Minimization in the DC Component of Transformer less Grid Connected PV Inverters

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Abstract— The main problems are produced in transformer less system is the dc component produced in inverter ac output. This dc component created power ripple and some harmonics. It is disturbed system operation and safety. In this paper developed new method for dc component minimization and create new software based blocking capacitor for dc component minimization called virtual capacitor. In this paper proportional integral controller is designed for provide regulation to dc component. The accurate extraction of dc component is very difficult so in this paper double time integral method is used for extract the dc component.

Key words: PV Array, DC Component, Proportional Integral Controller, Virtual Capacitor

I. INTRODUCTION

The grid connected photovoltaic system consist a line transformer between the (inverter) power converter and the grid. For the safety point of view the transformer gives galvanic isolation between the grid and PV system. It is ensures that no direct current component is injected into the grid. The low-frequency Transformers are bulky, heavy in weight and more costly and its power losses are brings down the overall system Efficiency. Now For removing the transformer and to achieve size, price and weight reduction and efficiency is also increasing of the system. So in this paper create an optimal grid connected PV system by removing the transformer from the system.

There are different issues created in transformer less system like level of voltage is disturbed between PV panel and grid, some dc component are presents in inverter output current and ground leakage current. The dc component is the main problem in transformer less structure. The IEEE standard has decides the value of dc component is below the 0.5% of the rated current. So in this paper create a new proposed system for dc component extraction and minimization.

The coupling transformers and blocking capacitors are added on the inverter ac side to minimize the dc component. But in this case the size and cost of the whole system is increased and also produce some power losses. So software based capacitor is used for block the dc component. So it is called “virtual capacitor”. The dc component is flowing in each phase and flowing between the phases. The value of dc component is very low as compared with the ac component. So it is very difficult to extract dc component in this system sliding window iteration method apply for dc component extraction. The PIR controller is designed to regulate the dc components.

II. DC COMPONENT

The average value of ac waveform is not equal to zero is called dc component. In case of ac waveform the average value is equal to zero due to positive half cycle and negative half cycle cancel each other.

A signal having a mean-value or DC component of zero is commonly referred to as mean-free or as having no DC component. It does not mean that it cannot be averaged, just that the average comes out as zero.

III. EXISTING SYSTEM

The grid connected photovoltaic system includes a transformer between the power conversion and grid. So the transformer is providing galvanic isolation between the PV system and grid. There is no dc component is injected to the grid and system operation is normal and system safety improves. In this system low frequency transformers are heavy, bulky and more expensive and its power loss brings down the system efficiency.

Drawbacks of existing system:

- increased weight and size
- extra power loss
- system efficiency decreased

IV. PROPOSED SYSTEM

Fig. 3.1 shows the proposed system. In this system transformer is removed and getting cost, weight and size reduction also efficiency became increased in 3 phase grid connected PV system. Now there are different methods is available for minimization of direct current component there are active and passive. Like example blocking capacitors and coupling transformer are inserted to the inverter side for minimization of the direct current component. The negative point of using the passive method is it can increase the cost, size and also weights is increased and produce some power losses. The minimization of the direct current component for single phase PV inverters is exactly different from the 3 phase PV inverters. In three phase PV inverter the DC current component flowing in each phases and flowing between the phases. It can be very difficult process to minimize the direct current component from the all phases at the same time due their connections. Now the new idea is produced for minimization of direct current called “Virtual capacitor” in single phase PV inverters. This virtual capacitor is replaced by the physical capacitor on inverter ac side and created new control method. The proportional integral resonant controller is also designed for controlling both line frequency signal and direct current.

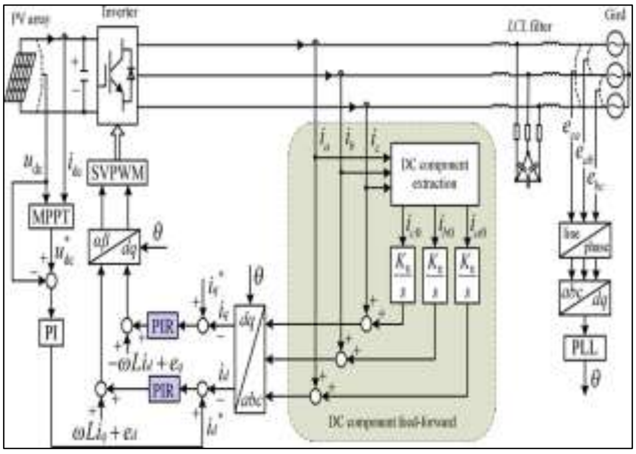

Fig. 1: proposed system

V. VIRTUAL CAPACITOR

The virtual capacitor is created for minimize the direct current component in stationary frame and also integrated to Photovoltaic inverter current loop in d-q frame with the proportional integral resonant controller.

In this step a series capacitor is put in series with ac side of the inverter for blocking the dc component as shown in fig. 2. For reduce the capacitive reactance at other frequencies, the capacitor value need to be large, which increase the cost, weight and size of the system. The series capacitor also reduces the system efficiency. So the physical capacitor is replaced by the software based method which mimics the operation of the series capacitor in a PV system.

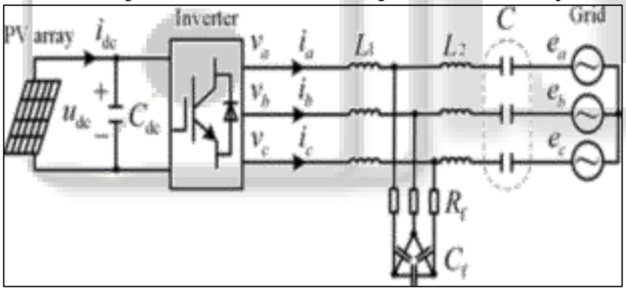

Fig. 2: three phase PV system with blocking capacitors

The proportional integral(PI) controller in the dq frame is used to regulate the d-axis and q-axis currents. The current control loop of three phase inverters with blocking capacitors in stationary abc frame is shown in fig. 4(a) where the variables with abc subscript denote the vectors of three phase voltages and currents.the fig. 4(b) shows the dc component if the direct current component is taken into account. the fig. 4(c) indicates the capacitor voltage feedback terminal is moved to feedback path. The physical capacitor is converted into the integral and feed forward path. Now the complete virtual capacitor is created in 3 phase system in abc frame.

Now To achieve a zero steady-state error for the direct current component, Fig. 4(d) replaces the P controller in Fig. 4(c) with an integral controller. Then, in order to apply the direct current component minimization method to the dual closed-loop control system in a synchronous frame, Fig. 4(d) is then transformed to a mixed abc and dq frame as shown in Fig. 4(e). The reference current Iabc0, the grid voltage eabc0, and the current controller is implemented in synchronous frame. The "virtual capacitor" in the feedback path is still implemented in the stationary a-b-c frame.

Now the fig. 4(d) is replaced p controller in fig.4(c) and achieving the steady state error. Then the fig.4 (d) is converted in both dq and abc frame shown in fig. 4(e).now assumed reference current is and the voltage of grid is and in synchronous frame current controller is created. Now the virtual capacitor in feedback path is created in abc reference frame.

Now the R controller is added in the PI controller. Now with addition virtual capacitor is added in to the feedback path it is seen in fig.4 (e). So the combination of R and PI controller developed new PIR controller. The PIR controller is used to control the line frequency signal and direct current. The virtual capacitor is developed by integrating the direct current component and added a feed forward on to the feedback path.

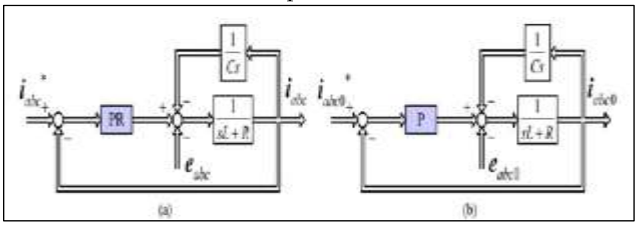

Fig. 4: (a) Current control loop in abc frame (b) direct current component control loop in abc frame

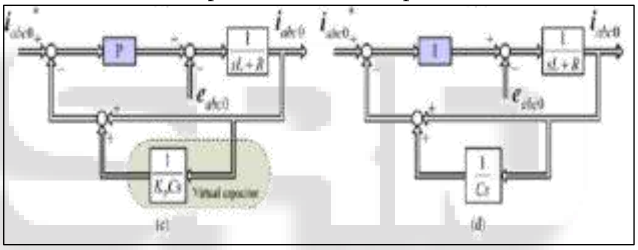

Fig. 4: (c): Transformation of the direct current control loop with virtual capacitor (d): Direct current control loop based on integral controller

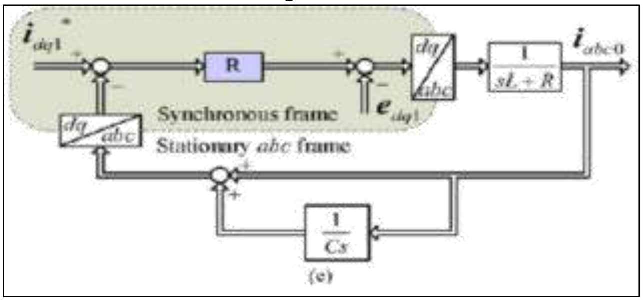

Fig. 4: (e): direct current control loop in both frame

Fig. 4: Implementation of the virtual capacitor

VI. PIR CONTROLLER DESIGN

The direct current component in the alternating current side in taking into account, the dq frame of current loop composed of line frequency and direct current component. The direct current component in rotational frame is derived from line frequency alternating component in the phase current. Now the line frequency alternating current component is derived from rotational frame which is comes from direct current component in the phase currents. The PIR controller is usefully for give control for both line frequency and direct current component in dq frame. The fig.5 shows the PIR controller.

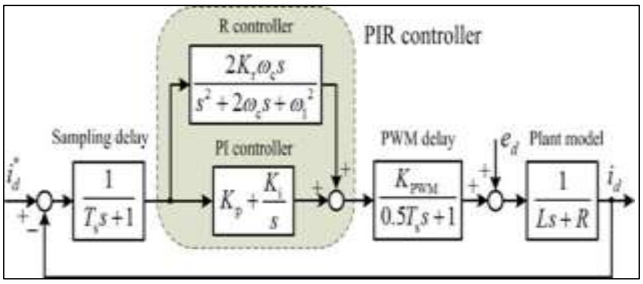

Fig. 5: PIR controller

Now when the direct current component is transformed into fundamental current the PI controller is used to regulate direct current component. When the line frequency component is converted into direct current component the R controller provide regulation to line frequency component. Now the value of PI controller is set for steady state performance of the current loop. The value of R controller is set for the direct current component minimization.

An infinite gain at the resonant frequency of only R controller is removing the steady state error. Now for making improvement In R controller the value is added in to the denominator in fig.5.the gain value is adjusted with the. When the is small it is gives good selectivity of frequency. When is large it leads to a higher bandwidth around resonant frequency.

VII. SIMULATION AND RESULTS

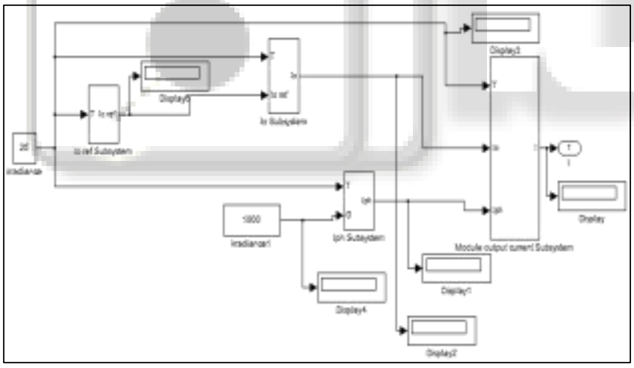

Fig. 6: complete simulation of solar cell

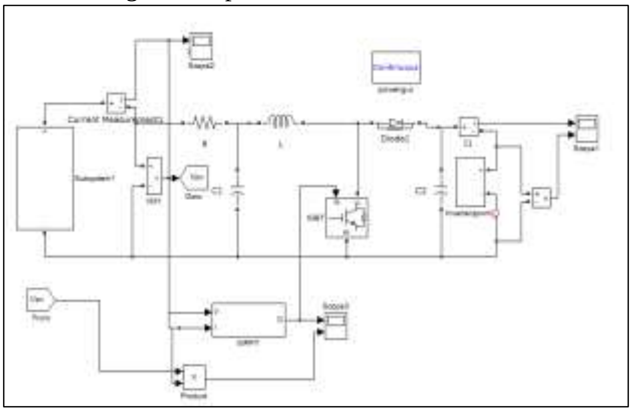

Fig. 7: MATLAB simulation of DC-DC boost converter with MPPT and Inverter

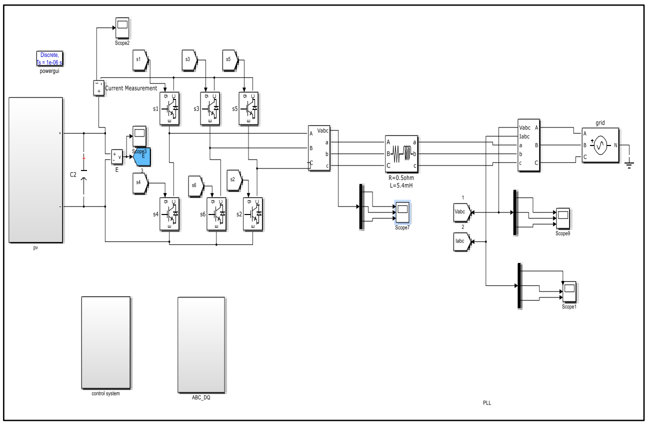

Fig. 8: Interconnection of transformer less grid connection of PV

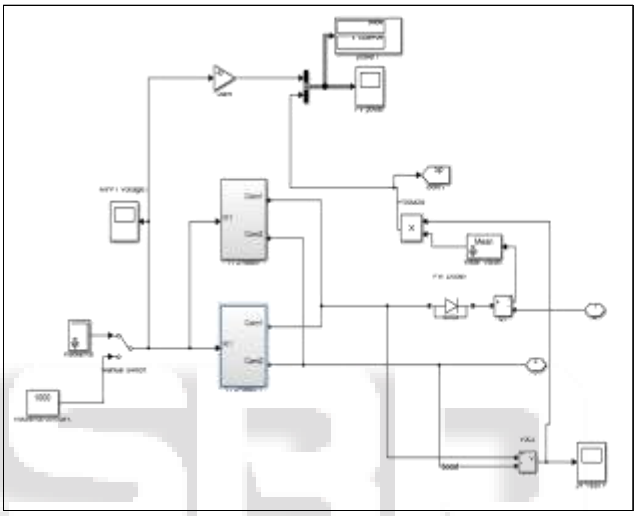

Fig. 9: PV systems for Power generation

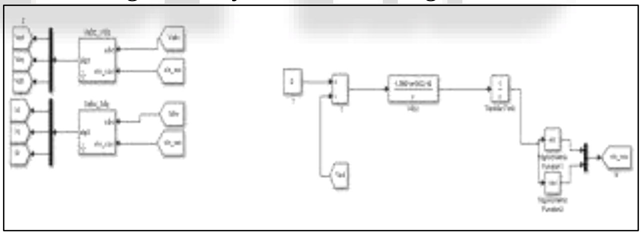

Fig. 10: PLL and Clark transformation

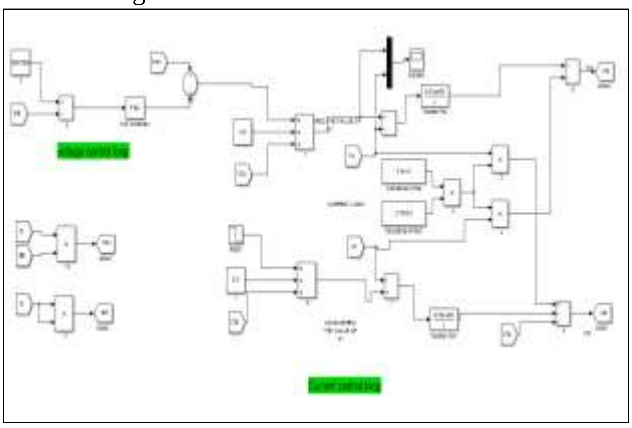

Fig. 11: Control scheme for inverter

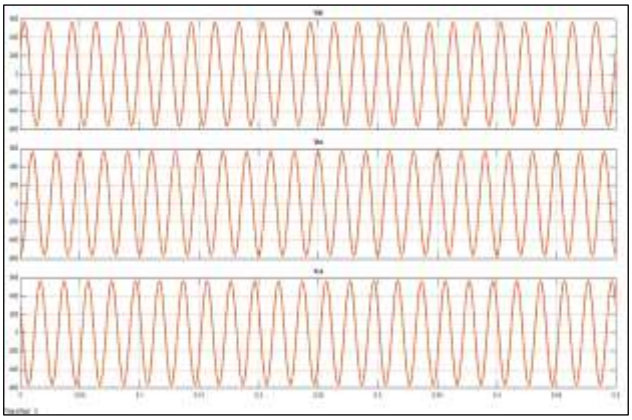

Fig. 12: Line voltage of grid

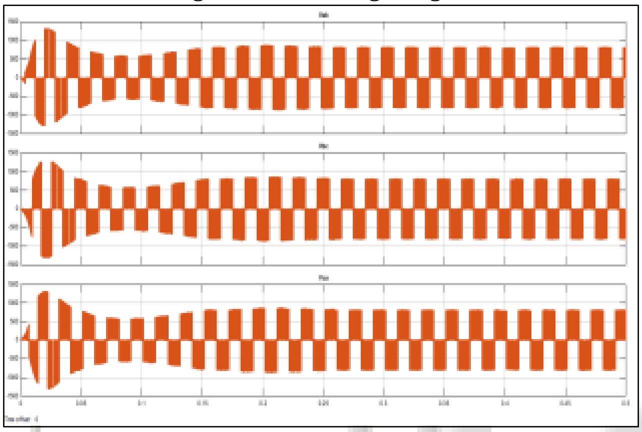

Fig. 13: Voltage of Inverter

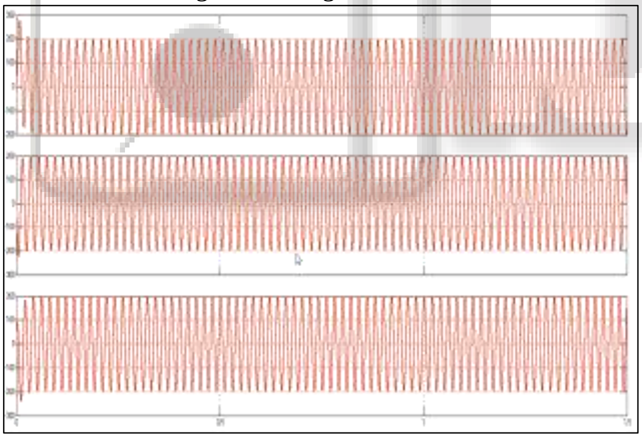

Fig. 14: Current waveforms of grid

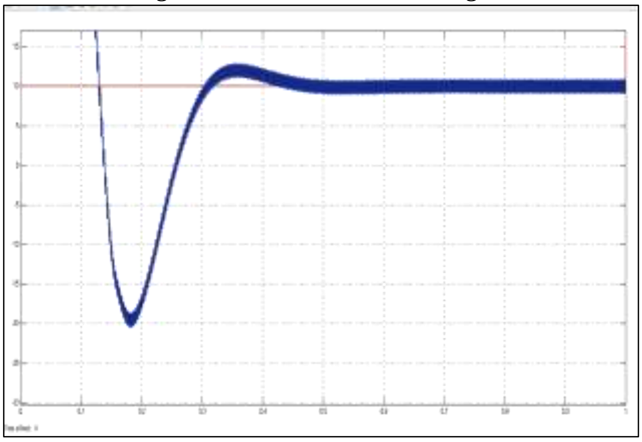

Fig. 15: Actual Id follows reference Id

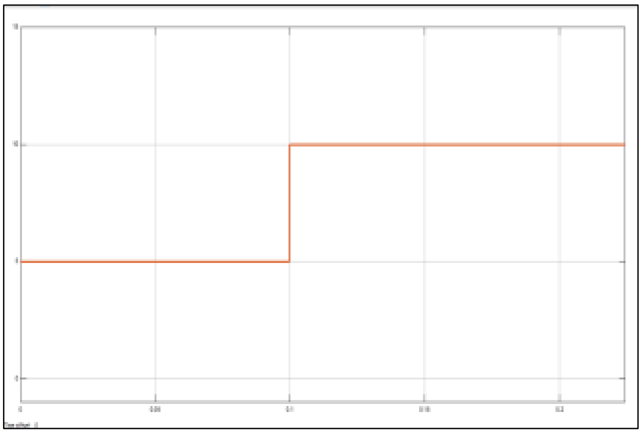

Fig. 16: Superposed DC component

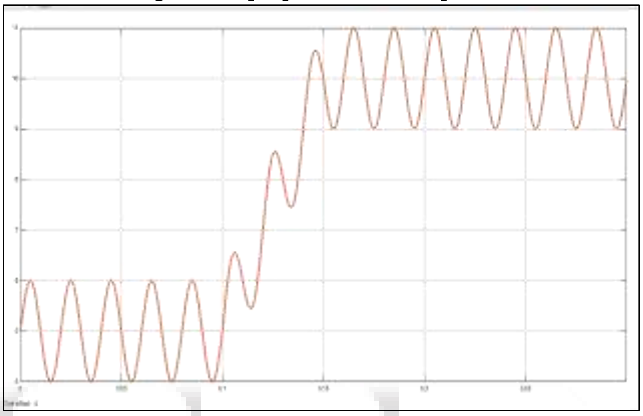

Fig. 17: component Extraction Result with one time integral

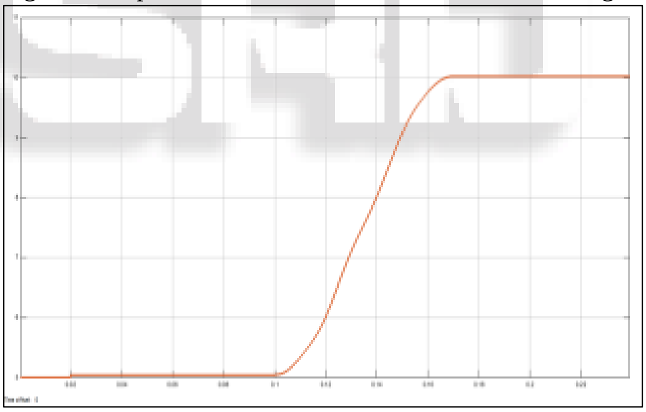

Fig. 18: DC components Extraction Result with two time integral

VIII. CONCLUSION

The new method is developed for extraction and minimize the dc component in transformer less PV system. The software based virtual capacitor designed for block the dc component and PIR controller is also designed for regulating dc current.by using this method cost minimized transformer less grid connected PV system developed.

REFERENCES

[1] TrishanEsram, Patric L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", Ieee Transation On Energy Conversion Vol. 22, No.2, June 2007.

[2] Samual Vasconcelos Araujo, Peter Zacharias and Regine Mallwitz, "Highly Efficient Single-Phase Transformer less Inverters for Grid-Connected Photovoltaic Systems", IEEE TRANSECTION ON INDUSTRIAL ELECTRONICS, VOL.57, NO.9, SEPTEMBER 2010.
[3] Dezso Sera, Laszlo Mathe, Tamaskerekes, And Remus Teodorescu, "On The Perturb-And-Observe And Incremental Conductance MPPT Methods For PV Systems", IEEE JOURNAL OF PHOTOVOLTAICS, VOL. 3, NO.3, JULY 2013.
[4] Hair NissahZainudin, SaadMekhilef, "Maximum Power Point Tracking Using Perturb & Observe Algorithm and Compare with another Algorithm", International journal of Digital Application & Contemporary research, Website www.ijdacr.com, Volume 2, Issue, September 2013.
[5] Qingzeng Yan, Xiaojie Wu, Xibo Yuan, member IEEE, Yiwen Geng and Qi Zhang, "Minimization of the DC Component in Transformerless Three-Phase Grid-Connected Photovoltaic Inverters", IEEE Transection Power Electronics, Vol. 30 No.7,July 2015.