# A Dual Stage Flyback Converter using VC Method

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**Abstract -** *This proposed work presents a control strategy for two stage fly-back converter. By using this two stage fly-back converter the instantaneous Voltage Control (VC) scheme is adopted to control the converter. The errors of the reference voltage and the feedback signal of the output voltage are compared. This compared output voltage is compensated with the PI controller with difference control strategy. By using this control strategy the output voltage of the PI controller is compared with the triangular wave to get the driving signals of the synchronous rectifier. This signal are used to shut down the driving signals or keep the driving signals on during the half cycle of the output voltage and by using this control strategy additional freewheeling power can be reduced. The circuit is simulated using MATLAB Simu-link.*

***Key Words***: *Fly back converter, voltage control method, PI controller.*

## 1. INTRODUCTION

Fly-back converter is used in both AC/DC and DC/DC conversion with a galvanic isolation between the input and output. In many ways, a dc-dc converter is the dc equivalent of a transformer. More precisely, the fly-back converter is just like a buck boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation.

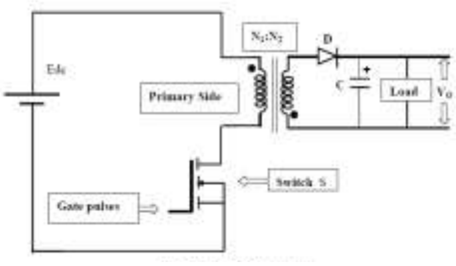


Fig: 1.1 Single stage fly-back converter

When MOSFET is switched on, current flows from the source to the primary winding N1 and energy is stored in the transformer's magnetic field. When the switch is turned off, the transformer tries to maintain the current flow through N1 by suddenly reversing the voltage across it generating a fly-back pulse. When the switch is chosen to have a very high breakdown voltage, through, so current simply cannot be maintained to the primary circuit .but because of the transformer action an even higher fly-back pulse is induced in the secondary winding N2 and here diode D1 is able to conduct during the pulse, delivering current to the load and recharging filter capacitor C1.

The fly-back converter again has two distinct phases in its switching cycle. During the first phase switch conducts and energy is store in the transformer core through the primary winding N1. Then in the second phase when switch is turned off, the stored energy is transformed into the load and C1 through the secondary winding.

DC to DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage declines as its stored power is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing.

The commonly used fly-back converter requires a single controllable switch like, MOSFET and the usual switching frequency is in the range of 50 kHz. A two-switch topology exists that offers better energy efficiency and less voltage stress across the switches. Input to the circuit may be unregulated dc voltage derived from the utility ac supply after rectification and some filtering. The ripple in dc voltage waveform is generally of low frequency and the overall ripple voltage waveform repeats at twice the ac mains frequency.

Since the fly-back converter circuit is operated at much higher frequency the input voltage, in spite of being unregulated, may be considered to have a constant magnitude during any high frequency cycle. A fast switching device, like a MOSFET, is used with fast dynamic control over switch duty ratio (ratio of ON time to switching time-period) to maintain the desired output voltage.

### *A. Mode-1 of Circuit Operation*.

Fig1.2 shows the current carrying part of the circuit and the circuit that is functionally equivalent to the fly-back circuit during mode-1. In the equivalent circuit

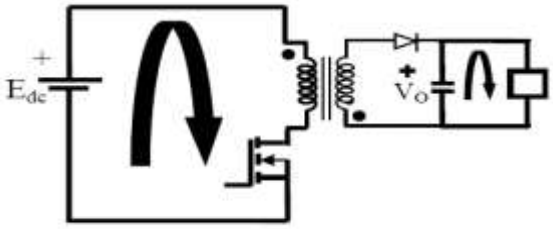


Fig 1.2 Current flow path during Mode 1 and equivalent circuit

Under Mode-1, the input supply voltage appears across the primary winding inductance and the primary current rises linearly is shown, the conducting switch or diode is taken as a shorted switch and the device that is not conducting is taken as an open switch. This representation of switch is in line with our assumption where the switches and diodes are assumed to have ideal nature, having zero voltage drops during conduction and zero leakage current during off state.

### *B. Mode-2 of Circuit Operation*

Mode2 starts when switch 'S' is turned off after conducting for some time. The primary winding current path is broken and according to laws of magnetic induction, the voltage polarities across the windings reverse. Reversal of voltage polarities makes the diode in the secondary circuit forward biased.

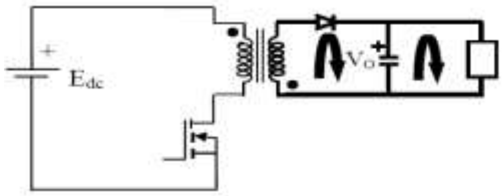


Fig 1.3 Current flow path during Mode 2 an equivalent circuit

### *C. Mode-3 of Circuit Operation*

Mode2 ends with turn ON of switch 'S' and then the circuit again goes to Mode-1 and the sequence repeats. The equivalent circuit during mode-3 of circuit operation. It may be noted here that even though the two windings of the fly-back transformer don't conduct simultaneously they are still coupled magnetically (linking the same flux) and hence the induced voltages across the windings are proportional to their number of turns.

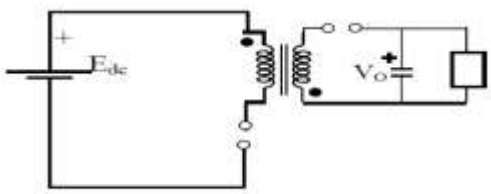


Fig 1.4 Current flow path during Mode3 and equivalent circuit

## 2. Two stage fly-back converter using synchronous rectifier

Most DC to DC converters are designed to move power in only one direction, from the input to the output. A bi-directional converter can move power in either direction, which is useful in applications requiring regenerative braking. One of the important features of DC-DC converters is the use of synchronous rectification which replaces the flywheel diode with a power MOSFET with low "On" resistance, thereby reducing switching losses.

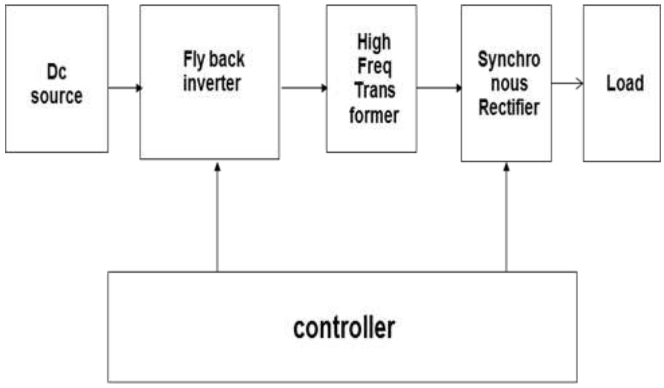


Fig 2.1 Block diagram of Fly-back converter

The DC supply is given to the fly-back inverter, the primary winding of the fly-back transformer is directly connected to the input dc voltage. Fly back Inverter is used to convert dc to ac voltage. By using this fly-back inverter the phase shift pulse method is used to control the inverter. It is directly connected to the fly-back transformer. High frequency transformer is used for step down purpose. The transformer size should be small due to high frequency. It is also used for isolation purpose. Fly-back transformer works differently from a normal transformer.

In a normal transformer, under load, primary and secondary windings conduct simultaneously such that the ampere turns of primary winding is nearly balanced by the opposing ampere-turns of the secondary winding (the small difference in ampere-turns is required to establish flux in the non-ideal core).but in fly-back transformer energy is stored in the transformer. Synchronous rectifier is used as a voltage-controlled resistor in a control loop which adjusts the Synchronous rectifier's resistance so that the output voltage is maintained within the regulation range.

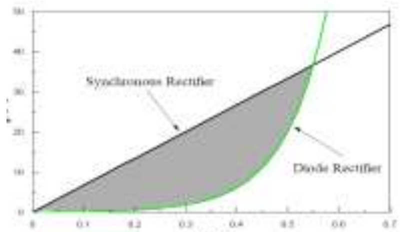


Fig 2.2 V-I characteristics of the synchronous rectifier

With properly designed gate drives. During the time switch Q1 is turned on, energy is stored in the transformer magnetizing inductance and transferred to the output after Q3 is turned off. The figure2.3 shows the two fly-back converters with synchronous rectifier which is operated alternately. This fly-back converter consists of four operation modes.

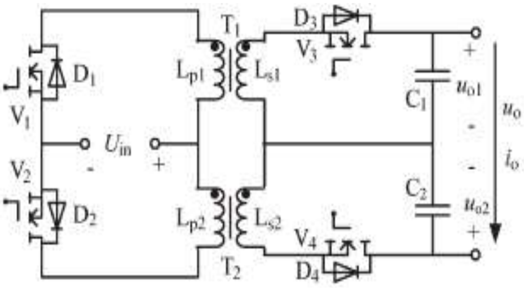


Fig 2.3 circuit diagram of two stage fly-back converter

***Mode A: When uo > 0 and i o > 0***

The two fly-back converters are working in mode A. Switch *V*1 is in the high frequency- modulation mode; *V*3 is working as a diode (the anti parallel diode) or a synchronous rectifier (SR). While switch *V*2 is off and *V*4 is on, converter II does not work. The output voltages of converters I and II are *uo*1 and 0, respectively. The inverter's output voltage, i.e., *uo*, is equal to *uo*1.

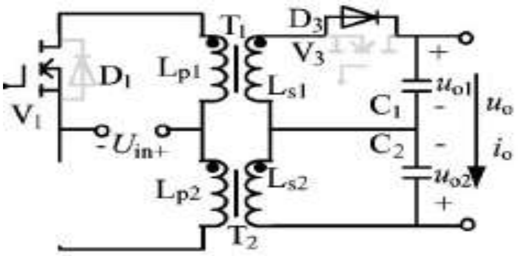


Fig 2.4 Mode A circuit diagram of two stage fly-back converter

***Mode B: When uo < 0 and i o > 0***

The two fly-back converters operation are in mode B. Switch V4 is working in the high frequency- modulation mode; V2 is working as a diode. While switch V1 is off and V3 is on, converter I do not work.

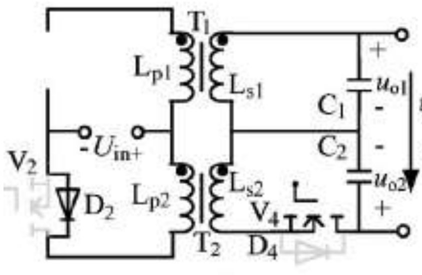


Fig 2.5 Mode B circuit diagram of two stage fly-back converter

***Mode C: When uo < 0 and io < 0***

The two fly-back converters operation are in mode C. Switch *V*2 is in the high-frequency modulation mode; *V*4 works as a diode. On the other hand, converter I do not work. The output voltages of converters I and II are 0 and *uo*2, respectively. The output voltage of the inverter is *uo* = −*uo*2. The freewheeling power is also 0.It shows the equivalent circuit.

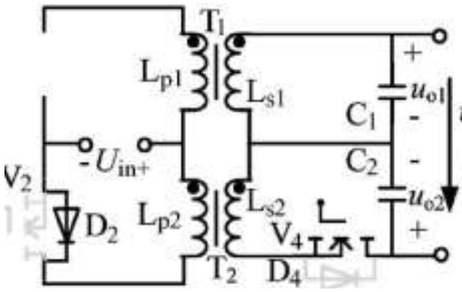


Fig 2.6 Mode C operation of two stage fly-back converter

***Mode D: When uo > 0 and i o < 0:***

The inverter is working in mode D. Switch *V*1 is in the high-frequency modulation mode; *V*3 is working as a diode. On the other hand, converter II does not work. The output voltages of converters I and II are *uo*1 and 0, respectively.

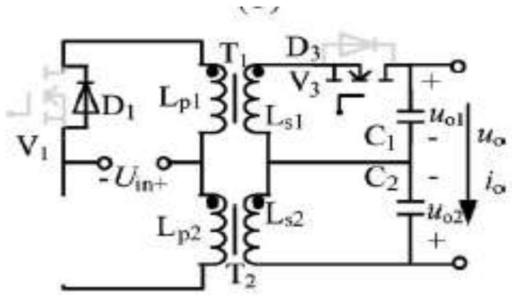


Fig 2.7 Mode D operation of two Stage fly-back converters

The fly-back transformer is used for voltage isolation as well as for better matching between input and output voltage and current requirements. Primary and secondary windings of the transformer are wound to have good coupling.

## 3. PI CONTROLLER

A PI Controller (proportional-integral controller) is a feedback controller which drives the plant to be controlled with a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. PI controllers are used for the closed loop system. The output voltage is compared with the triangular wave by using conditional operator. The output pulses of this pi controller are given to synchronous rectifier. This output pulses are used for synchronous rectifier to generate the pulses with 180 phase shift.

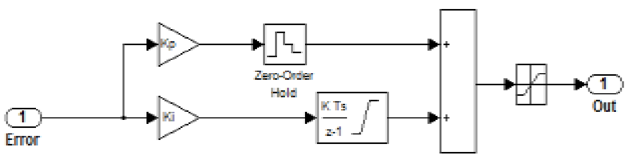


Fig 3.1 Simulink model of PI Controller

### A. Simulation results of two stage fly-back converter

The input dc supply is given to the fly-back inverter which converts dc to ac voltage by using the fly-back transformer. The primary of the fly-back transformer is directly connected to the input dc voltage. The main advantage of this fly-back transformer is it stores the energy when compared to the normal transformer.

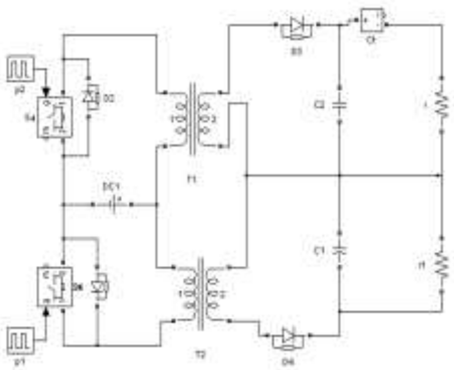

Fig 4.1 Open loop circuit diagram of two stage fly-back converter

When the switch is chosen to have a very high breakdown voltage, through, so current simply cannot be maintained to the primary circuit .but because of the transformer action an even higher fly-back pulse is induced in the secondary winding N2 and here diode D1 is able to conduct during the pulse, delivering current to the load and recharging filter capacitor C1.The fly-back converter again has two distinct phases in its switching cycle. The waveform shows the input voltage of the dc-dc converter with two stage fly-back converter is 24v.The primary winding of the fly-back transformer is directly connected to the dc input voltage.

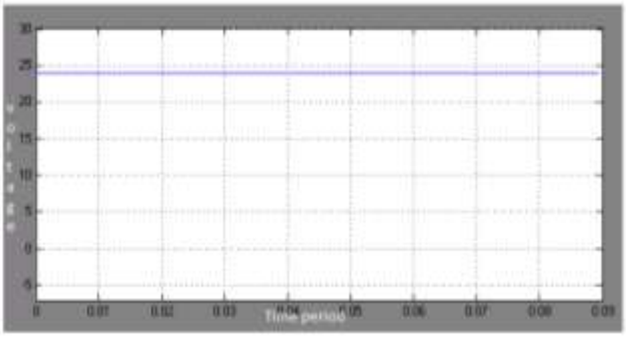

Fig 4.2 Input voltage

### *B. Triggering pulses*

The waveforms which are shown below are the triggering pulses of the MOSFET's Sa and Sb. The pulse width which are given for the triggering pulse p1 is 25% and the phase delay is zero and the pulse width which are given for the triggering pulse p2 is 25% and the phase delay is 0.01e-3.So for the two MOSFETs Sa and Sb the phase shift is 180.the amplitude of these triggering pulse is 1 which is shown in the waveforms that is voltage verses time period.

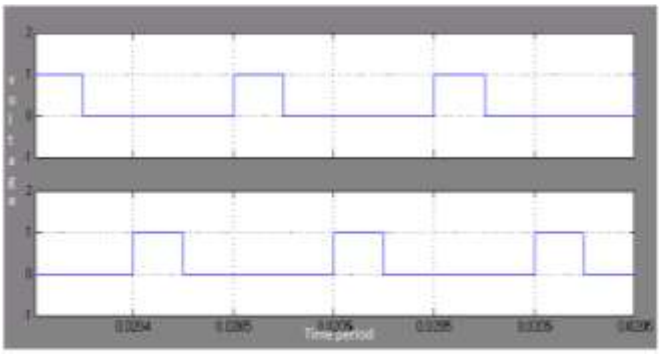

Fig 4.3 Triggering pulses of the fly-back inverter

### *C. Output voltage of fly-back converter 1*

The waveform shows the output voltage of the fly-back converter1 where the input voltage is 24v it has been boosted to 35v.so it is a boost converter. The waveform shows the voltage verses time.

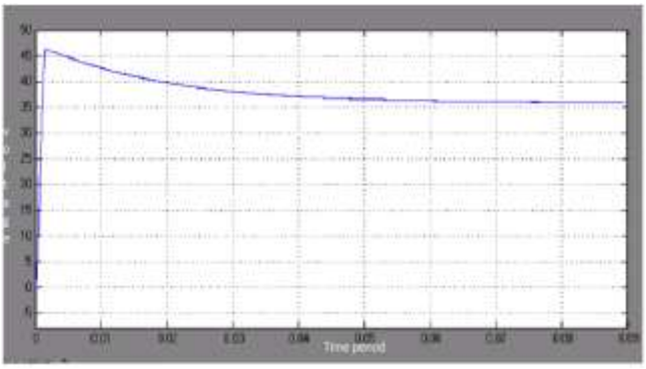

Fig 4.4Output voltage of converter 1

***D. Output voltage of fly-back converter 2***

The waveforms shows the output voltage of the fly-back converter2 where the input voltage is 24v it has been boosted to 35v.soit is a boost converter. The waveform shows the voltage verses time.

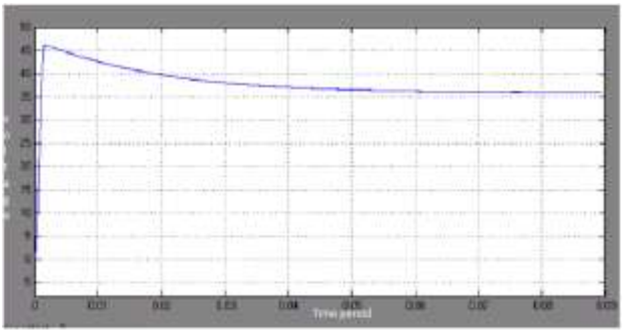

Fig 4.5 Output voltage of converter 2

***F. Closed loop circuit of the two stage fly-back converter***

The circuit diagram shows the closed loop control of the two stage fly-back converter. Here in this closed loop controller 5v disturbance is given in the input voltage. Total 29v is given in the input voltage with disturbance. By giving the set voltage 35v. The output voltage is maintained as 35v.The errors of the reference voltage and the feedback signal of the output voltage are compensated with a PI compensator. The Output signal of the PI compensator compares with a triangular wave to get the pulse signals of the two switches. The pulses are given to these switches with 180 phase shift.

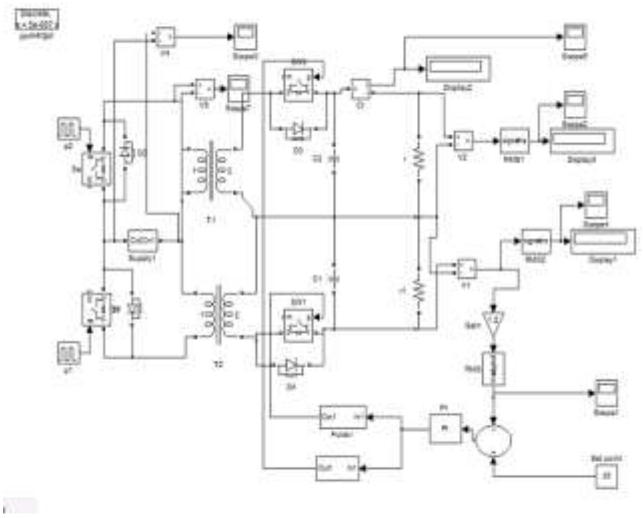

Fig 4.7 closed loop circuit of two stage fly-back converter

***G. Input voltage with disturbance***

The waveform shows the input voltage with disturbance. The input voltage of these fly back converters is 24v where the disturbance given in the input is 5v, so the voltage is increased to 29v, means that the steady state error is introduced from 24v to 29v.disturbance means change in the supply voltage.

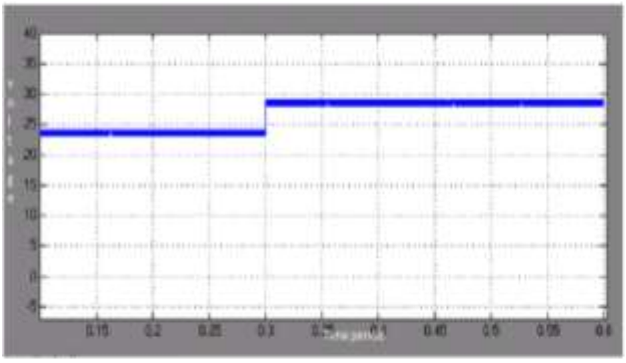


Fig 4.8 Input voltage with disturbance

***H. Output voltage with disturbance***

The waveform shows the closed loop output voltage of the two fly-back converters. Where the set voltage is 35v and the output voltage of these flyback converters is 35 when the disturbance is given as 5v.

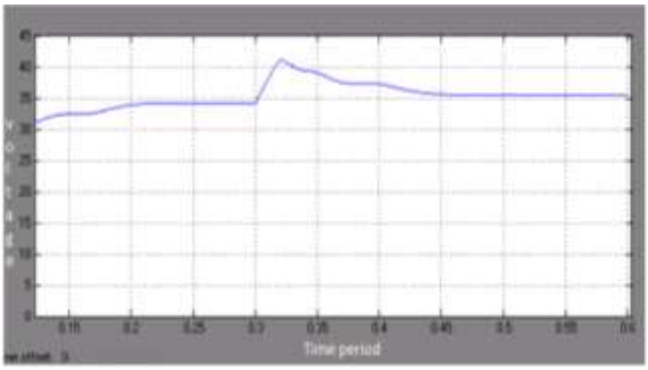


Fig 4.9 Output voltage of closed loop controller

**4. CONCLUSION**

The two stage fly-back converter for the instantaneous voltage control scheme is adopted to control the dc output voltage. The errors of the reference voltage and the feedback signal of the output voltage are compensated with the PI controller. The output signal of the PI controller compares with a triangle wave to get the driving signals of the two switches. The output signal of the comparator is a square wave that has the same frequency and phase angle with the reference voltage. These triangular carrier waves are used to generate the driving signals on during the half cycle of the output voltage.

**REFERENCES:**

[1] Dhinesh.V, "Online Grid Integrated Photovoltaic System with New Level Inverter System" in (IRJET) International Research Journal of Engineering and Technology, Volume 5, Issue 12, December 2018, Page. No. 1544-1547.

[2] Raja.R, Nagarajan.C "Performance Analysis Of LCL-T Filter Based 2 Stage Single Phase Gird Connected Module With ANN Controller Using PV Panel" in (CSTT) Current Signal Transduction Therapy Volume 13, Issue 2, September 2018, Page. No. 159-167. ISSN (Print): 1574-3624, DOI: 10.217 4/1574362413666180223124608, http://www.eurekaselect .com/160064 /article.

[3] Dhinesh.V, "Design of a Boost-Buck Converter Fed PMDC Motor" in (ESTIJ) Engineering Science and Technology-An International Journal Volume 3, Issue 4, August 2013, Page. No. 719-725.

[4] Raja.R, Nagarajan.C "Designing of LCL Filter and Stability Analysis of a Three Phase Grid Connected Inverter System" in (IJSETR), International Journal of Science, Engineering and Technology Research Volume 5, Issue 1, January 2016, Page.No.306-312. ISSN: 2278 – 7798, http://ijsetr.org/wp-content/uploads/2016/01/IJSETR-VOL-5-I SSUE-1-306-312.pdf.

[5] Dhinesh.V, "Design of Non Isolated Voltage Doubler Fed with Sepic Converter" in (IJAIR) International Journal of advanced and innovative research Volume 3, Issue 11, November 2014, Page. No. 124-129.

[6] S.Karthick "Step up DC-DC Converter with high voltage gain using switched inductor techniques", International Journal Of Innovative Research in technology Volume 2, Issue 9, ISSN: 2349-6002,Feb 2016.

[7] Raja.R, Nagarajan.C "Analysis of Grid Inverter System Using LCL Filter Based on Active and Passive Damping Methods" in (IJIRSET), International Journal of Innovative Research in Science, Engineering and Technology Volume 4, Special Issue 6th May 2015, Page.No.1244-1253. ISSN (Print): 2347 – 6710, http://www.ijirset.com/upload/2015/m ulticon/eee/33_RC.pdf.

[8] Dhinesh.V, "Soft Switching with Cascaded Transformers to Drive the PMDC Motor" in (IJAREEIE) International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Volume 4, Issue 2, February 2015, Page. No. 787-794.

[9] Raja.R. "An Efficient High-Step-Up Interleaved with a Common Active Clamp DC–DC Converter for Electric Vehicle" in (IEEE), Institute of Electrical and Electronics Engineers Explore on 10th to 12th April 2013, Page.No.760-764.DOI: 10.1109/ICEETS.2013.6533480, https://ieeexp lore.ieee.org/document/6533480.

[10] S.Karthick "High Step-Up DC-DC Converter Based on Voltage Multiplier Cell and Voltage-Stacking Techniques for Renewable Energy Applications", International Research Journal of Engineering and Technology Volume 5, Issue 11, e-ISSN: 2395-0056,Nov 2018

[11] Raja.R. "Performance of Variable Frequency ISPWM Technique for a Cascade Multilevel Inverter" in (IEEE), Institute of Electrical and Electronics Engineers Explore on 10th to 12th April 2013, Page.No.611-616. DOI: 10.1109/ ICEETS.2013.6533455, https://ieeexplore.ieee.org/docum ent/ 6533455.

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