PERFORMANCE OF SINGLE-STAGE SOLAR INVERTER USING HYBRID FILTER FOR POWER QUALITY IMPROVEMENT

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Abstract

Grid feeding inverter with photovoltaic technique is more popular now a days because they are environment friendly, but the issue with this type of inverter is they require high DC link voltage.

There are two topologies for grid feeding inverter i) Single stage inverter ii) Double stage inverter. Single stage inverter using conventional inverters need input DC voltage more than peak line-line voltage, so they are not much suitable while two stage topologies require less input DC voltage but it is more complex by means of circuit consideration.

So in this paper, performance of single stage solar inverter with input voltage less than peak of line-line voltage has been observed which can also reduce circuit complexity in comparison with two stage topology. In addition, harmonic filtering is provided with Hybrid active power filter (combination of both passive and active power filter).

Performance is analyzed by simulation and result of the proposed circuit is given in the paper which is carried by co-simulation between PSIM and MATLAB, which clearly shows the reduction in the THD.

Index Terms: Hybrid filter, d-q control, Harmonic compensation, THD.

I. INTRODUCTION

Now a days, energy plays most important role in moreover all sectors in the world. Especially industrialization highly depends upon production and distribution of energy. It requires reliable and highly efficient energy production.

Advancement in the renewable energy sources and the production from renewable energy sources are considered to be another option for conventional sources. Renewable energy sources can also be efficient for minimize our dependence on foreign fuel imports, reduces capital investment for plat installation and also reduces environmental pollution.

In all kind of renewable energy sources such as wind, sun and fuel cell etc. solar energy is one of the best energy source to utilize which converters photovoltaic energy from solar rays to electrical energy. All renewable energies are environment friendly. They does not make any kind of environmental pollution.

Grid connected solar power was developed more than two decades ago as alternative source to utility grid, especially in remote areas where utility cannot be provided or unstable.

Solar inverters are of two types:

i) Single stage
ii) Double stage

Single stage topology consist the direct conversion of DC solar PV energy to the AC power using conventional converters. In this input voltage is more than peak line-line voltage.

In double stage the DC input voltage is first boosted and then converted into the AC through converters.

Here, the single stage inverter topology is little bit modified, the peak line-line is maintained as such input DC voltage should not be greater than that. Along with this the filter has

been provided so that it could reduce circuit source harmonics which are caused due to non-linear load present in the grid. In paper, Hybrid filter has been used which is combination of passive and active filter. Both are connected in series with each other and in parallel with proposed single stage solar inverter circuit.

Passive filter contains R, L, C component combination as filter and active filter contains power electronic components. Power electronic inverter containing solar panel is acted as active filter. Solar panel in active filter had number of solar panels connected in series to increase the voltage magnitude. So that DC input of circuit should be less than peak line-line voltage.

In this paper using pure hybrid active filter is proposed for reducing the DC link voltage requirement and ensuring a single-stage system. d-q current control is used for active current control. A modified wide band current control has been used for harmonic compensation.

II. POWER CIRCUIT DIAGRAM

The proposed, single-stage solar inverter consists of hybrid filter along with three phase full bridge Voltage Source Inverter (VSI) connected to DC bus capacitor and PV array. The proposed solar inverter, filters the harmonic currents from the source effectively and at the same time supplies power from PV arrays to utilities.

Fig. 1. Shows the proposed system connected with 5kw non-linear load. In order to reduce size of passive filter it is designed for 7th harmonics with values (L=1mH, C=240uF). The capacitor has been selected to supply reactive power of 7kVAR (at 300(L-L)). Which can compensate for lagging load. In this circuit the required DC link voltage rating for the hybrid power filter is much smaller than that of a conventional pure active filter [12] because of the series capacitance of LC (passive) filter, bears most of fundamental voltage. Since Hybrid filters require less DC link voltage as compared to active filter so it can be preferred for single-stage solar inverters. Along with this there are more other factors such as reduction of switching ripple and less requirement of installation space in comparison of hybrid and pure active filter.

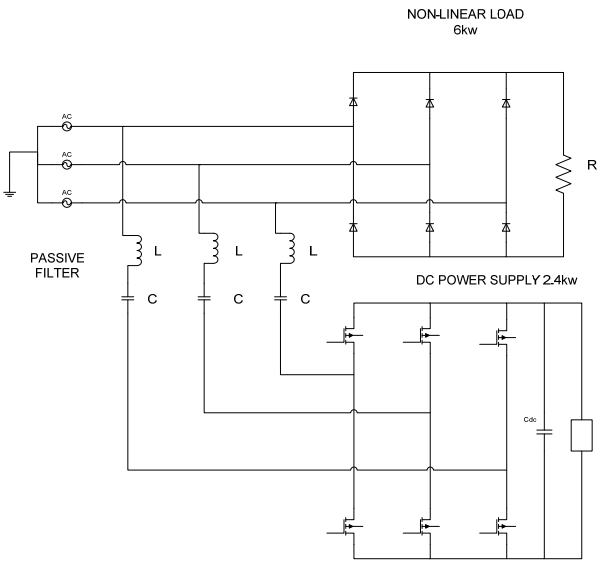


Fig. 1. Power circuit diagram of proposed single-stage solar inverter

III. CONTROL STRATEGY

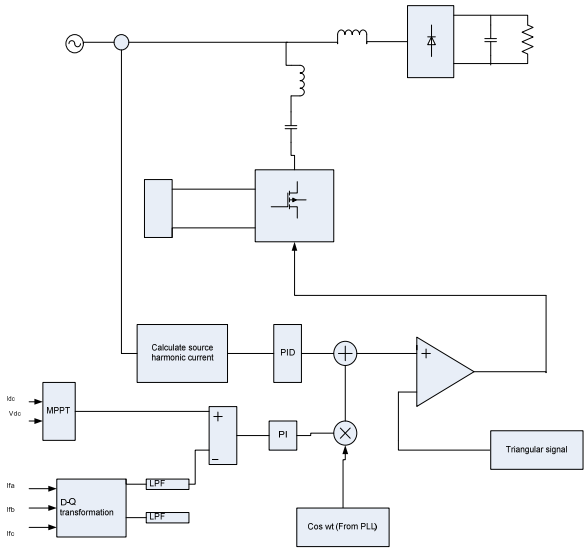


Fig. 2. Control strategy for proposed single-stage solar inverter

The control strategy of proposed single-stage solar inverter is shown in fig. 2. The source harmonic current is sensed and then given to PID controller which summed with multiplication of cosine of angle from PLL and PI controlled signal of comparison of MPPT and d-q transformation.

Filter currents are sensed through sensor and then transformed into d-q transformation using following formula,

$$\begin{bmatrix} IFa \\ IFb \\ IFc \end{bmatrix} = \begin{bmatrix} \sin \omega t & \cos \omega t \\ \sin(\omega t - 120) & \cos(\omega t - 120) \\ \sin(\omega t - 240) & \cos(\omega t - 240) \end{bmatrix} \begin{bmatrix} IFd \\ IFq \\ IFo \end{bmatrix}$$

Then value of IFd with negative value is given to comparator which has MPPT as positive input. The output is PI controlled and multiplied with cosine angle of PLL output.

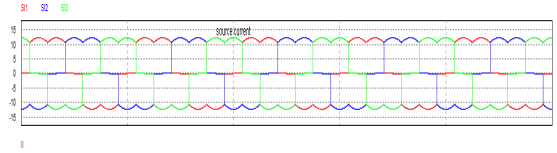
The above signal is further summed with source current harmonics with PID controller. And then compared with triangular signal which generates PWM pulses which are used to trigger the switches in the inverter.

IV. SIMULATION AND RESULT

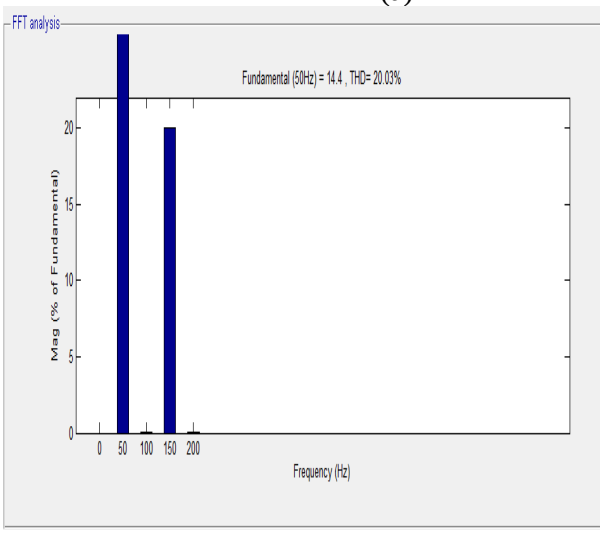
Simulation for this proposed model is done in PSIM and MATLAB software. And THD is the concerned factor for comparison of result. The two simulations THD results are compared one is proposed power circuit without hybrid active power filter and one is with controlled Hybrid active power filter.

Fig. 3 (a) shows the simulation output waveforms for proposed single-stage solar inverter without hybrid active power filter. And fig. 3. (b) shows the THD result for proposed single-stage solar inverter for same circuit.

The first waveform in Fig. 3. (a) shows source current of the circuit without filter.



(a)



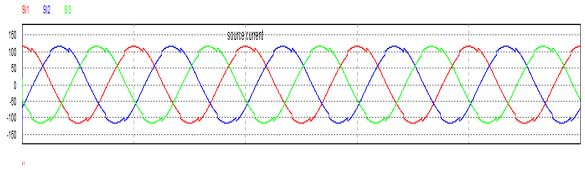
(b)

Fig. 3. THD of source current without hybrid active power filter

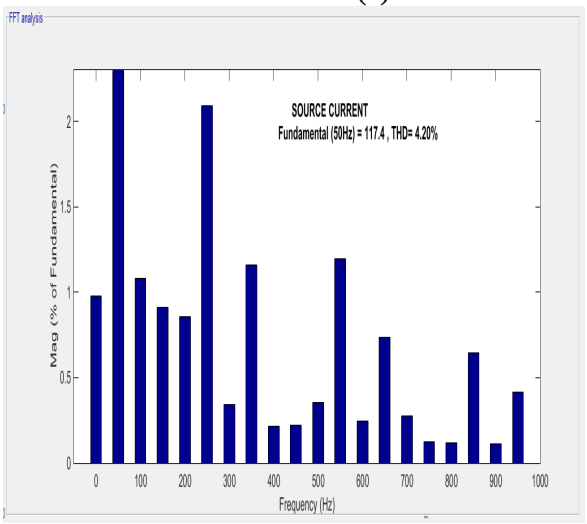
Fig. 4 (a) shows the simulation output waveform for proposed single-stage solar inverter with hybrid active power filter. And fig. 4. (b) shows the THD result for proposed single-stage solar inverter for same circuit. Fig. 4. (c) source voltage and solar voltage

The waveform in Fig. 4. (a) shows source current of the circuit with Hybrid Active Power filter.

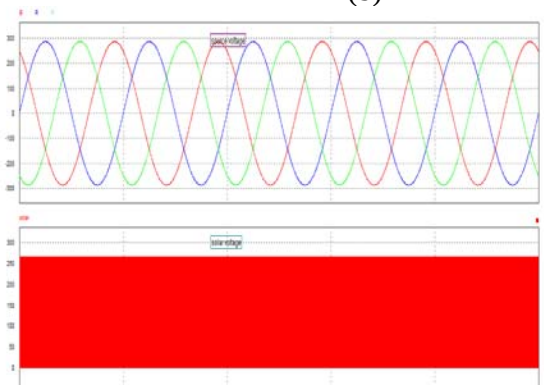
Fig. 4 . (c) shows the two waveforms, the first one is source voltage and second one is solar voltage. In single stage solar inverter solar is used as DC link voltage(250V) and wich has lower value than line-line source voltage(300V). Which is advantage of single-stage solar inverter over two-stage solar inverter.



(a)



(b)



(c)

Fig. 4. THD of source current with hybrid active power filter

V. CONCLUSION

In this paper, a single-stage solar inverter has been designed for a three phase grid-connected inverter which consists a single power stage conversion from low DC voltage source to the AC grid system, along with power quality improvement. A control method is a combined control system with harmonic control and D-Q control is presented. PSIM simulation results as output waveform and THD results are given for with and without hybrid active power filter for 5kw non-linear load and 7kVAR reactive power. Without filter proposed system shows THD as 20.03% and with filter it shows 4.20%.

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