AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ELECTRICAL POWER AND MACHINES DE-PARTMENT

Maximizing DG Output Power Using Multilevel Transformerless Inverter

Submitted by
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A thesis submitted to the faculty of Engineering at Ain-Shams University in Partial fulfillment of the requirements for the Degree of Master of Science

In

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Under supervision of

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STATEMENT

This thesis is submitted to Faculty of Engineering, Ain Shams University in partial fulfillment of the requirement for the degree of Master of Science in Electrical Power and Machines Engineering.

The work included in this thesis was carried out by the author, at the Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University.

No Part of this thesis has been submitted for a degree or qualification at any other universities.

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ABSTRACT

This thesis presents a new concept of single-phase grid connected PV system with unbalance controller algorithm. Different switching conditions according to the grid status have been discussed. New method of unbalance control and short circuit protection are proposed to make sure that the current and voltage values are within the unbalance limits which are a proper protection method to both PV system and the grid. The distribution system current profile can be properly regulated using adequate power management from the distributed inverters among the distribution network. System discretion with adequate simulation with a proposed distribution network connection is provided. The system can be applied easily to all PV grid connected inverters and can be easily controlled either automatically or manually be the networks operators.

The study also includes the effects of PV penetration on the voltage's waveforms at different levels, 22KV,11KV and 380V.

Small scale energy sources are widely used; their high-level penetration impact can negatively affect the distribution network. In order to solve the three-phase unbalance problem and save it within limits, a new control topology is proposed, this topology is based on switching the inverter output between the three phases according to the level of consumption. An adequate PQ controller with unbalance controller reference by detecting the highest error value in order to adjust the inverter output according to the status of the defected phase are presented. The synergy between the multilevel inverter topology and this unbalance controller with adequate PQ controller would be the major enhancement in PV single phase systems. This controller can be used in order to make a proper enhancement and improvement to the smart grid technology applications and also to the overall distribution power system.

An unbalance controller is presented using the theory of highest current (highest consumption) detection in order to drive the inverter to inject its output on it to reach the balance state, or at least decrease the unbalance limit. In additional, short circuit protection is done by checking the voltages magnitudes and make a fast comparison to make sure that the differences are within limits and are not severe differences result from short circuit error on the grid.

An adequate single-phase PQ controller is presented which depends on creating an imaginary 3 phases from single phase voltage and current by shifting the single phase 90^o on the space in order to perform parks transformation. Simulation results using Matlab/Simulink are presented.

It has been noticed that single phase PV systems can reduce the unbalance limit and reach to the balance state especially in small scale networks. Also there were no changes noticed at the voltage waveforms at all levels due to the PV penetration.

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List of Abbreviations

CM	Common Mode
CHR	Chien Hrones Reswick
DG	Distributed Generator
DPC	Direct Power Control
FB-DCBP	Full Bridge with DC Bypass
HV	High Voltage
IEC	International Electro-technical Commission
NPC	Neutral Point Clamp
OLTC	ON Load Tap Changer
OH5	Inverter Switching Strategy
PCC	Point of Common Coupling
PLC	Power Line Communication
PLD	Primary Loop Distribution
PWM	Pulse Width Modulation
PLL	Phase Locked Loop
PVU	Percentage Voltage Unbalance
PN-NPC	Positive-Negative Neutral Point Clamp
P-Q	Active and Reactive Power
PID	Proportional Integral Differential Controller

PSO	Particle Swarm Optimization
PV	Photovoltaic
RES	Renewable Energy Source
RDS	Radial Distribution System
SI-NPCTLI	Split Inductor Neutral Point Clamp Transformerless Inverter
SPMW	Sinusoidal Pulse Width Modulation
TSO	Transmission System Operator
THD	Total Harmonic Distortion
TLI	Transformerless Inverter
VFU	Voltage Unbalance Factor
WT	Wind Turbine
WF	Wind Farm
WG	Wind Generation