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An Interface System for Photovoltaic Based on Dual Cascaded Inverter

M.Sc. Thesis

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STATEMENT

This Thesis is submitted to Ain Shams University in partial fulfillment of the requirements for M.Sc. degree in Electrical Engineering.

The included work in this thesis has been carried out by the author at the department of electrical power and machines, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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Ahmed Samir

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Abstract

The power electronics converters are coming into wide scale in different fields due to their capability and flexibility of control, and high dynamic response to variable change of the load. Power electronics converters provide precise control over wide range of applications, such as electric drive systems, electric traction, ship propulsion and automotive application. In addition, these converters are used widely for energy conversion, grid connection, manufacturing, mining and petrochemical industry. All of these applications require cost reduction, high production rate, high performance and efficiency, which could be served by power electronics systems.

This thesis presents an interface system for photovoltaic based on dual cascaded inverter. This system is based on using dual cascaded inverter, consisting of main and auxiliary inverters. The PV array is connected to the main inverter through a boost converter for maximum power extraction, while the dc-side of the auxiliary inverter is connected to a capacitor bank. The main and auxiliary inverters are controlled to deliver the harvested maximum power from the PV array to the grid and to simultaneously regulate the dc-side voltage of the auxiliary inverter at a constant ratio from the dc-link voltage of the main inverter. Four Hysteresis controllers are proposed for the three-phase currents fed to the grid and the dc-side capacitor voltage of the auxiliary inverter. Two switching control methods are adopted for the dual cascaded inverter: the conventional Hysteresis Current Control (HCC) and the Space Vector Modulation (SVM) based HCC. The later technique offers reduced switching numbers for both inverters compared with the conventional HCC. The system has been also studied during fault / voltage sag condition. A low voltage ride through (LVRT) controller is adopted to fulfill the E.ON grid code requirements. The E.ON grid code ensures that the proposed PV interface system supplies reactive power to the grid according to the value of voltage at the point of common coupling.

The proposed dual cascaded inverter for the PV interface system is studied using EMTDC/PSCAD software package. Different test scenarios are conducted under different conditions to evaluate the dynamic behavior of the proposed system. Simulation results show fast dynamic response and accurate performance of the proposed control systems.

Key words: Dual cascaded inverter, Hysteresis current control (HCC), PV system, Space vector modulation (SVM), Space Vector modulation based Hysteresis current control (SVM based HCC).

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S_a, S_b and S_c: Region detector digital signals

V_{pv} and I_{pv}: Photovoltaic system output voltage and current respectively

V_M^* and V_A^*: Reference main and auxiliary inverter voltage respectively

V_M and V_A: Actual main and auxiliary inverter voltage respectively

V_{ra}^*, V_{rb}^* and V_{rc}^*: Reference grid voltages a, b and c

i_{ag}^*,, i_{bg}^* and i_{cg}^*: Reference grid side line currents a, b and c

i_{ag}, i_{ab} and i_{cg}: Actual grid side line currents a, b and c

a_i, b_i and c_i: Grid side current error signals a, b and c

V_i: Auxiliary inverter voltage error signal

V_{pcc}: Grid voltage at point of common coupling

V_n: Space voltage vector.

V_{zero}: Zero voltage vector.

V^*: Rectifier input space voltage vector.

V_r^*: Reference space voltage vector.

i_d^*, i_q^*: Reference direct and quadrature currents respectively.

L: Inductance output filter of the grid

PWM: Pulse width modulation

UPS: Uninterruptable Power Supply

HVDC: High Voltage Direct Current

THD: Total harmonic distortion

SVM: Space vector modulation

HCC: Hysteresis current control

CC: Current control.

SVPWM: Space vector pulse width modulation.

SVMHCC: Space vector modulation based hysteresis current control

CSVM Centered space vector modulation

P&O: Perturb and observe

MPPT: Maximum power point tracking

VSI: Voltage source inverter

CSI: Current source inverter

FCMLI:	Flying capacitor multi-level inverter
NPCMLI:	Neutral point clamped multi-level inverter
CHBMLI:	Cascaded multi-level inverter
PI:	Proportional integral.
PD:	Proportional derivative
PR:	Proportional resonator
LVRT:	Low voltage ride through