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Mitigation of Lower Order Harmonics in a Grid Connected Single Phase Pv-Inverter by Fuzzy Controller

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Abstract:

Generally the Power circuit topology of the $1-\varphi$ PV system will be a good choice for low-rated PV inverters of rating less than a kilowatt. But the disadvantage would be the relatively larger size of the interface transformer compared to topologies with a high-frequency link transformer. This system will not have any lower order harmonics in the ideal case. However, some factors result in lower order harmonics in the system such as on-state voltage drops on the switches, and the distortion in the grid voltage itself etc. This dc injection into the transformer primary will result in even harmonics being drawn from the grid, again contributing to a lower power quality.

In this project, a simple single-phase grid-connected photovoltaic (PV) inverter topology consisting of a boost section, a low-voltage single-phase inverter with an inductive filter, and a step-up transformer interfacing the grid is considered. A novel design of inverter current control that mitigates lower order harmonics is presented in this project. An adaptive harmonic compensation technique and its design are proposed for the lower order harmonic compensation The proposed method uses an LMS adaptive filter to estimate a particular harmonic in the grid current that needs to be attenuated. The estimated current is converted into an equivalent voltage reference using a proportional controller and added to the inverter voltage reference. To avoid dc biasing of the transformer, a novel PRI controller has been proposed and its design has been presented.

I. INTRODUCTION

Single-phase grid tied inverter is one among types of inverters widely used in photovoltaic (PV) generation system due to the advantages they offer. Application of PV as a source of electrical energy showed a tendency to increase in terms of generation capacity and in terms of its spread in large areas around the world. Many aspects trigger the trend; economic, technology and policy are some among many. The restricted reserve of fossil fuel sources and followed by the increasing cost of fossil fuel based electricity generation has motivated the effort to exploit other alternative energy sources. In the other hand, the high price of equipment and system of photovoltaic generation as the main constraint on implementing this renewable generation system shows significant reduction during recent years; implicates to declination of production cost per kW electric from photovoltaic. The maturity and continuously improved technology implemented on photovoltaic generation system that causes the photovoltaic power conversion more efficient, the typical advantages of PV generation compared with other electrical generation systems of renewable energy sources such as its flexibility and simplicity to build in any places, their dependency from transportation system are some technical factors causes the change to this type of renewable energy generation for electricity is preferred.

II. LITERATURE SURVEY

1) R. Kadri, J.-P. Gaubert, and G. Champenois, An improved maximum power point tracking for photovoltaic grid-connected inverter based onvoltage-oriented control.

In this paper, an improved maximum power point (MPP) tracking (MPPT) with better performance based on voltage-oriented control (VOC) is proposed to solve a fast-changing irradiation problem. In VOC, a cascaded control structure with an outer dc link voltage control loop and an inner current control loop is used. The currents are controlled in a synchronous orthogonal d , q frame using a decoupled feedback control. The reference current of proportional-integral (PI) d -axis controller is extracted from the dc-side voltage regulator by applying the energy-balancing control. Furthermore, in order to achieve a unity power factor, the q -axis reference is set to zero. The MPPT controller is applied to the reference of the outer loop control dc voltage photovoltaic (PV). Without PV array power measurement, the proposed MPPT identifies the correct direction of the MPP by processing the d -axis current reflecting the power grid side and the signal error of the PI outer loop designed to only represent the change in power due to the changing atmospheric conditions. Simulations and experimental results demonstrate that the proposed method provides effective, fast, and perfect tracking.

2) S. Jiang, D. Cao, Y. Li, J. Liu, and F. Z. Peng, Low-THD, fast-transient, and cost-effective synchronous-frame repetitive controller for three-phase UPS inverters.

This paper presents a novel synchronous-frame repetitive controller for three-phase UPS inverters. Distinguished from conventional repetitive control techniques, the proposed synchronous-frame approach minimizes the repetitive control time delay to one-sixth of the fundamental period such that the dynamic response is significantly improved. In order to overcome the harmonic distortions under severe load conditions (e.g., unbalanced and nonlinear), in this paper, three synchronous rotating frames are deliberately selected, in each of which the repetitive controller is incorporated. Resultantly, the (6n ±1)th harmonics as well as the triplen harmonics are compensated. Moreover, a high-performance fourth-order linear phase infinite-impulse-response filter is applied to further enhance the accuracy of steady-state tracking. The proposed controller is programmed on the 16-bit fixed-point digital signal processor (TI TMS320LF2407) and eliminates high-resolution current sensors for cost effectiveness. Simulations and experimental tests have been carried out based on an 18-kW three-phase UPS system. Low total harmonic distortion (<;0025;) has been achieved under heavily distorted nonlinear load and unbalanced load. Fast dynamic response has been demonstrated during step load transients.

3) B. Singh and J. Solanki, "An implementation of an adaptive control algorithm for a three-phase shunt active filter,"

This paper deals with the hardware implementation of a shunt active filter (SAF) for compensation of reactive power, unbalanced loading, and harmonic currents. SAF is controlled using an adaptive-linear-element (Adaline)-based current estimator to maintain sinusoidal and unity-power-factor source currents. Three-phase load currents are sensed, and using least mean square (LMS) algorithm-based Adaline, online calculation of weights is performed and these weights are multiplied by the unit vector templates, which give the fundamental-frequency real component of load currents. The dc bus voltage of voltage source converter (VSC) working as a SAF is maintained at constant value using a proportional-integral controller. The switching of VSC is performed using hysteresis-based pulse width-modulation indirect-current-control scheme, which controls the source currents to follow the derived reference source currents. The MATLAB-based simulation results and implementation results are presented.

III. Existing method:

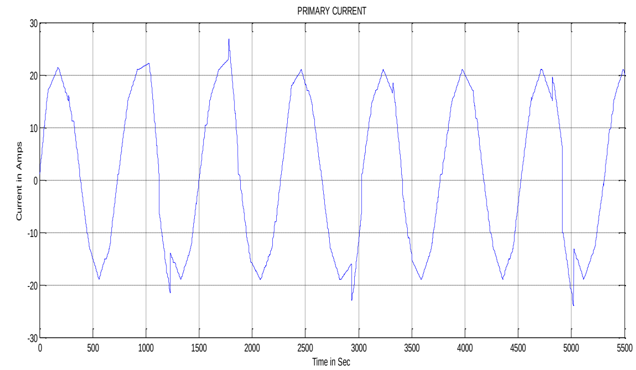
A simple single-phase grid-connected photovoltaic (PV) inverter topology consisting of a boost section, a low-voltage single-phase inverter with an inductive filter, and a step-up transformer interfacing the grid is considered. Ideally, this topology will not inject any lower order harmonics into the grid due to high-frequency pulse width modulation operation. However, thenonideal factors in the system such as core saturation-induced distorted magnetizing current of the transformer and the dead time of the inverter, etc., contribute to a significant amount of lower order harmonics in the grid current. A novel design of inverter current control that mitigates lower order harmonics is presented in this paper. An adaptive harmonic compensation technique and its design are proposed for the lower order harmonic compensation. In addition, a proportional-resonant-integral (PRI) controller and its design are also proposed. This controller eliminates the dc component in the control system, which introduces even harmonics in the grid current in the topology considered

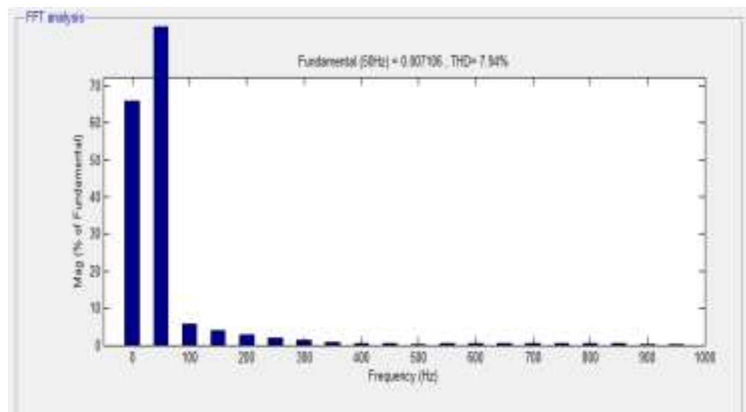
IV. Proposed method:

The proposed technique makes use of an LMS adaptive filter to estimate a selected harmonic within the grid modern-day that wishes to be attenuated. The expected current is converted into an equal voltage reference using a proportional controller and introduced to the inverter voltage reference. The design of the gain of a proportional controller to have an good enough harmonic compensation has been defined. To keep away from dc biasing of the transformer, a singular PRI controller has been proposed and its design has been provided. The PRI controller and the adaptive compensation scheme together improve the quality of the current injected into the grid. The complete current control scheme consisting of the adaptive harmonic compensation and the PRI controller has been verified by Simulation. The THD of grid current is reduced by using Fuzzy controller compared to PRI controller on both DC offset and LMS adaptive harmonic compensation. Hence the above results show good improvement in the grid current THD once the proposed fuzzy control is applied.

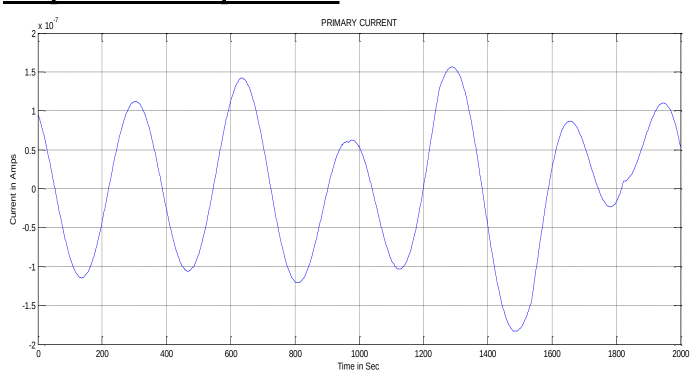
V. SIMULATION REULTS

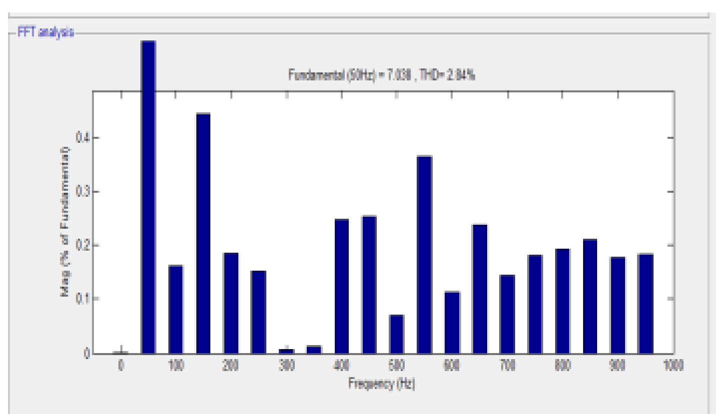
<u>Case 1:- No dc offset compensation and no adaptive harmonic compensation</u>



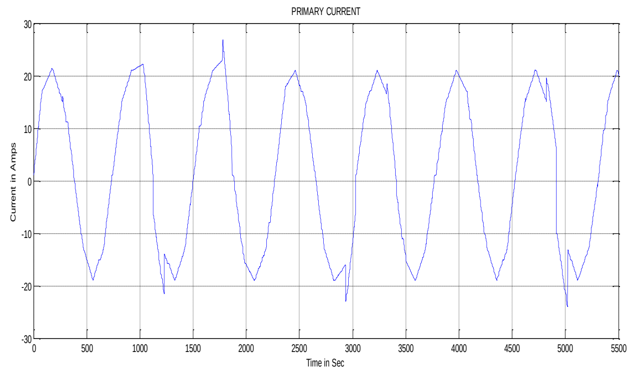


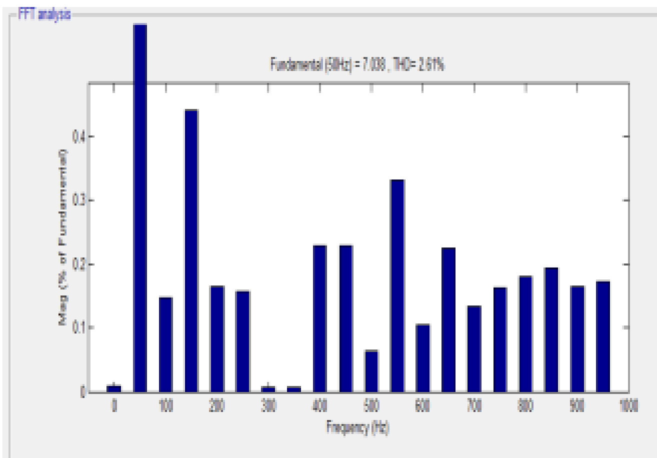
<u>Case 2:- No dc offset compensation but adaptive harmonic compensation is implemented</u>



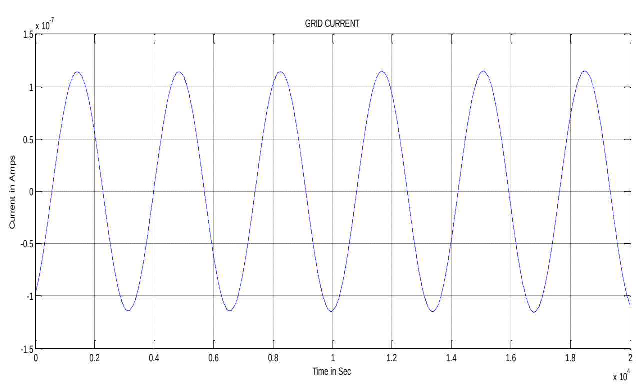


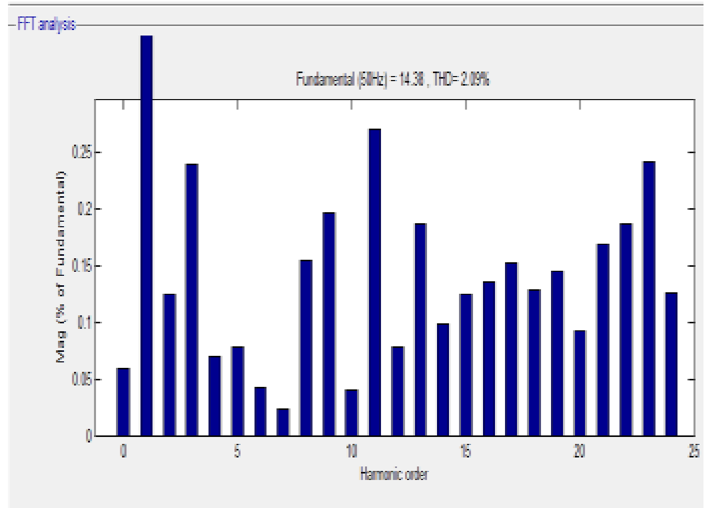
Case3:- DC offset compensation is implemented but no adaptive harmonic compensation



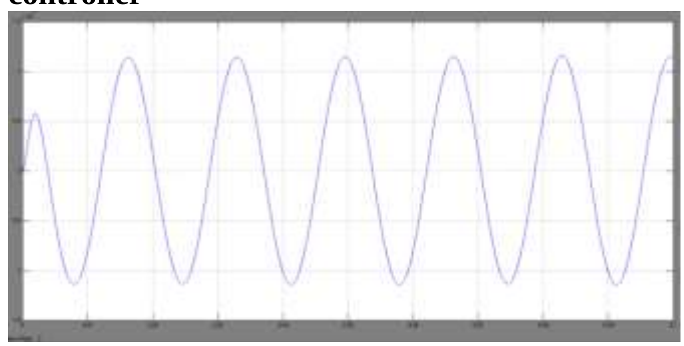


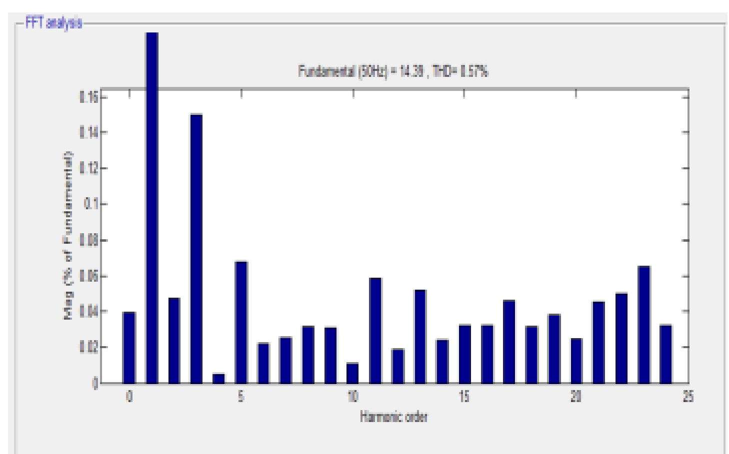
Case 4:- Both dc offset compensation and adaptive harmonic compensation are implemented





Case 4 Both dc offset compensation and adaptive harmonic compensation are implemented with Fuzzy controller





COMPARISON OF GRID CURRENT %THD OF PRI & FUZZY

	PRI %THD	FUZZY %THD
CASE 2	2.84	0.65
CASE 3	2.61	1.22
CASE 4	2.09	0.57

VI. CONCLUSION

The proposed technique makes use of an LMS adaptive filter to estimate a selected harmonic within the grid modern-day that wishes to be attenuated. The expected current is converted into an equal voltage reference using a proportional controller and introduced to the inverter voltage reference. The design of the gain of a proportional controller to have an good enough harmonic compensation has been defined. To keep away from dc biasing of the transformer, a singular PRI controller has been proposed and its design has been provided. The interaction between the PRI controller and the adaptive compensation scheme has been studied. The PRI controller and the adaptive compensation scheme together improve the quality of the current injected into the grid. The complete current control scheme consisting of the adaptive harmonic compensation and the PRI controller has been verified by Simulation. The %THD of grid current is reduced from 7.94% to 2.09% once both DC offset and LMS adaptive harmonic compensation are applied. Hence the above results show good improvement in the grid current %THD once the proposed current control is applied. The transient response of the whole system is studied by considering the startup transient and the overall performance is found to agree with the Simulation analysis.

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