2022 3rd International Conference for Emerging Technology (INCET)
Belgaum, India. May 27-29, 2022

Design and Implementation of Double Frequency Boost Converter

M.Nethra
PG Scholar/Power Electronics & Drives
Saranathan College of Engineering
Trichy, Tamilnadu, India – 620012
jaya98nethra@gmail.com

M.Marimuthu
Assistant Professor/EEE
Saranathan College of Engineering
Trichy, Tamilnadu, India – 620012
marimuthueeephd@gmail.com

S.Vijayalakshmi
Associate Professor/EEE
Saranathan College of Engineering
Trichy, Tamilnadu, India – 620012
bksviji@gmail.com

Abstract -- **A double frequency boost converter is employed in place of a traditional step up converter in this article. Due to high voltage stress, a regular step-up converter cannot maintain high gain, a high-frequency converter has poor performance, and a low-frequency converter has low efficiency. As a result of the dual frequency converter, performance, efficiency, and gain have all improved. The step up converter in this system can be powered by solar energy or wind energy. The proposed converter is simulated using MATLAB/Simulink and its performance compared against the other frequency converter.**

Keywords - Double Frequency Boost, Efficiency, Performance

I. INTRODUCTION

Power conversion control strategies to convert energy from one source to another source is a required key element in this era of power electronics controlled technologies. Due to high demand of energy consumption and fast diminishing of fossil fuels, most researchers are focusing on renewable energies. As these sources generate variably low voltages, a stabilized DC-DC converter is required to produce a stable output [1-6].

A boost converter (also known as a step-up converter) is a DC-to-DC power converter that increases voltage while decreasing current from the supply to the load.

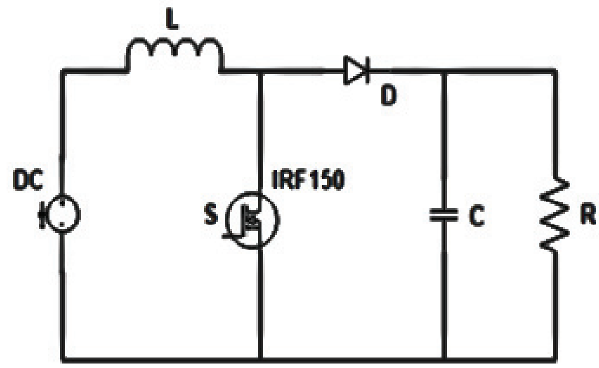

Fig. 1. Schematic diagram of boost converter

Switching losses are higher in DC-DC converters, hence switching strategies are utilised to mitigate them. Switching approaches have a key disadvantage in that they require variable-frequency control to regulate the output and generate undesired EMI harmonics, especially when the load varies greatly. Using interleaved converter is the only option to reduce the harmonics and to achieve higher efficiency but the major disadvantage of this technique is circulating current problem. To overcome this problem double frequency boost converter can be introduced.

II. DOUBLE FREQUENCY BOOST CONVERTER

This research presents a unique converter topology for high dynamic response and increase converter efficiency. This topology is made up of two boost cells, one of which functions at high frequency and the other at low frequency. When operated at high frequency, converter performance can be improved and at low frequency efficiency can be improved [7-11]. A double frequency boost converter can improve both efficiency and performance. The high-frequency switch is routed through the low-frequency switch in this converter's operation; on the other hand, using a high-frequency switching converter in tandem with a low-frequency converter improves the output voltage response. The power rating and power processing capability are both improved by using the converter paralleling method.

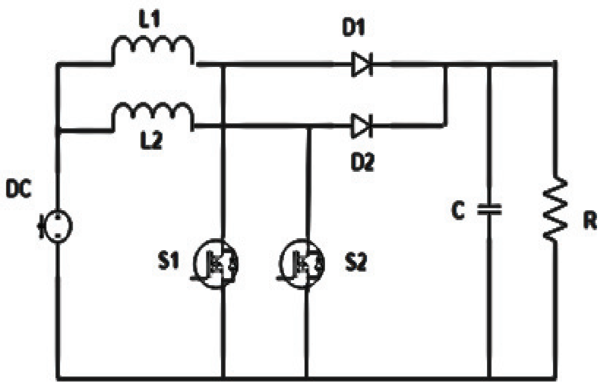

Fig. 2. Schematic diagram of double frequency boost converter

Figure 2 is a schematic diagram of a double frequency boost converter. The high-frequency boost cell, which contains L1, S1, and D1, operates at a higher frequency, whereas the low-frequency boost cell, which contains L2, S2, and D2, operates at a lower frequency. The high frequency boost cell improves output performance, while the low frequency boost cell improves converter efficiency. During the transient stage of load step down, an active switch is employed in this circuit to transmit energy stored in a low-frequency cell to the source.

It increases the transient responsiveness by working in conjunction with high-frequency cell switch S1. At a switching period of Tsh, the switch S1 works at a high frequency fh. The switch S2 operates at a low frequency of fl and a switching period of Tsl, on the other hand. The

2022 3rd International Conference for Emerging Technology (INCET) | 978-1-6654-9499-1/22/$31.00 ©2022 IEEE | DOI: 10.1109/INCET54531.2022.9825420

component values of the Double frequency boost converter are represented in Table I.

The circuit operation of double frequency boost converter is split up into four modes of operation. The switching states according to the status of switches S1 and S2 is listed in Table II.

TABLE I. DESIGN PARAMETER

Parameter	Values
Input voltage(Vs)	8V
Output voltage(Vo)	16V
Output power(Po)	10W
Ripple voltage (ΔVc)	0.070
Ripple current(ΔIl)	0.95
High frequency inductor (L1) for F_h=100KHZ	42.10µH
Low frequency inductor (L2) for F_l=10KHZ	421µH
Output capacitance	44µF
Resistance (Ro)	26Ω

TABLE II. SWITCHING MODES

Mode	S1	S2	D1	D2
1	ON	ON	OFF	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	ON	OFF
4	OFF	OFF	ON	ON

The modes of operations are explained below:

Mode 1:

In mode 1 of circuit operation, both switches S1 and S2 are ON and diodes D1 and D2 are OFF. Fig. 3a depicts mode 1 circuit.

$$V\text{dc} = VL1 \tag{1}$$

$$V\text{dc} = VL2 \tag{2}$$

$$-\, ic = io \tag{3}$$

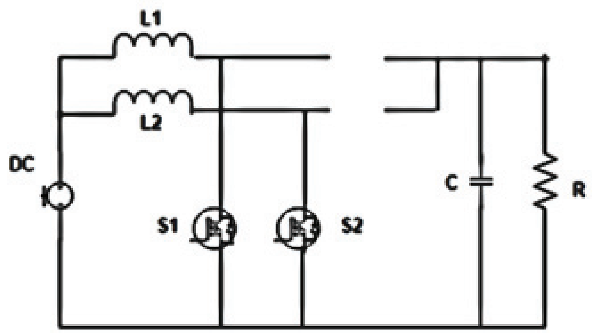

Fig. 3 (a) Mode 1 circuit of DF boost

Mode 2:

In the mode 2 operation, the switch $S1$ ON and $S2$ OFF and diode $D1$ OFF and $D2$ ON. The supply voltage is equal to the voltage across inductor L1. The supply voltage minus the load voltage equals the voltage across inductor L2. The current IL1 rises as the voltage VL1 across L1 becomes positive. The current IL2 through L2 reduces due to the negative voltage VL2 across L2. The load current is equal to the current through the inductor L2 minus the current through the capacitor. Fig. 3b shows a mode 2 circuit.

$$V\text{dc}=VL1 \tag{4}$$

$$VL2=VS-V0 \tag{5}$$

$$ic = iL2 - \text{io} \tag{6}$$

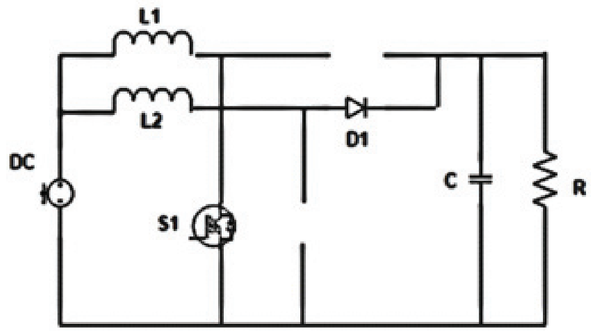

Fig. 3. (b) Mode 2 circuit of DF Boost

Mode 3:

In mode 3 operation, switches S1-OFF and S2-ON and diodes D1 is ON and D2 is OFF. The voltage VL1 across the inductor L1 is positive in this state, hence the current IL1 running through L1 rises while the current IL2 flowing through L2 remains unchanged. The operation of the Mode 3 circuit is shown in Fig. 3c.

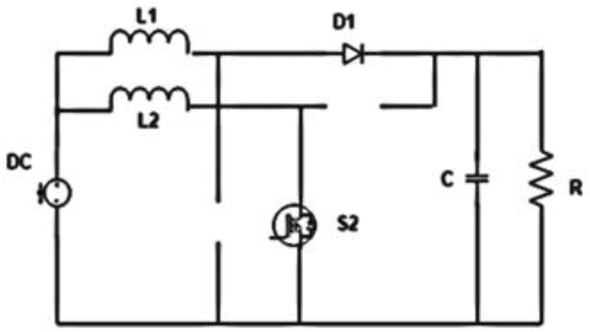

Fig. 3. (c) Mode 3 circuit of DF Boost

From Fig. 3c,

$$V\text{dc} = VL1 \tag{7}$$

$$V\text{dc}=VL2 \tag{8}$$

$$-ic = i\text{o} \tag{9}$$

Mode 4:

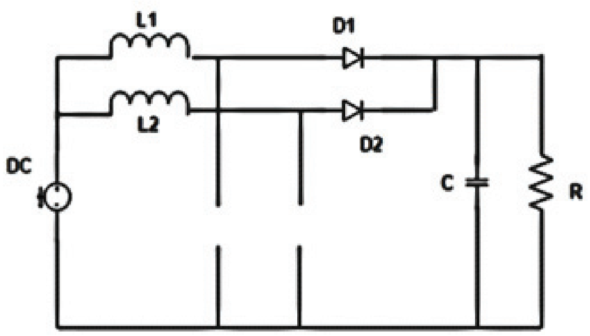

Fig. 3d Mode 4 circuit of DF Boost

The mode 4 circuit of double frequency boost converter is shown in Fig. 3d. Finally, in the mode 4 operation, the both switches $S1$ and S2 are OFF and both diodes $D1$ and $D2$

are ON. The supply voltage minus the load voltage equals the voltage across inductor L1. The supply voltage is equal to the voltage across inductor L2. The load current is equal to the current through the inductor L1 minus the current through the capacitor.

$$VS=VL2 \tag{10}$$

$$VL1=VS-V0 \tag{11}$$

$$ic = iL1 - i0 \tag{12}$$

The proposed double frequency boost converter is designed using the following values depicted in Table II. Boost converter is designed using the fundamental equations of boost converter. Using the design parameters from Table II, simulation is performed. Simulink diagram of double frequency boost converter using MATlab is depicted as shown in Fig.4. In Fig. 4 input source as a PV panel whose input voltage is 8V.

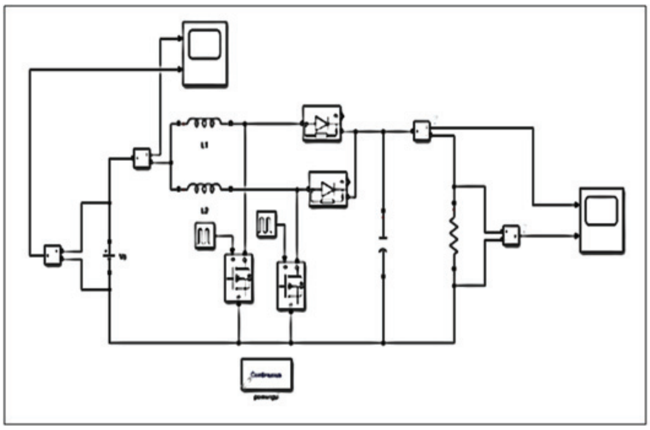

Fig. 4 Simulation circuit of DF boost converter

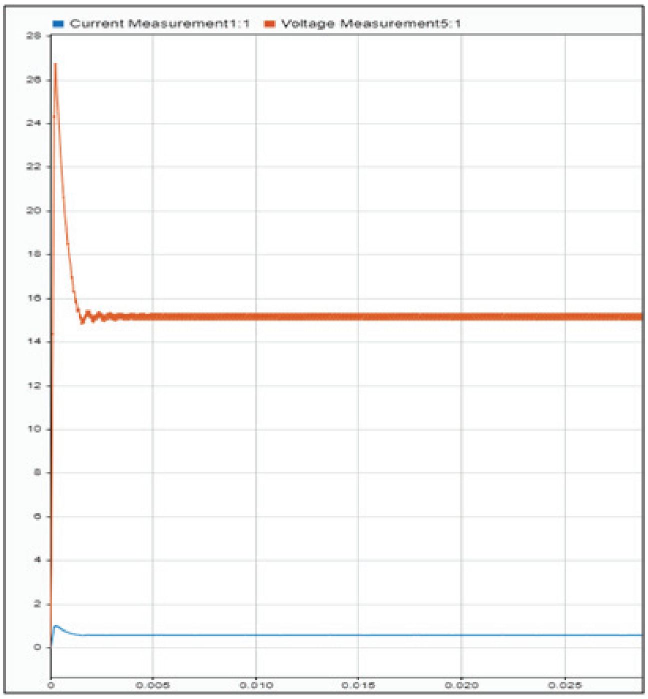

Fig. 5 Output voltage and output current of DF boost converter

It can be inferred that the switching frequency of high-frequency boost converter is same as that of higher frequency of double frequency boost, and the switching frequency of low-frequency boost converter is equal to the lower frequency of double frequency boost.

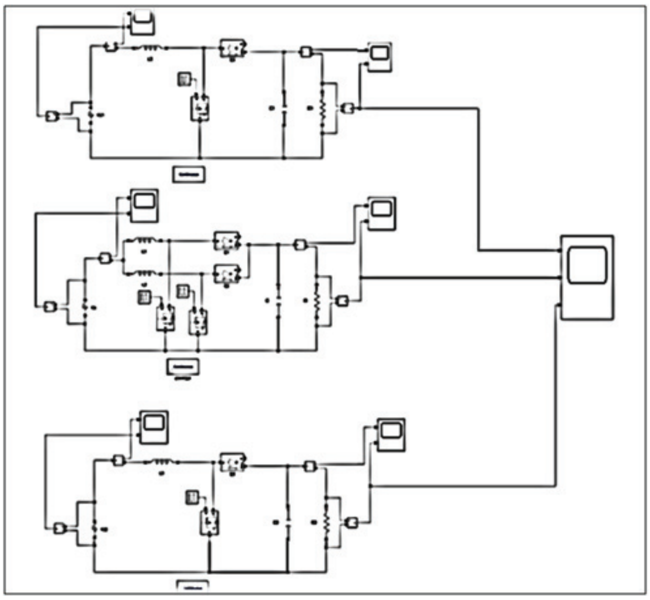

Fig. 6 Simulation circuit for Low Frequency Boost, High frequency Boost, and Double Frequency Boost converters.

The performance of double frequency boost, high frequency boost and low frequency boost is compared using the Fig. 6. Fig. 6 illustrates shows the Simulink diagram of all the three converters.

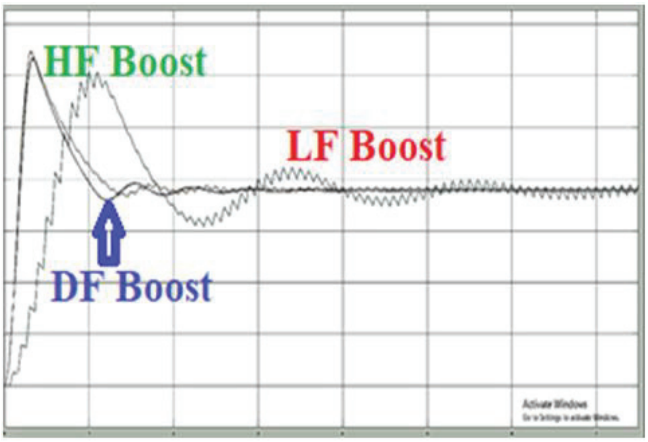

Fig. 7 Output voltage waveform for LF boost, HF boost and DF boost converter

Fig. 7 shows the comparison of output voltage for DF boost, HF boost, and LF boost converter. In high frequency boost converter, a peak overshoot is about 80% and its settling time is about 5ms. In low frequency boost converter, a peak overshoot is about 79% and its settling time is about 24ms. In double frequency boost converter, a peak overshoot is about 60% and its settling time is about 12ms.

TABLE III. ASSESSMENT OF PERFORMANCE FACTORS OF ALL STEP-UP CONVERTERS

Step-up converter	**Ts (ms)**	**Mp (%)**	**Tr (ms)**	**SSE (V)**	**Vro (V)**
Double frequency	12	60	1	0.02	0
High Frequency	5	80	0.05	0.05	Less
Low frequency	24	79	3	0.04	more

Table III shows the performance parameters of the double frequency boost, high frequency boost, and low frequency boost. From Table III Settling time (Ts) of DF boost is less than HF boost converter greater than LF boost converter. Peak over shoot voltage (Mp), Steady State Error (SSE), and rise time (Tr) is less than all other converters. This kind of converter does not have ripple voltage also [12-17]. Table III evidences that the DF boost converter performance is better than all additional boost converters.

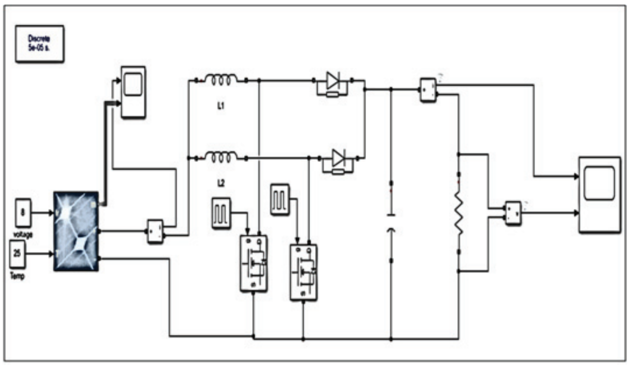

Fig. 3. Simulation circuit for PV fed DF Boost converter

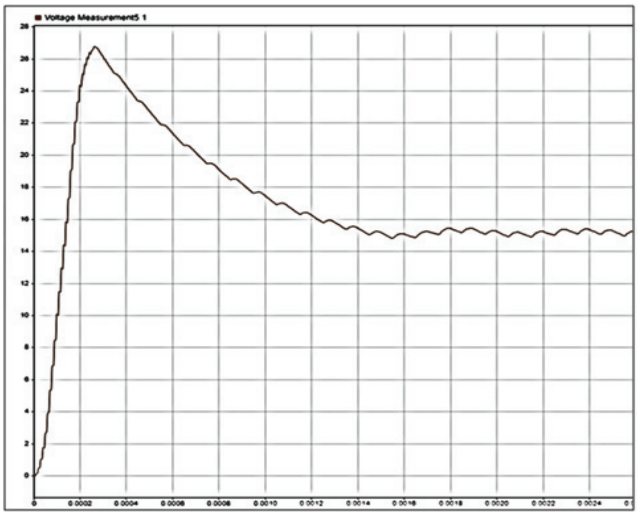

Fig. 4. Output voltage waveform of PV fed DF boost converter

In addition to it, in Fig. 8 PV is implemented as source to the double frequency boost converter and the result in shown in Fig. 9. The PV panel input voltage is 8V. The output voltage obtained from the PV fed double frequency boost converter (16V) is depicted in Fig. 9.

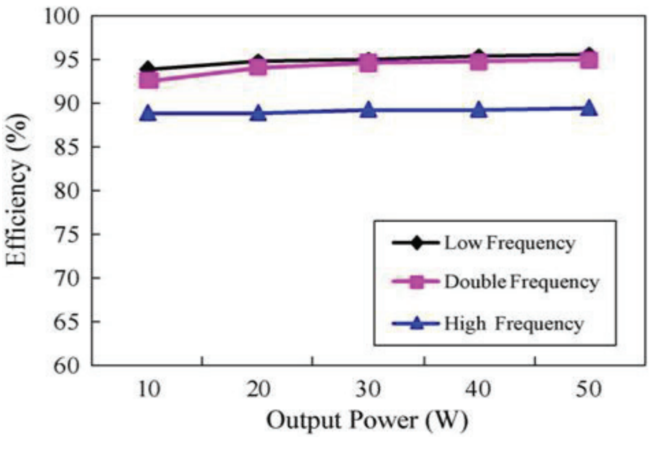

Fig. 5. Efficiency comparison of LF, HF and DF boost converters

The efficiency of the Double Frequency Boost, low frequency Boost and high frequency Boost are illustrated in Fig. 10. From the graph one can understand that the high frequency Boost converter has less efficiency than the other two Boost converters. The efficiency of the low frequency Boost and double frequency Boost are almost same.

III. CONCLUSION:

A unique topology for a double frequency boost converter was given in this research. Analytical results show that the double frequency boost converter not only has the same steady-state and transient performance as traditional boost converters, but also outperforms them in terms of efficiency. The suggested converter does not require load transient change information for accurate current control and does not suffer from current circulation, making it suitable for high-power applications.

Future research will look at whether the suggested Boost converter is suitable for EV and PV cell applications, as well as the implementation of a multilevel double frequency boost converter.

REFERENCES

[1] S. Vijayalakshmi, T. Sree Renga Raja, "Robust Discrete controller for double frequency buck converter, Automatika, DOI. 10.7305/automatika.2015.12.647, UDK. 621.314.1.049.76.076.1-55, ISSN 1848-3380. Vol. 56, No. 3, 2015, pp. 303-317.

[2] S. Vijayaakshmi, T. Sree Renga Raja, "Time domain based digital PWM controller for DC-DC converter, Automatika, DOI. UDK. IFAC.10.7305/Automatika. Vol. 55, No. 4, 2014, pp. 434-445.

[3] S. Vijayalakshmi, T. Sree Renga Raja, "Time domain based digital controller for buck-boost converter", Journal of Electrical Engineering Technology, http://dx.doi.org/10.5370/JEET.2014.9.5.1551,Vol. 9, No. 5: 1551-1561, 2014.

[4] S. Vijayalakshmi, Dr.T. Sree Renga Raja, "Design and Implementation of a Discrete Controller for Soft Switching DC - DC Converter", Journal of Electrical Engineering, vol.12, Edition .3, No. 25, 2012, ISSN: 1582-4594.

[5] M. Veerachary, "Analysis of fourth-order dc–dc converters: A flow graph approach", IEEE Trans. Ind. Electron., vol. 55, no. 1, pp. 133-141, Jan. 2008.

[6] M.Marimuthu, S.Vijayalakshmi (2020): "Symmetric Multi-Level boost inverter with single dc source using reduced number of switches" Technical Gazette 27, 5(2020),1585-1591.

[7] M.Marimuthu, S.Vijayalakshmi, R. Shenbagalakshmi "A Novel Non-isolated Single Switch Multilevel Cascaded DC–DC Boost Converter for Multilevel Inverter Application" Journal of Electrical Engineering & Technology volume 15, pages2157–2166 (2020).

[8] S.Vijayalakshmi, M.Marimuthu,"Implementation Of P & O Algorithm For Multi-Level Cascaded-Boost Converter", Solid State Technology, pp. 772-783, Vol. 64, Issue. 1, Jan 2021.

[9] Ravindran, V., Ponraj, R., PRAVEEN, R., Praveenkumar, K., Ravichandran, P. and Sivaramakrishnan, T., 2021, May. Simulated Design and Implementation of Solar based Water Pumping System. In 2021 2nd International Conference for Emerging Technology (INCET) (pp. 1-5). IEEE.

[10] Ravindran, V., Ponraj, R., Zameerbasha, S.S., Kanna, N.S., SamuelRaj, S. and Sabarish, B., 2021, May. Dynamic Performance Enhancement of Modified Sepic Converter. In *2021 2nd International Conference for Emerging Technology (INCET)* (pp. 1-5). IEEE.

[11] P. B, V. Ravindran, M. Marimuthu, S. Ragunathan, S. K and R. V, "Design and Implementation of PV Powered Air Cooler System Using Thermoelectric Cooler," 2021 Innovations in Power and Advanced Computing Technologies (i-PACT), 2021, pp. 1-6, doi: 10.1109/i-PACT52855.2021.9697007.IEEE.

[12] Ponraj, R.P., Sigamani, T. A novel design and performance improvement of symmetric multilevel inverter with reduced switches using genetic algorithm. *Soft Comput* **25,** 4597–4607 (2021).

[13] Ponraj, R.P., Sigamani, T. & Subramanian, V. A Developed H-Bridge Cascaded Multilevel Inverter with Reduced Switch Count. *J. Electr. Eng. Technol.* **16,** 1445–1455 (2021).

[14] T. Sigamani, R. P. Ponraj, and V. Ravindran, "Modified Single-Phase Matrix Converter with Z-source for Renewable Energy Systems," Third International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India,pp. 601-607.

[15] Marimuthu, M., Vijayalakshmi, S., Paranthagan, B., Venugopal, R., Srinithi, S., Yuvaraj, B., Soundarajan, R. and Vasantha Kumar, S.K., 2022. Non-isolated Multilevel Zeta Converter for MLI Application. In *Proceedings of International Conference on Power Electronics and Renewable Energy Systems* (pp. 21-30). Springer, Singapore.

[16] Paranthagan, B., Marimuthu, M. and Karthiga, M., 2015. Global maximum power point tracking under partial shading condition using SEPIC converter. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, *4*(2), pp.718-726.

[17] Kalavathy, G., Paranthagan, B. and Marimuthu, M., 2016. Global Maximum Power Point Tracking Under Partial Shading Condition Using Modified Sepic Converter. *Pakistan Journal of Biotechnology*, *13*(special issue 1), pp.88-92.