Electric Vehicle Charging Station Using Solar Pv Array

J. Nagarajan[1], M. Mownesh[2], T. Abisekh[3], K.Praveen[4]
[1]Assistant professor, Dept of Electrical and Electronics Engineering
[2, 3, 4]Dept of Electrical and Electronics Engineering
[1, 2, 3, 4] Dr.Mahalingam College of Engineering and Technology, Pollachi, Tamil Nadu.

Abstract*- In Electric vehicle, Battery charging system plays a major role in development of EVs. The reliability of the vehicle is influenced by the battery and power electronic converters used in the battery charger, as charging an EV battery from the grid increases its load demand. This leads to the proposal of a photovoltaic (PV) array based Electric Vehicle battery charging system. Various converters are used as the interface in this system for extracting the power from the renewable energy sources. Numerous paper have been developed in the development of renewable energy system employing different power electronic converters for electric vehicle energy storage applications. Hence this paper works is focused on the design and development of PV array-based EV battery charger. The proposed system facilitates uninterruptable charging of EV battery in constant voltage charging mode The SEPIC converter can handle a wide range of D.C input voltages while maintaining a steady output voltage. This paper deals the importance of SEPIC converters are used instead of other D.C-D.C-converters. This paper implemented using in this area of MATLAB software.*
Keywords: photovoltaic, SEPIC, PI.

I. INTRODUCTION

Ever increasing effect of greenhouse gases from the conventional engine lead to the environmental concern. This paved to the booming of pollution free Electric Vehicles (EV) in the automobile industry. However, charging of EV battery from the utility grid increases the load demand on the grid and eventually increases the electricity bills to the EV owners which necessitate the use of alternate energy sources. Due to inexhaustible and pollution free nature of Renewable Energy Sources (RES), it can be used to charge the EV battery. Thus, RES driven electric vehicle can be termed as “green transportation”. Solar is one of the promising renewable energy sources which can be easily tapped to utilize its energy to charge EV battery. With the use of power converter topologies, PV array power is utilised to charge the EV battery in the suggested system. Because of its high power density, high efficiency, light weight, and small size, lithium- ion batteries are commonly employed in electric vehicles. These batteries can also charge quickly and have a long lifecycle with a low self-discharge rate. They are also unlikely to explode if overcharged or short-circuited. These batteries require precise voltage regulation while charging. As a result, different power electronic converters with voltage controllers are employed to charge electric vehicle batteries.

Due to the intermittent nature of PV array, there is a need for power converter which is capable of providing constant output voltage irrespective of input voltage to charge the EV battery. In the existing literature, PV array-based EV battery charging system. Employing boost converter, buck converter is available. As more number of converters is employed in the existing system, there is a need for more controllers which in turn increase the losses of the system. Hence, it is necessary to design a PV array fed EV battery charger with lesser number of converters. Among different dc-dc converters, Sepic converter is preferred in the Standalone PV EV battery charger due to the capability of working in both boost and buck mode which will reduce the conversion stage. It also has the advantage of same input and output voltage polarity, low input current ripple and low Electromagnetic Interference (EMI).

MODELLING OF SOLAR PV PANEL

Photovoltaic is a subject of science and study that deals with devices that convert sunlight directly into electricity utilising photovoltaic semiconductors. Photovoltaic cells convert solar radiation directly into DC electrical energy. The photovoltaic panel is composed of many cells, placed in series Ns or in shunt Nsh. Where it can be modelled by current source connected in parallel with diode according with shunt and series resistor noted by and as illustrated in Fig.1.

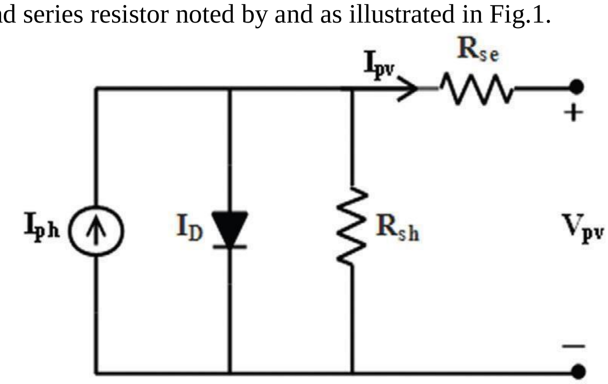


Fig 1: Equivalent circuit diagram of a PV cell.

The output current from a PV cell can be represented as:

$$Ipv = Iph - Id - Ish$$

The output current equation of the PV module can be written as

$$I = I_{ph} - I_d = I_0 \left[\exp\left(\frac{V}{AV_T}\right) - 1\right] - \frac{V + IR_s}{R_{sh}}$$

Where,

Ipv	PV cell current
Iph	Photon generated current in pv cell
Id	Current through the diode
Ish	Current through shunt resistance
Io	The inverse saturation current
A	The diode ideality factor
Vr	The thermal voltage of diode
Rs	The equivalent series resistance
Rsh	The equivalent shunt resistance

SEPIC CONVERTER

The single-ended primary inductor converter (SEPIC) is a type of DC-DC voltage converter that is able to both step-up ("Boost") and step-down ("Buck") an input voltage a useful characteristic for obtaining the maximum capacity from a battery when the silicon voltage requirement is above the battery's low.

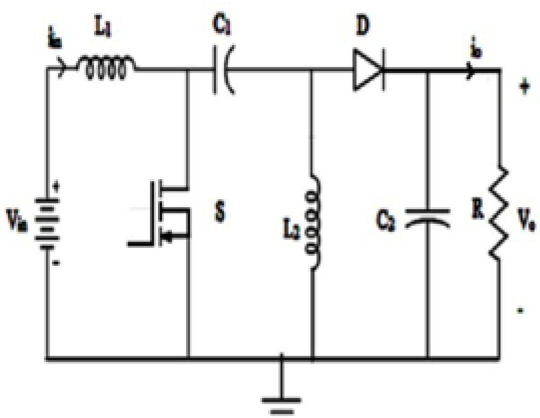


Fig2.1: Schematic diagram of Sepic-converter

OPERATION OF SEPIC CONVERTER

In all dc-dc converters, a high frequency pulse is employed to quickly turn on and off a MOSFET. What makes the SEPIC converter superior is what it performs as a result of this. When the pulse is high and the MOSFET is turned on, the input voltage charges inductor 1 and capacitor 1 charges inductor 2. The output is maintained by capacitor 2 while the diode is turned off. The inductors output through the diode to the load when the pulse is low/the MOSFET is off, and the capacitors are charged. The more the proportion of time the pulse is low (duty cycle), the higher the output. This is because the higher the voltage, the longer the inductors charge. This is because the higher the voltage, the longer the inductors charge. The capacitors will not be able to charge if the pulse is too lengthy, and the converter will fail.

SWITCHING MODE

Mode1 (on stage)

During ON stage of the switch, the diode "D" is in OFF condition is shown in Figure 2.2. The load current is supplied by the output capacitor C2, and the current via the source and load side inductors increases linearly.

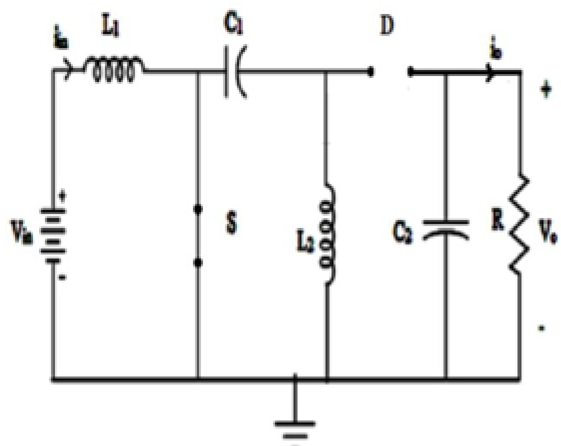


Fig 2.2: Sepic converter circuit diagram during on stage.

Mode2 (off stage)

During OFF stage of the switch, the diode "D" is in ON condition. The current through the input and output inductors decreases linearly, the load current is supplied by the coupling capacitor C1. In mode II, when the switch is turned OFF, voltage across output inductor L2 reverses its polarity momentarily which forward biases the diode D1 and the diode gets turned ON. The equivalent circuit for mode II is shown in Figure 2.3 Source voltage Vin and the energy stored in the input inductor L1 increase the voltage across the capacitor C1. Hence the current through the input inductor L1 increase the voltage across the capacitor C1. Hence the current through the input and the output inductors decrease linearly. The load current is now contributed by the energy stored in the output inductor L2. During this mode, the current through the output inductor L2 falls linearly from L22 I to L21 I Since the capacitor C1 charged fully, the inductor current L1 falls linearly from IL12 to IL11 at time t2 (Toff).

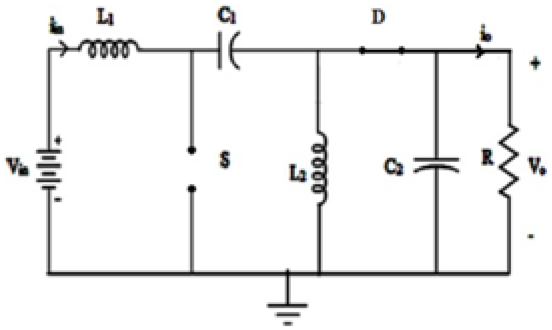


Fig 2.3: Sepic converter circuit diagram during off stage

Fig 2.3: Sepic converter circuit diagram during off stage

Parameters	Values
Input voltage (Vin)	16.9 V
Output voltage (Vo)	24 V
Rated power(P)	1020 W
Inductance (La, Lb)	2 mh
Capacitance(C1,C2)	0.67,200 uF
Switching frequency(Fs)	50000 HZ

DESIGN OF SEPIC CONVERTER

In the proposed charging system, Sepic converter provides the constant output voltage irrespective of the PV array voltage by adjusting its duty ratio using the PI controller. The Sepic converter consists of one switch, one diode, two inductors and two capacitors as shown . The major advantages of Sepic converter are:

(i) Depending on the duty ratio, it can function in both boost and buck modes.
(ii) It provides the output voltage with same polarity as input voltage unlike buck-boost and Cuk converters. The voltage gain of the Sepic converter is provided by

Duty ratio:

Dmax=[(Vdc+VD)/(Vpvmin+Vdc+VD)]

Capacitor:

C1=[(Idc×Dmax)/(ΔVc1×fsw)]
C2=[(Idc×Dmax)/(ΔVdc×fsw)]

Inductor:
La=Lb=[(Vpvmin×Dmax)/(2Δipv×fsw)]

where Dmax is maximum duty ratio **,**
Vd is the diode voltage drop,
VPV min is the minimum PV array voltage,
ΔiP V is the input current ripple, fsw is the switching frequency, Idc is the dc bus current,
ΔVC1 is the capacitor, C1 voltage ripple,
ΔVdc is the output voltage ripple,

PI CONTROLLER

In order to maintain constant voltage at the dc bus irrespective of variations in the PV array voltage, PI voltage controller is used in the proposed charging system to generate gate pulses to the switches in the Sepic converter by comparing the dc bus voltage, Vdc with reference dc bus voltage, Vdcref to get the error signal. Based on the error value, PI controller generates the control signal which is compared with 25 kHz ramp signal to obtain the gate pulses with appropriate duty ratio.

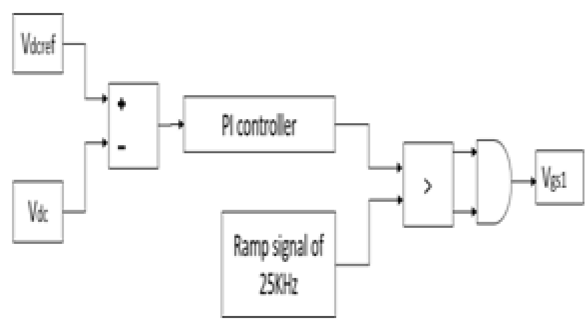


Fig3.1:Controller diagram of Sepic converter.

PROPOSED MODEL

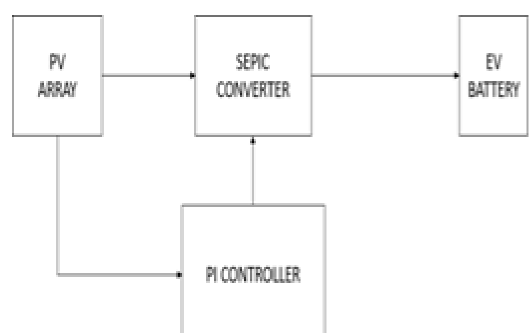


Fig3.2: block diagram of propose system.

Block diagram operation:

The construction and working of this system PV-EV charger consist of two pv arrays which are connected in series, a sepic converter, a pi-controller and a battery. A controller is used to generate the gate pulse to triggering the sepic converter for obtaining constant output voltage at dc link. The sepic converter provides constant output voltage irrespective of the pv array voltage by adjusting it duty ratio using the pi controller. In this charging system we used to charge a Lithium- ion battery which has high efficiency, high-power density, light weight, and compact size also this battery has more life span.

Parameters	**Values**
STC Power Rating	1020 W
No. of Cells in Series	96
Rated Current (Imax)	34 A
Rated Voltage (Vmax)	15 V
Short Circuit Current (Isc)	35 A
Open Circuit Voltage (Voc)	16 V

Table 3: solar panel specification

Simulation diagram of proposed system:

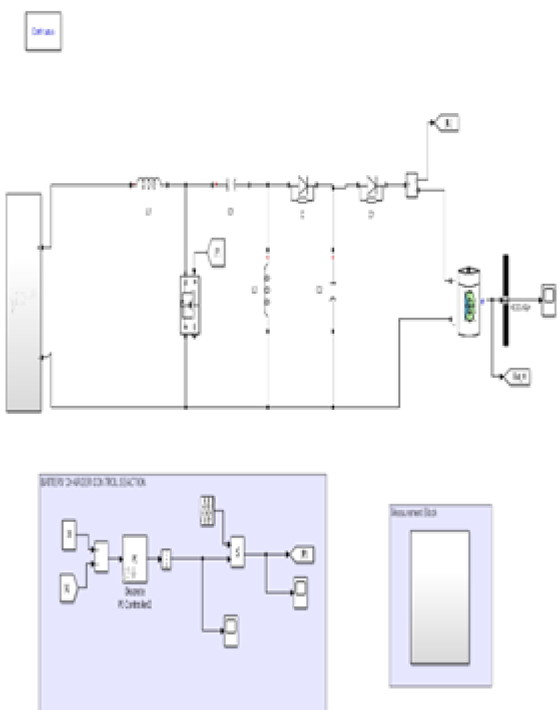


Fig4.1: simulation diagram Battery charger

SOLAR EQUIVALENT SIMULINK MODEL:

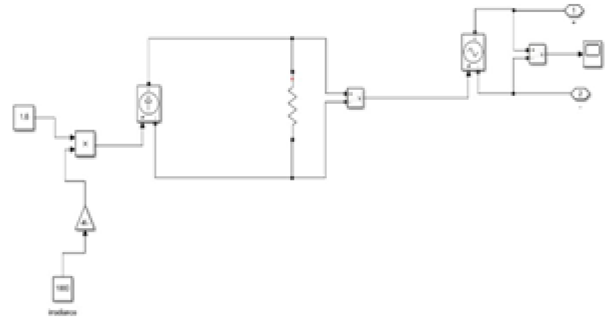
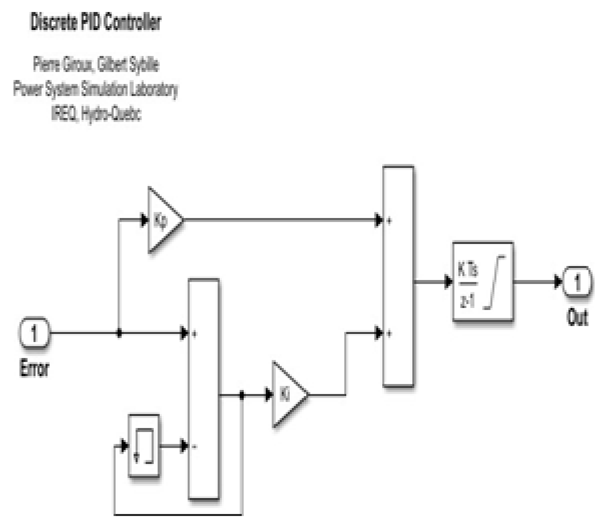


Fig 4.2 SOLAR SIMULINK MODEL

Controller Diagram:



4.3 PI Controller

BATTERY OUTPUT VOLTAGE:

Fig5.1: Battery output voltage

In this simulation the output battery voltage is taken as shown in the fig5.1 the output voltage of 26V is obtained which is used to charge for the electric vehicle.

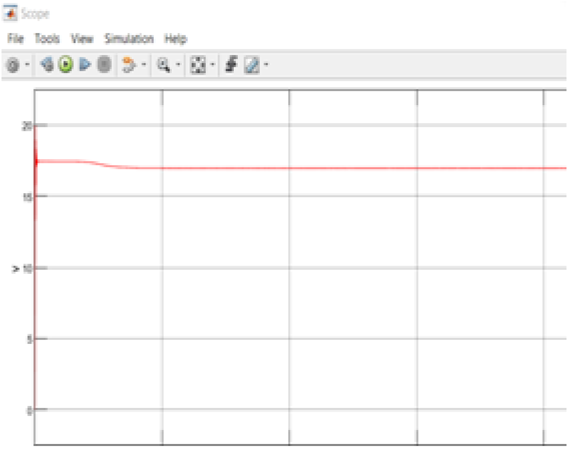


Fig5.2: PV output voltage

In this simulation the voltage from PV array as shown in the fig 3.5. The output voltage of the PV array which get 16V.

SIMULATION RESULT

Irradiation (w/m^2)	Panel Output voltage(v)	Sepic converter Output voltage(v)
1000	17.4	26
800	17.5	26
1000	14.6	26
1000	16.5	26
700	17.7	26
1000	16	26

In this table which shows the simulation result by using the MATLAB software. When the irradiation varies, the panel output voltages also changed. The panel output voltage is connected to the sepic converter to buck/boost or to maintain constant voltage.

EXPERIMENTAL SETUP AND RESULT

In hardware the prototype of the EV battery charger was fabricated and tested. The experiment is tested by using solar PV array as input voltage. MOSFET IRF540 and Diode RHRP30120 are used to fabricate sepic converter. The gate pulses of 50HZ switching frequency are fed to the MOSFET switches of sepic converter. Lead acid battery are used as EV charging battery. The value of capacitor and inductor are calculated.

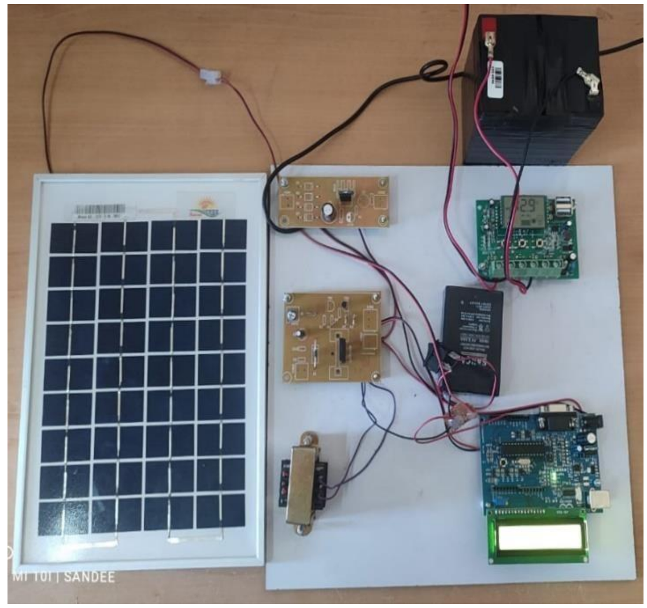


Fig5.3: Hardware photograph CONCLUSION

In this paper, the proposed off-board EV battery charging system fed from PV array is presented. This paper discusses the flexibility of the system to charge the EV battery constantly irrespective of the irradiation conditions and its performance is compared with existing charger.

Most battery-operated circuits require stepping up and down the input voltage, SEPIC converters are worth of the extra inductor and capacitor for the efficiency and stable operation they provide. While this paper does go into detail about simulation results for the SEPIC converter. The proposed system is designed and simulated in Simulink environment of the MATLAB software.

REFERENCES

[1] M. S.Tanveer, S. Gupta, R. Rai, N. K. Jha and M. Bansal, "Solar based electric vehicle charging station," 2019 2nd International Conference on Power Energy, Environment and Intelligent Control (PEEIC), 2019, pp. 407-410,doi: 10.1109/PEEIC47157.2019.8976673.

[2] S. Bhadra, P. Mukhopadhyay, S. Bhattacharya, S. Debnath, S. Jhampati and A. Chandra, "Design and Development of Solar Power Hybrid Electric Vehicles Charging Station," 2020 IEEE 1st International Conference for Convergence in Engineering (ICCE), 2020, pp. 285-289, doi: 10.1109/ICCE50343.2020.9290651

[3] A. M. Khatab, M. I. Marei and H. M. Elhelw, "An Electric Vehicle Battery Charger Based on Zeta Converter Fed from a PV Array," 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power

Systems Europe (EEEIC / I&CPS Europe), 2018, pp. 1-5, doi: 10.1109/EEEIC.2018.8494541.

[4] S. Kamble and P. S. Swami, "On-Board Integreted Charger for Electric Vehicle Based on Split Three Phase Insuction Motor," 2018 International Conference on Emerging Trends and Innovations In Engineering And Technological Research (ICETIETR), 2018, pp. 1-5, doi: 10.1109/ICETIETR.2018.8529144.

[5] Revathi, A. Ramesh, S. Sivanandhan, T. B. Isha, V. Prakash and S. G., "Solar Charger for Electric Vehicles," 2018 International Conference on Emerging Trends and Innovations In Engineering And Technological Research (ICETIETR), 2018, pp. 1-4, doi: 10.1109/ICETIETR.2018.8529129

[6] Y.Raghunandan, Shivatejamanala, “Modelling Of Dc-dc Converter For Solar Based Electric Vehicle”,2019