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RESEARCH ARTICLE

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ACTIVE POWER DECOUPLING IN SINGLE PHASE SYSTEM USING SYMMETRICAL HALF BRIDGE CIRCUIT

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ABSTRACT

The harmonic disturbance occurs in single-phase AC/DC or DC/AC systems due to the existence of double line frequency ripple power. This problem is overcome by the use of bulky electrolytic capacitors. Additional components such as inductors and capacitors are used to store the ripple power, which leads to an increase in the overall cost. In this project, a symmetrical half bridge circuit is used where the ripple power is absorbed by the DC link capacitor. A pair of switches and a small filtering capacitor is used in addition by which , nearly 10 times the capacitance reduction can be achieved. The input current and output voltage of the converter can be regulated by very small DC-link capacitor, thereby reducing the total cost. The normal performance of the system gets highly increased through this method of diverting the ripple power from the circuit.

Key Words—Active power decoupling, capacitance reduction, harmonic compensation, single-phase systems

INTRODUCTION

SINGLE-PHASE ac/dc or dc/ac power electronics systems have extremely wide applications in residential and industrial power supplies or conversion systems. Example applications are front-end power factor correction (PFC) converters in consumer power supplies [1]–[3], on-board chargers for plug in hybrid electric vehicles [4]–[6], and 5-kW (or less) grid connected photovoltaic (PV) inverters for distributed power generation [7]–[9].A well-known problem with such systems is that their ac-side instantaneous power contains a fluctuating component that changes at twice the fundamental frequency [10]. This fluctuating power is adverse to the system performance because it may potentially cause distorted input current of PFCs, overheating of batteries [11], and decreased maximum power point tracking (MPPT) efficiency of PV systems [12]. A very straight forward way to mitigate its negative impact is to use bulky electrolytic capacitors in the dc link so that they can act as buffers to the ac-side ripple power. However, those electrolytic capacitors are known to have high equivalent series resistance (ESR) and low ripple current capability, and their lifetime is also relatively short (several thousand hours) when stressed with the nominal voltage and the ripple current. Therefore, they may cause troubles in some applications where 20- or 25-year warranty period is required, e.g., LED drivers and solar inverters [12].

Recently, some active power decoupling methods have been proposed to cope with this problem, and the fundamental principle behind them is to introduce an extra active circuit in the system, so that the ripple power can be shifted away from the dc link and stored by other components with expanded lifetime, e.g., inductors and film capacitors, in a more efficient and effective way. Fig. 1(a) shows an active method which uses an inductor for ripple energy storage [13], and the inductor current is controlled to be sinusoidal which is accomplished through the proper modulation of the added third switching leg. A similar concept is presented in [14], where the lower switch of the third leg is replaced with a diode in order to save one active component, and in this case, the inductor current can be controlled as rectified sinusoidal in order to cancel those ac-side ripple power. Even though inductors are reliable and robust, they are generally of low power density and high power losses when used as energy storage elements for fundamental components, and therefore, the performance improvement could be very limited. In [12], the inductor is replaced by a film capacitor and the ripple power can then be compensated by controlling the voltage of the film capacitor to be rectified sinusoidal as shown in Fig. 1(b). However, such waveforms may contain high-order harmonics which will be difficult to track and control for a highly under damped second-order system. Using exactly the same circuit configuration, Wang *et al.* [15] propose to inject a dc offset in the capacitor reference voltage so that the harmonic content may become small and it may facilitate the closed-loop controller design. Nevertheless, since the capacitor voltage does not go down to zero, it will not be fully discharged, which means that the film capacitor is not fully utilized.

Circuit Diagram : Recently, some active power decoupling methods have been proposed to cope with this problem, and the fundamental principle behind them is to introduce an extra active circuit in the system, so that the ripple power can be shifted away from the dc link and stored by other components with expanded lifetime, e.g., inductors and film capacitors, in a more efficient and effective way.

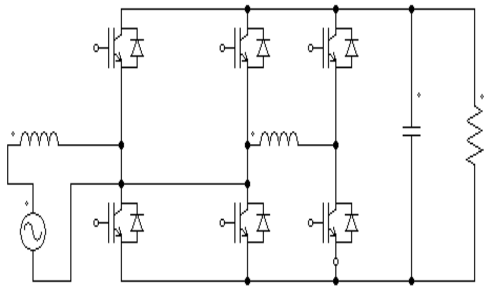

Fig 1 : Existing method (1)

Fig. 1 shows an active method which uses an inductor for ripple energy storage, and the inductor current is controlled to be sinusoidal which is accomplished through the proper modulation of the added third switching leg. A similar concept is presented in other area, where the lower switch of the third leg is replaced with a diode in order to save one active component, and in this case, the inductor current can be controlled as rectified sinusoidal in order to cancel those ac-side ripple power. Even though inductors are reliable and robust, they are generally of low power density and high power losses when used as energy storage elements for fundamental components, and therefore, the performance improvement could be very limited.

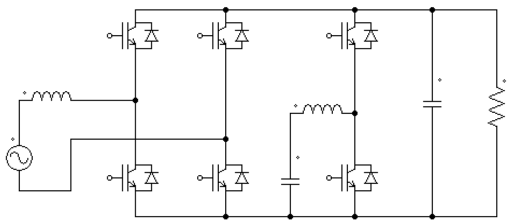

Fig 2 : Existing method (2)

Here the inductor is replaced by a film capacitor and the ripple power can then be compensated by controlling the voltage of the film capacitor to be rectified sinusoidal as shown in Fig. 2(2) However, such waveforms may contain high-order harmonics which will be difficult to track and control for a highly under damped second-order system. Using exactly the same circuit configuration, propose to inject a dc offset in the capacitor reference voltage so that the harmonic content may become small and it may facilitate the closed-loop controller design. Nevertheless, since the capacitor voltage does not go down to zero, it will not be fully discharged, which means that the film capacitor is not fully utilized.

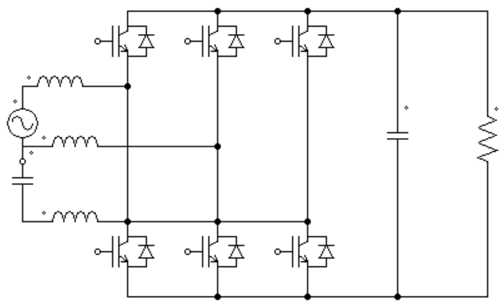

Fig 3 : Existing method (3)

The introduced half-bridge, together with one leg of the full-bridge rectifier, essentially forms another full-bridge circuit, and in this case, the voltage of the film capacitor can be controlled to be sinusoidal and it resolves all the difficulties mentioned previously. Even though being effective in ripple power compensation, this topology is not applicable in some circumstances, e.g., PFCs and unfolding bridge-based inverters, because the power flow is unidirectional. It may also become problematic in H5 inverters, where the full-bridge circuit will be intermittently isolated from the dc link in order to eliminate the leakage current.

Instead of using paralleled circuit configurations discussed previously propose a series compensation approach where a controlled voltage source is inserted in between the dc-link capacitor and the load and through this way, low-voltage semiconductors can be used to construct the active power decoupling circuit and to gain an improved system performance. However, the circuit is complicated with four MOSFETs and associated gate drivers, and the dc-link capacitance cannot be too small because it may potentially over modulate the frontend ac/dc rectifier. Even though the dc-link capacitance can be reduced regardless of the configurations of compensation circuits, a common problem for the existing active power decoupling methods is that, the system ripple power has to be absorbed by additional energy storage elements, either inductors or film capacitors, and this implies that the capacitance reduction is not optimized

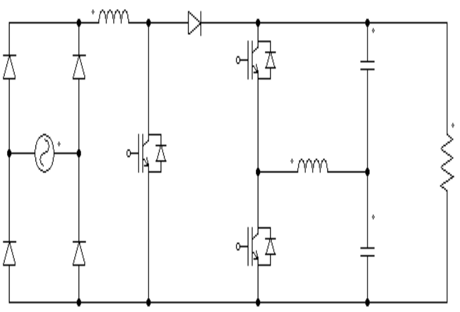

Fig 4: Proposed method

In order to achieve a simple and compact design, and also to break the limitation imposed by the front-end topology, this paper proposes a new topology to realize active power decoupling, and its circuit diagram is shown in Fig. 4. As can be seen, two identical film capacitors are employed and connected in series in the dc link, whose midpoint is then connected to another phase leg through a small filtering inductor. In this way, the dc-link capacitors may not only provide a high-voltage dc bus to support ac/dc or dc/ac conversion, but can also absorb the system ripple power. The added symmetrical half-bridge circuit is also easy to control, because the voltages of the two film capacitors will both be sinusoidal. Moreover, the capacitors can be alternatively discharged to zero in case that high ripple power compensation is required, and the power decoupling can be accomplished without using additional energy storage inductors or capacitors. The power flow involved in this circuit and the relevant controller design are detailed in this paper. Both simulation and experimental results are presented to prove the effectiveness of this concept.

Operating principle : The proposed symmetrical half-bridge circuit is shown in Fig. 2, which is applied to a single-phase PFC converter as an example here. It should be noted that and also as mentioned previously, the proposed active power decoupling method will not be constrained by its front-end topologies, and it can be basically used in any single-phase ac/dc or dc/ac systems, as long as there is a high-voltage dc bus available

In certain applications, e.g., PFC converters for computer power supplies, there is another requirement for the output capacitors, which is to maintain the output voltage for a short period even if its ac-side input voltage is lost where the common specification for this holdup time *t*holdup is 20 ms. If the minimum dc-link voltage *v*dc min is defined to be 250 V and the power losses of the PFC converter are neglected, the required capacitance is found to be 488.4 μF/kW, which is sufficient to provide ripple power compensation even only 0.5 modulation index is applied to the converter

Simulation Performance : The smooth dc-link voltage, the input line current can be well regulated by the PFC controller, and it is sinusoidal and in phase with the grid voltage. The two film capacitors can provide the required double-line frequency harmonic power, and the resultant output power can be almost constant. The dc-link voltage has very slight voltage variation, which is around 10 V, and this is caused by the inaccurate calculation of the voltage reference and the errors in the closed-loop control. some closed-loop modifications can be applied to fine tune the voltage reference and to achieve more precise power decoupling. However, this may further complicate the control system, and thus not implemented here. The voltage of the upper capacitor is noted to have approximately $\pi/4$ phase shift with the grid voltage, which matches well with the theoretical analysis.

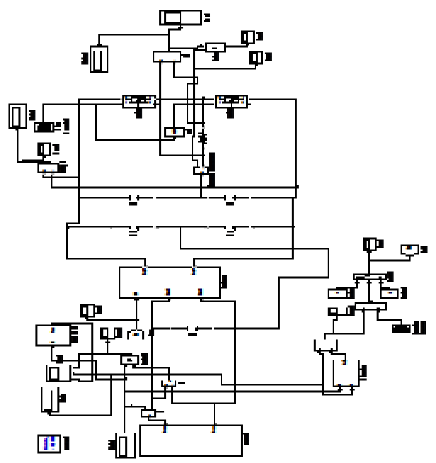

Fig 3: Simulation Diagram

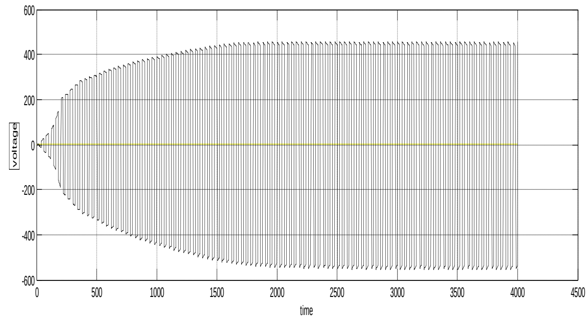

Fig 4 : Simulation Output

Discussion : Truth be told, the proposed symmetrical half-connect circuit can be viewed as a nonexclusive converter cell and it can be utilized to supplant the dc-join capacitors in other propelled converter topologies, e.g., neutral point-clamped (NPC) converters and measured multilevel converters (MMCs), to adapt to the framework fluctuating force issue. The NPC topology can be found in Co Energy IPG S arrangement single-stage PV inverters where a T-sort stage leg is utilized to give the three-level yield voltage. With this setup, the inverters might have settled PV terminal-to-ground possibilities and highlight decreased exchanging symphonious substance in the yield voltage. Be that as it may, the PV board voltage can be differing because of the swell force from the ac side, and this might prompt diminished MPPT proficiency. Keeping in mind the end goal to understand this issue, the proposed converter cell can be implanted into a solitary stage T-sort NPC inverter. Through appropriate control, the film capacitors in the dc connection can ingest those air conditioner side music and offer ascent to smoother PV voltage, and therefore higher sun powered vitality yields. The MMC converter is presently a standout amongst the most widely recognized sorts of voltage source converters utilized as a part of high-voltage direct present (HVDC) applications, since it has focal points like seclusion, multilevel waveforms, high accessibility, and in addition disappointment administration. In any case, a known issue of the MMC is that every sub module (SM) converter might require a vast and massive capacitor to hold the dc voltage. As the quantity of SM builds, the entire framework might turn out to be exceptionally gigantic in size. The proposed converter cell could be a potential possibility to understand this issue and the voltage of every SM can be kept about steady with greatly diminished capacitance. By and by, the capacitance decrease must be accomplished to the detriment of expanded number of dynamic segments and power misfortunes, and least dc-join capacitance is still required keeping in mind the end goal to securely ride through those lofty burden changes that happened in the framework. Another outline test is that, for both NPC and MMC applications, the dc-join voltage may contain twofold line recurrence swell force as well as the central fluctuating force. For this situation, the reference voltages of decoupling capacitors might never again be sinusoidal and rather, they are twisted waveforms and must be gotten through a shut circle controller, e.g., another voltage control circle that can manage the dc-join swell voltage to be zero. The possibility of this strategy will be contemplated in future examination work.

Conclusion

This paper has exhibited a symmetrical half-connect circuit to decouple the fluctuating force in single-stage ac/dc and dc/ac frameworks. The dc-join capacitors in the proposed framework may not just give a high-voltage dc transport to bolster power change, additionally ingest the framework swell force started from the ac side. The subsequent framework is more financially savvy when contrasted with other existing dynamic force decoupling strategies since it doesn't need extra detached parts to store the framework swell vitality. Test results under both relentless state and element operations were acquired from a 1-kW PFC model also, it daemonstrates that no less than ten times capacitance lessening can be accomplished by the proposed dynamic force decoupling circuit. The swell voltage in the dc join and also the THD of the brace current can be fundamentally diminished, which demonstrates the viability of the proposed arrangement. The proposed symmetrical half-extension can likewise be viewed as a non specific converter cell and may be a promising answer for end of the fluctuating power and the diminishment of dc-connection capacitance in other propelled topologies, e.g., NPCs and MMCs

References :

[1]. O. Garcia, J. A. Cobos, R. Prieto, P. Alou, and J. Uceda, "Single phasepower factor correction: A survey," *IEEE Trans. Power Electron.*, vol. 18,no. 3, pp. 749–755, May 2003.

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

[3]. L. Huber, Y. Jang, and M. M. Jovanovic, "Performance evaluation ofbridgeless PFC boost rectifiers," *IEEE Trans. Power Electron.*, vol. 23,no. 3, pp. 1381–1390, May 2008.

[4]. F. Musavi, W. Eberle, and W. G. Dunford, "A high-performance singlephasebridgeless interleaved PFC converter for plug-in hybrid electricvehicle battery chargers," *IEEE Trans. Ind. Appl.*, vol. 47, no. 4, pp. 1833–1843, Jul./Aug. 2011.

[5]. F. Musavi, M. Edington, W. Eberle, and W. G. Dunford, "Evaluation and efficiency comparison of front end AC–DC plug-in hybrid charger topologies," *IEEE Trans. Smart Grid*, vol. 3, no. 1, pp. 413–421, Mar. 2012.

[6]. M.Yilmaz and P. T.Krein, "Reviewof battery charger topologies, chargingpower levels, and infrastructure for plug-in electric and hybrid vehicles," *IEEE Trans. Power. Electron.*, vol. 28, no. 5, pp. 2151–2169, May 2013.

[7]. Y. Xue, L. Chang, S. B. Kjær, 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.

[8]. Q. Li and P.Wolfs, "A review of the single phase photovoltaic module integratedconverter topologies with three

different DC link configurations, "*IEEE Trans. Power Electron.*, vol. 23, no. 3, pp. 1320–1333, May 2008.

[9]. S. B. Kjaer, J. K. Pederson, and F. Blaabjerg, "A review of singlephasegrid-connected inverters for photovoltaic modules," *IEEE Trans.Ind. Appl.*, vol. 41, no. 5, pp. 1292–1306, Oct. 2005.

[10]. J. Kolar, U. Drofenik, J. Biela, M. Heldwein, H. Ertl, T. Friedli, andS. Round, "PWM converter power density barriers," *IEEJ Trans. Ind.Appl.*, vol. 128, no. 4, pp. 1–14, 2008.

[11]. T. Shimizu, T. Fujita, G. Kimura, and J. Hirose, "A unity power factorPWM rectifier with DC ripple compensation," *IEEE Trans. Ind. Electron.*,vol. 44, no. 4, pp. 447–455, Aug. 1997.

[12]. P. T. Krein, R. S. Balog, and M. Mirjafari, "Minimum energy andcapacitance requirements for single-phase inverters and rectifiers using a ripple port," *IEEE Trans. Power Electron.*, vol. 27, no. 11, pp. 4690–4698, Nov. 2012.

[13]. T. Shimizu, Y. Jin, and G. Kimura, "DC ripple current reduction on a single-phase PWM voltage-source rectifier," *IEEE Trans. Ind. Appl.*, vol. 36, no. 4, pp. 1419–1429, Sep./Oct. 2000.

[14]. M. Su, X. Long, Y. Sun, and J. Yang, "A active power decoupling methodfor single-phase AC/DC converters," *IEEE Trans. Ind. Informat.*, vol. 10,no. 1, pp. 461–468, Jan. 2014.

[15]. R. Wang, F. Wang, D. Boroyevich, and P. Ning, "A high power densitysingle-phasePWMrectifier with active ripple energy storage," *IEEE Trans.Power Electron.*, vol. 26, no. 5, pp. 1378–1383, May 2011.