High Performance DC-to-AC Converter Using Snubberless H-Bridge Power Switches and an Improved DC-to-DC Converter

Candidus U. Eya¹, Ayodeji Olalekan Salau², Stephen Ejiofor Oti³

 ^{1, 3} Department of Electrical Engineering, University of Nigeria, Nsukka, Nigeria
 ² Department of Electrical/Electronics and Computer Engineering, Afe Babalola University, Ado Ekiti, Nigeria

Received: August 20, 2020. Revised: March 9, 2021. Accepted: April 6, 2021. Published: April 8, 2021.

Abstract: This paper presents the analysis, modeling, simulation, and implementation of a high performance DC-to-AC (DC-AC) converter. The system comprises of a combination of DC power source, stress less DC-to-DC (DC-DC) voltage converter, two snubberless power switches, and control unit. The system is portable, has a two-stage transformation input voltage and amplification with no transformer and occupies less space unlike the classical twostage inverter systems. In addition, the system produces a constant DC boosted voltage with less stress on both the source and DC storage capacitor which are not found in conventional converters. The proposed power electronic converter system produced the following results: pure sine voltage and current waveforms, total harmonic distortion (THD) of 4.294%, power output of 5740W, efficiency of 98.9%, power loss of 60W and fast dynamic response. The target areas of applications of the proposed converter are in medium and small scale industries.

Keywords: DC-DC converter, high performance, snubberless, converter,

I. INTRODUCTION

High performance of DC-to-AC (DC-AC) converters convert DC power to AC power at

desired output voltages, currents, and frequencies [1]. The conversion of DC power to AC power is not imaginary but is real for power electronic components. In recent times, the demand for power electronic converters has increased mainly due to industrialization and the quest to provide an alternative power supply to remote parts of the globe because of the lack of constant power supply in most developing countries [2]. The DC-AC power converter has numerous applications ranging from lightening of bulbs in our different respective homes, used in driver motors for small and medium scale industries, uninterruptible power supply in telecommunication industries, farm storage systems, biomedical laboratories, etc. These converters exist in various forms such as single phase, three phase, five phase, and six phase inverters; single stage, double stage, and multistage inverters; two level, three level and multilevel inverters; transformer-based and transformer-less inverters; voltage and current source inverters and many other classifications [3-7].

Typically in a single stage inverter, the inversion is performed by one stage conversion. It has merit of low power circuit cost and high conversion efficiency. However, they have enormous complex control methods (double loop feedback scheme, quad-loop feedback systems, and so on), high switching losses, elevated control component counts, large input voltage level due to low transformation ratio, high load transiency, and complicated control computations. Based on these challenges in single stage inverter, the overall efficiency or performances of these inverters are reduced which also leads to increase in control conduction losses of the power switches [8-10]. In addition, they experience a reverse recovery problem in antiparallel diodes. On the other hand, multilevel inverters have low harmonics distortions and high power handling capabilities but are expensive due to their large number of components [11-15]. Similarly, the two-stage DC-to-AC power converter is another interesting type of inverter. This is because it is mostly used when the source voltage is low whereas AC applications require high voltages due to their high transformation ratio. Some typical examples are incorporated in Fuel cells, solar panels, super capacitors, rectified output voltage from wind power, etc. Twostage DC-AC power converters are placed between the source voltage and AC power loads to avoid using power transformers and its associated problems as observed in conventional inverters in raising an output voltage. There are numerous two-stage power inverters which have been proposed by a number of researchers [16-23]. Some classical examples are shown in Fig. 1 [16-19] and Fig. 2 [20-23]. The two-stage power inverters in Figs. 1 and 2 suffer from huge stray capacitances and inductances; electromagnetic interferences, large space, power losses, high voltage stresses on both source supply and capacitors, and are expensive due to the inclusion of snubber circuits during practical implementation.



Fig. 1. Two-stage boost DC-AC converter.



Volume 15, 2021

Fig. 2. Cascaded two-stage DC-AC power converter.

In this paper, we evaluate the performance of a two-stage DC-to-AC power converter with snubberless H-bridge power switches and less stressful DC-to-DC (DC-DC) converter. The identified research problems which are addressed in this paper are: (i) issue of stray capacitances and inductances that occur in Hbridge inverters due to the use of two separate switches on each leg of the H-bridge inverter of a classical two-stage inverter system, (ii) inclusion of a snubber circuit in H-bridge inverters due to excess voltage during the off period in a classical two-stage inverter system, (iii) voltage stresses that occur on storage and filtering capacitors when DC-DC power switches are ON which leave the load to depend completely on the capacitors, (iv) Time consumed and cost when two separate power switches are joined on each leg of a Hbridge inverter during practical experimentation, (v) large space and size of heat sink of the two separate switches of each leg of a H-bridge of an inverter. With the resolution of the stated challenges, the efficiency of the proposed system will increase and power losses will be minimized, hence increasing the performance and the reliability of the proposed system.

The H-bridge power switch used in this research work is IXYSFII 40-06D (IXYS ISOPLUS FII 40-06D). IXYSFII 40-06D has two inbuilt power switches with five pinouts per one leg of H-bridge inverter unlike the classical H-bridge inverter with six pinouts where the two power switches are separated. During the practical implementation, the cost and time of soldering the two switches are eliminated unlike when building the conventional H-bridge inverters. Secondly, the issues of stray capacitance, electromagnetic interference and inductance which are common in the classical H-bridge inverters are highly minimized. Thirdly, the large space and power losses are also mitigated due to the nature of the power switches used in the Hbridge inverter. This inverter does not need snubber circuit. This is because during its turnoff period, its freewheeling diode (HiPerfred diode) has the capability of handling up to 18000W at a temperature of 25°C and 9000W at a temperature of 90°C [24]. Moreover, the improved DC-DC power converter proposed ensures that during conduction, the voltage source and the capacitor storage share the stress unlike in the traditional two-stage DC-AC power converter where the capacitors are meant to bear the whole stress when the power diodes are in OFF state or the voltage source completely takes up the whole stress during the ON state of the power switch. Furthermore, because of the nature and type of stress shared between the source and the capacitor during conduction, the DC-DC converter uses the advantage to supply constant boosted DC voltage at the input rail of the inverter. The circuit diagram of the proposed system is shown in Fig. 3. It is made of power voltage source (Vs), two IGBTs, two IXYSFII 40-06D (represented by M1 and M2), and a load. In the proposed system, the lower harmonics orders are reduced with the aid of pulse-with modulation schemes such as DCtriangular based scheme and sinusoidal pulsewidth modulation.



Fig. 3. Proposed DC-to-AC converter.

II. ANALYSIS AND OPERATIONAL PRINCIPLES OF THE PROPOSED SYSTEM

The proposed system operates in two modes (Mode 1 and Mode 2). In Mode 1, the low level voltage is converted to high level voltage (boosted voltage, V_{b1}) and the output is placed at the input inverter rail, whereas in Mode 2, the boosted voltage is inverted to AC voltage at the operating frequency of the reference voltage.

(A) Mode 1: Mode 1 is further classified into two subsections. During the first subsection operation of this stage, the IGBT without anti-parallel diode, S_a and power

diode, D_2 are turned ON and forward biased, whereas the IGBT with anti-parallel diode, S_b and power diode, D_1 are switched OFF and reverse biased. At this point, the current flows from the source to place the boosted voltage, V_b across the inverter input terminals. The paths of the current flow are: $V_s \rightarrow L_1 \rightarrow L_2 \rightarrow$ $D_2 \rightarrow C \rightarrow V_s$ to build magnetic energy linearly in L1, plus $L_2 \rightarrow D_2 \rightarrow C \rightarrow V_s$ to charge the capacitor, and $L_2 \rightarrow D_2 \rightarrow Z_{inv} \rightarrow$ V_s to place the boosted voltage at the input inverter terminals. The circuit configuration is shown in Fig. 4. In Mode 1, three loops are created with three loop currents designated as I1, I2, and I3 as shown in Fig. 4.



Fig. 4. Circuit configuration of the first subsection of Mode 1 of the proposed system.

The relationship between the source voltage, V_s , impedances of the inductances of the inductances of the inductors, Z_{L1} , Z_{L2} , capacitance of the capacitor Z_c , and the impedance of the inverter Z_{inv} , neglecting the impedance of power diode, Z_{D1} are expressed in Eq. (1).

$$\begin{bmatrix} V_{s} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} I_{1} \\ I_{2} \\ I_{3} \end{bmatrix} \begin{bmatrix} Z_{L1} + Z_{sa} & -Z_{sa} & 0 \\ -Z_{sa} & Z_{sa} + Z_{L2} + Z_{c} & -Z_{c} \\ 0 & -Z_{c} & Z_{c} + Z_{inv} \end{bmatrix}$$
(1)

The loop currents I_1 , I_2 and I_3 flowing in Fig. 4 are given by Eqs. (2)-(4).

$$I_{1} = \frac{V_{s}[(Z_{sa}+Z_{L2}+Z_{c})(-Z_{c}+Z_{inv})-Z_{c}^{2}}{[Z_{L1}+Z_{sa}][Z_{sa}Z_{c}+Z_{sa}Z_{inv}+Z_{L2}Z_{c}+Z_{L2}Z_{inv}+Z_{c}^{2}+Z_{c}Z_{inv})-Z_{c}^{2}+Z_{sa}^{2}(Z_{c}+Z_{inv})}$$
(2)

$$I_{2} = \frac{V_{s}[Z_{sa}(Z_{c}+Z_{inv})]}{[Z_{L1}+Z_{sa}][Z_{sa}Z_{c}+Z_{sa}Z_{inv}+Z_{L2}Z_{c}+Z_{L2}Z_{inv}+Z_{c}^{2}+Z_{c}Z_{inv})-Z_{c}^{2}+Z_{sa}^{2}(Z_{c}+Z_{inv})}$$
(3)

$$I_{3} = \frac{V_{s}Z_{sa} Z_{C}}{[Z_{L1} + Z_{sa}][Z_{sa} Z_{C} + Z_{sa} Z_{inv} + Z_{L2} Z_{C} + Z_{L2} Z_{inv} + Z_{C}^{2} + Z_{C} Z_{inv}) - Z_{C}^{2} + Z_{sa}^{2} (Z_{C} + Z_{inv})}$$
(4)

Then, the boosted voltage, V_{b1} after the first subsection of Mode 1 is given by Eq. (5).

$$V_{b1} = I_3 Z_{inv}$$
(5)

During the second subsection operation of mode 1, S_b is switched ON and the power diode, D1 is forward biased, while S_a and the power diode D_2 are turned OFF and reverse biased. This causes the current flow from the source to place the boosted voltage, V_{b1} ,

across the inverter input terminals. Therefore, the paths of the current flow are: $V_s \rightarrow L_1 \rightarrow L_2 \rightarrow S_b \rightarrow V_s$ to build magnetic energies linearly in L1 and L2, and $L_1 \rightarrow D_1 \rightarrow C \rightarrow V_s$ to charge the capacitor, and $L_1 \rightarrow D_1 \rightarrow Z_{inv} \rightarrow V_s$ to place the boosted voltage, V_{b2} at inverter input terminals. The proposed circuit configuration is shown in Fig. 6. The second subsection of Mode 1 gives another set of three loop currents, I4, I5, and I6 as shown in Fig. 5.



Fig. 5. Circuit configuration of second subsection of Mode 1 of the proposed system.

The supply voltage, Vs, and loop currents, I_4 , I_5 and I_6 are related with impedances Z_{L1} , Z_{L2} , Z_{sb} , Z_C , Z_{inv} of L₁, L₂, S_b, C of the inverter using the Eq. (6).

$$\begin{bmatrix} V_{s} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} I_{4} \\ I_{6} \\ I_{7} \end{bmatrix} \begin{bmatrix} Z_{L1} + Z_{sb} & -Z_{L1} - Z_{sb} & 0 \\ -Z_{L1} - Z_{sb} & Z_{C} + Z_{L2} + Z_{sb} & -Z_{c} \\ 0 & -Z_{C} & Z_{C} + Z_{inv} \end{bmatrix}$$
(6)

The loop currents **I4**, **I5**, and **I6** flowing in Fig. 5 are given by Eqs. (7)-(9).

$$I_{4} = \frac{V_{s}[(Z_{sb}+Z_{L2}+Z_{c})(Z_{c}+Z_{inv})-Z_{c}^{2}}{[Z_{L1}+Z_{L2}+Z_{sb}][-Z_{c}^{2}-Z_{c}Z_{inv}+Z_{L2}Z_{c}+Z_{L2}Z_{inv}+Z_{c}^{2}+Z_{c}Z_{inv}+Z_{sb}Z_{inv})-Z_{c}^{2}}$$
(7)

$$I_{5} = \frac{V_{s}[(Z_{sb}+Z_{L2})(-Z_{C}+Z_{inv})]}{[Z_{L1}+Z_{L2}+Z_{sb}][-Z_{C}^{2}-Z_{C}Z_{inv}+Z_{L2}Z_{C}+Z_{L2}Z_{inv}+Z_{C}^{2}+Z_{C}Z_{inv}+Z_{sb}Z_{inv})-Z_{C}^{2}}$$
(8)

$$I_{6} = \frac{V_{s}Z_{sb} + Z_{L2}}{[Z_{L1} + Z_{L2} + Z_{sb}][-Z_{c}^{2} - Z_{c}Z_{inv} + Z_{L2}Z_{c} + Z_{L2}Z_{inv} + Z_{c}^{2} + Z_{c}Z_{inv} + Z_{sb}Z_{inv}) - Z_{c}^{2}}$$
(9)

Therefore the boosted voltage, V_{b2} after the second subsection of Mode 1 is given by Eq. (10).

$$V_{b2} = I_6 Z_{inv} \tag{10}$$

Also, when V_{b1} of Eq. (5) is equal to V_{b2} of Eq. (10), then the boosted voltage is

$$V_{b} = V_{b1} = V_{b2}$$
 (11)

This shows that the constant boosted voltage is established across the inverter input terminals when either S_a or S_b is in the ON state. Moreover under the operation of Mode 1, the relationship between boosted voltage and the duty cycle, D can be deduced using Eq. (12).

$$V_{b=} \frac{2V_{s}D + V_{s} + V_{L1}}{1 - 2D}$$
(12)

Eq. (12) shows that in generation of boosted voltage, no matter which switch is turned ON, the voltage across L_1 must be

added. Therefore, the minimum inductance is given by Eq. (13).

$$L_{min} = \frac{V_{s}I_{s}Z_{inv}[1-2D]^{2} - DT[V_{s}+V_{L1}+V_{b}]}{2V_{s}D+V_{s}}$$

where T=1/f is the switching period,

To turn either S_a or S_b ON, the Eqs. (14) and (15) are compared to generate the switching pulses.

$$t_{r1} = \begin{bmatrix} 0 & \frac{1}{2f_c} & \frac{1}{f_c} \\ 0 & A_r & 0 \end{bmatrix}$$
(14)
$$d_c = A_d e^0$$
(15)

where t_{r1} , f_c , A_r , d_c , and A_d represent triangular wave, switching frequency of carrier wave, amplitude of triangular wave, dc modulating signal, and amplitude of the dc modulating signal. Over-modulation occurrence is avoided in switching S_a and S_b provided that $A_d < A_r$.

(B) Mode 2: In Mode 2, V_{b1} is converted to AC voltage when the direct current passes through the inversion regions of M1 (IXYSFII 40-06D) and M2 (IXYSFII 40-06D) of the Hbridge converter. M1 represents one leg of the H-bridge (half-bridge), while M2 represents the second leg of the inverter. M1 consists of two IGBT switches serially stacked together to form one module switch but functions by complementing each other. It has five pinout terminals. At the time of converting the boosted voltage to AC voltage, the power switches on each leg of the H-bridge should not be turned at the same time. The switching signals for the power switches M1 and M2 are obtained by comparing the sine wave and phase shifted sine wave reference signals of Eqs. (16) and (17) with the triangular wave of Eq. (18).

$$S_{1.ref} = A_a sin\theta \tag{16}$$

$$S_{2.ref} = A_a \sin(\theta - 180) \tag{17}$$

$$C_{r1} = \begin{bmatrix} 0 & \frac{1}{2f} & \frac{3}{4f} & \frac{1}{f} \\ 0 & A_c & 0 & -A_c \end{bmatrix}$$
(18)

The expression for converting the DC boost voltage to AC voltage v_{ac} is given by Eq. (19) [24].

$$v_{ac} = m_a V_b \cos\left(\theta_i - \frac{\pi}{2}\right)$$
 (19)

where m_a and θ_i are the amplitude modulation and phase of the two-stage single phase DC-to-AC converter. The efficiency, ε of the two-stage boost DC-AC converter in this research work is computed using Eq. (20).

$$\varepsilon = \frac{output \ power \times 100}{Input \ power} \tag{20}$$

III. MODELING OF THE PROPOSED SYSTEM

The proposed system is modeled in MatLab/Simulink 2018 environment. The parameters used for the modeling are presented in the Table. 1.

Type of inverter	Single phase two-		
used	stage boost DC-AC		
	converter		
	parameters		
Input voltage and	48V DC and		
boosted voltage	450V DC		
DC input power	5800W (5.8kW)		
Switching	2.50kHz and		
frequencies of	1.07kHz		
carriers			
AC output	338.9V		
voltage (rms)	(240Vrms)		
Inverter output	5740W (5.74kW)		
power			
L1 = L2 of DC-	6.88mH		
DC circuit			
DC-DC capacitor	1200µF		
Load resistance,	45Ω , 5.5mH and		
inductance and	50µF		
capacitance			
Proportional and	1.01 and 0.57		
integral values			
Total harmonics	4.294%		
distortion (THD)			
Efficiency	98.9%		

The designed MatLab/Simulink block of the proposed system is shown in Fig. 6. The system was modeled in R2018a environment. It consists of the power supply, DC-DC power circuit converter, DC-AC power converter, feedback system, measuring instrument, total harmonics distortion (THD) measuring devices, and power GUI. It was observed from the THD display unit that the proposed system achieved 4.294% THD.



Fig. 6. MatLab/Simulink model of the proposed system.

IV. RESULTS AND DISCUSSION OF SIMULATIONS AND EXPERIMENTATION OF THE PROPOSED SYSTEM

(A) RESULTS AND DISCUSSION OF PROPOSED MATLAB/SIMULINK SIMULATIONS

The source DC voltage and the results of the boosted voltage are shown in Fig. 7. The

results indicate that the DC supply voltage is 48VDC and at 0 < t < 0.05s, the voltage supplied to the inverter terminal transiently increased from zero voltage until it is stabilized at 450VDC at $0.05 < t \le 1s$ which is the boosted constant voltage supplied to the input terminals of the inverter.



Fig. 7. Source DC voltage and DC-DC boosted voltage versus time.



Fig. 8. Input power versus time.

The input power waveform obtained is presented in Fig. 8. The power waveform relatively mimicked the behavior of the boosted waveform with little exception on the dynamic time response. The average input power according to Fig. 8 is 5800W.The proposed inverter output voltage and current waveforms are shown in Fig. 9. At 0 < t <0.02s, the AC voltage and current transiently increased from 0 until it stabilized at 338.89V and 33.89A. This implies that the steady state or stability is reached at an early point in this type of inverter system. Furthermore, it is observed that the current and voltage time responses of the output inverter current and voltage varies due to the action of IXYSFII 40-06D during the conversion of DC power to AC power. Secondly, it has a pure sine wave with little distortions unlike the conventional ones.



Fig. 9. DC-AC converter output voltage and current waveforms.

The spectral characteristic of the proposed system is shown in Fig. 10. The results show that the AC output voltage reaches its peak at 338.89V and has a THD of 4.294% at a fundamental frequency of 50Hz. The results indicate that the system achieves a small

power loss, is efficient and has as a THD of 4.294% which is in the acceptable range of IEEE standards. The results in Fig. 10(a) shows that a wider range of time intervals of 0 < t < 5s is obtained for the output voltage.



Fig. 10. Spectral output voltage characteristics of inverter.



Fig. 11. Spectral output current characteristics of inverter.

In Fig. 11(a)-(b), we show the result of the output current characteristics. Similar results were achieved in Fig. 10 except for the amplitude of current which is 33.89A.

The power output waveform of the proposed system is shown in Fig. 12. From the

power plot against time, it can be observed that the average power output of the proposed system is 5740W. When 5740W is subtracted from the power input of the system, 5800W, the difference is 60W. This 60W is the power loss of the system.



Fig. 12. Power output of the proposed system versus time.

Fig. 13 presents the statistical analysis of the characteristics of the outputs of the proposed inverter system. Fig. 13(a) shows the histogram plot which can be used to indicate the transient and steady states of the load current. Along the current axis, at a current range of $0 < I_{inv} \le +27A$ and $0 > I_{inv} \ge$ -27A shows a dynamic state of current, while at $+27A < I_{inv} \le +33.89A$ and -27A < $I_{inv} \le -33.89A$ indicates the stable region of the current. The spherical plot of current show that as the spherical lines spread (rarefaction) as they leave zero indicating an unstable state but is compressed at the current range of $+27A < I_{inv} \leq +33.89A$ and $-27A < I_{inv} \leq -33.89A$ under the stable state. Fig. 13(c) and Fig. 13(d) represent the spherical and histogram plots of the output voltage of the inverter which is also mimicked in Fig. 13(a) and Fig. 13(b) but differ on the range of numbers based on the dynamic and steady state characteristics of the proposed system.



Fig. 13. Statistical analysis of the characteristics of output the proposed inverter.

(B) EXPERIMENTAL RESULTS AND DISCUSSION

The results for the dc input voltage waveform is shown in Fig. 14. From the oscilloscopic display, it was observed that the source voltage is 48V.

The DC-DC boosted voltage represented by Eq. (12) is shown in Fig. 15. The level of the boosted voltage is 450VDC.

In Fig. 16, we give a representation of the DC-triangular wave-based modulation scheme. The results show that a triangular waveform of 7.20V with carrier frequency of 2.50 kHz is compared to generate the switching pulses for triggering S_a and S_b of the DC-DC converter as shown in Fig. 17.

Tek	n		Stop	M Pos: 0.000s	Save/Rec
					Action Save Image
					File Format Bmp
2				i a an ta	About Saving Images
					Select Folder
2 Ma 1 Po: 2 Po:	ximum s Duty s Duty	0.00V 247m%? 99.3%?	1 Period 1 Maximum 1 Frequency	2.024ms? 48.0V 494.0Hz?	Save TEK0001.BM P
Please v	. <mark>0V</mark> /ait	2 5.00V	M 500us	<u>Ch1 -∕ 20.0V</u> Apr 01	< <mark>10Hz</mark> , 2021, 00:15)

Fig. 14. DC source voltage.

Tek		Ready	М	Pos: 0.000s	Save/Rec
					Action Save Image
	· · · · · · · · · · · · · · · · · · ·				File Format Bmp
2)					About Saving Images
					Select Folder
2 Maximum 1 Pos Duty 2 Pos Duty	0.00 100% 99.7	V 6? %?	Period Maximum Frequency	4.000us? 450V 250.0kHz?	Save TEK0002.BM P
1 250V Please wait	2 5.00	/ <u>)(</u> M 5	500us	Ch1 / 200V · Apr 01	< <mark>10Hz</mark> , 2021, 00:19)

Fig. 15. DC-DC boosted Voltage.



Fig. 16. DC-triangular wave modulation scheme.



Fig. 17. S_a and S_b switching pulses.

The sinusoidal pulse width modulation for the proposed system is shown in Fig. 18. It was observed that the carrier wave has a frequency of 1.077 kHz and a maximum voltage of 8.40V whereas the modulating reference signal has a peak voltage of 7.40V. This ensured that the over modulation was completely prevented. The modulating and carrier wave shown in Fig. 18 were represented mathematically in Eqs. 16 and 18. After comparison with the aid of TL 084, and passing them through 4049, 4081, 4050 CMOS ICs and driver circuits, the switching signals in Fig. 19 is produced.



Fig. 18. Sinusoidal pulse width modulation scheme.



Fig. 19. Switching signals of the first leg of the H-bridge inverter of the proposed system.

Fig. 20 was produced when the expression in Eq. (17) was compared with Eq. (18) and their output signals were passed through the processing circuits. The signals produced in Fig. 20 were used to trigger the second leg of the H-bridge inverter of the proposed system.



Fig. 20. Triggering signals for second leg of H-bridge inverter of the proposed system.



Fig. 21. Prototype of high performance DC-AC converter using snubberless h-bridge power switches with a stressless DC-DC converter.

The complete prototype of the high performance direct current-to-alternating current converter using snubberless h-bridge power switches with an improved DC-DC converter with oscilloscopic display of pure sine wave is shown in Fig. 21. Some useful studies and applications can be found in [26], [27], [28].

V. CONCLUSION

A high performance DC-to-AC converter using snubberless H-bridge power switches and an improved DC-DC converter has been analyzed, modeled, simulated in MatLab/Simulink environment, and implemented. achieve our aim, we used reduced sizes of H-bridge inverter power switches with a less stressful DC-DC power converter. The results show that the statistical histograms and spherical plots obtained can be graphically used to analyze the dynamics and steady state condition of the inverter output system. Further results indicated that the developed system is highly efficient and reliable, giving an efficiency of 98.9% with a fast dynamic response and power loss of 60W.

References

- M. H. Rashid. Power Electronics Hand book. 3rd Ed. Butterworth-Heinemann, 30 Corporate Drive, suite 400. Burlington, MA 01803, USA, 2011.
- [2] M. U. Agu, Principles of Power Electronics Circuits, UNN Press, Nigeria, 2019.
- [3] G. C. Diyoke and C. U. Eya. Modeling and Simulation of Five-Phase Induction Motor Fed With Pulse Width Modulated Five-Phase Multilevel Voltage Source Inverter Topologies,' Journal of Advances in Electrical Devices Volume 4 Issue 2, pp. 6-22, 2019
- [4] B. Jyothi, M. V. G. Rao, T. Karthik. Modelling and Simulation of Five Phase Induction Motor Fed with Five Phase Inverter Topologies. Indian Journal of Science and Technology, vol. 8, no. 19, pp. 1- 8, 2015.
- [5] G. C. Jiang, X. Li, Y. Chen, and J. Liu. A dc-link voltage self-balanced method for a diode-clamped modular multilevel converter with minimum number of voltage sensors. IEEE Transaction. Power Electron, vol. 28, no. 5, pp. 2125-2139, 2013. DOI: 10.1109/TPEL.2012.2212915.
- [6] C.U. Eya, O. Crescent, J. M. Ukwejeh. Solar-powered five level output voltage of dc-to-ac converter using simplified capacitor voltage controlled scheme (SCVCS). IEEE PES/IAS PowerAfrica, Abuja, Nigeria, pp. 1-6, 2019. DOI:

10.1109/PowerAfrica46609.2019.9078 670

- [7] A. O. Salau, C. U. Eya, O. C. Onyebuchi. Nonzero staircase modulation scheme for switching DC-DC boost converter. Journal of Control Science and Engineering, vol. 2020, 8347462, pp. 1-15, 2020. DOI: 10.1155/2020/8347462.
- [8] R. Akhit. A new Technique of PWM boost inverter for solar home application. BRAC University Journal, vol. 4, issues 1, pp. 39-45, 2007.
- [9] S. Rajendran and S. S. Kumer. A solar power generation for single phase DC-AC inverter with non-linear variable structure control. Sci. Bull, vol. 76, issue 4, 2014.
- [10] R. Akhter and A. Hoque. Analysis of a PWM Boost inverter for solar home application. World Academy of Science, Engineering and Technology, PWASET, vol. 17, pp. 793-797, 2006.
- [11] G. R Zhu, S.C Tan, Y.chen and C.K Tse. Mitigation of Low frequency current ripple in fuel-cell inverter systems through waveform control. IEEE Transaction, Power Electronics, vol. 28, no. 2, pp. 779-792, 2013.
- [12] C. U. Eya, A. O. Salau, S. E. Oti. Uninterruptible DC-powered boost differential inverter with a Sensorless Changeover System. WSEAS Transactions on Circuits and Systems, vol. 20, pp. 10-26, 2021. DOI: 10.37394/23201.2021.20.2
- [13] C. U. Eya and M. U. Agu. Solar-based Boost differential single phase inverter. Nigeria Journal of Technology, vol. 34., no. 1, pp. 164-176, 2015.
- [14] B. Wu, et al. A New hybrid boosting converters for renewable energy applications. IEEE Transaction on Power Electronics, vol. 31, no. 2, pp. 1203-1215, 2016.

- [15] B. P. Baddigadiga and M. Ferdowsi. A high voltage gain DC-DC converter based on Modified Dickson Charger Pump Voltage Multiplier. IEEE Transaction on Power Electronics, vol. 32, no. 10, pp. 7707 –7715, 2017.
- [16] F. Gao, D. Li, P. C. Loh, Y. Tang, and P. Wang. Indirect dc link voltage control of two stage single phase PV Inverter. Energy conversion Congress and Exposition, pp. 1166-1172, 2009.
- [17] F. He, Z. Zhao, L. Yaun and S. Lu. A DC-link voltage control scheme for single phase grid-connected PV Inverters Energy conversion Congress and Exposition, pp. 3941-3945, 2011.
- [18] S. H. Lee, T. P. An, and H. Cha. Mitigation of Low frequency Ac ripple in single-phase photovoltaic power conditioning. Journal of Power electronics, vol. 10, pp. 1-7, 2006.
- [19] C. U. Eya. Practical implementation of an improved standby boost uninterruptible power supply, vol. 3, pp. 1-7, 2014.
- [20] S. Poshtkouhi, A. Biswas and O. Trescases. DC-DC converter for high granularity, sub-string MPPT in Photovoltaic applications using a virtual parallel connection. Proc. IEEE 27th Annu. Appl. Power Electron. Conf. Expo., pp. 86–92, 2012.
- [21] M. Forouzesh, Y. Siwakoti, Saman A. Gorji, F. Blaabjerg, and B. Lehman. Step-Up DC–DC Converters: A Comprehensive Review of Voltage-Boosting Techniques, Topologies, and Applications. IEEE Transactions on Power Electronics, vol. 32, no. 12, pp. 9143-9178, 2017.
- [22] T. M. Aiswarya and M. Prabhakar. An efficient High Gain DC-DC Converter for Automotive Applications. International Journal of Power Electronicsm, vol. 6, pp. 242-252, 2015.

- [23] B. E. Elnaghi, M. E. Dessouki, M. N. Abd-Alwahab and E. Eikholy. Development of two stage Converter for single-phase Inverter without Transformer for PV systems, vol. 9, pp. 101-111, 2019.
- [24] www.data sheet of IXYS ISOPLUS FII 40-06D.com, 2011
- [25] T. L. Skvarenina. The power Electronics Handbook Industrial Electronics Series. CRC Press, Library of Congress Cataloging-in-Publication, 2002.
- [26] Nur Aqilah Othman, Hamzah Ahmad, The Analysis of Covariance Matrix for Kalman Filter based SLAM with Intermittent Measurement, Int. J. of Applied Mathematics, Computational Science and Systems Engineering, pp.66-70, Volume 1, 2019
- [27] S.Sivaperumal, V. Sundarapandian, "Hybrid Synchronization of Hyperchaotic Qi Systems via Sliding Mode Control", Int. J. of Applied Mathematics, Computational Science and Systems Engineering, pp.71-75, Volume 1, 2019.
- [28] Rashed Bahrekazemi, Alireza Jalilian, "Assessment of Different Compensation Strategies in Hybrid Active Power Filters", Int. J. of Applied Mathematics, Computational Science and Systems Engineering, pp.19-24, Volume 2, 2020.

Creative Commons Attribution License 4.0 (Attribution 4.0 International, CC BY 4.0)

This article is published under the terms of the Creative Commons Attribution License 4.0 https://creativecommons.org/licenses/by/4.0/deed.en_US