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Solar-Powered High Gain Modified Buck Boost Converter for E-Vehicle Charging System

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ABSTRACT: This project proposes a solar and bidirectional battery based power assisted electric vehicle and battery balancing system. Due to its high efficiency and reduced emissions, new zero-emission hybrid electric vehicles have been selected as an attractive challenge for future transport applications. New zero - emission hybrid electric, on the other hand, has some major drawbacks from the complicated charging process. The hybrid electrical fuel cell system is introduced as the main source to intelligently control multi-source activities (solar, battery). To regulate energy demand and supply, an intelligent energy management system is proposed and tested through several constraints. The proposed approach system aims to act quickly against sudden circumstances related to hydrogen depletion in the prediction of the required fuel consumption basis. The proposed strategy tends to define the proper operating system according to energy demand and supply. The obtained results show that the designed system meets the targets set for the energy management unit by referring to an experimental velocity database.

KEYWORDS: Electric Vehicle; Solar; MPPT; P&O Algorithm; Transformerless Buck Boost Converter; Bidirectional DC/DC Converter; PI Controller.

I. INTRODUCTION

Air pollution, particularly PM, is a serious challenge facing by transportation sector of various countries. The World Health Organization (WHO) reported 3.7 million death tragedies in the world below 60 in 2012 due to atmospheric air pollution, 90% population are located in developing countries [1]. Presently 1.7 million child expires a year and total 9 million people died each year, says WHO [2,3]. And nearly 18% of premature births (before 37 weeks gestation) (globally) are related to exposure to outdoor air pollution [3]. China reported 1.22 and 1.28 million premature death cases in 2005 and 2010, respectively [4]. According to an estimate of the 2017 Global Burden of Disease, atmospheric air pollution is responsible for more than 4.2 million early deaths, of these, India accounts for 1.1 million each year expires [5]. Although due to smaller vehicle fleet relative to large population, India fixes low per capita transportation emissions. The big factor is the exponential growth of vehicle fleet, because of the growth in vehicle sales (about 10 million in 2007 to over 21 million in 2016 and expected to nearly double to about 200 million by 2030 in India [6]. A number of health and medical organizations claimed that the diesel engine exhaust is more prone to cancer in humans [7]. Also, rising fuel costs and growing public concerns on environmental problems such as air quality, global warming, etc. have led the governments and automobile industries to develop eco-friendly, emissionfree means of transportation [8] i.e. green transportation systems e.g. walking, cycling, regular public conveyance, and rail transport system, etc. Vehicles include natural gas vehicle, hybrid energy vehicle, electric vehicle, hydro- genpowered vehicle, and solar energy vehicle [9].

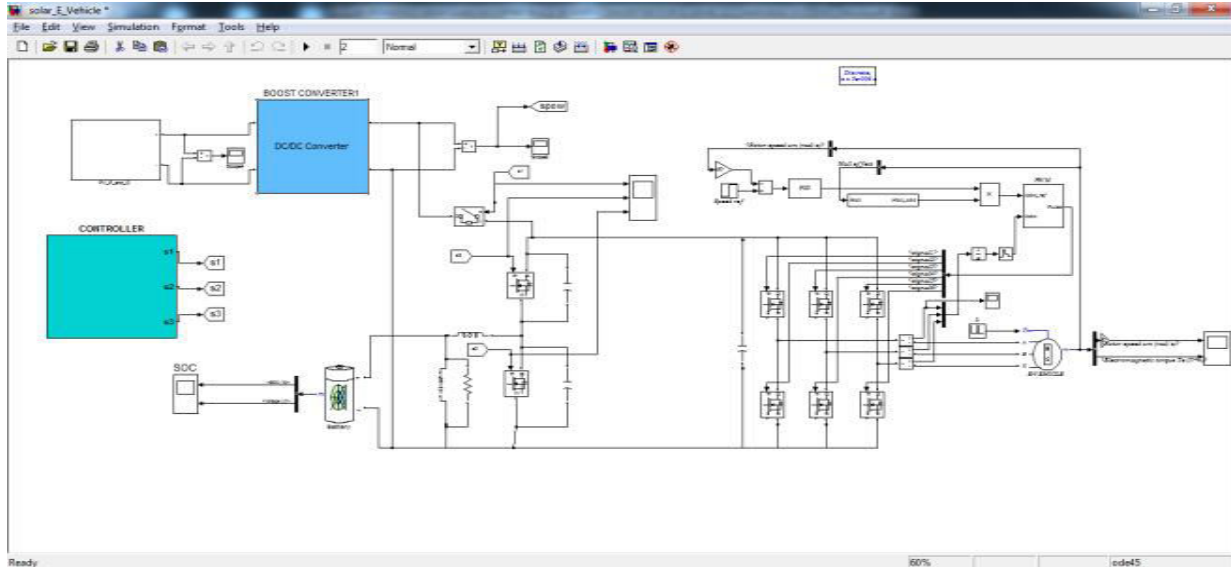


Fig 1: HIGH GAIN DC-DC CONVERTER:

Vehicle emission standards are adopted to incorporate soot free fleet services around the world [10,11]. Countries like Europe, the United States, Japan, and India adopt Euro 6/VI equivalent standards (for light- and heavy-duty vehicles) that reduce 99% emissions like (NO_x), (NH₃), (N₂O), etc. [12,6] and justifying the regulation of risk of ischemic heart disease, lung cancer, stroke, and asthma [13]. But the best option is renewable energy.

The outcome of this paradigm shift, EVs and PHEVs are emerging as attractive alternatives to ICEVs [14]. Owing to the importance of EVs, the national and international governments worldwide (U.S.A., U.K., China, Germany, France, Japan, Norway, Netherlands, etc.) have passed various resolutions and supervisory steps and allocated substantial fund to encourage EV and PEV deployment and implementation [15]. Long-term planning scenarios specify that the EVs must capture almost entire global vehicle fleet, mostly propelled by renewable sources, by 2050 to avoid worst-case global climate change scenarios [16].

II. LITERATURE REVIEW

A three-level isolated MI converter is introduced in [6], with fewer components and less voltage stress on the power electronic components. When the converter circuit input inductors are selected appropriately, they operate in discontinuous conduction mode (DCM), allowing independent power distribution between the input sources. However, a transformer is required for insulation, resulting in an increased size and cost. Further, the DCM mode of operation requires complicated control schemes. In [7], a bidirectional DC-DC converter with a multi-input transformer for hybrid wind-PV-battery systems is presented. Wind power is captured in the proposed circuit through a half-bridge auxiliary converter coupled to a transformer. In contrast, PV energy is harnessed using a bidirectional buck-boost converter that controls battery charging and discharging. A single-phase, full-bridge bidirectional converter is used to deliver power to the loads and communicate with the grid. However, the system is more expensive because of the inclusion of three converters and a multi-winding transformer. Due to the existence of a transformer, isolated MI converters are only useful in highly demanding situations. As a result, non-isolated MI converters with a simple structure and higher energy density have gained popularity, considering their affordability.

An MI DC-DC boost converter is proposed in [8], which comprises a battery storage device and two boost converters, with an additional capacitor substituted in one of the converters. However, the proposed architecture has more components, a complicated control method, and lower efficiency. A high-voltage-gain MI converter with an inductor in a single-architecture form is presented in [9]. Here, zero voltage switching (ZVS) of two of the four primary switches and the management of the bidirectional power flow between the lower and upper sides of voltage require complex control techniques. In addition, coupled inductors and switches increase both the size and cost. A non-isolated MI DC-

DC converter circuit is described in [10], which receives output power from a group of low-powered small wind turbines. The designed circuit architecture consists of two stages with a network of DC-DC converters, which leads to the need for more components and a cumbersome system. Furthermore, numerous steps in operation decrease the overall efficiency of the converter. A modular, non-isolated MI DC-DC converter without a coupled inductor is proposed in [11]. The proposed design uses fewer components to produce the appropriate voltage gain, which can lower the converter's dimensions, weight, price, and losses while increasing its efficiency. However, significant stress on the power electronic components necessitates complex control schemes for continuous-input-current operation.

Recently, [12] introduced a three-input DC-DC boost converter. It has a standard buck–boost and a boost converter with one bidirectional battery port and two unidirectional power source ports. The large number of passive and semiconductor components in the system has resulted in an increased size and cost with less efficiency. A further MISO step-up converter is introduced in [13], where the load is fed from two sources either separately or simultaneously. This structure is simple and improves the power output, power source utilization, and fault tolerance of the source. However, the switches are subjected to high voltage stress and thus operate with lower efficiency. An MI DC-DC converter based on SEPIC is presented in [14], with an initial stage that connects many input voltage sources and a battery management system (BMS) stage that allows the charging and discharging of the battery. However, during the operation of the proposed converter, the power electronic components and diodes are subject to considerable stress. The large number of components in the system further increases the costs and reduces the efficiency. An MI buck DC-DC converter with a single inductor is proposed in [15]. While there are fewer parts, the suggested architecture may not be acceptable for high-voltage applications since the output voltage is less than the lowest input voltage. Additionally, all input diodes must be changed out for power switches to allow bidirectional operation, practically doubling the switch count, which increases the switching losses and voltage stress on switches and raises the price.

A modified double-input DC–DC converter with a bridge-type configuration, capable of integrating renewable and non-renewable sources and storage systems, is presented in [16]. In the same structure, the suggested converter will work in step-down, step-up, and step-up/down mode. The topology can supply power to the load even if one of the input sources is not available. However, a complex control system is required to drive multiple-input voltage sources simultaneously and for the bidirectional power flow. A transformer-less high-voltage-gain DC-DC MI converter is recommended in [17]. The converter combines the conventional boost and buck–boost converters. It has reduced voltage stress on the power electronic components, and a wide control range of the input sources. However, additional diodes required for the multi-input converter to work continuously increase the cost and component count. A MISO DC-DC power converter described in [18] allows communication between multiple energy sources with different power levels using a dual boost converter connected to the same DC bus. This circuit demands a complex control mechanism for its operations. S. Mohammadi et al. [19] introduced a high-voltage-gain non-isolated MI DC-DC converter, in which the load on the switches can be reduced by adding more input units and selecting a lower duty ratio for each unit. However, the requirement for numerous components makes operation costly and inefficient.

A non-isolated MI boost DC-DC converter with fewer components and higher efficiency is suggested in [20], having input sources that can supply a common load while being completely managed and running concurrently. With this structure, any voltage or current sources can be taken as the converter's input and plugged into and unplugged from the converter using a plug-and-play interface. The range of suggested converter applications in various low to high voltage and power ranges can be extended by enhancing the converter voltage gains by adding additional input sources. However, the performance of the converter is analyzed with two fixed DC sources. The benefits of this converter topology have prompted further research in the converter to determine the feasibility of incorporating solar PV as one of the sources.

III. METHODS

MAXIMUM POWER POINT TRACKING Most extreme Power Point Tracking (MPPT) is helpful apparatus in PV application. Sun oriented radiation and temperature are the primary factor for which the electric power provided by a photovoltaic framework. The voltage at which PV module can create greatest power is called 'most extreme power point (pinnacle control voltage)'. The primary rule of MPPT is in charge of separating the greatest conceivable power from the photovoltaic and feed it to the heap by means of dc-to-dc converter which steps up/ down the voltage to

required size [5]. The operating point of a PV generator is located at the intersection of its current-voltage curve with the load-line. This operating point may be far from the maximum power point (MPP) of the generator wasting a significant part of the available solar power. To achieve optimum matching between the PV generator and the load, an MPP tracker, normally comprised of a simple dc-dc converter, is used. The duty ratio of the converter is controlled by an MPPT algorithm to maximize the power delivered to the load.

A number of different MPPT algorithms have been proposed [1-3], including the P&O algorithm. This simple algorithm does not require previous knowledge of the PV generator characteristics or the measurement of solar intensity and cell temperature and is easy to implement. The algorithm perturbs the operating point by increasing or decreasing a control parameter by a small amount and measures the PV array output power before and after the perturbation. If the power increases, the algorithm continues to perturb the system in the same direction; otherwise the system is perturbed in the opposite direction.

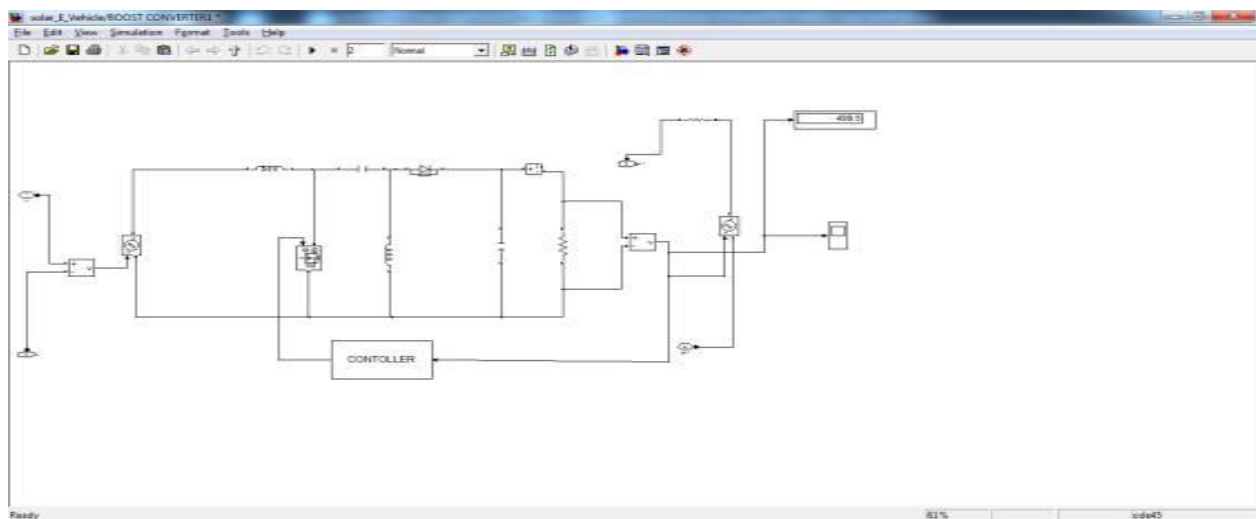


Fig 2: High Gain Modified Buck Boost Converter

There are two common approaches for implementing the P&O algorithm; reference voltage perturbation [4-10] and direct duty ratio perturbation [5, 7, 11-13]. For reference voltage perturbation, the PV array output voltage reference is used as the control parameter in conjunction with a controller (usually a PI controller) to adjust the duty ratio of the MPPT power converter. The PI controller gains are tuned while operating the system at a constant voltage equal to the standard test condition (STC) value of the MPP voltage. These gains are kept constant while the reference voltage is controlled by the MPPT algorithm. For direct duty ratio perturbation, the duty ratio of the MPPT converter is used directly as the control parameter.

TRANSFORMERLESS BUCK-BOOST CONVERTER

Identifying, evaluating and analysing the growing environmental issues addresses us to use more efficient, clean source of energy. Taking fuel cells into account, it is an effective alternative clean energy source and has less hazardous effects on the environment. Due to its high efficiency, steady operation with a renewable source of energy it can be used as power supplies that have better backup facilities and many other brilliant features. The fuel cell output voltage is variable and due to its low output, directly it cannot be connected to load. To overcome difficulties and to make it more beneficial, the buck-boost dc-dc converter is essential for the applications which required constant DC voltage. The conventional buck-boost converter efficiency is low and due to its limited effects, it is not proper for fuel cells sources [1]. A several boost dc-dc converters have been introduced to get high-level voltage gain and high efficiency and a novel control technique can be introduced to operate with low duty cycle [2]. A flyback converter with low duty cycle can achieve high-level voltage gain. It can be done so by raising the turn's ratio of the transformer but its converter efficiency is low due to leakage inductor and reverses recovery problems. The power switches suffer voltage spike through it [3, 4]. High amount of voltage gain dc-dc converters with a coupled inductor is another option. Here, the leakage inductance of this coupled capacitor adds voltage stress and cause high voltage spike [5, 6].

A high conversion ratio bi-directional dc-dc converter consists of five switches. It decreases the efficiency and increases the circuit cost and conduction losses [7]. Two power switches are utilized in a transformerless interleaved high buck converter, and it charges converter capacitor. Voltage Gain for transformerless buck-boost dc-dc converters are doubles that of traditional buck-boost converter. The paper here presents a transformerless buckboost dc-dc converter with low voltage stress on the switch and high boost voltage gain is designed and it utilizes only single switch [8]. The designed converter voltage gain is higher than other converters like buck-boost, boost, ZETA, SEPIC and CUK converters. The designed converter consists of single switch. The output voltage is greater than the voltage stress across diode and switch, so the efficiency of designed converter can be enhanced and conduction loss of power switch can be reduced. The designed converter functions as a power supply and its input current is discontinues, hence it is convenient for low power and low voltage applications. The converter here can be widely used, it can be used in gadgets like mobiles and LED drives, electric vehicles and systems with fuel cell. Simulations results are provided so as to verify the feasibility of the converter.

IV. RESULT ANALYSIS

In Matlab programming, functions are used to encapsulate a computation so that it can be used repeatedly without having to duplicate code wherever it is needed. In addition, a function can insulate its calling script from having to worry about its implementation details. In Simulink, subsystems play a similar role. Using subsystems in Simulink has these advantages: It helps reduce the number of blocks displayed in the model window.

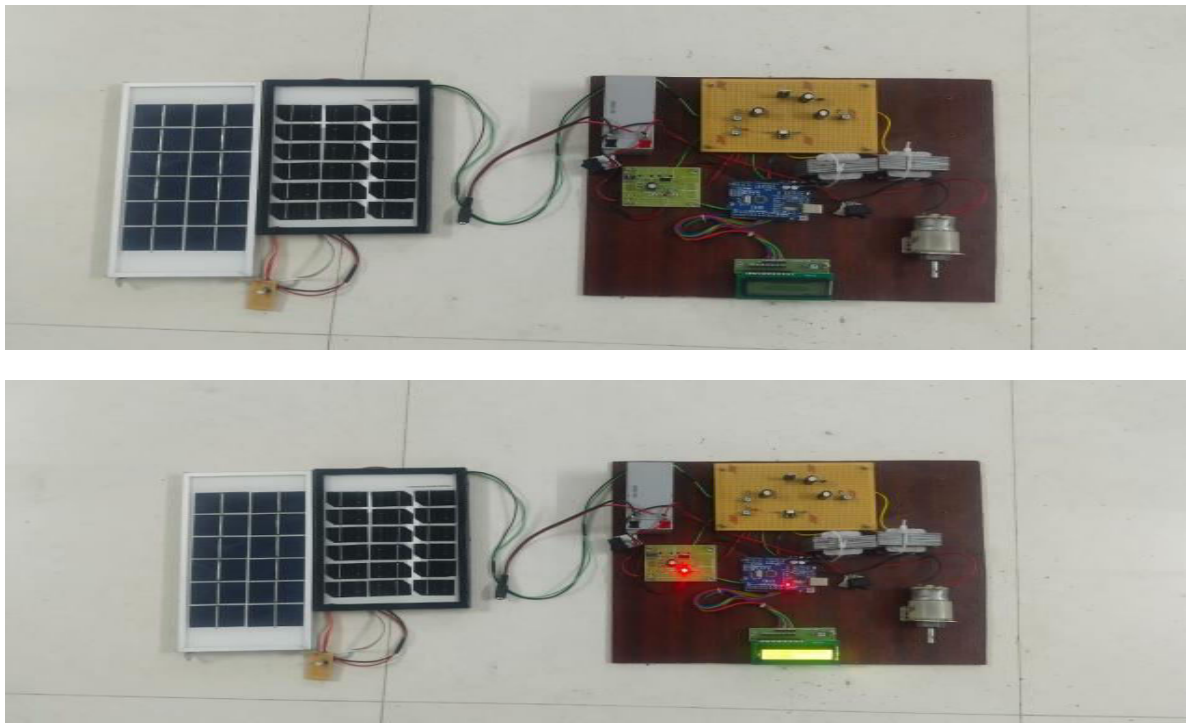


Fig 3: Hardware Module:

- Functionally related blocks can be kept together.
- It permits the establishment of a hierarchical block diagram,
- Subsystem block is on one layer and the blocks that make up that subsystem are on another.

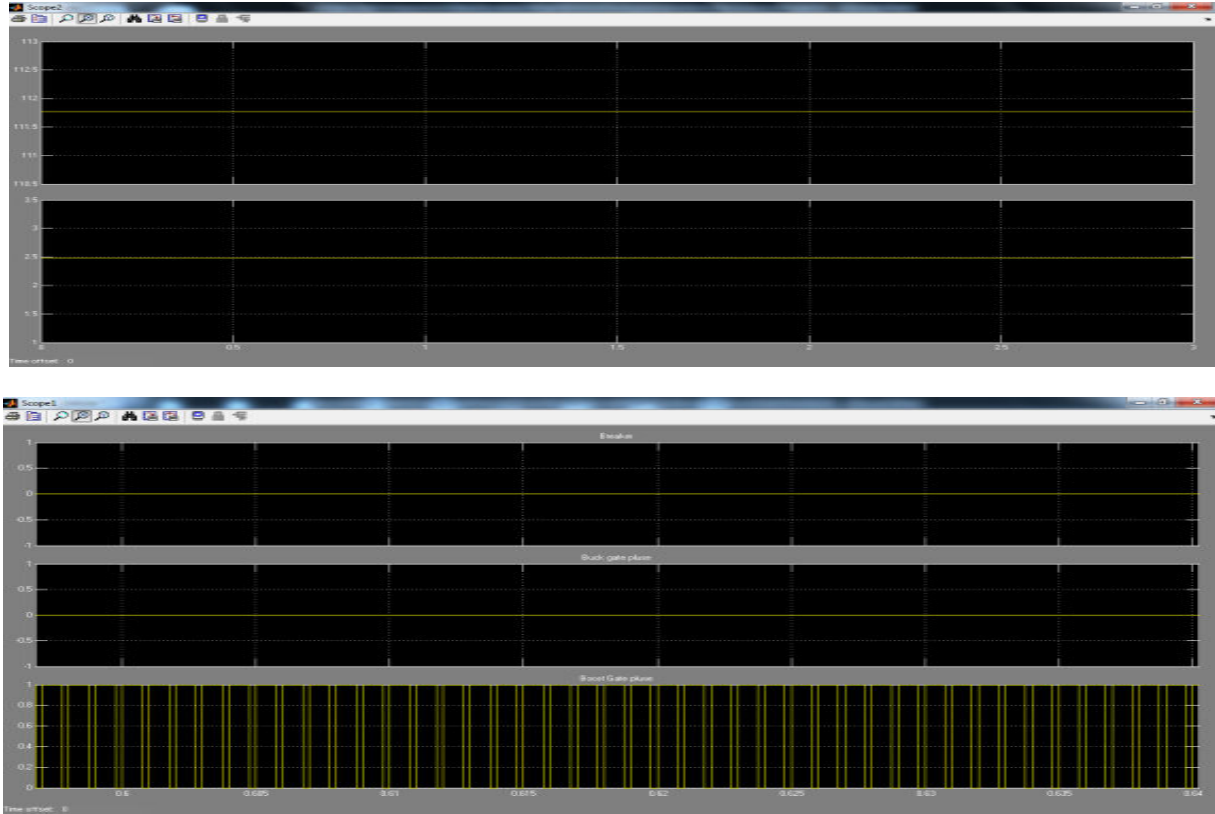


Fig 4: E-Vehicle Spedd And Torque:

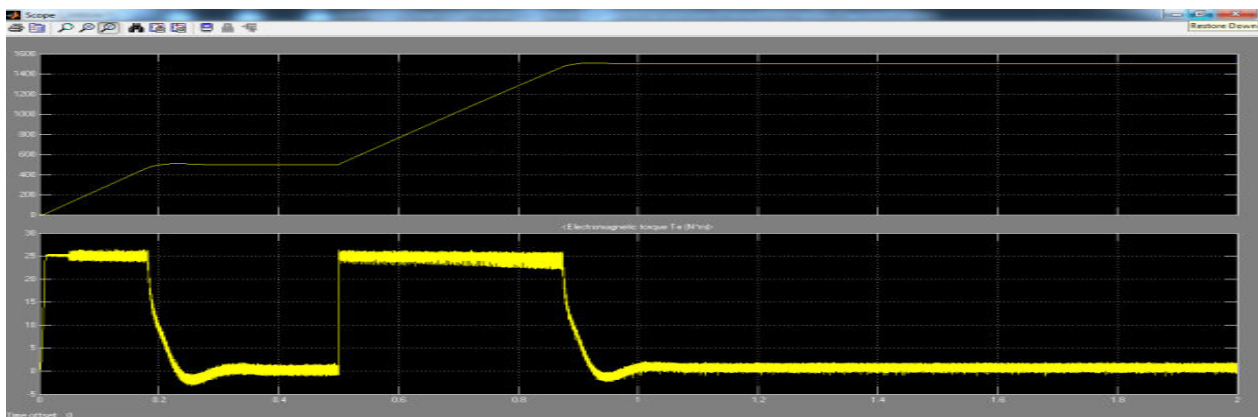


Fig 5: Solar Voltage And Current

The proposed system has been implemented using MATLAB Simulink. The input voltage for both dc voltage is set to 100V and 150V. The triggering pulse for a switch from s1 to s5 is set to 100khz. The typical simulation results of buck-buck,buck-boostbuck-boost, and buck-buck-boost converters using MATLAB-SIMULINK, respectively. Two dc voltage sources, V1 = 100 V and V2 = 150 V, are used for the input voltage sources. The switching commands S1 and S5 have fixed duty ratios of 0.5 at a switching frequency of 100 kHz. The typical DC output value of simulated buck-buck converter is 125 V.

In this converter, the main semiconductor is turned ON persistently, and for the second semiconductor, the square influx of high recurrence is applied to the entryway terminal. The subsequent semiconductor is in leading when the on state and the current information stream from the inductor L during that time semiconductor. The adverse terminal was energizing the attractive field around the inductor. The D2 diode can't lead in light of the fact that the anode is on the expected ground by profoundly directing the subsequent semiconductor.

V. CONCLUSION

In this study, we describe and test a solar PV battery-fed electric vehicle using a transformerless buck-boost converter for optimum power point tracking. A transformerless buckboost converter may operate in both buck and boost modes, depending on the output needs. Typically, a buck-boost converter is used between the solar panel and the load side's DC bus. The MPPT algorithm controls the transformerless buck boost converter (P&O). We provide the PV voltage and current to P&O MPPT, which generates the duty cycle. The pulse will be generated when the PWM generator has processed the duty cycle. When that pulse is applied to the Buck boost converter, it will extract the maximum power from the PV panel. The PMDC motor will operate as an electric vehicle, taking power from both solar and battery sources depending on irradiance and temperature. A bidirectional DC/DC converter operated by a DC bus voltage control system is attached to the battery. Since the PMDC motor rating is 90V, we must maintain the DC bus voltage at 90V in order to run the EV system. This process will be carried out through the PI controller, which will produce the duty cycle for the PWM generator, after which the PWM generator will generate the pulses for the bidirectional converter to regulate the current flow in the system as well as to maintain the voltage across the DC bus. The experimental findings suggest that the topology could successfully increase the energy transfer efficiency of MPPT technology, which meets the future development of EV systems.

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