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International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 3 Issue 6 June, 2014 Page No. 6718-6721

Reduction Of Ground Current In A Transformerless Photo Voltic Inverter Connected To Grid

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***Abstract*—When no transformer is used in a grid-connected photovoltaic (PV) system, a galvanic connection between the grid and the PV array exists. In these conditions, dangerous ground currents (common-mode currents) can appear through the stray capacitance between the PV array and the ground. This current increase conducted and radiated electromagnetic emissions, harmonics injected in the utility grid and losses.In this paper, an improved output filter for reduction of common mode voltage and ground current in a grid connected full bridge(FB) inverter is proposed .A model for measurement of this ground voltage and current is build by using simulation software. Finally ground voltage and current of a FB inverter using conventional LCL filter and proposed filter is measured and compared with satisfactory results.**

***Keywords* —ground current, photovoltaic (PV) systems, transformerless inverter.**

INTRODUCTION

The energy demand of the world is increasing day by day. Conventional energy sources are main supplier of energy to the world. But these all are exhaustible means non renewable sources of energy and also increases environmental pollution, global warming and climate change.

So for fulfilling these higher energy demands renewable energy sources are most reliable,safe and long time available source of energy. There are many types of renewable energy sources like solar power (PV modules), hydropower, geothermal and wind energy[1].and these all are long time available, much cleaner and more cost-effective sources of energy[2].

Among all renewable energy sources, Hydropower generation requires large capital cost, a huge amount of water storage e.g. Dams and has limited generating capacity, wind power generation requires flow of high winds to rotate the windmills which makes it applicable only for hilly areas or sea costs .Due to all these limitations, these power generation units cannot be installed near or within every residential area/city. On the other hand in solar power generation or photovoltaic (PV) generation the energy is generated by direct sun radiations falling at PV panels [2] .So these generating units can easily be installed at any place near or within the city, terrace of houses, over the canals etc..Due to this advantage and With the help of government incentives the use of PV generation is becoming more and more widespread all over the world[7].

Earlier a line frequency or high frequency transformer is used to isolate the PV panels from the grid.This isolation transformer gives personnel safety, reduces electromagnetic interference (EMI) noise and steps up or step down the voltage levels fig (1), but line-frequency transformer increases the weight and the high-frequency transformer requires more switching devices and conversion stages, hence reduces the overall system efficiency, performance, and reliability [6], [3].and increases the cost, makes the system more complex.

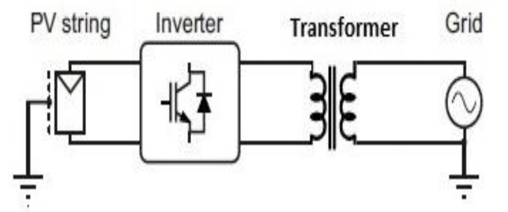

Fig. 1 PV system when transformer is connected between inverter and grid

Hence many topologies uses transformerless inverter for getting increased efficiency and reliability, reduced losses, costs and size. But when no transformer is used in a grid-connected photovoltaic (PV) system a common mode voltage between the PV panels and ground appears, which injects an additional ground current (common-mode currents) in the inverter/grid fig (2) which increases the electromagnetic emissions, harmonics and losses in the system.

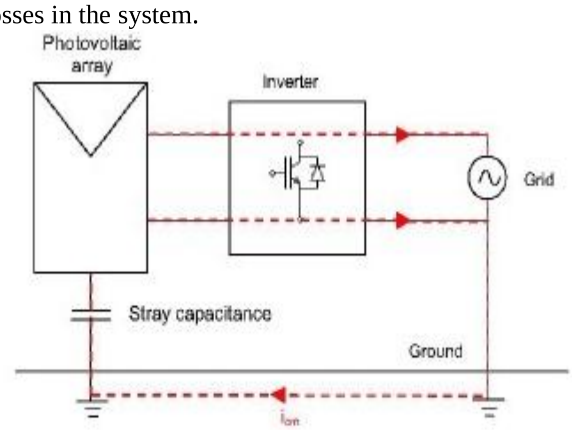

Fig. 2. Common-mode currents in a transformerless system

Many researches had been done for elimination this ground current in transformerless photovoltaic system. most of the topologies uses a passive LCL filter between FB inverter and grid for reduction of Ground current [9],[10],[11],as shown in fig(3).

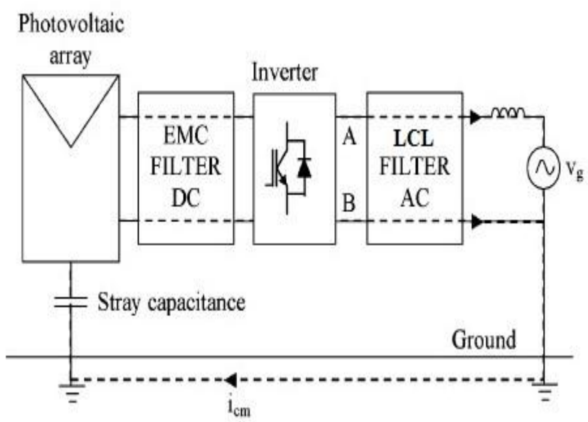

Fig .3. Block diagram of conventional transformerless inverter with LCL filter

But this Passive LCL filter reduces the ground current to a certain limit.In this paper two split capacitors with conventional LCL filter are used to implement a new output filter for grid connected FB inverter.This proposed filter is able to give more reduction in ground current as compared to conventional LCL filter .Model for measurement of ground current and ground voltage by this improved filter is build by using simulation software. Finally measurement and comparision of ground current for FB inverter using conventional LCL filter and this proposed filter is done and found satisfactory results.

FULL BRIDGE TOPOLOGY

Figure 4 shows the standard full bridge topology with AC harmonic filter for PV applications. The full bridge is connected to the single-phase grid (240 Vrms). The LCL type ac filter (L_{ac1}, C_{DM}, L_{ac2}) is the mostly used as harmonic filter for reducing ground current. Different switching patterns can be used in transformerless single phase inverter bridges.

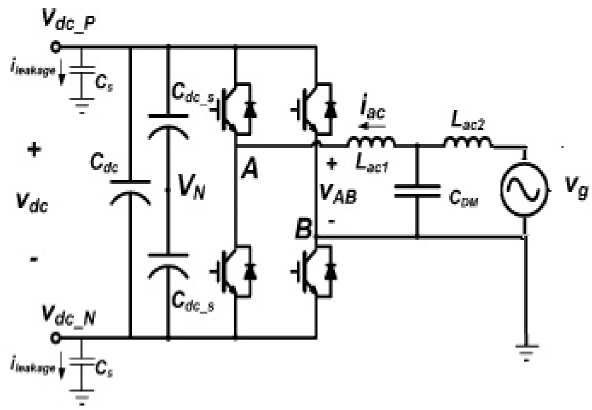

Fig. 4 Full Bridge Inverter with conventional LCL filter

COMMON-MODE CURRENTS IN TRANSFORMERLESS PV SYSTEMS

When no transformer is used, a galvanic connection between the ground of the grid and the PV panel occurs. Due to which a common-mode resonant circuit appears, consisting of the stray capacitance between the PV modules and the ground, the dc and ac filter elements, and the grid impedance (Fig.3). Due to varying common-mode voltage this resonant circuit is got excited and as a result common-mode currents are produced[6]. Due to the large surface of the PV generator, its stray capacity with respect to the ground reaches to very high values in damp environments or on rainy days [4], [13] . Which creates the problem of ground current due to the great dependence of the ground capacitance on environmental conditions and hence the resonant frequency of the system. These high values can generate ground currents above the permissible standards [8]. These currents causes conducted and radiated electromagnetic interferences, distortion in the grid current and additional losses in the system [4]. These leakage currents can be limited or avoided by avoiding excitation of this resonant circuit. This can be done by choice of suitable passive filter.[4], [5].

The instantaneous commonmode Voltage V_{CM} in the full-bridge inverter of Fig. 4 can be calculated from the voltage of the two mid-points of both legs V_{AO} and V_{BO} as

$V_{CM}=(V_{AO} + V_{BO})/2$

To avoid leakage currents, the common-mode voltage must be kept constant during all commutation states

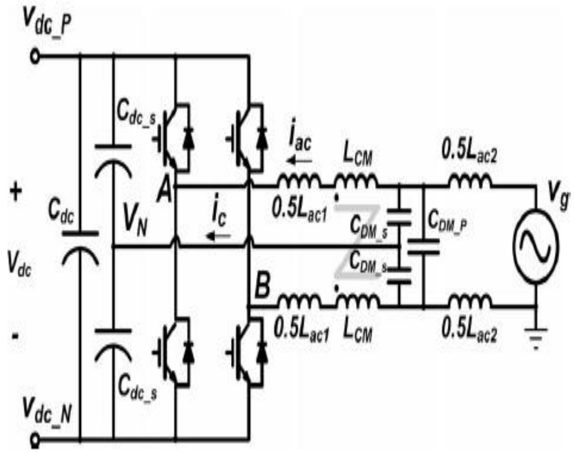

Fig.5 Proposed Modified Full Bridge Inverter

PROPOSED MODIFIED FULL-BRIDGE INVERTER

Fig no 5 shows the proposed modified full-bridge inverter with two split capacitors and the *LCL* harmonic filter for reduction of ground current and voltage.In this paper, a passive filter structure is proposed to utilize the ac passive *LCL* harmonic filter and one CM choke from the ac EMI filter to reduce the high-frequency dc-side leakage current. $C_{DM\_ P}$ and two split capacitors $C_{DM\_ S}$ are used as the first-stage DM capacitor C_{DM}. The CM choke L_{CM}, normally one part of the EMI filter, is connected betweenthe first-stage DM inductor (boost inductor) L_{ac1} and the split capacitors $C_{DM\_ S}$, as shown in Fig. 5. Then, the midpoint of the dc link and the midpoint of the split capacitor $C_{DM\_ S}$ are connected electrically to each other.

The proposed inverter structure does not introduce any extra components, but rather reconfigures the ac passive components without any damping resistor.Thus, there is a guaranteed reliable operation of inverter as compared to other solutions. It does not require control for extra switches, and little extra cost and small loss are introduced in the proposed solution.

SIMULATION RESULTS

The simulation is conducted for FB inverter with conventional LCL filter and with modified filter. The simulink model of proposed filter is shown in fig.(6).The system parameters are shown in Tables I and II. 5 µF stray capacitors without any damping resistor is assumed. As shown in Fig.(7) & (8) , the total ground current has been attenuated from 15.32 mA to 0.7 mA. Similarly the ground voltage is also reduced from 7.48 kV to 0.096 kV by using this modified Filter.

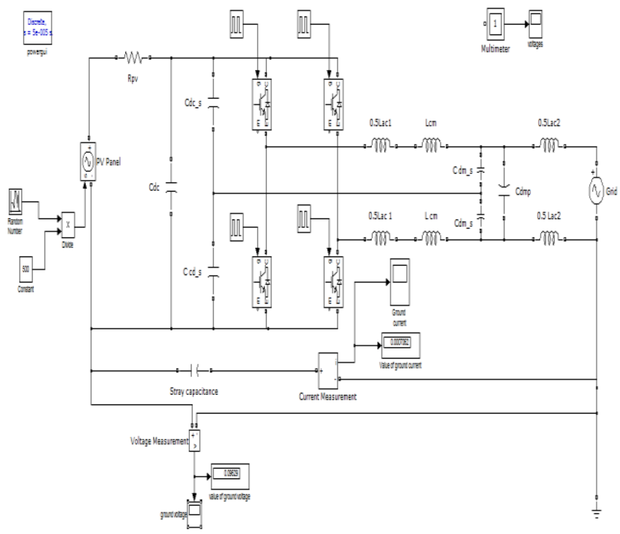

Fig. 6 simulation model for ground current and voltage

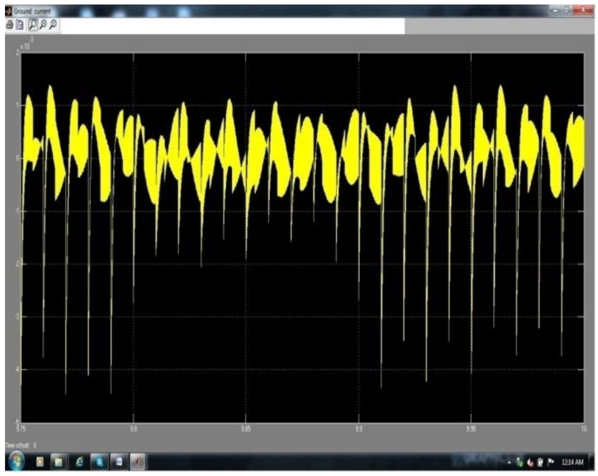

Fig. 7 Ground current with proposed filter

Fig. 8 Ground voltage with proposed filter

CONCLUSION

Without the isolation capabilities of the transformer, a resonant circuit arises due to the ground capacitance of the PV panels.if this circuit is excited the common mode voltage and ground current is produced. In this paper, the ground current and ground voltage of a grid connected single-phase transformerless FB inverter with proposed filter was evaluated and compared by using simulation. Waveforms of the measured ground voltage and leakage current are shown and compared with conventional LCL filter. After analyzing the results ,it is observed that proposed filter reduces the ground current as well as ground voltage more efficiently as compared to conventional LCL filter.

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