



Control Scheme for the Reduction of Peak Current and Current Harmonics in Grid Connected Photovoltaic Inverters

Jinu John¹, Alan M George²

M.Tech Scholar, Department of EEE, ASIET, Kalady, Kerala, India¹

Assistant Professor, Department of EEE, ASIET, Kalady, Kerala, India²

ABSTRACT: Peak current and current harmonics are main problems associated in a grid connected photovoltaic system under unbalanced voltage sag. During the voltage sag, the photovoltaic source should operate with increasing converter currents to maintain the injection of the generated power causes peak current in the system. There are number of grid fault controllers are used in voltage sag condition. Using these controllers, considering the condition of minimum peak current causes injection large current harmonics distortion during sag voltage. In this paper present a control scheme used to minimize peak current and current harmonics distortion, which can be implemented in unbalanced voltage sag condition.

KEYWORDS: Voltage sag, Peak current, Photovoltaic (PV) inverter, gridfault, Current harmonics

I. INTRODUCTION

Grid-connected photovoltaic power systems are power systems energized by solar energy which are connected to the utility grid. Grid-connected PV power systems consist of PV panels, MPPT, inverters, power conditioning control units and grid connection equipment. Solar energy gathered by photovoltaic solar panels and delivery to a power grid, it must be conditioned for use, by a grid-connected inverter

Photovoltaic distributed generations have dc output voltage, so they should connect to grid via power electronic converters. The operation of power electronic interfaces during extreme voltage disturbance is harmful and can damage power electronic converters. According to IEEE defines power quality as: "The concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment". Voltage sag has become one of the major power quality concerns in recent years. As applications of power electronics in the different sectors grow rapidly, these causes sensitive loads easily interrupted by voltage sags and the resulting losses are significant

II. GRID CONNECTED SYSTEM

During voltage sag, one or more phase voltages at the point of common coupling (PCC) are reduced and the currents supplied by the PV source must be increased in order to maintain the same amount of injected power as in nominal conditions. Thus, the PV system can be viewed as a high-reliability current source that must inject all the generated power to the grid. The source should be able to override the large currents caused by temporary voltage sags, and continue feeding the grid according to the standards. These over currents, which can double the nominal values, can damage the power systems and switches as well as the interconnection lines, unless the source is disconnected. Fig: 1 shows the block diagram representation of grid-connected three-phase PV inverter.

During the voltage sag, the source should operate with increasing converter currents to maintain the injection of the generated power. This undesired operation may result in system disconnections due to over currents. The quality of power is mainly governed by practices and standards on voltage, frequency, and harmonics. In particular, PV systems should have low current harmonic distortion to assure that no adverse effects are caused to other equipment connected

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to the utility grid. The common practice is to accept a maximum total harmonic distortion (THD) of 5% at rated inverter output.

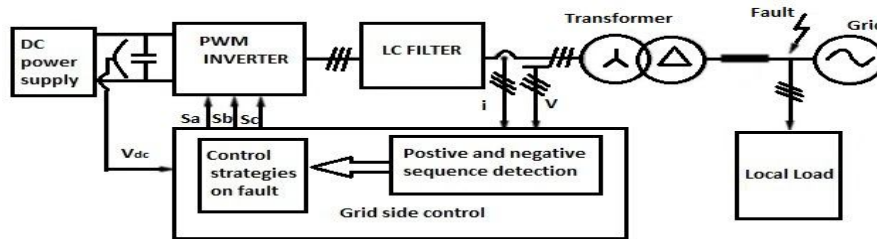


Fig:1 Grid-connected three-phase PV inverter

The different methods based on the reference current generation in grid fault controllers are; the 1st approach is the instantaneous unity power factor control (IUPFC), which must be used when the injected current i is required to follow exactly the voltage v . The second approach, the average unity power factor control, is implemented to avoid the appearance of current harmonics that increase the current THD in a grid connected system. Third, the instantaneous positive-sequence control (IPSC) gives an injected current that only follows the positive voltage sequence v^+ . Fourth, the average positive-sequence control (APSC) provides a current that follows the averaged positive-voltage sequence, avoiding the appearance of current harmonics in the system. And fifth, the positive negative sequence compensation control (PNSCC) gives a constant injected active power and low current THD [3].

From the above five grid fault controllers, obtain a generalized method for reference current generation;

$$i_r = \frac{P_r(V^+ + \alpha V^-)}{|V^+|^2 + \beta(1 + \alpha)V^+V^- + \alpha|V^-|^2} \dots (1)$$

$$n = \frac{V^-}{V^+} \dots (2)$$

The unbalance factor n Eq.(2) is calculated on the basis of positive and negative sequence voltage. The optimal values of α and β are given using interpolation in a look-up table. The value of α is varied from -1 to 1 and β varies from 0 to 1. Used with Eq.(1) to obtain the reference current i_r [4].

III. DESIGNING OF THE CONTROL SCHEME

The field of overcurrent reduction solutions that based on the control scheme, which avoid any increase in the number of electronic devices. In the selection of a proper reference current is proposed to override grid faults and achieve different power quality requirements especially peak current during voltage sag. In this method proposes a controller for a PV inverter that ensures minimum peak values in the grid-injected currents during the voltage sag. This study is based on the generalized algorithm and design method is developed in order to search for the control parameter values that minimize the peak currents.

Basic control block diagram during voltage sags is shown in fig.2. The inverter should supply a reference current i synchronized with the grid voltage. The detection block is responsible for extracting the positive and negative synchronization sequences from the voltage [1]. The reference generation block uses these voltage sequences and the reference power signal from the external dc-link voltage controller P_r to generate the reference current vector i_r . As a last stage, current controller produces the pulses to the inverter.

In order to reduce the peak current to its minimum, noninteger values are proposed for α and β when computing the expression of the reference current vector i_r . A simple searching algorithm is used offline to find the optimum values of α and β for each unbalance factor n . With each pair alpha, beta for a given unbalance factor, the peak values over a line

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period are computed. Then for each n , a single pair alpha, beta giving minimum peak current values is stored in a look-up table. When sag is detected, n is computed online. Then the appropriate values of α and β are retrieved from the look-up table to obtain the reference currents. This reference current i_r is given to the input of resonant current controller. The resonant current control has

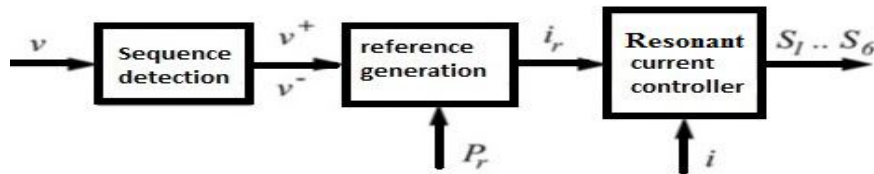


Fig.2 Control block

been extensively employed to reduce the current harmonic distortion in a grid-connected distributed generation applications, including photovoltaic (PV) inverters. In this control uses a proportional-resonant (PRES) compensator to track the fundamental component of the current reference signal and a resonant harmonic (RESH) compensator to attenuate the most important current harmonics. Space vector modulation signal S_a, S_b, S_c pulses to the inverter.

A. Detection of Positive and Negative Sequences

The grid voltage is a crucial issue in order to have full control over the power that is delivered from the DPGS to the grid. In this section, characterization is performed by means of a positive and negative sequence voltage detector based on a second-order generalized integrator. The proposed positive- and negative-sequence detection system that provides an effective solution for grid synchronization of power converters in the presence of grid faults. The calculation of the instantaneous symmetrical components on the alpha-beta reference frame makes it possible to use only two SOGIBPFs.

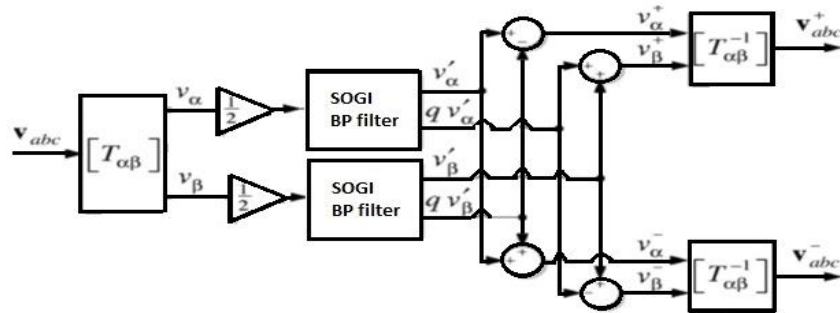


Fig.3 Extracting the positive and negative sequences voltage of the grid

B. Current Controller

The resonant current control has been extensively employed to reduce the current harmonic distortion in a wide range of grid-connected distributed generation applications, including photovoltaic (PV) inverters. This control uses a proportional-resonant (PRES) compensator to track the fundamental component of the current reference signal and a resonant harmonic (RESH) compensator to attenuate the most important current harmonics.

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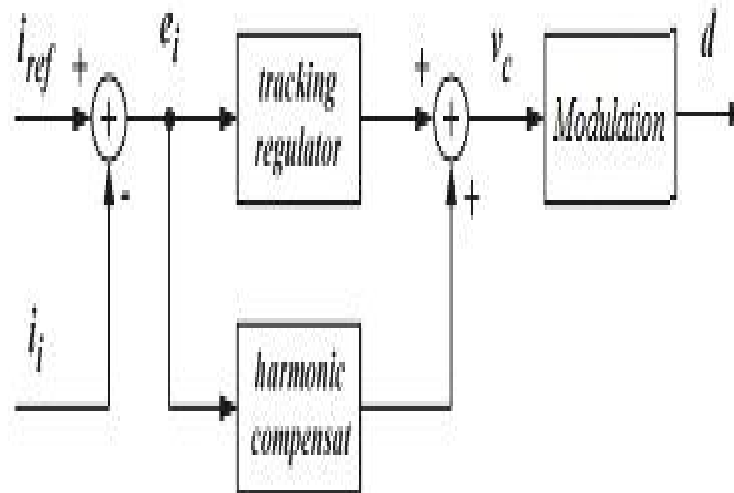


Fig.4 Block diagram of resonant current control

IV. SIMULATION MODEL

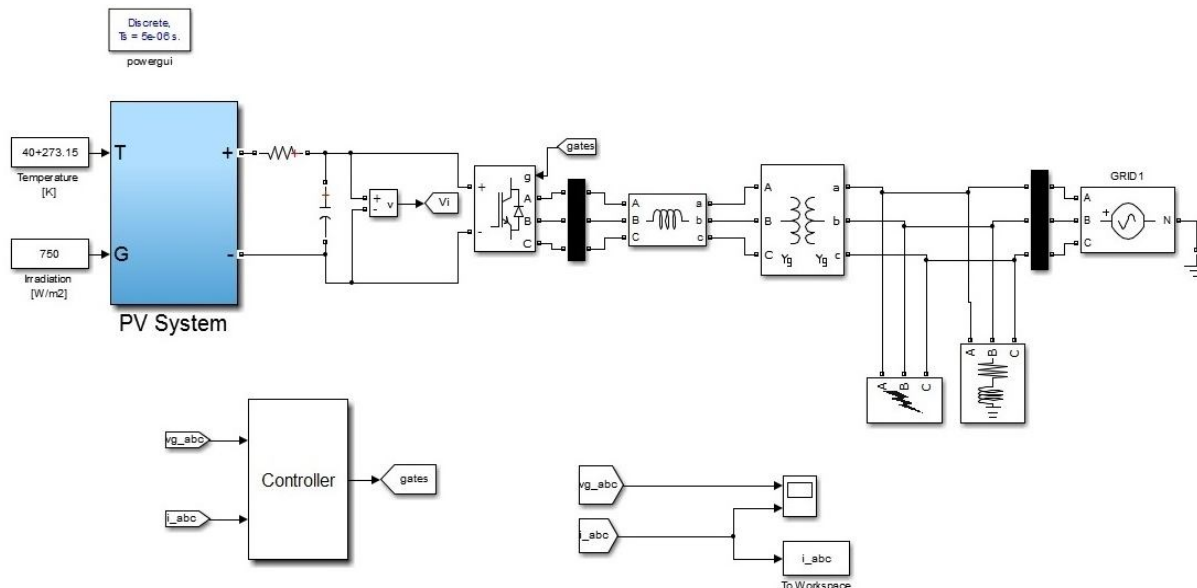


Fig.5 Simulation model of generalized control scheme

V. RESULT ANALYSIS

In order to evaluate the performance of the controller, a deep symmetrical sag with an unbalance factor n was used, and a performance comparison with a reference controller. Fig.6 the output of pv to grid connected system during voltage sag with a time period of .3 to .5 sec. Comparing with previous controller, we can see that overcurrent reduced during LLLG. But presence of current harmonics during the current is high.it about 30.61%.

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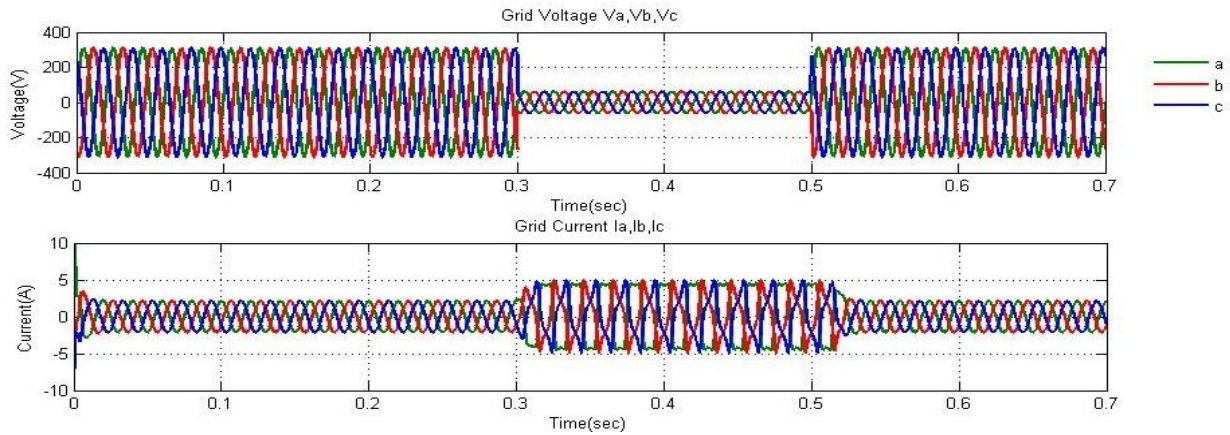


Fig.6 Grid voltage & current during voltage sag using generalized controller-LLLG fault [Existing control]

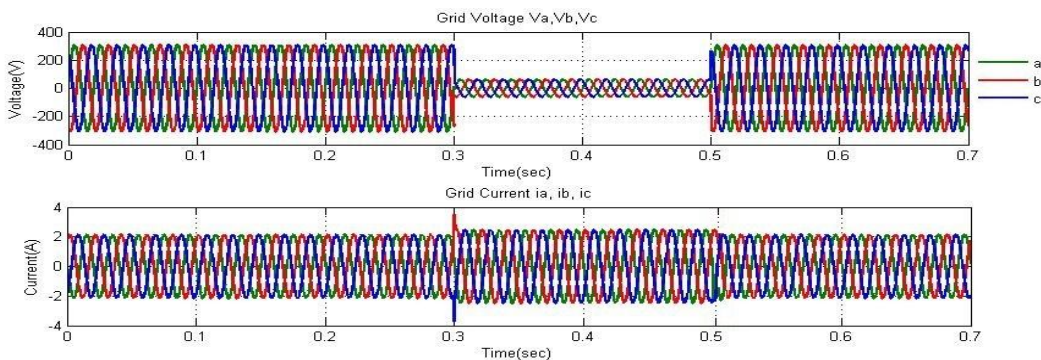


Fig.7 Grid output voltage & current during LLL-G fault [Proposed control]

From the fig.7 it can be analysed that by incorporating the resonant current controller into the existing peak current reduction scheme current harmonics and peak current is reduced. By analysis using resonant controller incorporate with peak current reduction method peak current and harmonics are reduce large extent. Fig.8 shows the change in peak current and current harmonics.

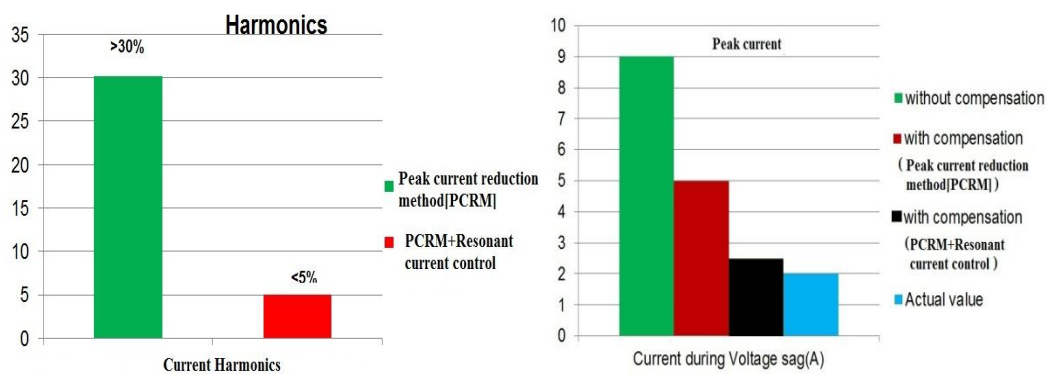


Fig.8 a.) Harmonic current variation existing & proposed controller;
b.) Peakcurrent variation during voltage sag



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IV. CONCLUSION

This paper has presented a controller for a grid connected three-phase PV inverter, which ensures minimum peak values in the grid-injected currents during unbalanced voltage sags. Also it reduces current harmonics during the period of voltage sag where large harmonics are presented due to the reference current injection.

Existing control strategy, peakcurrent reduction using reference current generation method injects grid current which causes large current THD .In existing Control method current THD is greater than 30% even though the peakcurrent is reduced.

To improve the performance of the system resonant current controller incorporated in grid connected PV inverter. By doing so, the current harmonic distortion and peak current can be reduced during voltage sag. The current THD is less than 5%.So when compared to existing peakcurrent reduction method, both current THD and peakcurrent can be reduced and hence it is more preferred.

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