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# Solar Based Grid Tied System for Continuous Operation Using GAN Switches

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**ABSTRACT:** The pulse-width-modulation plus phase-shift control technique paves the way for decoupled regulation of the output voltage and power by presenting two control freedoms, which allows the input voltage to vary in a wide range. To diminish the current stress of switches and minimize the conduction loss, the root-mean-square (RMS) current of inductance and the boundary condition of the phase-shift controller in different operation cases are studied. In this proposed system a stacked three-port three-level converter (STPTLC) using MOSFET switches is proposed for interfacing the renewable energy sources with load for applications. A three-port three-level converter (STPTLC) deriving from asymmetrical bidirectional half-bridge (ABHB) modules for applications such as hybrid Battery-PV DC-microgrid systems, HEV, and fuel-cell supplied power systems.

### I. INTRODUCTION

There are growing appeals for renewable energy sources (RES) such as photovoltaic (PV) and fuel cell (FC) because of the inexhaustibility and low carbon emission. RES has been widely adopted for applications such as hybrid electric vehicle (HEV), hybrid renewable energy systems, and the residential RES-based power system. Nevertheless, power generation of these volatile RES is unpredictable as the pattern of their power production depends on the weather; thus, to overcome this problem, an energy storage device should be adopted that can deliver the backup power with a fast-dynamic response. Aside from semiconductor devices, developments in the topology of power converters have further improved the power systems performance for high-frequency and high-efficiency applications. To manage the power flow in a micro-grid, the ESSs are usually required to store the excess energy generated by RESs and release it when the RESs are not sufficient or during peak energy consumption period. Bidirectional DC-DC converter is necessary for ESSs besides the power converters for the RESs.

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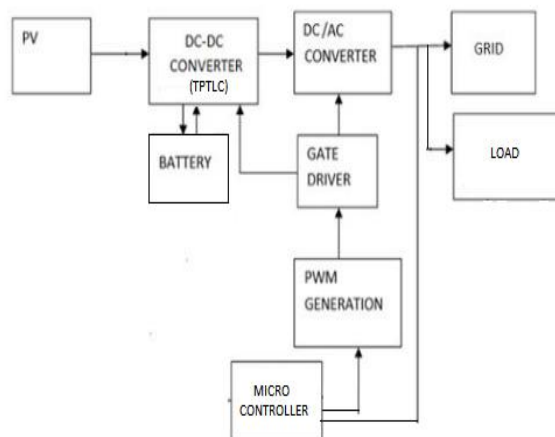


Fig 1: BLOCK DIAGRAM

The proposed TPTLC benefits from the intrinsic advantages of ABHB converter, which include the ZVS performance, bidirectional power transfer capability, and high power-density due to the small input filter. The converter takes advantage of pulse-width modulation (PWM) plus phase-shift modulation (PPSM) technique in terms of providing two control freedoms to regulate the power flow and voltage independently. Due to employing multilevel configuration, the voltage stress across switches is reduced, that results in lower conduction losses. Compared to the classical solutions, the TPTLC can directly charge and discharge the battery while the power is not required to pass through the transformer; so, a more compact power conversion system with higher efficiency is ensured. The design procedure of controllers becomes simple.

PV:

PV array has non-linear I-V characteristic and output power depends on environmental conditions such as solar irradiation and temperature. The point on the I-V, P-V characteristic curve of PV array where the PV system produces its maximum output power is called as Maximum Power Point (MPP). The purpose of MPPT is to adjust the solar operating voltage close to MPP under changing environmental conditions. In order to continuously gather the maximum power from the PV array, they have to operate at their MPPT despite of the inhomogeneous change in environmental conditions.

There are different types of MPPTs. The conventional MPPTs are generally based on the —hill climbing method and give an accurate MPP but the time taken to obtain the MPP is larger, thereby resulting in a lesser efficiency. They are also economically favorable Modern MPPT techniques are faster and find the MPP with lesser time and by executing a smaller number of cycles as they have the ability to deal with non-linearity and models which are not mathematically defined. 3.1 Perturb & Observe Method In this method, the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called the perturb and observe method and is most common, but this method can result in oscillations of power output. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in toplevel efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

In the P&O algorithm, the inputs of the MPPT system are the power output in watts and the working voltage of the PV module. A perturbation is given to the system and the change in power is observed. If the value of change in power is

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positive, a similar perturbation is applied in order to check for a higher power. If the change in the power output is negative, then the sign of the perturbation is reversed.

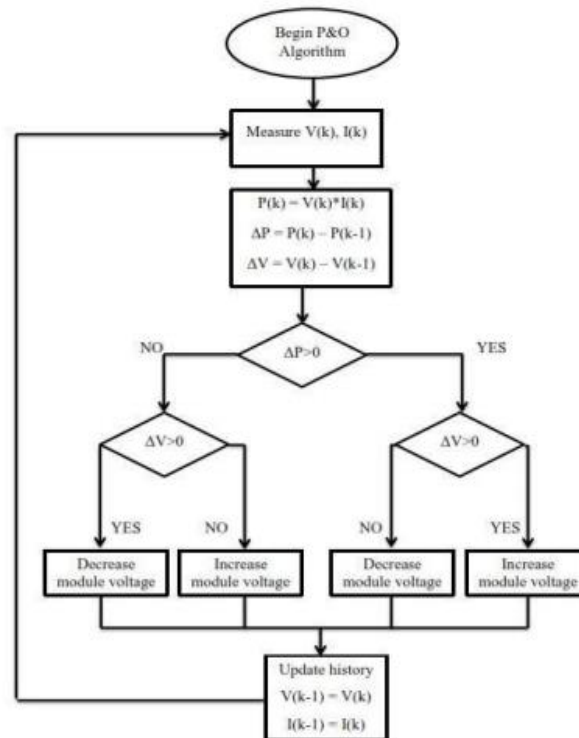


Fig 2: Work Flow

The waveform of inductor current with coupled inductors, as shown in the red solid lines. And the inductor current with non-coupling inductors for the three-level DC/DC converter in the dashed lines is set as the benchmark. Comparing with the inductor current waveform in interleaving buck converter, now inductor current ripple is not determined solely by one equivalent inductance in the three-level case. Instead, the first three time intervals determine the inductor current ripple together.

The equivalent inductance concept to analyze the effect of coupled inductors in the steady-state performance of three-level DC/DC converter, and to provide guidance for coupling design. With the equivalent inductance analysis for interleaving buck as a reference, the same method is applied to derive the equivalent inductance in three-level DC/DC converter. The connection between equivalent inductance and both inductor current ripple and output current ripple is built. For inductor current ripple, it is not determined by one equivalent inductance, and a new steady-state equivalent inductance is derived for its determination. For output current ripple, it is decided by the  $L_{eq2}$ , or the leakage inductance of the coupled inductors.

To design the coupled inductors, a two-step procedure is provided based on the current ripple requirements. The leakage inductance  $L_{lk}$  is designed based on the maximum output current ripple requirement, and then mutual inductance  $M_{ab}$  will be designed based on the maximum inductor current ripple requirement. To have a fair comparison between coupling and non-coupling inductors, the same output current ripple is assumed and  $L_{eq2}$  of coupled inductors is equal to the non-coupling inductance  $L_{nc}$ . Under this condition, it is discovered that strong coupling is desired for inductor current ripple reduction. And by analyzing the magnetic circuit, the strong coupling can

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be designed by controlling the air gaps in the magnetic core, and both small inductor current ripple and output current ripple can be achieved.

## II. BACKGROUND WORK

A TPC is a well-established means of realizing a highly regulated dc-link bus in systems with multiple sources. Since the input port is connected to a RES such as PV, TPC has to have the maximum power tracking capability. Due to the volatility of renewable energy sources, presence of an energy storage element is necessary to supply the mismatched power. In this section, the proposed STPTLC is thoroughly studied. Stacking converters such as that depicted in Fig.2 aims at improving the efficiency and voltage gain without requiring any extra component. It is obvious that the power can transfer among three ports directly without using any transformer. The clamp circuit limits the voltage stress of switches; hence switches with smaller on-resistance RDS(ON) can be used, leading to lower conduction loss. Compared to other TPC, STPTLC offers the soft-switching for a wide range of power and input voltage and needs a smaller number of switches and inductors to achieve high voltage gain. Symbols are defined as follows: filter inductors LB1, LB2, power switches S1, S2, S3, S4, auxiliary capacitor Caux, clamp capacitor CC, and output capacitor CO.  $V_{out}$  denotes the voltage of high-voltage port (HVP), which is equal to summation of voltage of clamp capacitor and output capacitor,  $V_{Cc}+V_{Co}$ . In Fig.2, the battery is emulated by a voltage source VBT. Also, the solar panel is modeled as an ideal voltage source VPV in series with a diode DPV. The voltage across switches S2 and S3 are symbolized by  $V_{ab}$  and  $V_{db}$ , respectively. The gate pulse of switches S2 and S4 are complementary to that of switches S1 and S3, respectively. The inductor LB1 is adopted as a filter to reduce the battery current ripple, and the inductor LB2 is used to form a resonant circuit to realize ZVS performance and confine the peak current of HVP switches. The main switches S1 and S3 can transfer the power from PV to the battery and the load, respectively. While no extra voltage stress is added across the switches, an auxiliary capacitor is added to the circuit to extend the range of softswitching performance, which forms a resonant tank with the inductor LB2. This auxiliary capacitor stores the magnetic energy of inductor LB2, and released it to the output capacitor Co.

Methods

## III. POWER SUPPLY UNIT BLOCK

All digital circuits work only with low DC voltage. A power supply unit is required to provide the appropriate voltage supply. This unit consists of transformer, rectifier, filter and a regulator. AC voltage typically of 230Vrms is connected to a transformer which steps that AC voltage down to the desired AC voltage level. A diode rectifier then provides a full wave rectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting DC voltage usually has some ripple or AC voltage variations. Regulator circuit can use this DC input to provide DC voltage that not only has much less ripple voltage but also remains in the same DC value, even when the DC voltage varies, or the load connected to the output DC voltage changes. The required DC supply is obtained from the available AC supply after rectification, filtration and regulation. Block diagram of power supply unit is shown in Figure 2.1

The main components used in the power supply unit are Transformer, Rectifier, Filter and Regulator. The 230V AC supply is converted into 9V AC supply through the transformer. The output of the transformer has the same frequency as in the input AC power. This AC power is converted into DC power through diodes. Here the bridge diode is used to convert AC supply to the DC power supply. This converted DC power supply has the ripple content and for normal operation of the circuit, the ripple content of the DC power supply should be as low as possible. Because the ripple content of the power supply will reduce the life of the circuit. So to reduce the ripple content of the DC power supply, the large value of capacitance filter is used.

This filtered output will not be the regulated voltage. For this purpose IC7805 regulator IC is used in the circuit.

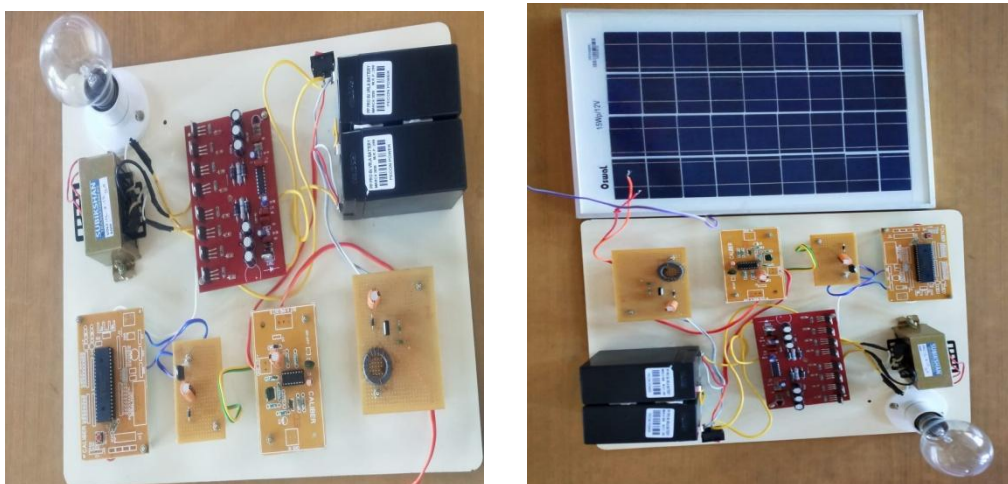
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### IV. RESULT



**Perturb & Observe Method** In this method, the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called the perturb and observe method and is most common, but this method can result in oscillations of power output. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in toplevel efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

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### V. CONCLUSION

A voltage source inverter is one where the independently controlled ac output is a voltage waveform. A current source inverter is one where the independently controlled ac output is a current waveform. Some industrial applications of inverters are for adjustable- speed ac drives, induction heating, stand by air-craft power supplies, UPS uninterruptible power supplies) for computers, HVDC transmission lines etc. An inverter changes DC voltage from batteries or solar panels, into standard household AC voltage so that it can be used by common tools and appliances. Essentially, it does the opposite of what a battery charger or "converter" does. DC is usable for some small appliances, lights, and pumps, but not much else. Some DC appliances are available, but with the exception of lights, fans and pumps there is not a wide selection. Most other 12 volt items we have seen are expensive and/or poorly made compared to their AC cousins. The most common battery voltage inputs for inverters are 12, 24, and 48 volts DC - a few models also available in other voltages. There is also a special line of inverters called a utility intertie or grid tie, which does not usually use batteries - the solar panels or wind generator feeds directly into the inverter and the inverter output is tied to the grid power.

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## REFERENCES

- [1] F. Xue, R. Yu and A. Q. Huang, "A 98.3% Efficient GaN Isolated Bidirectional DC-DC Converter for DC Microgrid Energy Storage System Applications," IEEE Trans. Ind. Electron., vol. 64, no. 11, pp. 9094-9103, Nov. 2017.
- [2] Y. Guan, Y. Wang, D. Xu and W. Wang, "A 1 MHz Half-Bridge Resonant DC/DC Converter Based on GaN FETs and Planar Magnetics," IEEE Trans. Power Electron., vol. 32, no. 4, pp. 2876-2891, April 2017.
- [3] H. Li et al., "Paralleled operation of high-voltage cascode GaN HEMTs," IEEE J. Emerg. Sel. Topics Power Electron., vol. 4, no. 3, pp. 815-823, Sep. 2016.
- [4] D. Reusch and J. Strydom, "Understanding the effect of PCB layout on circuit performance in a high-frequency gallium-nitride-based point of load converter," IEEE Trans. Power Electron., vol. 29, no. 4, pp. 2008-2015, Apr. 2014.
- [5] C. Zhao et al., "Design and Implementation of a GaN-Based, 100-kHz, 102-W/in<sup>3</sup> Single-Phase Inverter," IEEE J. Emerg. Sel. Topics Power Electron., vol. 4, no. 3, pp. 824-840, Sept. 2016.
- [6] X. Zhu, B. Zhang, Z. Li, H. Li and L. Ran, "Extended Switched-Boost DC-DC Converters Adopting Switched-Capacitor/Switched-Inductor Cells for High Step-up Conversion," IEEE J. Emerg. Sel. Topics Power Electron., vol. 5, no. 3, pp. 1020-1030, Sept. 2017.
- [7] F. Wu, X. Li, F. Feng, and H. Gooi, "Multi-Topology Mode Grid- Connected Inverter to Improve Comprehensive Performance of Renewable Energy Source Generation System," IEEE Trans. Power Electron., vol. 32, no. 5, pp. 3623-3633, May 2017.
- [8] D. Yang, M. Yang, and X. Ruan, "One-cycle control for a double-input DC/DC converter," IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4646-4655, Nov. 2012.
- [9] F. Locment, M. Sechilariu and I. Houssamo, "DC Load and Batteries Control Limitations for Photovoltaic Systems. Experimental Validation," IEEE Trans. Power Electron., vol. 27, no. 9, pp. 4030-4038, Sept. 2012.
- [10] H. Wu, K. Sun, L. Zhu and Y. Xing, "An Interleaved Half-Bridge Three- Port Converter With Enhanced Power Transfer Capability Using Three- Leg Rectifier for Renewable Energy Applications," IEEE J. Emerg. Sel. Topics Power Electron., vol. 4, no. 2, pp. 606-616, June 2016.
- [11] M. Uno, R. Oyama, and K. Sugiyama, "Partially-Isolated Single- Magnetic Multi-Port Converter Based on Integration of Series-Resonant Converter and Bidirectional PWM Converter," IEEE Trans. Power Electron., vol. 33, no. 11, pp. 9575-9587, Nov. 2018.
- [12] F. Kardan, R. Alizadeh, and M. R. Banaei, "A New Three Input DC/DC Converter for Hybrid PV/FC/Battery Applications," IEEE J. Emerg. Sel. Top. Power Electron., vol. 5, no. 4, pp. 1771-1778, Dec. 2017.
- [13] L. Wang, Z. Wang, and H. Li, "Asymmetrical duty cycle control and decoupled power flow design of a three-port bidirectional DC-DC converter for fuel cell vehicle application," IEEE Trans. Power Electron., vol. 27, no. 2, pp. 891-904, Feb. 2012.
- [14] J. Zeng, W. Qiao, and L. Qu, "An Isolated Three-Port Bidirectional DC-DC Converter for Photovoltaic Systems With Energy Storage," IEEE Trans. Ind. Appl., vol. 51, no. 4, pp. 3493-3503, July-Aug. 2015.
- [15] J. L. Duarte, M. Hendrix, and M. G. Simões, "Three-port bidirectional converter for hybrid fuel cell systems," IEEE Trans. Power Electron., vol. 22, no. 2, pp. 480-487, March 2007.
- [16] V. N. S. R. Jakka, A. Shukla and G. D. Demetriades, "Dual-Transformer- Based Asymmetrical Triple-Port Active Bridge (DT-ATAB) Isolated DC-DC Converter," IEEE Trans. Ind. Electron., vol. 64, no. 6, pp. 4549-4560, June 2017.
- [17] A. Nahavandi, M. T. Hagh, M. B. B. Sharifian and S. Danyali, "A Nonisolated Multiinput Multioutput DC-DC Boost Converter for Electric Vehicle Applications," IEEE Trans. Power Electron., vol. 30, no. 4, pp. 1818-1835, April 2015.
- [18] H. Wu, K. Sun, S. Ding and Y. Xing, "Topology Derivation of Nonisolated Three-Port DC-DC Converters From DIC and DOC," IEEE Trans. Power Electron., vol. 28, no. 7, pp. 3297-3307, July 2013.
- [19] H. Zhu, D. Zhang, B. Zhang and Z. Zhou, "A Nonisolated Three-Port DC-DC Converter and Three-Domain Control Method for PV-Battery Power Systems," IEEE Trans. Ind. Electron., vol. 62, no. 8, pp. 4937-4947, Aug. 2015.
- [20] Y. Hu, W. Xiao, W. Cao, B. Ji and D. J. Morrow, "Three-Port DC-DC Converter for Stand-Alone Photovoltaic Systems," IEEE Trans. Power Electron., vol. 30, no. 6, pp. 3068-3076, June 2015.

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