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DESIGN AND IMPLEMENTATION OF A ANFIS CONTROLLER BASED MULTI-INPUT SINGLE OUTPUT DC-DC CONVERTER

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ABSTRACT

This paper presents a multi-input single output DC-DC converter with an ANFIS (Adaptive Neuro-Fuzzy Inference System) controller to enhance power efficiency. The ANFIS controller utilizes a combination of fuzzy logic and artificial neural network to optimize the DC-DC converter's switching frequency and duty cycle for efficient power transfer. The DC-DC converter can take in multiple input sources and provide a regulated output voltage with decreased power losses. The project involves designing the ANFIS controller and implementing it on a digital signal processor. The simulation results demonstrate that the ANFIS controller significantly enhances the power sharing capability of the DC-DC converter compared to traditional techniques. This paper has practical applications in electric vehicles, renewable energy systems, and other power electronics systems where efficient power conversion is essential.

Keywords—Multi-input single-output (MISO)converters, source fault tolerant.

INTRODUCTION

Multiple-input converters (MICs) has the tremendous performance over conventional solutions [1-3] that employ multiple single converters: 1) MICs has a compact in size and a lower cost because of sharing the reactive components and active power switches. 2) Higher power density. 3) MICs avoid the complex communication among multiple different power sources due to the unified power management with centralized control and 4) improve the dynamic performance. Therefore, MICs are an excellent candidate for EVs and grid connected applications which is economic and good development prospects [4-7]. Mostly, the non-isolated MICs are based on the structure of the boost or buck dc–dc converters. In [8], two independent voltage sources are successfully integrated by using the time multiplexing scheme and reduced device count which results, reduction in cost, size and power losses. However, in this conFig.uration the output voltage is still negative. Based upon a time-sharing concept a MIC is presented in [9], and it can operate in different modes of operation, such as boost, buck and buck–boost mode; nevertheless, only one input power source is allowed to deliver energy at a time. Multi-input buck-boost converter is in [10], it can improve the utilization of energy sources as compared with the presented topology in [9]. However, additional switches are required in series with the energy sources otherwise, it may be leads to inappropriate operation.

In [11, 12], bridge type MISO topology is suggested for performing the buck, boost, and buck-boost operations in single converter and improved the performance of the MISO converter. This type of conFig.uration further extended with additional switch is used in [13] which results, bidirectional power flow capability is provided through usage of a battery. Over a decade, few topologies are developed which pulled the attention towards hybridizing the energy sources with high voltage gain and effective energy storage system for EVs and renewable energy source applications in [14-19]. These topologies are greatly impacted on part count, associated control scheme and size. The energy sources are operated individually or simultaneously with a proper time delay between them and it may be difficult to get a wide range of duty cycle operation.

Based on the upgrade of MISO topologies, capable of deliver the power from two power sources to load individually or simultaneously. In the case of one input source is powered off, the other port stands the operation which results, the output voltage will be less than the existing input voltage, which means that the converter is not able to maintain the expected output voltage in the single input case. This paper proposes MISO converter with source fault tolerant. It can improve the output voltage, energy source utilization and, concerned about fault tolerant when one of the inputs is fail.

LITERATURE REVIEW

S.-K. Changchien, T.-J. Liang, J.-F. Chen, and L.-S. Yang, Proposes A novel high step-up dc-dc converter for fuel cell energy conversion is presented in this paper. The converter utilizes a multi winding coupled inductor and a voltage doubler to achieve high step-up voltage gain. The voltage on the active switch is clamped, and the energy stored in the leakage inductor is recycled. Therefore, the voltage stress on the active switch is reduced, and the conversion efficiency is improved. Finally, a 750-W laboratory prototype converter supplied by a proton exchange membrane fuel cell power source and an output voltage of 400 V is implemented. The experimental results verify the performances, including high voltage gain, high conversion efficiency, and the effective suppression of the voltage stress on power devices. The high step-up converter can feasibly be used for low-input-voltage fuel cell power conversion applications.

Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang, proposes A novel high step-up dc-dc converter with coupled-inductor and switched-capacitor techniques is in this paper. The capacitors are charged in parallel and are discharged in series by the coupled inductor, stacking on the output capacitor. Thus, the converter can achieve high step-up voltage gain with appropriate duty ratio. Besides, the voltage spike on the main switch can be clamped. Therefore, low on-state resistance RDS(ON) of the main switch can be adopted to reduce the conduction loss. The efficiency can be improved. The operating principle and steady-state analyses are discussed in detail. Finally, a prototype circuit with 24-V input voltage, 400-V output voltage, and 200-W output power is implemented in the laboratory. Experiment results confirm the analysis and advantages of the converter.

M. R. Banaei and H. A. F. Bonab, Proposes A novel transformer less buck-boost dc-dc converter is in this paper. The presented converter voltage gain is higher than that of the conventional boost, buck-boost, CUK, SEPIC, and ZETA converters, and high voltage can be obtained with a suitable duty cycle. In this converter, only one power switch is utilized. The voltage stress across the power switch is low. Hence, the low on-state resistance of the power switch can be selected to decrease conduction loss of the switch and improve efficiency. The presented converter has simple structure; therefore, the control of the converter will be easy. The principle of operation and the mathematical analyses of the converter are explained. The validity of the presented converter is verified by the experimental results.

Rehman, Z., Al-Bahadly, I., Mukhopadhyay, S.: Proposes Power electronics DC–DC converters are being widely used in various applications like hybrid energy systems, hybrid vehicles, aerospace, satellite applications and portable electronics devices. In the recent past, a lot of research and development has been carried out to enhance the reliability, efficiency, modularity and cost effectiveness of these converters. A number of new topologies have been and new characteristics of power conversion have been defined. DC–DC converters have made a successful transition from single input–single output to multi-input–multioutput converters. These converters are now able to interface different level inputs and combine their advantages to feed the different level of outputs. Research is continued to bring down the cost and reduce the number of components while keeping the continuous improvement in the areas like reliability and efficiency of the overall system. The study of different multi-input DC–DC converter topologies suggests that there is no single topology which can handle the entire goals of cost, reliability, flexibility, efficiency and modularity single handed. This paper presents some of the recent trends in the development of multi-input and multioutput DC–DC converters. Methods to synthesize multi-input converters, their operational principles, merits and demerits are studied.

CIRCUIT CONFIG.URATION

Here new simplified MISO boost converter has been evolved, which is depicted in Fig.. 1. In this scheme, to avoid time multiplexing concept in integration of different types of the energy sources, which results utilization of energy sources are increased and improves the output voltage. In addition, to achieve the source fault tolerant on input source V1. In normal operating condition the inductor L1, L2 are energized by the voltage sources V1, V2 respectively. In the case input port V1 is fail, which is separated from the circuit through the breaker and it can maintain the more than single input source supplied voltage from the available input port V2 which facilitates is achieved through the converter. The scheme enhances the reliability of energy conversion and making it robust against one of the input power sources is off or failure condition.

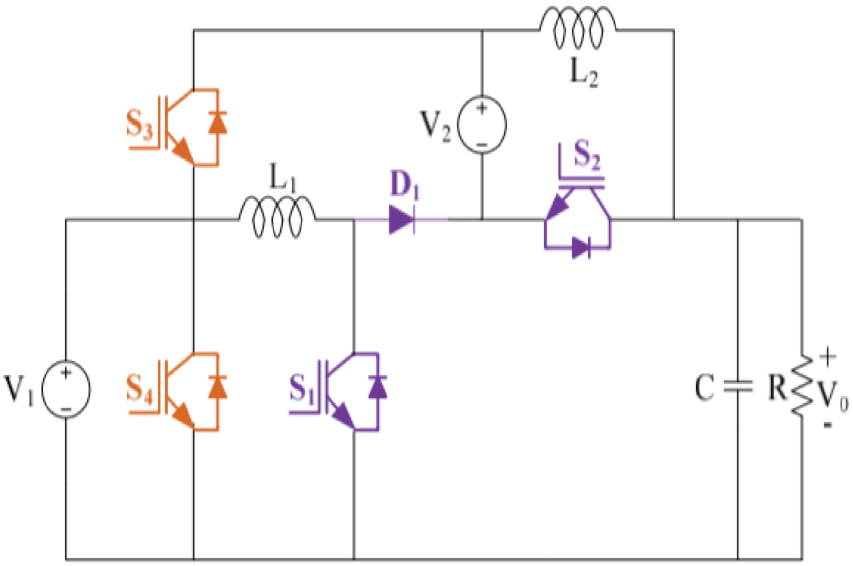


Fig. 1. Schematic of multi-input single-output converter

A. Circuit topology and operation of the converter in one of the input-port is out of work case.

Source-port-fault-tolerant MISO boost converter is illustrated in Fig.. 2. In the case V1 is out of work, inductor L1, L2 are energized by the available input source V2. There are two different types of operating states under the condition and corresponding equivalent circuits are shown in Fig.. 2(a-b).

Mode 1:
In this mode, V1 consider as fail, the inductor L1, L2 are energized by the available source V2 through the switches S2, S3, and D1 respectively. Similarly, capacitor C is discharging their stored energy to load resistance R.

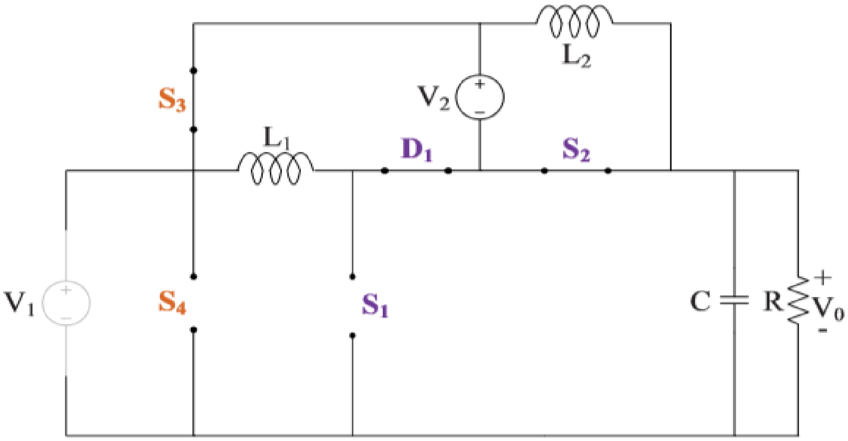


Fig. 2(a). Equivalent circuit of operation during mode1

Mode 2: In mode 2, inductor L1, L2 are deenergized and transfer their stored energy to capacitor C and load resistance R through source port-2, switch S4 and D1 respectively. Corresponding equivalent circuit is shown in Fig.. 2(b).

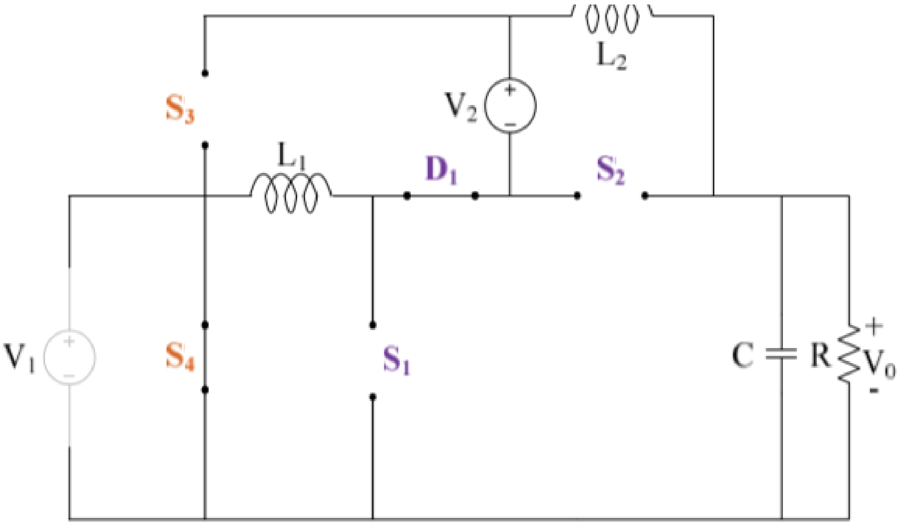


Fig. 2(b). Equivalent circuit of operation during mode2

According to volt-sec balance equation output voltage expression of the MISO converter in VI is out of work condition as follows,

$$V_o = \frac{V_1 + V_2}{(1 - D)} \tag{1}$$

B. Circuit topology & operation of the converter in input-sources are available condition.

Mode 1: In this mode, switch S1 and S2 are turned ON, so remaining switches S3, S4 and D1 are turned OFF, the corresponding equivalent circuit of the converter in this mode is shown in Fig.. 2(c). Inductor L1, L2 is energized by the source V1 and V2 respectively. Capacitor C is discharging their stored energy to load resistance R. Current flows through the inductor and voltage across capacitor equations are as follows.

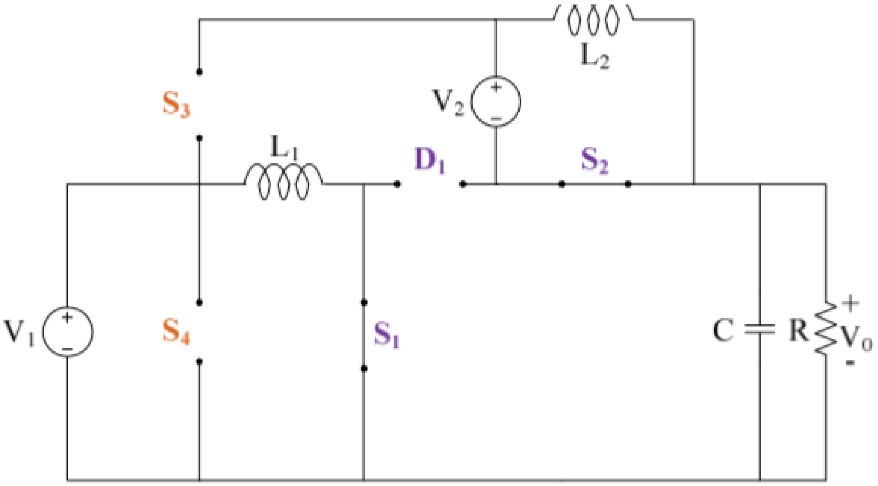


Fig. 2(c). Equivalent circuit of operation during mode1

$$i_{L1}(t) = \frac{V_1}{L_1}t \tag{2}$$

$$i_{L2}(t) = \frac{V_2}{L_2}t \tag{3}$$

$$v_c(t) = v_c(0)e^{\frac{-1}{RC}t} \tag{4}$$

Mode 2:
In this mode, switch S1, S2, S3 and S4 are turned OFF, the corresponding equivalent circuit of the converter in this mode is shown in Fig.. 2(d). In this mode inductor L1, L2 is deenergized and transfer their stored energy to capacitor C and load resistance R through diode D1. Current flows through the inductor and voltage across the capacitor equations are as follows

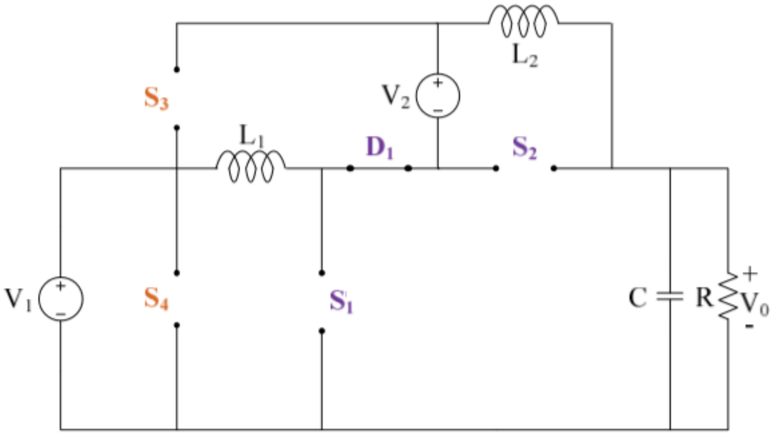


Fig. 2(d). Equivalent circuit of operation during mode2

The inductor current and voltage across capacitor are given by

$$i_{L1}(t) = i_{L2}(t) = \frac{V_1 + V_2}{R} + e^{(-\alpha t)}[c_1 \cos w_d t + c_2 \sin w_d t] \tag{5}$$

$$v_c(t) = (V_1 + V) - \frac{(L_1 + L_2)}{2C} e^{(-\alpha t)} \left[\cos w_d t \left(\frac{\alpha c_1}{R} + w_d c_2 \right) + \sin w_d t \left(-\alpha c_2 + \frac{w_d c_1}{R} \right) \right] \quad (6)$$

The values of c1 and c2 are obtained by applying the initial conditions. According to the volt-sec balance principle output voltage of the converter in MISO operation as follows

$$V_o = \frac{V_1 + V_2}{(1-D)} \quad (7)$$

where ‘D’ is the duty ratio.

This section based on the operating modes, the voltage, and current stresses on the active components, such as power switches in the converter during the CCM operation has been discussed. This result helps for proper selection of switches and further increasing the lifetime of the switches [21]. Voltage and current stresses are calculated in both the sources available case.

Voltage stresses

Mode 1: $V_{SW3} = V_{SW4} = V_o$ (8)

Mode 2: $V_{SW1} = V_{SW2} = V_o$ (9)

Current stresses :

Mode 1: $i_{SW1} = i_{L1},\ i_{SW2} = i_{L2},\ i_{SW2} = 0,\ i_{sw4} = 0$ (10)

Mode 2: $i_{D1} = i_{L1} = i_{L2}$ (11)

Parameters Design:

$L_{1\min} = L_{2\min}$	$\frac{2}{27}\left[\frac{R_{L\max}}{f_s}\right]$	5mH
$C_{\min}$	$\frac{D_{\max} V_o}{V_{cpp} R_{L\max} f_s}$	220uF

Parameter Ratings:

Symbol	Parameter
Input Voltage, Vg	25V
Output Voltage, Vo	100V
Output Current, Io	2A
Output Power, Po	200W

SMALL SIGNAL ANALYSIS:

The power converter's small signal analysis focuses on simulating the averaged, linearized, small signal AC behavior around a system state operating point. The data collected during this inquiry can be utilized to forecast the system transfer function, which is important for the creation of the feedback loop. For various operating modes of the converter, the small signal analysis and state space equation of current flows via the inductor and voltage across the capacitor are carried out [20]. The state space matrices were given in eq. s: (12-(14).

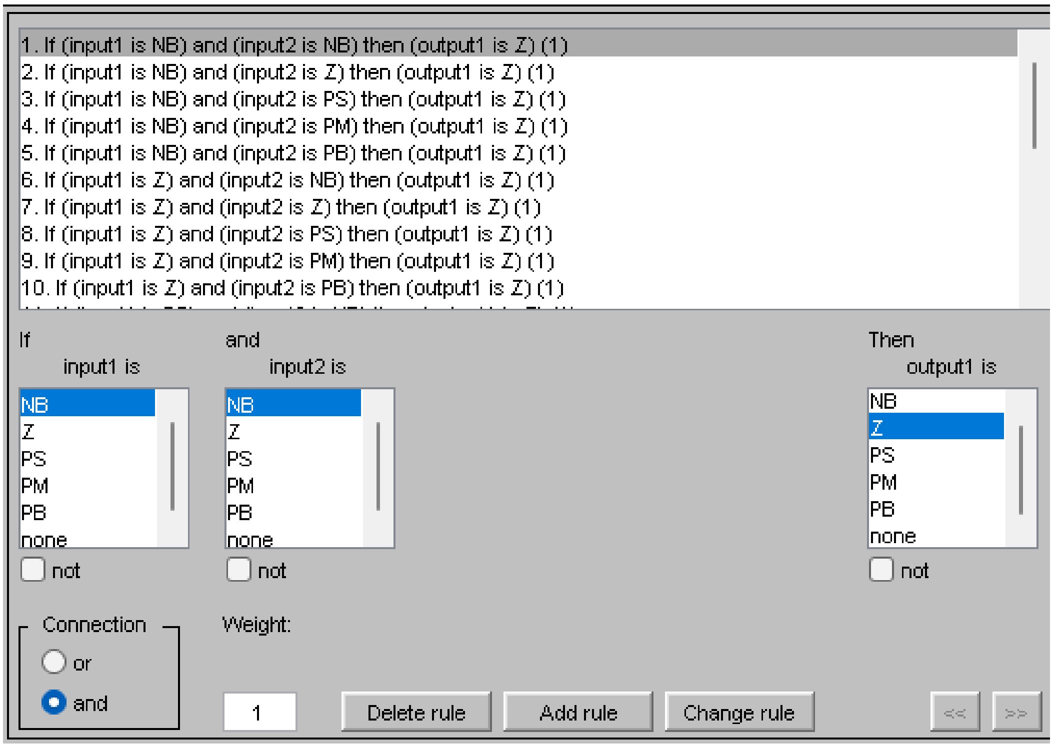
$$\frac{d}{dt}\begin{bmatrix} i_{L1}(t) \\ i_{L2}(t) \\ v_c(t) \end{bmatrix} = A\begin{bmatrix} i_{L1}(t) \\ i_{L2}(t) \\ v_c(t) \end{bmatrix} + BV_{dc} \qquad (12)$$

$$A = \begin{bmatrix} 0 & 0 & \frac{-(1-D)}{(L_1+L_2)} \\ 0 & 0 & \frac{-(1-D)}{(L_1+L_2)} \\ \frac{(1-D)}{C} & 0 & \frac{-1}{RC} \end{bmatrix} \qquad (13)$$

$$b = \begin{bmatrix} \frac{V_1 D}{L_1} + \frac{(V_1+V_2)(1-D)}{(L_1+L_2)} \\ \frac{V_2 D}{L_2} + \frac{(V_1+V_2)(1-D)}{(L_1+L_2)} \\ 0 \end{bmatrix}; \; q = [0\,0\,1] \qquad (14)$$

Formulation of ANFIS Controller

The ANFIS structure of the system which is being modelled is considered as the better model for which the Root mean square error (RMSE) is the minimum. The consequent parameters of the initial fuzzy model are updated by using the Least squares estimation (LSE) algorithm.The rules which are obtained from the clustering, or the grid partition-based method are updated by neural network which uses back propagation learning method with gradient descent algorithm. This updating leads to the optimization of the premise parameters of the fuzzy membership functions to give the final fuzzy model.



1. If (input1 is NB) and (input2 is NB) then (output1 is Z) (1)
2. If (input1 is NB) and (input2 is Z) then (output1 is Z) (1)
3. If (input1 is NB) and (input2 is PS) then (output1 is Z) (1)
4. If (input1 is NB) and (input2 is PM) then (output1 is Z) (1)
5. If (input1 is NB) and (input2 is PB) then (output1 is Z) (1)
6. If (input1 is Z) and (input2 is NB) then (output1 is Z) (1)
7. If (input1 is Z) and (input2 is Z) then (output1 is Z) (1)
8. If (input1 is Z) and (input2 is PS) then (output1 is Z) (1)
9. If (input1 is Z) and (input2 is PM) then (output1 is Z) (1)
10. If (input1 is Z) and (input2 is PB) then (output1 is Z) (1)

If input1 is: NB

and input2 is: NB

Then output1 is: Z

Connection: ● and

Weight: 1

Fig. 2e Rule Editor

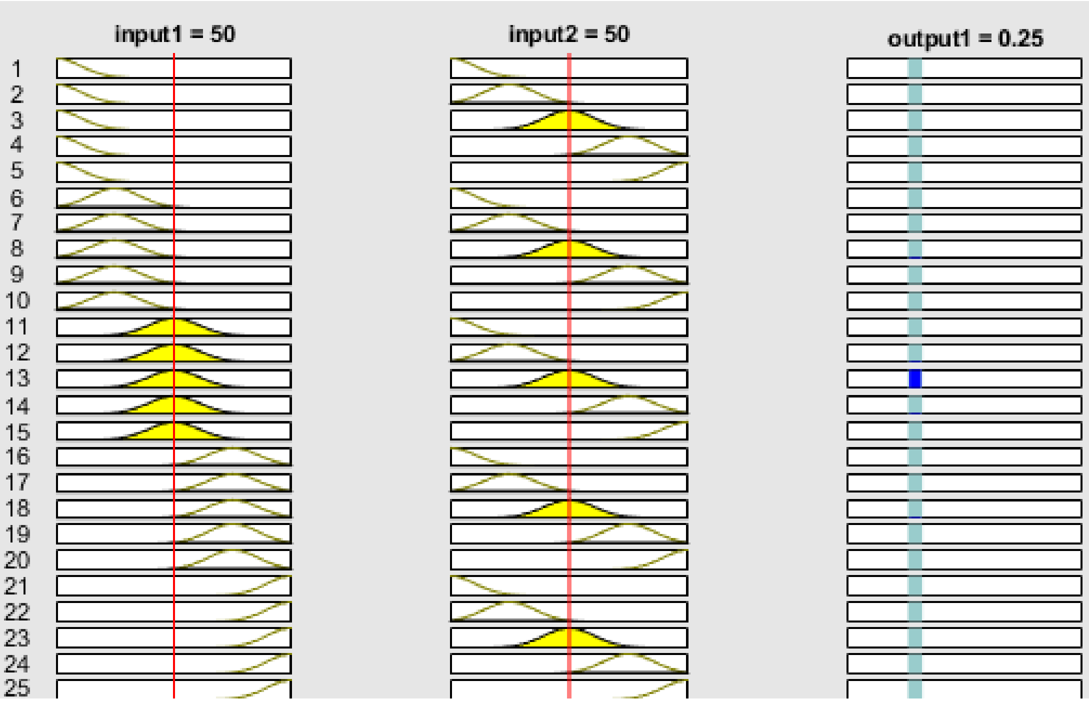


Fig. (2f) Surfaces of Input-1, Input-2 and Output variables.

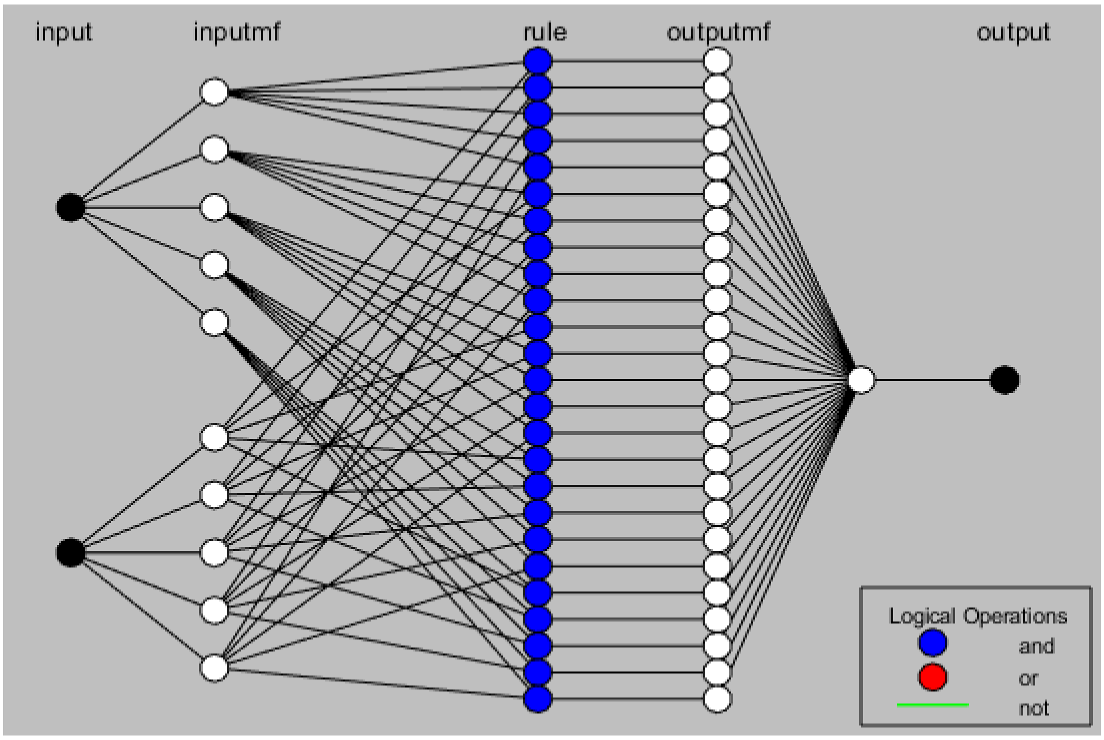


Fig. 2g IF–THEN rules for learning capability to approximate nonlinear functions.

By using ANFIS controller the duty cycles to turn-on/off the switches were obtained and the resulting waveforms are as given below.

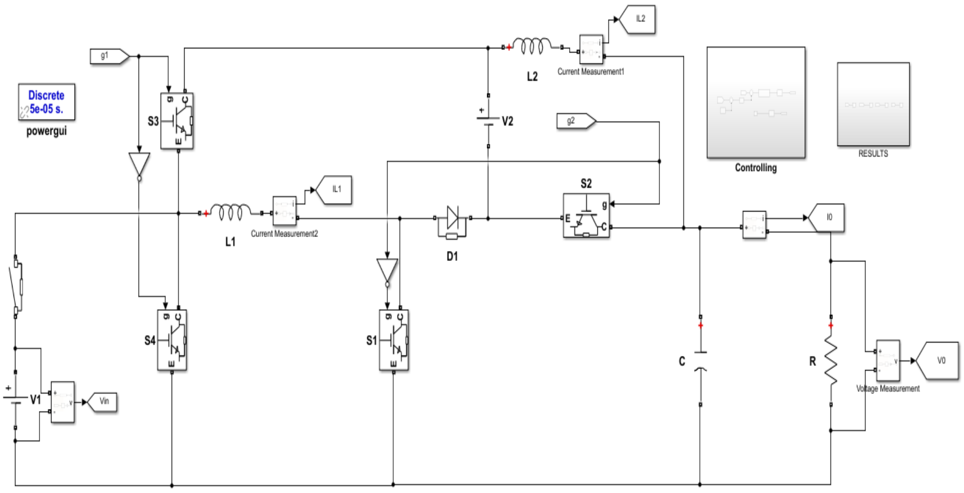


Fig.3.Simulation circuit Configuration

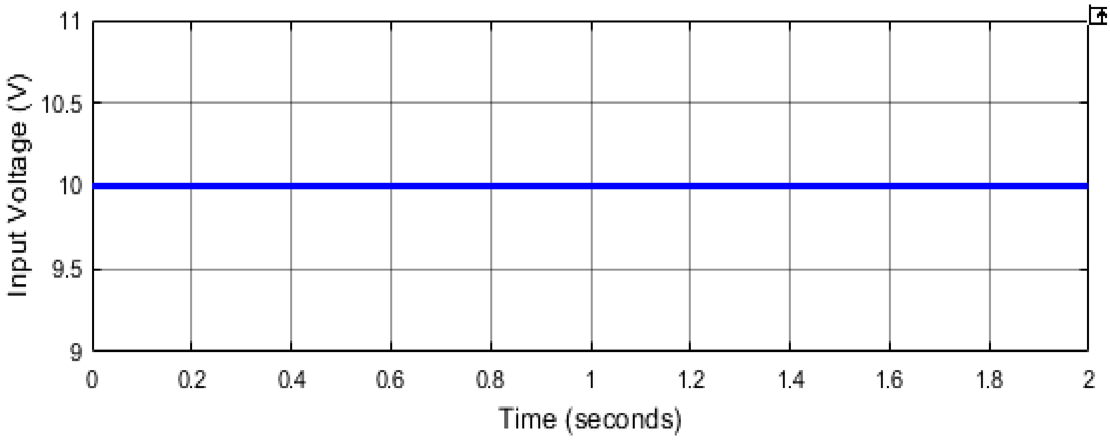


Fig. 4 input voltage vs Time

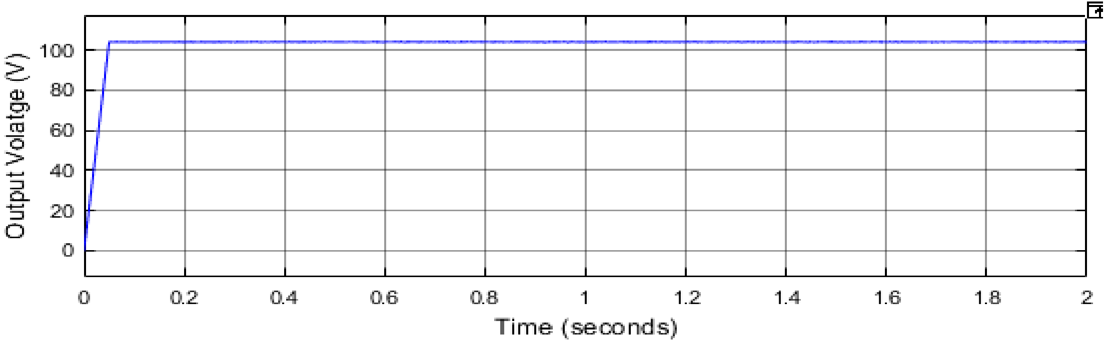


Fig. 5 output voltage vs Time

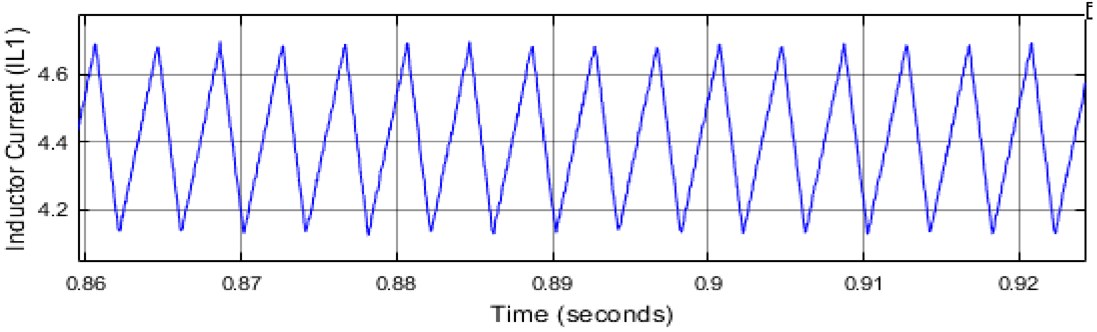


Fig.6 inductor current i_{L1} Vs Time

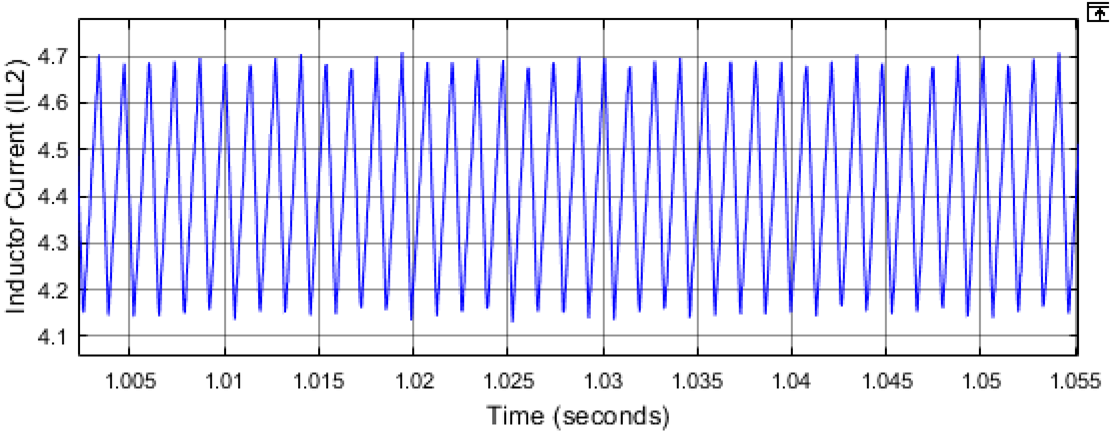


Fig. 7 inductor current i_{L2} VS Time

CONCLUSION

The converter, the Design and Implementation of an ANFIS controller based Multi-Input Single Output DC-DC Converter for enhanced power sharing is a promising endeavour with potential benefits in energy transfer, power management, and cost reduction. The ANFIS controller effectively improves the dynamic response of the DC-DC converter by adjusting the duty cycle of the switches according to the input voltage and load current.

REFERENCES

[1] S.-K. Changchien, T.-J. Liang, J.-F. Chen, and L.-S. Yang, “Novel high step-up DC-DC converter for fuel cell energy conversion system,” IEEE Trans. Ind. Electron., vol. 57, no. 6, pp. 2007–2017, Jun. 2010.
[2] Y. P. Hsieh, J. F. Chen, T. J. Liang, and L. S. Yang, “Novel high step-up DC–DC converter with coupled-inductor and switched-capacitor techniques,” IEEE Trans. Ind. Electron., vol. 59, no. 2, pp. 998–1007, Feb. 2012.
[3] M. R. Banaei and H. A. F. Bonab, "A Novel Structure for Single Switch Non-Isolated Transformerless Buck-Boost dc-dc Converter," IEEE Trans. Ind. Electron., vol. 64, no. 1, pp. 198-205, Jan. 2017.
[4] Rehman, Z., Al-Bahadly, I., Mukhopadhyay, S.: ‘Multiinput DC–DC converters in renewable energy applications – An overview’, Elsevier J. Renew. Sustain. Energy Rev., vol. 41, pp. 521–539, 2015.
[5] Ebrahim Babaei, Okhtay Abbasi, “Structure for multi-input multi-output dc–dc boost converter”, IET Power Electron., vol. 9, no. 1, pp. 9–19, 2016.
[6] Karteek Gummi and Mehdi Ferdowsi, “Derivation of new double-input DC-DC converters using the building block methodology” Masters Theses, Missouri University of Science and Technology, 2008.
[7] Ali Deihimi, Mir EsmaeelSeyedMahmoodieh, Reza Iravani, “A new multi-input step-up DC–DC converter for hybrid energy systems”, Electric Power Systems Research, vol. 149, pp. 111-124, 2017
[8] Kushal K., Madhuri C., “Experimental realization of a multi-input buckboost DC-DC converter,” Turkish Journal of Electrical Engineering & Computer Sciences, 2017
[9] Bryan G. Dobbs and Patrick L. Chapman, “A Multiple-Input DC-DC Converter Topology”, IEEE Power Electronics Letters, vol. 1, no. 1, pp. 6-9, Mar. 2003.
[10] A. Khaligh, J. Cao and Y.-J. Lee, "A Multiple-Input DC–DC Converter Topology," IEEE Trans. Power Electron., vol. 24, no. 3, pp. 862–868, Mar. 2009.
[11] SivaprasadAthikkal, Gangavarapu Guru Kumar, Kumaravel Sundaramoorthy, and Ashok Sankar, “Design, Fabrication and Performance Analysis of a Two Input—Single Output DC-DC converter,” energies journal, vol. 10, pp. 2-18, 2017.
[12] Kumar. L, Jain S., “A multiple source DC/DC converter topology”, J. of Electrical Power and Energy Syst., vol. 51, pp. 278-291, 2013.