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Multi Port Converter Configuration based on FLC & ANFIS Controller

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ABSTRACT

This study explores the implementation of a Fluffy Rationale Regulator (FLC) and an Adaptive Neuro-Fuzzy Inference System (ANFIS) Regulator for a modified configuration of a non-segregated four-port power electronic interface, suitable for electric vehicle (EV) applications. This converter accommodates diverse energy sources with varying voltage and current characteristics, allowing simultaneous buck and boost output. The proposed four-port converter (FPC) is characterized by reduced component count and an optimized control system, enhancing reliability and cost-effectiveness. Its bidirectional power flow capability makes it suitable for regenerative braking in EVs. The steady-state and dynamic behavior are analyzed, and a control scheme is presented for managing power flow between different energy sources. A small signal model is derived for converter design, and the validity of the design and its performance are confirmed through experimentation.

INDEX TERMS--Multi-port converter, electric vehicle, bidirectional dc/dc converter, battery storage, regenerative charging, Fuzzy Logic Controller, ANFIS Controller.

INTRODUCTION

Expanding natural contamination, the fast ascent in fuel cost, a dangerous atmospheric devation, and exhaustion of petroleum derivatives have prompted the improvement of cutting edge vehicle innovations. In this way car businesses have begun fabricating eco-accommodating electric (EV) and half and half electric vehicles (HEV). In such vehicles, the engine drive framework is a significant part. An effective power electronic converter is expected to impel the engine drive framework. On account of EV, this power electronic converter should have the bidirectional capacity to communicate the energy assets with battery and engine drive frameworks. Various examination work has been accounted for by the analysts in the writing on power electronic connection points for EV frameworks. Various geographies of non-separated three-port converter combined from double information (DIC) or double result (DOC) converter alongside the single info single result (SISO) converter is managed in [1]. A move forward converter joining the elements of KY converter and buck-support converter with a high voltage change proportion is introduced in[2].The technique for further developing the transformation productivity involving the interleaving idea in a twofold switch buck-support converter is proposed [3]. A non-separated support converter with high voltage gain fit for adjusting consequently under an unbalancing load condition is dissected in [4]. Bang and Stop [5] depict buck flowed buck-help power factor adjustment converter for wide information voltage varieties. The previously mentioned converters are unidirectional with the SISO arrangement. A non-confined bidirectional dc/dc converter in [6] is a SISO model that utilizes four dynamic switches. An examination of two unique bidirectional converters, for example, flowed buck-support capacitor in the center and flowed buck-help inductor in the center is done in [7].

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To accomplish high power thickness and improve proficiency, zero-voltage change three-level dc/dc converter with the delicate exchanging highlight is proposed [8]. The converter in [9] is a three-port bidirectional geography that utilizes three inductors and three dynamic changes to deliver either buck or lift yield. Various designs of equal buck-support converters, converters with two modules of super capacitors and their power the board control methodologies are very much researched in [10].
A Multi-port energy converter in [11] utilizes a solitary leg dynamic changing component for the multi-utilitarian activity to control and deal with the result power.
While contrasting the above-said converter and the essential buck-support converter, it utilizes more inactive components. A bidirectional high addition move forward/down dc converter in [12] which has been acknowledged as a non-secluded structure has an in-constructed DC transformer which expands the size of the converter. The single switch buck-support geography introduced in works in SISO mode and it acquires the elements of CUK converters and overrides the issues experienced in KY converter. Non-detached multi-input multi-yield dc/dc converters introduced in is a lift converter implied for photovoltaic applications with unidirectional power stream.
The difficulty of a multi-input single-yield n-stage converter in [17], [18] is that main (n-1) stages do the buck-help activity and the nth stage works as a lift converter with power moved from source to stack generally. The circuit setup in [19], [20] is planned with exchanged capacitor procedure for different data sources applications. Here, the quantity of dynamic and latent parts utilized in this setup rises to the quantity of information sources, which thus expands the circuit design and control intricacy. The usage of single inductor based non-segregated multi-port converter proposed in [21], [22] is restricted to low power applications one dynamic switch for coordinating differentiated load gadgets. Multiport dc/dc converter in [23] is a detached bidirectional converter. A Multi-twisting transformer in it which helps in moving the power expands the size of the converter. Various designs of multiport bidirectional dc/dc converters are determined with the blend of dc-connect and attractive coupling [24]. Completely directional widespread dc/dc converter [25] works as a SISO converter. A double information double result converter reasonable for the crossover electric vehicle is proposed [26].
It has the essential hindrance of battery power not being helped across the heap. A sun oriented power helped EV with battery reinforcement has been in [27]. To catalyze the energy between the battery and sun powered in the above EV a dc/dc converter structure has been introduced. The quantity of switches in this converter differs in light of the quantity of battery modules (Express assuming there exists 'n' no. of battery modules, then, at that point, the framework requires '2n' quantities of switches for viable activity). For successful power the board between the ultra-capacitor and battery and to smother the issues, for example, cheating of ultra-capacitor and high battery current during top power, a fluffy rationale control based energy the executives methodology has been proposed [28].
The significant commitment of this paper is to propose a solitary stage transformer less four-port (FPC) bidirectional buck-help converter with just three switches. Contrasted and the geographies introduced in the writing , the proposed converter enjoys benefits, for example, a particular construction with diminished part count and joining of expanded sources in the contribution with various voltage-current qualities. Aside from the above-said highlights, the proposed converter can give yield not exactly the base info voltage (buck) or more prominent than the greatest information voltage (support). The decrease of exchanging misfortunes works on the productivity of the proposed converter.

PERFORMANCE ANALYSIS OF MULTIPORT BUCK-BOOST CONVERTER:A.STRUCTURE OF FPC TOPOLOGY:

The utilization of a solitary energy asset can't satisfy the heap need because of information power varieties and dynamic burden in the electric vehicular framework. Thusly, the hybridization of erratic energy assets is required. This original copy centers around combining a converter geography that might interact different energy assets with the drive at any point train of a vehicle. Figure 1 (a) and (b) portray the job of force electronic connection point in the power arrangement of an electric vehicle framework.

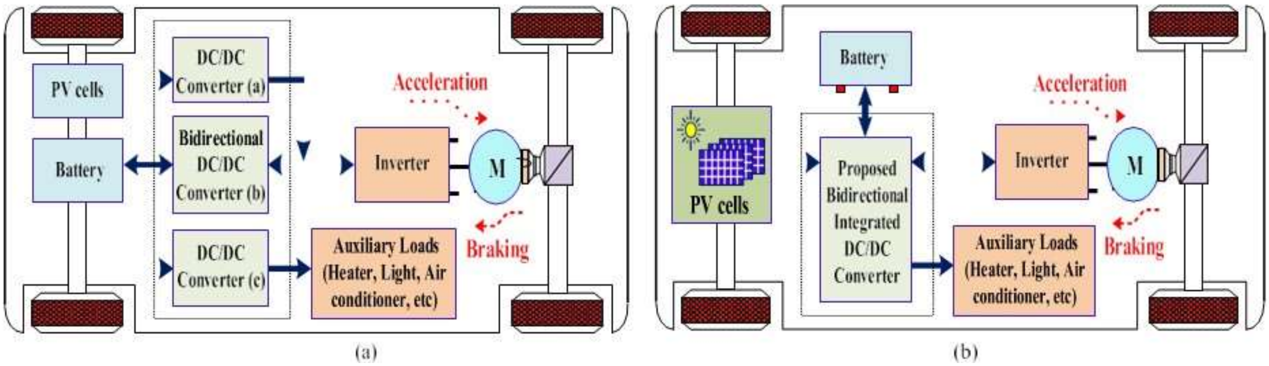

Fig.1 Block diagram of (a) Conventional converter (b) Proposed integrated four-port converter (FPC) interface in an electric vehicle system.

Figure 2 shows the proposed geography of a four-port (FPC) converter. Conspicuous elements of the proposed converter are: , Bidirectional power stream capacity , Individual power stream control between the sources , Simple plan, control, and execution process As displayed in Figure 2 the power stream among burden and information sources is constrained by the controllable switches $Q1$, $Q2$, and $Q3$. As seen from Figures 3a to 3e five unique conditions of activity can be considered for the proposed converter. The state 1 is a (solitary information double result) SIDO state.

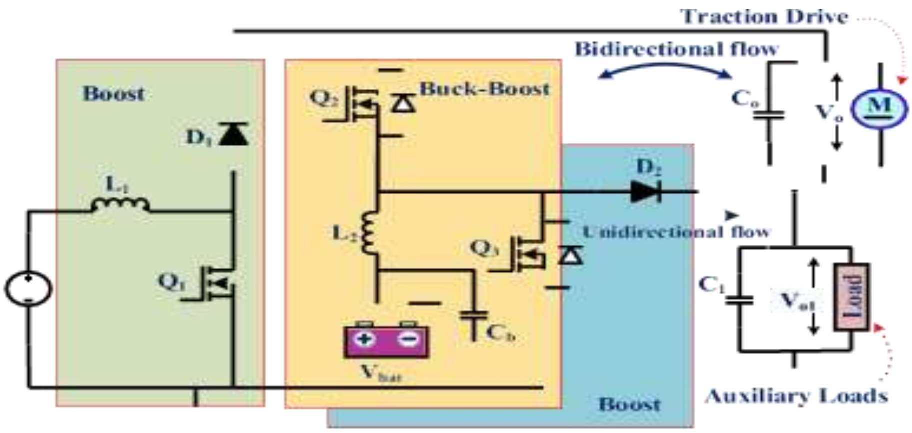

Fig.2 Topology diagram of four-port (FPC) converter

In this state (see Figure 3a), the drive train of EV (load) is controlled by the power produced from PV. The battery in the proposed geography can be charged either from the information PV power or from the heap (see Figure 3b and Figure 3e). In state 5, because of regenerative slowing down the energy getting back from the heap is put away in the battery. Because of low illumination and in the event that the PV can't create the power, the battery releases to meet the whole burden necessity (see Figure 3c). During top power interest, the battery unit and PV give the important ability to drive train. The converter then, at that point, works in the DIDO state (see Figure 3d). Exchanging plans of the proposed converter and identical circuits under various working states are portrayed in Figures 4 and 5 separately.

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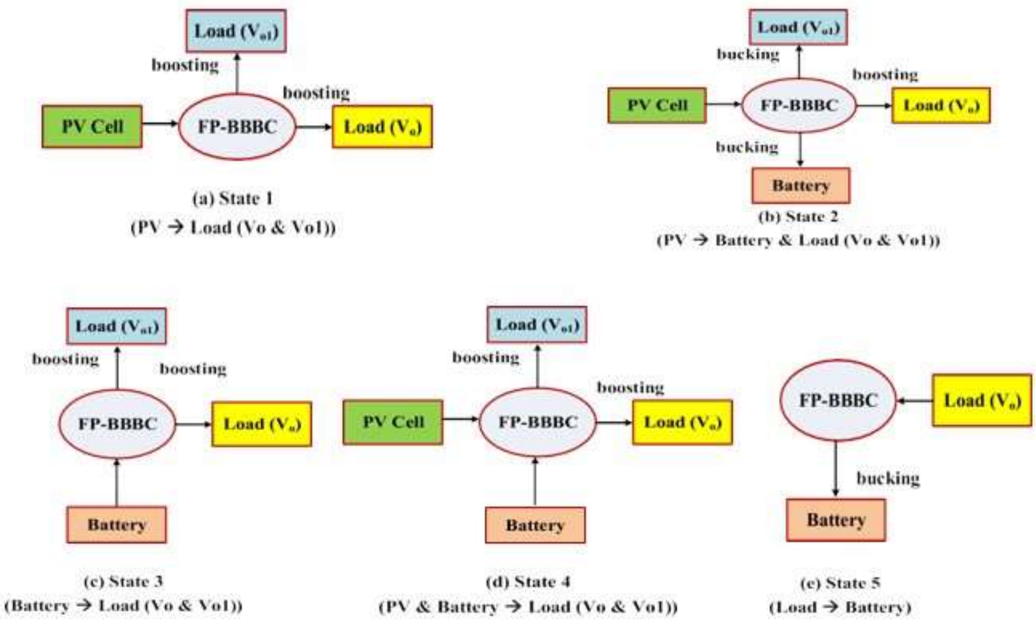

Fig.3 a) State 1(boost), b) State 2 (buck & boost), c) State 3 (boost), d) State 4 (boost), e) State 5 (buck)

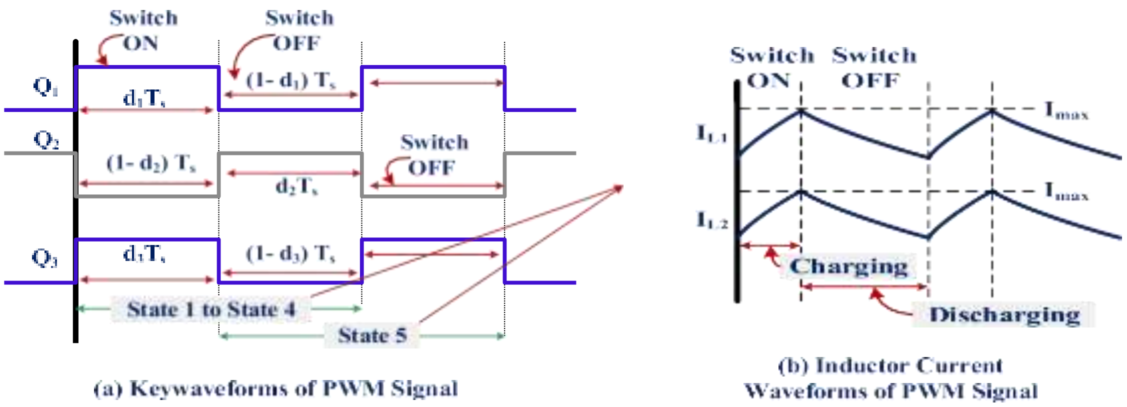

Fig.4 State of operation of proposed FPC

B. OPERATING MODES -STATE OF OPERATION:

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

In this state, PV moves the power separately to the heap. The Exchanging plans of different working gadgets are displayed in Table 2. Switches $Q1$ and $Q3$are turned ON and, $Q2$ is switched OFF, during the time stretch 0 to $d1Ts$. While considering $Vpv > Vbat$ (see Figure 5 (a) and (b)), the voltage Vpv shows up across the inductor $L1$, bringing about the ascent of inductor current with the positive slant. During time span $d1Ts$. to Ts, switches $Q1$, $Q3$ are switched off and $Q2$ is turned on. Energy put away in inductor $L1$ during the past time stretch d1Ts is released to the result capacitor through the diode $D1$. Here Ts. is the exchanging time span.

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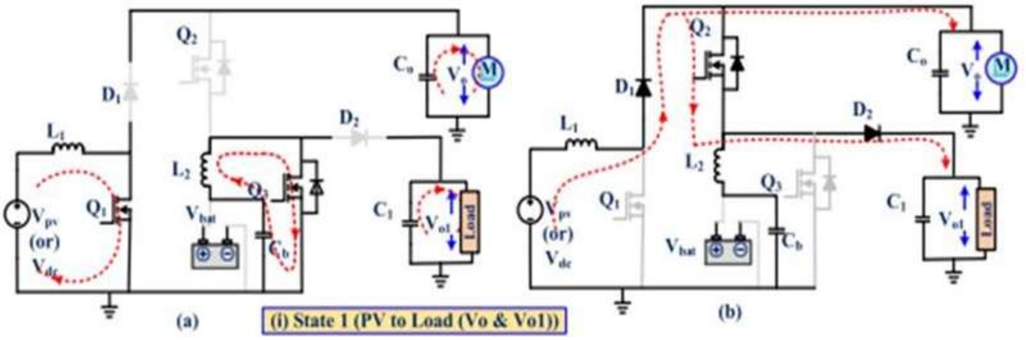

Fig.5 State1 (PV to Load (V_0 & V_{01}))

$$V_0 = \frac{1}{1-d_1} V_{pv} \quad (1)$$

$$V_{01} = \frac{1}{1-d_1} V_{pv} \quad (2)$$

2) STATE 2- SITO (SINGLE INPUT THREE OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV TO BATTERY AND LOAD):

Activity in this state is like state 1. At the point when the battery should be charged from PV (see Figure 5 (c) and (d)), $Q2$ works with $d2 < 0.5$ to charge the battery. $Q3$ works in basically the same manner as that of $Q1$ with $d1 > 0.5$ to create supported yield across the heap. Voltages $Vbat$, Vpv, and $V0$, $V01$ are connected by the situation.

$$V_0 = \frac{1}{1-d_1} V_{pv} \quad (3)$$

$$V_{01} = d_2 V_{pv} \quad (4)$$

$$V_{bat} = d_2 V_{pv} \quad (5)$$

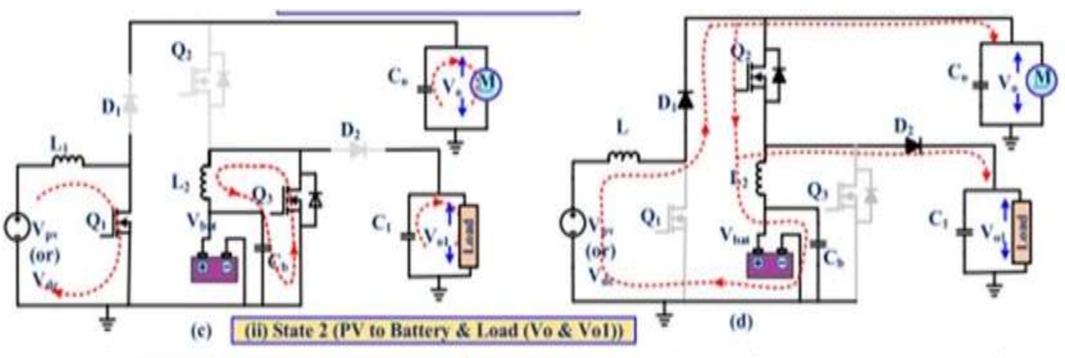

Fig.5 State 2 (PV to Battery & Load (V_0 & V_{01}))

3) STATE 3 - SIDO STATE OF THE CONVERTER (POWER TRANSFER FROM THE BATTERY)

In this express, the energy put away in the battery is moved to the heap. During the time span 0 to $d3T$, releasing activity of the battery causes the inductor current $iL2$ to straightly rise. Between the stretches $d3Ts$ to T , the current $iL2$ diminishes with a negative slant. ON-OFF condition of switch $Q3$ gives a supported result across the drive train.

As $Q1$ doesn't participate in moving the energy from battery to as $Q1$ doesn't partake in moving the energy from battery to the heap, it is kept in OFF condition all through the condition of activity (see Figure 5 (e) and (f)). The result voltage across the heap due to releasing the battery is given as

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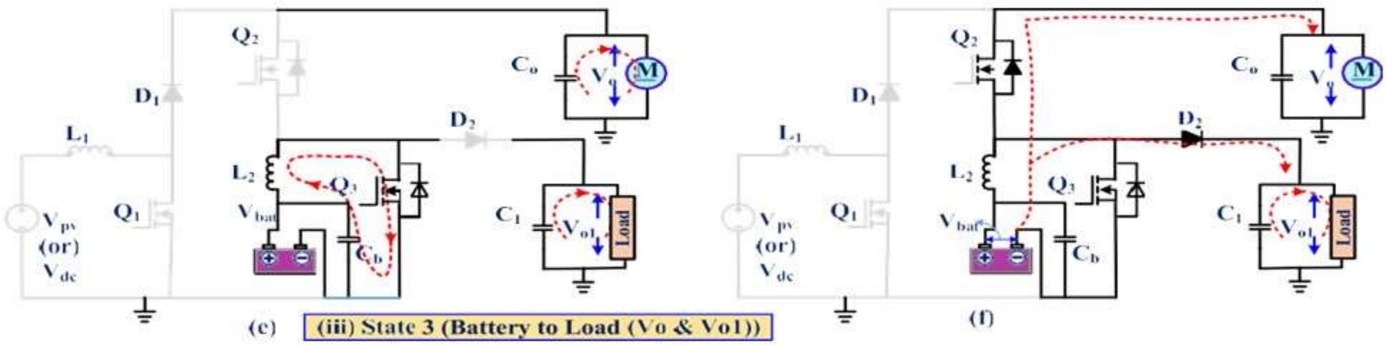

Fig.5 State 3 (Battery to Load (V_0 & V_{01}))

$$V_0 = \frac{1}{1-d_3} V_{bat} \tag{6}$$

$$V_{01} = \frac{1}{1-d_3} V_{bat} \tag{7}$$

4) STATE 4 – DIDO (DUAL INPUT DUAL OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV AND BATTERY)

At the point when the power interest from EV is high, the battery and PV supply, ability to satisfy the need (see Figure 5 (g) and (h)). During time span 0 to $d1Ts$ gated switches $Q1$ and $Q3$ charge the inductor and cause the flows $iL1$ and $iL2$ to directly rise. $Q2$ is furnished with the free entryway signal at this stretch. Then again during the off time of switches $Q1$, $Q3$ the inductor flows $iL1$ and $iL2$ decline with the negative slant. Hence supported power from both battery and PV is conveyed to the heap through diodes $D1$ and $D2$. Net result voltage because of the power conveyance of both the sources still up in the air from Eqs.(8):

$$V_0 = \frac{1}{1-d_1} V_{pv}\ , \text{(or)} \quad V_0 = \frac{1}{1-d_3} V_{bat} \tag{8}$$

$$V_{01} = \frac{1}{1-d_1} V_{pv}\ , \text{(or)} \quad V_{01} = \frac{1}{1-d_3} V_{bat} \tag{9}$$

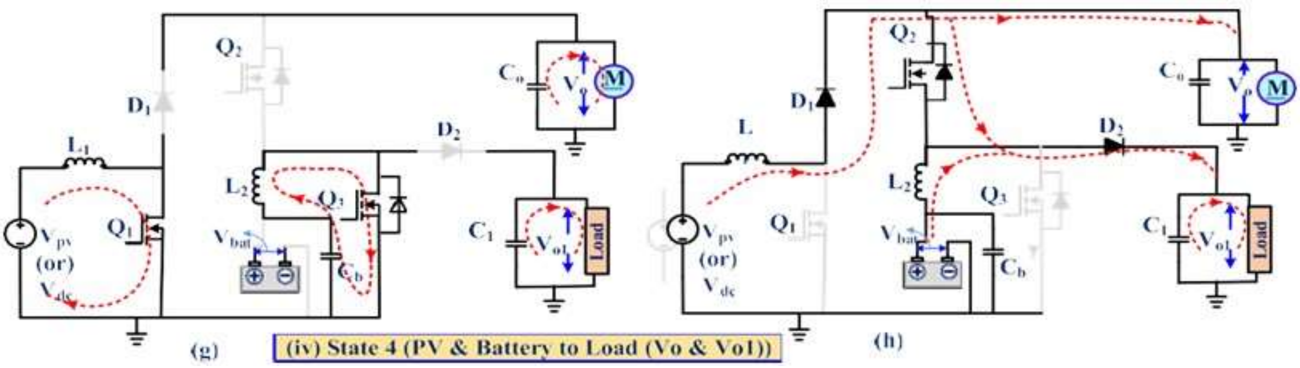

Fig.5 State 4 (PV & Battery to Load (V_0 & V_{01}))

5) STATE 5 - SIDO STATE OF THE CONVERTER (POWER TRANSFER FROM LOAD TO BATTERY)

During regenerative braking, the kinetic energy stored in the drive train is fed back to the battery (see Figure 5 (i) and (j)). The switching sequence of this state is given as follows: $Q1$ is permanently in the off condition; $Q2$, $Q3$ is turned ON and $Q2$ is turned OFF. The ON-OFF state of $Q2$ along with $Q2$ charges the battery.

$$V_{bat} = d_2 V_0 \tag{10}$$

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In same state, the battery is supplied by the second output through regenerative braking power. The control relation is derived as,

$$V_{01} = d_3 V_0 \quad (11)$$

C.CONVERTER FAULT ANALYSIS:

The converter shortcoming condition is examined Thinking about 4 unique cases :-

Case-1: If switch $Q1$ opens, the helped PV power won't be accessible as the diode $D1$ will be opposite one-sided. The converter works in SIMO state and keeps on driving the heaps with the accessible battery power. At, a similar time the regenerative power in the event that accessible will accuse the battery of the guide of switches $Q2$ and $Q3$.

Case-2: If switch $Q2$ opens, the PV module can not drive the assistant burdens and the battery can't be charged during regenerative slowing down. Notwithstanding, the PV modules will actually want to drive the footing drive with its accessible power and the converter works in SISO state.

Case-3: If switch $Q3$ opens, the charging and releasing activity will be impacted. Battery can not convey helped yield across the heaps?

Case-4 Because of turning (ON-OFF) activity, switch $Q1$ conveys supported yield across the heaps through diode $D1$. Be that as it may, in the event that diode $D1$ opens, the heap won't be conveyed with helped result and there will be coursing current through the inductor $L1$ and the switch which thus will produce heat in the know. Additionally, if the diode $D2$ opens, there won't any power provided through the diode $D2$ to the heap.

III. DYNAMIC MODELING:

A legitimate control conspire is expected to fix the obligation patterns of a singular change in the converter to direct the result voltages, the charging, and releasing activities of the battery. Consequently, to plan such regulators, dynamic demonstrating of the converter utilizing a little sign model should be gotten. The state-space normal model of the four-port converter is determined in light of the state-space depiction of the converter in each exchanging state. Following are the means engaged with reasoning the normal model.

Deduction of state-space condition during open close state of switches, Averaging the reasoned state conditions, Irritation, Framework creation.

To acquire the little sign model, the ongoing through the inductors and voltage across the capacitors are expected as state factors. As five working conditions of the introduced converter utilize various mixes of the two information sources and produce either buck, lift, or buck-help yields all the while five unique models can be acquired. State factors in condition (12), (13) and (14) comprise of DC parts (I, d, V) and annoyances (ˆi, dˆ, v). Irritations are accepted to ˆ have little varieties north of one exchanging period. Supplanting the state boundaries with the amount of consistent state boundaries and irritation esteems, the accompanying requirements can be inferred.

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$$\begin{aligned} i_{L1} &= I_{L1} + \tilde{\imath}_{L1} \\ i_{L2} &= I_{L2} + \hat{\imath}_{L2} \\ v_0 &= V_0 + \hat{v}_0 \end{aligned} \tag{12}$$

$$\begin{aligned} v_{01} &= V_{01} + \hat{v}_{01} \\ v_{bat} &= V_{bat} + \hat{v}_{bat} \end{aligned} \tag{13}$$

$$\begin{aligned} d_1 &= d_1 + \hat{d}_1 \\ d_2 &= d_2 + \hat{d}_2 \\ d_3 &= d_3 + \hat{d}_3 \end{aligned} \tag{14}$$

A. STATE 1 (V_{pv}→ LOAD [BOOST OPERATION])

As the converter is viewed as working in CCM, the switches (see Figure 5 (a) and (b)) $Q1$ is ON, $Q2$ is OFF for a time of $d1T$, and $Q1$ is OFF, $Q2$ is ON for a period (1-$d1Ts$). Subbing the irritations, it is feasible to get.

$$\frac{d(\hat{v}_0)}{dt} = \left(\frac{1-d_1}{c_0}\right)\hat{\imath}_{L1} - \left(\frac{\hat{d}_1}{c_0}\right) I_{l1} - \left(\frac{1}{c_0\, r_0}\right)\hat{v}_0 \tag{15}$$

$$\frac{d(\hat{v}_{01})}{dt} = \left(\frac{1-d_1}{c_1}\right)(\hat{\imath}_{L1} + \hat{\imath}_{L2}) - \left(\frac{\hat{d}_1}{c_1}\right)(I_{L1} + I_{L2}) - \left(\frac{1}{c_1\, r_1}\right)\hat{v}_{01} \tag{16}$$

$$\hat{d}_1 I_{L1} = (1-d_1)\,\hat{\imath}_{L1} - \left(c_0 + \frac{1}{r_0}\right)\hat{v}_0 \tag{17}$$

$$\hat{d}_1 I_{L1} = (1-d_1)\,(\hat{\imath}_{L1} + \hat{\imath}_{L2}) - \left(c_1 + \frac{1}{r_1}\right)\hat{v}_{01} \tag{18}$$

$$\frac{1}{\hat{d}_1}\begin{bmatrix} \hat{\imath}_{L1} \\ \hat{v}_0 \\ (\hat{\imath}_{L1} + \hat{\imath}_{L2}) \\ \hat{v}_{01} \end{bmatrix} = \begin{bmatrix} L_1 & (1-d_1) & 0 & 0 \\ (1-d_1) & \left(c_0 + \frac{1}{r_0}\right) & 0 & 0 \\ 0 & 0 & (L_1 + L_2) & (1-d_1) \\ 0 & 0 & (1-d_3) & \left(c_1 + \frac{1}{r_1}\right) \end{bmatrix}^{-1} \times \begin{bmatrix} I_{L1} \\ V_0 \\ (I_{L1} + I_{L2}) \\ V_{01} \end{bmatrix} \tag{19}$$

B. STATE 2 (V_{pv} → V_{bat} & LOAD [BUCK & BOOST])

In this state, $Q1$ and $Q3$ are kept ON and $Q2$ stays in the OFF state as in Figure 5 (c) and (d). Integrating the annoyances are given as,

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$$\frac{d_1(V_0+\hat{v}_0)}{dt} = \left(\frac{1-d_1-\hat{d}_1}{c_0}\right)(I_{L1}+\hat{\imath}_{L1}) - \left(\frac{1}{c_0\,r_0}\right)(V_0+\hat{v}_0) \tag{20}$$

$$\frac{d_2(V_{01}+\hat{v}_{01})}{dt} = \left(\frac{1}{c_0}\right)(I_{L2}+\hat{\imath}_{L2}) - \left(\frac{1}{c_1\,r_1}\right)(V_{01}+\hat{v}_{01}) \tag{21}$$

$$\frac{d_2(V_{bat}+\hat{v}_{bat})}{dt} = \left(\frac{1}{c_b}\right)(I_{L2}+\hat{\imath}_{L2}) - \left(\frac{1}{c_b}\right)(V_{bat}+\hat{v}_{bat}) \tag{22}$$

$$\frac{1}{\hat{d}_1\&\hat{d}_2\&\hat{d}_3}\begin{bmatrix}\hat{\imath}_{L1}\\ \hat{\imath}_{L2}\\ \hat{v}_0\\ \hat{v}_{bat}\\ \hat{v}_{01}\end{bmatrix} = \begin{bmatrix} L_1 & 0 & (1-d_1) & 0\\ 0 & 0 & 0 & (-d_2)\\ (1-d_1) & 0 & -\left(c_0+\frac{1}{r_0}\right) & 0\\ 0 & -1 & 0 & -1\\ (1-d_3) & 0 & -\left(c_1+\frac{1}{r_1}\right) & 0\end{bmatrix}^{-1}\begin{bmatrix}V_0\\ V_{bat}\\ V_{01}\\ I_{L1}\\ I_{L2}\end{bmatrix} \tag{23}$$

C. STATE 3 (V_{bat}→ LOAD [BOOST])

During this express, the switch $Q3$ is ON and $Q2$ is OFF condition, inductor $L2$ is charged. Switch $Q3$ is OFF and $Q2$ is ON, inductor $L2$ is released from Figure 5 (e) and (f). Little sign conditions that can be found are

$$\frac{1}{\hat{d}_3}\begin{bmatrix}\hat{\imath}_{L2}\\ \hat{v}_{01}\\ \hat{v}_0\end{bmatrix} = \begin{bmatrix} L_2 & (1-d_3) & 0\\ (1-d_3) & \left(c_1+\frac{1}{r_1}\right) & 0\\ 0 & (1-d_3) & \left(c_0+\frac{1}{r_0}\right)\end{bmatrix}^{-1} \times \begin{bmatrix}I_{L2}\\ V_{01}\\ V_0\end{bmatrix} \tag{24}$$

D. STATE 4 (V_{pv} and V_{bat} → LOAD [BOOST])

As state 4 joins the activity (see Figure 5 (g) and (h)) of state 1 and state 3, the normal model of the converter with the exchanging arrangement displayed in Table 2 can be determined as

$$\frac{1}{\hat{d}_1\&\hat{d}_3}\begin{bmatrix}\hat{\imath}_{L1}\\ \hat{v}_0\\ \hat{\imath}_{L2}\\ \hat{v}_{01}\end{bmatrix} = \begin{bmatrix} L_1 & (1-d_1) & 0 & 0\\ (1-d_1) & \left(c_0+\frac{1}{r_0}\right) & 0 & 0\\ 0 & 0 & L_2 & (1-d_3)\\ 0 & 0 & (1-d_3) & \left(c_1+\frac{1}{r_1}\right)\end{bmatrix}^{-1} \times \begin{bmatrix}I_{L1}\\ V_0\\ I_{L2}\\ V_{01}\end{bmatrix} \tag{25}$$

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E. STATE 5 (LOAD → V_{bat} [BUCK AND BOOST])

$$\frac{d(I_{L2} + \hat{\imath}_{L2})}{dt} = \left(\frac{d_2 - \hat{d}_2}{L_2}\right) V_{brake} - \left(\frac{1}{L_2}\right) (v_{bat} + \hat{v}_{bat}) \tag{26}$$

$$\frac{d(V_0 + \hat{v}_0)}{dt} = \left(\frac{I_{L2} + \hat{\imath}_{L2}}{C_b}\right) - \left(\frac{v_{bat} + \hat{v}_{bat}}{C_b}\right) \tag{27}$$

$$\frac{d(\hat{\imath}_{L2})}{dt} = -\frac{v_{bat}}{L_2} - \frac{\hat{v}_{bat}}{L_2} \tag{28}$$

$$\frac{d(\hat{V}_{bat})}{dt} = \left(\frac{I_{L2} + \hat{\imath}_{L2}}{C_b}\right) - \left(\frac{\hat{v}_{bat}}{C_b}\right) \tag{29}$$

$$\frac{1}{\hat{d}_2}\begin{bmatrix}\hat{\imath}_{L2}\\ \hat{v}_{bat}\end{bmatrix} = \begin{bmatrix}-L_2 & -1\\ -1 & (1 + C_b)\end{bmatrix}^{-1}\begin{bmatrix}I_{L2}\\ V_{bat}\end{bmatrix} \tag{30}$$

This state can be called as a recovering state as the heap power is negative. To store the regenerative slowing down energy in the battery, $Q1$ is kept OFF, $Q2$, and $Q3$ are controlled as displayed in Figure 5 (I) and (j). During regenerative activity, since the result voltage is more noteworthy than Vpv, the converter works in buck mode and charges the battery. Averaging the state conditions more than one period, the little sign model can be reasoned as in condition underneath:

FUZZY LOGIC CONTROLLER:

Fluffy Rationale Regulator (FLC) is a complex numerical technique that permits taking care of troublesome reproduced issues with many data sources and result variables.Fuzzy Rationale Regulator works with loose inputs,it needn't bother with an exact numerical model and it can deal with nonlinearity well.Fuzzzy Rationale Framework is more powerful contrasted with the traditional nonlinear controller.The activity of FLC has 4 orders to be specific, Fuzzification ,Rule base, Surmising motor and De-Fuzzification.

Fuzzification:

Fuzzification is the most common way of changing a fresh set to fluffy set or a fluffy set to a fuzzier set. Enrollment capability (MF) values are distributed to the etymological factors, utilizing five subsets: NB(negative big),NS(negative small),ZE(zero),PS(positive small),PB(positive big).These boundaries are fuzzified with the utilization of pre-characterized input participation functions,which can have different shapes.The most normal are: Three-sided , ringer , Trapezoidal , Sinusoidal , Dramatic etc.The rule network is utilized to portray fluffy sets and fluffy administrators in type of restrictive explanations.

Table.1 Fuzzy rules

ΔVpv*[o/p]	ΔVpv[i/p]					
ΔPpv[i/p]		NB	NS	ZE	PS	PB
	NB	PS	PB	NB	NB	NS
	NS	PS	PS	NS	NS	NS
	ZE	ZE	ZE	ZE	ZE	ZE
	PS	NS	NS	PS	PS	PS
	PB	NS	NB	PB	PB	PS

V_{pv} = Reference Voltage
ΔP_{pv} = Change in power
NB = Negative Big
NS = Negative Small
ZE = Zero
PB = Positive Big
PS = Positive Small

Induction strategy:

Induction motor fundamentally comprises of fluffy rule base and fluffy ramifications sub-blocks.The inputs are presently fuzzified and taken care of to the derivation motor and the standard base is applied.The yield fluffy set is the recognized utilizing fluffy ramifications method.Here we are utilizing MIN-MAX fluffy ramifications technique.

Induction component permits planning given contribution to a result utilizing fluffy logic.It utilizes all pieces participation functions,logical activities and in the event that rules.The most normal kinds of surmising frameworks are Mamdani and Sugeno technique.

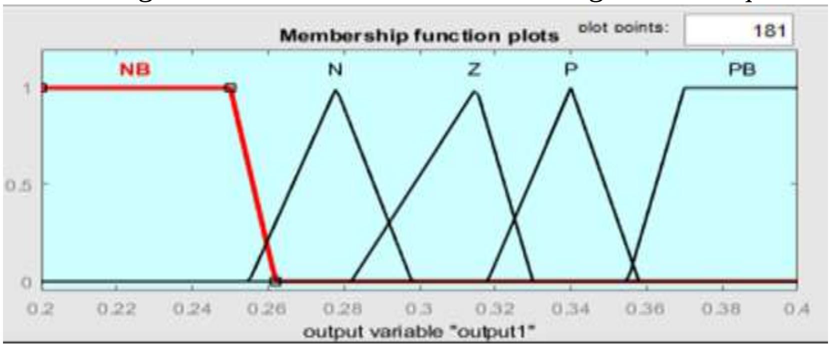


Fig.6 Output

De-Fuzzification:

De-Fuzzification is the most common way of changing a fluffy set in to a fresh set or a changing over a fluffy part in to a fresh member.There are a few numerical strategies accessible: Centroid , Bisector , Mean , Greatest and Weighted normal.

Focal point of gravity is the technique to register the result of this FLC to produce the obligation ratio(D).The focus of gravity strategy is both extremely quick and straightforward technique.

SIMULATION MODELS & RESULTS USING FUZZY LOGIC CONTROLLER:

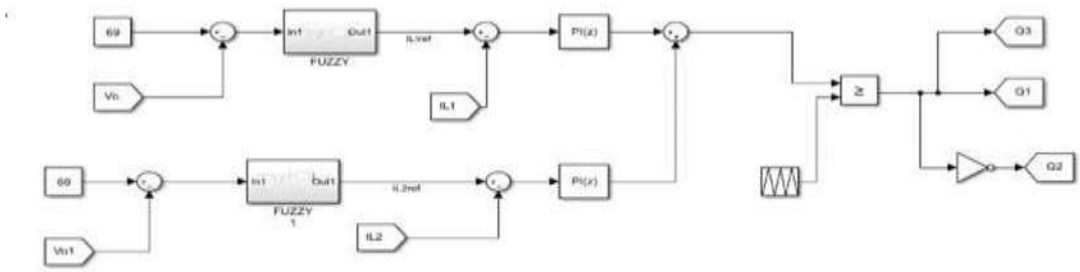
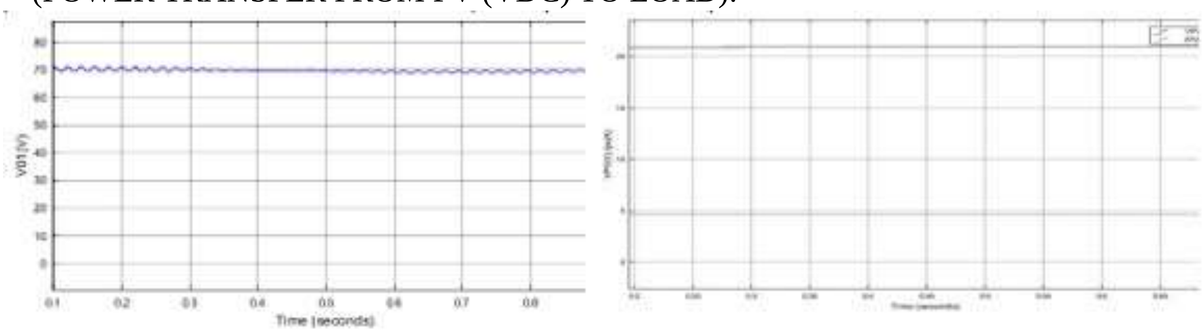


Fig. 7 Controlling Block of FUZZY Logic Controller

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



(a) (b)

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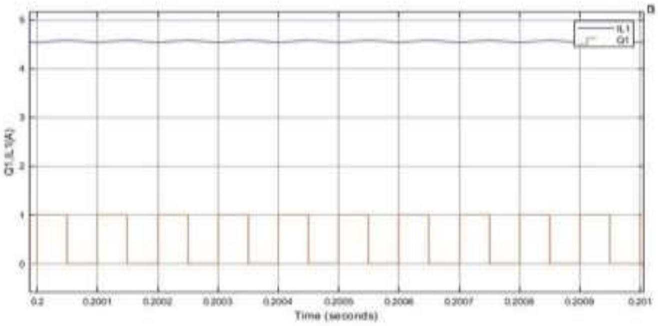

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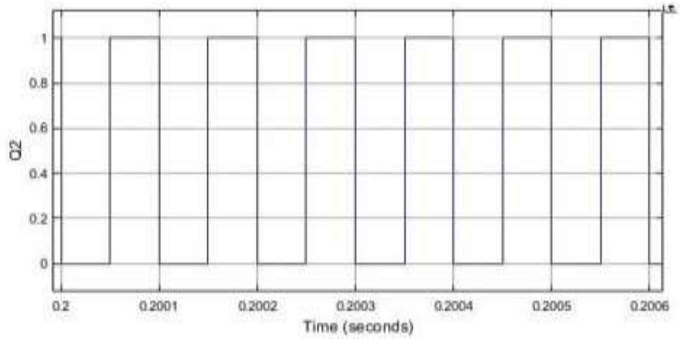

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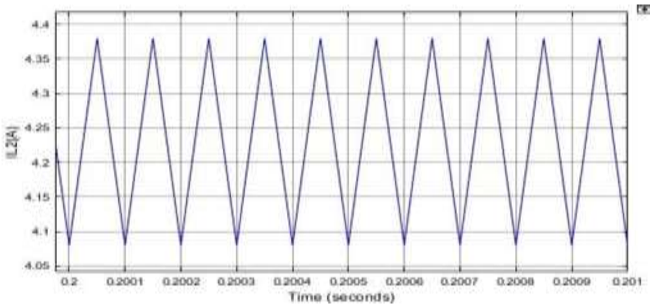
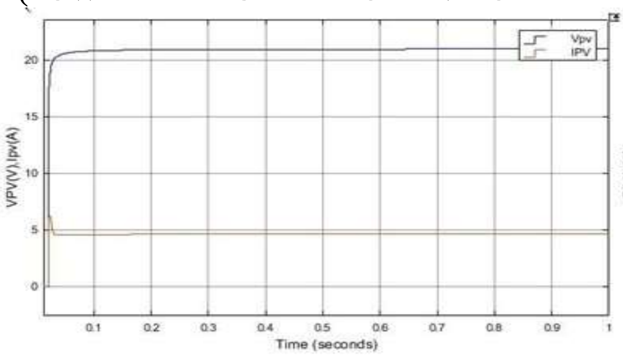


(e)

Fig. 8: (a) $Voltage(V_{01})$; **(b)** $Voltage(V_{pv})$, $Current(I_{pv})$; **(c)** $Gate\ pulse(Q_1)$, $Inductor\ Current(I_{L1})$; **(d)** $Gate\ Pulse(Q_2)$; **(e)** $Inductor\ Current(I_{L2})$

2) STATE 2- SITO (SINGLE INPUT THREE OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV TO BATTERY AND LOAD):



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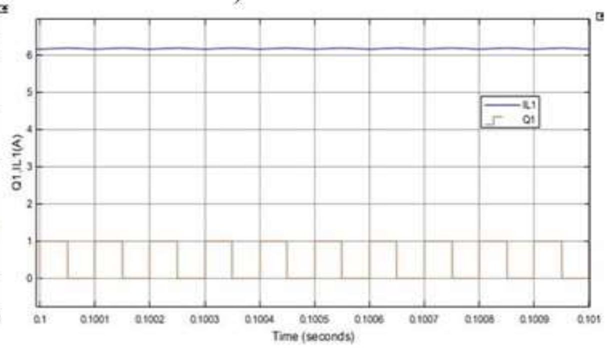

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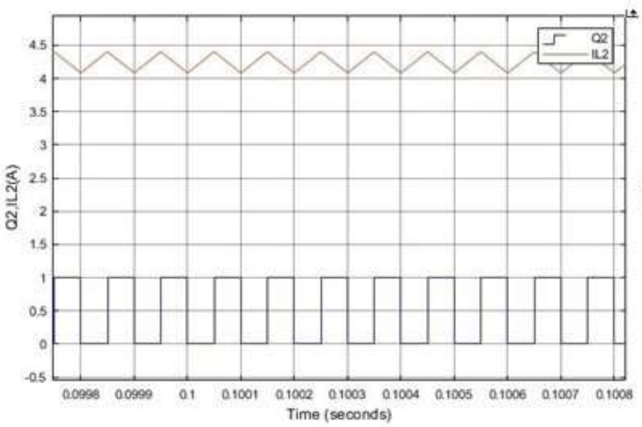

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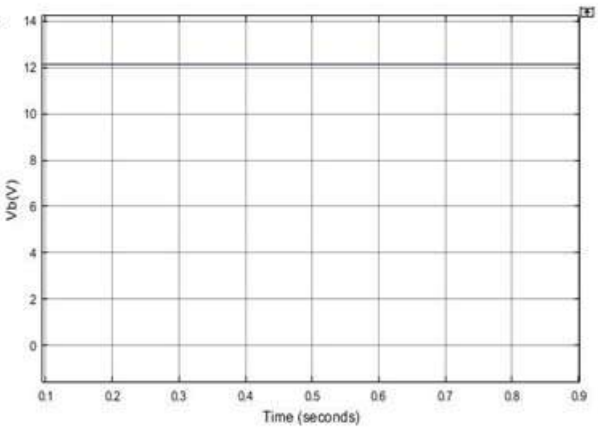

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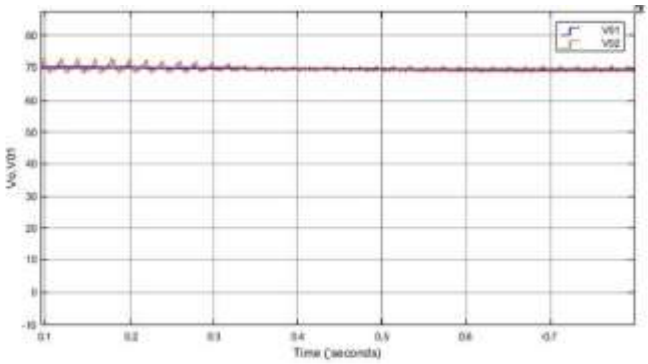
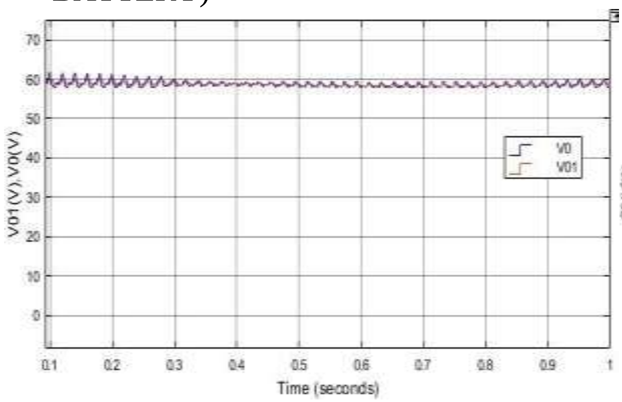


(e)

Fig. 9: (a) $Voltage(V_{pv}), Current(I_{pv})$**; (b)** $Inductor\ current(I_{l1})$**; (c)** $Gate\ pulse(Q_2), Inductor\ Current(I_{l2})$**; (d)** $Battery\ Voltage(V_{bat})$**; (e)** $Voltages(V_0), (V_{01})$

3) STATE 3 - SIDO STATE OF THE CONVERTER (POWER TRANSFER FROM THE BATTERY)



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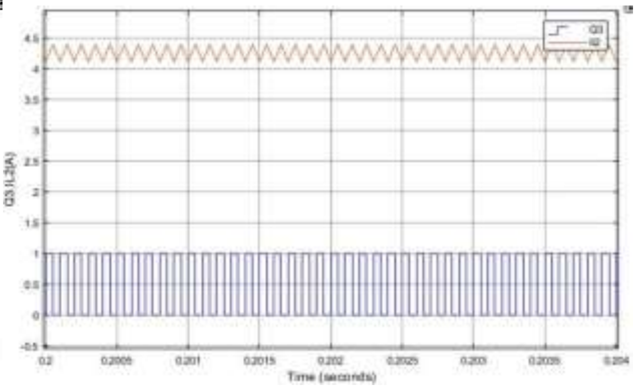

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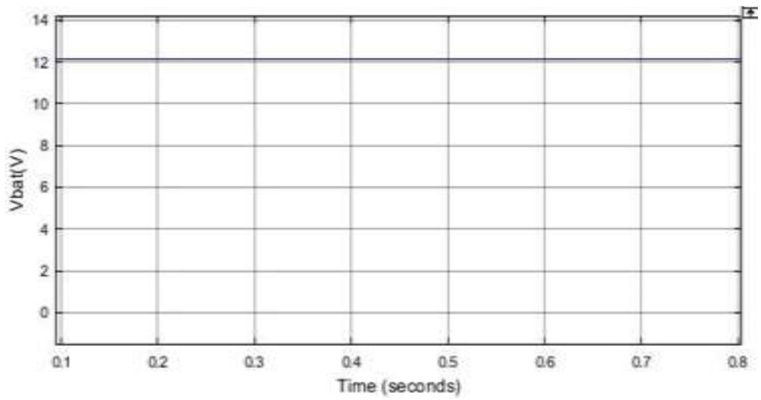

(c)

Fig. 10: (a) $Voltage(V_0), (V_{01})$**; (b)** $Inductor\ Current(I_{l2})$**; (c)** $Battery\ Voltage(V_{bat})$

4) STATE 4 – DIDO (DUAL INPUT DUAL OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV AND BATTERY)

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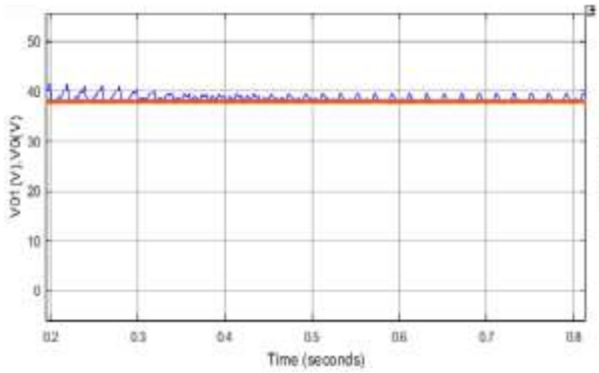

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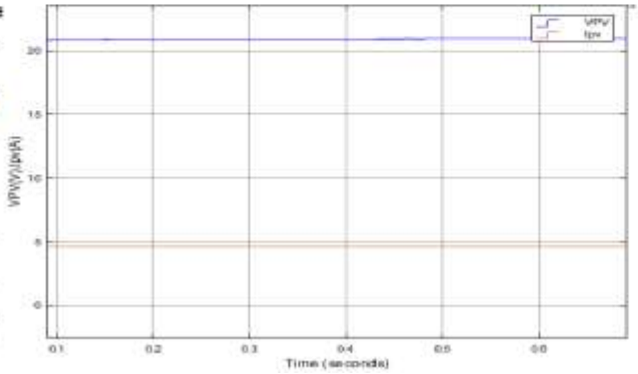

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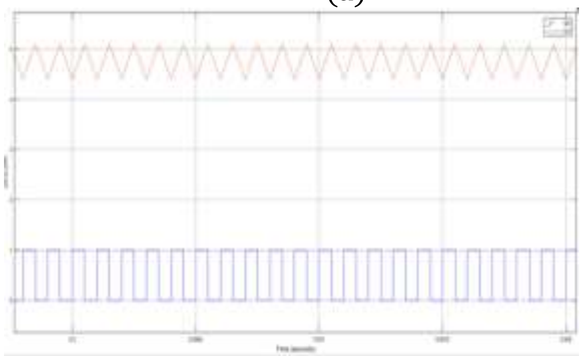

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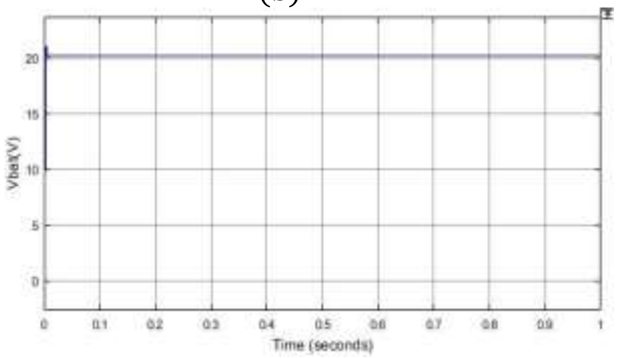

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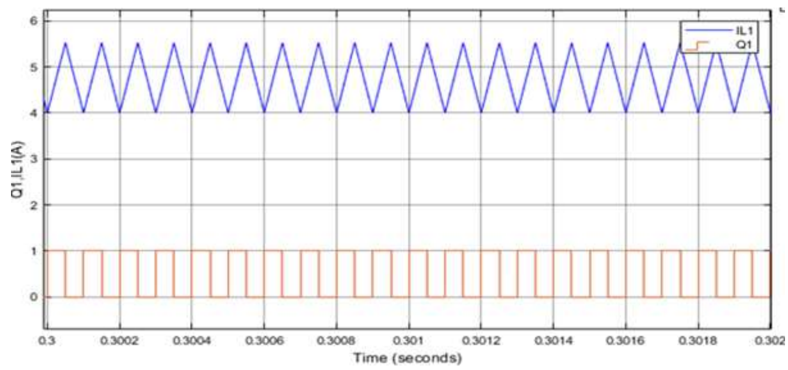
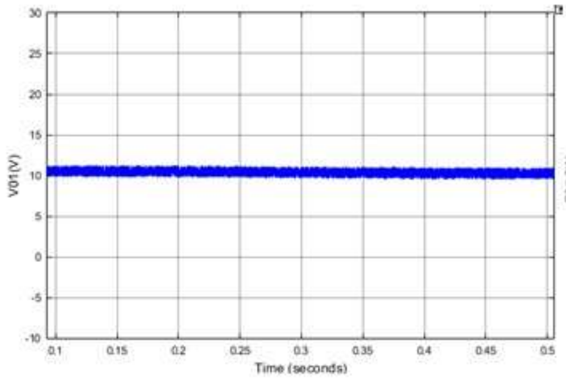


(e)

Fig. 11: (a) $Voltage(V_{01}), (V_0)$; **(b)** $Voltage(V_{pv}), Current(I_{pv})$; **(c)** $Inductor\ current(I_{l2})$; **(d)** $Battery\ Voltage(V_{Bat})$; **(e)** $Inductor\ Current(I_{l1})$

5) STATE 5 - SIDO STATE OF THE CONVERTER (POWER TRANSFER FROM LOAD TO BATTERY)



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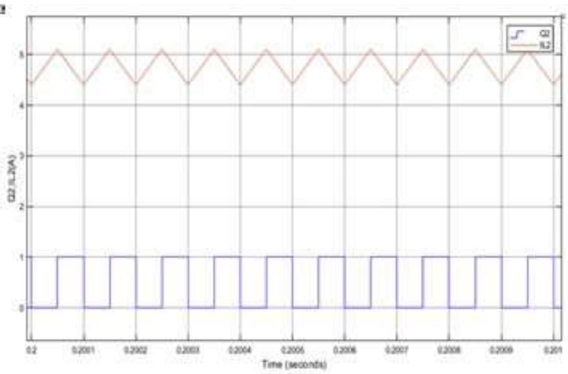

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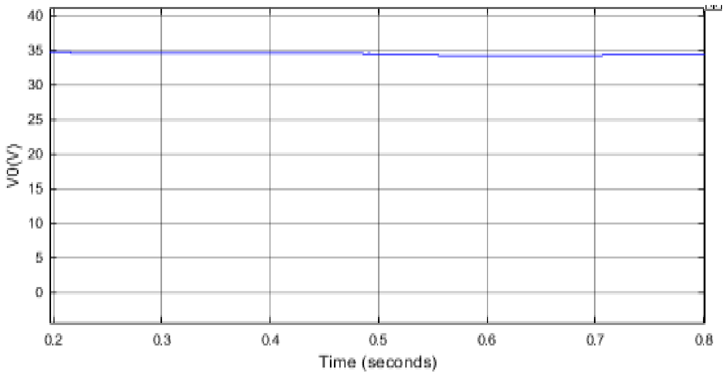

(c)

Fig. 12: (a) $Voltag(V_{01})$; (b)$Inductor\ Current(I_{l2})$; (c) $Voltage(V_0)$

ADAPTIVE NETWORK BASED FUZZY INFERENCE SYSTEM (ANFIS) :

ANFIS is the combination of brain network with fluffy induction framework. ANFIS Regulator modifies PI boundaries (Kp,i) as per the adjustment of force framework working condition at the hour of aggravation. Fluffy rationale is a part of man-made consciousness, described by fuzzification ,defuzzification and rule base . Fluffy rationale manages phonetic factors and brain organization. Requires info and result data set for preparing. For the most part, for straight data set back spread network is utilized and for nonlinear data set multi-facet feed forward brain network is liked.

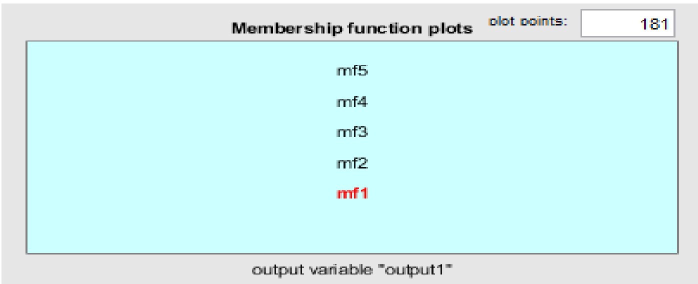

Fig.13: $Output$

ANFIS Rules:

E/EC	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

E =Error
EC= Change in Error
NB= Negative Big
NM=Negative Medium
NS= Negative Small
ZE=Zero
PB=Positive Big
PM=Positive Medium
PS=Positive Small

Table.2 ANFIS Rules

The factors for input Enrollment Capability (MF) are Negative Huge (NB),Negative Little (NS),Negative Medium (NM),Zero(Z),Positive Little (PS),Positive Medium(PM),Positive Big(PB) as fluffy subsets. Blunder (e)/change of mistake (de) is the info and outputis the ideal control signal. Here, three-sided enrollment capabilities (MFs) as low, medium and high are thought of. After choice of a legitimate MF for input, the standard base is made and In the event that… rationale is utilized to make rule base.

Induction is applied to go on with centroid strategy for defuzzification. After defuzzification, the fresh worth is gotten as result. In brain network,weight is refreshed according to the information rule and preparing go on till the mistake becomes zero. Choice of the appropriate MF will result into the no blunder in less number of cycles.

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

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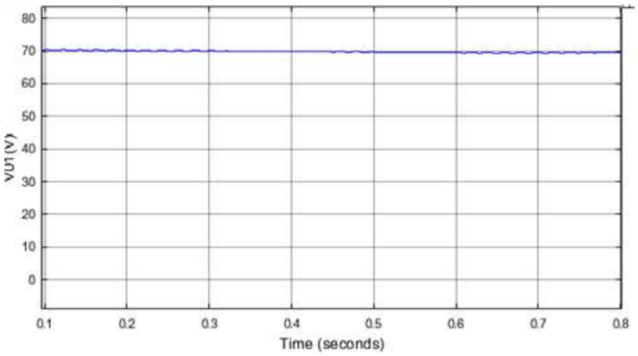

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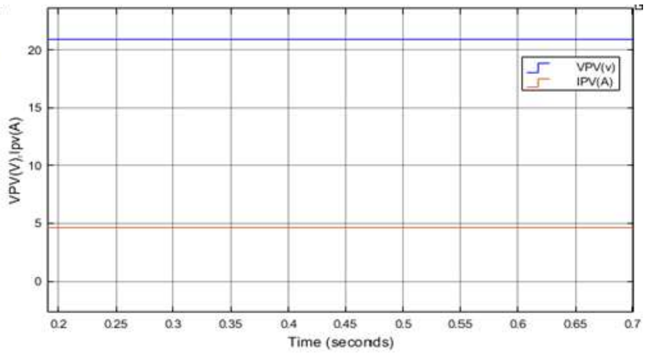

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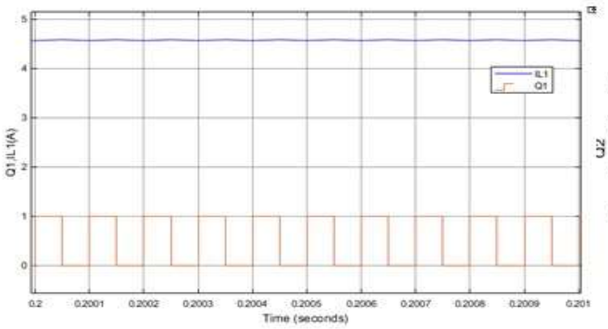

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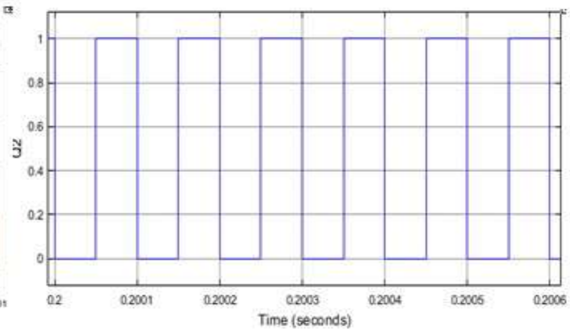

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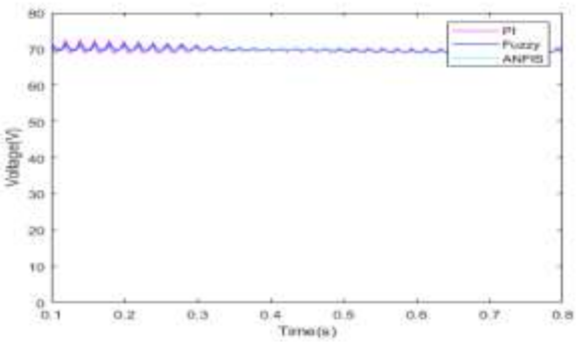

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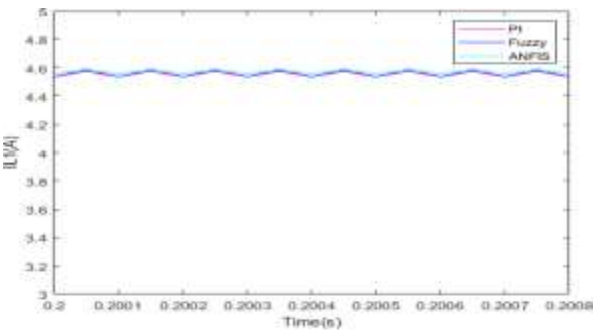

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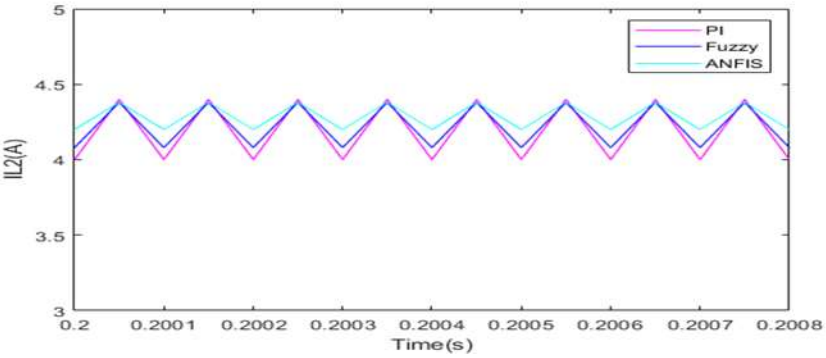

(g)

Fig. 14: (a) $Voltage(V_{01})$; **(b)** $Voltage(V_{pv})$, $Current(I_{pv})$; **(c)** $Inductor\ Current(I_{l1})$; **(d)** $Gate\ Pulse(Q_2)$; **(e)** $Voltage(V_0)$; **(f)** $Inductor\ current(I_{l1})$; **(g)** $Inductor\ Current(I_{l2})$;

2) STATE 2- SITO (SINGLE INPUT THREE OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV TO BATTERY AND LOAD):

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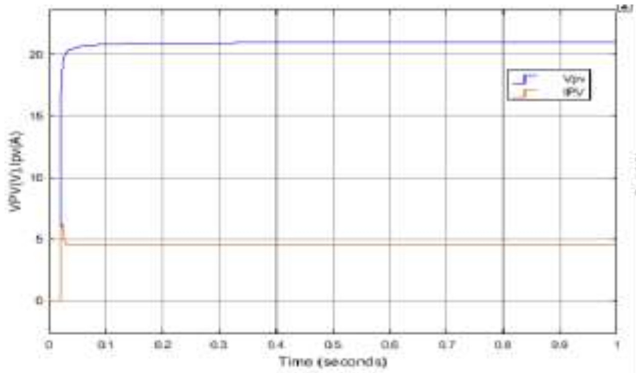

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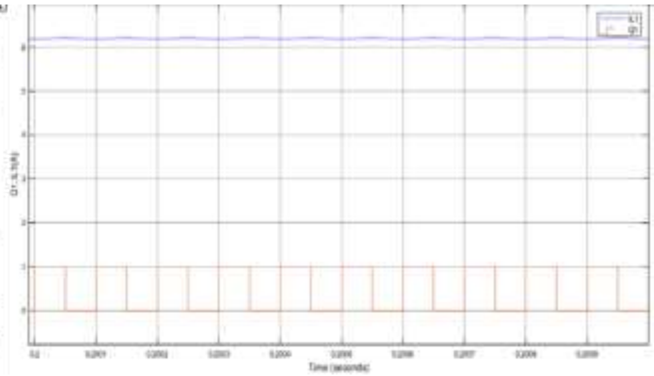

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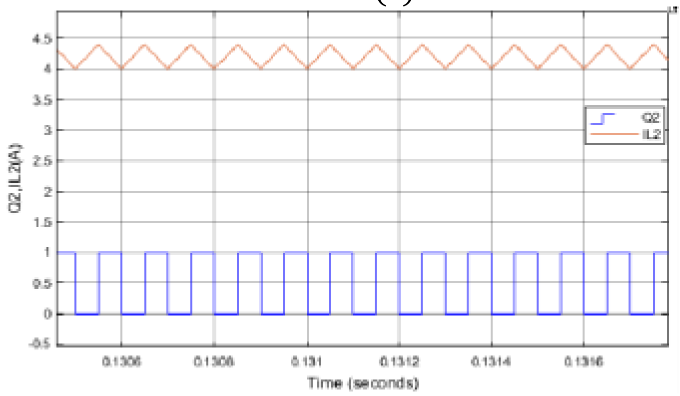

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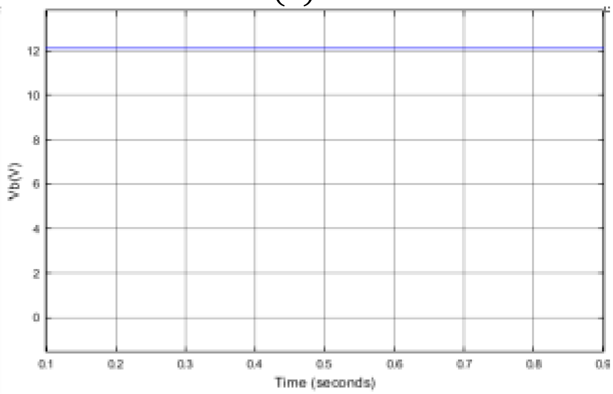

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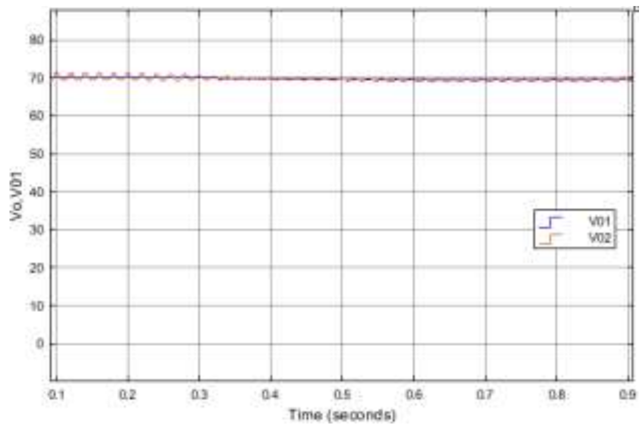

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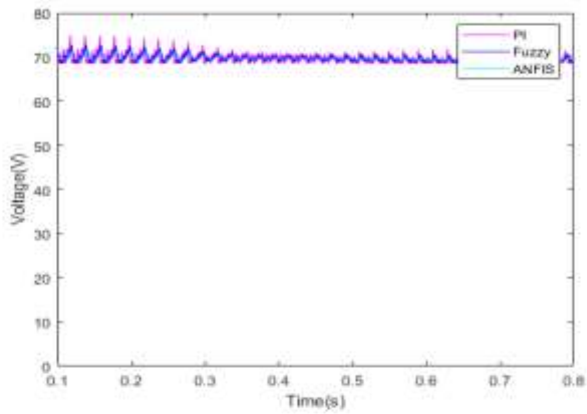

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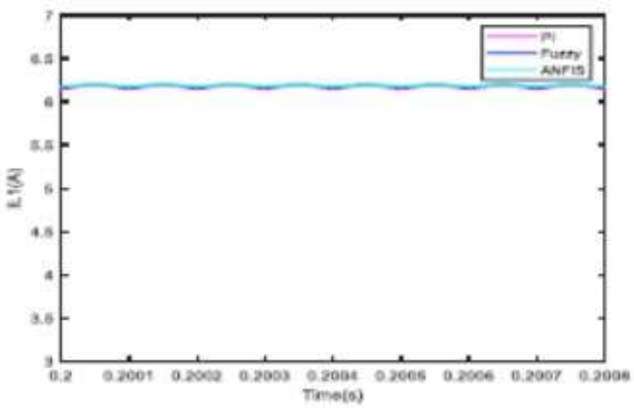

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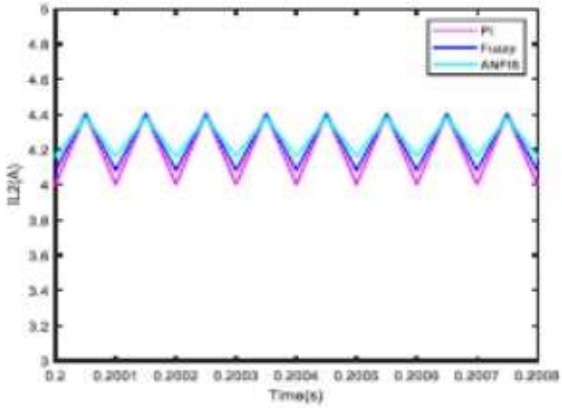

(h)

Fig. 12: (a) $Voltage(V_{pv}), Current(I_{pv})$; (b) $Inductor\ Current(I_{l1})$; (c) $Inductor\ current(I_{l2})$; (d)

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Battery Voltage(V_{bat}); (e) *Voltages*(V_o), (V_{01}); (f) *Volatge*(V_0); (g) *Inductor Current*(I_{l1}); (h) *Inductor current*(I_{l2})

3) STATE 3 - SIDO STATE OF THE CONVERTER (POWER TRANSFER FROM THE BATTERY)

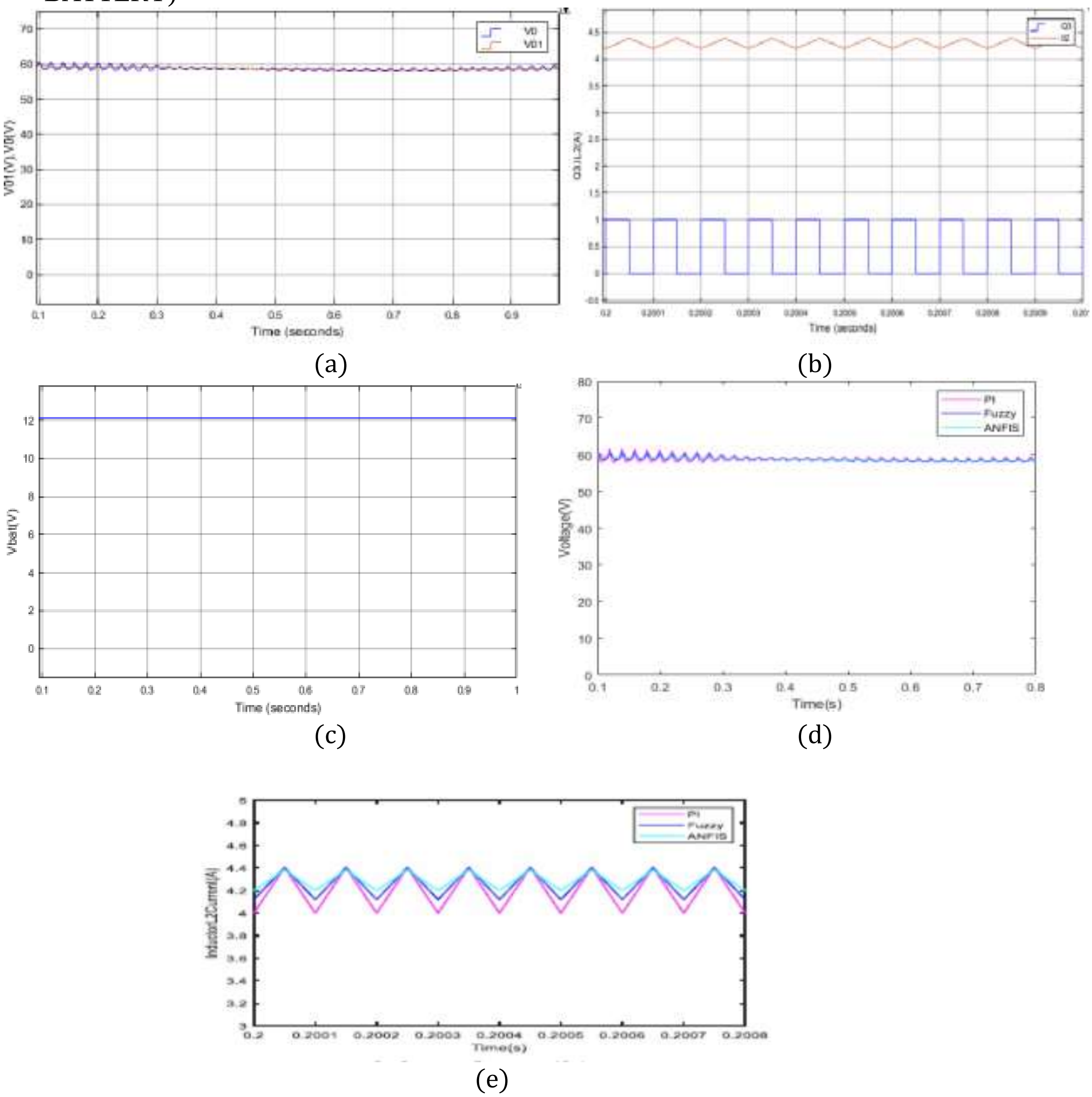
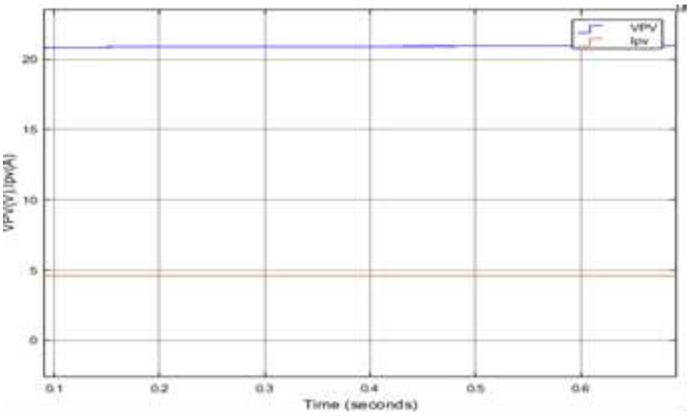
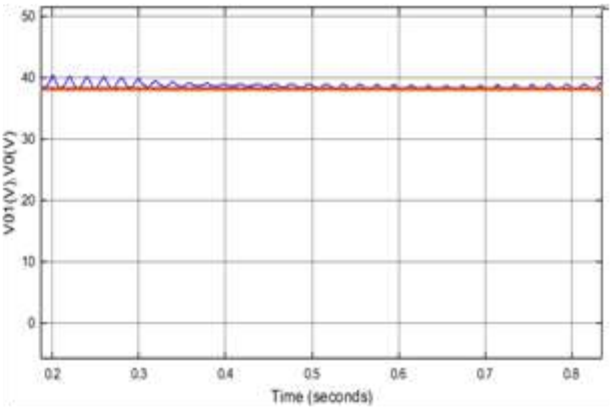


Fig. 12: (a)*Voltage*(V_0), (V_{01}); (b) *Inductor Current*(I_{l2}); (c) *Battery Voltage*(V_{bat}); (d) *Voltage*(V_0); (e) *Inductor Current*(I_{l2})

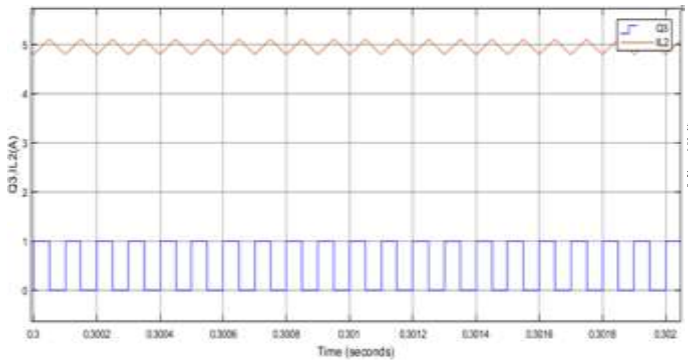
4) STATE 4 – DIDO (DUAL INPUT DUAL OUTPUT) STATE OF THE CONVERTER (POWER TRANSFER FROM PV AND BATTERY)


VPV
Ipv
VPV(V),Ipv(A)
Time (seconds)

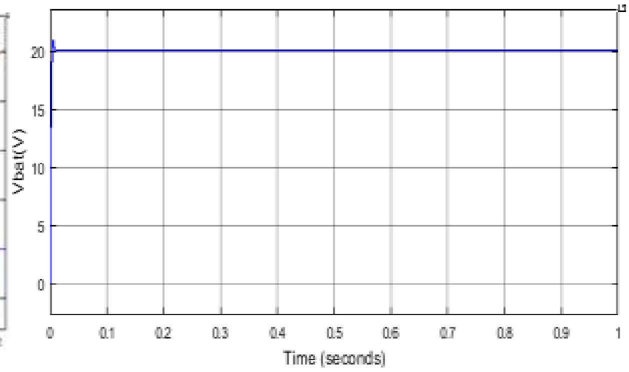
(a)


V01(V),V0(V)
Time (seconds)

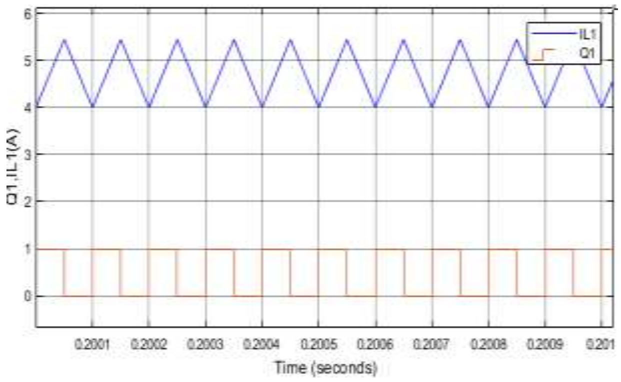
(b)


Q3
IL2
Q3,IL2(A)
Time (seconds)

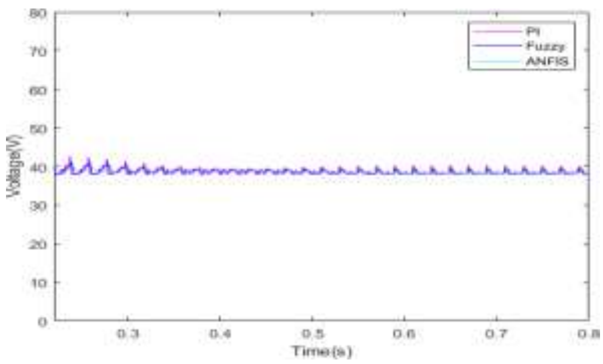
(c)


Vbat(V)
Time (seconds)

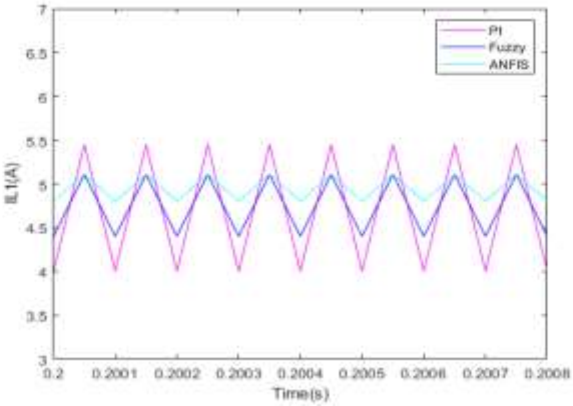
(d)


IL1
Q1
Q1,IL1(A)
Time (seconds)

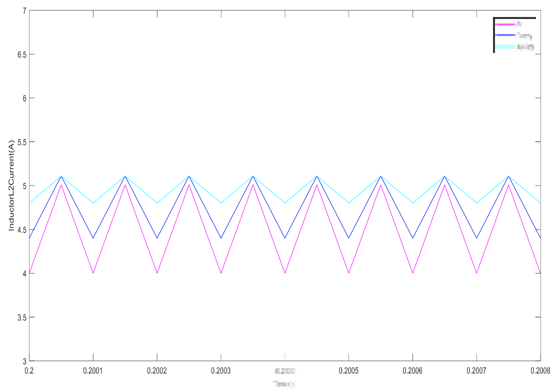
(e)


PI
Fuzzy
ANFIS
Voltage(V)
Time(s)

(f)


PI
Fuzzy
ANFIS
IL1(A)
Time(s)

(g)



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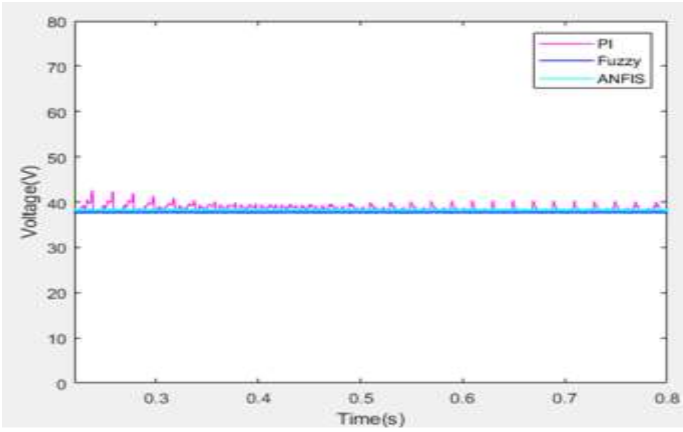
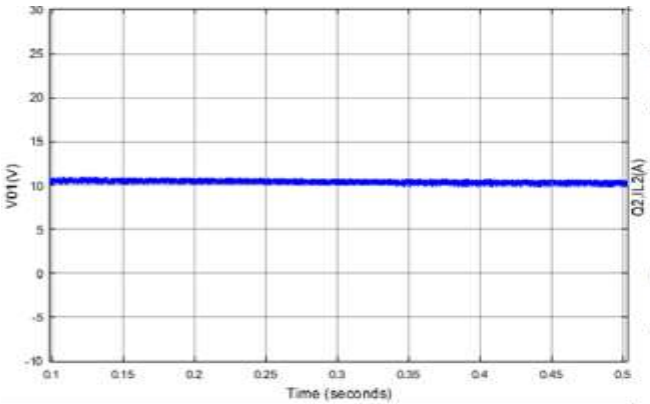


(i)

Fig. 12: (a)$Voltage(V_0)$, (V_{01}); (b) $Inductor\ Current(I_{l2})$; (c) $Battery\ Voltage(V_{bat})$; (d) $Voltage(V_0)$; (e) $Inductor\ Current(I_{l2})$; (f) $Voltage(V_0)$; (g) $Inductor\ Current(I_{l1})$; (h) $Inductor\ Current(I_{l2})$; (i) $Voltage(V_0)$

5) STATE 5 - SIDO STATE OF THE CONVERTER (POWER TRANSFER FROM LOAD TO BATTERY)



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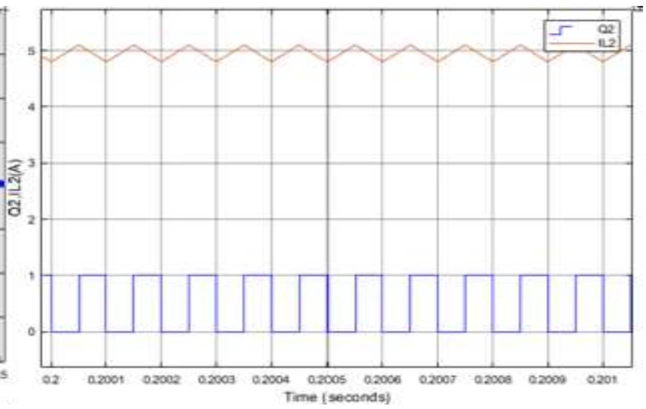

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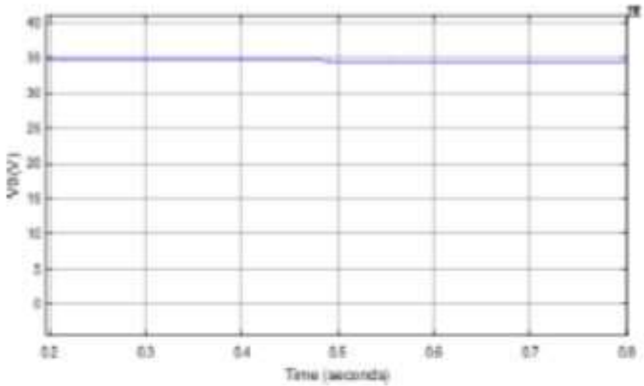

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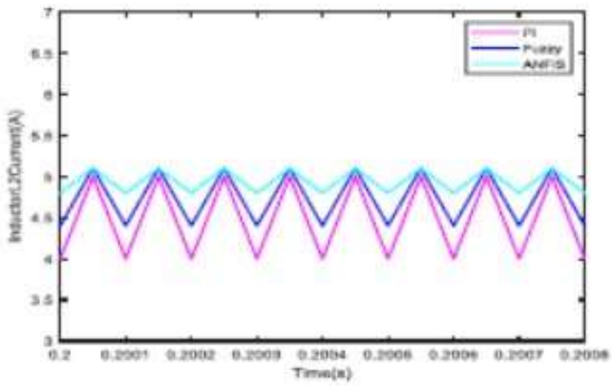
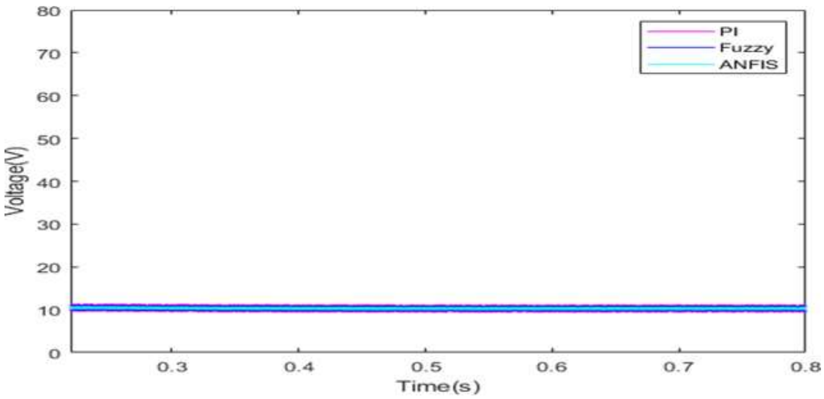


(d)



(e)

Fig. 12: (a)$Voltage(V_0)$, (V_{01}); (b) $Inductor\ Current(I_{l2})$; (c) $Battery\ Voltage(V_{bat})$; (d) $Inductor\ Current(I_{l1})$; (e) $Voltage(V0)$;

CONCLUSION:

In this undertaking, an ANFIS and Fluffy Rationale Regulator is utilized to execute a changed design of non detached, four - port (two information and two result ports) converter, power electronic connection points for use in electric vehicle (EV) applications. Contrasted with existing buck help converter, the Four-port converter (FPC) enjoys the benefits of a)producing buck, support, buck-help yield even without the utilization of an extra transformer b)having bidirectional power stream ability with decreased part count c)individual power stream control between the sources d)handling numerous assets of various voltage and current limit e)easy configuration, control and execution process. Contrasted with PI Regulator, the Fluffy rationale regulator and ANFIS regulator has less motions, low consistent state blunder and less symphonious waves. Contrasted with PI and Fluffy controller,ANFIS Regulator has great execution ,more prominent proficiency and it diminishes the exchanging misfortunes.

REFERENCES:

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

[2] 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.

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

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

[5] T. Bang and J.-W. Park, ‘‘Development of a ZVT-PWM buck cascaded buck–boost PFC converter of2 kW with the widest range of input voltage,’’ IEEE Trans. Ind. Electron., vol. 65, no. 3, pp. 2090– 2099, Mar. 2018.

[6] 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.

[7] 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.

[8] 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.

[9] 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.

[10] M. B. Camara, H. Gualous, F. Gustin, and A. Berthon, ‘‘Design and new control of DC/DC converters to share

ISSN2454-9940
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Vol 15, Issue .1 Jan 2024

energy between supercapacitors and batteries in hybrid vehicles,'' IEEE Trans. Veh. Technol., vol. 57, no. 5, pp. 2721–2735, Sep. 2008.

[11] T. Kim and S. Kwak, ''Single pole switch leg based multi-port converter with an energy storage,'' IET Power Electron., vol. 9, no. 6, pp. 1322–1330, May 2016.

[12] H. Wu, Y. Lu, L. Chen, P. Xu, X. Xiao, and Y. Xing, ''High step-up/stepdown non-isolated BDC with built-in DC-transformer for energy storage systems,'' IET Power Electron., vol. 9, no. 13, pp. 2571–2579, Oct. 2016.

[13] A. Ajami, H. Ardi, and A. Farakhor, ''Design, analysis and implementation of a buck-boost DC–DC converter,'' IET Power Electron., vol. 7, no. 7, pp. 1906–1914, Nov. 2014.