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Designing Of A Modified Sepic Based Dc –Dc Converter For Renewable Energy Applications

[1]Mr. Prathamesh Sukhadev More, [2]Mrs.S. P. Diwan,

[1]Post Graduate Student, [2]Assistant Professor,

[1]Electrical Engineering Department

[1]Walchand College of Engineering sangli,India

Abstract: This Paper proposes a modified SEPIC Based DC –DC converter For renewable Energy Applications. In that DC-DC Boost converter is used. SEPIC converter work as a buck-boost both operations can perform as per required output. The SEPIC converter output is non-inverted and is controlled to take out the maximum power from a Photovoltaic (PV) array. In the design of SEPIC converter perturb and observe algorithm control technique is used for maximum power-point tracking. It is also used to get the appropriate duty ratio SEPIC converter switch. The proposed system is simulated using the MATLAB/Simulation software.

Index Terms **- DC-DC Converter, PV array, MPPT, SEPIC Converter, MATLAB/SIMULINK.**

I. INTRODUCTION

Renewable energy sources such as photovoltaic (PV) panels and fuel cells (FCs) have attracted the attention of most researchers. Renewable energy sources are more advantageous than fossil fuels because of their abundance, pollution-free and sustainability. However, application of renewable energy sources has some limitations due to their output characteristics. For instance, the low output voltage of the PV panels must be boosted to be suitable for grid integration. Output voltage and power regulations of FCs are another issue that must be addressed.

Therefore, power converters are the best solution for these challenges. The output voltage of the PV panels and FCs is a low .Therefore, a step-up DC/DC converter is needed to boost and regulate the voltage. The new boost DC-DC converter which has a high voltage conversion gain. Then, the increased voltage can be feed to grid via an inverter. One can suggest the series connection of the PV panels, but there will also be several problems such as partial shading issue[1].Another challenge for these DC/DC converters is their input current characteristics. For each pv panel maximum power point tracking is required. In order to realize MPPT, the converter should have a continuous input current. FCs are also required to have a continuous output current so that their output power can be regulated. DC/DC converter with continuous input current increases the dynamic performance of the system. All in all, in order to use a DC/DC converter in renewable energy sources, it is necessary they have a high voltage gain and continuous input current. Conventional boost converters can be used as single-switch single-stage structures. However, their voltage conversion gains are not useful for renewable energy application. They can acquire high voltage gains in high duty ratios of the power switch. However, the performance of the converter will be severely disturbed.

Many converter structures with different control technique have been proposed recently with the advantage of high voltage gain and improved conversion efficiency .There have been applied some techniques such as switched capacitors and voltage lift to obtain high voltage gain. The drawback of these converter is flowing high charging current through the main switch.it is the most important drawback of these converters which decrease the efficiency of the converter. Recently proposed coupled-inductor based DC/DC converters can get the high voltage gain]. The main disadvantage of this structure is that the voltage spikes are generated on semiconductor due to the energy stored in the leakage inductance of the coupled inductor.it is the drawback of these converter. Active and passive clamp circuits are introduced to solve the aforementioned problem. with coupled-inductor its structures are presented in]. The coupled-inductor which is placed at the input stage of the converter and its leakage inductance cause the input current to be discontinuous or to have high current ripple which affects the efficiency of the converter. Therefore, they are not use full for renewable energy generating application.The most commonly used algorithm is Maximum power point tracking (MPPT), there are two methods of the algorithm Perturb and observe (P & O) and Incremental conductance (INC) is used to operate the SEPIC converter. Mostly (INC) incremental conductance is used, it has high accuracy. The duty cycle is increase or decreases accordingly based on the incremental conductance and instantaneous conductance both relations can decide the direction of perturbation. There is a duty cycle increase with a fixed size of perturbation for the right MPP, when the operating point gets MPP then perturbation stops.

II. DC/DC CONVERTER

DC-DC converters provides constant output voltage to various Direct Current appliances. Presence of parasitic elements in the boost converters, has some constraints in static gain. Reverse recovery problem prevails in diode functioned in large voltage & current. DC-DC boost converter is a most efficient topology which ensures good efficiency along with low cost. DC-DC boost converter topologies are used to increase the output voltage level. Boost converter boost up the input voltage. Boost converter and Buck converter are the two DC/DC converter. In Buck converter the output voltage is less than the input voltage to the converter. In Boost converter the output voltage is greater than the input voltage to the converter. To satisfy the need of high voltage application ,DC/DC voltage boost converter applications with a higher voltage conversion application with a higher voltage conversion ratio around ten times and higher efficiency ,lower switching losses, lower input current ripple and reduced dimensions are required. The conversion ratio of the converter can be conducted by obtaining coupled inductors.in some cases combine fly-back converter and hybrid boost to step up output voltage by using coupled inductors. These type of Dc-Dc converter also called a DC-DC power converter or voltage regulator.

Efficiency of converter

$$\eta\% = Pout/Pin*100$$

III. PV Array

Solar cell transforms solar radiation into direct current by using solar energy. PV array is a combination of a solar cell. In PV array the solar cells are connected in series and in parallel. To achieve the high output voltage, the cells should be connected in series whereas attains large Iout the cell should be connected in parallel. Solar radiation is input for the array and array convert this radiation into electricity. A photovoltaic is a linked collection of a photovoltaic module. A photovoltaic module is made of multiple interconnected solar cells. The array direct converts solar energy into electrical energy. PV modules sometimes called as solar panels. The application and study of photovoltaic devices is known as photovoltaic.

In Proposed system the PV array is designed for P_{mpp} = 5.02 *kw* total maximum power capacity. There are 10 parallel strings and 2 series strings. Open-circuit voltage is 75.6 V and short circuit current is 82.8 A. It is reported that the peak power is generally produced between 71% to 78% of open-circuit voltage and between 78% to 92% of short circuit current.

(a) Design of PV Array

Table 1: PV Array parameters

Parameter	Value
Parallel String	10
Series String	2
Maximum Power	250.096 Watt
Open Circuit Voltage	75.6 Volts
Short Circuit Current	82.8 Amp
Total Maximum Power	5.002 KW

IV. Maximum Power-Point Tracking (MPPT)

Power point tracking is one technique which is used for the variable power sources like solar to maximize the energy extraction as conditions vary. This technique can also be used in wind system and optical power transmission but most commonly used in the photovoltaic system. The most commonly used algorithm is Maximum power point tracking (MPPT), there are two methods of the algorithm Perturb and observe (P & O) and Incremental conductance (INC) is used to operate the SEPIC converter. Mostly (INC) incremental conductance is used, it has high accuracy. The duty cycle is increase or decreases accordingly based on the incremental conductance and instantaneous conductance both relations can decide the direction of perturbation. There is a duty cycle increase with a fixed size of perturbation for the right MPP, when the operating point gets MPP then perturbation stops. MPPT devices are used in an electric power converter system that perform voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors. Solar inverters convert DC power to AC power and may incorporate MPPT.

In P and O method the controller adjusts the voltage from the array by a small amount and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called perturb and observe (P&O) and is most common, although this method can cause power output to oscillate. It is also 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 method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted. MPPT algorithms frequently sample panel voltages and currents, then adjust the duty ratio accordingly. The use of the MPPT has some advantages that is simplicity means this algorithm solves only one linear equation.so it requires little computation. Therefore this method is very much simple. Also this technique is useful in both analog or digital circuit. Temperature changes with slow rate with time ,oscillation and instability are non-factors. There is one more important advantage is low cost means temperature sensors which are used in system are usually cheap. And also they are robust against noise.

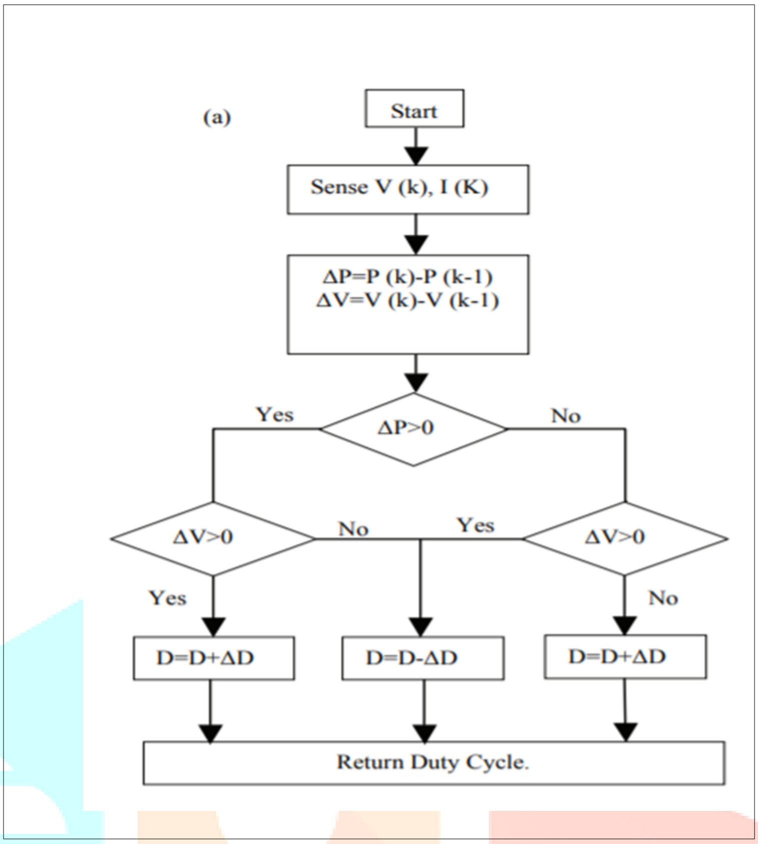

Figure 1: *flow chart of MPPT algorithm.*

V. SEPIC Converter

The single-ended primary-inductor converter (SEPIC) can operate from an input voltage that is greater or less than the regulated output voltage. SEPIC converter can act as both a buck and boost converter, the SEPIC also has minimal active components, a simple controller, and clamped switching waveforms both gives low- noise operation. SEPIC is one type of DC/DC Converter which convert DC voltage to the another level as required. SEPIC converter operate more efficiently with the ideal resistance regardless of the load. SEPIC has some features, due to that this converter is the most acceptable converter for the maximum power extraction from solar panel. They are as follows.

- The I-V curve of a solar panel is swept the entire curve.
- There is a Low ripple at the input.
- Linkage of the Inductors is possible on the same core.
- Output is non-inverted.
- The gate driver circuitry is simple.

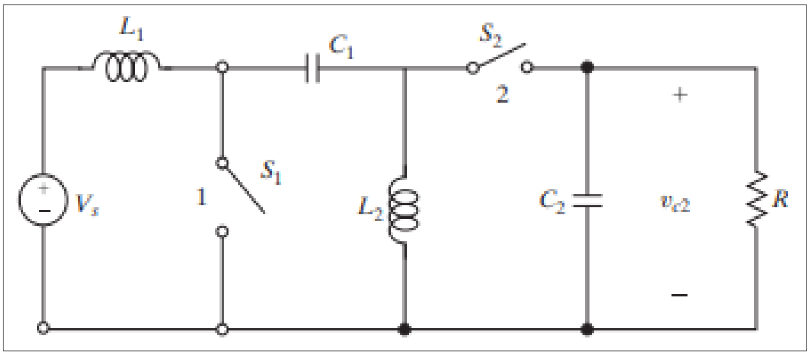

Figure 2: *Basic block diagram of SEPIC Converter.*

(a) Mode Operation

The basic block diagram of the SEPIC converter is shown in Fig. 1. Is that we can see that there is an input voltage source and two inductors and two capacitors there is a one IGBT or MOSFET are typical transistor used as switch S1, in SEPIC converter energy interchange between inductor and capacitor to control the output voltage one voltage level to another voltage level in dc supply. The output voltage can be controlled by IGBT work as switch S1. SEPIC converter operate in two modes that is continuous mode and discontinuous mode. In SEPIC, Converter said to be in continuous conduction mode if the current flowing through inductor L1 and L2 never fall to zero during an operating cycle. A SEPIC is said to be in discontinuous-conduction mode or discontinuous mode if the current through either of inductors L1 or L2 is allowed to fall to zero during an operating cycle. The average current flow through inductor L2 is the same as load current hence the independent of the input voltage.

Average voltages, written as:

$$V_{IN} = V_{L1} + V_{C1} + V_{L2} \quad (1)$$

The average voltage V_{C1} is equal to V_{IN} , V_{L1}=-V_{L2} , because this reason, the two inductors can be wound on the same core, the most of the basic of the transformer-isolated, due to Flyback converter. Currents can be given as follows (average value of currents passing through capacitor should be zero)

$$I_{D1} = I_{L1} - I_{L2} \quad (2)$$

When IGBT switch S1 is closed (turned-on), current flows through inductor L1 and Current start increase comes from the input source and current in inductor in inductor L2 decrease goes to negative. When S1 is ON and at the instance voltage is approximately negative of capacitor . There is Diode is opened and capacitor C1 is a charge it supplies the energy, this energy increases the flow of the current in inductor L2 and also increases stored energy in inductor L2. Shown in Fig. 3.

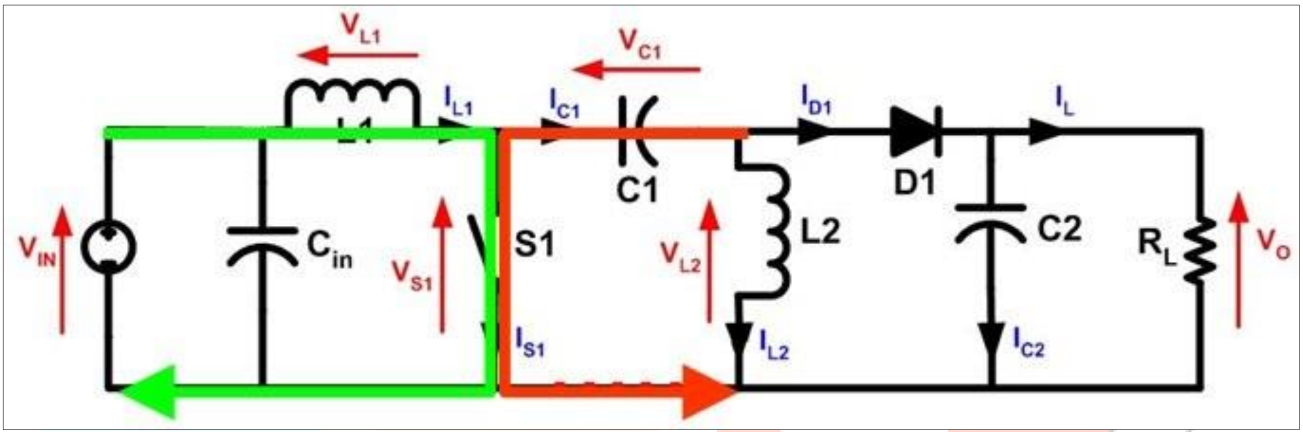

Figure 3: *when IGBT is ON then current flows through L1 and C1 also discharges current flow from L2.*

When IGBT switch S1 is turned off, the capacitor current I_{C1} becomes the same as the inductor current I_{L1}, since inductors do not allow instantaneous changes in current. The current I_{L2} will continue in the negative direction, in fact it never reverses direction. It can be seen from the diagram that a negative I_{L2} will add to the current I_{L1} to increase the current delivered to the load. Using Kirchhoff's Current Law, it can be shown that $I_{D1} = I_{C1} - I_{L2}$. It can then be concluded, that while S1 is off, power is delivered to the load from both L2 and L1. C1, however is being charged by L1 during this off cycle (as C2 by L1 and L2), and will in turn recharge L2 during the following on cycle.

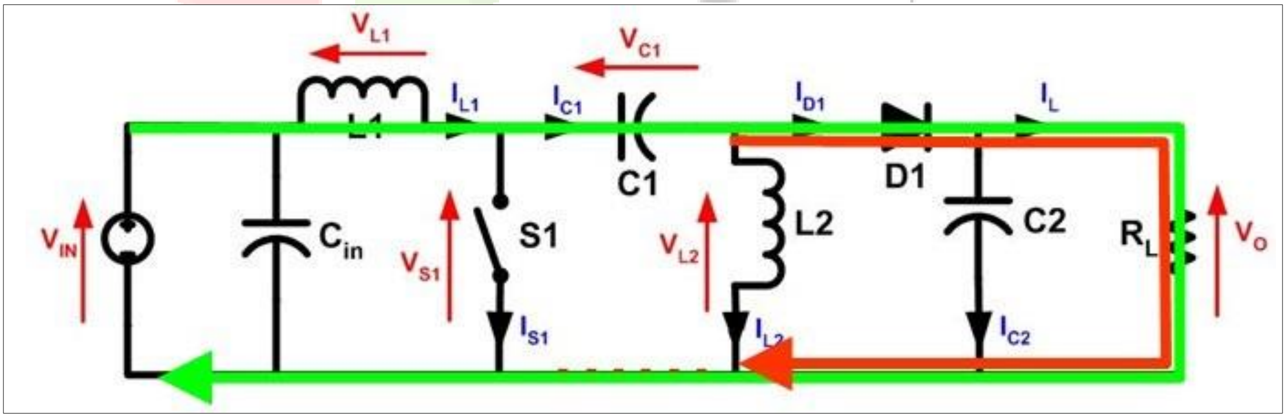

Figure 4: *With S1 open current through L1 and current through L2 produce current through the Load*

(b) Design of SEPIC Converter

In proposed system the input for the SEPIC Converter is Photovoltaic. In system voltage of the solar PV array, $V_{PV} = V_{mpp}$=56.7V. Duty cycle , D of the SEPIC is,

$$D = \frac{Vdc}{Vdc + Vpv} \tag{3}$$

Then L_1 , L_2 and C_1 , C_2 are estimated.

$$L1 = \frac{D*Vpv}{Fsw*\Delta IL1} \tag{4}$$

$$L2 = \frac{(1-D)*Vpv}{Fsw*\Delta IL2} \tag{5}$$

$$C1 = \frac{D*Idc}{Fsw*\Delta Vc1} \tag{6}$$

$$C2 = \frac{D*Idc}{8*Fsw*\Delta Vc2} \tag{7}$$

Table 2: SEPIC Converter parameter

Parameter	Value
Duty cycle	0.57
L1	32mH
L2	32mH
C1	300µf
C2	200µf

VI. BLOCK DIAGRAM PROPOSED SYSTEM

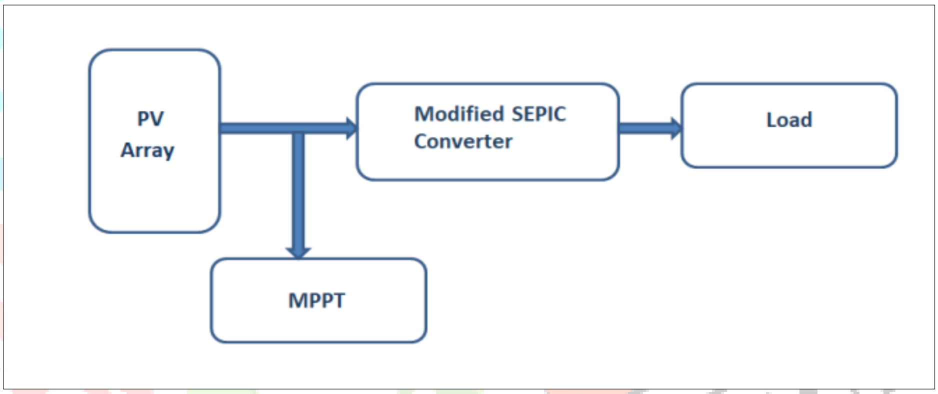

Figure 5: *Block diagram of proposed system.*

VII. MATLAB Simulation

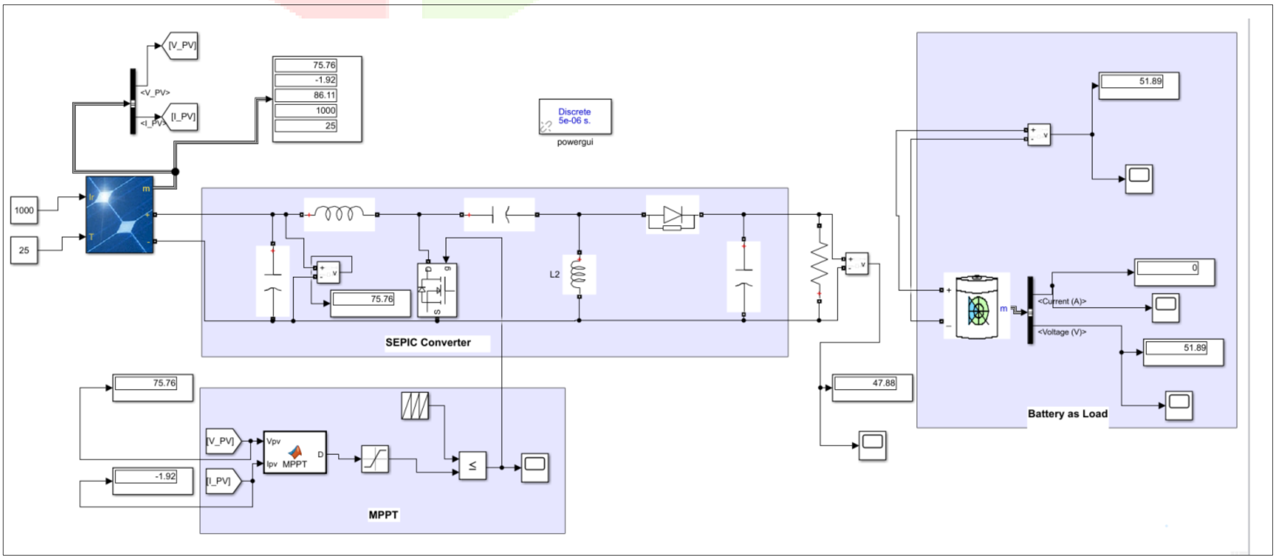

Figure 6: *MATLAB Simulation.*

Results

- PV Array output graph

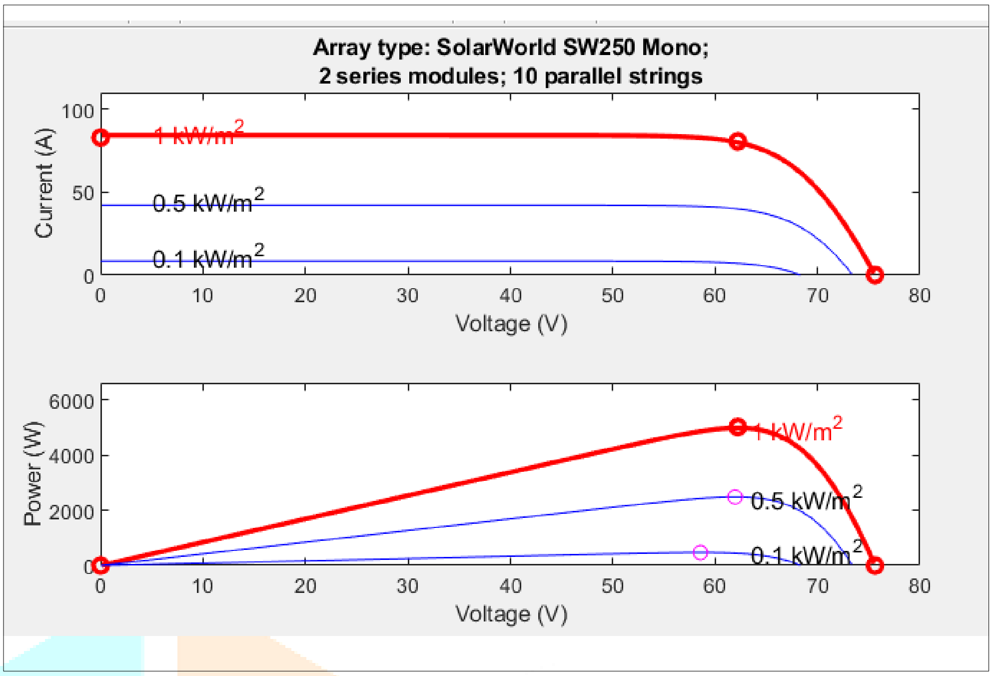

Figure 7: *PV array output voltage vs current and voltage vs power graph.*

- Output voltage of SEPIC Converter

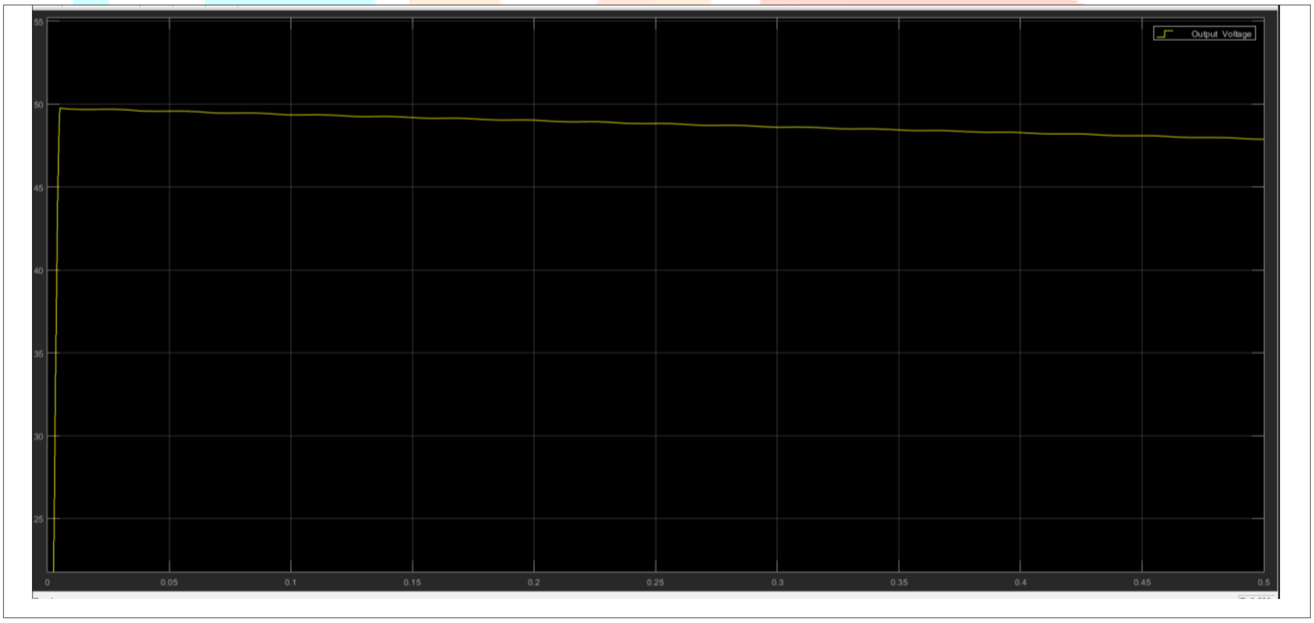

Figure 8: *Output voltage graph of the SEPIC Converter*

CONCLUSION

This paper presents the SEPIC converter used for solar energy conversion. The SEPIC converter is connected to the solar PV array for conversion purpose. The P and O method is used for the MPPT algorithm for maximum accuracy and maximum power output at a constant voltage level to get the battery charge of an electrical vehicle. The proposed system is simulated on MATLAB simulation software. The simulation results show that how the conversion of Solar energy to electricity works. SEPIC converter is more power efficient, having non-inverted output and also it Increases battery endurance of portable equipment. Modified SEPIC offers a advantage like low input current ripple, less voltage switching stress. The overall efficiency of the system gets improved with the proposed modified SEPIC design. Modified SEPIC can be used as an alternative for conventional SEPIC converter.

REFERENCES

[1] A. Ajami, H. Ardi, A. Farakhor, "A Novel High Step-up DC/DC converter Based on Integrating Coupled Inductor and Switched-Capacitor techniques for Renewable Energy Applications," *IEEE Trans. Power Electron.*, vol. 30, no. 8, pp. 4255-4263, Aug. 2015.

[2]Sureshkumaar, G., Kannan, N., Thomas, S. & S, P. (2019). Matlab/simulink simulations based modified sepic DC to DC converter for renewable energy applications. Journal of Advanced Research in Dynamical and Control Systems, 11(4):285–295.

[3] Premkumar, M.; Subramaniam, U.; Haes Alhelou, H.; Siano, P. Design and Development of Non-Isolated Modified SEPIC DC-DC Converter Topology for High-Step-Up Applications: Investigation and Hardware Implementation. *Energies* 2020.

[4] T. J. Liang, J. H. Lee, S. M. Chen, J. F. Chen, and L. S. Yang, "Novel isolated high-step-up DC–DC converter with voltage lift," *IEEE Trans. Ind. Electron.*, vol. 60, no. 4, pp. 1483–1491, Apr. 2013.

[5] A. Ajami, H. Ardi, A. Farakhor, "A Novel High Step-up DC/DC converter Based on Integrating Coupled Inductor and Switched-Capacitor techniques for Renewable Energy Applications," *IEEE Trans. Power Electron.*, vol. 30, no. 8, pp. 4255-4263, Aug. 2015.

[6] C. L. Wei and M. H. Shih, "Design of a switched-capacitor DC-DC converter with a wide input voltage range," *IEEE Trans. Circuits Syst.*, vol. 60, no. 6, pp. 1648–1656, Jun. 2013.

[7] B. Axelrod, Y. Beck, Y. Berkovich, "High step-up DC–DC converter based on the switched-coupled-inductor boost converter and diode-capacitor multiplier: steady state and dynamics", *IET Power Electron.*, vol. 8, no. 8, pp. 1420–1428, Feb. 2015.

[8] Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang, "Novel high step-up DC–DC converter with coupled-inductor and switched-capacitor techniques," *IEEE Trans. Ind. Electron.*, vol. 59, no. 2, pp. 998–1007, Feb. 2012.

[9] T. F. Wu, Y. S. Lai, J. C. Hung, and Y. M. Chen, "Boost converter with coupled inductors and buck–boost type of active clamp," *IEEE Trans. Ind. Electron.*, vol. 55, no. 1, pp. 154–162, Jan. 2008.

[10] L. S. Yang, T. J. Liang, H. C. Lee, and J. F. Chen, "Novel high step-up DC–DC converter with coupled-inductor" *IEEE Trans. Ind. Electron.*, vol. 58, no. 9, pp. 4196–4206, Sep. 2011.