi controller proportional term.*
Ki	*Pi controller integral term.*
$v_{cd}*$	*Capacitor Voltage reference in d-axis.*
$v_{cd.}$	*Capacitor Voltage in d-axis*
$v_{cq}*$	*Capacitor Voltage reference in q-axis.*
v_{cq}	*Capacitor Voltage in q-axis.*
i_{VSI}	*Inductor current of voltage source inverter.*
i_L	*Local load current.*
i_{Ld}	*Local load current component in d-axis.*
i_{Lq}	*Local Load current component in q-axis.*
R_s	*Local load resistance.*
X_s	*Local load reactance.*
v_c	*Local Load Voltage.*
v_g	*Utility Voltage.*
v_{Gq}	*Utility Voltage component in q-axis.*
v_{Gd}	*Utility Voltage component in d-axis.*
$i_{VSId}*$	*Voltage source inverter reference current in d-axis.*
$i_{VSIq}*$	*Voltage source inverter reference current in q-axis.*
V_{max}	*Maximum allowable load voltage.*
i_{Gd}^*	*Grid Current reference in d-axis.*
i_{Gq}^*	*Grid Current reference in q-axis.*
P_g	*Active power injected to the grid.*
Q_g	*Reactive power injected to the grid.*
Vn	*Rated rms phase voltage.*
P_{DG}	*Active Power generated by distributed generator.*
Q_{DG}	*Reactive Power generated by distributed generator.*