Speed Control of Dc Motor Using Z-Source DC-DC Converter

Karthika Nair[1], Prof. A S Shajilal[2]

PG Scholar, Department of Electrical and Electronics Engineering, Mar Baselios College of Engineering and Technology, Kerala, India[1]

Professor & Head of Department, Department of Electrical and Electronics Engineering, Mar Baselios College of Engineering and Technology, Kerala, India[2]

ABSTARCT: This paper presents analysis of a novel high step up z-source based dc-dc converter that has higher voltage gain than the z-source converter. Compared with the conventional Z source dc-dc converter, the proposed converter can obtain higher voltage gain with lower voltage stresses of switch and the impedance network capacitor and operate with wide-range load. Therefore, the proposed Z-source dc-dc converter not only has lower cost but also has smaller weight and size. The Z-source converter can be employed as dc-dc converter to boost the PV panel voltages. It also offers other advantages, such as clamped switched voltage, high voltage gain, isolation of energy source from the load and positive polarity for output voltage. Therefore, this is a good choice for high step-up applications.The proposed dc-dc converter is evaluated experimentally for converting 24 V DC input to 300 V DC output at 100W and to validate the simulation results.

KEYWORDS: Z-Source Converter, Photovoltaic, High-step up application, DC-DC converter.

I. INTRODUCTION

Nowadays, the pollution issues caused by fossil fuels have adverse influences on the planet. Climate change imposes a global threat to the economic and social development of the societies. The Kyoto Protocol was one of the first environmental acts to reduce the rate of carbon emissions due to human activities. The main reason behind the excessive carbon emissions is the excessive combustion of fossil fuels. Therefore, fossil fuels problems can be counted as following:

- Giant amounts of carbon dioxide are released into the atmosphere.
- Carbon dioxide leads to greenhouse effect or the global warming.
- Coal-burning stations release Sulfur dioxide gas which causes to acid rain.
- Fossil fuels supplies are limited and are not renewable.

Therefore, renewable energy sources such as fuel-cells and solar panels are employed to generate electrical energy. On the other hand, renewable energy sources can be relied on for the long-term. They can be cost-effective and efficient. PV cells are attractive since they solar energy directly to electrical energy. However, they generate the low output voltage and the higher voltage is needed for grid-connected inverters, so the demand of using high step-up dc-dc converters is increased. The conventional solution was to use the several PV cells in series, however, because of the module mismatch and shadow effect of PV cells, the output power is decreased. Furthermore since several solar panels need to be used in this method, the total cost is increased and the efficiency is decreased. Another solution to this problem is to use a high step-up dc-dc converter to boost the output voltage of solar panels. One of the main advantages of z-source dc-dc converter is its larger dc voltage gain, in comparison to the common dc-dc converters, such as the boost converter. Therefore, it may be a good choice for high step-up application such as photo-voltaic.Furthermore, high efficiency, low device voltage stress and wide voltage gain range make it a good candidate for photo-voltaic and high voltage step-up applications. Also, by choosing appropriate turns ratio of the coupled inductors, the proposed converter can be used for a wide range of voltage gain.

II. Z- SOURCE CONVERTER

Z-source converter has been proposed by Fang ZhengPeng in 2002. It can be used for DC-to-DC, DC-to-AC, AC-to-DC and AC-to-AC power conversion purposes. Here Z-source DC-DC converter is considered for the applications that need a high step up DC-DC converter to boost up the DC voltage. Figure 1 indicates the general structure of z-source converter.

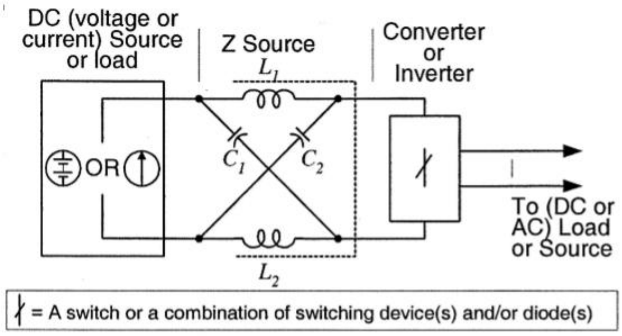

Fig. 1 Z-source converter structure

Low output voltage energy sources like fuel cells and PV cells need a high step up DC-DC converter to boost the voltage and also to provide a protection buffer between the load and energy source. Figure 2 shows z-source converter topology.

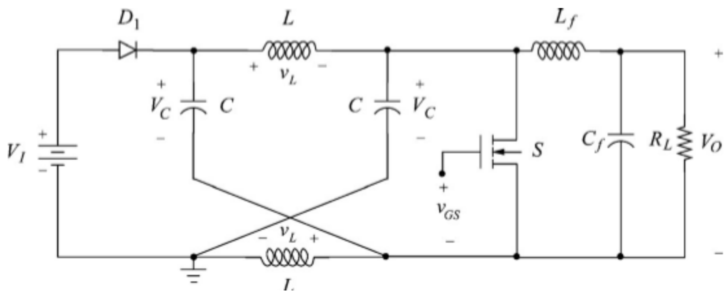

Fig. 2 Z Source Converter topology

Some of z-source converter advantages in comparison to the conventional boost converters are as below:

- Z-source dc-dc converter voltage gain in more than boost converter.
- Energy source and load side are isolated from each other for the situation that short-circuit or any disturbance is happened in the load side, since the input diode (D_1) is off when the switch S is on. It is awesome for converter safety in case that the input energy source, fuel or PV cell, is expensive.
- It has second order filter at the output.
- Based on the voltage gain expression, for D > 0.5, the output voltage is inverted, so it can be used where such a feature is needed.

III. HIGH STEP-UP Z-SOURCE DC-DC CONVERTER WITH FLYBACK AND VOLTAGE MULTIPLIER

Now a day's pollution problem caused by fossil fuels has lead more investigations on renewable energy systems. But P-V cells and fuel-cells output low level voltage than required therefore, high gain dc-dc converters are used to boost this low voltage. The Z source converter can be employed as dc-dc converter to boost the PV panel voltages. Z source converter is a power conversion topology that can both buck and boost the input voltage using passive elements.

Figure 3 shows the proposed converter topology. As it is shown in this figure, this converter is formed by combining the z-source converter with the fly-back converter and voltage multiplier method. So two coupled inductors are used instead of the z source network inductors. Also the voltage multipliers are used in the output to increase the voltage gain. In the proposed converter, the voltage pulses across the coupled inductors are used to increase the output voltage of the converter and therefore to increase the voltage ratio. So these pulses charge the output capacitors C_{o2} - C_{o5} through diodes D_{o2} - D_{o5} and it causes to increase the output voltage since these capacitors are settled in series at the output.

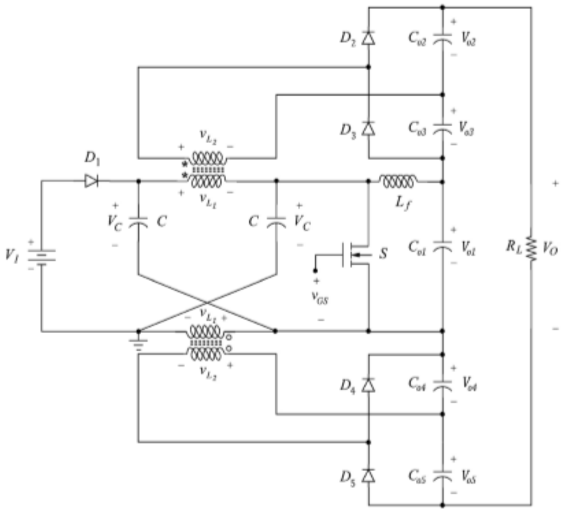

Fig. 3 Proposed Converter Topology

IV. OPERATION PRINCIPLE OF THE PROPOSED CONVERTER

Operation principle of the z-source part of the proposed converter is similar to the operation principle of the z-source converter that was explained in the chapter one. So it is focused on the parts that have been added to form the proposed converter. Since it includes one main switch, the operation principle of this converter is divided to two time intervals. One of them for the switch on time and the other one for the switch off time. First, the operation principle of the proposed converter is analysed for the time that switch is on, and then switch off time. Capital letter D indicates duty cycle of the main switch S.

1) $0 \leq t \leq DT$

This operation mode is started when active switch S is turned on. Then the input diode D_1 is turned off. So the main active switch S and the input diode of the proposed converter operate in the complementary manner. Then, the capacitors C voltage is applied across the inductors L_1 and since this voltage is positive and constant, inductors L_1 current are increased linearly and with a constant slope.

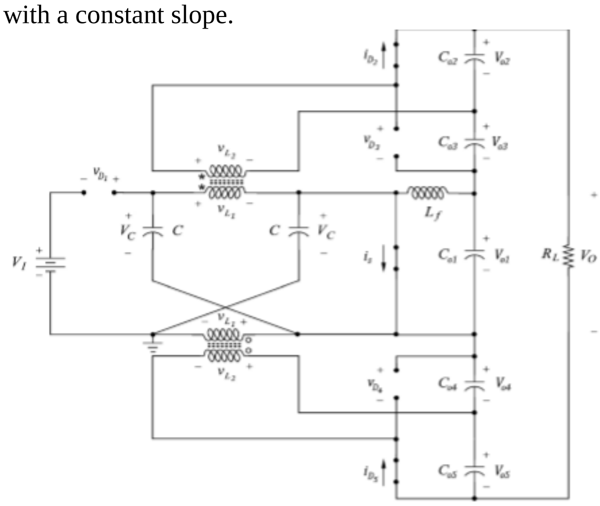

Fig. 4 Equivalent circuit of the proposed converter when the switch is ON

The turn ratio of the couple inductors L_1 and L_2 is defined as $= \frac{n1}{n2}$, therefore, n times of the voltage across inductors L_1 is applied across inductors L_2. This cause the D_2 and D_5 to be turned on. So the capacitors C_{o2} and C_{o5} are charged in this time interval. When the diodes D_2 and D_5 are turned on, the negative voltage is applied across diodes D_3 and D_4 and makes these diodes to be turned off. Since the filter inductor L_f voltage is negative in this operation mode, the inductor current is decreased linearly and its energy is lost. Figure 4 shows the proposed converter equivalent circuit in the first operation mode when the active switch S is on.

2. DT ≤ t≤T

This operation mode is started when the active switch S is turned off. Then the voltage across it keeps increasing till the input diode D_1 is turned on. So the voltage across the switch (the switch stress voltage) is clamped. As it is mentioned earlier, the input diode D_1 and switch S operate in complementary manner. Since the input diode D_1 is on, the input source supplies energy, therefore the power is supplied to the converter in this operation mode. Also since the proposed converter has an input diode, the input current of this converter is not continuous.

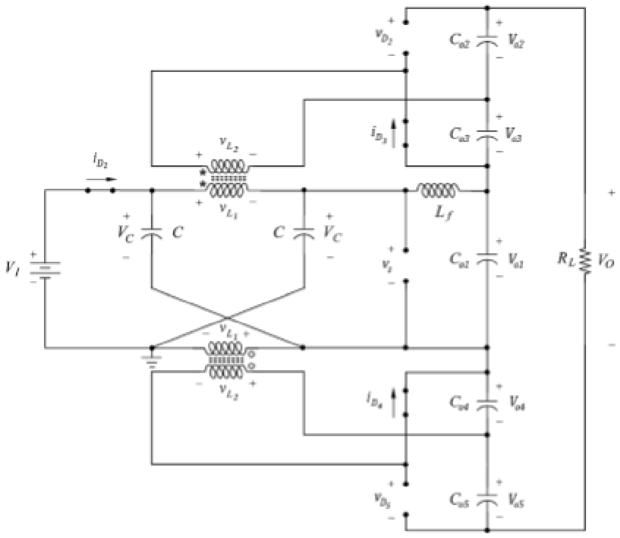

Fig. 5 Equivalent circuit of the proposed converter when the switch S is OFF

In this operation mode, the voltage across inductors L_1 is negative, so this negative voltage is induced across inductors L_2 and then diodes D_3 and D_4 are turned on. Therefore, capacitors C_{o3} and C_{o4} are charged in this operation mode. The voltage across diodes D_1 and D_5 is negative, so they are off in this operation mode. Furthermore capacitors C and the filter inductor Lf are charged in this mode. These set of equations can be written for this operation mode.

V. RESULT AND DISCUSSION

Photovoltaic (PV) power systems are becoming increasingly important in modern electrical grids. In recent years, PV power systems have drawn significant research attention in modelling and simulation studies for stand-alone and grid-tied systems. Simulation based implementation is being widely popular in research, especially for large scale analysis. PV module is the basic building block to construct the PV systems. In terms of power electronics the solar cell can be considered as a current source that exhibits non-linear characteristics. It was applied to develop a 250W PV module in order to simulate its behaviour. The results were compared to the original characteristics curves. This model can generate the I-V and P-V characteristics of the PC cell and module.

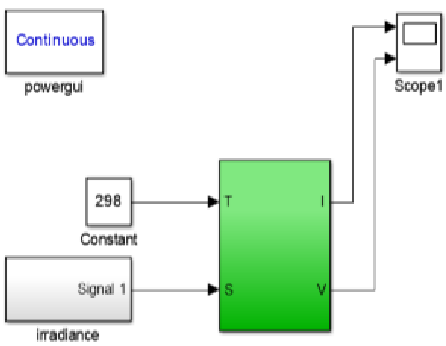

Fig. 6 Simulation diagram of PV module

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 9, Issue 5, May 2020||

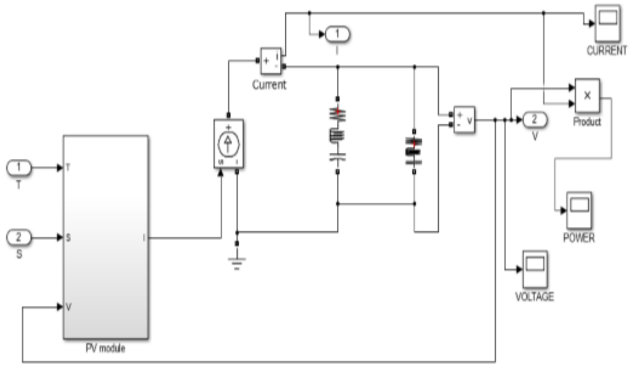

Fig. 7 Circuit diagram of subsystem

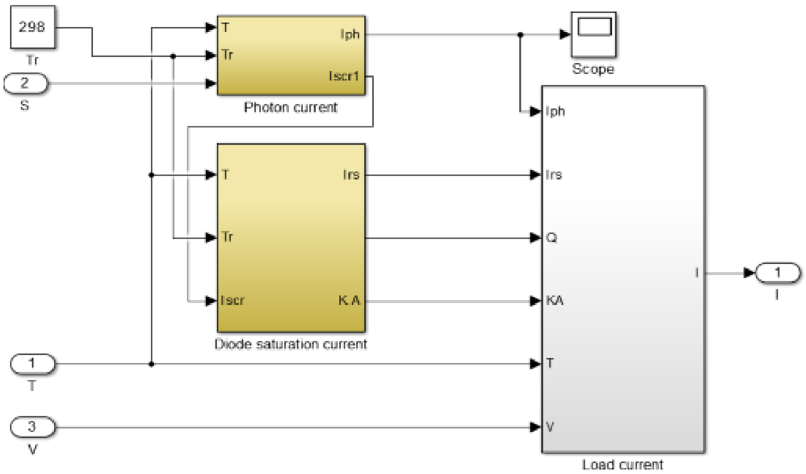

Fig. 8 Simulation diagram of PV subsystem

The I-V and P-V curves are typically passes through the following parameters:

Short-circuit current (I_{sc}): It is defined as the maximum current that can be produced by solar cell when its terminals are shorted. The maximum current depends on generation of electron-hole pair of P-N junction when the radiation falling on the solar panel.

Open-circuit voltage (V_{oc}): It is the maximum voltage produced by solar cell when its terminals are open. The maximum current depends on generation of electron-hole pair of P-N junction when the radiation falling on the solar panel.

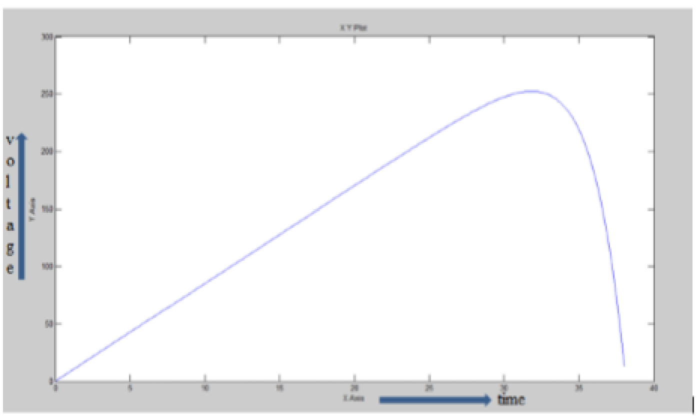

Fig. 9 Voltage characteristics

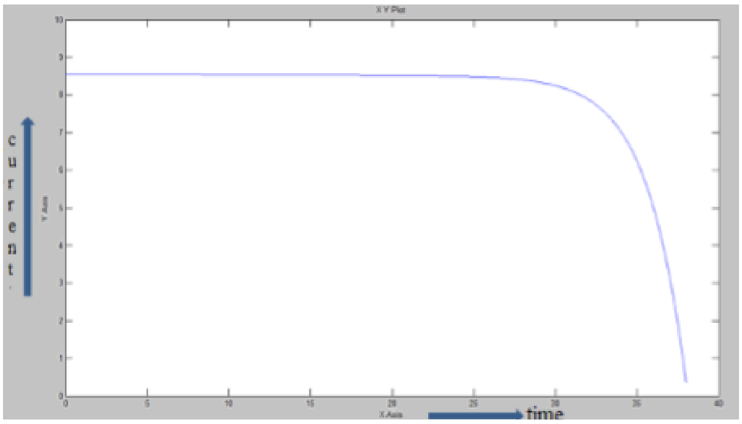

Fig. 10 Current characteristics

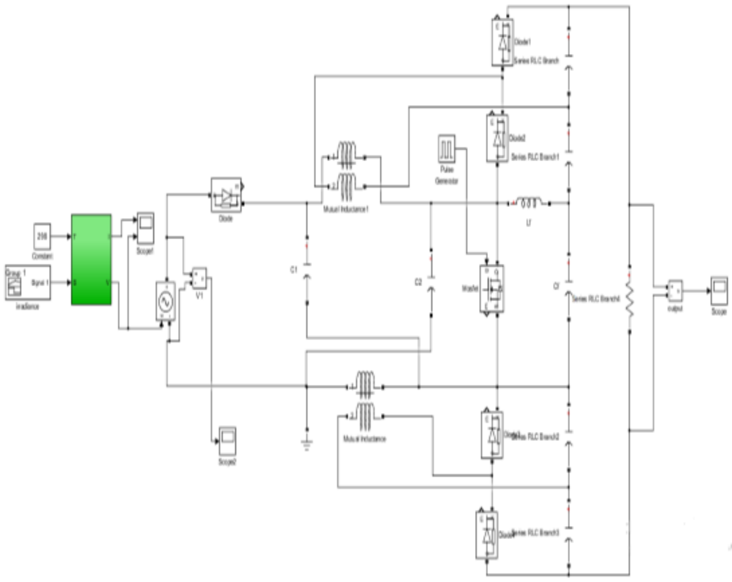

Fig. 11 Simulation of Proposed Z source converter

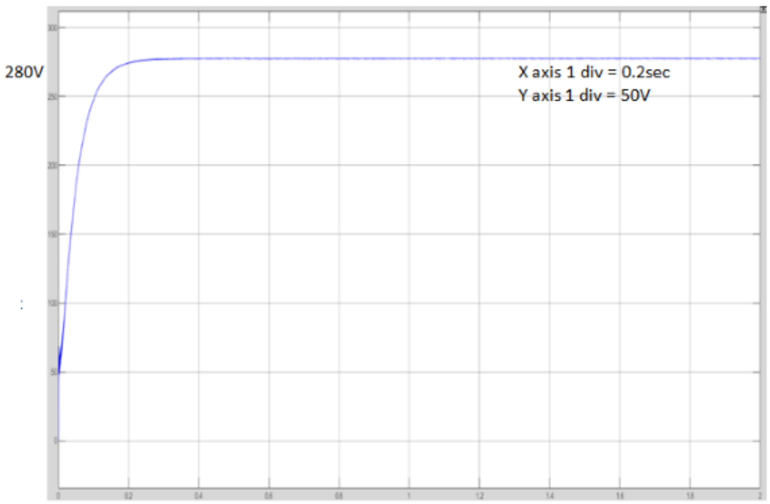

Fig. 12 Output graph of Proposed Z source converter

Table I. Parameter specifications of proposed Z source Converter

PARAMETERS	VALUE
Input Voltage	24 V
Output Voltage	160V
Switching frequency (f_{sw})	100KHz
magnetizing inductances	357 µH
L_f	600 µH
Capacitors C	220 µF
Duty cycle	0.4
Capacitors C_{o1},C_{o2},C_{o3},C_{o4},C_{o5}	47 µF

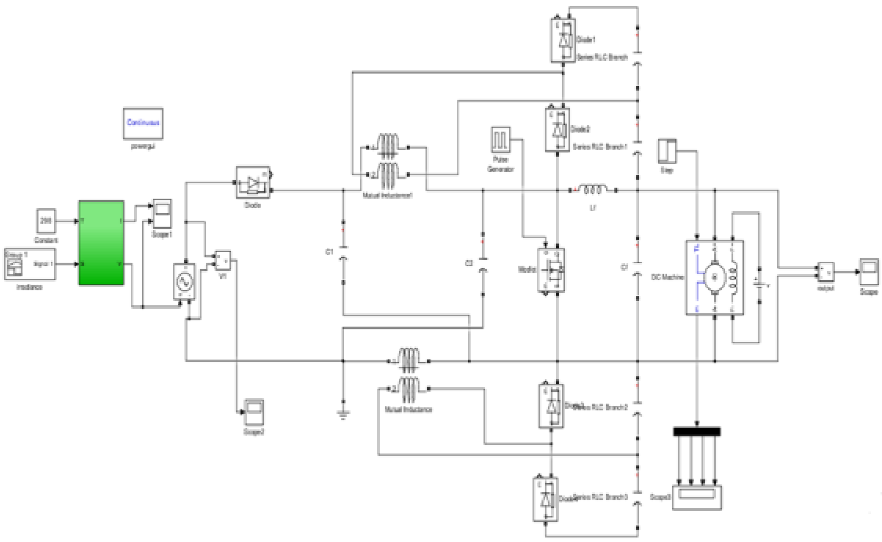

Fig. 13 Speed control of separately excited DC Motor using Z source converter

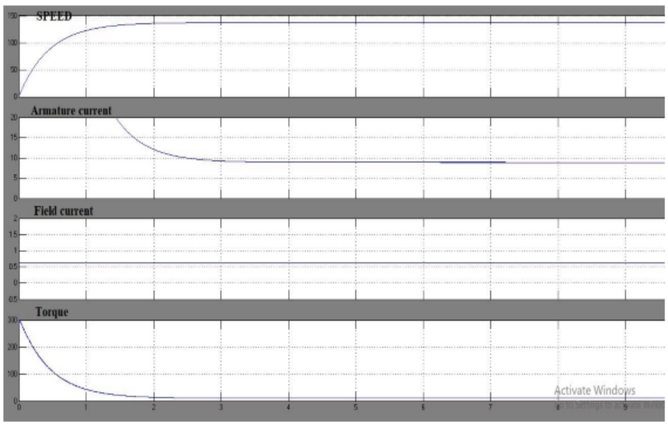

Figure: 14 Output graph

VI. CONCLUSION

An attempt has been made to develop a PV model in MATLAB/SIMULINK environment, and solar insolation one may get the different output voltage and current from PV panel. Also, it is clear that, this model can be modified for any rated voltage and current by changing the values of solar constant. The output voltage and current from PV decreases, as the irradiance decreases. Moreover, increase in temperature leads to decrease in performance, from the PV Model. But, by changing the solar constant, the performance of the PV model is good when compared to increase of temperature. Z source converter is a power conversion topology that can both buck and boost the input voltage using passive elements. A main advantage of z-source dc-dc converter is its larger dc voltage gain, in comparison to the common dc-dc converters. A modified Z-source dc-dc converter is proposed in this paper. Compared with the conventional Z-source dc-dc converter, the proposed converter can obtain higher voltage gain with lower voltage stresses of switch and the impedance network capacitor and operate with wide-range load. Therefore, the proposed Z-source dc-dc converter not only has lower cost but also has smaller weight and size. It eliminates the problem of complexity and large duty cycle in conventional high step-up converters. Furthermore, our converter has high efficiency, low semiconductor device voltage stress and a wide range of voltage gains. This is achieved by choosing proper coupled inductor turns ratio that makes it a good candidate for high step-up applications. This includes photo-voltaic applications, by increasing the low voltage of the solar panels, or maximum power point tracking and droop control in micro grid applications. The future scope of this paper can be further expanded by using MPPT Algorithm.

REFERENCES

[1]. F. Evran and M. T. Aydemir, “Z-source-based isolated high step-up converter,” IET Power Electronics, vol. 6, no. 1, pp. 117–124, 2013.

[2]. S.-M. Chen, T.-J. Liang, L.-S. Yang, and J.-F. Chen, “A safety enhanced, high step-up dc–dc converter for ac photovoltaic module application,” IEEE Transactions on power electronics, vol. 27, no. 4, pp. 1809–1817, 2012.

[3]. Y.-P. Hsieh, J.-F. Chen, T.-J. Liang, and L.-S. Yang, “Analysis and implementation of a novel single-switch high step-up dc-dc converter,” IET Power Electronics, vol. 5, no. 1, pp. 11–21, 2012.

[4]. W. Li and X. He, “Review of non-isolated high-step-up dc-dc converters in photovoltaic grid-connected applications,” IEEE Transactions on Industrial Electronics, vol. 58, no. 4, pp. 1239–1250, 2011.