IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 6, June 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 6, June 2021 ||

| DOI:10.15662/IJAREEIE.2021.1006014 |

Dual Output DC-DC Boost-Cuk Converter

Merin P Jose[1], Jeena Joy[2]

PG Student [PE], Dept. of EEE, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India[1]

Assistant professor, Dept. of EEE, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India[2]

ABSTRACT: Power converters play an important role in FuelCell applications of vehicles providing the required voltage gain. This paper deals with the new non-isolated DC-DC converters used for such applications. There has been increasing interest in various eco-friendly vehicles such as electric vehicles and plugin hybrid electric vehicles, which have a significant potential to reduce environmental pollution. The converter used combines the main characteristics of both quadratic Boost and Cuk converter having a single active power switch. The voltage stress across the switch is less when compared to other converters. Each Fuel Cell phase is based on the quadratic Boost and Cuk converters(HQBC). They have been designed to offer a very high voltage gain. The high step-up DC-DC converter for fuel cell vehicles based on merged quadratic boost-cuk converter is simulated in MATLAB/SIMULINK version 2017a. The efficiency of the converter is about 80% in the DC-DC boost-cuk converter. This converter give a high voltage gain with small voltage ripple when compared to quadratic DC-DC boost converter and can be used to get dual output which can be used for fuel cell applications.

KEYWORDS: Fuel cell electric vehicles, single switch, Boost and Cuk converter, Dual output.

I.INTRODUCTION

The transportation sector plays a vital role for modern society. Lot of modifed vehicles are emerging day by day with more efficiency and performance. Given its importance it is almost impossible to globally reduce the number of transportation vehicles on the roads, oceans and skies despite the environmental problems created by their massive use. To reduce critical levels of pollution, especially in big cities, many countries have adopted restricted policies to the use of internal combustion engines[1]. Electric vehicles (EVs) have emerged in the recent years as a feasible alternative to internal combustion engine (ICE) vehicles aiming to reduce the high petroleum dependency and to reduce pollution which is the major threat that we are facing today. Electric vehicle is more efficient, enviornment friendly, and cleaner than the vehicle that relies on fossile fuels, especially when smart grids have become omnipresent[2]. Electric vehicle research has been mainly focused on the design and optimization of energy storage devices(ESDs), power electronics for energy conversion on-board, design of powertrain component types and sizes[1], grid charging management[2], among other aspects.

A hybrid electric drive train utilizes two or more energy sources for propulsion. In a typical HEV drive train, the internal combustion engine and a secondary energy storage device or power source, such as battery, fuel cell, or ultracapacitors, provide traction power[4]. Power converters play an important role in Fuel-Cell applications. Conventional DC-DC Boost is unsuitable because it have some limitations such as low efficiency at high duty cycle ratio, high frequency looses, reverse recovery problems. To overcome these problems several DC-DC Boost topologies have been proposed to increase the voltage level of the FC[1].

DC-DC Boost converters may donot provide wide voltage gain, low voltage stress for power switches and reduced input current ripple at the same time. So to reduce input high step-up Boost converters with quadratic gain characteristics in combine with Cuk converter with dual output are proposed. They have been designed to oer a very high voltage gain and can used for the application of two different voltage levels at a time.

II.CIRCUIT CONFIGURATION

Quadratic Boost DC-DC converters have been used and studied due to their high voltage gain characteristics. This converter is characterized by a simple structure using a single active switch (Fig. 1). The voltage stress that the active switch must withstand is lower than that of the output voltages of the converter. The topology of the converter is obtained by merging a quadratic Boost with Cuk converter. The proposed quadratic DC-DC Boost cuk (HQBC)converter has dual output which can be used for fuel cell applications or for any other applications.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 6, June 2021 ||

| DOI:10.15662/IJAREEIE.2021.1006014 |

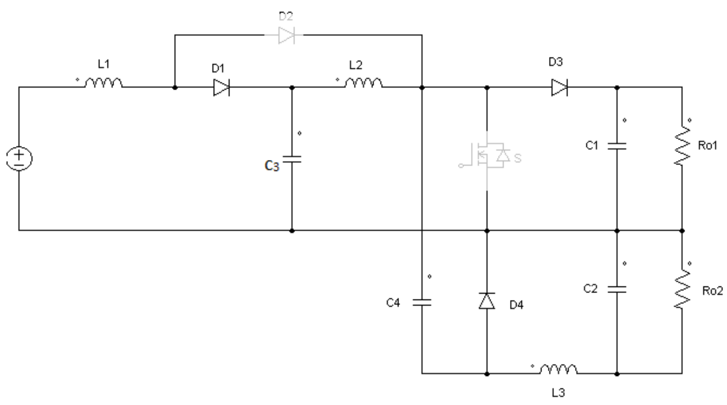


Fig. 1. Dual Output DC-DC Boost Cuk converter

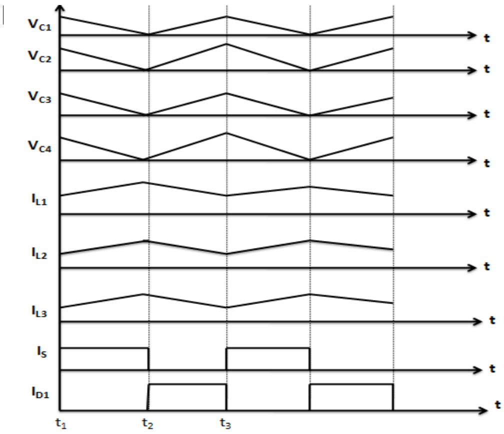


Fig. 2. Theoretical Waveform

III.PRINCIPLE OF OPERATION

The principle of operation of the converter is as shown in figure 2. The switching period of the dual output converter is divided into two time intervals and have two modes of operations.

1) Interval [t1 -t2] (corresponding to fig.3): In the instant t1 the switch S turns on starting the 1st stage and finishing the previous transient process. The energy from the DC source and capacitors C3, C2 and C1 starts to be transferred to inductors,L1, L2 and L3, increasing their respective currents. Diodes D1, D3 and D4 will be turned off and D2 is turned on.

2) Interval [t2 -t3] (corresponding to fig.4): This subinterval is associated to the 2nd stage and started with the turn-off of switch S. The energy stored in the inductors L1, L2 and L3 will be transferred to capacitors C3,C1 and C2, decreasing the inductor currents.

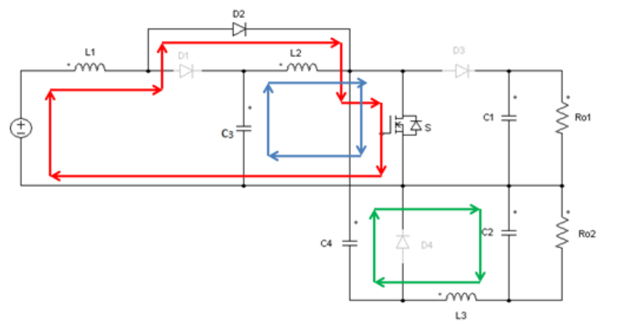


Fig. 3. Mode1 operation of dual output converter

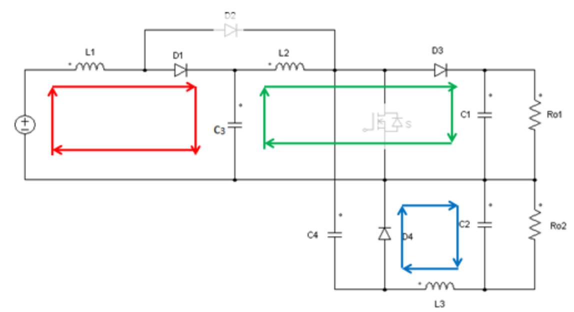


Fig. 4. Mode2 operation of dual output converter

IV. SIZING OF PASSIVE COMPONENTS

The passive elements (inductors and capacitors) are sized according to a given limit for their state variable ripple. For inductors the maximum current ripple (ΔI_L) will be taken as a percentage of the inductor average current and voltge ripple (ΔV_O) is taken as a percentage of the output voltage V_O.

$Vo/Vi=(1+D)/(1-D)^2$ ---------------------- (1)

D get its maximum value at 0.5. So $D_{boundary}=0.5$. ΔI_L is taken as 20 to 40% of I_O.

$L_1 = D_{boundary} *(V_O/(\Delta I_{L1} *f))$ ---------------------- (2)

The values for all the three inductors used in this dual output converter are same Taken ΔV_O as 1 to 5% of V_O and here ΔV_{C1} and ΔV_{C3} is taken as 4% of V_O, ΔV_{C4} is taken as 2% of V_O.

$C_1 = (D*I_O)/(\Delta V_{C1} *f)$ ------------------------(3)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 6, June 2021 ||

| DOI:10.15662/IJAREEIE.2021.1006014 |

Here the values of capacitors C_1 and C_2 are taken to be same.

$C_3 = (D*I_O)/((1-D)^2 *\Delta V_{C3}*f)$ ------------------------(4)

$C_4 =(D*I_O)/(\Delta V_{C4} *f)$ ------------------------(5)

V. SIMULATION RESULTS

The prototype of dual output quadratic DC-DC Boost Cuk converter have nominal power of 160W, 24V input voltage, inductors L1=10mH, L2=10mH and L3=10mH and Capacitors C1=C2=100µF, C3= 40µF and C4= 20µF. To avoid human audible noise we use a switching frequency of 20kHz. Power semiconductors selected were the UJC06505K for the MOSFETs, the SCS240AE2HR for the diodes D1 and D1 and the VS-60EPU04PbF for the diodes D1 and D1. The dual output for this converter is obtained with a duty cycle of 0.6 conforming the expected gain of this converter.

A. SIMULATION PARAMETERS

Parameters	Specification
Input voltage (V_{in})	24V
Switching frequency (f_s)	20KHz
Load resistance(R_{01}=R_{02})	160Ω
Capacitor (C_1= C_2, C_3, C_4)	100µF,40µF,20µF
Inductor(L_1 = L_2= L_3)	10mH

Simulation results are obtained by using MATLAB. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy way to use environment where problems and solutions are expressed in familiar mathematical notation. SIMULINK is a software package for modelling, simulating, and analysing dynamical systems.

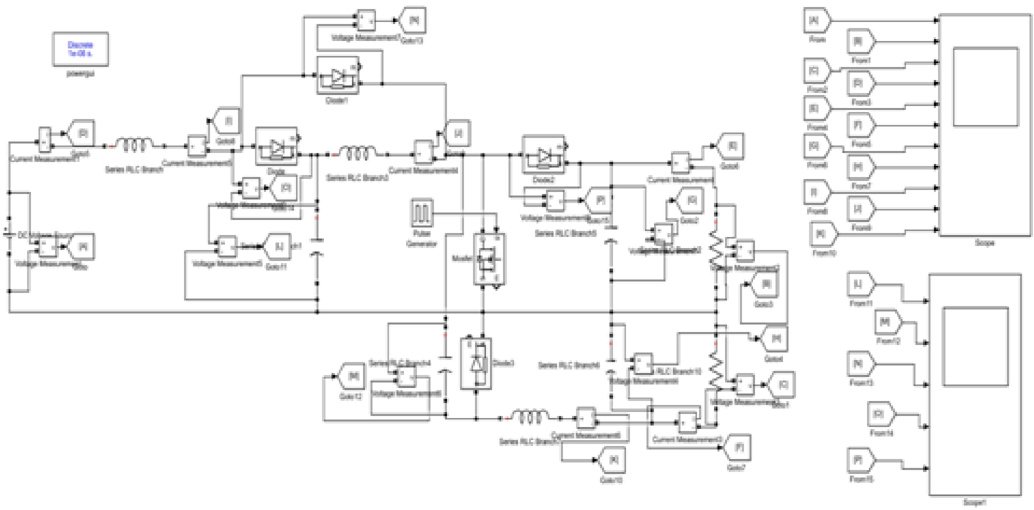


Fig.5. Simulink Model Of Dual Output DC-DC Boost-Cuk Converter

The dual output quadratic DC-DC Boost-Cuk converter is simulated in MATLAB/SIMULINK by choosing the parameters listed in the Table and the Simulink model is shown in figure 5.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 6, June 2021 ||

| DOI:10.15662/IJAREEIE.2021.1006014 |

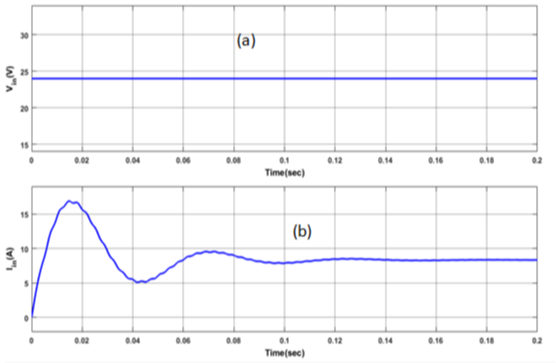


Fig. 6. (a) Input Voltage (V_{IN}) (b) Input current (I_{IN})

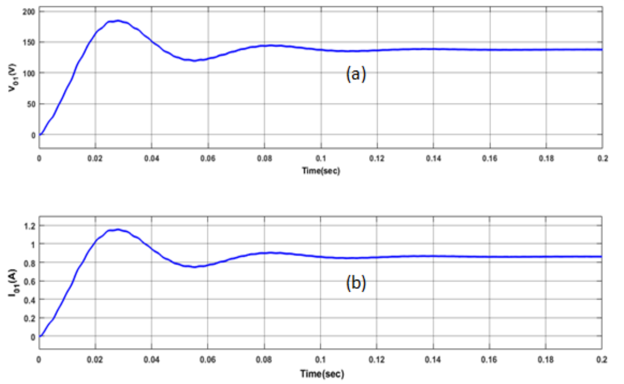


Fig. 7. (a) Output Voltage (V_{O1}) (b) Output current (I_{O1})

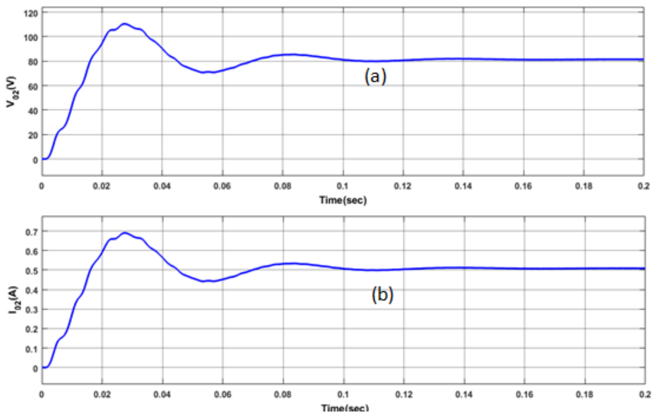


Fig. 8. (a) Output Voltage (V_{O2}) (b) Output current (I_{O2})

From the figure 6, it can be seen that the input voltage V_{IN} is 24 V and the switching frequency is chosen to be 20 kHz and the duty ratio of S to 0.6. The input current obtained have the value of 8.3A with a small current ripple of 0.06A. Figure 7 and 8 shows the dual ouput obtained. The first ouput voltage obtained is 137V with a voltage ripple of 0.3V and its corresponding output current is 0.86A with a ripple of 0.002A. The second ouput voltage obtained is 81.45V with a voltage ripple of 0.3V and its output current is 0.509A with a ripple of 0.001A.

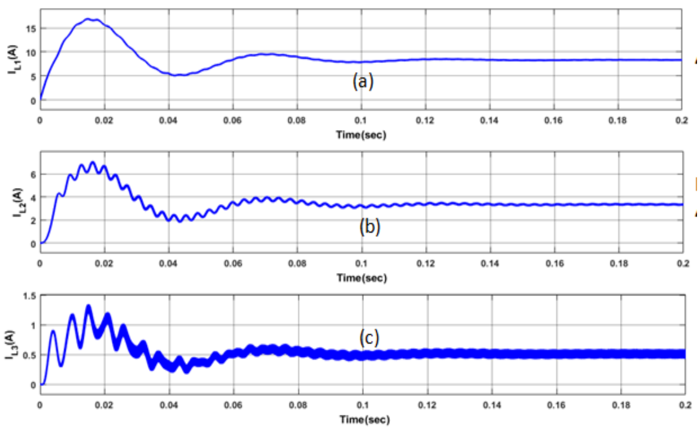


Fig. 9. Inductor Currents (a) L_1 (b) L_2 and (c) L_3

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 6, June 2021 ||

| DOI:10.15662/IJAREEIE.2021.1006014 |

From the Figure 9, the inductor current of L_1=8.3A with a ripple of 0.05A, L_2=3.3A with a ripple of 0.15A and L_3=0.5A with a ripple of 0.1A is shown respectively.

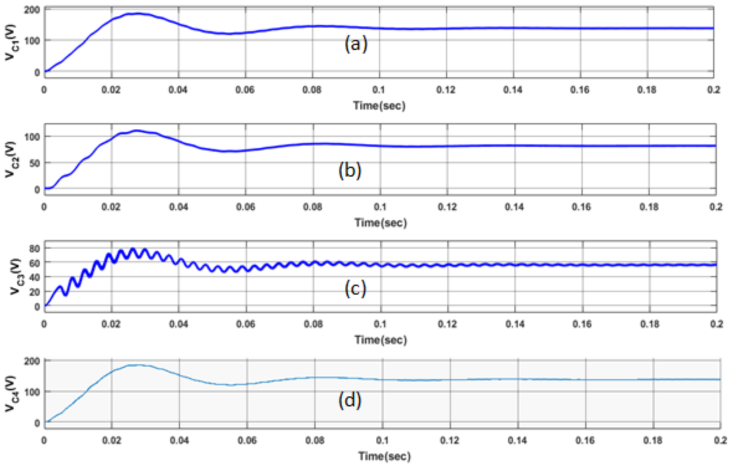


Fig. 10. Voltage across(a)V_{C1} (b) V_{C2} (c) V_{C3} and (d)V_{C4}

Voltage across the capacitors V_{C1} is 137V with a ripple of 0.3V , V_{C2} is 81.45V with a ripple of 0.03V, V_{C3} is 55V with a ripple of 2V and V_{C4} is 137V with a ripple of 0.02V.

VI. ANALYSIS

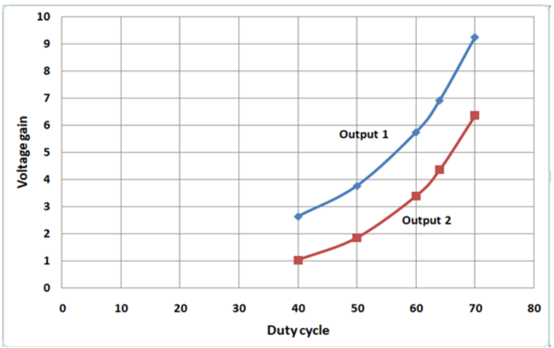


Fig. 12. Analysis of voltage gain Vs Duty cycle

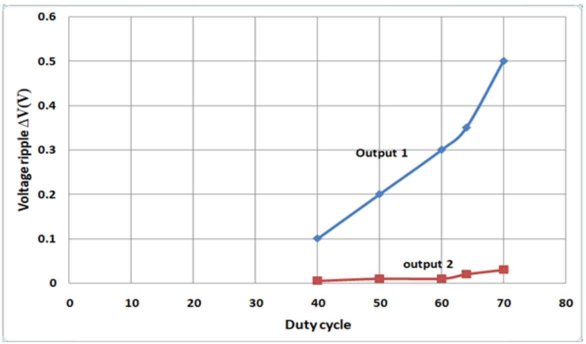


Fig. 13. Analysis of voltage ripple Vs Duty cycle

The above figure 12 showes the analysis of voltage gain with duty ratio of converter. From the figure it is seen that the voltage gain of output 1 is higher than that of output 2. The maximum voltage gain obtained is 9.2 for output 1 and 6.3 for output 2 of the dual converter. As the value of duty cycle increases the voltage ripple for corresponding converter increases and it can be seen from figure 13.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 6, June 2021 ||

| DOI:10.15662/IJAREEIE.2021.1006014 |

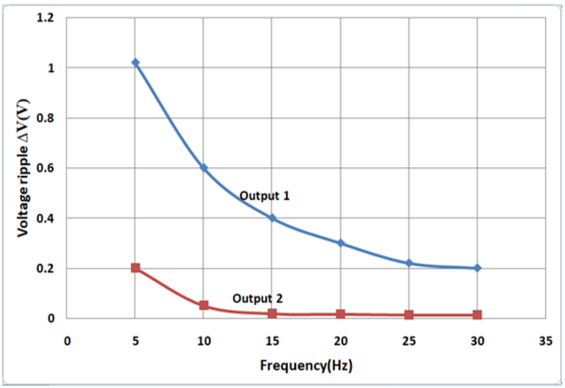


Fig. 14. Analysis of voltage ripple Vs Frequency

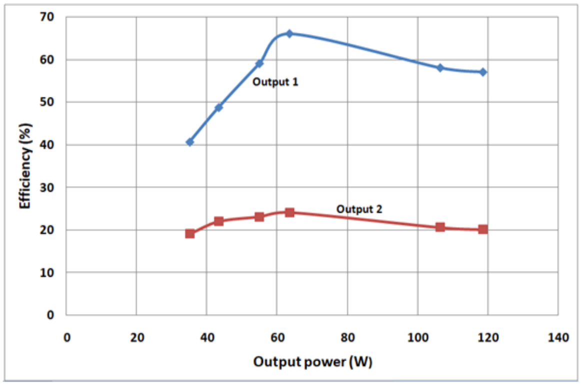


Fig. 15. Analysis of efficiency Vs output power

It is clear that the voltage ripple of dual converter decreases with increase in frequency. As frequency increases voltage ripple of the converters decreases from a high value as shown in figure 14. As in the above figure15, the efficiency increases with increase in output power and reaches its maximum value and then it starts decreasing for the dual outputs of the converter. These all are the output simulation results obtained from the dual output DC-DC Boost Cuk converter.

V. CONCLUSION

The Dual Output DC-DC Boost-Cuk converter were obtained by integrating both a quadratic Boost and a Cuk converter around a single active power switch. This converter can be used for dual purpose or applications of different voltage levels. The dual output DC-DC HQBC converters are characterized by increased voltage gains compared to the quadratic Boost converter. The maximum efficiency is 80% for an input voltage of 24V in this converter. This can be used for fuel cell applications and since it have dual ouput of different voltages. We can use it for two applications at a time.

REFERENCES

[1] Vitor Feranao Pires, Armando Cordeiro, Daniel Foito and Jose Fernando Silva,"High Step-Up DC-DC Converter for Fuel Cell Vehicles Based on Merged Quadratic Boost-CUK", IEEE Transactions on Vehicular Technology,vol. 68, no. 8,pp. 7521-7529, Aug. 2019.

[2] F. Zhang, X. Zhang, M. Zhang, and A. S. E. Edmonds, Literature review of electric vehicle technology and its applications, 5th IEEE International Conference on Computer Science and Network Technology, Changchun, China,pp. 1011, Dec. 2016.

[3] C. C. Chan, A. Bouscayrol, and K. Chen, Electric, hybrid, and fuel-cell vehicles: Architectures and modeling, IEEE Transactions on Vehicular Technology, vol. 59, no. 2, pp. 589-598, Feb. 2010.

[4] A. Emadi, K. Rajashekara, S. S. Williamson, and S. M. Lukic, Topological overview of hybrid electric and fuel cell vehicular power system architectures and configurations, IEEE Transactions on Vehicular Technology, vol. 54, no. 3, pp. 763-770, May 2005.

[5] A. Khaligh and Z. Li, Battery, ultracapacitor, fuel cell and hybrid energy storage systems for electric, hybrid electric, fuel cell, and plug-in hybrid electric vehicles: State-of-the-art, IEEE Transactions on Vehicular Technology., vol. 59, no. 6, pp. 2806-2814, 2010.

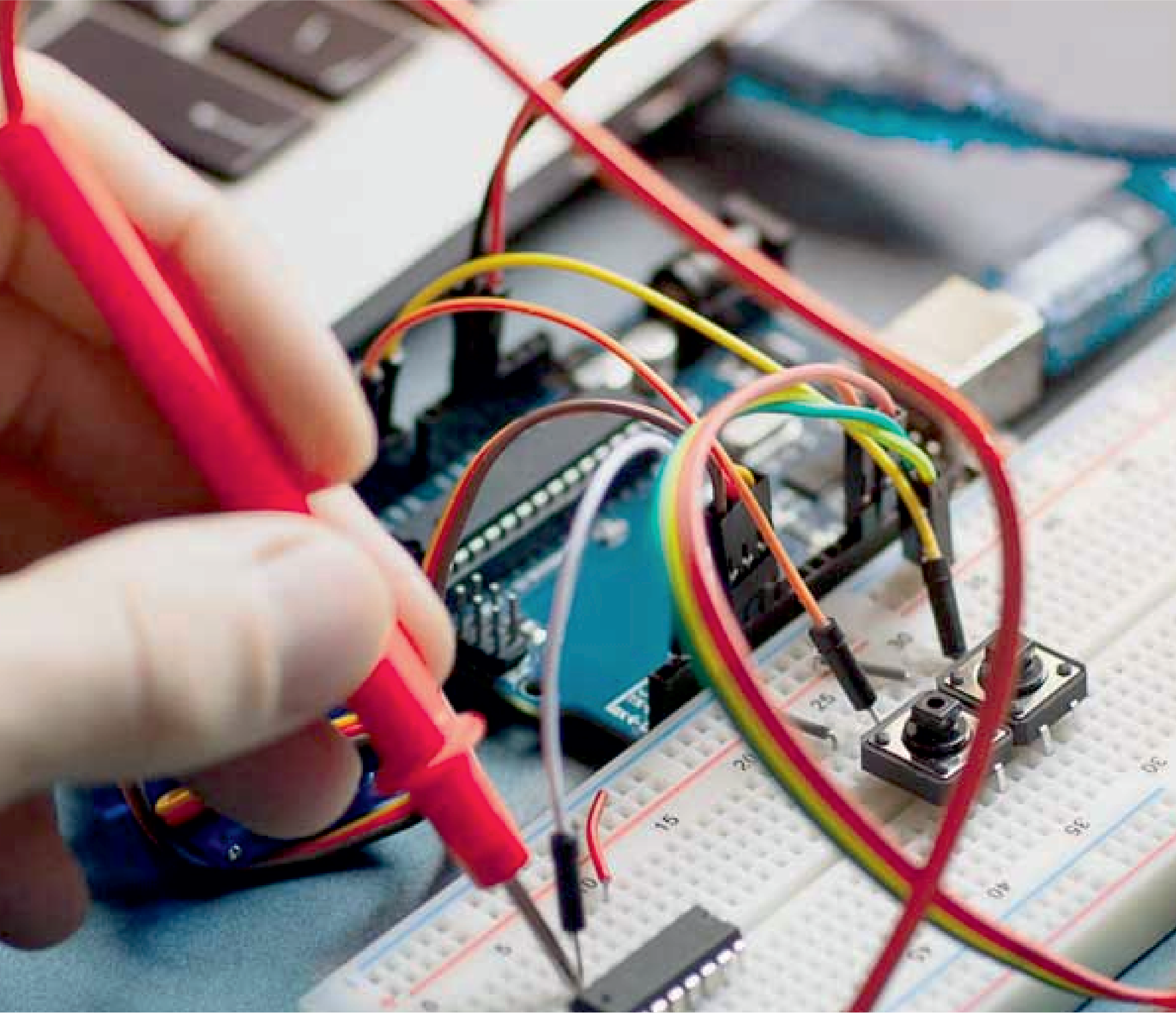
[6] C-M. Lai, Y-H Cheng, M-H. Hsieh, and Y-C. Lin, Development of a bidirectional DC/DC converter with dual-battery energy storage for hybrid electric vehicle system, IEEE Transactions on Vehicular Technology,vol. 67, no. 2,pp. 1036-1052, Feb. 2018.

[7] C. Liu and J. Lai, Low frequency current ripple reduction technique with active control in a fuel cell power system with inverter load, IEEE Transaction on Power Electronics., vol. 22, no. 4, pp. 1429-1436, 2007.

[8] Z. Geng, T. Hong, K. Qi, J. Ambrosio, and D. Gu, Modular regenerative emulation system for dc-dc converters in hybrid fuel cell vehicle applications, IEEE Transactions on Vehicular Technology , vol. 67, no. 10, pp. 9233-9240, 2018.

[9] P.Wang, L. Zhou, Y. Zhang, J. Li, and M. Sumner, Input-parallel outputseries DC-DC boost converter with a wide input voltage range, for fuel cell vehicle, IEEE Transactions on Vehicular Technology , vol. 66, no. 9, pp. 7771-7781, 2017.

[10] M.W. Beraki, J. P. F. Trovo, M.S. Perdigo, and M. R. Dubois, Variable inductor based bidirectional DCDC converter for electric vehicle, IEEE Transactions on Vehicular Technology, vol. 66, no. 10, pp. 8764-8772, 2017.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 7.282

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

www.ijareeie.com

Scan to save the contact details