Design of DC to Single-Phase AC Voltage Source Converter with Active Power Decoupling Based on Flying Capacitor DC/DC Converter

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Abstract: Nowadays, a power decoupling method used for a dc to single-phase ac converter that uses a flying capacitor dc/dc converter (fcc) & also the voltage source inverter. In practice a small flying capacitor is used for both a boost operation and a double-line-frequency power ripple reduction a sizeable electrolytic capacitor is replaced by dc-link capacitor components design of, e.g., the boost inductor & the flying capacitor are for controlling experiments are being done using a 1.5 kW prototype to come to know about validity of the proposed control from above tests shown that 74.5 dc link voltage ripple is reduced & also total harmonic distortion at load of 1.1kw max system efficient 95.4% is resulted from Pareto format optimization the high power density the power densities of 3 power decoupling topologies boost topology, a buck topology and the proposed topology are compared the proposed topology achieve the (5.3kw/dm) power density.

***Index Terms*—**Active power decoupling, flying capacitor dc/dc converter (FCC), photovoltaic (PV) system, power density design.

I. Introduction

The research on photovoltaic (PV) is increased as a sustainable power solution photovoltaic serving 228GW in2015 to connect the photovoltaic (PV) source to single phase ac grid power converter systems (pass) are used these PCSs should have high efficiency, maintenance free, small size. To achieve above parameters 2-stage conversion using a dc/dc converter & a voltage source (VSI) is generally applied for high efficiency & high power density flying –capacitor dc/dc converter used in 2-stage power conversion by using a low on-resistance switching power device owing to the use of low voltage rating those advantage are obtained by this technique harmonics of inductor voltage can decreased for that reason inductor volume can also decreased the switched capacitor converter (SCC) is a commonly used configuration in FCC converter topology without large inductor the boost-up operation can be achieved by SCC. A small inductor is used on dc side to avoid inrush current due to the flying capacitor a small inductor flying capacitor is used on dc side also serve for a high boost ratio.

Due to the single-phase ac grid double line frequency power ripple occurs in the dc side due to this ripples in a performance maximum power point tracking (MPPT) would decrease. To decrease power ripple a bulky electrolytic capacitor is used, i.e., a passive power decoupling method. According to the Arrhenius law electrolytic capacitor limits the life-time of the power converter.

Active power decoupling methods used to solve this problem small passive energy buffer & switching devices used in active power decoupling power ripples are compensated by active power decoupling rather than an electrolytic capacitor, it uses film capacitor or ceramic capacitor.

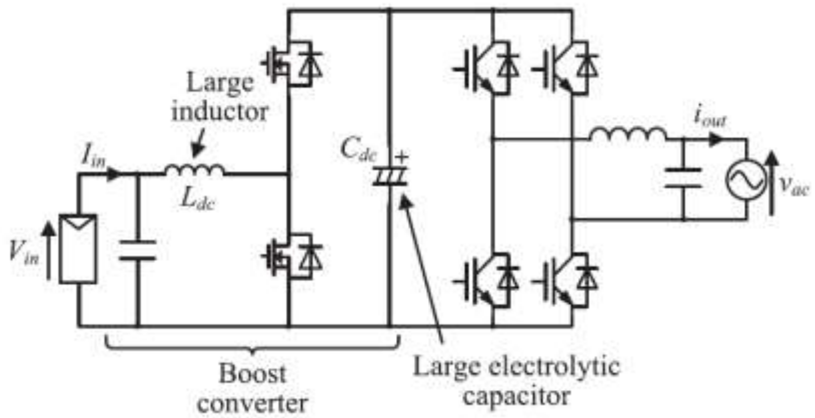

Fig. 1. DC to single-phase ac grid-connected converter with typical boost converter.

The active power decoupling technique classified into two types that whether connected in parallel or series of power decoupling technique & additional power decoupling circuit is connected to the dc link or ac side. Power decoupling capacitance can be reduced by using power decoupling technique the active power decoupling method by using series or parallel connection due to the loss from the auxiliary components the efficiency of converter reduced. A key technology in dynamic power decoupling capability is that no ancillary components are used in improving efficiency & high power density.

This paper deals with active power decoupling method based on the FCC, not any that this paper also deals with typical dc/dc converter made without any auxiliary components that has advantage about small size cost & losses. This paper mainly focused on a multilevel dc/dc converter that has capacitive storage high boost ratio can be achieved by the FCC which has a small flying capacitor that capacitor also contribute boost operation and double-line frequency. Power ripple compensation for that reason capacitor of dc link value can be decreased this converter can be used for multi-level converter also by comparing to the typical boost converter the conduction losses, and the inductor size are minimized however the active power decoupling control reduces the PV input current control performance because the voltage fluctuation of the flying capacitor disturbs the input current control that disturbances are reduced by the proposed input current control.

This paper is prepared as follows in section ii it explains the configuration of the proposed converter. In part III, it gives describes of active power decoupling in section IV it explains the component design of the proposed converter & operation is then demonstrated experimentally. In this section converter loss analysis is done & high-efficiency design is discussed. In section V, the condition for the high power density is an evaluation with the panto front optimization when the switching frequency is changed.

II. CIRCUIT CONFIGURATION

A two-stage DC to single – phase ac grid connected converted with a typical boost converter. Fig 1 shows a typical boost converter of dc to 1-o ac grid-connected converter. The boost converter increases the PV input voltage above the peak value of the grid voltage by the VSI the generated power is fed to the 1-0 grid. Because of double-line-frequency power ripple of the 1-0 network a bulky electrolytic capacitor Cdc for the boost operation of the PV input voltage Vin a large dc inductor Ldc is used. The life-time is limited by the electrolytic capacitor.

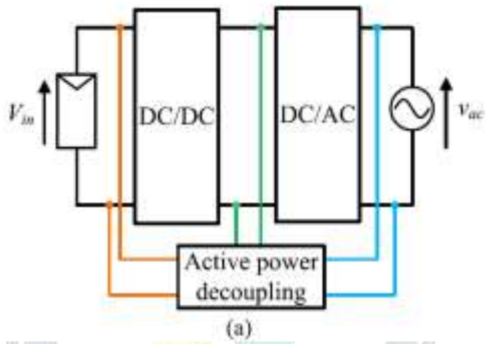

Fig.2: Block diagram of proposed system

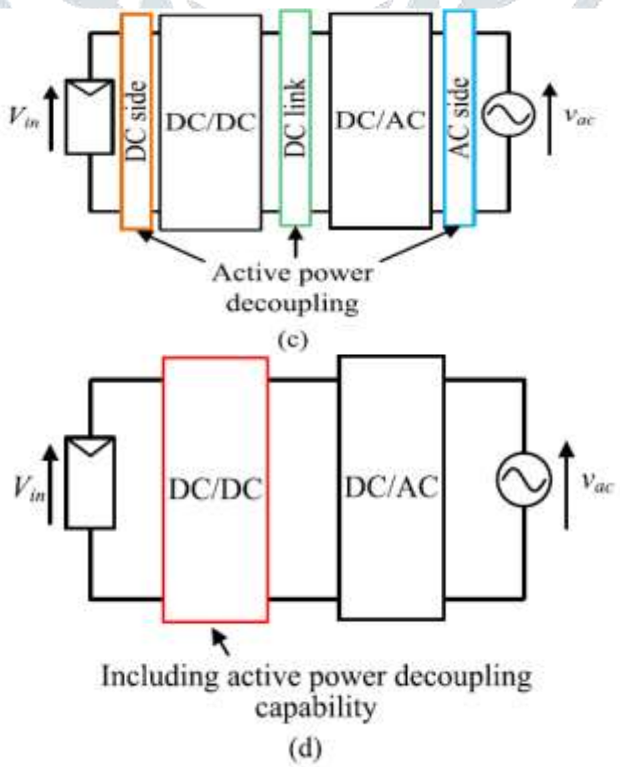

Fig. 2. Active power decoupling approaches. (a) Parallel-connected topology. (b) Conventional power decoupling circuit in parallel connection. (c) Series-connected topology. (d) Proposed approach.

Single-phase DC–AC power electronic converters suffer from pulsating power at double the line frequency. The commonest practice to handle the issue is to provide a huge electrolytic capacitor for smoothening out the ripple. However, the electrolytic capacitors having short end of lifetime limit the overall lifetime of the converter. Another way of handling the ripple power is by active power decoupling (APD) using the storage devices and a set of semiconductor switches. Here, a novel topology has been proposed in implementing APD. The topology claims the benefit of (1) reduced stress on converter switches and (2) using smaller capacitance value, thus alleviating the use of electrolytic capacitor and in turn improving the lifetime of the converter. The circuit consists of a third leg, a storage capacitor and a storage inductor.

It presents the benchmark study of ac and dc active power decoupling circuits for second order harmonic mitigation in kW scale single-phase inverters. First of all, a brief comparison of recently reported active power decoupling circuits is given, and the best solution that can achieve high efficiency and high power density is identified and comprehensively studied, and the commercially available film capacitors, the circuit topologies, and the control strategies adopted for active power decoupling are all taken into account. Then, an adaptive decoupling voltage control method is proposed to further improve the performance of dc decoupling in terms of efficiency and reliability.

III. PROPOSED PV-STORAGE SYSTEM ARCHITECTURE

3.1 DESIGN OF PROPOSED SYSTEM

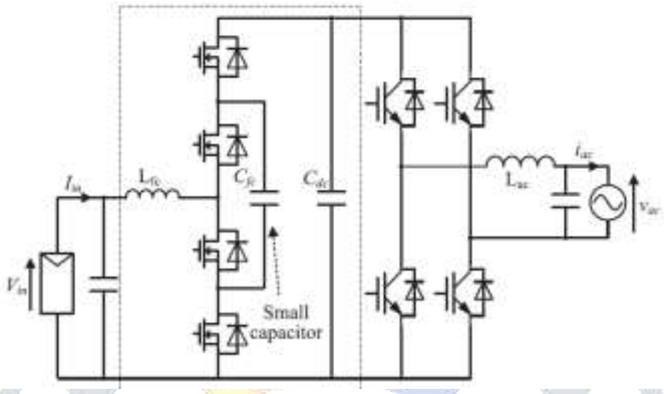

Fig. 3. DC to single-phase ac grid-connected converter with FCC.

The proposed active power decoupling approach does not require additional component. Fig 3 shows active power decoupling of dc to 1-0 or grid connected converted with the FCC for the boost operation of the PV input voltage Vin & the power decoupling capability a small flying capacitor CFC is used in proposed method the FCC has many advantages over the typical boost converter.

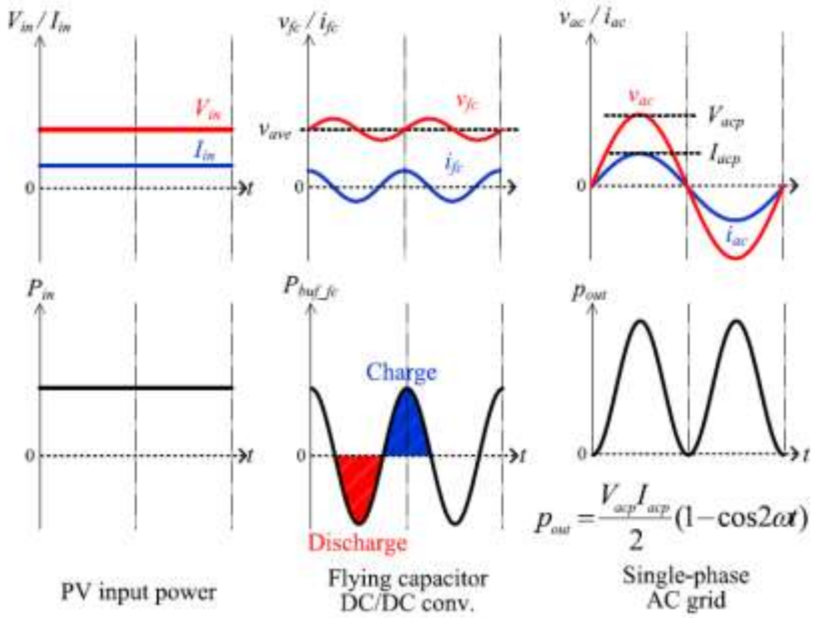

Fig. 4. Principle of the active power decoupling. Buffer power *P*buf fc is charge and discharge by the flying capacitor *C*fc. The *P*buf fc is given by the mismatch in instantaneous power between input power *P*in and output power *P*out .

First low on-resistance present in the low voltage rating device is used because the drain-source voltage of each MOSFET can be decreased due to the improve in the number of levels that is the characteristic of the multilevel topology. For that reason conduction losses are reduced the boost inductor Lfc size is small as compared to that of the typical boost more covert since the inductor voltage is clamped to the flying capacitor voltage and the conflict value between the dc link voltage & the floating capacitor voltage the boost operation is accomplished by only the boost inductor in the typical boost converter but in the FCC converters the boost inductor & the flying capacitor is used for boost operation as compared to standard boost converter the FCC converter the inductor current ripple becomes low therefore compared to typical boost converter FCC has small inductance.
The flying capacitor voltage is maintained content in the conventional control for the FCC at the half of the dc link voltage. In this proposed paper the floating capacitor voltage is fluctuated to realize active power decoupling the DC-link capacitance can be minimized & the big size electrolytic capacitor is not required when dynamic power decoupling is achieved by the FCC. The proposed converter has no additional components & has a simple configuration.
In active power decoupling methods, the decrease in the converter efficiency is an important technical issue. As compared to conventional active power decoupling topologies the active power decoupling has the potential to achieve low-efficiency degradation or other hand in the paper grid connection uses 2-level VSI. A multilevel inverter topology can also be used to reduce the use of the grid-connected inductor & for high efficiency here in this paper FCC is mainly **focused.**

IV. RESULTS AND DISCUSSION

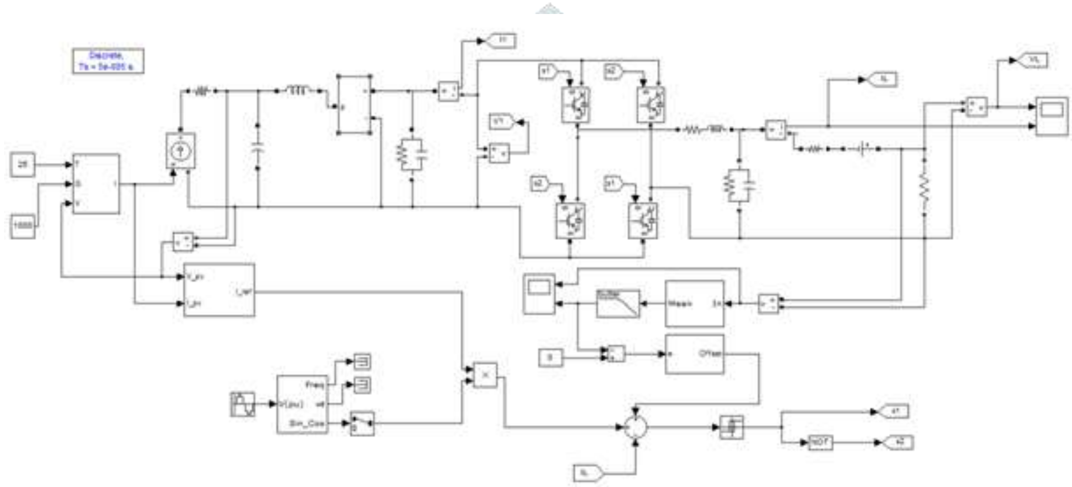

Fig.5 proposed circuit simulation diagram

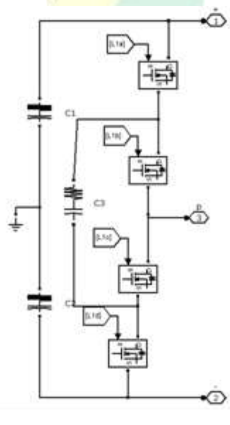

Fig.6 flying capacitor converter

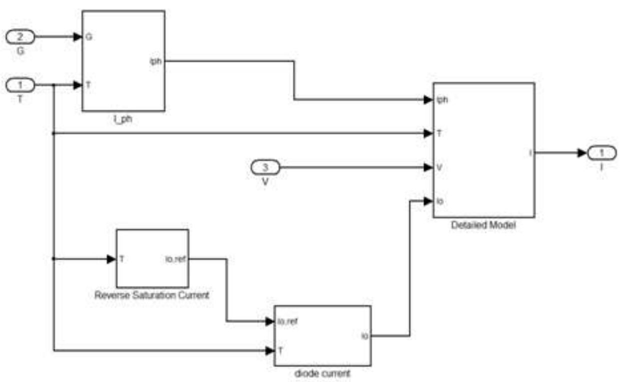

Fig.7 solar PV equivalent

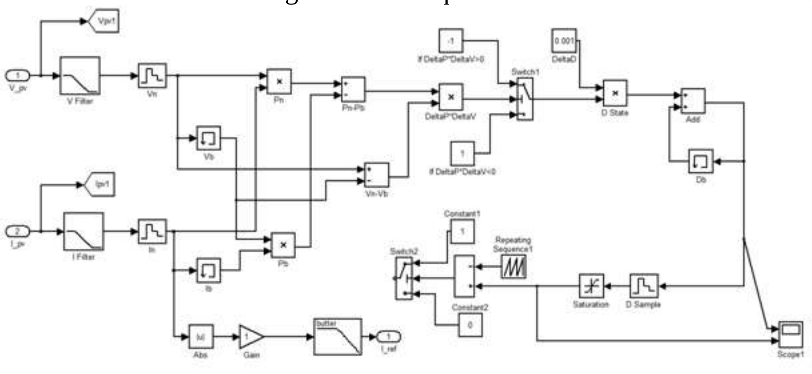

Fig: 8. Solar PV MPPT control

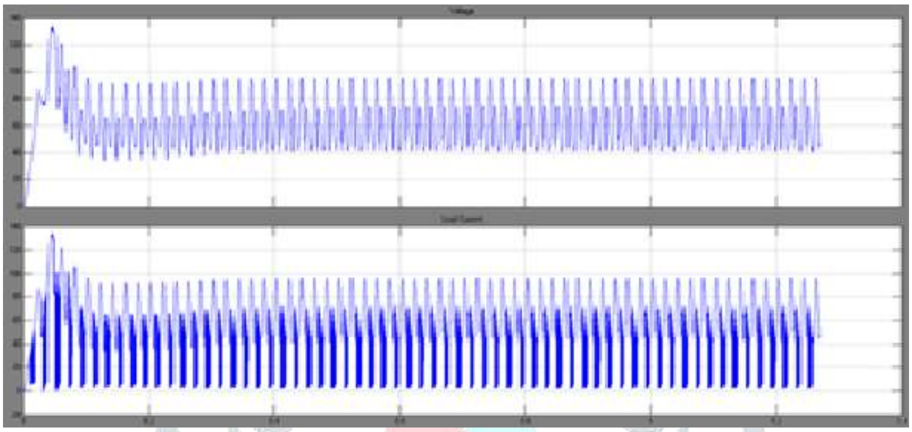

Fig: 9. Solar PV Vpv and Ipv

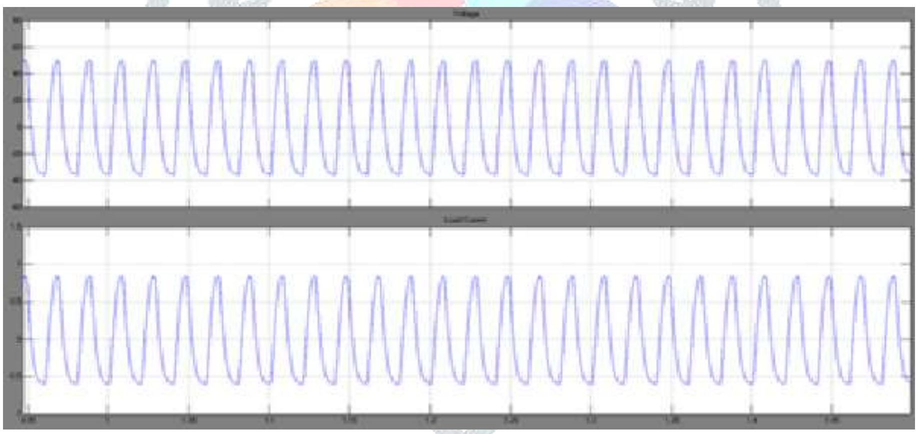

Fig.10 output voltage and current

V. CONCLUSION

In this paper, an active power decoupling method With an FCC was proposed. The proposed converter does not require additional components for the dynamic power decoupling, and the boost inductor value could be reduced, as compared To the typical boost converter. Also, the active power decoupling control that uses a small flying capacitor was proposed along with the clarification of the component design. A high power density, a high-efficiency design was demonstrated By the Pareto optimization. In this paper, three topologies, a boost-type active power decoupling topology, a buck-type active power decoupling topology, and the proposed active power decoupling was compared in term of the power density. As a result, the proposed converter was shown to achieve the highest power density of 5.3 kW/dm3. Finally, the experimental results confirmed that the dc-link voltage fluctuation was reduced by 74.5% by the proposed Active power decoupling method. Moreover, in the boot up inductor design, the inductor current ripple approximately agreed with the design value with an error of 4.7%. Thus, the experimental results confirmed the validity of the inductor design. The maximum efficiency achieved in the experiment was 95.4%. To improve the efficiency, the converter loss was evaluated. As a result, it was confirmed that the switching loss should be reduced. Moreover, the inverter output current THD was less than 5%, and the output power factor was approximately unity at the rated output power. Based on these results, the fundamental operation was confirmed.

VI. REFERENCES

[1] International Energy Agency (IEA):, "Trends 2016 in photovoltaic applications," Report IEA PVPS, T1-30, 2016.

[2] F. Zhang, L. Du, F. Z. Peng, and Z. Qian, "A new design method for high-power high-efficiency switched-capacitor DC-DC converters," *IEEE Trans. Power Electron*, vol. 23, no. 2, pp. 823–840, Mar. 2008.

[3] M. Shen, F. Z. Peng, and L. M. Tolbert, "Multilevel DC-DC power conversion system with multiple DC sources," *IEEE Trans. Power Electron*, vol. 23, no. 1, pp. 420–426, Jan. 2008.

[4] W.-Q. H. Cha, F. Z. Peng, and L. M. Tolbert, "55-kW variable 3X DCDC converter for plug-in hybrid electric vehicles," *IEEE Trans Power Electron.*, vol. 27, no. 4, pp. 1668–1678, Apr. 2012.

[5] X. Lyu, N. Ren,Y. Li, and D. Cao, "A SiC-based high power density singlephase inverter with in-series and in-parallel power decoupling method," *IEEE J. Emerg. Sel. Topics Power Electron.*, vol. 4, no. 3, pp. 893–901, Sep. 2016

[6] Y. Xue, L. Chang, S. B. Kjaer, J. Bordonau, and T. Shimizu, "Topologies of single-phase inverters for small distributed power generators: An overview," *IEEE Trans. Power Electron.*, vol. 19, no. 5, pp. 1305–1314, Sep. 2004

[7] H. Hu *et al.*, "A three-port flyback for PV microinverter applications with power pulsation decoupling capability," *IEEE Trans. Power Electron.*, vol. 27, no. 9, pp. 3953–3964, Feb. 2012.

[8] H. Hu, S. Harb, N. Kutkut, I. Batarseh, and Z. J. Shen, "Power decoupling techniques for micro-inverters in PV systems—A review," in *Proc. IEEE Energy Convers. Congr. Expo.*, Nov. 2010, pp. 3235–3240.

[9] T. Shimizu,K.Wada, andN.Nakamura, "Flyback-type single-phase utility interactive inverter with power pulsation decoupling on the DC input for anAC photovoltaic module system," *IEEE Trans. Power Electron.*, vol. 21, no. 5, pp. 1264–1272, Sep. 2006.

[10] F. Shinjo, K. Wada, and T. Shimizu, "A single-phase grid-connected inverter with a power decoupling function," in *Proc. IEEE Power Electron. Spec. Conf.*, Jun. 2007, pp. 1245–1249.

[11] F. Schimpf and L. Norum, "Effective use of film capacitors in single-phase PV-inverters by active power decoupling," in *Proc. 36th Annu. Conf. IEEE Ind. Electron. Soc.*, Nov. 2010, pp. 2784–2789.

[12] K. H. Chao and P. T. Cheng, "Power decoupling methods for single-phase three-poles AC/DC converters," in *Proc. IEEE Energy Convers. Congr. Expo.*, Sep. 2009, pp. 3742–3747.

[13] R.Wang, F.Wang, R. Lai, P. Ning, R. Burgos, and D. Boroyevich, "Study of energy storage capacitor reduction for single phase PWM rectifier," in *Proc. 2009 24th Annu. IEEE Appl. Power Electron. Conf. Expo.*, Feb. 2009, pp. 1177–1183.

[14] C.-T. Lee, Y.-M. Chen, L.-C. Chen, and P.-T. Cheng, "Efficiency improvement of a DC/AC converter with the power decoupling capability," in *Proc. 2012 24th Annu. IEEE Appl. Power Electron. Conf. Expo.*, Feb. 2012, pp. 1462–1468.

[15] Y. Ohnuma, K. Orikawa, and J.-I. Itoh, "A single-phase current-source PV inverter with power decoupling capability using an active buffer," *IEEE Trans. Ind. Appl.*, vol. 51, no. 1, pp. 531–538, Feb. 2015.

[16] Y. Tang and F. Blaabjerg, "Power decoupling techniques for single-phase power electronics systems—An overview," in *Proc. IEEE Energy Convers. Congr. Expo.*, Sep. 2015, pp. 2541–2548.

[17] Y. Tang, F. Blaabjerg, P. C. Loh, C. Jin, and P. Wang, "Decoupling of fluctuating power in single-phase systems through a symmetrical halfbridge circuit," *IEEE Trans. Power Electron.*, vol. 30, no. 4, pp. 1855– 1865, Apr. 2015.

[18] H. Hu, S. Harb, N. Kutkut, I. Batarseh, and Z. John Shen, " review of power decoupling techniques for micro-inverters with three different decoupling capacitor locations in PV systems," *IEEE Trans. Power Electron.*, vol. 28, no. 6, pp. 2711–2726, Jun. 2013.

[19] S. B. Kjaer, J.K. Pedersen, and F.Bllabjerg "Areviewof single-phase gridconnected inverters for photovoltaic modules," *IEEE Trans. Ind. Appl.*, vol. 41, no. 5, pp. 1292–1306, Sep./Oct. 2005.

[20] Y. Xia, J. Roy, and R. Ayyanar "A high perfermance T-type single phase double granded transformer-less photovoltaic inverter with active power decoupling," in *Proc. IEEE Energy Convers. Congr. Expo.*, Sep. 2016, pp. 1–7.

[21] B. Singh, B. N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, and D P. Kothari, "A review of single-phase improved power quality ACDC converters," *IEEE Trans. Ind. Electron.*, vol. 50, no. 5, pp. 962–981, Oct. 2003.