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SEPIC CONVERTER BASED SMART GRID SYSTEM

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ABSTRACT
In this paper, comparison of a buck boost converter, Quadratic boost converter and SEPIC converter with smart grid is done using Mat lab Simulink. The outcomes are evaluated in terms of output voltage, output power& output voltage ripple. The mat lab outcome attained illustrates a developed dynamic-performance by utilizing SEPIC converter with smart grid.

Keywords: Hybrid system, wind energy, transformer coupled boost dual-half-bridge bidirectional converter, bidirectional buck-boost converter, maximum power point tracking, full bridge bidirectional converter, battery charge control.

1. INTRODUCTION

An electric power industry is in the mid of a critical period in its evolution. Large scale changes in both transmission and distribution levels are expected to occur in the near future. Power generation is the key factor to determine the economic growth and industrial development of any country. Indian power sector is facing number of challenges and despite significant growth in generation over the years, it has been suffering from shortages and supply constraints. To meet the energy challenge and create a 21st century energy economy, we need a 21st century electric grid. In distribution levels, many smaller renewable generators are connected to the network.

Fossil fuels are non-renewable, they draw on finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve. This forces the use of many types of renewable energy resources – such as wind and solar energy. Renewable energy sources are used so as to reduce the pressure on the current sources of energy. At the moment, the use of renewable sources will prevent destruction of the environment.

Application of individual distributed generators can cause as many problems as it may solve. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a ―micro grid‖. Microgrids use various distributed generation technologies such as micro turbine, fuel cell, and photovoltaic system, wind turbine together with energy storage device like battery, condenser and flywheel. There are several reasons why micrograds are so interesting. First, because they involve alternative energy sources, and the most alternative sources offer far higher efficiency and less environmental issues than standard

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power generation. Secondly, as they are to be on the site which they are to supply, losses due to transmitting electricity is proportionally eliminated.

Bidirectional Power Flow Control in a DC Micro grid through a Switched-Capacitor Cell Hybrid DC–DC Converter is presented by Cornea. This paper focuses on a bidirectional hybrid dc-dc converter suitable as an interface between two dc voltage buses in various applications including microgrids. The switched-capacitor cell, incorporated in the converter topology, gives the advantage of high voltage conversion ratio without using a transformer.

Author introduced by Analysis and implementation of a non-isolated bidirectional DC-DC converter with high voltage gain.

Non-isolated High Gain DC–DC Converter for DC Microgrids is given by Lakshmi. In this paper, a non-isolated high gain dc-dc converter is proposed without using the voltage multiplier cell and/or hybrid switched-capacitor technique. The proposed topology utilizes two nonisolated inductors that are connected in series/parallel during discharging/charging mode. The operation of switches with two different duty ratios is the main advantage of the converter to achieve high voltage gain without using extreme duty ratio.

Author presented by single-switch high step-up converter based on coupled inductor and switched capacitor techniques with quasi-resonant operation. This study presents a novel single-switch high step-up dc-dc converter employing a quasi-resonant operation with high efficiency and low ripple continuous input current characteristics. Active Power Flow Control between DC Micro grid is presented by Maiti. Next author introduced by optimal interconnection planning of community microgrids with renewable energy sources. A distributed cooperative control framework for synchronized reconnection of a multi-bus micro grid, the topology of the communication network can be flexible which supports the plug-and-play feature of microgrids. Fast and deterministic synchronization can be achieved with tolerance to communication latency.

Implementation of Bidirectional Resonant DC Transformer in Hybrid AC/DC Micro-Grid is suggested by Huang. Finally Fractional Order PID Control for Solar PV and Battery Storage Systems Using Three -Level NPC Inverter is introduced by Azam.

Author presented by Fractional-order PID controller design of frequency deviation in a hybrid renewable energy generation and storage system. Here, a fractional-order proportional–integral–derivative (FOPID) controller is implemented for frequency deviation control of a proposed hybrid fractional-order power generation and energy storage system.

Application of fractional-order voltage controller in building-integrated photovoltaic and wind turbine system, this work presents a voltage control system using fractional-order operators in the smart residential building-integrated hybrid renewable power plant (solar + wind). In this research article, fractional-order proportional–integral/proportional–integral–derivative controllers are proposed on a synchronous frame for a pulse-width modulation based three-phase voltage source inverter in residential building-integrated

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solar panel and wind turbines system (building-integrated photovoltaic/wind turbine system) in order to improve the quality of injected voltage to building.

2. QUADRATIC-BOOST-CONVERTER

a).Circuit-Description

Single-switch-elevated-voltage-gain-quadratic-boost-converter contain triple-diode, couple of inductor &couple of capacitor D1, D2, L1, L2, C1, C2 respectively. Duty-cycle (D) controlled in pulse-generator for power-MOSFET (S) where 'D' is approximately chosen as 0.5 &load-resistor as 'R'. By assumption 'QBC' operated in continuous-conduction-mode. 'The circuit-diagram of QBC' is delineated in Fig-1.

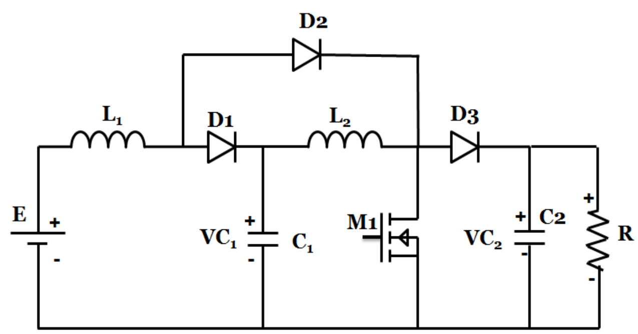

Fig-1. 'The circuit-diagram of QBC'

'When-Switch is in-ON', then 'D2' conduct at the time 'D1& D3' misconduct-following to that inductor 'L1 &L2' current-driven by input-voltage& 'voltage in capacitorC1'. The load-current-flows by the 'discharging-of Capacitor-C2' [6].

The 'voltage-gain &input-inductor-current' is given in equation-(1) & (3).

$$\frac{V_0}{V_{in}} = \frac{V_a}{V_{in}} = \frac{1}{(1-D)^2} \ldots\ldots\ldots \ (1)$$

$$V_{in} I_M = V_0 I_N \ldots\ldots\ldots\ (2)$$

$$I_M = \frac{V_{in}}{(1-D)^2 * S} \ldots\ldots\ldots\ldots\ (3)$$

b).Analysis-Formula

'The-components present in the quadratic-boost-converter' can be-designed from the following-formula.

$$L_a = \frac{ED(1-D)^2}{2I_0 \int s} \ldots\ldots\ldots\ (4)$$

$$L_b = \frac{ED}{2I_0 \int s} \ldots\ldots\ldots\ldots\ (5)$$

$$C_a = \frac{I_0 D}{(1-D)\Delta V C_a \int s} \ldots\ldots\ (6)$$

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$$C_b = \frac{I_0 D}{\Delta V C_b \int s} \ldots\ldots\ldots\ldots\ (7)$$

PV-panel-voltage is fed to the quadratic-boost-converter instead of DC-voltage- source & the-performance is-analyzed.

3. RESEARCH GAP

The exceeding literature does not deal comparison of a buck boost converter, Quadratic boost converter and SEPIC converter with smart grid. Hence, this work deals with comparison of a buck boost converter, Quadratic boost converter and SEPIC converter with smart grid.

4. SYSTEM DESCRIPTION

In this paper, a non-isolated bidirectional dc-dc converter is presented. The proposed converter consists of two boost converters to enhance the voltage gain. Four power switches with their body diodes are employed in the proposed converter. Also, two inductors and a capacitor are used as passive components. Hybrid Battery-Photovoltaic DC bus system is appeared in Fig 2.

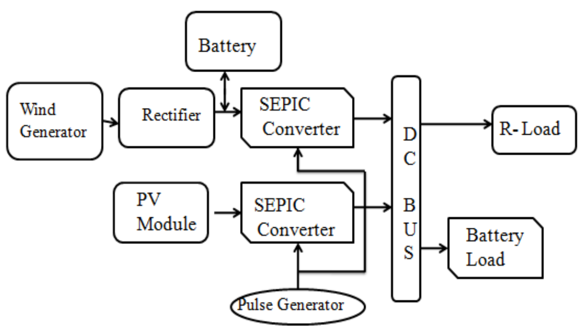

Fig 2. Proposed block diagram of Hybrid Battery-Photovoltaic DC bus system

5. RESULTS AND DISCUSSION

Detailed simulation studies are carried out on MATLAB/ Simulink platform and the results obtained for various operating conditions are presented in this section. Circuit diagram of buck boost converter with smart grid is shown in Fig 3.

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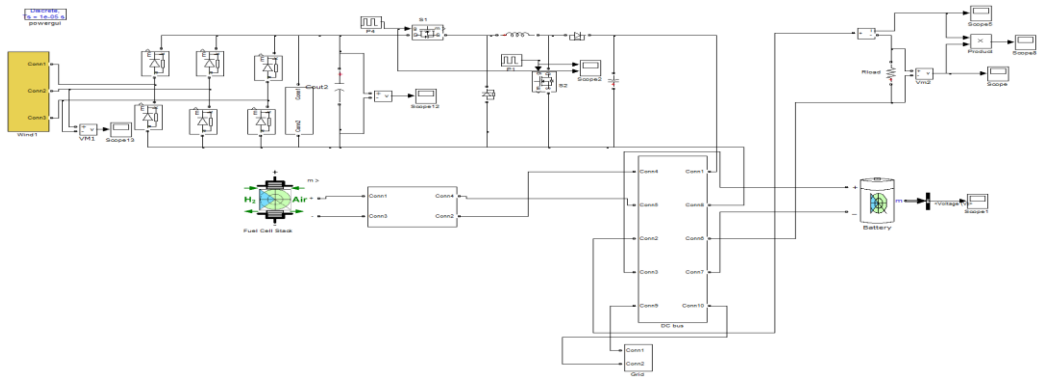

Figure 3 Circuit diagram of buck boost converter with smart grid

Input voltage of BBC with SG system is shown in Fig 4 and its peak value is 15 V.

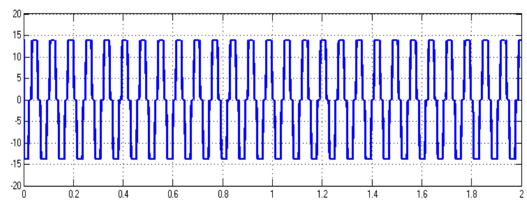

Figure 4 Input voltage of BBC with SG system

Voltage across Rectifier of BBC with SG system is shown in Fig 5 and its value is 12.5 Volts.

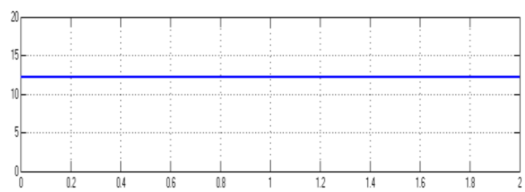

Figure 5 Voltage across Rectifier of BBC with SG system

Switching pulse of buck boost converter S1, S2 are shown in Fig 6 and its peak to peak value is 1 Volts.

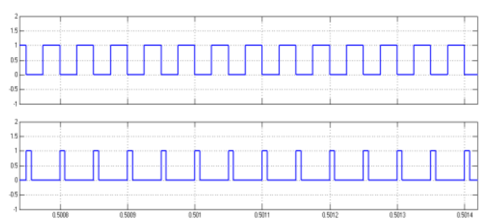

Figure 6 Switching pulse of buck boost converter S1, S2

Voltage across R-load of BBC with SG system is shown in Fig 7 and its value is 71 Volts.

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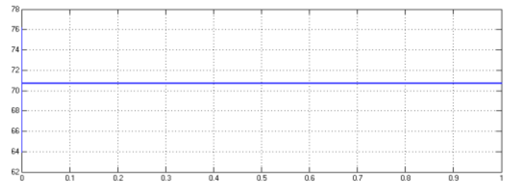

Figure 7 Voltage across R-load of BBC with SG system

Ripple voltages across R-load of BBC with SG system is shown in Fig 8 and its value is 70.729 Volts.

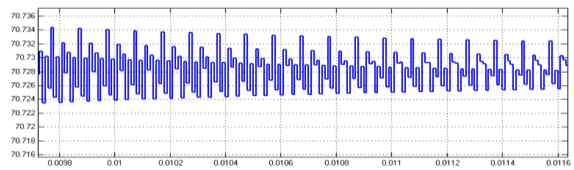

Figure 8 Ripple voltages across R-load of BBC with SG system

Current through R-load of BBC with SG system is shown in Fig 9 and its value is 0.445 A.

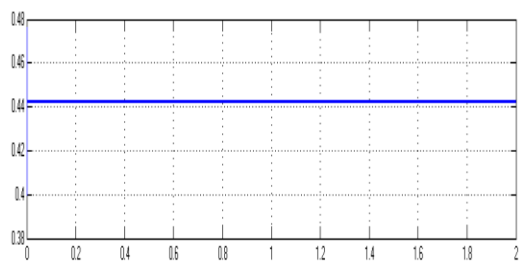

Figure 9 Current through R-load of BBC with SG system

Output power of BBC with SG system is shown in Fig 10 and its value is 32 watts.

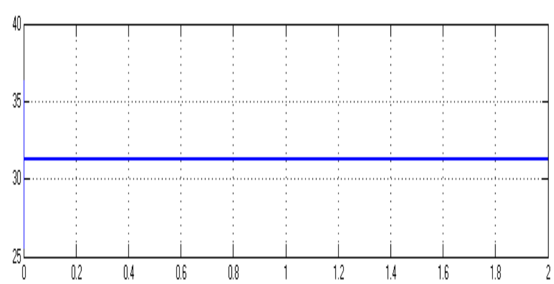

Figure 10 Output power of BBC with SG system

Circuit diagram of Quadratic boost converter with smart grid system is shown in Fig 11.

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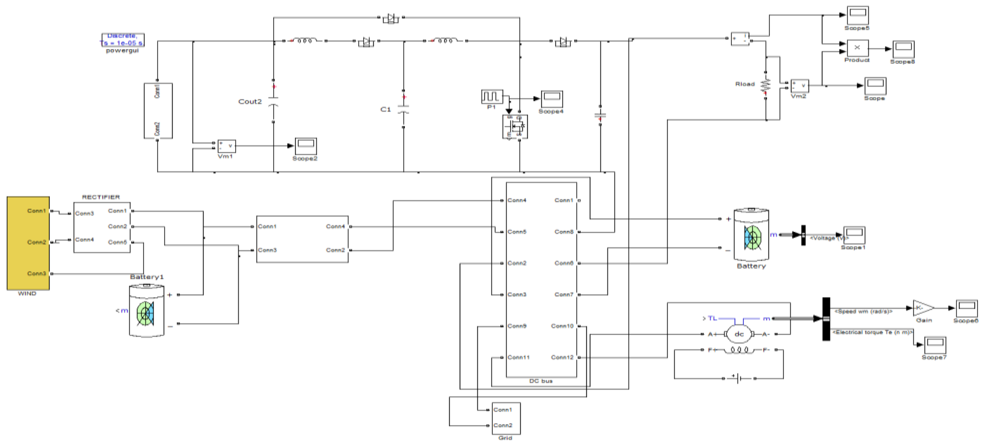

Figure 11 Circuit diagram of Quadratic boost converter with smart grid

Input voltage of QBC with SG system is shown Fig 12 and its value is 14 Volts.

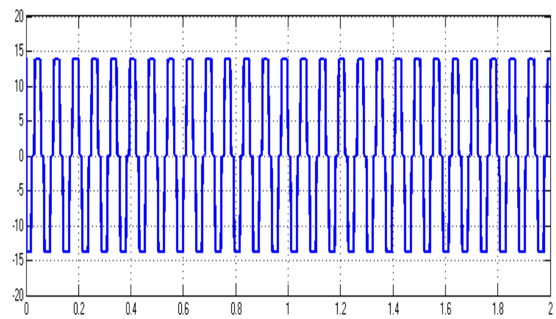

Figure 12 Input voltage of QBC with SG system

Voltage across Rectifier of QBC with SG system is shown in Fig 13 and its value is 12.5 Volts.

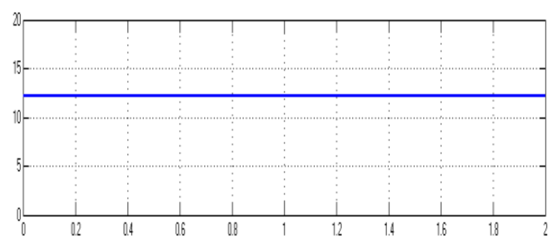

Figure 13 Voltage across Rectifier of QBC with SG system

Switching pulse of QBC S1 is shown in Fig 14 and its peak to peak value is 1 Volts.

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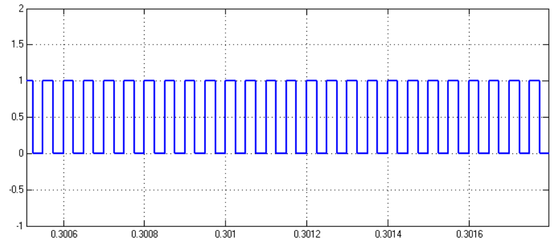

Figure 14 Switching pulse of QBC S1

Voltage across R-load of QBC with SG system is shown in Fig 15 and its value 79 Volts.

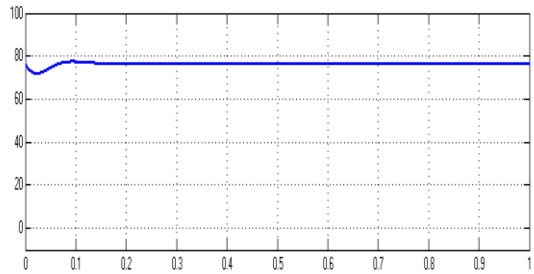

Figure 15 Voltage across R-load of QBC with SG system

Ripple voltage across R-load of QBC with SG system is shown in Fig 16 and its value is 76.99 Volts.

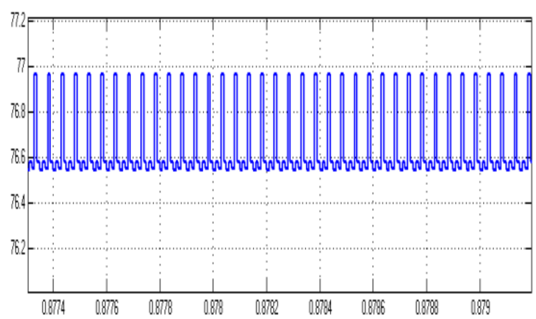

Figure 16 Ripple voltage across R-load of QBC with SG system

Current through R- load of QBC with SG system is shown in Fig 17 and its value 0.76 A

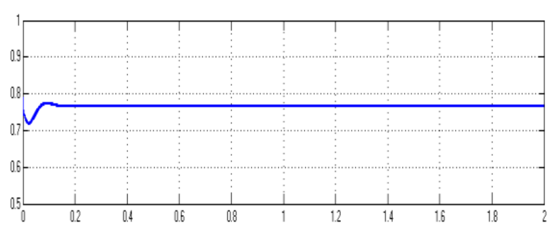

Figure 17 Current through R- load of QBC with SG system

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Output power of QBC with SG system is shown in Fig 18 and its value is 60 watts.

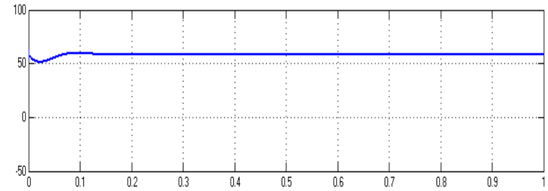

Figure 18 Output power of QBC with SG system

Motor speed of QBC with SG system is shown in Fig 19 and its value is RPM.

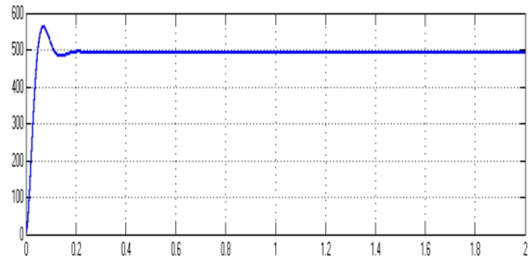

Figure 19 Motor speed of QBC with SG system

Motor torque of QBC with SG system is shown in Fig 20 and its value is 0.9 N-m.

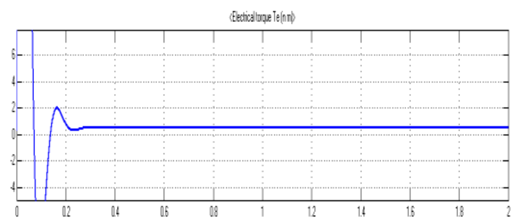

Figure 20 Motor torque of QBC with SG system

Circuit diagram of SEPIC converter with smart grid is shown in Fig 21.

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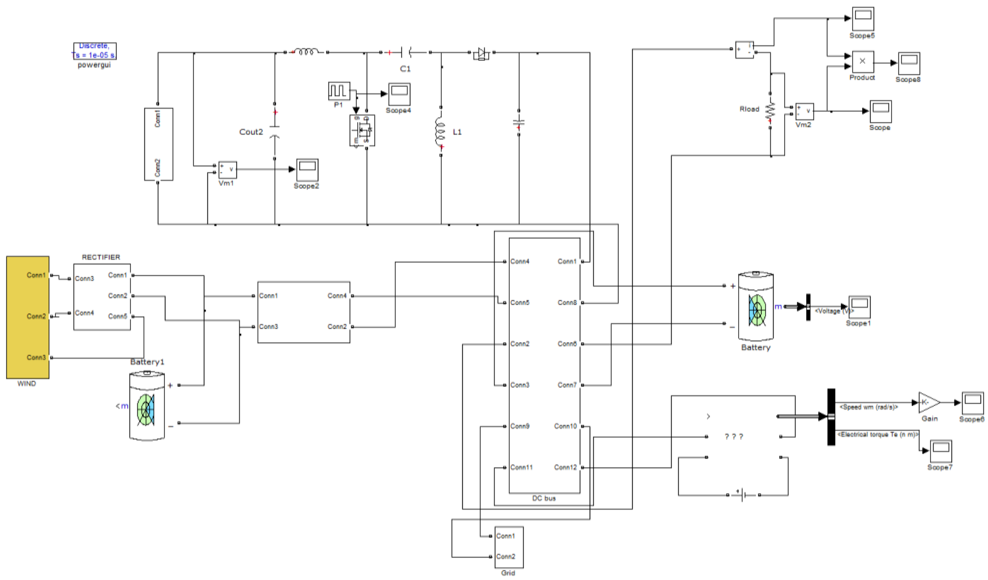

Figure 21 Circuit diagram of SEPIC converter with smart grid

Voltage across PV of SEPIC converter with SG system is shown in Fig 22 and its value is 13 Volts.

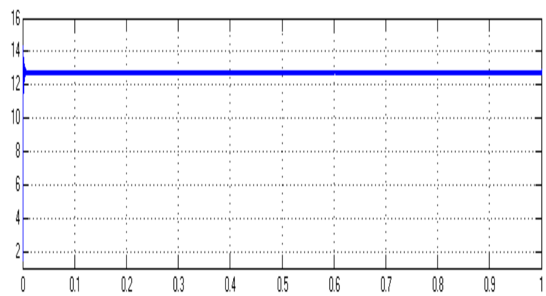

Figure 22 Voltage across PV of SEPIC converter with SG system

Voltage across wind of SEPIC converter with SG system is shown in Fig 23 and its value is 14 Volts.

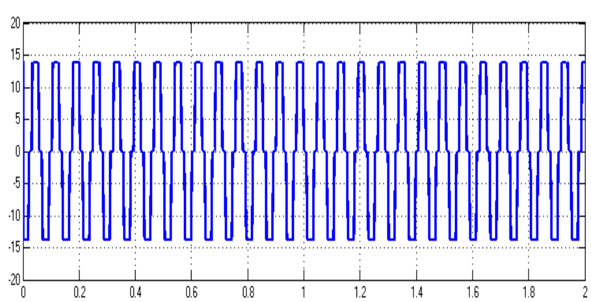

Figure 23 Voltage across wind of SEPIC converter with SG system

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Switching pulse of SEPIC converter S1 is shown in Fig 24 and its peak to peak value is 1 Volts.

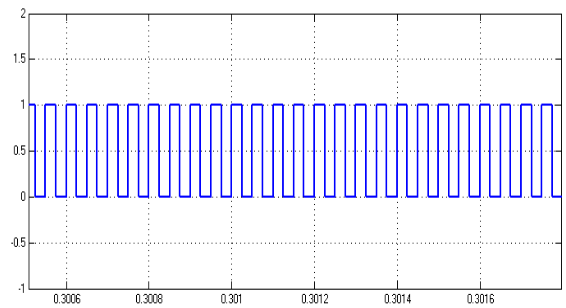

Figure 24 Switching pulse of SEPIC converter S1

Voltage across R-load of SEPIC converter with SG system

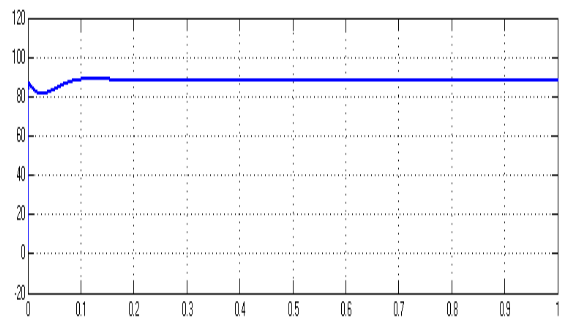

Figure 25 Voltage across R-load of SEPIC converter with SG system

Ripple voltage across R-Load of SEPIC converter with SG system is shown in Fig 26 and its value is 88.299 Volts

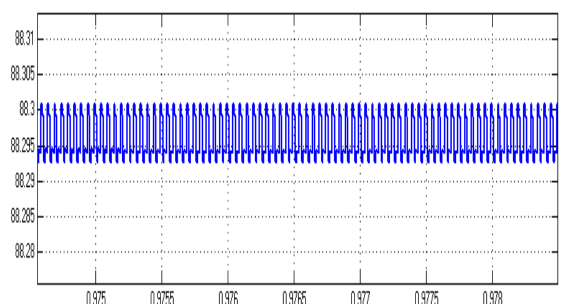

Figure 26 Ripple voltage across R-Load of SEPIC converter with SG system

Current through R-load of SEPIC converter with SG system is shown in Fig 27 and its value is 0.89 A.

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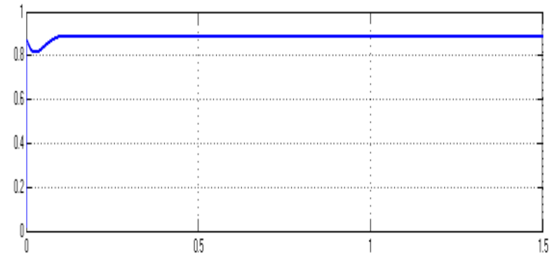

Figure 27 Current through R-load of SEPIC converter with SG system

Output power of SEPIC converter with SG system is shown in Fig 28 and its value is 75 watts.

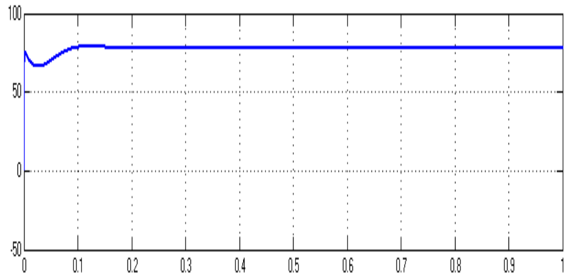

Figure 28 Output power of SEPIC converter with SG system

Motor speed of SEPIC converter with SG system is shown in Fig 29 and its value is 700 RPM.

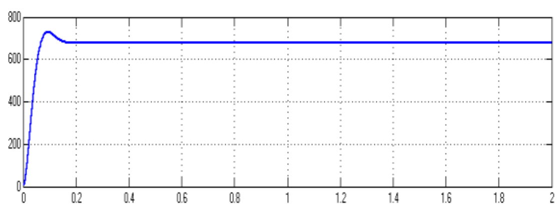

Figure 29 Motor speed of SEPIC converter with SG system

Motor torque of SEPIC converter with SG system is shown in Fig 30 and its value is 0.7 N-m.

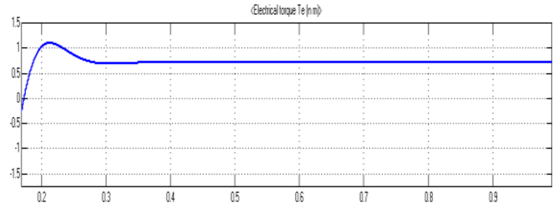

Figure 30 Motor torque of SEPIC converter with SG system

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Comparison of output voltage, output power is given by Table-1. By using SEPIC converter, the output voltage is increased from 70V to 88V; output voltage ripple is reduced from 0.01V to 0.005V and output power is enhanced from 32W to 78W. Hence, outcome represents that SEPIC converter with smart grid is superior to buck boost converter and QBC with smart grid.

TABLE -1 COMPARISON OF OUTPUT VOLTAGE, OUTPUT POWER

Converters	V_{in}	V_o	V_{or}	P_o
Buck boost	12V	70V	0.01V	32W
QBC	12V	77V	0.40V	59W
SEPIC	12V	88V	0.005V	78W

6. CONCLUSION

Buck boost converter, Quadratic boost converter and SEPIC converter with smart grid are simulated and outcomes are presented. By using SEPIC converter, the output voltage is increased from 70V to 88V; output voltage ripple is reduced from 0.01V to 0.005V and output power is enhanced from 32W to 78W. Hence, outcome represents that SEPIC converter with smart grid is superior to buck boost converter and QBC with smart grid.

REFERENCES

1. O. Cornea, G. Andreescu, N. Muntean and D. Hulea, "Bidirectional Power Flow Control in a DC Microgrid Through a Switched-Capacitor Cell Hybrid DC–DC Converter," in *IEEE Transactions on Industrial Electronics*, vol. 64, no. 4, pp. 3012-3022, April 2017.
2. H. Ardi, A. Ajami, F. Kardan, S. Nikpour, "Analysis and implementation of a non-isolated bidirectional DC-DC converter with high voltage gain", *IEEE Trans. Ind. Electron.*, vol. 63, no. 8, pp. 4878-4888, Aug. 2016.
3. M. Lakshmi and S. Hemamalini, "Nonisolated High Gain DC–DC Converter for DC Microgrids," in *IEEE Transactions on Industrial Electronics*, vol. 65, no. 2, pp. 1205-1212, Feb. 2018.
4. M. Forouzesh, K. Yari, A. Baghramian, S. Hasanpour, "Single-switch high step-up converter based on coupled inductor and switched capacitor techniques with quasi-resonant operation", *IET Power Electron.*, vol. 10, no. 2, pp. 240-250, Oct. 2017.[]
5. U. Vuyyuru, S. Maiti and C. Chakraborty, "Active Power Flow Control Between DC Microgrids," in *IEEE Transactions on Smart Grid*, vol. 10, no. 5, pp. 5712-5723, Sept. 2019.
6. L. Che, X. Zhang, M. Shahidehpour, A. Alabdulwahab, A. Abusorrah, "Optimal interconnection planning of community microgrids with renewable energy sources", *IEEE Trans. Smart Grid*, vol. 8, no. 3, pp. 1054-1063, May 2017.
7. X. Li et al., "Flexible interlinking and coordinated power control of multiple DC microgrids clusters", *IEEE Trans. Sustain. Energy*, vol. 9, no. 2, pp. 904-915, Apr. 2018.

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8. K. Rouzbehi, J. I. Candela, A. Luna, G. B. Gharehpetian, P. Rodriguez, "Flexible control of power flow in multiterminal DC grids using DC–DC converter", *IEEE J. Emerg. Sel. Topics Circuits Syst.*, vol. 4, no. 3, pp. 1135-1144, Sep. 2016.
9. D. Shi et al., "A distributed cooperative control framework for synchronized reconnection of a multi-bus microgrid", *IEEE Trans. Smart Grid*, vol. 9, no. 6, pp. 6646-6655, Nov. 2018.
10. J. Huang, J. Xiao, C. Wen, P. Wang and A. Zhang, "Implementation of Bidirectional Resonant DC Transformer in Hybrid AC/DC Micro-Grid," in *IEEE Transactions on Smart Grid*, vol. 10, no. 2, pp. 1532-1542, March 2019.
11. R. Haghmaram, F. Sedaghati, R. Ghafarpour, "Power exchange among microgrids using modular-isolated bidirectional DC–DC converter", *Elect. Eng.*, vol. 99, no. 1, pp. 441-454, 2017.
12. T. Tanaka, Y. Takahashi, K. Natori, Y. Sato, "High-efficiency floating bidirectional power flow controller for next-generation DC power network", *IEEJ J. Ind. Appl.*, vol. 7, no. 1, pp. 29-34, 2018.
13. Rizky Ajie Aprilianto, Subiyanto, Tole Sutikno, “Modified SEPIC Converter Performance for Grid-connected PV Systems under Various Conditions”
14. B. Sreenivasa Raju , K. V. Satheesh Babu , S. MD. Ghousul Azam “Fractional Order PID Control for Solar PV and Battery Storage Systems Using Three -Level NPC Inverter” International Journal of Scientific Engineering and Technology Research (IJSETR) ISSN 2319-8885 Vol.04,Issue.40, October-2015, Pages:8672-8681.
15. K. Nosrati, H. R. Mansouri and H. Saboori, "Fractional-order PID controller design of frequency deviation in a hybrid renewable energy generation and storage system," in *CIRED - Open Access Proceedings Journal*, vol. 2017, no. 1, pp. 1148-1152, 10 2017.
16. Ozan Gul, Nusret tan, “Application of fractional-order voltage controller in building-integrated photovoltaic and wind turbine system” First Published July 17, 2019 Research Article https://doi.org/10.1177/0020294019858213