Design of Smart Autonomous Solar Panel with Cascaded Sepic-Boost Converter for High Voltage Renewable Applications

Rubi Kumari (rk.ee.sit@gmail.com)
Sikkim Manipal University
Pawan Pyakurel
Sikkim Manipal University
Bijay Rai
Sikkim Manipal University
Moumi Pandit
Sikkim Manipal University
Karma Sonam Sherpa
Sikkim Manipal University
dibyadeep bhattacharya
Sikkim Manipal University

Research Article

Keywords: Solar Tracker, Dual Axis, Cascaded SEPIC-Boost Converter, High Gain, Renewable Energy Applications

Posted Date: August 1st, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1880316/v1

Abstract

Solar energy is most admired alternative to traditional energy sources. Special attention is required to improve solar gathering techniques in mountainous regions like Sikkim, where sun availability is unreliable but irradiance level is high. This paper proposes a hardware model for smart autonomous self-adjusting solar panel whose output is fed to DC-DC Cascaded SEPIC-Boost Converter for high voltage renewable based applications. The developed renewable system is designed to adjust the panel in a position where maximum voltage is extracted. The output of the solar panel is fed to the DC-DC cascaded converter. A detailed circuit analysis is performed to evaluate the system's efficiency and voltage gain. The converter is examined with different duty cycles. The proposed converter generates 40 V DC output with 20 V DC input voltage from solar panel at 50% duty ratio and gives 90% efficiency. The feasibility of the converter is confirmed with results obtained from an experimental prototype.

I. Introduction

The world has faced various significant challenges and problems to make a non-polluting, inexhaustible energy generating systems in recent times. Additionally, the frequent electricity shortages, depletion of fossil fuels, increase of air pollution, and quantity of toxic gasses in the air have forced researchers to move toward renewable energy sources [1]. As per the data analysis report produced by the International Renewable Energy Agency (IRENA) in 2018, the USA leads electric power generation through various renewable energy resources [2]. After the USA, China produces around 68,000 GWh of energy, followed by Brazil and Germany. India ranks at the 9th position with 20,000 GWh capacity of electric power generation from renewable resources [1,3,4,5]. During the Paris Agreement in 2015, India committed to increase its sustainable renewable energy share from 30% to 40% by 2030 [3,20,21]. This includes a lofty goal of deploying 175 GW of renewable energy by 2022, with solar energy accounting for 100 GW of that total [3]. The dissemination and development of solar energy are being prioritized in order to meet India's increasing energy demand in a sustainable manner.

At present, various types of renewable sources like solar, wind power, hydropower, biomass energy, and many others are engaged in supplying and fulfilling the energy demand [6]. Among different renewable sources, solar energy is the most important and necessary source of sustainable energy. It is a popular alternative pathway for meeting the current demand of electric supply [7,8]. They are the most reliable source of clean energy. It is preferable to maximize the power output in order to increase its efficiency [5]. It is observed that applying a tracking system instead of a stationary array can increase the energy extracted from solar panels by 20 to 30 percent [5,15].

A solar tracker follows the sun's path so that the sunbeam reaches the panel surface perpendicularly, allowing the PV module to produce the maximum electricity. Solar trackers are classified into two types: single axis and dual axis [16]. A single-axis solar tracker can only track the sun in one direction [17]. Its single axis is parallel to the local north meridian. Due to its two degrees of freedom, the dual-axis type can follow the sun's path in both directions, allowing it to track the sun's daily and seasonal motions [17].

It is found that, there is 20% rise in the overall efficiency in single axis tracking when compared to a fixed PV module [18]. But, in terms of tracking the direction of the sun, a dual-axis PV system outperforms a single-axis system. [19]. The Dual Axis PV system is an improved version of Single-axis tracking allowing the panel to rotate in complete 360°. It ensures that panels are always oriented toward the sun, regardless of season or time of day, resulting in up to 45 percent more solar energy [14].

But the electric power generated by renewable energy is unsystematic and irregular in nature [15]. Usually, in such cases, the low voltage from the dc source is converted to a higher voltage. According to the literature, much work has been done in the last decade to implement and design a highly efficient DC-DC converters for various applications. In Ref. [16], J. P. Lee et al. proposed the control and design of a topology using PV DC-DC converter. The converter is designed to work under different load conditions. J. K.Park et al. [11] proposed a resonant voltage doubler step-up DC-DC converter. The experiments were conducted on a (1.2 kW) DC-DC Converter at a fixed switching frequency of 70 kHz. The authors of [12] proposed a method for improving output power and voltage through solar tracking with SEPIC (Single Ended Primary Inductor Converter) controlled by a PIC microcontroller. But these conventional converters fail to operate at higher conversion ratios. Other classical voltage boosting techniques like multilevel, interleaved, switched capacitors, coupled inductors and voltage multiplier cells, include stability limitations around the operating points [15].

Literature states that though the traditional single-switch boost converter can achieve high voltage at unity duty cycle but complexities will arise at extremely high duty cycle like large switching turn-off time [17]. A cascade connection is a method of achieving higher conversion ratios without the use of a transformer. The integration of simple boost converter with the SEPIC converter increases the voltage gain. Selection of boost converter is done due to its capability of generating high step-up voltage. Whereas, the SEPIC converter is opted because of its non-inverting output as well as low input current ripple nature [17,18,22,23,25]. The voltage conversion ratio of the topology is $D/(1-D)^2$.

In this article, the maximum tracking of the sunlight is performed in the Sikkim Region. Sikkim is India's 22nd state, located in the northeast. Because of its Himalayan location, Sikkim has a geographically diverse climate that ranges from subtropical to high alpine. The climate of Sikkim varies from subtropical in the south to tundra in the north. The majority of Sikkim's inhabited areas have a temperate climate, with summer temperatures rarely exceeding 28 °C. In most of Sikkim, the average annual temperature is around 18°C [21]. Lower solar irradiance can be increased if cascaded converters are used. This paper proposes a hardware model to harvest maximum solar energy by integrating the dual axis solar tracker with DC-DC Cascaded SEPIC-Boost Converter. To increase the output of the dual axis solar tracking system, the proposed system employs the P&O method of the MPPT algorithm.

This paper's main contributions are summarised below:

A. It presents a dual-axis PV tracking system, which gathers the maximum solar light energy with the help of the MPPT algorithm.

B. Convert the output voltage from the solar panel to suitable amplitude for various applications using a cascaded SEPIC-Boost Converter. The developed cascaded converter is tested and implemented using a hardware setup and practical results were gathered.

This paper is organized as follows: the mechanical description of the solar panel is described in section II. Design analysis of the cascaded SEPIC-Boost converter is discussed in Section III. Experimental results for a 20 V DC input voltage from solar panel at 50% duty ratio are presented in Section IV. Section V brings this paper to a close.

I I. Solar Panel Description

The synchronisation of the tilt angle of the PV tracking system with the seasonal change of the sun’s altitude makes the solar tracking most effective. An ideal tracker allows the solar modules to face the sun while compensating for changes in the sun's altitude angle and latitudinal offset. As a result, a single-axis tracking system does not maximise the efficiency of the solar panel, whereas double-axis tracking ensures cosine effectiveness. The proposed system focuses on increasing the output of a dual axis PV tracking system through P&O technique. When combined with a cascaded DC-DC SEPIC-Boost converter, this MPPT algorithm improves the overall efficiency of the system. Thus, the maximum efficiency of the proposed system is derived by converting output voltage from the PV to suitable amplitude using cascaded converter.

A mechanical structure is designed to support both solar panels. The mechanical support structure is supported with four actuators at the four corners. The actuators allow the mechanical framework and solar panels to move at the angle specified by the microcontroller. Figure 1 shows the setup of the dual-axis PV tracking panel.

The mechanical structure is composed of the following parts:

- *Actuators*: Four actuators are connected at the four corners of the mechanical structure using a movable joint set to provide the required movement of the structure. The actuators are connected with a stepper motor to provide an extension of 10 mm, as shown in Fig. 2.
- *Jolt Connector*: The nut bolt connector set is specially designed to provide free rotation of the system for 360 degrees.

Two solar panels of 100W each and 12V rating are connected in series for tracking maximum energy. They are designed to rotate along the two axes using the P&O algorithm and four actuators controlled by the microcontroller. Two servo motors have been used, one for vertical axis control and another one for horizontal axis control. With the help of these two servo motors, the solar panel's position is controlled to obtain the optimum angle between solar radiation and the solar panel. Four LDRs are used to sense the direction of solar radiation and the required angle of vertical and horizontal rotation is calculated, and accordingly, the microcontroller sends the signal to the servo motors for the appropriate angle of rotation. The control algorithm works on the difference between the signals received from LDRs. In case of no difference, the panel does not move. reset button is used to return the panel to its initial position at a 40-degree inclination. The control program keeps measuring the generated voltage at various angles during movement. Then the solar panel is positioned at the angle which receives maximum solar energy so that maximum voltage can be generated. The process is repeated within a fixed interval of time as shown in Fig. 3.

I I I. Working Principle Of Cascaded Sepic-boost Converter

When operating at higher duty ratios, the conventional SEPIC Converter loses its ability to produce high voltage gain. The SEPIC converter's gain is increased by inserting a boost converter between the input inductor and the controlled power semiconductor device. The cascaded boost-SEPIC Converter's circuit diagram is shown in Fig. 4.

The redesigned SEPIC converter operates in conduction and non – conducting modes. The source voltage V_{in}magnetizes the inductor L_1 during conduction mode, followed by the diode D_2 and switch S. Through switch S; capacitor C_1 magnetizes inductor L_2. Capacitor $C_{2,}$ on the contrary, magnetizes inductor L_3via the semi-controlled device S. During the conduction mode, the current via inductors L_1, L_2, and L_3 increases linearly. In the non-conduction mode, however, inductor currents drop linearly. The L_1 demagnetizes as a result of the capacitor C_1 and the V_{in} and D_1. L_1 and L_3 are also demagnetized as a result of capacitors $C_2$and C_3, followed by D_2 and D_3, correspondingly [34]. Figure 5 shows the proposed circuit in conduction and non-conduction mode

During conduction mode, switch S is turned on. The voltage across inductor L_1, L_2, L_3 during on state is:

$$V_{L1} = V_{in} - 3V_d$$

$$V_{L2} = V_{C1} - 2V_d \text{ ——(1)}$$

$$V_{L3} = V_{C2} - 2V_d$$

The voltage across inductor L_1, L_2, L_3 during off state is:

$$V_{L1} = V_{in} - V_{C1} - 2V_d$$

$$V_{L2} = V_{in} - V_{L1} - V_{C2} - V_0 - 2V_d \text{ ——(2)}$$

$$V_{L2} = V_{C1} - V_{C2} - V_0 - 2V_d$$

$$V_{L3} = V_0 - 2V_d$$

As per volt second balance method for inductorL_1

$(V_{in} - 3V_d)D + (V_{in} - V_{C1} - 2V_d)(1-D) = 0$

$V_{C1} = (\frac{Vin}{1-D})$ -2V_d $(\frac{1+D}{1-D})$ ——(3)

As per volt second balance method for inductorL_2

$(V_{C1} - 2V_d)\ D + (V_{C1} - V_{C2} - V_0 - 2V_d)\ (1-D) = 0$

$V_{C2} = (\frac{V_{C1}}{1-D})$ -2V_d $(\frac{1}{1-D})$- V_0 ——(4)

As per volt second balance method for inductorL_3

$(V_{C2} - 2V_d)D + (V_0 - 2V_d)\ (1-D) = 0$

$V_0 = (\frac{DV_{C2}}{1-D})$ -2V_d $(\frac{1}{1-D})$

$V_0 = \frac{DV_{C1}}{1-D}$ -2V_d ——(5)

From Eq. (3)

$V_0 = \frac{D}{(1-D)^2} V_{in} - 2V_d\ (\frac{2D^2-D+1}{(1-D)^2})$ ——(6)

Neglecting the internal resistances of the circuit. Thus, the voltage gain of the proposed Converter is: -

$$\boxed{V_0 = \frac{D}{(1-D)^2} V_{in}}$$

When operating at higher duty ratios, the conventional SEPIC Converter loses its ability to produce high voltage gain. The SEPIC converter's gain is increased by inserting a boost converter between the input inductor and the controlled power semiconductor device. The cascaded boost-SEPIC Converter's circuit diagram is shown in Fig. 4.

The redesigned SEPIC converter operates in conduction and non – conducting modes. The source voltage V_{in}magnetizes the inductor L_1 during conduction mode, followed by the diode D_2 and switch S. Through switch S; capacitor C_1 magnetizes inductor L_2. Capacitor $C_{2,}$ on the contrary, magnetizes inductor L_3via the semi-controlled device S. During the conduction mode, the current via inductors L_1, L_2, and L_3 increases linearly. In the non-conduction mode, however, inductor currents drop linearly. The L_1 demagnetizes as a result of the capacitor C_1 and the V_{in} and D_1. L_1 and L_3 are also demagnetized as a result of capacitors $C_2$and C_3, followed by D_2 and D_3, correspondingly [34]. Figure 5 shows the proposed circuit in conduction and non-conduction mode

During conduction mode, switch S is turned on. The voltage across inductor L_1, L_2, L_3 during on state is:

V_{L1} =V_{in} – 3V_d

V_{L2} =V_{C1} – 2V_d ——(1)

V_{L3} = V_{C2} – 2V_d

The voltage across inductor L_1, L_2, L_3 during off state is:

V_{L1} = V_{in} – V_{C1} – 2V_d

V_{L2} = V_{in} - V_{L1} - V_{C2} – V_0 – 2V_d ——(2)

V_{L2} = V_{C1} - V_{C2} – V_0 – 2V_d

V_{L3} = V_0 – 2V_d

As per volt second balance method for inductorL_1

(V_{in} – 3V_d)*D* + (V_{in} – V_{C1} – 2V_d)*(1-D)* = 0

V_{C1} = ($\frac{Vin}{1-D}$) -2V_d ($\frac{1+D}{1-D}$) ——(3)

As per volt second balance method for inductorL_2

(V_{C1} – 2V_d) *D* + (V_{C1} - V_{C2} – V_0 – 2V_d) *(1-D)* = 0

V_{C2} = ($\frac{V_{C1}}{1-D}$) -2V_d ($\frac{1}{1-D}$)- V_0 ——(4)

As per volt second balance method for inductorL_3

(V_{C2} – 2V_d)*D* + (V_0 – 2V_d) *(1-D)* = 0

V_0 = ($\frac{DV_{C2}}{1-D}$) -2V_d ($\frac{1}{1-D}$)

V_0 = $\frac{DV_{C1}}{1-D}$ -2V_d ——(5)

From Eq. (3)

V_0 = $\frac{D}{(1-D)^2}$ V_{in} – 2V_d ($\frac{2D^2-D+1}{(1-D)^2}$) ——(6)

Neglecting the internal resistances of the circuit. Thus, the voltage gain of the proposed Converter is: -

$$V_0 = \frac{D}{(1-D)^2} V_{in}$$

I V. Result And Discussion Of The Proposed System

A. Dual Axis solar tracking system

Table 1 presents the solar data collected on 25.07.2021. The observation of solar irradiance using a dual-axis has been observed considering both the conditions, i.e., with a solar tracker and without the solar tracker. The precise analyses while comparing the valves of both fixed and tracking configurations at different positions using graphical representation is shown in Fig. 6. It is clear from the data in Table 1 that the value of solar irradiance with the tracker is high compared to without a tracker. The DC-DC cascaded SEPIC-Boost Converter is designed considering 20.75 V (from Table 1) as the input. This voltage has been selected based on the parameters of the circuit as mentioned in Table 2. After incorporating the MPPT into a solar power system and replacing fixed solar panels with Dual Axis Tracking linked panels, the redesigned system became more efficient. The solar tracker continuously monitors the sun's movement in both azimuth and horizontal directions, allowing for maximum light energy absorption. The MPPT draws the maximum amount of power from the panel and feeds the output to the DC-DC cascaded SEPIC-Boost Converter.

Table 1

shows the sunlight intensity with and without tracking on 25.07.2021

Date	**Time**	**Position of the panel**	**Voltage with tracker (V)**	**Voltage without tracker (V)**
25-07-2021	9:08:00	303.54	38.95	38.59
25-07-2021	9:37:00	306.89	38.6	38.20
25-07-2021	10:03:00	309.42	39.1	38.63
25-07-2021	11:19:00	321.63	38.66	38.19
25-07-2021	12:21:00	321.33	38.58	37.89
25-07-2021	13:23:00	318.83	38.3	37.66
25-07-2021	13:54:00	321.23	38.71	37.93
25-07-2021	14:25:00	322.43	38.51	37.51
25-07-2021	14:55:00	320.53	38.36	37.73
25-07-2021	15:27:00	310.73	38.2	37.58
25-07-2021	15:58:00	313.43	38.03	37.41
25-07-2021	16:10:00	314.46	37.01	36.55
25-07-2021	16:41:00	313.16	36.85	36.44
25-07-2021	17:11:00	312.86	33.73	33.69
25-07-2021	17:43:00	310.46	32.32	31.85
25-07-2021	18:10:00	317.99	29.1	28.77
25-07-2021	18:22:00	315.99	20.75	20.47

B. Experimental Set-up of the Hardware Model.

Figure 7 shows the hardware setup of the experimental model. A PWM Pulse Frequency and Duty Cycle module was utilised to alter the pulse and switching frequency in the proposed model. The projected converters are based on the Table 2 parameters.

Table 2
Design Parameters of the Converters

Sl. No.	Parameters	Cascaded Boost-SEPIC Converter
1.	Input Voltage	20V
2.	Switching Frequency	22KHz
3.	Load	400Ω, 1.1Amps
4.	Duty Ratio	50%
5.	Output Voltage	38V
6.	Inductors (L_1, L_2, L_3)	0.3μH
7.	Capacitors (C_1, C_2) Output Capacitor (C_3)	47μF, 63V 47μF, 200V

A comparative study of generated voltage as measured on 25th July 2021 has been carried out. The solar panel data is gathered in both scenarios, i.e., with and without a tracker. Graphs are illustrated in Figs. 8 and 9. The data from Table 1 is utilized to validate the suggested model. The rating of the cascaded converter is suitable for a maximum voltage of 50V. Therefore, the 17th output of Table 1 has been used as the converter input for validation.

Thus, the 20V output coming from the solar panel has been considered as the input for the DC-DC cascaded SEPIC-Boost Converter. The switching frequency used is 22KHz. A PWM generator is used to feed square pulse and switching frequency of 22KHz to the cascaded Converter. Figure 8 shows the square pulse provided to the gate terminal of the MOSFET IRF540N. The inductor values (L1, L2, L3) considered for the project are 0.3μH. The capacitor values (C1, C2) selected are of rating 47μF with a voltage tolerance of 63V. The output capacitor (C3) is 47μF with a voltage tolerance of up to 200V. The load selected for the proposed Converter is a resistive load of rating 400 ohms and 1.1Amps. The input current measured is 0.3Amps. Whereas the output current measured is 0.13Amps. The voltage appearing across the output capacitor C3 at a 50% duty ratio is 38V for 20V input. Figure 9 shows the output voltage waveform of 38V at a 50% duty ratio. Maximum efficiency of 90% was observed at 50% of the rated output power. Efficiency is improved throughout the entire range of operation.

A 400 resistive load with a 1.5Amp rating is used. At 400 load, the prototype designed achieves a maximum efficiency of 90%. The remaining 10% represents internal losses that occur across various circuit components such as inductors, switches, diodes, and so on.

V. Conclusion

In this paper, dual axis PV tracking for DC-DC cascaded converters is successfully designed and tested. The designed dual-axis tracker worked properly with the capability to control the system for generating maximum solar power. The results showed that the dual-axis solar tracking system is highly efficient in terms of electrical energy output when compared to a fixed solar system. To further increase the efficiency, a 20V solar output is fed to a DC-DC cascaded SEPIC-Boost Converter. The converter was examined using various switching frequencies and duty cycles. The proposed converter generates a 40 V DC output from a 20 V input received from a solar panel at a 50% duty ratio. The efficiency of the entire system output is 90%. 10% of the efficiency is affected due to the presence of losses occurring across each component. Efficiency is improved throughout the entire range of operation. The energy gained can be efficiently used for a variety of high-voltage applications.

Declarations

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

1. Ali Sabri Allw, Ikhlas Hameem Shallal, “Evaluation Of Photovoltaic Solar Power Of a Dual-Axis Solar Tracking System”, Journal Of Southwest Jiaotong University, Volume 5 Issue No. 1, ISSN: 0258-2724, Feb 2020.
2. Bala Kalanithi, S.Rajesh, “MPPT controller based solar tracking system”, IOSR Journal of Mechanical and Civil Engineering, ISSN: 2278-1684, 2014.
3. Rachana Rai & Neeta D. Sharma, “Renewable Energy in Sikkim”, International Journal of Business Management & Research, Volume 4 Issue No. 6, ISSN: 2249-8036, Dec 2014.
4. Aashish Tiwari, Mayuri Vora, Prajkta Shewate, Vrushali Waghmare, “Sun Tracking Solar Panel with Maximum Power Point Tracking”, International Journal of Engineering Science and Computing, Volume 6 Issue No. 3, March 2016.
5. Adarsh S., Abhishek Anand, Jayant Singla, “Increasing the efficiency of a PV system using dual axis solar tracking”, International Journal of Advances in Science Engineering and TechnologyVolume- 3, Issue-2, April-2015.
6. Rashid Ahammed Ferdaus, Mahir Asif Mohammed, Sanzidur Rahman, Sayedus Salehin and Mohammad Abdul Mannan, “Energy Efficient Hybrid Dual Axis Solar Tracking System”, Journal of Renewable Energy, Volume 2014.
7. G. Deb and A. B. Roy, “Use of solar tracking system for extracting solar energy,” International Journal of Computer and Electrical Engineering, Volume 4, Issue No. 1, pp. 42–46, 2012.
8. T. Tudorache and L. Kreindler, “Design of a solar tracker system for PV power plants,” Acta Polytechnica Hungarica, Volume. 7, Issue No. 1, pp. 23–39, 2010.

9. Fathy M. Mustafa and Seif A. Ahmed, “Design and Implementation of Dual-Axis Solar Tracking System”, International Advanced Research Journal in Science, Engineering and Technology, Vol. 4, Issue 11, November 2017.
10. Ruma Sinha, Lokesh V, Ranganath P, Abdul Bashith, Sunil R, “Implementation of Dual Axis Solar Tracker using MPPT and OFF MPPT for Isolated Microgrid System”, International Journal of Research and Analytical Reviews, Volume 6, Issue 2, 2019.
11. Shyam Joseph Antony, K.Meera, M.Sangeetha, K.Vimalika, “Improving the Efficiency of Solar Energy Output with two-Axis Solar Tracking System and MPPT-SEPIC Converter”, International Journal of Innovative Science and Research Technology, Volume 3, Issue 2, February 2018.
12. Kalyani Gaikar, Asmita Jadhav, Prof. Sanchali Kshirsagar, “Dual Axis Solar Tracking, Harvesting and Measuring Using LPC2148 Microcontroller”, International Research Journal of Engineering and Technology, Volume 7, Issue No. 7, May 2020.
13. Hengyu Li, Chongyang Zhao, Hao Wang, Shaorong Xie and Jun Luo, “An Improved PV System Based on Dual Axis Solar Tracking and MPPT”, International Conference on Mechatronics and Automation, 2014.
14. Carlos Robles Algarín, Adalberto Ospino Castro, Jose Casas Naranjo, “Dual-Axis Solar Tracker for Using in Photovoltaic Systems”, International Journal of Renewable Energy Research, Volume 7 Issue No. 1, 2017.
15. Rubi Kumari, Moumi Pandit, K.S. Sherpa, “A comprehensive study on evolution and advancement of DC–DC cascaded converters: a review”, Australian Journal of Electrical and Electronics Engineering, Volume 19, Issue 1, 2022.
16. Falah I Mustafa, Sharmid Sakhir, FaizF Mustafa, “Simple Design and Implementation of Solar tracking System Two Axis with Four Sensors for Baghdad city”, The 9th International Renewable Energy Congress (IREC 2018).
17. M. Zakir HossainID1, Jeyraj A / L Selvaraj, N. A. Rahim, “High voltage-gain full-bridge cascaded dc-dc converter for photovoltaic application”, PLOS ONE, November 2018.
18. Ahmad J. Sabzali, Esam H. Ismail, “Integrated Double Boost–SEPIC DC–DC Converter for Renewable Energy Systems”, Renewable Energy: Generation and Applications, 2014.
19. Monika Mohan, KanishMathew ,Rinosh Thomas, AuthorSwathi V.U, Biju K, “Automatic Solar Tracking System using MPPT with Mirror Booster”, International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, Vol. 4, Issue 4, April 2016.
20. Vinod Nandal, Raj Kumar and S. K Singh, “Solar Resource Assessment and Potential in Indian Context”, EasyChair preprints, Nov 2017.
21. Abhinandan Baruah, MousumiBasu, DeeshankAmuley, “Modeling of an autonomous hybrid renewable energy system for electrification of a township: A case study for Sikkim, India”, Renewable and Sustainable Energy Reviews, Electronics, Instrumentation and Control Engineering, Volume 135, January 2021.

22. Ahmad J. Sabzali, Esam H. Ismail, “Integrated Double Boost–SEPIC DC–DC Converter for Renewable Energy Systems”, Renewable Energy: Generation and Applications, 2014.
23. Ahmad J. Sabzali, Esam H. Ismail, Hussain M. Behbehani, “High voltage step-up integrated double Boost-Sepic DC-DC converter for fuel-cell and photovoltaic applications”, Renewable Energy, 2014.
24. Ibrahim Alhamrouni, M. K. Rahmat, F. A. Ismail, Mohamed Salem, Awang Jusoh5, T. Sutikno, “Design and development of SEPIC DC-DC boost converter for photovoltaic application”, International Journal of Power Electronics and Drive System (IJPEDS), Vol. 10, No. 1, pp. 406~413, March 2019.
25. P.K.Maroti, S. Padmanaban, M.S.Bhaskar, F.Blaabjerg, P.Siano, V.Fedak, V.K.Ramachandramurthy, “A High Gain Modified SEPIC DC-to-DC Boost Converter for Renewable Energy Applications”, IEEE, 2017.

Figures

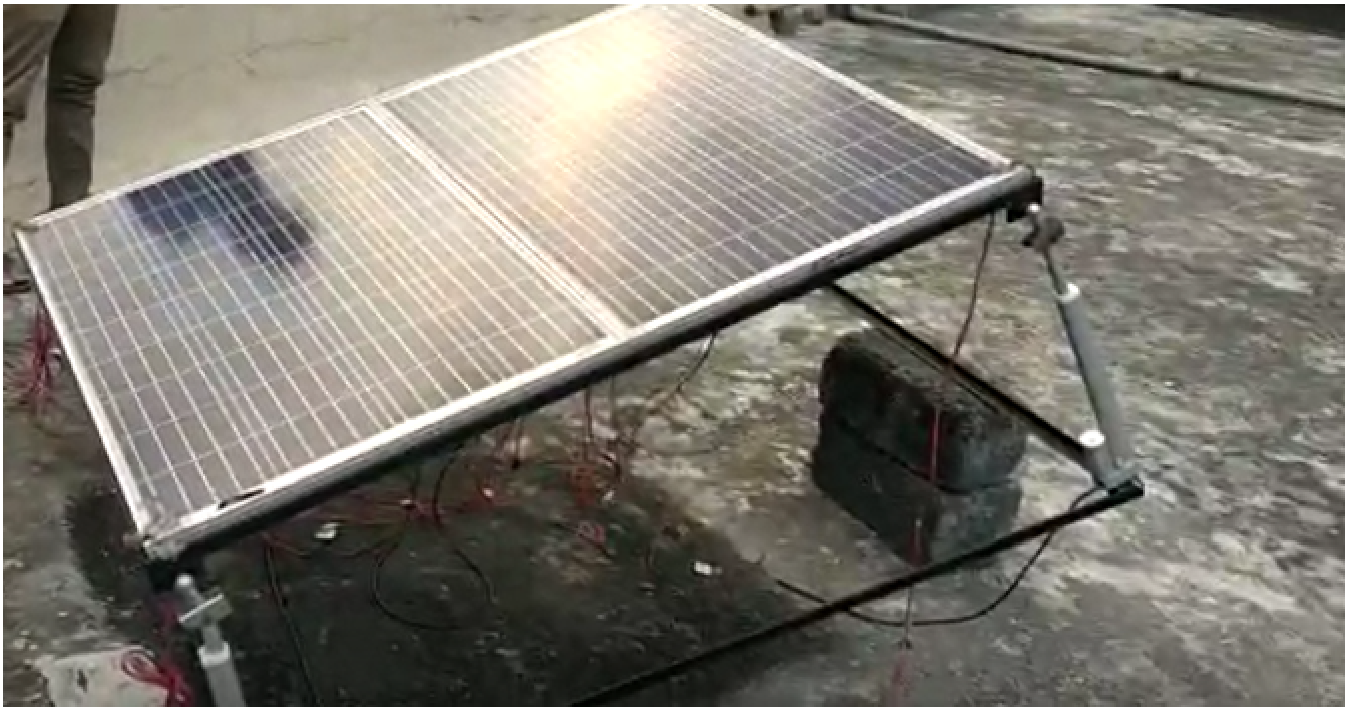
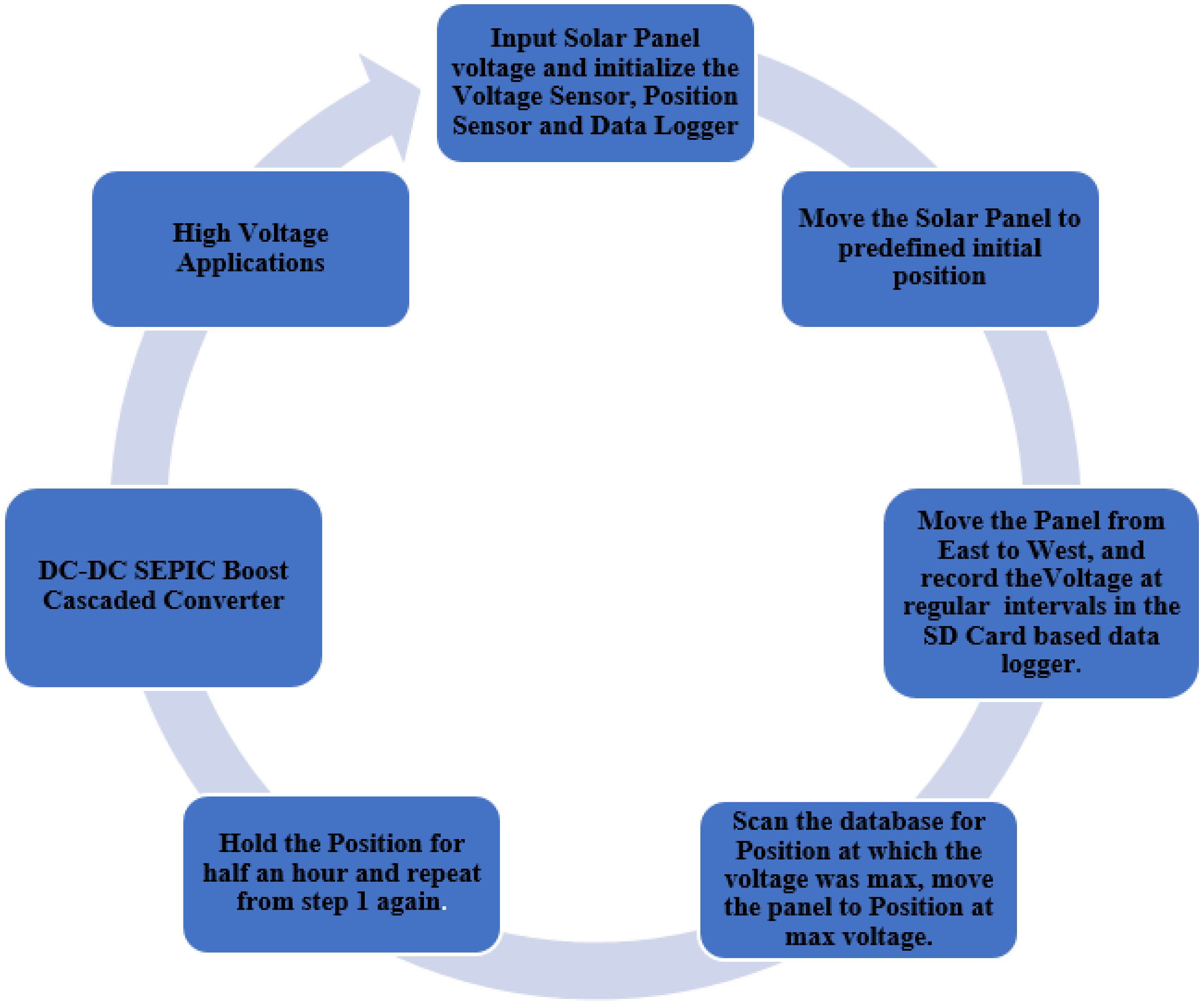


Figure 1

Dual-axis Solar tracking panel

Figure 2

(a) Actuators (b) Actuators with extensions



Input Solar Panel voltage and initialize the Voltage Sensor, Position Sensor and Data Logger

Move the Solar Panel to predefined initial position

Move the Panel from East to West, and record theVoltage at regular intervals in the SD Card based data logger.

Scan the database for Position at which the voltage was max, move the panel to Position at max voltage.

Hold the Position for half an hour and repeat from step 1 again.

DC-DC SEPIC Boost Cascaded Converter

High Voltage Applications

Figure 3

Process flow of the system

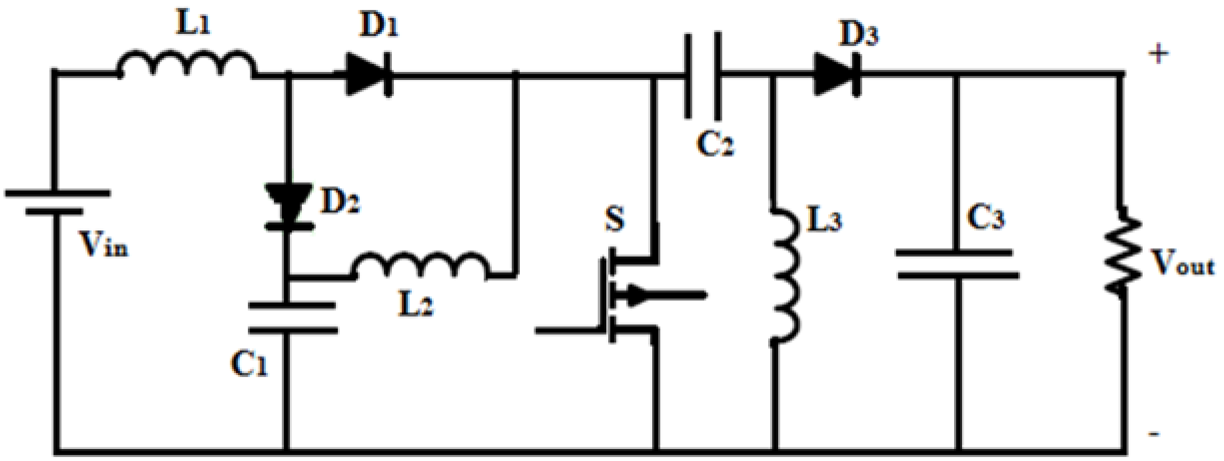


Figure 4

Cascaded Boost-SEPIC Converter

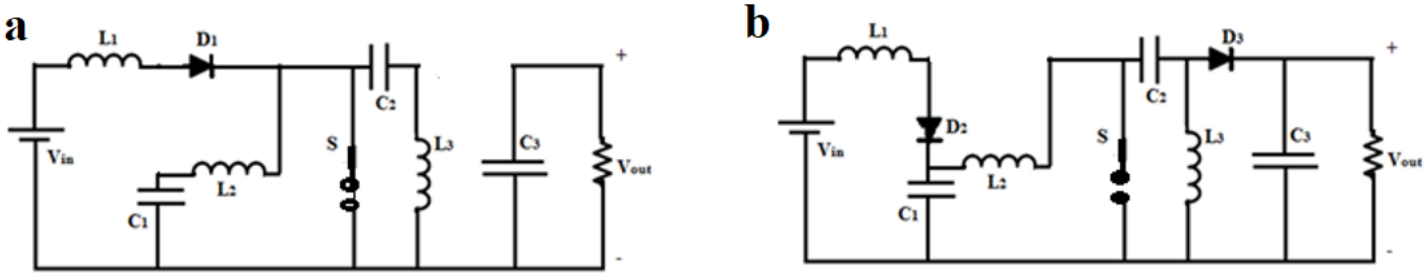


Figure 5

(a) Conduction Mode (b) Non-Conduction Mode

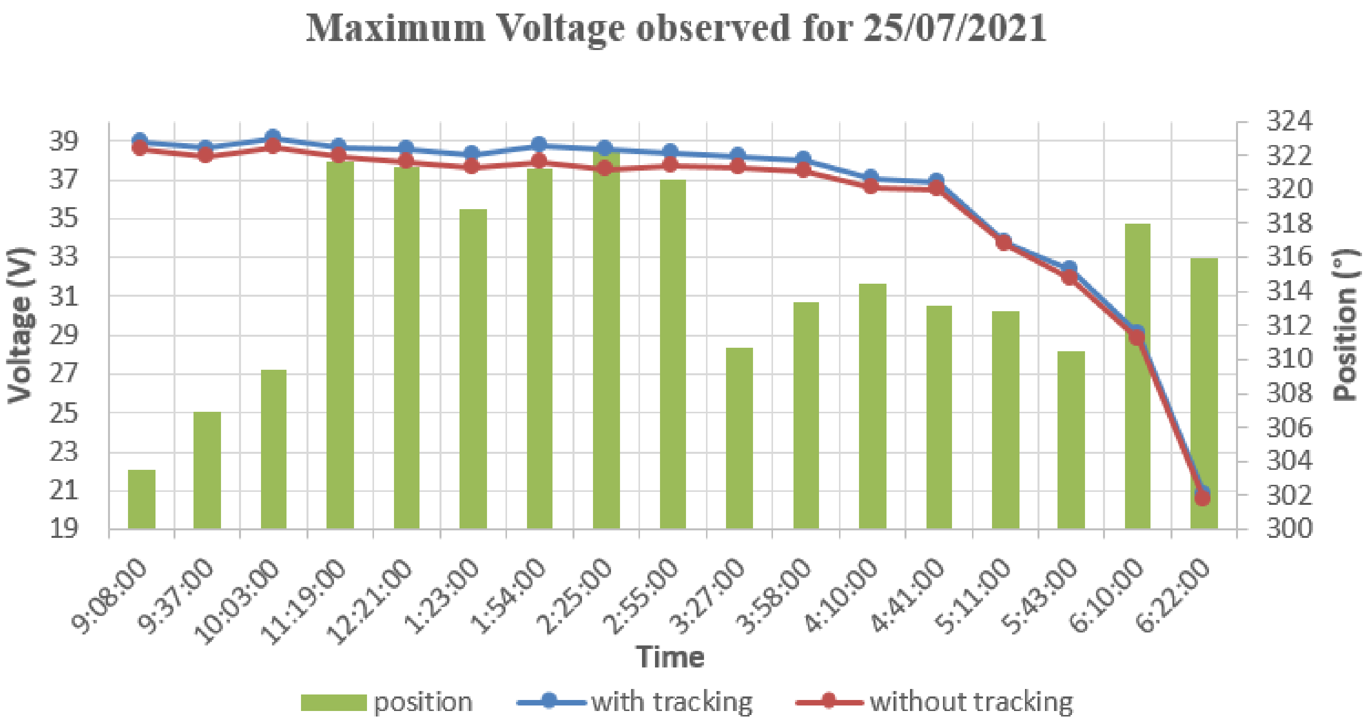


Figure 6

Graphical Representation of the data

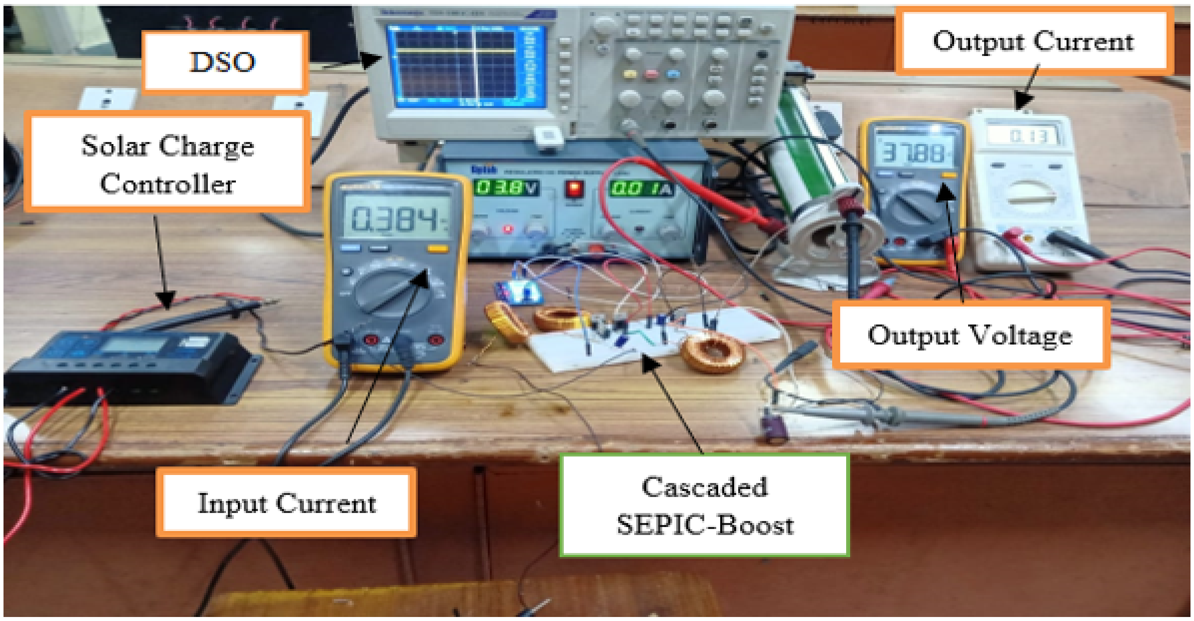


Figure 7

Cascaded Boost-SEPIC Converter Experimental Setup with 19V input from Solar Panel

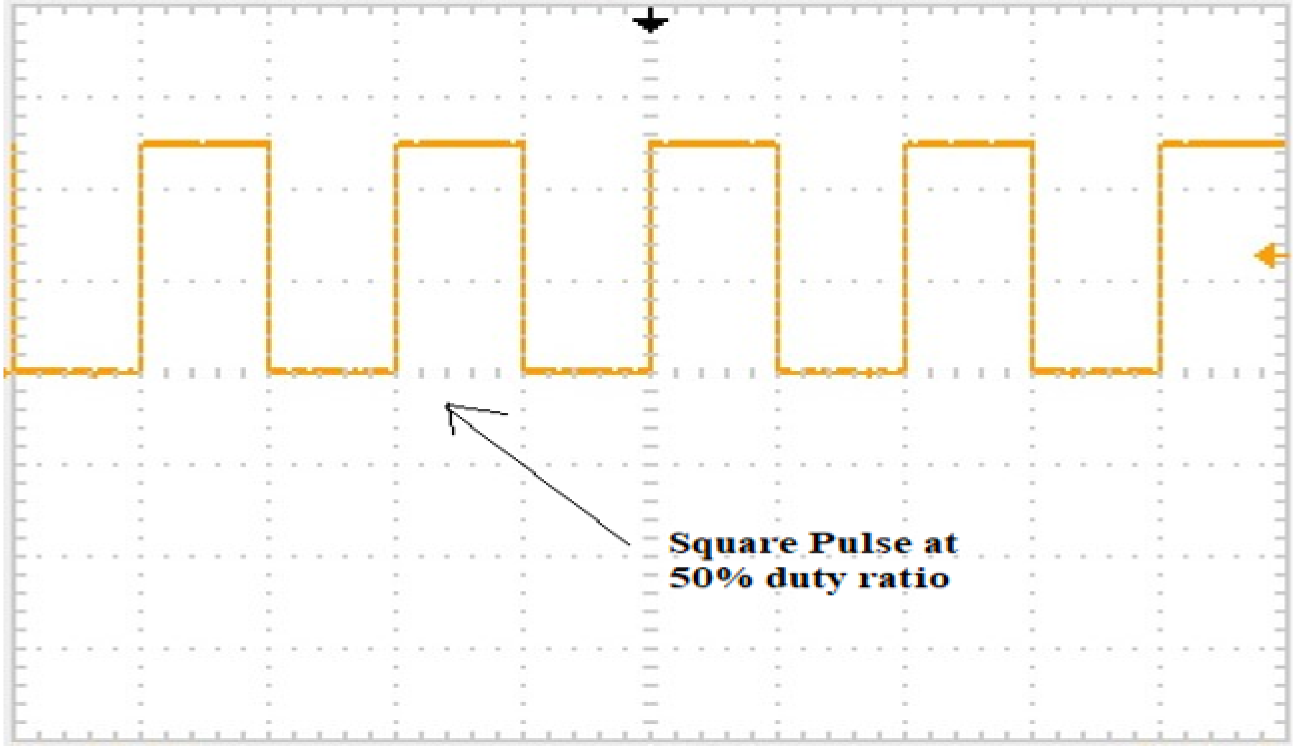


Figure 8

Square pulse fed to the gate terminal of the MOSFET IRF540N

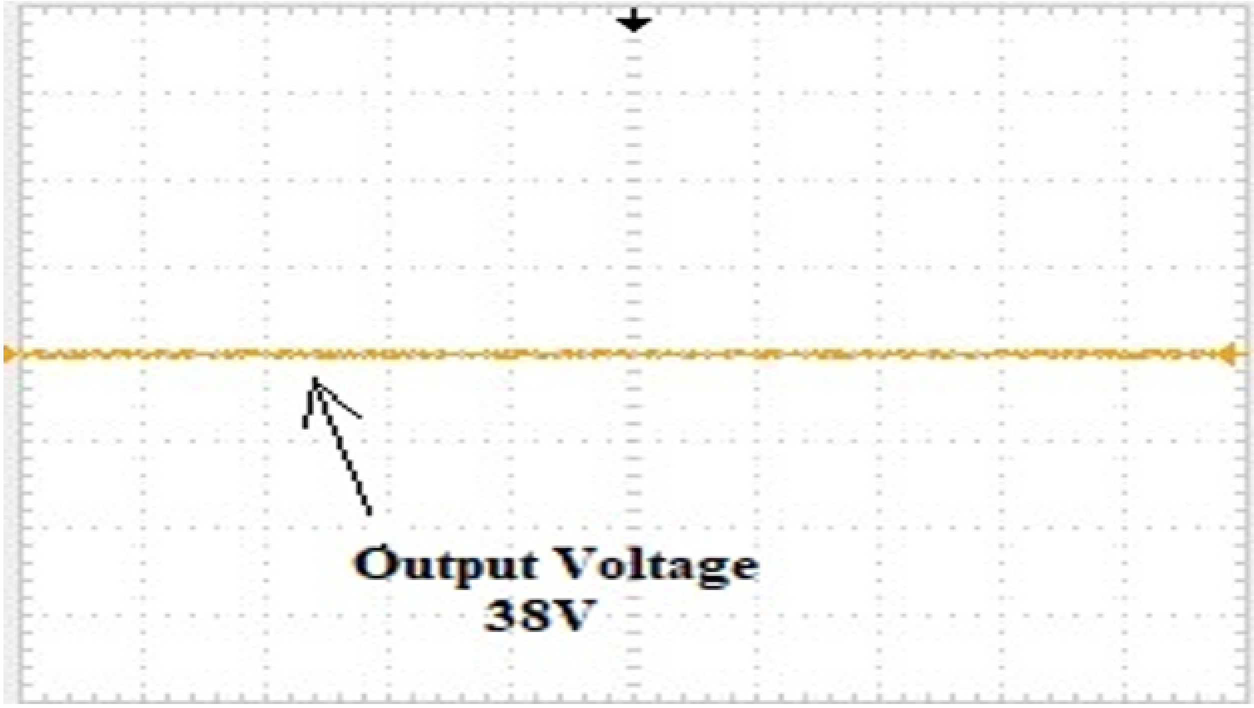


Figure 9

Output voltage waveform of 38V at 50% duty ratio