High Step-up Transformer-Free Inverter Systems with Passive Power Decoupling

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Abstract - *A new, high-step-up inverter connected to the grid is proposed in this article. The topology consists of two phases. First phase is a single high level switch DC to DC converter with bipolar outputs and second stage is a traditional grid-connected DC to AC half-bridge inverter. PV Module negative grounding has resulted in the removal of unnecessary earth leakage-currents in PV network. The suggested topology features easy structure, the use of few semiconductor switches, easy control and high performance. Discuss technical analysis and the circuit principal operation.*

Key Words*: *Inverter, Transformer free, coupling inductor, setup converter, PV system, Decoupling, High Step-up, DC to DC converter.

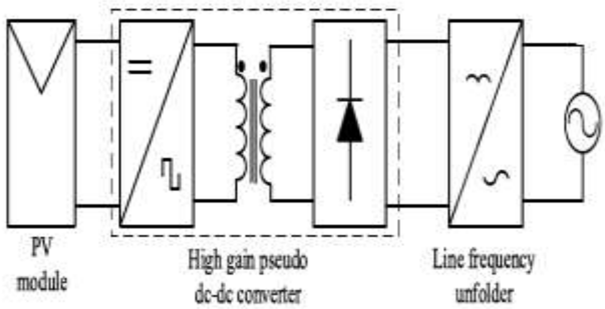
1. INTRODUCTION

Renewable Energy sources are the perfect fossil-fuel substitute. The preferred distinctiveness of the renewable power sources are cheap, clean and plentiful electricity. Photovoltaic devices take advantage of leading clean energy technologies and is learned and grown considerably in up to date [1-2]. AC module is the latest advancement in PV processing. AC module is a revolutionary pre-assembled module which consists of a micro inverter and single or two PV modules [3]. AC module structure maximizes energy output for each PV module by means of individual Maximum Power Point Tracking. In AC Module technology, performance problems in conventional PV systems caused by partial shade from trees, clouds or roof obstructions as well as module differences are solved. While higher costs are anticipated for AC-modules, suitable to the modularity there is potential for massive output and therefore a reduction in the overall device price.

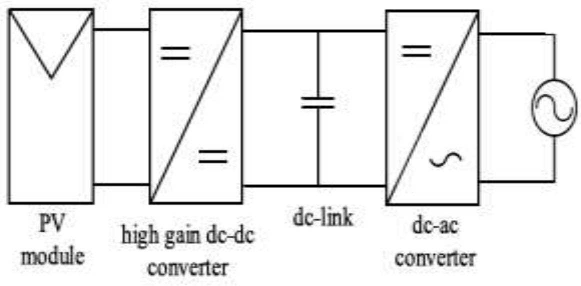
The AC module yields extra energy and lower deployment and design costs [4]. The key challenge of design in AC modules is to build a more robust, powerful and cost-effective gird associated inverter. The decline in the price of the PV module in recent years has ended the worth of the grid associated inverter more noticeable in the AC module [2]. Because of the rising popularity of AC modules and the design challenges listed above, significant work have been carried out to intend more powerful and dependable micro inverters. Most DC to DC and DC to AC converters are tested for AC modules [1-6].

Since the voltage produced by the PV system is reasonably low, a high boost conversion is needed to meet the full-bridge high-voltage bus requirements, Half-bridge, or inverters connected to grid. So designing high-step DC to AC converters is the key challenge within AC modules. Micro inverters have gradually captured the residential roof-top-PV market in recent years over a simple installation and preservation, removal of high voltage dc wiring, plug and play principle, and higher power output under partial shading as individual dedicated micro inverter module achieves the MPPT of each solar panel [7-8].

Single step micro inverter can be mounted in a single switch stage followed by an un folder (fig- 1 (a)) as established in [9] by one switch fly back, or in [10] by continuous current mode zeta converter, or in [11] by one stage step up inverter, or in [12] by forward converter with parallel primary and series secondary transformer. Another way to implementation is to have two-switching stages as shown in Fig. 1b [13]. Further, transformer free description is a preferred option as a resourceful micro inverter resolution [14] with the elimination of lossy transformer. The DC to DC step implemented by means of high frequency transformer in additional losses [15] mainly since the occurrence of the transformer leakage inductance which able to bring extra voltage strain owing to which switches through higher voltage rating needs to be used.



(a)



(b)

Fig -1: Micro inverter accomplishment with (a) one switching step followed By a supply frequency un folder, (b) double-switching step consisting of DC to DC and DC to AC step.

2. SYSTEM EXPLANATION AND WORKING

Fig-.2 shows the 3ϕ EDR boost step followed by a double grounded voltage swing inverter consider in favor of the non-isolated micro inverter purpose. Function of every step is discussed next. The converter provisions for a 300 W micro inverter are prearranged in Table-1. The DC and AC sides' interconnection obligation, realization of the PLL (phase locked loop), and grid organization in grid associated mode are extremely comparable to the new micro inverters.

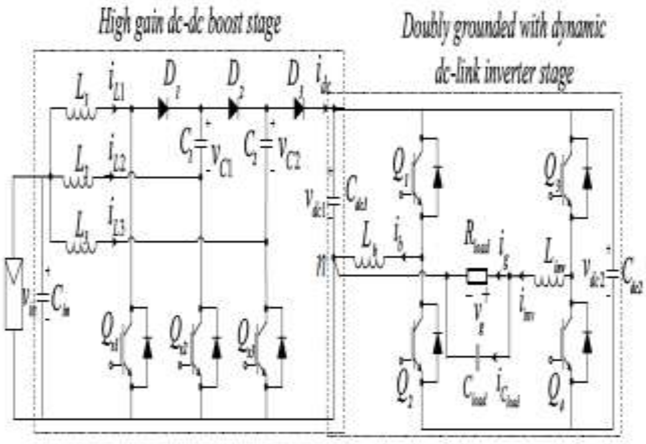


Fig -2: Projected transformer free micro inverter topologies with 3ϕ EDR boost as DC-DC step and double ground voltage swing inverter as DC-AC step.

2.1Double ground voltage swing inverter: DC to AC step

The output from the DC to AC step is the input as fit as the primary DC link Vdc1 of the DC to AC step implement through the double ground voltage swing inverter. The inverter be a cross mixture of a synchronous enhance and a HB. The previous step boost its input to a superior voltage V_{dc2} (a second DC link), as it is beneficial to execute the decoupling at a superior DC voltage starting the standpoint of capacitance quantity. Fig-.3 shows the dual duty ratio of DC to AC step w.r.t. V_{dc1} and V_g at unity pf operation. It is observed that apart from the main DC component, dbb also has 2ω component.

Table -1: Parameter and Rating

Parameter and Rating		
S.No	Parameter	Rating
1	PV input	20-40V
2	Output	120V,60Hz,300W
3	Power Factor	0.7Lag-0.7 lead
4	Switching Frequency	100/50 kHz

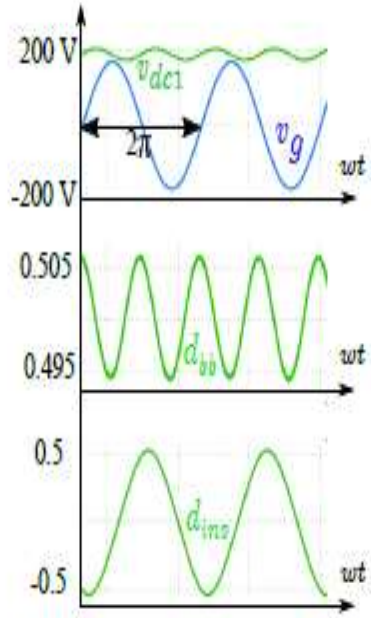


Fig-3: Duty ratio of the increase and the HB inverter in the DC to AC step over a grid cycle w.r.t to the first DC link and grid voltages.

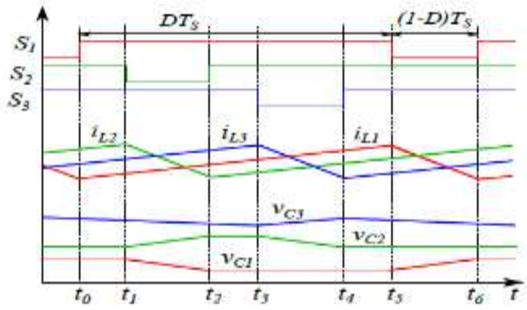
2.2 3ϕ EDR Boost: high gain DC to DC step

The PV panel is directly connected to the input of the DC to DC step, V_{in}. V_{in} have a representative voltage variety of 20-40 V to contain the incomplete shading condition. Also the output from the EDR boost is v_{dc1} which has a large 120 Hz swing, supposedly approximately 30 V (starting 180 V to 210 V) to partially deal with the control decoupling (the major decoupling come starting Vdc2 swing).

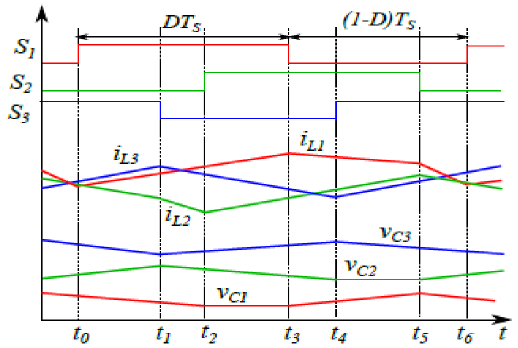
3. DESIGN OF CONVERTER AND SIMULATION OUTCOME

3.1Inductor design

The elevated gain of boost step inductor Li (for i = 1; 2; 3) is calculated for region I process base on the allowable higher frequency ripple current of 20% the supposed current of each interleaved stage.



(a)



(b)

Fig-4: Gate signals, interleaved inductor currents, and switched capacitor voltages for operation in (a) Zone I, (b) Zone II

3.2 Decoupling capacitance optimization

As pointed out earlier in, the capacitance value have refusal closed shape equation as together the DC links contain double supply frequency ripple part and maintain the power decoupling together. This is dissimilar from anywhere the decoupling is in use mind of by a solitary capacitor and its worth is a straight onward purpose of the converter's parameter which can be in a straight line computed.

3.3 Controller implementation

Fig-5: show the controller obstruct diagram designed for the projected micro inverter topology in standalone form. It has four control block every of which is implement with essential PI controller.

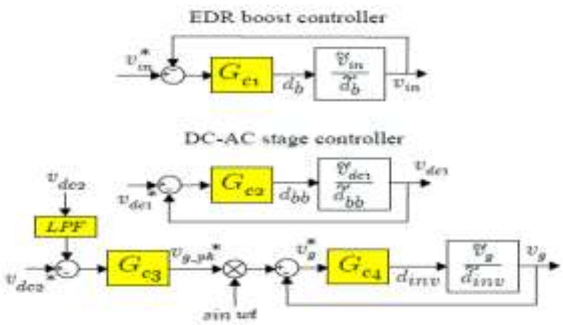


Fig -5: Controller blocks illustration in stand-alone process for the projected Transformer free micro inverter topology.

3.4 Simulation results

The simulation outcomes obtainable here match to the grid associated process with LCL filter. The input is obtain on or after a thorough PV representation based on a 300 W PV component beneath usual temperature and pressure with 1000 W/m2 solar irradiance. Fig-6 shows the input voltage and current waveform Fig-7 gives the waveforms for V_{dc1}, V_{dc2}-V_{dc1}, V_g, and I_g Further, Fig-8 give the equivalent waveforms for a dynamic transform in the solar irradiance beginning 1000 W/m² to730 W/m² at 0.2 second.

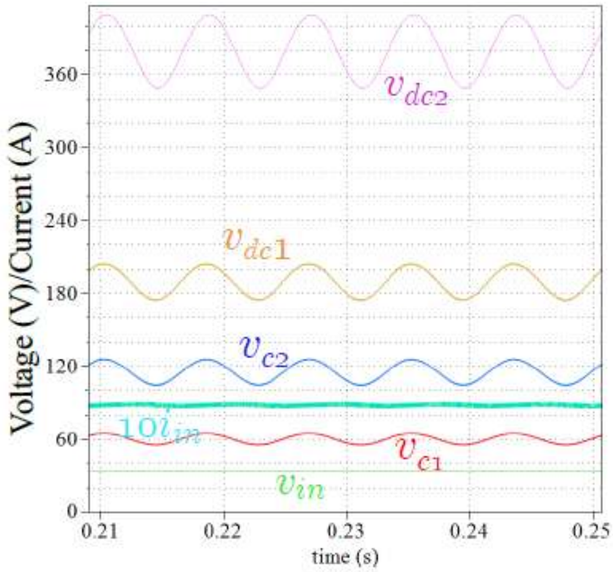


Fig-6: simulation for input voltage and current waveforms

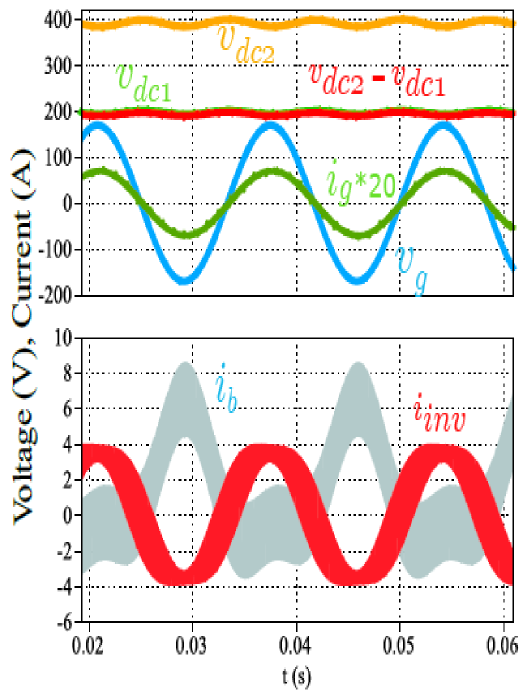


Fig-7: shows the waveforms for V_{dc1}, V_{dc2}-V_{dc1}, V_g, and I_g

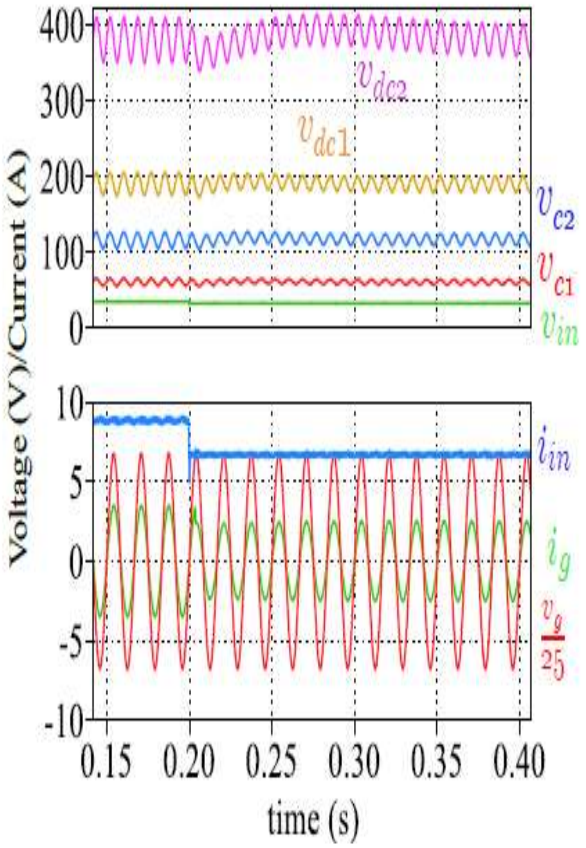


Fig-8: The equivalent waveforms for a dynamic transform in the solar irradiance beginning 1000 W/m^2 to730 W/m^2 at 0.2 second.

3. CONCLUSION

The heart of the manuscript is to discover a transformer free topology for PV micro inverter purpose which can attend to every three challenges that is the higher gain prerequisite, improvement of the higher frequency common mode leakage current, and decrease of the capacitance necessary to hold up twice line frequency power decoupling – all collectively from side to side a solitary power adaptation system. The micro inverter topology is implementing by means of high grow EDR increase as DC to DC step and double grounded voltage swing inverter as DC to AC step. With higher efficiency presentation the front end improves is competent of achieve high and changeable increase as necessary to edge PV module to grid.

REFERENCES

[1] Yaosuo Xue; Liuchen Chang; Sren Baekhj Kjaer; Bordonau, J.; Shimizu, T., "Topologies of single-phase inverters for small distributed power generators: an overview," IEEE Trans. Power Electron. , vol.19, no.5, pp.1305,1314, Sept. 2004.
[2] Soeren B. Kjaer, John K. Pedersen and Frede Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules", IEEE Trans. Ind. Electron. , vol. 41, No. 5, Sep. 2005.
[3] David Meneses, Frede Blaabjerg, , O´ scar Garc´ıa, and Jos´e A. Cobos, "Review and comparison of step-Up transformer less topologies for photovoltaic AC-module application. " IEEE Trans. Power Electron. , vol. 28, no. 6, pp. 2649-2663, June 2013.
[4] Quan Li and Peter Wolfs, "A review of the single phase photovoltaic module integrated converter topologies with three different DC link configurations", IEEE Trans. Power Electron. , vol. 23, NO. 3, May 2008.
[5] Wuhua Li, and Xiangning He, "Review of non isolated high-step-up DC/DC converters in photovoltaic grid-connected applications", IEEE Trans. Ind. Electron. , VOL. 58, NO. 4, April 2011.
[6] Blaabjerg, F., "Optimal design of modern transformer less PV inverter topologies," IEEE Trans. Energy Conversion, vol.28, no.2, pp.394,404, June 2013.
[7] S. H. Lee, W. J. Cha, J. M. Kwon, and B. H. Kwon, "Control strategy of flyback micro inverter with hybrid mode for pv ac modules," IEEE Transactions on Industrial Electronics, vol. 63, no. 2, pp. 995–1002, Feb 2016.
[8] S. H. Lee, W. J. Cha, B. H. Kwon, and M. Kim, "Discrete-time repetitive control of flyback ccm inverter for pv power applications," IEEE Transactions on Industrial Electronics, vol. 63, no. 2, pp. 976– 984, Feb 2016.
[9] N. Sukesh, M. Pahlevaninezhad, and P. K. Jain, "Analysis and implementation of a single-stage flyback PV microinverter with soft switching," IEEE Transactions on Industrial Electronics, vol. 61, no. 4, pp. 1819– 1833, April 2014.
[10] R. K. Surapaneni and A. K. Rathore, "A single-stage CCM zeta microinverter for solar photovoltaic AC module," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 4, pp. 892–900, Dec 2015.
[11] A. Abramovitz, B. Zhao, and K. M. Smedley, "High-gain single-stage boosting inverter for photovoltaic applications," IEEE Transactions on Power Electronics, vol. 31, no. 5, pp. 3550–3558, May 2016.
[12] D. Meneses, O. Garca, P. Alou, J. A. Oliver, and J. A. Cobos, "Grid connected forward microinverter with primary-parallel secondary-series transformer," IEEE Transactions on Power Electronics, vol. 30, no. 9, pp. 4819–4830, Sept 2015.
[13] R. K. Surapaneni and P. Das, "A z-source derived coupled inductor based high voltage gain microinverter," IEEE Transactions on Industrial Electronics, vol. PP, no. 99, pp. 1–1, 2017.
[14] V. Gautam and P. Sensarma, "Design of Cuk derived transformer less common grounded PV micro-inverter in CCM," IEEE Transactions on Industrial Electronics, vol. PP, no. 99, pp. 1–1, 2017.
[15] S. Kouro, J. I. Leon, D. Vinnikov, and L. G. Franquelo, "Grid-connected photovoltaic systems: An overview of recent research and emerging PV converter technology," IEEE Industrial Electronics Magazine, vol. 9, no. 1, pp. 47–61, March 2015.

[16] H. Zhang, X. Li, B. Ge, and R. S. Balog, "Capacitance, dc voltage utilization, and current stress: Comparison of double-line frequency ripple power decoupling for single-phase systems," IEEE Industrial Electronics Magazine, vol. 11, no. 3, pp. 37–49, Sept 2017.
[17] Y. P. Siwakoti and F. Blaabjerg, "Common-ground-type transformer less inverters for single-phase solar photovoltaic systems," IEEE Transactions on Industrial Electronics, vol. PP, no. 99, pp. 1–1, 2017.
[18] W. Li and X. He, "Review of non isolated high-step-up DC/DC converters in photovoltaic grid-connected applications," IEEE Transactions on Industrial Electronics, vol. 58, no. 4, pp. 1239–1250, April 2011.