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AN ADAPTIVE DUAL INPUT-DUAL OUTPUT CONVERTER WITH NON-ISOLATED FEATURES FOR USE IN ELECTRIC VEHICLES

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ASTRACT

In recent times, dc/dc converters with high voltage conversion have been observed in a range of power electronics applications. Specifically, the multi-port converter architectures hold the key to the solutions for electric vehicle and DC microgrid applications. The redesigned non-isolated four-port (two input and two output) power electronic interface structure that can be applied to electric vehicle (EV) applications is the main topic of this article. This converter's capacity to handle energy sources with varying voltage and current characteristics is its primary feature. Throughout its operation, the proposed topology can concurrently produce a buck and boost output. The suggested four-port converter (FPC) is implemented with fewer components and a more straightforward control scheme, increasing the converter's dependability and economy. Additionally, this converter has the ability to flow electricity in both directions, which makes it appropriate for charging an electric vehicle's battery while it is regeneratively braking. A control strategy to manage the power flow between the various energy sources is described, along with an analysis of the converter's steady-state and dynamic behavior. The suggested converter is designed using an extracted small-signal model. Through the use of MATLAB modeling and testing findings under various operating modes, the validity of the converter design and its performance behavior are confirmed.

1.INTRODUCTION

1.1Overview

Modern car technologies are a result of growing environmental pollution, a sharp increase in fuel prices, global warming, and the depletion of fossil fuels. As a result, the automotive industry has begun producing environmentally friendly electric and hybrid vehicles (HEV). The motor drive system is a crucial part of these vehicles. Powered by an effective power electronic converter, the motor drive system operates. When it comes to electric vehicles, this power electronic converter needs to be able to communicate both ways with battery and motor drive systems. Researchers have published a great deal of research on power electronic interfaces for electric vehicle systems in the literature. Different non-isolated three-port converter topologies are covered, including single input single output (SISO) and dual input/dual output (DIC/DOC) converter topologies. A step-up converter that combines buck-boost and KY converter features a voltage conversion ratio-rich converter. A double switch buck-boost converter's conversion efficiency can be increased by applying the interleaving principle, according to a suggested way. An analysis is conducted on a non-isolated boost converter that has large voltage gains and can automatically balance when the load is not balancing. The buck cascaded buck-boost power factor is described by Bang and Park.

TABLE 1. Components comparison.

Bidirectional Buck-Boost Converters in paper	No. of Inputs	No. of Outputs	No. of Inductors	No. of Switches	No. of Diodes	No. of Capacitors
H. Kang, et. al [4]	1	1	1	4	-	3
M. Badawy, et. al [7]	1	1	2	4	-	2
A. Hasanzadeh, et. al [8]	1	1	6	6	-	4
M. Reza Banaei, et. al [13]	1	1	2	1	2	3
A. Ajami, et. al [14]	1	1	3	1	2	4
B. Vural, et. al [18]	2	1	2	5	2	1
A. Khaligh, et. al [25]	1	1	1	5	5	2
T. K. Santhosh, et. al [26]	1	2	1	4	-	2
Proposed converter (FPC)	Single Input→Three Output (or) Double Input→Double Output		2	3	2	3

converter for broad input voltage changes used for correction. The converters listed above have a SISO layout and are unidirectional. A SISO type with four active switches is a non-isolated bidirectional dc/dc converter. Two distinct bidirectional converters, one with a cascading buck-boost inductor and the other with a cascading buck-boost capacitor in the middle, are compared. Zero-voltage transition three-level dc/dc converter with soft switching feature is presented to achieve high power density and improve efficiency. Using three inductors and three active switches, the converter with its three-port bidirectional architecture can generate buck or boost output. Many parallel buck-boost converter architectures, as well as converters with two supercapacitor modules and related power management control schemes, have been thoroughly studied. A single leg active switching element is used in a multi-port energy converter to perform multiple functions, including managing, and regulating the output power. The a forementioned dc converter uses more passive components in comparison to the standard buck-boost converter. An integrated DC transformer in a bidirectional high gain step-up/down dc converter, achieved as a non-isolated structure, adds bulk to the converter.

The proposed single switch buck-boost topology overcomes the issues with the KY converter and runs in SISO mode, gaining the advantages of CUK converters. Non-isolated multi-input multi-output dc/dc converters are a type of boost converter designed for unidirectional power flow photovoltaic applications. One limitation of a multi-input single-output n-stage converter is that it can only perform buck-boost operations in (n-1) stages. The nth stage functions as a boost converter, constantly transferring power from the source to the load. For applications requiring many inputs, the circuit architecture is developed using the switched capacitor technique. Here, the number of input sources is equal to the number of active and passive components employed in this design, increasing the control complexity and circuit layout.

The suggested non-isolated multi-port converter with a single inductor is only suitable for low power applications requiring a single active switch to integrate several load devices. An isolated bidirectional converter is a multiport dc/dc converter. The converter's size is increased by a multi-winding transformer that aids in power transfer. Various multiport bidirectional dc/dc converter topologies are derived using a combination of magnetic coupling and dc-link. A universal dc/dc converter with full direction functions similarly to a SISO converter. It is suggested to use a dual input, dual output converter with the hybrid electric car. The primary drawback is that battery power is not increased during the load.

solar-powered electric vehicle with backup batteries. A dc/dc converter construction has been proposed in the EV mentioned above to catalyze the energy transfer between the sun and battery. The quantity of battery modules determines how many switches are needed in this converter. For example, if there are 'n' battery modules, the system needs '2n' switches to function properly. A fuzzy logic control-based energy management technique has been presented to provide effective power management between the ultracapacitor and battery, as well as to suppress difficulties such ultracapacitor overcharging and excessive battery current during peak power.

This paper's primary contribution is the suggestion of a single-stage, transformer-less, four-port

(FPC) three-switch bidirectional buck boost converter. The suggested converter has benefits over the topologies reported in the literature (refer to Table 1), including a modular design with fewer components and the ability to integrate many sources with various voltage-current characteristics at the input. Apart from the aforementioned characteristics, the suggested converter can provide an output that is either larger or less than the highest input voltage (boost) or less than the minimum input voltage (buck).

The efficiency of the suggested converter is increased by the decrease in switching losses. The structure of this document is as follows. The fundamental concept for creating FPC and its modes of operation are explained in Section II. Section III provides the small-signal analysis dynamic model of the converter. Sections IV and V provide examples of how the suggested converter's features were validated using experimental data and a power budgeting control technique. Section VI offers the climax, at last.

1.2 MULTIPORT BUCK-BOOST CONVERTER PERFORMANCE ANALYSIS

1.2.1 The framework of FPC topology

The electric vehicle system's dynamic load and fluctuating input power make it impossible to meet load demand with a single energy source. Consequently, it is necessary to hybridize arbitrary energy resources. The main goal of this book is to create a converter topology that could interface a vehicle's drive train with different energy supplies. The function of the power electronic interface in an electric vehicle's power system is shown in Figure 1.1(a) and (b).

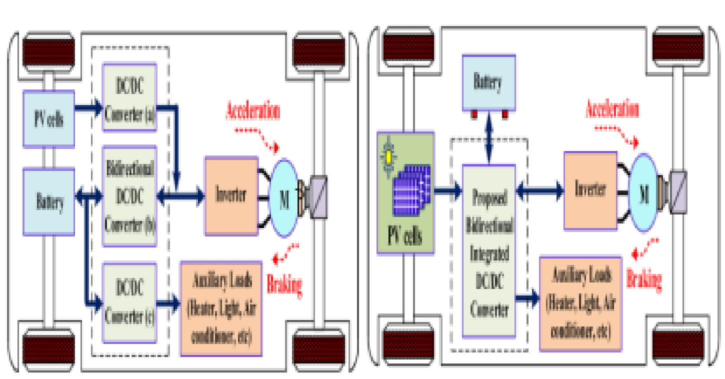
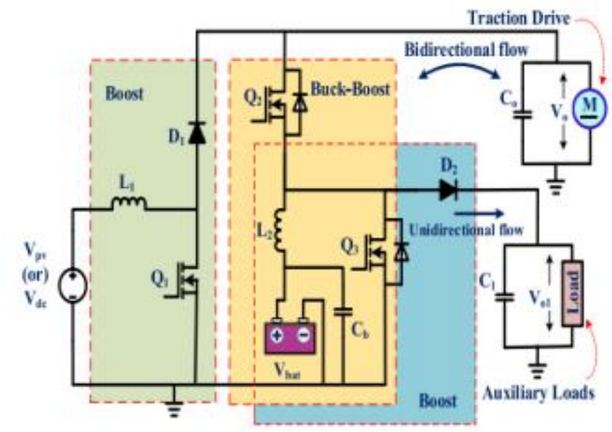


Fig. 1.1: Block diagram of the proposed integrated four-port (b) and conventional converter (a) converter (FPC) interface in an electric vehicle system.



The suggested topology for a four-port (FPC) converter is depicted in Figure 1.2.

Among the suggested converter's standout qualities are:

- The ability to transfer electricity in both directions
- Control over the individual power flow between the sources
- Simple process for design, control, and implementation

2.DC-DC CONVERTER BASICS

An apparatus that takes a DC input voltage and outputs a DC voltage is called a DC-to-DC converter. The voltage levels of the input and the output are typically different. DC-to-DC converters are also utilized for power bus regulation, noise isolation, and other purposes. A few common DC-to-DC converter topologies are detailed here.

2.1 BUCK CONVERTER STEP-DOWN CONVERTER

When the transistor in this circuit turns ON, voltage Vin is applied to one end of the inductor. The inductor current tends to increase with this voltage. The current will still flow through the inductor and now pass through the diode while the transistor is off.

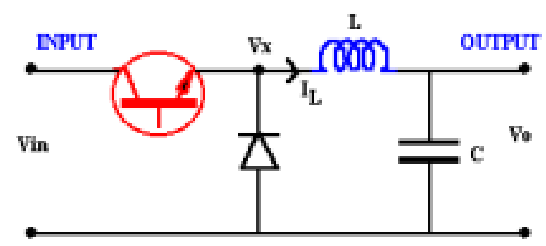


Fig.2.1 Buck Converter

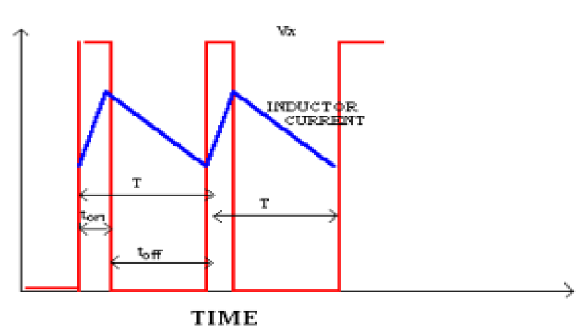


Fig:2.2. Voltage and current changes

Let's examine how the inductor current varies throughout a single cycle in order to examine the voltages in this circuit. Based on the relationship

$$V_x - V_o = L\frac{di}{dt}$$

$$di = \int_{ON}(V_x - V_o)dt + \int_{OFF}(V_x - V_o)dt$$

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The shift in current is satisfactory.

2.2 BOOST CONVERTER STEP-UP CONVERTER

The basic boost converter is seen schematically in Figure 6. When a greater output voltage than input is needed, this circuit is employed.

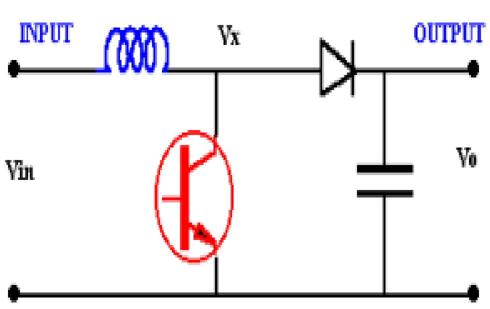

Fig:2.3. Boost Converter Circuit

3.OPERATING MODES- STATE OF OPERATION

As can be seen from Figures 3a through 3e, the suggested converter can operate in five different states. A (single input dual output) SIDO state is represented by state 1. In this condition (see Figure 3a), the power produced by PV powers the EV's drive train (load). In the suggested topology, the battery can be charged by the load or by the PV power input (refer to Figures 3b and 3e).

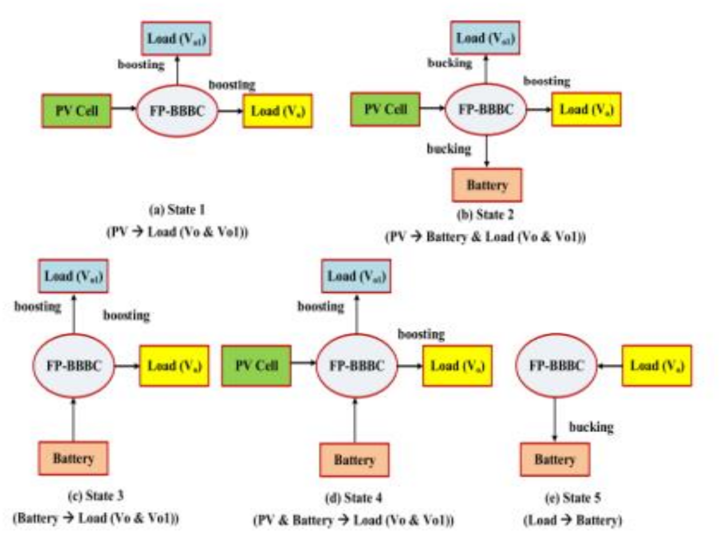

Fig:3.1. a) State 1(boost), b) State 2 (buck & boost), c) State 3 (boost), d) State 4 (boost), e) State 5 (buck).

3.1 OPERATING MODES

3.1.1 STATE 1-SIDO (SINGLE INPUT DUAL OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV (Vdc) TO LOAD)

PV distributes the power to each load separately in this state. Table 2 displays the switching strategies of several operating devices. During the interval 0 to d1Ts, switches Q1 and Q3 are turned ON and Q2 is turned OFF. When taking into account that Vpv>Vbat (refer to Figure 5(a) and (b)), the voltage Vpv emerges across the inductor L1, causing the inductor current to rise with a positive slope.

$$V_o = \frac{1}{1-d_1} V_{pv}$$

$$V_{o1} = \frac{1}{1-d_1} V_{pv}$$

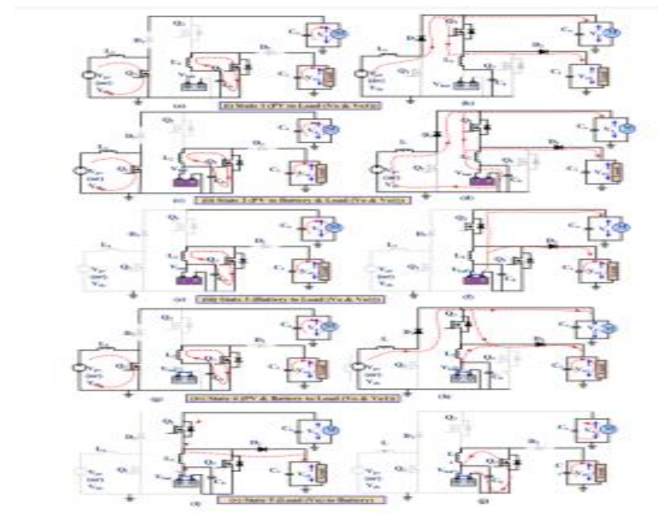

Fig:3.4. Typical diagram of all the states (i) State 1, (ii) State 2, (iii) State 3, (iv) State 4, & (v) State 5.

TABLE 2. State of operation.

No. of States	Input Sources	MOSFET Switches			Inductors		Diodes		Battery	Capacitors		Outputs	
		Q_1	Q_2	Q_3	L_1	L_2	D_1	D_2	V_{bat}(SOC)	C_1	C_2	(V_o)	(V_{o1})
State 1 ($V_{pv}>V_{bat}$)	(V_{pv}) or (V_{bat})	ON	OFF	ON	↑	↑	OFF	OFF	-	↓	↓	Boost	Boost
		OFF	ON	OFF	↓	↓	ON	ON		↑	↑		
State 2 ($V_{pv}>V_{bat}$)	(V_{pv}) or (V_{bat})	ON	OFF	ON	↑	↓	OFF	OFF	↑	↓	↓	Boost	Boost
		OFF	ON	OFF	↓	↑	ON	ON		↑	↑		
State 3 ($V_{pv}<V_{bat}$)	(V_{bat})	-	OFF	ON	-	↑	-	OFF	↓	↓	↓	Boost	Boost
		-	ON	OFF	-	↓	-	ON		↑	↑		
State 4 ($V_{pv}=V_{bat}$)	(V_{pv}) and (V_{bat})	ON	OFF	ON	↑	↑	OFF	OFF	↓	↓	↓	Boost	Boost
		OFF	ON	OFF	↓	↓	ON	ON		↑	↑		
State 5 ($V_{pv}=0$, $V_{bat}<V_{load}$)	Regenerative braking power	-	ON	OFF	-	↑	-	ON	↑	↓	↓	Buck	Buck
		-	OFF	ON	-	↓	-	OFF		↑	↑		

4.PULSE WIDTH MODULATION

4.1 What is PWM

The best way to switch the power devices of the solar system controller and achieve consistent voltage battery charging is to use pulse width modulation, or PWM. When using PWM regulation, the solar array's current tapers based on the state of the battery and the necessity for recharging. Take a look at a waveform like this one, which shows a voltage transitioning between 0 and 12 volts. It follows that a "suitable device" connected to its output will see the average voltage and believe it is being fed 6v, or precisely half of 12v, as the voltage is at 12v for exactly the same amount of time as it is at 0v. Consequently, we may change the 'average' voltage by changing the positive pulse's width.

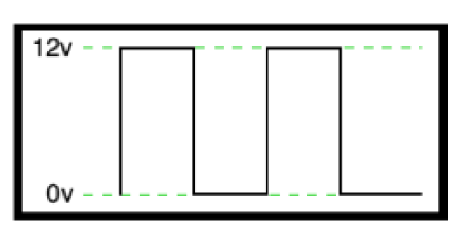

Fig.4.1 Average voltage exactly half of 12v

In a similar vein, the average voltage will be 3/4 of 12v, or 9v, as indicated below, provided the switches maintain the voltage at 12 for three times as long as at 0v.

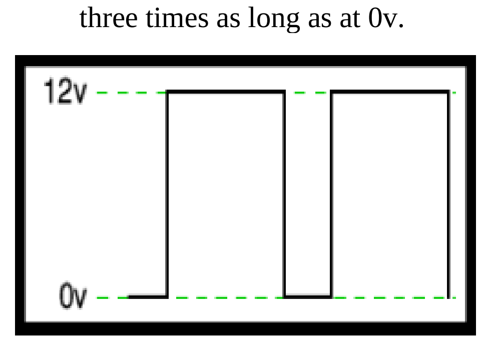

Fig:4.2 Average voltage will be 3/4 of 12v

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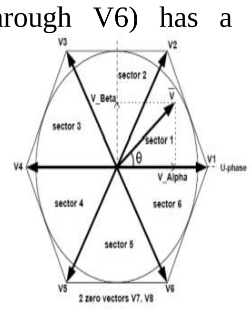
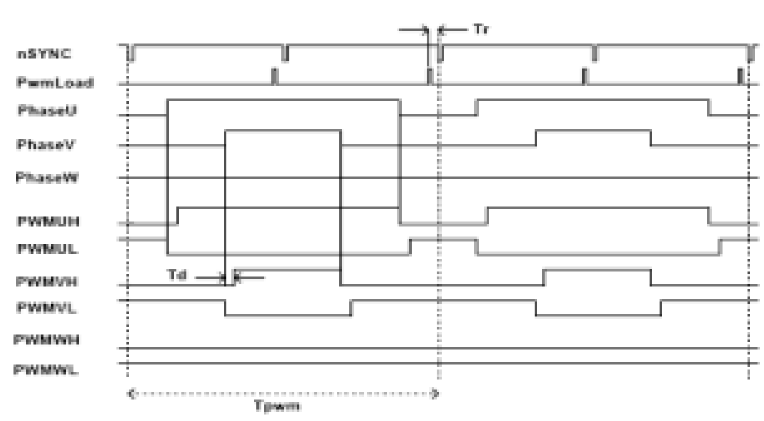
4.2 SPACE VECTOR PWM

After receiving instructions for the modulation index, the Space Vector PWM generating module creates the proper gate drive waveforms for every PWM cycle. The SVPWM module's setup and operation are covered in this section. There are eight different switching states for a three-phase, two-level inverter with a dc link design, which determines the inverter's output voltage. In the Space Vector plane (Figure: Space Vector Diagram), every inverter switching state produces a voltage Space Vector (V1 to V6 active vectors, V7 and V8 zero voltage vectors). Each active vector (V1 through V6) has a magnitude of 2/3 Vdc (dc bus voltage).



4.3 Symmetrical and Asymmetrical Mode Operation

For PWM waveform production, there are two modes of operation: Center Aligned Symmetrical PWM (Figure) and Center Aligned Asymmetrical PWM (Figure). Every half a PWM cycle (Tpwm), as Pwm Load happens every half a PWM cycle (see Figures for symmetrical and asymmetrical PWM). The volt-sec can be adjusted accordingly. The inverter voltage Config = 0 while using symmetrical PWM mode allows for double the switching frequency's rate of change in the inverter voltage. However, this will result in a higher current harmonic at the expense of a wider voltage control bandwidth.



5. PI CONTROLLER

Proportional Integral Derivative (PID) control can also be performed by using solely the proportional and integral terms as PI control. The most common type is the PI controller, which is even more so than complete PID controllers. The system receives the value of the controller output, u(t), as the modified variable input.

$$e(t)=SP-PV$$

$$u(t)=u_{bias}+K_c e(t)+\frac{K_c}{\tau_I}\int_0^t e(t)dt$$

5.1 DISCRETE PI CONTROLLER

Discrete sampling periods are used in the implementation of digital controllers, and the integral of the error must be approximated using a discrete form of the PI equation. In this version, Δt is used as the time interval between sample instances, and nth is the number of sampling instances. The continuous form of the integral is replaced with a summation of the error.

$$u(t)=u_{bias}+K_c e(t)+\frac{K_c}{\tau_I}\sum_{i=1}^{n} e_i(t)\Delta t$$

5.2 ADVANTAGES AND DISADVANTAGES

The integral term in a PI controller causes the steady-state error to reduce to zero, which is not the case for proportional-only control in general. The lack of derivative action may make the system steadier in the steady state in the case of noisy data. This is because derivative action is more sensitive to higher-frequency terms in the inputs.

5.3 INTEGRAL ACTION AND PI CONTROL

Similar to the P-Only controller, the Proportional-Integral (PI) algorithm calculates and sends a controller output (CO) signal to the last control element (such as a valve or variable speed pump) at each sample time, T. The controller error, e(t), and the controller tuning settings have an impact on the calculated CO obtained via the PI method.

6. SIMULATION RESULTS

6.1 SIMULATION CIRCUITS

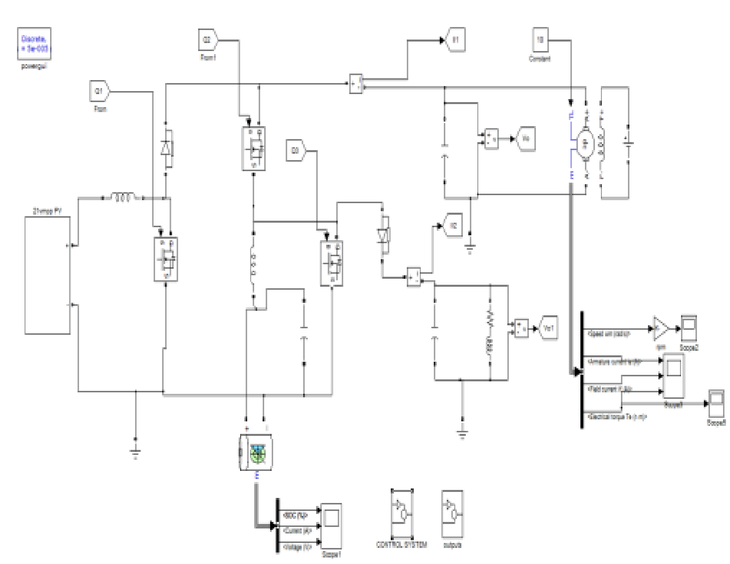


Fig: 6.1.Simulink Model of a Multifunctional Non- Isolated Dual Input- Dual Output Converter

6.1.1 Control Circuit

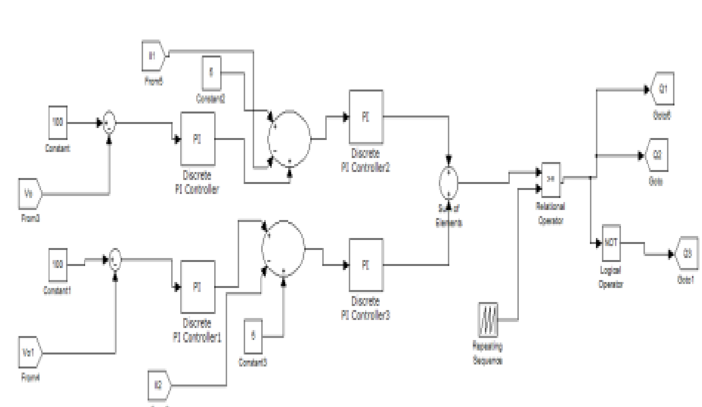


Fig:6.2. Simulink Model of a Control Circuit

6.2 SIMULATION RESULTS

6.2.1 Output waveforms across Motor Load (Vo):

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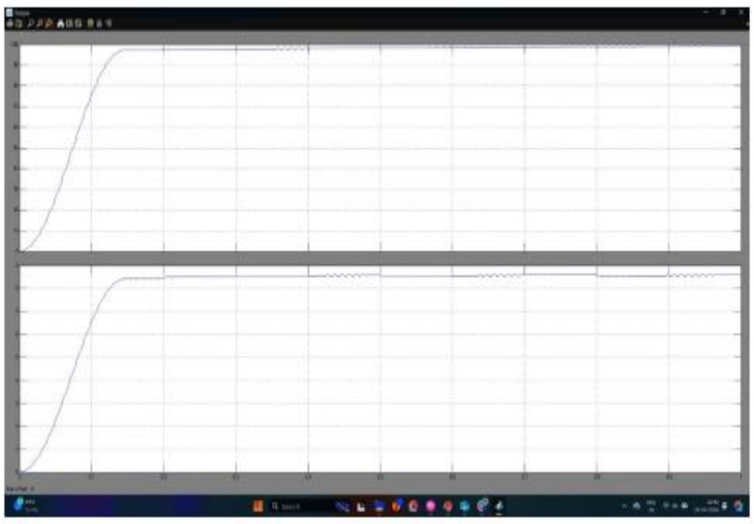

Fig:6.3. Output waveforms of a voltage and current across Motor load(V0)

6.2.2 Output waveforms across Auxiliary Load (Vo1):

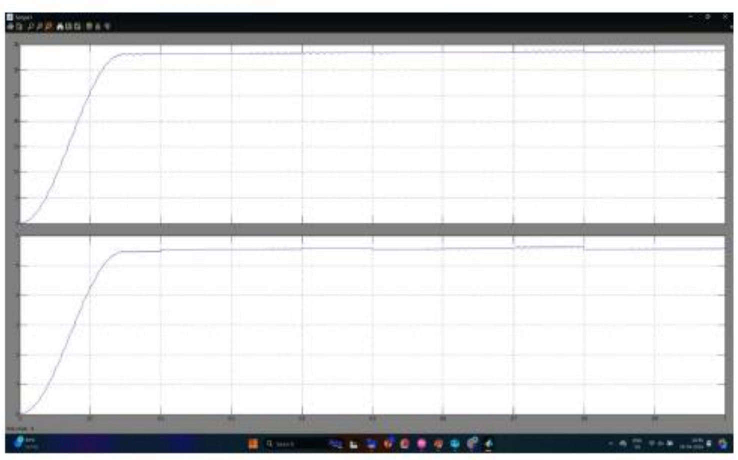

Fig:6.4. Output voltage and current waveforms across auxiliary Load(V01)

6.3 Battery SOC, Current and Voltage Parameters

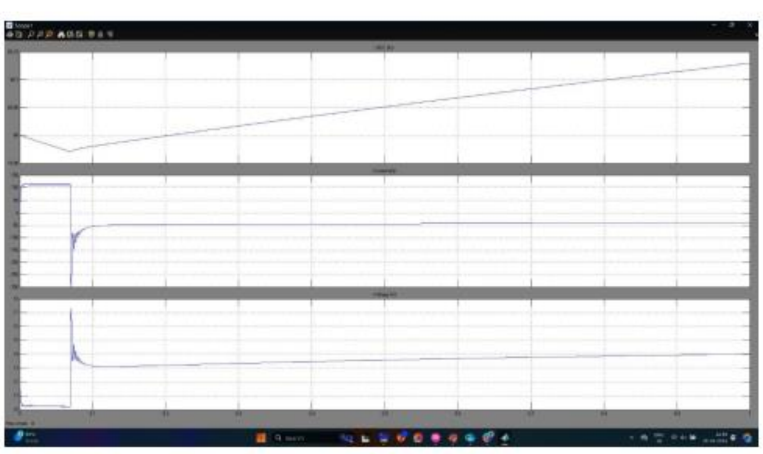

Fig:6.5. State of charge (SOC), Voltage & Current In the battery

7.CONCLUSION

This research proposes a hybridization strategy for EVs using a single-stage four-port (FPC) buck-boost converter. This converter offers the following advantages over other buck-boost converter topologies found in the literature: a) it can produce buck, boost, or buck-boost output without the need for an additional transformer; b) it can have bidirectional power flow capability with fewer components; and c) it can handle multiple resources with varying voltage and current capacities. To show the functions of the suggested converter, mathematical analysis has been done. It has been decided to budget the power flow between the input sources using a simple control technique. Ultimately, a low voltage simulation model has been used to confirm the converter's functionality. Results from simulation confirm that the suggested four-port buck-boost architecture is feasible.

REFERENCES

[1] K. Suresh, C. Bharatiraja, N. Chellammal, Mohd Tariq, Ripon K. Chakrabortty, Michael J. Ryan and Basem Alamri **"**A Multifunctional Non-Isolated Dual Input-Dual Output Converter for Electric Vehicle Applications**"** Received March 22, 2021, accepted April 12, 2021, date of publication April 21, 2021, date of current version May 4, 2021.Digital Object Identifier 10.1109/ACCESS.2021.3074581.

[2] H. Wu, Y. Xing, Y. Xia, and K. Sun, ''A family of non-isolated three-port converters for standalone renewable power system,'' IEEE Trans. Power Electron., vol. 1, no. 11, pp. 1030–1035, 2011.

[3] K. I. Hwu, K. W. Huang, and W. C. Tu, ''Step-up converter combining KY and buck-boost converters,'' Electron. Lett., vol. 47, no. 12, pp. 722–724, Jun. 2011.

[4] H. Xiao and S. Xie, ''Interleaving double-switch buck–boost converter,'' IET Power Electron., vol. 5, no. 6, pp. 899–908, Jul. 2012.

[5] H. Kang and H. Cha, ''A new non isolated High-Voltage-Gain boost converter with inherent output voltage balancing,'' IEEE Trans. Ind. Electron., vol. 65, no. 3, pp. 2189–2198, Mar. 2018.

[6] T. Bang and J.-W. Park, ''Development of a ZVT-PWM buck cascaded buck–boost PFC converter of 2 kW with the widest range of input voltage,'' IEEE Trans. Ind. Electron., vol. 65, no. 3, pp. 2090–2099, Mar. 2018.

[7] C.-C. Lin, L.-S. Yang, and G. W. Wu, ''Study of a non-isolated bidirectional DC–DC converter,'' IET Power Electron., vol. 6, no. 1, pp. 30–37, Jan. 2013.

[8] M. A. Khan, A. Ahmed, I. Husain, Y. Sozer, and M. Badawy, ''Performance analysis of bidirectional DC–DC converters for electric vehicles,'' IEEE Trans. Ind. Appl., vol. 51, no. 4, pp. 3442–3452, Jul. 2015.

[9] S. Dusmez, A. Khaligh, and A. Hasanzadeh, ''A zero-voltage-transition bidirectional DC/DC converter,'' IEEE Trans. Ind. Electron., vol. 62, no. 5, pp. 3152–3162, May 2015.

[10] H. Zhu, D. Zhang, B. Zhang, and Z. Zhou, ''A nonisolated three-port DC–DC converter and three-domain control method for PV-battery power systems,'' IEEE Trans. Ind. Electron., vol. 62, no. 8, pp. 4937–4947, Aug. 2015.

[11] M. B. Camara, H. Gualous, F. Gustin, and A. Berthon, ''Design and new control of DC/DC converters to share energy between supercapacitors and batteries in hybrid vehicles,'' IEEE Trans. Veh. Technol., vol. 57, no. 5, pp. 2721–2735, Sep. 2008.