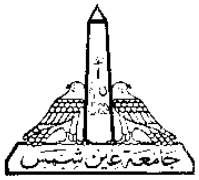

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FACULTY OF ENGINEERING

Electrical Power and Machines Engineering

Optimal Design of Transformer less Grid-Connected PV Inverters

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

by

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STATEMENT

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering Engineering, Faculty of Engineering, Ain shams University.

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

With the reduction of available fossil fuels, the research in the area of renewable energy systems has been exponentially innovated in order to provide effective solar power solutions. The main objective of this thesis is increasing the efficiency and reduce the Levelized Cost Of the Electricity (LCOE) of the output power for the PV inverters. This goal has been achieved by determining the optimum inclination angle of photovoice panels during summer and winter and defined the optimum values of LCL output filter of PV inverter. Furthermore, provided a comparison between the three types of PV panels.

A case study was developed based on a real PV system which installed in Heliopolis University for Sustainable Development (HUSD). This system consists of three different modules (Mono-crystalline, Poly-crystalline, and Thin film), where each type is connected to an inverter with output power 1.5 KW. The adjusting results revealed that the suitable inclination angle for both summer and winter seasons is 30^{o} for the three investigated PV modules. Additionally, the Thin Film PV panels found to be the most efficient PV type among the installed modules. Grid-connected inverters were utilized with LCL output filter to attenuate the switching harmonics generated from Pulse- width modulations (PWM).

The optimum design of LCL filter was calculated to minimize the LCOEO using the Genetic Algorithm (GA) and the Water Cycle Algorithm (WCA) techniques. The comparison between these techniques indicates that the WCA has minimized the LCOE by 9% - 45% than the GA during a one-year test, while the two years test shows a reduction by 5% to 26.6%. The experiments results discovered that the inverter which connected to Monocrystalline modules is probably the best replacement for each all types of inverters in case of emergency failure.

Keywords: Photovoltaic (PV), Levelized Cost Of the Electricity (LCOE), Genetic Algorithm (GA), Water Cycle Algorithm (WCA) techniques, Inclination angle, Grid Inductance L_g

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L_1	**Inverter inductance side**
L_g	**Grid inductance side**
f	**Nominal frequency of the electric grid.**
f_{sw}	**Switching frequency.**
$f_{sw,max}$	**Maximum switching speed capability of the**
R_{dr}	**LCL-filter damping resistor**
R_1	**Resistor inverter side**
R_2	**Resistor Grid side**
C_f	**LCL-filter capacitor.**
i_i	**Inverter output current**
i_c	**Capacitor current**
i_g	**Grid current**
Nvar	**Number of variables in a WCA problem**
Raindrop	**WCA single Solution**
$(X_1, X_2, X_3, \ldots, X_{Nvar})$	**WCA decision variable values**
N_{Sn}	**The number of streams the in WCA**
N_{pop}	**The number of populations in the WCA**
N_{sr}	**Number of rivers summation in WCA**
X	**the distance between the stream and the river in the WCA**
LB -UB	**WCA lower and upper boundaries**
d_{max}	**WCA Coefficient near to zero**
μ	**WCA searching area coefficient**
E_y	**Energy injected into the electric grid**