International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 9 (2015) pp. 24407-24422

http://www.ripublication.com

# Investigation On Full Bridge And Coupled Inductor ZVS DC-DC Converter Fed PMDC Motor

**S.A.Elankurisil[1] K.K.Saravannan [2] N.Stalin[3], P.Mahendra Peruman[4]**

[1] *Professor/EEE, Adhiparasakthi Engineering college*
*Melmaruvathur, tamilnadu, India,*
*email[1]: saelankurisil@gmail.com,*
[2] *Assistant professor/EEE, University college of Engineering*
*Panruti, tamilnadu, India*, email[2]: saravannan.santi@gmail.com
[3]*Assistantprofessor/PetrochemicalTechnology,*
*Anna University-BIT, Trichy,, tamilnadu,*
*India*, email[3]: mnstalin@annauniv.edu
[4]Assistant *professor/EEE, Adhiparasakthi Engineering college*
*Melmaruvathur, tamilnadu, India, email[4]: m.peruman @gmail.com,*

## Abstract

The Power converters are extensively used in medium to high power application. For most of these applications, the most desirable features of isolated converter are high efficiency, high power density, high reliability and low electromagnetic interference. A soft switching which is bidirectional DC-DC converter is proposed. Soft switching technique is used to achieve high power density, good switching frequency and improved efficiency. The switching losses proportionally increase with an increase in switching frequency, thus limiting the maximum switching frequency of the power converters. But, high switching frequencies are the best solution when low weight and size converters are needed. This paper present work, two topology of converter are designed and simulated. Looking at the social relevance aspect, this bidirectional converter behaviour is simulated with DC motor applications. Use of this experimented prototype would further improve the social relevance on the terminal users in terms of cost, size, operation, compatibility and reliability. The results are compared and the best one is identified. Hardware has implemented for the isolated and non-isolated Coupled inductor bidirectional DC-DC converter.

**Keywords:** Bidirectional DC-DC converter, Full Bridge DC-DC Converter, Coupled Inductor DC-DC Converter, Boost converter PM D.C motor.

**1 INTRODUCTION**

It is used as an energy storage device which consists of resonant inductors and diodes to recover the energy stored in the capacitors back to the supply side. Many authors have studied experimentally and numerically the operation of power converters at higher switching frequencies and power levels. They have analyzed different converter topologies to minimize the switching losses and stress of the power semiconductor devices. Some of these literature related to the present study are presented. The design procedures for selecting step down ratio transformer which do not solve the problems like the leakage inductance and parasitic capacitance which resulted in reducing efficiency [1]-[2]. The design of high frequency switching mode power supplies could be applied for high power application. This has been presently recognized and so the FB-ZVS-PWM (Full Bridge Zero Voltage Switching Pulse Width Modulation) is considered as one of the best power converters. This is because it possesses the basic desirable characteristics of both the hard switching PWM converters and the soft switching ones, while avoiding their major drawbacks, such as commutation losses in the former and variable switching frequency and high conduction losses in the second group. However, the power switches of the FB-ZVS-PWM converter are subjected to the maximum input voltage level [3-4], The snubber, proposed by these authors, uses an auxiliary switch to discharge the snubber capacitor. Generic snubber cell is identified for all the non-isolated DC-DC converters It was implemented a soft-switching active snubber to reduce the turn-off loss of the IGBT (Insulated Gate Bipolar Transistor) in a buck converter.to reduce the switching losses [5-7]. A lossless turn on snubber and mainly used to reduce the turn-off loss. The turn-off loss depends on the size of the snubber capacitance in the converter [8]. There have been proposed that when switching frequency increases, switching losses decreases and Electro Magnetic Interference (EMI) noise increase.

These problems are solved by using soft switching techniques. The MOSFET operates at Zero Voltage Switching (ZVS) turn-off and near Zero Current Switching (ZCS) turn-on. The freewheeling diode is also commutated under ZVS. As an example, operation principles, theoretical analysis, relevant equations and experimental results of a boost converter equipped with the converter are presented in detail [9].

This paper was proposed a passive lossless snubber cell for non-isolated PWM DC-DC converters. A general passive loss less snubber cell for non-isolated PWM DC-DC converters was explained. The general snubber cell is the contribution of a turn-on snubber and a turn-off snubber. Energy recovery is achieved by passive components only. Component values of the snubber inductor, snubber capacitor and buffer capacitor can be determined [10]. A passive soft-switching snubber which employs a diode/capacitor snubber circuit for each switching device in an inverter to provide low dv/dt and low switching loss to the device. The circuit uses a transformer based energy regenerative circuit to recover the energy captured in the snubber capacitors [11]. It was implemented an increasing new he ripple focus on the power electronic converter interface for DC energy sources. DC energy sources that have a role in distributed generation and sustainable energy systems are the photovoltaic (PV) panel, the fuel cell stack and batteries of these converters. Each half panel or panel substring connecting into series strings avoid many of these problems. This paper examined the advantages, difficulties and implementation issues of using a cascaded converter connection for a series string of PV panels or more generally DC energy sources. A proposed residential grid connected solar installation consisting of twelve 12V, 60W, and PV panels is used12].In the bidirectional converter which can operate with a continuous inductor current, fixed switching frequency and switch stress of a conventional bidirectional DC-DC converter which improve the efficiency of the filter regardless of the direction of power flow[13-22].

## 2. **FULL BRIDGE ISOLATED BIDIRECTIONAL DC-DC CONVERTER**

It is well suitable for low input voltage and high current application. A dual full bridge topology is developed to achieve higher power rating, power density and efficiency. However switching losses have been an obstacle for high frequency operation. In general, various soft switching techniques have been used to reduce the switching losses and stress of a power device. The significant performance improvements, as well as cost, size and weight reduction could be achieved with the help of soft-switching. Fig 2.1 shows the full bridge isolated bidirectional DC-DC from low voltage side to the high voltage side, the circuit works in boost mode, to keep high voltage side at a desired high value.

In the other direction of power flow, the circuit works in buck mode to keep low voltage side at a desired low value. The output voltage is rectified and filtered to get smooth DC. Converter with π filter. The circuit consists of inductor in the input side and two full bridges, each are placed on each side of the main transformer. Each switching device has a small parallel capacitor for soft switching. When power flows from low voltage side to the high voltage side, the circuit works in boost mode, to keep high voltage side at a desired high value. In the other direction of power flow, the circuit works in buck mode to keep low voltage side at a desired low value of high frequency switching mode power supplies could be applied for high power application. The output voltage is rectified and filtered to get the smooth DC. The isolated bidirectional DC-DC converters are widely used in UPS battery charging and discharging systems [13-18]. This converter can be operated with constant frequency at the entire circuit. The bidirectional DC-DC converter is operated with the transformer. The proposed full isolated bidirectional DC-DC converter is compared at the load side of π filter.

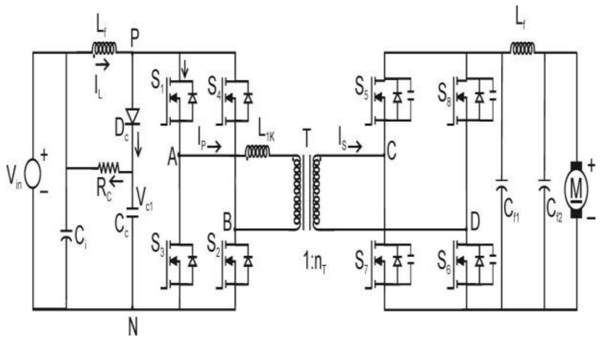



**Fig 2.1 Isolated boost full bridge DC-DC converters**

The circuit operates bidirectional DC-DC converter as shown in Eig 2.1.Isolated boost full bridge DC-DC converter is used for medium and high power application. The work analyses the reason for the proposal PI controller and discusses the cause for the inability of performing the same operation in the open loop. This is because of the fact that the open loop is unable to maintain the constant voltage with the variations of inputs. The boost inductance L and the output filter capacitor *C* are calculated based on the following equations.

$$L = Vo\delta / f \Delta I \quad (2.1)$$

$$Io = Vo / R \quad (2.2)$$

$$Po = Vo^2 / R \quad (2.3)$$

$$E_1 = 4.44 N_1 \Phi_f f \quad (2.4)$$

$$E_2 = 4.44 N_2 \Phi_f f \quad (2.5)$$

$$C = \delta /2 f R \quad (2.6)$$

$$Vo = Vin\delta \quad (2.7)$$

Where δ = duty cycle and ΔI = ripple current in amps. Applying Kirchhoff's rule as shown in Eig 2.1 and rearranging the terms, the following results are obtained.

$$Vo = \frac{V_{in}}{(1-\delta)} \quad (2.8)$$

Resonant impedance $Z = \sqrt{\frac{L_r}{C_s}}$ (2.9)

Resonant frequency $\omega = \frac{1}{\sqrt{L_r C_s}}$ (2.10)

$$C_s = \frac{I_L t}{2V_o} \quad (2.11)$$

Therefore,

$$L = V_{in} \frac{dt_{on}}{dI} \quad (2.12)$$

= 5μH

Similarly, the current through the output capacitor *C* is,

$$I_o = C\frac{dV_o}{dt_{on}} \tag{2.13}$$

Therefore,

$$C = I_o\frac{dt_{on}}{dV_o} \tag{2.14}$$

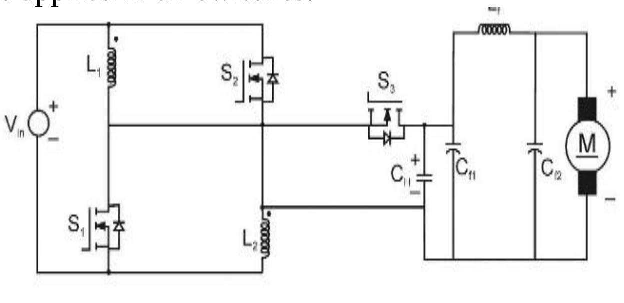
= 100 μF

The transfer function of a PI controller is often written in this form.

$$G_p i(s) = K_p + K_i/s \tag{2.15}$$

**3. COUPLEDINDUCTOR BASED DC-DC CONVERTER**

The bidirectional DC-DC converters are widely used in UPS battery charging and discharging systems. Eig 3.1 shows the coupled inductor based bidirectional DC-DC converter. This converter employs a coupled inductor with the same winding turns in the primary and secondary sides. In step up mode, the primary and secondary windings of the coupled inductor are operated in parallel-charge and series discharge to achieve high step up voltage gain. In step down mode, the primary and secondary windings of the coupled inductor are operated in series-charge and parallel-discharge to achieve high step down voltage gain. It is used in high voltage operation. Zero voltage switching is applied in all switches.




**Eig 3.1 Coupled inductor bidirectional DC-DC converter**

$$L_1 = L_2 = L \tag{3.1}$$

$$M = k\sqrt{L_1 L_2} = kL \tag{3.2}$$

$$V_{L1} = L_1 \frac{di_{L1}}{dt} + M \frac{di_{L2}}{dt} = L \frac{di_{L1}}{dt} + kL \frac{di_{L2}}{dt} \quad (3.3)$$

$$V_{L2} = M \frac{di_{L1}}{dt} + L_2 \frac{di_{L2}}{dt} = kL \frac{di_{L1}}{dt} + L \frac{di_{L2}}{dt} \quad (3.4)$$

$$V_o = V_C = \frac{1-\delta}{1-2\delta} V_i \quad (3.5)$$

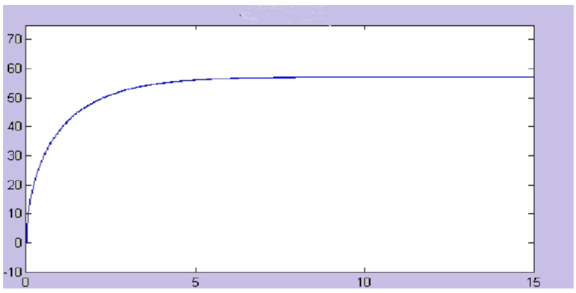
$$Z_r = \sqrt{\frac{L_{r1}}{C_{r2}}} = \sqrt{\frac{L_{r2}}{C_{r4}}} \quad (3.6)$$

$$\omega_r = \frac{1}{\sqrt{L_{r1}C_{r2}}} = \frac{1}{\sqrt{L_{r2}C_{r4}}} \quad (3.7)$$

Thus, the converter has higher step up and step down voltage gains than the conventional and full bridge bidirectional DC-DC boost/buck converter.

## 4 SIMULATION RESULTS OF FULL BRIDGE DC-DC CONVERTER

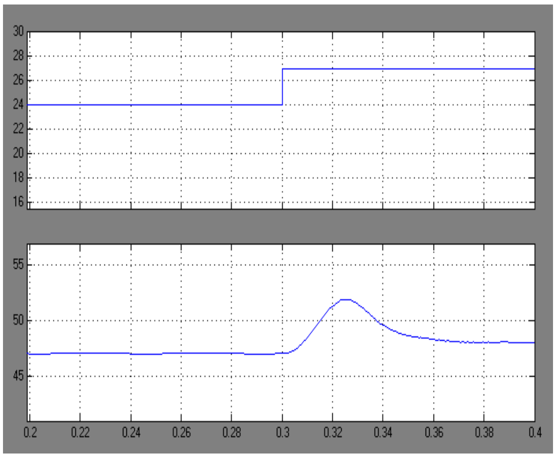
Full bridge DC-DC converter is modelled and simulated using SIMULINK version 7.9 of MATLAB and the results presented here. The output voltage of boost mode operation is 54V. It is shown in Eig4.1It is observed the simulation of boost mode with motor load the output voltage and speed are increased in the proposed full bridge isolated DC- DC converter.




Time (sec).

**Eig 4.1 Output voltage in boost mode**

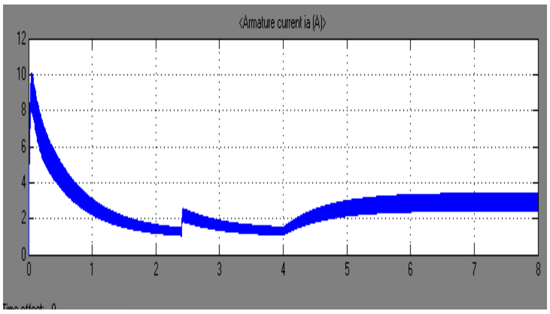
Open loop output voltage waveform with step input voltage and the output voltage waveform for closed loop controlled converter are shown in Fig 4.2 (a) and (b). Irrespective of the input voltage applied, the output voltage is maintained constant. There is a steady state error in the output of open loop system. The output voltage is sensed and it is compared with the reference voltage. The error signal is given to the comparator through PI controller




Time (sec)

**Fig 4.2 (a) DC output voltage with stepchange at the input (b) DC output voltage for the closed loop controlled converter operation**

This gives high output voltage and efficiency; and any further increments of input voltage will not significantly increase the ripple content. The reduction in the ripple of the proposed converter compared with the conventional one at different input voltage and load conditions, Closed loop output current is 2.5 A as shown in Eig4.3 Comparison of efficiency in boost mode is shown in table1



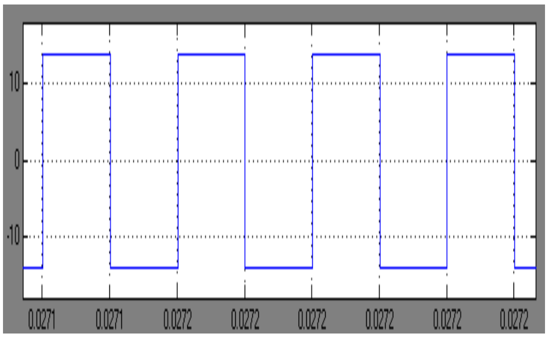

Time(sec)

**Eig 4.3 Armature current of closed loop system**

**Table 1 Comparison of efficiency in boost mode**

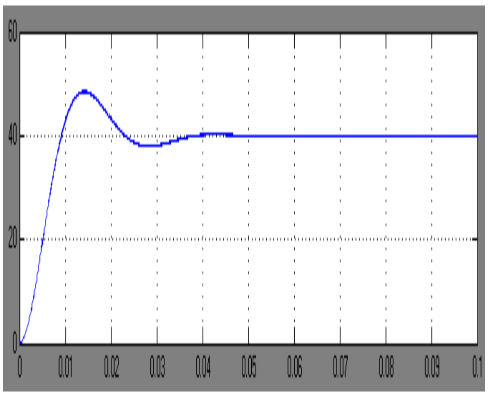
| Input voltage(V) | Conventional full bridge Efficiency% | Proposed full bridge Efficiency% |
|---|---|---|
| 12 | 81.23 | 84.93 |
| 16 | 84.85 | 85.31 |
| 20 | 85.82 | 88.42 |
| 24 | 88.10 | 89.58 |

It is observed the simulation of boost mode with motor load the magnetizing leakage reactance is decreased than the conventional isolated full bridge DC- DC converter. Voltage across the inductor value which is 11V is shown in Eig 4.4. The boosted DC output voltage of 40V is show in Eig4.5. The DC output current of 4amp is shown in Eig 4.5. It is observed the simulation of boost mode ripple is decreased than the conventional non- isolated DC- DC converter., it is important to improve the efficiency Parameters used for simulation ( Full Bridge DC-DC Converter& Coupled inductor) are presented in the table 2 and 3 respectively




Time (sec)

**Eig 4.4Voltage across the inductor $L_2$**




Time(sec)

**Eig 4.5 Output voltage waveform**

Time(sec)

**Eig4.6 Output current waveform**

**Table 2 Parameters used for simulation (Full Bridge DC-DC Converter)**

| | |
|---|---|
| Input Voltage | 12-15V |
| Switching Frequency | 20KHz |
| Pulse period | 5µs |
| Capacitance | 1500µf |
| Load Resistance | 1000Ω |
| Diode | MUR150 |
| MOSFET | IRF840 |
| Transformer | High frequency transformer |

**Table 4 Parameters used for Simulation (Coupled Inductor)**

| | |
|---|---|
| Input Voltage | 12V-15V |
| Switching Frequency | 55KHz |
| Pulse period | 18µs |
| InductanceL1=L2 | 1Mh |
| Capacitance | 500µf |
| Load Resistance | 10Ω |
| Diode | MUR150 |
| MOSFET | IRF840 |

**Table 5 Performance of coupled inductor with Various Filters**

| Filters | Parameters | Load Values (with motor) | Load Values (without motor) |
|---|---|---|---|
| C Filter | Input Voltage | 12V | 12V |
| | Output voltage | 72V | 74V |
| | THD | 3.1% | 3.11% |
| | Efficiency | 91.67% | 92.67% |
| LC Filter | Input Voltage | 12V | 12V |
| | Output voltage | 45V | 56V |
| | THD | 2.3% | 2.2% |
| | Efficiency | 87.5% | 88% |
| π Filter | Input Voltage | 12V | 12V |
| | Output voltage | 60.98 | 45V |
| | THD | 2.6% | 2.3% |
| | Efficiency | 90.03% | 92.95% |
| RC Filter | Input Voltage | 12V | 12V |
| | Output voltage | 49V | 64V |
| | THD | 3.0% | 3.0% |
| | Efficiency | 82.04% | 84.34% |

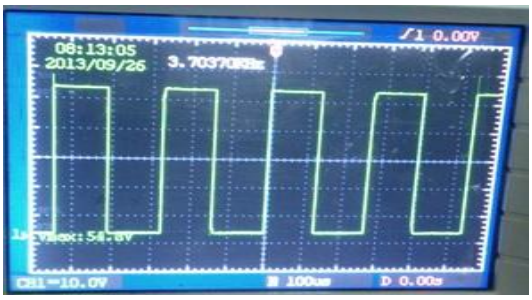
**5.HARDWARE RESULT OF FULL BRIDGE DC-DC CONVERTER**

Transformer, it can be used to step down or step up a DC voltage source. The regulation is normally achieved by PWM at a fixed frequency. The switching device used here is n-channel enhancement MOSFET. After smoothing out the ripples, the regulated voltage is fed to the 0-24V, 2.5A, 96W, DC motor. They provide smooth acceleration control, high efficiency and fast dynamic response. A laboratory model for the isolated boost DC to DC coverter is fabricated and tested.Hardware is implemented as shown in Fig 5.1. Boost mode voltage which is 45.6V is shown in Eig5.2. Fig 5.3 shows the transformer secondary voltage which is 54.07V. Experimental results further demonstrated the feasibility of the proposed ideas. The efficiency with motor load is 90%.

**Eig 5.1Hardware circuit for full bridge isolated DC-DC Converter**


**Time (sec) X-axis 1unit=18µsecy-axis 1unit=20 V**

**Eig 5.2 Boost output voltage**




Time (sec) X-axis 1unit=18µsecy-axis 1unit=10V

**Eig 5.3Transformer secondary voltage**

When R-load is connected to this coupled inductor bidirectional DC-DC converter, the efficiency is 92.58%. Boost mode coupled inductor output voltage is 45.6V as shown in Eig5.4


Time (sec) X-axis 1unit=18µsec y-axis 1unit=20V

**Eig 5.4 Boost mode coupled inductor output voltage**

The different values of the input voltage, the output voltage, input power, output power and hence efficiency is calculated. The values are tabulated and they are given in Table6. The different values of the input voltage and efficiency are calculated as shown in Fig 5.5.

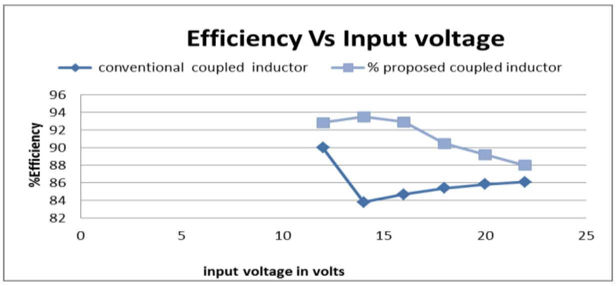



**Fig5.5 Input voltage and %Efficiency**

**Table 6 Simulation and Experimental Result of proposed converter**

| Input voltage (V) | Output voltage (V) | Input power (W) | Output power (W) | Efficiency (%) | Mode |
|---|---|---|---|---|---|
| 12 | 28 | 62.23 | 53.33 | 85.98 Conventional | Simulation |
| 12 | 30 | 60.45 | 54.37 | 89.94 Proposed | Simulation |
| 12 | 54.56 | 30 | 60.45 | 89.94 Proposed | Full bridge hardware |
| 12 | 35 | 60.45 | 54.56 | 90.28 Conventional | Simulation |
| 12 | 40 | 60.97 | 56.67 | 92.94 Proposed | Simulation |
| 12 | 56.67 | 40 | 60.97 | 92.94 Proposed | Coupled non-isolated hardware |

## 6.CONCLUSION

Full bridge DC-DC converter is isolated between the two sides through a transformer. The open loop and closed loop results are presented. This circuit is capable of performing DC-DC Conversion with high efficiency. Coupled inductor DC-DC converter in open loop operation with resistive load and DC motor load. The circuit configuration of the coupled inductor DC-DC converter is superior to the full bridge DC-DC converter. It is very simple, less in size, and less in space. In this work, the performance of the coupled inductor DC-DC converter with π filter that produces 90% higher efficiency are compared with the other converters. The coupled inductor DC-DC converter has higher step-up and step down voltage gains and lower average value of the switch current than the conventional bidirectional boost/buck converter. The hardware and simulation results are presented From the investigation, it has been found that the proposed nonisolated coupled inductor converter has better output voltage and efficiency than that of the conventional and full bridge converter.

## REFERENCES

[1] Lizhu, ; “A Novel Soft Commutating Isolated Boost Full Bridge ZVS- PWM Power DC-DC Converter for Bidirectional High Power Application”, IEEE Transactions on Power electronics, Vol. 21, No. 2. (2006)

[2] Sen P.C; “Thyristor DC Drives John Willey and Sons Incs(1981.

[3] PINHEIRO J., D Barbi i. “The Three-level ZVS-PWM DC-DC Converter”, IEEE Trans. Power Electron, Vol.8, No.4, (1993), pp. 486-492.

[4] Hai feng.fan, Hui li,, ;“High-Frequency Transformer Isolated Bidirectional DC–DC Converter Modules With High Efficiency Over Wide Load Range for

20 kVA Solid-State-State Transformer", IEEE Transactions on Power Electronics, Vol.26, No.13, (1996), pp.3599-3608.
[5] Ahmed elasser, David A.Torrey; "Soft Switching Active Snubbers for DC-DC Converters", IEEE Transactions on Power Electronics, Vol.11, No.5, (1996), pp. 710-722.
[6] Pritam das S. "Analysis and Design of a Non Isolated Bidirectional ZVS-PWM DC-DC Converter with Coupled Inductors", IEEE Transactions on Power Electronics, Vol. 25, No.10, (2010), pp. 2630-2641.
[7] Pritamdas, "A Non Isolated Bidirectional ZVS-PWM Active Clamped DC-DC Converter", IEEE Transaction on Power Electronics, Vol. 24, No. 2, (2009), pp. 553-558.
[8] RodriguesJ.P."Three-level Zero Voltage Switching Pulse-width Modulation DC–DC Boost Converter with Active Clamping", IEEE Power Electron., Vol. 3, No. 3, (2010), pp. 345-354
[9] .Seheng ye, Eric myer yan, Fei liu, Xiaodong liu, ;"Soft Switching Active Snubbers for dc-dc Converters", IEEE Transactions on Power Electronics, Vol.23, No.5, (2008), pp. 2363-2376..
[10] Simon ang,, Alejandro olira, "Power Switching Converters", CRC Press, Taylor and Transis Group. (2005),
[11] Tseng, C.J. Chen C.L. "A Passive Lose Less Snubber Cell for Non-Isolated PWM DC-DC Converters", IEEE Transaction Industrial Electron Vol.45, No.4, (1998), pp.593-601.
[12] Walker G.R., Sernia P.C."Cascaded DC–DC Converter Connection of Photo Voltaic Modules", IEEE Trans. Power Electron. Vol. 19, No. 4, (2004), pp 1130-1139.
[13] Wei chen, Ping rong, Zhengyu lu, ;"Snubber Less Bidirectional DC-DC Converter with New CLLC Resonant Tank Featuring in Minimized Switching Loss", IEEE transactions on Industrial Electronics, Vol. 57, No. 9, (2010), pp. 3075-3086.
[14] Xin kong, Ashwin.M.Khambadkone "Analysis and Implementation of a High Efficiency Interleaved Current Fed Full Bridge Converter for Fuel Cell Systems", IEEE Transaction Power Electron, Vol. 22, No. 2, (2007), pp. 543-550.
[15] Xinke wu.. "Low Voltage and Current Stress ZVZCS Full Bridge DC-DC Converter Using Center Tapped Rectifier Reset", IEEE on Industrial Electronics, Vol.55, No.3, (2008), pp.1470-1477.
[16] Yanhui xie, jing sun, James S. Freudenberg, "PowerFlowCharacterization of a Bidirectional Galvanically Isolated High-Power DC/DC Converter Over a Wide Operating Range", IEEE Transactions on Power Electronics, Vol.25, 1, No.1, (2010), pp. 54-66.
[17] Zhezhang, Ziwei ouyang., "Analysis and Design of a Bidirectional Isolated DC–DC Converter for Fuel Cells and Super capacitors Hybrid system", IEEE Transactions on Power Electronics, Vol.27, No.2, (2012), pp.848-859.

[18] Busquets monge S., "Voltage Balancing Control of Diode-clamped Multilevel Converters with Passive Front-ends", IEEE Trans. Power Electron, Vol. 23, No. 4(2008),, pp. 1751-1758.

[19] Caux S., Lachaize J. "Modelling and Control of Fuel Cell System and Sto;rage Elements in Transport Application", Elsevier, Journal of Process Control, Vol. 15, No. 4, (2005), pp. 481-489.

[20] Ching-jung tseng, Chern- lin chen, "Novel ZVT-PWMConverts with Active Snubbers", IEEE Transaction Power Electron, Vol.13 No. 5, (1998) pp. 861-869.

[21] Duan R.Y, Lee J.D ;"High-efficiency bidirectional DC-DC converter with Coupled Inductor", IET Power Electron, Vol.1, Iss.3, (2012), pp.115-123.

[22] Zhao J.F, JIang J.G, Yang X.W, AC–DC–D.C with isolated converter", IET on Power Electron, Vol.3, Iss.4, (2010), 472–479.

**Authors Biography**

**ELANKURISIL** is working as a Professor, Department of Electrical and Electronics Engineering, Adhiparasakthi Engineering College, Melmaruvathur, Chennai, Tamil Nadu India. He received the Bachelor degree in Engineering from the Madras University, Chennai, India in 1998 Master of Engineering and Ph.D in 2006 and 2014 from Sathyabama University, Chennai, India. He has been in the teaching field for more than fifteen years. His areas of interests are Power Electronics Converters and its applications, fuzzy controller and neural controller Microprocessor and Microcontrollers.

**SARAVANNAN** is working as an Assistant Professor, Department of Electrical and Electronics Engineering, university college of Engineering, panruti India. He received the Bachelor degree in Engineering from the Annamalai University, Chdmbaramai, India in 2002 Master of Engineering in 2005 from Sathyabama University, Chennai, India. He has been in the teaching field for more than ten years. His areas of interests are Power Electronics Converters and its applications, Microprocessors and Microcontrollers

**STALIN** is working as a Assistant Professor, Department of Petrochemical Technology, Anna University Tiruchirappalli, Tamil Nadu, India. He received the Bachelor degree in Engineering from the Bharathidasan University, Tiruchirappalli, India in 1999 Master of Engineering and Ph.D in 2003 and 2009 from NIT, Tiruchirappalli, India. He has been in the teaching field for more than five years. His areas of interests are Power Electronics Converters and its applications, fuzzy controller and neural controller Microprocessor and Microcontrollers and Renewable energy sources.

**MAHENDRA PERUMAN** is working as a Asst Professor, Department of Electrical and Electronics Engineering, Adhiparasakthi Engineering College, Melmaruvathur, Chennai, Tamil Nadu India. He received the Bachelor degree in Engineering from the Anna University, Chennai, India in 2007 Master of Engineering from the Anna University, Chennai, India in 2010 He has been in the teaching field for more than five years. His areas of interests are Power Electronics Converters and its applications, fuzzy controller and neural controller Control System, Digital Signal Processing Microprocessor and Microcontrollers.