ISSN (Online) : 2455 - 3662
SJIF Impact Factor :5.148

EPRA International Journal of

Multidisciplinary Research

Monthly Peer Reviewed & Indexed International Online Journal

Volume: 5 Issue: 3 March 2019

Published By :EPRA Publishing

Volume: 5 | Issue: 3 | March 2019 || SJIF Impact Factor: 5.148 ISSN (Online): 2455-3662

EPRA International Journal of
Multidisciplinary Research (IJMR) Peer Reviewed Journal

SINGLE STAGE SINGLE PHASE BOOST INVERTER FOR LOW POWER APPLICATION

Dr. M. Kaliamoorthy
Associate Professor,
EEE Dept, Dr.Mahalimgam College of Engineering and Technology (Autonomous),
Pollachi 642 003, T.N,
India

K. Mythili
UG Scholar
EEE Dept, Dr.Mahalimgam College of Engineering and Technology (Autonomous),
Pollachi 642 003, T.N,
India

M. Abinaya
UG Scholar
EEE Dept, Dr.Mahalimgam College of Engineering and Technology (Autonomous),
Pollachi 642 003, T.N,
India

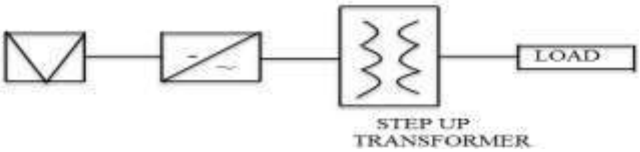
S. Karthikeyan
UG Scholar
EEE Dept, Dr.Mahalimgam College of Engineering and Technology (Autonomous),
Pollachi 642 003, T.N,
India

ABSTRACT

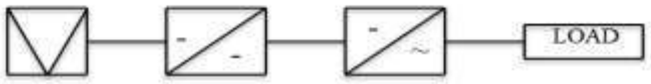
The output voltage of a traditional full-bridge inverter is lower than the input dc voltage. In applications when the input voltage is low, the front-end step-up converter is usually required, presenting a two-stage power conversion. Dual boost inverter (DBI) can realize single-stage conversion, which has the advantages of a simple structure, less power devices, and buck–boost ability. The traditional modulation strategy of DBI makes all power switches operate in high frequency and sustain high voltage/current stress, which leads to heavy conduction and switching loss. This paper proposed a modulation strategy, namely, half cycle modulation (HCM), which makes power switches work in high frequency just in half cycle, and can greatly reduce the conduction and switching loss of the power devices. Furthermore, to reduce the current circulation loss in DBI, an improved DBI with two clamping switches is proposed based on HCM, which can bypass the inductor current with low stress switches; therefore, the loss caused by circulation current can be greatly reduced. A detailed analysis and comparison between the traditional and HCM strategies are given in this paper. Finally, a 500 VA DBI prototype is designed in the lab. The advantages of the proposed HCM strategy and improved DBI with two clamping switches are verified by experimental results.

I. INTRODUCTION

Renewable technologies are considered as clean sources of energy and optimal use of these resources minimize environmental impacts, produce minimal secondary waste and are sustainable based on current and future economical and social societal needs. Solar energy is a major renewable energy source with the potential to meet the many of the challenges facing the world. This power sources is increases in popularity because it is versatile with many benefits to people and environment. The power produced from solar PV system is DC power, but most of the domestic and industrial applications are using AC power. So DC to AC conversion i.e. inverter is mandatory in Photo Voltaic (PV) application. Further the Voltage generated from PV panels has low magnitude (30-60V) and it needs to be amplified and inverter to the required domestic voltage level (230V).
Existing configuration of inverters are,
Inverter with transformer:



Drawback: Since this system has a step up transformer, the size of the inverter is very large. Thus the system is too bulky and costly.
Inverter with boost converter:



Drawback: Since this system has two stage of conversion, drop in each stage is high and contains more power devices which lead to high switching losses, which are leading to decrease in efficiency. Hence the main objective of this proposal is to develop a single stage power conversion boost inverter suitable for PV application with less cost. Dual Boost inverter (DBI) can realize single-stage conversion, which has the advantages of simple structure, less power devices and buck-boost ability. The traditional modulation strategy of DBI makes all power switches operate in high frequency and sustain high voltage/current stress, which leads to heavy conduction and switching loss. We proposes the half cycle modulation (HCM) strategy, which makes power switches work in high frequency just in half cycle, and can reduce the conduction and switching loss of the power devices greatly.

II. DUAL BOOST INVERTER

Dual boost inverter is the device which converts input dc from PV cell into AC 230V output which is used in domestic applications. It uses two boost converters which are connected in back to back in which the one boost converter is the mirror image of another. The DBI consists of two boost converters whose outputs are out-of-phase sinusoidal voltages with the same dc bias. The output voltage of DBI can be higher than the dc input voltage based on the step-up characteristic of a boost converter. A dynamic linear zing modulator-based boost inverter was proposed to improve its power bandwidth. Traditional modulation method makes each group of the bidirectional boost dc/dc converters produce the sinusoidal ac voltage with same dc bias.

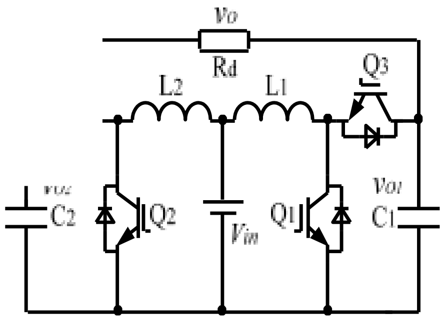


FIGURE 1 DUAL BOOST INVERTER

The operational principle of the DBI converter under traditional modulation strategy is given as follows. Four power switches- Q_1, Q2, Q3, and Q4 which are working at high frequency. V_{o1}, Vo2-voltage across C_1, C2. V_{in}-input Dc voltage. V_m-magnitude of output AC voltage. V_{dc}-off set voltage. d_1,d_2- duty cycle of Q_1,Q_2. Through appropriate control logic V_{o1},V_{o2} can be as follows:

MODES OF OPERATION:

Before analysis, some assumptions are given:
1. All switches and diode are ideal,
2. All the capacitor and inductor are ideal.

Mode 1 [t_0, t_1]: At t_0, Q_1, Q_4 is turned on; the input voltage is applied on L_1, and the input current charges L_1. Load current i_o will flow through Q_4 (D_4) to V_{in}, which supplied by C_1.
Mode 2 [t1,t2]: The period is dead time. At t1,Q 1, Q2, and Q3 are turned off, Q4 is turned on, and the current iL1 flowsthrough D3 or D1 (accordingtothecurrentdirection), as shown in Fig. 4(b). Load current io flows through Q4 (D4) to Vin.
3) Mode 3 [t2, t3]: Att2, Q 3 is turned on and iL1 flows through Q3 (D3). Load current io flows through Q4 (D4) to Vin. The current-flow path is shown in Fig. 4(c).
4) Mode 4 [t3,t4]: The period is also dead time, and the operating mode is the same as that of mode 2.
5) Mode 5 [t6, t7]: Att6, Q 2, Q 3 are turned on, the input voltage is applied on L2, and the input current charges L2. Load current io flows through Q3 (D3) to Vin, which is supplied by C2, as shown in Fig. 4(d).
6) Mode 6 [t7, t8]: The period is dead time. At t7,Q 1,Q 2, and Q4 areturnedoff,Q3 is turned on, and the current iL2 flows through D4 or D2(according to the current direction),as v shown in Fig.4(e). Load current io flows through Q3 (D3) to Vin.
7) Mode 7 [t8,t9]: Att8,Q 4 is turned on and iL2 flows through Q4(D4). Load current io flows through Q3(D3) to Vin. The current-flow path is shown in Fig. 4(f).
8) Mode 8 [t9,t10]: The period is also dead time, and the operating mode is the same as that of mode 6.

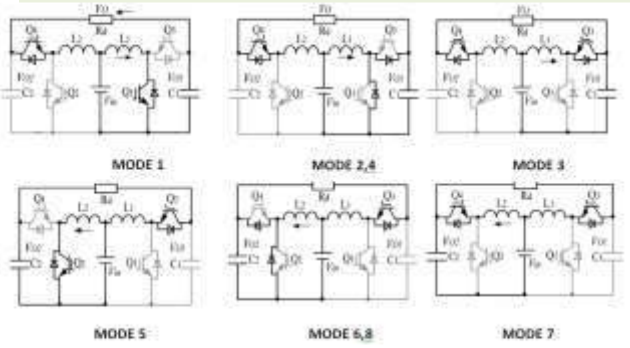


FIGURE 2 MODES OF OPERATION

Under HCM, a sinusoidal output voltage can be generated by differing the voltage of *C1*, *C2*, the same as traditional modulation from dual boost inverter. Only half of the switches are working in high frequency under HCM compared with T-M, which obviously reduces the switching loss of the DBI.

III.COMPARISON OF T-M AND HCM OF DBI

According to the analysis of both HCM and T-M, a sinusoidal output voltage can be generated by differing the voltages of C1 and C2. The detailed comparison between two modulation strategies is given in the following. Not all switches are working under high frequency in HCM thus the switching losses in HCM is less compared to T-M. In the period that the output voltage is positive, Q_4 has no switching loss and Q_2 has neither switching loss nor conduction loss compared with T-M. In the period that the output voltage is negative, Q_3 has no switching loss and Q1 has neither switching loss nor conduction loss compared with T-M. In addition to this, voltage/current stress in HCM is also low when compared with T-M. Due to the symmetry of the circuit, comparison of voltage/current stress and the inductor current ripple between the two modulations is shortly given by graphs.

VOLTAGE STRESS:

In the period that output voltage is positive, the voltage stress of Q_1 ,Q_3 under HCM is obviously lower than T-M, except the time that the output voltage getting its maximum. In the period that output voltage is negative, the voltage stress of Q_3 *is* zero, Q_1 is equal to V_{in}, which is also lower than T-M

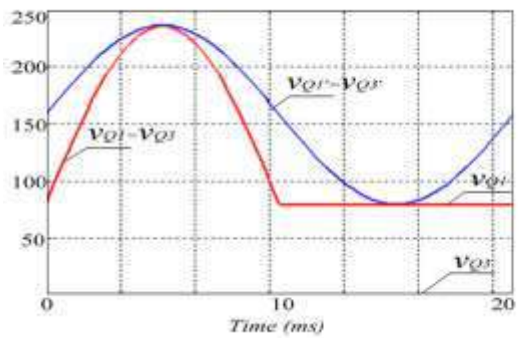


FIGURE 3 VOLTAGE STRESS FOR SWITCHES

CURRENT STRESS

For switches;

The RMS current of *IQ1*_rms, *IQ3*_rms is lower than *IQ1_rms*', *IQ3*_rms under different input voltage. Besides, *IQ1_rms* is higher than *IQ3*_rms when the input voltage is low; *IQ1*_rms is lower than *IQ3_rms* with the increase of the input voltage. The relation of *IQ1_rms*' and *IQ3_rms*' is similar to *IQ1_rms*, *IQ3_rms with* the change of input voltage.

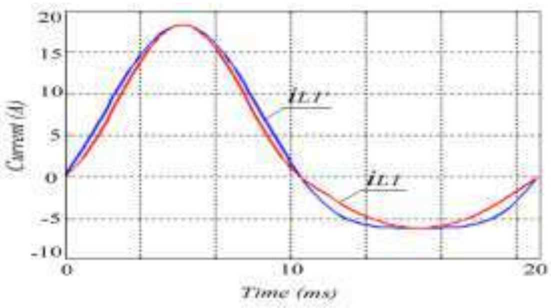


FIGURE 4 CURRENT STRESS OF INDUCTOR

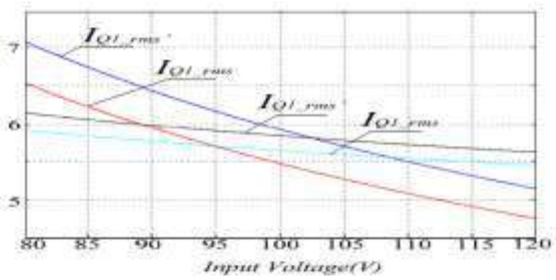


FIGURE 5 CURRENT STRESS OF SWITCHES

For inductor;

Thus *iL1(t)* is lower than *iL1(t)'*, which means the core loss and copper loss of inductor under H-M is lower than T-M

From the above analysis, voltage stress of Q1, Q3 under HCM is obvious lower than that of T-M during the period. The condition is the same for Q2, Q 4 considering the symmetrical operation of the two groups. Fig. 6 illustrates that the current stress of Q1, Q3 under HCM is also lower than that of T-M under different input voltage. Fig. 7 indicates the rms current of inductance under HCM is also and conduction loss of switches, and the copper loss of inductors under HCM is always lower than that of T-M, which can greatly improve the system overall efficiency.

IV. IMPROVED DUAL BOOST INVERTER

In both modulation strategy of DBI, circulation current exist all the time that leads to copper and core loss in the inductor L1 and L2 all the time. In a half cycle, only one inductor is needed to boost the output. Thus more circulation current flows through other output side. Thus to reduce such circulation current, other output side can be clamping to V_{in} by using a clamping switch. So the clamping switches operating in line frequency and thus voltage stress and current stress is much lower than T-M and HCM. Thus clamping switches also reduces inductor core loss and copper loss generated by circulation current.

The switching mode of the converter with clamping switches is similar to half cycle modulation. In the period that output voltage is positive, *Q4* is turned off, voltage of *C2* is clamped to *Vin* by clamping switch *Q6*, and the load current *io* flow through *Q6* to *Vin*, which is supplied by *C1*. In the period that output voltage is negative, *Q3* is turned off, voltage of *C1* is clamped to *Vin* by clamping switch *Q5*, and the load current *io* flow through *Q5* to *Vin*, which is supplied by *C2*. Fig. 10 gives the control logic under HCM with clamping switches.

FIGURE 6 DUAL BOOST INVERTER WITH CLAMPED SWITCHES AND HCM MODULATION

FIGURE 6.1 DUAL BOOST INVERTER WITH CLAMPED SWITCHES

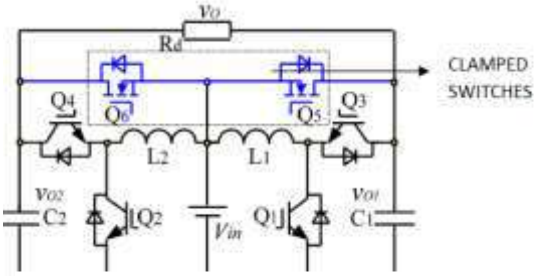
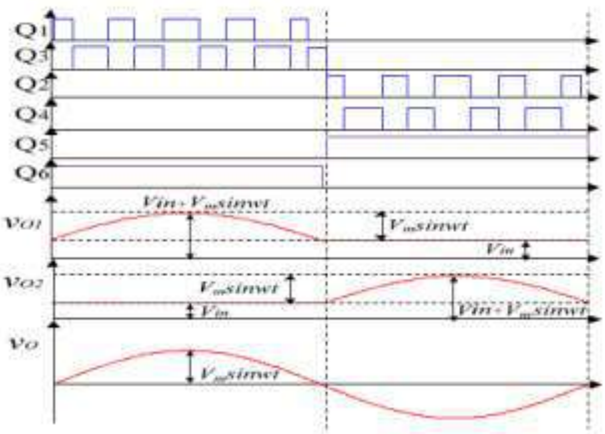


FIGURE 6.2 HCM MODULATION



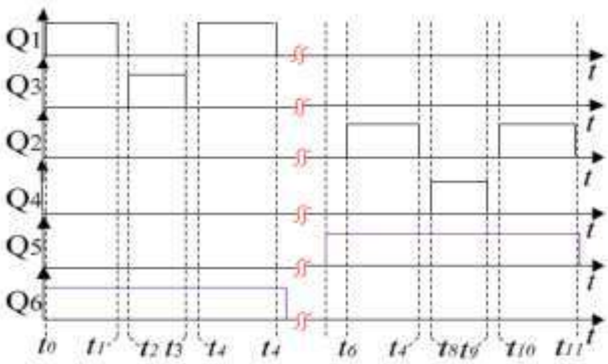
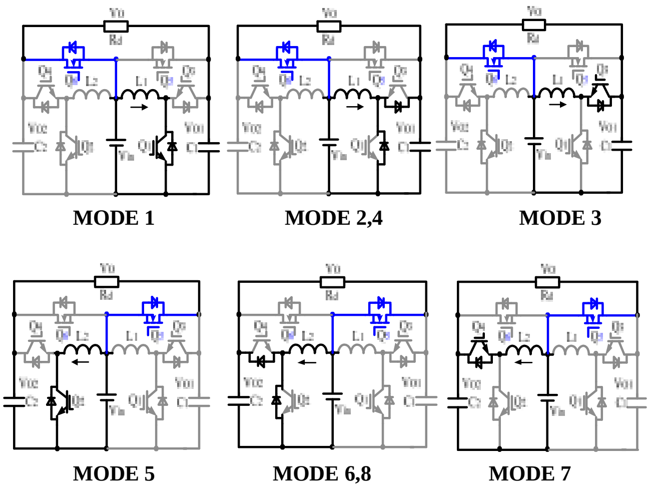


FIGURE 6.3 CONTROL STRATEGY

6.3 MODES OF OPERATION:

The modes of operation of the improved converter with clamping switches are similar to the converter under HCM, except clamping switches.

FIGURE 6.4 MODES OF OPERATION



The current stress of clamping switch is io, the voltage stress of clamping switch is (Vo-Vin), which is lower than both of T-M and HCM. The clamping switches obviously have a further lower voltage stress, leading a lower conduction loss. Thus the clamping switches reduce the inductor core loss and copper loss generated by circulation current. For positive half cycle,Q_6 is in ON state and the load current flows through Q_6 to Vin which is supplied by C_1. For negative half cycle,Q_5 is in ON state and the load current flows through Q_5 to Vin which is supplied by C_2.

Because the operating states of high frequency switches is the same, so the conduction loss of line frequency conduction path in the improved DBI and DBI with HCM is shown in TABLE .

POWER	LOSSES	LOW FREQUENCY IGBT/MOSFET	INDUCTOR
300W	DBI	4.6W	0.95W
300W	IMPROVED DBI	0.11W	0
500W	DBI	7.65W	2.13W
500W	IMPROVED DBI	0.3W	0

TABLE - Conduction loss of line frequency in improved DBI

V. SIMULATION AND RESULTS

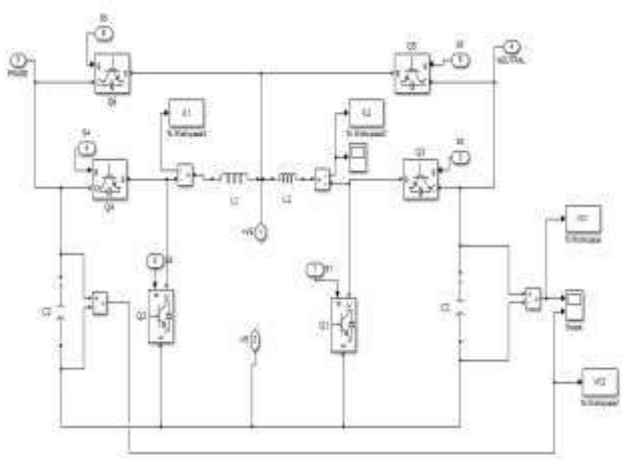


FIGURE7 SIMULATION OF POWER CIRCUIT

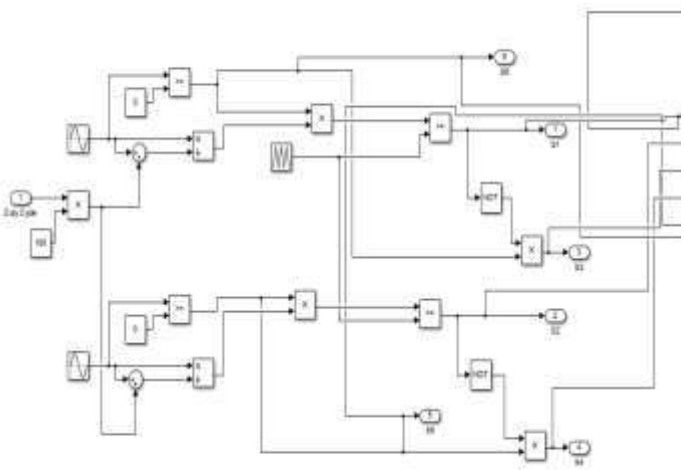


FIGURE8 SWITCHING PULSE GENERATION

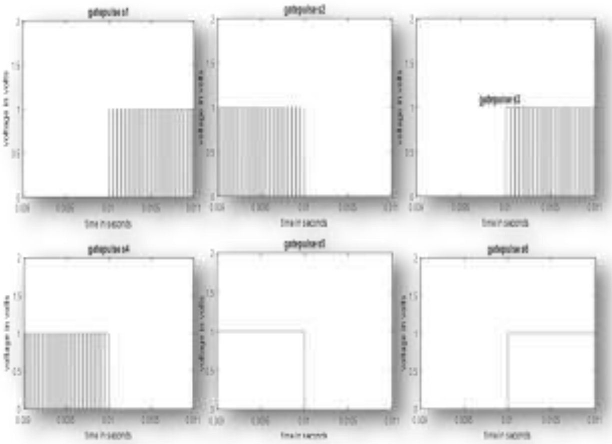
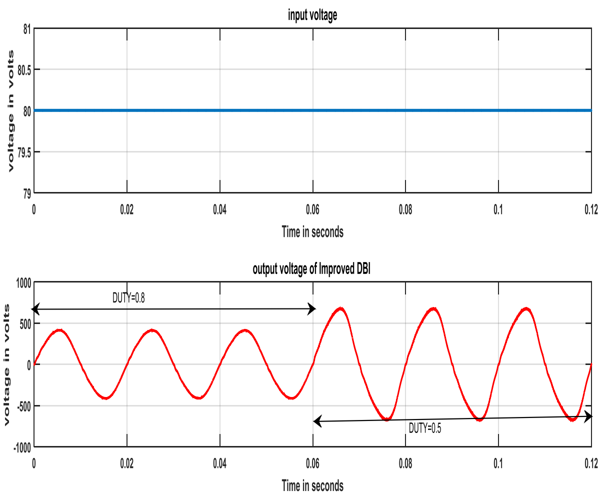


FIGURE9 GATE PULSE FOR HALF WAVE MODULATION- IMPROVED DBI



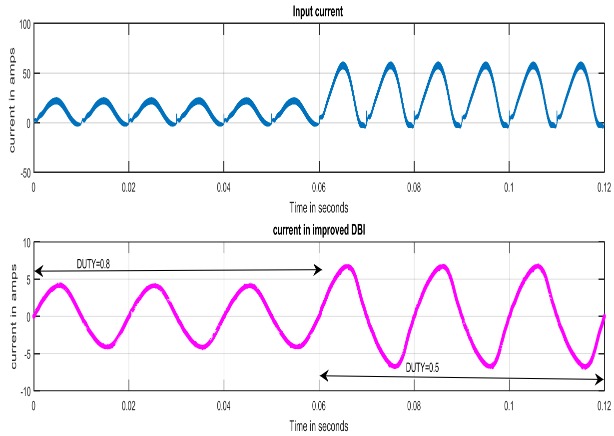


FIGURE10 OUTPUT WAVEFORM FOR IMPROVED DBI

CONCLUSION

In this project an improved DBI under half cycle modulation with clamping switches was simulated and results were obtained. According to the analysis and experimental results, the half cycle modulation strategy with clamping switches of DBI keeps the advantage of buck-boost ability. Furthermore, it brings the following advantages over the original one:

1) Only half of the switches are working in high frequency under HCM compared with T-M, which obviously reduces the switching loss of the DBI.

2) The voltage / current stress of the switches is lower with HCM than TM, which will further reduce the switching loss and conduction loss of the power switches.

3) The inductor current is lower with HCM, which also reduce the magnetic loss.

4) Clamping switches is helpful to low the current circulation loss of inductor and IGBT. With low stress MOSFET, it can also reduce the conduction loss of circulation current. The efficiency of DBI can be improved with HCM because high frequency switches is less than traditional modulation, also the inductor current stress is lower; in addition, the improved DBI can further improve the efficiency because of the low conduction loss by introducing low stress switches.

REFERENCES

1. *P.Sanchis, A.Ursaea and E.Gubia, "Boost DC to AC inverter: A new control strategy " IEEEtrans. power electron.,vol-20,no.2,pp.343353,March-2005.*
2. *D.Cortes, N.Vazquez and J.A.Gallegos, "dynamical sliding – mode control of the boost inverter" IEEEtrans.Ind.Electron, vol-56, no.9, pp.3467-3476, Sep-2009.*
3. *B. Bose, "Global warming: Energy, environmental pollution, and the impact of power electronics," IEEE Trans. Ind. Electron. Mag., vol. 4, no. 1, pp. 6–17, Mar. 2010.*
4. *W. Zhao, C. Lu, and V. G. Agelidis, "Current control of gridconnected boost inverter with zero steady-state error," IEEE Trans. Power Electron., vol. 26, no. 10, pp. 2825–2832, Oct. 2011.*
5. *R. O. Caceres and I. Barbi, "A boost DC–AC converter: Analysis, design, and experimentation," IEEE Trans. Power Electron., vol. 14, no. 1, pp. 134–141, Jan. 1999.*

6. Y. Chen and K. Smedley, "Three-phase boost-type grid-connected inverter," IEEE Trans. Power Electron., vol. 23, no. 5, pp. 2301– 2309, Sep. 2008.
7. B. Mirafzal, M. Saghaleini, and A. K. Kaviani, "An SVPWM based switching pattern for stand-alone and grid-connected three-phase single stage boost inverters," IEEE Trans. Power Electron., vol. 26, no. 4, pp. 1102–1111, Apr. 2011.
8. Q. Li and P. Wolfs, "A review of the single phase photovoltaic module integrated converter topologies with three different dc link
9. configurations," IEEE Trans. Ind. Electron., vol. 23, no. 3, pp. 1320– 1333, May 2008.
10. S. B. Jeer, J. K. Pedersen, and F. Blaabjerg, "A review of singlephase grid-connected inverters for photovoltaic modules," IEEE Trans. Ind. Appl., vol. 41, no. 5, pp. 1292–1306, Sep. 2005.
11. G. S. Ilango, P. S. Rao, A. Karthikeyan, and C. Nagamani, "Singlestage sine-wave inverter for an autonomous operation of solar photovoltaic energy conversion system," Renew. Energy, vol. 35, no. 1, pp. 275–282, 2010.
12. L. S. Yang and T. J. Liang, "Analysis and implementation of a novel bidirectionalDC–DCconverter, IEEETrans.Ind.Electron" vol.59, no.1, pp. 422–434. Jan. 2012.
13. Y. Zhou and W. Huang, "Single-stage boost inverter with coupled inductor," IEEE Trans. Power Electron., vol. 27, no. 4, pp. 1885– 1893, Apr. 2012.
14. M.Rashid, Power Electronics: Circuits, Devices and Applications, 3rded. Englewood Cliffs, NJ: Prentice-Hall, Aug. 2003.
15. G. Escobar, R. Ortega, H. Sira-Ramírez, J.-P. Vilain, and I. Zein, "An experimental comparison of several nonlinear controllers for power converters, IEEEControlSyst.Mag" vol.19, no.1, pp.66–82, Feb.1999.
16. D.Cortes, J.Alvarez, J.Alvarez, and A.Fradkov, "Tracking control of the boost converter," Proc. Inst. Elect. Eng.—Control Theory Appl., vol. 151, no. 2, pp. 218–224, Mar. 2004.